APPENDIX K
SACRAMENTO DWSC MODELING RESULTS SUMMARY (2010)

Sacramento DWSC Modeling Results Summary

DRAFT

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May, 2010

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1.0 INTRODUCTION

USACE is conducting a reevaluation study for the deepening of the Sacramento River Deep Water Ship Chanel (SACRDWSC). The SACRDWSC begins at Collinsville on the Sacramento River through a man made channel near Rio Vista and reaches its end at the port of Sacramento (Figure 1). It is of interest to evaluate the effect of deepening on the hydrologic and hydrodynamic parameters. The parameters of interest are river stage, discharge, and salinity. In an effort to evaluate and quantify the impact of the deepening of the SACRDWSC on these parameters, model simulations have been completed for the baseline or Year 0 (2011) and Year 50 (2061) condition, both with and without project. A brief comparison of the simulation results will be made herein. Sea level rise is the primary contribution to differences in the year 0 and year 50 simulations (both with and without project). An estimated sea level increase of 0.6 m was used to characterize the year 50 conditions, based on NRC Curve III (ER1105-2-100).

A comparison of the hydrologic and hydrodynamic parameters is discretized into five reaches along the SACDWSC (Figure 2). Reach 1 is located furthest downstream, and extends from mile marker -2.0 near Suisun Bay upstream to 4.0 near Sandy Beach Park. Reach 2 is the second longest reach, beginning at mile marker 4.0 and extending upstream to mile marker 14.0 near Ryer Island. Reach 3 begins at mile marker 14.0 and extends upstream to the entrance of the man-made channel near Miner Slough at 18.5. Reach 4 is the longest reach in the study, nearly covering the entire extent of the manmade channel, beginning at marker 18.5 and extending to marker 35.0 near the Yolo County line. Reach 5 is the most upstream reach defined in the study and beginning at marker 35.0 and extending to marker 43.0 at the Port of Sacramento.

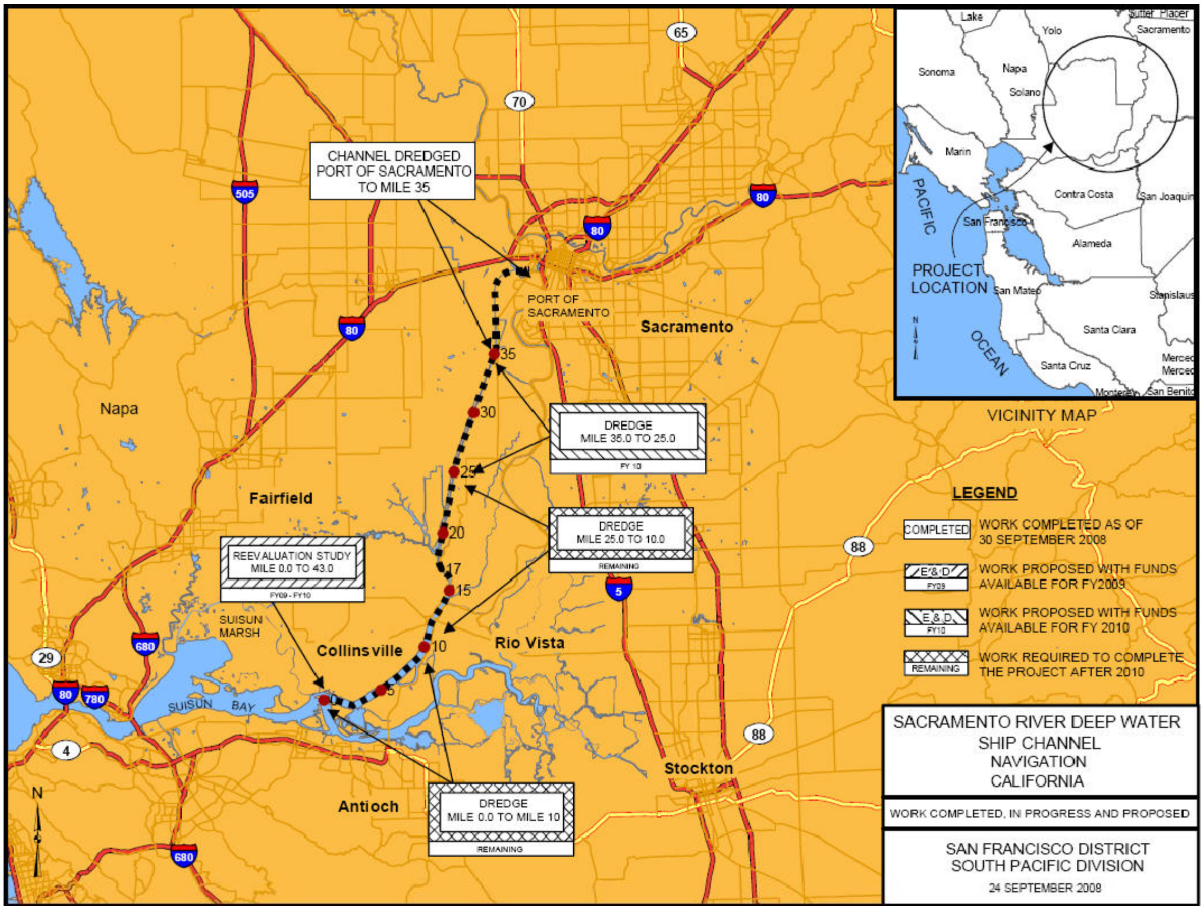


Figure 1. Map of Sacramento Deep Water Ship Channel. The navigational channel is highlighted with black/red dashes.

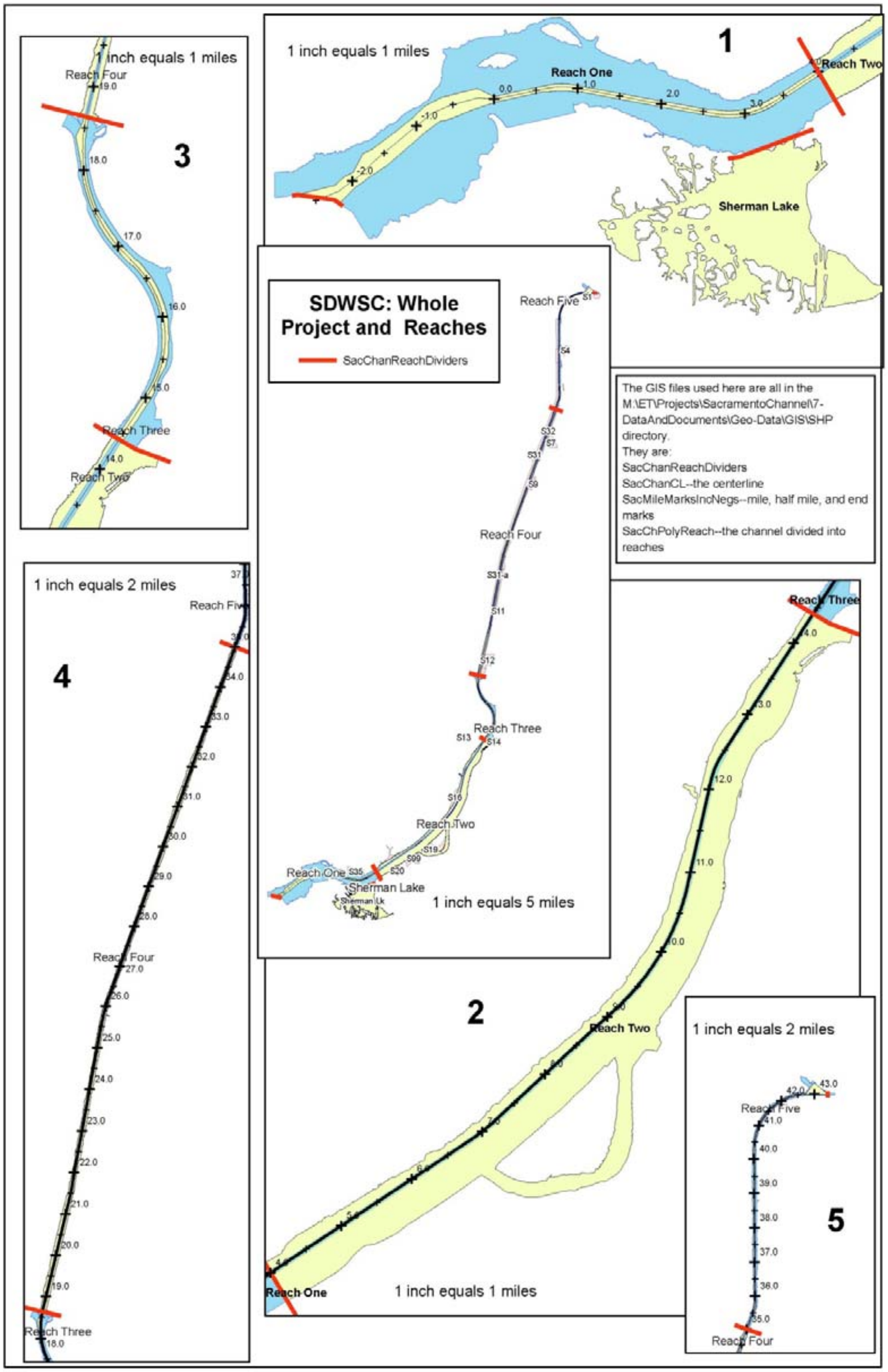


Figure 2. Defined reaches along the SACRDWSC.

The UnTRIM three-dimensional hydrodynamic model for the San Francisco Bay and delta system, developed by Drs. Michael Mac Williams and Edward Gross, is being used for this study. This model builds on an existing model of San Francisco Bay and the Sacramento-San Joaquin Delta developed for the Department of Water Resources (DWR) as part of the Pelagic Organism Decline (POD) project. The UnTRIM model extends from the Pacific Ocean through the entire Sacramento-San Joaquin Delta (Figure 3). The model predicts time series of stage, flow and salinity of water bodies at various cells in the computation domain. Model calibration was performed for a one-year period from April 2007 to March 2008, using measured stage, flow, and salinity data of the San Francisco Bay and Sacramento-San Joaquin Delta at various locations. Model validation was performed for a one year period from April 1994 to March 1995, also using measured stage, flow and salinity data. The years of 1994 and 2007 are considered to be dry or drought years.

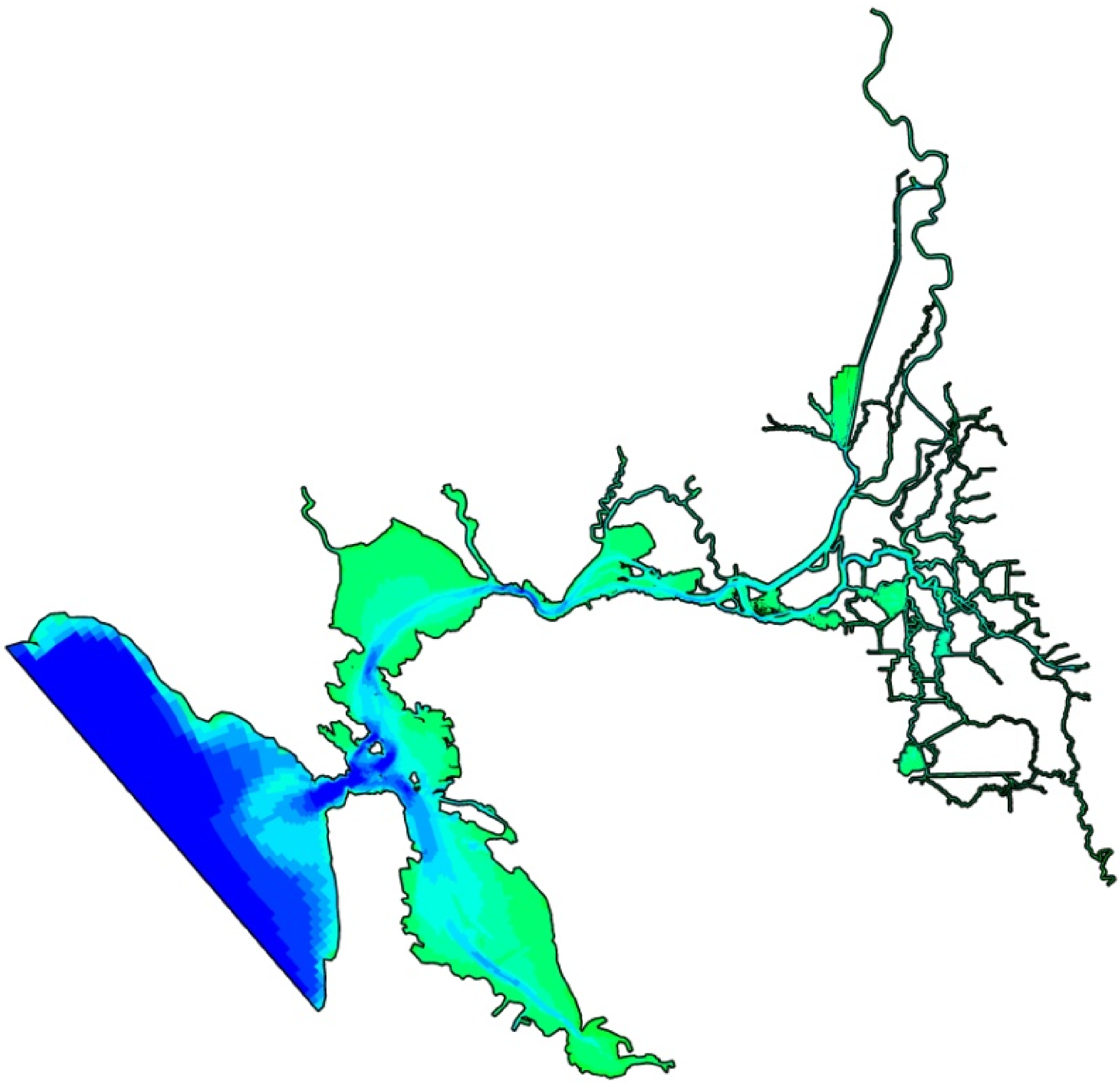


Figure 3. UnTRIM San Francisco Bay-Delta Model domain.

2.0 RIVER STAGE

River stage is a combination of freshwater river inflows (i.e. rainfall, runoff, snow melt, upstream flow) and tidal driven ocean flow. Locations within each of the 5 characterized reaches along the SACRDWSC were used for comparison of with and without project conditions at the baseline condition (Year 0, 2011) and 50 years beyond the baseline condition (Year 50, 2061). These stations have been selected, as they are considered to be representative, well distributed stations that can quantify the temporal and spatial variations in river stage. Accordingly, time series model output has been generated of predicted river stage to aid in determination any impact of resulting in channel deepening.

2.1 Year 0 With and Without Project Comparison

Stage comparisons are made at stations along the Sacramento River located at Martinez, Collinsville, Rio Vista, Cache Slough at Ryer Island, the USGS Station 11455335 near Rio Vista, and the Port of Sacramento. These stations represent reaches 1 through 5 of the SACRDWSC (Figure 2). Figures illustrating stage comparisons are shown here in. These figures compare a 15-day period of water level variability of two scenarios: (1.) the without project condition and (2.) deepening of the SACRDWSC only scenario. Additionally, comparisons of daily averaged stage without and with project condition for the full simulation year and change in stage with project conditions are included in this section.

Error! Reference source not found. shows predicted stage at Martinez. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. Minimal change in stage is predicted with project conditions.

Error! Reference source not found. shows predicted stage at Collinsville. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. Minimal change in stage is predicted with project conditions.

Error! Reference source not found. shows the predicted stage at Rio Vista. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. A reduction is stage is predicted during high water events occurring from January through March of the simulation year. The decrease in stage is on the order of 1 cm.

Error! Reference source not found. shows predicted stage at Cache Slough at Ryer Island. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. A reduction is stage is predicted during high water events occurring from January through March of the simulation year. The decrease in stage is on the order of 2 cm.

Error! Reference source not found. shows predicted stage at the USGS Station. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. A reduction is stage is predicted during high water events occurring from January through March of the simulation year. The decrease in stage is on the order of 3 cm.

Error! Reference source not found. shows the predicted stage at the Port of Sacramento. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. A reduction is stage is predicted during high water events occurring from January through March of the simulation year. The decrease in stage is on the order of 2 cm.

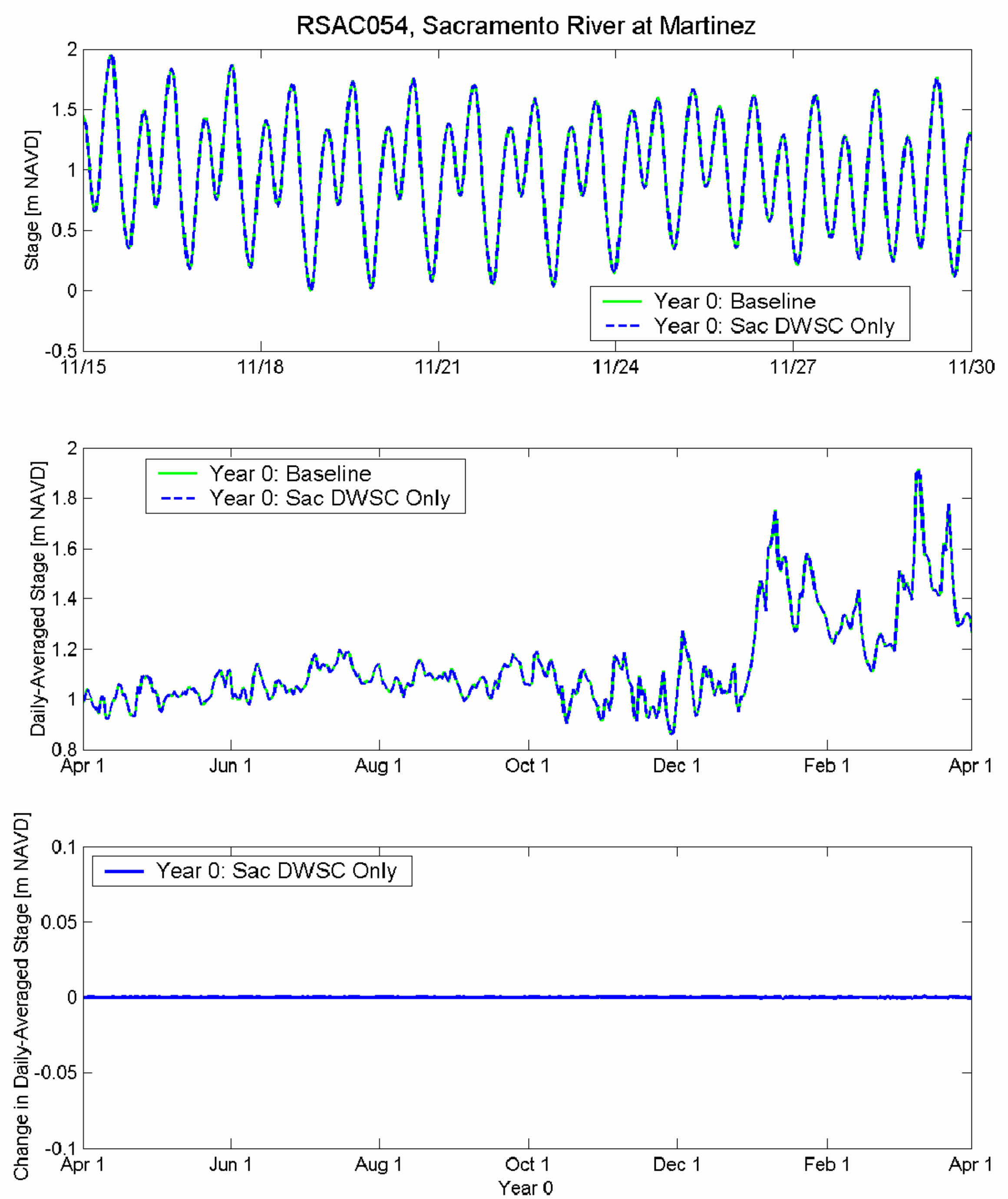


Figure 4. Predicted stage at Sacramento River at Martinez (RSAC054) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 0 simulation period (middle); predicted increase in daily-averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

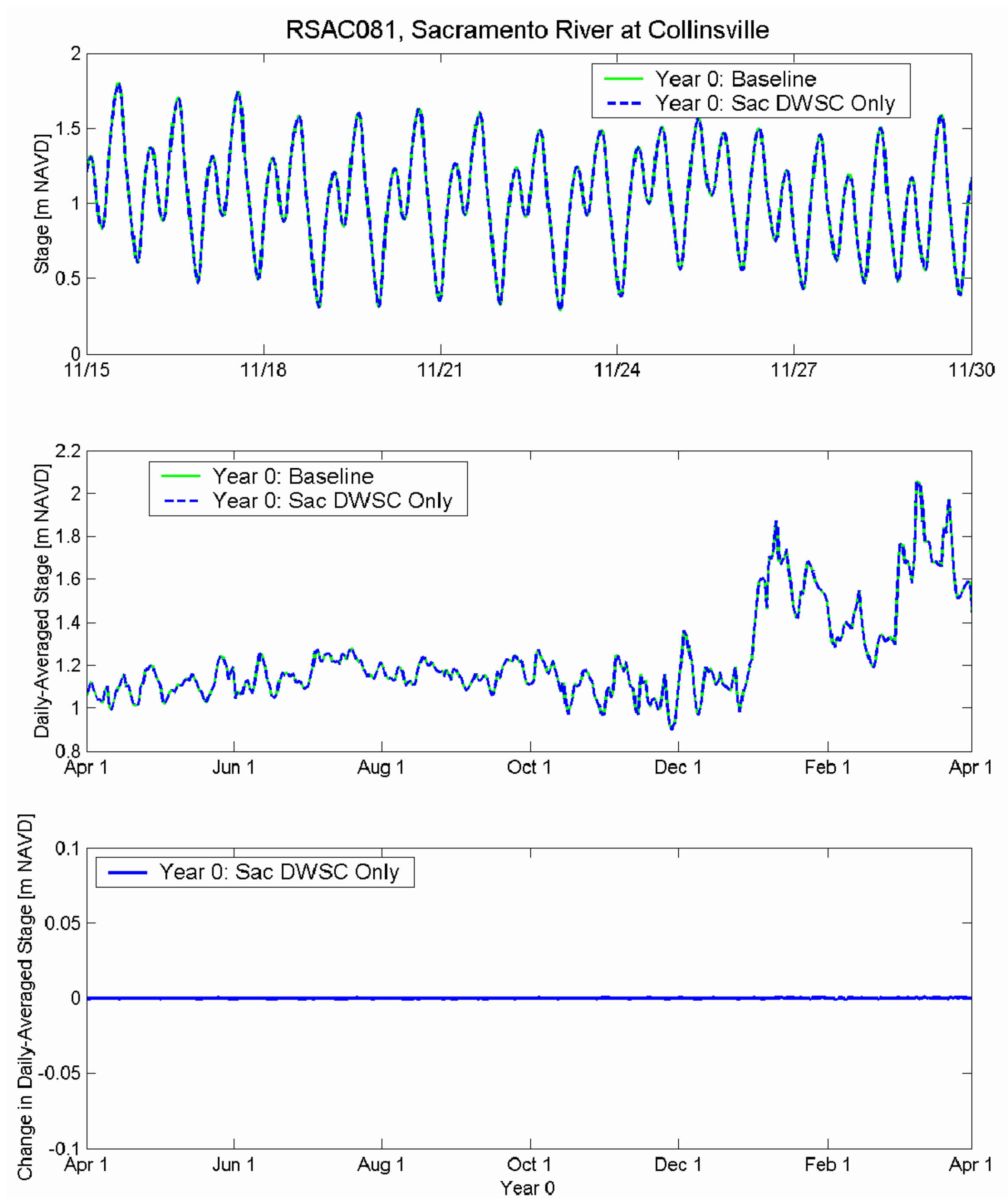


Figure 5. Predicted stage at Sacramento River at Collinsville (RSAC081) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 0 simulation period (middle); predicted increase in daily-averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

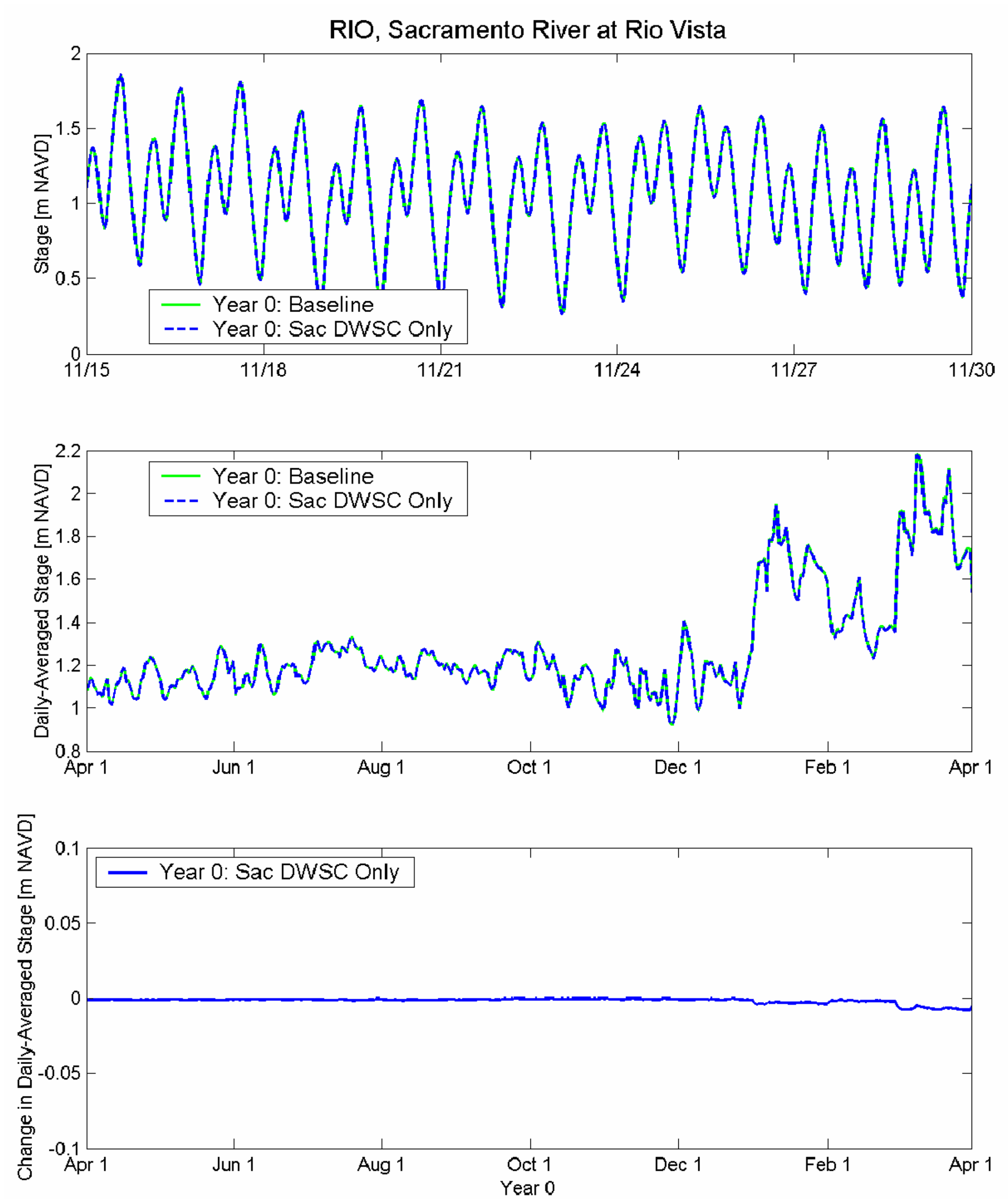


Figure 6. Predicted stage at Sacramento River at Rio Vista (RIO) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 0 simulation period (middle); predicted increase in dailyaveraged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

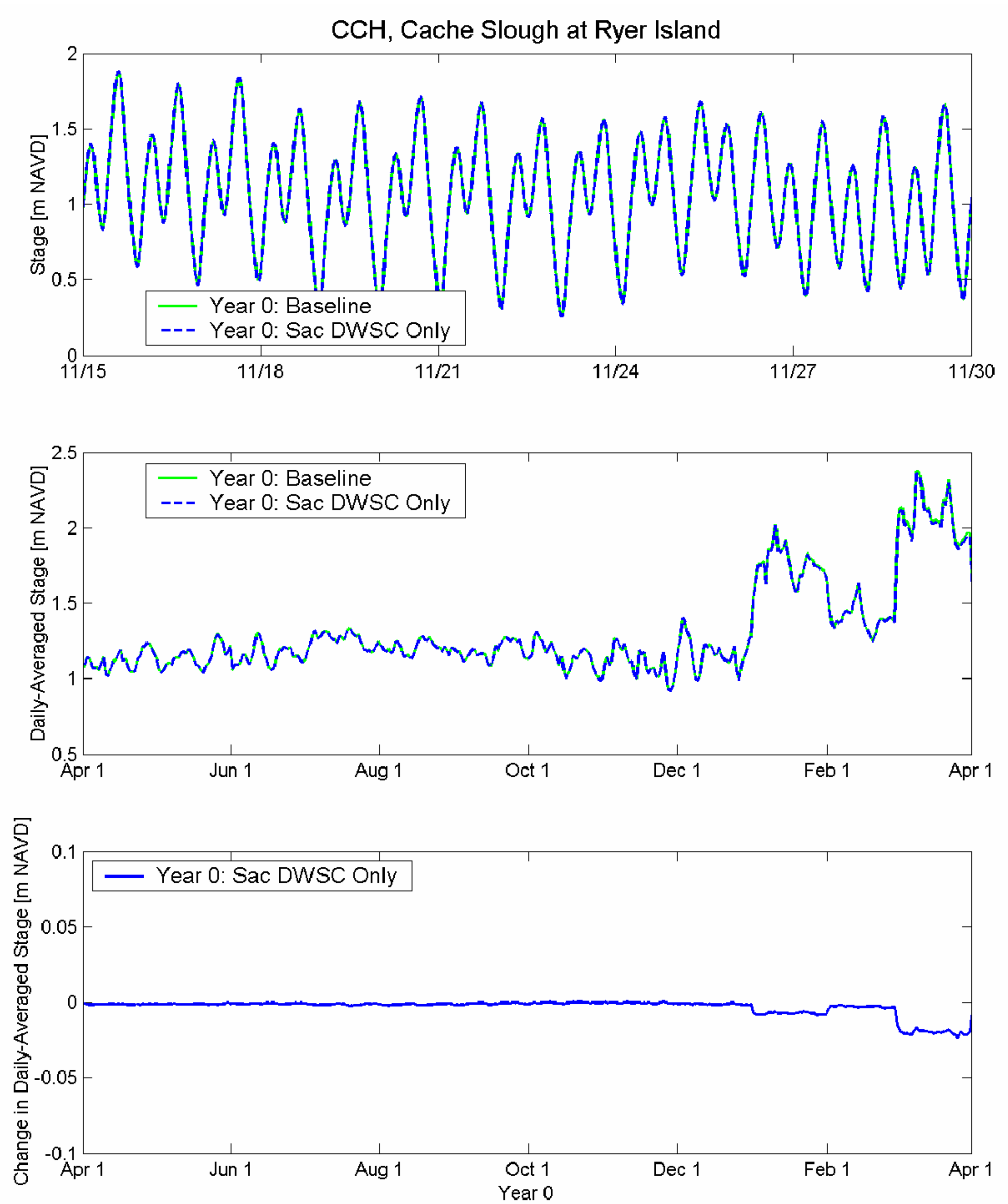


Figure 7. Predicted stage at Sacramento River at Cache Slough at Ryer Island (CCH) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 0 simulation period (middle); predicted increase in daily-averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

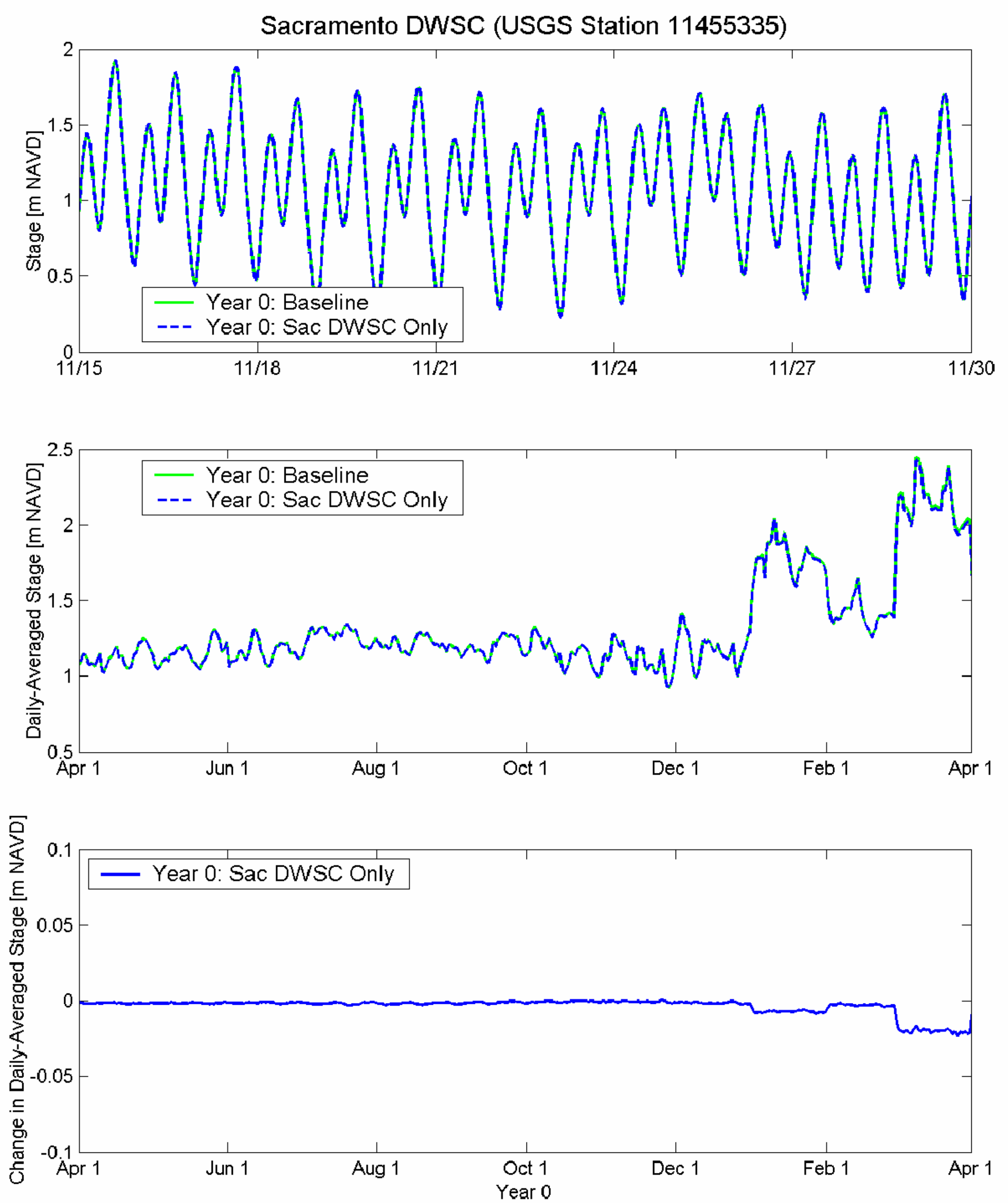
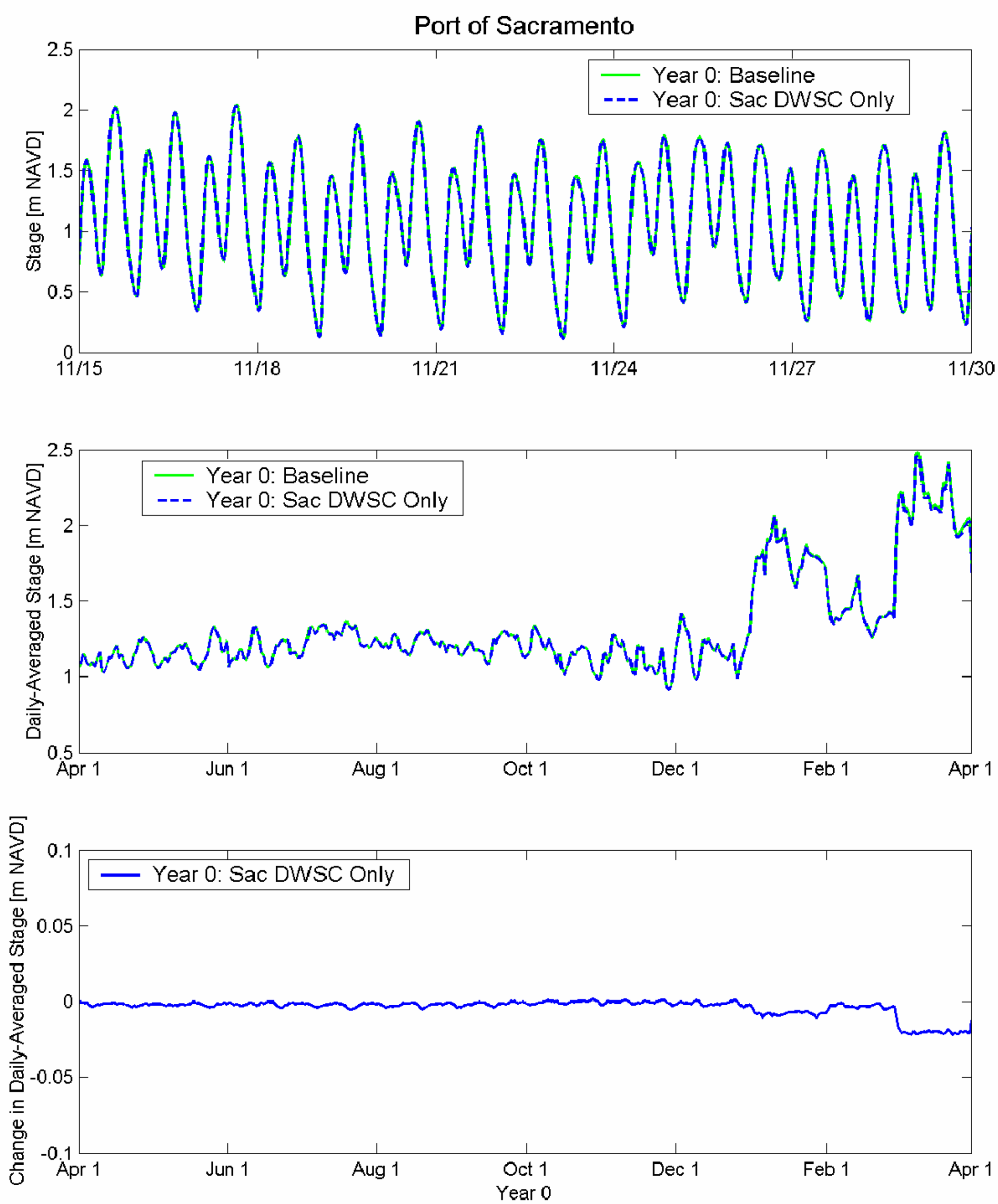


Figure 8. Predicted stage at Sacramento DWSC (USGS Station 11455335) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 0 simulation period (middle); predicted increase in daily-averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).



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2.2 Year 50 With and Without Project Comparison

Stage comparisons are made at stations along the Sacramento River located at Martinez, Collinsville, Rio Vista, Cache Slough at Ryer Island, the USGS Station 11455335 near Rio Vista, and the Port of Sacramento. These stations represent reaches 1 through 5 of the SACRDWSC (Figure 2). Figures illustrating stage comparisons are shown here in. These figures compare a 15-day period of water level variability of two scenarios: (1.) the without project condition and (2.) deepening of the SACRDWSC only scenario. Additionally, comparisons of daily averaged stage without and with project condition for the full simulation year and change in stage with project conditions are included in this section.

Figure 10 shows predicted stage at Martinez. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. Minimal change in stage is predicted with project conditions.

Figure 11 shows predicted stage at Collinsville. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. Minimal change in stage is predicted with project conditions.

Figure 12 shows the predicted stage at Rio Vista. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. A reduction is stage is predicted during high water events occurring from January through March of the simulation year. The decrease in stage is on the order of 1 cm.

Figure 13 shows predicted stage at Cache Slough at Ryer Island. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. A reduction is stage is predicted during high water events occurring from January through March of the simulation year. The decrease in stage is on the order of 3 cm.

Figure 14 shows predicted stage at the USGS Station. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. A reduction is stage is predicted during high water events occurring from January through March of the simulation year. The decrease in stage is on the order of 3 cm.

Figure 15 shows the predicted stage at the Port of Sacramento. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average stage is nearly identical. A reduction is stage is predicted during high water events occurring from January through March of the simulation year. The decrease in stage is on the order of 2 cm.

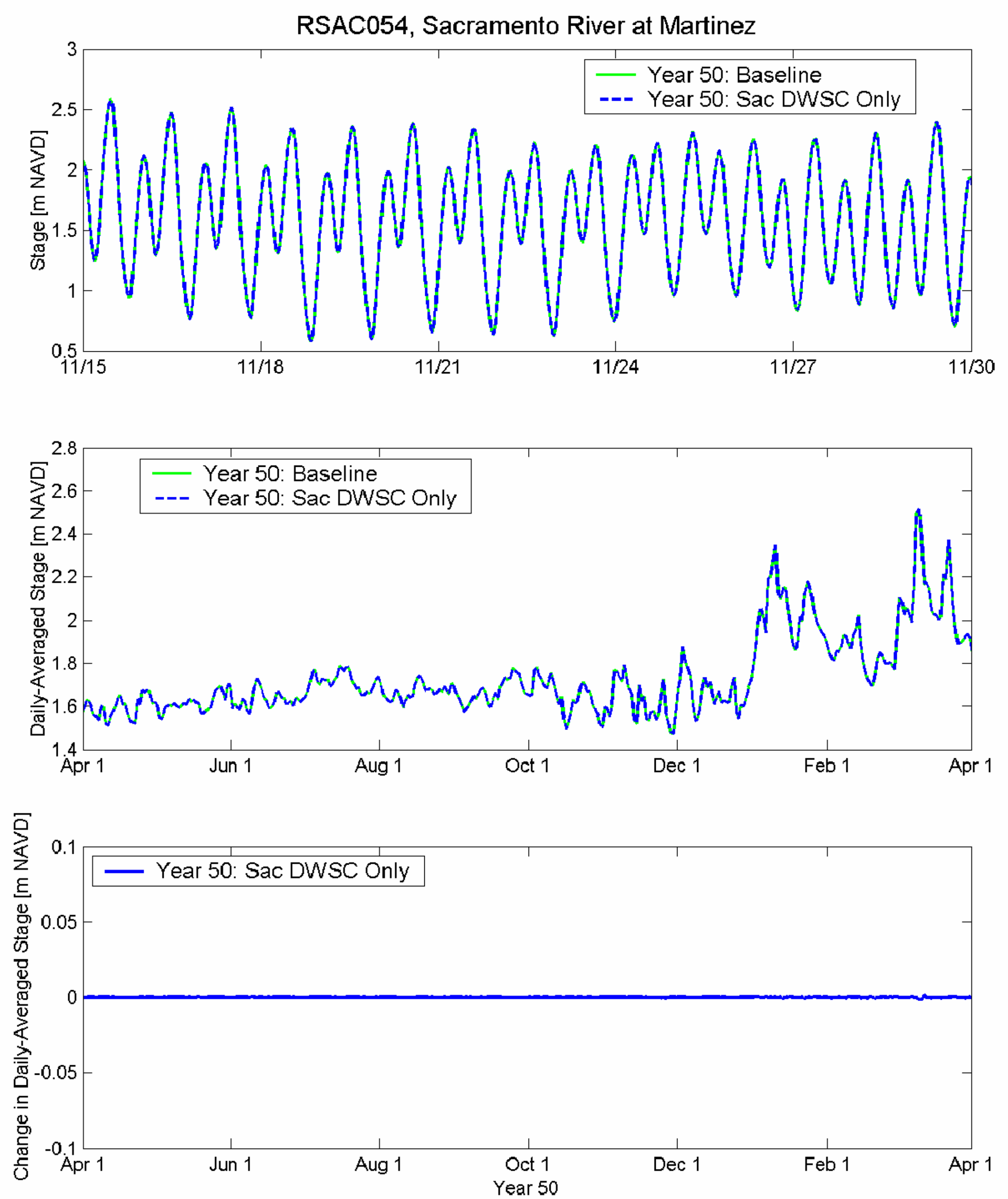

Figure 10. Predicted stage at Sacramento River at Martinez (RSAC054) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 50 simulation period (middle); predicted increase in daily-averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

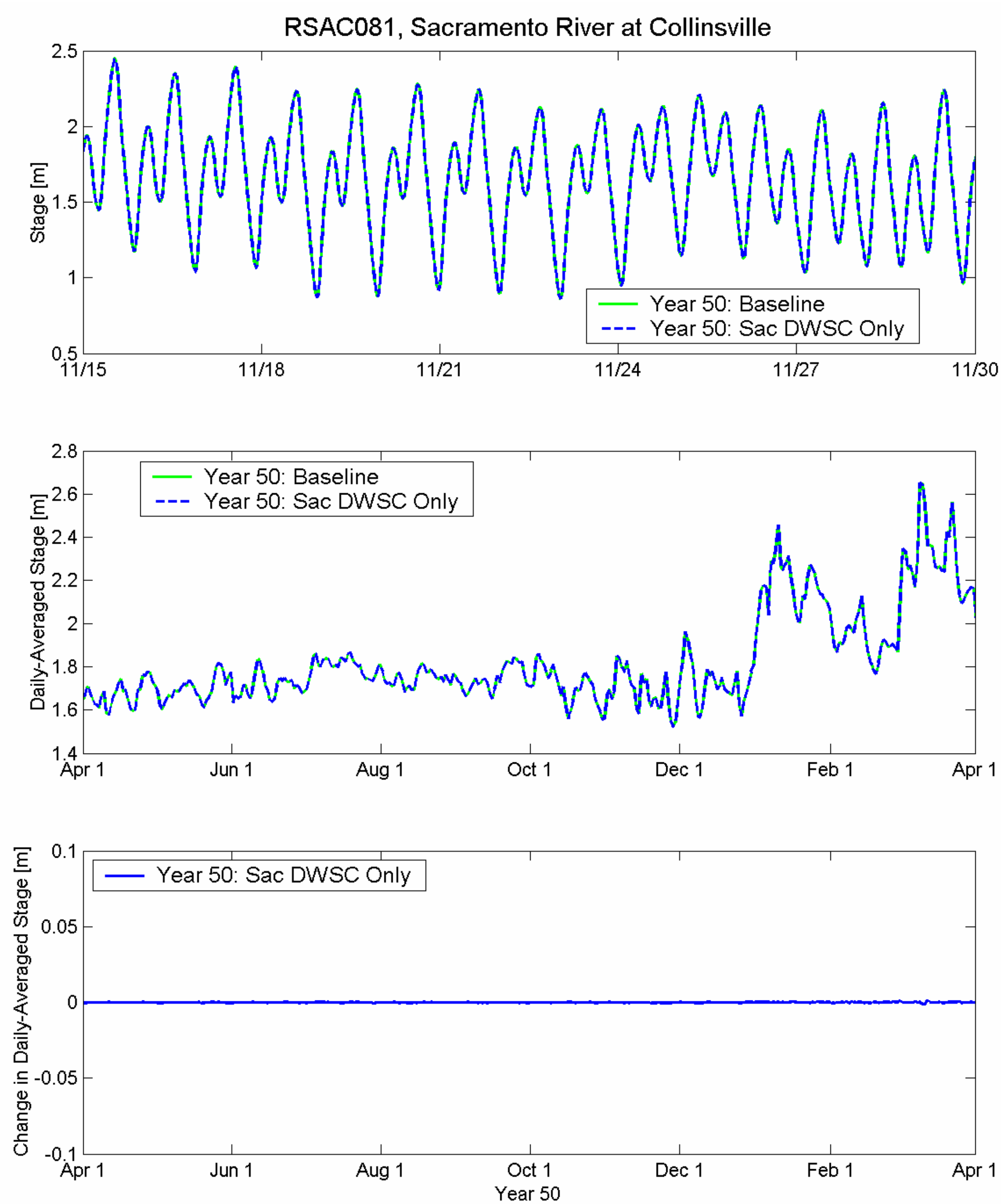

Figure 11. Predicted stage at Sacramento River at Collinsville (RSAC081) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 50 simulation period (middle); predicted increase in daily-averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

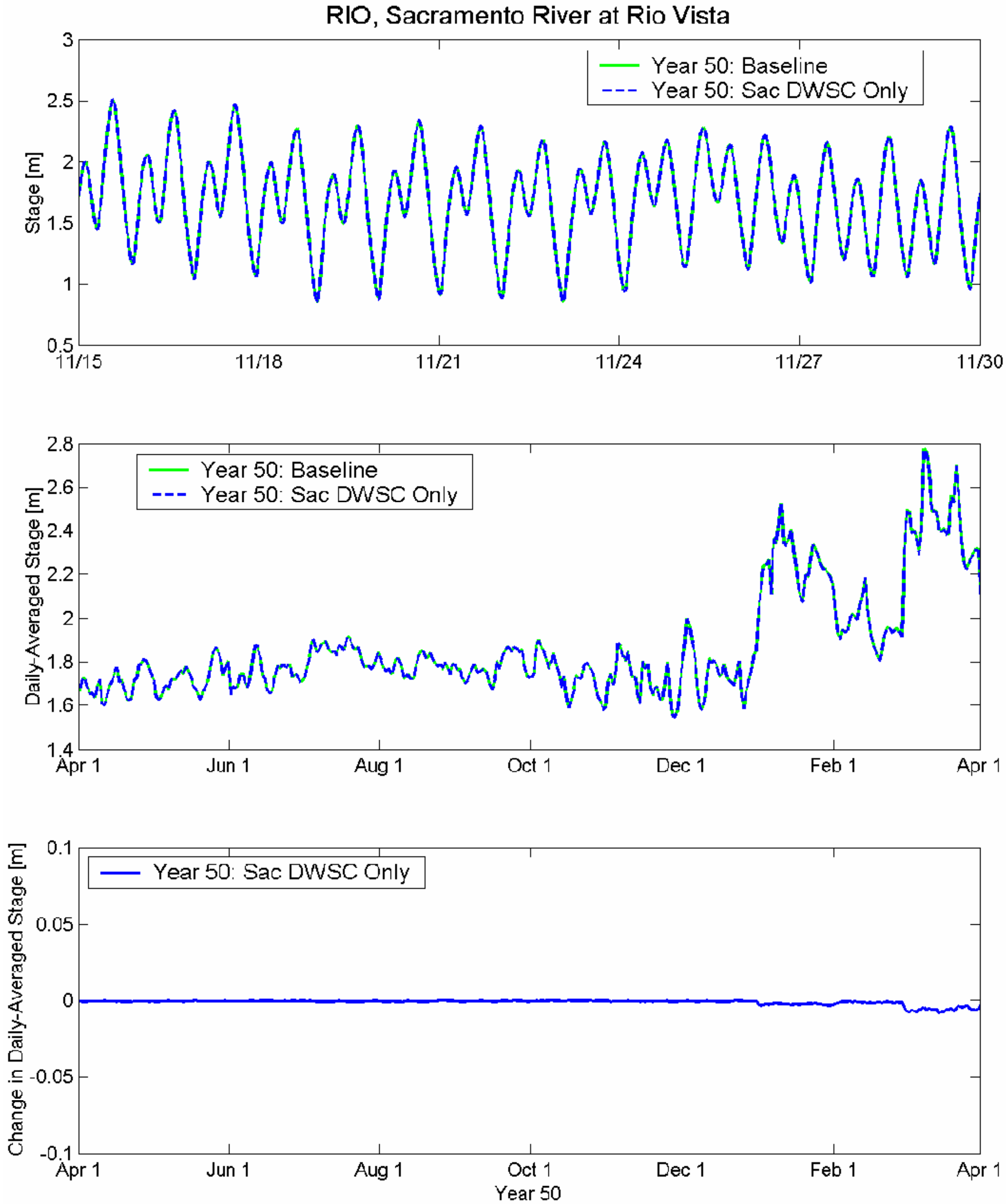

Figure 12. Predicted stage at Sacramento River at Rio Vista (RIO) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 50 simulation period (middle); predicted increase in daily averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

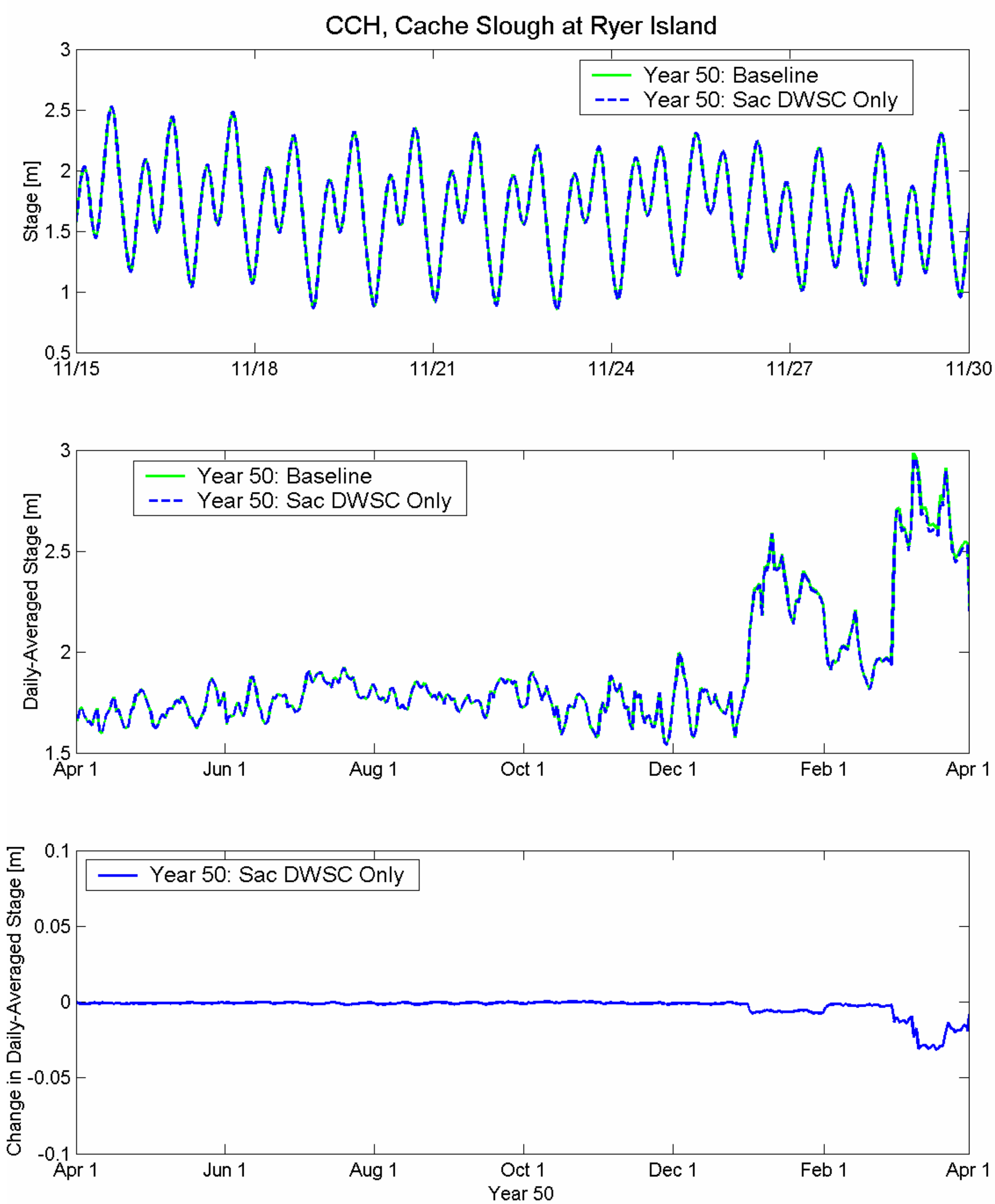

Figure 13. Predicted stage at Sacramento River at Cache Slough at Ryer Island (CCH) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 50 simulation period (middle); predicted increase in daily-averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

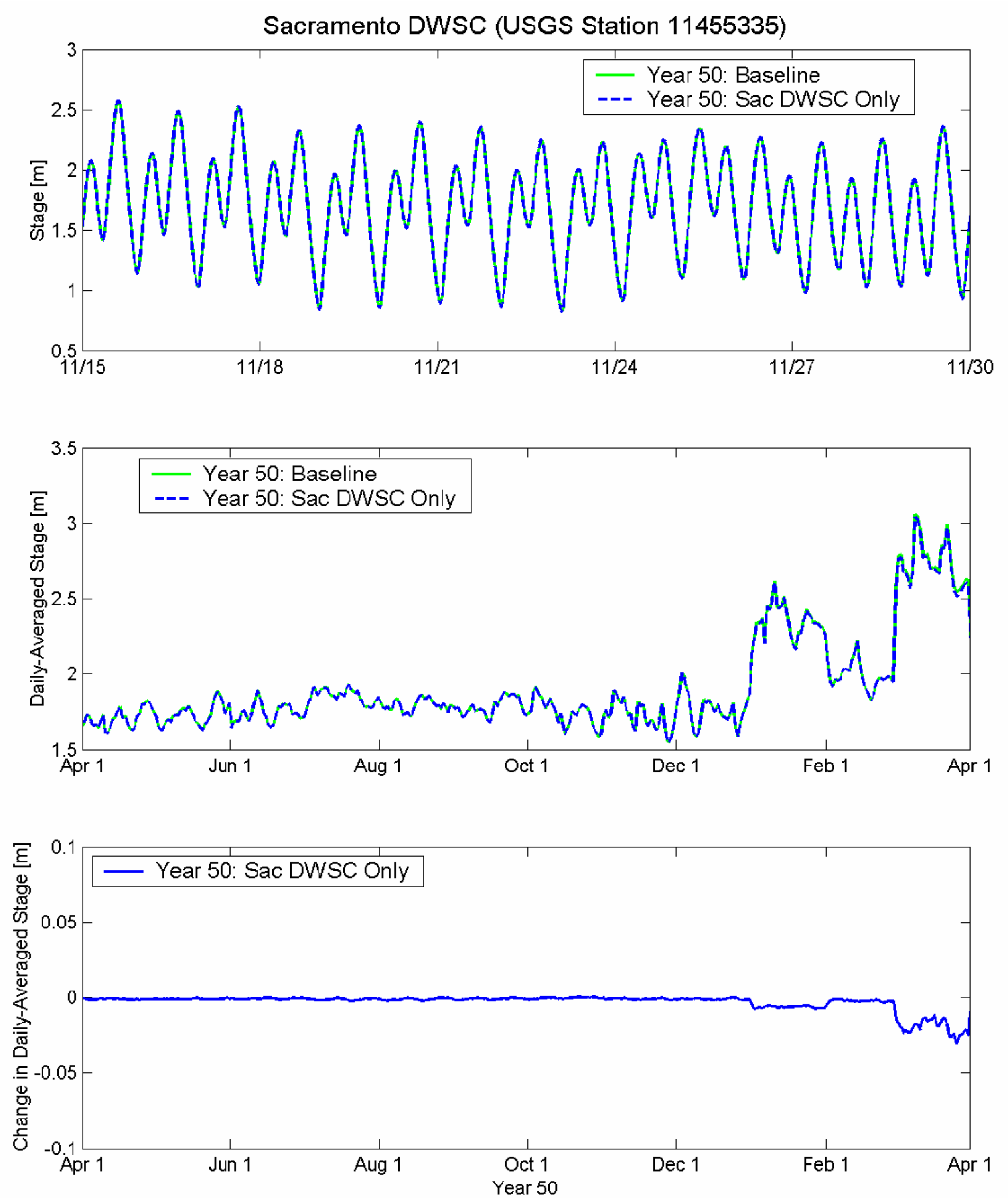

Figure 14. Predicted stage at Sacramento DWSC (USGS Station 11455335) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged stage for Year 50 simulation period (middle); predicted increase in daily-averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

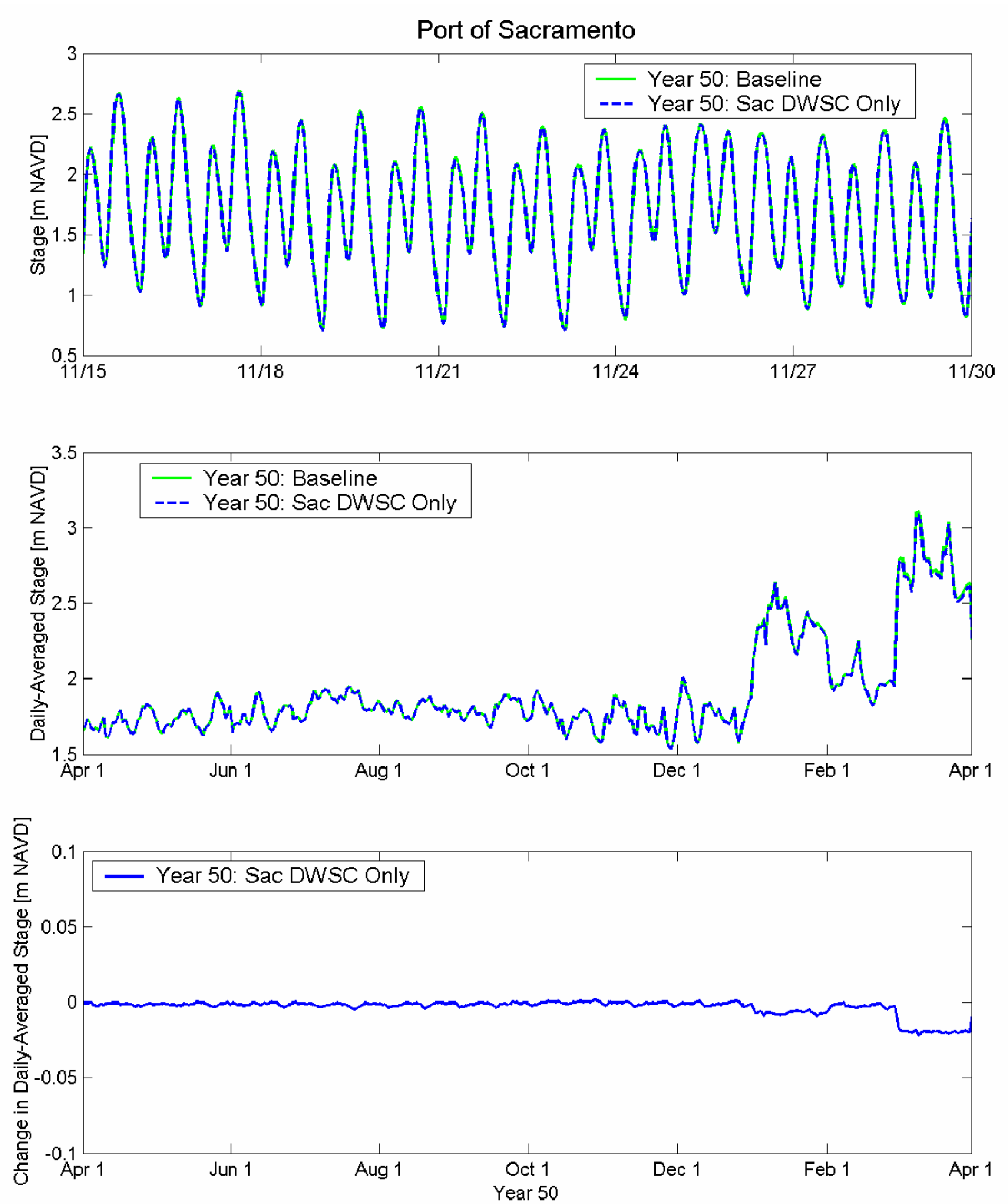

Figure 15. Predicted stage at the Port of Sacramento for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); dailyaveraged stage for Year 50 simulation period (middle); predicted increase in daily-averaged stage for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

3.0 DISCHARGE

Comparison of the Year 0 and Year 50 with and without project conditions are made in this section at each of the 5 defined reaches within SACRDWSC.

3.1 Year 0 With and Without Project Comparison

Flow comparisons are made at stations along the Sacramento River located near Chipps Island, Rio Vista, Cache Slough at Ryer Island, the USGS Station 11455335 near Rio Vista, Miner Slough, Steamboat Slough, Sutter Slough, and the Georgiana Slough. These stations represent reaches 1 through 5 of the SACRDWSC (Figure 2). Figures illustrating flow comparisons are shown here in. These figures compare a 15-day period of flow variability of two scenarios: (1.) the without project condition and (2.) deepening of the SACRDWSC only scenario. Additionally, comparisons of daily averaged flow without and with project condition for the full simulation year and change in flow with project conditions are included in this section.

Figure 16 shows predicted flow at Chipps Island. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 1% and 0.1% during high flow conditions.

Figure 17 shows predicted flow at Rio Vista. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 2.5% during typical flow conditions and 0.1% during high flow conditions.

Figure 18 shows the predicted flow at Cache Slough at Ryer Island. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 2.5% and 0.1% during high flow conditions.

Figure 19 shows predicted flow at the USGS Station. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order 10%. Flow predictions at this station show little change in flow on the high flow events occurring from January to March.

Figure 20 shows predicted flow at the Miner Slough. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 5% decrease during and 0.9% increase during high flow conditions.

Figure 21 shows the predicted flow at the Steamboat Slough. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During both typical and high flow events almost no change is predicted.

Figure 22 shows the predicted flow at the Sutter Slough. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 2% decrease and 0 to 0.1% increase during high flow conditions.

Figure 23 shows the predicted flow at the Georgiana. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 1% and approximately 0% change during high flow conditions.

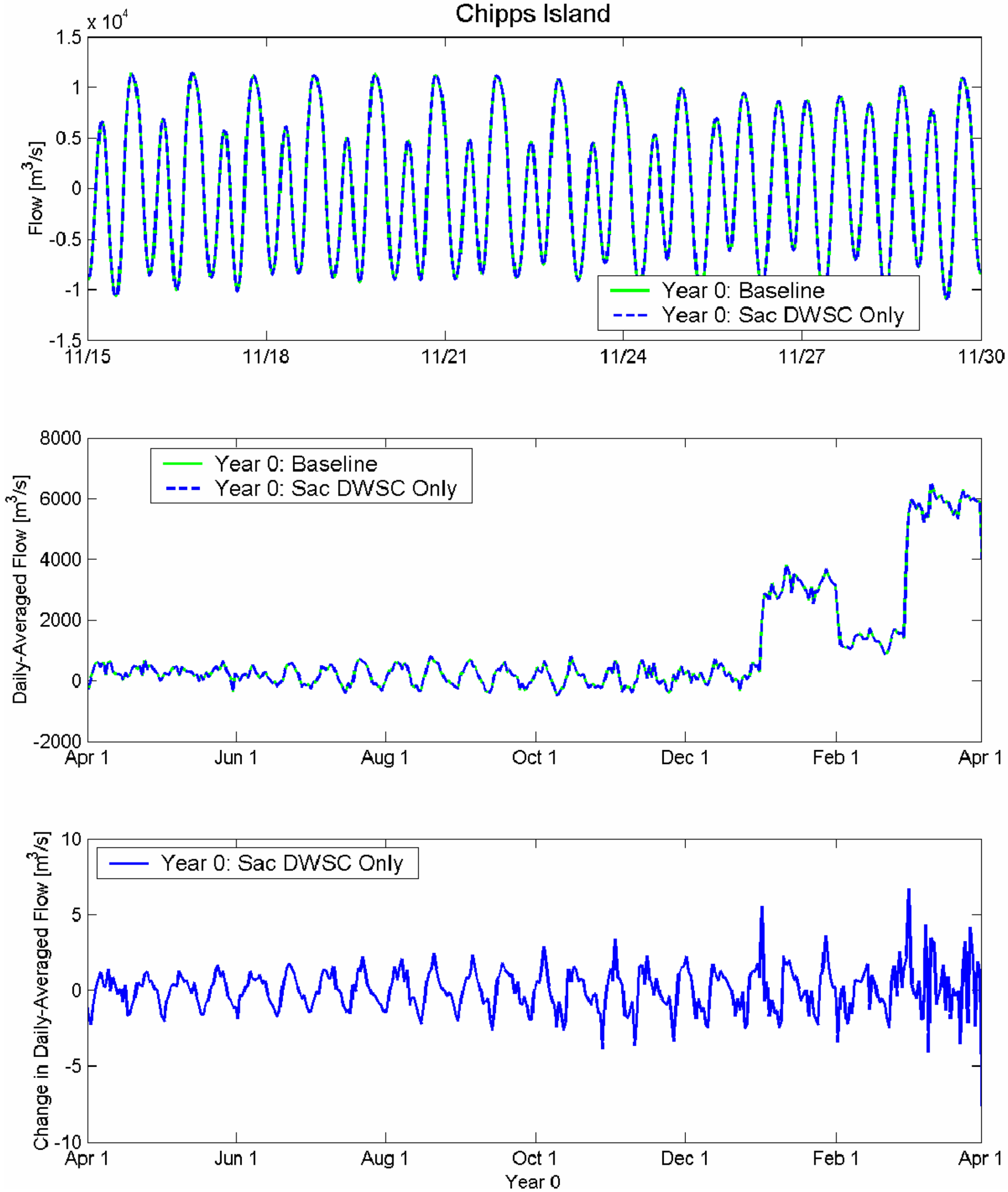

Figure 16. Predicted flow at Chipps Island for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 0 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

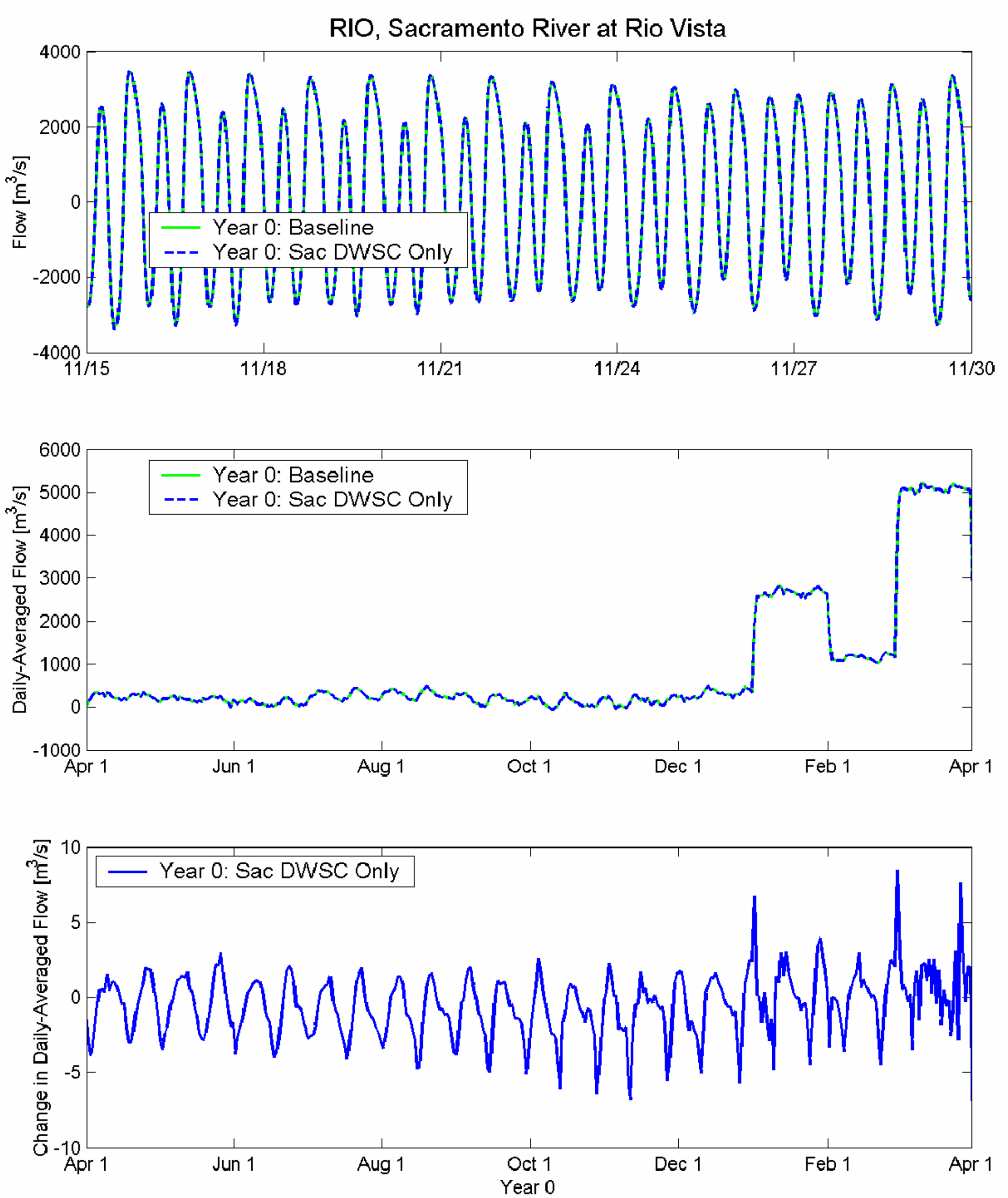

Figure 17. Predicted flow at Sacramento River at Rio Vista (RIO) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 0 simulation period (middle); predicted increase in dailyaveraged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

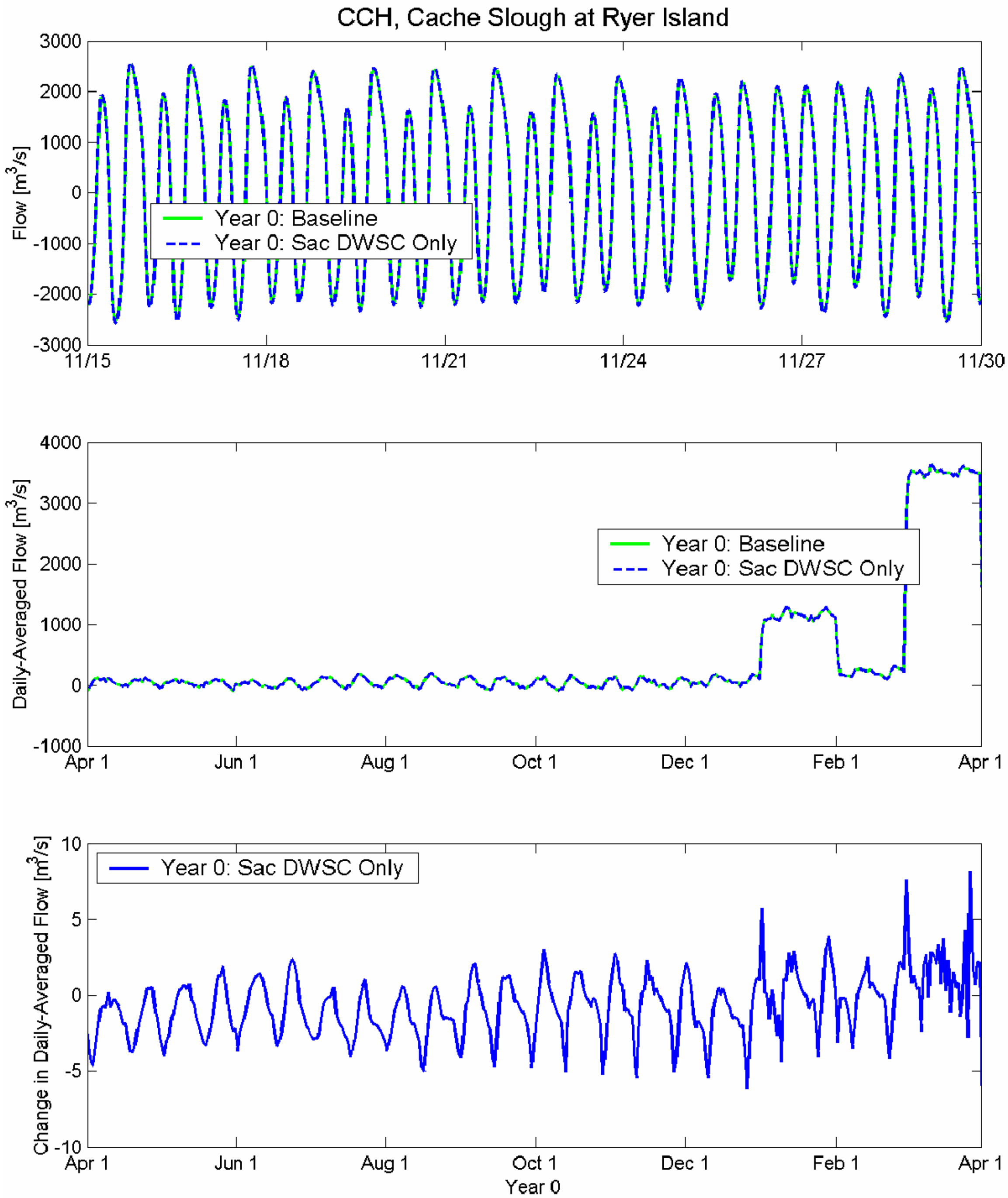

Figure 18. Figure 4.2-3 Predicted flow at Cache Slough at Ryer Island (CCH) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 0 simulation period (middle); predicted increase in dailyaveraged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

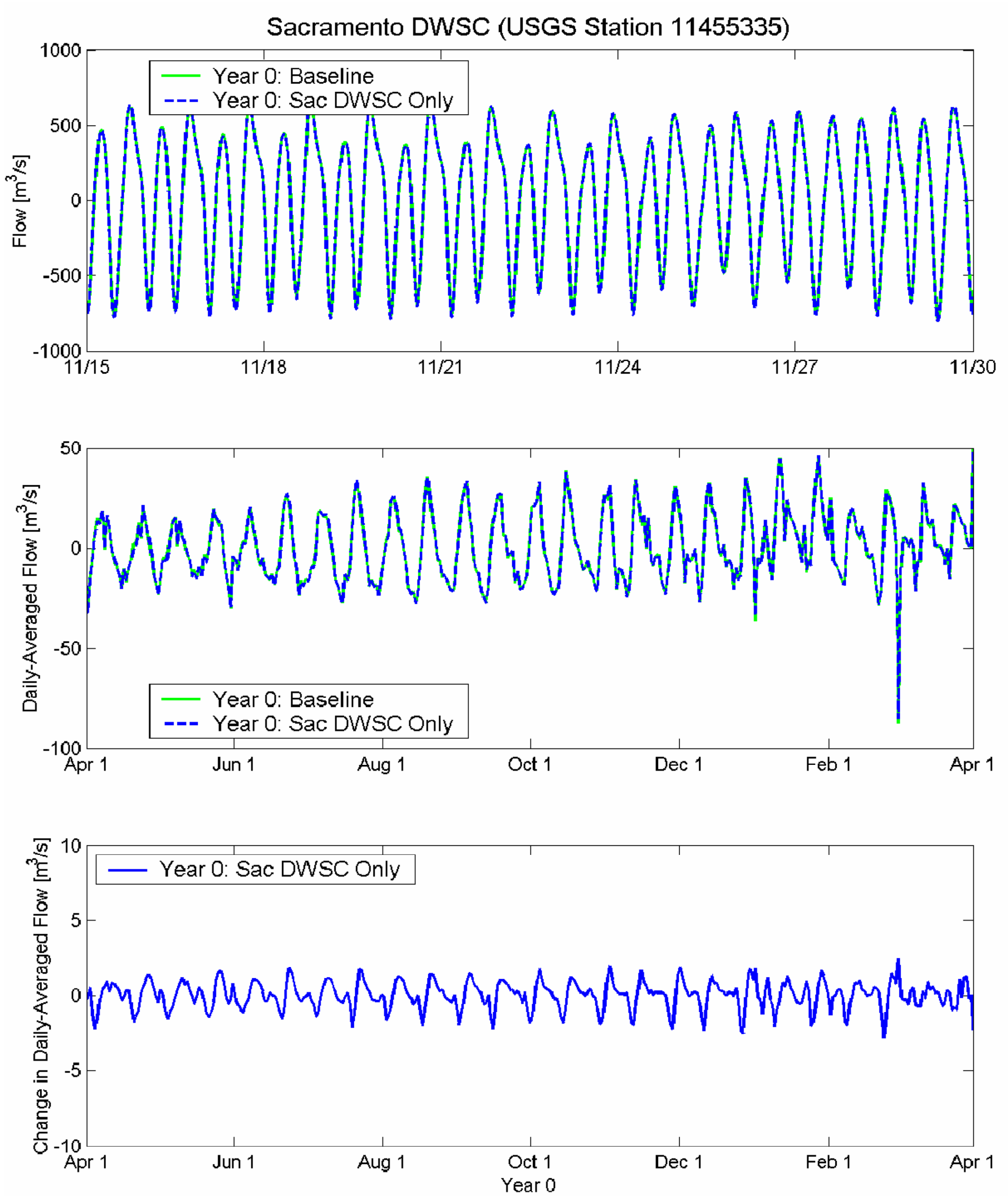

Figure 19. Predicted flow at Sacramento DWSC (USGS Station 11455335) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 0 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

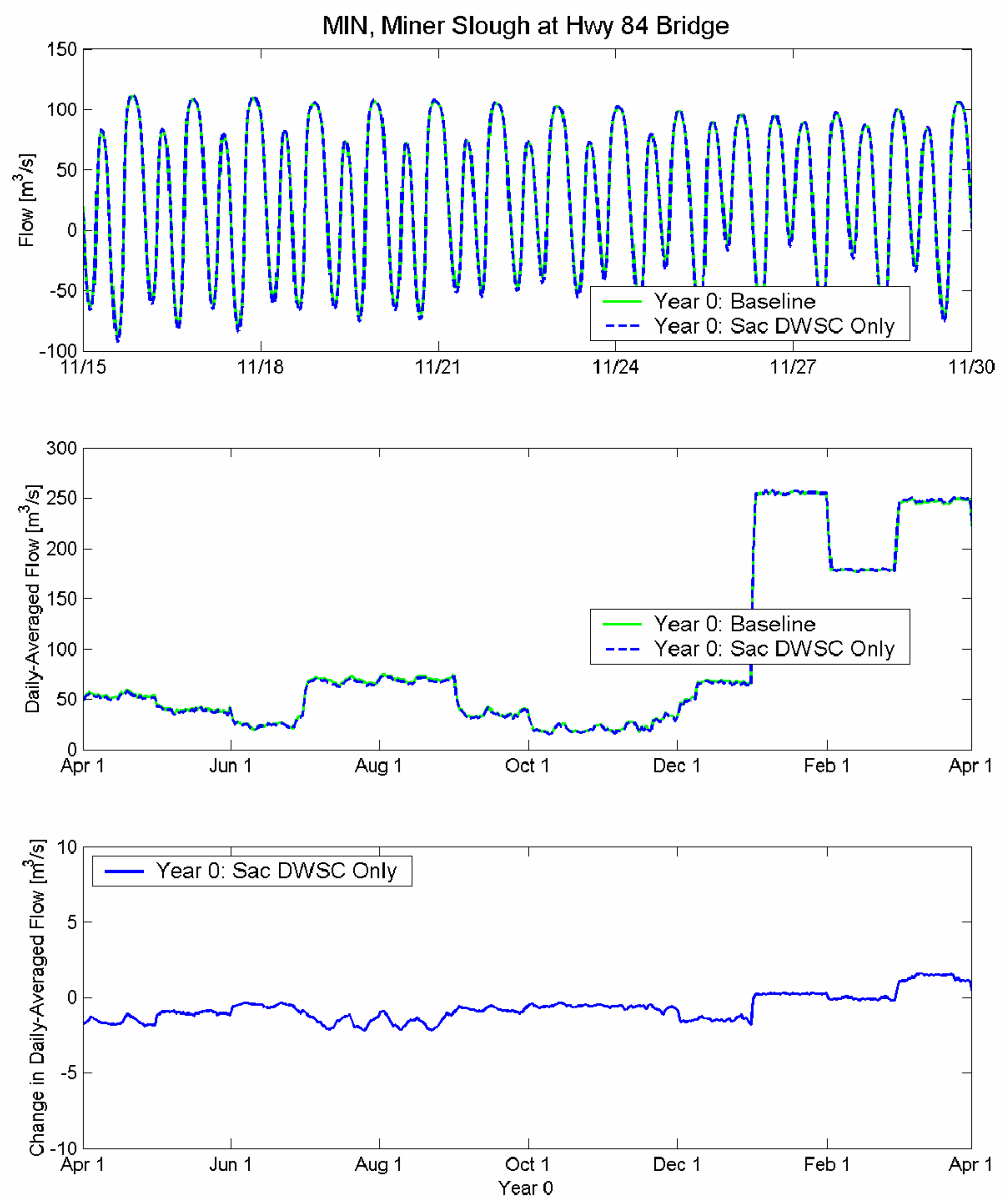

Figure 20. Predicted flow at Miner Slough at Highway 84 Bridge (MIN) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 0 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

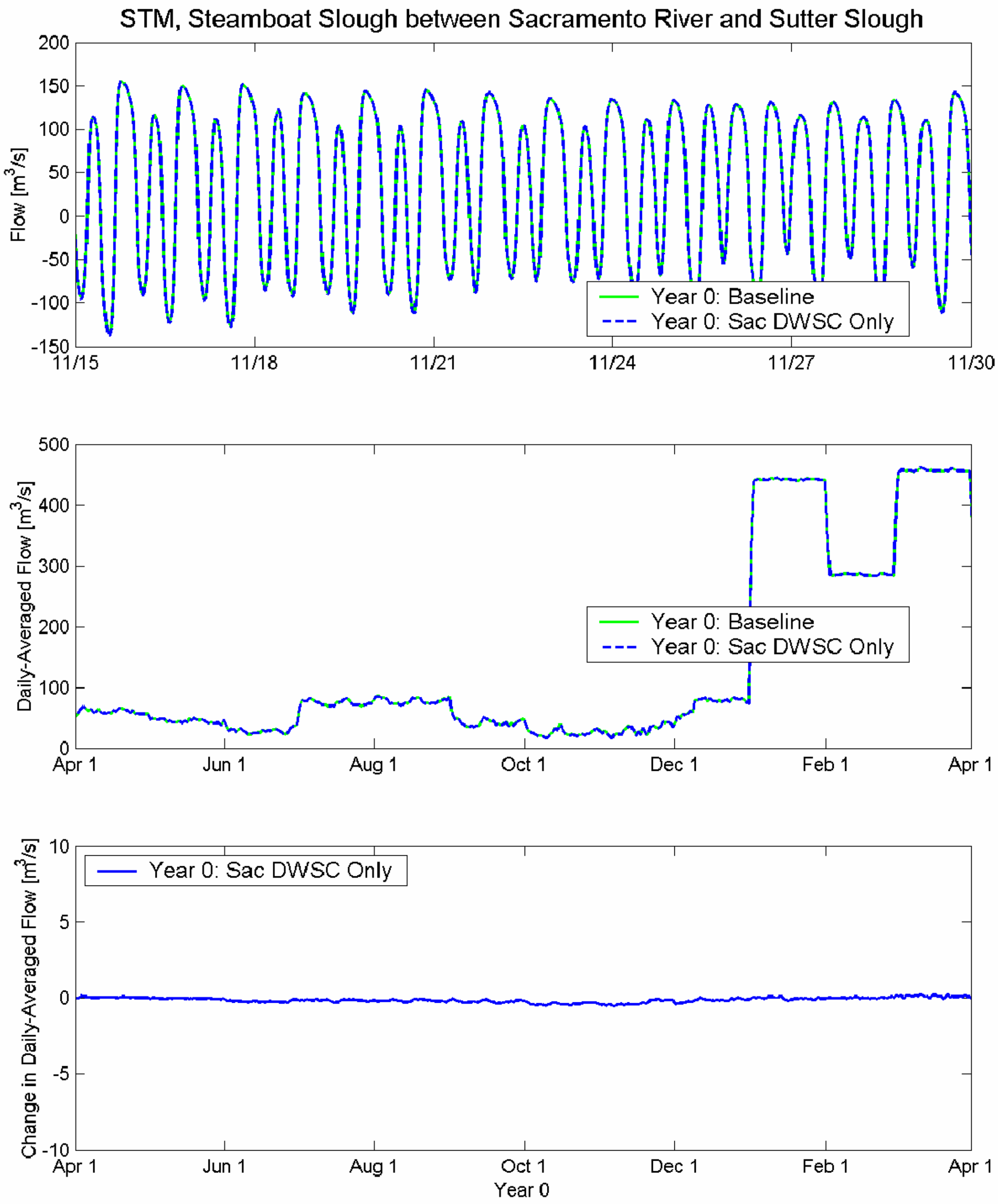

Figure 21. Predicted flow at Steamboat Slough between Sacramento River and Sutter Slough (STM) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 0 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

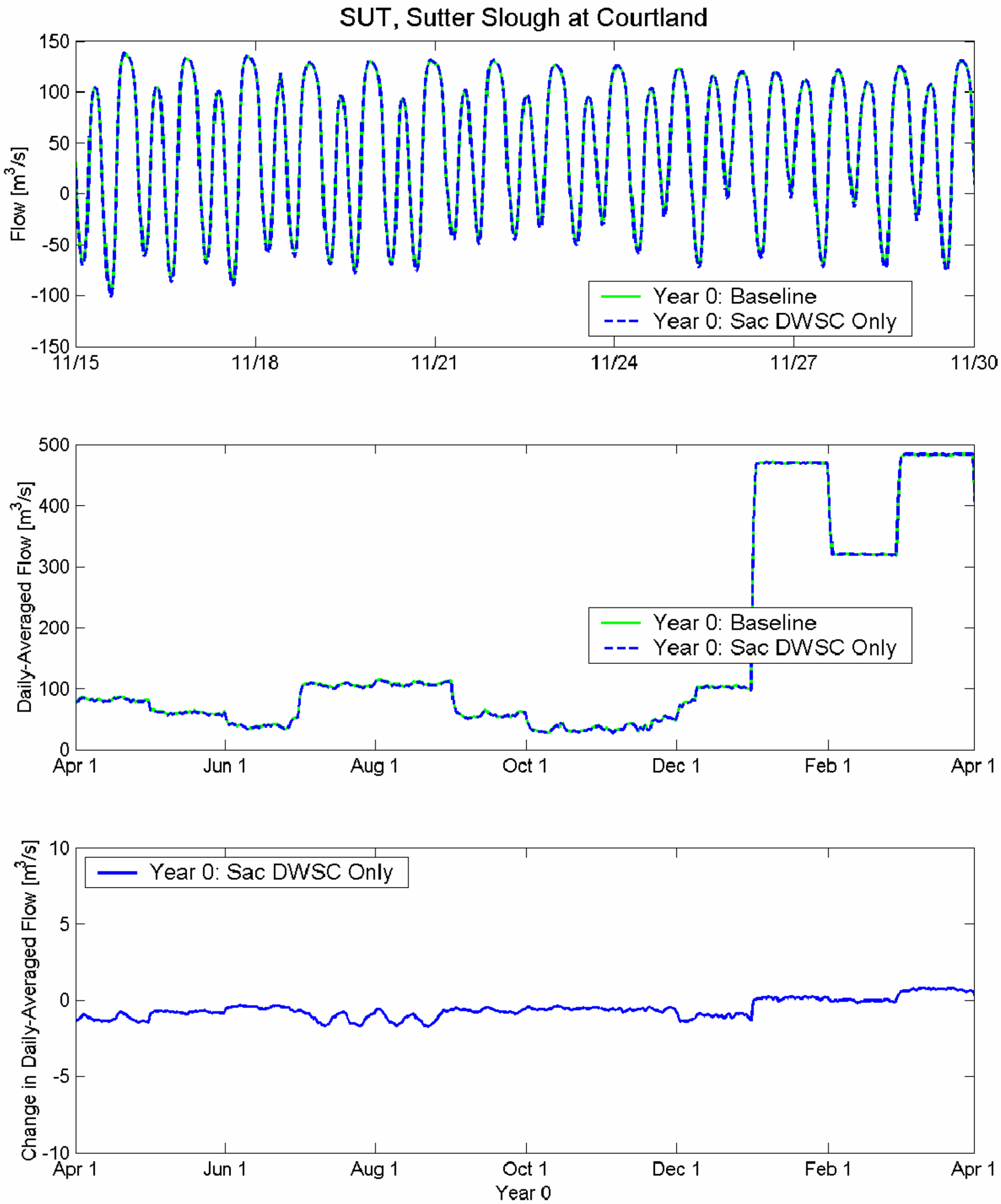

Figure 22. Predicted flow at Sutter Slough at Courtland (SUT) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 0 simulation period (middle); predicted increase in dailyaveraged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

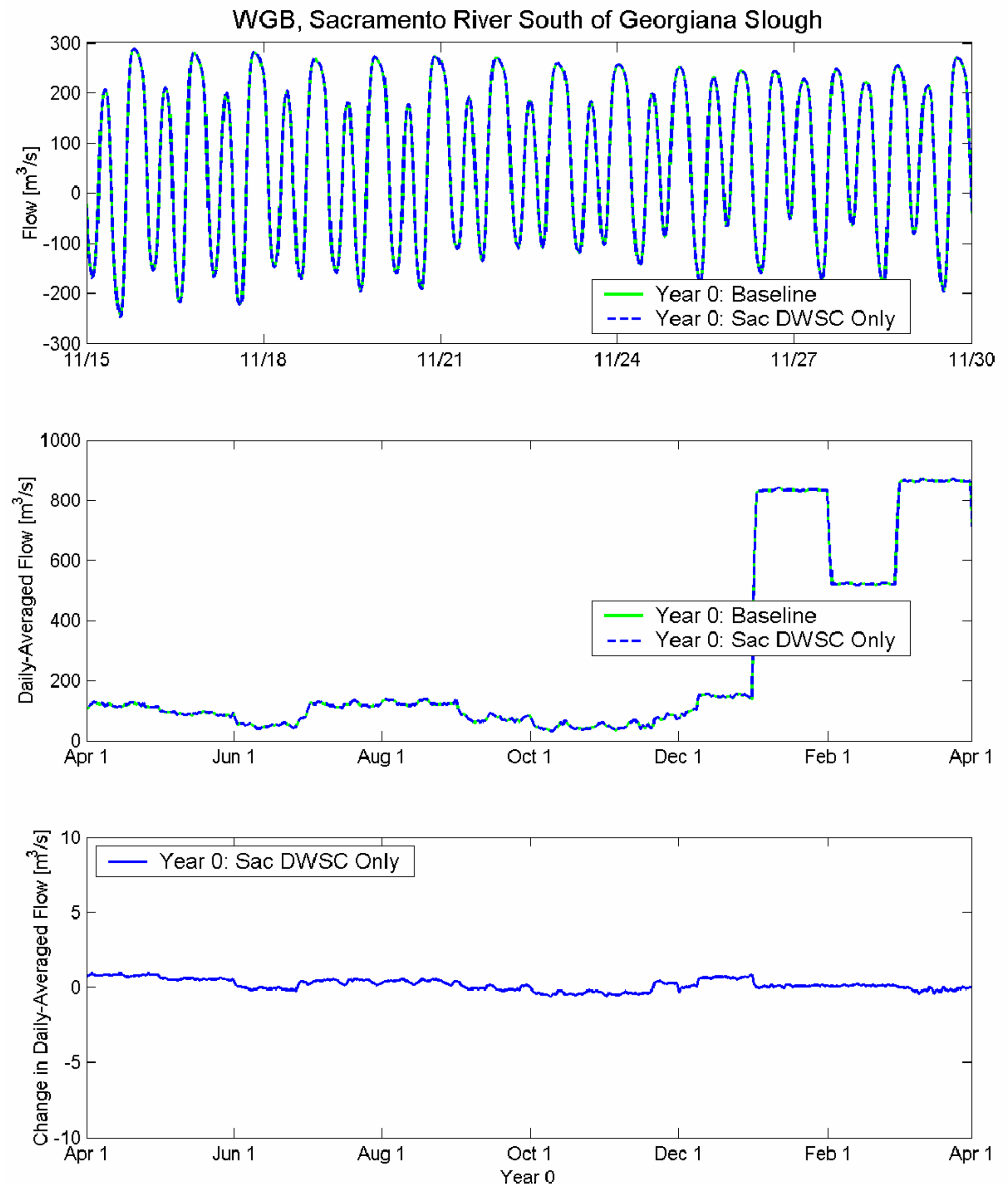

Figure 23. Predicted flow at Sacramento River South of Georgiana Slough (WGB) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 0 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

3.2 Year 50 With and Without Project Comparison

Flow comparisons are made at stations along the Sacramento River located near Chipps Island, Rio Vista, Cache Slough at Ryer Island, the USGS Station 11455335 near Rio Vista, Miner Slough, Steamboat Slough, Sutter Slough, and the Georgiana Slough. These stations represent reaches 1 through 5 of the SACRDWSC (Figure 2). Figures illustrating flow comparisons are shown here in. These figures compare a 15-day period of flow variability of two scenarios: (1.) the without project condition and (2.) deepening of the SACRDWSC only scenario. Additionally, comparisons of daily averaged flow without and with project condition for the full simulation year and change in flow with project conditions are included in this section.

Figure 16 shows predicted flow at Chipps Island. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 1% and 0.1% during high flow conditions.

Figure 17 shows predicted flow at Rio Vista. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 2.5% during typical flow conditions and 0.1% during high flow conditions.

Figure 18 shows the predicted flow at Cache Slough at Ryer Island. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 5% and 0.2% during high flow conditions.

Figure 19 shows predicted flow at the USGS Station. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order 12%. Flow predictions at this station show little change in flow on the high flow events occurring from January to March.

Figure 20 shows predicted flow at the Miner Slough. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 5% decrease during and 0.9% increase during high flow conditions.

Figure 21 shows the predicted flow at the Steamboat Slough. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During both typical and high flow events almost no change is predicted.

Figure 22 shows the predicted flow at the Sutter Slough. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 2% decrease and 0 to 0.1% increase during high flow conditions.

Figure 23 shows the predicted flow at the Georgiana. Comparisons of the both scenarios, baseline and with project, show identical results during the 15-day period, similarly, daily average flow is nearly identical. Minimal change in flow is predicted with project conditions. During typical flow conditions predicted change in flow is on the order of 1% and 0 to 0.1% during high flow conditions.

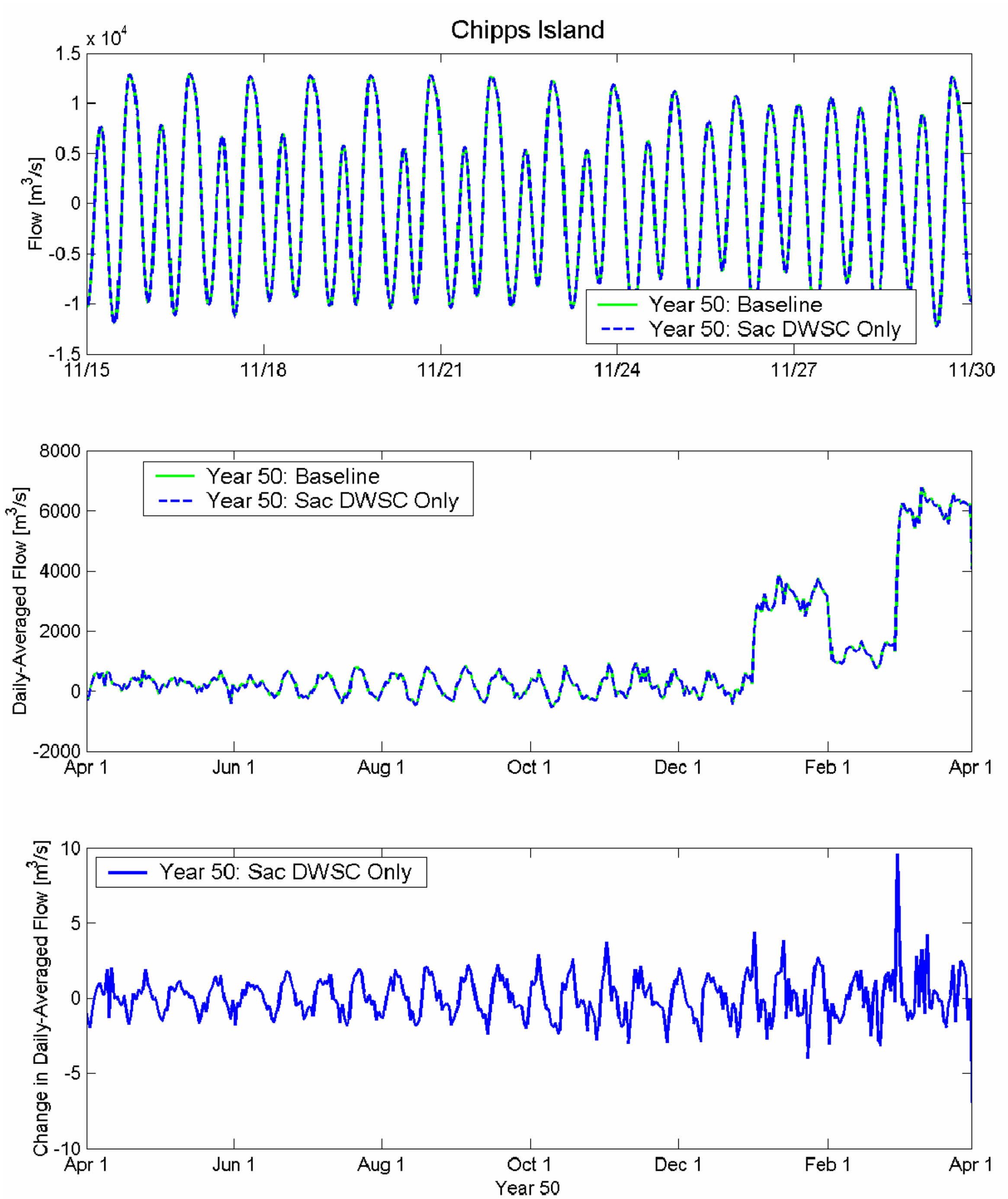

Figure 24. Predicted flow at Chipps Island for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 50 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

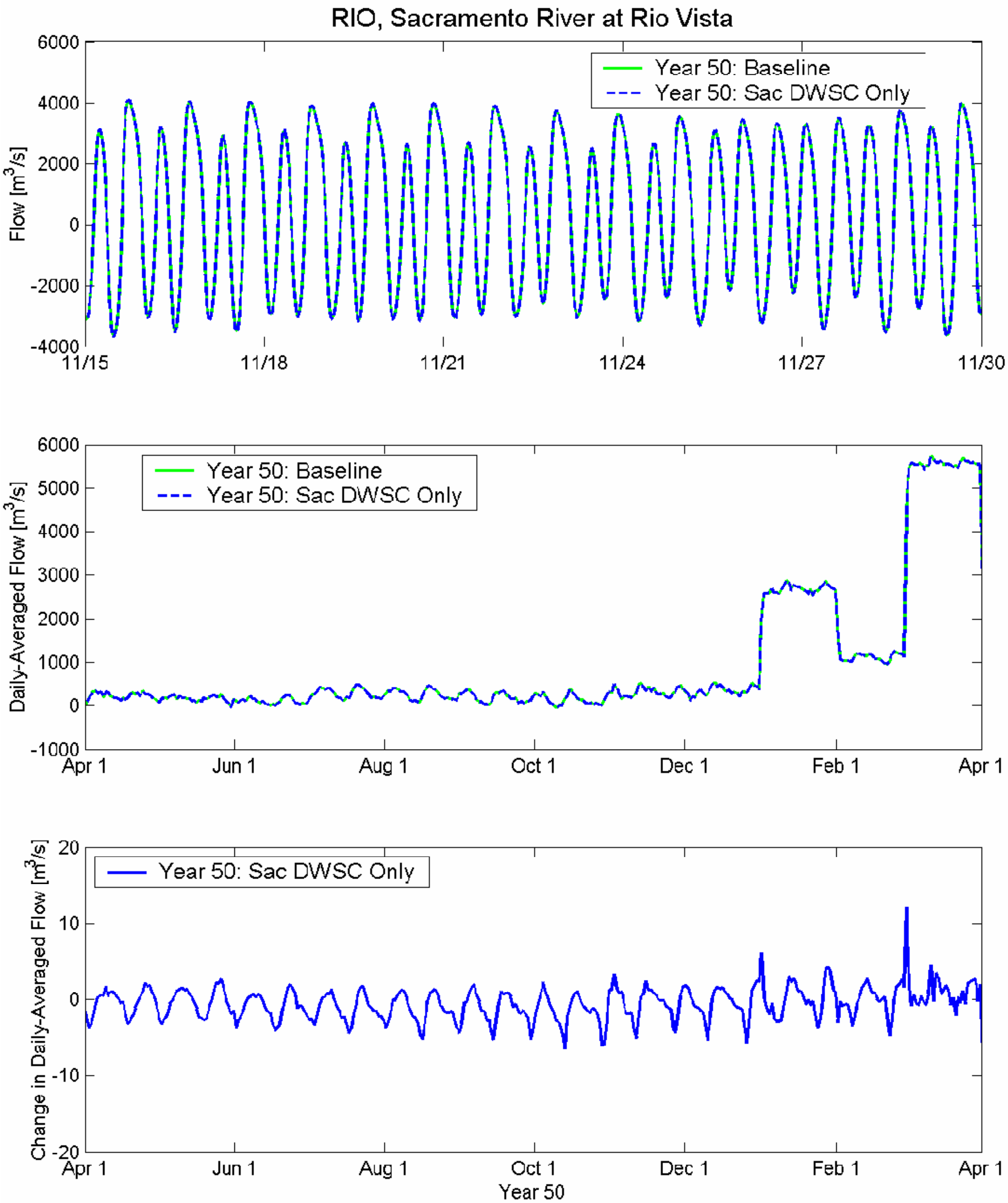

Figure 25. Predicted flow at Sacramento River at Rio Vista (RIO) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 50 simulation period (middle); predicted increase in daily averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

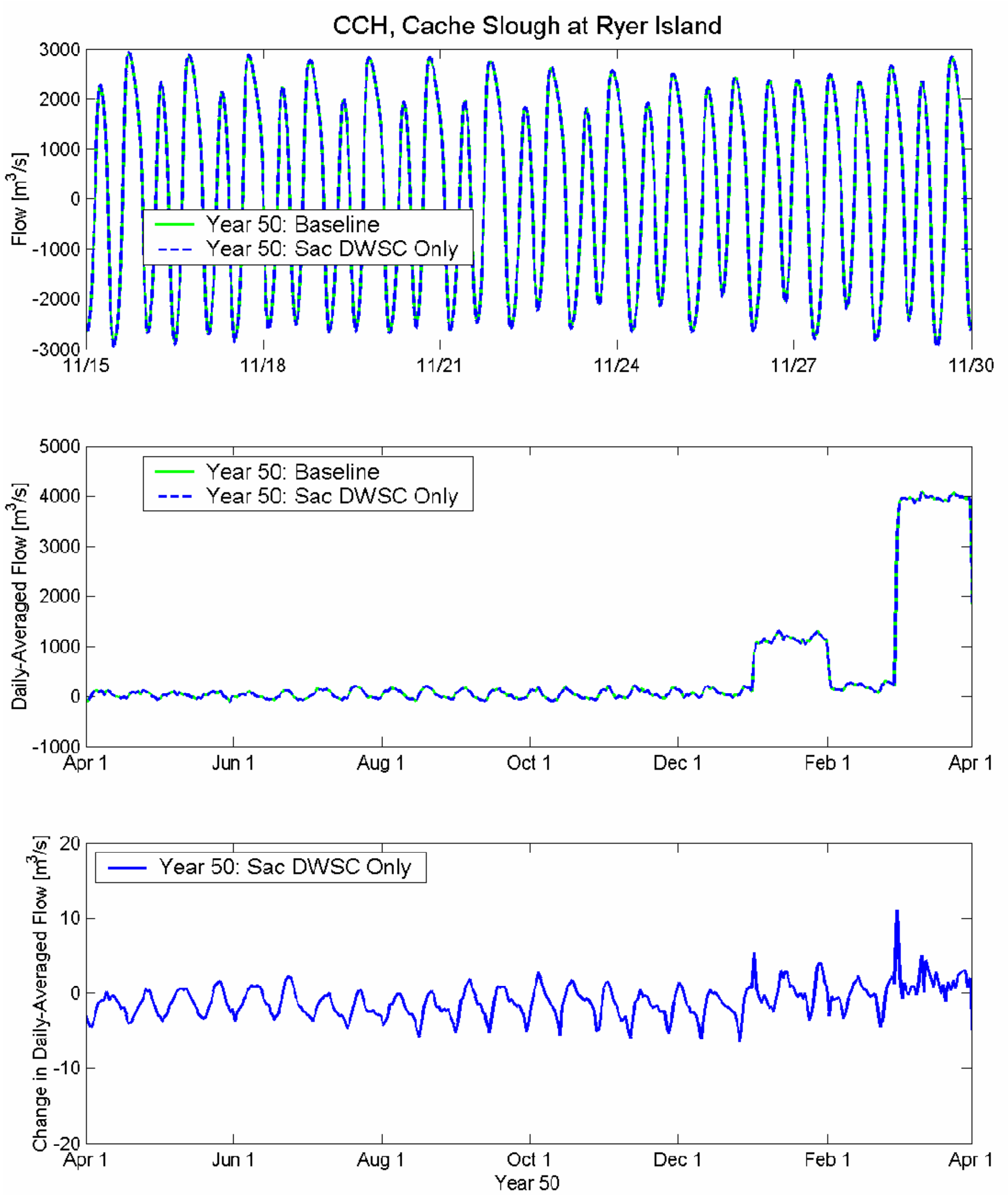

Figure 26. Predicted flow at Cache Slough at Ryer Island (CCH) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 50 simulation period (middle); predicted increase in daily averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

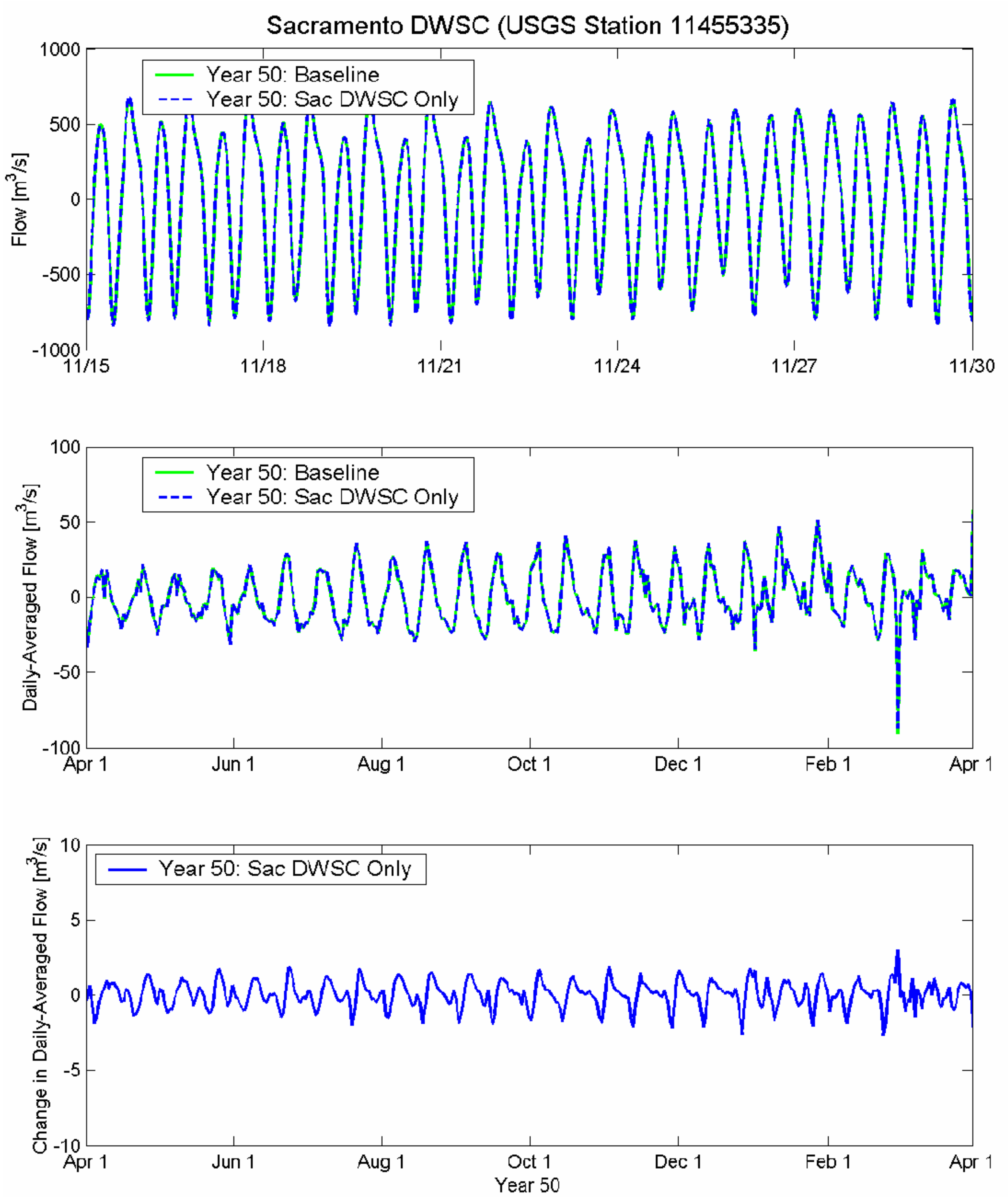

Figure 27. Figure 5.2-3 Predicted flow at Sacramento DWSC (USGS Station 11455335) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 50 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

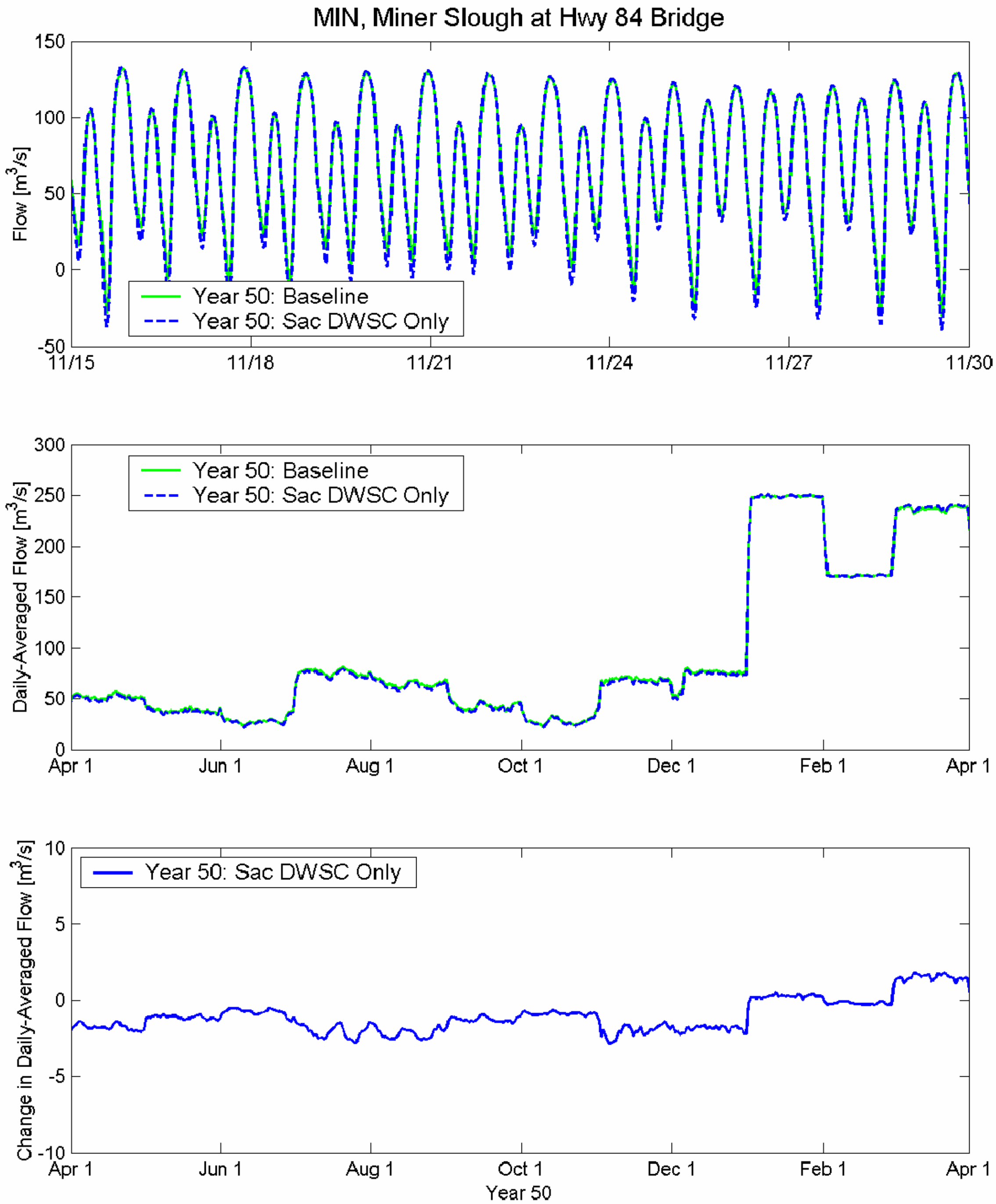

Figure 28. Predicted flow at Miner Slough at Highway 84 Bridge (MIN) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 50 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

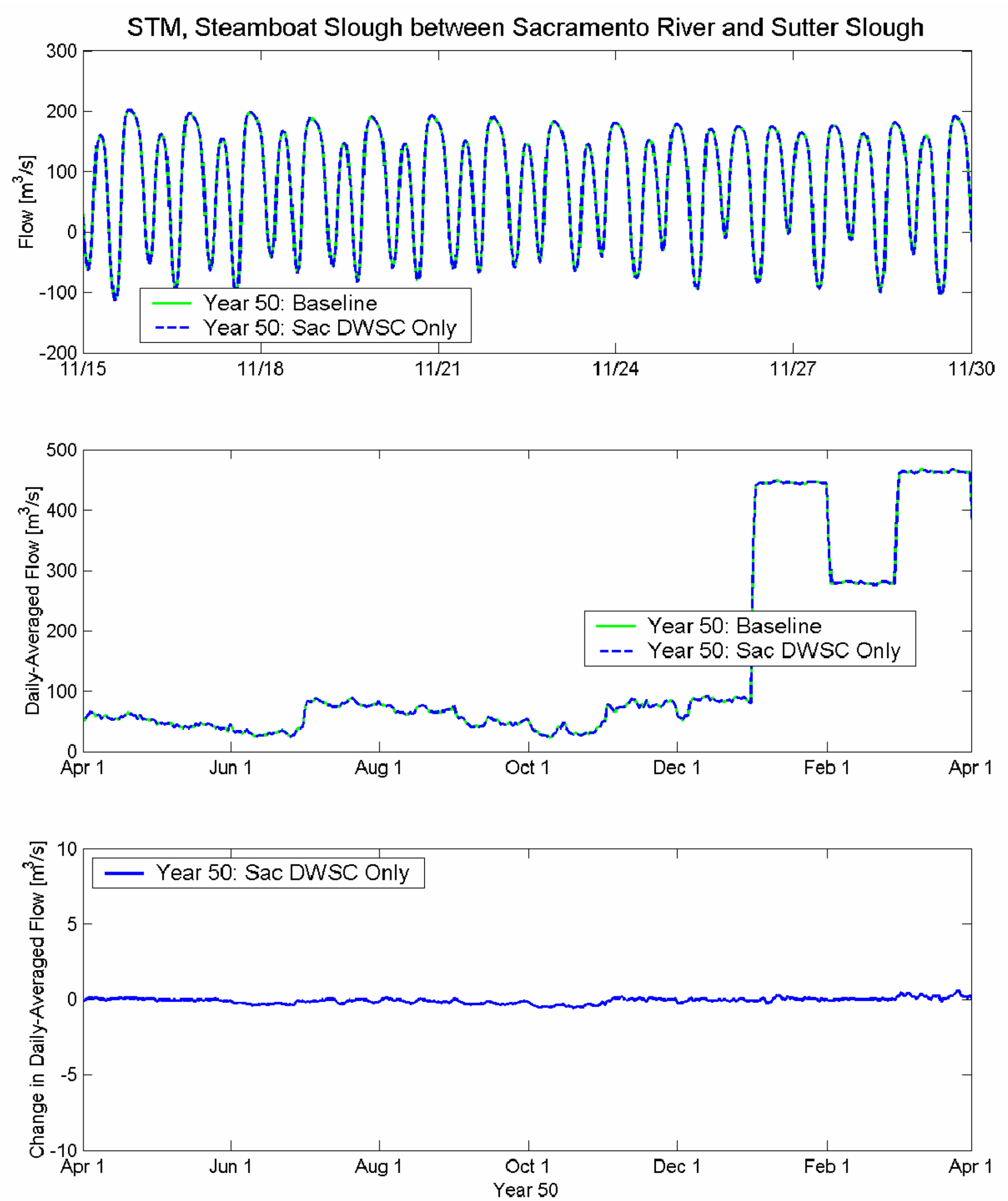

Figure 29. Predicted flow at Steamboat Slough between Sacramento River and Sutter Slough (STM) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 50 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

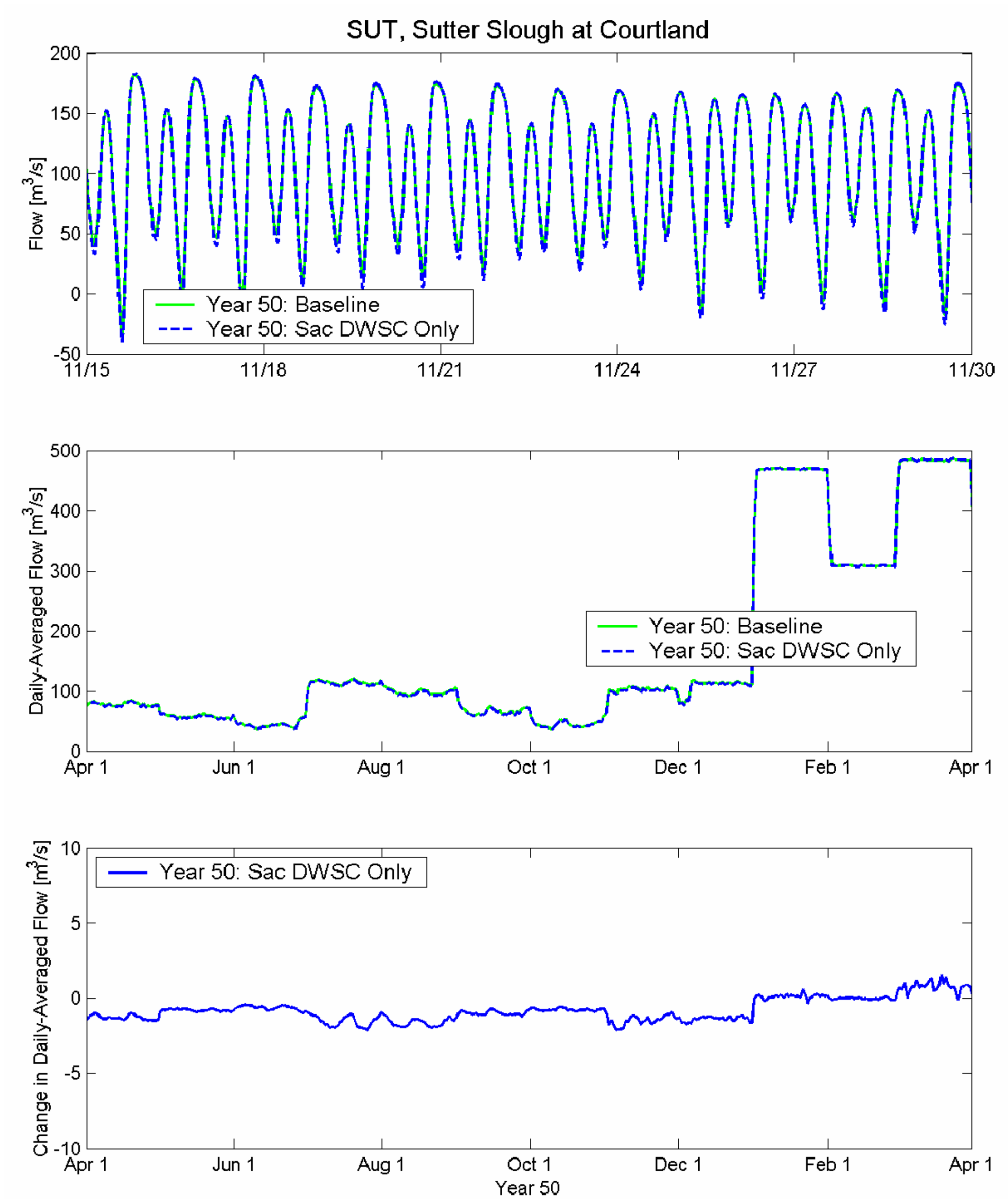

Figure 30. Predicted flow at Sutter Slough at Courtland (SUT) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 50 simulation period (middle); predicted increase in dailyaveraged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

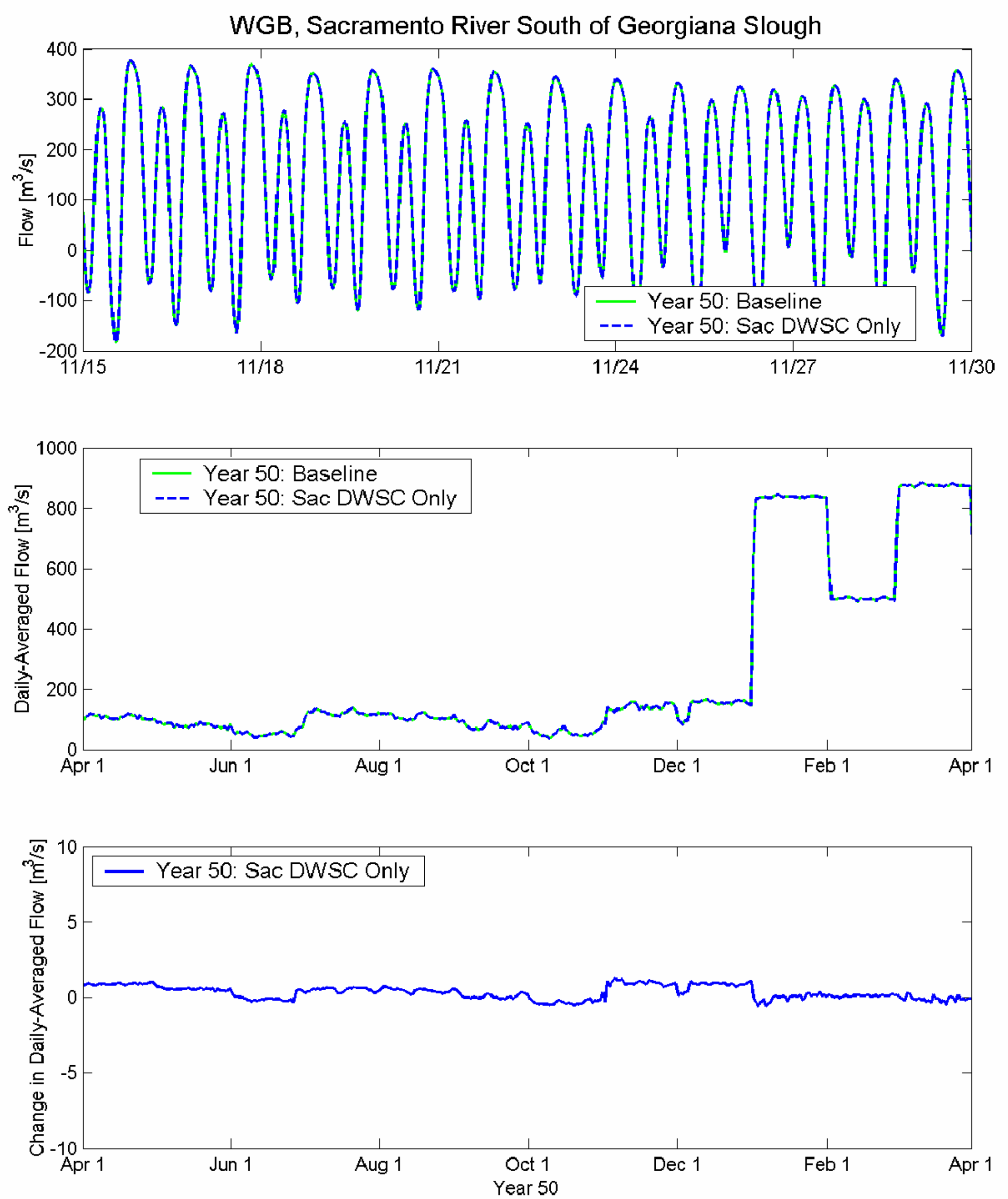

Figure 31. Predicted flow at Sacramento River South of Georgiana Slough (WGB) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged flow for Year 50 simulation period (middle); predicted increase in daily-averaged flow for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

4.0 SALINITY

The current upstream extents of salinity intrusion may be altered as a result of deepening the SACRDWSC. The changes in salinity levels could be attributed to the increased flux of channel flow which may enhance gravitational circulation. Salinity intrusion is quantified by X2. X2 is defined as the distance from the Golden Gate Bridge to the tidally averaged near-bed 2-psu (practical salinity units) isohaline (constant salinity). Therefore, an increase in X2 as a result of the proposed channel deepening would indicate that more salt intrusion would occur. The path that is used to measure X2 in the model is illustrated in Figure 32 of this summary.

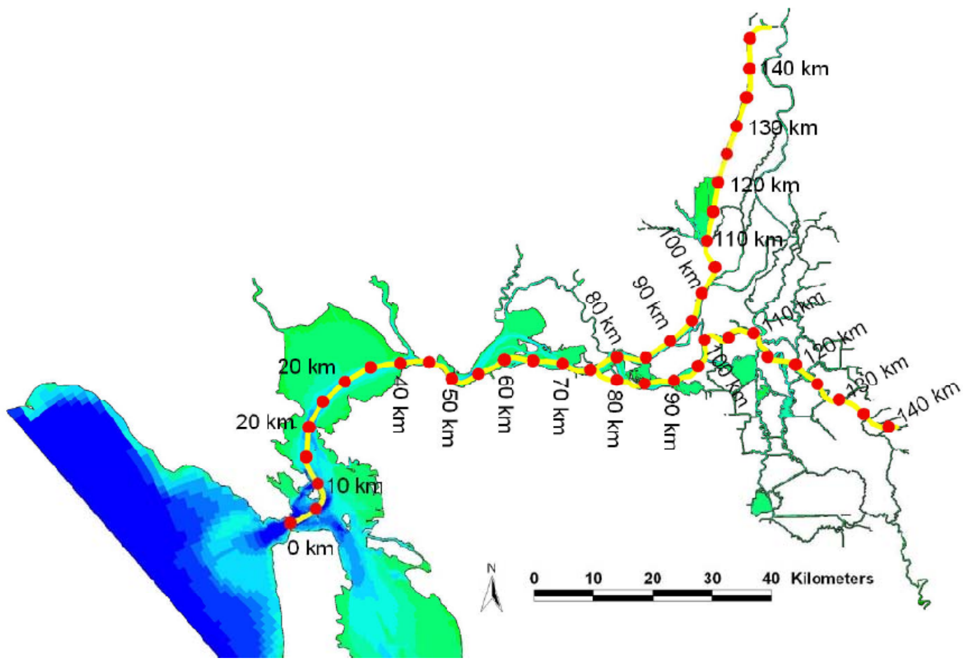

Figure 32. Path in which X2 will be measured

4.1 Year 0 With and Without Project Comparison

4.1.1 Predicted X2

Figure 33 shows the predicted X2 measured from Golden Gate to the Port of Sacramento for the baseline scenario and the deepening of SACRDWSC only scenario. The deepening scenario shows little change in X2 from the baseline condition with the deepening of the SACRDWSC from April to June and January to March. A small increase in X2 is predicted from July to September on the order of 1 km. Another increase in X2 is predicted from October to January on the order of 2 km.

Maximum X2 for the baseline condition (96.3 km) is predicted to occur on December 3 of the simulation year. With project conditions, X2 is predicted to increase 0.9 km beyond the baseline scenario to 97.3 km (**Error! Reference source not found.**).

Additionally, Figure 35 through Figure 37 illustrates the effect of river inflow with X2. During the dry season X2 is near Collinsville (Figure 35); however, during the rainy season X2 extends upstream to Rio Vista (Figure 36) due to the gravitational circulation effect. After a large rainfall event the entire system appears to be flushed and the vertical stratification of salinity is dramatically reduced. X2 is observed downstream near Carquinez Bridge (Figure 37).

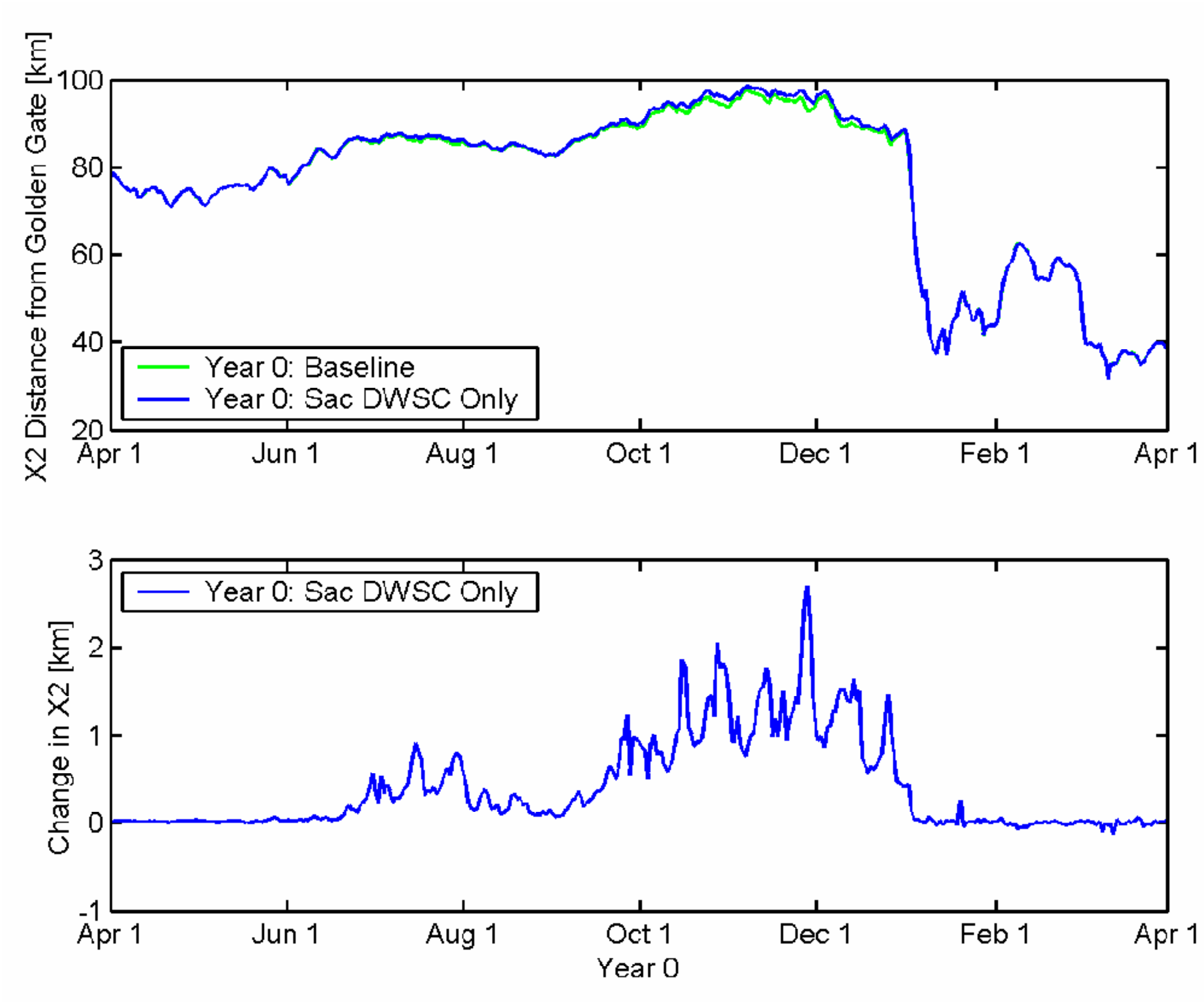

Figure 33. Predicted X2 measured from the Golden Gate to the Port of Sacramento along the Sacramento transect on Figure 3.3-8 during Year 0 simulation period for Baseline scenario and Sacramento DWSC Only deepening scenario (top); Predicted change in X2 measured along the Sacramento transect relative to Baseline scenario for Sacramento DWSC Only deepening scenario for Year 0 (bottom).

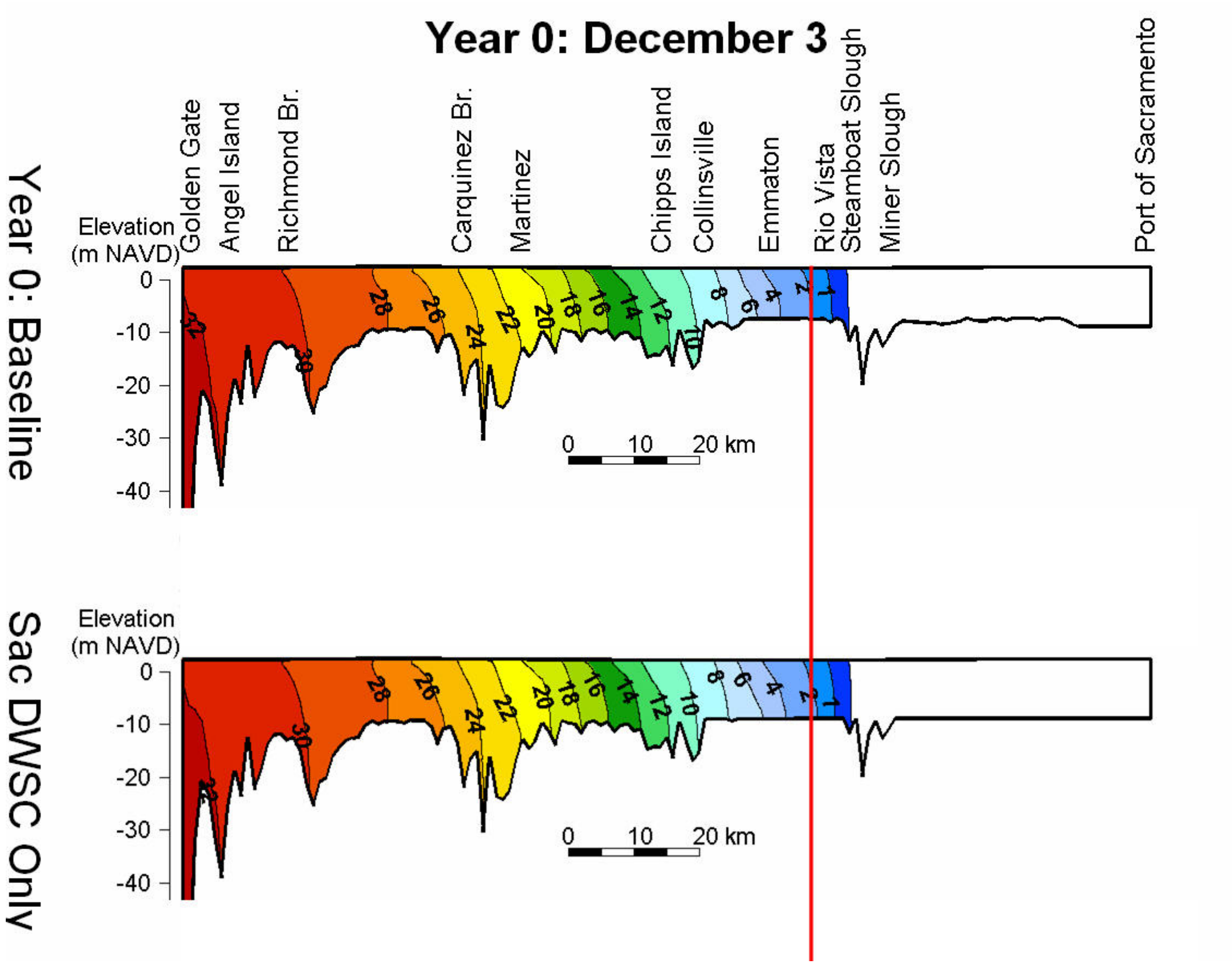

Figure 34. Predicted daily-averaged salinity profile along the axis of San Francisco Bay from the Golden Gate to the Port of Sacramento on December 3, the day of maximum predicted X2, for Baseline scenario (top), Sacramento DWSC Only deepening scenario (bottom) for Year 0. The vertical red line indicates X2 for the Baseline scenario.

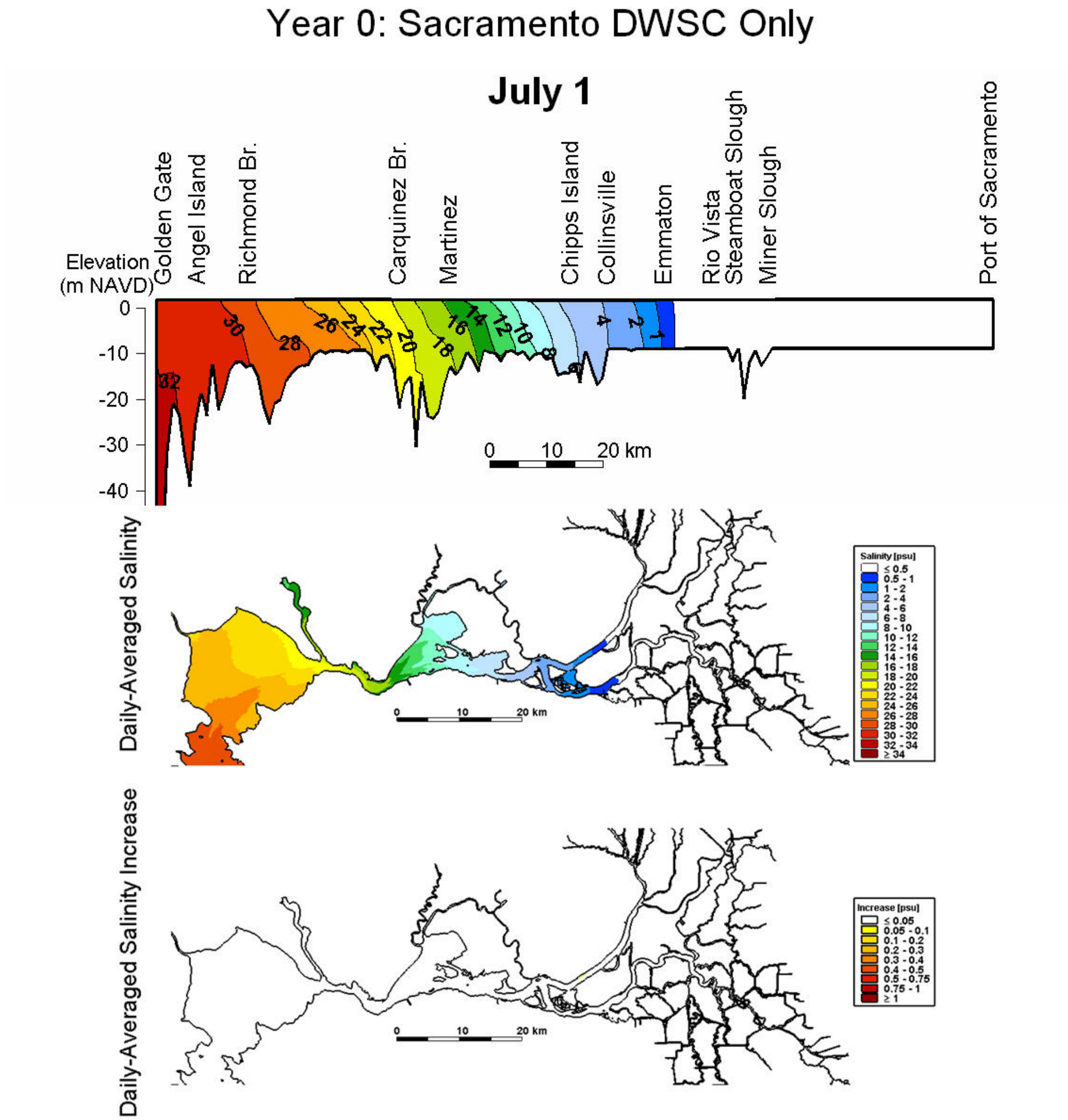

Figure 35. Predicted daily-averaged salinity profile along the axis of San Francisco Bay from the Golden Gate to the Port of Sacramento on July 1 for the Year 0 Sacramento DWSC Only deepening scenario (top); Predicted depth-averaged daily-average salinity on July 1 for the Year 0 Sacramento DWSC Only deepening scenario (middle); predicted increase in depth-averaged daily-average salinity on July 1 relative to the Year 0 Baseline scenario for the Year 0 Sacramento DWSC Only deepening scenario.

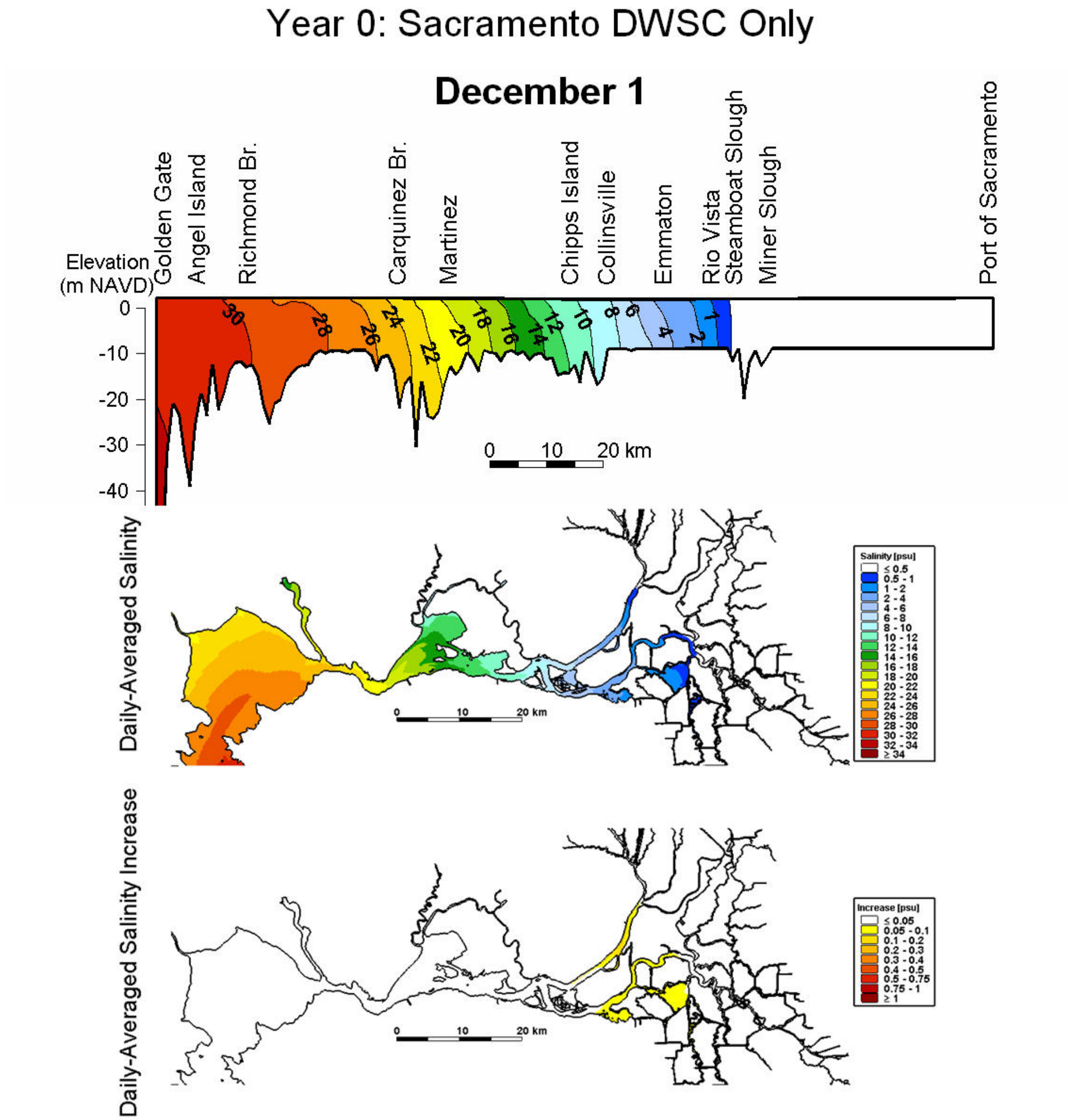

Figure 36. Predicted daily-averaged salinity profile along the axis of San Francisco Bay from the Golden Gate to the Port of Sacramento on December 1 for the Year 0 Sacramento DWSC Only deepening scenario (top); Predicted depth-averaged daily-average salinity on December 1 for the Year 0 Sacramento DWSC Only deepening scenario (middle); predicted increase in depth-averaged daily-average salinity on December 1 relative to the Year 0 Baseline scenario for the Year 0 Sacramento DWSC Only deepening scenario.

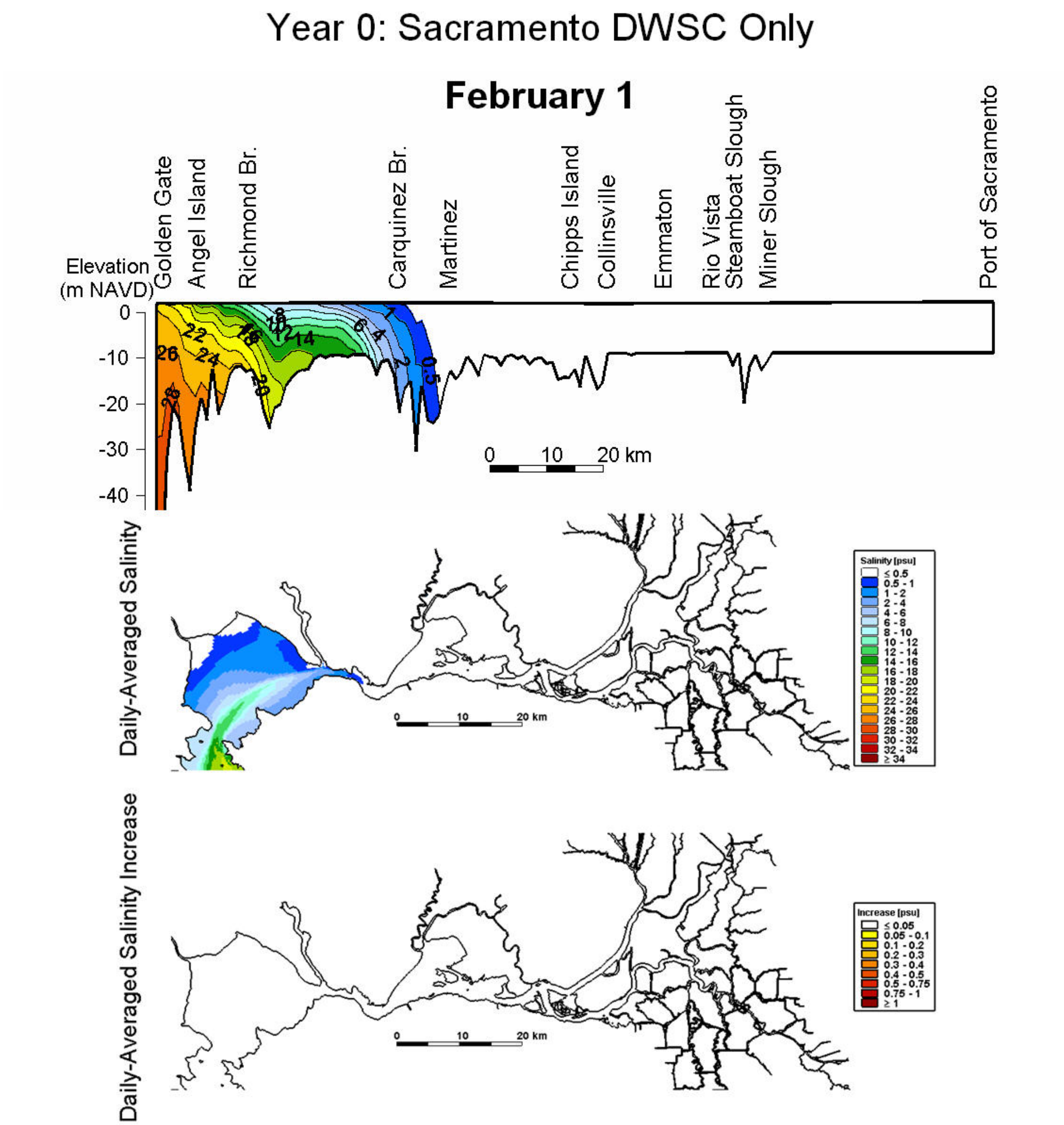

Figure 37. Predicted daily-averaged salinity profile along the axis of San Francisco Bay from the Golden Gate to the Port of Sacramento on February 1 for the Year 0 Sacramento DWSC Only deepening scenario (top); Predicted depth-averaged daily-average salinity on February 1 for the Year 0 Sacramento DWSC Only deepening scenario (middle); predicted increase in depth-averaged daily-average salinity on February 1 relative to the Year 0 Baseline scenario for the Year 0 Sacramento DWSC Only deepening scenario.

4.1.2 Salinity Time Series

Salinity comparisons are made at stations along the Sacramento River located at Martinez, Benicia Bridge, Mallard Island, Emmaton, Rio Vista and Port of Sacramento. These stations represent reaches 1 through 5 of the SACRDWSC (Figure 2). Figures illustrating salinity comparisons are shown here in. These figures compare a 15-day period of salinity variability of two scenarios: (1.) The without project condition and (2.) deepening of the SACRDWSC only scenario. Additionally, comparisons of daily averaged salinity without and with project condition for the entire simulation year and change in salinity with project conditions are included in this section.

Figure 38 shows predicted salinity at Martinez. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical, indicating roughly no predicted change in salinity with project conditions.

Figure 39 shows predicted salinity at Benicia. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical, indicating roughly no predicted change in salinity with project conditions.

Figure 40 shows predicted salinity at Mallard Island. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical, indicating roughly no predicted change in salinity with project conditions.

Figure 41 shows predicted salinity at Emmaton. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical. Increased salinity is predicted with project conditions from July through January of the simulation year. Maximum increase in salinity is 0.1 psu.

Figure 42 shows predicted salinity at Rio Vista. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical. Increased salinity is predicted with project conditions from October through December of the simulation year. Maximum increase in salinity is 0.13 psu.

Figure 43 shows predicted salinity at the Port of Sacramento. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical, indicating roughly no predicted change in salinity with project conditions.

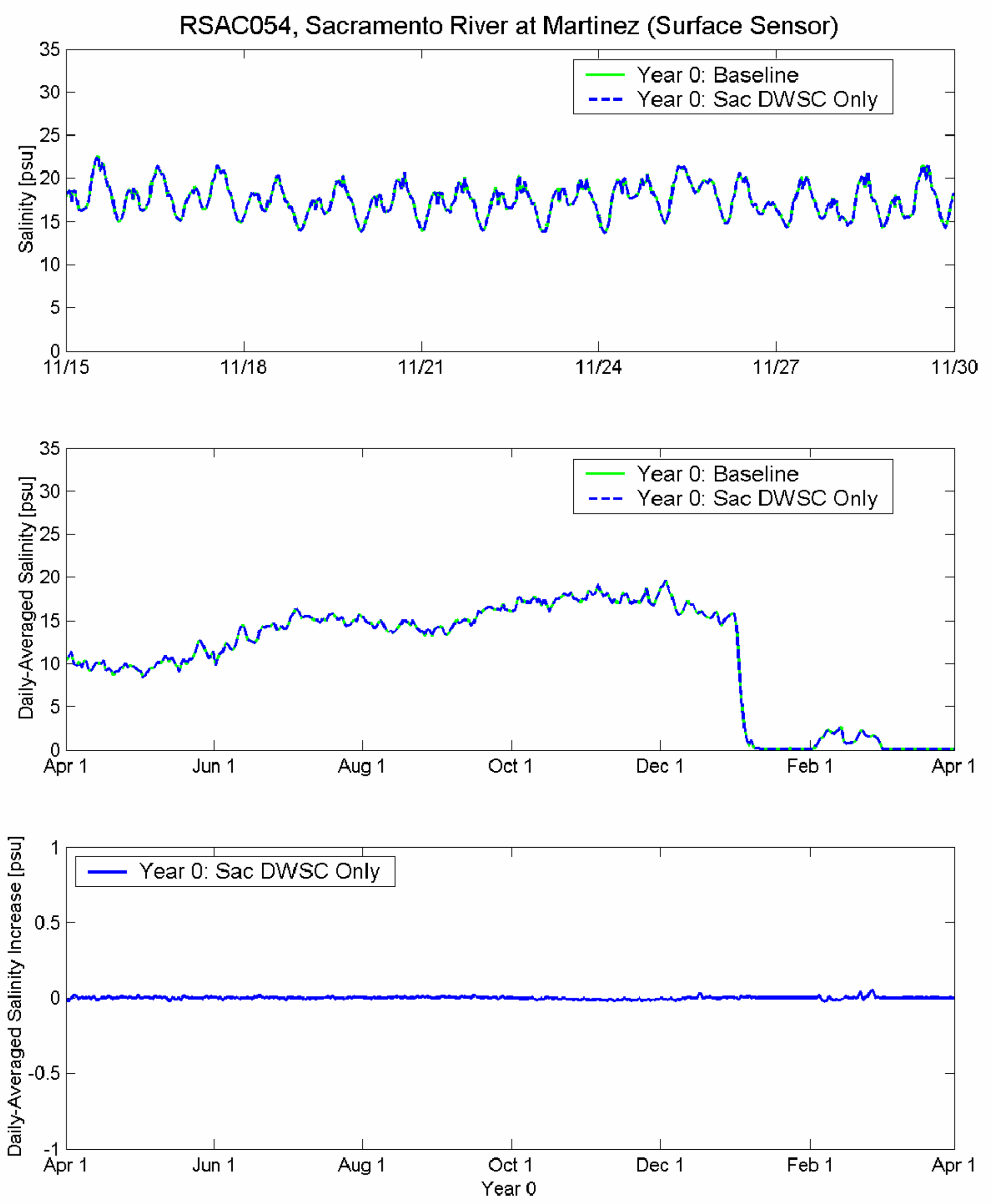

Figure 38. Predicted salinity at Sacramento River at Martinez (RSAC054) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 0 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

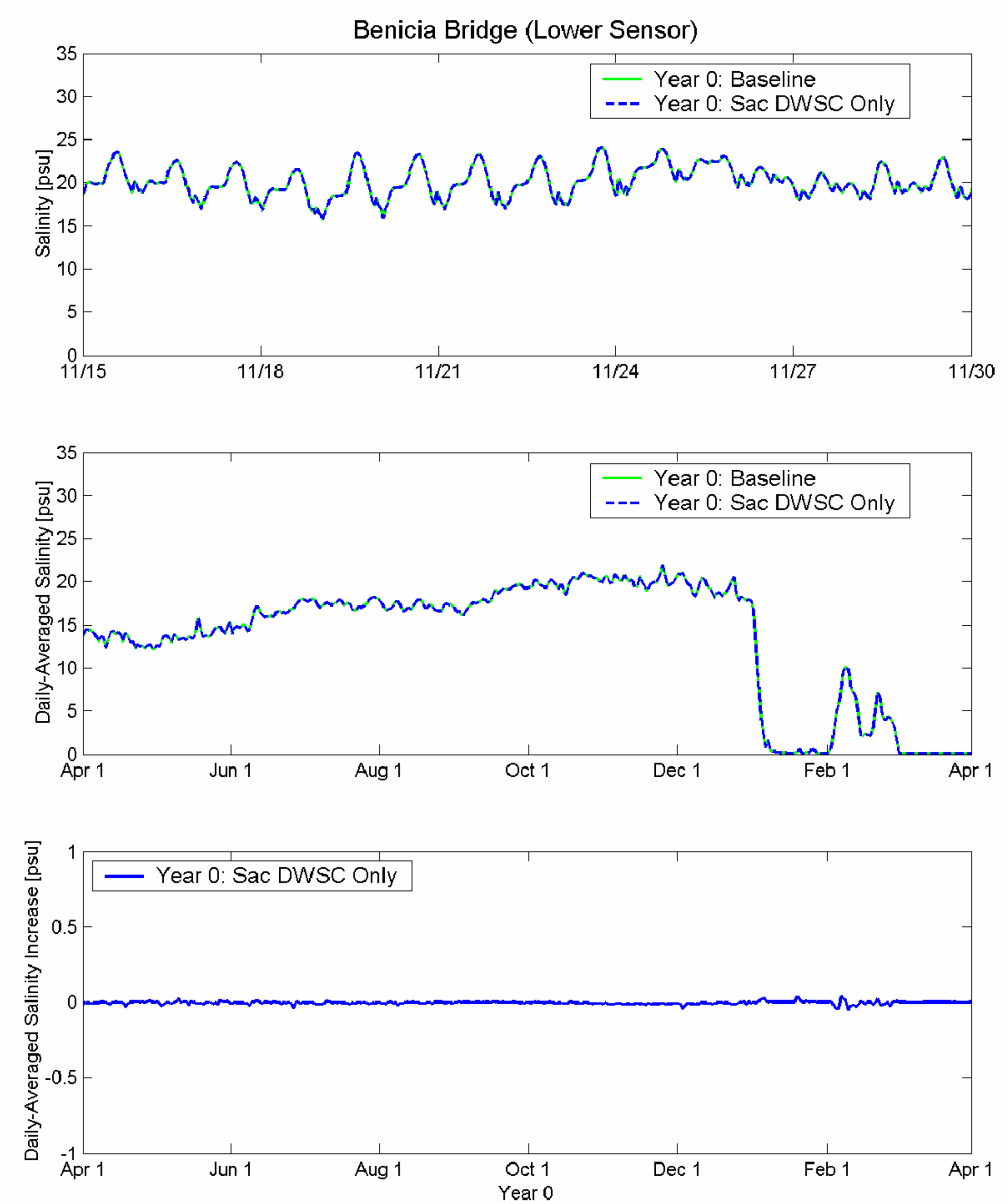

Figure 39. Predicted salinity at Benicia Bridge Lower Sensor for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 0 simulation period (middle); predicted increase in dailyaveraged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

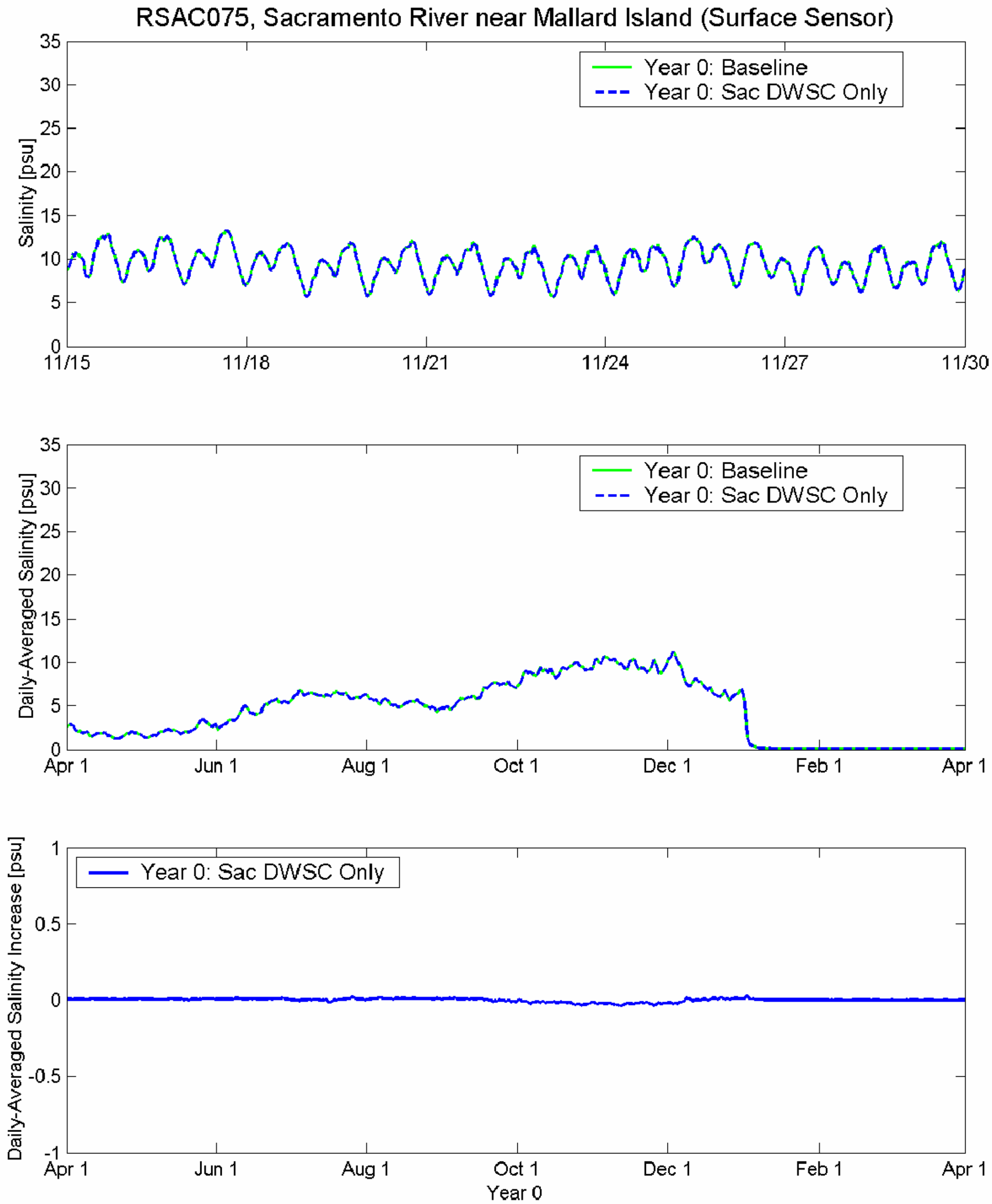

Figure 40. Predicted salinity at Sacramento River near Mallard Island (RSAC075) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 0 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

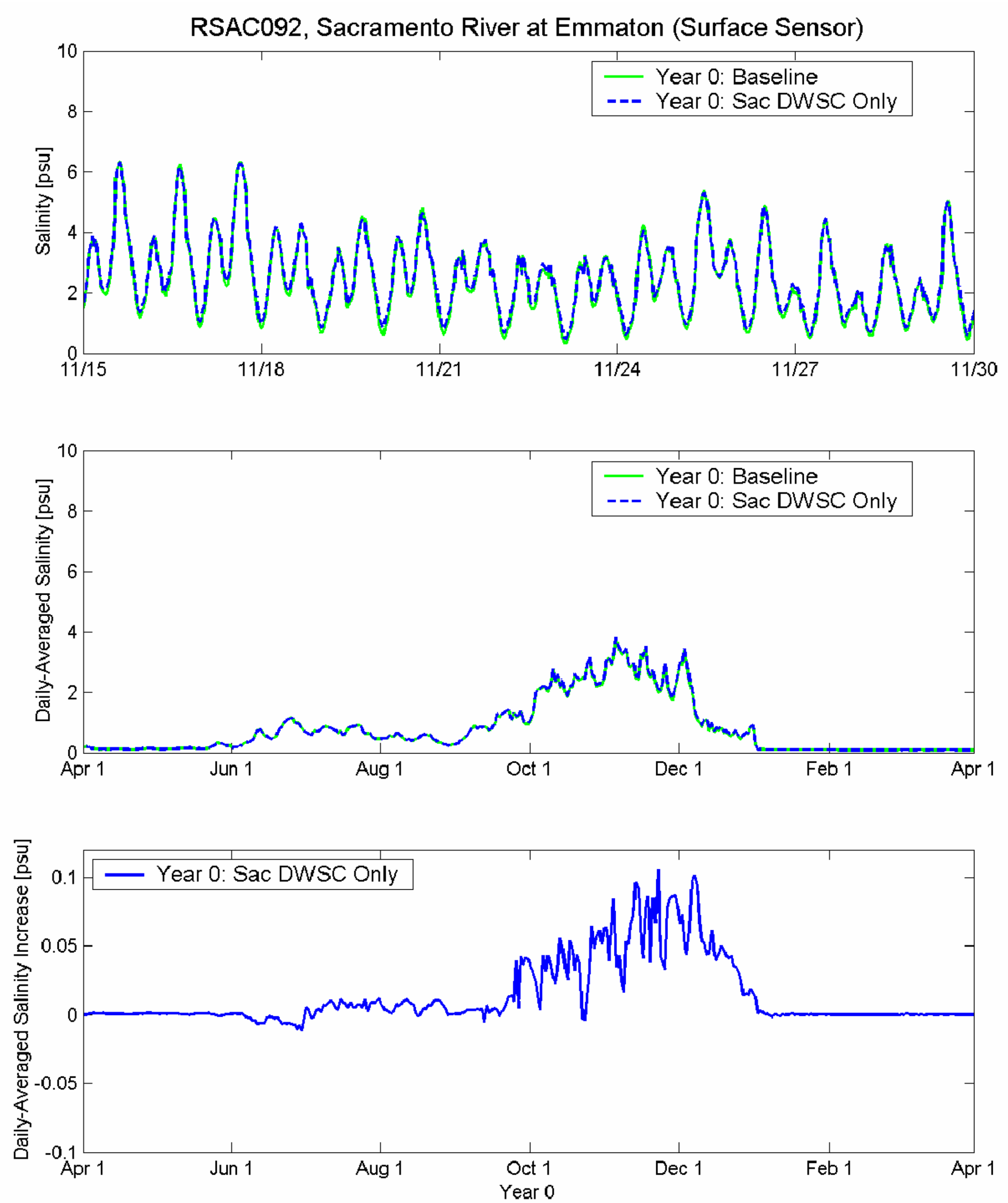

Figure 41. Predicted salinity at Sacramento River at Emmaton (RSAC092) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 0 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

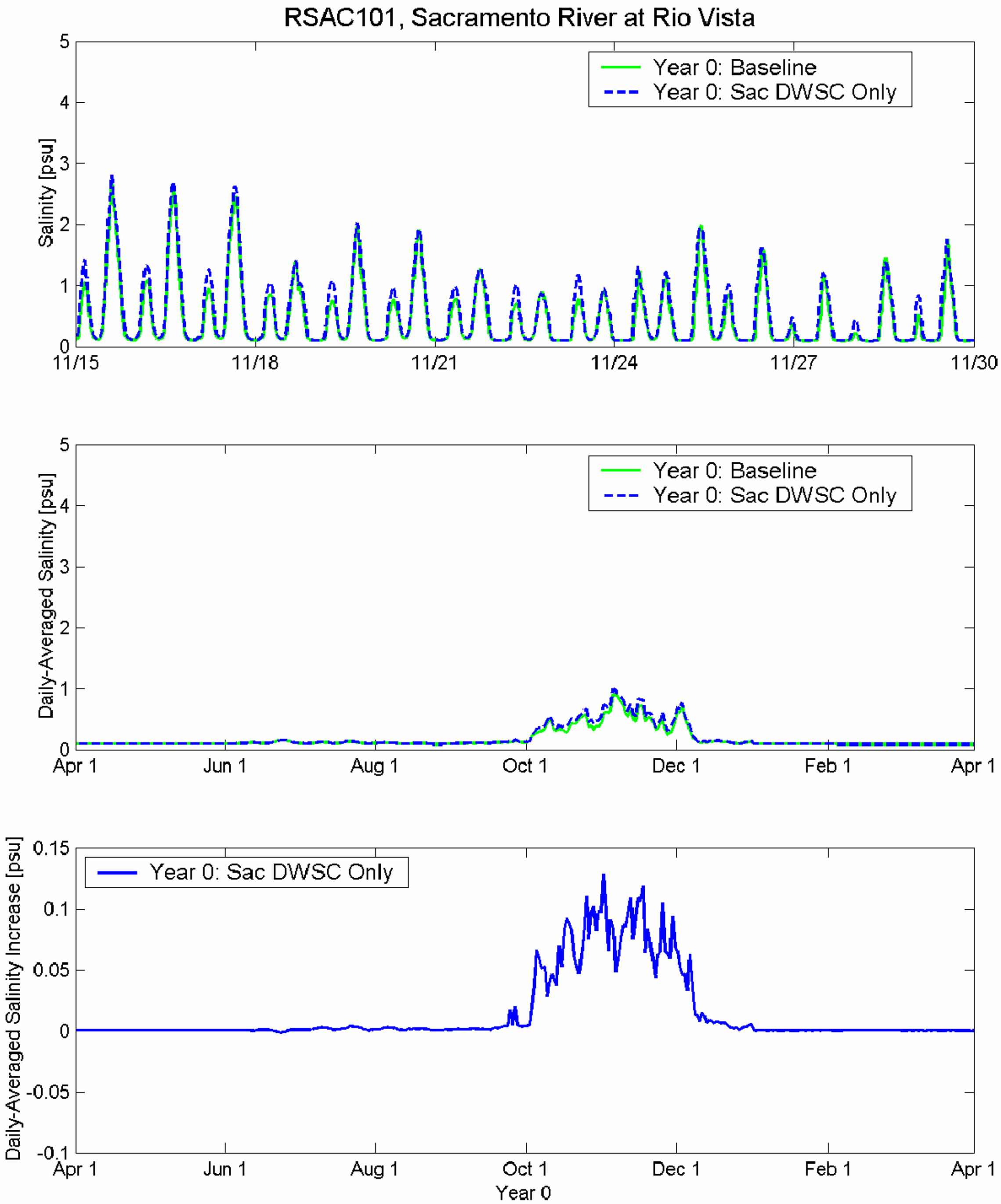

Figure 42. Predicted salinity at Sacramento River at Rio Vista (RSAC101) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 0 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

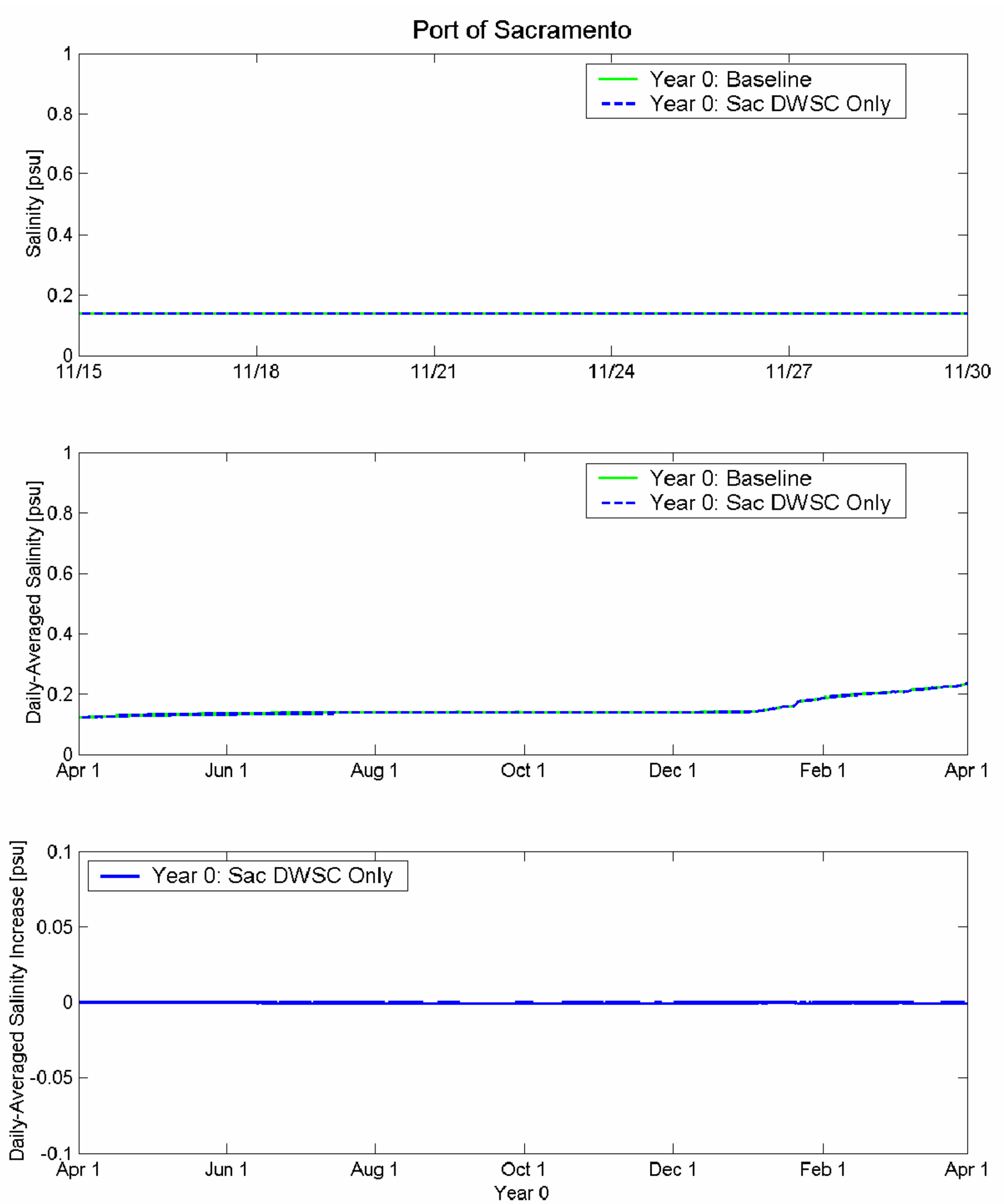

Figure 43. Predicted salinity at the Port of Sacramento for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); dailyaveraged salinity for Year 0 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 0 simulation period (bottom).

4.2 Year 50 With and Without Project Comparison

4.2.1 Predicted X2

Figure 44 shows the predicted X2 measured from Golden Gate to the Port of Sacramento for the baseline scenario and the deepening of SACRDWSC only scenario. The deepening scenario shows little change in X2 from the baseline condition with the deepening of the SACRDWSC from April to June and January to March. A small increase in X2 is predicted from July to September on the order of 1 km. Another increase in X2 is predicted from October to January on the order of 2 km.

Maximum X2 for the baseline condition (96.5 km) is predicted to occur on October 24 of the simulation year. With project conditions, X2 is predicted to increase 1.3 km beyond the baseline scenario to 97.8 km (Figure 45).

Additionally, Figure 46 through Figure 48 illustrates the effect of river inflow with X2. During the dry season X2 is near Chipps Island (Figure 46); however, during the rainy season X2 extends upstream to Collinsville (Figure 47) due to the gravitational circulation effect. After a large rainfall event the entire system appears to be flushed and the vertical stratification of salinity is dramatically reduced. X2 is observed downstream near Carquinez Bridge (Figure 48).

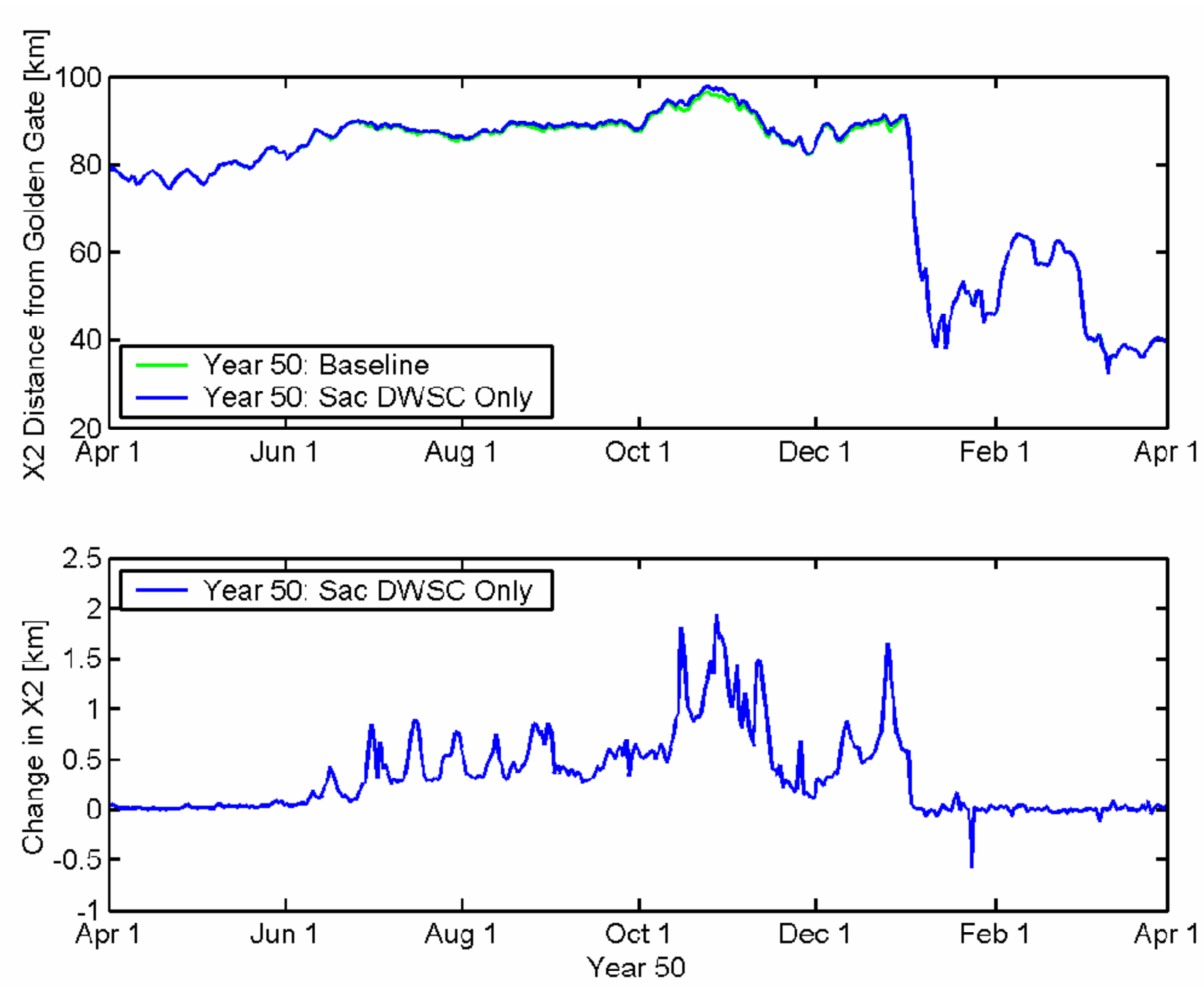

Figure 44. Predicted X2 for Year 50 with and without project conditions (top), and change in X2 with and without project conditions (bottom).

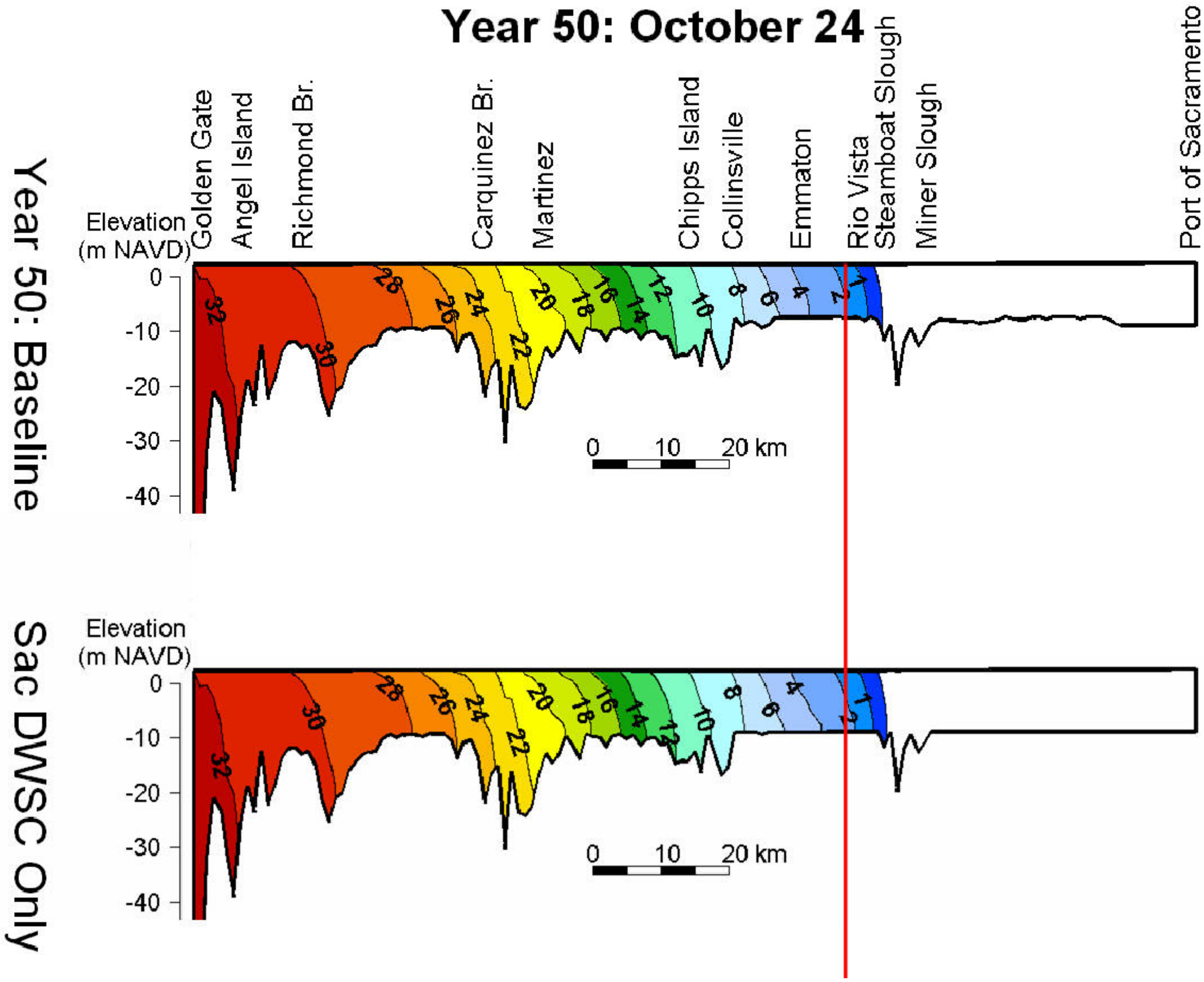

Figure 45. Predicted daily-averaged salinity profile along the axis of San Francisco Bay from the Golden Gate to the Port of Sacramento on October 24, the day of maximum predicted X2, for Baseline scenario (top) and Sacramento DWSC Only deepening scenario (bottom) for Year 50. The vertical red line indicates X2 for the Baseline scenario.

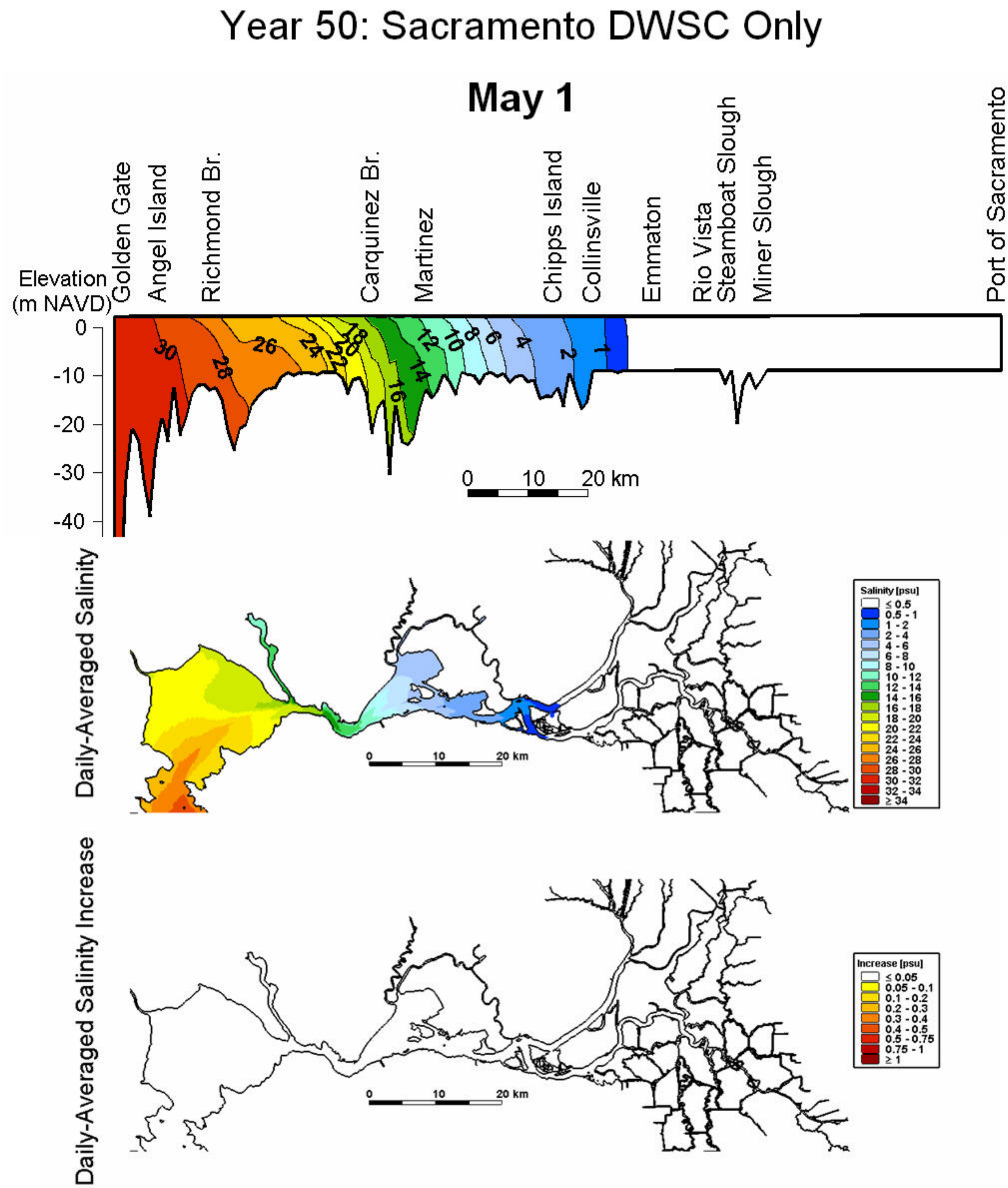

Figure 46. Predicted daily-average salinity profile along the axis of San Francisco Bay from the Golden Gate to the Port of Sacramento on May 1, 1994 for the year 50 with-project condition (top); predicted depth-averaged daily-average salinity on May 1, 1994 for the with-project condition (middle); predicted increase (increase = with project – without project) in depth-averaged daily average salinity on May 1.

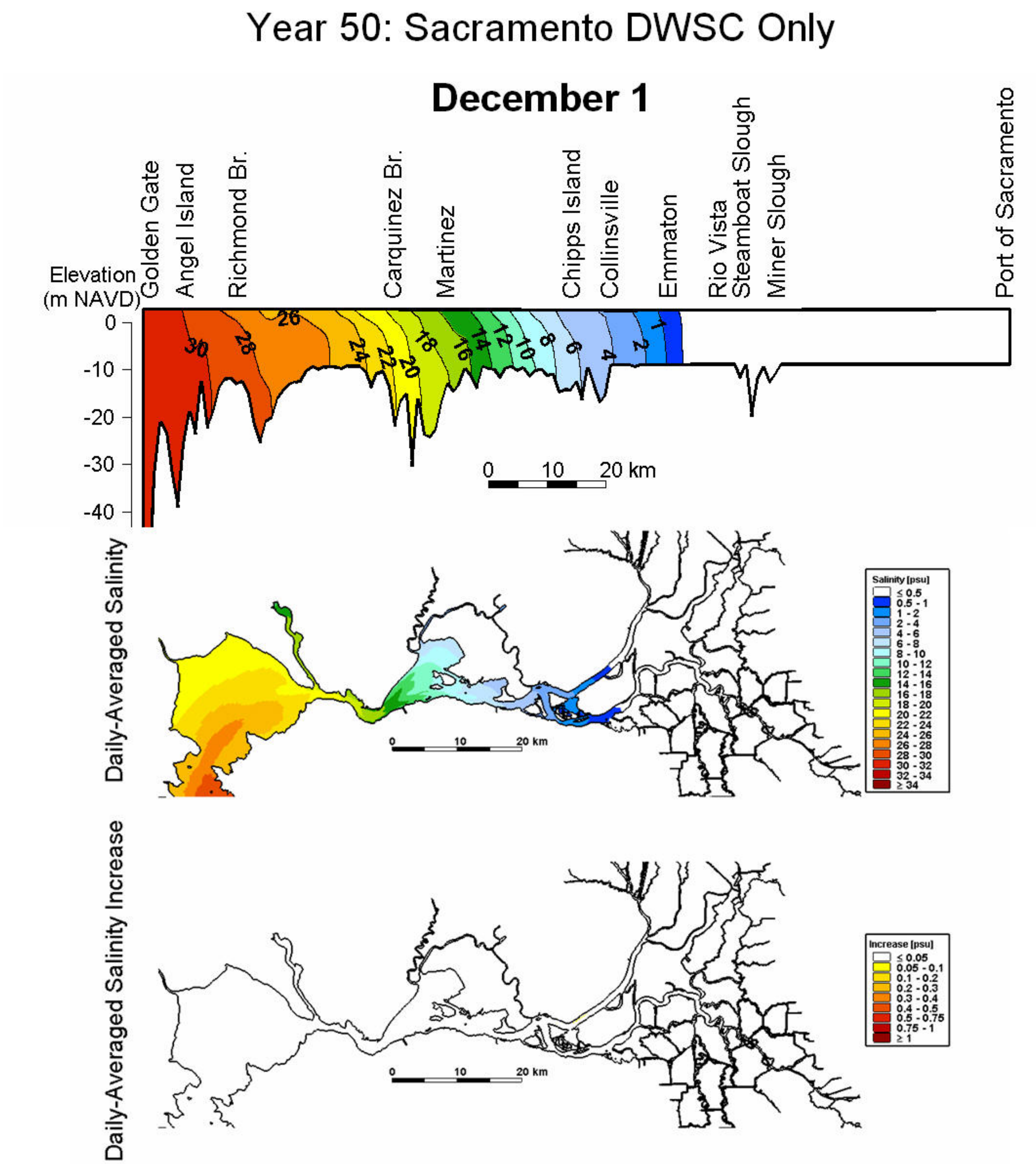

Figure 47. Predicted daily-average salinity December 1, 1994 for the year 50 with-project condition (top); predicted depth-averaged daily-average salinity on December 1, 1994 for the with-project condition (middle); predicted increase (increase = with project – without project) in depth-averaged daily average salinity on December 1.

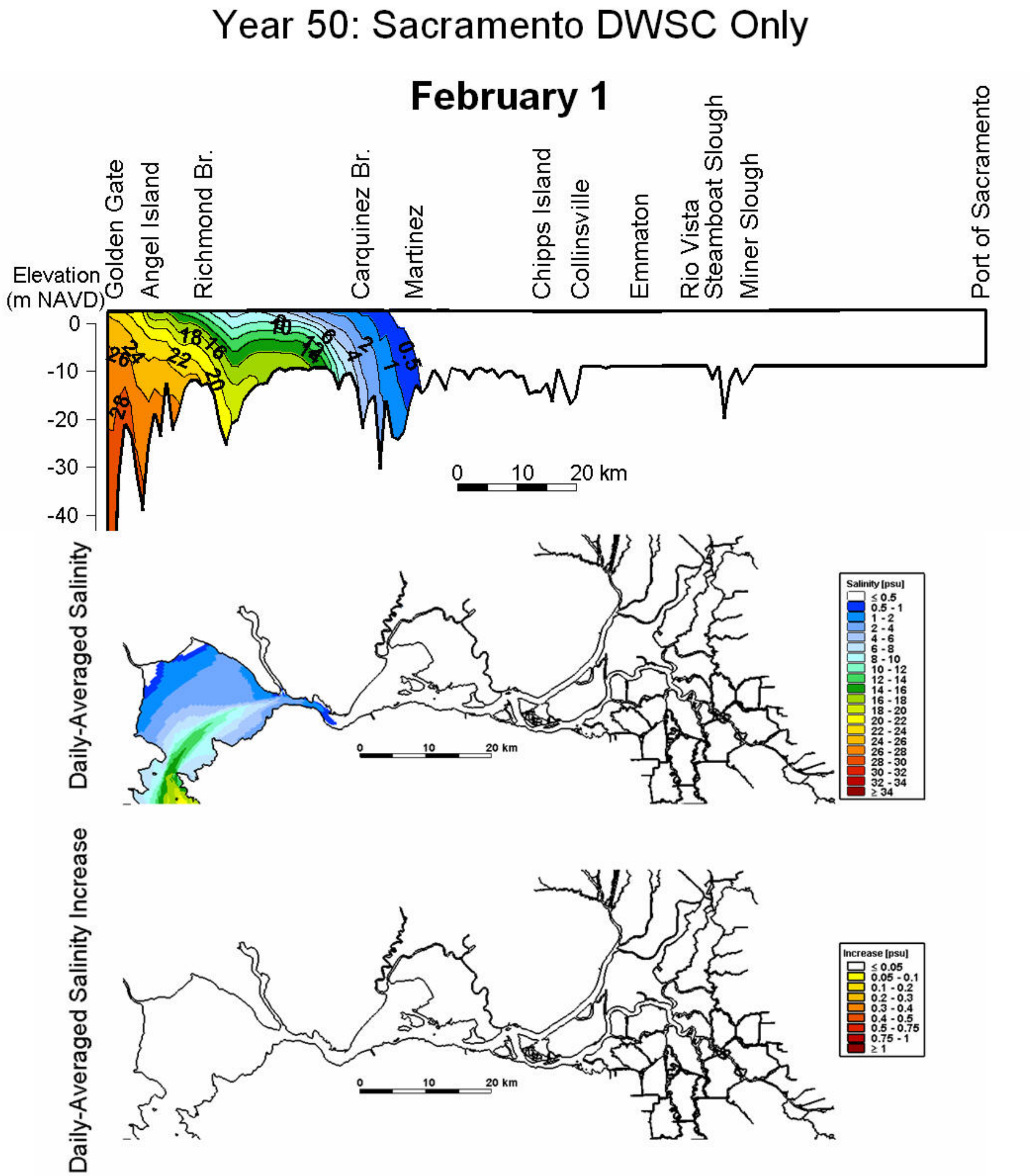

Figure 48. Predicted daily-average salinity profile along the axis of San Francisco Bay from the Golden Gate to the Port of Sacramento on February 1, 1995 for the year 50 with-project condition (top); predicted depth-averaged daily-average salinity on February 1, 1995 for the with-project condition (middle); predicted increase (increase = with project – without project) in depth-averaged daily average salinity on February 1.

4.1.2 Salinity Time Series

Salinity comparisons are made at stations along the Sacramento River located at Martinez, Benicia Bridge, Mallard Island, Emmaton, Rio Vista and Port of Sacramento. These stations represent reaches 1 through 5 of the SACRDWSC (Figure 2). Figures illustrating salinity comparisons are shown here in. These figures compare a 15-day period of salinity variability of two scenarios: (1.) without project condition and (2.) deepening of the SACRDWSC only scenario. Additionally, comparisons of daily averaged salinity without and with project condition for the entire simulation year and change in salinity with project conditions are included in this section.

Figure 49 shows predicted salinity at Martinez. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical, indicating roughly no predicted change in salinity with project conditions.

Figure 50 shows predicted salinity at Benicia. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical, indicating roughly no predicted change in salinity with project conditions.

Figure 51 shows predicted salinity at Mallard Island. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical, indicating roughly no predicted change in salinity with project conditions.

Figure 52 shows predicted salinity at Emmaton. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical. Increased salinity is predicted with project conditions from July through January of the simulation year. Maximum increase in salinity is 0.08 psu.

Figure 53 shows predicted salinity at Rio Vista. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical. Increased salinity is predicted with project conditions from October through December of the simulation year. Maximum increase in salinity is 0.11 psu.

Figure 54 shows predicted salinity at the Port of Sacramento. Predicted salinity for both scenarios show identical results for the 15-day comparison. Similarly, daily average salinity results are nearly identical, indicating roughly no predicted change in salinity with project conditions.

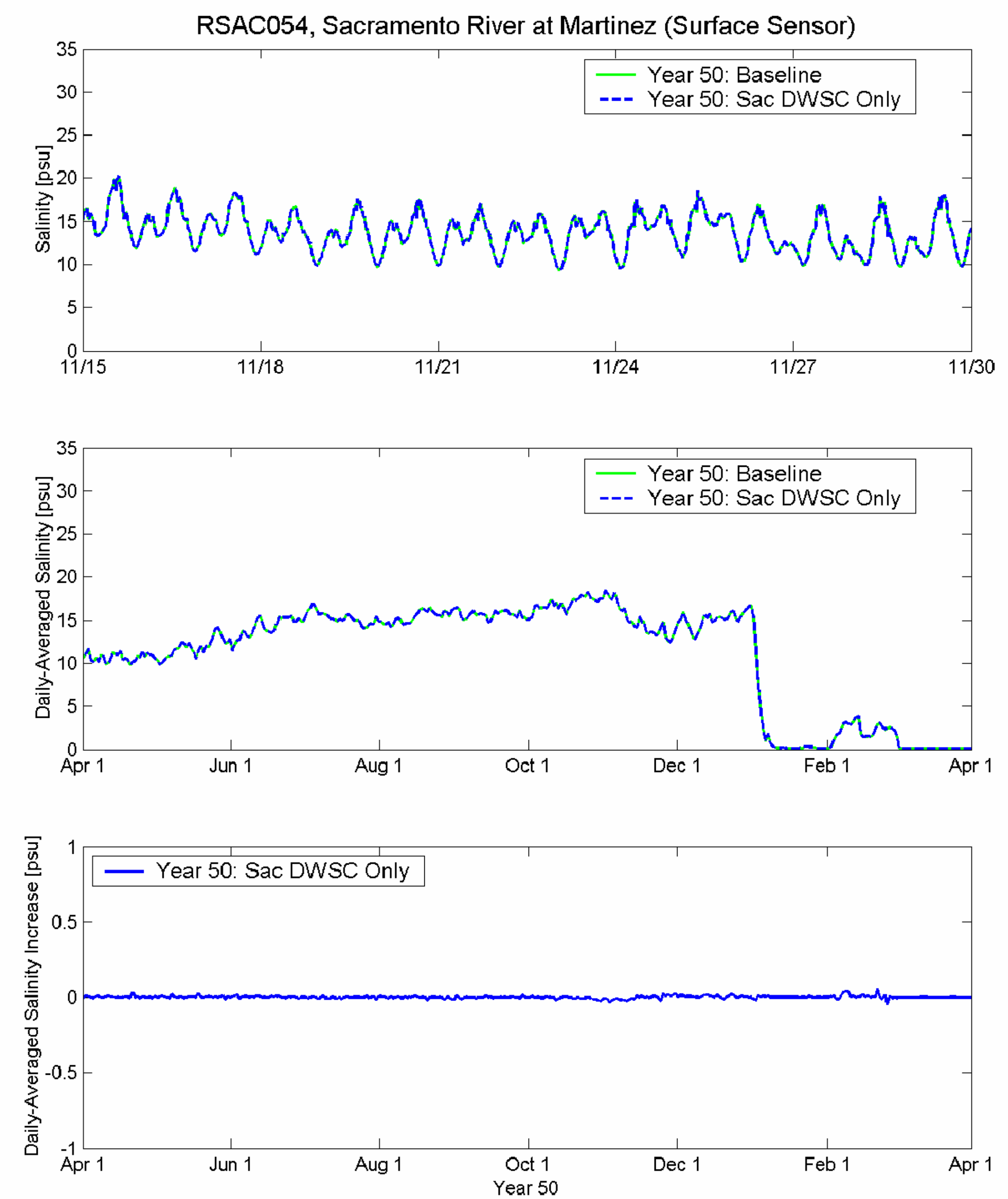

Figure 49. Predicted salinity at Sacramento River at Martinez (RSAC054) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 50 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

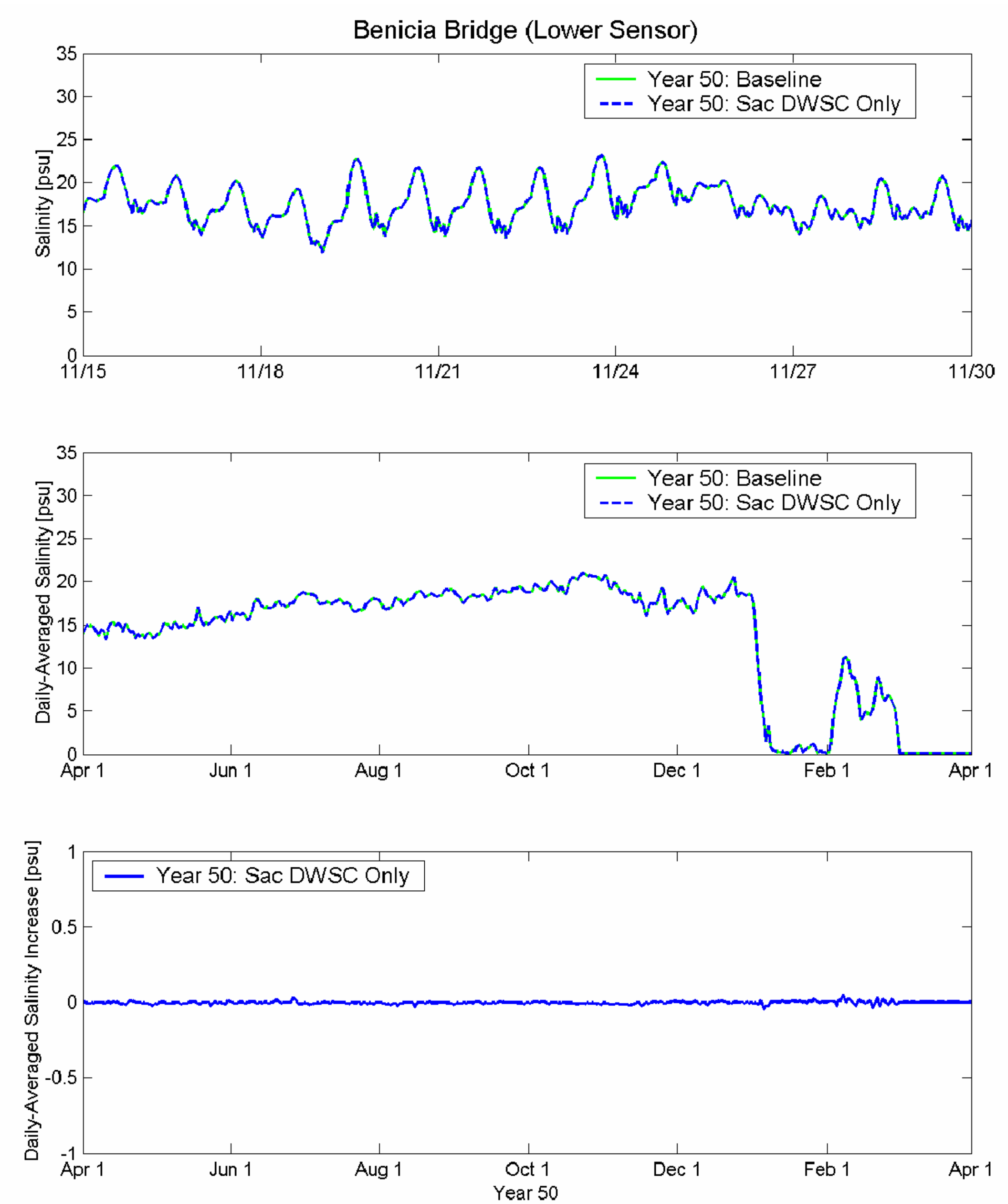

Figure 50. Predicted salinity at Benicia Bridge Lower Sensor for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 50 simulation period (middle); predicted increase in dailyaveraged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

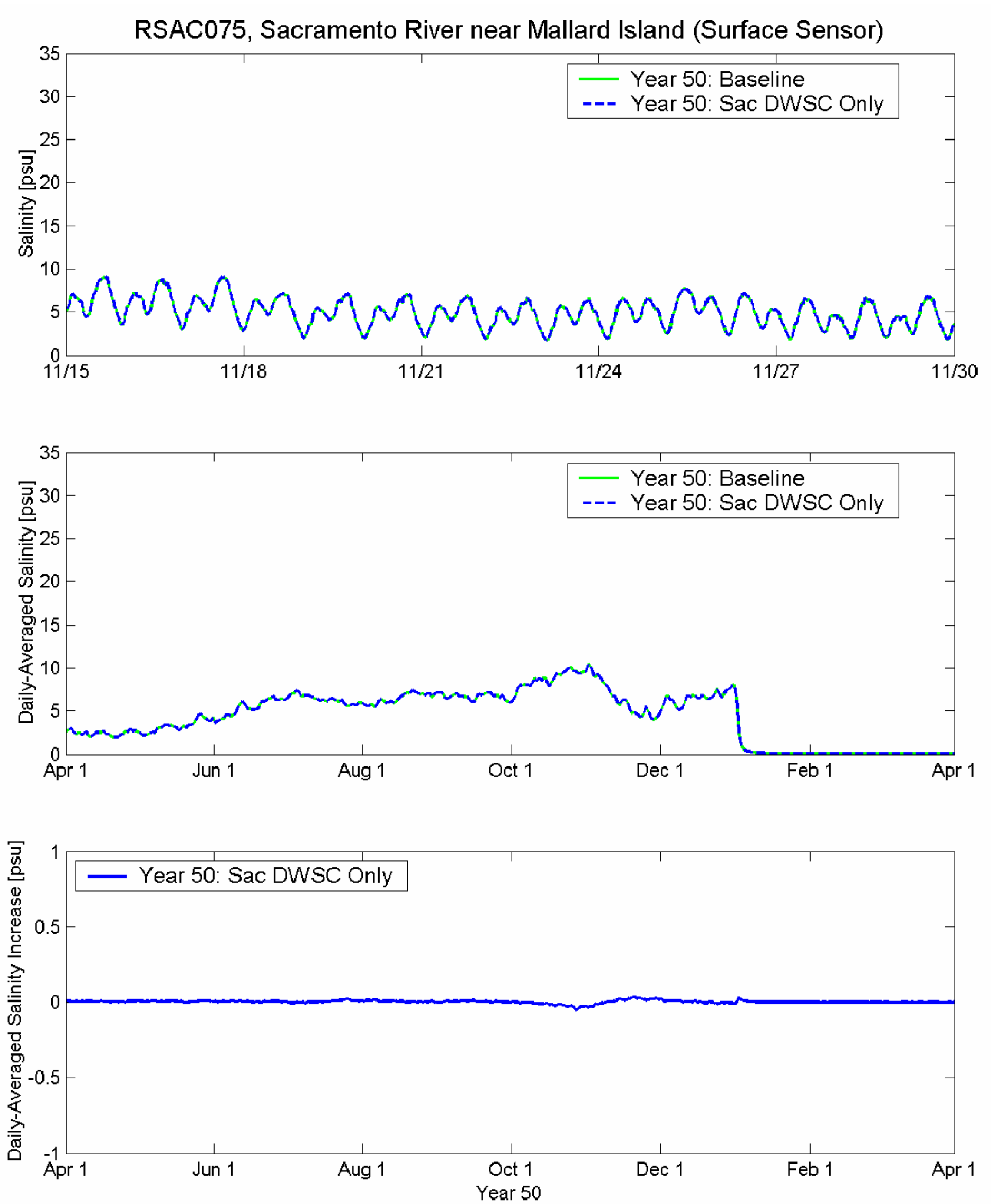

Figure 51. Predicted salinity at Sacramento River near Mallard Island (RSAC075) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 50 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

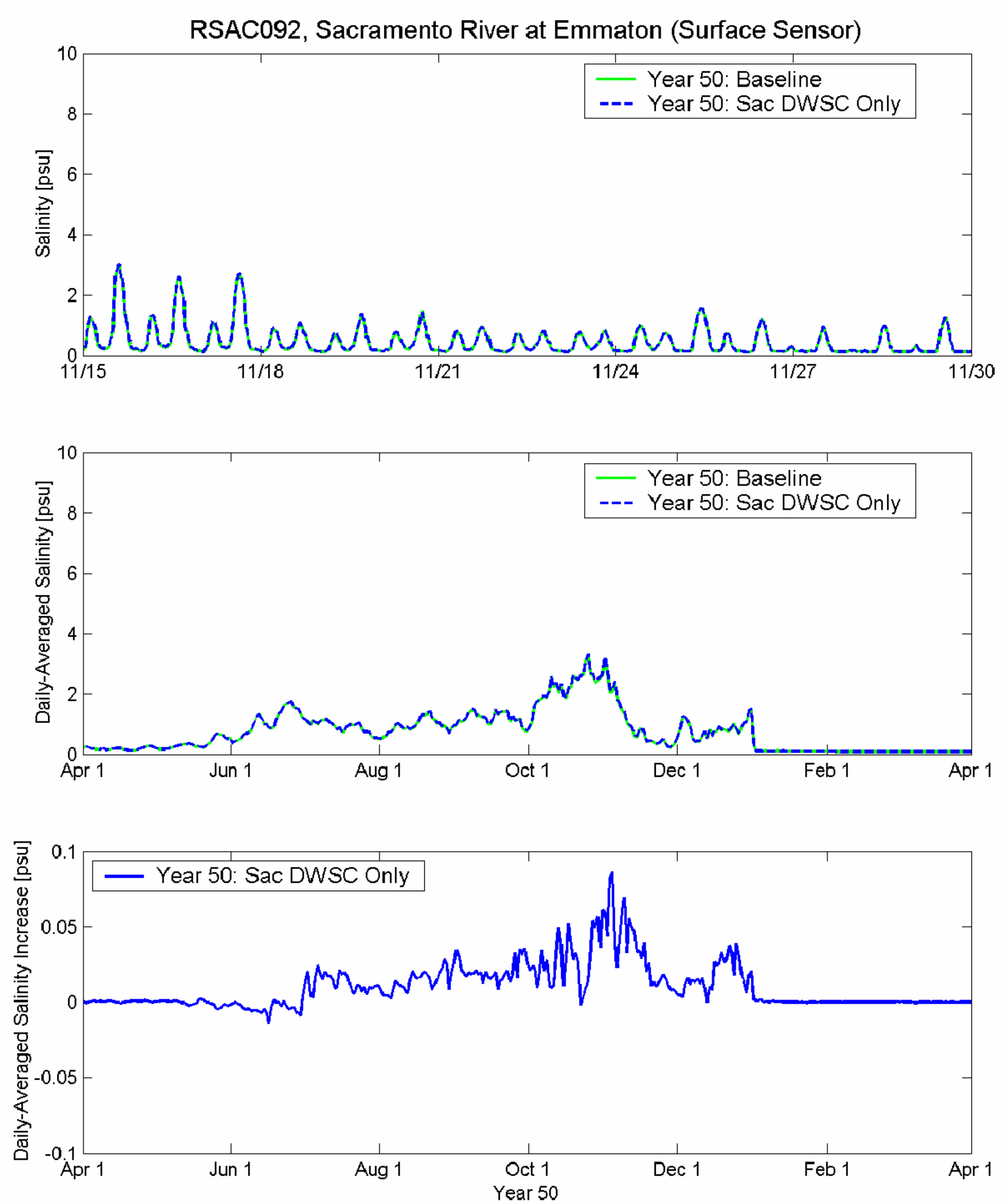

Figure 52. Predicted salinity at Sacramento River at Emmaton (RSAC092) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 50 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

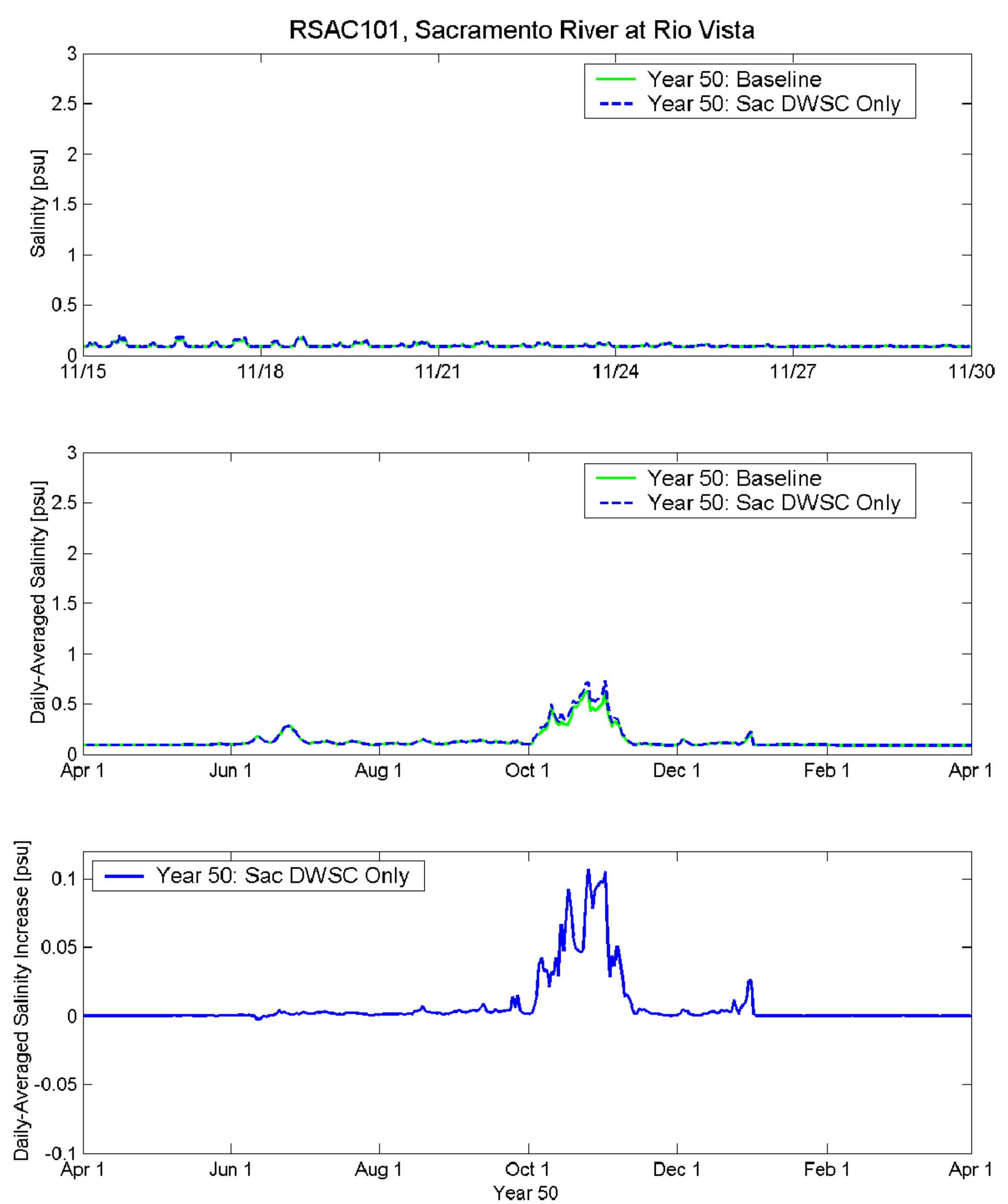

Figure 53. Predicted salinity at Sacramento River at Rio Vista (RSAC101) for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 50 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

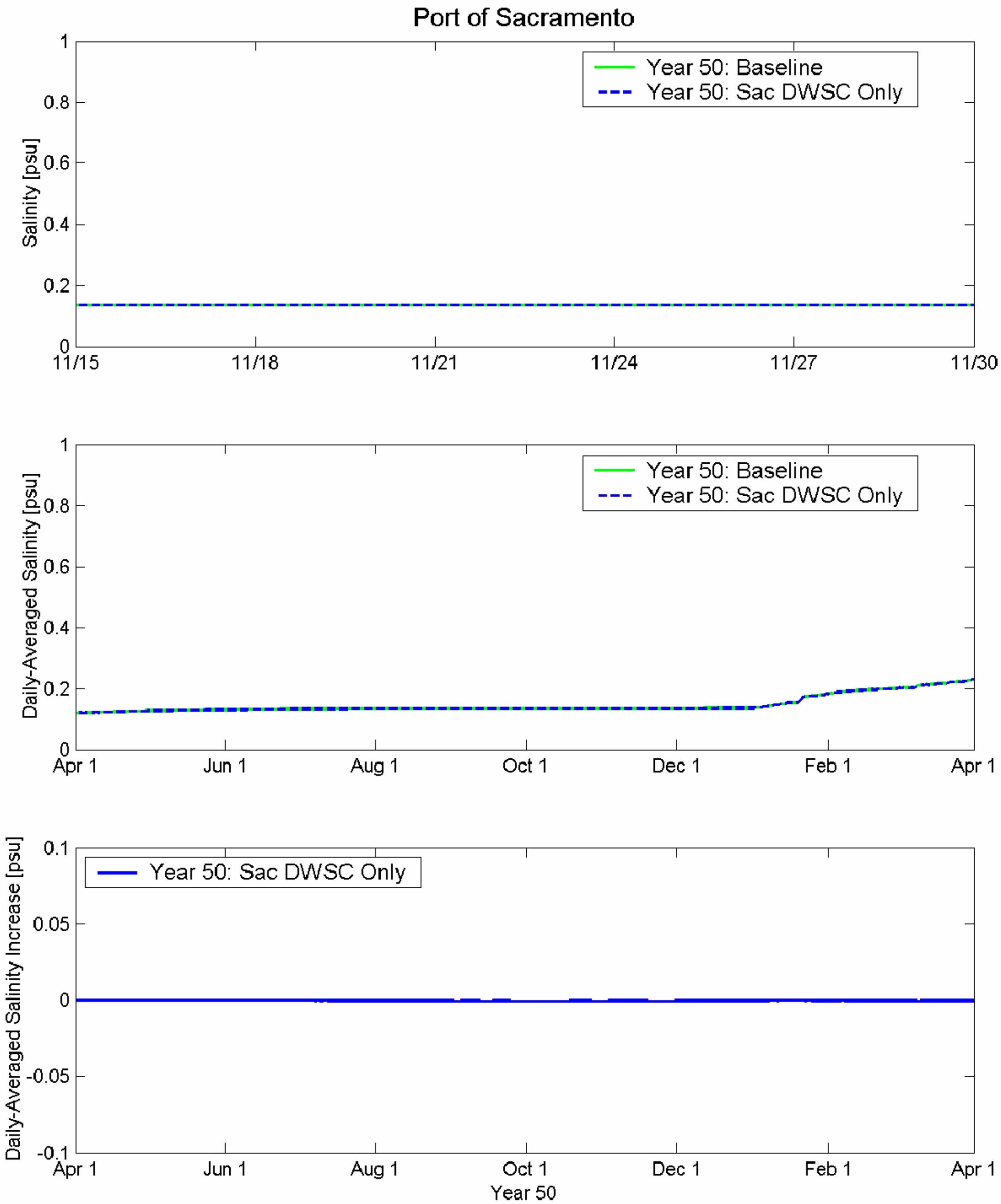

Figure 54. Predicted salinity at the Port of Sacramento for Baseline scenario and Sacramento DWSC Only deepening scenario: tidal time-scale variability over a 15-day period (top); daily-averaged salinity for Year 50 simulation period (middle); predicted increase in daily-averaged salinity for the Sacramento DWSC Only deepening scenario relative to Baseline scenario during Year 50 simulation period (bottom).

1.0 PROJECTED O&M DREDGING

Historically, annual dredging occurs at the SACRDWSC. Table 1 and Figure 55 show tabulated and graphical dredge volume records from the SACRDWSC. Dredging occurs primarily along Reach 2 and Reach 5 of the channel. The upstream extents of Reach 2, miles 3.5 to 14.0, occur at the confluence of the Sacramento River and the manmade portion of the SACRDWSC suggesting Sacramento River input may increase localized dredging. Reach 5, miles 33 to 42, is located at the most upstream extents of the SACRDWSC. Decreased relative velocity within Reach 5 may cause a low energy conditions that may promote sediment settling. Reaches 1, 3, and 4 appear to be stable. Dredge records indicate a decline in dredge volume since 1965 to present day. Average dredge volume from 2000 to 2009 is 171,200 cy and from 2005 to 2009 is 154,400 cy.

Elevated bank erosion as a result of increased side slope area with channel deepening may cause additional sedimentation within the SACRDWSC. The side slope area is estimated to increase by 15% for the 35 ft deepening alternative. Conservatively, a similar increase in dredge volume is expected. Based on average dredge volume from 2005 to 2009 and 2000 to 2009 it is estimated that the dredge volume increase will range from 23,000 to 25,000 cy. If the decline in dredge volume continues, average dredge volumes could reduce to 100,000 cy increasing SACRDWSC dredge volumes by 15,000 cy. Preliminary computations indicate dredge volume increases could be from 15,000 cy to 25,000 cy. For the 33 ft deepening alternative, an estimated increase in side slope area of 10% is expected; a similar conservative increase of maintenance dredging is also anticipated resulting in a dredge volume increase of 10,000 to 17,000 cy.

Table 1. Historical maintenance dredge volumes at SACRDWSC.

Year	Volume	Year	Volume (cy)	Year	Volume (cy)	Year	Volume (cy)
1966	2,220,000	1977	-	1988	-	1999	220,000
1967	183,800	1978	270,500	1989	-	2000	525,000
1968	-	1979	-	1990	-	2001	286,400
1969	890,600	1980	-	1991	-	2002	35,300
1970	-	1981	1,372,000	1992	-	2003	93,100
1971	712,000	1982	1,212,000	1993	238,000	2004	-
1972	146,000	1983	-	1994	-	2005	351,000
1973	-	1984	1,432,000	1995	103,800	2006	240,000
1974	1,065,300	1985	544,000	1996	-	2007	1,000*
1975	314,300	1986	940,000	1997	815,600	2008	125,000
1976	-	1987	-	1998	-	2009	55,000

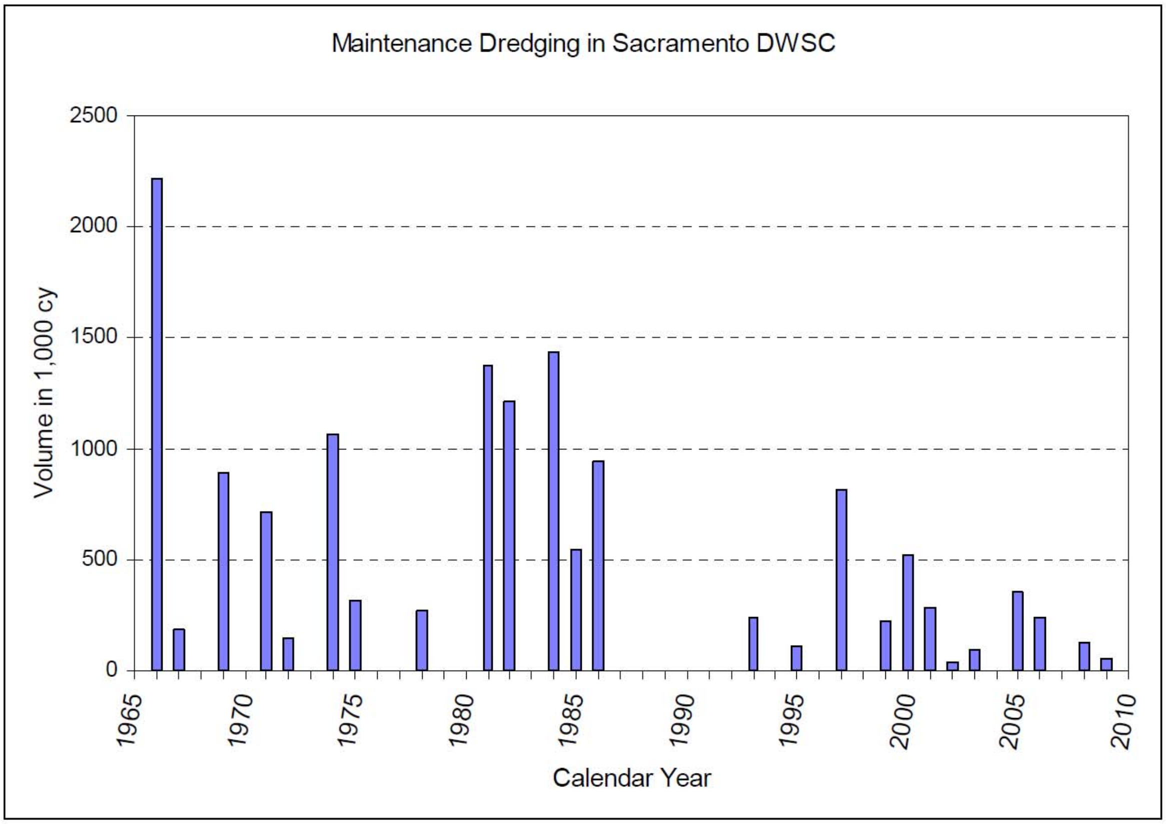

Figure 55. Historical maintenance dredge volumes at SACRDWSC.

2.0 CONCLUSIONS

A reevaluation study for the deepening of the SACRDWSC is being conducted to determine the effects of channel deepening on the hydrologic and hydrodynamic parameters, specifically river stage, river flow and salinity. To evaluate the changes in these parameters, model simulations have been completed for the baseline or Year 0 (2011) and Year 50 (2061) with and without project conditions. A brief comparison of simulation results was discussed herein.

Both Year 0 and Year 50 model computations indicate little or no change in river stage and discharge. Variations in river stage with and without project conditions ranged from 0 to approximately 3 cm. Accordingly, deviations in flow ranged from 0.0 to approximately 12% with and without project conditions during typical flow conditions and 0.0 to approximately 0.9% during flood or high flow conditions.

Maximum changes in X2 for both Year 0 and Year 50, with and without project conditions, is on the order of 2 km. Also investigated was the change in X2 with project condition when X2 is at a maximum without project condition. Year 0 without project condition maximum X2 occurs on December 3 where daily averaged X2 is 96.3 km. X2 is predicted to increase 0.9 km beyond baseline conditions to 97.2 km with project conditions. Year 50 without project condition maximum X2 occurs on October 24 where daily averaged X2 is 96.5 km. X2 is predicted to increase 1.3 km beyond baseline conditions to 97.8 km with project conditions.

Preliminary estimates of increased maintenance dredge volumes resulting from channel deepening to 35 and 33 ft were estimated based on increased side slope area and average dredge volumes from 2000 to 2009 and 2005 to 2009. An increase in dredge volume of 15,000 to 25,000 cy and 10,000 to 17,000 cy is expected for the 35 and 33 feet deepening alternatives, respectively.