FINAL INTEGRATED GENERAL REEVALUATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

SAN FRANCISCO BAY TO STOCKTON, CALIFORNIA NAVIGATION STUDY

APPENDIX B: Water Resources

JANUARY 2020

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1. Purpose of Report

This report summarizes the potential impacts to hydrology, coastal hydrodynamics, and salinity intrusion caused by the potential deepening of the Pinole Shoal Channel, and Suisun Bay Channel to Avon. These three channels are under consideration for deepening as part of the San Francisco Bay to Stockton Navigation Improvement Project (Project) that is being conducted by the U.S. Army Corps of Engineers (USACE). This report will serve as an appendix to the Project's integrated feasibility study and environmental impact statement report.

2. Background

The extents of the Project are shown in Figure 1. The Project begins at the Golden Gate Bridge and transits the central San Francisco Bay and through San Pablo Bay to an area east of the Carquinez Bridge in Solano County, California. San Francisco Bay and San Pablo Bay have mixed semi-diurnal tides (two unequal high tides and two unequal low tides). The channels as described in the section above are authorized to be maintained at 35-feet mean lower low water (MLLW) with 2-feet of allowable over depth for existing (without-project) conditions.

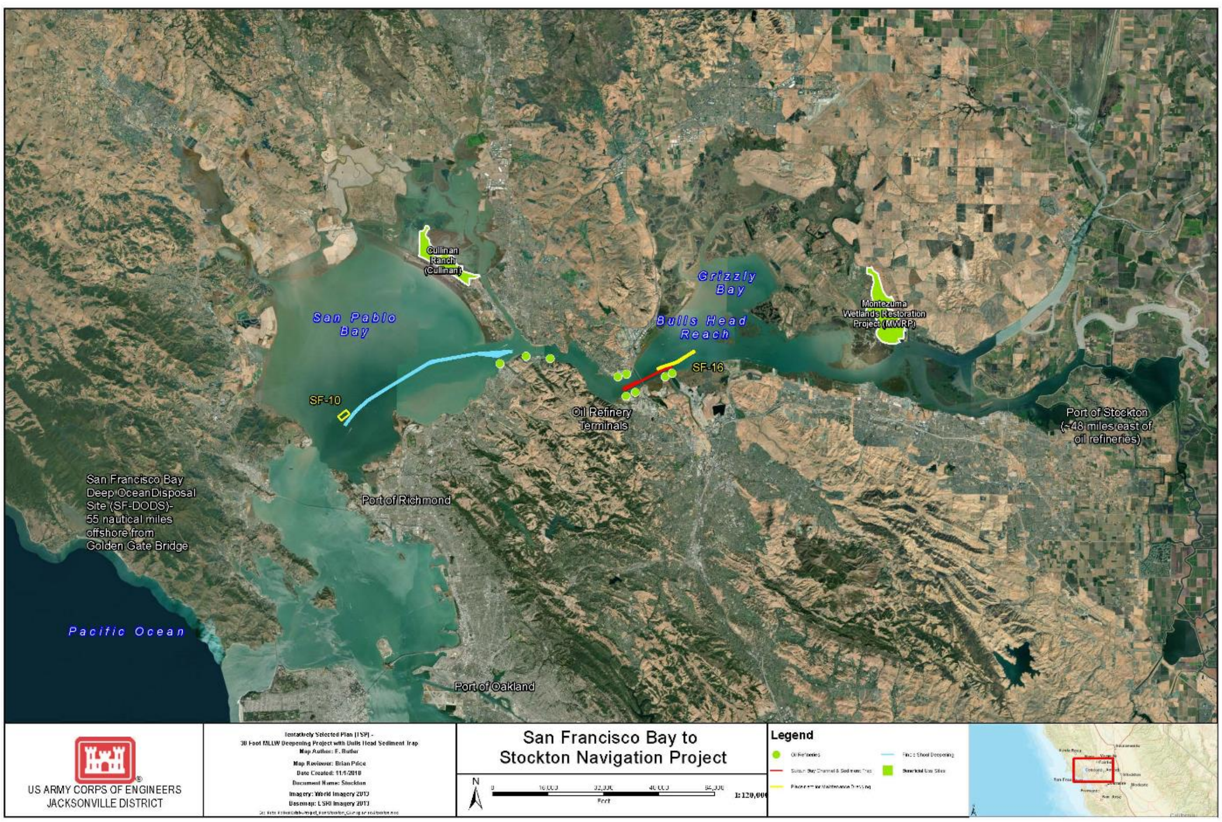


Figure 1. Project area

The Recommended Plan of the Project proposes deepening the Pinole Shoal and Suisun Bay Channels to 38 feet MLLW with 2-feet of allowable over depth, dredging a 2,600-foot long sediment trap at Bullshead Reach to 42 feet MLLW with 2-feet of allowable over depth, and leveling a rock outcrop located to the west of Pinole Shoal to 43 feet MLLW.

A typical cross section of the Recommended Plan for the Pinole Shoal and Suisun Bay Channels is shown in Figure 2.

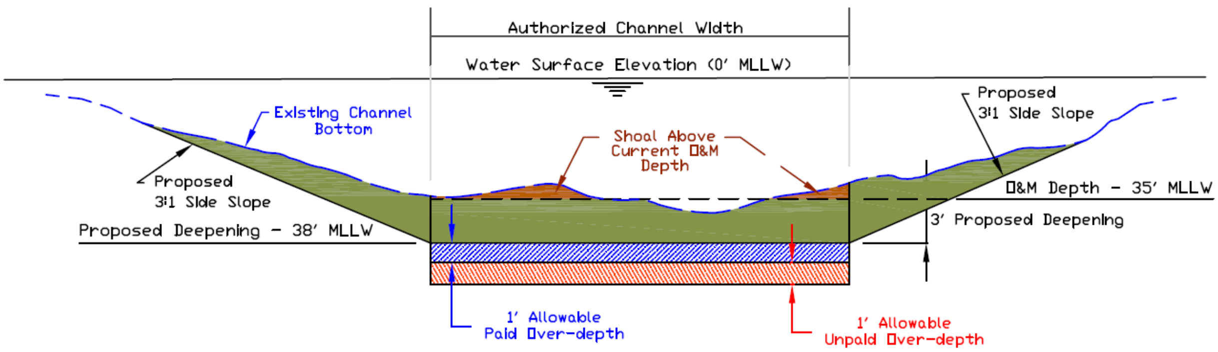


Figure 2. Typical cross section of the Recommended Plan

3. Engineering Analyses for the Project

The feasibility study analyzed potential impacts to hydrology, coastal hydrodynamics, and salinity that would result from implementation the Recommended Plan. A separate analysis was also conducted to determine viability of advanced dredging for the Bulls Head Channel.

3.1. Hydrology

The Project involves navigational channel deepening and does not involve any significant changes in land use surrounding San Francisco Bay and San Pablo Bay. Therefore, the development of a numerical hydrologic model to evaluate potential changes in runoff directly into the two bays, or into the rivers and tributaries that feed into the two bays, was not necessary for the Project. It is estimated that any channel deepening for the Recommended Plan of the Project would not have any significant hydrological impacts.

3.2. Coastal Hydrodynamics and Salinity

The Recommended Plan of the Project involves navigation channel deepening that would potentially impact coastal hydrodynamics (water elevation and flow rates) within San Francisco Bay and San Pablo Bay. Furthermore, navigation channel deepening would potentially increase salinity intrusion into the Sacramento-San Joaquin Delta. Salinity intrusion can affect species that reside within the Bay-Delta system, and can affect water quality at various water intake facilities within the southern portion of the Delta. To evaluate potential impacts to coastal hydrodynamics and salinity, the UnTRIM Bay-Delta Model was used.

3.2.1. Background on the UnTRIM Bay-Delta Model

The UnTRIM Bay-Delta Model is a hydrodynamic and salinity model that has been utilized for various other studies within the San Francisco District of the Corps of Engineers. The model is deemed as “allowed for use” by the USACE hydrology and hydraulics community of practice. These studies include, but are not limited to: the Sacramento River Deep Water Ship Channel Project, the South San Francisco Bay Shoreline Study, and the Redwood City Navigation

Feasibility Study. The setup and results of UnTRIM as a hydrodynamic and salinity model have been reviewed by various resource agencies in the San Francisco Bay Area, and have been published in numerous papers and peer-reviewed publications (MacWilliams et al., 2014, and MacWilliams et al., 2015). These resource agencies include, but are not limited to: U.S. Environmental Protection Agency, San Francisco Bay Conservation and Development Commission, Contra Costa Water District, and the California Department of Water Resources (DWR).

3.2.2. Model Setup

3.2.2.1 Model Domain and Grid System

The model domain extends from the Pacific Ocean near San Francisco to the San Francisco Bay and Sacramento-San Joaquin Delta, as illustrated in Figure 3. The model utilizes an unstructured grid system, as illustrated in Figure 4. The model boundary conditions include inflows, drinking water export facilities, wind stations, evaporation and precipitation, and flow control structures. The model has been calibrated and validated using water level, flow, and salinity data collected in San Francisco Bay and the Sacramento-San Joaquin Delta at National Oceanic Atmospheric Administration, United States Geological Survey (USGS), and DWR monitoring stations.

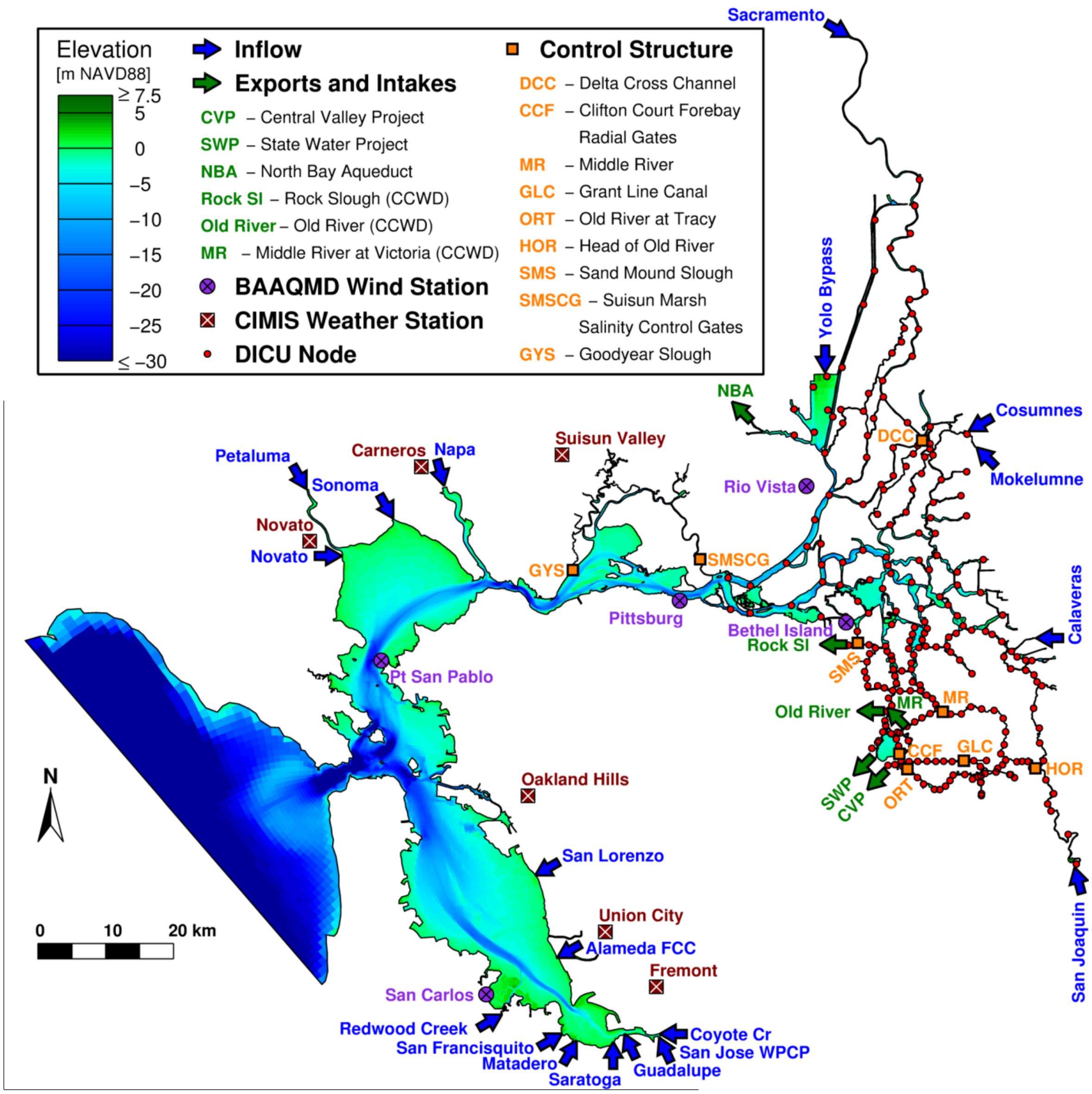


Figure 3. UnTRIM model domain (project area shown in black box)

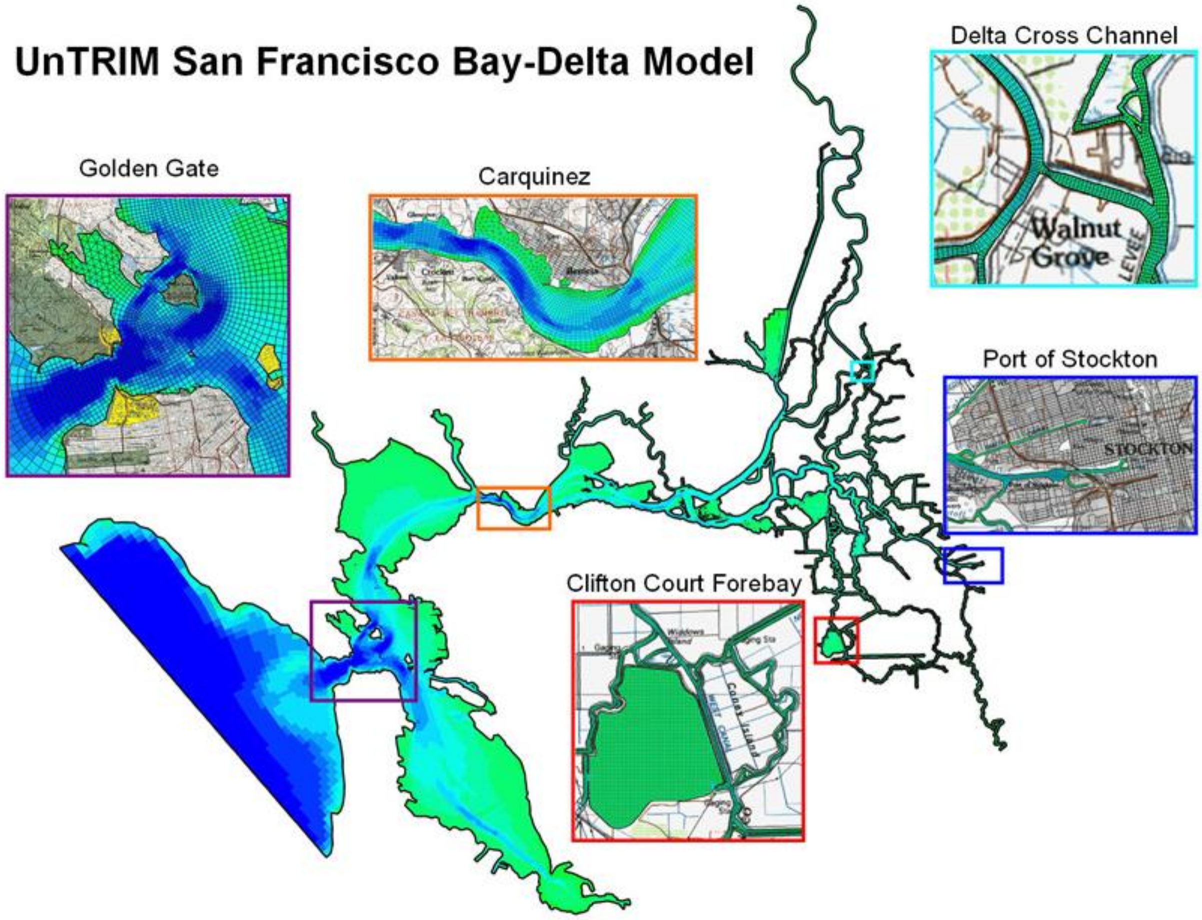


Figure 4. UnTRIM model's unstructured grid system

3.2.2.2 Year-0 Inputs

For the hydrology and operating conditions of year-0, the model considered a critical water year, below normal water year, and wet water year for without project conditions and the Recommended Plan. Water year classifications are determined by the California Department of Water Resources based on measured runoff. Critical water years have lower inflow and outflow in the Sacramento-San Joaquin Deltas than wet water years. As a result, critical water years tend to represent saltier conditions than wet water years. Water Year 2014 was designated as a critical water year and was chosen for evaluation. Water Year 2012 was designated as a below normal water year. Water Year 2011 was designated as a wet water year and was chosen for evaluation.

3.2.2.3 Year-50 Inputs

For year-50, potential sea level rise due to climate change was considered. USACE Engineering Regulation (ER) 1100-2-8162 provides guidance for incorporating the physical effects of projected future sea level change into a feasibility study (USACE, 2013). The following National Research Council (NRC) equation is utilized:

$$E(t_2) - E(t_1) = 0.0017(t_2 - t_1) + b(t_2^2 - t_1^2)$$

Where:

E(t) is the eustatic sea level change, in meters, as a function of t.

0.0017 represents the historic global mean sea level change rate of 1.7 millimeters per year.

t_1 is the time between the project's construction date and 1992.

t_2 is the time between a future date at which one wants an estimate for sea level change and 1992.

b is a constant, dependent on evaluating a low (NRC Curve I), intermediate (NRC Curve 2), and high (NRC Curve 3) sea level change scenario.

Note that 1992 above is used as a start in this equation because it is the center year of the National Oceanic and Atmospheric Administration (NOAA) National Tidal Datum Epoch of 1983-2001.

Because the hydrology and operating conditions in the Sacramento-San Joaquin Delta cannot be predicted 50 years in advance, the model considered Water Year 2014 conditions (a critical water year) but modified them to account for the highest possible sea level rise for year-50 conditions for the without project conditions and Recommended Plan. The official USACE seal level change calculator tool was utilized to determine the sea level change scenarios for the three curves mentioned above. Results from the calculator tool are shown in Figure 5. Projections are based on the San Francisco, CA tide gauge, which is the closest gauge to the Project. Note that when this modeling effort was undertaken, it was assumed that the project start date would be 2019 so Year-50 was assumed to be 2069.

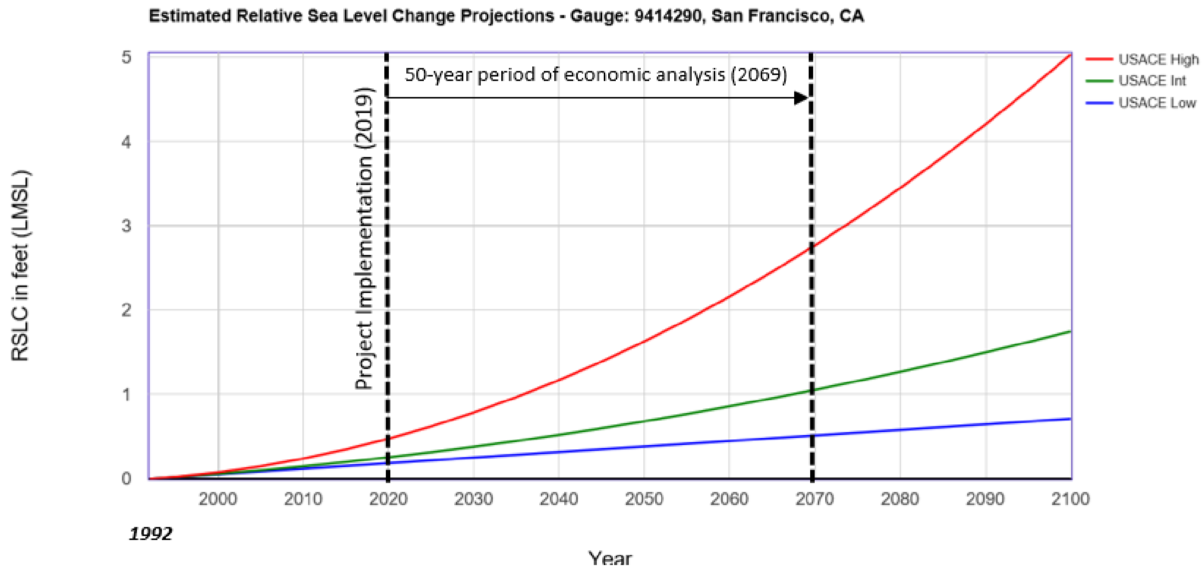


Figure 5. Projections of sea level rise for San Francisco tide gauge, based on ER 1110-28162 and based on a start date of 1992, which corresponds to the midpoint of the current National Tidal Datum Epoch of 1983-2001 (In 2069, sea level rise is expected to be 2.7 feet with respect to the 1992 epoch based on the USACE High scenario, 1 ft for the Intermediate scenario, and 0.5 ft for the Low Scenario)

Based on the high scenario, a total of 2.38 feet of sea level rise was estimated between 2014 (year of the hydrologic input, as described above) and 2069. The highest sea level change scenario was chosen for evaluation in the model because it was anticipated to have the most impact to hydrodynamics and salinity for the Recommended Plan. As demonstrated later in this appendix, the modeling results found that there would be no changes to hydrodynamics for the Recommended Plan when compared to without-project conditions for the high scenario, and it is anticipated a similar result would occur for the low and medium scenarios if they were run; the modeling results found that the changes to salinity for the Recommended Plan when compared to without-project conditions would not be significant for the high scenario, and it is anticipated a similar result would occur for the low and medium scenarios if they were run.

3.2.3. X2

The UnTRIM Bay-Delta Model evaluates the change in position of X2 in San Francisco Bay and the Sacramento-San Joaquin Delta as a result of navigation channel deepening. X2 is defined as the position of the 2 practical salinity units bottom salinity value, measured along the axis shown in measured in kilometers (Figure 6). The State Water Resources Control Board adopted X2 as a water quality standard to help restore the relationship between springtime precipitation and the geographic location and extent of estuarine habitat. Water Rights Decision 1641 (D-1641) requires freshwater inflows to the Bay sufficient to maintain X2 at specific locations for specific numbers of days each month during the spring months of February through June, known as the “Spring X2” requirement. This requirement at Port Chicago (where X2 is equivalent to 64 km) applies only in months when the average electrical conductivity during the 14 days just before the first day of the month is less than or equal to 2.64 millimhos per centimeter. However, when X2 is less than 64 kilometers there are no current regulatory requirements that regulate the position of X2. Channel deepening as part of the Recommended Plan occurs on the X2 transect from approximately 30 km to 60 km.

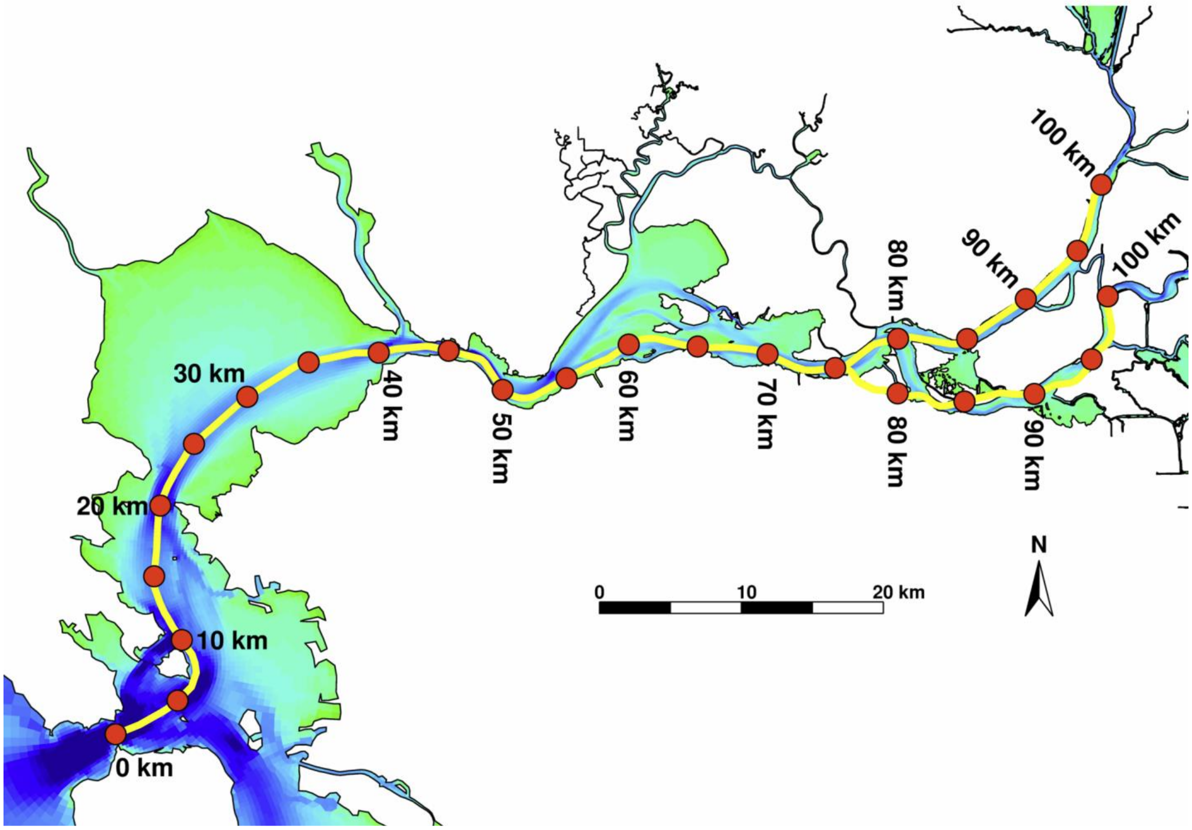


Figure 6. X2 transect (channel deepening as part of the Recommended Plan occurs on the transect from approximately 30 km to 60 km)

3.2.4. Chloride Levels at Water Intakes

The UnTRIM Bay-Delta Model also evaluates the change in chloride levels at various water intake locations within the Sacramento-San Joaquin Delta as a result of navigation channel deepening. D-1641 stipulates specific water quality objectives for municipal and industrial, agricultural, and fish and wildlife beneficial uses. Locations for which these objectives are monitored are shown in Figure 7. These D-1641 water quality standards are typically based on either Electrical Conductivity (EC) or concentrations of Cl- (chloride), measured in milligrams per liter (mg/L). The D-1641 water quality objectives for municipal and industrial beneficial use stipulate a maximum allowable concentration of 250 mg/l chloride at the municipal water intakes. Model outputs for the chloride levels at the various water intake locations are presented as concentrations of chloride in mg/L. The model outputs focused on a lot of water intake locations that are owned by the Contra Costa Water District (CCWD) since they are located in the southern portion of the Sacramento-San Joaquin Delta and are geographically close to the Project.

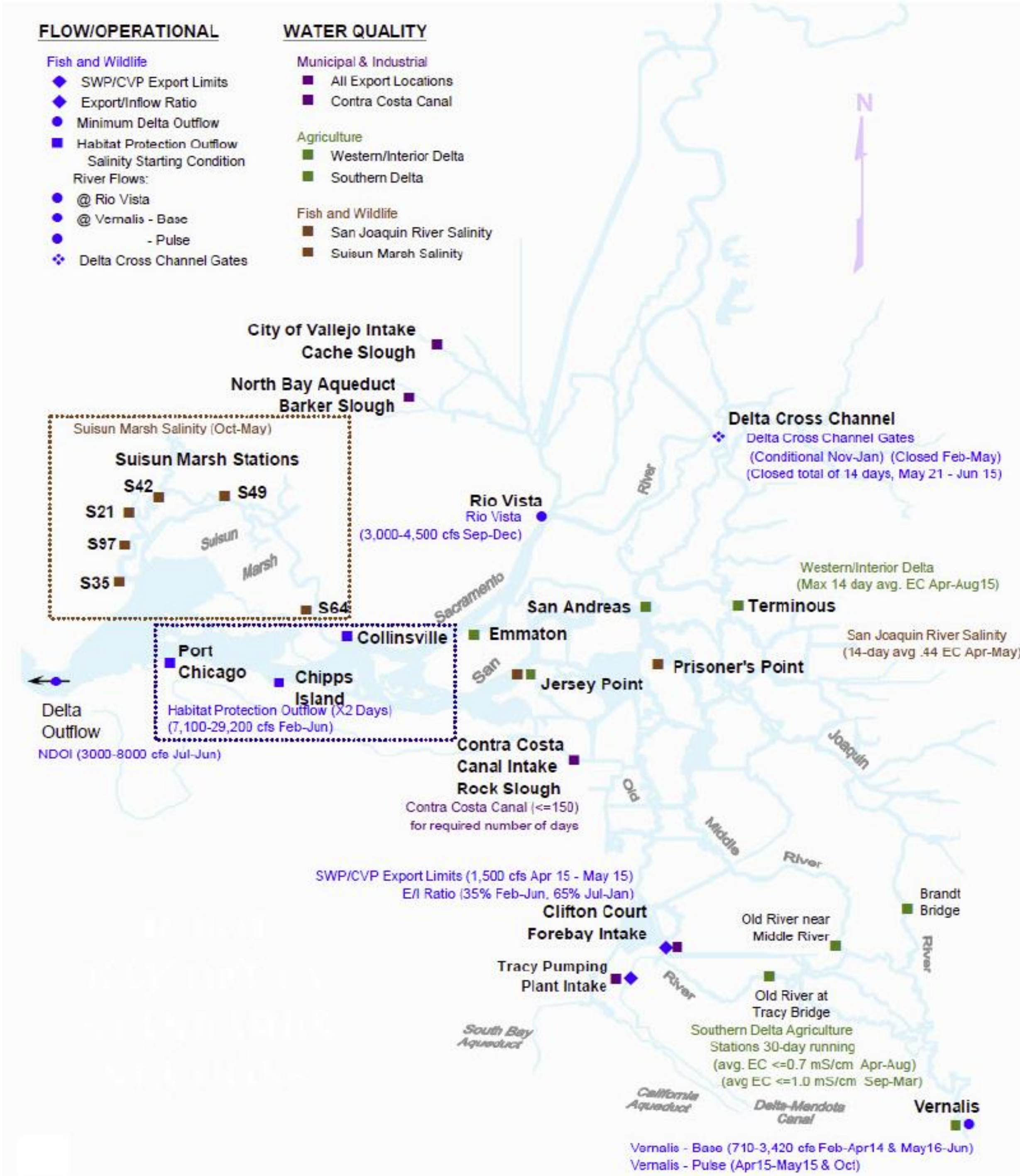


Figure 7. Locations of monitored D-1641 water quality objectives (channel deepening as part of the Recommended Plan occurs from location labeled "Delta Outflow" to approximately the location labeled "Port Chicago")

3.2.5. Model Results

Full results from the hydrodynamic and salinity model runs are included in the *San Francisco Bay to Stockton Navigation Improvement Project, Hydrodynamic and Salinity Intrusion Modeling*

Report, a report produced by Anchor QEA and included in the list of references of this appendix. The following subsections will briefly go over the most notable results from the model. References to “without-project conditions” are based on the currently authorized channel depths within the study area, and not based on any advanced dredging activity that may have occurred previously since the timing of such advanced dredging may vary from year to year. Furthermore, basing the without-project conditions on the currently authorized channel depths allowed for an evaluation of the maximum potential impacts to hydrodynamics and salinity since it would assume the need for greater dredging to occur the proposed depth of the Recommended Plan. References to movement of X2 are based on the transect shown in Figure 6. Locations of the Delta Mendota Canal Intake, CCWD Middle River at Victoria Canal Intake and the CCWD Rock Slough Intake referenced below are shown in Figure 7.

All of the following figures and tables relating to X2 and chloride, particularly with respect to the terms of the time-averaging periods, were developed with input provided by water contractors that attended meetings with the project delivery team.

The environmental appendix to main feasibility report of the Project provides an analysis of the significance of the modeled change in X2 and chloride levels at water intakes for year-0 and year-50.

3.2.5.1. Year-0

The model predicts no significant change in water levels or flow for the Recommended Plan when compared to without-project conditions for year-0 for a critical, below normal, and wet water year. An example for predicted change in water level for a below normal water year for the Sacramento River at Martinez is shown in Figure 8 (X2 location of approximately 50 km).

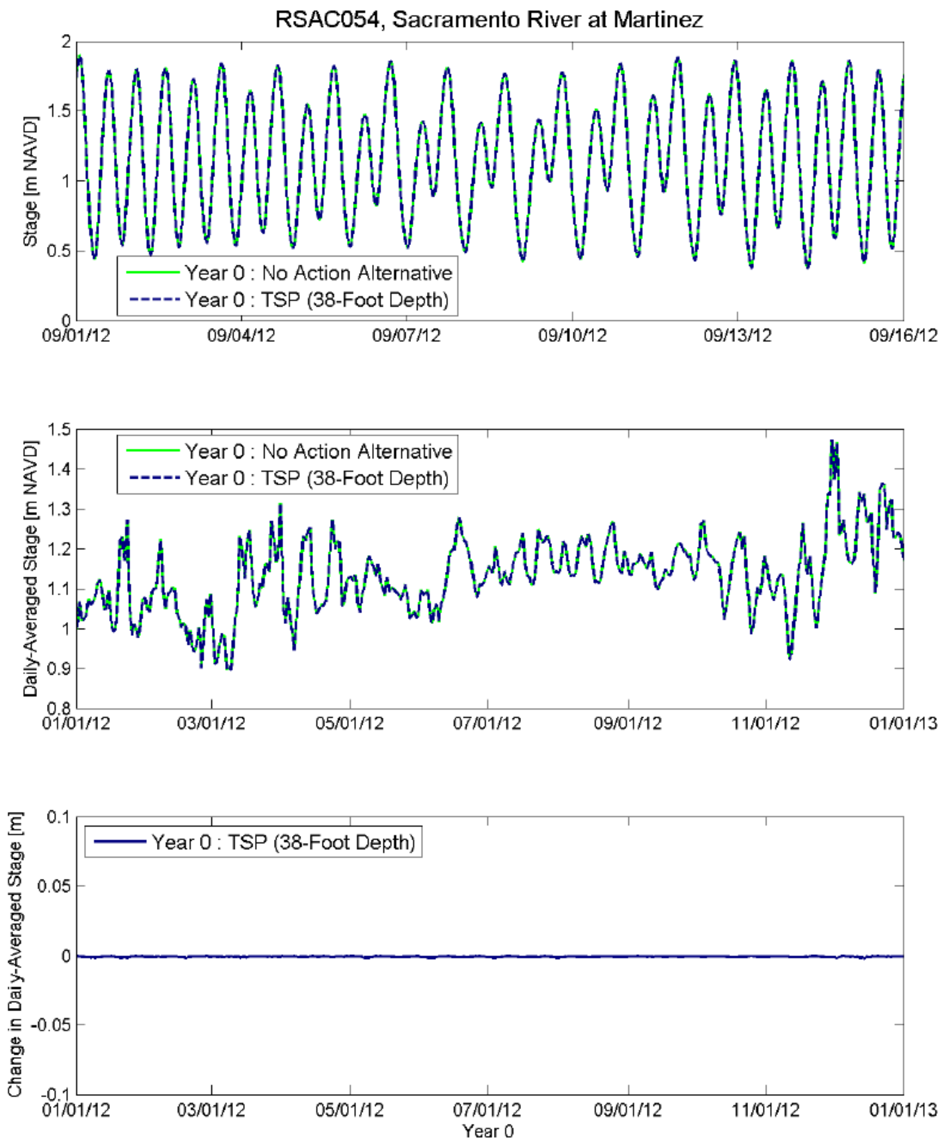


Figure 8. Predicted change in water level for Year-0 conditions for a below normal water year

For a critical water year, the model predicts an annual average change of 0.17 kilometers in X2 for Year-0 for the Recommended Plan when compared to without-project conditions. The predicted change is illustrated in Figure 9. The environmental analysis found the change to be insignificant.

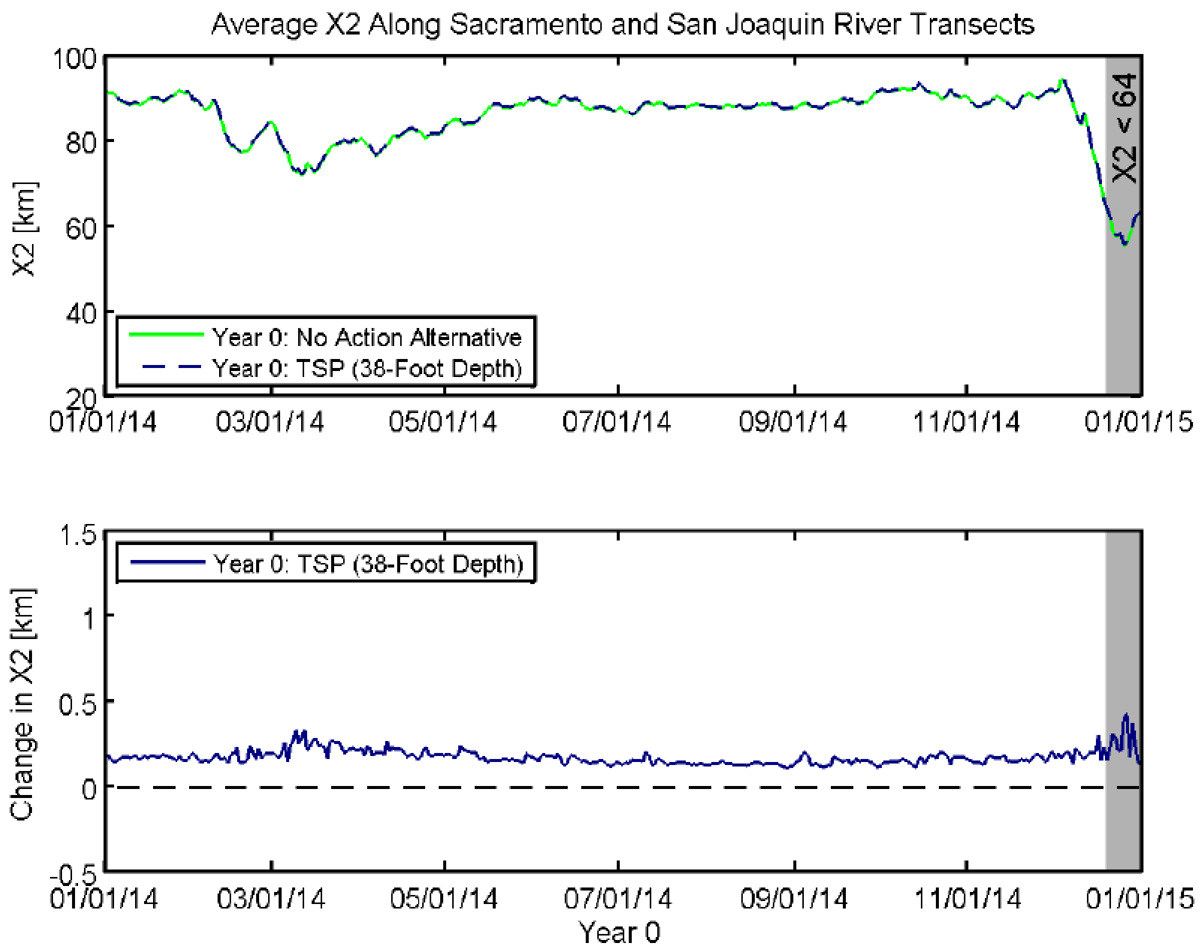
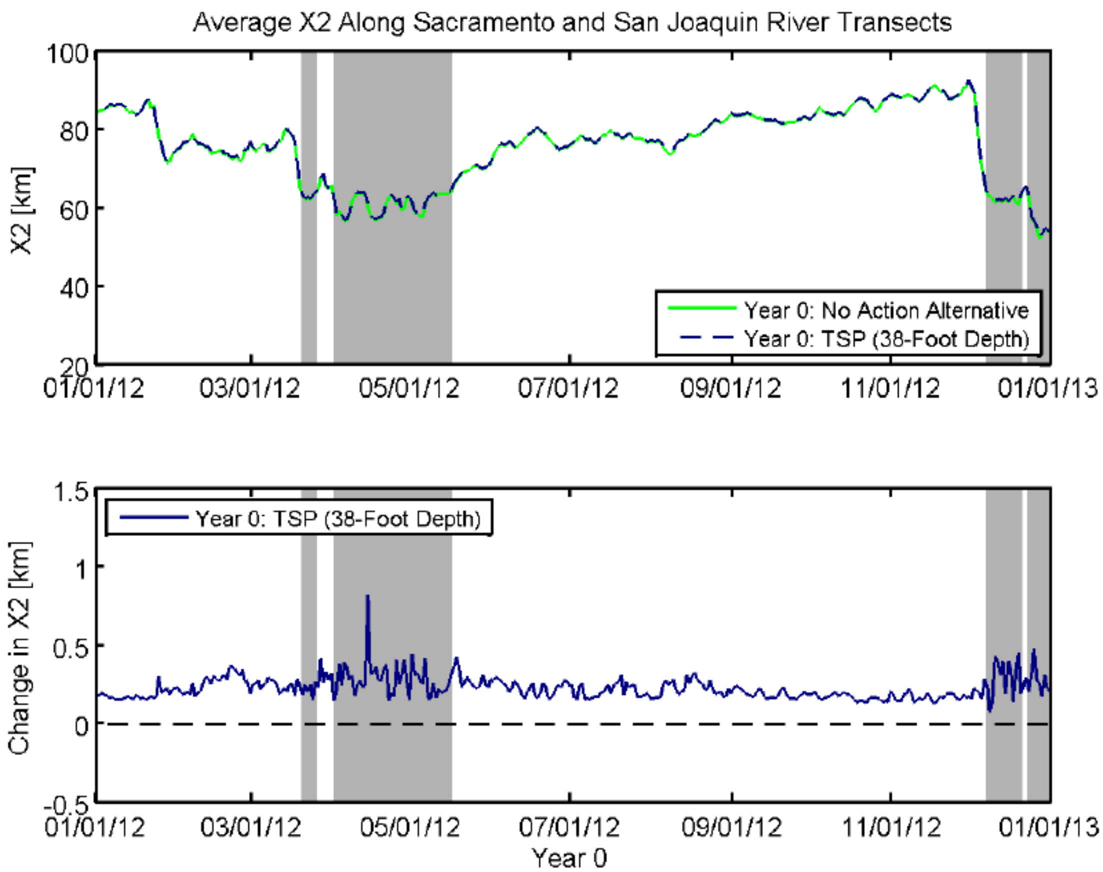


Figure 9. Predicted change in X2 for Year-0 for critical water year

Also for a critical water year, the model predicts the maximum monthly average change in chloride concentration ranging from 1.8 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.6 mg/L at the CCWD Rock Slough Intake for year-0 for the Recommended Plan when compared to without-project conditions. The environmental analysis found the change to be insignificant.

For a below normal water year, the model predicts an annual average change of 0.21 kilometers in X2 for Year-0 for the Recommended Plan when compared to without-project conditions; for when X2 is greater than 64 kilometers, the average change is also 0.21 kilometers. When X2 is less than 64 kilometers there are no current regulatory requirements that regulate the position of X2. The predicted change is illustrated in Figure 10. The environmental appendix to main feasibility report of the Project provides an analysis of the significance of the modeled change in X2. The analysis found the change to be insignificant.



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 10. Predicted change in X2 for Year-0 for a below normal water year

Also for a below normal year, the model predicts the maximum monthly average change in chloride concentration ranging from 1.1 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.1 mg/L at the CCWD Rock Slough Intake for year-0 for the Recommended Plan when compared to without-project conditions. The environmental analysis found the change to be insignificant.

For a wet water year, the model predicts an annual average change of 0.27 kilometers in X2 for Year-0 for the Recommended Plan when compared to without-project conditions; for when X2 is greater than 64 kilometers, the average change is 0.23 kilometers. When X2 is less than 64 kilometers there are no current regulatory requirements that regulate the position of X2. The predicted change is illustrated in Figure 11. The environmental appendix to main feasibility report of the Project provides an analysis of the significance of the modeled change in X2. The analysis found the change to be insignificant.

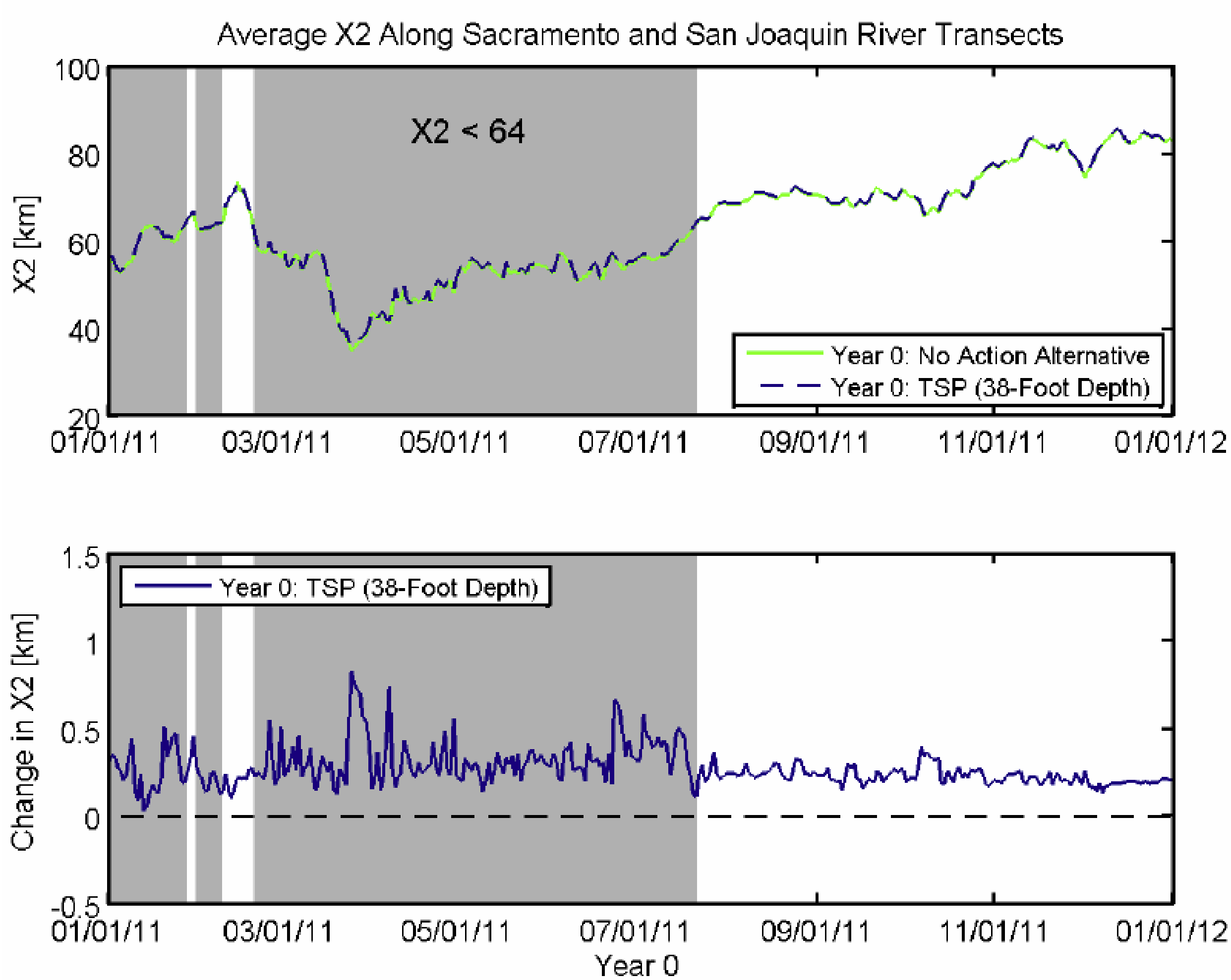


Figure 11. Predicted change in X2 for Year-0 for wet water year

Also for a wet water year, the model predicts the maximum monthly average change in chloride concentration ranging from 0.1 mg/L at the CCWD Middle River at Victoria Canal Intake to 1.1 mg/L at the CCWD Rock Slough Intake for year-0 for the Recommended Plan when compared to without-project conditions. The environmental analysis found the change to be insignificant.

The predicted changes in X2 and chloride levels tend to be higher for the critical water year than the wet water year, which is expected given that critical water years have lower inflow and outflow in the Sacramento-San Joaquin Delta.

3.2.5.2. Year-50 (Sea Level Rise)

The model predicts no significant change in water levels or flow for the Recommended Plan when compared to without-project conditions for year-50 for a critical water year. An example for predicted change in water level for the Sacramento River at Martinez is shown in Figure 12.

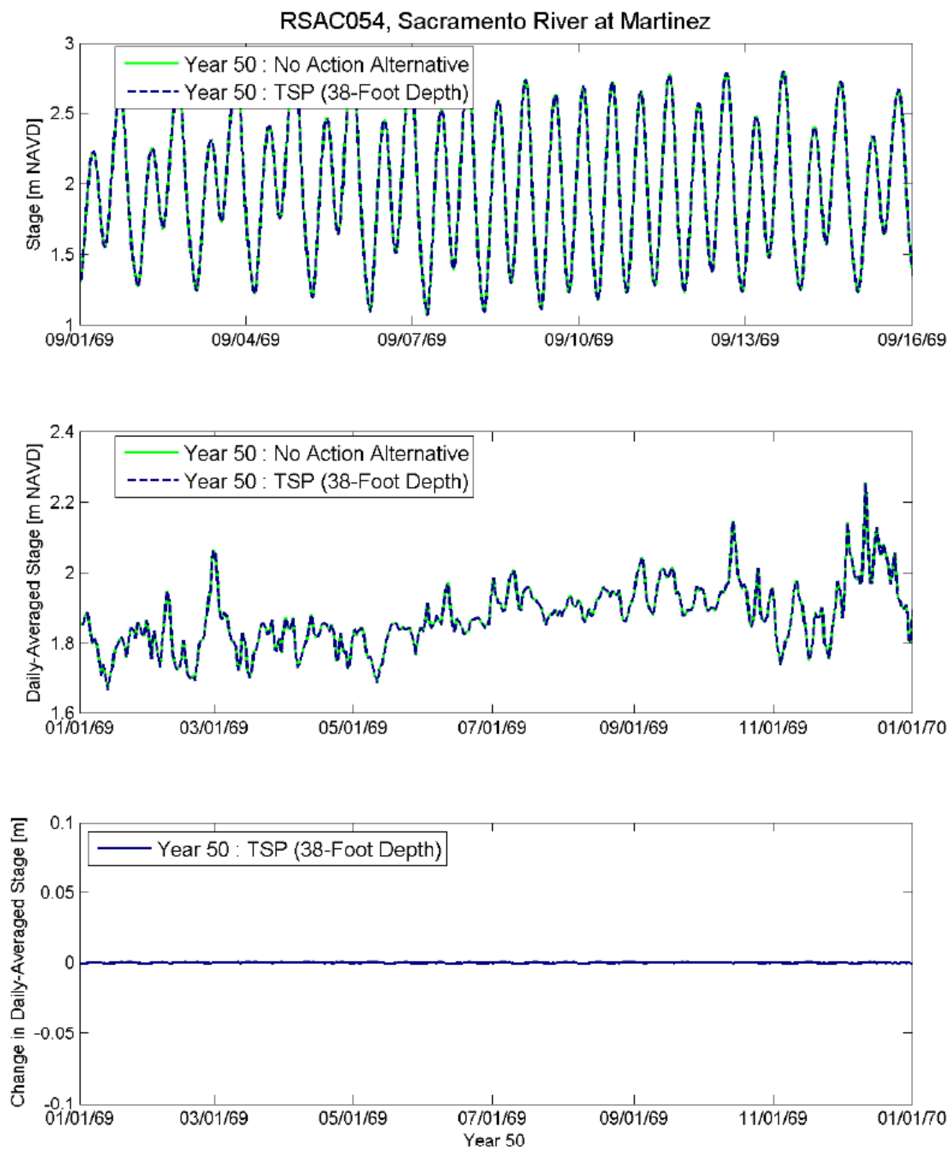


Figure 12. Predicted change in water level for Year-50 conditions for critical water year

For a critical water year, the model predicts an annual average change of 0.17 kilometers in X2 for Year-50 for the Recommended Plan when compared to without-project conditions. The predicted change is illustrated in Figure 13. The environmental analysis found the change to be insignificant.

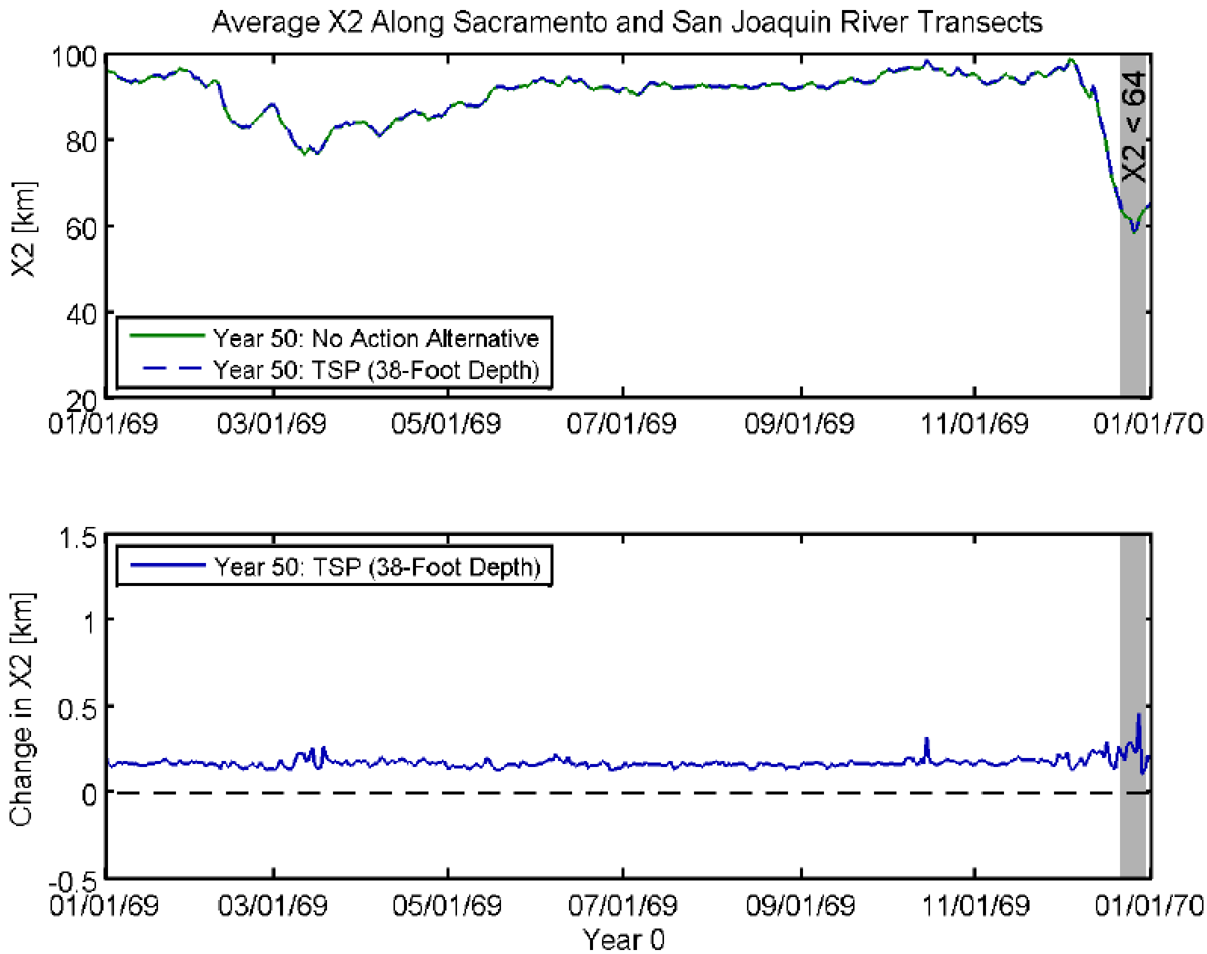


Figure 13. Predicted change in X2 for Year-50 for critical water year

Also for a critical water year, the model predicts the maximum monthly average change in chloride concentration ranging from 3.6 mg/L at the Delta Mendota Canal Intake to 7.2 mg/L at the CCWD Rock Slough Intake for year-50 the Recommended Plan when compared to without-project conditions. The environmental analysis found the change to be insignificant.

3.3. Bulls Head Shoal Channel

The Bulls Head Channel is located within the Suisun Bay Channel. This particular channel has experienced historical issues with sedimentation rates because of the configuration of the channel bottom as it transitions from a shallow depth to deep depth as it passes underneath Interstate 680. To determine the viability of advanced maintenance dredging, an analysis of hydrographic survey data and the application of an empirical equation for sedimentation was conducted. The results of this analysis are included in a technical memorandum titled *Analysis of Bulls Head Shoal Channel Hydrographic Surveys to Estimate Sedimentation Rate, Dredging Frequency, and the Potential Effectiveness of Targeted Advanced Maintenance Dredging* produced by Delta Modeling Associates and included in the list of references of this appendix.

The analysis found that advanced maintenance dredging could reduce the dredging frequency by hundreds of days, and therefore could provide a cost and time savings to the Project.

4. References

Anchor QEA. San Francisco Bay to Stockton Navigation Improvement Project, Hydrodynamic and Salinity Intrusion Modeling Report. April 2019.

Delta Modeling Associates. Technical Memorandum: Analysis of Bulls Head Shoal Channel Hydrographic Surveys to Estimate Sedimentation Rate, Dredging Frequency, and the Potential Effectiveness of Targeted Advanced Maintenance Dredging. March 4, 2015.

MacWilliams M.L., Sing, P.F., Wu, F., and Hedgecock, N., 2014. Evaluation of the potential salinity impacts resulting from the deepening of the San Francisco Bay to Stockton Navigation Improvement Project, in Proceedings of 33rd PIANC World Congress, San Francisco, CA, June 2014. 13 p.

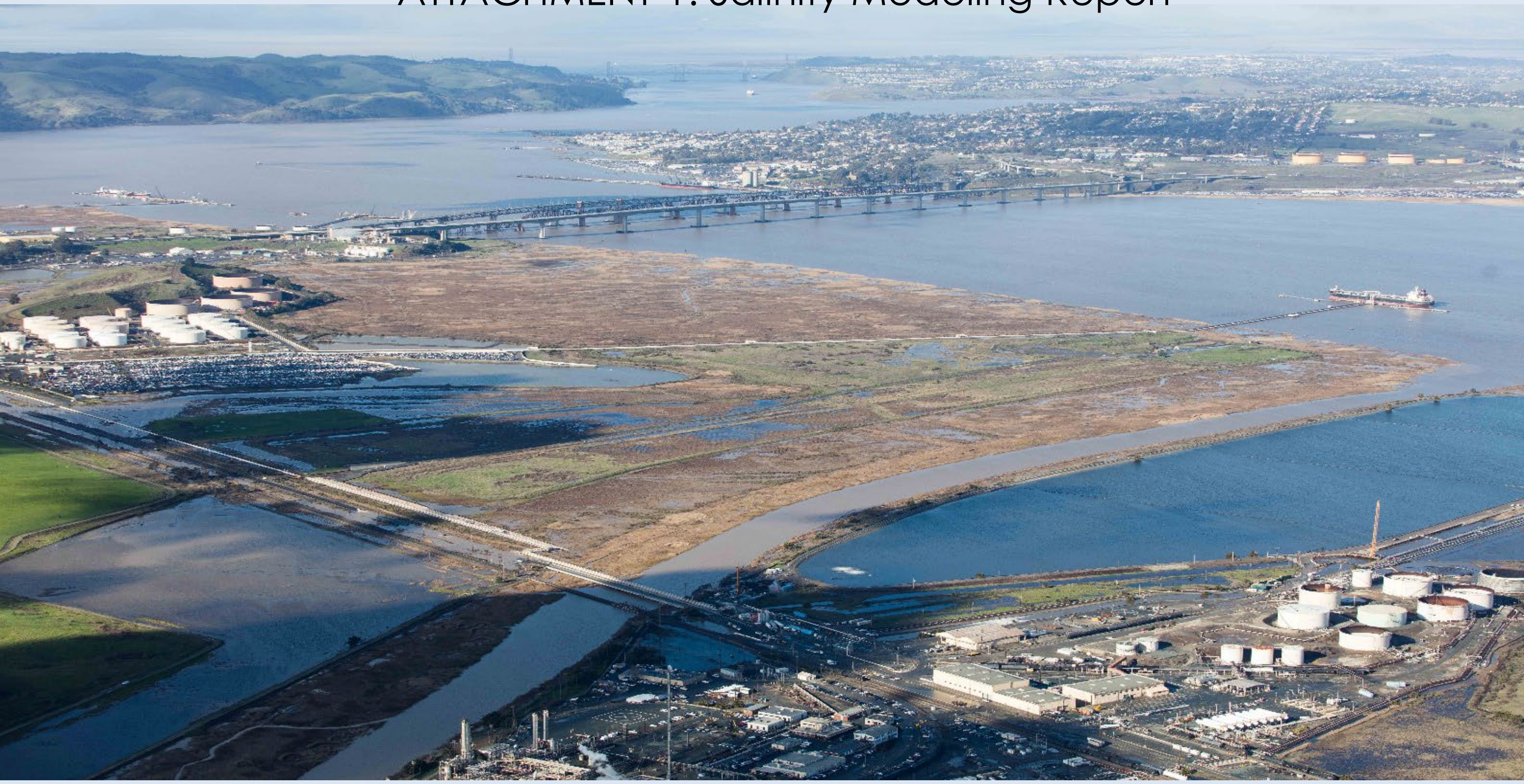
MacWilliams, M.L., Bever, A.J., Gross, E.S., Ketefian, G.A., Kimmerer, W.J., 2015. Three-Dimensional Modeling of Hydrodynamics and Salinity in the San Francisco Estuary: An Evaluation of Model Accuracy, X2, and the Low Salinity Zone, San Francisco Estuary and Watershed Science.

USACE. Engineering Regulation (ER) 1110-2-8162, Incorporating Sea Level Change in Civil Works Programs. December 2013.

FINAL INTEGRATED GENERAL REEVALUATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

SAN FRANCISCO BAY TO STOCKTON, CALIFORNIA NAVIGATION STUDY

APPENDIX B: Water Resources
ATTACHMENT 1: Salinity Modeling Report



JANUARY 2020

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SAN FRANCISCO BAY TO STOCKTON NAVIGATION IMPROVEMENT PROJECT

HYDRODYNAMIC AND SALINITY INTRUSION MODELING REPORT

FINAL DRAFT

Prepared for

U.S. Army Corps of Engineers
San Francisco District
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April 2019

SAN FRANCISCO BAY TO STOCKTON NAVIGATION IMPROVEMENT PROJECT

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April 2019

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE) is conducting a reevaluation study for deepening the San Francisco Bay to Stockton Navigation Improvement Project deep-draft navigation channels. USACE is assessing the feasibility of deepening the existing 35-foot mean lower low water (MLLW) channel to a maximum depth of 38 feet MLLW between the West Richmond Channel and the Avon Terminal. The project area includes the West Richmond Channel, the Pinole Shoal Channel, and the western part of the Suisun Bay Channel. Given concerns about increased salt intrusion into the Sacramento-San Joaquin Delta which may result from the channel deepening project, a three-dimensional (3-D) hydrodynamic and salinity model has been used to simulate salt intrusion under currently maintained conditions and under the channel deepening proposed as part of the project (MacWilliams et al. 2014).

The modeling and analysis documented in this report was completed for USACE, San Francisco District, to evaluate the deepening of the Western Reach of the San Francisco Bay to Stockton Navigation Improvement Project in accordance with the existing project authorization. This analysis evaluates the deepening of only the Western Reach of the San Francisco Bay to Stockton Navigation Improvement Project, defined as the reach extending from the western end of the Richmond Channel in Central Bay to the Avon Terminal in Suisun Bay. Preliminary analysis was conducted to evaluate the potential salinity effects of deepening the Western Reach to either -37 feet MLLW (37-Foot MLLW Alternative) or -38 feet MLLW (38-Foot MLLW Alternative), with no deepening east of the Avon terminal. The effects of the proposed project deepening on X2, the distance up the axis of the estuary to the daily-averaged 2 practical salinity units (psu) near-bed salinity, and on water quality at municipal and industrial water intake and export locations in the Sacramento-San Joaquin Delta were evaluated.

Because the exact weather, hydrology, and water project operations for a future year cannot be predicted in advance, this analysis evaluated the effects of the 37-Foot MLLW Alternative and the 38-Foot MLLW Alternative on salinity during both a wet water year and a critical water year representative of the range of possible Year 0 conditions.

The 37-Foot MLLW Alternative was predicted to result in an annual-average increase in X2 of 0.03 kilometer (km) during a critical water year and 0.08 km during a wet water year. The 38-Foot MLLW Alternative was predicted to result in an annual-average increase in X2 of 0.11 km during a critical water year and 0.20 km during a wet water year.

Under Year 0 conditions, the 37-Foot MLLW Alternative was predicted to result in a maximum monthly average change in chloride (Cl^-) concentration ranging from 0.3 milligram per liter (mg/L) at the Contra Costa Water District (CCWD) Middle River at Victoria Canal Intake to 0.7 mg/L at the CCWD Rock Slough Intake during a critical water year. During the wet water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 0.0 mg/L at the CCWD Middle River at Victoria Canal Intake and the West Canal at the mouth of Clifton Court Forebay (CCF) to 0.2 mg/L at the CCWD Rock Slough Intake under the 37-Foot MLLW Alternative. The Water Rights Decision 1641 (D-1641) water quality objectives for municipal and industrial beneficial use stipulate a maximum allowable Cl^- concentration of 250 mg/L at the municipal water intakes. Thus, the maximum monthly average change in Cl^- concentration predicted to result from the 37-Foot MLLW Alternative during the 2 years evaluated was less than 0.3% of the allowable Cl^- concentration.

Under Year 0 conditions, the predicted maximum monthly average change in Cl^- concentration for the 38-Foot MLLW Alternative ranged from 1.2 mg/L at the CCWD Middle River at Victoria Canal Intake and the Delta-Mendota Canal at Tracy Pumping Plant to 2.4 mg/L at the CCWD Rock Slough Intake during a critical water year. During the wet water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 0.0 mg/L at the CCWD Middle River at Victoria Canal Intake and the West Canal at the mouth of CCF to 0.2 mg/L at the CCWD Rock Slough Intake under the 38-Foot MLLW Alternative. The maximum monthly average change in Cl^- concentration predicted to result from the 38-Foot MLLW Alternative during the 2 years evaluated was less than 1.0% of the allowable Cl^- concentration, and the project effects on water quality at the D-1641 stations for municipal and industrial beneficial uses during wet water years were much lower than during critical water years.

Based on the results of these evaluation of these two preliminary alternatives, the Tentatively Selected Plan (TSP) was developed. The TSP proposes the following:

- Deepen the existing maintained channel depth of the Pinole Shoal Channel and Suisun Bay Channel from -35 feet to -38 feet MLLW, with approximately 13.2 miles of new regulatory depths
- Dredge a 2,600-foot long sediment trap at Bulls Head Reach with a depth of -42 feet MLLW, plus 2 feet of overdepth
- Level the rock outcropping located to the west of Pinole Shoal from a peak of 39.7 ft MLLW to 43 feet MLLW

The TSP differs from the 38-Foot MLLW Alternative due to the inclusion of the sediment trap at Bulls Head Reach and leveling the rock outcropping west of Pinole Shoal, but is otherwise identical to the 38-Foot MLLW Alternative.

This analysis evaluated the effects of the TSP on water levels, flow, and salinity during a wet water year, a below normal water year, and a critical water year representative of the range of possible Year 0 conditions. The evaluation of the TSP effects on salinity during both the wettest (wet) and driest (critical) water year types and an intermediate water year type (below normal) provides an assessment of the full range of effects on salinity that are likely to result from the TSP.

The TSP was predicted to result in an annual-average increase in X2 of 0.17 km during a critical water year, 0.21 km during a below normal water year, and 0.27 km during a wet water year. For all 3 years, the largest predicted increases in X2 occurred at the lowest values of X2, corresponding to the periods when the salinity gradients were pushed west into San Pablo Bay resulting in stratification in the Pinole Shoal Channel or the western part of the Suisun Bay Channel. Because lower values of X2 occurred during the wet water year than during the critical water year, the effects of the channel deepening on X2 were larger during the wet water year than during the critical water year.

For the TSP, the predicted maximum monthly average change in Cl^- concentration under Year 0 conditions ranged from 1.8 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.6 mg/L at the CCWD Rock Slough Intake during a critical water year. During the below normal water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 1.1 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.1 mg/L at the CCWD Rock Slough Intake under the TSP. During the wet water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 0.1 mg/L at the CCWD Middle River at Victoria Canal Intake and the West Canal at the mouth of CCF to 1.1 mg/L at the CCWD Rock Slough Intake under the TSP. The maximum monthly average change in Cl^- concentration predicted to result from the TSP during the 2 years evaluated was less than 1.5% of the allowable Cl^- concentration, and the project effects on water quality at the D-1641 stations for municipal and industrial beneficial uses during wet water years were much lower than during critical water years.

The effect of the TSP on water levels was evaluated at three continuous monitoring stations spanning the geographic extent of the project area. These comparisons show that there is virtually no change in predicted water level at any of the stations evaluated for the 3 years simulated. The effect of the TSP on flows was evaluated at three locations in San Francisco Bay spanning the geographic extent of the project area. These comparisons show that the predicted flows for the No Action Alternative and the TSP are nearly identical, with only very small differences in tidally-averaged flows at each location for the 3 years evaluated. These very small differences in tidally-averaged flows likely result from small phase differences in tidal propagation as a result of the channel deepening.

The effect of the 38-Foot MLLW Alternative and of the TSP on salinity were evaluated for a critical water year representative of possible Year 50 conditions which included 2.38 feet of sea level rise (SLR) based on the USACE High Curve (USACE 2013, 2015) at the San Francisco National Oceanic and Atmospheric Administration station (9414290). For the 38-Foot MLLW Alternative under Year 50 conditions, the predicted annual-average increase in X2 resulting from the channel deepening was 0.11 km, which is identical to what was predicted for Year 0 conditions for a critical water year. For the TSP under Year 50 conditions, the predicted annual-average increase in X2 resulting from the channel deepening was 0.17 km, which is also identical to what was predicted for the TSP under Year 0 conditions for a critical water year. This suggests that the Project effects on X2 are likely to be nearly identical under future and existing conditions for a given hydrology and outflow regime.

Because the Year 50 conditions did not include changes to Delta operations to offset the increased salinity intrusion resulting from sea level rise, the baseline X2 under the Year 50 NO Action Alternative was on average 4.31 km higher than under baseline X2 under the Year 0 No Action Alternative, resulting in higher baseline salinity conditions in the Delta under Year 50. During the critical water year under these Year 50 conditions, the predicted annual-average change in Cl^- concentration resulting from the 38-Foot MLLW Alternative ranged from 1.5 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.0 mg/L at the CCWD Rock Slough Intake. During the critical water year under these Year 50 conditions, the predicted annual-average change in Cl^- concentration resulting from the TSP ranged from 2.3 mg/L at the CCWD Middle River at Victoria Canal Intake to 4.6 mg/L at the CCWD Rock Slough Intake. While these values are higher than were predicted under Year 0 conditions, the predicted Cl^- concentrations at these locations under the Year 50 No Action Alternative were significantly higher than under the Year 0 No Action Alternative due to the large upstream shift in X2. If operations were modified to offset SLR and maintain X2 at the same position as under Year 0 conditions, the expected effects of the channel deepening would be more like those predicted for Year 0 conditions. However, even with these very conservative conditions for Year 50, which included higher baseline salinity in the Delta and did not include operational response to offset the effects of SLR, the predicted maximum monthly average change at any of the export locations was 7.2 mg/L, which is less than 3.0% of the allowable Cl^- concentration based on the D-6141 water quality objective of a 250 mg/L Cl^- concentration at the municipal water intakes.

Under both Year 0 and Year 50 conditions, the 37-Foot MLLW Alternative, the 38-Foot MLLW Alternative, and the TSP all resulted in significantly smaller predicted effects on both X2 and on water quality at municipal and industrial water intake and export locations in the Sacramento-San Joaquin Delta than the previous scenarios which evaluated deepening of both the Eastern Reach and the Western Reach (MacWilliams et al. 2014).

The effect of the TSP on the area and position of the Low Salinity Zone was analyzed for the critical water year, below normal water year, and wet water year evaluated. For each simulation, the daily-averaged LSZ habitat area for each day was then calculated by summing up the total area of the grid cells with depth-averaged daily-averaged salinity between 0.5 psu and 6 psu. This allowed for a comparison of the change in LSZ area resulting from the

TSP for each day of the simulation. Due to the non-monotonic relationship between the area of the LSZ and X2 which is largely controlled by the geometry of the estuary (see MacWilliams et al. 2015), the small landward shift (increase) of X2 which results from the TSP can result in either a decrease or an increase in the area of the LSZ on each day. During the critical water year evaluated, the predicted monthly-average change in the area of the LSZ resulting from the TSP ranged from a decrease of 290 acres to an increase of 266 acres. The predicted monthly-average change in the area of the LSZ resulting from the TSP in the below normal water year evaluated ranged from a decrease of 587 acres to an increase of 446 acres. During the wet water year evaluated, the predicted monthly-average change in the area of the LSZ resulting from the TSP ranged from a decrease of 284 acres to an increase of 417 acres.

The predictions of X2 and the predicted change in X2 resulting from the TSP for each day during the critical water year, below normal water year, and wet water year evaluated were used to develop an empirical function to estimate the effects of the TSP on X2. This function was applied to the DAYFLOW estimate of X2 for a 10-year period spanning from 2008 through 2017. This relationship was validated using the predictions of annual-average X2 for the 3 years for which the TSP was simulated. Based on the results of the model simulations, the TSP was predicted to result in an annual-average increase in X2 of 0.17 km during 2014 (a critical water year), 0.21 km during 2012 (a below normal water year), and 0.27 km during 2011 (a wet water year). Based on the empirical function, the TSP was predicted to result in an annual-average increase in X2 of 0.18 km during 2014 (0.01 km higher), 0.21 km during 2012 (identical), and 0.26 km (0.01 km lower) during 2011. Thus, all three estimates were within 0.01 km (10 m) of the annual-average change predicted using the hydrodynamic model. Based on the empirical function, the estimated annual-average change in X2 from the TSP ranged from 0.18 km to 0.27 km for the 10 water years between 2008 and 2017.

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LIST OF ACRONYMS AND ABBREVIATIONS

3-D	three-dimensional
BO	Biological Opinion
CCF	Clifton Court Forebay
CCW	CCWD Middle River at Victoria Canal Intake
CCWD	Contra Costa Water District
CHCCC06	CCWD Rock Slough Intake
CHDMC004	Delta-Mendota Canal at Tracy Pumping Plant
CHWST0	West Canal at mouth of Clifton Court Forebay
Cl^-	chloride
CVP	Central Valley Project
D-1641	Water Rights Decision 1641
Delta	Sacramento-San Joaquin Delta
DMC	Delta-Mendota Canal
DWSC	Deep Water Ship Channel
km	kilometer
LSZ	Low Salinity Zone
$m^2 s^{-1}$	meters squared per second
mg/L	milligrams per liter
MLLW	mean lower low water
mmhos/cm	millimhos per centimeter
OMR	Old and Middle River
PCE	primary constituent element
psu	practical salinity unit
ROLD034	CCWD Old River Intake
RPA	Reasonable and Prudent Alternative
SLR	sea level rise
SWP	State Water Project

SWRCB	State Water Resources Control Board
TSP	Tentatively Selected Plan
TRIM	Tidal, Residual, Intertidal & Mudflat model
TUCP	Order that Approved a Temporary Urgency Change in License and Permit Terms and Conditions Requiring Compliance
UnTRIM	Unstructured Tidal, Residual, Intertidal & Mudflat model
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
X2	distance up the axis of the estuary to the daily-averaged 2 practical salinity units (psu) near-bed salinity

1 INTRODUCTION

This report documents the three-dimensional (3-D) hydrodynamic modeling conducted for the U.S. Army Corps of Engineers (USACE), San Francisco District, using the Unstructured Tidal, Residual, Intertidal & Mudflat Model (UnTRIM) San Francisco Bay-Delta model in support of the San Francisco Bay to Stockton Navigation Improvement Project Deepening Study. This report is divided into the following ten primary sections:

- **Section 1. Introduction.** This section provides a summary of the scope and organization of the report.
- **Section 2. Background.** This section provides an overview of the San Francisco Bay to Stockton Navigation Improvement Project, gives a brief summary of previous modeling conducted for this study, and lists the objectives of the analysis presented in this report.
- **Section 3. Modeling Approach.** This section provides brief descriptions of the Unstructured Tidal, Residual, Intertidal & Mudflat (UnTRIM) hydrodynamic model, the UnTRIM Bay-Delta model, the channel deepening scenarios evaluated, and the approach used to evaluate the project effects on salinity and X2.
- **Section 4. Evaluation of Preliminary Alternatives During a Critical and Wet Water Year.** This section provides the results of the preliminary scenario simulations that evaluated the effects of the 37-Foot mean lower low water (MLLW) Alternative and 38-Foot MLLW Alternative under both critical and wet water years.
- **Section 5. Evaluation of the Tentatively Selected Plan During a Critical, Below Normal, and Wet Water Year.** This section provides the results of the scenario simulations that evaluated the effects of the Tentatively Selected Plan (TSP) under a critical, below normal, and wet water year.
- **Section 6. Evaluation of Alternatives Under Future Conditions with Sea Level Rise.** This section provides the results of the scenario simulations that evaluated the effects of the 38-Foot MLLW Alternative and the TSP under future conditions with sea level rise (SLR).
- **Section 7. Analysis of the Effects of the TSP on the Low Salinity Zone.** This section provides an analysis of the effects of the TSP on the area and position of the Low Salinity Zone for the critical water year, below normal water year, and wet water year evaluated.

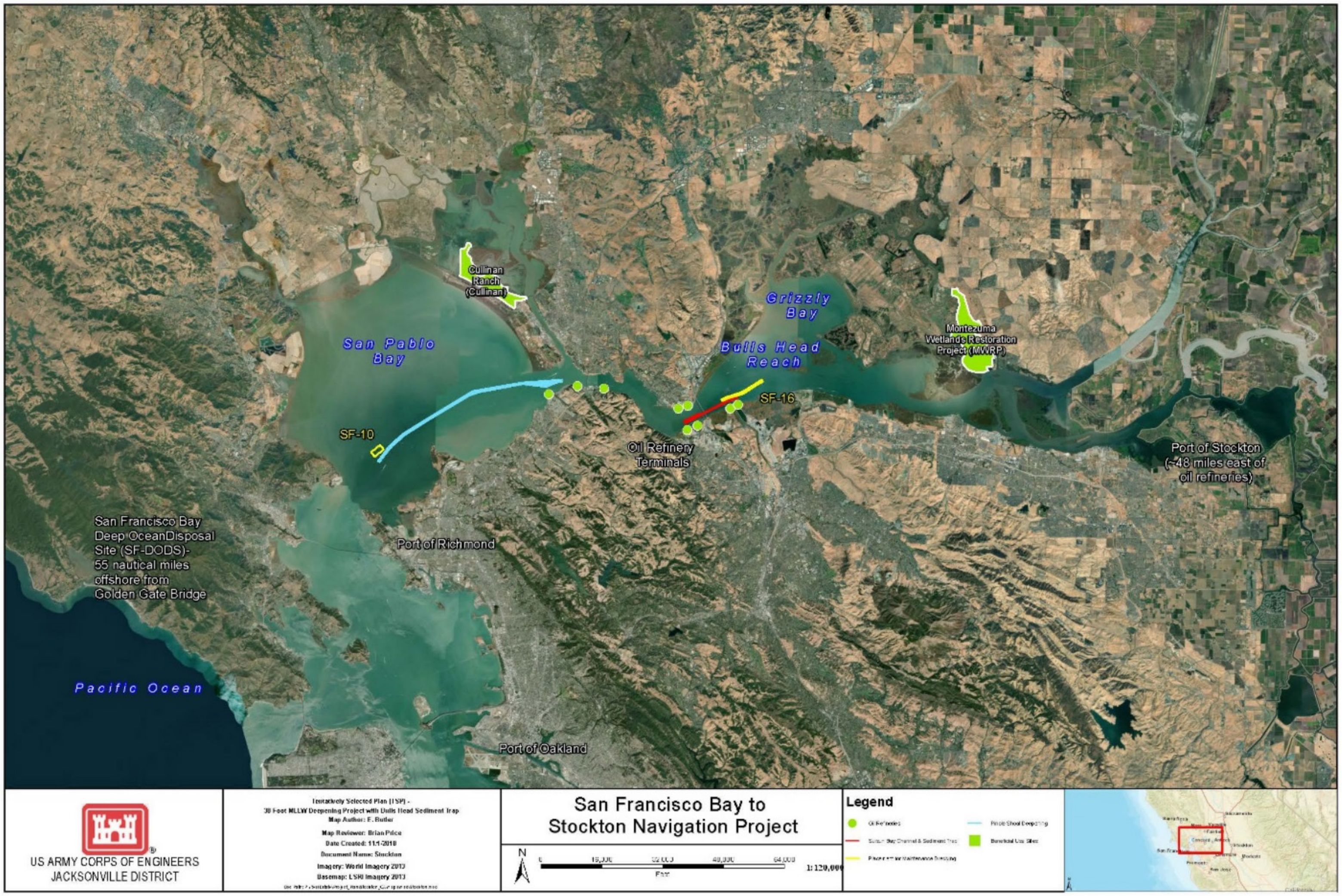
- **Section 8. Assessment of the Effects of the TSP on X2 over a 10-Year Historical Period.** This section presents an empirical function developed using the predicted effects on X2 from the critical water year, below normal water year, and wet water year. This function is applied to support an effects determination of the TSP on the location of X2 over a 10-year historical period spanning 2008 through 2017.
- **Section 9. Discussion.** This section presents a brief summary of the assumptions and uncertainty associated with developing representative conditions for the Year 0 and Year 50 simulations.
- **Section 10. Summary and Conclusions.** This section presents a brief summary of the results and analysis presented in this report and the primary conclusions derived from these results.

2 BACKGROUND

2.1 Overview of San Francisco Bay to Stockton Navigation Improvement Project Study

The San Francisco Bay to Stockton Navigation Improvement Project consists of deep-draft navigation channels that extend from San Francisco Bay to the Port of Stockton (Figure 2.1-1). The existing depths of these navigation channels are inefficient for many commercial vessels. To use these channels, many existing vessels must partially load or await favorable tides. Current trends in the shipping industry toward larger, deeper-draft vessels will likely increase the costs associated with the depth restrictions or further limit the vessels that can access the Port of Stockton. USACE is assessing the feasibility of deepening the existing 35-foot MLLW channel to a maximum depth of 38 feet MLLW between the western end of the Richmond Channel in Central Bay to the Avon Terminal in Suisun Bay (Figure 2.1-1).

As part of this assessment, the UnTRIM San Francisco Bay-Delta model (MacWilliams et al. 2007, 2008, 2009, 2015) was applied to evaluate the potential for hydrodynamic and salinity impacts under the proposed channel deepening alternatives for both base year (Year 0) and future (Year 50) conditions. The project area is located in Central San Francisco Bay, San Pablo Bay, and Suisun Bay and includes the West Richmond Channel, the Pinole Shoal Channel, and the western part of the Suisun Bay Channel (Figure 2.1-1). However, the model domain for this study encompasses all of San Francisco Bay and the Sacramento-San Joaquin Delta region to allow for an evaluation of project effects throughout the entire system (see Figure 3.1-1).



Note: The Avon terminal is located at the eastern end of the Western Reach.
Source: USACE, San Francisco District

Figure 2.1-1

Study Area

2.2 Previous Modeling for San Francisco Bay to Stockton Navigation Project

MacWilliams and Gross (2012) provided a comprehensive evaluation of the effects of deepening of the Sacramento River Deep Water Ship Channel and the San Francisco Bay to Stockton Navigation Improvement Project Channels on water levels, flows, and salinity throughout San Francisco Bay and the Sacramento-San Joaquin Delta. Because their analysis demonstrated that the channel deepening did not have any significant effects on either water levels or flows in the Delta, subsequent analysis has focused primarily on the effect of the channel deepening on salinity.

MacWilliams et al. (2014) provide a description of the hydrodynamic and salinity modeling conducted for USACE in support of the San Francisco Bay to Stockton Navigation Improvement Project deepening study, an overview of the predicted project effects on salinity for a range of navigation channel deepening scenarios under Year 0 conditions, and a brief assessment of the effectiveness of several potential approaches to mitigate the project effects on salinity. MacWilliams et al. (2014) evaluated four different channel depths combined with three different salinity mitigation alternatives. MacWilliams (2011) evaluated five different depth combinations for the eastern and western reaches. Delta Modeling Associates (2014a, 2014b) evaluated the potential for marsh restoration in Big Break and Franks Tract to be used to offset the salinity effects resulting from the channel deepening.

2.3 Study Objectives

The primary objective of this study was to evaluate the effects of deepening the San Francisco Bay to Stockton Navigation Improvement Project channels on hydrodynamics and salinity in San Francisco Bay and the Sacramento-San Joaquin Delta under a range of hydrologic conditions and channel depths. These objectives were accomplished by the following analyses, which are presented in this report:

- Evaluating the effects of two preliminary project alternatives on salinity and X2 under both wet and dry conditions (Section 4)
- Evaluating the effects of the TSP on salinity and X2 under both wet and dry conditions (Section 5)
- Evaluating the effects of one preliminary alternative and the TSP on salinity and X2 under future conditions that include SLR (Section 6)

3 MODELING APPROACH

3.1 UnTRIM Model Description

The hydrodynamic model used in this technical study is the 3-D hydrodynamic model UnTRIM (Casulli and Zanolli 2002). A complete description of the governing equations, numerical discretization, and numerical properties of UnTRIM is included in Casulli and Zanolli (2002, 2005), Casulli (1999), and Casulli and Walters (2000).

The UnTRIM model solves the 3-D Navier-Stokes equations on an unstructured grid in the horizontal plane. The boundaries between vertical layers are at fixed elevations, and cell heights can be varied vertically to provide increased resolution near the surface or other vertical locations. Volume conservation is satisfied by a volume integration of the incompressible continuity equation, and the free-surface is calculated by integrating the continuity equation over the depth and using a kinematic condition at the free-surface as described in Casulli (1990). The numerical method allows full wetting and drying of cells in the vertical and horizontal directions. The governing equations are discretized using a finite difference-finite volume algorithm. Discretization of the governing equations and model boundary conditions are presented in detail by Casulli and Zanolli (2002). All details and numerical properties of this state-of-the-art 3-D model are well-documented in peer reviewed literature (Casulli and Zanolli 2002, 2005).

3.1.1 Turbulence Model

The turbulence closure model used in the present study is a two-equation model comprised of a turbulent kinetic energy equation and a generic length-scale equation. The parameters of the generic length-scale equation are chosen to yield the k-ε closure (Umlauf and Burchard 2003). The Kantha and Clayson (1994) quasi-equilibrium stability functions are used. All parameter values used in the k-ε closure are identical to those used by Warner et al. (2005), including the minimum eddy diffusivity and eddy viscosity values, which were $5x10^{-6}$ m^2 s^{-1}. The numerical method used to solve the equations of the turbulence closure is a semi-implicit method that results in tridiagonal positive-definite matrices in the water column of each grid cell and ensures that the turbulent variables remain positive (Deleersnijder et al. 1997).

3.1.2 Previous Applications

The Tidal, Residual, Intertidal & Mudflat (TRIM) 3-D model (Casulli and Cheng 1992) and UnTRIM model have been applied previously to San Francisco Bay (Cheng and Casulli 2002; MacWilliams and Cheng 2007; MacWilliams and Gross 2007; MacWilliams et al. 2007, 2008, 2015). The TRIM3D model (Casulli and Cattani 1994), which follows a similar numerical approach on structured horizontal grids, has been widely applied in San Francisco Bay (e.g., Cheng et al. 1993; Cheng and Casulli 1996; Gross et al. 1999, 2006), and a 2-D version, TRIM2D, was used in the San Francisco Bay Physical Oceanographic Real-Time System (Cheng and Smith 1998). Thus, the UnTRIM numerical approach has been well-tested in San Francisco Bay, and is very well suited to perform the types of analysis used in this study.

3.1.3 UnTRIM Bay-Delta Model

The UnTRIM San Francisco Bay-Delta model (UnTRIM Bay-Delta model) is a 3-D hydrodynamic model of San Francisco Bay and the Sacramento-San Joaquin Delta (MacWilliams et al. 2007, 2008, 2009, 2015), which has been developed using the UnTRIM hydrodynamic model (Casulli and Zanolli 2002, 2005; Casulli 2009). The UnTRIM Bay-Delta model extends from the Pacific Ocean through San Francisco Bay and the entire Sacramento-San Joaquin Delta (Figure 3.1-1). The model takes advantage of the grid flexibility allowed in an unstructured mesh by gradually varying grid cell sizes, beginning with large grid cells in the Pacific Ocean and gradually transitioning to finer grid resolution in the smaller channels of the Sacramento-San Joaquin Delta (Delta). This approach offers significant advantages both in terms of numerical efficiency and accuracy, and allows for local grid refinement for detailed analysis of local hydrodynamics, while still incorporating the overall hydrodynamics of the larger estuary in a single model. The resulting model contains more than 130,000 horizontal grid cells and more than 1 million 3-D grid cells. Figure 3.1-1 provides an overview of the boundary conditions applied in the UnTRIM Bay-Delta model. Additional details regarding the model boundary conditions and a detailed description of the model calibration and validation is presented by MacWilliams et al. (2015).

The UnTRIM Bay-Delta model has been applied to San Francisco Bay and the Sacramento-San Joaquin Delta as part of the Delta Risk Management Strategy (MacWilliams and Gross 2007), several studies to evaluate the mechanisms behind the Pelagic Organism Decline (e.g., MacWilliams et al. 2008, MacWilliams and Bever 2013), and the Bay Delta Conservation Plan (MacWilliams and Gross 2010). The UnTRIM Bay-Delta model has also been applied for a range of studies by USACE, including the Hamilton Wetlands Restoration Project (MacWilliams and Cheng 2007), the Sacramento River Deep Water Ship Channel Deepening Study (MacWilliams et al. 2009), the South San Francisco Bay Shoreline Study (MacWilliams et al. 2012b), and several studies of sediment transport in support of the San Francisco Bay Regional Dredged Material Management Program (MacWilliams et al. 2012a; Bever and MacWilliams 2013, 2014).

The UnTRIM Bay-Delta model has been calibrated using water level, flow, and salinity data collected in San Francisco Bay and the Delta in numerous previous studies (e.g., MacWilliams et al. 2008, 2009, 2015; MacWilliams and Gross 2010). The model has been shown to accurately predict salinity, tidal flows, and water levels throughout the San Francisco Bay and Sacramento-San Joaquin Delta under a wide range of conditions. A detailed description of the model validation is presented in MacWilliams et al. (2015) and the associated supplemental materials which are available through *San Francisco Estuary and Watershed Science* (MacWilliams et al. 2015, Appendix A: Comprehensive Set of Quantitative Error Evaluation Metrics for Comparisons Between Observed and Predicted Water Level, Tidal Flow, Current Speed and Salinity During the 1994–1997 Simulation Period).

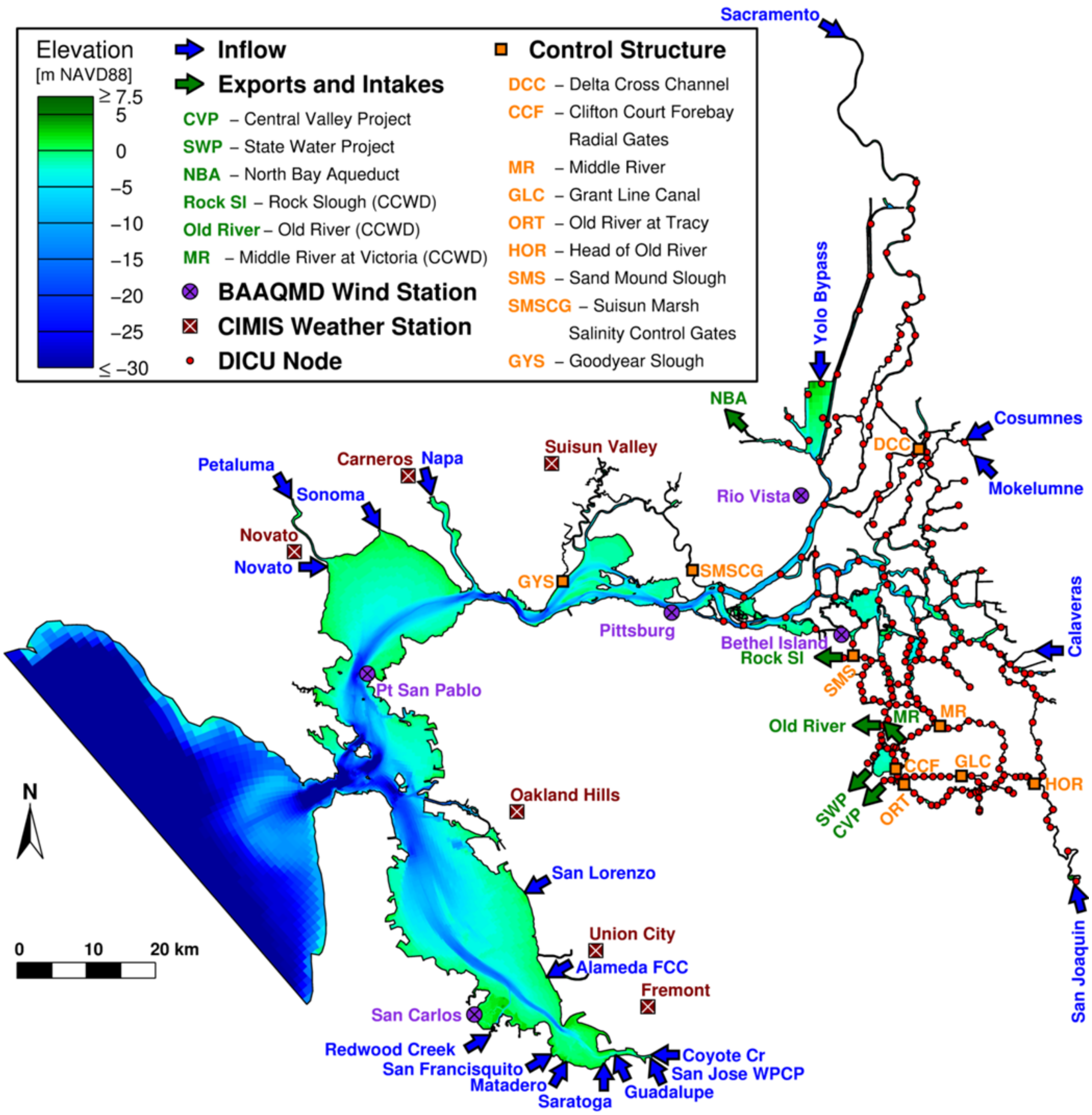


Figure 3.1-1
UnTRIM San Francisco Bay-Delta Model Domain, Bathymetry, and Locations of Model Boundary Conditions Which Include Inflows, Export Facilities, Intakes for the Contra Costa Water District (CCWD), Wind Stations from the Bay Area Air Quality Management District (BAAQMD), Evaporation and Precipitation from California Irrigation Management Information System (CIMIS) Weather Stations, Delta Island Consumptive Use (DICU), and Flow Control Structures

3.2 Channel Deepening Scenarios

As part of the Sacramento River DWSC Deepening study and the San Francisco Bay to Stockton Navigation Improvement Project deepening study, the UnTRIM Bay-Delta model was refined to include the exact alignments of the federal navigation channels (Figure 2.1-1) to evaluate the proposed deepening of the Sacramento River DWSC and the San Francisco Bay to Stockton DWSC (MacWilliams et al. 2009). The resulting model has been used for the evaluation of the proposed deepening of the Sacramento River DWSC (MacWilliams and Gross 2012) and the San Francisco Bay to Stockton Navigation Improvement Project (MacWilliams et al. 2014). The simulations conducted for this analysis considers four different channel geometries, as described in the following sections: the No Action Alternative; the 37-Foot MLLW Alternative; the 38-Foot MLLW Alternative; and the TSP.

3.2.1 No Action Alternative

The model geometry for the No Action Alternative was developed beginning with the existing bathymetry of San Francisco Bay based on available bathymetric data and channel surveys provided by USACE (MacWilliams and Gross 2012; MacWilliams et al. 2014). Any portions of the currently authorized channels for the entire reach of the San Francisco Bay to Stockton Navigation Improvement Project channels that were shallower than the currently maintained channel depth of 35 feet MLLW plus 2 feet of overdepth were then deepened to 37 feet MLLW (including overdepth). This configuration represents the current channel conditions following dredging to the full channel depth plus overdepth and was used as the baseline condition which was compared to each of the deepening alternatives to evaluate the project effects.

3.2.2 37-Foot MLLW Alternative

The model geometry for the 37-Foot MLLW Alternative was developed beginning with the channel geometry for the No Action Alternative. Any portions of the West Richmond Channel, the Pinole Shoal Channel, and the Suisun Bay Channel west of the Avon Terminal that were shallower than 37 feet MLLW plus 2 feet of overdepth were deepened to 39 feet MLLW (including overdepth). This configuration corresponds to a maximum of 2 feet of deepening relative to the No Action Alternative; however, not all potions of the channel footprint were deepened because some areas were already deeper than 39 feet MLLW. The primary reaches requiring deepening for the 37-Foot MLLW Alternative were the center portion of the Suisun Bay Channel (Figure 3.2-1) and a small area near Bulls Head Shoal in the Suisun Bay Channel (Figure 3.2-2). Based on the available bathymetry data, minimal to no additional deepening would be required in the West Richmond Channel for the 37-Foot MLLW Alternative.

3.2.3 38-Foot MLLW Alternative

The model geometry for the 38-Foot MLLW Alternative was developed beginning with the channel geometry for the No Action Alternative. Any portions of the West Richmond Channel, the Pinole Shoal Channel, and the Suisun Bay Channel west of the Avon Terminal that were shallower than 38 feet MLLW plus 2 feet of overdepth were deepened to 40 feet MLLW (including overdepth). This configuration corresponds to a maximum of 3 feet of deepening relative to the No Action Alternative; however, not all potions of the channel footprint were deepened because some areas were already deeper than 40 feet MLLW. The primary reaches requiring deepening for the 38-Foot MLLW Alternative were the center portion of the Suisun Bay Channel (Figure 3.2-3) and an area near Bulls Head Shoal in the Suisun Bay Channel (Figure 3.2-4). Based on the available bathymetry data, minimal to no additional deepening would be required in the West Richmond Channel for the 38-Foot MLLW Alternative.

3.2.4 Tentatively Selected Plan

The model geometry for the TSP was developed beginning with the channel geometry for the 38-Foot MLLW Alternative. The rock outcropping located to the west of Pinole Shoal was lowered from a peak of 39.7 feet MLLW to 43 feet MLLW, which is visible as a small dot at the western end of the Pinole Shoal Channel in Figure 3.2-5. The model geometry was deepened over the area of the 2,600-foot long sediment trap at Bulls Head Reach to a depth of 42 feet MLLW, plus 2 feet of overdepth, corresponding to a total depth of 44 feet MLLW (Figure 3.2-6). The adjustment of the bathymetry to account for the removal of the small rock outcrop on the western end of the Pinole Shoal Channel and the additional 4 feet of deepening for the sediment trap at Bulls Head Shoal were the only difference between the model geometry for the 38-Foot MLLW Alternative and the TSP.

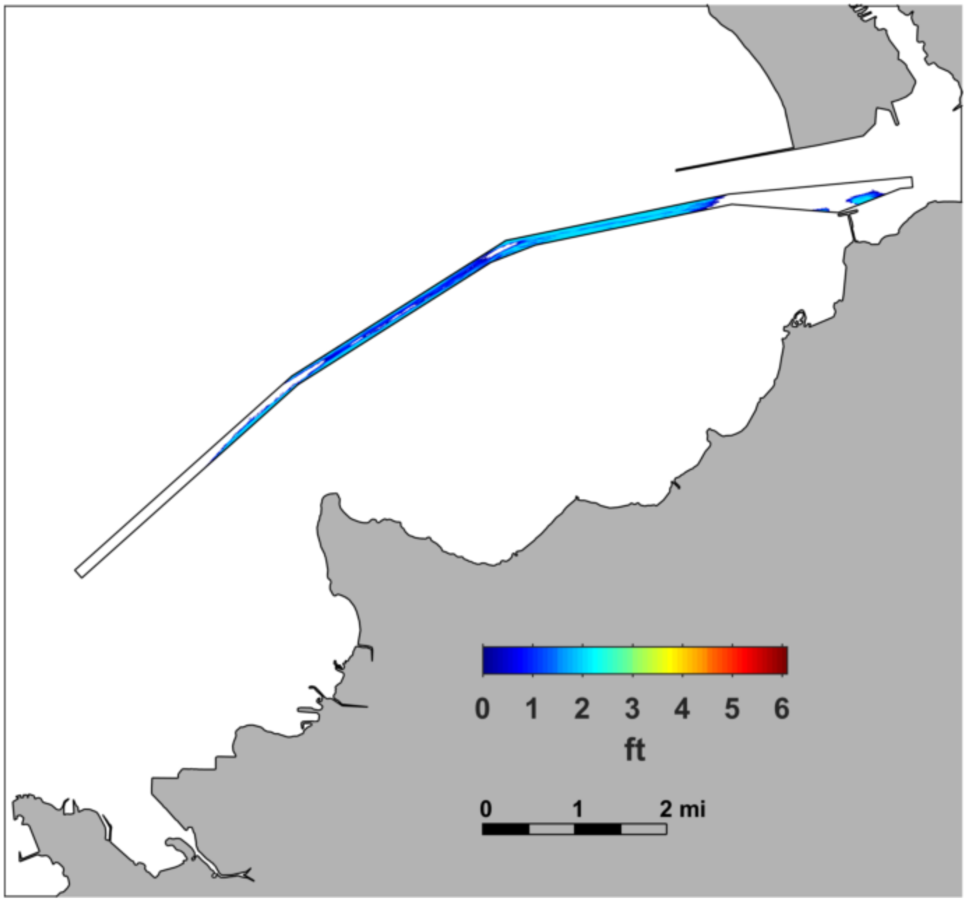


Figure 3.2-1

Channel Deepening in Pinole Shoal Channel for the 37-Foot MLLW Alternative

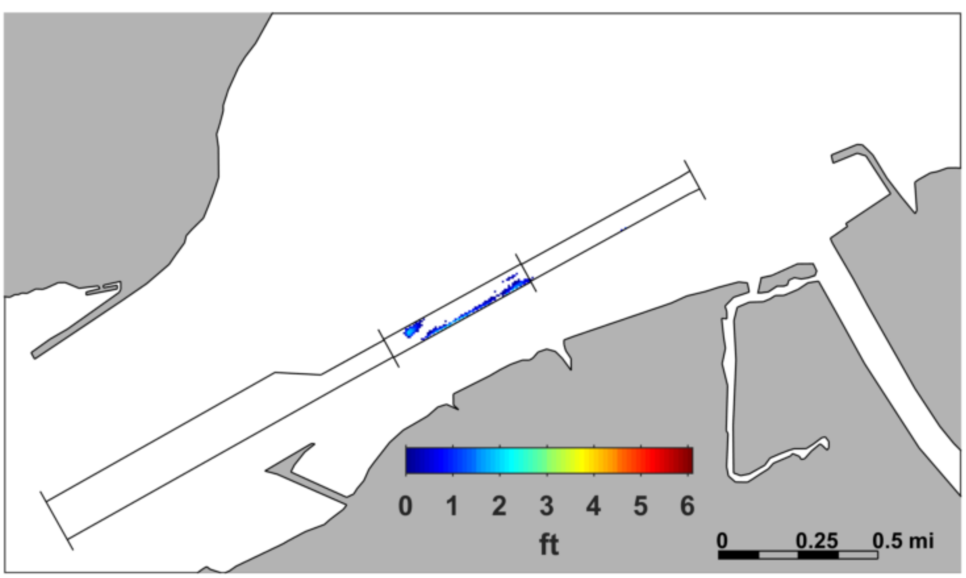


Figure 3.2-2

Channel Deepening in Suisun Bay Channel for the 37-Foot MLLW Alternative

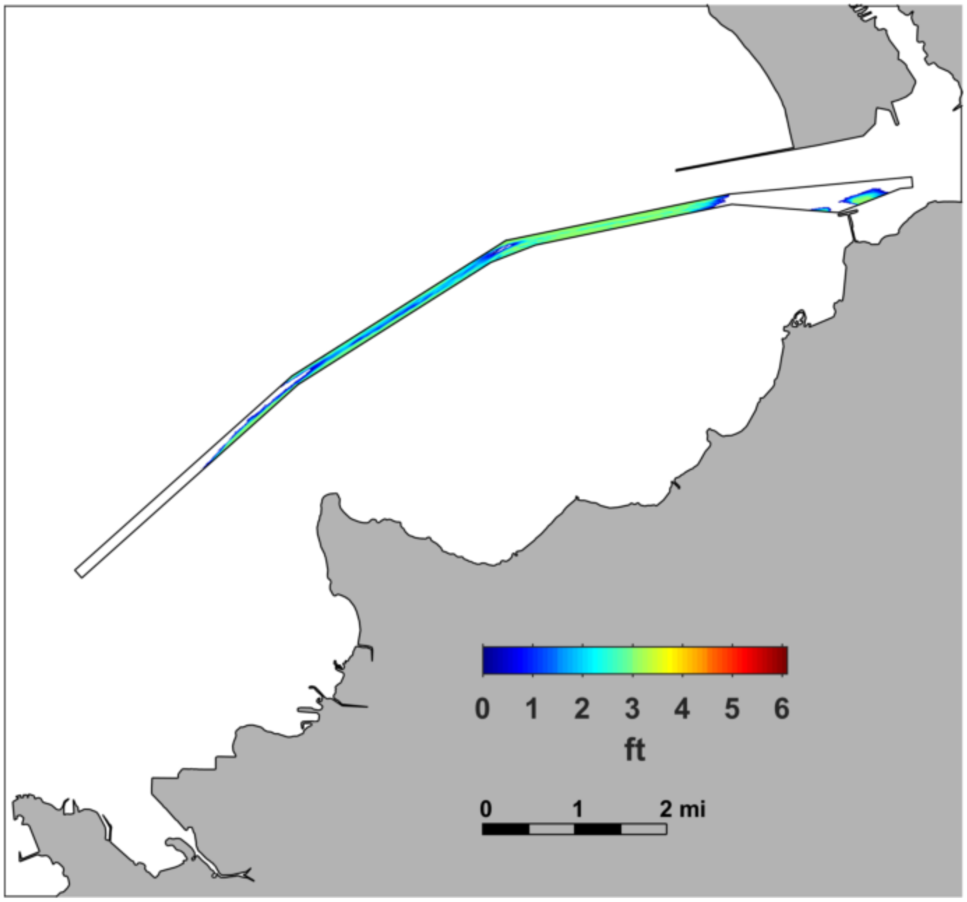


Figure 3.2-3

Channel Deepening in Pinole Shoal Channel for the 38-Foot MLLW Alternative

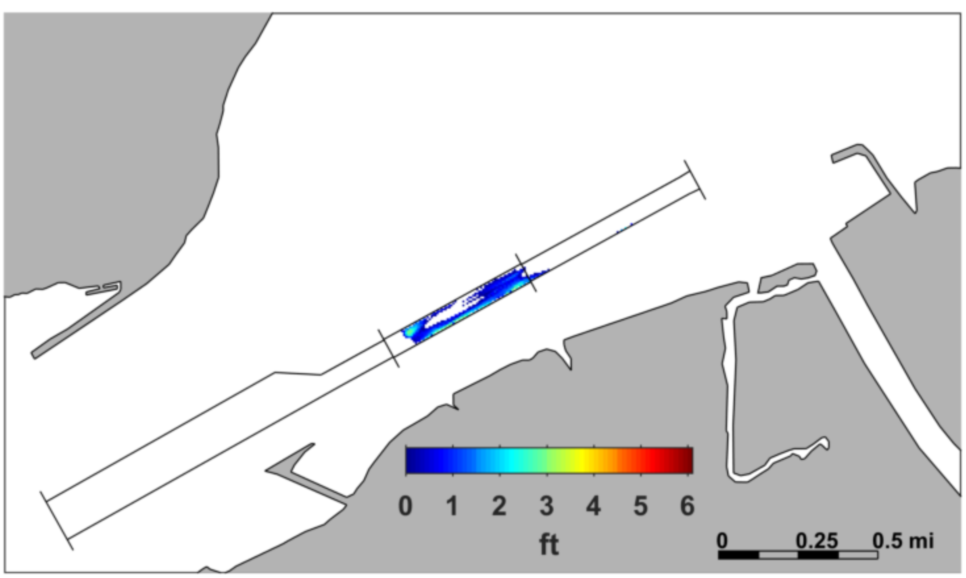


Figure 3.2-4

Channel Deepening in Suisun Bay Channel for the 38-Foot MLLW Alternative

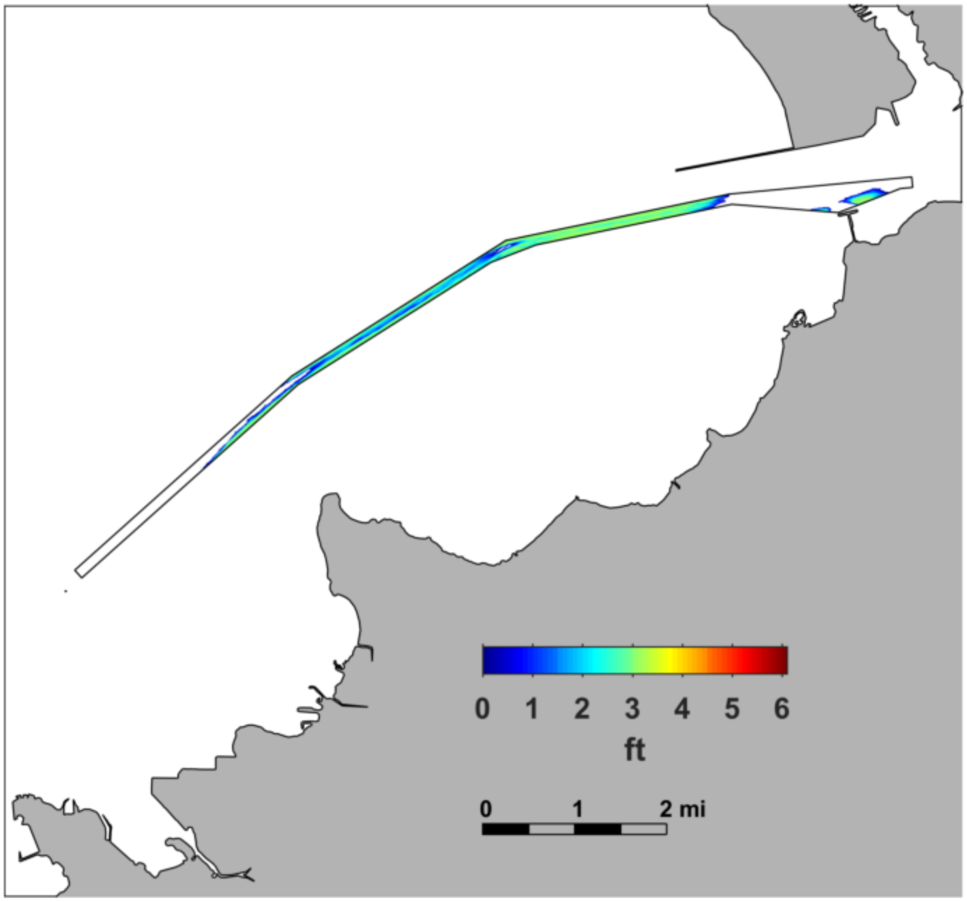


Figure 3.2-5

Channel Deepening in Pinole Shoal Channel for the TSP

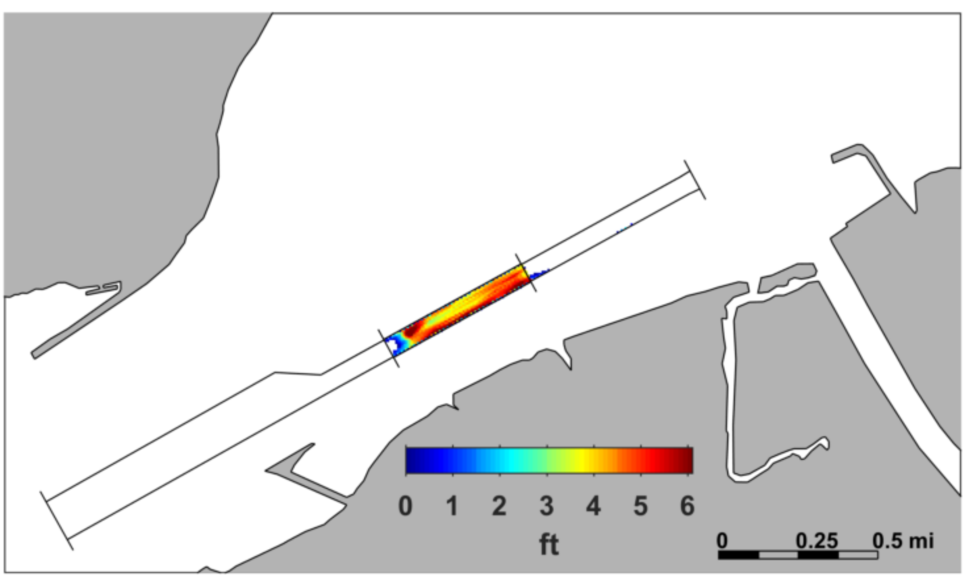


Figure 3.2-6

Channel Deepening in Suisun Bay Channel for the TSP

3.3 Model Boundary Conditions

Some of the previous simulations conducted for this study (e.g., MacWilliams and Gross 2012) made use of monthly flow projections from CalSim II to develop model boundary conditions. The primary motivation for this was that historical conditions that incorporated the most recent biological opinions for Delta Smelt (USFWS 2008) were not available when the initial modeling began in 2009. However, the use of monthly flows can create unrealistic conditions, and when available actual historical conditions are preferable. To eliminate any potential artifacts associated with using monthly boundary conditions derived from CalSim II on the effects analysis, each model geometry was evaluated under recent historical conditions for a 1-year period during and following both a critical water year (2014) and during and following a wet water year (2011). The results of these scenarios are presented in the following sections.

3.3.1 Critical Water Year Boundary Conditions

Water year 2014, which spans from October 1, 2013, through September 30, 2014, was designated as a critical water year (CDWR 2016), the driest classification category. For this analysis, the 1-year period spanning from January 1, 2014, through December 31, 2014 was chosen to allow for evaluation of the winter and spring period during a critical water year, followed by the fall period between October 1 and December 31 of the subsequent water year. During nearly this entire period, both Delta inflow and outflow were extremely low (Figure 3.3-1).

3.3.2 Below Normal Water Year Boundary Conditions

Water year 2012, which spans from October 1, 2011, through September 30, 2012, was designated as a below normal year (CDWR 2016), the middle of five water year classification categories. For this analysis, the 1-year period spanning January 1, 2012, through December 31, 2012, was chosen to allow for evaluation of the winter and spring period during a below normal year, followed by the fall period between October 1 and December 31 of the subsequent water year. During this period, both Delta inflow and outflow were higher than in the critical water year evaluated but were both relatively low throughout the year with only a few short periods when outflow exceeded 1000 m^3/s (Figure 3.3-2).

3.3.3 Wet Water Year Boundary Conditions

Water year 2011, which spans from October 1, 2010, through September 30, 2011, was designated as a wet water year (CDWR 2016), the wettest classification category. For this analysis, the 1-year period spanning from January 1, 2011, through December 31, 2011 was chosen to allow for evaluation of the winter and spring period during a wet water year, followed by the fall period between October 1 and December 31 of the subsequent water year. During nearly this entire period, both Delta inflow and outflow were significantly higher throughout the wet water year (Figure 3.3-3) than during the critical water year (Figure 3.3-1).

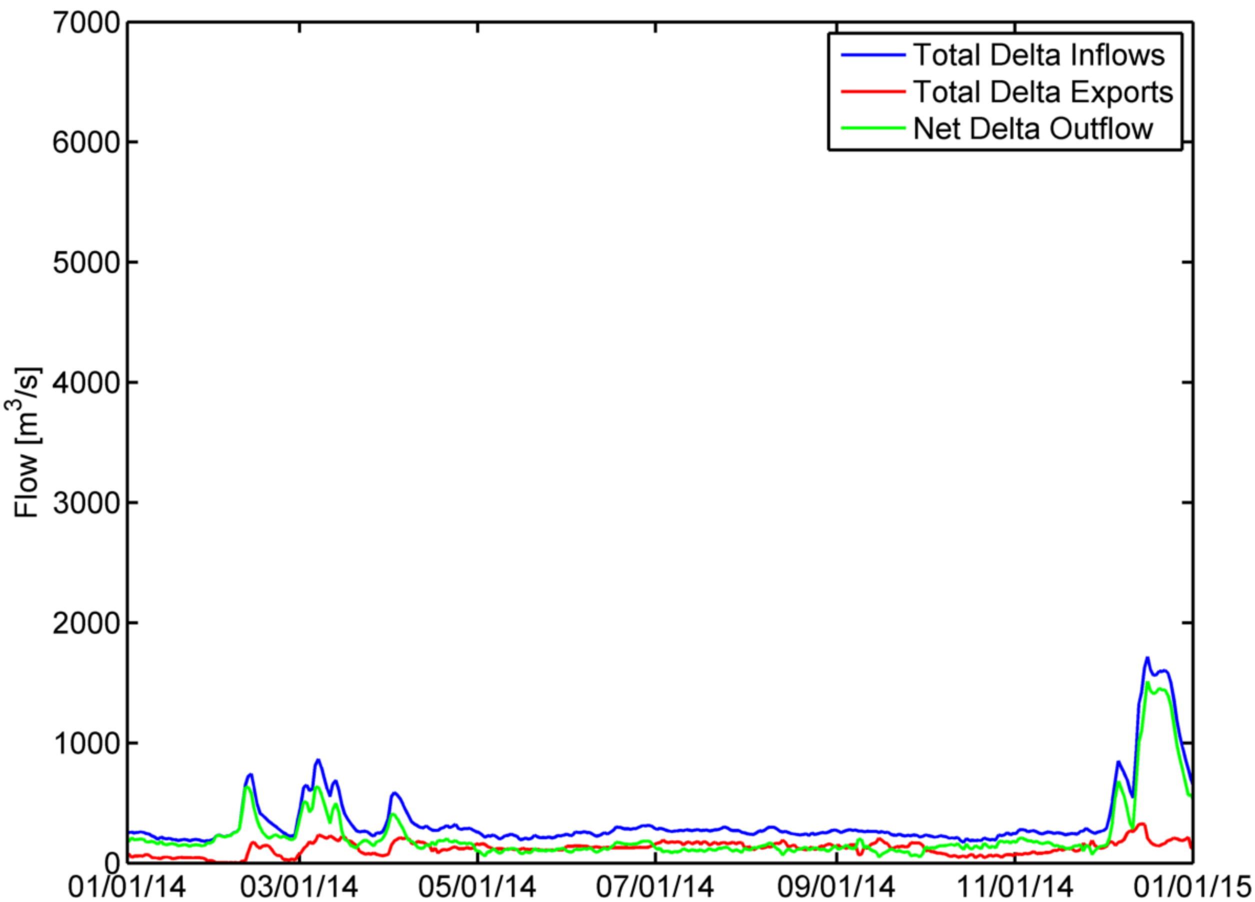


Figure 3.3-1

Total Delta Inflow, Exports, and Outflow for Year 0 Simulation Period Based on 2014 Historical Conditions

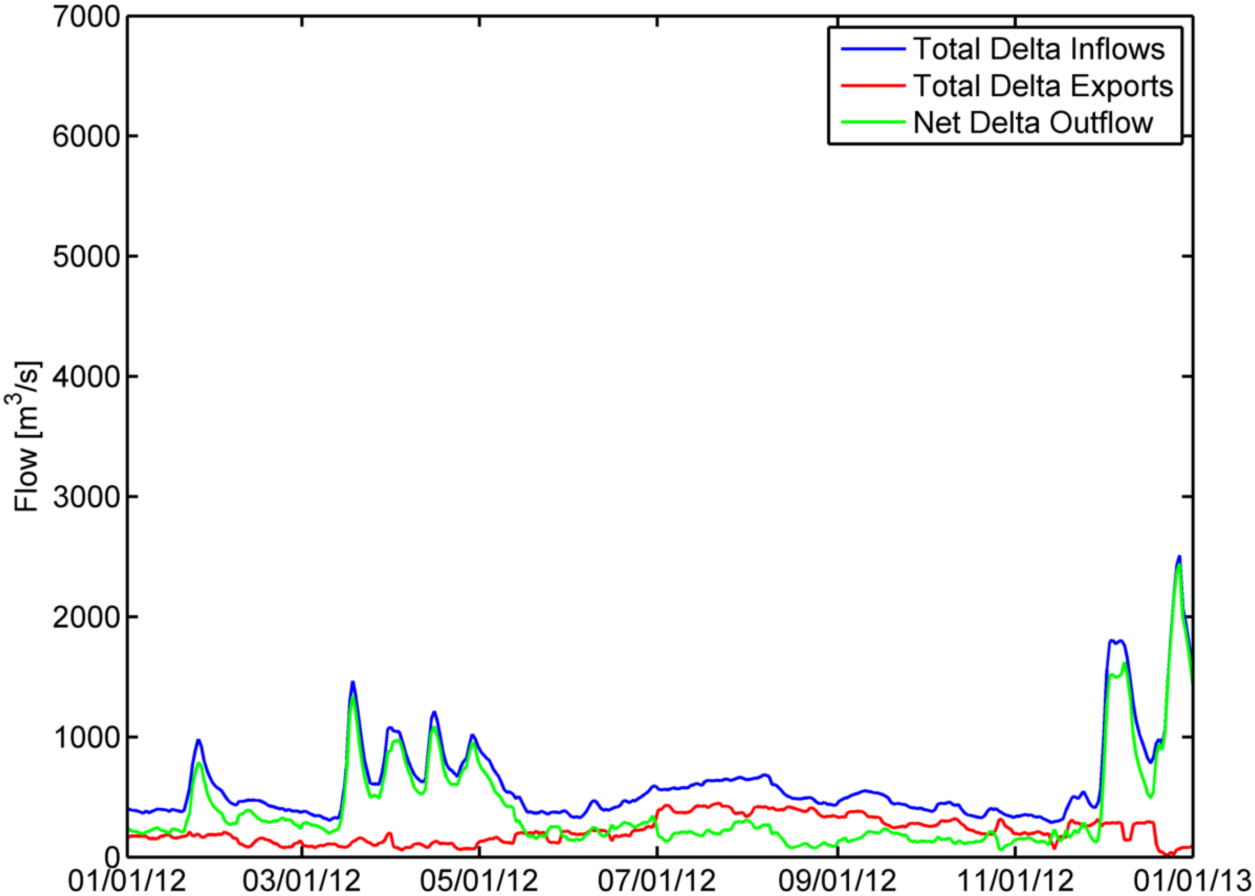


Figure 3.3-2

Total Delta Inflow, Exports, and Outflow for Year 0 Simulation Period Based on 2012 Historical Conditions

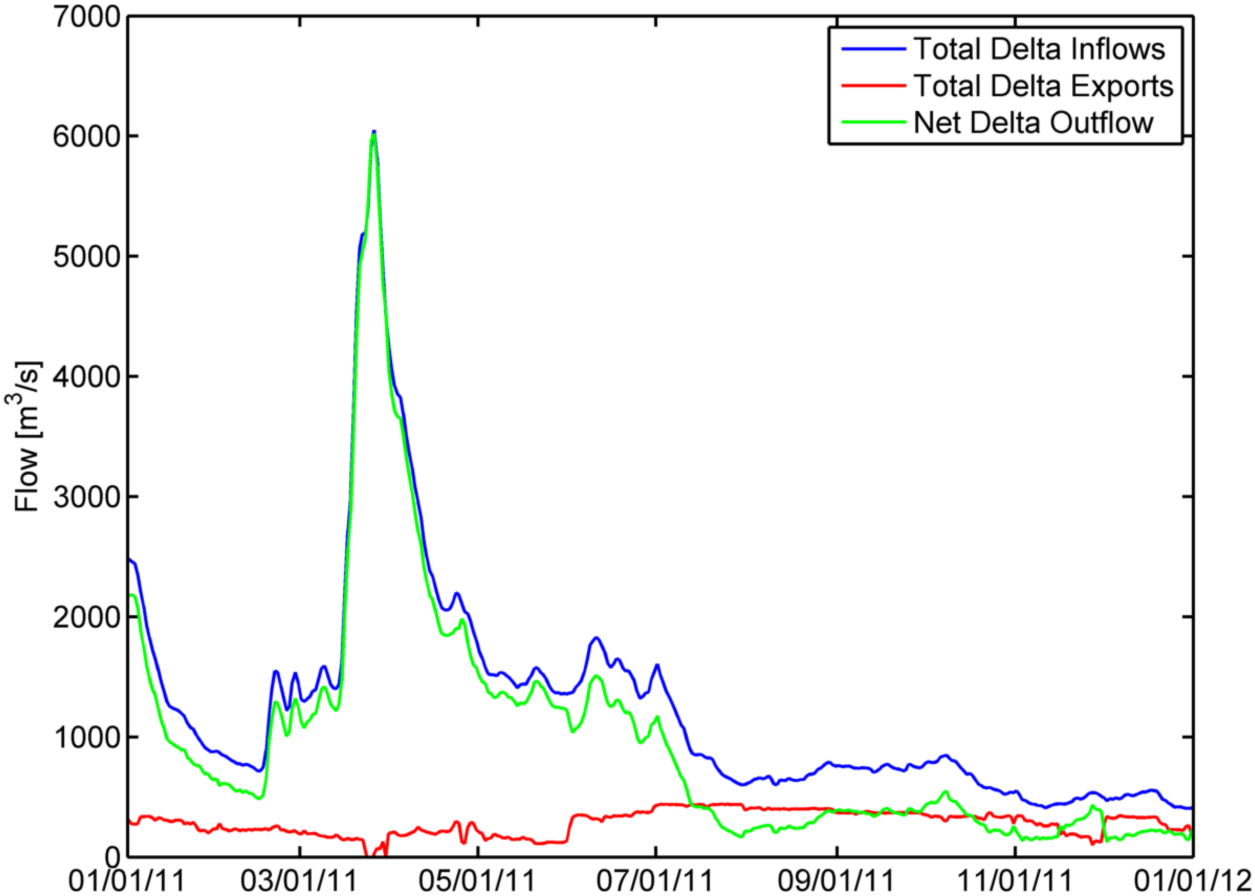


Figure 3.3-3

Total Delta Inflow, Exports, and Outflow for Year 0 Simulation Period Based on 2011 Historical Conditions

3.4 Evaluation of Effects on Salinity and X2

The abundance or survival of several estuarine biological populations in the San Francisco Estuary have historically been positively related to freshwater flow, as indexed by the position of the daily-averaged 2 practical salinity units (psu) isohaline near the bed, or X2 (Jassby et al. 1995; Kimmerer et al. 2009, 2013). In 1995, the State Water Resources Control Board (SWRCB) adopted X2 as a water quality standard to help restore the relationship between springtime precipitation and the geographic location and extent of estuarine habitat. As implemented in Water Rights Decision 1641 (D-1641; SWRCB 2000), this standard requires freshwater inflows to the Bay sufficient to maintain X2 at specific locations for specific numbers of days each month during the spring (February through June). The objective of this "Spring X2" requirement is to help restore the relationship between springtime precipitation and the geographic location and extent of estuarine habitat. The Biological Opinion (BO) for Delta Smelt (*Hypomesus transpacificus*) calls for efforts to increase outflow to enlarge the area of habitat with suitable salinity for this fish and has established X2 requirements during fall months following wet or above normal water years (USFWS 2008). As a result, impacts to X2 directly affect fish and wildlife through changes to the salinity distribution, and potentially also affect water supply reliability during periods of the year when the position of X2 is managed by regulating Delta outflow. The Spring X2 requirement at Port Chicago (SWRCB 2000) applies only in months when the average electrical conductivity at Port Chicago (X2 = 64 km) during the 14 days just before the first day of the month is less than or equal to 2.64 millimhos per centimeter (mmhos/cm). However, when X2 is less than 64 km there are no current regulatory requirements that regulate the position of X2. As a result, the effects of the channel deepening on X2 are evaluated both over the entire year and for the portion of the year that X2 is greater than 64 km.

In the UnTRIM Bay-Delta model, X2 was calculated on each day for each deepening scenario as the distance from the Golden Gate to the location where the daily-averaged near-bed salinity was 2 psu along the axis of the estuary along the two transects shown in Figure 3.4-1. For X2 greater than 75 km, X2 was averaged between the Sacramento (north) and San Joaquin (south) transects (Figure 3.4-1). For each DWSC deepening scenario, the predicted X2 was compared to the predicted X2 for the No Action Alternative during each day of the analysis period. The predicted change in X2 provides one measure of the potential salinity impacts associated with the deepening of the San Francisco Bay to Stockton Navigation Improvement Project channels.

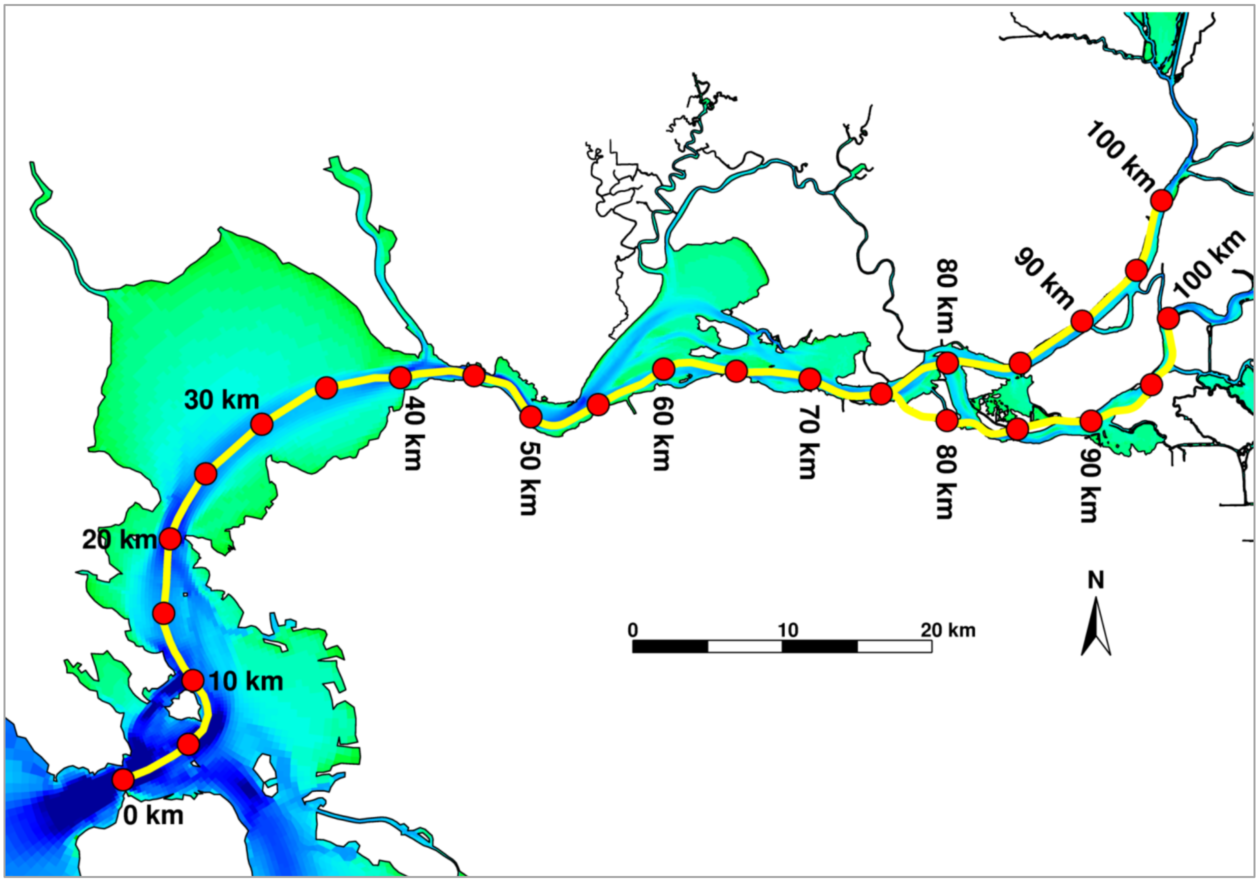


Figure 3.4-1
Transects Along the Axis of Northern San Francisco Bay Used to Measure X2 in the UnTRIM Bay-Delta Model

3.5 Evaluation of Effects on D-1641 Water Quality Objectives

Water Rights Decision 1641 (D-1641; SWRCB 2000) contains the current water right requirements to implement the Bay-Delta flow-dependent objectives. Several specific water quality objectives for municipal and industrial, agricultural, and fish and wildlife beneficial uses stipulated by D-1641 are presented in this section. Each of the scenarios modeled in this study is evaluated based on each of the standards listed below.

D-1641 stipulates specific water quality objectives for municipal and industrial, agricultural, and fish and wildlife beneficial uses. These D-1641 water quality standards are typically based on either electrical conductivity, measured in mmhos/cm, or concentrations of Cl^- (chloride), measured in milligrams per liter (mg/L). For evaluation of the potential impacts of the proposed deepening of the San Francisco Bay to Stockton Navigation Improvement Project channels on these water quality objectives, the predicted salinity at each D-1641 station was converted to electrical conductivity and concentration of Cl^-, as described in MacWilliams and Gross (2012).

The D-1641 water quality objectives for municipal and industrial beneficial uses, shown in Table 3-1, are based on concentration of Cl^- at water export locations. The first set of standards stipulate the number of days that maximum mean daily concentration of Cl^- must be less than 150 mg/l (approximately 0.34 psu) either at Contra Costa Canal at Pumping Plant #1 or at the Antioch Water Works intake. The minimum number of days during which this objective should be met ranges from 155 days for a “critical” water year to 240 days for a “wet” water year. The second set of standards stipulates a maximum allowable concentration of 250 mg/l Cl^- (approximately 0.52 psu) at the municipal water intakes. For the purposes of this study, this standard is also evaluated at the CCWD intake on Old River (ROLD034) and at the CCWD Middle River at Victoria Canal Intake (CCW). The analysis presented here focuses on the potential water quality impact at each of the five major intake and export locations in the south Delta (Figure 3.5-1). Comparisons for Barker Slough at North Bay Aqueduct Intake and Cache Slough at City of Vallejo Intake are now presented because none of the alternatives evaluated have any effects on electrical conductivity at these locations in the North Delta.

The D-1641 water quality objectives for agricultural beneficial uses in the Western Delta, shown in Table 3-2, are based on the maximum 14-day running average of mean daily electrical conductivity, and are in place from April 1 to August 15. Similar water quality objectives for agricultural beneficial uses are in place in the interior and southern Delta, but comparisons at these locations are not shown because none of the alternatives have a significant effect on electrical conductivity at these locations.

Table 3-1
D-1641 Water Quality Objectives for Municipal and Industrial Beneficial Uses

Compliance Location	Station Index	Parameter	Description	Water Year Type	Time Period	Value
Contra Costa Canal at Pumping Plant #1 **-or-** San Joaquin River at Antioch Water Works Intake	CHCCC06 RSAN007	Chloride (Cl^-)	Maximum mean daily 150 mg/l Cl^- for at least the number of days shown during the Calendar Year. (Percentage of calendar year shown in parentheses)	W AN BN D C		No. of days ≤ 150 mg/l Cl^- 240 (66%) 190 (52%) 175 (48%) 165 (45%) 155 (42%)
Contra Costa Canal at Pumping Plant #1 **-and-** West Canal at mouth of Clifton Court Forebay **-and-** Delta-Mendota Canal at Tracy Pumping Plant **-and-** Barker Slough at North Bay Aqueduct Intake **-and-** Cache Slough at City of Vallejo Intake	CHCCC06 CHWST0 CHDMC04 SLSAR3 SLCCH16	Chloride (Cl^-)	Maximum mean daily (mg/l)	All	Oct – Sep (all year)	250 mg/l Cl^-

Notes:
AN = Above Normal Water Year
BN = Below Normal Water Year
C = Critical Water Year
D = Dry Water Year
W = Wet Water Year

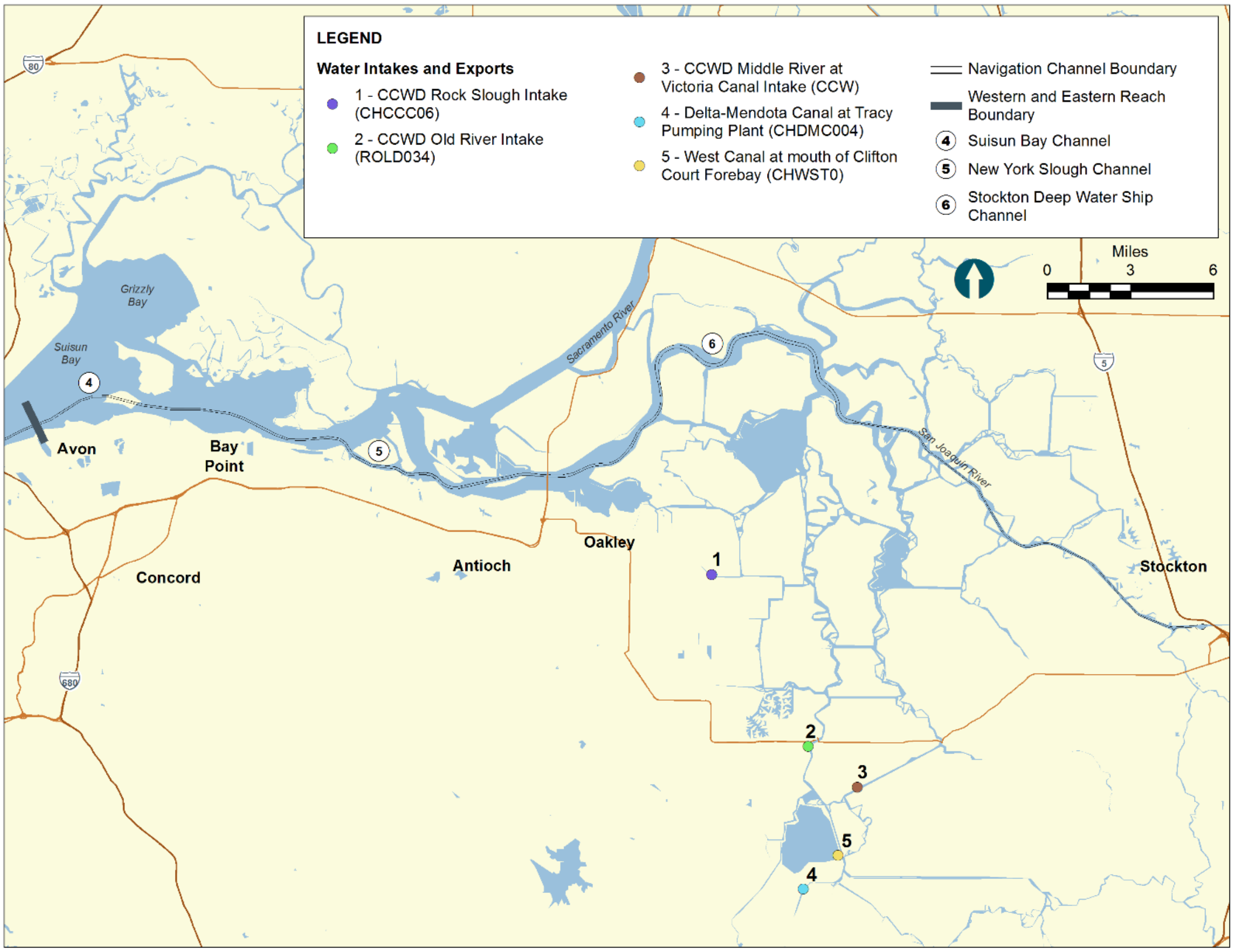


Figure 3.5-1

Locations of Water Intakes and Water Exports in the South Delta

Table 3-2

D-1641 Water Quality Objectives for Agricultural Beneficial Uses in the Western Delta

Compliance Location	Station Index	Parameter	Description	Water Year Type	Time Period	Value
Western Delta						
Sacramento River at Emmaton	RSAC092	EC	Maximum 14-day running average of mean daily EC (mmhos/cm)		0.45 EC April 1 to:	EC from date shown to Aug 15
				W	Aug 15	----
				AN	Jul 1	0.63
				BN	Jun 20	1.14
				D	Jun 15	1.67
				C	----	2.78
San Joaquin River at Jersey Point	RSAN018	EC	Maximum 14-day running average of mean daily EC (mmhos/cm)		0.45 EC April 1 to:	EC from date shown to Aug 15
				W	Aug 15	----
				AN	Aug 15	----
				BN	Jun 20	0.74
				D	Jun 15	1.35
				C	----	2.20

Notes:
AN = Above Normal Water Year
BN = Below Normal Water Year
C = Critical Water Year
D = Dry Water Year
EC = Electrical Conductivity
W = Wet Water Year

3.6 Evaluation of Effects on Water Levels

Water level (stage) time series provide information about potential water level impacts over time at a fixed location. For each TSP simulation, water level time series comparisons were made at three continuous monitoring stations in San Francisco Bay spanning from seaward of the Pinole Shoal Channel at Richmond to the western end of the Delta at Mallard Island (Figure 3.6-1). For each comparison, three separate plots are shown. The top plot shows the tidal time-scale variability of stage over a 15-day period for the No Action Alternative and the TSP. The middle plot shows daily-averaged stage during the full simulation year for each scenario. The bottom plot shows the predicted change in daily-averaged stage for the TSP scenario relative to the corresponding No Action Alternative. The figures provide a quantitative measure of potential impacts of the TSP on stage on both tidal and annual time scales.

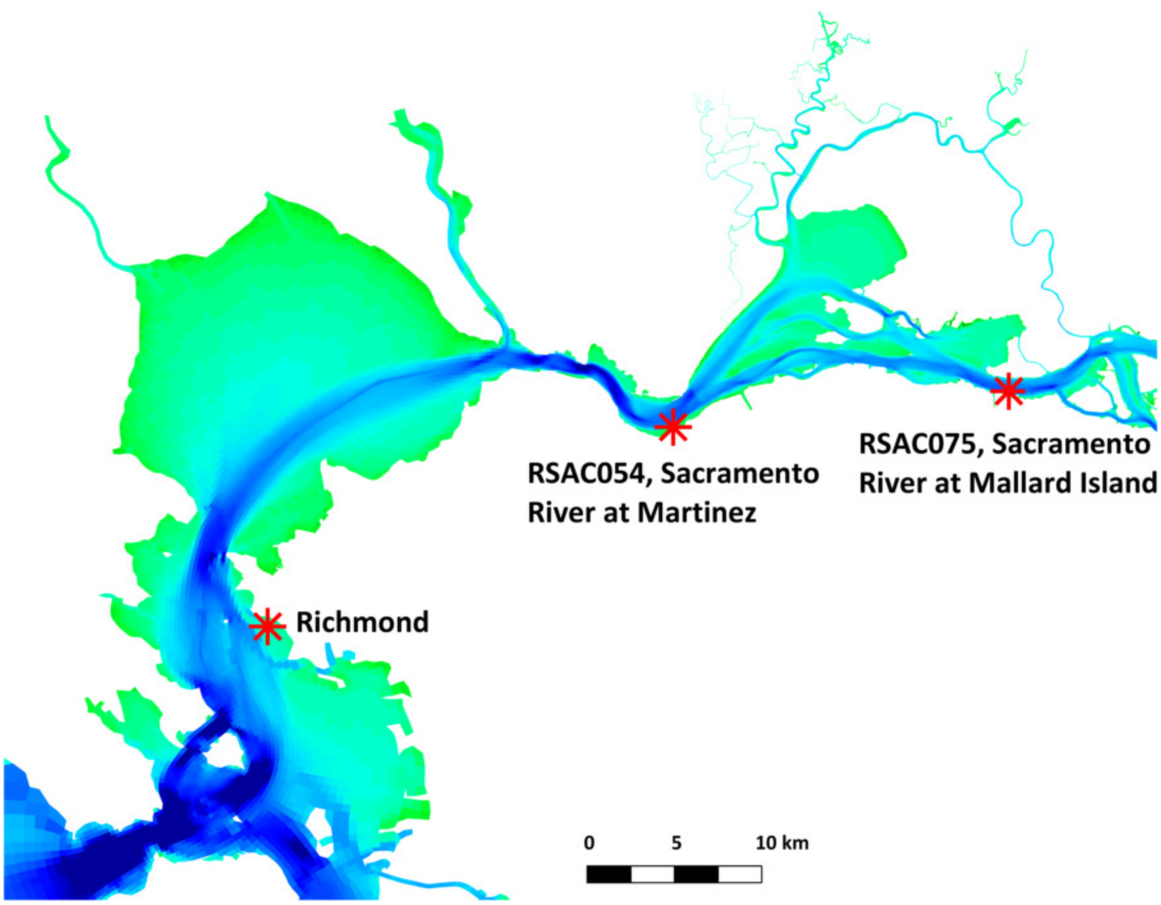


Figure 3.6-1

Location of Continuous Monitoring Stations in San Francisco Bay Where Water Level Time Series Comparisons Were Made to Evaluate Potential Effects of the TSP on Water Levels

3.7 Evaluation of Effects on Tidal Flows

Flow time series provide information about potential impacts to tidal flows over time at a fixed location. For each TSP simulation, flow comparisons were made at three cross-sections in San Francisco Bay spanning from seaward of the Pinole Shoal Channel at Point San Pablo to the western end of the Delta at Chipps Island (Figure 3.7-1). For each comparison, three separate plots are shown. The top plot shows the tidal time-scale variability of tidal flows over a 15-day period for the No Action Alternative and the TSP. The middle plot shows the tidally-averaged flow during the full simulation year for each scenario. The bottom plot shows the predicted change in tidally-averaged flow for the TSP scenario relative to the corresponding No Action Alternative. The figures provide a quantitative measure of potential impacts of the TSP on tidal and net flows on both tidal and annual time scales.

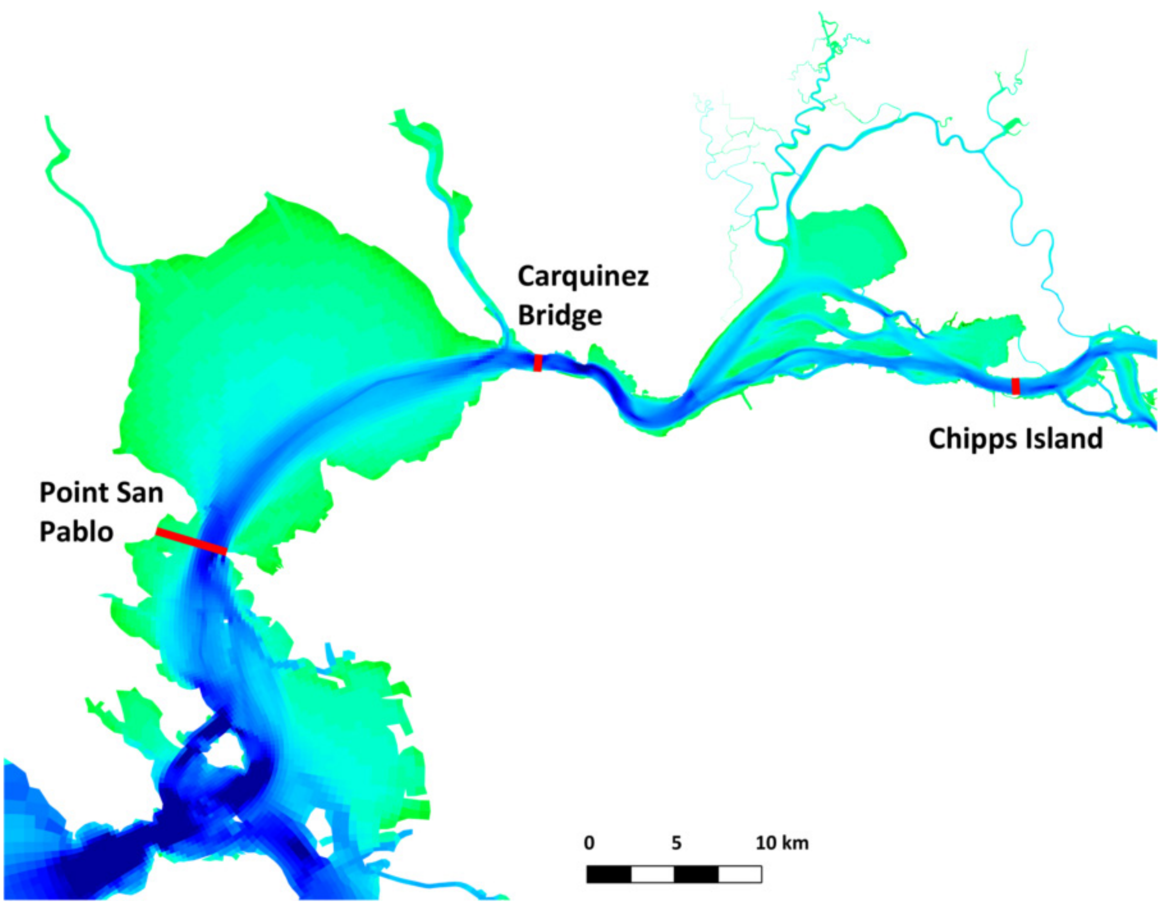


Figure 3.7-1

Location of Cross-Sections in San Francisco Bay Where Flow Time Series Comparisons Were Made to Evaluate Potential Effects of the TSP on Tidal Flows

4 EVALUATION OF PRELIMINARY ALTERNATIVES DURING A CRITICAL AND WET WATER YEAR

4.1 Evaluation of Effects on Salinity and X2 During a Critical Water Year

This section presents the evaluation of the two preliminary alternatives, the 37-Foot MLLW Alternative and the 38-Foot MLLW Alternative, on salinity during and following a critical water year. The period evaluated is based on historical conditions between January 1, 2014, and December 31, 2014, as described in Section 3.3.1.

4.1.1 Evaluation of 37-Foot MLLW Alternative During a Critical Water Year

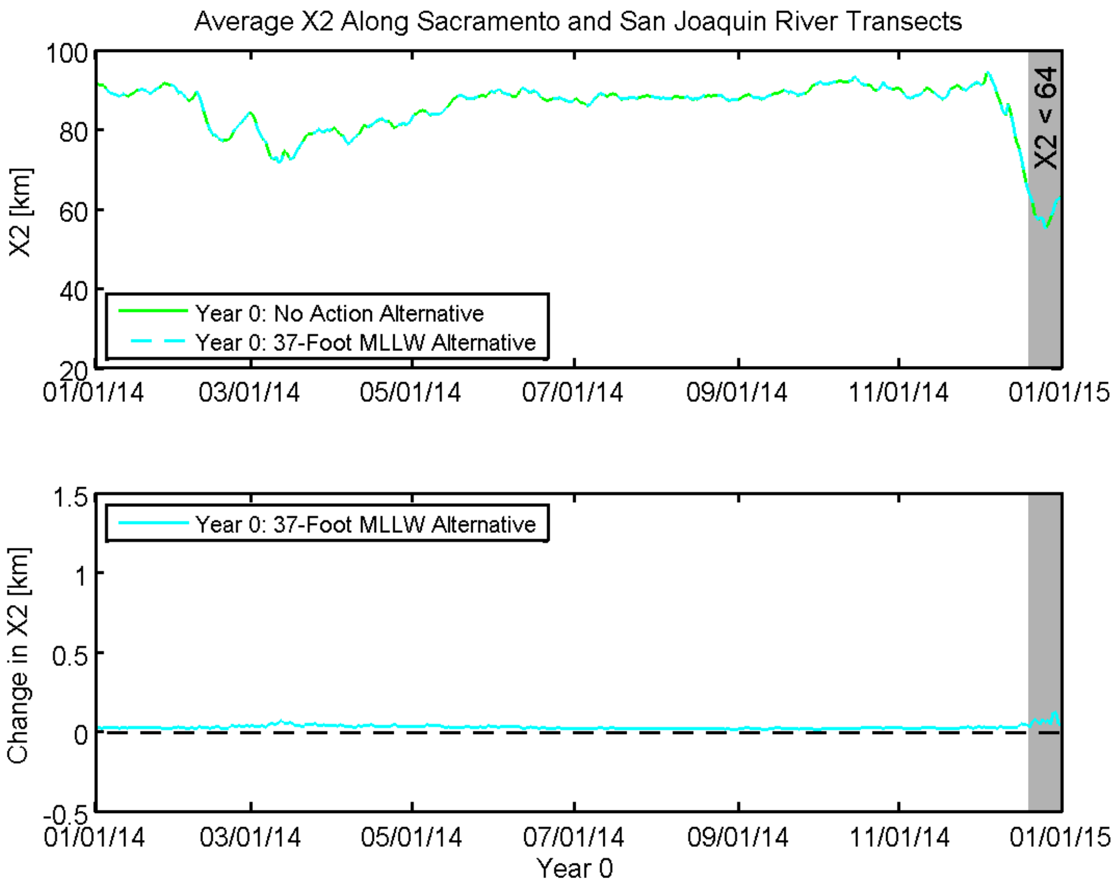
4.1.1.1 Effect of 37-Foot MLLW Alternative on X2

During 2014, X2 remained elevated throughout the year (Figure 4.1-1, top), with X2 remaining above 70 km through the first 11 months of the year and dropping below 64 km only in December due to higher outflows (See Figure 3.3-1). For the 37-Foot MLLW Alternative, X2 was predicted to increase throughout the year as a result of the deepening (Figure 4.1-1, bottom), with a predicted annual-average increase of 0.03 km. Similarly, during the period of the year when X2 was greater than 64 km, the predicted average increase in X2 resulting from the 37-Foot MLLW Alternative was 0.03 km (Table 4-1).

Table 4-1
Predicted Change in X2 for 37-Foot MLLW Alternative and 38-Foot MLLW Alternative During a Critical Water Year

Alternative	Change in X2 (km)	
	Annual-Average	Change for X2 > 64
No Action Alternative	Baseline	Baseline
37-Foot MLLW Alternative	0.03	0.03
38-Foot MLLW Alternative	0.11	0.11

Notes:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2, so the average change for periods when X2 >64 is also shown separately.
km = kilometers
MLLW = Mean Lower Low Water



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 4.1-1
Predicted X2 for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in X2 Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Critical Water Year (Bottom)

4.1.1.2 Effect of 37-Foot MLLW Alternative on Water Quality at D-1641 Stations

The effect of the 37-Foot MLLW Alternative on the predicted Cl^- concentration at the five intake and export locations in the south Delta (locations shown in Figure 3.5-1) was evaluated to assess the potential effects on water quality at the municipal and industrial intakes at which D-1641 has established water quality criteria. Figures 4.1-2 through 4.1-6 show the mean daily Cl^- concentration for the No Action Alternative and the 37-Foot

MLLW Alternative and the predicted change in Cl^- concentration resulting from the 37-Foot MLLW Alternative during 2014. Table 4-2 summarizes the predicted annual-average change in Cl^- concentration and the maximum predicted monthly average change in Cl^- concentration at five intake and export locations. During the critical water year, the predicted annual-average change in Cl^- concentration ranged from 0.2 mg/L at the CCWD Middle River at Victoria Canal Intake to 0.4 mg/L at the CCWD Rock Slough Intake. The predicted maximum monthly average change ranged from 0.3 mg/L at the CCWD Middle River at Victoria Canal Intake to 0.7 mg/L at the CCWD Rock Slough Intake. The predicted monthly average change in Cl^- concentration during each month in 2014 for both the 37-Foot MLLW Alternative and the 38-Foot MLLW Alternative is included at the end of Section 4.1 in Table 4-4.

Table 4-2

Predicted Annual-Average and Maximum Monthly Average Change in Cl^- Concentration Relative to the No Action Alternative for the 37-Foot MLLW Alternative at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Critical Water Year

Year 0 Critical Water Year (2014)	Change in Chloride Concentration (mg/L Cl^-)	
	Annual-Average Change	Max Monthly Average Change
West Canal at Mouth of Clifton Court Forebay (CHWST0)	0.3	0.5
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)	0.2	0.4
CCWD Rock Slough Intake (CHCCC06)	0.4	0.7
CCWD Old River Intake (ROLD034)	0.3	0.6
CCWD Middle River at Victoria Canal Intake (CCW)	0.2	0.3

Notes:
CCWD = Contra Costa Water District
mg/L Cl^- = Concentration of chloride in milligrams per liter

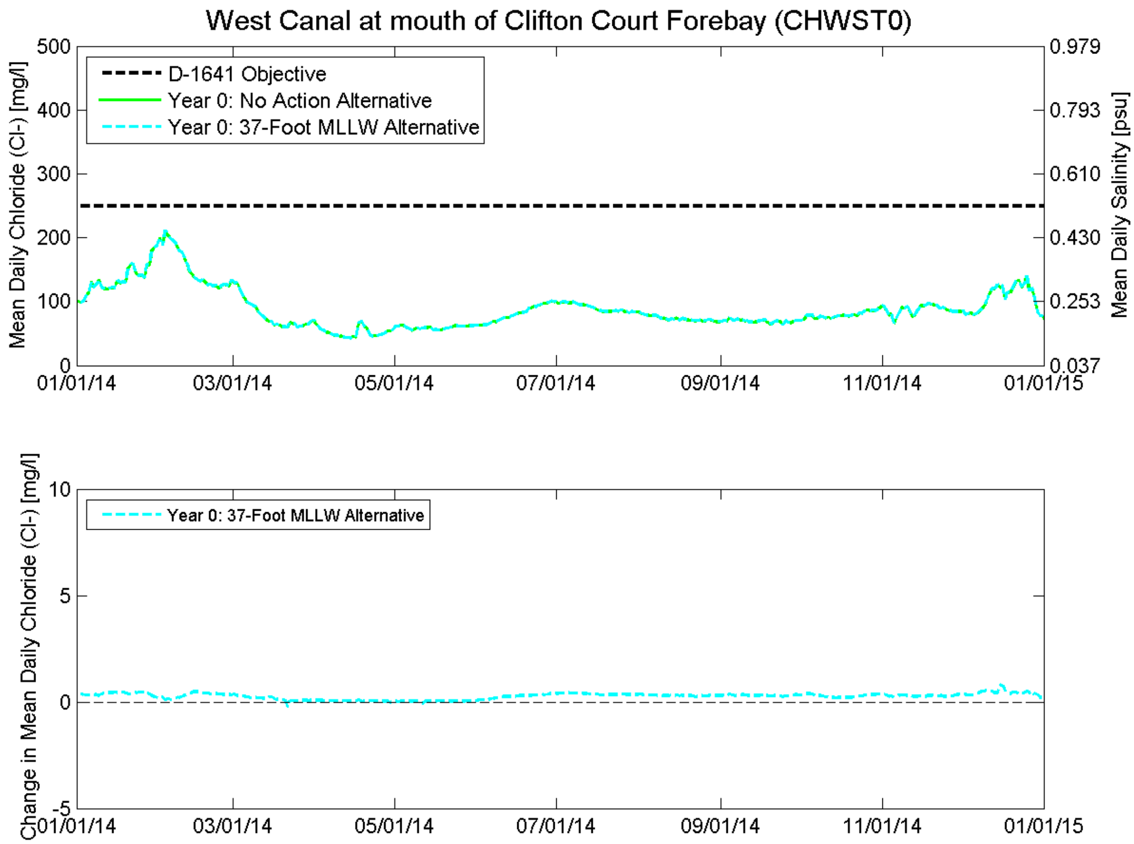


Figure 4.1-2

Predicted Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Critical Water Year (Bottom)

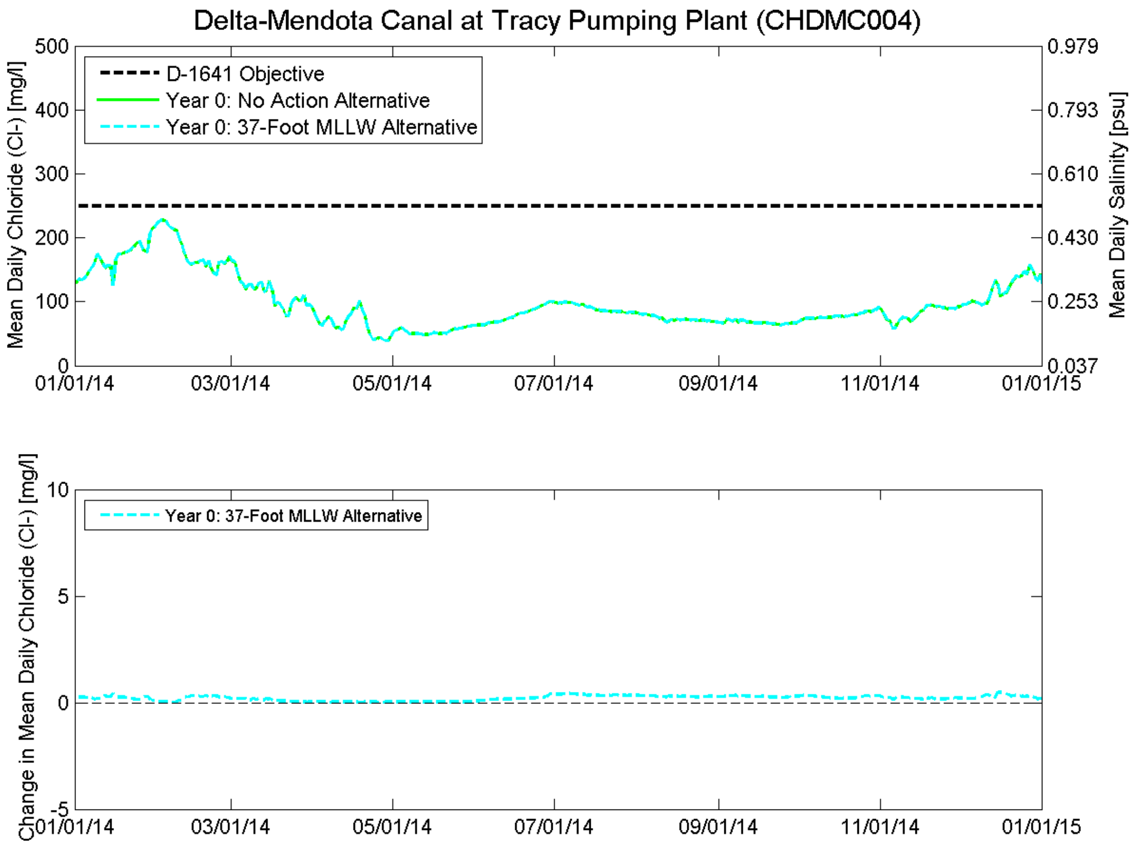


Figure 4.1-3

Predicted Mean Daily Cl^- Concentration at the Tracy Pumping Plant (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Tracy Pumping Plant Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Critical Water Year (Bottom)

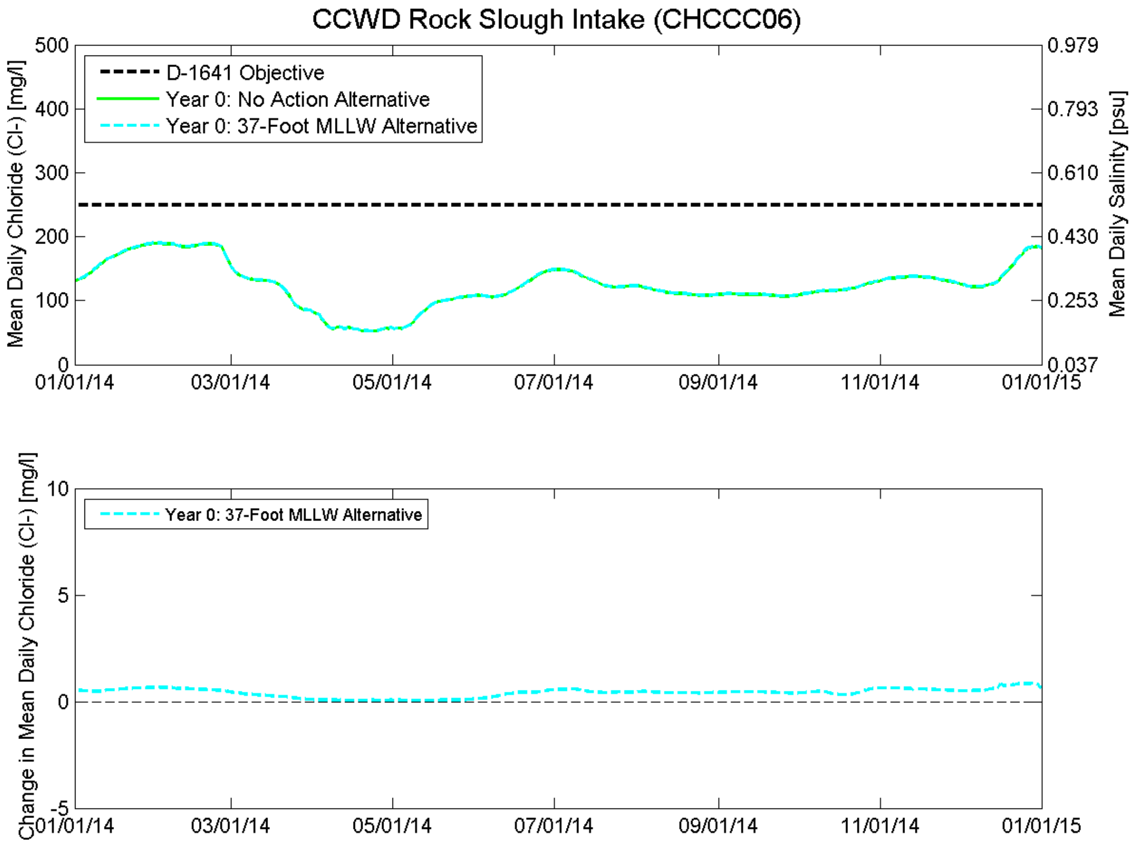


Figure 4.1-4

Predicted Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Critical Water Year (Bottom)

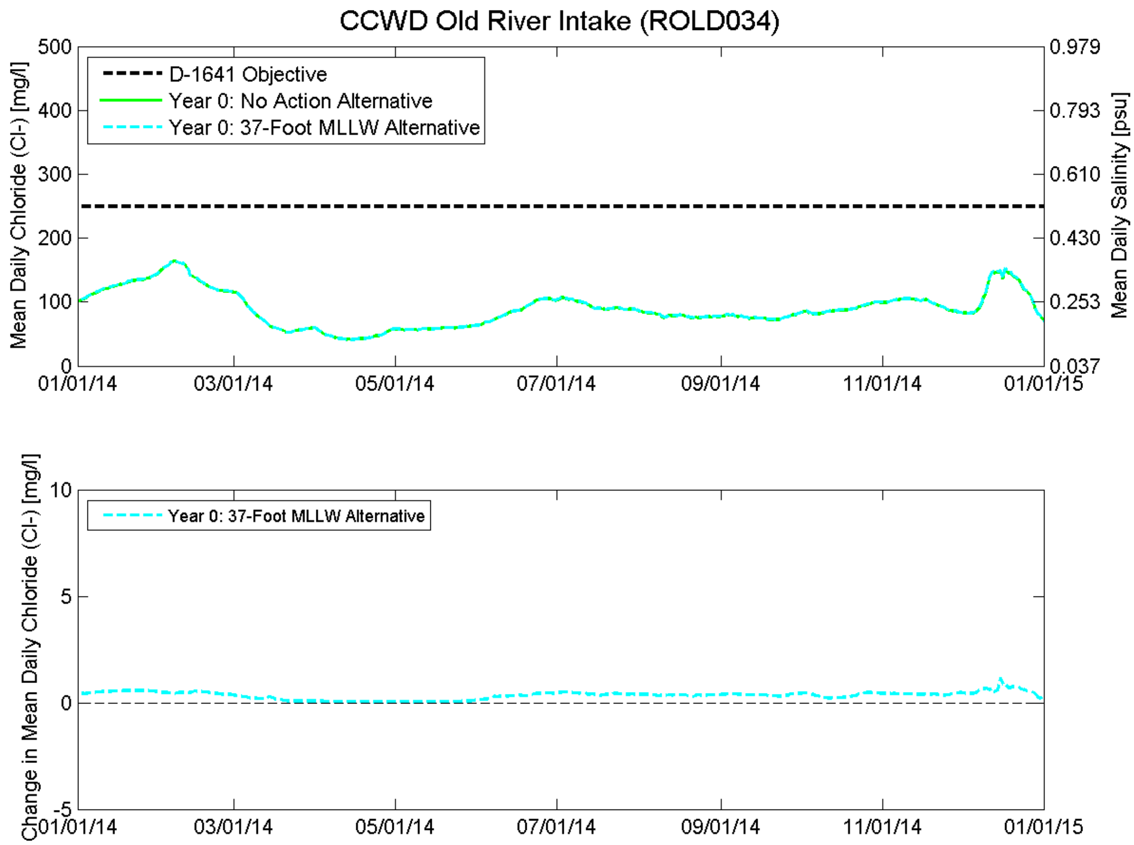


Figure 4.1-5

Predicted Mean Daily Cl^- Concentration at the CCWD Old River Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Old River Intake Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Critical Water Year (Bottom)

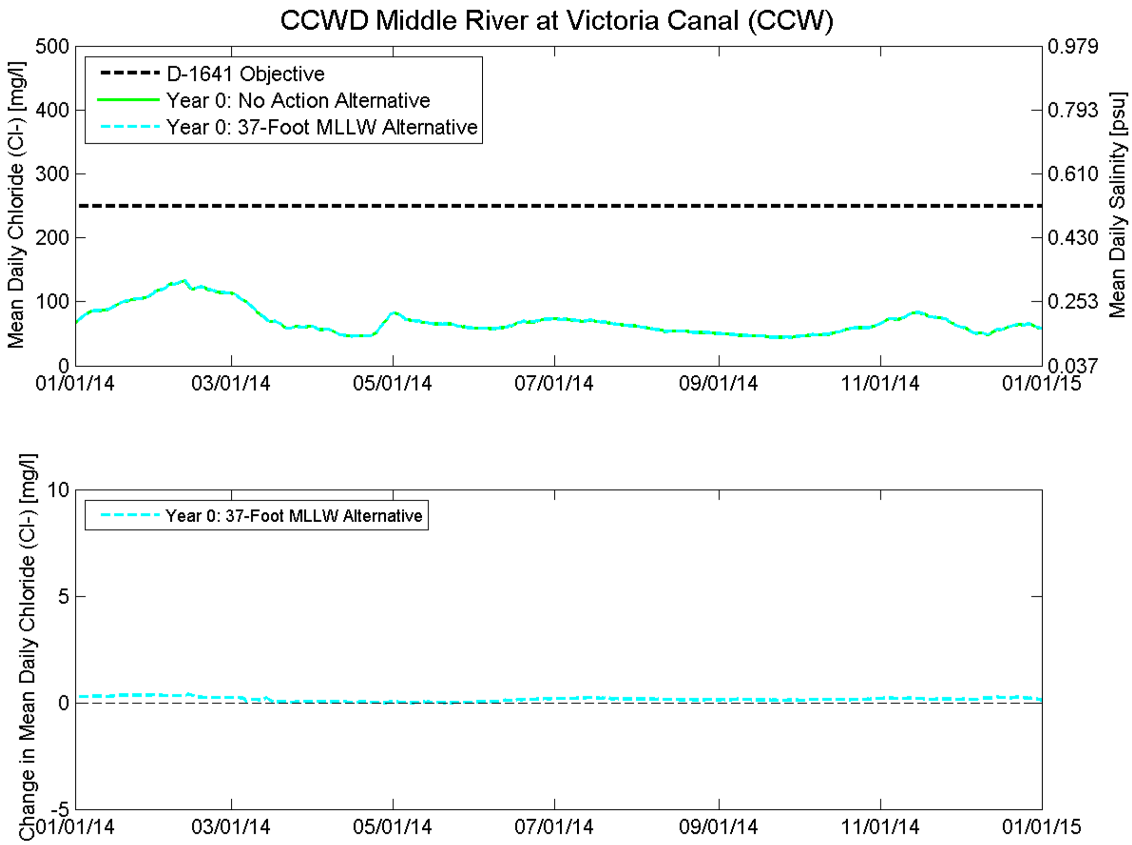


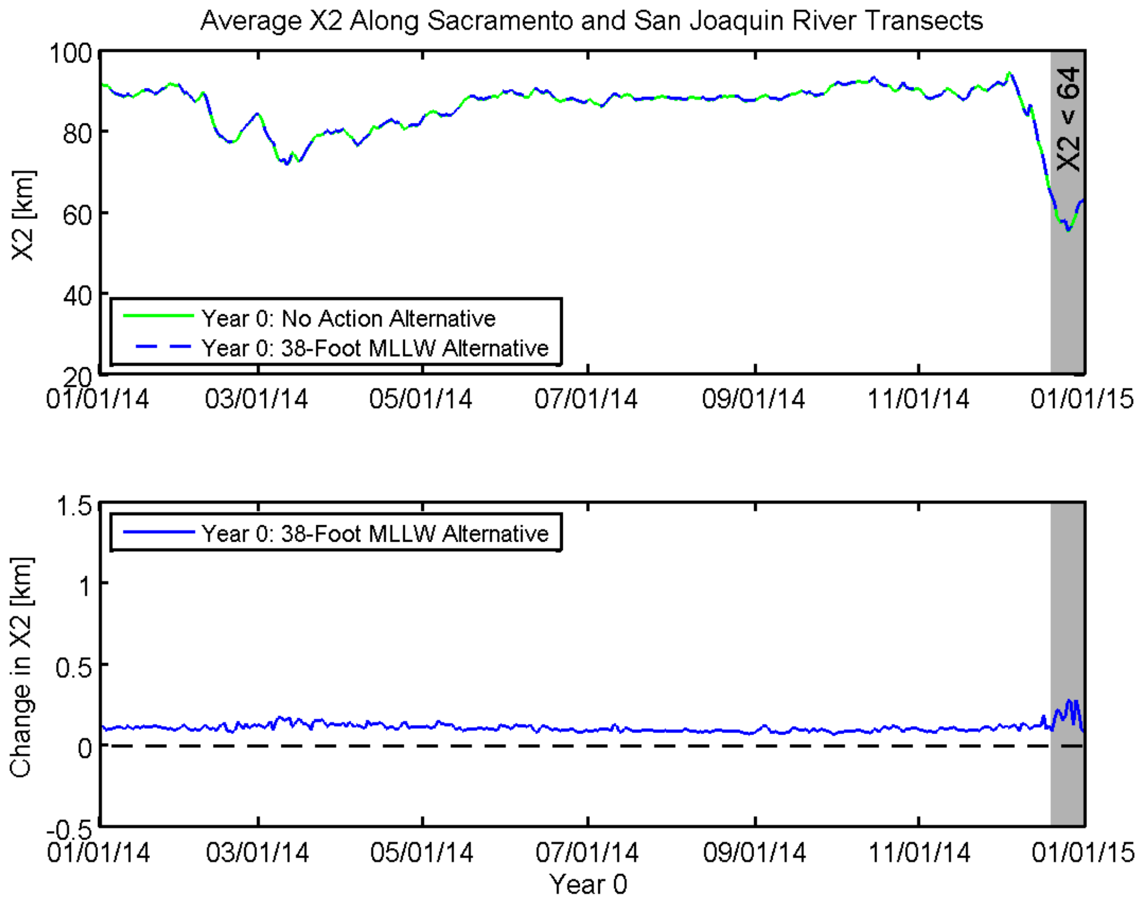
Figure 4.1-6

Predicted Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Critical Water Year (Bottom)

4.1.2 Evaluation of 38-Foot MLLW Alternative During a Critical Water Year

4.1.2.1 Effect of 38-Foot MLLW Alternative on X2

During 2014, X2 remained elevated throughout the year (Figure 4.1-7, top), with X2 remaining above 70 km through the first 11 months of the year and dropping below 64 km only in December due to higher outflows (see Figure 3.3-1). For the 38-Foot MLLW Alternative, X2 was predicted to increase throughout the year relative to the baseline No Action Alternative (Figure 4.1-7, bottom), with a predicted annual-average increase of 0.11 km. Similarly, during the period of the year when X2 was greater than 64 km, the predicted average increase in X2 resulting from the 38-Foot MLLW Alternative was 0.11 km (Table 4-1).



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 4.1-7

Predicted X2 for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in X2 Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

4.1.2.2 Effect of 38-Foot MLLW Alternative on Water Quality at D-1641 Stations

The effect of the 38-Foot MLLW Alternative on the predicted Cl^- concentration at the five intake and export locations in the south Delta (locations shown in Figure 3.5-1) was evaluated to assess the potential effects on water quality at the municipal and industrial intakes at which D-1641 has established water quality criteria. Figures 4.1-8 through 4.1-12 show the mean daily Cl^- concentration for the No Action Alternative and the 38-Foot MLLW Alternative and the predicted change in Cl^- concentration resulting from the 38-Foot MLLW Alternative during 2014. Table 4-3 summarizes the predicted annual-average change in Cl^- concentration and the maximum predicted monthly average change in Cl^- concentration at five intake and export locations. During the critical water year, the predicted annual-average change in Cl^- concentration ranged from 0.6 mg/L at the CCWD Middle River at Victoria Canal Intake to 1.4 mg/L at the CCWD Rock Slough Intake. The predicted maximum monthly average change ranged from 1.2 mg/L at the CCWD Middle River at Victoria Canal Intake and the Delta-Mendota Canal at Tracy Pumping Plant to 2.4 mg/L at the CCWD Rock Slough Intake. The predicted monthly average change in Cl^- concentration during each month in 2014 for both the 37-Foot MLLW Alternative and the 38-Foot MLLW Alternative is included in Table 4-4.

Table 4-3
Predicted Annual-Average and Maximum Monthly Average Change in Chloride Concentration Relative to the No Action Alternative for the 38-Foot MLLW Alternative at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Critical Water Year

Year 0 Critical Water Year (2014)	Change in Chloride Concentration (mg/L Cl^-)	
	Annual-Average Change	Max Monthly Average Change
West Canal at Mouth of Clifton Court Forebay (CHWST0)	0.9	1.6
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)	0.7	1.2
CCWD Rock Slough Intake (CHCCC06)	1.4	2.4
CCWD Old River Intake (ROLD034)	1.2	2.1
CCWD Middle River at Victoria Canal Intake (CCW)	0.6	1.2

Notes:
CCWD = Contra Costa Water District
mg/L Cl^- = Concentration of chloride in milligrams per liter

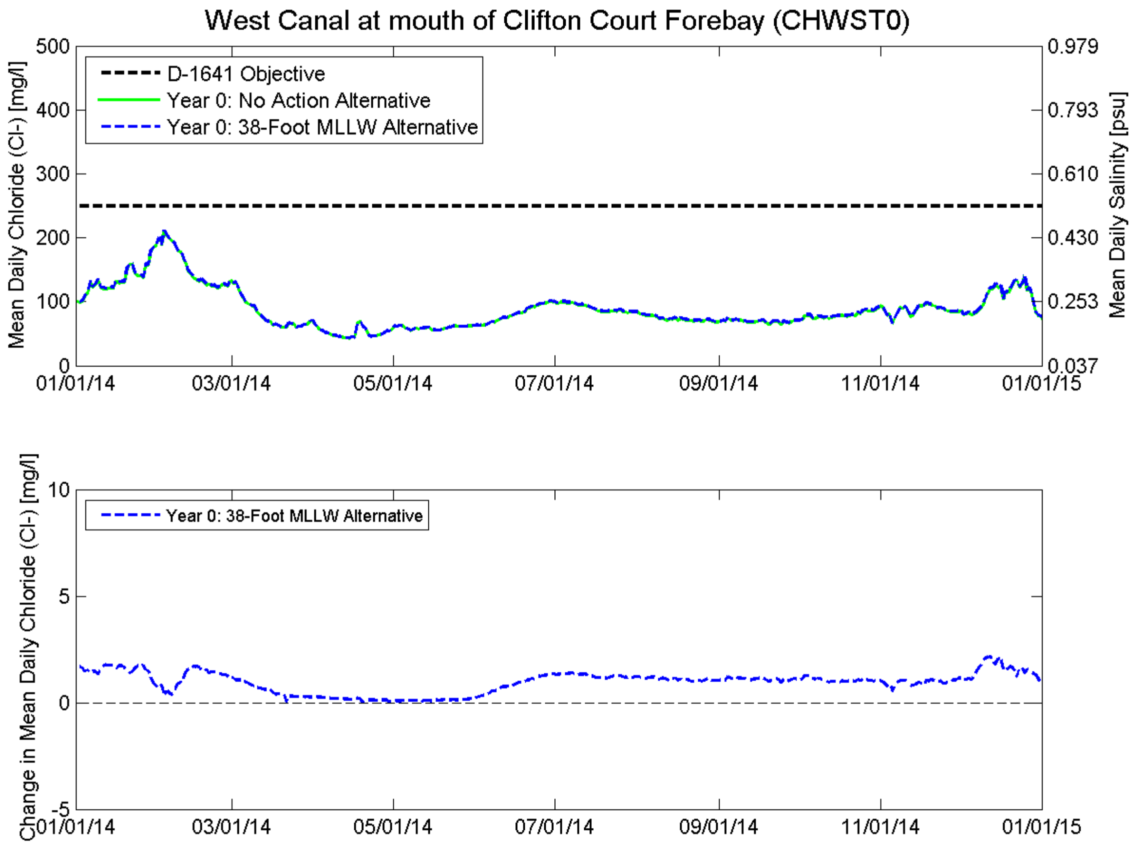


Figure 4.1-8

Predicted Mean Daily Cl- Concentration at the Entrance to Clifton Court Forebay (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl- Concentration at the Entrance to Clifton Court Forebay Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

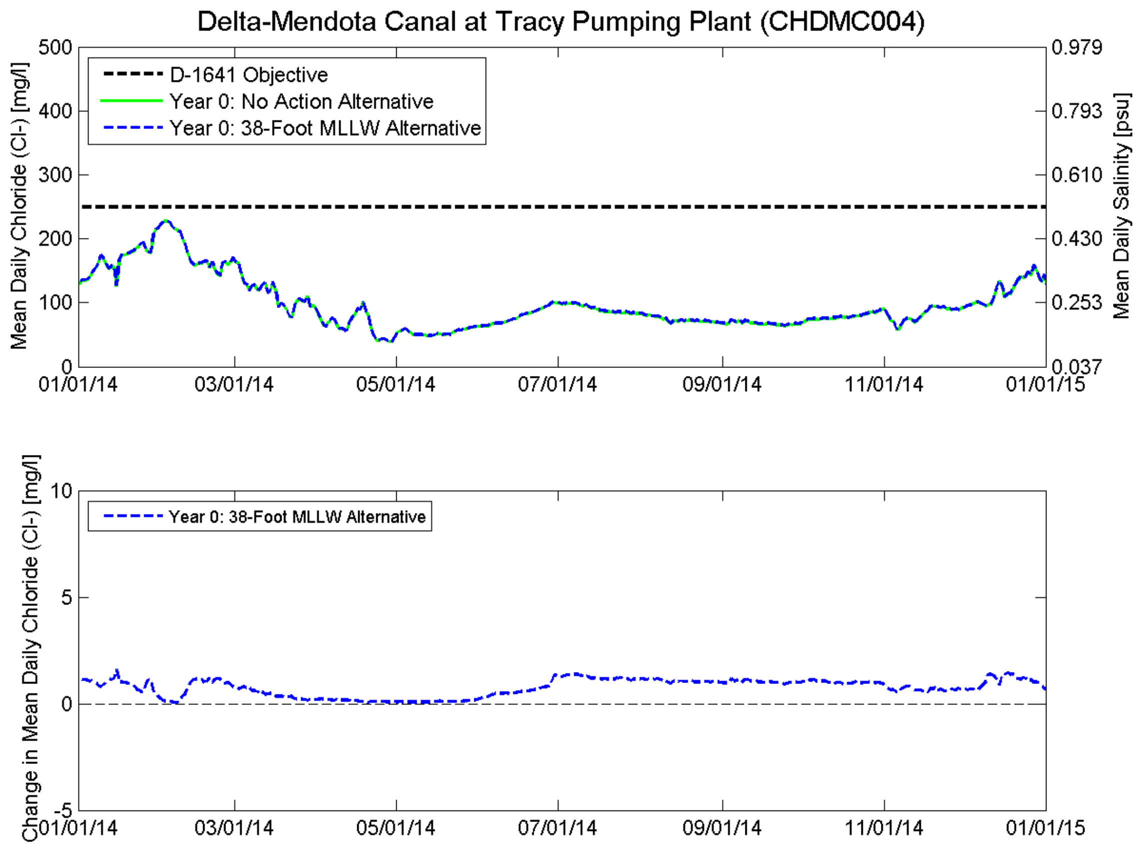


Figure 4.1-9

Predicted Mean Daily Cl- Concentration at the Tracy Pumping Plant (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl- Concentration at the Entrance to Tracy Pumping Plant Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

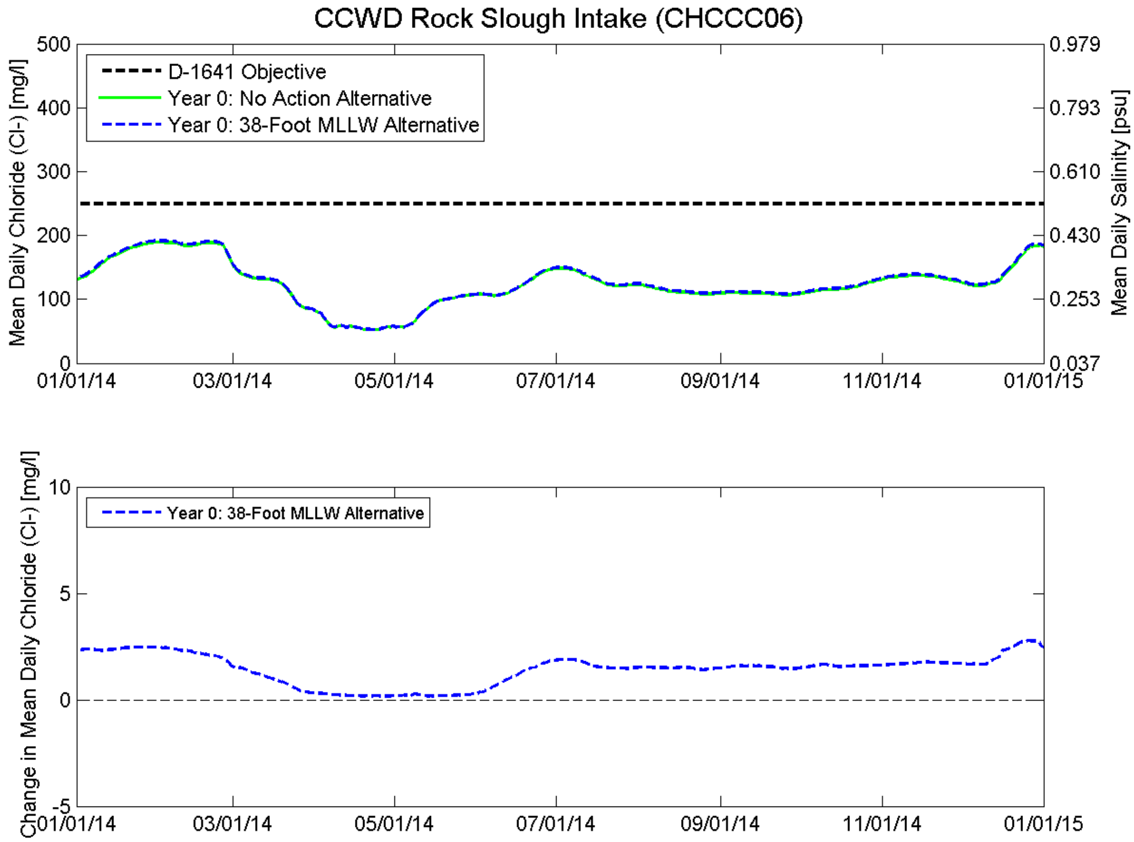


Figure 4.1-10

Predicted Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

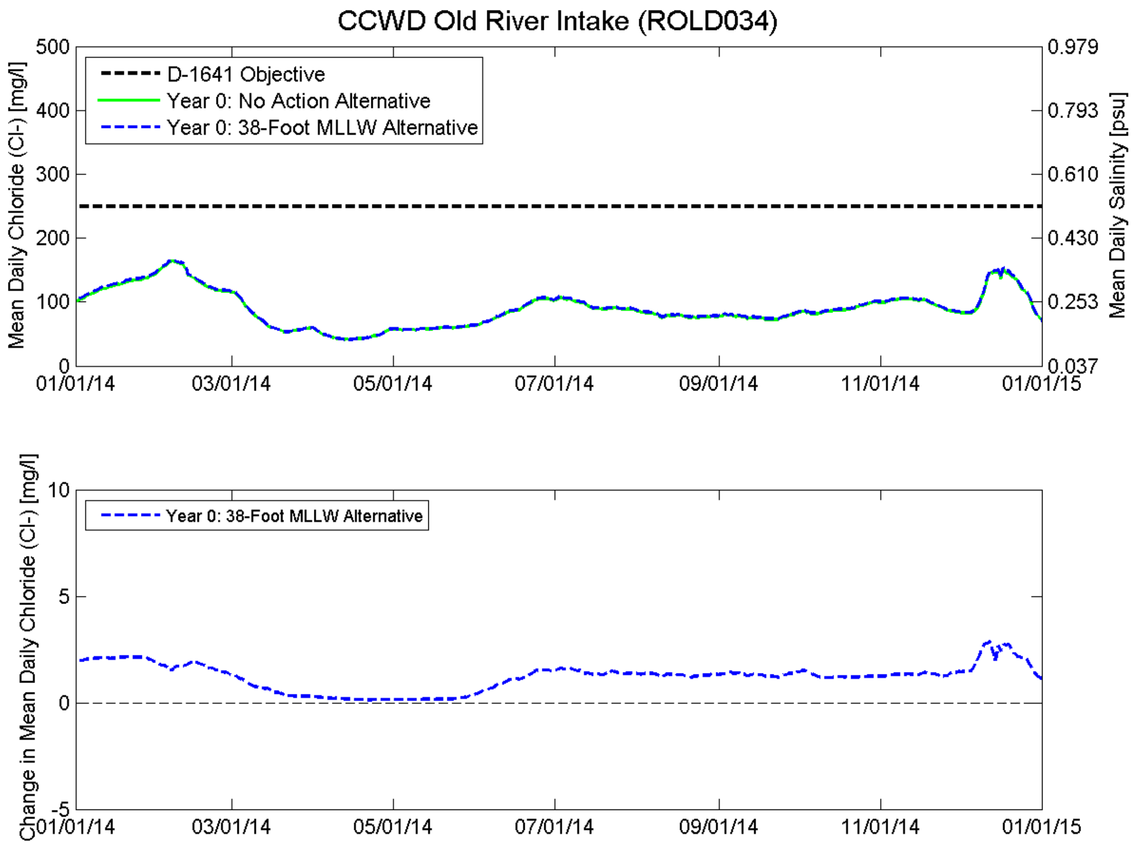


Figure 4.1-11

Predicted Mean Daily Cl⁻ Concentration at the CCWD Old River Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl⁻ Concentration at the CCWD Old River Intake Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

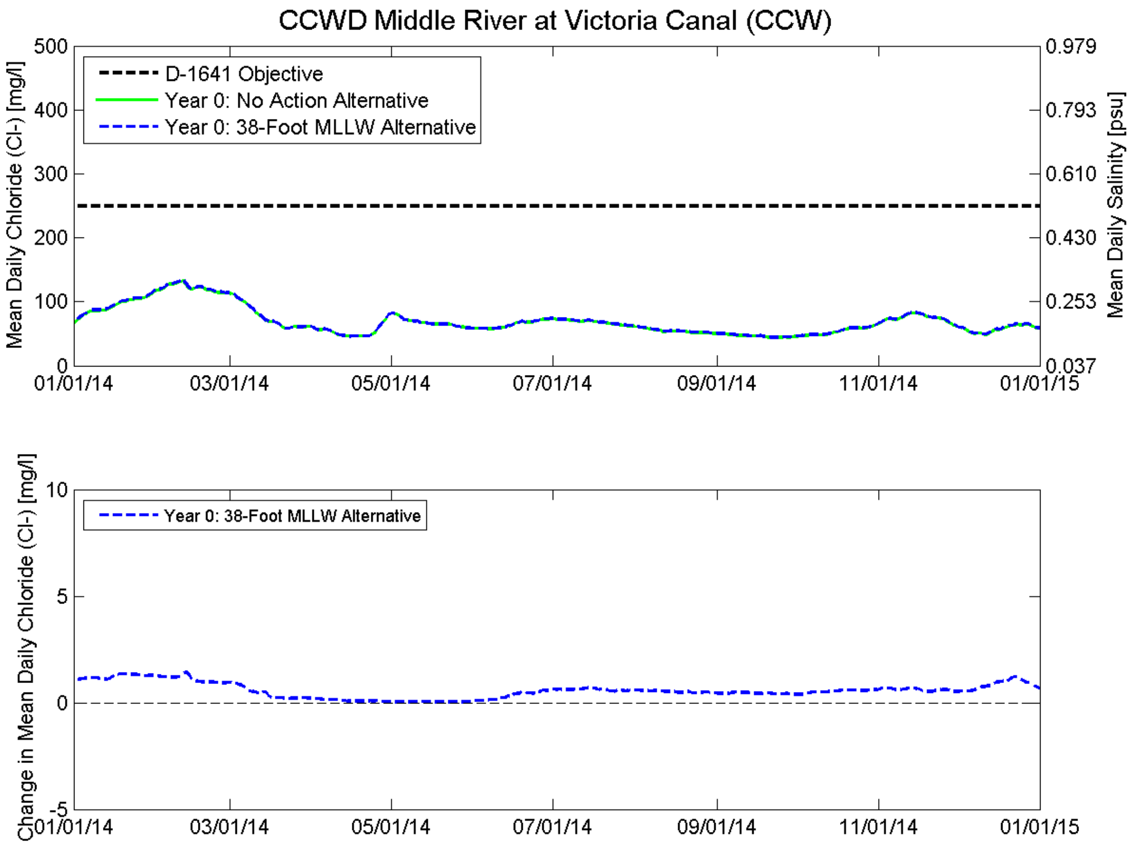


Figure 4.1-12

Predicted Mean Daily Cl⁻ Concentration at the CCWD Middle River at Victoria Canal Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl⁻ Concentration at the CCWD Middle River at Victoria Canal Intake Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

Table 4-4

Predicted Monthly Average Cl^- Concentration and Predicted Change in Cl^- Relative to the No Action Alternative for 37-Foot MLLW Alternative and 38-Foot MLLW Alternative at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Critical Water Year

Year 0 Critical Water Year (2014)	Baseline Conc. Cl^- (mg/L Cl^-)	37-Foot MLLW Alternative			38-Foot MLLW Alternative		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent	Conc. Cl^- (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent
West Canal at Mouth of Clifton Court Forebay (CHWST0)							
January	134.8	135.2	0.4	0.3	136.3	1.5	1.1
February	153.2	153.5	0.3	0.2	154.3	1.1	0.7
March	78.8	78.9	0.1	0.1	79.4	0.6	0.8
April	51.3	51.4	0.1	0.2	51.5	0.2	0.4
May	59.4	59.5	0.1	0.2	59.6	0.2	0.3
June	80.8	81.0	0.2	0.2	81.6	0.8	1.0
July	89.9	90.3	0.4	0.4	91.2	1.3	1.4
August	73.1	73.4	0.3	0.4	74.2	1.1	1.5
September	69.0	69.3	0.3	0.4	70.1	1.1	1.6
October	79.0	79.3	0.3	0.4	80.1	1.1	1.4
November	86.7	87.0	0.3	0.3	87.6	0.9	1.0
December	105.5	106.0	0.5	0.5	107.1	1.6	1.5
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)							
January	168.1	168.4	0.3	0.2	169.1	1.0	0.6
February	179.8	179.9	0.1	0.1	180.5	0.7	0.4
March	113.6	113.7	0.1	0.1	114.0	0.4	0.4
April	64.0	64.1	0.1	0.2	64.2	0.2	0.3
May	54.0	54.0	0.0	0.0	54.1	0.1	0.2
June	78.7	78.9	0.2	0.3	79.3	0.6	0.8
July	89.9	90.3	0.4	0.4	91.1	1.2	1.3
August	73.0	73.3	0.3	0.4	74.1	1.1	1.5
September	67.2	67.5	0.3	0.4	68.2	1.0	1.5
October	78.0	78.2	0.2	0.3	79.0	1.0	1.3
November	81.6	81.8	0.2	0.2	82.3	0.7	0.9
December	119.5	119.8	0.3	0.3	120.5	1.0	0.8

Year 0 Critical Water Year (2014)	Baseline Conc. Cl^- (mg/L Cl^-)	37-Foot MLLW Alternative			38-Foot MLLW Alternative		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent	Conc. Cl^- (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent
CCWD Rock Slough Intake (CHCCC06)							
January	166.4	166.9	0.5	0.3	168.8	2.4	1.4
February	184.7	185.3	0.6	0.3	186.9	2.2	1.2
March	119.7	120.0	0.3	0.3	120.7	1.0	0.8
April	58.7	58.8	0.1	0.2	59.0	0.3	0.5
May	86.6	86.7	0.1	0.1	86.8	0.2	0.2
June	121.6	122.0	0.4	0.3	122.8	1.2	1.0
July	132.4	132.9	0.5	0.4	134.1	1.7	1.3
August	112.9	113.3	0.4	0.4	114.4	1.5	1.3
September	109.0	109.4	0.4	0.4	110.5	1.5	1.4
October	118.1	118.6	0.5	0.4	119.7	1.6	1.4
November	134.2	134.8	0.6	0.4	136.0	1.8	1.3
December	145.6	146.3	0.7	0.5	147.8	2.2	1.5
CCWD Old River Intake (ROLD034)							
January	125.1	125.6	0.5	0.4	127.2	2.1	1.7
February	138.0	138.5	0.5	0.4	139.7	1.7	1.2
March	70.9	71.1	0.2	0.3	71.6	0.7	1.0
April	46.9	46.9	0.0	0.0	47.0	0.1	0.2
May	58.9	59.0	0.1	0.2	59.1	0.2	0.3
June	86.8	87.1	0.3	0.3	87.8	1.0	1.2
July	94.4	94.8	0.4	0.4	95.8	1.4	1.5
August	78.7	79.0	0.3	0.4	80.0	1.3	1.7
September	76.3	76.6	0.3	0.4	77.6	1.3	1.7
October	88.8	89.1	0.3	0.3	90.0	1.2	1.4
November	97.7	98.1	0.4	0.4	99.0	1.3	1.3
December	114.3	114.9	0.6	0.5	116.4	2.1	1.8

Year 0 Critical Water Year (2014)	Baseline Conc. Cl^- (mg/L Cl^-)	37-Foot MLLW Alternative			38-Foot MLLW Alternative		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent	Conc. Cl^- (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent
CCWD Middle River at Victoria Canal Intake (CCW)							
January	93.8	94.1	0.3	0.3	95.0	1.2	1.3
February	121.3	121.6	0.3	0.2	122.4	1.1	0.9
March	76.4	76.5	0.1	0.1	76.9	0.5	0.7
April	54.1	54.1	0.0	0.0	54.2	0.1	0.2
May	67.3	67.3	0.0	0.0	67.3	0.0	0.0
June	64.4	64.6	0.2	0.3	64.8	0.4	0.6
July	68.0	68.2	0.2	0.3	68.6	0.6	0.9
August	54.3	54.4	0.1	0.2	54.8	0.5	0.9
September	46.4	46.5	0.1	0.2	46.9	0.5	1.1
October	53.6	53.8	0.2	0.4	54.2	0.6	1.1
November	74.0	74.2	0.2	0.3	74.7	0.7	0.9
December	57.5	57.7	0.2	0.3	58.3	0.8	1.4

Notes:
CCWD = Contra Costa Water District
mg/L Cl^- = Concentration of chloride in milligrams per liter
MLLW = mean lower low water

4.2 Evaluation of Effects on Salinity and X2 During a Wet Water Year

This section presents the evaluation of the two preliminary alternatives, the 37-Foot MLLW Alternative and the 38-Foot MLLW Alternative, on salinity during and following a wet water year. The period evaluated is based on historical conditions between January 1, 2011, and December 31, 2011, as described in Section 3.3.2.

4.2.1 Evaluation of 37-Foot MLLW Alternative During a Wet Water Year

4.2.1.1 Effect of 37-Foot MLLW Alternative on X2

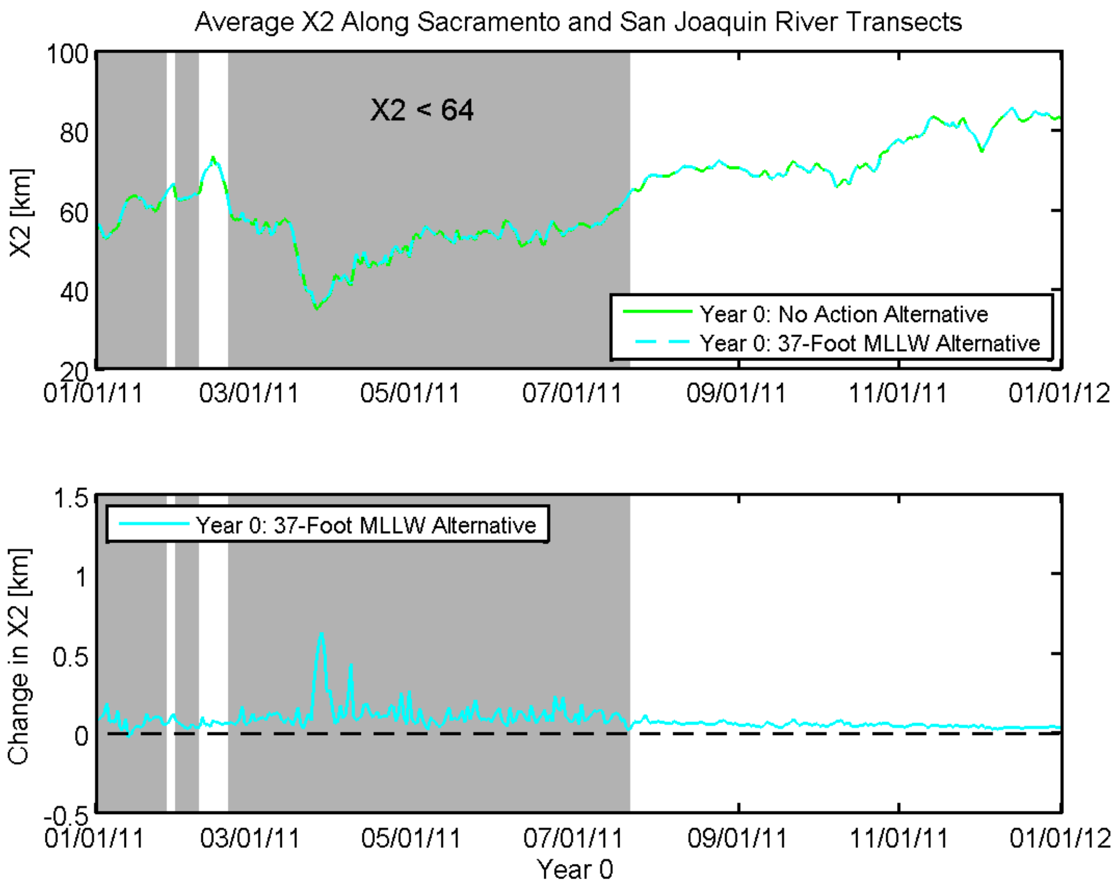
During 2011, X2 was relatively low throughout the year, with X2 remaining below 64 km for most of the first half of the year (Figure 4.2-1, top). For the 37-Foot MLLW Alternative, X2 was predicted to increase throughout the year relative to the baseline No Action Alternative (Figure 4.2-1, bottom), with a predicted annual-average increase of 0.08 km. During the period of the year when X2 was greater than 64 km, the predicted average increase in X2 resulting from the 37-Foot MLLW Alternative was 0.05 km (Table 4-5). The largest predicted increases in X2 occurred at the lowest values of X2, corresponding to the periods when the salinity gradients were pushed west into San Pablo Bay, resulting in stratification in the portions of the Pinole Shoal Channel that would be deepened under the 37-Foot MLLW Alternative.

The U.S. Fish and Wildlife Service (USFWS) BO released on December 15, 2008, includes Reasonable and Prudent Alternative (RPA) actions to protect threatened Delta Smelt. The RPA actions in the USFWS BO include limits on exports to control Old and Middle River (OMR) flows and managing the X2 position in the fall (Fall X2) through increasing Delta outflow when the preceding year was wetter than normal. The Fall X2 RPA stipulates that the average monthly position of X2 be maintained at 74 km for September, October, and November following a wet water year and that the average monthly position of X2 be maintained at 81 km for September, October, and November following an above normal water year. Based on the wet year simulated, the effect of the 37-Foot MLLW Alternative during the Fall X2 period following the wet water year of 2014 was predicted to be 0.05 km or less, which is smaller than the uncertainty associated with the current methods available for estimating X2 from field observations. MacWilliams et al. (2015) provide a detailed discussion of the uncertainty associated with the approaches commonly used to estimate X2.

Table 4-5
Predicted Change in X2 for 37-Foot MLLW Alternative and 38-Foot MLLW Alternative During a Wet Water Year

Alternative	Change in X2 (km)	
	Annual-Average	Change for X2 > 64
No Action Alternative	Baseline	Baseline
37-Foot MLLW Alternative	0.08	0.05
38-Foot MLLW Alternative	0.20	0.15

Notes:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2, so the average change for periods when X2 >64 is also shown separately.
km = kilometers
MLLW = Mean Lower Low Water



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 4.2-1
Predicted X2 for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in X2 Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Wet Water Year (Bottom)

4.2.1.2 Effect of 37-Foot MLLW Alternative on Water Quality at D-1641 Stations

The effect of the 37-Foot MLLW Alternative on the predicted Cl^- concentration at the five intake and export locations in the south Delta (locations shown in Figure 3.5-1) was evaluated to assess the potential effects on water quality at the municipal and industrial intakes at which D-1641 has established water quality criteria. Figures 4.2-2 through 4.2-6 show the mean daily Cl^- concentration for the No Action Alternative and the 37-Foot

MLLW Alternative and the predicted change in Cl^- concentration resulting from the 37-Foot MLLW Alternative during 2011. Table 4-6 summarizes the predicted annual-average change in Cl^- concentration and the maximum predicted monthly average change in Cl^- concentration at five intake and export locations. During the wet water year, the predicted annual-average change in Cl^- concentration was 0.0 mg/L at all five intake and export locations in the south Delta. The predicted maximum monthly average change ranged from 0.0 mg/L at the CCWD Middle River at Victoria Canal Intake and the West Canal at mouth of CCF to 0.2 mg/L at the CCWD Rock Slough Intake. The predicted monthly average change in Cl^- concentration during each month in 2011 for both the 37-Foot MLLW Alternative and the 38-Foot MLLW Alternative is included at the end of Section 4.2 in Table 4-8.

Table 4-6

Predicted Annual-Average and Maximum Monthly Average Change in Chloride Concentration Relative to the No Action Alternative for the 37-Foot MLLW Alternative at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Wet Water Year

Year 0 Wet Water Year (2011)	Change in Chloride Concentration (mg/L Cl^-)	
	Annual-Average Change	Max Monthly Average Change
West Canal at Mouth of Clifton Court Forebay (CHWST0)	0.0	0.0
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)	0.0	0.1
CCWD Rock Slough Intake (CHCCC06)	0.0	0.2
CCWD Old River Intake (ROLD034)	0.0	0.1
CCWD Middle River at Victoria Canal Intake (CCW)	0.0	0.0

Notes:
CCWD = Contra Costa Water District
mg/L Cl^- = Concentration of chloride in milligrams per liter

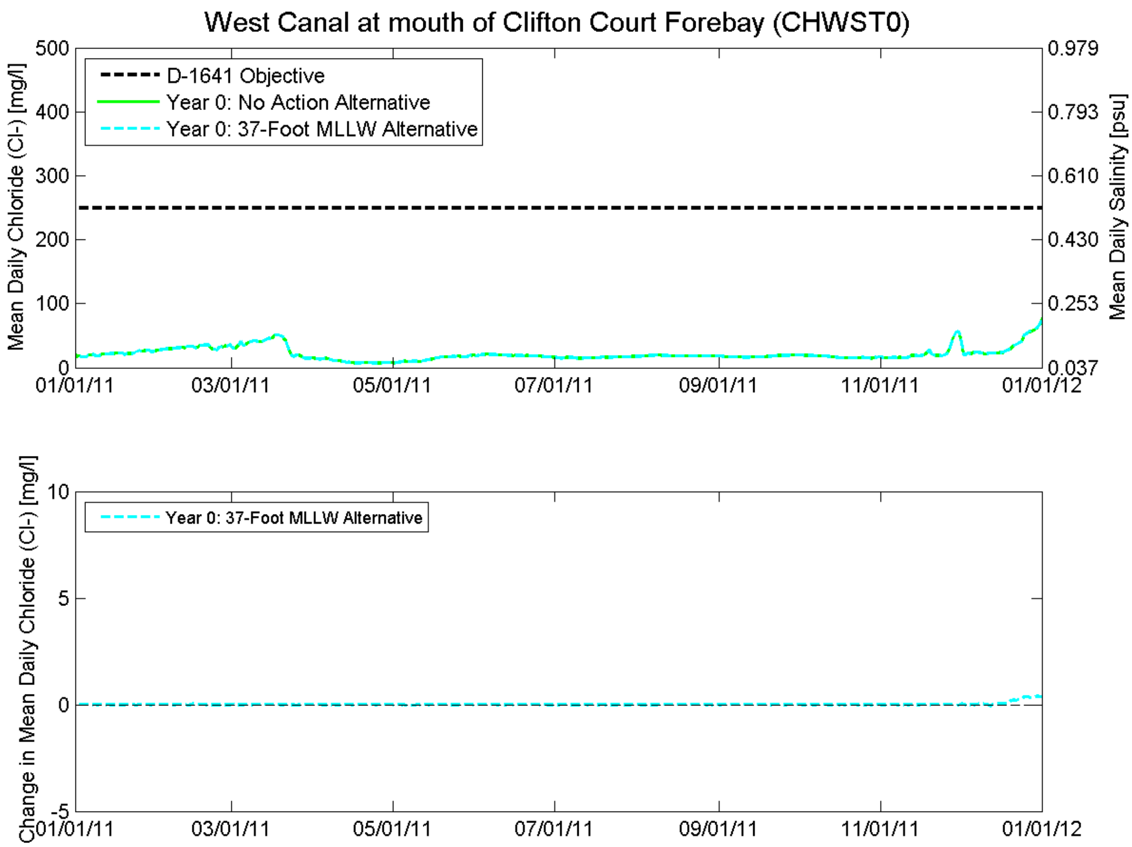


Figure 4.2-2

Predicted Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Wet Water Year (Bottom)

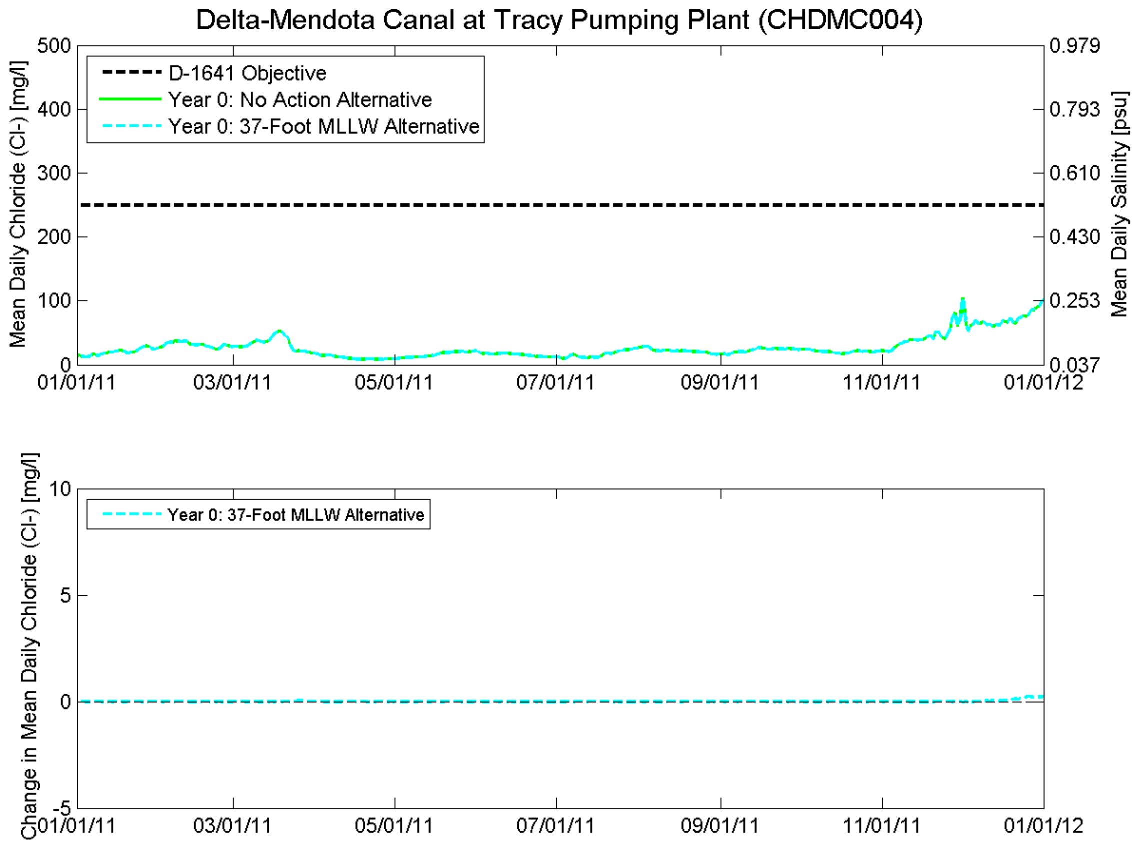


Figure 4.2-3

Predicted Mean Daily Cl^- Concentration at the Tracy Pumping Plant (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Tracy Pumping Plant Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Wet Water Year (Bottom)

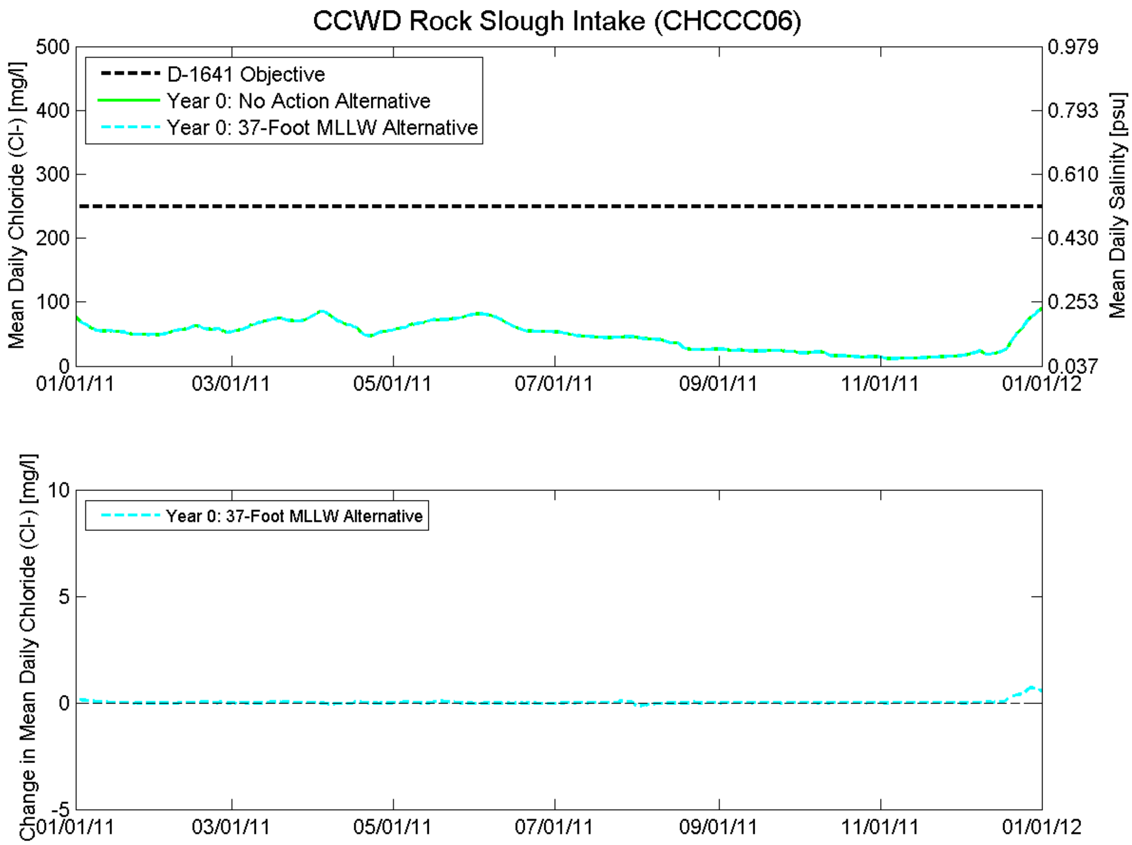


Figure 4.2-4

Predicted Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Wet Water Year (Bottom)

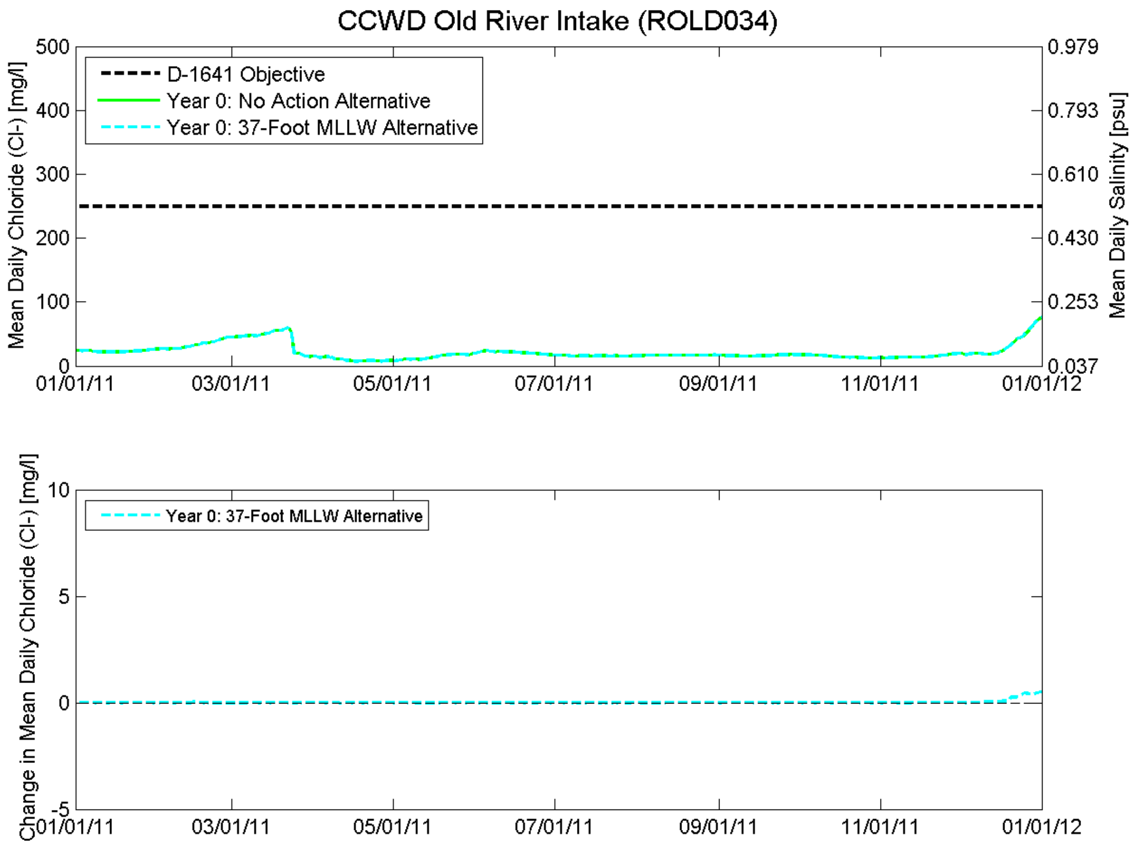


Figure 4.2-5

Predicted Mean Daily Cl$^-$ Concentration at the CCWD Old River Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl$^-$ Concentration at the CCWD Old River Intake Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Wet Water Year (Bottom)

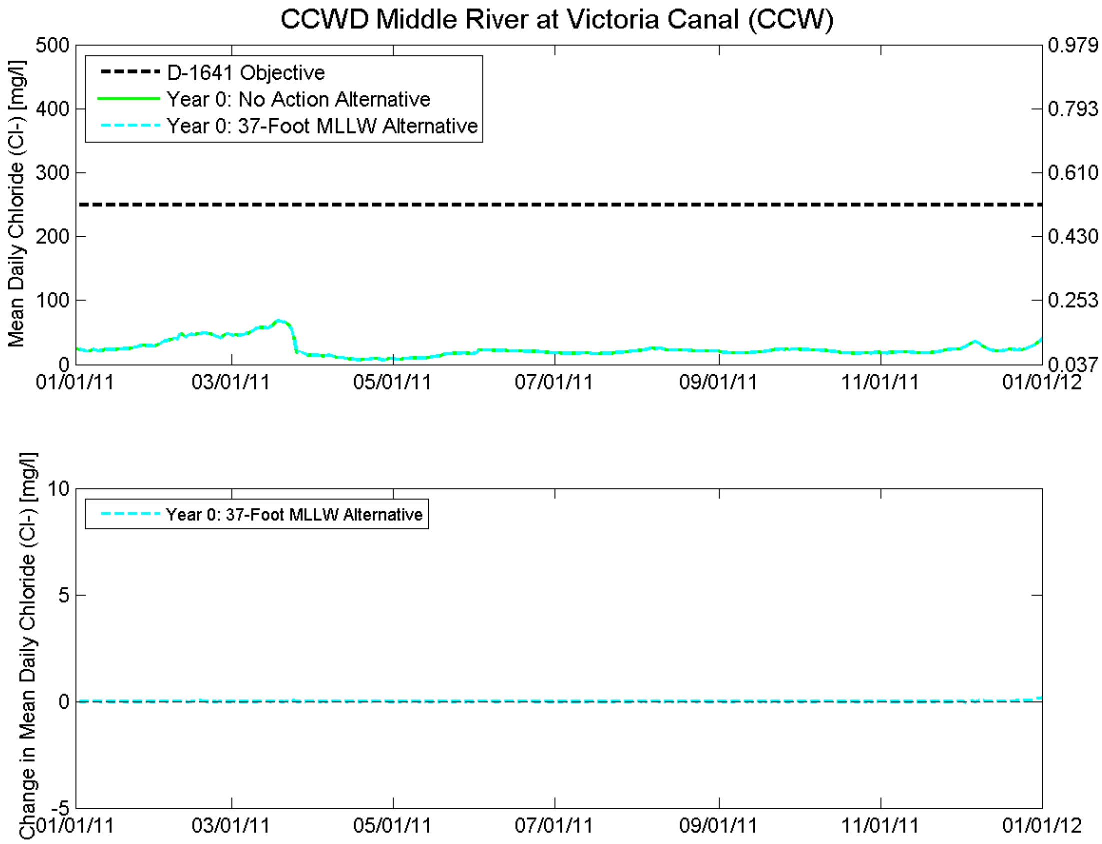


Figure 4.2-6

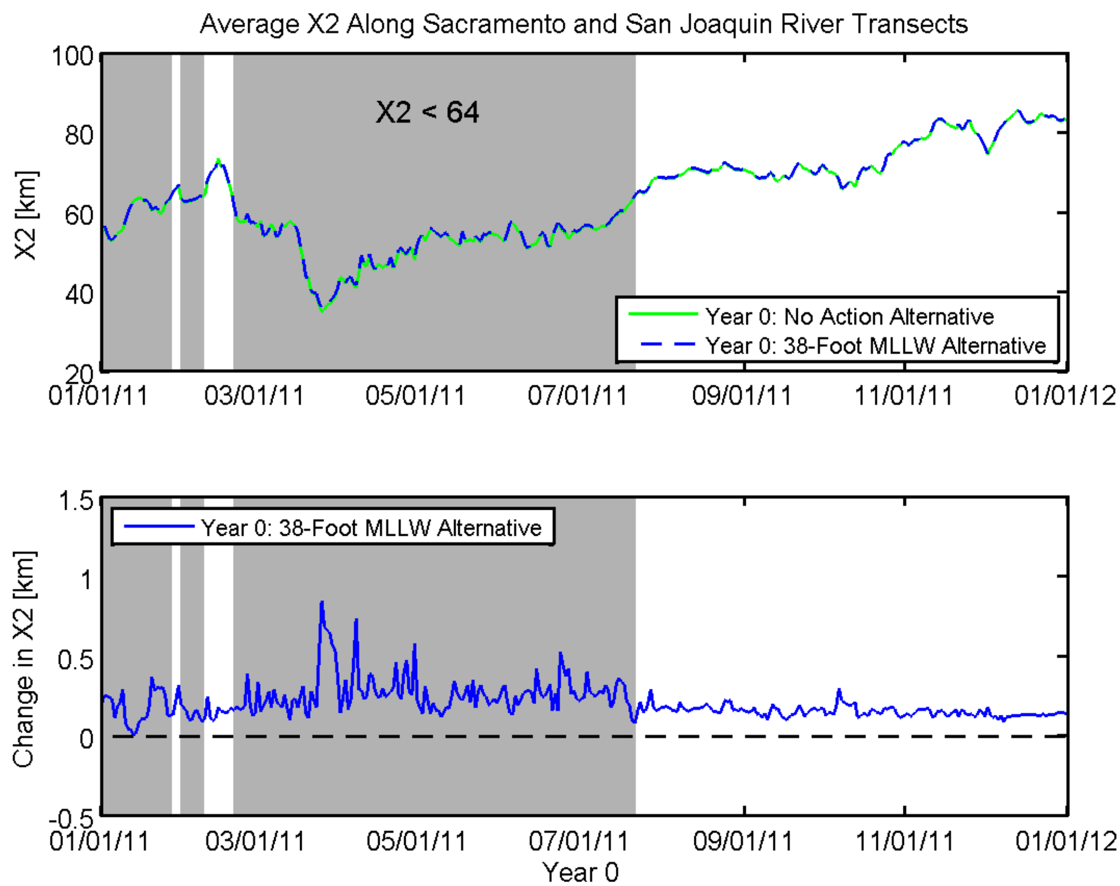
Predicted Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 37-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake Relative to the Year 0 No Action Alternative for the 37-Foot MLLW Alternative During a Wet Water Year (Bottom)

4.2.2 Evaluation of 38-Foot MLLW Alternative During a Wet Water Year

4.2.2.1 Effect of 38-Foot MLLW Alternative on X2

X2 was relatively low throughout 2011, remaining below 64 km for most of the first half of the year (Figure 4.2-7, top). For the 38-Foot MLLW Alternative, X2 was predicted to increase throughout the year (Figure 4.2-7, bottom), with a predicted annual-average increase of 0.20 km. During the period of the year when X2 was greater than 64 km, the predicted average increase in X2 resulting from the 38-Foot MLLW Alternative was 0.15 km (Table 4-5). The largest predicted increases in X2 occurred at the lowest values of X2, corresponding to the periods when the salinity gradients were pushed west into San Pablo Bay, resulting in stratification in the Pinole Shoal Channel.

The USFWS BO released on December 15, 2008, includes RPA actions to protect threatened Delta Smelt. The RPA actions in the USFWS BO include limits on exports to control OMR flows and managing Fall X2 through increasing Delta outflow when the preceding year was wetter than normal. The Fall X2 RPA stipulates that the average monthly position of X2 be maintained at 74 km for September, October, and November following a wet water year and that the average monthly position of X2 be maintained at 81 km for September, October, and November following an above normal water year. Based on the wet year simulated, the effect of the 38-Foot MLLW Alternative during the Fall X2 period following the wet water year of 2014 was predicted to be 0.15 km or less, which is smaller than the uncertainty associated with the current methods available for estimating X2 from field observations. MacWilliams et al. (2015) provide a detailed discussion of the uncertainty associated with the approaches commonly used to estimate X2.



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 4.2-7
Predicted X2 for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in X2 Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Wet Water Year (Bottom)

4.2.2.2 Effect of 38-Foot MLLW Alternative on Water Quality at D-1641 Stations

The effect of the 38-Foot MLLW Alternative on the predicted Cl^- concentration at the five intake and export locations in the south Delta (locations shown in Figure 3.5-1) was evaluated to assess the potential effects on water quality at the municipal and industrial intakes at which D-1641 has established water quality criteria. Figures 4.2-8 through 4.2-12 show the mean daily Cl^- concentration for the No Action Alternative and the 38-Foot

MLLW Alternative and the predicted change in Cl^- concentration resulting from the 38-Foot MLLW Alternative during 2011. Table 4-7 summarizes the predicted annual-average change in Cl^- concentration and the maximum predicted monthly average change in Cl^- concentration at five intake and export locations. During the wet water year, the predicted annual-average change in Cl^- concentration was 0.0 mg/L at four of the five intake and export locations in the south Delta, and the maximum predicted annual-average change was 0.1 mg/L at the CCWD Rock Slough Intake. The predicted maximum monthly average change ranged from 0.1 mg/L at the CCWD Middle River at Victoria Canal Intake to 0.8 mg/L at the CCWD Rock Slough Intake. The predicted monthly average change in Cl^- concentration during each month in 2011 for both the 37-Foot MLLW Alternative and the 38-Foot MLLW Alternative is included in Table 4-8.

Table 4-7

Predicted Annual-Average and Maximum Monthly Average Change in Chloride Concentration Relative to the No Action Alternative for the 38-Foot MLLW Alternative at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Wet Water Year

Year 0 Wet Water Year (2011)	Change in Chloride Concentration (mg/L Cl^-)	
	Annual-Average Change	Max Monthly Average Change
West Canal at Mouth of Clifton Court Forebay (CHWST0)	0.0	0.4
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)	0.0	0.3
CCWD Rock Slough Intake (CHCCC06)	0.1	0.8
CCWD Old River Intake (ROLD034)	0.0	0.3
CCWD Middle River at Victoria Canal Intake (CCW)	0.0	0.1

Notes:
CCWD = Contra Costa Water District
mg/L Cl- = Concentration of chloride in milligrams per liter

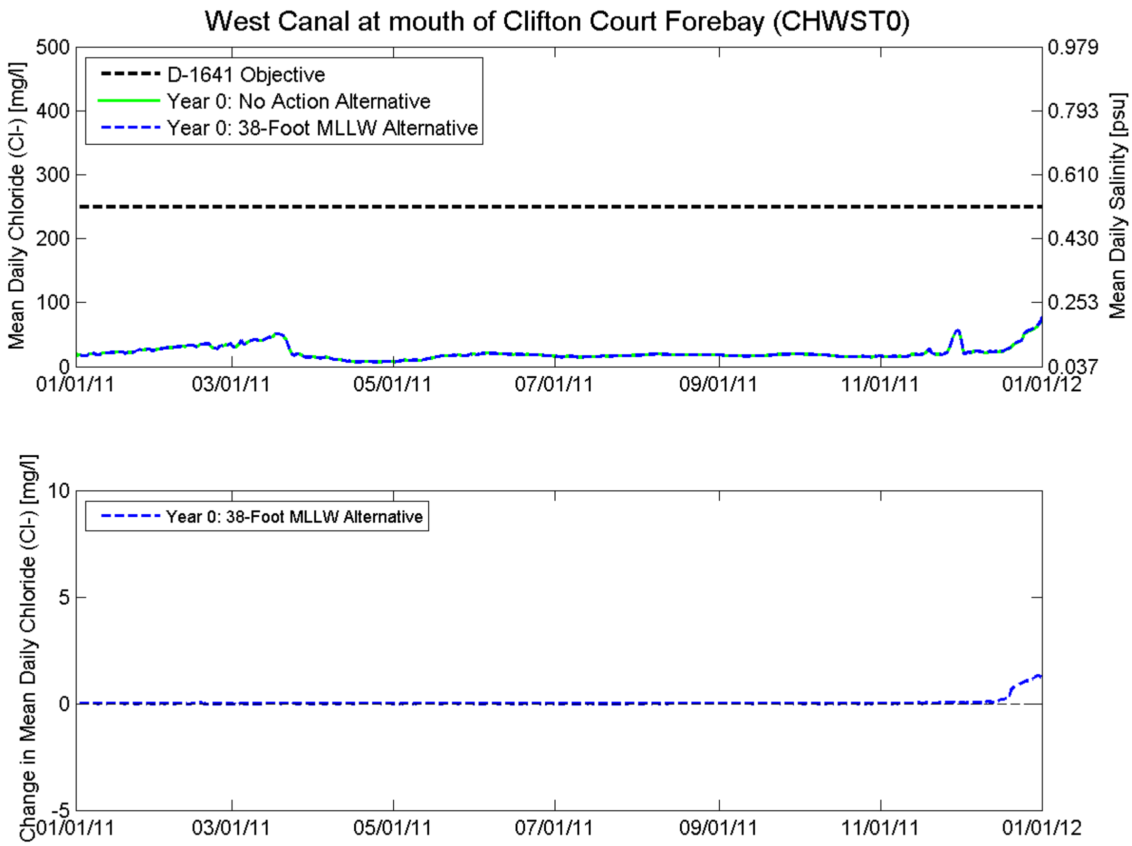


Figure 4.2-8

Predicted Mean Daily Cl⁻ Concentration at the Entrance to Clifton Court Forebay (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl⁻ Concentration at the Entrance to Clifton Court Forebay Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Wet Water Year (Bottom)

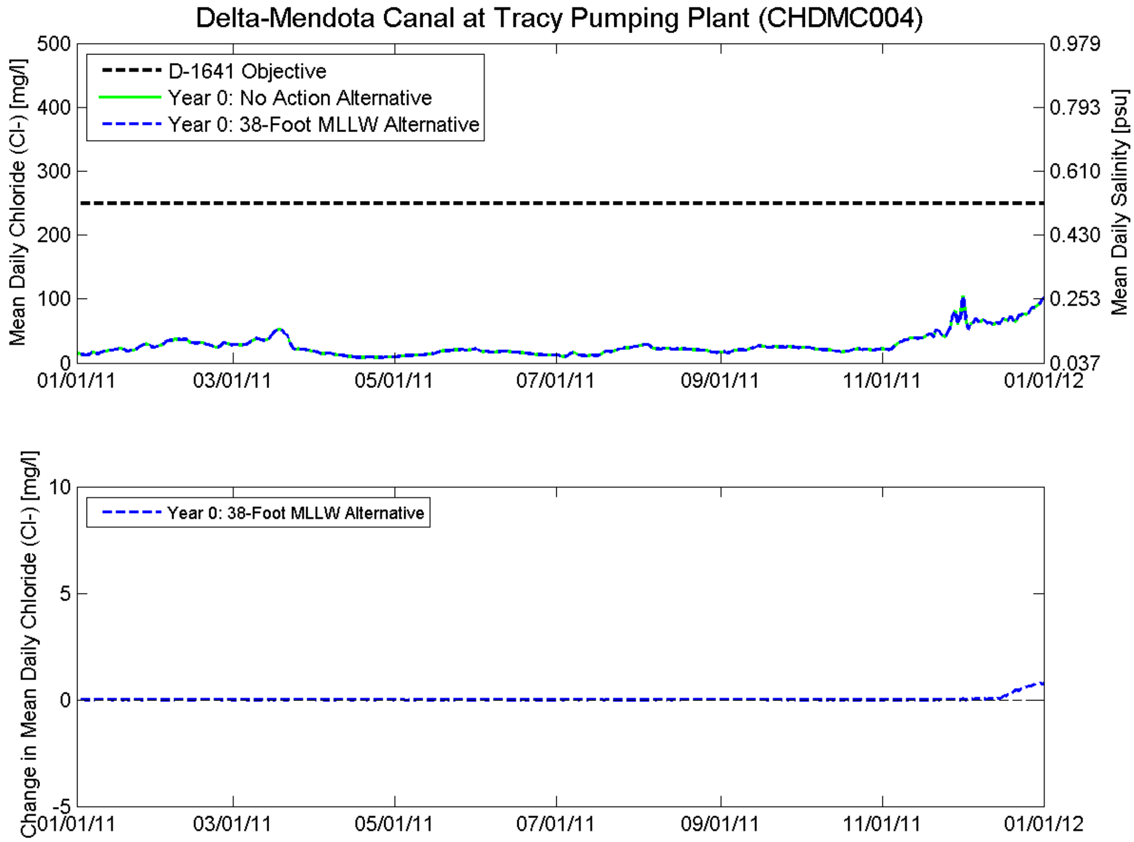


Figure 4.2-9

Predicted Mean Daily Cl^- Concentration at the Tracy Pumping Plant (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Tracy Pumping Plant Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Wet Water Year (Bottom)

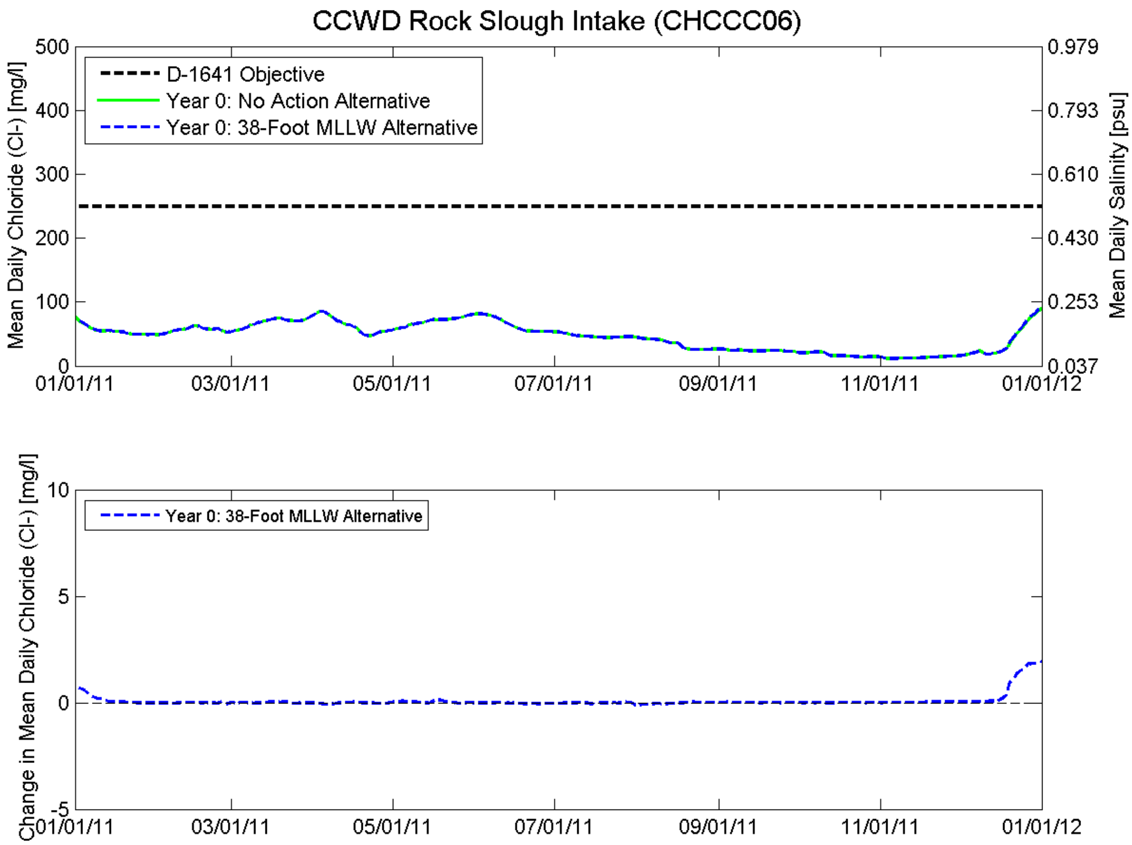


Figure 4.2-10

Predicted Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Wet Water Year (Bottom)

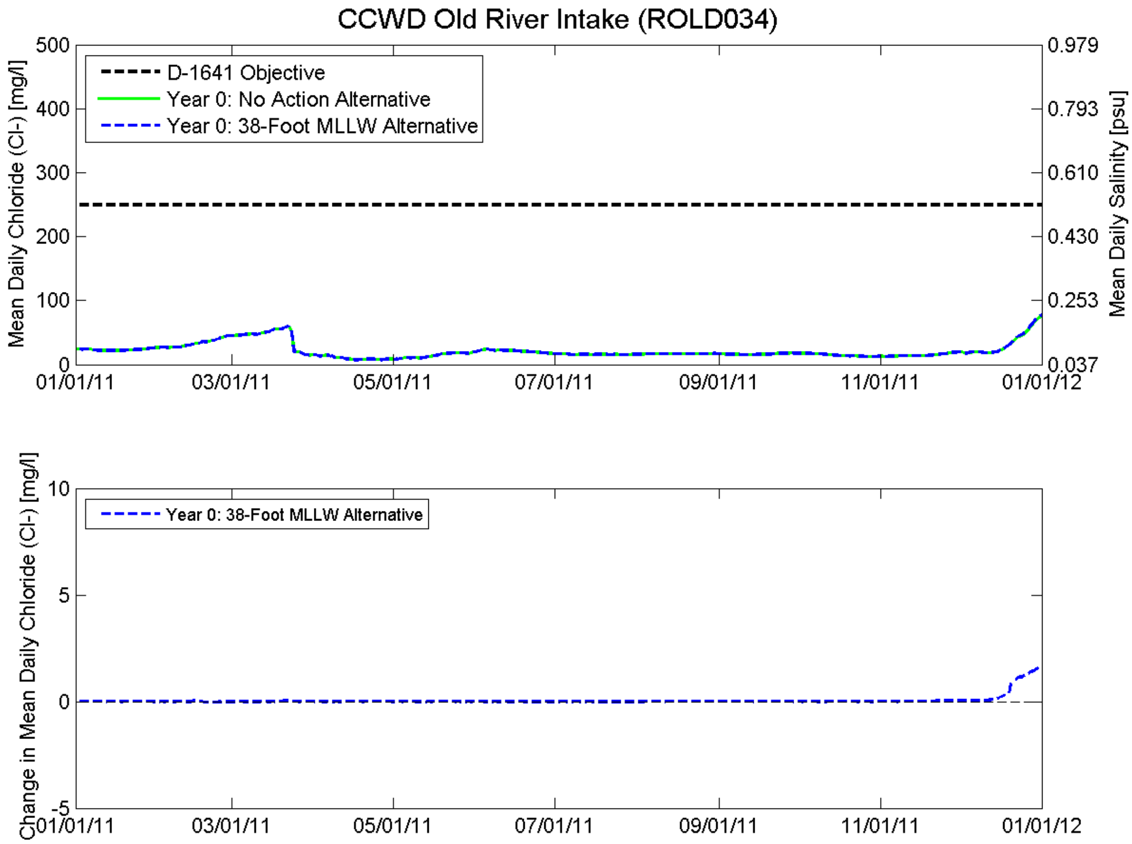


Figure 4.2-11

Predicted Mean Daily Cl^- Concentration at the CCWD Old River Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Old River Intake Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Wet Water Year (Bottom)

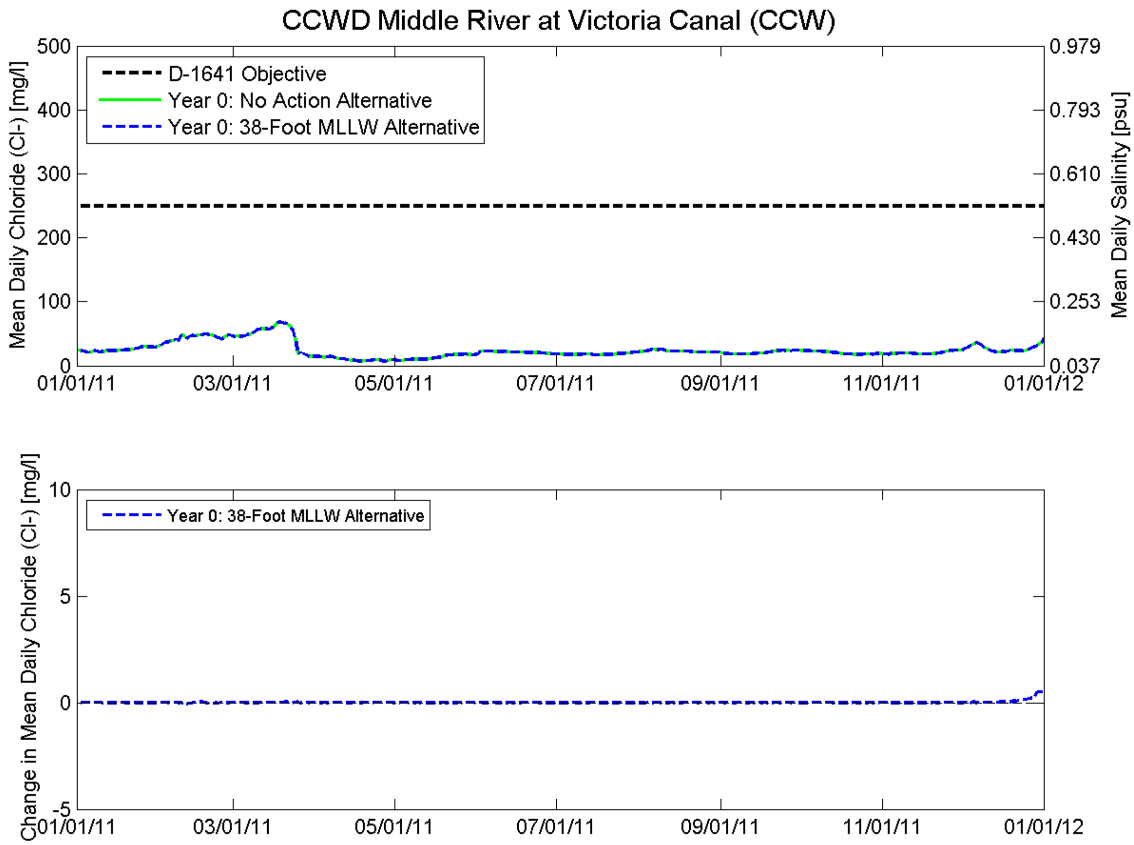


Figure 4.2-12

Predicted Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the 38-Foot MLLW Alternative During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Wet Water Year (Bottom)

Table 4-8

Predicted Monthly Average Cl^- Concentration and Predicted Change in Cl^- Relative to the No Action Alternative for 37-Foot MLLW Alternative and 38-Foot MLLW Alternative at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Wet Water Year

Year 0 Wet Water Year (2011)	Baseline Conc. Cl^- (mg/L Cl^-)	37-Foot MLLW Alternative			38-Foot MLLW Alternative		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent	Conc. Cl (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent
West Canal at Mouth of Clifton Court Forebay (CHWST0)							
January	21.8	21.8	0.0	0.0	21.8	0.0	0.0
February	31.0	31.0	0.0	0.0	31.0	0.0	0.0
March	30.5	30.5	0.0	0.0	30.5	0.0	0.0
April	9.4	9.4	0.0	0.0	9.4	0.0	0.0
May	13.6	13.6	0.0	0.0	13.6	0.0	0.0
June	18.8	18.8	0.0	0.0	18.8	0.0	0.0
July	16.0	15.9	-0.1	-0.6	15.9	-0.1	-0.6
August	18.4	18.4	0.0	0.0	18.4	0.0	0.0
September	17.6	17.6	0.0	0.0	17.6	0.0	0.0
October	16.8	16.8	0.0	0.0	16.8	0.0	0.0
November	21.0	21.0	0.0	0.0	21.0	0.0	0.0
December	30.1	30.1	0.0	0.0	30.5	0.4	1.3
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)							
January	20.0	20.0	0.0	0.0	20.0	0.0	0.0
February	30.1	30.1	0.0	0.0	30.1	0.0	0.0
March	30.0	30.0	0.0	0.0	30.0	0.0	0.0
April	11.0	11.0	0.0	0.0	11.0	0.0	0.0
May	15.9	15.9	0.0	0.0	15.9	0.0	0.0
June	15.7	15.7	0.0	0.0	15.7	0.0	0.0
July	16.2	16.2	0.0	0.0	16.2	0.0	0.0
August	21.7	21.7	0.0	0.0	21.7	0.0	0.0
September	22.6	22.6	0.0	0.0	22.6	0.0	0.0
October	20.9	20.9	0.0	0.0	20.9	0.0	0.0
November	40.5	40.5	0.0	0.0	40.5	0.0	0.0
December	71.8	71.9	0.1	0.1	72.1	0.3	0.4

Year 0 Wet Water Year (2011)	Baseline Conc. Cl^- (mg/L Cl^-)	37-Foot MLLW Alternative			38-Foot MLLW Alternative		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^-		Conc. Cl (mg/L Cl^-)	Change in Cl^-	
			(mg/L Cl^-)	Percent		(mg/L Cl^-)	Percent
CCWD Rock Slough Intake (CHCCC06)							
January	55.2	55.2	0.0	0.0	55.3	0.1	0.2
February	56.2	56.2	0.0	0.0	56.2	0.0	0.0
March	68.2	68.2	0.0	0.0	68.2	0.0	0.0
April	63.7	63.7	0.0	0.0	63.6	-0.1	-0.2
May	69.9	69.9	0.0	0.0	69.9	0.0	0.0
June	64.8	64.7	-0.1	-0.2	64.7	-0.1	-0.2
July	47.0	47.0	0.0	0.0	47.0	0.0	0.0
August	32.0	32.0	0.0	0.0	32.0	0.0	0.0
September	24.0	24.0	0.0	0.0	24.0	0.0	0.0
October	17.2	17.2	0.0	0.0	17.2	0.0	0.0
November	13.2	13.2	0.0	0.0	13.2	0.0	0.0
December	33.1	33.3	0.2	0.6	33.9	0.8	2.4
CCWD Old River Intake (ROLD034)							
January	23.3	23.3	0.0	0.0	23.3	0.0	0.0
February	32.3	32.3	0.0	0.0	32.3	0.0	0.0
March	39.0	39.0	0.0	0.0	39.0	0.0	0.0
April	9.9	9.9	0.0	0.0	9.9	0.0	0.0
May	13.9	13.9	0.0	0.0	13.9	0.0	0.0
June	20.8	20.8	0.0	0.0	20.8	0.0	0.0
July	15.9	15.9	0.0	0.0	15.9	0.0	0.0
August	16.7	16.7	0.0	0.0	16.7	0.0	0.0
September	16.3	16.3	0.0	0.0	16.3	0.0	0.0
October	14.7	14.7	0.0	0.0	14.7	0.0	0.0
November	14.8	14.8	0.0	0.0	14.8	0.0	0.0
December	28.9	29.0	0.1	0.3	29.2	0.3	1.0

Year 0 Wet Water Year (2011)	Baseline Conc. Cl^- (mg/L Cl^-)	37-Foot MLLW Alternative			38-Foot MLLW Alternative		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^-		Conc. Cl (mg/L Cl^-)	Change in Cl^-	
			(mg/L Cl^-)	Percent		(mg/L Cl^-)	Percent
CCWD Middle River at Victoria Canal Intake (CCW)							
January	24.9	24.9	0.0	0.0	24.9	0.0	0.0
February	43.7	43.7	0.0	0.0	43.7	0.0	0.0
March	44.1	44.1	0.0	0.0	44.1	0.0	0.0
April	10.0	10.0	0.0	0.0	10.0	0.0	0.0
May	13.0	13.0	0.0	0.0	13.0	0.0	0.0
June	20.9	20.9	0.0	0.0	20.9	0.0	0.0
July	18.2	18.2	0.0	0.0	18.2	0.0	0.0
August	22.6	22.6	0.0	0.0	22.6	0.0	0.0
September	20.7	20.7	0.0	0.0	20.7	0.0	0.0
October	20.1	20.1	0.0	0.0	20.1	0.0	0.0
November	20.0	20.0	0.0	0.0	20.0	0.0	0.0
December	26.4	26.4	0.0	0.0	26.5	0.1	0.4

Notes:
CCWD = Contra Costa Water District
mg/L Cl^- = Concentration of chloride in milligrams per liter

5 EVALUATION OF TSP DURING A CRITICAL, BELOW NORMAL, AND WET WATER YEAR

5.1 Model Assumptions for TSP Scenarios

The model assumptions for evaluation of the TSP were identical to those used to evaluate the preliminary alternatives presented in Section 4. The only difference between the TSP and the 38-Foot MLLW Alternative is the adjustment of the bathymetry to account for the removal of the small rock outcrop at the western end of the Pinole Shoal Channel and the additional 4 feet of deepening of the sediment trap at Bulls Head Shoal, as discussed in Section 3.2.4.

5.2 Evaluation of Effects of TSP on Salinity and X2 During a Critical Water Year

This section presents the evaluation of the effects on the TSP on salinity during and following a critical water year. The period evaluated is based on historical conditions between January 1, 2014, and December 31, 2014, as described in Section 3.3.1.

5.2.1 Effect of TSP on X2 During a Critical Water Year

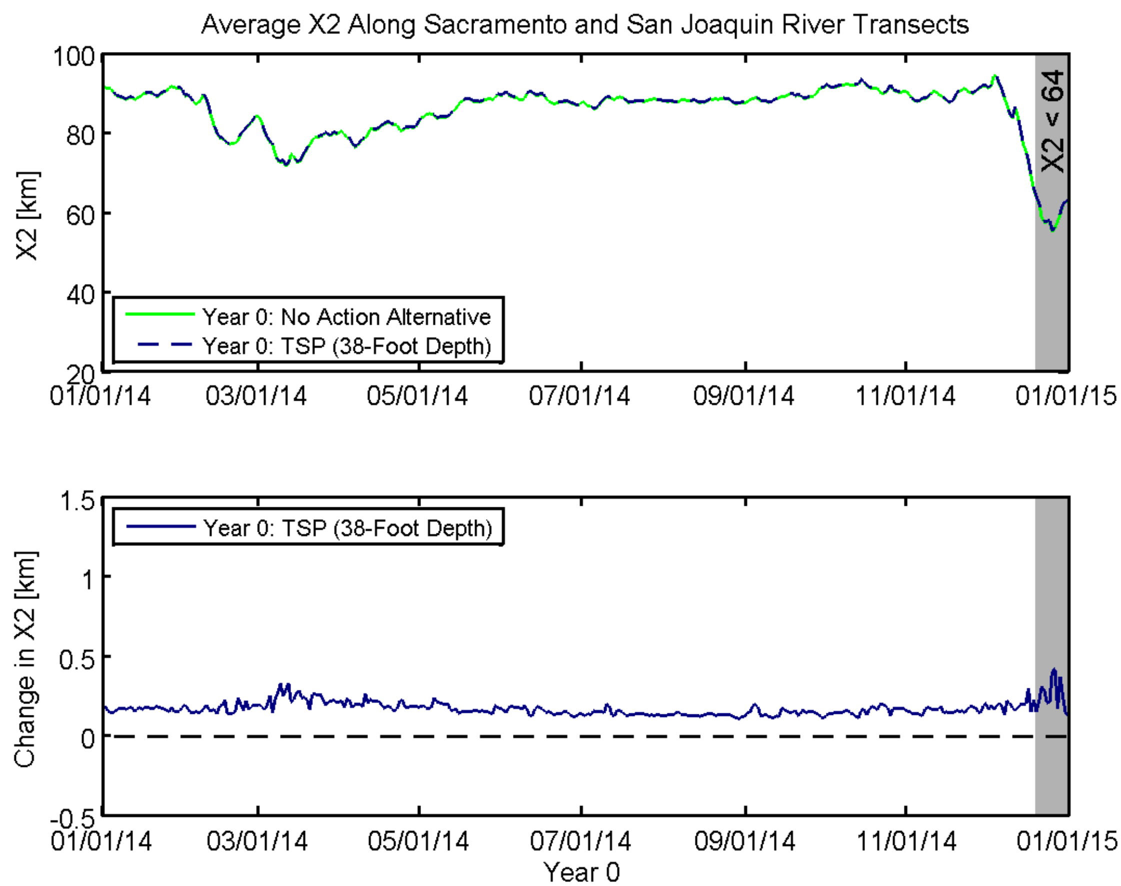
X2 remained elevated throughout 2014 (Figure 5.2-1, top), remaining above 70 km through the first 11 months of the year and dropping below 64 km only in December due to higher outflows (See Figure 3.3-1). For the TSP, X2 was predicted to increase throughout the year relative to the baseline No Action Alternative (Figure 5.2-1, bottom), with a predicted annual-average increase of 0.17 km. Similarly, during the period of the year when X2 was greater than 64 km, the predicted average increase in X2 resulting from the TSP was 0.17 km (Table 5-1). Because the primary difference between the 38-Foot MLLW Alternative and the TSP is the inclusion of the sediment trap at Bulls Head Shoal which results in more deepening of the Suisun Bay Channel under the TSP (Figure 3.2-6) than under the 38-Foot MLLW Alternative (Figure 3.2-4). The larger increase in X2 for the TSP relative to the 38-Foot MLLW Alternative (Table 4-1; Figure 4.1-1) during the critical water year can be attributed to the additional deepening of the Suisun Bay Channel for the sediment trap.

Table 5-1

Predicted Change in X2 for the TSP During a Critical Water Year

Alternative	Change in X2 (km)	
	Annual-Average	Change for X2 > 64
No Action Alternative	Baseline	Baseline
TSP (38-Foot Depth)	0.17	0.17

Notes:
When X2 is less than 64 km there are no current regulatory requirements that regulate the position of X2, so the average change for periods when X2 >64 is also shown separately.
km = kilometers
TSP = Tentatively Selected Plan



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 5.2-1
Predicted X2 for the Year 0 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in X2 Relative to the Year 0 No Action Alternative for the TSP During a Critical Water Year (Bottom)

5.2.2 Effect of TSP on Water Quality at D-1641 Stations During a Critical Water Year

The effect of the TSP on the predicted Cl^- concentration at the five intake and export locations in the south Delta (locations shown in Figure 3.5-1) was evaluated to assess the potential effects on water quality at the municipal and industrial intakes at which D-1641 has established water quality criteria. Figures 5.2-2 through 5.2-6 show the mean daily Cl^-

concentration for the No Action Alternative and the TSP and the predicted change in Cl^- concentration resulting from the TSP during 2014. Table 5-2 summarizes the predicted annual-average change in Cl^- concentration and the maximum predicted monthly average change in Cl^- concentration at five intake and export locations. During the critical water year, the predicted annual-average change in Cl^- concentration ranged from 0.9 mg/L at the CCWD Middle River at Victoria Canal Intake to 2.2 mg/L at the CCWD Rock Slough Intake. The predicted maximum monthly average change ranged from 1.8 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.6 mg/L at the CCWD Rock Slough Intake. The predicted monthly average change in Cl^- concentration during each month in 2014 for the TSP is included in Table 5-3.

Figure 5.2-7 shows the number of days that the maximum mean daily concentration of Cl^- is less than 150 mg/l at CHCCC06 and RSAN007. To meet the critical water year water quality objective, the number of days that mean daily concentration of Cl^- is less than 150 mg/l should exceed 155 days at either CHCCC06 or RSAN007. At CHCCC06, the mean daily concentration of Cl- is less than 150 mg/l for 301 days under the Year 0 No Action Alternative and 293 days for the Year 0 TSP scenario (a decrease of 8 days relative to the Year 0 No Action Alternative). At RSAN007, the mean daily concentration of Cl^- is less than 150 mg/l for 22 days under the Year 0 No Action Alternative and 22 days for the Year 0 TSP scenario (no change relative to the Year 0 No Action Alternative). Because this standard stipulates that daily mean chloride concentration must be less than 150 mg/l for at least 155 days during a critical water year at either at Contra Costa Canal at Pumping Plant #1 or at the Antioch Water Works intake, this standard is met for both the Year 0 No Action Alternative and the Year 0 TSP scenario because this water quality standard is met at CHCCC06 under both scenarios for the critical water year evaluated.

The D-1641 water quality objectives for agricultural beneficial uses in the Western Delta, shown in Table 3-2, are based on the maximum 14-day running average electrical conductivity. The western Delta water quality objectives for agricultural beneficial use depend on water year type on the Sacramento River and apply only from April 1 to August 15. Water year 2014 (from October 1, 2013, through September 30, 2014) was classified as a critical water year. Because the April 1 through August 15 period falls within water year 2014, the critical year water quality objectives shown in Table 3-2 are applied for the western Delta stations.

Figure 5.2-8 shows the predicted 14-day running average electrical conductivity on the Sacramento River at Emmaton for the Year 0 No Action Alternative and the Year 0 TSP scenario. Small increases in 14-day running average electrical conductivity under the Year 0 TSP scenario are predicted between May and December. The water quality objectives for agricultural beneficial use apply from April 1 through August 15. However, in 2014 the State Water Resources Control Board (SWRCB) issued an Order that Approved a Temporary Urgency Change in License and Permit Terms and Conditions Requiring Compliance (TUCP) with the Delta Water Quality Objectives in Response to Drought Conditions. Under this order, the D-1641 water quality objective was not required to be met in at Emmaton during 2014 when the TUCP was in effect. As seen in Figure 5.2-8, the water quality objective of maximum 14-day running average electrical conductivity on the Sacramento River at Emmaton was exceeded under both the No Action Alternative and the TSP scenario. However, under the TUCP, this water quality objective was not required to be met during this period. Relative to the No Action Alternative, the TSP resulted in 1 additional day in July and 1 additional day in August that the D-1641 water quality objective was exceeded relative to the No Action Alternative, indicating that the effect of the TSP would have a very small effect on electrical conductivity at this location even under drought conditions in 2014 during the critical water year evaluated.

Figure 5.2-9 shows the predicted 14-day running average electrical conductivity on the San Joaquin River at Jersey Point for the Year 0 No Action Alternative and the Year 0 TSP scenario. Small increases in 14-day running average electrical conductivity under the Year 0 TSP scenario are predicted between May and November. The water quality objectives for agricultural beneficial use apply from April 1 through August 15. The water quality objective of maximum 14-day running average electrical conductivity on the San Joaquin River at Jersey Point was not predicted to be exceeded under the Year 0 No Action Alternative or the Year 0 TSP scenario during the critical water year evaluated.

Table 5-2

Predicted Annual-Average and Maximum Monthly Average Change in Chloride Concentration Relative to the No Action Alternative for the TSP at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Critical Water Year

Year 0 Critical Water Year (2014)	Change in Chloride Concentration (mg/L Cl^-)	
	Annual-Average Change	Max Monthly Average Change
West Canal at mouth of Clifton Court Forebay (CHWST0)	1.5	2.5
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)	1.1	1.8
CCWD Rock Slough Intake (CHCCC06)	2.2	3.6
CCWD Old River Intake (ROLD034)	1.9	3.3
CCWD Middle River at Victoria Canal Intake (CCW)	0.9	1.8

Notes:
CCWD = Contra Costa Water District
mg/L Cl- = Concentration of chloride in milligrams per liter

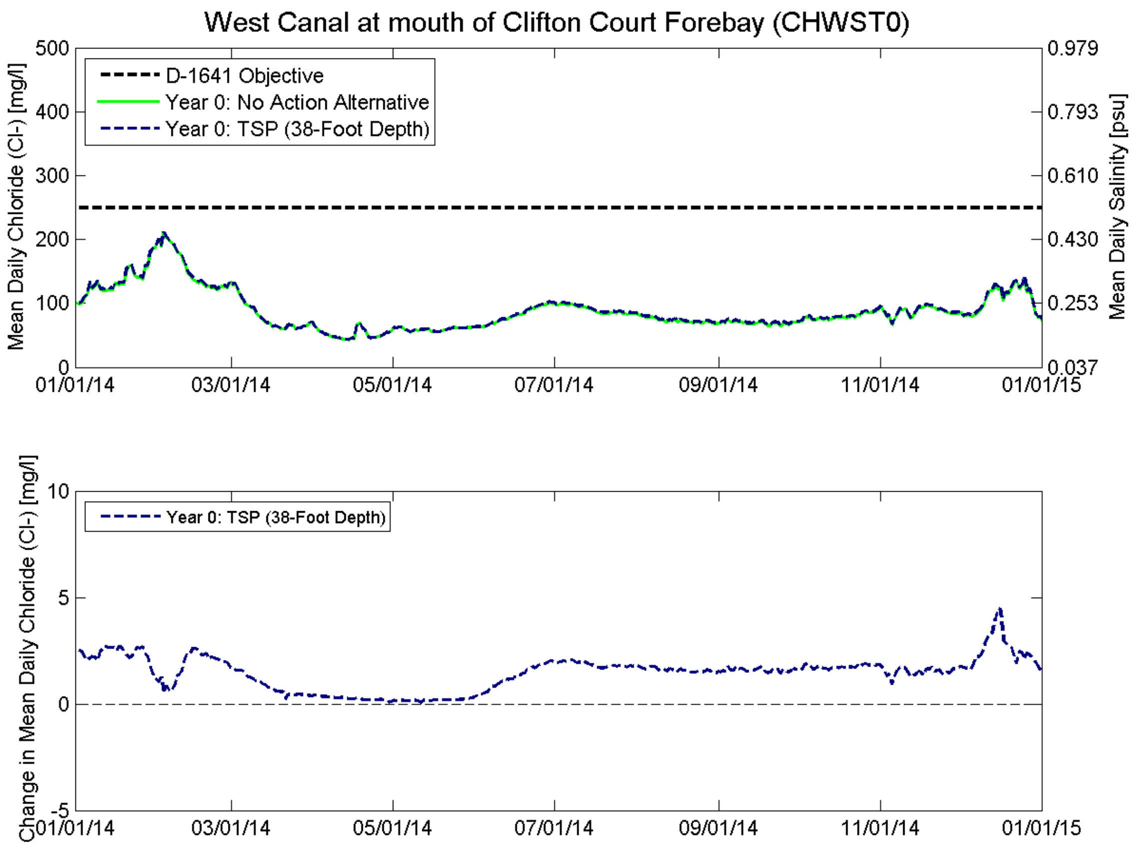


Figure 5.2-2

Predicted Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay Relative to the Year 0 No Action Alternative for the TSP During a Critical Water Year (Bottom)

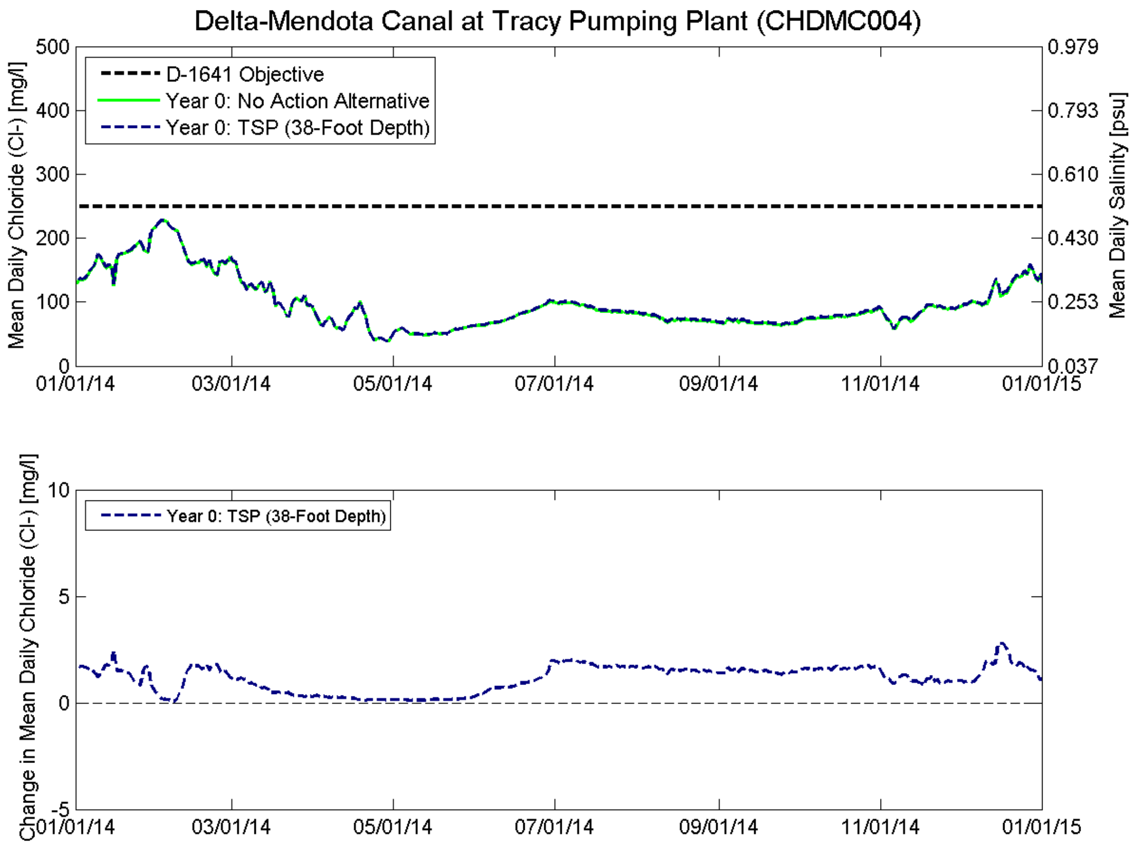


Figure 5.2-3

Predicted Mean Daily Cl$^-$ Concentration at the Tracy Pumping Plant (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl$^-$ Concentration at the Entrance to Tracy Pumping Plant Relative to the Year 0 No Action Alternative for the TSP During a Critical Water Year (Bottom)

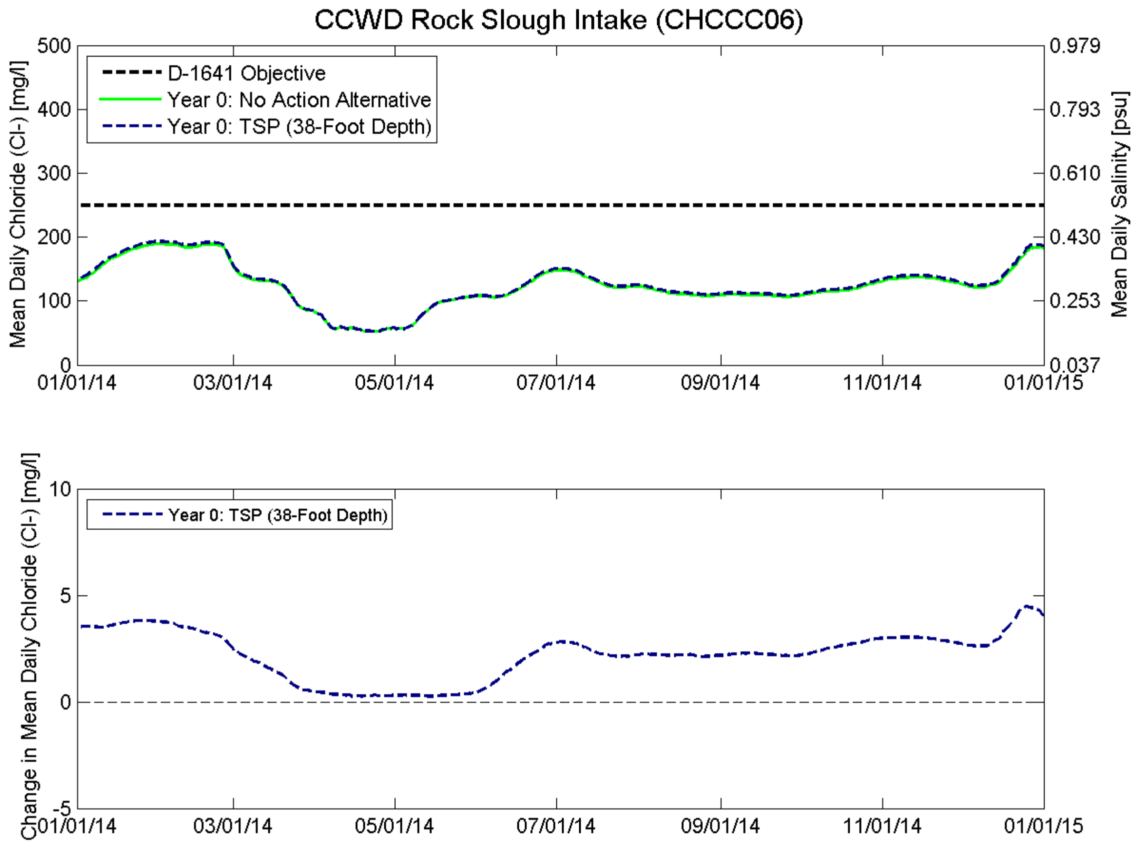


Figure 5.2-4

Predicted Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake Relative to the Year 0 No Action Alternative for the TSP During a Critical Water Year (Bottom)

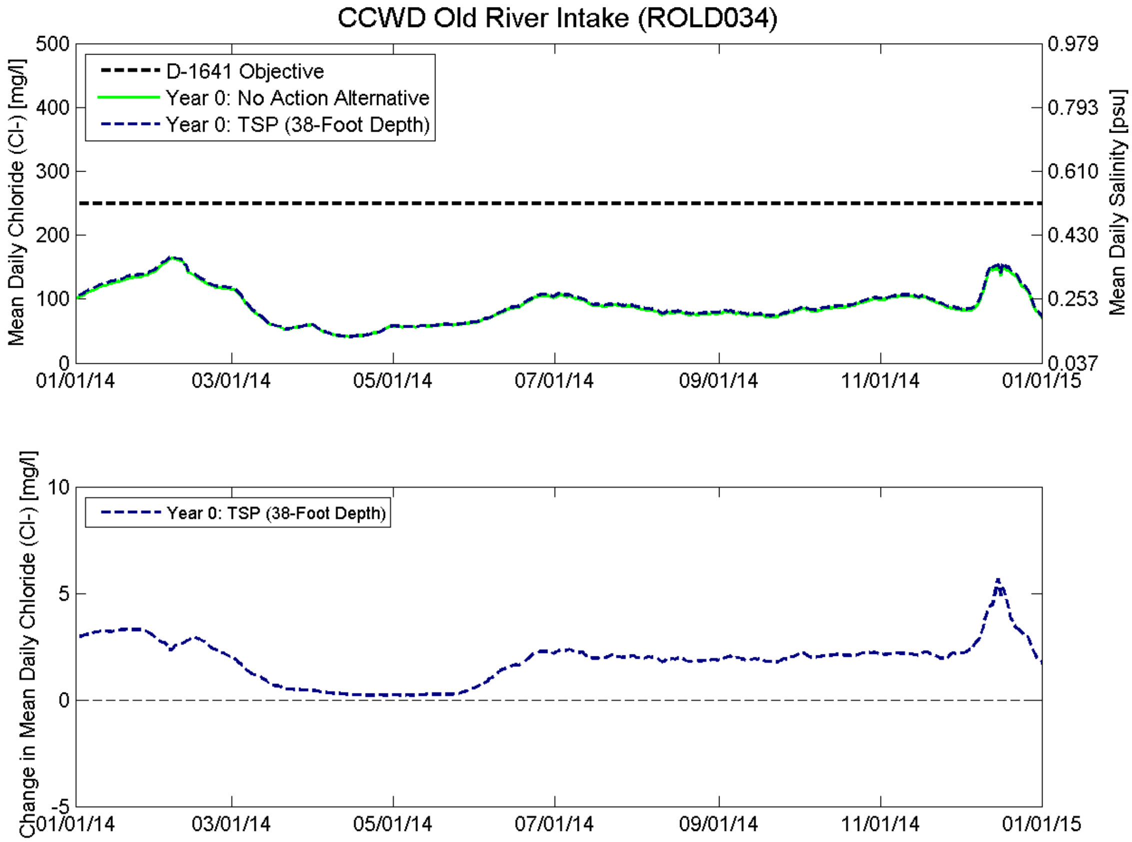


Figure 5.2-5

Predicted Mean Daily Cl^- Concentration at the CCWD Old River Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Old River Intake Relative to the Year 0 No Action Alternative for the TSP During a Critical Water Year (Bottom)

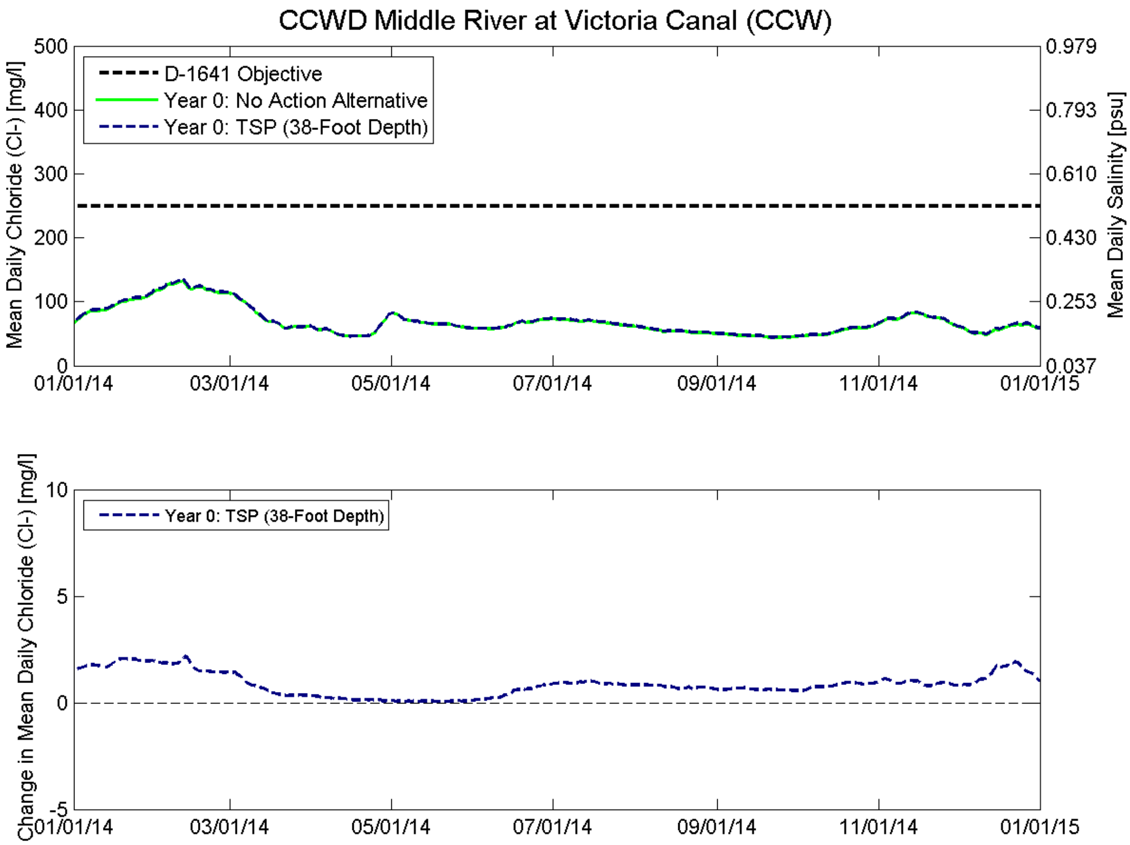


Figure 5.2-6

Predicted Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake Relative to the Year 0 No Action Alternative for the TSP During a Critical Water Year (Bottom)

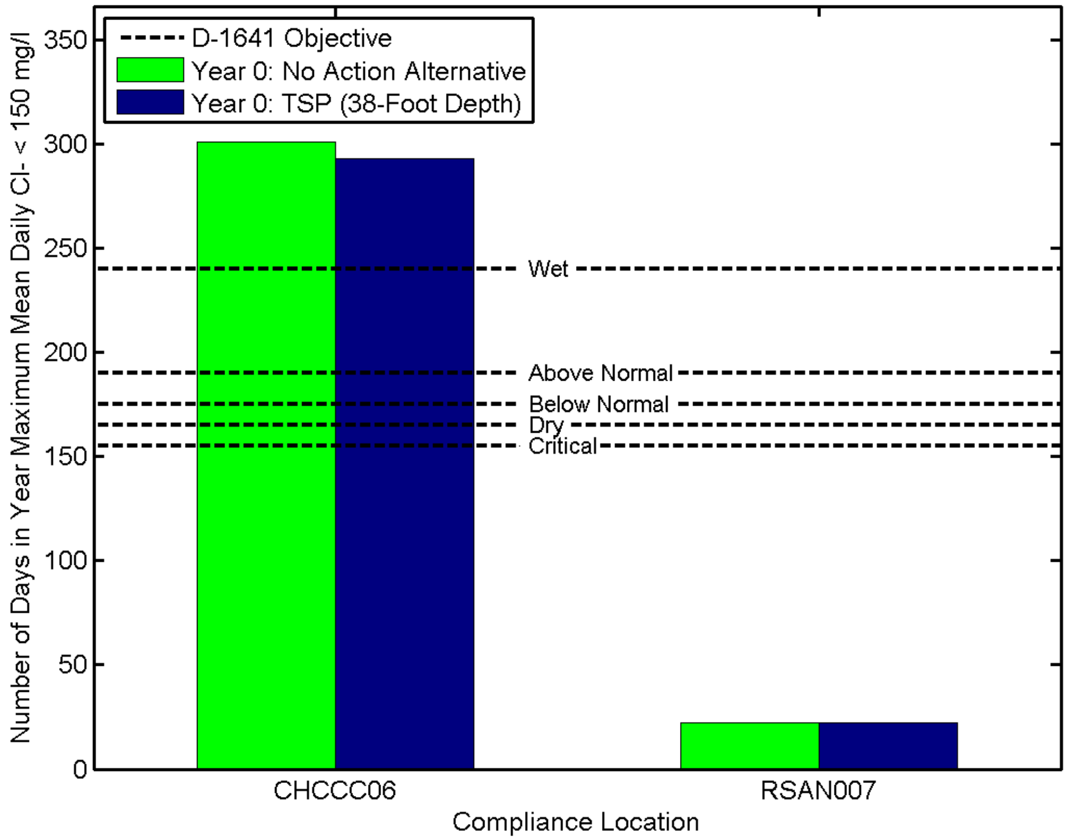


Figure 5.2-7

Number of Days During the Year 0 Simulation Period That Predicted Mean Daily Concentration of Cl^- Is Less Than 150 mg/L at Contra Costa Canal at Pumping Plant #1 (CHCCC06) and the Antioch Water Works Intake (RSAN007) for the Year 0 No Action Alternative and the TSP During a Critical Water Year

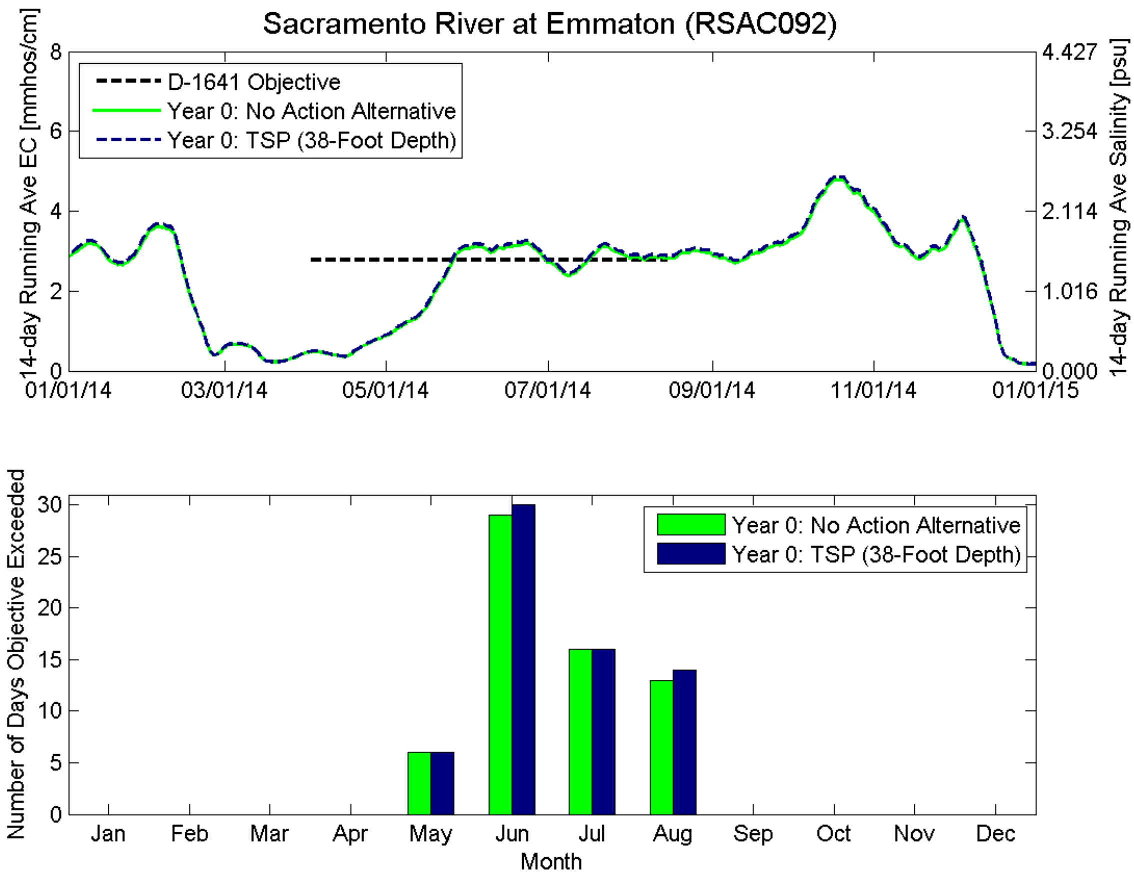


Figure 5.2-8

Predicted 14-Day Running Average Electrical Conductivity at Sacramento River at Emmaton (RSAC092) for the Year 0 No Action Alternative and the TSP During a Critical Water Year (Top); Number of Days Each Month That Predicted 14-Day Running Average Electrical Conductivity at RSAC092 Exceeds D-1641 Water Quality Objectives for Each Scenario During Year 0 for the Critical Water Year Evaluated (Bottom)

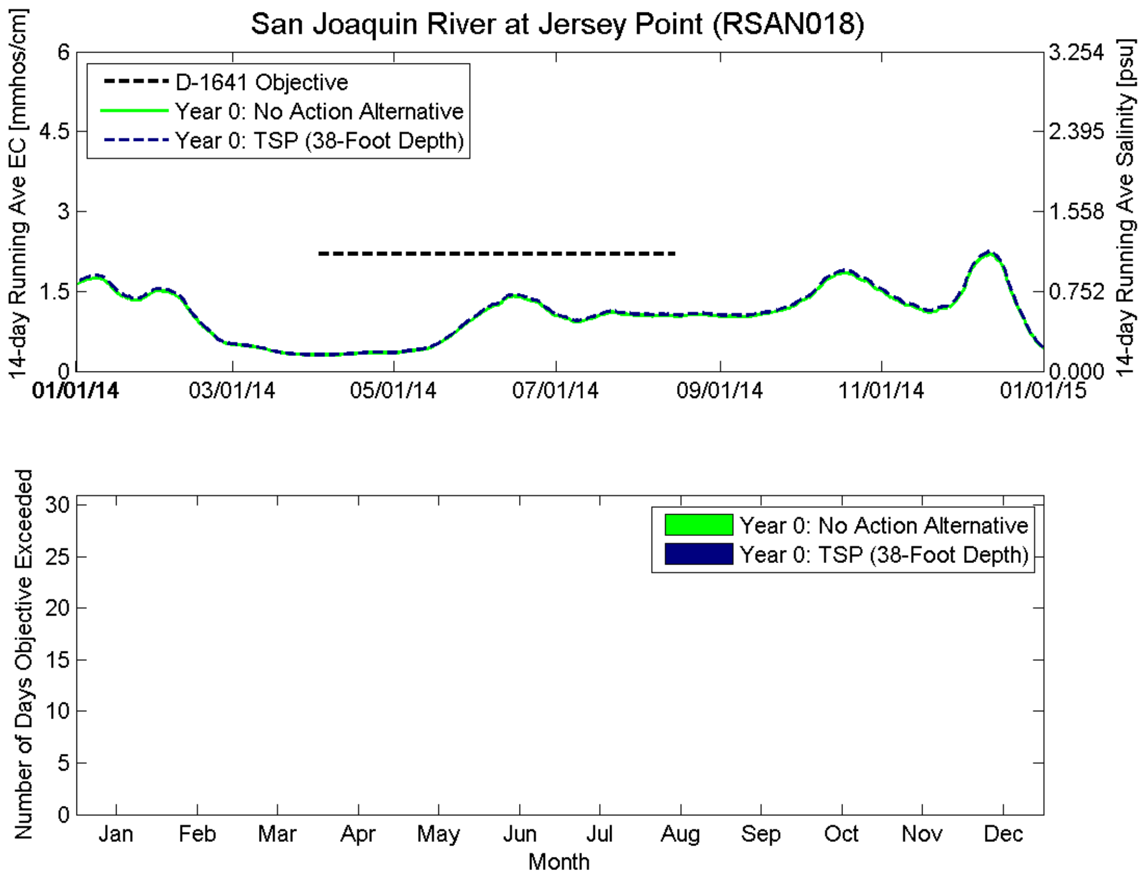


Figure 5.2-9

Predicted 14-Day Running Average Electrical Conductivity at San Joaquin River at Jersey Point (RSAN018) for the Year 0 No Action Alternative and the TSP During a Critical Water Year (Top); Number of Days Each Month That Predicted 14-Day Running Average Electrical Conductivity at RSAN018 Exceeds D-1641 Water Quality Objectives for Each Scenario During Year 0 for the Critical Water Year Evaluated (Bottom)

Table 5-3

Predicted Monthly Average Cl^- Concentration and Predicted Change in Cl^- Relative to the No Action Alternative for TSP at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Critical Water Year

Year 0 Critical Water Year (2014)	Baseline Conc. Cl^- (mg/L Cl^-)	TSP (38-Foot Depth)		
			Change in Cl^-	
		Conc. Cl^- (mg/L Cl^-)	(mg/L Cl^-)	Percent
West Canal at Mouth of Clifton Court Forebay (CHWST0)				
January	134.8	137.1	2.3	1.7
February	153.2	155.0	1.8	1.2
March	78.8	79.6	0.8	1.0
April	51.3	51.6	0.3	0.6
May	59.4	59.6	0.2	0.3
June	80.8	82.0	1.2	1.5
July	89.9	91.8	1.9	2.1
August	73.1	74.7	1.6	2.2
September	69.0	70.6	1.6	2.3
October	79.0	80.7	1.7	2.2
November	86.7	88.2	1.5	1.7
December	105.5	108.0	2.5	2.4
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)				
January	168.1	169.6	1.5	0.9
February	179.8	180.9	1.1	0.6
March	113.6	114.2	0.6	0.5
April	64.0	64.2	0.2	0.3
May	54.0	54.1	0.1	0.2
June	78.7	79.6	0.9	1.1
July	89.9	91.7	1.8	2.0
August	73.0	74.6	1.6	2.2
September	67.2	68.6	1.4	2.1
October	78.0	79.6	1.6	2.1
November	81.6	82.7	1.1	1.3
December	119.5	121.1	1.6	1.3

Year 0 Critical Water Year (2014)	Baseline Conc. Cl^- (mg/L Cl^-)	TSP (38-Foot Depth)		
			Change in Cl^-	
		Conc. Cl^- (mg/L Cl^-)	(mg/L Cl^-)	Percent
CCWD Rock Slough Intake (CHCCC06)				
January	166.4	170.0	3.6	2.2
February	184.7	188.1	3.4	1.8
March	119.7	121.1	1.4	1.2
April	58.7	59.1	0.4	0.7
May	86.6	86.9	0.3	0.3
June	121.6	123.3	1.7	1.4
July	132.4	134.8	2.4	1.8
August	112.9	115.1	2.2	1.9
September	109.0	111.2	2.2	2.0
October	118.1	120.7	2.6	2.2
November	134.2	137.2	3.0	2.2
December	145.6	149.0	3.4	2.3
CCWD Old River Intake (ROLD034)				
January	125.1	128.3	3.2	2.6
February	138.0	140.6	2.6	1.9
March	70.9	71.9	1.0	1.4
April	46.9	47.1	0.2	0.4
May	58.9	59.2	0.3	0.5
June	86.8	88.3	1.5	1.7
July	94.4	96.5	2.1	2.2
August	78.7	80.5	1.8	2.3
September	76.3	78.2	1.9	2.5
October	88.8	90.9	2.1	2.4
November	97.7	99.8	2.1	2.1
December	114.3	117.6	3.3	2.9

Year 0 Critical Water Year (2014)	Baseline Conc. Cl^- (mg/L Cl^-)	TSP (38-Foot Depth)		
			Change in Cl^-	
		Conc. Cl^- (mg/L Cl^-)	(mg/L Cl^-)	Percent
CCWD Middle River at Victoria Canal Intake (CCW)				
January	93.8	95.6	1.8	1.9
February	121.3	123.0	1.7	1.4
March	76.4	77.1	0.7	0.9
April	54.1	54.3	0.2	0.4
May	67.3	67.4	0.1	0.1
June	64.4	64.9	0.5	0.8
July	68.0	68.9	0.9	1.3
August	54.3	55.0	0.7	1.3
September	46.4	47.1	0.7	1.5
October	53.6	54.4	0.8	1.5
November	74.0	75.0	1.0	1.4
December	57.5	58.8	1.3	2.3

Notes:
mg/L Cl- = Concentration of chloride in milligrams per liter
CCWD = Contra Costa Water District

5.2.3 *Effect of TSP on Water Levels During a Critical Water Year*

Water level comparisons were made at three locations spanning the geographic extent of the project (Figure 3.6-1). For each water level comparison figure included in this section, the top plot shows the tidal time-scale water level variability over a 15-day period for the No Action Alternative and the TSP scenario. The middle plot shows daily-averaged stage during the full simulation year for each scenario. The bottom plot shows the predicted change in daily-averaged stage for the TSP scenario relative to the No Action Alternative. Because the predicted water level is nearly identical between scenarios, a dashed line is used for the TSP scenario because it is plotted on top of the line for the No Action Alternative. Comparisons of the predicted water level for the No Action Alternative and the TSP were made at the Richmond station (Figure 5.2-10) which is seaward of the Pinole Shoal Channel, Martinez (Figure 5.2-11) which is located west of the Suisun Bay Channel, and Mallard Island (Figure 5.2-12). These comparisons show that the predicted water levels for the No Action Alternative and the TSP are nearly identical, and there is virtually no change in predicted water level at any of the stations evaluated during the critical water year evaluated.

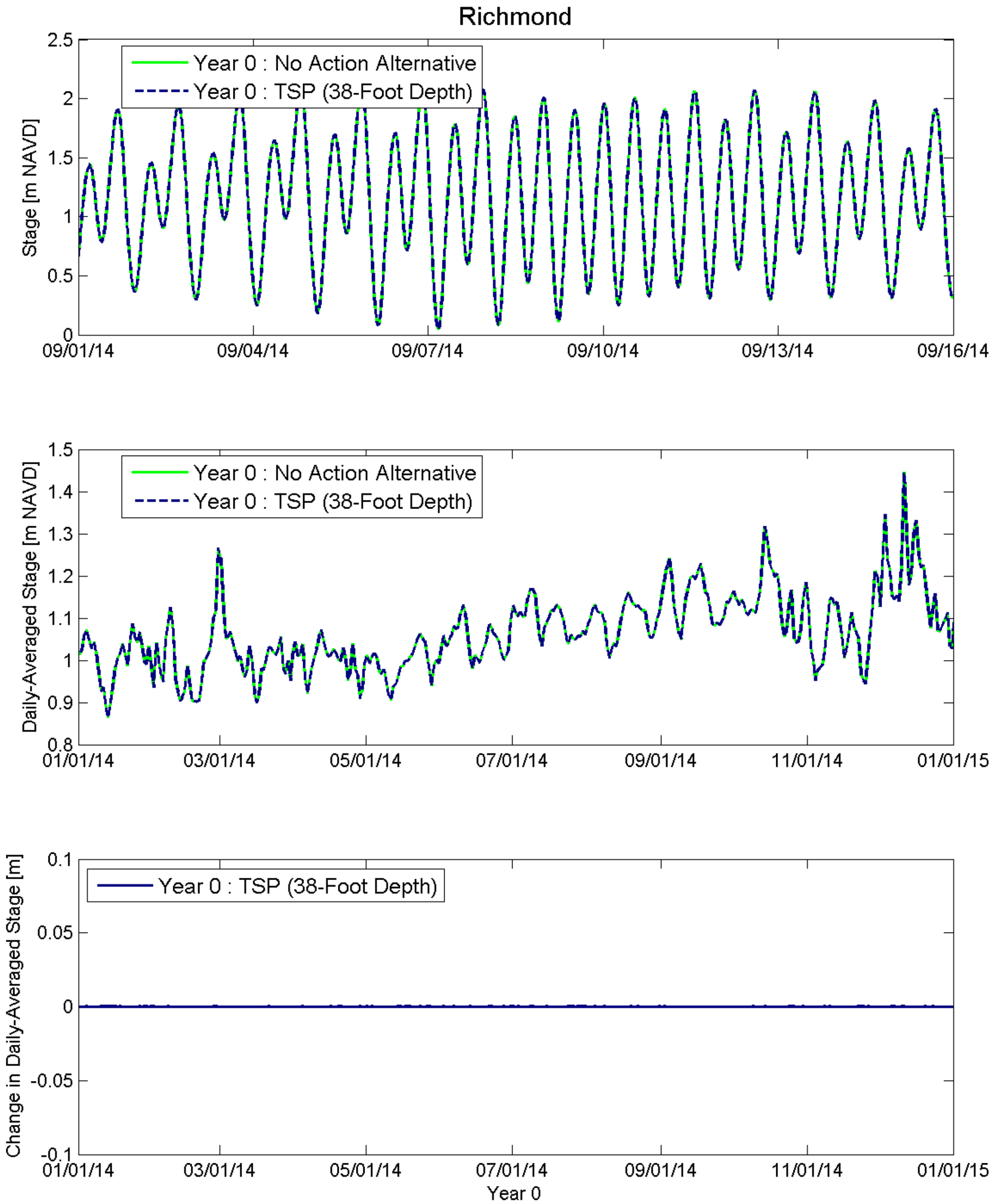


Figure 5.2-10

Predicted Stage at the NOAA Richmond Station for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Critical Water Year Evaluated

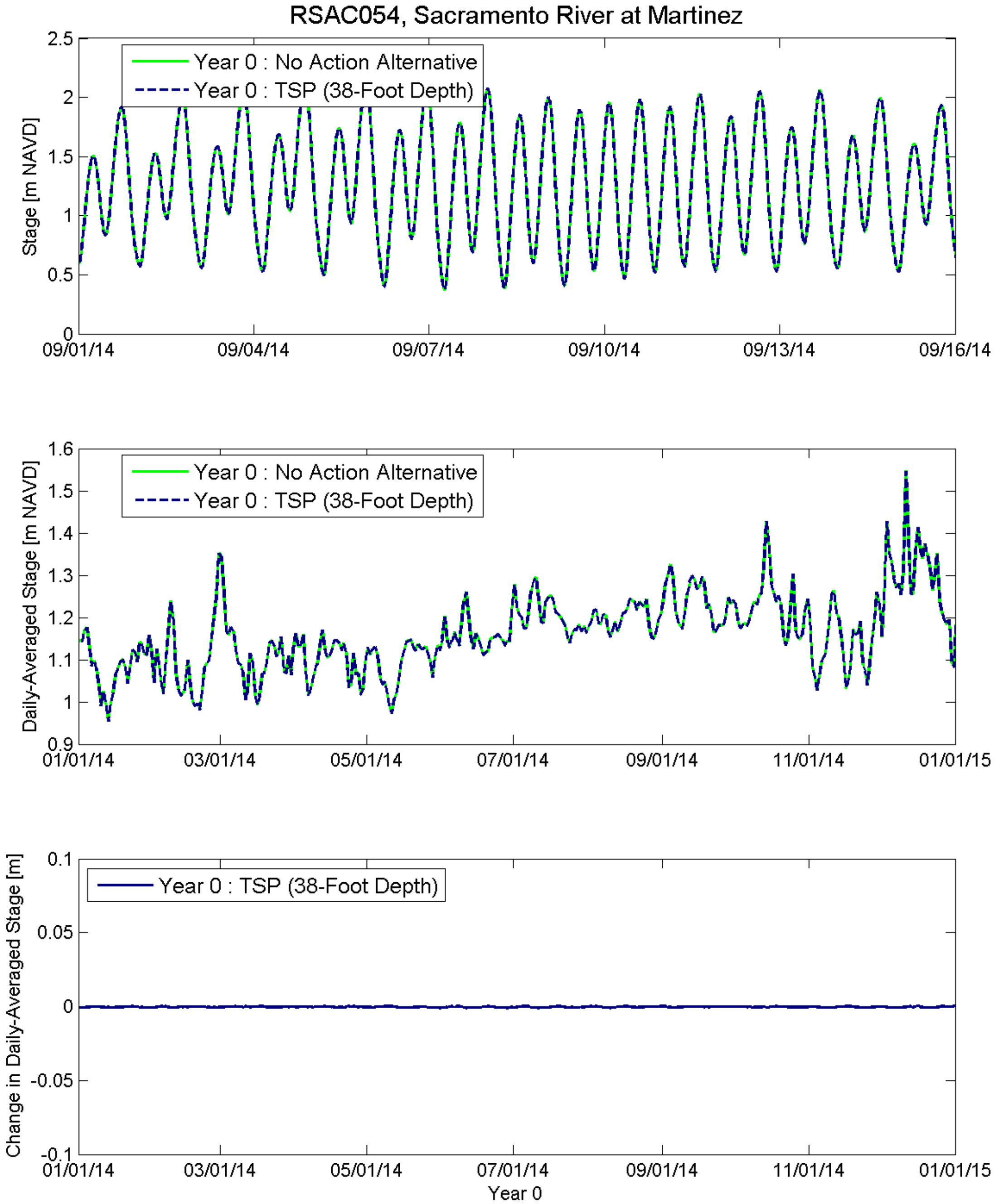


Figure 5.2-11

Predicted Stage at Sacramento River at Martinez (RSAC054) for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Critical Water Year Evaluated

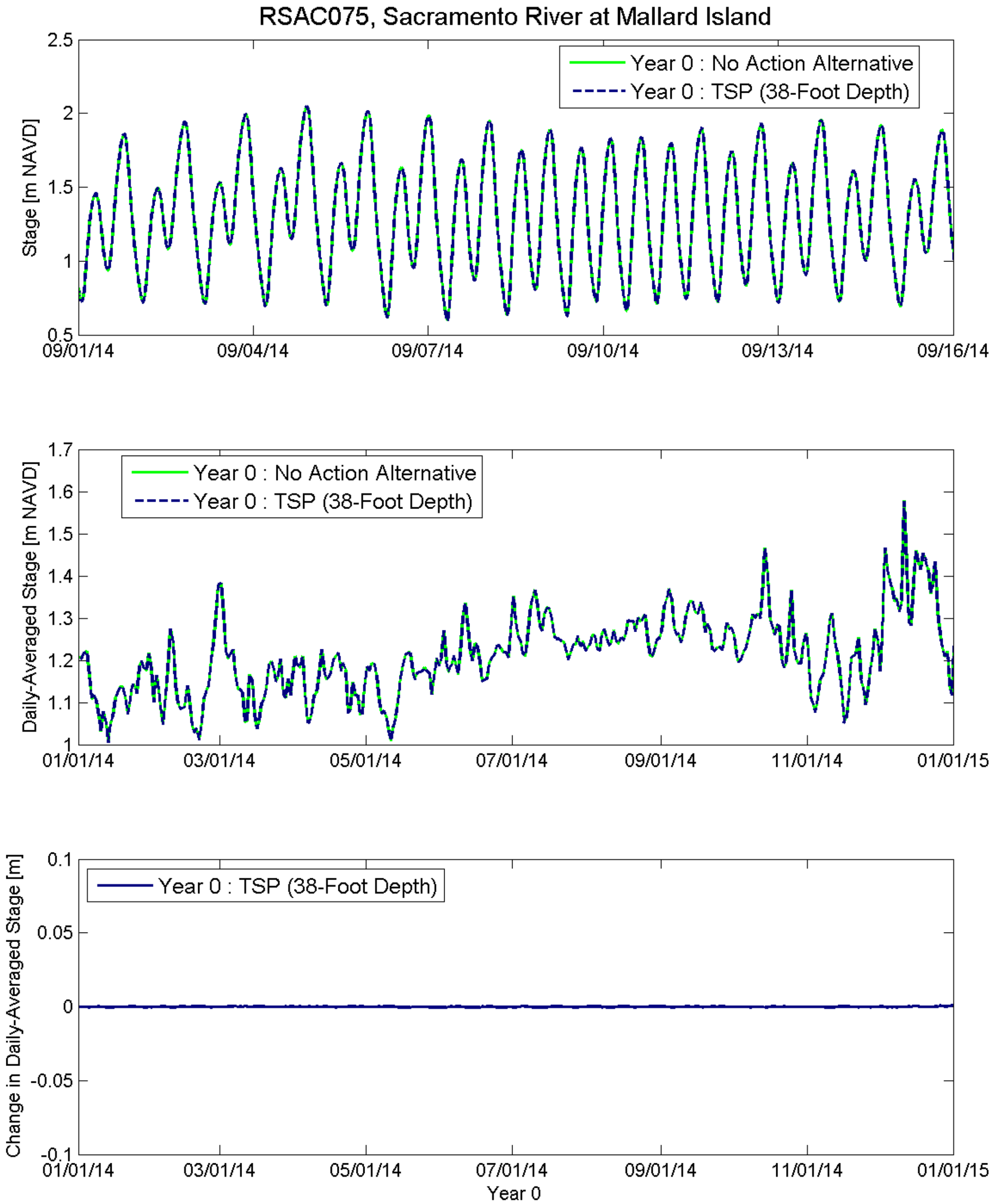


Figure 5.2-12

Predicted Stage at Sacramento River at Mallard Island (RSAC075) for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Critical Water Year Evaluated

5.2.4 Effect of TSP on Tidal Flows During a Critical Water Year

Flow time series comparisons were made at three locations in San Francisco Bay spanning the geographic extent of the project (Figure 3.7-1). For each flow comparison figure included in this section, the top plot shows the tidal time-scale flows over a 15-day period for the No Action Alternative and the TSP scenario. The middle plot shows tidally-averaged flow during the full simulation year for each scenario. The bottom plot shows the predicted change in tidally-averaged flow for the TSP scenario relative to the No Action Alternative. Because the predicted flow is nearly identical between scenarios, a dashed line is used for the TSP scenario because it is plotted on top of the line for the No Action Alternative. Comparisons of the predicted flow for the No Action Alternative and the TSP were made at the Point San Pablo (Figure 5.2-13) which is seaward of the Pinole Shoal Channel, Carquinez Bridge (Figure 5.2-14) which is located west of the Suisun Bay Channel, and Chipps Island (Figure 5.2-15) which is east of the project area. These comparisons show that the predicted flows for the No Action Alternative and the TSP are nearly identical, with only very small differences in tidally-averaged flows at each location during the critical water year evaluated. These very small differences in tidally-averaged flows are several orders of magnitude smaller than the tidal and tidally-averaged flows and likely result from small phase differences in tidal propagation as a result of the channel deepening.

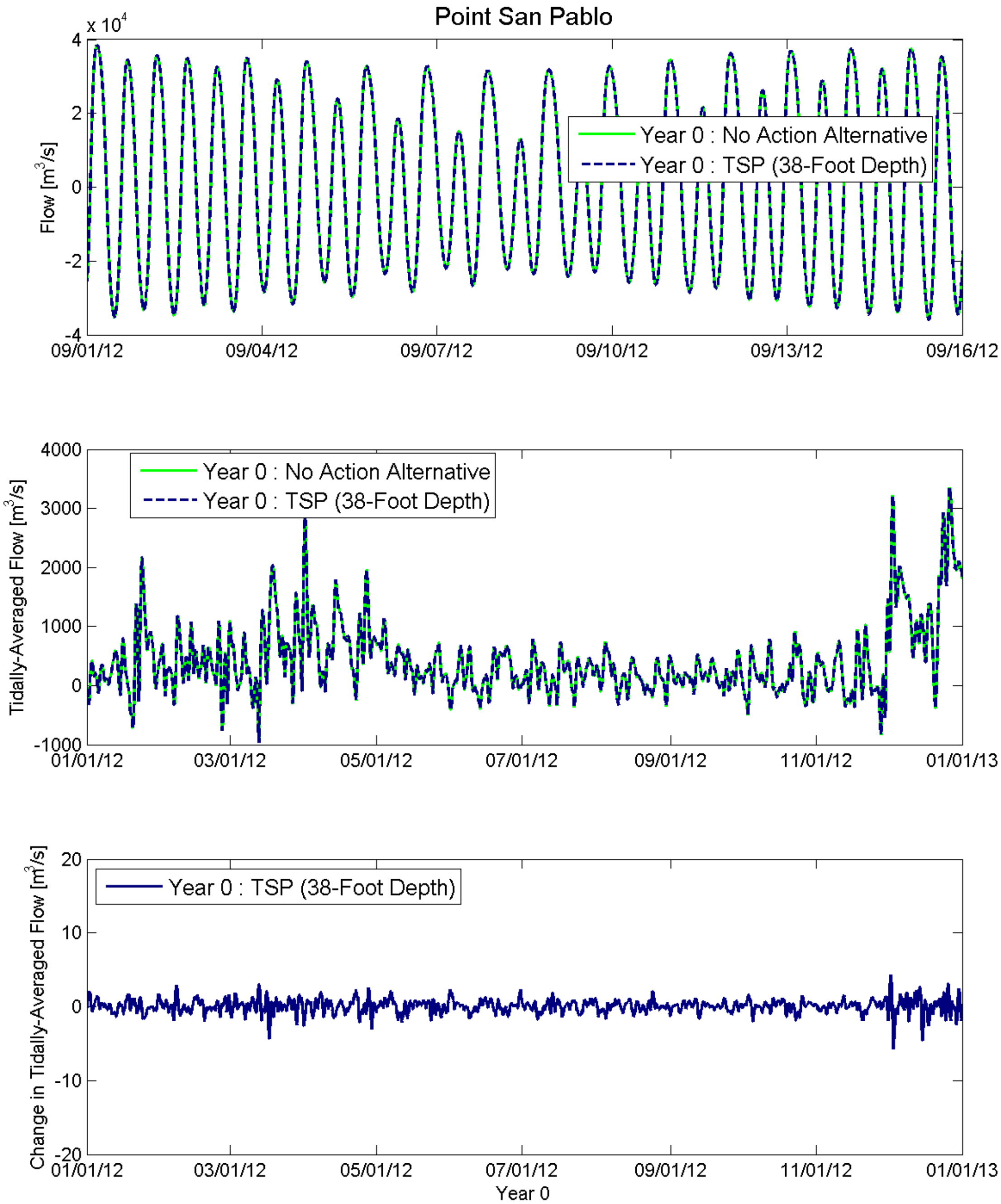


Figure 5.2-13

Predicted Tidal Flow at Point San Pablo for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Critical Water Year Evaluated

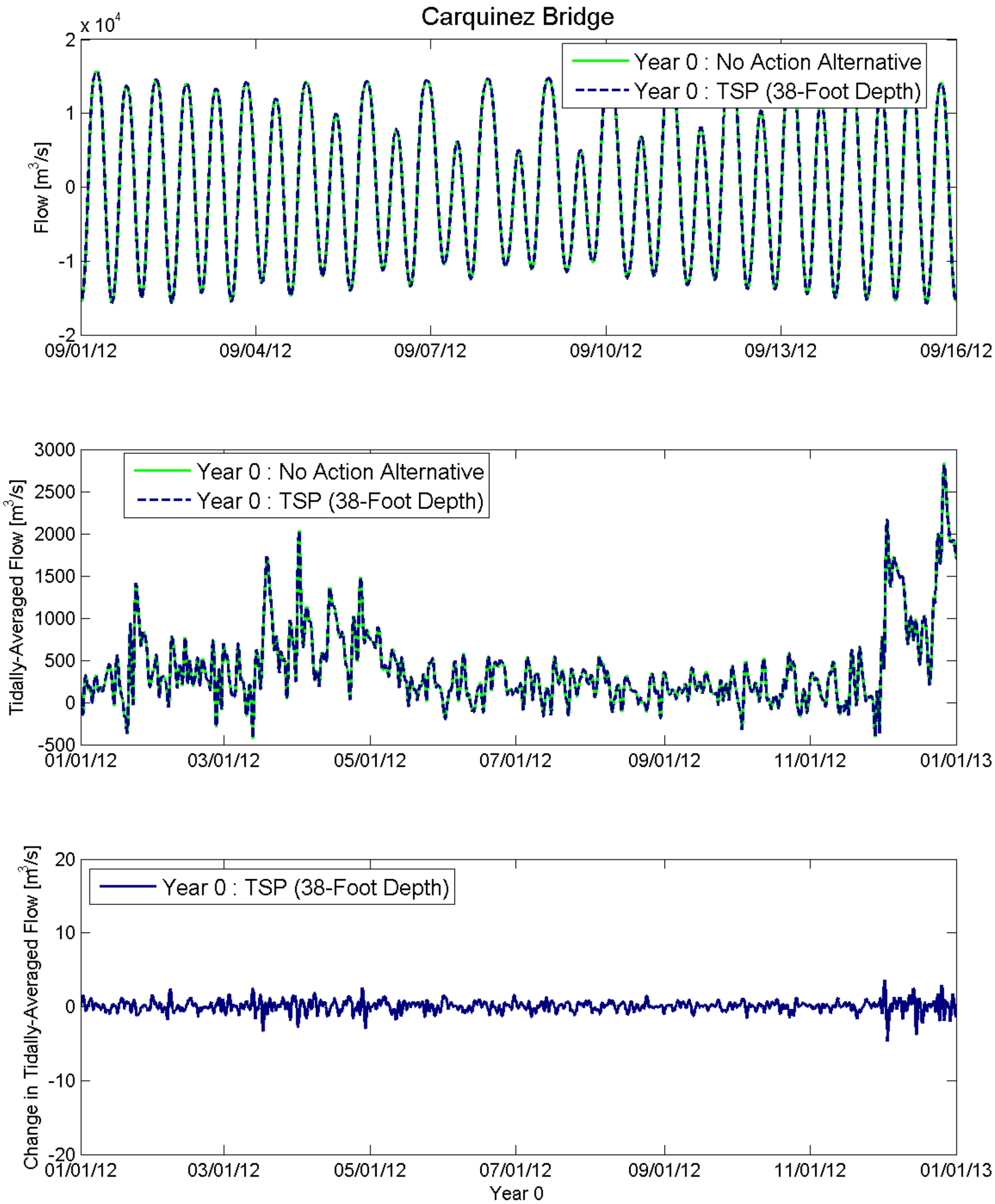


Figure 5.2-14

Predicted Tidal Flow at Carquinez Bridge for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Critical Water Year Evaluated

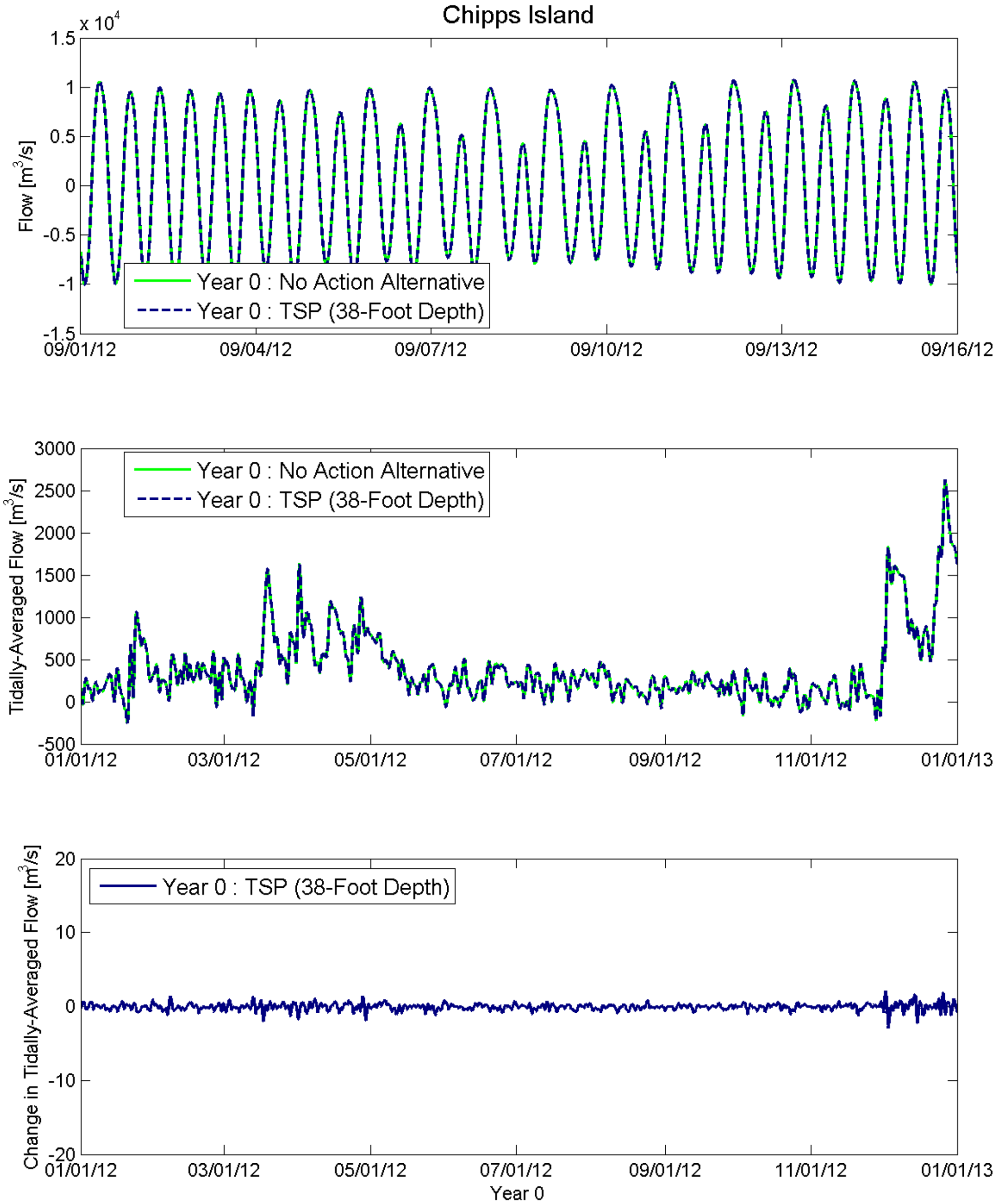


Figure 5.2-15

Predicted Tidal Flow at Chipps Island for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Critical Water Year Evaluated

5.3 Evaluation of Effects of TSP on Salinity and X2 During a Below Normal Water Year

This section presents the evaluation of the effects on the TSP on salinity during and following a below normal water year. The period evaluated is based on historical conditions between January 1, 2012, and December 31, 2012, as described in Section 3.3.2.

5.3.1 Effect of TSP on X2 During a Below Normal Water Year

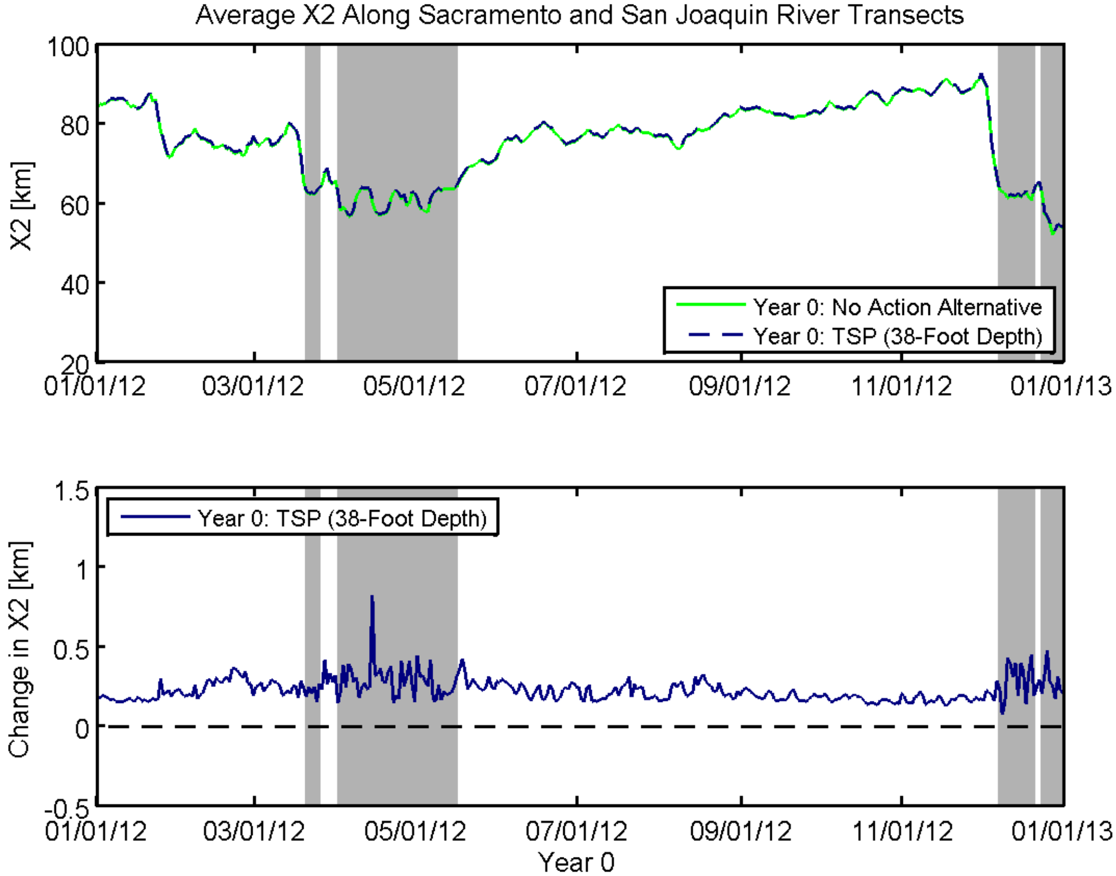
X2 remained elevated throughout 2014 (Figure 5.3-1, top), remaining above 70 km through the first 11 months of the year and dropping below 64 km only in December due to higher outflows (Figure 3.3-1). For the TSP, X2 was predicted to increase throughout the year relative to the baseline No Action Alternative (Figure 5.3-1, bottom), with a predicted annual-average increase of 0.21 km. Similarly, during the period of the year when X2 was greater than 64 km, the predicted average increase in X2 resulting from the TSP was 0.21 km (Table 5-4).

Table 5-4

Predicted Change in X2 for the TSP During a Below Normal Water Year

Alternative	Change in X2 (km)	
	Annual-Average	Change for X2 > 64
No Action Alternative	Baseline	Baseline
TSP (38-Foot Depth)	0.21	0.21

Notes:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2, so the average change for periods when X2 >64 is also shown separately.
km = kilometers
TSP = Tentatively Selected Plan



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 5.3-1
Predicted X2 for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year (Top); Predicted Change in X2 Relative to the Year 0 No Action Alternative for the TSP During a Below Normal Water Year (Bottom)

5.3.2 Effect of TSP on Water Quality at D-1641 Stations During a Below Normal Water Year

The effect of the TSP on the predicted Cl^- concentration at the five intake and export locations in the south Delta (locations shown in Figure 3.5-1) was evaluated to assess the potential effects on water quality at the municipal and industrial intakes at which D-1641 has established water quality criteria. Figures 5.3-2 through 5.3-6 show the mean daily Cl^-

concentration for the No Action Alternative and the TSP and the predicted change in Cl^- concentration resulting from the TSP during 2014. Table 5-5 summarizes the predicted annual-average change in Cl^- concentration and the maximum predicted monthly average change in Cl^- concentration at five intake and export locations. During the Below Normal water year, the predicted annual-average change in Cl^- concentration ranged from 0.3 mg/L at the CCWD Middle River at Victoria Canal Intake to 1.1 mg/L at the CCWD Rock Slough Intake. The predicted maximum monthly average change ranged from 1.1 mg/L at the CCWD Middle River at Victoria Canal Intake to 2.5 mg/L at the CCWD Rock Slough Intake. The predicted monthly average change in Cl^- concentration during each month in 2014 for the TSP is included in Table 5-6.

Figure 5.2-7 shows the number of days that the maximum mean daily concentration of Cl^- is less than 150 mg/l at CHCCC06 and RSAN007. To meet the below normal water year water quality objective, the number of days that mean daily concentration of Cl^- is less than 150 mg/l should exceed 175 days at either CHCCC06 or RSAN007. At CHCCC06, the mean daily concentration of Cl^- is less than 150 mg/l for 346 days under the Year 0 No Action Alternative and 346 days for the Year 0 TSP scenario (no change relative to the Year 0 No Action Alternative). At RSAN007, the mean daily concentration of Cl^- is less than 150 mg/l for 136 days under the Year 0 No Action Alternative and 132 days for the Year 0 TSP scenario (a decrease of 4 days relative to the Year 0 No Action Alternative). Because this standard stipulates that daily mean chloride concentration must be less than 150 mg/l for at least 175 days during a below normal water year at either Contra Costa Canal at Pumping Plant #1 or the Antioch Water Works intake, this standard is met for both the Year 0 No Action Alternative and the Year 0 TSP scenario because this water quality standard is met at CHCCC06 under both scenarios for the below normal water year evaluated.

The D-1641 water quality objectives for agricultural beneficial uses in the Western Delta, shown in Table 3-2, are based on the maximum 14-day running average electrical conductivity. The western Delta water quality objectives for agricultural beneficial use depend on water year type on the Sacramento River and apply only from April 1 to August 15. Water year 2012 (from October 1, 2011, through September 30, 2012) was classified as a below normal water year. Because the April 1 through August 15 period falls within water year 2012, the below normal year water quality objectives shown in Table 3-2 are applied for the western Delta stations.

Figure 5.3-8 shows the predicted 14-day running average electrical conductivity on the Sacramento River at Emmaton for the Year 0 No Action Alternative and the Year 0 TSP scenario. No significant changes in 14-day running average electrical conductivity under the Year 0 TSP scenario are predicted on the Sacramento River at Emmaton during the below normal water year. The water quality objectives for agricultural beneficial use apply from April 1 through August 15. As seen in Figure 5.3-8, the water quality objective of maximum 14-day running average electrical conductivity on the Sacramento River at Emmaton is not exceeded for any days under the Year 0 No Action Alternative or the Year 0 TSP scenario during the below normal water year evaluated.

Figure 5.3-9 shows the predicted 14-day running average electrical conductivity on the San Joaquin River at Jersey Point for the Year 0 No Action Alternative and the Year 0 TSP scenario. No significant changes in 14-day running average electrical conductivity under the Year 0 TSP scenario are predicted on the San Joaquin River at Jersey Point during the below normal water year. The water quality objectives for agricultural beneficial use apply from April 1 through August 15. The water quality objective of maximum 14-day running average electrical conductivity on the San Joaquin River at Jersey Point was not predicted to be exceeded under the Year 0 No Action Alternative or the Year 0 TSP scenario during the below normal water year evaluated.

Table 5-5

Predicted Annual-Average and Maximum Monthly Average Change in Chloride Concentration Relative to the No Action Alternative for the TSP at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Below Normal Water Year

Year 0 Below Normal Water Year (2012)	Change in Chloride Concentration (mg/L Cl^-)	
	Annual-Average Change	Max Monthly Average Change
West Canal at mouth of Clifton Court Forebay (CHWST0)	0.7	1.9
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)	0.5	1.2
CCWD Rock Slough Intake (CHCCC06)	1.1	3.1
CCWD Old River Intake (ROLD034)	0.9	2.5
CCWD Middle River at Victoria Canal Intake (CCW)	0.3	1.1

Notes:
CCWD = Contra Costa Water District
mg/L Cl- = Concentration of chloride in milligrams per liter

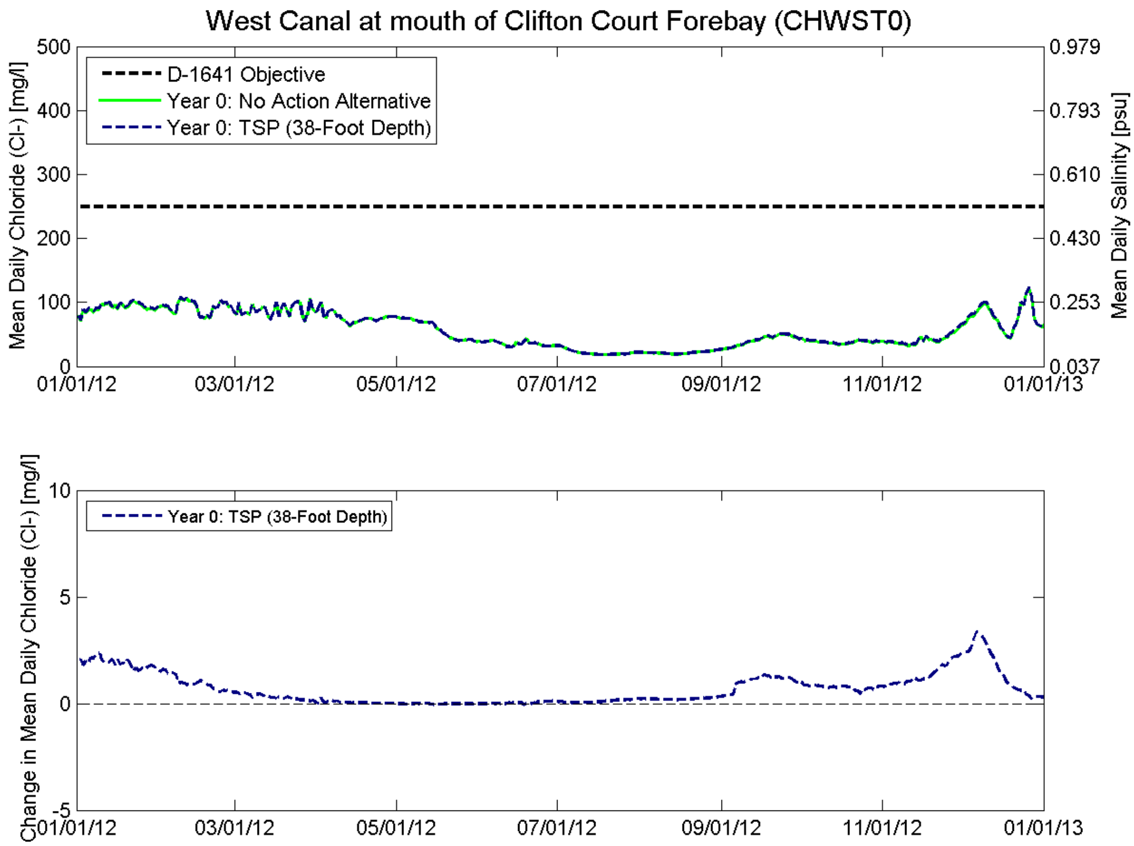


Figure 5.3-2

Predicted Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay Relative to the Year 0 No Action Alternative for the TSP During a Below Normal Water Year (Bottom)

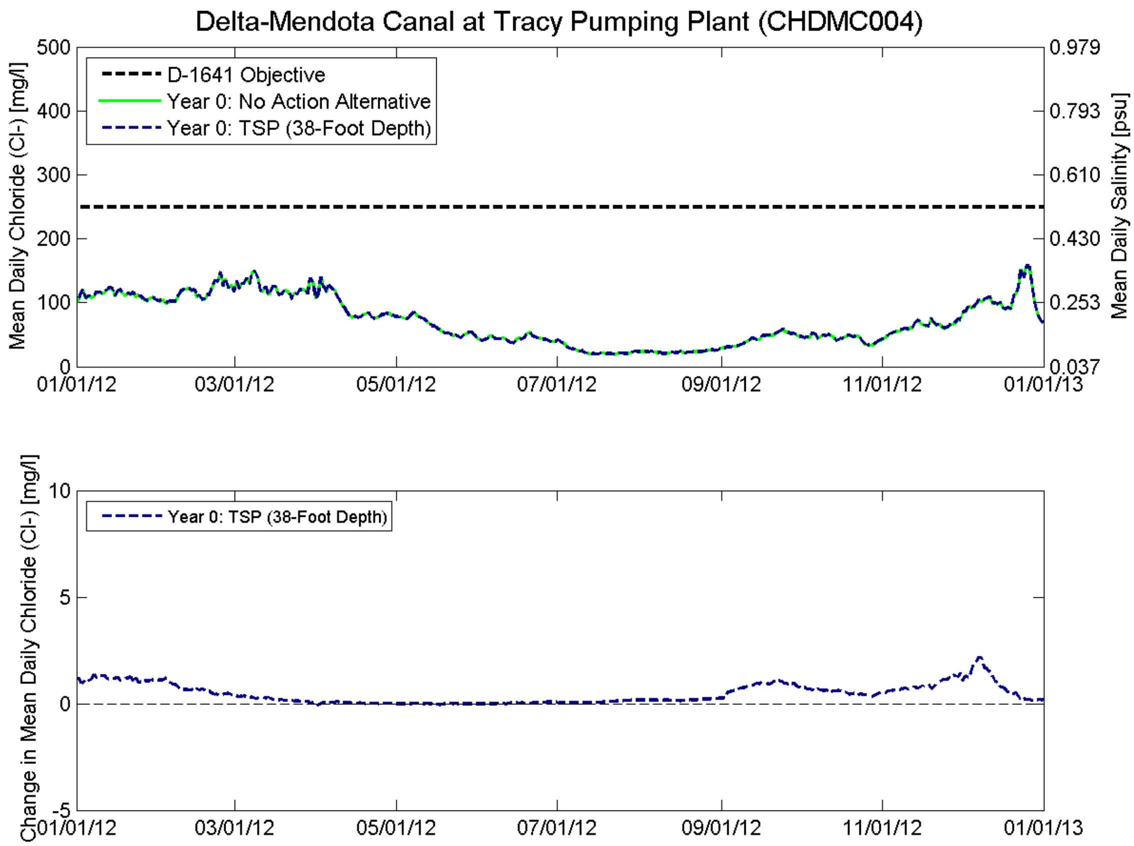


Figure 5.3-3

Predicted Mean Daily Cl^- Concentration at the Tracy Pumping Plant (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Tracy Pumping Plant Relative to the Year 0 No Action Alternative for the TSP During a Below Normal Water Year (Bottom)

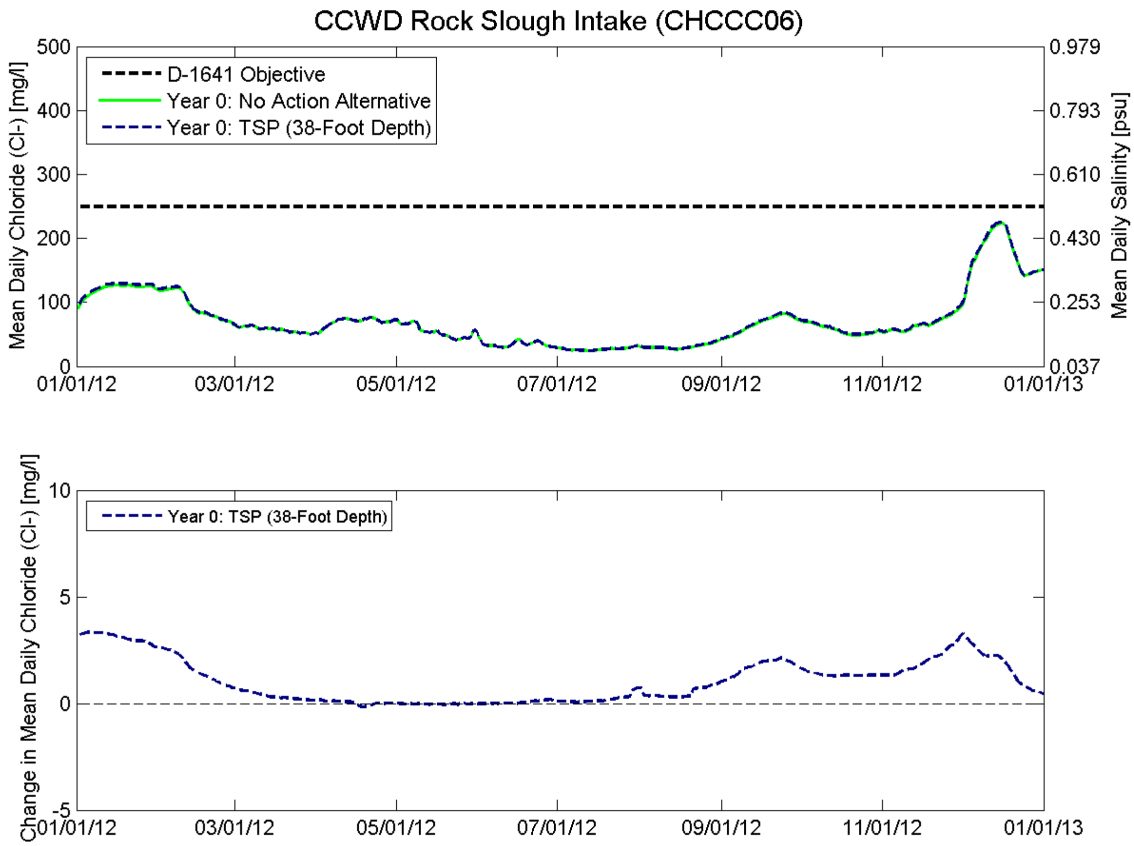


Figure 5.3-4

Predicted Mean Daily Cl$^-$ Concentration at the CCWD Rock Slough Intake (location shown in Figure 3.4-2) for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year (Top); Predicted Change in Mean Daily Cl$^-$ Concentration at the CCWD Rock Slough Intake Relative to the Year 0 No Action Alternative for the TSP During a Below Normal Water Year (Bottom)

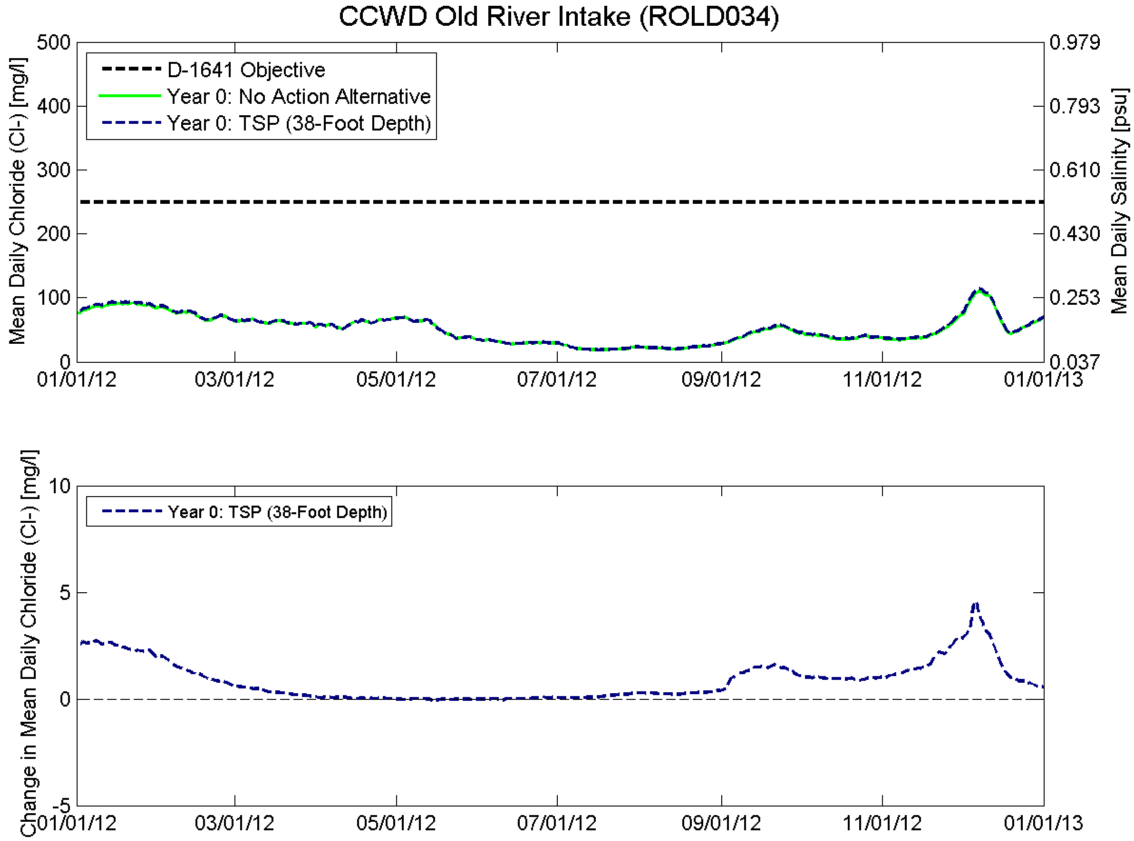


Figure 5.3-5

Predicted Mean Daily Cl^- Concentration at the CCWD Old River Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Old River Intake Relative to the Year 0 No Action Alternative for the TSP During a Below Normal Water Year (Bottom)

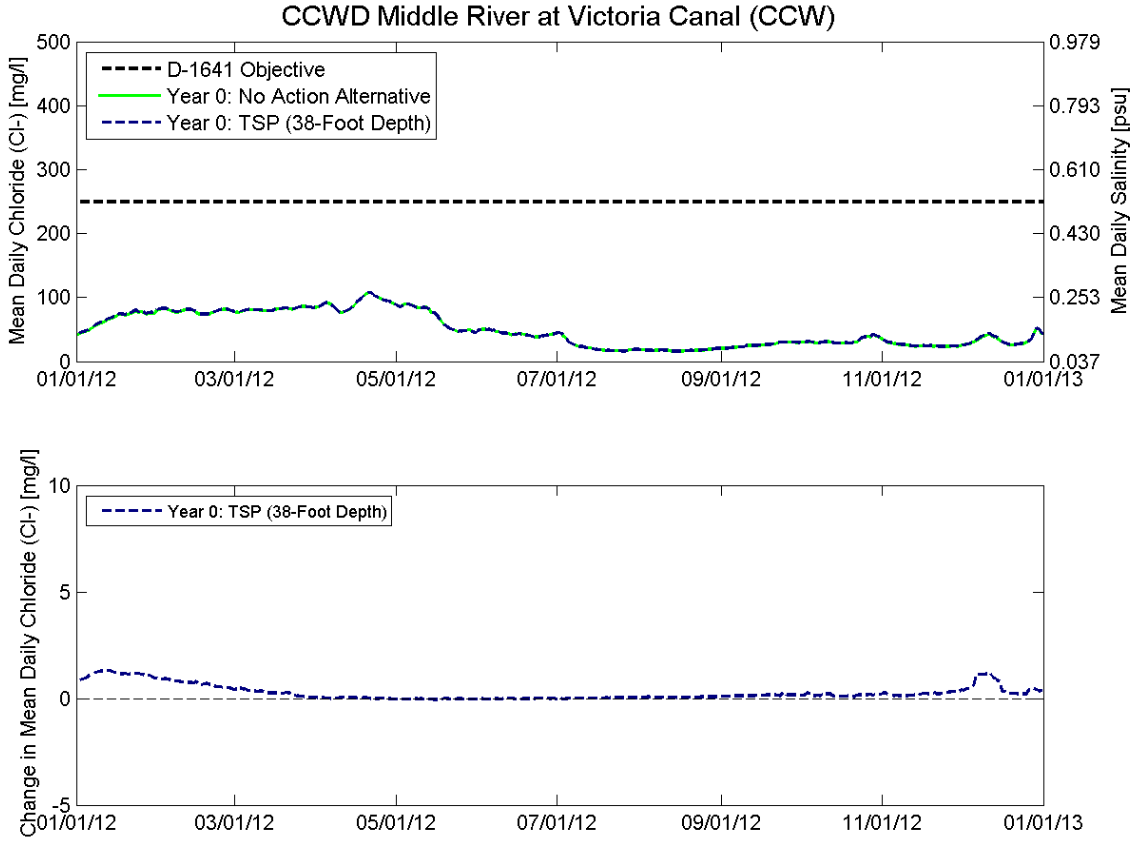


Figure 5.3-6

Predicted Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake Relative to the Year 0 No Action Alternative for the TSP During a Below Normal Water Year (Bottom)

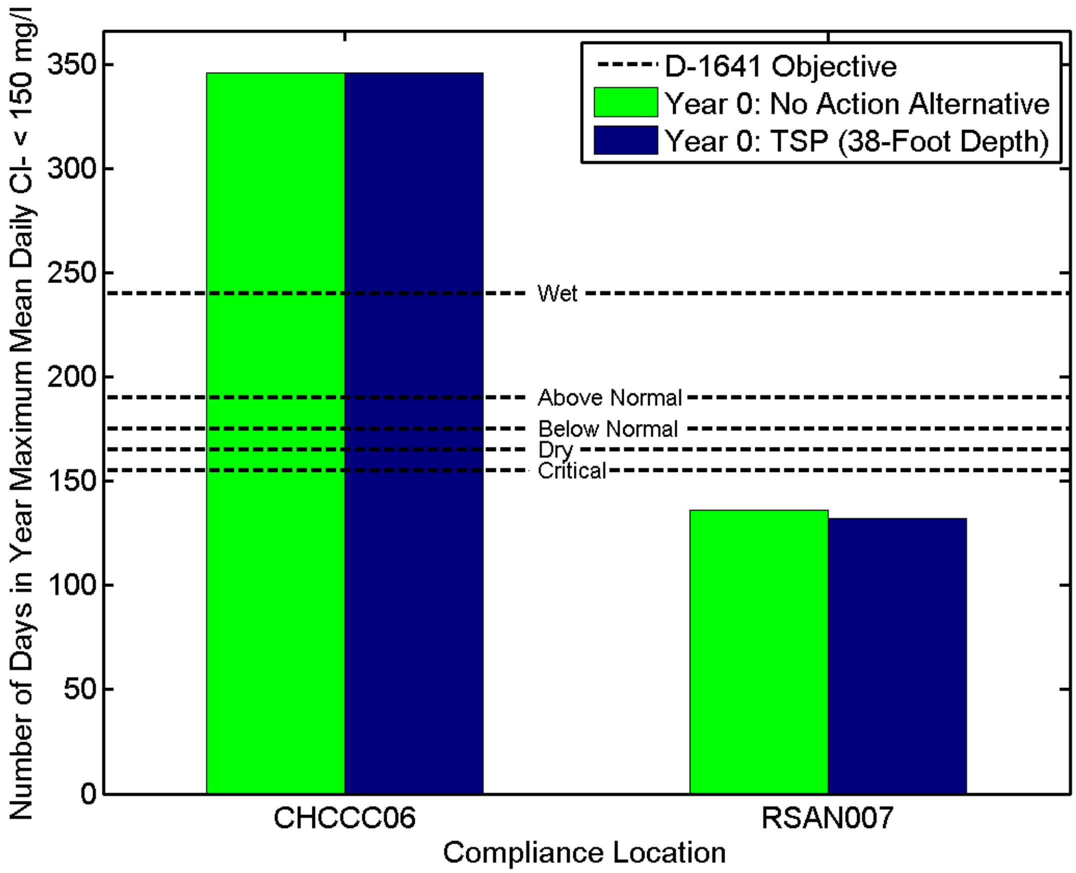


Figure 5.3-7

Number of Days During the Year 0 Simulation Period That Predicted Mean Daily Concentration of Cl^- Is Less Than 150 mg/L at Contra Costa Canal at Pumping Plant #1 (CHCCC06) and the Antioch Water Works Intake (RSAN007) for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year

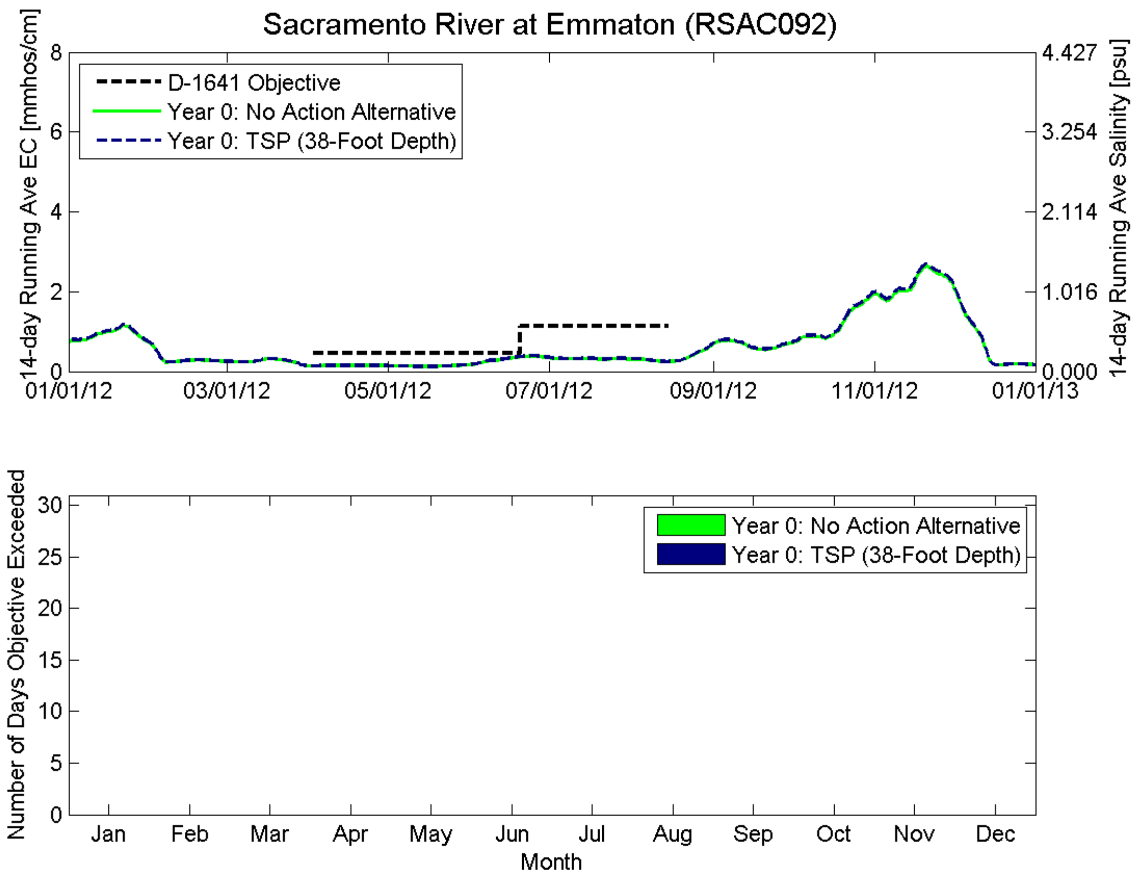


Figure 5.3-8

Predicted 14-Day Running Average Electrical Conductivity at Sacramento River at Emmaton (RSAC092) for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year (Top); Number of Days Each Month That Predicted 14-Day Running Average Electrical Conductivity at RSAC092 Exceeds D-1641 Water Quality Objectives for Each Scenario During Year 0 for the Below Normal Water Year Evaluated (Bottom)

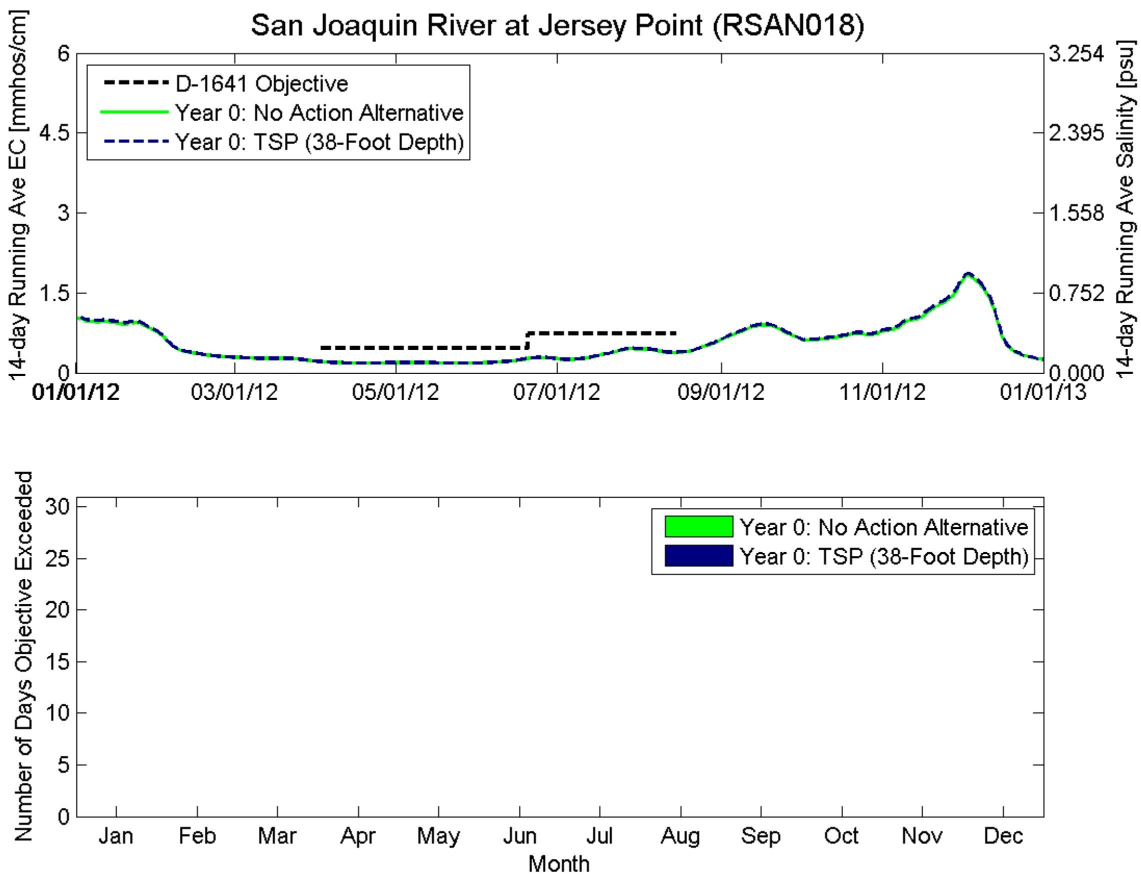


Figure 5.3-9

Predicted 14-Day Running Average Electrical Conductivity at San Joaquin River at Jersey Point (RSAN018) for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year (Top); Number of Days Each Month That Predicted 14-Day Running Average Electrical Conductivity at RSAN018 Exceeds D-1641 Water Quality Objectives for Each Scenario During Year 0 for the Below Normal Water Year Evaluated (Bottom)

Table 5-6

Predicted Monthly Average Cl^- Concentration and Predicted Change in Cl^- Relative to the No Action Alternative for TSP at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Below Normal Water Year

Year 0 Below Normal Year (2012)	Baseline Conc. Cl^- (mg/L Cl^-)	TSP (38-Foot Depth)		
			Change in Cl^-	
		Conc. Cl^- (mg/L Cl^-)	(mg/L Cl^-)	Percent
West Canal at Mouth of Clifton Court Forebay (CHWST0)				
January	91.3	93.2	1.9	2.1
February	92.0	93.0	1.0	1.1
March	87.5	87.8	0.3	0.3
April	76.4	76.4	0.0	0.0
May	57.9	57.9	0.0	0.0
June	35.4	35.5	0.1	0.3
July	21.5	21.6	0.1	0.5
August	21.4	21.6	0.2	0.9
September	39.8	40.8	1.0	2.5
October	37.8	38.6	0.8	2.1
November	41.2	42.6	1.4	3.4
December	77.5	79.1	1.6	2.1
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)				
January	111.5	112.7	1.2	1.1
February	116.0	116.6	0.6	0.5
March	123.1	123.3	0.2	0.2
April	92.7	92.7	0.0	0.0
May	62.7	62.7	0.0	0.0
June	43.5	43.6	0.1	0.2
July	23.5	23.6	0.1	0.4
August	23.2	23.4	0.2	0.9
September	43.2	44.0	0.8	1.9
October	43.9	44.5	0.6	1.4
November	61.7	62.6	0.9	1.5
December	104.5	105.4	0.9	0.9

Year 0 Below Normal Year (2012)	Baseline Conc. Cl^- (mg/L Cl^-)	TSP (38-Foot Depth)		
			Change in Cl^-	
		Conc. Cl^- (mg/L Cl^-)	(mg/L Cl^-)	Percent
CCWD Rock Slough Intake (CHCCC06)				
January	120.1	123.2	3.1	2.6
February	94.2	95.8	1.6	1.7
March	57.1	57.4	0.3	0.5
April	69.5	69.6	0.1	0.1
May	54.4	54.4	0.0	0.0
June	34.0	34.1	0.1	0.3
July	26.8	27.0	0.2	0.7
August	30.0	30.5	0.5	1.7
September	65.6	67.3	1.7	2.6
October	57.0	58.4	1.4	2.5
November	65.8	67.8	2.0	3.0
December	172.7	174.5	1.8	1.0
CCWD Old River Intake (ROLD034)				
January	87.1	89.6	2.5	2.9
February	73.3	74.6	1.3	1.8
March	61.7	62.1	0.4	0.6
April	60.5	60.6	0.1	0.2
May	52.5	52.5	0.0	0.0
June	30.0	30.0	0.0	0.0
July	21.1	21.3	0.2	0.9
August	22.6	22.8	0.2	0.9
September	44.6	45.9	1.3	2.9
October	38.7	39.6	0.9	2.3
November	43.5	45.2	1.7	3.9
December	73.8	75.8	2.0	2.7

Year 0 Below Normal Year (2012)	Baseline Conc. Cl^- (mg/L Cl^-)	TSP (38-Foot Depth)		
			Change in Cl^-	
		Conc. Cl^- (mg/L Cl^-)	(mg/L Cl^-)	Percent
CCWD Middle River at Victoria Canal Intake (CCW)				
January	65.8	66.9	1.1	1.7
February	78.4	79.1	0.7	0.9
March	81.6	81.9	0.3	0.4
April	91.6	91.6	0.0	0.0
May	68.0	67.9	-0.1	-0.1
June	43.7	43.6	-0.1	-0.2
July	21.9	22.0	0.1	0.5
August	17.6	17.6	0.0	0.0
September	25.7	25.9	0.2	0.8
October	31.7	31.9	0.2	0.6
November	25.3	25.5	0.2	0.8
December	32.4	33.1	0.7	2.2

Notes:
mg/L Cl^- = Concentration of chloride in milligrams per liter
CCWD = Contra Costa Water District

5.3.3 Effect of TSP on Water Levels During a Below Normal Water Year

Water level comparisons were made at three locations spanning the geographic extent of the project (Figure 3.6-1). For each water level comparison figure included in this section, the top plot shows the tidal time-scale water level variability over a 15-day period for the No Action Alternative and the TSP scenario. The middle plot shows daily-averaged stage during the full simulation year for each scenario. The bottom plot shows the predicted change in daily-averaged stage for the TSP scenario relative to the No Action Alternative. Because the predicted water level is nearly identical between scenarios, a dashed line is used for the TSP scenario because it is plotted on top of the line for the No Action Alternative. Comparisons of the predicted water level for the No Action Alternative and the TSP were made at the Richmond station (Figure 5.2-10) which is seaward of the Pinole Shoal Channel, Martinez (Figure 5.2-11) which is located west of the Suisun Bay Channel, and Mallard Island (Figure 5.2-12). These comparisons show that the predicted water levels for the No Action Alternative and the TSP are nearly identical, and there is virtually no change in predicted water level at any of the stations evaluated during the below normal water year evaluated.

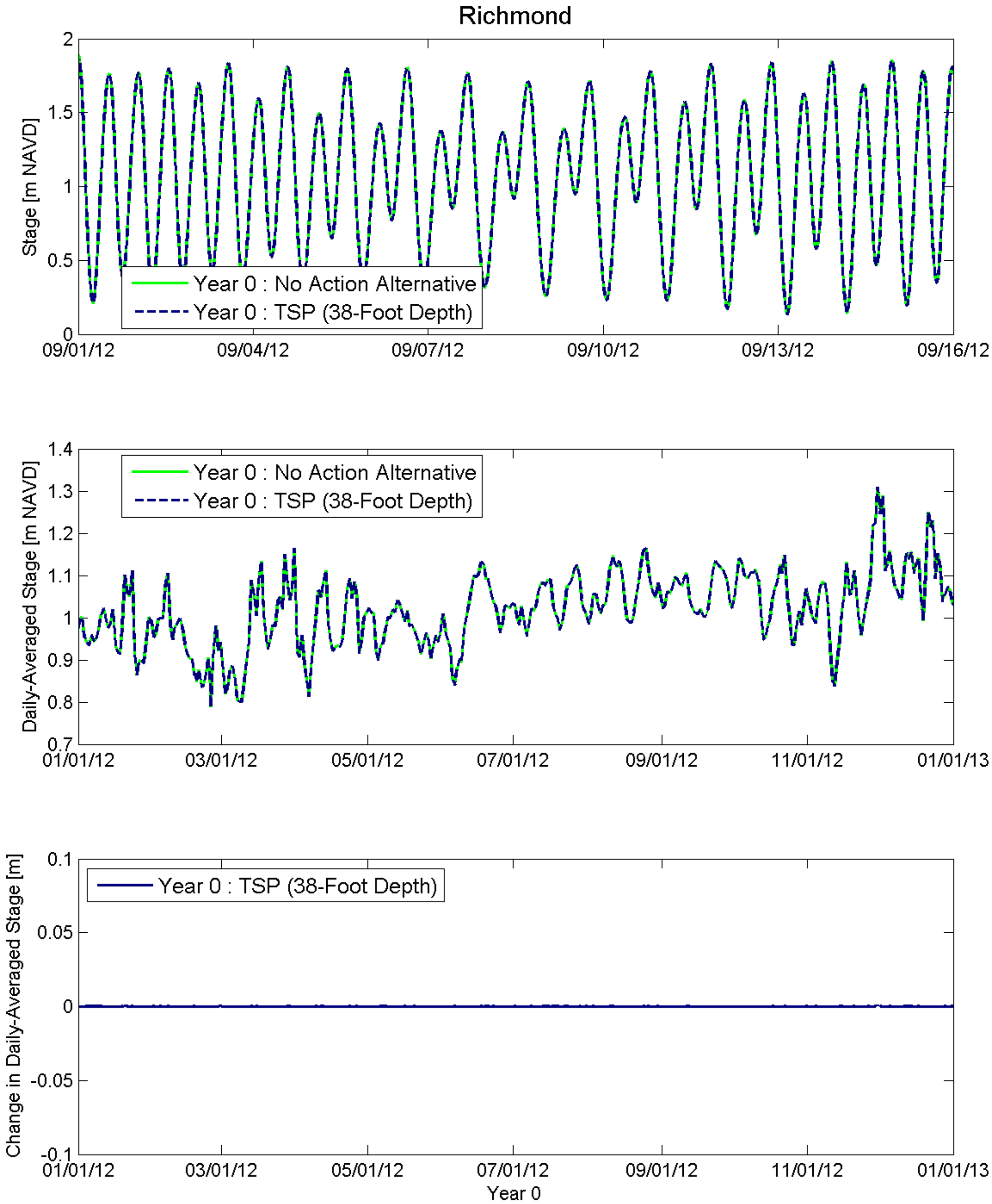


Figure 5.3-10

Predicted Stage at the NOAA Richmond Station for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Below Normal Water Year Evaluated

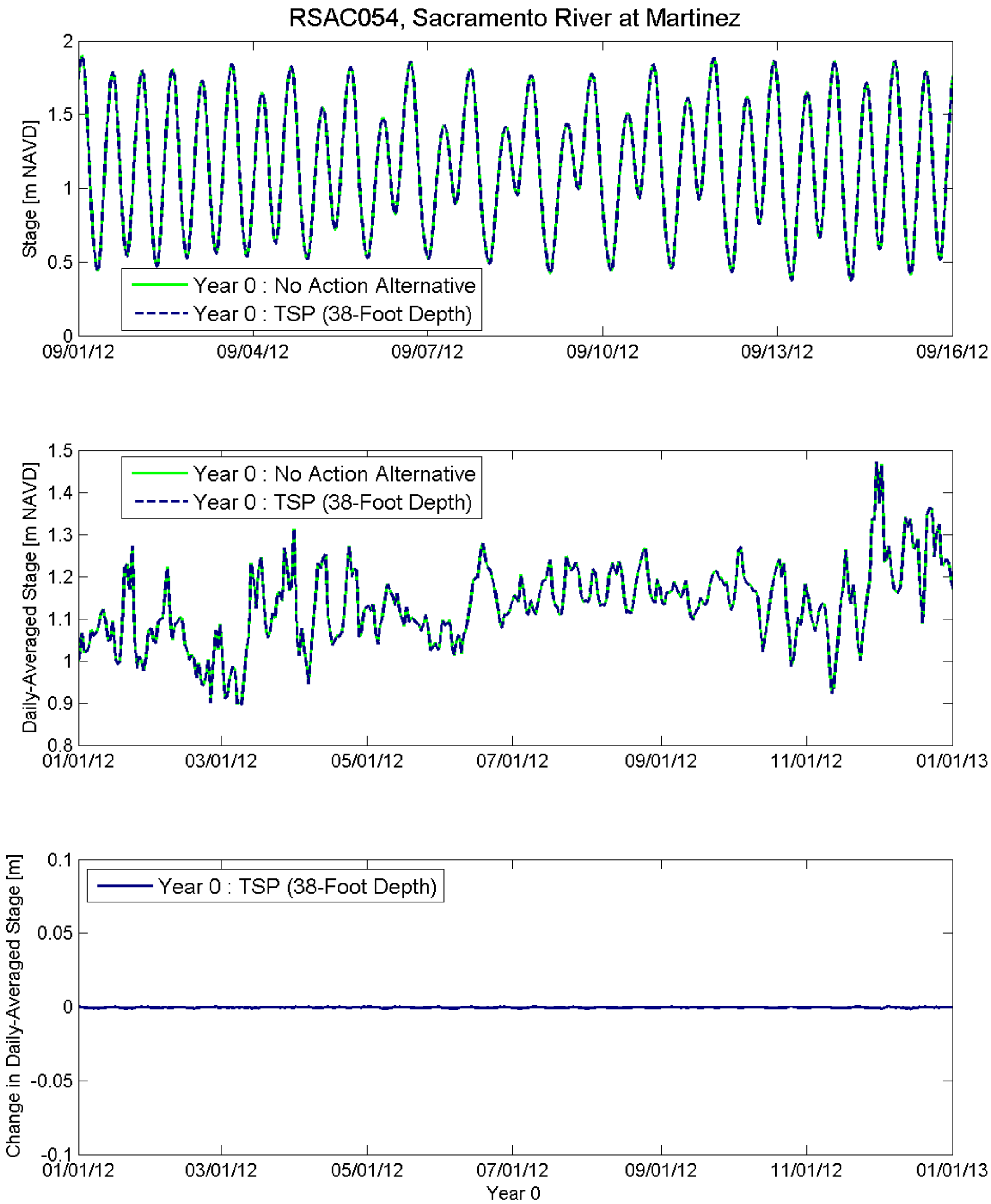


Figure 5.3-11

Predicted Stage at Sacramento River at Martinez (RSAC054) for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Below Normal Water Year Evaluated

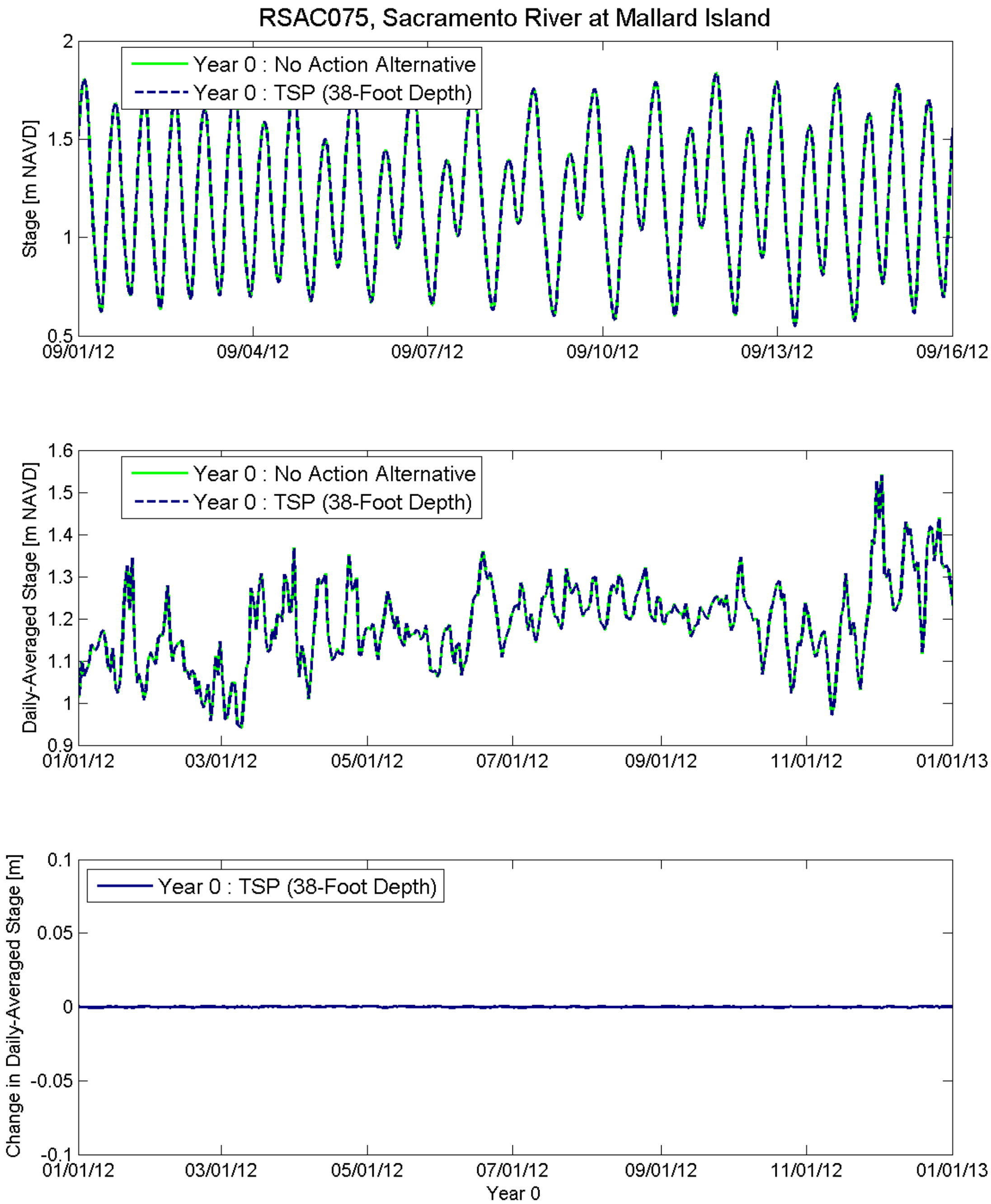


Figure 5.3-12

Predicted Stage at Sacramento River at Mallard Island (RSAC075) for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Below Normal Water Year Evaluated

5.3.4 Effect of TSP on Tidal Flows During a Below Normal Water Year

Flow time series comparisons were made at three locations in San Francisco Bay spanning the geographic extent of the project (Figure 3.7-1). For each flow comparison figure included in this section, the top plot shows the tidal time-scale flows over a 15-day period for the No Action Alternative and the TSP scenario. The middle plot shows tidally-averaged flow during the full simulation year for each scenario. The bottom plot shows the predicted change in tidally-averaged flow for the TSP scenario relative to the No Action Alternative. Because the predicted flow is nearly identical between scenarios, a dashed line is used for the TSP scenario because it is plotted on top of the line for the No Action Alternative. Comparisons of the predicted flow for the No Action Alternative and the TSP were made at the Point San Pablo (Figure 5.3-13) which is seaward of the Pinole Shoal Channel, Carquinez Bridge (Figure 5.3-14) which is located west of the Suisun Bay Channel, and Chipps Island (Figure 5.3-15) which is east of the project area. These comparisons show that the predicted flows for the No Action Alternative and the TSP are nearly identical, with only very small differences in tidally-averaged flows at each location during below normal water year evaluated. These very small differences in tidally-averaged flows are several orders of magnitude smaller than the tidal and tidally-averaged flows and likely result from small phase differences in tidal propagation as a result of the channel deepening.

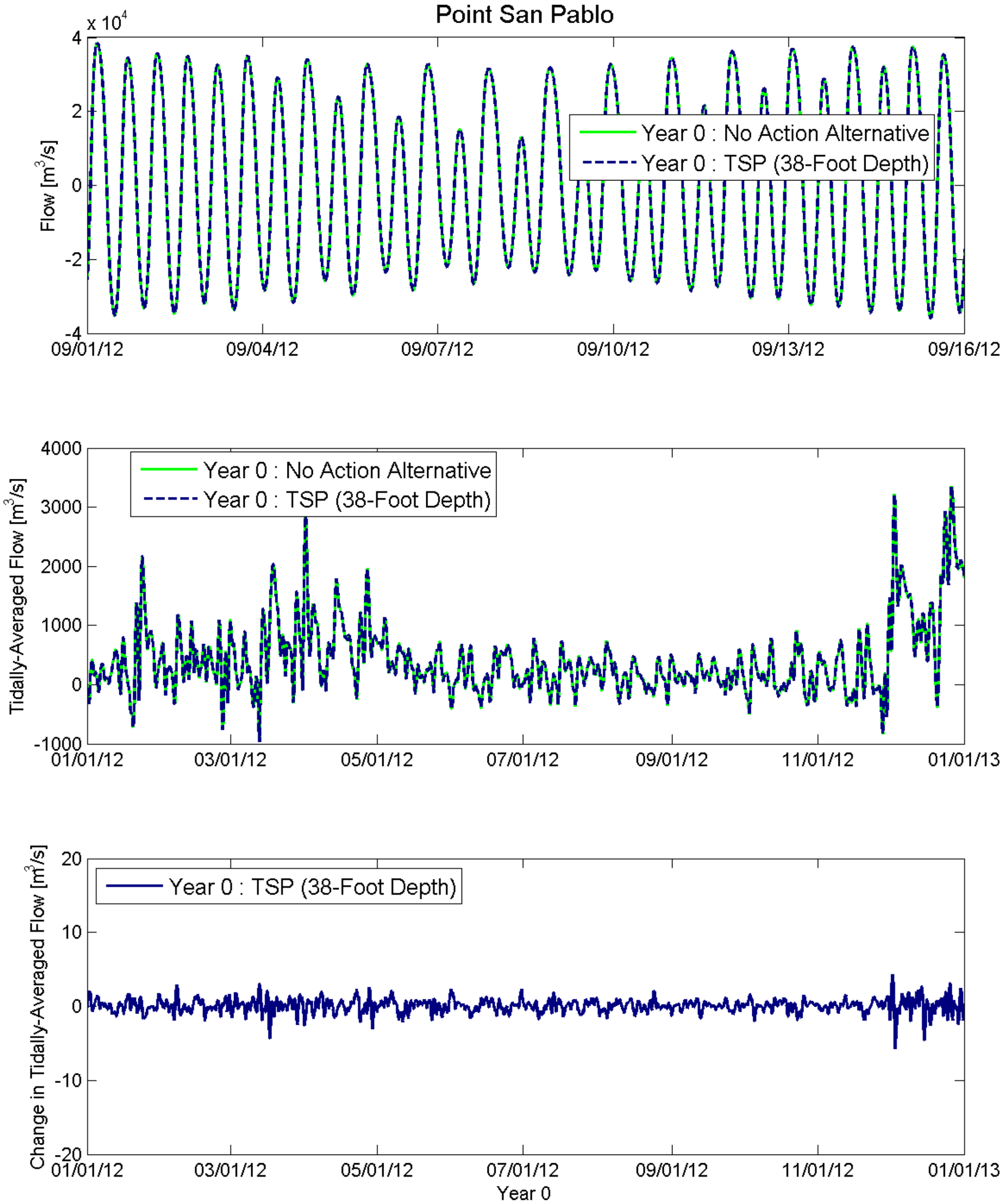


Figure 5.3-13

Predicted Tidal Flow at Point San Pablo for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Below Normal Water Year Evaluated

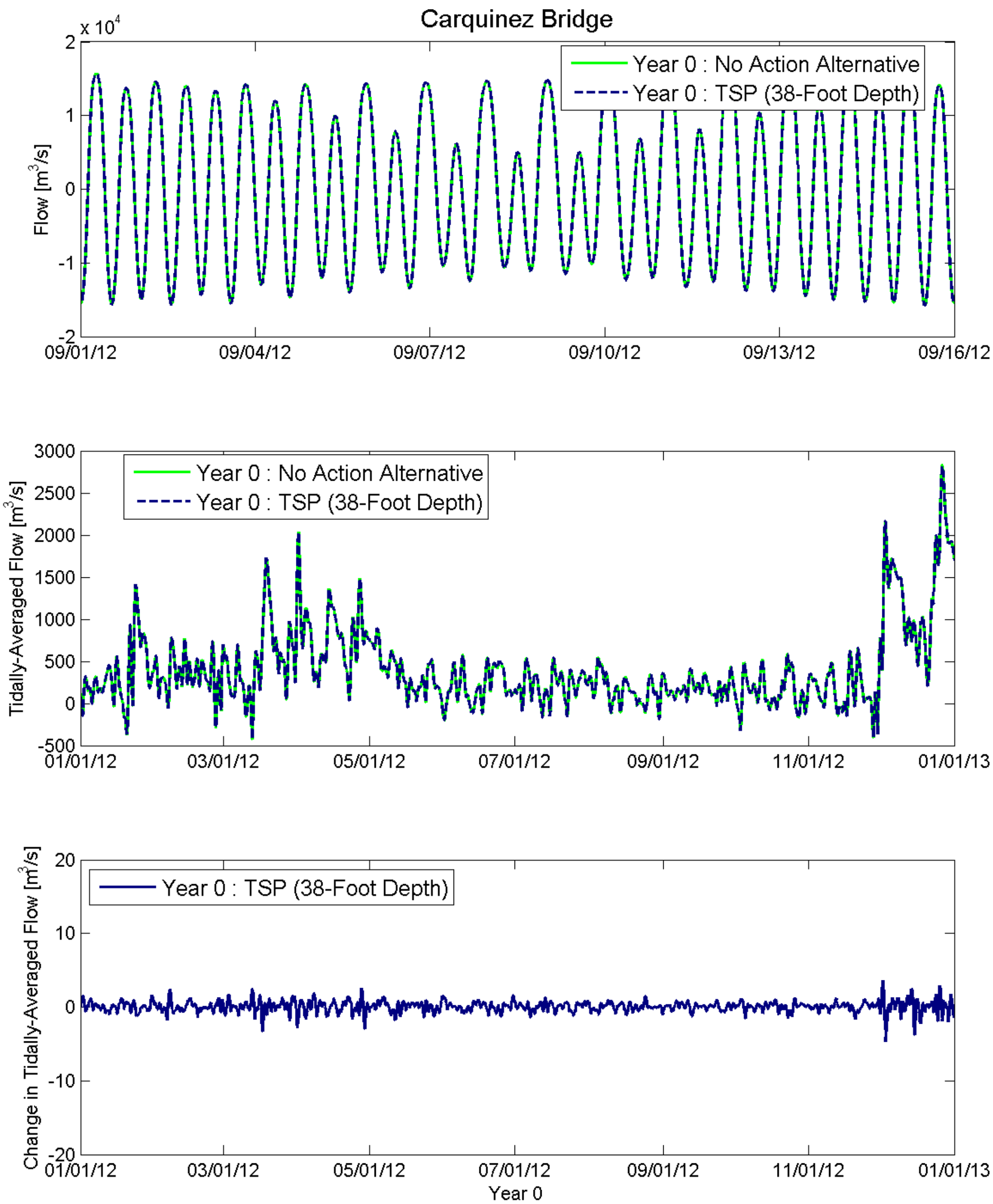


Figure 5.3-14

Predicted Tidal Flow at Carquinez Bridge for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Below Normal Water Year Evaluated

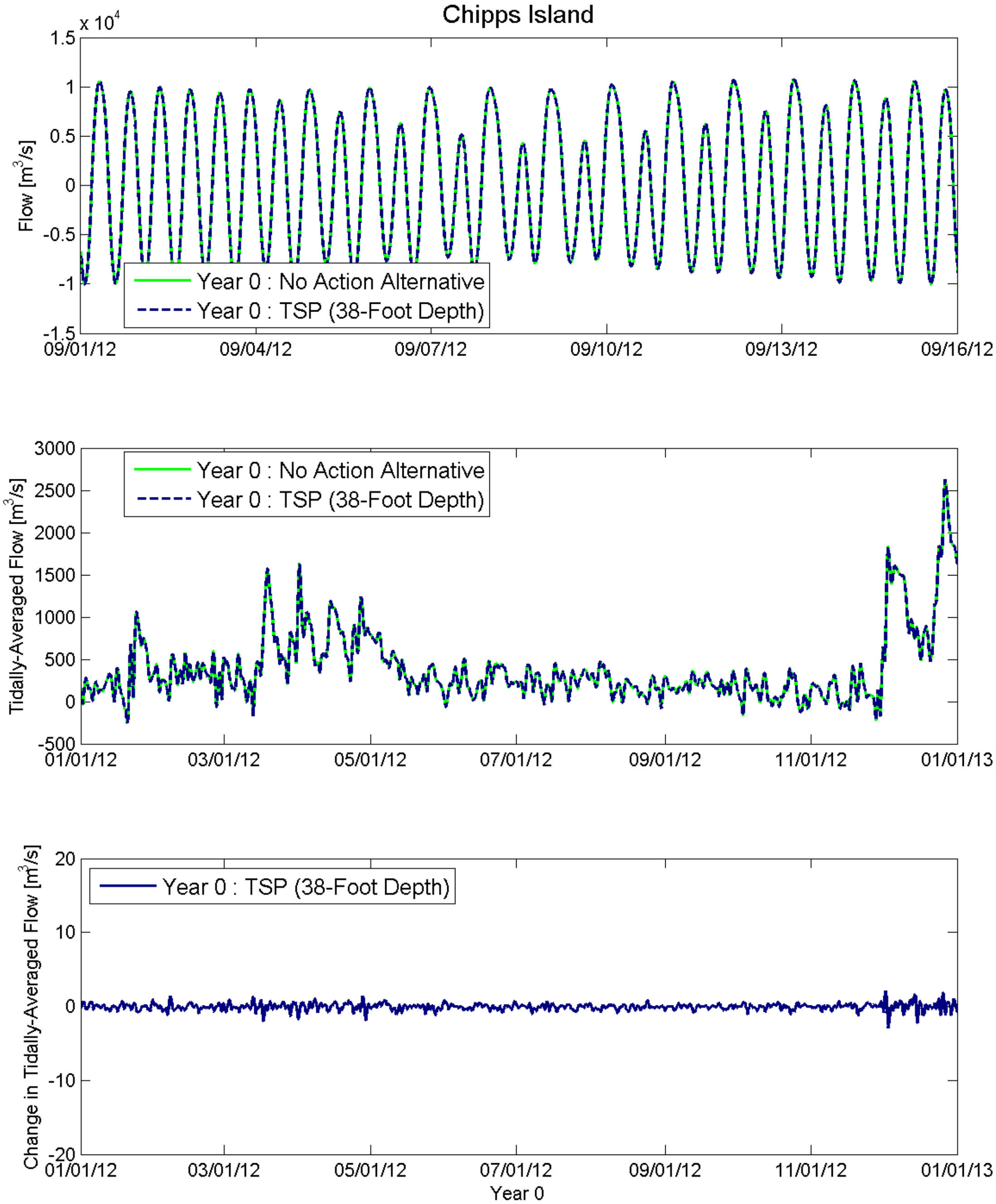


Figure 5.3-15

Predicted Tidal Flow at Chipps Island for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Below Normal Water Year Evaluated

5.4 Evaluation of Effects of TSP on Salinity and X2 During a Wet Water Year

This section presents the evaluation of the TSP on salinity during and following a wet water year. The period evaluated is based on historical conditions between January 1, 2011, and December 31, 2011, as described in Section 3.3.3.

5.4.1 Effect of TSP on X2 During a Wet Water Year

X2 was relatively low throughout 2011, remaining below 64 km for most of the first half of the year (Figure 5.4-1, top). For the TSP, X2 was predicted to increase throughout the year relative to the baseline No Action Alternative (Figure 5.4-1, bottom), with a predicted annual-average increase of 0.27 km. During the period of the year when X2 was greater than 64 km, the predicted average increase in X2 resulting from the TSP was 0.23 km (Table 5-7). The largest predicted increases in X2 occurred at the lowest values of X2, corresponding to the periods when the salinity gradients were pushed west into San Pablo Bay, resulting in stratification in the portions of the Pinole Shoal Channel that would be deepened under the TSP.

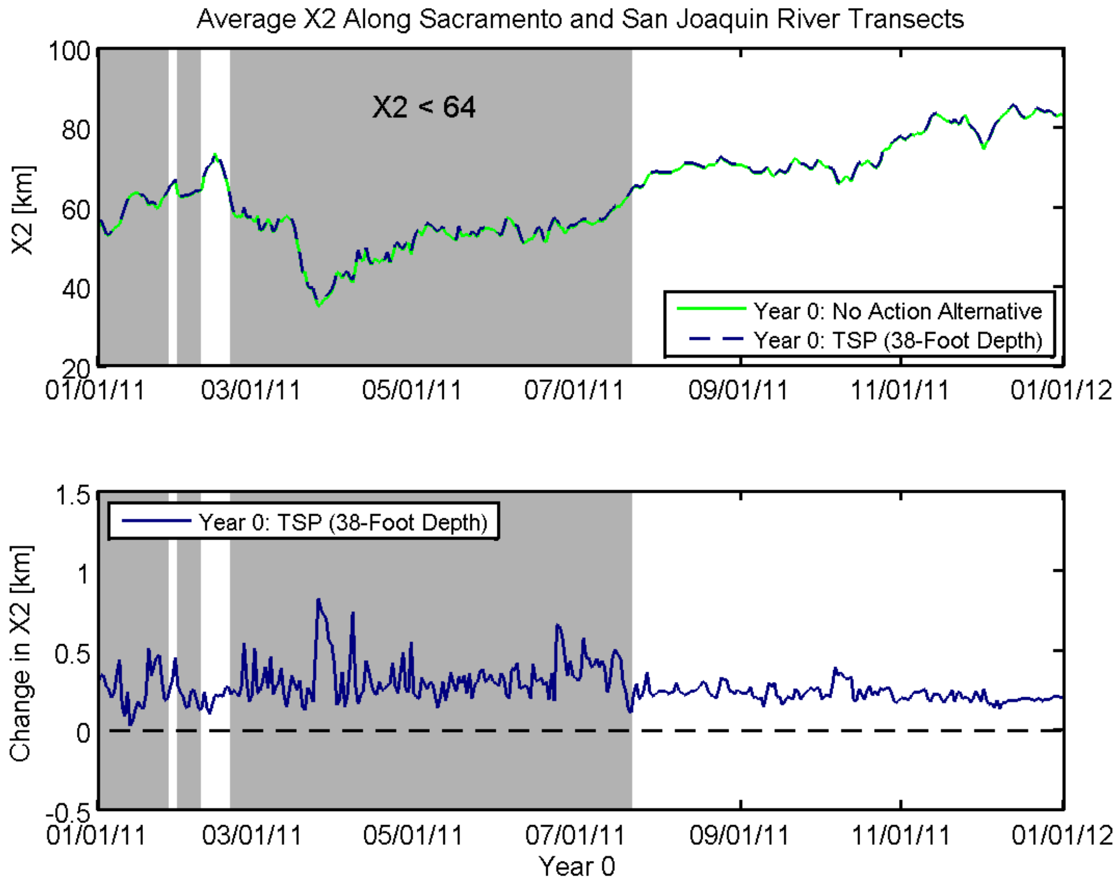
The USFWS BO released on December 15, 2008, includes RPA actions to protect threatened Delta Smelt. The RPA actions in the USFWS BO include limits on exports to control OMR flows and managing Fall X2 through increasing Delta outflow when the preceding year was wetter than normal. The Fall X2 RPA stipulates that the average monthly position of X2 be maintained at 74 km for September, October, and November following a wet water year and that the average monthly position of X2 be maintained at 81 km for September, October, and November following an above normal water year. Based on the wet year simulated, the effect of the TSP during the Fall X2 period (October through November) following the wet water year of 2014 was predicted to be about 0.20 to 0.25 km, which is smaller than the uncertainty associated with the current methods available for estimating X2 from field observations. MacWilliams et al. (2015) provide a detailed discussion of the uncertainty associated with the approaches commonly used to estimate X2 based on either surface salinity measurements or regression relationships based on outflow.

Table 5-7

Predicted Change in X2 for the TSP During a Wet Water Year

Alternative	Change in X2 (km)	
	Annual-Average	Change for X2 > 64
No Action Alternative	Baseline	Baseline
TSP (38-Foot Depth)	0.27	0.23

Notes:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2, so the average change for periods when X2 >64 is also shown separately.
km = kilometers
TSP = Tentatively Selected Plan



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 5.4-1
Predicted X2 for the Year 0 No Action Alternative and the TSP During a Wet Water Year (Top); Predicted Change in X2 Relative to the Year 0 No Action Alternative for the TSP During a Wet Water Year (Bottom)

5.4.2 Effect of TSP on Water Quality at D-1641 Stations During a Wet Water Year

The effect of the TSP on the predicted Cl^- concentration at the five intake and export locations in the south Delta (locations shown in Figure 3.5-1) was evaluated to assess the potential effects on water quality at the municipal and industrial intakes at which D-1641 has established water quality criteria. Figure 5.4-2 through Figure 5.4-6 show the mean daily Cl^- concentration for the No Action Alternative and the TSP and the predicted change in Cl^-

concentration resulting from the TSP during 2011. Table 5-8 summarizes the predicted annual-average change in Cl^- concentration and the maximum predicted monthly average change in Cl^- concentration at five intake and export locations. During the wet water year, the predicted annual-average change in Cl^- concentration was 0.0 mg/L at two of the five intake and export locations in the south Delta, and the maximum predicted annual-average change was 0.1 mg/L at the remaining three locations. The predicted maximum monthly average change ranged from 0.1 mg/L at the CCWD Middle River at Victoria Canal Intake to 1.1 mg/L at the CCWD Rock Slough Intake. The predicted monthly average change in Cl^- concentration during each month in 2011 for both the TSP is included in Table 5-9 at the end of Section 5.4.

Figure 5.4-7 shows the number of days that the maximum mean daily concentration of Cl^- is less than 150 mg/l at CHCCC06 and RSAN007. To meet the wet water year water quality objective, the number of days that mean daily concentration of Cl^- is less than 150 mg/l should exceed 240 days at either CHCCC06 or RSAN007. At CHCCC06, the mean daily concentration of Cl- is less than 150 mg/l for 365 days under the Year 0 No Action Alternative and 365 days for the Year 0 TSP scenario (no change relative to the Year 0 No Action Alternative). At RSAN007, the mean daily concentration of Cl^- is less than 150 mg/l for 308 days under the Year 0 No Action Alternative and 308 days for the Year 0 TSP scenario (no change relative to the Year 0 No Action Alternative). Because this standard stipulates that daily mean chloride concentration must be less than 150 mg/l for at least 240 days during a wet water year at either Contra Costa Canal at Pumping Plant #1 or the Antioch Water Works intake, this standard is met for both the Year 0 No Action Alternative and the Year 0 TSP scenario because this water quality standard is met at both CHCCC06 and RSAN007 under both scenarios for the wet water year evaluated.

The D-1641 water quality objectives for agricultural beneficial uses in the Western Delta, shown in Table 3-2, are based on the maximum 14-day running average electrical conductivity. The western Delta water quality objectives for agricultural beneficial use depend on water year type on the Sacramento River and apply only from April 1 to August 15. Water year 2011 (from October 1, 2010, through September 30, 2011) was classified as a wet water year. Because the April 1 through August 15 period falls within water year 2011, the wet year water quality objectives shown in Table 3-2 are applied for the western Delta stations.

Figure 5.4-8 shows the predicted 14-day running average electrical conductivity on the Sacramento River at Emmaton for the Year 0 No Action Alternative and the Year 0 TSP scenario. No significant changes in 14-day running average electrical conductivity under the Year 0 TSP scenario are predicted on the Sacramento River at Emmaton during the wet water year. The water quality objectives for agricultural beneficial use apply from April 1 through August 15. As seen in Figure 5.4-8, the water quality objective of maximum 14-day running average electrical conductivity on the Sacramento River at Emmaton is not exceeded for any days under the Year 0 No Action Alternative or the Year 0 TSP scenario during the wet water year evaluated.

Figure 5.4-9 shows the predicted 14-day running average electrical conductivity on the San Joaquin River at Jersey Point for the Year 0 No Action Alternative and the Year 0 TSP scenario. No significant changes in 14-day running average electrical conductivity under the Year 0 TSP scenario are predicted on the San Joaquin River at Jersey Point during the wet water year. The water quality objectives for agricultural beneficial use apply from April 1 through August 15. The water quality objective of maximum 14-day running average electrical conductivity on the San Joaquin River at Jersey Point was not predicted to be exceeded under the Year 0 No Action Alternative or the Year 0 TSP scenario during the wet water year evaluated.

Table 5-8

Predicted Annual-Average and Maximum Monthly Average Change in Chloride Concentration Relative to the No Action Alternative for the TSP at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Wet Water Year

Year 0 Wet Water Year (2011)	Change in Chloride Concentration (mg/L Cl^-)	
	Annual-Average Change	Max Monthly Average Change
West Canal at Mouth of Clifton Court Forebay (CHWST0)	0.1	0.6
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)	0.0	0.4
CCWD Rock Slough Intake (CHCCC06)	0.1	1.1
CCWD Old River Intake (ROLD034)	0.1	0.5
CCWD Middle River at Victoria Canal Intake (CCW)	0.0	0.1

Notes:
CCWD = Contra Costa Water District
mg/L Cl^- = Concentration of chloride in milligrams per liter

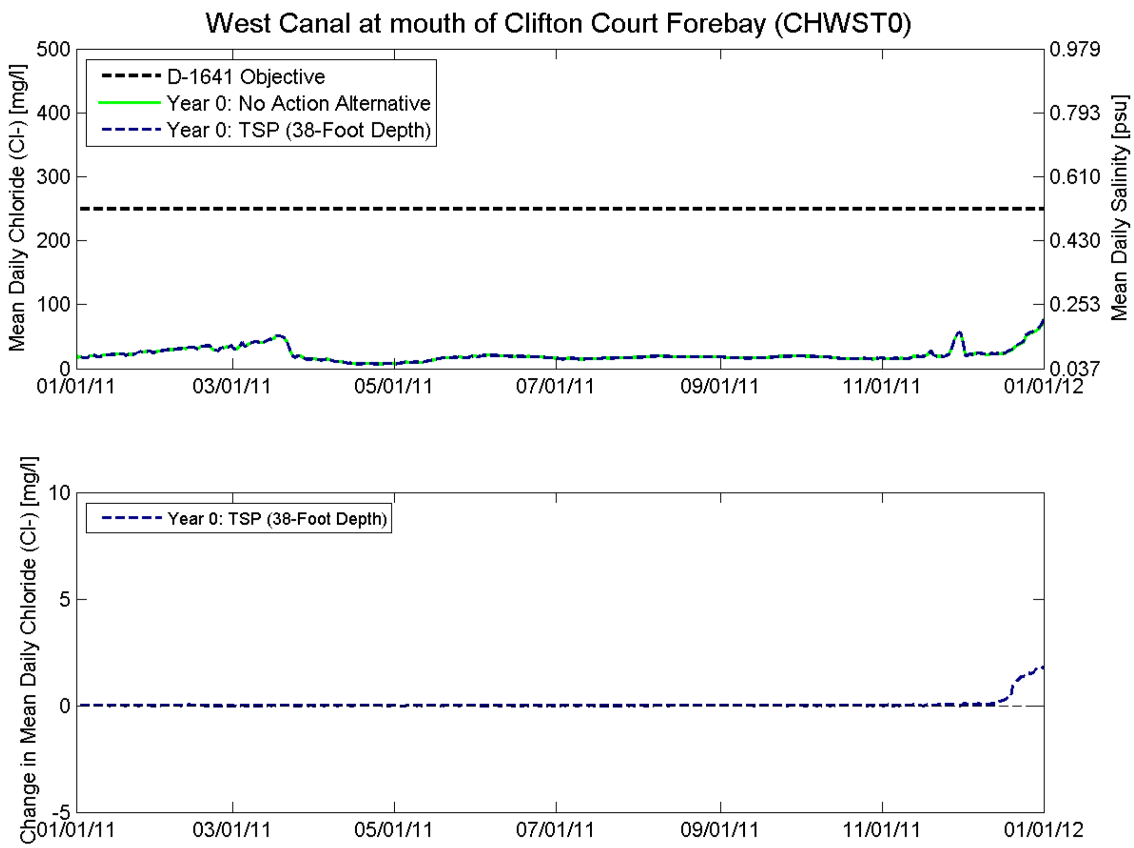


Figure 5.4-2

Predicted Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay Relative to the Year 0 No Action Alternative for the TSP During a Wet Water Year (Bottom)

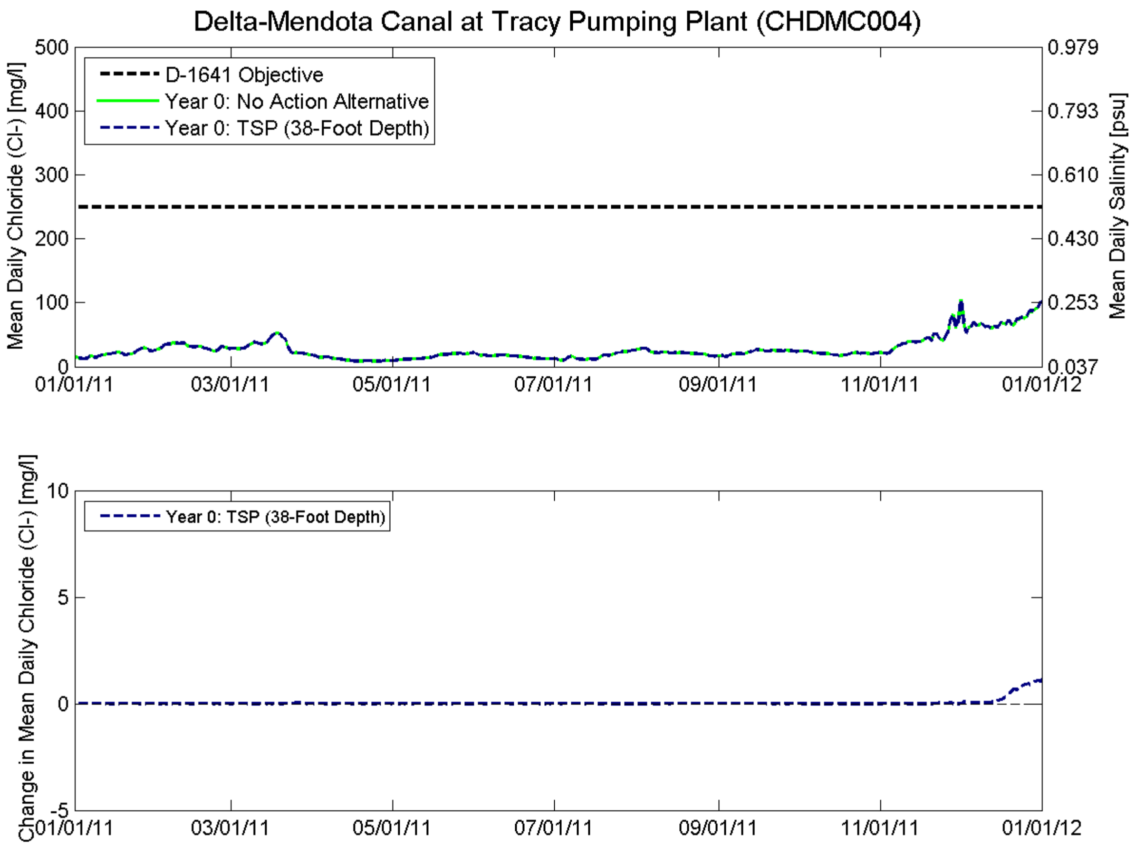


Figure 5.4-3

Predicted Mean Daily Cl^- Concentration at the Tracy Pumping Plant (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Tracy Pumping Plant Relative to the Year 0 No Action Alternative for the TSP During a Wet Water Year (Bottom)

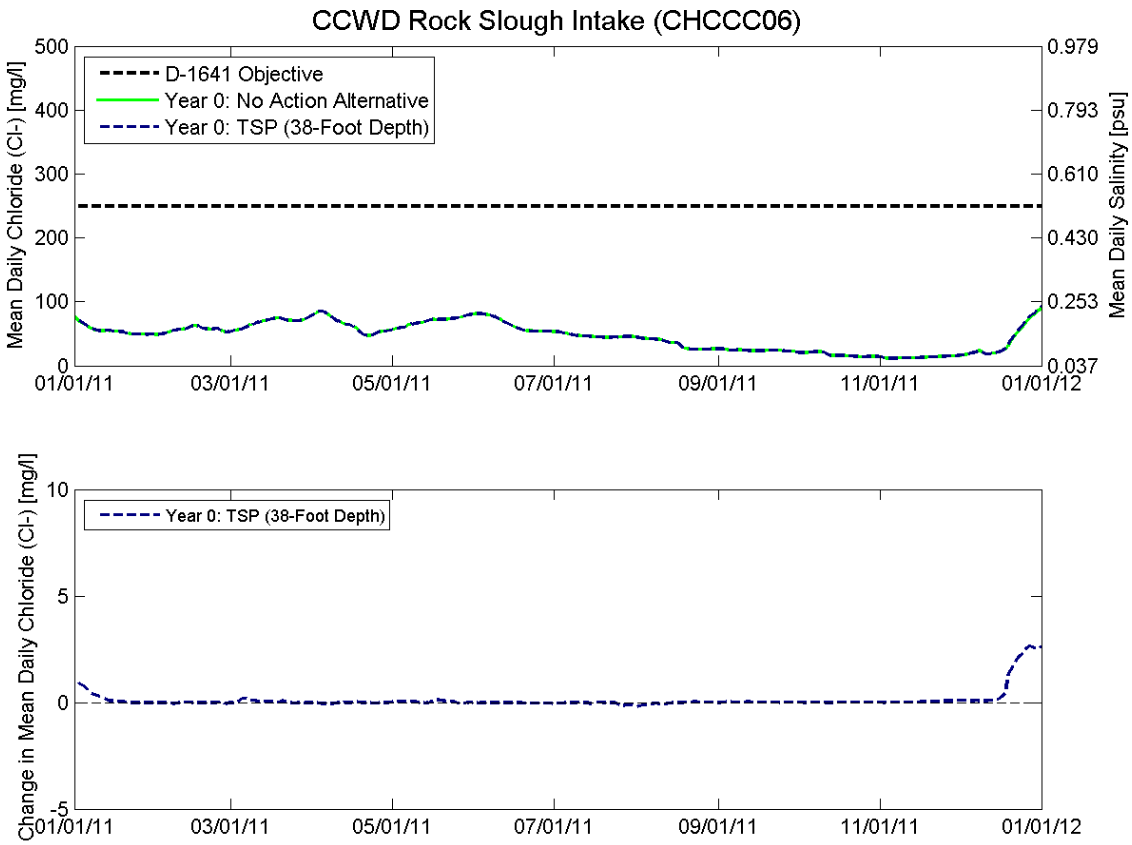


Figure 5.4-4

Predicted Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake Relative to the Year 0 No Action Alternative for the TSP During a Wet Water Year (Bottom)

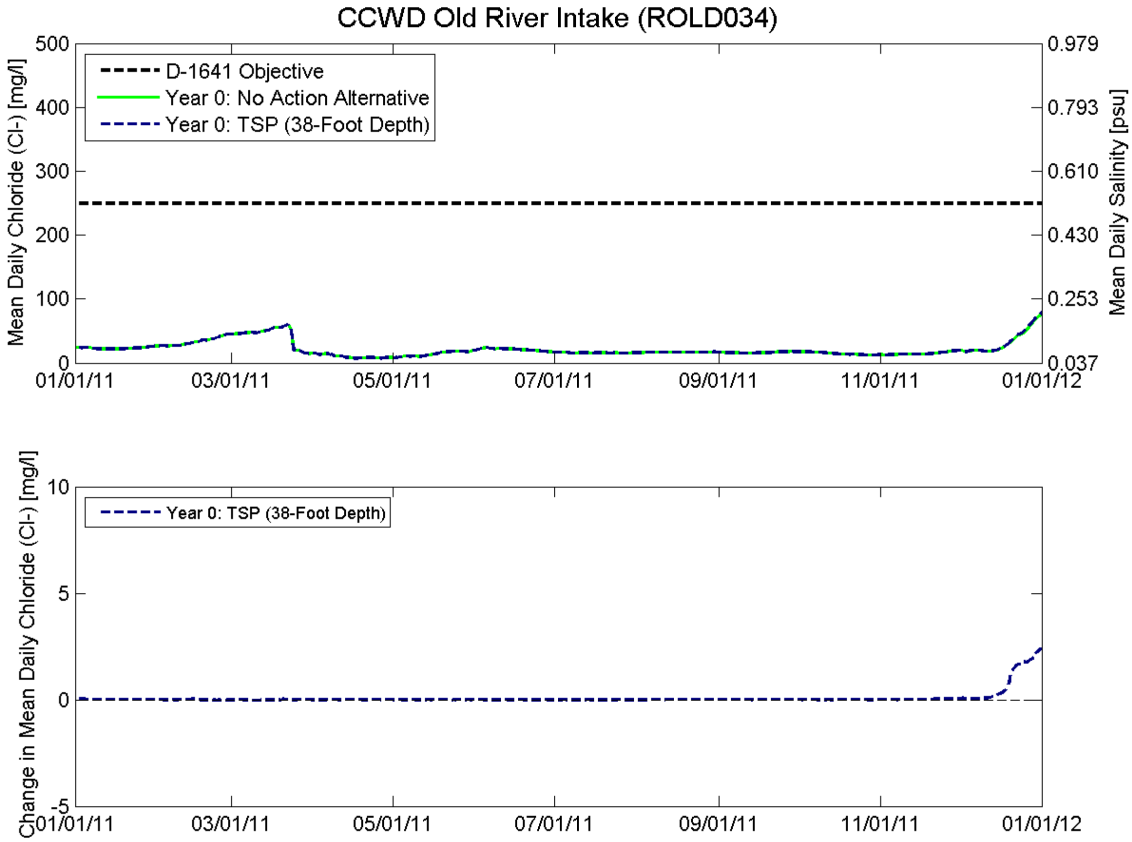


Figure 5.4-5

Predicted Mean Daily Cl^- Concentration at the CCWD Old River Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Old River Intake Relative to the Year 0 No Action Alternative for the TSP During a Wet Water Year (Bottom)

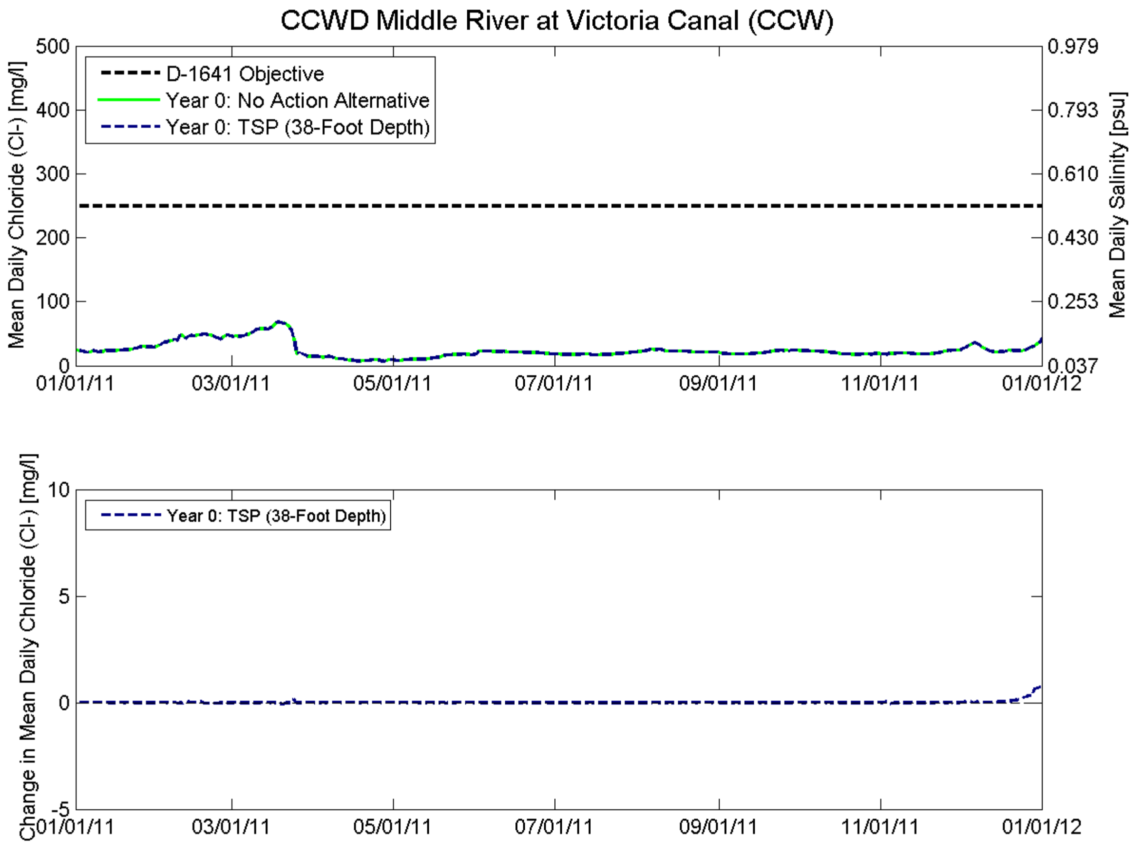


Figure 5.4-6

Predicted Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake (location shown in Figure 3.5-1) for the Year 0 No Action Alternative and the TSP During a Wet Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake Relative to the Year 0 No Action Alternative for the TSP During a Wet Water Year (Bottom)

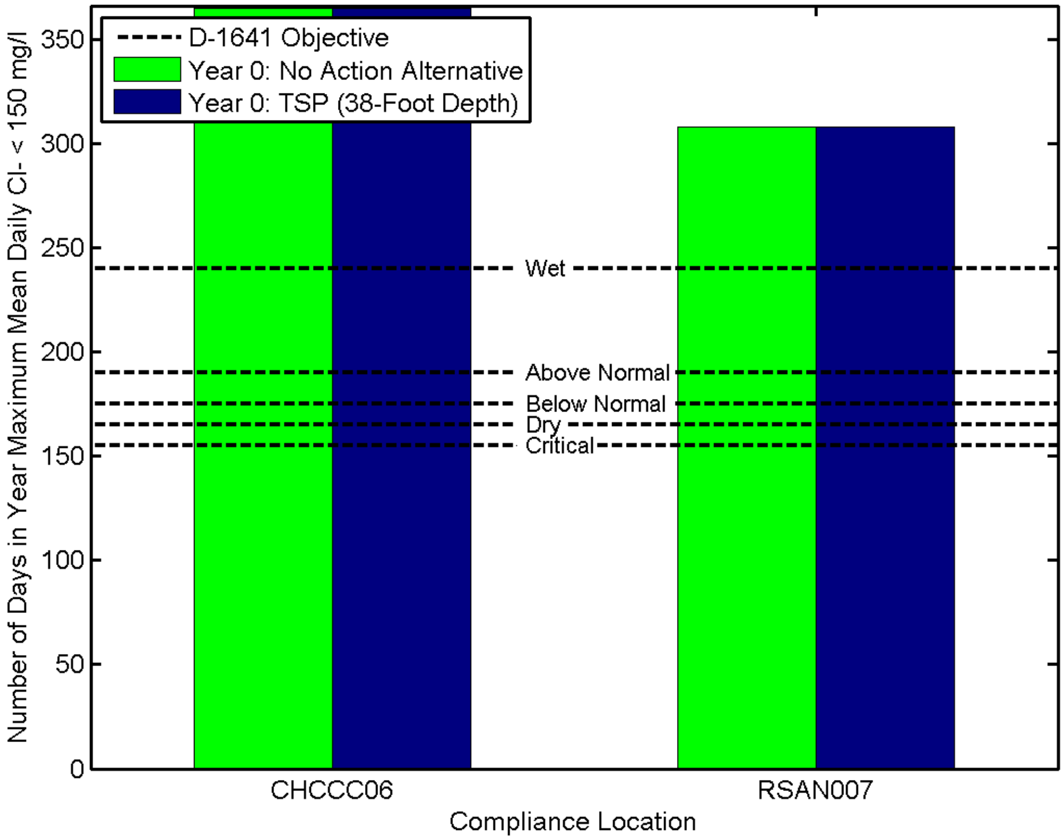


Figure 5.4-7

Number of Days During the Year 0 Simulation Period That Predicted Mean Daily Concentration of Cl^- Is Less Than 150 mg/L at Contra Costa Canal at Pumping Plant #1 (CHCCC06) and the Antioch Water Works Intake (RSAN007) for the Year 0 No Action Alternative and the TSP During a Wet Water Year

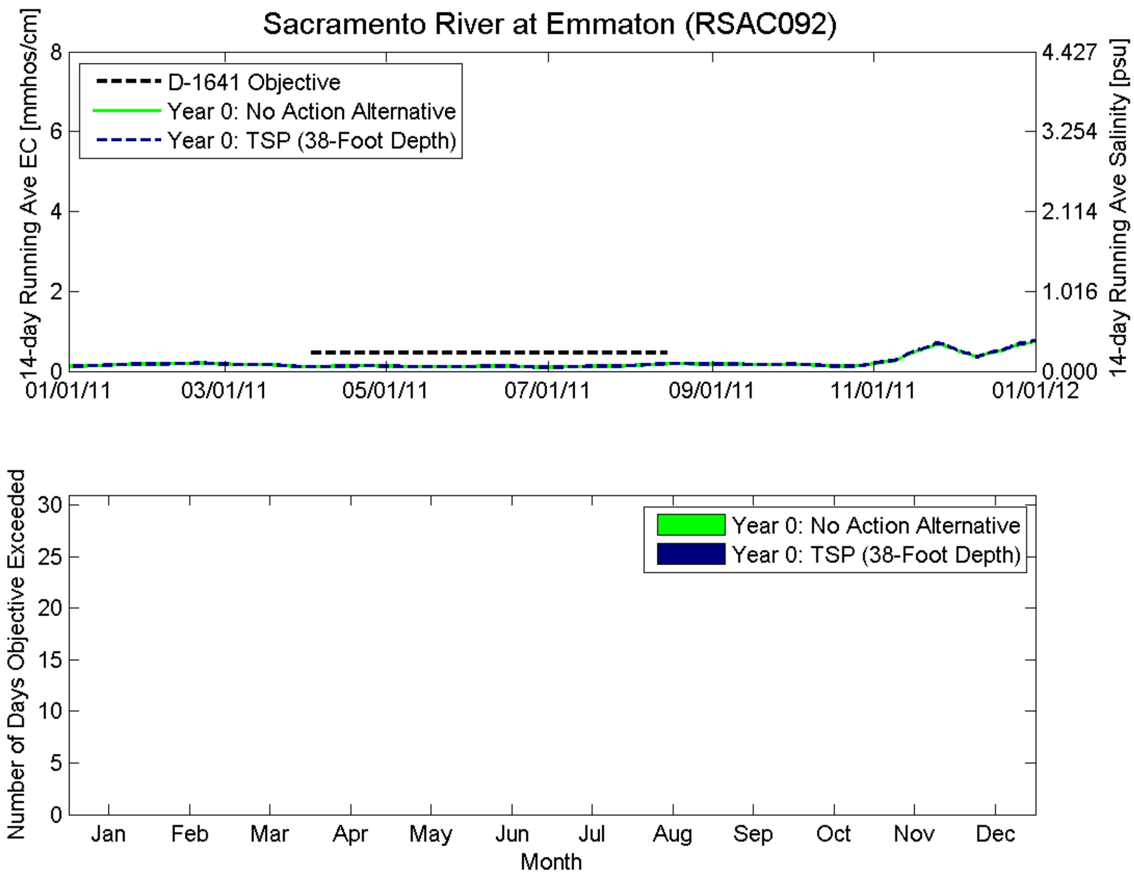


Figure 5.4-8

Predicted 14-Day Running Average Electrical Conductivity at Sacramento River at Emmaton (RSAC092) for the Year 0 No Action Alternative and the TSP During a Wet Water Year (Top); Number of Days Each Month That Predicted 14-Day Running Average Electrical Conductivity at RSAC092 Exceeds D-1641 Water Quality Objectives for Each Scenario During Year 0 for the Wet Water Year Evaluated (Bottom)

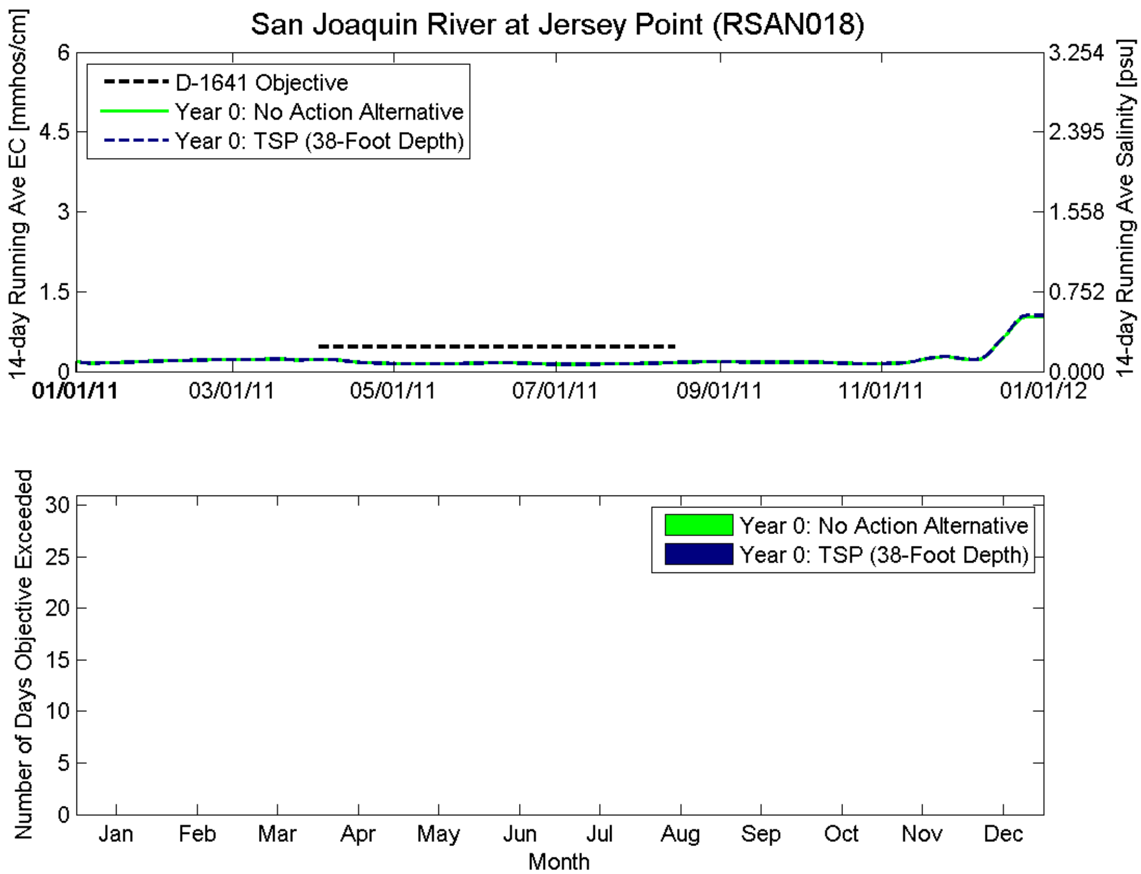


Figure 5.4-9
Predicted 14-Day Running Average Electrical Conductivity at San Joaquin River at Jersey Point (RSAN018) for the Year 0 No Action Alternative and the TSP During a Wet Water Year (Top); Number of Days Each Month That Predicted 14-Day Running Average Electrical Conductivity at RSAN018 Exceeds D-1641 Water Quality Objectives for Each Scenario During Year 0 for the Wet Water Year Evaluated (Bottom)

Table 5-9
Predicted Monthly Average Cl^- Concentration and Predicted Change in Cl^- Relative to the No Action Alternative for TSP at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Wet Water Year

Year 0 Wet Water Year (2011)	Baseline Conc. Cl^- (mg/L Cl^-)	TSP (38-Foot Depth)		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent
West Canal at Mouth of Clifton Court Forebay (CHWST0)				
January	21.8	21.8	0.0	0.0
February	31.0	31.0	0.0	0.0
March	30.5	30.5	0.0	0.0
April	9.4	9.4	0.0	0.0
May	13.6	13.6	0.0	0.0
June	18.8	18.8	0.0	0.0
July	16.0	15.9	-0.1	-0.6
August	18.4	18.4	0.0	0.0
September	17.6	17.6	0.0	0.0
October	16.8	16.8	0.0	0.0
November	21.0	21.0	0.0	0.0
December	30.1	30.7	0.6	2.0
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)				
January	20.0	20.0	0.0	0.0
February	30.1	30.1	0.0	0.0
March	30.0	30.0	0.0	0.0
April	11.0	11.0	0.0	0.0
May	15.9	15.9	0.0	0.0
June	15.7	15.7	0.0	0.0
July	16.2	16.2	0.0	0.0
August	21.7	21.7	0.0	0.0
September	22.6	22.6	0.0	0.0
October	20.9	20.9	0.0	0.0
November	40.5	40.5	0.0	0.0
December	71.8	72.2	0.4	0.6

Year 0 Wet Water Year (2011)	Baseline Conc. Cl^- (mg/L Cl^-)	TSP (38-Foot Depth)		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^-	
			(mg/L Cl^-)	Percent
CCWD Rock Slough Intake (CHCCC06)				
January	55.2	55.4	0.2	0.4
February	56.2	56.1	-0.1	-0.2
March	68.2	68.2	0.0	0.0
April	63.7	63.6	-0.1	-0.2
May	69.9	69.9	0.0	0.0
June	64.8	64.7	-0.1	-0.2
July	47.0	47.0	0.0	0.0
August	32.0	31.9	-0.1	-0.3
September	24.0	24.0	0.0	0.0
October	17.2	17.2	0.0	0.0
November	13.2	13.3	0.1	0.8
December	33.1	34.2	1.1	3.3
CCWD Old River Intake (ROLD034)				
January	23.3	23.3	0.0	0.0
February	32.3	32.3	0.0	0.0
March	39.0	39.0	0.0	0.0
April	9.9	9.9	0.0	0.0
May	13.9	13.9	0.0	0.0
June	20.8	20.8	0.0	0.0
July	15.9	15.9	0.0	0.0
August	16.7	16.7	0.0	0.0
September	16.3	16.3	0.0	0.0
October	14.7	14.7	0.0	0.0
November	14.8	14.8	0.0	0.0
December	28.9	29.4	0.5	1.7

Year 0 Wet Water Year (2011)	Baseline Conc. Cl^- (mg/L Cl^-)	TSP (38-Foot Depth)		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^-	
			(mg/L Cl^-)	Percent
CCWD Middle River at Victoria Canal Intake (CCW)				
January	24.9	24.9	0.0	0.0
February	43.7	43.7	0.0	0.0
March	44.1	44.1	0.0	0.0
April	10.0	10.0	0.0	0.0
May	13.0	13.0	0.0	0.0
June	20.9	20.9	0.0	0.0
July	18.2	18.2	0.0	0.0
August	22.6	22.6	0.0	0.0
September	20.7	20.7	0.0	0.0
October	20.1	20.1	0.0	0.0
November	20.0	20.0	0.0	0.0
December	26.4	26.5	0.1	0.4

Notes:
mg/L Cl^- = Concentration of chloride in milligrams per liter
CCWD = Contra Costa Water District

5.4.3 *Effect of TSP on Water Levels During a Wet Water Year*

Water level comparisons were made at three locations spanning the geographic extent of the project (Figure 3.6-1). For each water level comparison figure included in this section, the top plot shows the tidal time-scale water level variability over a 15-day period for the No Action Alternative and the TSP scenario. The middle plot shows daily-averaged stage during the full simulation year for each scenario. The bottom plot shows the predicted change in daily-averaged stage for the TSP scenario relative to the No Action Alternative. Because the predicted water level is nearly identical between scenarios, a dashed line is used for the TSP scenario because it is plotted on top of the line for the No Action Alternative. Comparisons of the predicted water level for the No Action Alternative and the TSP were made at the Richmond station (Figure 5.4-10) which is seaward of the Pinole Shoal Channel, Martinez (Figure 5.4-11) which is located west of the Suisun Bay Channel, and Mallard Island (Figure 5.4-12). These comparisons show that the predicted water levels for the No Action Alternative and the TSP are nearly identical, and there is virtually no change in predicted water level at any of the stations evaluated during the wet water year evaluated.

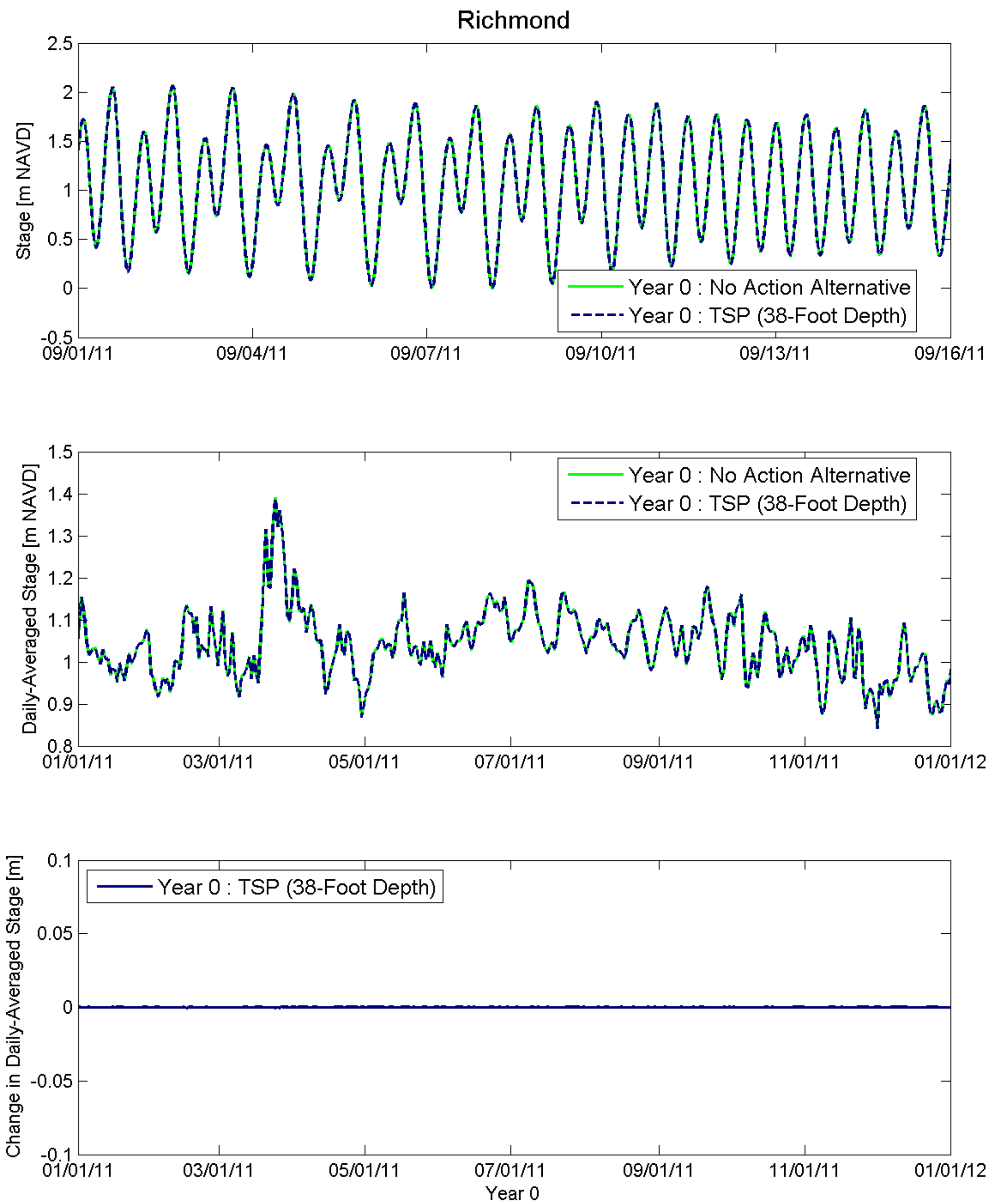


Figure 5.4-10

Predicted Stage at the NOAA Richmond Station for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Wet Water Year Evaluated

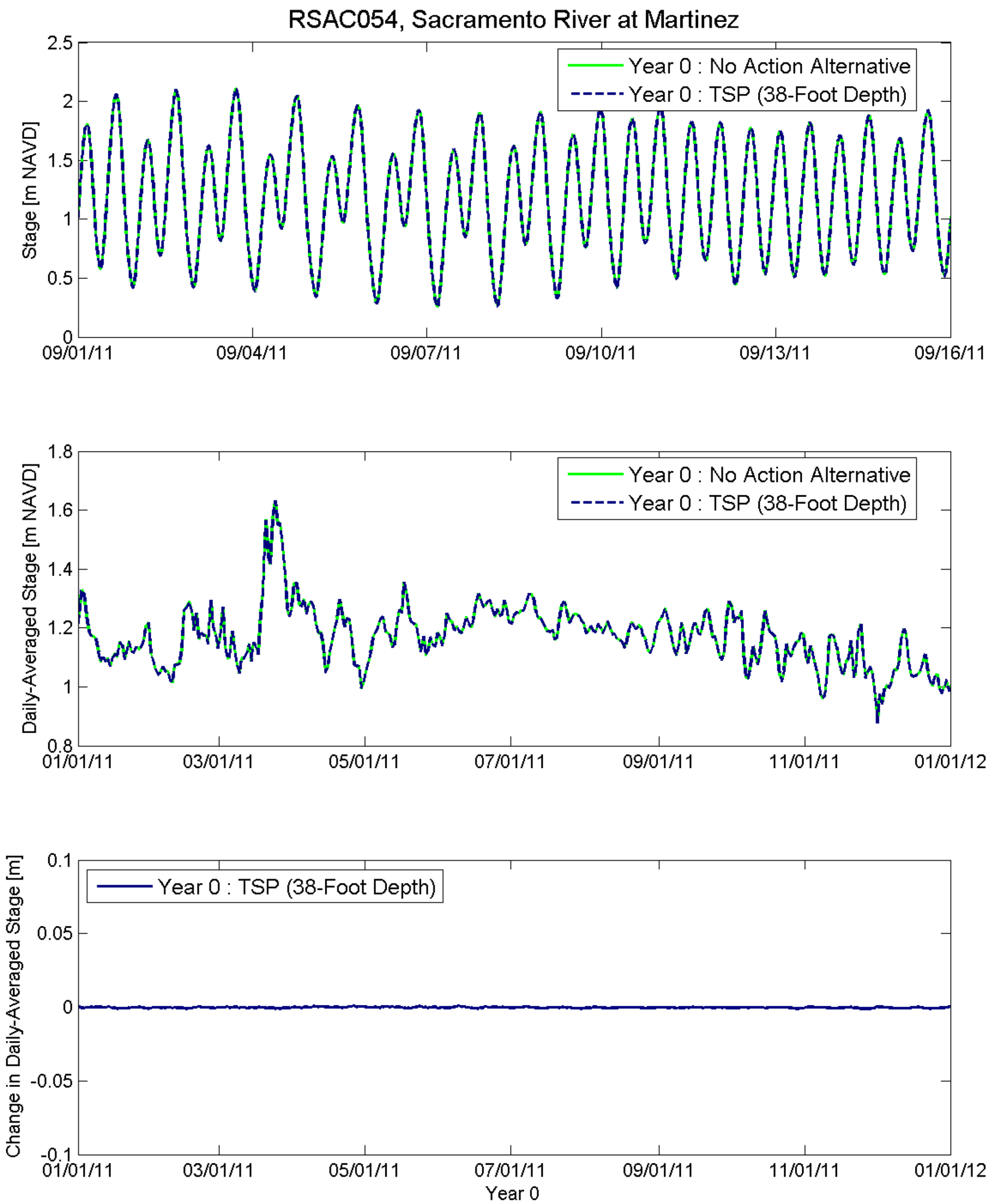


Figure 5.4-11

Predicted Stage at Sacramento River at Martinez (RSAC054) for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Wet Water Year Evaluated

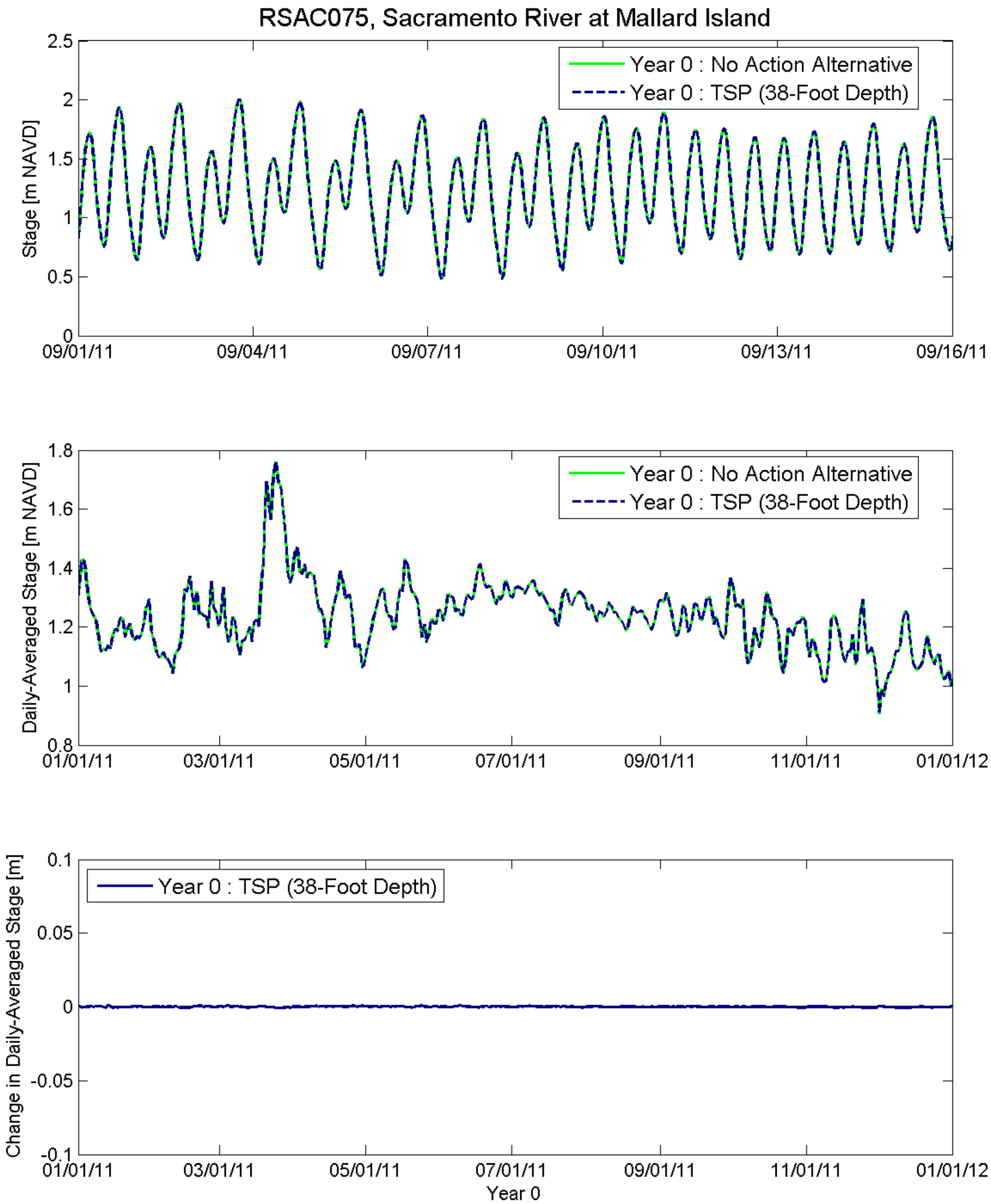


Figure 5.4-12

Predicted Stage at Sacramento River at Mallard Island (RSAC075) for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Wet Water Year Evaluated

5.4.4 Effect of TSP on Tidal Flows During a Wet Water Year

Flow time series comparisons were made at three locations in San Francisco Bay spanning the geographic extent of the project (Figure 3.7-1). For each flow comparison figure included in this section, the top plot shows the tidal time-scale flows over a 15-day period for the No Action Alternative and the TSP scenario. The middle plot shows tidally-averaged flow during the full simulation year for each scenario. The bottom plot shows the predicted change in tidally-averaged flow for the TSP scenario relative to the No Action Alternative. Because the predicted flow is nearly identical between scenarios, a dashed line is used for the TSP scenario because it is plotted on top of the line for the No Action Alternative. Comparisons of the predicted flow for the No Action Alternative and the TSP were made at the Point San Pablo (Figure 5.4-13) which is seaward of the Pinole Shoal Channel, Carquinez Bridge (Figure 5.4-14) which is located west of the Suisun Bay Channel, and Chipps Island (Figure 5.4-15) which is east of the project area. These comparisons show that the predicted flows for the No Action Alternative and the TSP are nearly identical, with only very small differences in tidally-averaged flows at each location during the wet water year evaluated. These very small differences in tidally-averaged flows are several orders of magnitude smaller than the tidal and tidally-averaged flows and likely result from small phase differences in tidal propagation as a result of the channel deepening.

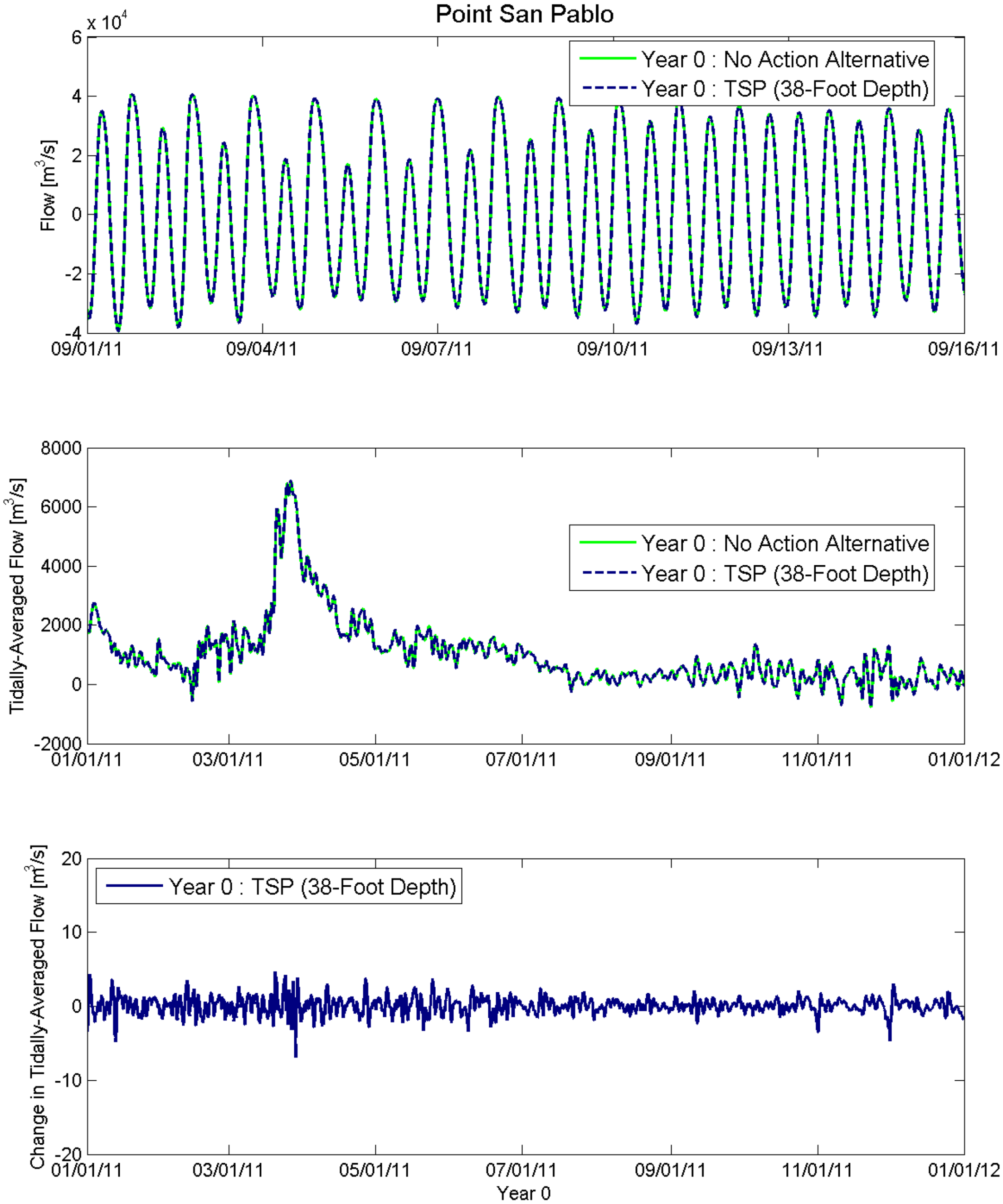


Figure 5.4-13

Predicted Tidal Flow at Point San Pablo for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Wet Water Year Evaluated

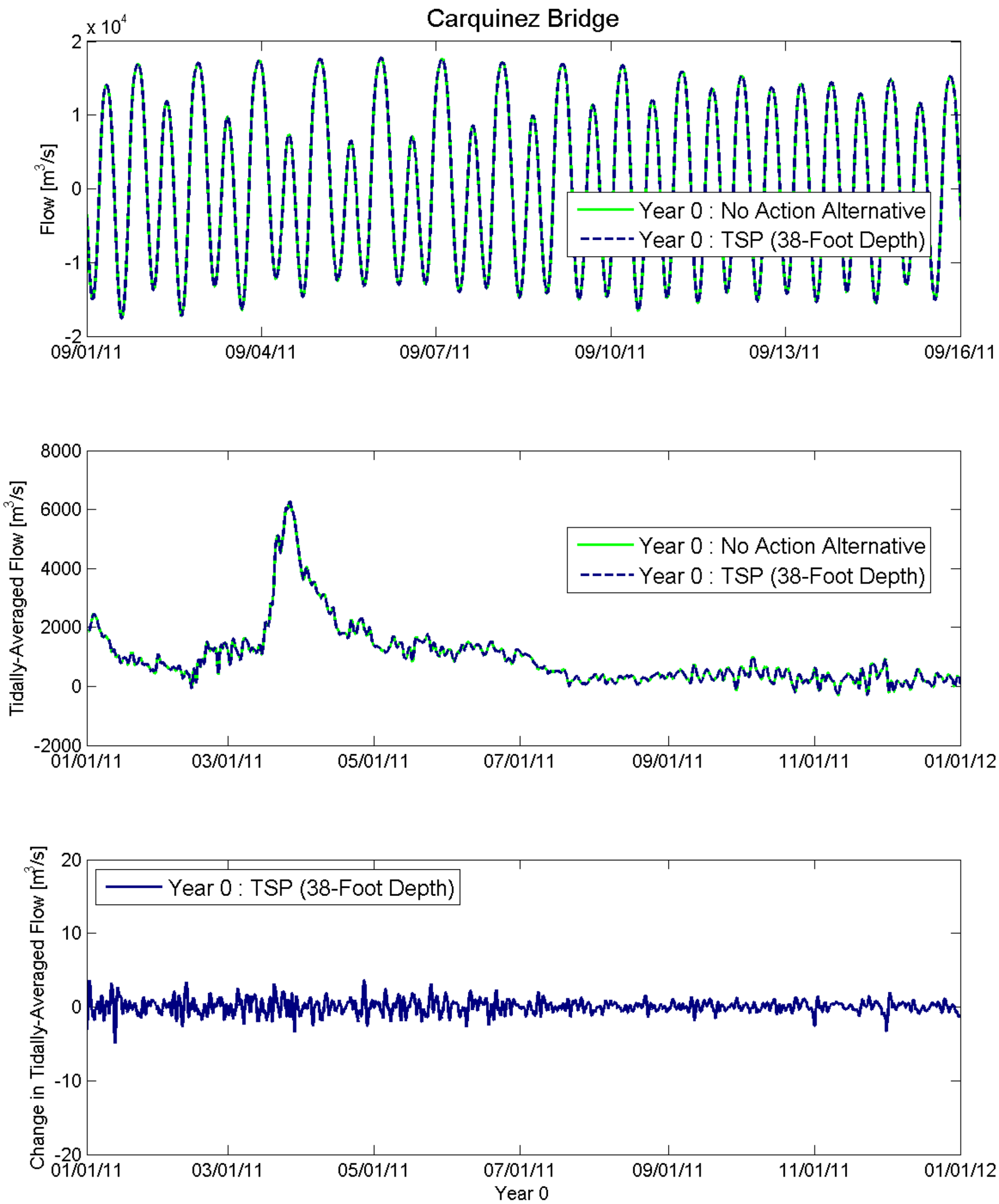


Figure 5.4-14

Predicted Tidal Flow at Carquinez Bridge for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Wet Water Year Evaluated

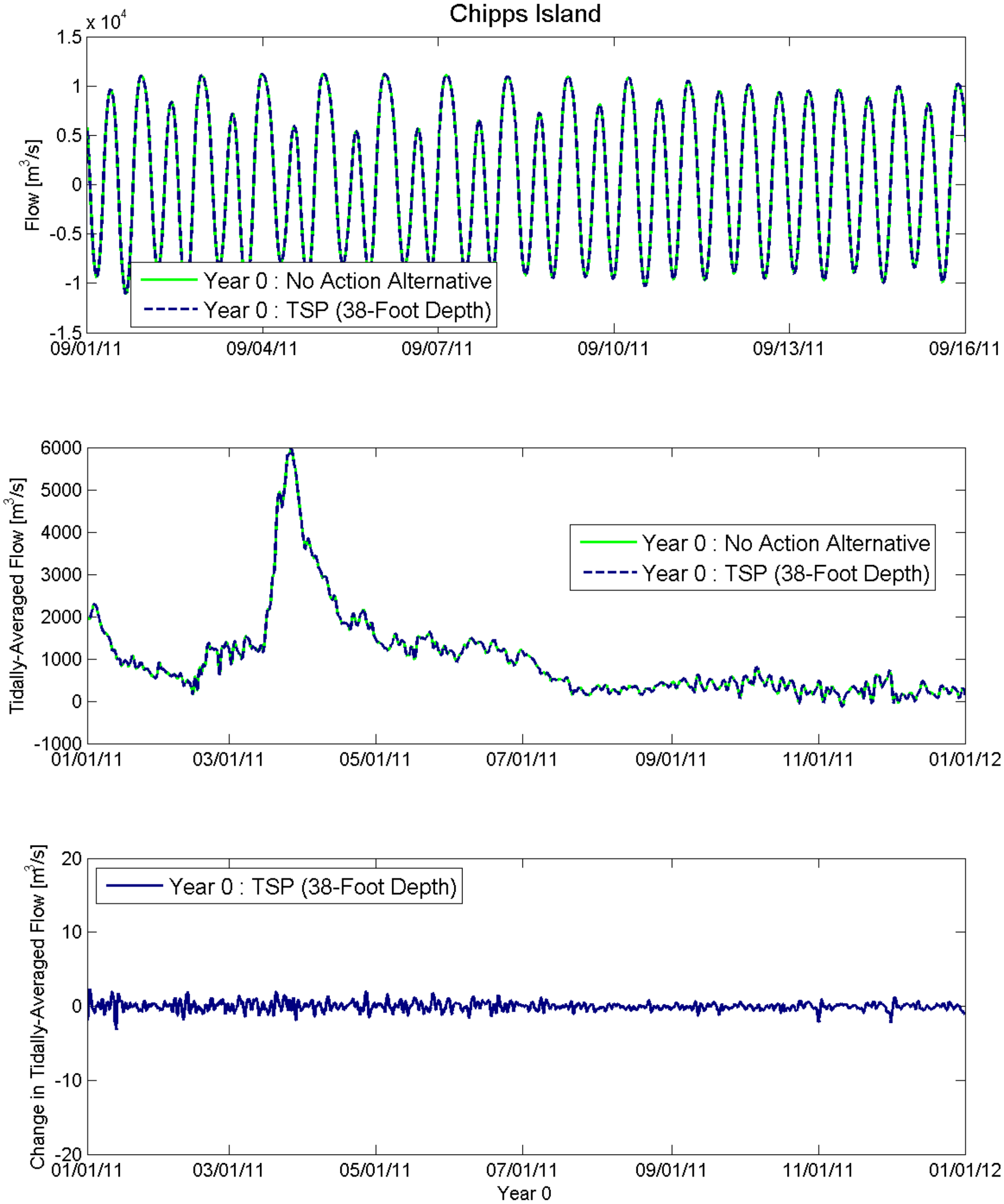


Figure 5.4-15

Predicted Tidal Flow at Chipps Island for the Year 0 No Action Alternative and the Year 0 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Wet Water Year Evaluated

6 EVALUATION OF ALTERNATIVES UNDER FUTURE CONDITIONS WITH SEA LEVEL RISE

The 38-Foot MLLW Alternative and TSP were evaluated for a 1-year period both during and following a critical water year under future conditions including SLR. The 37-Foot MLLW Alternative was not evaluated under future conditions.

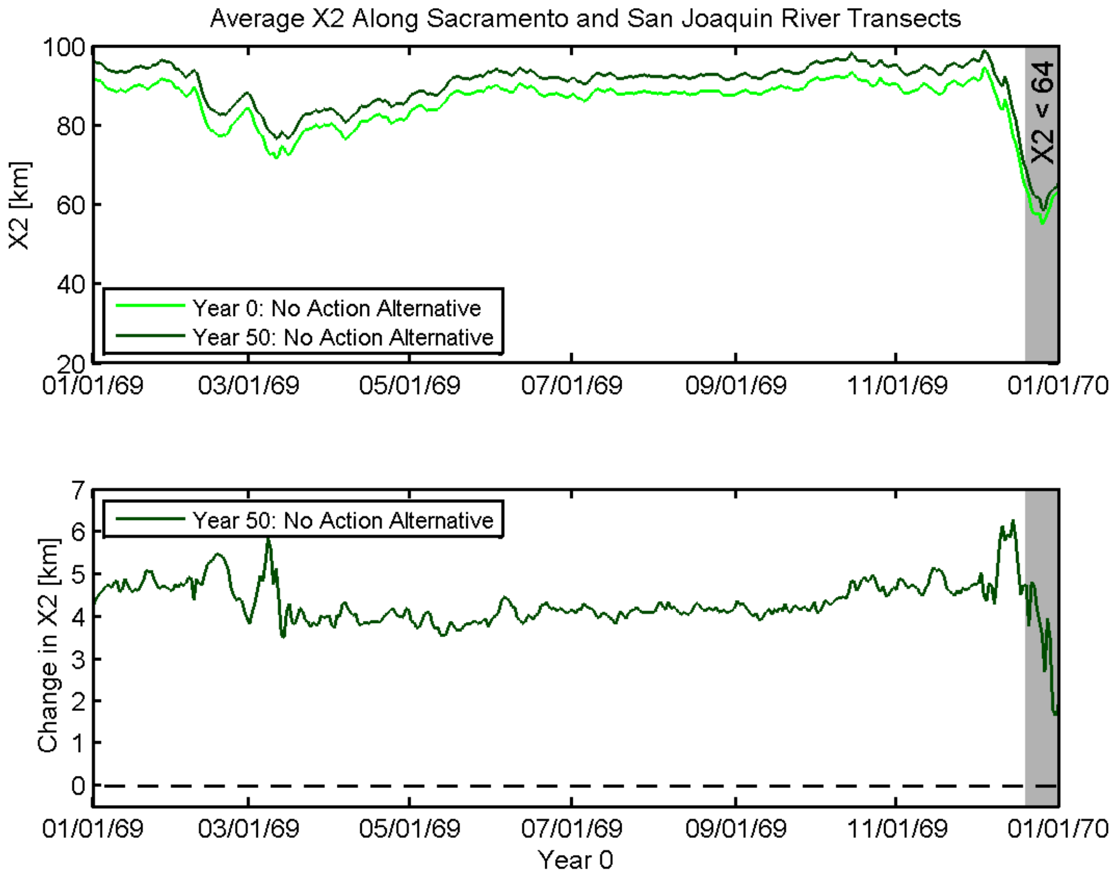
6.1 Boundary Conditions for Future Conditions Year 50 Scenario

Because the exact weather, hydrology, and operating conditions cannot be predicted in advance, representative conditions for 2069 (Year 50) were developed for the hydrodynamic simulations using 2014 hydrology corresponding to a critical water year and modified to account for SLR. SLR was included in the No Action Alternative (Baseline) and with-project scenario by adjusting the National Oceanic and Atmospheric Administration San Francisco station (9414290) water level from the model forcing year of 2014 for the projected SLR between 2014 and 50 years after the project start year (2069) based on the USACE High Curve (USACE 2015). Based on the USACE High Curve (USACE 2013, 2015), a total of 2.38 feet (72.5 cm) of SLR was estimated between 2014 and 2069.

Based on 2.38 feet of SLR between 2014 and 2069, the Year 50 conditions result in an average increase in X2 of 4.31 km relative to the Year 0 conditions in the No Action Alternatives (Figure 6.1-1). This is consistent with previous analyses which have evaluated the effect of a wide range of SLR values between 15 and 140 cm on X2 (e.g., MacWilliams and Gross 2010). Because water quality objectives are required to be met under future conditions, in practice, Delta operations would be modified to offset the effect of this increase in SLR on salinity to the extent that this increase causes the D-1641 water quality objectives to be exceeded. However, the most recent available CalSim II projections for future conditions from the State Water Project Delivery Capability Report (CDWR 2015) at the time this analysis was conducted include the operational response for a maximum of 15 cm of SLR under the Early Long Term (2035) conditions.

Because the amount of SLR considered in this analysis (72.5 cm) greatly exceeds the amount for which estimates of operational response are available, a conservative approach was used to evaluate the effects of channel deepening under Year 50 conditions for this study. Future conditions are evaluated for a critical water year based on 2014 hydrology and 2.38 feet (72.5 cm) of SLR, but without operational response. This results in higher predicted salinity under the Year 50 No Action Alternative in the Delta than would be likely to occur if water operations were adjusted to offset the increased salinity intrusion that results from this SLR (as evidenced by the 4.31 km shift in X2 shown in Figure 6.1-1). If operations were modified to offset SLR and maintain X2 at the same position as under Year 0 conditions, the expected deepening effects would be nearly identical to those predicted for Year 0 conditions in Sections 4 and 5.

Because the effect of the channel deepening on water quality at the Delta intake and export locations is generally larger when salinity is higher in the Delta, the predicted deepening effects under the Year 50 conditions are expected to be higher than is likely to occur if Delta operations offset some of the salinity increase resulting from SLR. Therefore, the estimated effects of the 38-Foot MLLW Alternative and the TSP on salinity under the Year 50 conditions should be considered as a high-end estimate of the future project deepening effects, as it is unlikely that X2 would be allowed to shift 4 km further upstream under a critical water year without changes to Delta operations to offset this salinity shift resulting from SLR.



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 6.1-1
Predicted X2 for the Year 0 No Action Alternative and the Year 50 No Action Alternative During a Critical Water Year (Top); Predicted Change in X2 Relative to the Year 0 No Action Alternative for the Year 50 No Action Alternative During a Critical Water Year (Bottom)

6.2 Evaluation of Effects on Salinity and X2 During a Critical Water Year in Year 50

This section presents the evaluation of the effects of channel deepening on salinity during and following a critical water year under future Year 50 conditions. The period evaluated is based on historical hydrologic conditions between January 1, 2014, and December 31, 2014, modified to include the USACE High SLR curve for Year 50, as described in Section 6.1.

6.2.1 Evaluation of 38-Foot MLLW Alternative During a Critical Water Year in Year 50

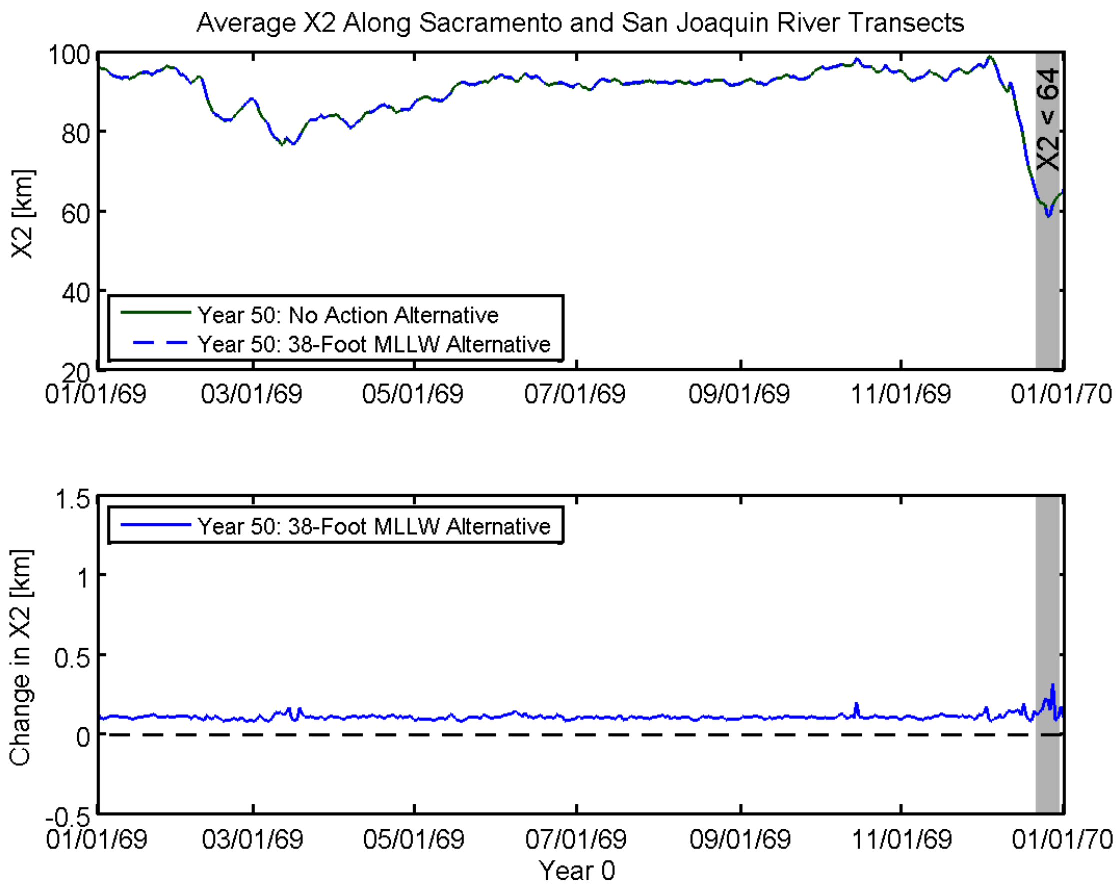
6.2.1.1 Effect of 38-Foot MLLW Alternative on X2 for Year 50

Similar to the Year 0 2014 critical water year scenario, in the Year 50 scenario X2 remained elevated throughout the year (Figure 6.2-1, top), remaining above 70 km through the first 11 months of the year and dropping below 64 km only in December due to higher outflows (see Figure 3.3-1). For the 38-Foot MLLW Alternative, X2 was predicted to increase throughout the year relative to the baseline No Action Alternative (Figure 6.2-1, bottom), with a predicted annual-average increase of 0.11 km (110 meters). Similarly, during the period of the year when X2 was greater than 64 km, the predicted average increase in X2 resulting from the 38-Foot MLLW Alternative was 0.11 km (Table 6-1). These increases in X2 for Year 50 are identical to what was predicted for Year 0 for the 38-Foot MLLW Alternative (Table 4-1). This suggests that the effects of the channel deepening on X2 are likely to be nearly identical under future and existing conditions, even if X2 shifts by several kilometers under future conditions relative to the current position (see Figure 6.1-1).

Table 6-1
Predicted Change in X2 for the 38-Foot MLLW Alternative
During a Critical Water Year under Year 50 Conditions

Year 50 Alternative	Change in X2 (km)	
	Annual-Average	Change for X2 > 64
No Action Alternative	Baseline	Baseline
38-Foot MLLW Alternative	0.11	0.11

Notes:
km = kilometers
MLLW = Mean Lower Low Water
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2, so the average change for periods when X2 >64 is also shown separately.



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 6.2-1
Predicted X2 for the Year 50 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in X2 Relative to the Year 50 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

6.2.1.2 Effect of 38-Foot MLLW Alternative on Water Quality at D-1641 Stations for Year 50

The effect of the 38-Foot MLLW Alternative on the predicted Cl^- concentration at the five intake and export locations in the south Delta (locations shown in Figure 3.5-1) was evaluated under Year 50 conditions to assess the potential effects on water quality at the municipal and industrial intakes at which D-1641 has established water quality criteria. Figures 6.2-2 through 6.2-6 show the mean daily Cl^- concentration for the No Action

Alternative and the 38-Foot MLLW Alternative and the predicted change in Cl^- concentration resulting from the 38-Foot MLLW Alternative during Year 50 (2069). As seen in these figures, the predicted Cl^- concentrations are significantly higher under Year 50 conditions than under Year 0 conditions (see Figures 4.1-8 through 4.1-12) due to the large upstream shift in X2 (Figure 6.1-1). Table 6-2 summarizes the predicted annual-average change in Cl^- concentration and the maximum predicted monthly average change in Cl^- concentration at five intake and export locations. During the critical water year under these Year 50 conditions, the predicted annual-average change in Cl^- concentration resulting from the 38-Foot MLLW Alternative ranged from 1.5 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.0 mg/L at the CCWD Rock Slough Intake. The predicted maximum monthly average change resulting from the 38-Foot MLLW Alternative ranged from 2.5 mg/L at the Delta-Mendota Canal at Tracy Pumping Plant to 4.6 mg/L at the CCWD Rock Slough Intake. The predicted monthly average change in Cl^- concentration during each month in 2069 for both the Year 50 No Action Alternative (Baseline) and the Year 50 38-Foot MLLW Alternative are included in Table 6-5 at the end of Section 6.2.

Table 6-2
Predicted Annual-Average and Maximum Monthly Average Change in Chloride Concentration Relative to the No Action Alternative for the 38-Foot MLLW Alternative at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Critical Water Year under Year 50 Conditions

Year 50 Critical Water Year (2014)	Change in Chloride Concentration (mg/L Cl^-)	
	Annual-Average Change	Max Monthly Average Change
West Canal at Mouth of Clifton Court Forebay (CHWST0)	2.0	2.9
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)	1.6	2.5
CCWD Rock Slough Intake (CHCCC06)	3.0	4.6
CCWD Old River Intake (ROLD034)	2.6	4.1
CCWD Middle River at Victoria Canal Intake (CCW)	1.5	2.8

Notes:
CCWD = Contra Costa Water District
mg/L Cl^- = Concentration of chloride in milligrams per liter

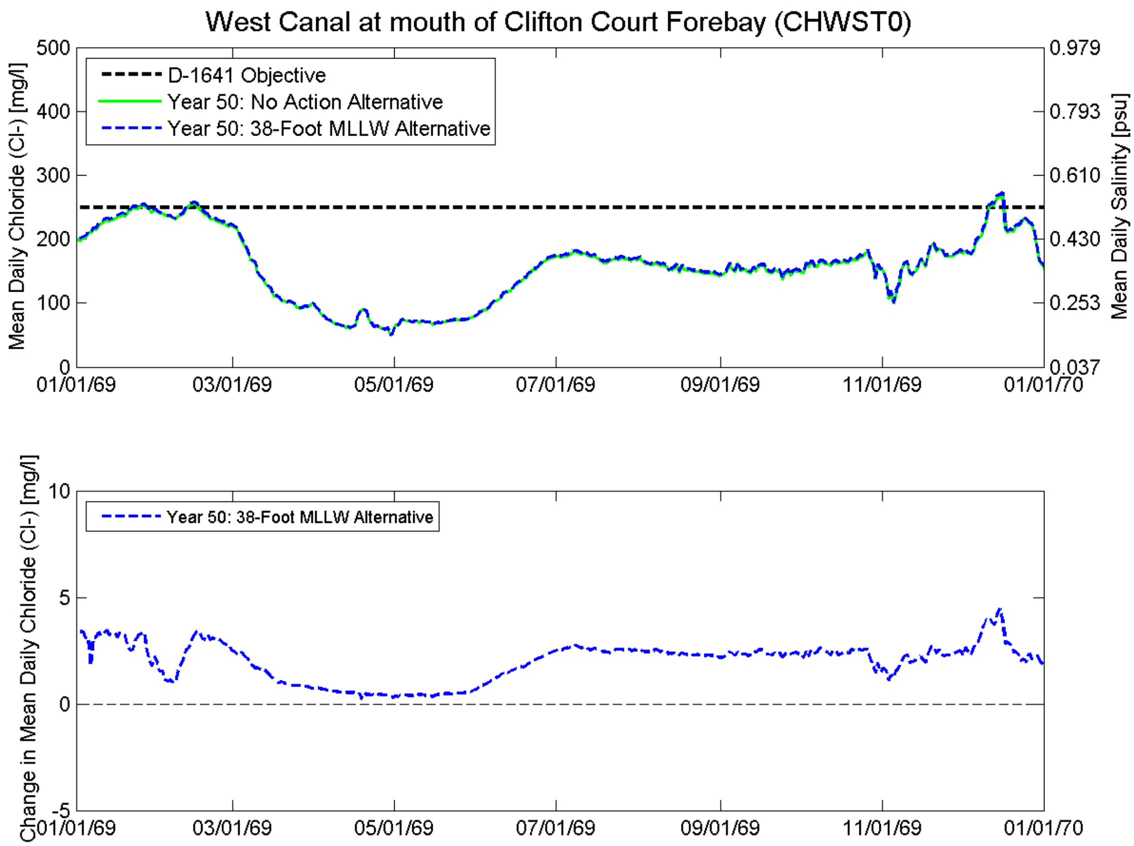


Figure 6.2-2

Predicted Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay Relative to the Year 50 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

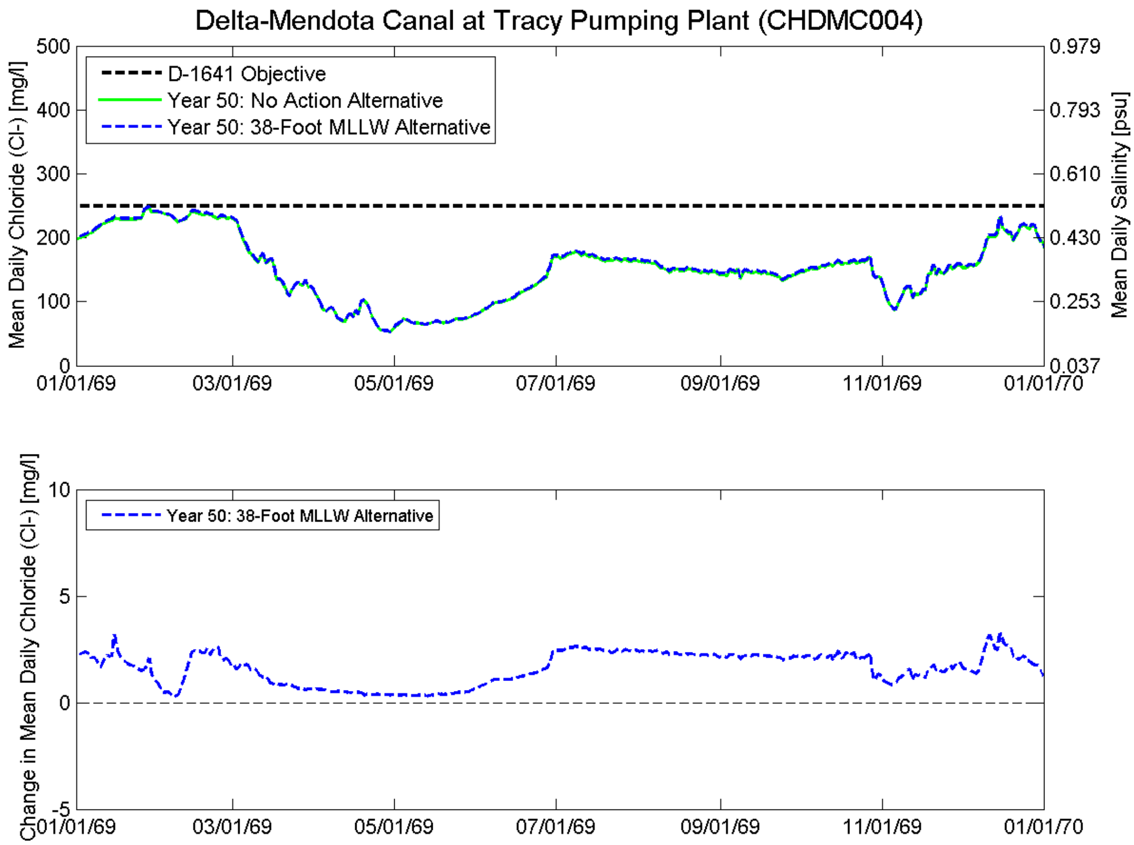


Figure 6.2-3

Predicted Mean Daily Cl^- Concentration at the Tracy Pumping Plant (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Tracy Pumping Plant Relative to the Year 50 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

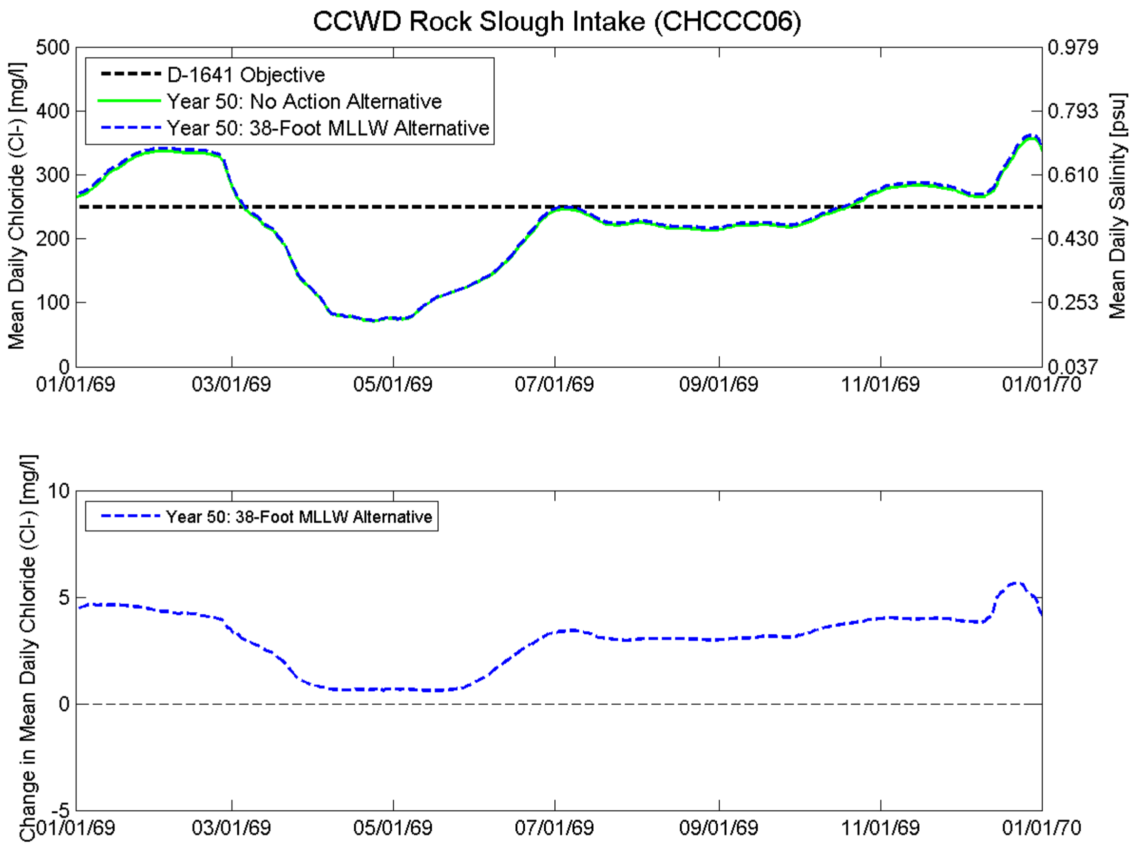


Figure 6.2-4

Predicted Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Rock Slough Intake Relative to the Year 0 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

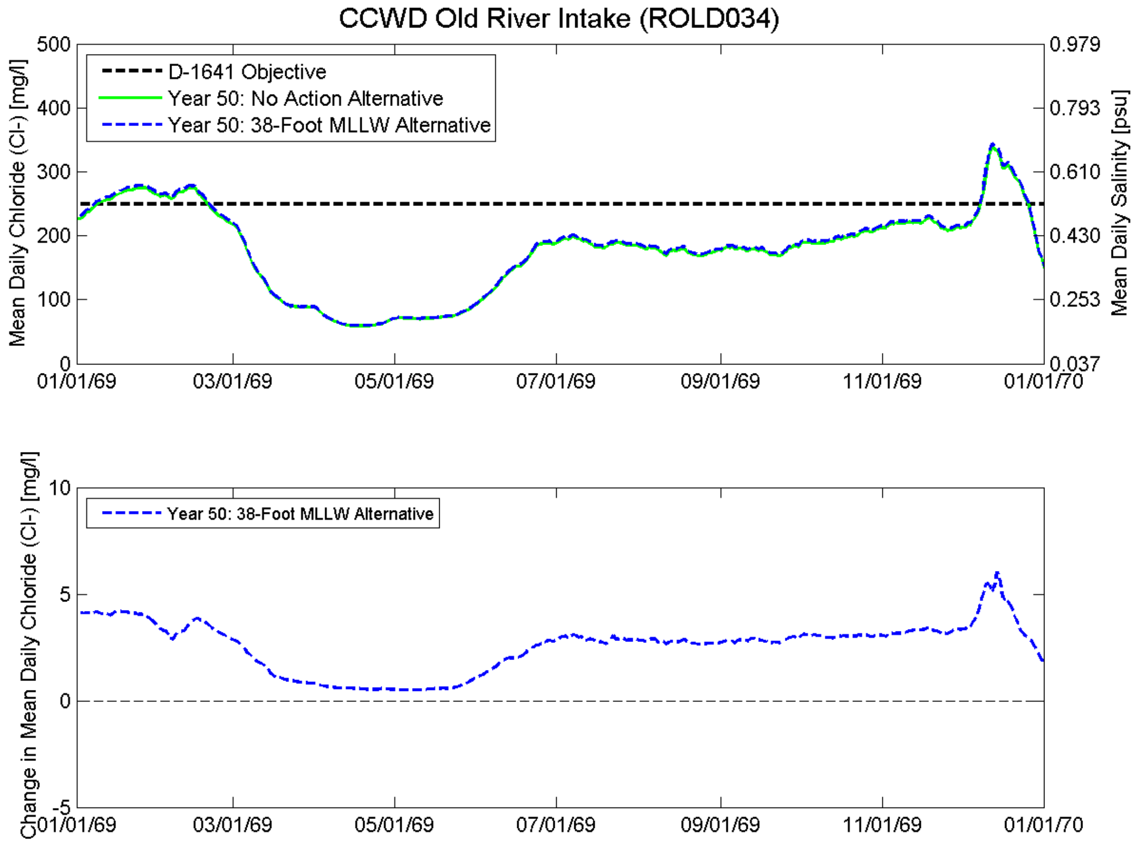


Figure 6.2-5

Predicted Mean Daily Cl$^-$ Concentration at the CCWD Old River Intake (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl$^-$ Concentration at the CCWD Old River Intake Relative to the Year 50 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

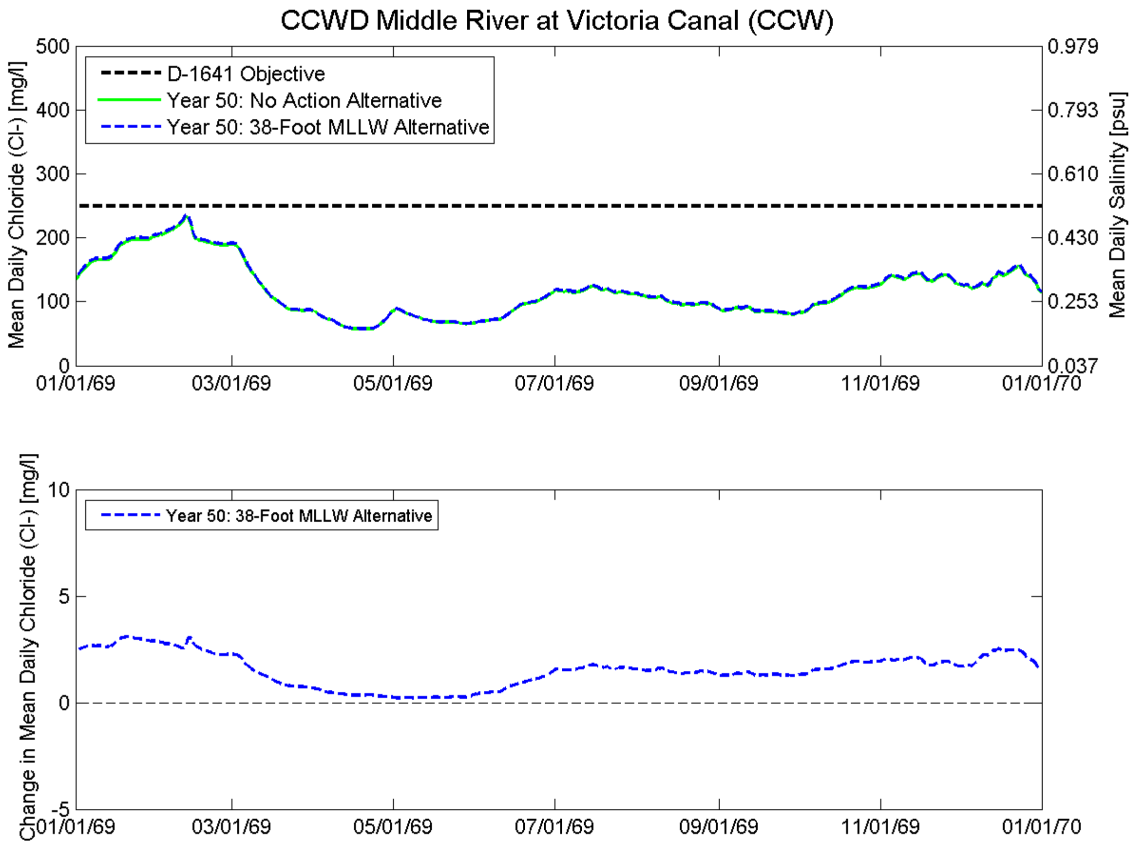


Figure 6.2-6

Predicted Mean Daily Cl$^-$ Concentration at the CCWD Middle River at Victoria Canal intake (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the 38-Foot MLLW Alternative During a Critical Water Year (Top); Predicted Change in Mean Daily Cl$^-$ Concentration at the CCWD Middle River at Victoria Canal Intake Relative to the Year 50 No Action Alternative for the 38-Foot MLLW Alternative During a Critical Water Year (Bottom)

6.2.2 Evaluation of TSP During a Critical Water Year in Year 50

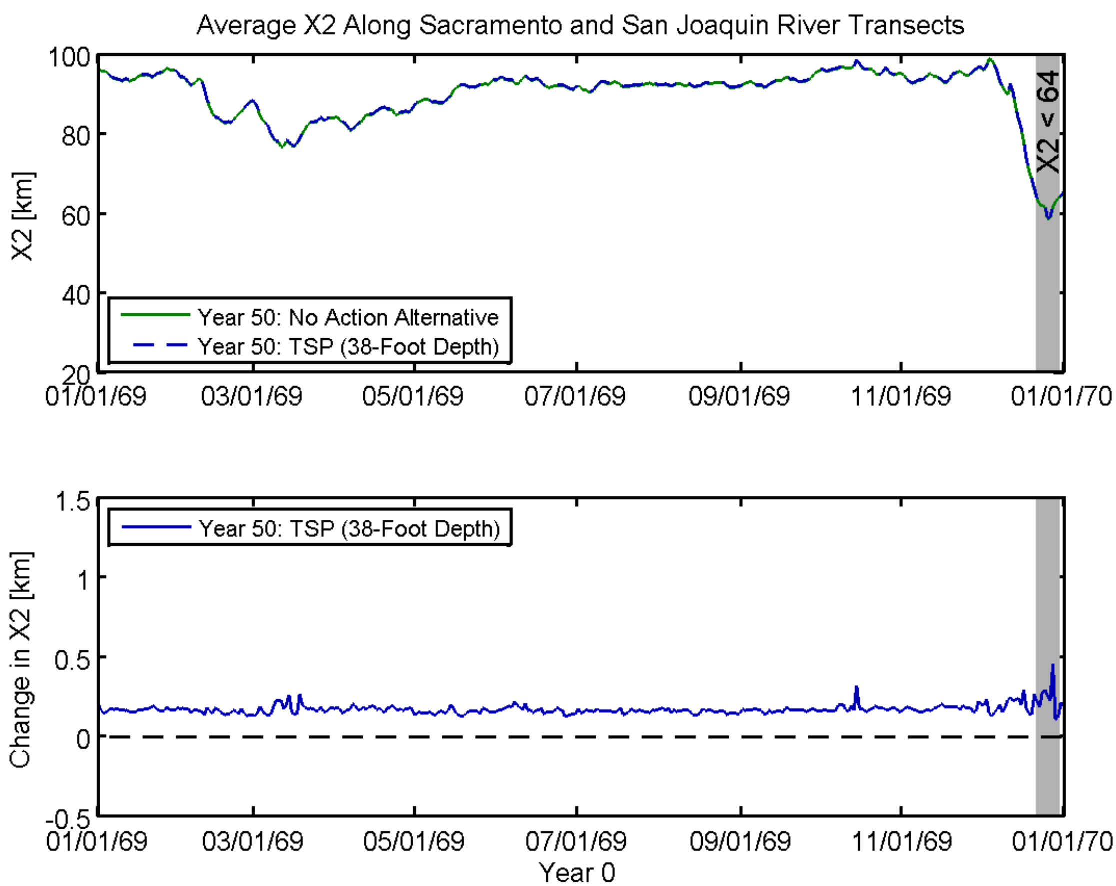
6.2.2.1 Effect of TSP on X2 for Year 50

Similar to the Year 0 2014 critical water year scenario, in the Year 50 scenario X2 remained elevated throughout the year (Figure 6.2-7, top), remaining above 70 km through the first 11 months of the year and dropping below 64 km only in December due to higher outflows (see Figure 3.3-1). For the TSP, X2 was predicted to increase throughout the year relative to the baseline No Action Alternative (Figure 6.2-7, bottom), with a predicted annual-average increase of 0.17 km. Similarly, during the period of the year when X2 was greater than 64 km, the predicted average increase in X2 resulting from the TSP was 0.17 km (Table 6-3). These increases in X2 for the TSP in Year 50 are identical to what was predicted in Year 0 for the TSP (Table 5-1). This suggests that the effects of the TSP on X2 are likely to be nearly identical under future and existing conditions, even if X2 shifts by several kilometers under future conditions relative to the current position (see Figure 6.1-1).

Table 6-3
Predicted Change in X2 for TSP During a Critical Water Year under Year 50 Conditions

Year 50 Alternative	Change in X2 (km)	
	Annual-Average	**Change for X2 > 64**
No Action Alternative	Baseline	Baseline
TSP (38-Foot Depth)	0.17	0.17

Notes:
km = kilometers
MLLW = Mean Lower Low Water
TSP = Tentatively Selected Plan
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2, so the average change for periods when X2 >64 is also shown separately.



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Periods when the predicted X2 for the No Action Alternative is less than 64 km are shaded in grey.

Figure 6.2-7
Predicted X2 for the Year 50 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in X2 Relative to the Year 50 No Action Alternative for the TSP During a Critical Water Year (Bottom)

6.2.2.2 Effect of TSP on Water Quality at D-1641 Stations for Year 50

The effect of the TSP on the predicted Cl^- concentration at the five intake and export locations in the south Delta (locations shown in Figure 3.5-1) was evaluated under Year 50 conditions to assess the potential effects on water quality at the municipal and industrial intakes at which D-1641 has established water quality criteria. Figures 6.2-8 through 6.2-12 show the mean daily Cl^- concentration for the No Action Alternative and the TSP and the predicted change in Cl^- concentration resulting from the TSP during Year 50 (2069). As seen in these figures, the predicted Cl^- concentrations are significantly higher under Year 50 conditions than under Year 0 conditions (see Figures 5.2-2 through 5.2-6) due to the large upstream shift in X2 (Figure 6.1-1). Table 6-4 summarizes the predicted annual-average change in Cl^- concentration and the maximum predicted monthly average change in Cl^- concentration at five intake and export locations. During the critical water year under these Year 50 conditions, the predicted annual-average change in Cl^- concentration resulting from the TSP ranged from 2.3 mg/L at the CCWD Middle River at Victoria Canal Intake to 4.6 mg/L at the CCWD Rock Slough Intake. The predicted maximum monthly average change resulting from the TSP ranged from 3.6 mg/L at the Delta-Mendota Canal at Tracy Pumping Plant to 7.2 mg/L at the CCWD Rock Slough Intake. The predicted monthly average change in Cl^- concentration during each month in 2069 for the Year 50 TSP are included in Table 6-5.

As discussed in Section 6.1, the boundary conditions for the Year 50 simulation include the effects of 2.38 feet (72.5 cm) of SLR, but do not include operational response. This results in higher predicted salinity under the Year 50 No Action Alternative in the Delta than would be likely to occur if water operations were adjusted to offset the increased salinity intrusion that results from this SLR (as evidenced by the 4.31 km shift in X2 shown in Figure 6.1-1). As a result of this higher salinity, the water quality objective of 250 mg/L Cl^- concentration is exceeded under the Year 50 No Action Alternative at both the CCWD Rock Slough Intake and the CCWD Old River Intake. The largest predicted increases in maximum monthly average change in Cl^- concentration resulting from the TSP occurred at these two locations. Because water operations would need to be modified to offset the effects of SLR to maintain the water quality objectives at these locations under the Year 50 No Action Alternative, these results are likely overstating the effects of the TSP in year 50 on Cl^- concentrations at these locations. If operations were modified to offset SLR and maintain X2 at the same position as under Year 0 conditions, the expected deepening effects on Cl^- concentrations at these locations would be more similar to those predicted for the critical water year under Year 0 conditions (Table 5-2).

Table 6-4

Predicted Annual-Average and Maximum Monthly Average Change in Chloride Concentration Relative to the No Action Alternative for the TSP at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Critical Water Year under Year 50 Conditions

Year 50 Critical Water Year (2014)	Change in Chloride Concentration (mg/L Cl^-)	
	Annual-Average Change	Max Monthly Average Change
West Canal at Mouth of Clifton Court Forebay (CHWST0)	3.0	4.5
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)	2.4	3.6
CCWD Rock Slough Intake (CHCCC06)	4.6	7.2
CCWD Old River Intake (ROLD034)	3.9	6.4
CCWD Middle River at Victoria Canal Intake (CCW)	2.3	4.2

Notes:
CCWD = Contra Costa Water District
mg/L Cl^- = Concentration of chloride in milligrams per liter

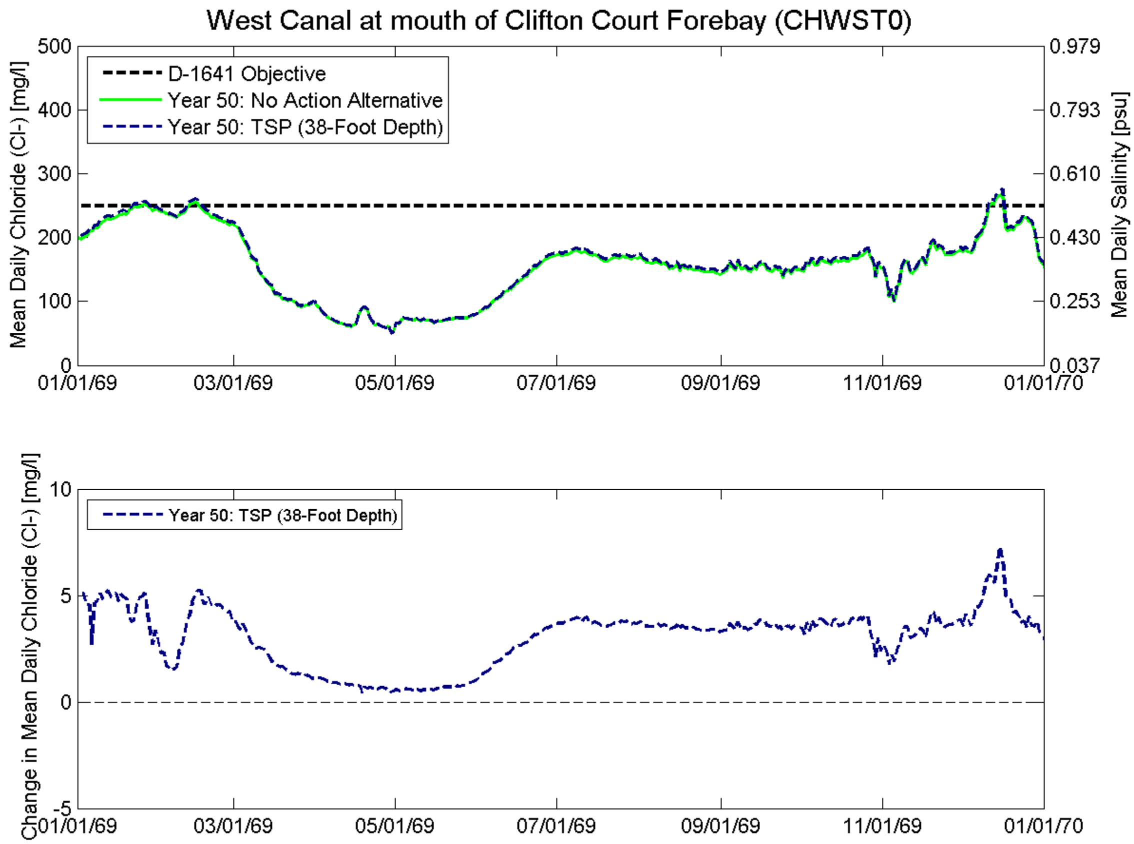


Figure 6.2-8

Predicted Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Clifton Court Forebay Relative to the Year 50 No Action Alternative for the TSP During a Critical Water Year (Bottom)

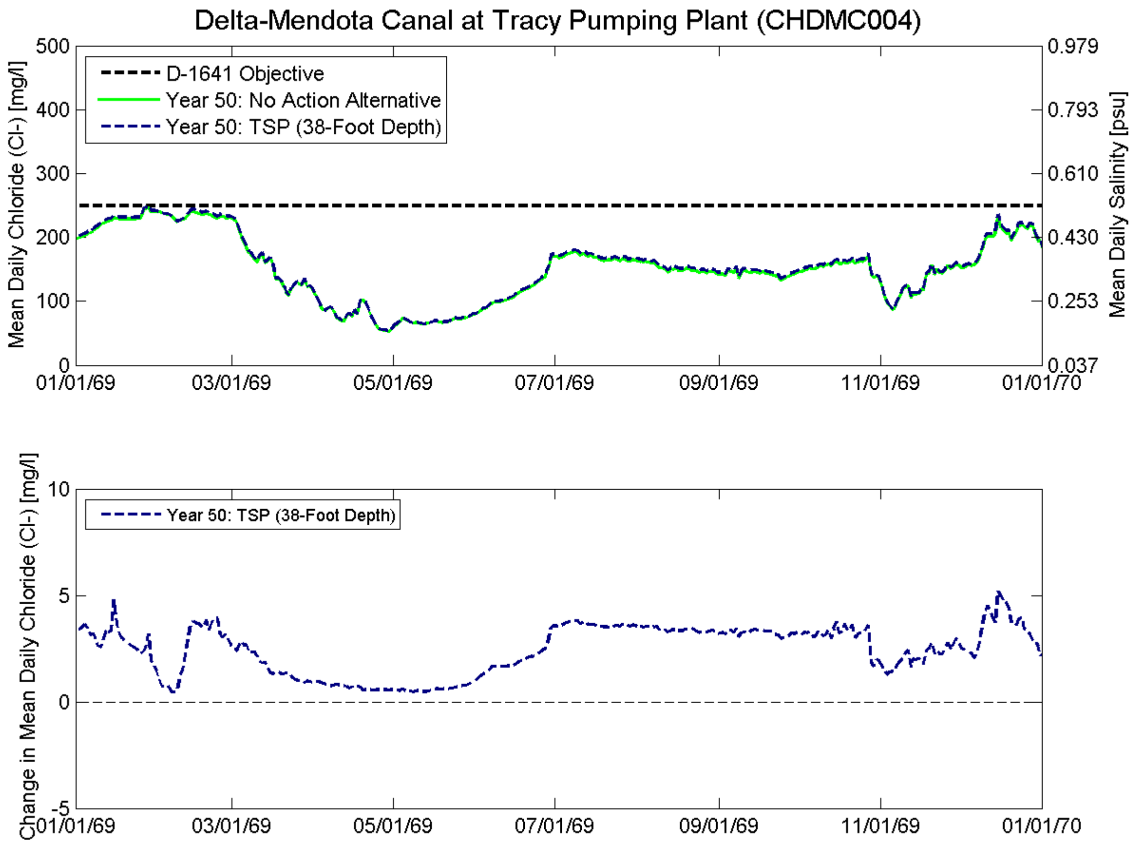


Figure 6.2-9

Predicted Mean Daily Cl^- Concentration at the Tracy Pumping Plant (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the Entrance to Tracy Pumping Plant Relative to the Year 50 No Action Alternative for the TSP During a Critical Water Year (Bottom)

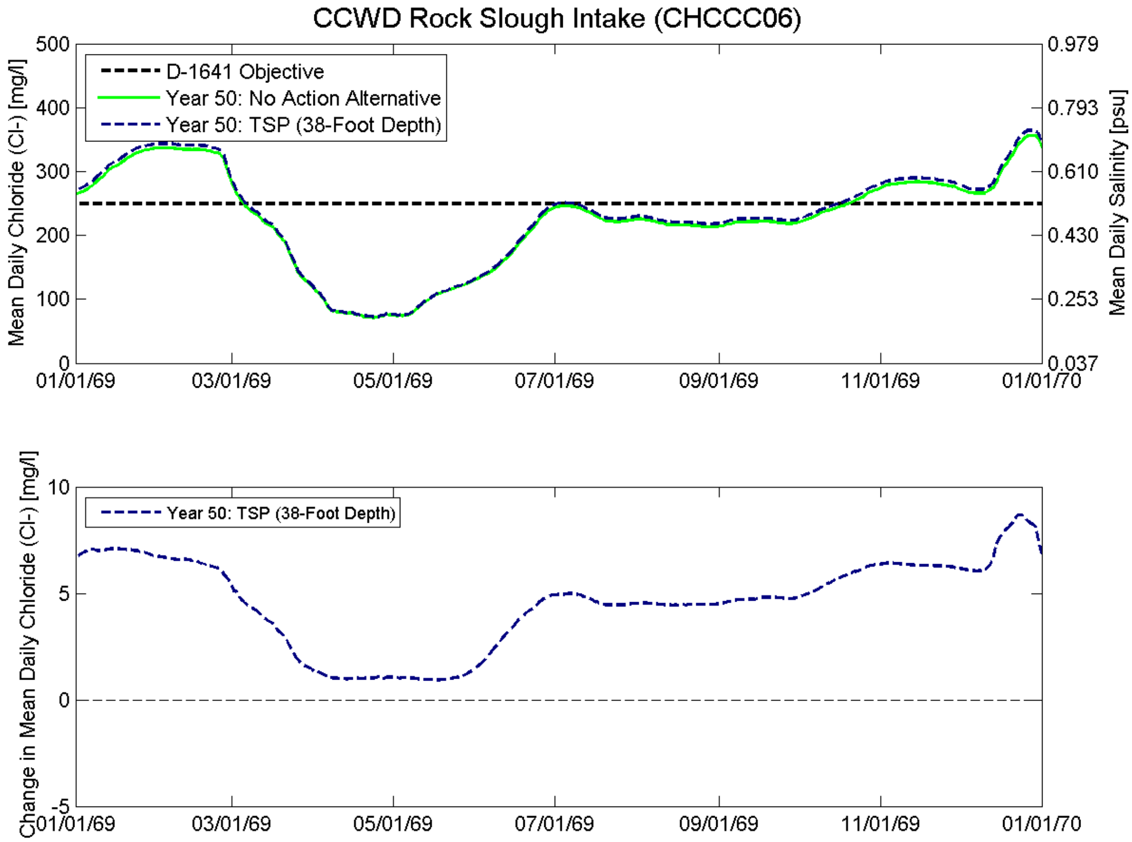


Figure 6.2-10

Predicted Mean Daily Cl- Concentration at the CCWD Rock Slough Intake (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl- Concentration at the CCWD Rock Slough Intake Relative to the Year 0 No Action Alternative for the TSP During a Critical Water Year (Bottom)

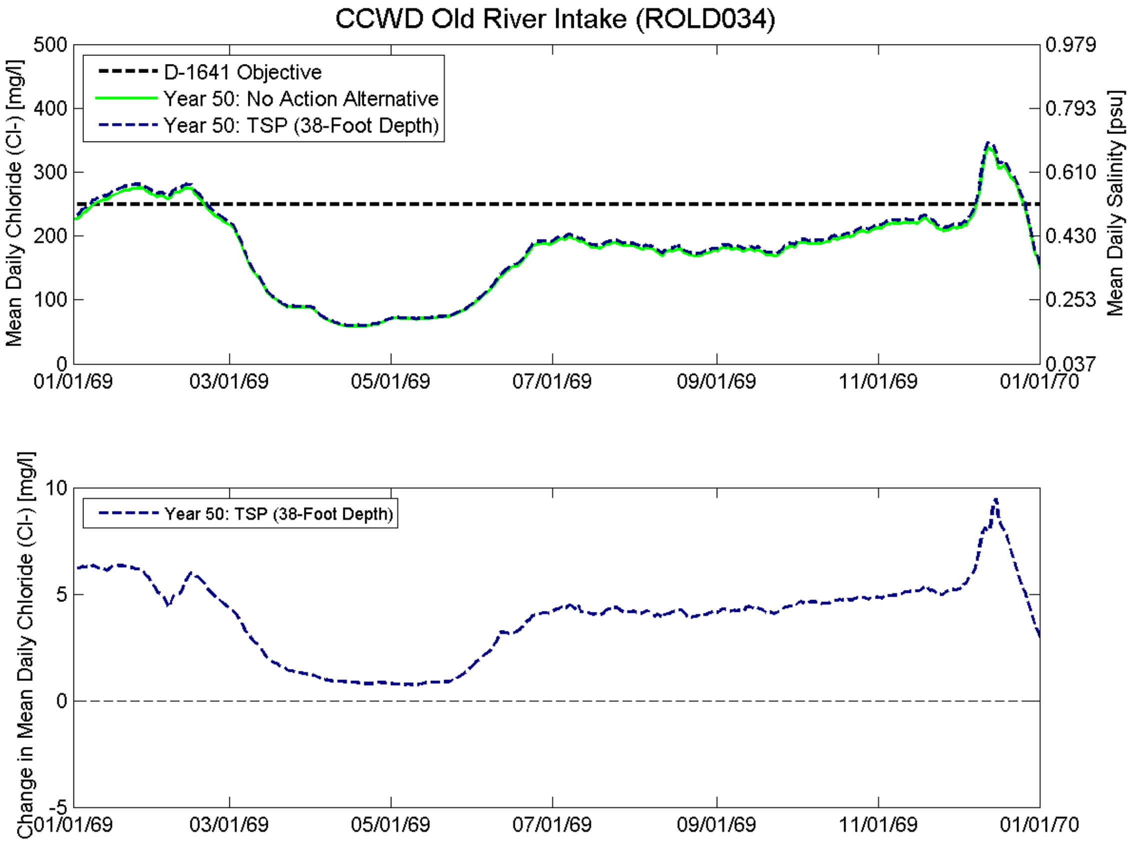


Figure 6.2-11

Predicted Mean Daily Cl^- Concentration at the CCWD Old River Intake (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Old River Intake Relative to the Year 50 No Action Alternative for the TSP During a Critical Water Year (Bottom)

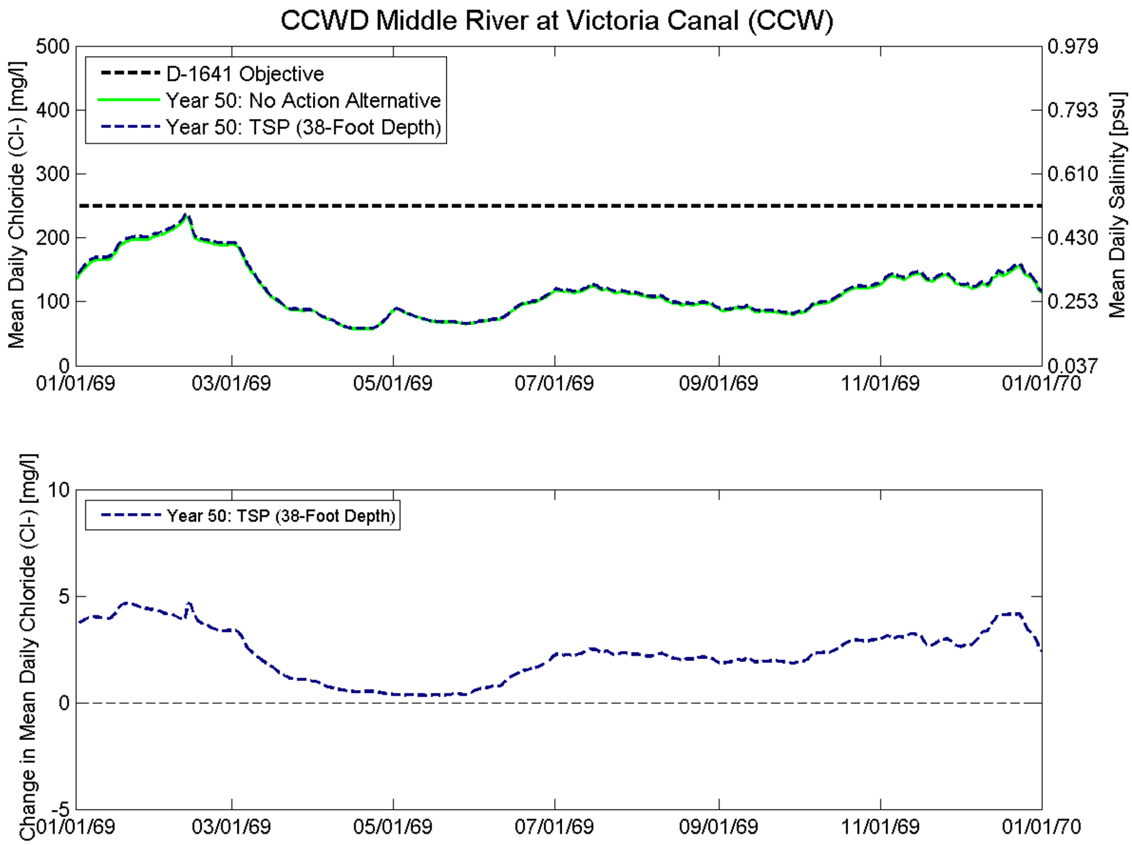


Figure 6.2-12

Predicted Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal intake (location shown in Figure 3.5-1) for the Year 50 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in Mean Daily Cl^- Concentration at the CCWD Middle River at Victoria Canal Intake Relative to the Year 50 No Action Alternative for the TSP During a Critical Water Year (Bottom)

Table 6-5

Predicted Monthly Average Cl^- Concentration and Predicted Change in Cl^- Relative to the No Action Alternative for 38-Foot MLLW Alternative and TSP at the D-1641 Stations for Municipal and Industrial Beneficial Uses During a Critical Water Year under Year 50 Conditions

Year 50 Critical Water Year (2014)	Year 50 Baseline Conc. Cl^- (mg/L Cl^-)	Year 50 38-Foot MLLW Alternative			Year 50 TSP (38-Foot Depth)		
		Conc. Cl^-	Change in Cl^-		Conc. Cl	Change in Cl^-	
		(mg/L Cl^-)	(mg/L Cl^-)	Percent	(mg/L Cl^-)	(mg/L Cl^-)	Percent
West Canal at Mouth of Clifton Court Forebay (CHWST0)							
January	230.3	233.2	2.9	1.3	234.7	4.4	1.9
February	236.5	238.9	2.4	1.0	240.2	3.7	1.6
March	132.6	134.0	1.4	1.1	134.7	2.1	1.6
April	69.9	70.4	0.5	0.7	70.7	0.8	1.1
May	71.5	72.0	0.5	0.7	72.2	0.7	1.0
June	128.3	129.9	1.6	1.2	130.8	2.5	1.9
July	170.9	173.5	2.6	1.5	174.6	3.7	2.2
August	153.7	156.1	2.4	1.6	157.2	3.5	2.3
September	150.2	152.5	2.3	1.5	153.7	3.5	2.3
October	162.1	164.4	2.3	1.4	165.6	3.5	2.2
November	158.1	160.1	2.0	1.3	161.3	3.2	2.0
December	214.1	216.9	2.8	1.3	218.6	4.5	2.1
Delta-Mendota Canal at Tracy Pumping Plant (CHDMC004)							
January	224.0	226.0	2.0	0.9	227.0	3.0	1.3
February	233.6	235.3	1.7	0.7	236.1	2.5	1.1
March	154.3	155.4	1.1	0.7	156.0	1.7	1.1
April	78.5	78.9	0.4	0.5	79.2	0.7	0.9
May	69.4	69.8	0.4	0.6	70.0	0.6	0.9
June	113.6	114.9	1.3	1.1	115.6	2.0	1.8
July	168.4	170.9	2.5	1.5	172.0	3.6	2.1
August	151.2	153.5	2.3	1.5	154.5	3.3	2.2
September	142.8	144.9	2.1	1.5	146.0	3.2	2.2
October	154.8	156.8	2.0	1.3	157.9	3.1	2.0
November	126.3	127.7	1.4	1.1	128.5	2.2	1.7
December	194.4	196.5	2.1	1.1	197.8	3.4	1.7

Year 50 Critical Water Year (2014)	Year 50 Baseline Conc. Cl^- (mg/L Cl^-)	Year 50 38-Foot MLLW Alternative			Year 50 TSP (38-Foot Depth)		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent	Conc. Cl (mg/L Cl^-)	Change in Cl^- (mg/L Cl^-)	Change in Cl^- Percent
CCWD Rock Slough Intake (CHCCC06)							
January	305.6	310.2	4.6	1.5	312.6	7.0	2.3
February	330.0	334.1	4.1	1.2	336.4	6.4	1.9
March	200.7	202.8	2.1	1.0	204.0	3.3	1.6
April	81.1	81.8	0.7	0.9	82.1	1.0	1.2
May	101.1	101.8	0.7	0.7	102.1	1.0	1.0
June	182.7	185.0	2.3	1.3	186.2	3.5	1.9
July	232.5	235.7	3.2	1.4	237.2	4.7	2.0
August	217.7	220.7	3.0	1.4	222.2	4.5	2.1
September	219.8	222.9	3.1	1.4	224.6	4.8	2.2
October	245.6	249.2	3.6	1.5	251.3	5.7	2.3
November	280.3	284.2	3.9	1.4	286.6	6.3	2.2
December	304.8	309.4	4.6	1.5	312.0	7.2	2.4
CCWD Old River Intake (ROLD034)							
January	258.4	262.5	4.1	1.6	264.6	6.2	2.4
February	253.6	257.0	3.4	1.3	258.8	5.2	2.1
March	125.9	127.4	1.5	1.2	128.2	2.3	1.8
April	65.2	65.8	0.6	0.9	66.1	0.9	1.4
May	74.7	75.3	0.6	0.8	75.6	0.9	1.2
June	149.0	151.1	2.1	1.4	152.2	3.2	2.1
July	188.6	191.5	2.9	1.5	192.8	4.2	2.2
August	175.3	178.1	2.8	1.6	179.4	4.1	2.3
September	177.2	180.0	2.8	1.6	181.5	4.3	2.4
October	196.9	199.9	3.0	1.5	201.6	4.7	2.4
November	217.4	220.6	3.2	1.5	222.5	5.1	2.3
December	262.4	266.4	4.0	1.5	268.8	6.4	2.4

Year 50 Critical Water Year (2014)	Year 50 Baseline Conc. Cl^- (mg/L Cl^-)	Year 50 38-Foot MLLW Alternative			Year 50 TSP (38-Foot Depth)		
		Conc. Cl^- (mg/L Cl^-)	Change in Cl^-		Conc. Cl (mg/L Cl^-)	Change in Cl^-	
			(mg/L Cl^-)	Percent		(mg/L Cl^-)	Percent
CCWD Middle River at Victoria Canal Intake (CCW)							
January	178.0	180.8	2.8	1.6	182.2	4.2	2.4
February	203.4	205.9	2.5	1.2	207.2	3.8	1.9
March	119.3	120.6	1.3	1.1	121.2	1.9	1.6
April	66.4	66.8	0.4	0.6	67.0	0.6	0.9
May	72.8	73.0	0.2	0.3	73.1	0.3	0.4
June	87.5	88.3	0.8	0.9	88.8	1.3	1.5
July	116.5	118.1	1.6	1.4	118.8	2.3	2.0
August	99.9	101.3	1.4	1.4	102.0	2.1	2.1
September	85.4	86.7	1.3	1.5	87.3	1.9	2.2
October	107.1	108.8	1.7	1.6	109.7	2.6	2.4
November	136.6	138.6	2.0	1.5	139.6	3.0	2.2
December	134.3	136.5	2.2	1.6	137.8	3.5	2.6

Notes:
CCWD = Contra Costa Water District
mg/L Cl^- = Concentration of chloride in milligrams per liter

6.2.2.3 Effect of TSP on Water Levels During a Critical Water Year in Year 50

Water level comparisons were made at three locations spanning the geographic extent of the project (Figure 3.6-1). For each water level comparison figure included in this section, the top plot shows the tidal time-scale water level variability over a 15-day period for the Year 50 No Action Alternative and the Year 50 TSP scenario. The middle plot shows daily-averaged stage during the full simulation year for each scenario. The bottom plot shows the predicted change in daily-averaged stage for the Year 50 TSP scenario relative to the Year 50 No Action Alternative. Because the predicted water level is nearly identical between scenarios, a dashed line is used for the Year 50 TSP scenario because it is plotted on top of the line for the No Action Alternative. Comparisons of the predicted water level for the Year 50 No Action Alternative and the Year 50 TSP were made at the Richmond station (Figure 6.2-13) which is seaward of the Pinole Shoal Channel, Martinez (Figure 6.2-14) which is located west of the Suisun Bay Channel, and Mallard Island (Figure 6.2-15). These comparisons show that the predicted water levels for the No Action Alternative and the TSP are nearly identical in Year 50, and there is virtually no change in predicted water level at any of the stations evaluated during the critical water year evaluated.

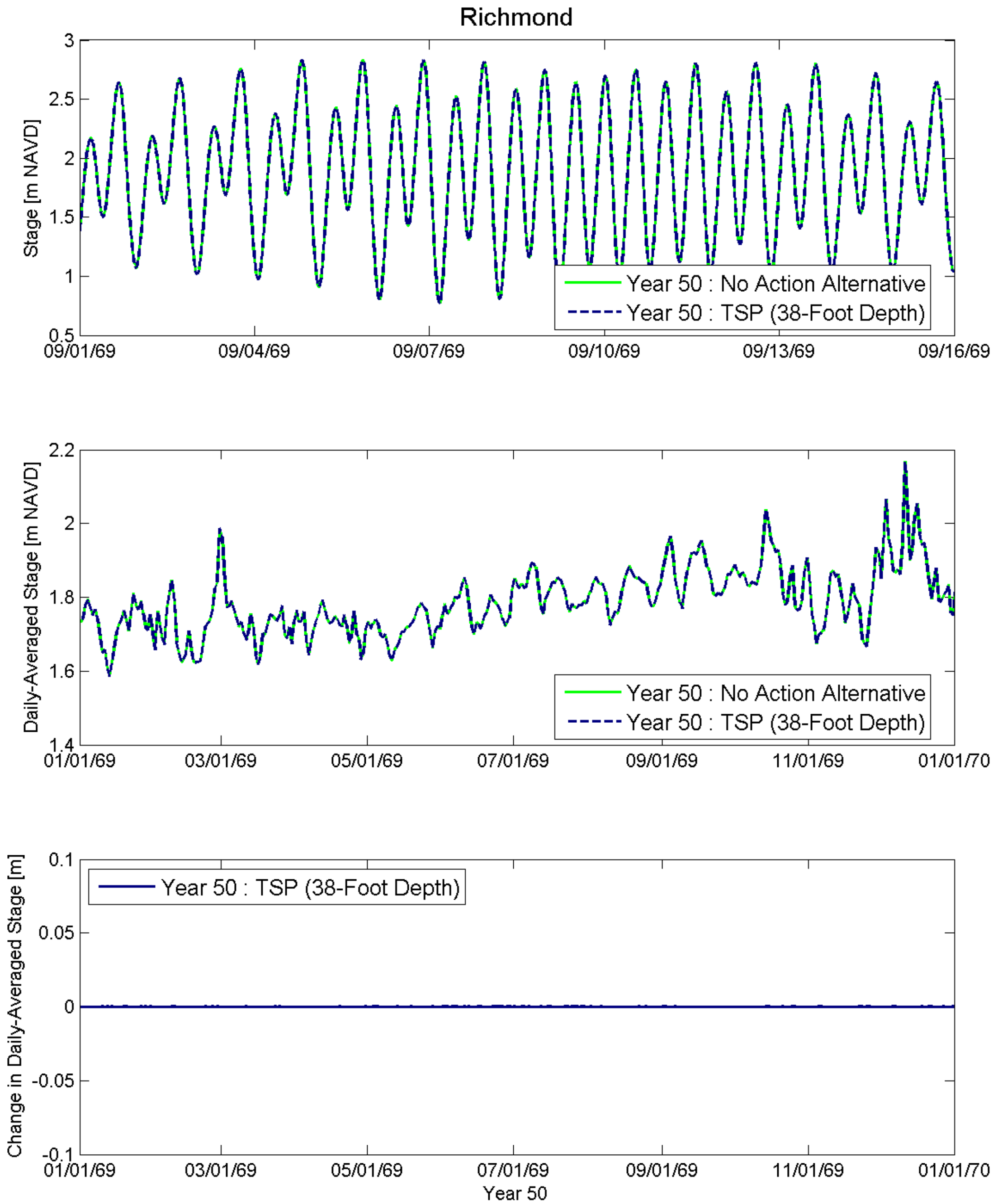


Figure 6.2-13

Predicted Stage at the NOAA Richmond Station for the Year 50 No Action Alternative and the Year 50 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Critical Water Year Evaluated in Year 50

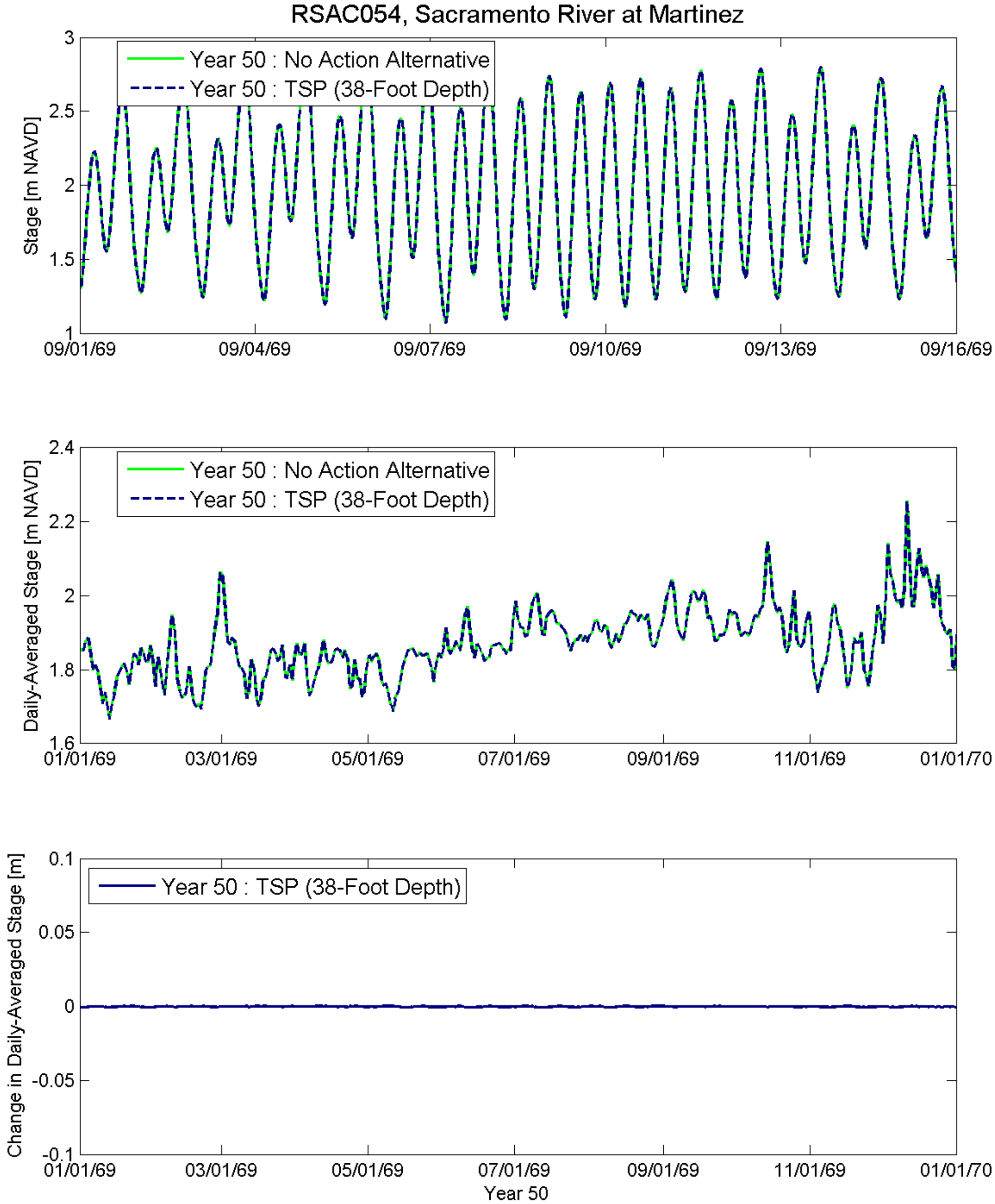


Figure 6.2-14

Predicted Stage at Sacramento River at Martinez (RSAC054) for the Year 50 No Action Alternative and the Year 50 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Critical Water Year Evaluated in Year 50

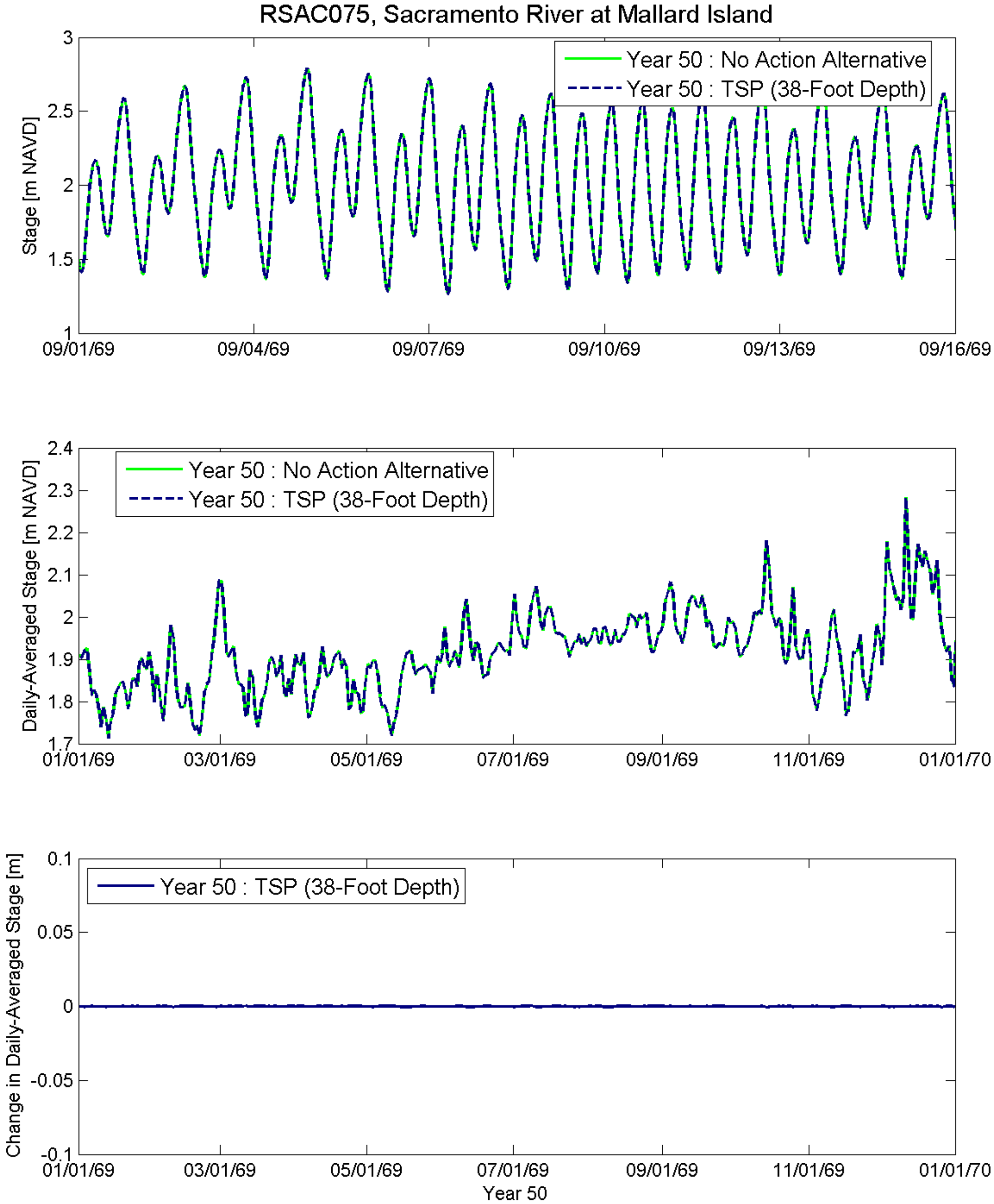


Figure 6.2-15

Predicted Stage at Sacramento River at Mallard Island (RSAC075) for the Year 50 No Action Alternative and the Year 50 TSP Scenario over a 15-Day Period (Top); Daily-Averaged Stage (Middle); and Predicted Change in Daily-Averaged Stage (Bottom) for the Critical Water Year Evaluated in Year 50

6.2.2.4 Effect of TSP on Tidal Flows During a Critical Water Year in Year 50

Flow time series comparisons were made at three locations in San Francisco Bay spanning the geographic extent of the project (Figure 3.7-1). For each flow comparison figure included in this section, the top plot shows the tidal time-scale flows over a 15-day period for the Year 50 No Action Alternative and the Year 50 TSP scenario. The middle plot shows tidally-averaged flow during the full simulation year for each scenario. The bottom plot shows the predicted change in tidally-averaged flow for the Year 50 TSP scenario relative to the Year 50 No Action Alternative. Because the predicted flow is nearly identical between scenarios, a dashed line is used for the Year 50 TSP scenario because it is plotted on top of the line for the No Action Alternative. Comparisons of the predicted flow for the Year 50 No Action Alternative and the Year 50 TSP were made at the Point San Pablo (Figure 6.2-16) which is seaward of the Pinole Shoal Channel, Carquinez Bridge (Figure 6.2-17) which is located west of the Suisun Bay Channel, and Chipps Island (Figure 6.2-18) which is east of the project area. These comparisons show that the predicted flows for the No Action Alternative and the TSP are nearly identical in Year 50, with only very small differences in tidally-averaged flows at each location during the critical water year evaluated. These very small differences in tidally-averaged flows are several orders of magnitude smaller than the tidal and tidally-averaged flows and likely result from small phase differences in tidal propagation as a result of the channel deepening.

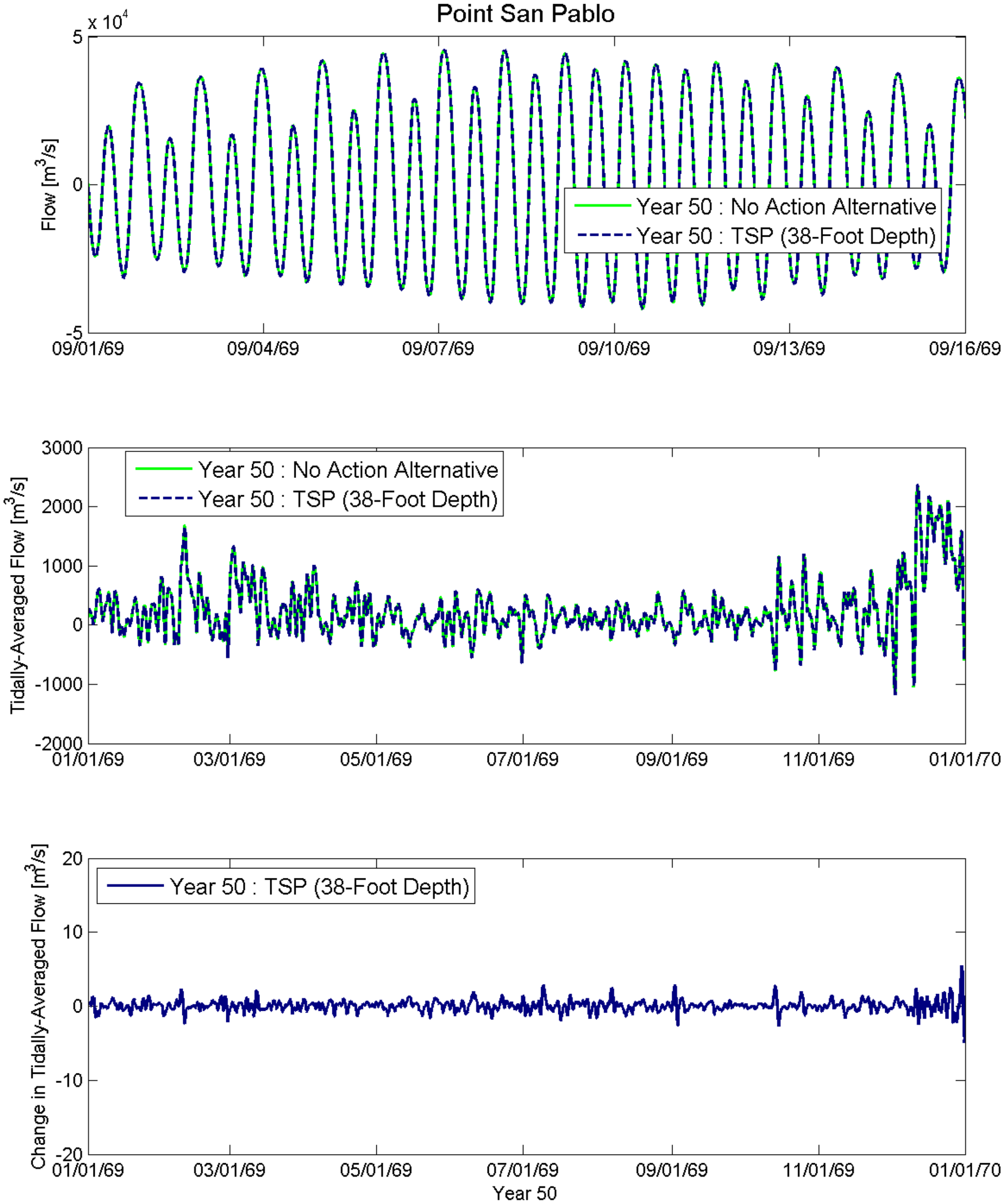


Figure 6.2-16

Predicted Tidal Flow at Point San Pablo for the Year 50 No Action Alternative and the Year 50 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Critical Water Year Evaluated in Year 50

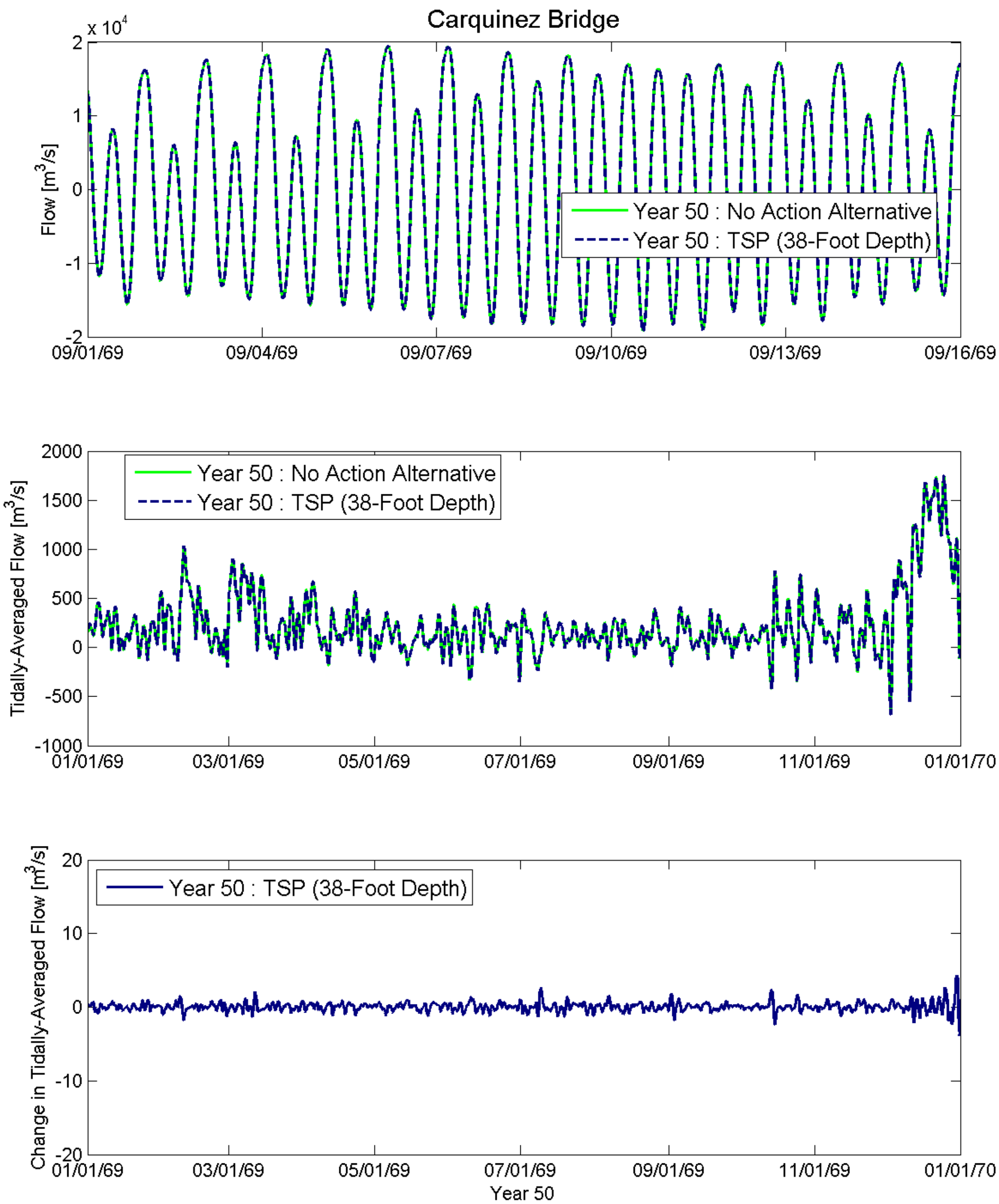


Figure 6.2-17

Predicted Tidal Flow at Carquinez Bridge for the Year 50 No Action Alternative and the Year 50 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Critical Water Year Evaluated in Year 50

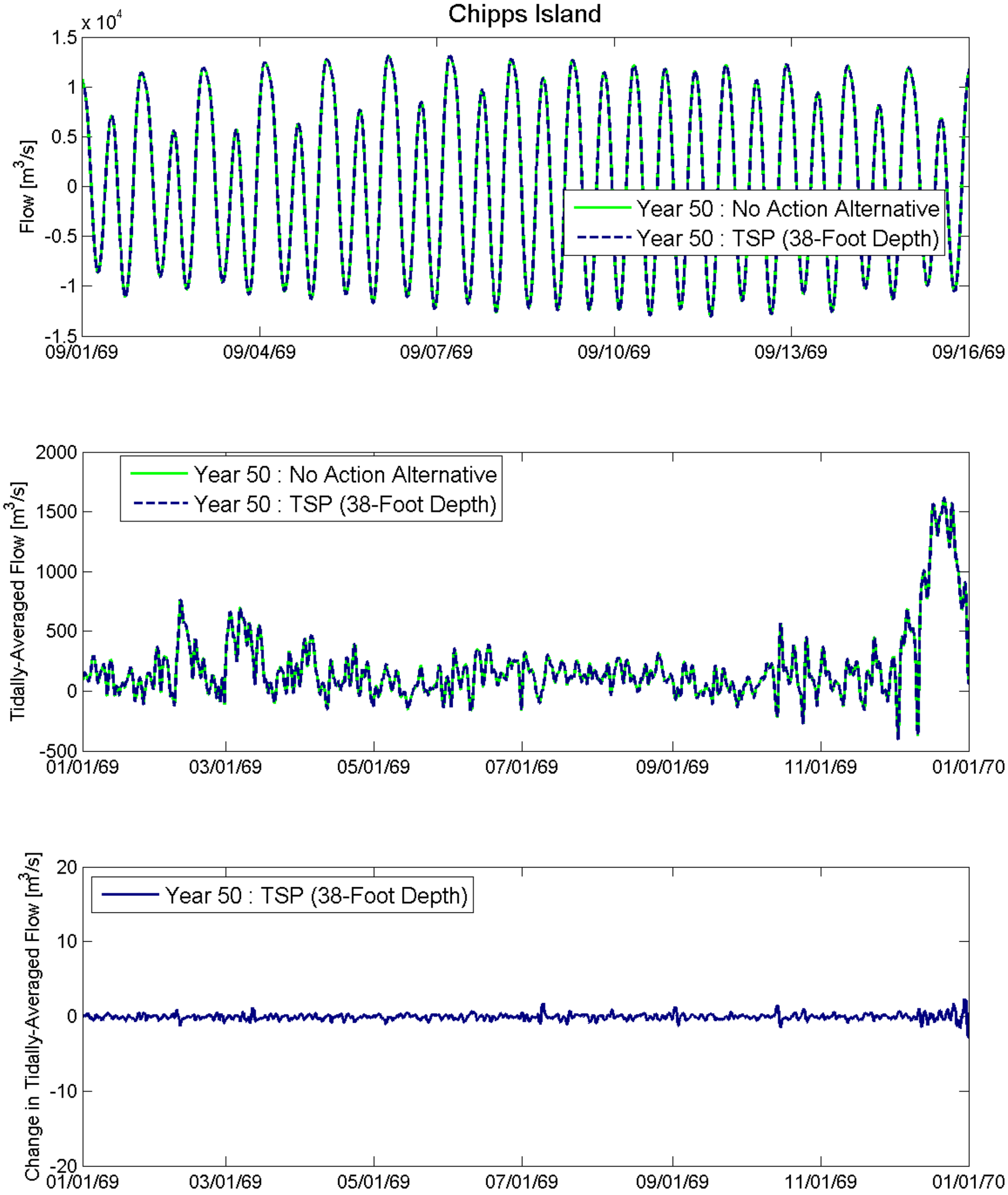


Figure 6.2-18

Predicted Tidal Flow at Chipps Island for the Year 50 No Action Alternative and the Year 50 TSP Scenario over a 15-Day Period (Top); Tidally-Averaged Flow (Middle); and Predicted Change in Tidally-Averaged Flow Resulting from the TSP (Bottom) for the Critical Water Year Evaluated in Year 50

7 ANALYSIS OF THE EFFECTS OF THE TSP ON THE LOW SALINITY ZONE

This section provides an analysis of the effects of the TSP on the area and position of the Low Salinity Zone for the critical water year, below normal water year, and wet water year evaluated. Because Delta Smelt spend most of their life cycle in the low salinity zone, salinity is a primary constituent element (PCE) of Delta Smelt critical habitat. The salinity PCE for Delta Smelt is defined as the Low Salinity Zone (LSZ), which ranges from 0.5 psu to 6 psu (USFWS 2008). As a result, this analysis focuses specifically on the areal extent of the LSZ and the impact of the proposed deepening of the San Francisco Bay to Stockton Navigation Improvement Project deep-draft navigation channels on the area and extent of the LSZ.

This analysis was conducted for Year 0 TSP scenarios which were conducted for a critical water year (Section 5.2), a below normal water year (Section 5.3), and a wet water year (Section 5.4). The historical conditions used to develop these scenarios are described in Section 3.3.

7.1 LSZ Analysis Approach

In this analysis, the LSZ habitat area is calculated using the predicted depth-averaged daily-averaged salinity following the approach developed by Delta Modeling Associates (2014c). For each model time step (90 seconds), the depth-averaged salinity is calculated within each grid cell in the model domain, and then the daily-averaged depth-averaged salinity is calculated from the depth-averaged salinity calculated at each of 960 model time steps in each day. The daily-averaged LSZ habitat area for each day is then calculated by summing up the total area of the grid cells with depth-averaged daily-averaged salinity between 0.5 psu and 6 psu within a specified geographic range. For this analysis, the geographic range extends from San Pablo Bay through Franks Tract and covers the domain shown in Figures 7.2-1. Area within the salinity range of the LSZ that is not within the domain of these maps was not counted as LSZ habitat in this analysis. For example, areas with the salinity range of the LSZ which occur in South San Francisco Bay or outside the geographic extent of Figure 7.2-1 are not included in this analysis.

7.2 Evaluation of the Effect of the TSP on the Low Salinity Zone During a Critical Water Year

This section presents the evaluation of the effects on the TSP on the LSZ during and following the critical water year analyzed in Section 5.2. The period evaluated is based on historical conditions between January 1, 2014, and December 31, 2014, as described in Section 3.3.1. For each day during this period, the geographic extent and area of the LSZ were calculated for both the No Action Alternative and the TSP. Figures 7.2-1 and 7.2-2 show, respectively, the predicted geographic extent of the LSZ for the No Action Alternative and the TSP on April 1 of the critical water year evaluated. The predicted LSZ area for the No Action Alternative and the TSP varies over the year (Figure 7.2-3, top) as the salinity gradient moves along the axis of the estuary. Due to the non-monotonic relationship between the area of the LSZ and X2 which is largely controlled by the geometry of the estuary (see MacWilliams et al. 2015), the small landward shift (increase) of X2 which results from the TSP during the critical water year (Section 5.2.1) can result in either a decrease or an increase in the area of the LSZ on each day (Figure 7.2-3, bottom). This results because, as the salinity gradient moves upstream as a result of the increase in X2, some regions on the western end of the LSZ are removed from the LSZ as the daily averaged salinity increases above 6 psu, whereas other regions on the eastern edge of the LSZ are added to the LSZ as the daily-averaged salinity increases from less than 0.5 psu to more than 0.5 psu. Examples of the change in LSZ extent resulting from the TSP in the critical water year are shown for April 1 (Figure 7.2-4), July 1 (Figure 7.2-5), and September 1 (Figure 7.2-6). Depending on the area removed from the LSZ and the area added to the LSZ, this can result in either an increase or decrease in the LSZ area (Figure 7.2-3, bottom). For example, on April 1 the area of the LSZ is predicted to decrease by 270 acres as a result of the TSP, on July 1 the area of the LSZ is predicted to increase by 55 acres as a result of the TSP, and on September 1 the area of the LSZ is predicted to increase by 643 acres as a result of the TSP during the critical water year evaluated. The predicted monthly-average area of the LSZ for the No Action Alternative ranges from 13,422 acres to 23,354 acres during the critical water year, and the monthly-average area of the LSZ for the TSP ranges from 13,552 to 23,468 acres (Table 7-1). The predicted monthly-average change in the area of the LSZ resulting from the TSP in the critical water year evaluated ranges from a decrease of 290 acres to an increase of 266 acres (Table 7-1).

Table 7-1

Predicted Monthly Average Area of the LSZ and the Predicted Change in Monthly-Averaged Area of the LSZ for the TSP for Each Month During a Critical Water Year

Year 0 Critical Water Year (2014)	Monthly-Average Area of LSZ (acres)		Monthly-Average Change in Area of LSZ (acres)
	No Action Alternative	TSP (38-Foot Depth)	
January 2014	16196	16281	85
February 2014	17739	17539	-200
March 2014	21908	21692	-216
April 2014	21748	21492	-256
May 2014	16163	15873	-290
June 2014	15836	15912	76
July 2014	13450	13552	102
August 2014	13422	13688	266
September 2014	14215	14313	98
October 2014	15039	15065	26
November 2014	15633	15597	-36
December 2014	23354	23468	114

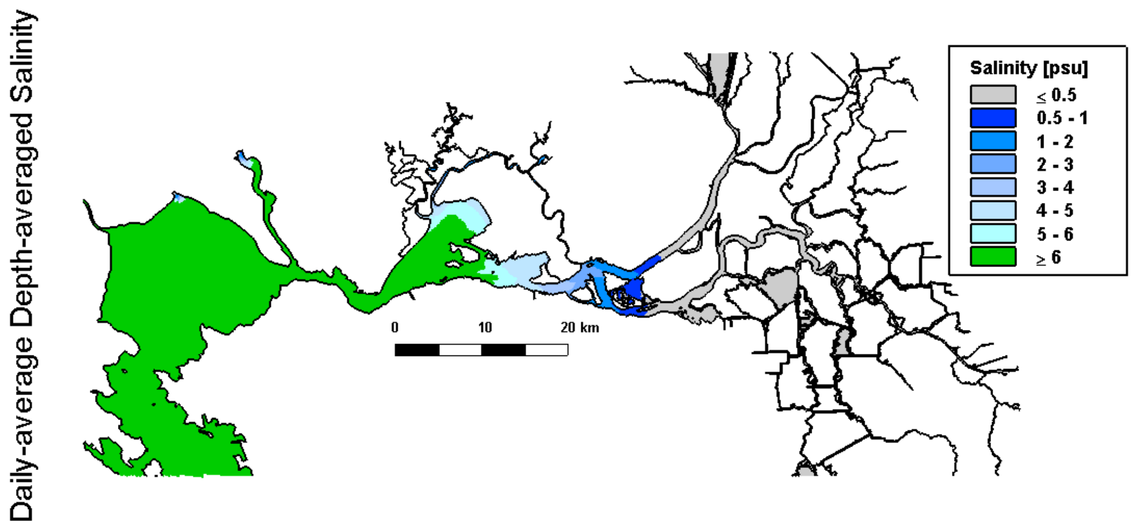


Figure 7.2-1

Predicted Geographic Extent of the LSZ for the Year 0 No Action Alternative During a Critical Water on April 1, 2014

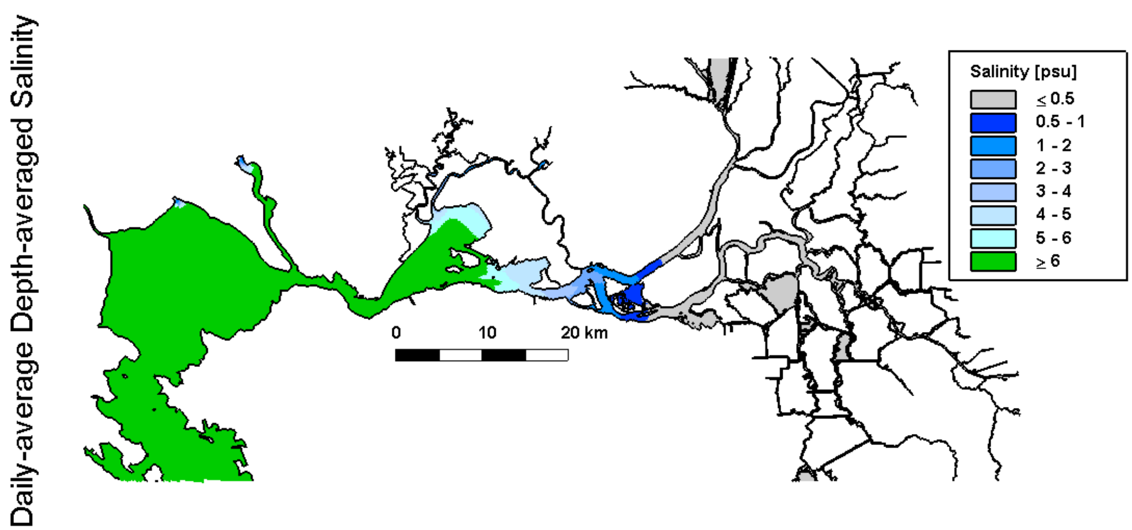


Figure 7.2-2

Predicted Geographic Extent of the LSZ for the Year 0 TSP (38-Foot Depth) During a Critical Water on April 1, 2014

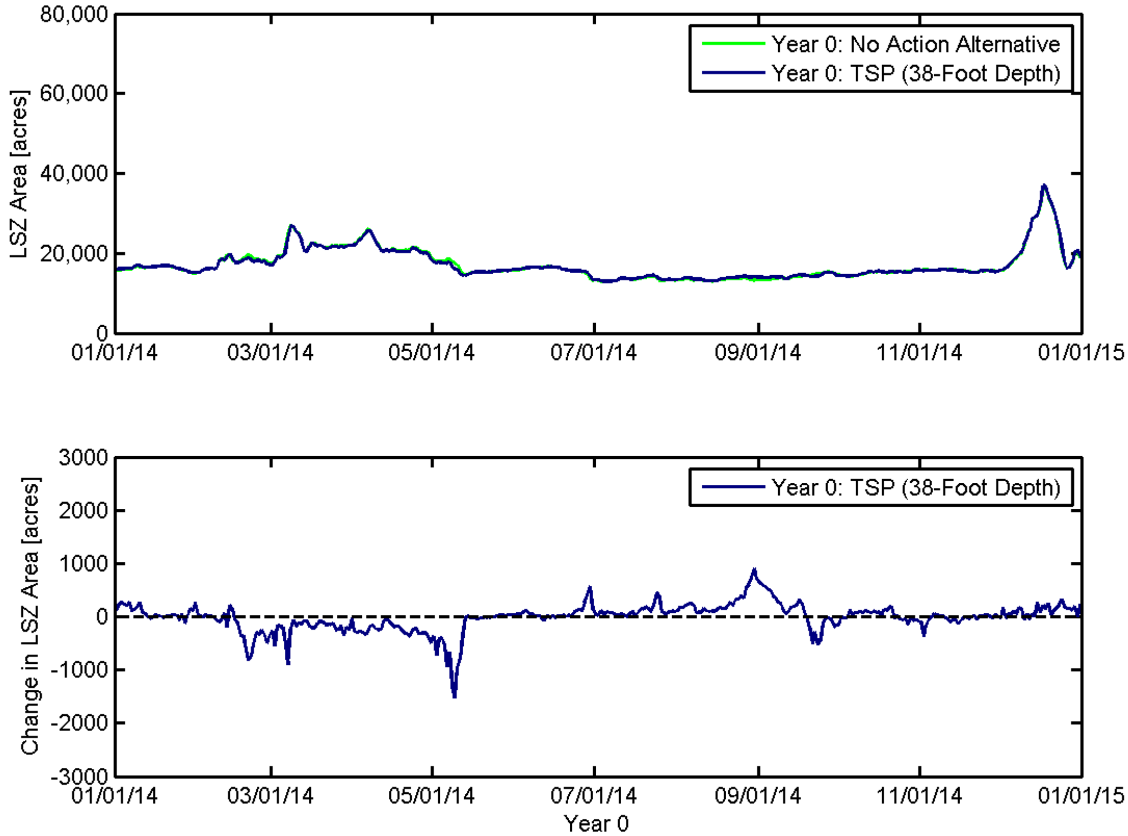


Figure 7.2-3
Predicted Area of the LSZ for the Year 0 No Action Alternative and the TSP During a Critical Water Year (Top); Predicted Change in LSZ Area Relative to the Year 0 No Action Alternative for the TSP During a Critical Water Year (Bottom)

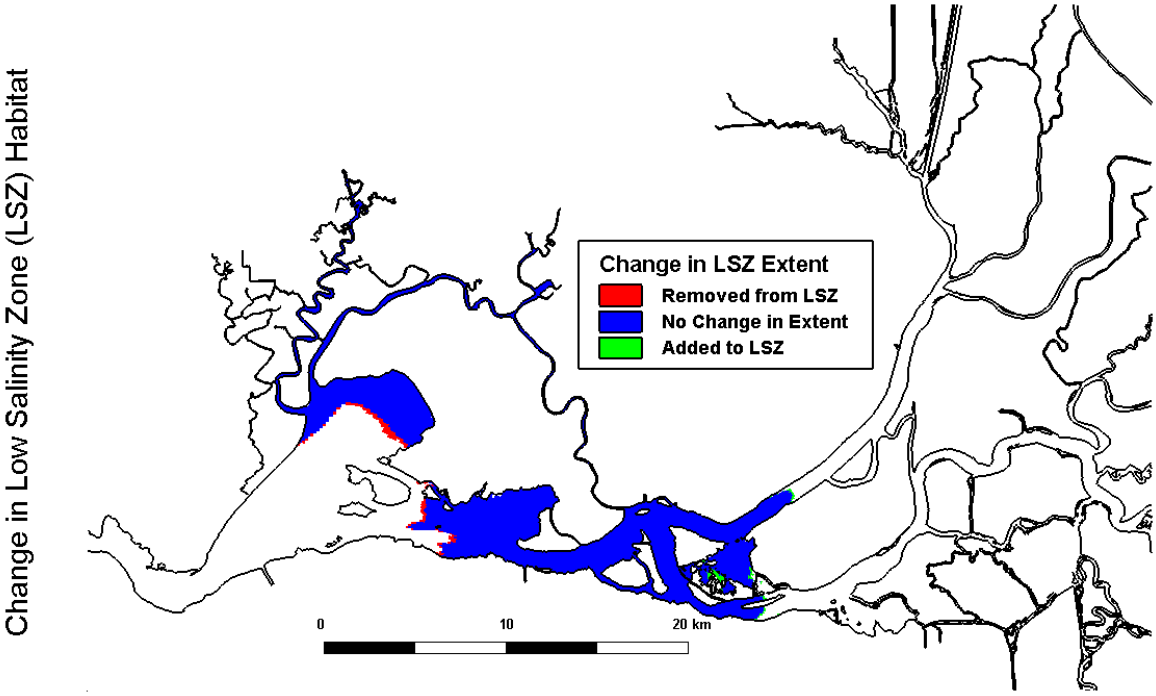


Figure 7.2-4

Predicted Change in Geographic Extent of the LSZ Resulting from the Year 0 TSP (38-Foot Depth) During a Critical Water Year on April 1, 2014

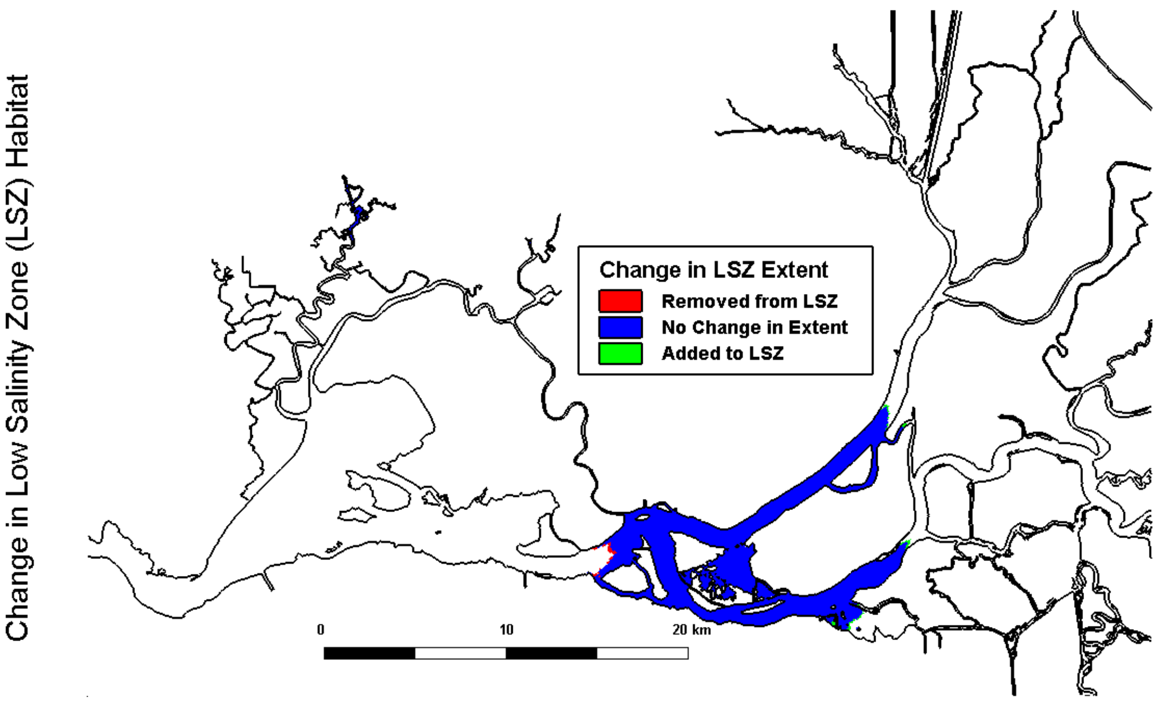


Figure 7.2-5

Predicted Change in Geographic Extent of the LSZ Resulting from the Year 0 TSP (38-Foot Depth) During a Critical Water Year on July 1, 2014

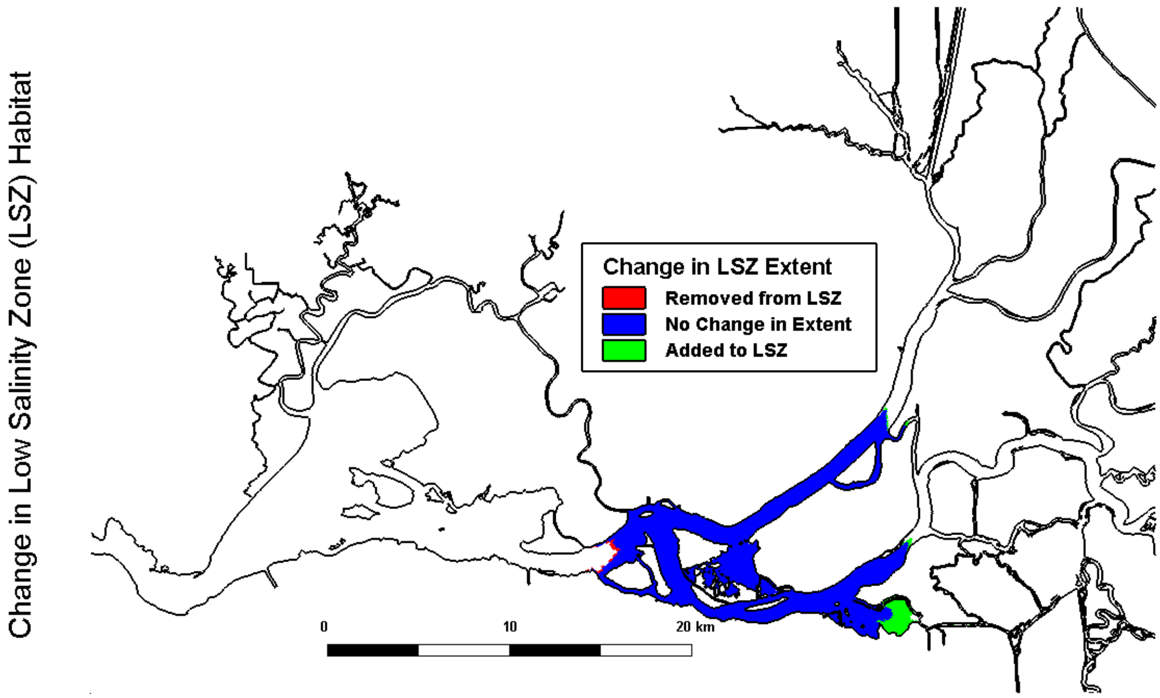


Figure 7.2-6

Predicted change in geographic extent of the LSZ resulting from the Year 0 TSP (38-Foot Depth) During a Critical Water Year on September 1, 2014

7.3 Evaluation of the Effect of the TSP on the Low Salinity Zone During a Below Normal Water Year

This section presents the evaluation of the effects on the TSP on the LSZ during and following the below normal water year analyzed in Section 5.3. The period evaluated is based on historical conditions between January 1, 2012, and December 31, 2012, as described in Section 3.3.2. For each day during this period, the geographic extent and area of the LSZ were calculated for both the No Action Alternative and the TSP. Example figures showing the predicted geographic extent of the LSZ for the No Action Alternative and the TSP on April 1 of the below normal water year evaluated are shown in Figures 7.3-1 and 7.3-2, respectively. Relative to the critical water year (Figures 7.2-1 and 7.2-2), the LSZ is shifted further west on April 1 during the below normal water year (Figures 7.3-1 and 7.3-2). The predicted LSZ area for the No Action Alternative and the TSP varies over the year (Figure 7.3-3, top) as the salinity gradient moves along the axis of the estuary. Due to the non-monotonic relationship between the area of the LSZ and X2 which is largely controlled by the geometry of the estuary (see MacWilliams et al. 2015), the small landward shift (increase) of X2 which results from the TSP during the below normal water year (Section 5.3.1) can result in either a decrease or an increase in the area of the LSZ on each day (Figure 7.3-3, bottom). This results because as the salinity gradient moves upstream as a result of the increase in X2, some regions on the western end of the LSZ are removed from the LSZ as the daily averaged salinity increases above 6 psu, whereas other regions on the eastern edge of the LSZ are added to the LSZ as the daily-averaged salinity increases from less than 0.5 psu to more than 0.5 psu. Examples of the change in LSZ extent resulting from the TSP in the below normal water year are shown for April 1 (Figure 7.3-4), July 1 (Figure 7.3-5), and October 1 (Figure 7.3-6). Depending on the area removed from the LSZ and the area added to the LSZ, this can result in either an increase or decrease in the LSZ area (Figure 7.3-3, bottom). For example, on April 1 the area of the LSZ is predicted to increase by 100 acres as a result of the TSP, on July 1 the area of the LSZ is predicted to decrease by 195 acres as a result of the TSP, and on October 1 the area of the LSZ is predicted to decrease by 74 acres as a result of the TSP during the below normal water year evaluated. The predicted monthly-average area of the LSZ for the No Action Alternative ranges from 14,083 acres to 26,705 acres during the below normal water year, and the monthly-average area of the LSZ for the TSP ranges from 13,966 to 26,807 acres (Table 7-2). The predicted monthly-average change in the area of the LSZ resulting from the TSP in the below normal water year evaluated ranges from a decrease of 587 acres to an increase of 446 acres (Table 7-2).

Table 7-2
Predicted Monthly Average Area of the LSZ and the Predicted Change in Monthly-Averaged Are of the LSZ for the TSP for Each Month During a Below Normal Water Year

Year 0 Below Normal Water Year (2012)	Monthly-Average Area of LSZ (acres)		Monthly-Average Change in Area of LSZ (acres)
	No Action Alternative	TSP (38-Foot Depth)	
January 2012	16926	16854	-72
February 2012	23723	23542	-181
March 2012	24464	24350	-114
April 2012	18155	18601	446
May 2012	22585	22789	204
June 2012	22151	21795	-356
July 2012	21217	20630	-587
August 2012	20670	20304	-366
September 2012	15821	15674	-147
October 2012	14083	13966	-117
November 2012	15699	15732	33
December 2012	26705	26807	102

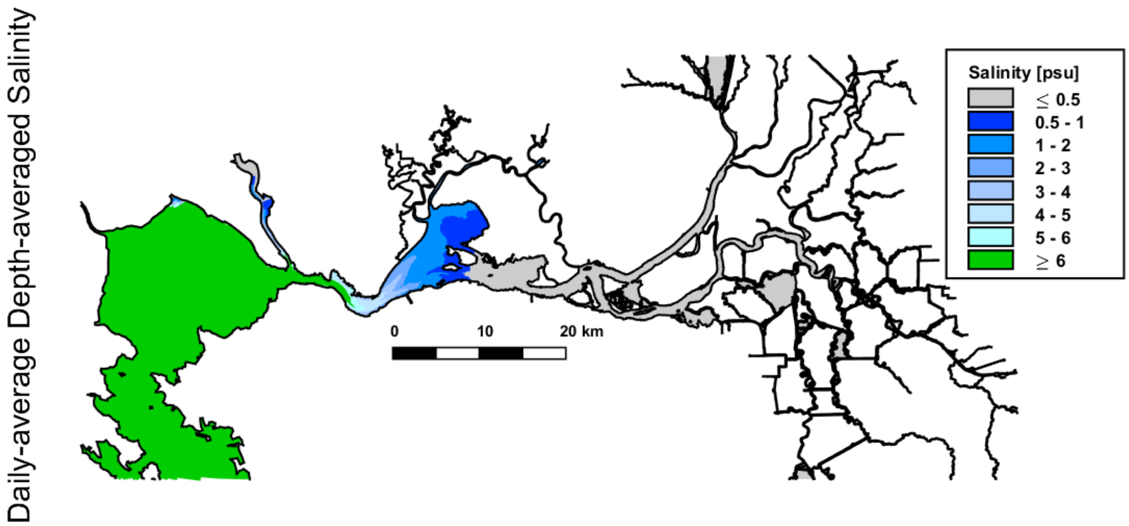


Figure 7.3-1

Predicted Geographic Extent of the LSZ for the Year 0 No Action Alternative During a Below Normal Water Year on April 1, 2012

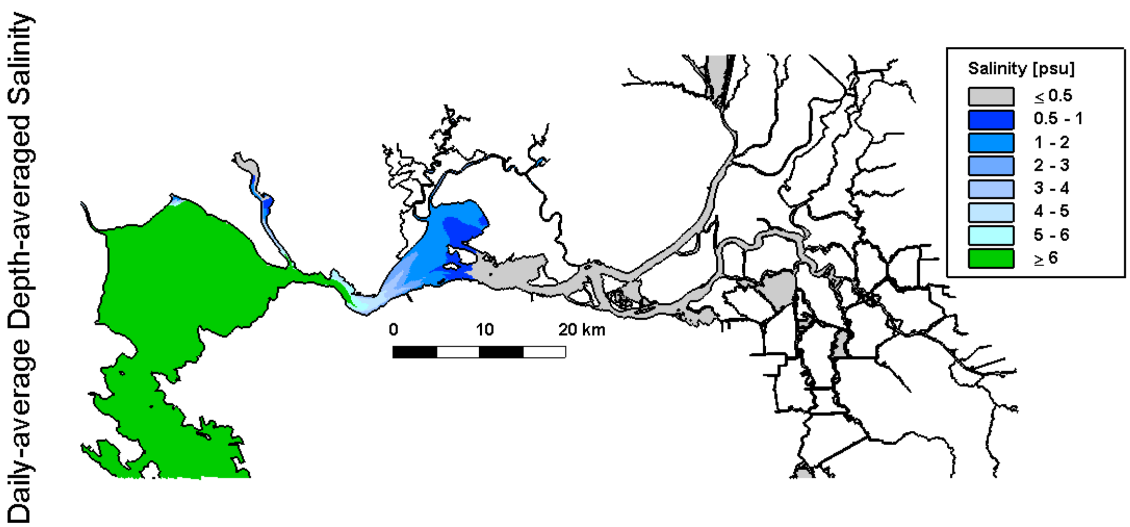


Figure 7.3-2

Predicted Geographic Extent of the LSZ for the Year 0 TSP (38-Foot Depth) During a Below Normal Water Year on April 1, 2012

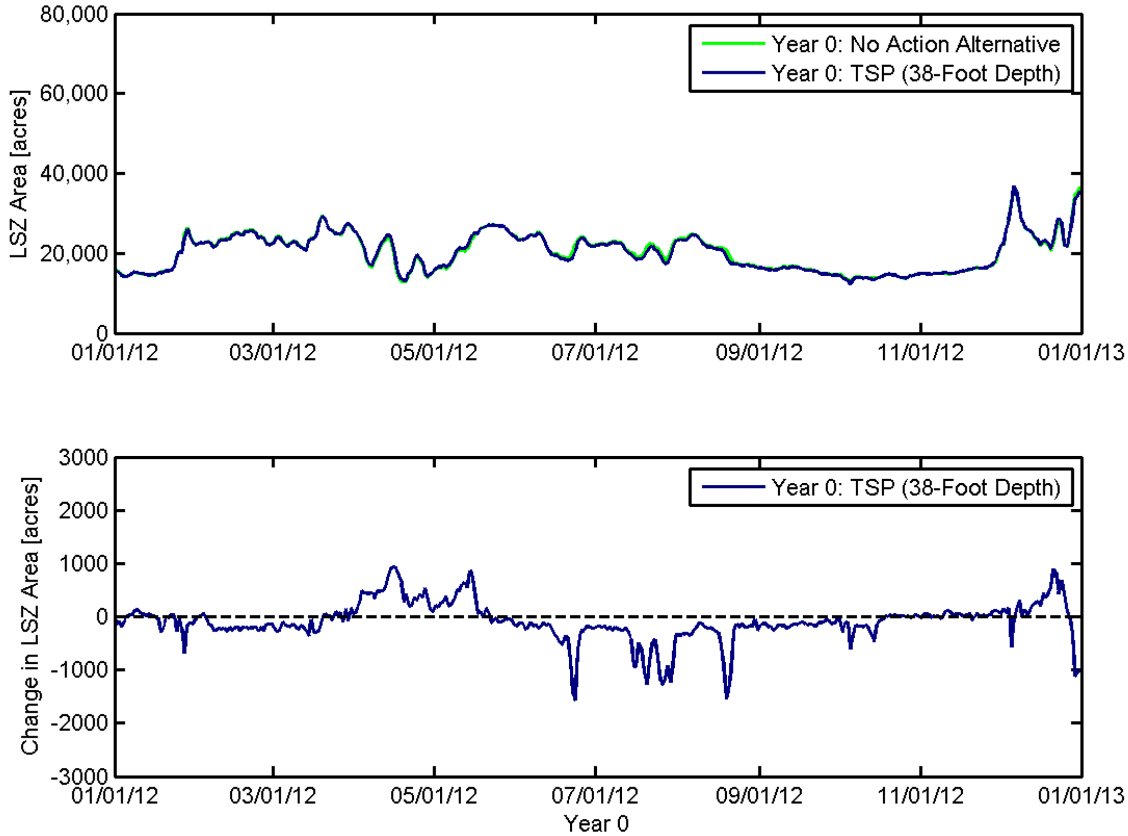


Figure 7.3-3

Predicted Area of the LSZ for the Year 0 No Action Alternative and the TSP During a Below Normal Water Year (Top); Predicted Change in LSZ Area Relative to the Year 0 No Action Alternative for the TSP During a Below Normal Water Year (Bottom)

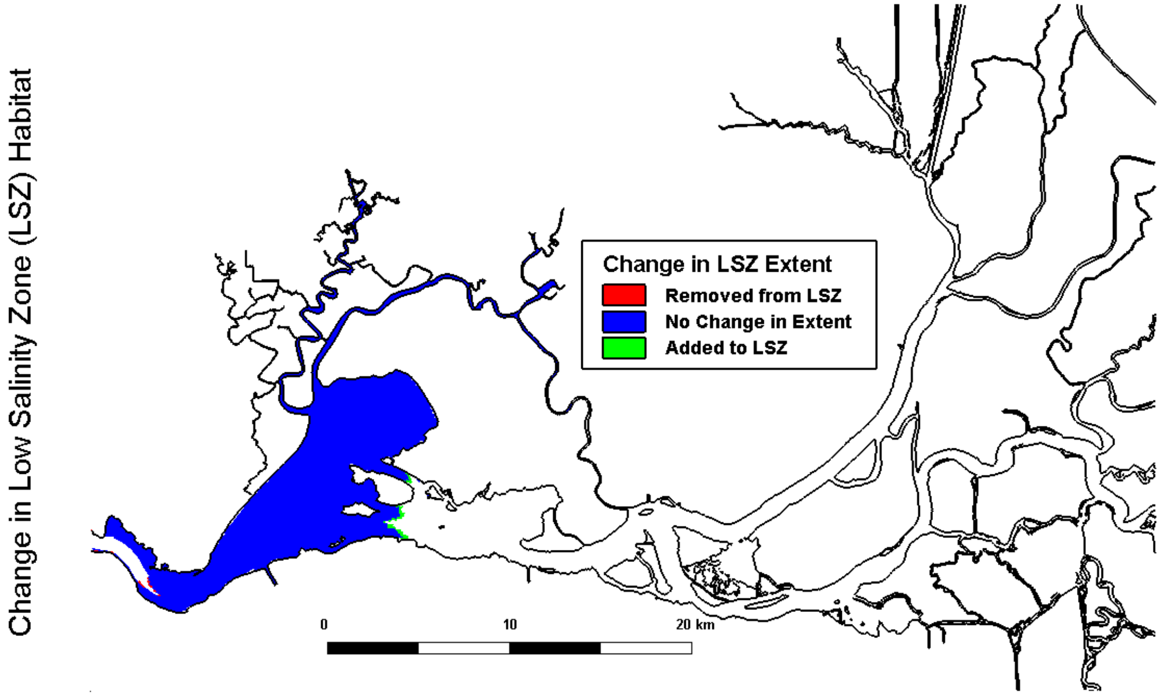


Figure 7.3-4

Predicted Change in Geographic Extent of the LSZ Resulting from the Year 0 TSP (38-Foot Depth) During a Below Normal Water on April 1, 2012

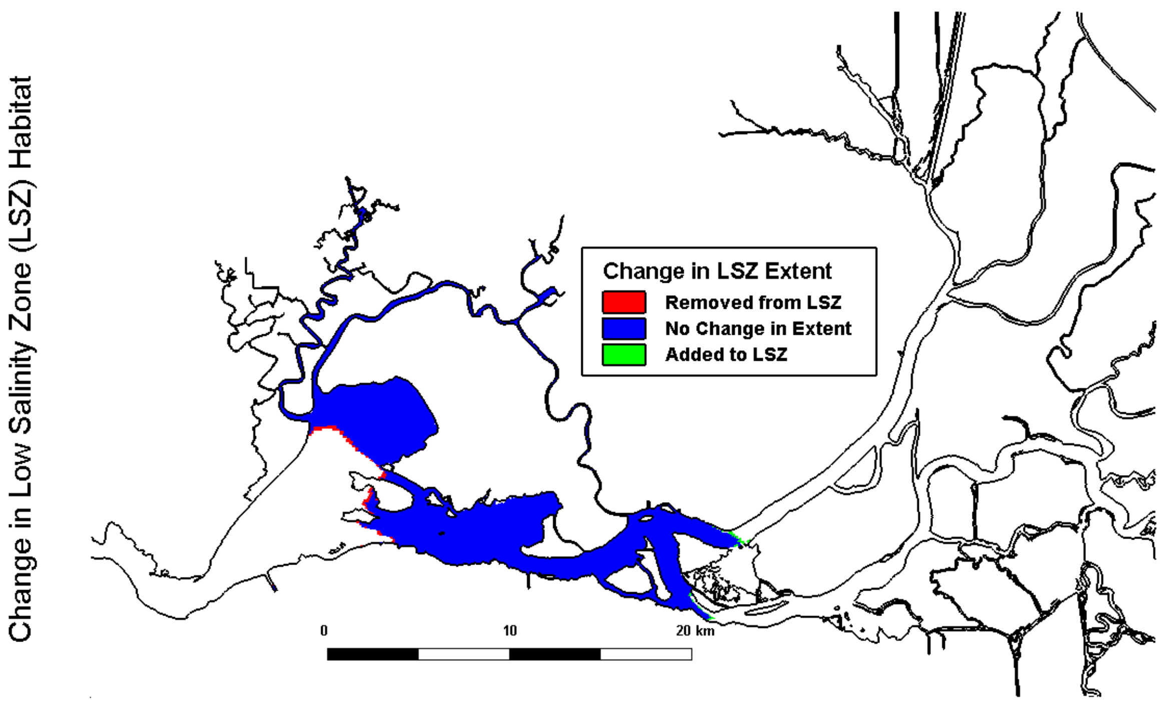


Figure 7.3-5

Predicted Change in Geographic Extent of the LSZ Resulting from the Year 0 TSP (38-Foot Depth) During a Below Normal Water Year on July 1, 2012

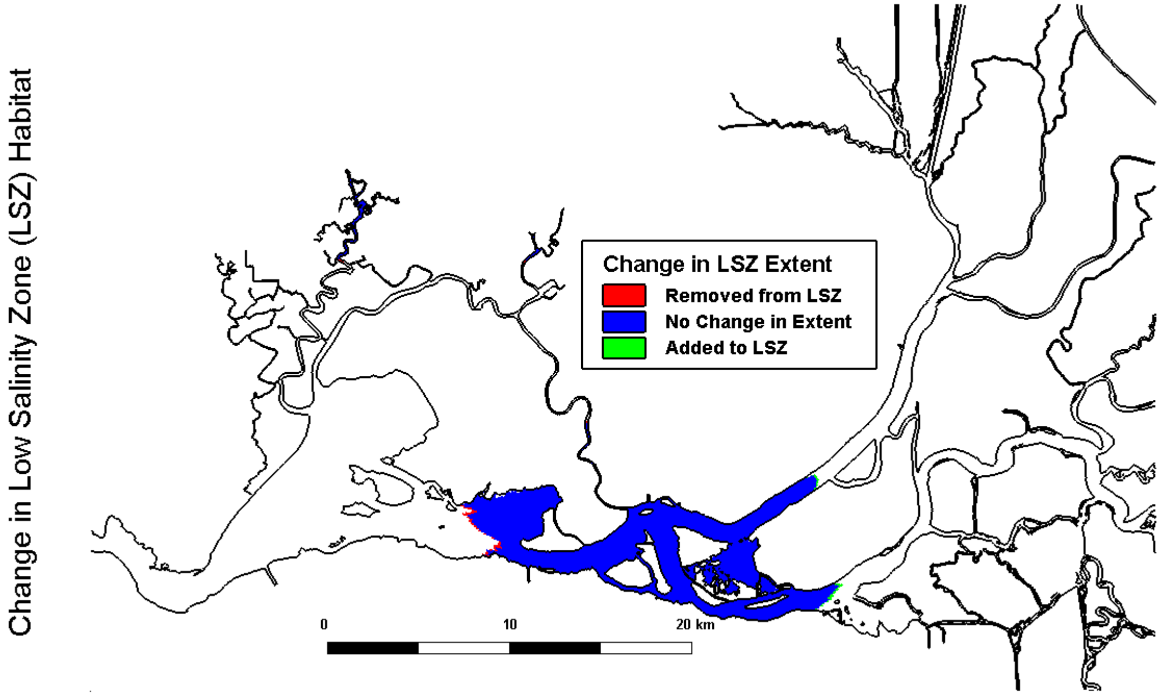


Figure 7.3-6

Predicted Change in Geographic Extent of the LSZ Resulting from the Year 0 TSP (38-Foot Depth) During a Below Normal Water on October 1, 2012

7.4 Evaluation of the effect of the TSP on the Low Salinity Zone during a Wet Water Year

This section presents the evaluation of the TSP on the LSZ during and following the wet water year analyzed in Section 5.4. The period evaluated is based on historical conditions between January 1, 2011, and December 31, 2011, as described in Section 3.3.3. For each day during this period, the geographic extent and area of the LSZ were calculated for both the No Action Alternative and the TSP. Example figures showing the predicted geographic extent of the LSZ for the No Action Alternative and the TSP on April 1 of the wet water year evaluated are shown in Figures 7.4-1 and 7.4-2, respectively. Relative to the critical water year (Figures 7.2-1 and 7.2-2) and below normal water year (Figures 7.3-1 and 7.3-2), the LSZ is shifted significantly further west into San Pablo Bay on April 1 during the below normal water year (Figures 7.4-1 and 7.4-2). The predicted LSZ area for the No Action Alternative and the TSP varies over the year (Figure 7.4-3, top) as the salinity gradient moves along the axis of the estuary. Due to the non-monotonic relationship between the area of the LSZ and X2 which is largely controlled by the geometry of the estuary (see MacWilliams et al. 2015), the small landward shift (increase) of X2 which results from the TSP during the wet water year (Section 5.4.1) can result in either a decrease or an increase in the area of the LSZ on each day (Figure 7.4-3, bottom). This results because as the salinity gradient moves upstream as a result of the increase in X2, some regions on the western end of the LSZ are removed from the LSZ as the daily averaged salinity increases above 6 psu, whereas other regions on the eastern edge of the LSZ are added to the LSZ as the daily-averaged salinity increases from less than 0.5 psu to more than 0.5 psu. Examples of the change in LSZ extent resulting from the TSP during and following the wet water year are shown for August 1 (Figure 7.4-4), October 1 (Figure 7.4-5), and November 1 (Figure 7.4-6). Depending on the area removed from the LSZ and the area added to the LSZ, this can result in either an increase or decrease in the LSZ area (Figure 7.4-3, bottom). For example, on August 1 the area of the LSZ is predicted to decrease by 29 acres as a result of the TSP, on October 1 the area of the LSZ is predicted to decrease by 19 acres as a result of the TSP, and on November 1 the area of the LSZ is predicted to decrease by 234 acres as a result of the TSP during the below normal water year evaluated. The predicted monthly-average area of the LSZ for the No Action Alternative ranges from 12,130 acres to 51,372 acres during the wet water year, and the monthly-average area of the LSZ for the TSP ranges from 11,935 to 51,680 acres (Table 7-3). The predicted monthly-average change in the area of the LSZ resulting from the

TSP in the wet water year evaluated ranges from a decrease of 284 acres to an increase of 417 acres (Table 7-3).

Table 7-3

Predicted Monthly Average Area of the LSZ and the Predicted Change in Monthly-Averaged Are of the LSZ for the TSP for Each Month During a Wet Water Year

Year 0 Wet Water Year (2011)	Monthly-Average Area of LSZ (acres)		Monthly-Average Change in Area of LSZ (acres)
	No Action Alternative	TSP (38-Foot Depth)	
January 2011	22406	22222	-184
February 2011	23065	23482	417
March 2011	31528	31743	215
April 2011	51372	51680	308
May 2011	20580	20296	-284
June 2011	12130	11935	-195
July 2011	16095	16200	105
August 2011	25754	25685	-69
September 2011	25160	25090	-70
October 2011	24558	24497	-61
November 2011	17541	17290	-251
December 2011	16394	16221	-173

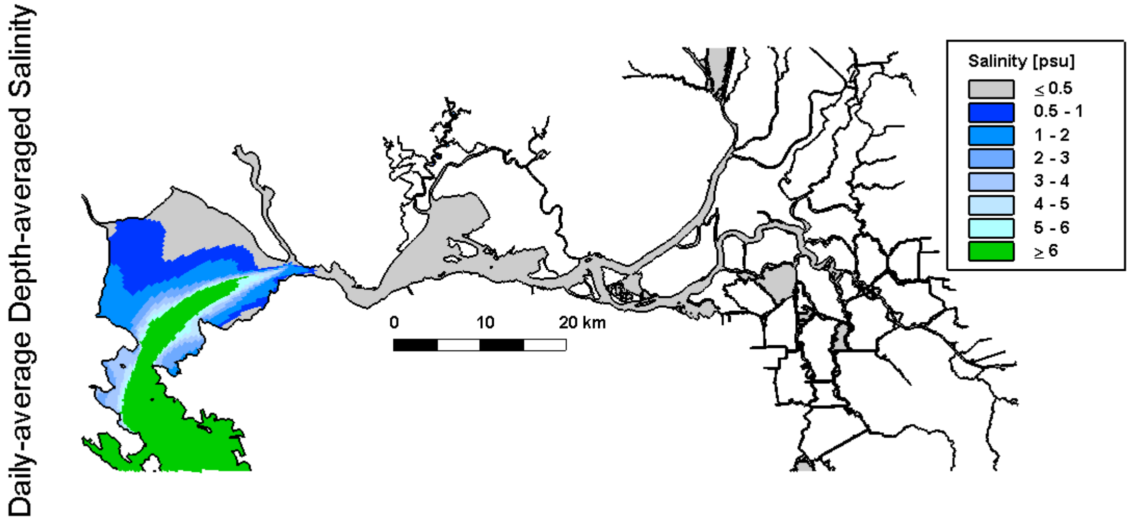


Figure 7.4-1

Predicted Geographic Extent of the LSZ for the Year 0 No Action Alternative During a Wet Water Year on April 1, 2011

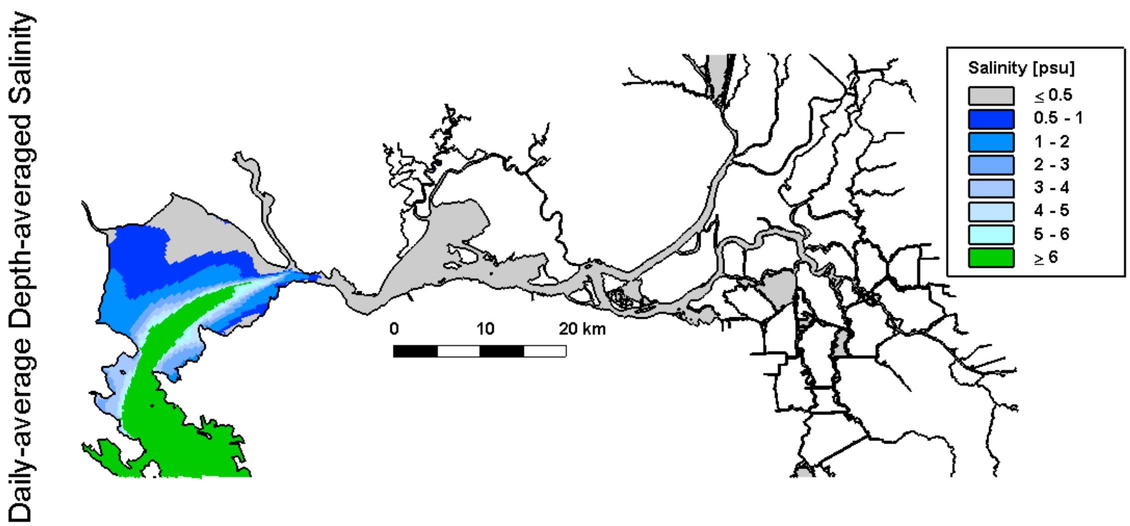


Figure 7.4-2

Predicted Geographic Extent of the LSZ for the Year 0 TSP (38-Foot Depth) During a Wet Water Year on April 1, 2011

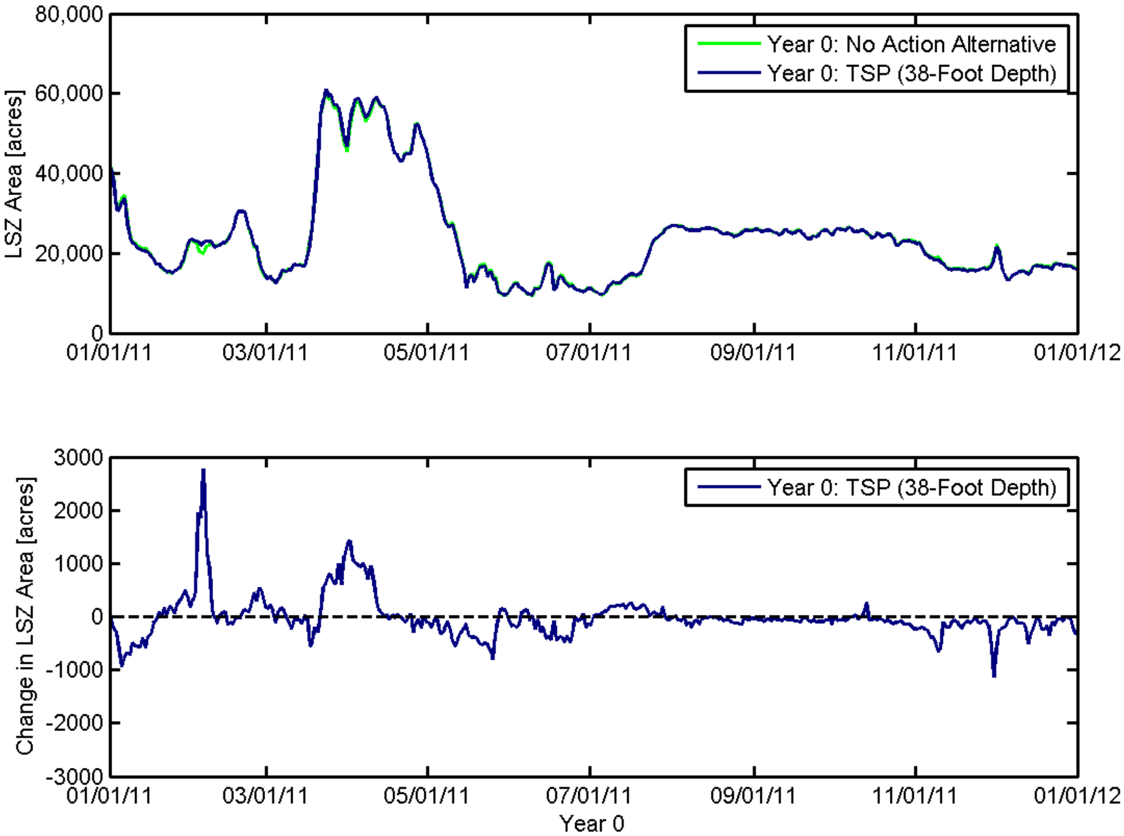


Figure 7.4-3
Predicted Area of the LSZ for the Year 0 No Action Alternative and the TSP During a Wet Water Year (Top); Predicted Change in LSZ Area Relative to the Year 0 No Action Alternative for the TSP During a Wet Water Year (Bottom)

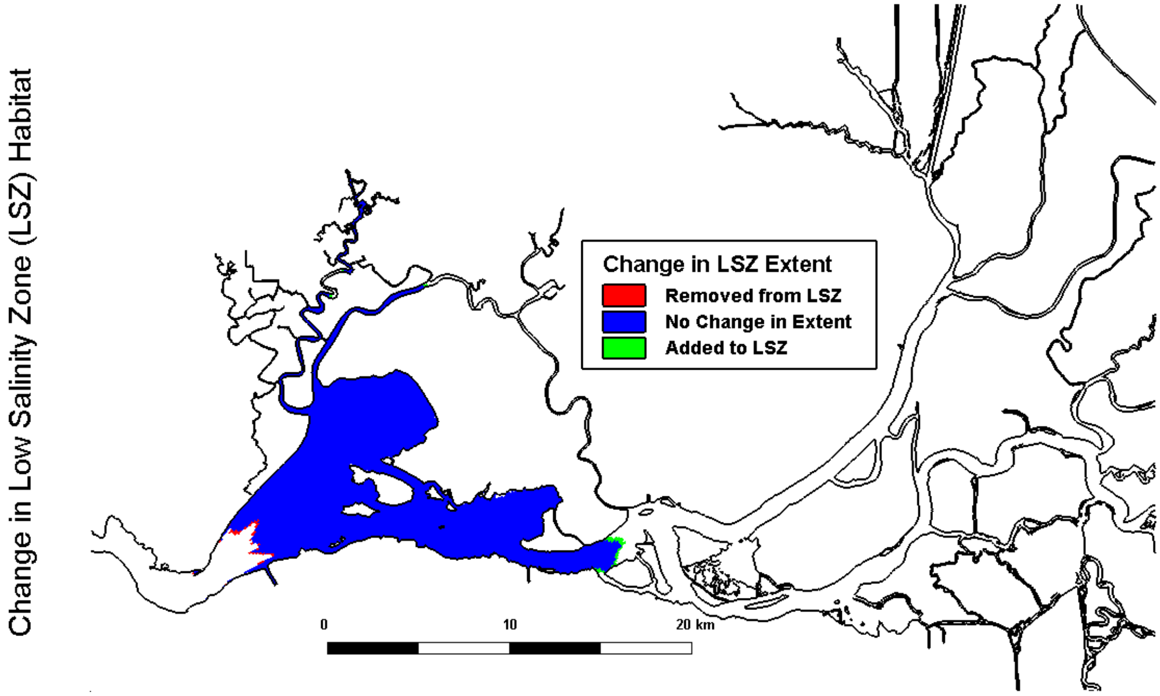


Figure 7.4-4
Predicted Change in Geographic Extent of the LSZ Resulting from the Year 0 TSP (38-Foot Depth) During a Wet Water Year on August 1, 2011

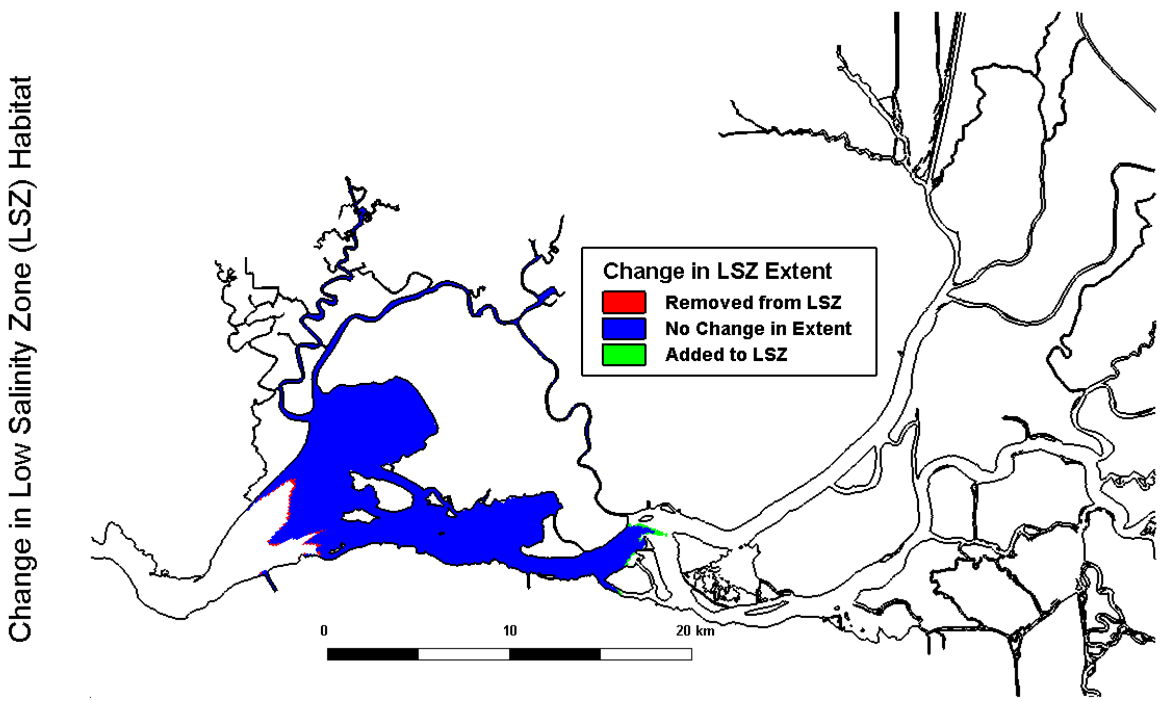


Figure 7.4-5
Predicted Change in Geographic Extent of the LSZ Resulting from the Year 0 TSP (38-Foot Depth) During a Wet Water Year on October 1, 2011

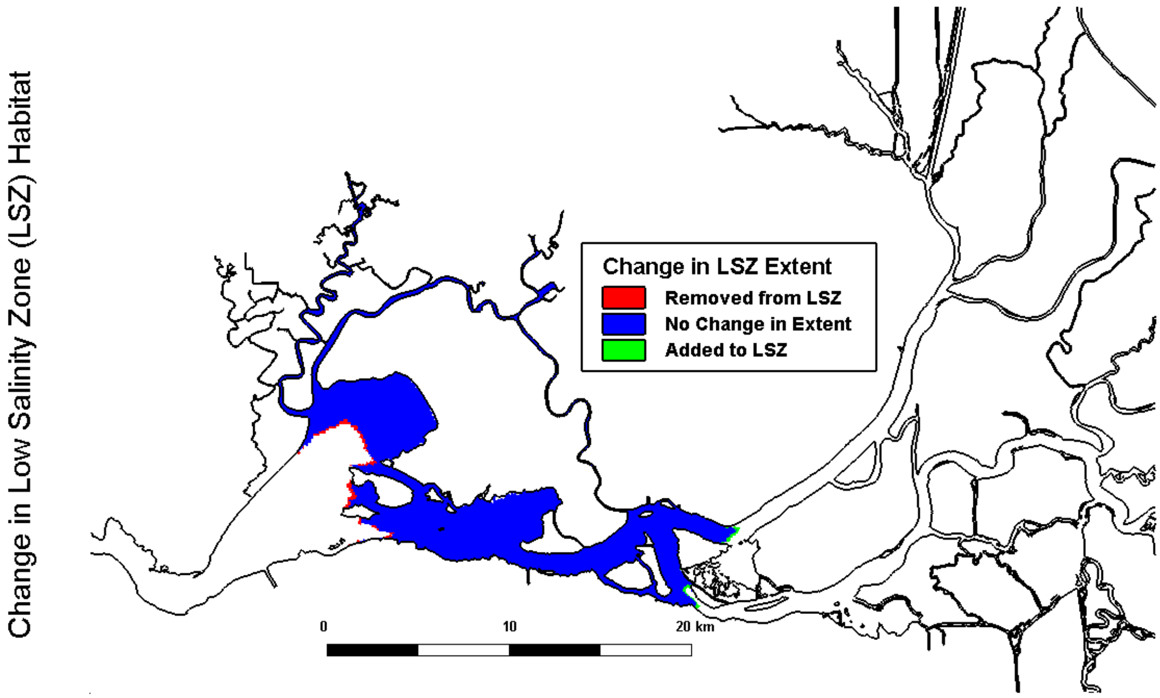


Figure 7.4-6
Predicted Change in Geographic Extent of the LSZ Resulting from the Year 0 TSP (38-Foot Depth) During a Wet Water Year on November 1, 2011

8 ASSESSMENT OF THE EFFECTS OF THE TSP ON X2 OVER A 10-YEAR HISTORICAL PERIOD

This section presents an empirical function developed using the predicted effects on X2 from the critical water year, below normal water year, and wet water year. This function is applied to support an effects determination of the TSP on the location of X2 over a 10-year historical period spanning 2008 through 2017. This period was selected to span the full range of historic conditions that have occurred since the BO for Delta Smelt (USFWS 2008) went into effect.

8.1 X2 Analysis Approach

The predictions of X2 and the predicted change in X2 resulting from the TSP for each day during the critical water year, below normal water year, and wet water year evaluated were used to develop an empirical function to estimate the effects of the TSP on X2. Model predictions for these 3 years show that as X2 increases the change in X2 resulting from the TSP decreases (Figure 8.1-1). A second-order polynomial was fit to the model predictions to estimate the relationship between X2 and the predicted change in X2, as shown in Equation 1:

$$\Delta X2 = C1 * X2^2 + C2 * X2 + C3 \qquad (1)$$

where:

$\Delta X2$	=	change in X2
$C1$	=	0.000015737266
$C2$	=	-0.006700727277
$C3$	=	0.631749454656

This function was applied to the DAYFLOW (CDWR 2019) estimate of X2 for a 10-year period spanning from 2008 through 2017, as described in Section 8.2.

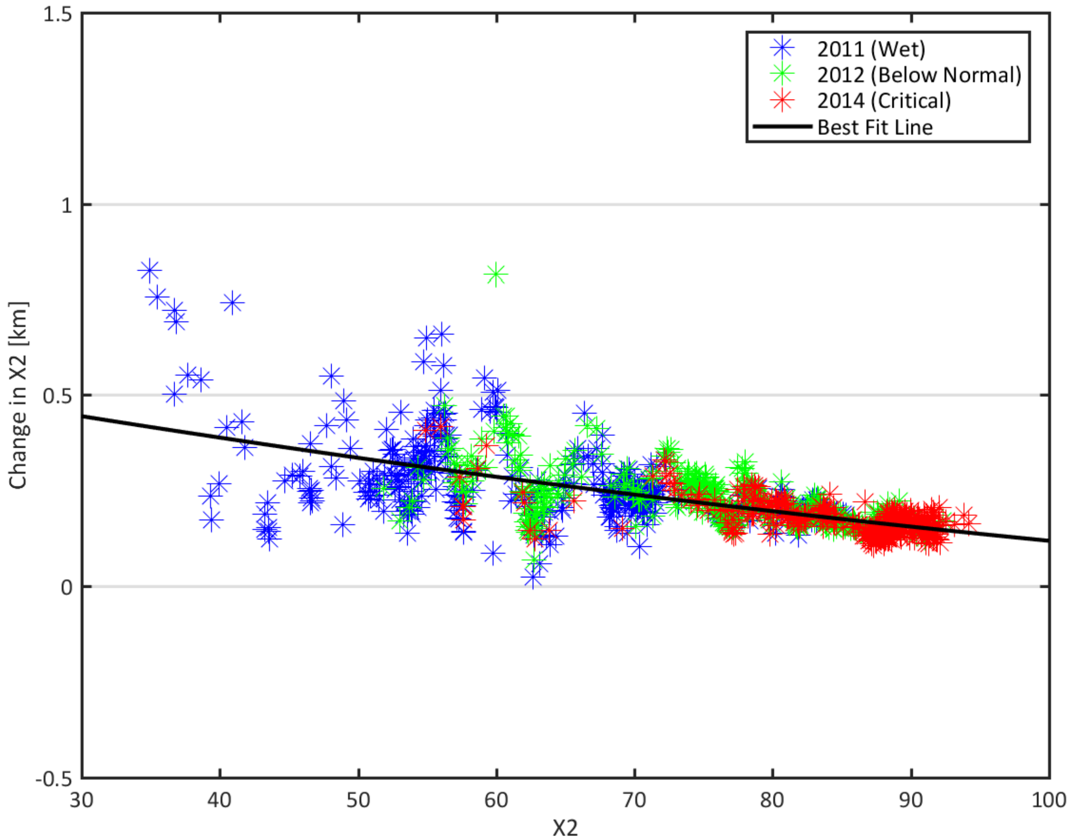


Figure 8.1-1
Predicted Change in Geographic Extent of the LSZ Resulting from the Year 0 TSP (38-Foot Depth) During a Wet Water Year on November 1, 2011

8.2 Application of X2 Function for Water Years 2008 to 2017

Equation 1 was applied to the DAYFLOW (CDWR 2019) estimate of X2 for a 10-year period spanning from 2008 through 2017 (Figure 8.2-1, top) to estimate the predicted change in X2 that would result for each day over a 10-year period (Figure 8.2-1, bottom). Based on the empirical function, the estimated annual-average change in X2 from the TSP ranged from 0.18 km to 0.27 km for the 10 water years between 2008 and 2017 (Table 8-1).

Table 8-1

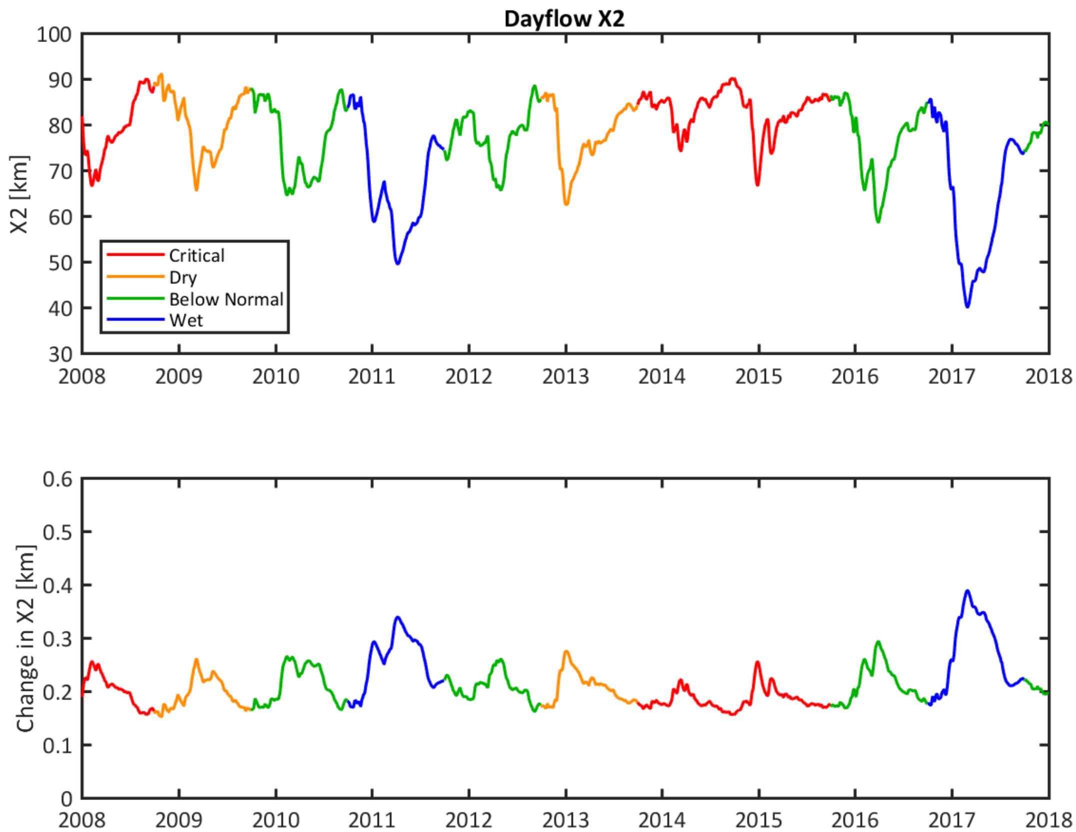
Predicted Change in X2 for the TSP for Water Years 2008 to 2017 Based on X2 Function

Water Year	Water Year Type	Change in X2 (km)	
		Annual-Average	Change for X2 > 64
2008	Critical	0.19	0.19
2009	Dry	0.20	0.20
2010	Below Normal	0.22	0.22
2011	Wet	0.26	0.22
2012	Below Normal	0.21	0.20
2013	Dry	0.20	0.20
2014	Critical	0.18	0.18
2015	Critical	0.19	0.19
2016	Below Normal	0.22	0.21
2017	Wet	0.27	0.22

Notes:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2, so the average change for periods when X2 >64 is also shown separately.
km = kilometers
TSP = Tentatively Selected Plan

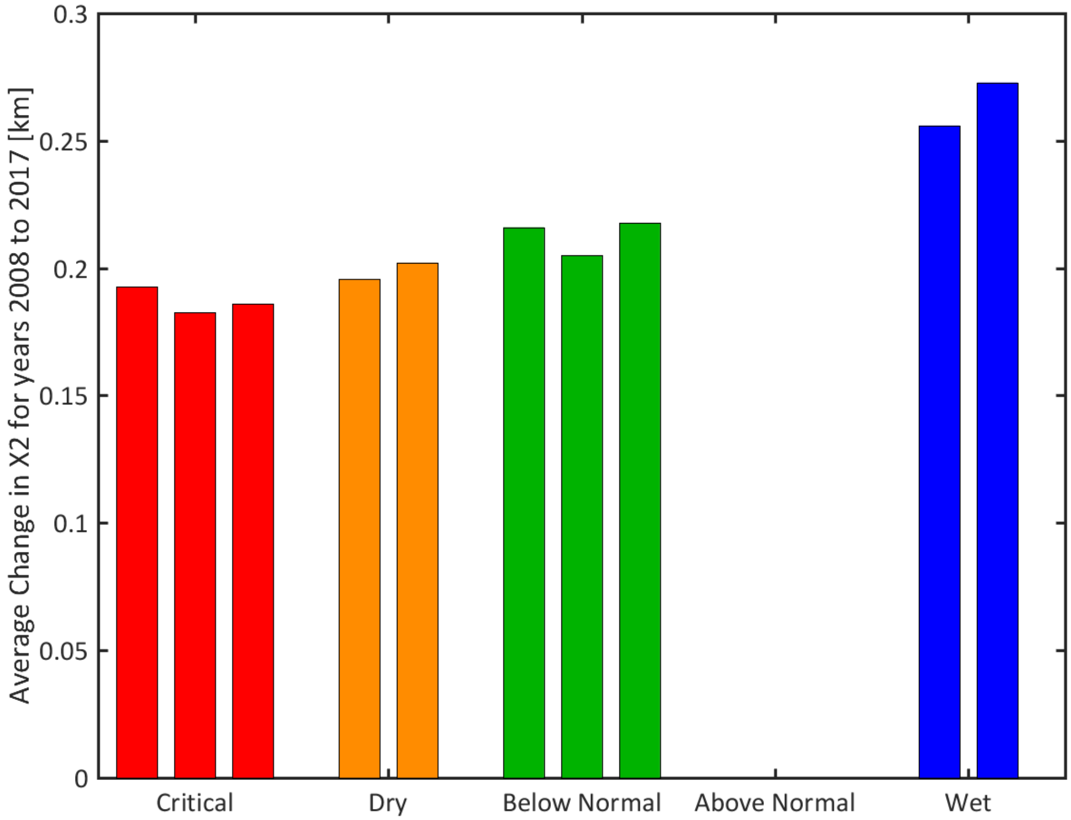
This relationship was validated using the predictions of annual-average X2 for the 3 years for which the TSP was simulated. Based on the results of the TSP scenario simulations (Section 5), the TSP was predicted to result in an annual-average increase in X2 of 0.17 km during 2014 (a critical water year), 0.21 km during 2012 (a below normal water year), and 0.27 km during 2011 (a wet water year). Based on the empirical function, the TSP was predicted to result in an annual-average increase in X2 of 0.18 km during 2014 (0.01 km higher), 0.21 km during 2012 (identical), and 0.26 km (0.01 km lower) during 2011. Thus, all three estimates were within 0.01 km (10 m) of the annual-average change predicted using the hydrodynamic model.

In general, the estimated change in X2 was smallest during critical water years and largest during wet water years (Table 8-1, Figure 8.2-2). The estimated change in X2 was also calculated only using periods when X2 was greater than 64 km. When only including periods when X2 was greater than 64 km, the result was identical to the estimated annual-averaged change in X2 for the critical and dry water years, but lower than the annual-average for 2 of the 3 below normal water years and both wet water years (Table 8-1). When only including periods when X2 was greater than 64 km, the average change in X2 was still smallest during critical water years and largest during wet water years, but the variability across year types was smaller (Figure 8.2-3).



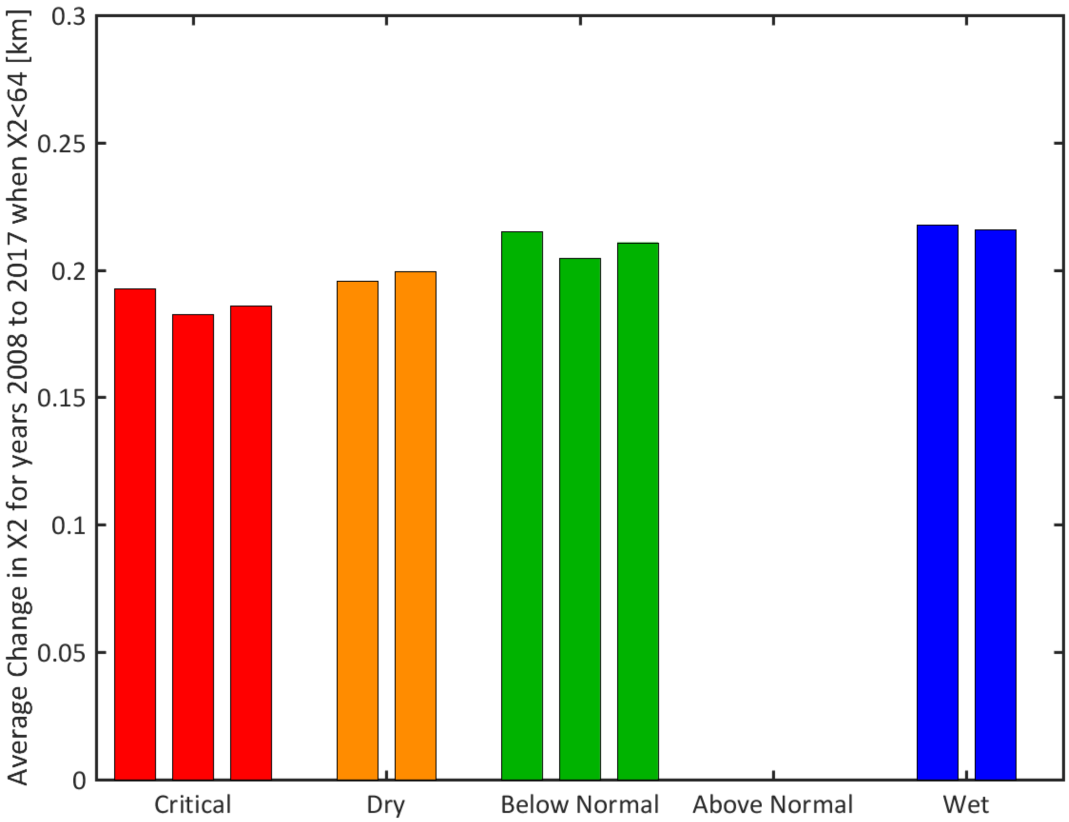
Note: Line color designates water year type, as indicated in the legend.

Figure 8.2-1
DAYFLOW (CDWR 2019) Estimate of X2 (Top) and Estimated Change in X2 Resulting from the TSP Derived from Equation 1 (Bottom)



Note: No above normal water years occurred during 2008 to 2017. Bar color designates water year type.

Figure 8.2-2
Average Annual Change in X2 for Each Year from 2008 Through 2017, with Years Grouped by Water Year Type (Table 1-1)



Note:
When X2 is less than 64 km, there are no current regulatory requirements that regulate the position of X2. Bar color designates water year type. No above normal water years occurred during 2008 to 2017.

Figure 8.2-3
Average Annual Change in X2 for Periods When X2 Was Greater Than 64 km for Each Year from 2008 Through 2017, with Years Grouped by Water Year Type (Table 1-1)

8.3 The Effects of Channel Deepening During All Water Year Types

Water years in California span from October 1 of the previous calendar year to September 30, such that water year 2014 spans from October 1, 2013, to September 30, 2014. This designation allows for all the precipitation over the "wet season" to be included in a single water year (rather than 2 calendar years). Water years are classified in five categories ranging from critical (driest), dry, below normal, above normal, and wet (wettest) based on inflows to the Sacramento-San Joaquin Delta, which are used to calculate Sacramento and San Joaquin Valley Water Year Hydrologic Classification Indices. Table 8-2 shows the predicted occurrence of each water year type, based on the Sacramento Valley Water Year Hydrologic Classification for the 112-year period of record and for the 82-year CalSim II simulation period. The distribution of water year types for the full period of record is also shown graphically in Figure 8.3-1. Over the 112-year period of record between water years 1906 and 2017, wet water years have occurred 33.0% of the time and critical water years have occurred 14.3% of the time.

Because the exact weather, hydrology, and water project operations for a future year cannot be predicted in advance, this analysis simulated the effects of the TSP on salinity during a critical water year (Section 5.2), a below normal water year (Section 5.3), and a wet water year (Section 5.4). The evaluation of the channel deepening effects on salinity during the wettest and driest conditions, as well as an intermediate water year classification (below normal), provides an assessment of the full range of effects on salinity that are likely to result from the TSP.

Table 8-2
Percent Occurrence of Each Water Year Type Based on the Sacramento Valley Water Year Hydrologic Classification for the Period of Record and for the CalSim II Simulation Period

Water Year Type	Period of Record (1906 - 2017)	CalSim II Simulation Period (1922 - 2003)
Critical	14.3	14.6
Dry	20.5	22.0
Below Normal	18.8	17.1
Above Normal	13.4	14.6
Wet	33.0	31.7

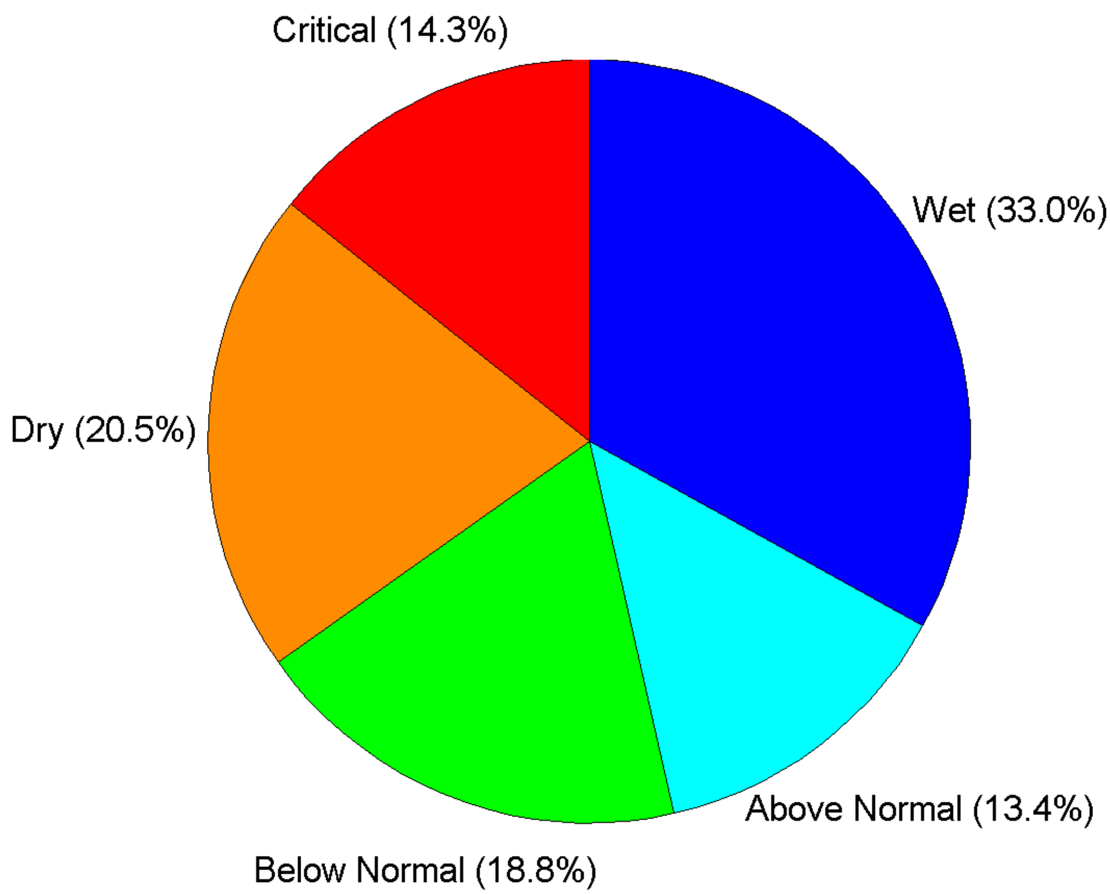


Figure 8.3-1
Percent Occurrence of Each Water Year Type Based on the Sacramento Valley Water Year Hydrologic Classification for the 112-Year Period of Record Between Water Years 1906 and 2017

9 DISCUSSION

The TSP scenarios analyzed in Section 5 evaluated the effects of the channel deepening during and following a wet water year (the wettest classification), a critical water year (the driest classification), and a below normal water year (the middle classification). Section 8 provides a discussion of how these results apply to other years and other water year types. The scenarios presented in Section 6 evaluated the effect of the channel deepening under Year 50 conditions that included SLR but did not incorporate operational response of the water projects to maintain the existing water quality objectives in the Delta, which resulted in higher salinity that would have occurred in future conditions that included operational response. Section 9.1 provides a discussion of how these assumptions affect the analysis and the implications for interpreting the results of these scenarios.

Based on the analysis presented in Section 5, the TSP was predicted to result in an annual-average increase in X2 of 0.17 km during a critical water year, 0.21 km during a below normal water year, and 0.27 km during a wet water year. For the 3 years evaluated, the largest predicted increases in X2 occurred at the lowest values of X2, corresponding to the periods when the salinity gradients were pushed west into San Pablo Bay, resulting in stratification in the Pinole Shoal Channel and the western part of the Suisun Bay Channel. Because lower values of X2 occurred during the wet water year than the critical water year, the effects on X2 were larger during the wet water year than during the critical water year. During the wet water year, outflow was relatively high throughout the summer (Figure 3.3-3) and salinity was pushed further west, resulting in more stratified conditions in Western Suisun Bay and in San Pablo Bay in the western reach of the project than during the critical water year when outflow was much lower (Figure 3.3-1). The occurrence of stratified conditions in the reach of the project channel proposed to be deepened (see Figures 3.2-1 through 3.2-6) due to the higher outflow is the primary reason that channel deepening had a larger effect on X2 during the wet water year than during the critical water year.

The analysis presented in Section 5 predicted that the TSP would result in a maximum monthly average change in Cl^- concentration ranging from 1.8 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.6 mg/L at the CCWD Rock Slough Intake during a critical water year. During the below normal water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 1.1 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.1 mg/L at the CCWD Rock Slough Intake under the TSP. During the wet water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 0.1 mg/L at the CCWD Middle River at Victoria Canal Intake and the West Canal at the mouth of CCF to 1.1 mg/L at the CCWD Rock Slough Intake under the TSP. Thus, for water quality at the D-1641 stations for municipal and industrial beneficial uses, the predicted effects of the channel deepening on Cl^- concentration at the South Delta intakes and exports during wet water years were lower than the below normal water year, and much lower than during critical water years.

9.1 Sensitivity of Predicted Effect on X2 and Water Quality at D-1641 Stations to Uncertainty in Future Hydrologic Loading

The hydrology for 2014 was selected to bracket the lowest outflow conditions for Year 50 because both Delta inflow and outflow were extremely low during 2014 (Figure 3.3-1) and the Year 0 conditions demonstrated that the deepening effects on water quality at the D-1641 stations were larger for the critical water year than for the wet water year. Hydrologic loading from freshwater runoff is highly managed using upstream reservoirs to store spring runoff and then release that water downstream to the Central Valley Project and State Water Project in the South Delta, which divert water for municipal and agricultural use. Because both Delta outflow and Delta diversions are highly managed in order to maintain water quality objectives, a change in hydrologic loading during a critical year would need to be offset by Delta and reservoir operations because outflow is already actively managed. As a result, a small change in hydrologic loading would be expected to result in an even smaller change in Delta outflow during a critical water year. Thus, the evaluation of the deepening effects would not be expected to have a high sensitivity to uncertainty in future hydrologic loading.

However, there is significant uncertainty in how Delta operations will change in the future in response to SLR. The 2.38 feet of SLR simulated for the Year 50 conditions in this study resulted in an average increase in X2 of 4.31 km (Figure 6.1-1) due to increased salinity intrusion. As a result, the water quality at several of the export locations exceeded the D-1641 water quality objectives at some export locations under the simulated Year 50 baseline No Action Alternative conditions (e.g., Figures 6.2-2, 6.2-4, 6.2-5, 6.2-8, 6.2-10, and 6.2-11). Operationally, Delta inflows and exports are managed to meet the D-1641 water quality objectives at these locations, so it is expected that inflow would need to be increased or exports would need to be decreased in order to increase outflow and offset this increase in salinity in the Delta resulting from SLR. Because the Year 50 simulations presented here did not include these changes to operations (because it is not known how these changes will be implemented), the estimates of salinity effects resulting from the deepening on water quality during a critical water year in Year 50 should be considered maximum estimates. Under conditions in which the effects of SLR on salt intrusion into the Delta are offset through Delta operations, the effects of the channel deepening in Year 50 would be expected to be more similar to the effects predicted for Year 0.

10 SUMMARY AND CONCLUSIONS

A 3-D hydrodynamic and salinity model was used to simulate the potential changes in salt intrusion for the 37-Foot MLLW Alternative, the 38-Foot MLLW Alternative, and the TSP for the San Francisco Bay to Stockton Navigation Improvement Project. The potential effects of the channel deepening on X2, the distance up the axis of the estuary to the daily-averaged 2 psu near-bed salinity, and on water quality (Cl^- concentration) at municipal and industrial water intake and export locations in the Sacramento-San Joaquin Delta were evaluated for each scenario.

10.1 Summary of Analysis of Effects of Preliminary Alternatives

Because the exact weather, hydrology, and water project operations for a future year cannot be predicted in advance, this analysis evaluated the effects of the 37-Foot MLLW Alternative and the 38-Foot MLLW Alternative on salinity during both a wet water year and a critical water year representative of the range of possible Year 0 conditions. Historical periods from 2011 and 2014 were selected for the wet and critical water years, respectively. The use of historical boundary conditions removed some of the limitations associated with using monthly CalSim II estimates for boundary conditions, as was done in previous analyses (e.g., MacWilliams et al. 2014). The 37-Foot MLLW Alternative and the 38-Foot MLLW Alternative resulted in significantly smaller predicted effects on both X2 and on water quality at municipal and industrial water intake and export locations in the Sacramento-San Joaquin Delta than the previous scenarios, which evaluated deepening of both the Eastern Reach and the Western Reach (MacWilliams et al. 2014).

The 37-Foot MLLW Alternative was predicted to result in an annual-average increase in X2 of 0.03 km during a critical water year and 0.08 km during a wet water year. The 38-Foot MLLW Alternative was predicted to result in an annual-average increase in X2 of 0.11 km during a critical water year and 0.20 km during a wet water year.

Under Year 0 conditions, the 37-Foot MLLW Alternative was predicted to result in a maximum monthly average change in Cl^- concentration ranging from 0.3 mg/L at the CCWD Middle River at Victoria Canal Intake to 0.7 mg/L at the CCWD Rock Slough Intake during a critical water year. During the wet water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 0.0 mg/L at the CCWD Middle River at Victoria Canal Intake and the West Canal at mouth of CCF to 0.2 mg/L at the CCWD Rock Slough Intake under the 37-Foot MLLW Alternative.

Under Year 0 conditions, the predicted maximum monthly average change in Cl^- concentration resulting from the 38-Foot MLLW Alternative ranged from 1.2 mg/L at the CCWD Middle River at Victoria Canal Intake and the Delta-Mendota Canal at Tracy Pumping Plant to 2.4 mg/L at the CCWD Rock Slough Intake during a critical water year. During the wet water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 0.0 mg/L at the CCWD Middle River at Victoria Canal Intake and the West Canal at mouth of CCF to 0.2 mg/L at the CCWD Rock Slough Intake under the 38-Foot MLLW Alternative. Thus, for water quality at the D-1641 stations for municipal and industrial beneficial uses, the predicted effects of channel deepening during wet water years were much lower than during critical water years.

10.2 Summary of Analysis of the Effects of TSP Scenarios During Year 0

The TSP differs from the 38-Foot MLLW Alternative due to the inclusion of the sediment trap at Bulls Head Reach and leveling the rock outcropping west of Pinole Shoal, but is otherwise identical to the 38-Foot MLLW Alternative.

This analysis evaluated the effects of the TSP on water levels, flow, and salinity during a wet water year, a below normal water year, and a critical water year representative of the range of possible Year 0 conditions. Historical periods from 2011, 2012, and 2014 were selected for the wet, below normal, and critical water years, respectively. The evaluation of the TSP effects on salinity during both the wettest (wet) and driest (critical) water year types and an intermediate water year type (below normal) provides an assessment of the full range of effects on salinity that are likely to result from the TSP.

The TSP was predicted to result in an annual-average increase in X2 of 0.17 km during a critical water year, 0.21 km during a below normal water year, and 0.27 km during a wet water year (Table 10-1). For all 3 years, the largest predicted increases in X2 occurred at the lowest values of X2, corresponding to the periods when the salinity gradients were pushed west into San Pablo Bay, resulting in stratification in the Pinole Shoal Channel or the western part of the Suisun Bay Channel.

Table 10-1
Predicted Change in X2 for the TSP During a Critical Water Year, a Below Normal Water Year, and a Wet Water Year

TSP Simulation Period	Change in X2 (km)	
	Annual-Average	Change for X2 > 64
Critical Water Year (2014)	0.17	0.17
Below Normal Water Year (2012)	0.21	0.21
Wet Water Year (2011)	0.27	0.23

Notes:
When X2 is less than 64 km there are no current regulatory requirements that regulate the position of X2, so the average change for periods when X2 >64 is also shown separately.
km = kilometers
TSP = Tentatively Selected Plan

Under Year 0 conditions, the predicted maximum monthly average change in Cl^- concentration resulting from the TSP ranged from 1.8 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.6 mg/L at the CCWD Rock Slough Intake during a critical water year. During the below normal water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 1.1 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.1 mg/L at the CCWD Rock Slough Intake under the TSP. During the wet water year evaluated, the predicted maximum monthly average change in Cl^- concentration ranged from 0.1 mg/L at the CCWD Middle River at Victoria Canal Intake and the West Canal at mouth of CCF to 1.1 mg/L at the CCWD Rock Slough Intake under the TSP. Thus, for water quality at the D-1641 stations for municipal and industrial beneficial uses, the effects of channel deepening during wet water years were much lower than during critical water years.

The effect of the TSP on the area and position of the LSZ was analyzed for the critical water year, below normal water year, and wet water year evaluated. For each simulation, the daily-averaged LSZ habitat area for each day was then calculated by summing up the total area of the grid cells with depth-averaged daily-averaged salinity between 0.5 psu and 6 psu. This allowed for a comparison of the change in LSZ area resulting from the TSP for each day of the simulation. Due to the non-monotonic relationship between the area of the LSZ and X2 which is largely controlled by the geometry of the estuary (see MacWilliams et al. 2015), the small landward shift (increase) of X2 which results from the TSP can result in either a decrease or an increase in the area of the LSZ on each day. During the critical water year evaluated, the predicted monthly-average change in the area of the LSZ resulting from the TSP ranged from a decrease of 290 acres to an increase of 266 acres. The predicted monthly-average change in the area of the LSZ resulting from the TSP in the below normal water year evaluated ranged from a decrease of 587 acres to an increase of 446 acres. During the wet water year evaluated, the predicted monthly-average change in the area of the LSZ resulting from the TSP ranged from a decrease of 284 acres to an increase of 417 acres.

10.3 Summary of Effects During Year 50

The effect of the 38-Foot MLLW Alternative and the TSP on salinity was evaluated for a critical water year representative of possible Year 50 conditions which included 2.38 feet of SLR based on the USACE High Curve (USACE 2015). For the 38-Foot MLLW Alternative under Year 50 conditions, the predicted annual-average increase in X2 resulting from the channel deepening was 0.11 km, which is identical to what was predicted for Year 0 conditions for a critical water year. For the TSP under Year 50 conditions, the predicted annual-average increase in X2 resulting from the channel deepening was 0.17 km, which is identical to what was predicted for Year 0 conditions for a critical water year.

During the critical water year under Year 50 conditions, the predicted annual-average change in Cl^- concentration resulting from the 38-Foot MLLW Alternative ranged from 1.5 mg/L at the CCWD Middle River at Victoria Canal Intake to 3.0 mg/L at the CCWD Rock Slough Intake. For the TSP, during the critical water year under Year 50 conditions, the predicted annual-average change in Cl^- concentration ranged from 2.3 mg/L at the CCWD Middle River at Victoria Canal Intake to 4.6 mg/L at the CCWD Rock Slough Intake. Because the Year 50 simulations did not include changes to Delta operations to offset the effects of SLR on salinity (as how these changes will be implemented is not known), the estimates of salinity effects resulting from the channel deepening on water quality during a critical year in Year 50 should be considered maximum estimates. Under conditions in which the effects of SLR on salt intrusion into the Delta are offset through Delta operations, the effects of the channel deepening in Year 50 would be expected to be more similar to the effects predicted for Year 0.

10.4 Estimation of the Effects of the TSP on the Period from 2008 through 2017

The predictions of X2 and the predicted change in X2 resulting from the TSP for each day during the critical water year, below normal water year, and wet water year evaluated were used to develop an empirical function to estimate the effects of the TSP on X2. This function was applied to the DAYFLOW estimate of X2 for a 10-year period spanning from 2008 through 2017. This relationship was validated using the predictions of annual-average X2 for the 3 years for which the TSP was simulated. Based on the results of the model simulations, the TSP was predicted to result in an annual-average increase in X2 of 0.17 km during 2014 (a critical water year), 0.21 km during 2012 (a below normal water year), and 0.27 km during 2011 (a wet water year). Based on the empirical function, the TSP was predicted to result in an annual-average increase in X2 of 0.18 km during 2014 (0.01 km higher), 0.21 km during 2012 (identical), and 0.26 km (0.01 km lower) during 2011. Thus, all three estimates were within 0.01 km (10 m) of the annual-average change predicted using the hydrodynamic model. Based on the empirical function, the estimated annual-average change in X2 from the TSP ranged from 0.18 km to 0.27 km for the 10 water years between 2008 and 2017.

11 ACKNOWLEDGMENTS

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