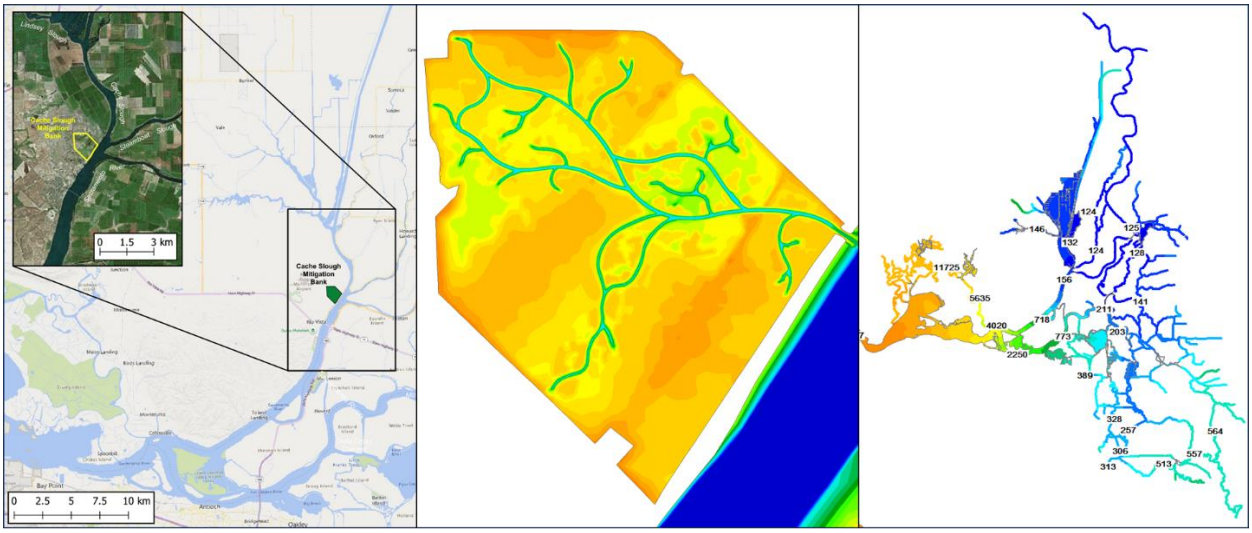
RESOURCE MANAGEMENT ASSOCIATES
WATER RESOURCES ENGINEERING

Cache Slough Mitigation Bank Project Modeling Evaluation of Water Quality Changes



DRAFT TECHNICAL MEMORANDUM

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Executive Summary

The RMA Bay-Delta model was applied to evaluate water quality impacts of the Cache Slough Mitigation Bank (CSMB) Project (Project) relative to Base and Future conditions. The Base condition includes recently constructed or underway tidal marsh restoration projects while the Future condition additionally includes restoration of Prospect Island, McCormack Williamson Tract and the Little Egbert Multi-Benefit Project (LEMBP). The CSMB Project was added to each of these model grids to evaluate Project impacts. The CSMB Project and all other restoration sites are represented in sufficient detail to achieve the modeling goal of assessing regional water quality impacts.

The RMA Bay-Delta model is a widely accepted tool that has been shown to be effective at predicting salinity distribution throughout the Delta. The model has been applied to flow and salinity impacts analysis for numerous tidal marsh restoration projects throughout the Bay-Delta.

The evaluation periods were January 1 to December 31, 2018 and January 1 to December 31, 2020. These periods cover a below normal hydrology (2018) and a dry year hydrology (2020). Periods were selected to reflect some of the historical salinity variation, including yearly and seasonal fluctuations in the dynamic Bay-Delta system.

The RMA Bay-Delta model is a 2-D depth averaged / 1-D cross-sectionally averaged model extending from the Golden Gate to the Sacramento River above the confluence with the American River, and to the San Joaquin River near Vernalis. The 2-D elements are employed to represent areas of open water and large channels (e.g., Suisun Bay, Cache Slough Complex, Cache Slough, the lower Sacramento River and tidal marsh restoration areas) while the 1-D elements are used to represent the channelized portions of the Delta.

The hydrodynamic model predicts depth and velocity throughout the model domain. These results are used to drive salt transport in the water quality model. In the model, Electrical Conductivity (EC) is used as a surrogate for salinity similar to other Delta models such as DWR DSM2.

The model has been calibrated for the years 2018 and 2020 during a parallel modeling effort that has focused on improving model boundary conditions in the Cache Slough Complex (RMA, 2023).

Water Quality Evaluation

Electrical conductivity (µmhos/cm or µSiemens/cm), or EC, was modeled as a surrogate for salinity. EC is used as a stand-in for the more precise term of Specific Conductance (SC) for the electrical conductance corrected to 25° C. The RMA Bay-Delta model is limited to computing a depth-averaged EC. EC is directly correlated with salinity, such that increases in EC correspond to increases in salinity. EC can also be used to estimate concentrations of particular forms of salt such as chlorides and bromides.

The State Water Resources Control Board (SWRCB) Decision 1641 (D-1641) was adopted December 29, 1999 and revised on March 15, 2000. D-1641 is the implementation plan for the 1995 Bay-Delta Plan, with respect to the operation of water projects within the Delta watershed, and includes water quality objectives to protect Municipal and Industrial (M&I) beneficial uses in the Delta, as well as water quality objectives to protect Fish and Wildlife beneficial uses. Salinity impacts were evaluated for select D-1641 compliance locations and Contra Costa Water District intake locations:

D-1641 Station ID	Location	Beneficial Use
D22	Sacramento River at Emmaton	Agriculture
D15	San Joaquin River at Jersey Point	Agriculture, Fish and Wildlife
D29	San Joaquin River at Prisoners Point	Fish and Wildlife
C5	Contra Costa Canal at Pumping Plant 1	Municipal and Industrial
C9	West Canal at mouth of Clifton Court Forebay	Municipal and Industrial
DMC1	Delta-Mendota Canal at Tracy Pumping Plant	Municipal and Industrial
SLBAR3	Barker Slough NBA Intake	Municipal and Industrial
C19	City of Vallejo Intake Cache Slough	Municipal and Industrial
C2	Sacramento River at Collinsville	Fish and Wildlife
D12	San Joaquin River at Antioch	Municipal and Industrial
	CCWD[1] Intake at Mallard Slough	
	CCWD Intake at Old River	
	CCWD Intake at Victoria Canal	

A map of these locations is shown in Figure 1. The locations were selected to assess the potential for the Project to affect salinity intrusion in the Delta.

[1] Contra Costa Water District

The D-1641 evaluation periods include the Fish and Wildlife, and Agriculture compliance periods during 2018 and 2020, which vary by location.

To evaluate Project impacts on water quality, modeled EC for all four scenarios was monthly averaged and compared for select D-1641 compliance locations and water exports. The modeling results showed that the CSMB Project has very small impacts on regional salinity in the Delta, relative to Base and Future conditions. The largest increase is 0.4%, occurring at Emmaton during the summer of 2020. The largest decrease is less than 0.1%, occurring at Antioch during the fall of 2018 and beginning of 2020. Salinity increases at North Bay Aqueduct and City of Vallejo intakes are less than 0.1% and salinity increases at south Delta exports and CCWD water intakes are 0.1% or less.

Model results were processed to determine the potential for the CSMB Project to cause non-compliance with the D-1641 water quality objectives. Seasonal EC standards apply to Agriculture, Fish and Wildlife compliance stations at the Sacramento River at Emmaton (D22), Sacramento River at Collinsville (C2), and the San Joaquin River at Jersey Point (D15) and Prisoners Point (D29) and chloride standards at the water intakes. The Project did not cause any EC changes at the D-1641 stations that were large enough to impact compliance.

Modeled EC and Martinez volumetric source fraction results were post-processed to produce chloride concentrations to assess compliance at the water intakes. No violations of the maximum mean daily chloride objectives occurred at any of the intakes under any of the modeled configurations or time periods. Relative to the Base and Future conditions, the CSMB restoration Project had no impact on these values. Antioch does not meet the criteria for number of days below a threshold for any of the scenarios, but the Project does not make this worse.

Evaluation of changes to X2 indicated that the Project would generally increase monthly averaged X2 by less than 0.01 km.

Bromide concentrations were estimated from modeled EC and Martinez volumetric source fraction. Project impacts on Bromide were very small throughout the model domain. The largest increases occurred at the NBA intake in Barker Slough during the fall of 2020. Changes at this location ranged from -0.02% to 0.3%. Bromide increases of up to 0.2% occurred in the fall at the south Delta water intakes. The largest percent bromide decreases of less than 0.1% occurred at Antioch.

CSMB marsh tracer and tracer age Simulations were performed for the With Project and Future with Project conditions over the 2018 and 2020 simulation periods to examine the fate of DOC that could potentially be produced in the marsh plain on the Project site. Modeled tracer concentrations were very low outside the project site and the tracer excursion was

predominantly downstream. Low concentrations of tracer reached Chipps Island on peak ebb tide with an age of over 30 days. On flood tide, the same low concentration of tracer moved upstream, just into Liberty Island with an age of around 6 to 8 days. Results were similar for the current and Future conditions. Tracer concentrations remained extremely low at the NBA intake in Barker Slough or the City of Vallejo intake in Cache Slough, indicating that a very small fraction of any DOC potentially produced on the Project site would end up at these intakes.

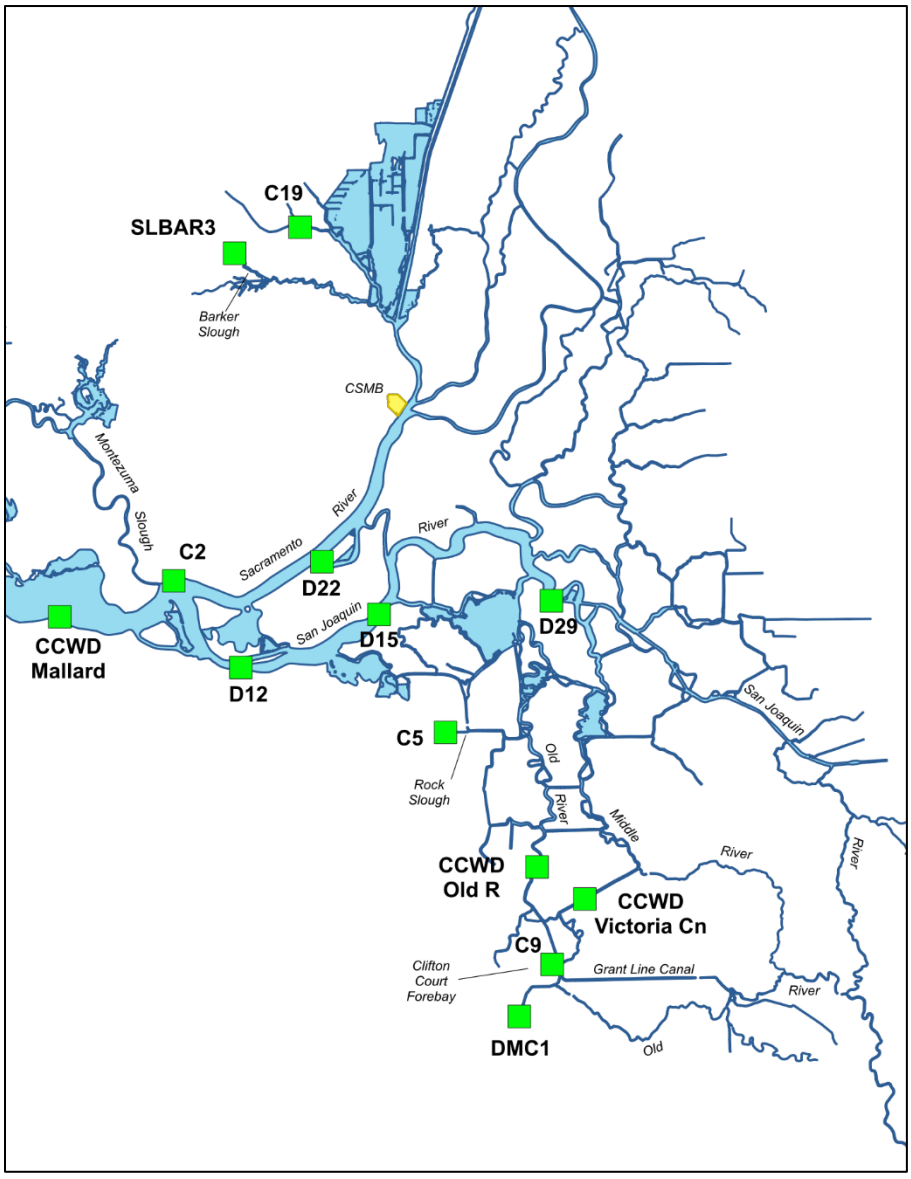

Figure 1 D-1641 compliance locations used for the model evaluation of Project salinity impacts.

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Introduction

Cache Slough Mitigation Bank (CSMB) is an approximately 350-acre site located in the northern Sacramento-San Joaquin Delta, bounded by Cache Slough on the east (Figure 2). A proposed restoration project (Project) was analyzed with and without future projects (Prospect Island, McCormack Willamson Tract and Little Egbert Multi-Benefit Project [LEMBP]). The CSMB Project design includes an external breach to Cache Slough and internal channels.

Hydrodynamic and water quality model simulations were performed to assess potential Project impacts on salinity and chloride at water intakes and salinity compliance standards, and X2. Impacts were considered relative to Base and Future cases, where there is no tidal action in CSMB under the modeled conditions.

CSMB Project impacts on bromide and dissolved organic carbon (DOC) were also evaluated.

Background

The RMA Bay-Delta model of the San Francisco Bay and Sacramento – San Joaquin River Delta system was applied to assess salinity impacts for the Project. The RMA Bay-Delta model is a widely accepted tool that is effective at predicting EC throughout the Bay-Delta (RMA, 2023). The model has been applied to flow and salinity impacts analysis for numerous restoration projects in the Bay-Delta system, including Bay Delta Conservation Plan, Regional Salinity, Suisun Marsh PEIR/EIS, LEMBP, Prospect Island, Lookout Slough, McCormack-Williamson Tract, Decker Island, Winter Island, Dutch Slough, Chipps Island, Mallard Farms, Tule Red, Grizzly King, Bradmoor Island, Arnold Slough, Hill Slough and Wings Landing (see for example RMA, 2009, 2012, 2013, 2015a, 2015b and 2018). The RMA Bay-Delta model has undergone continual development over more than 25 years to reflect currently available data and meet project needs. Similarly, since their original development in the 1970's, the RMA2 and RMA11 computational models have been updated over the years to best utilize the latest scientific knowledge and technology, and to meet new project needs.

Methods

The model evaluation was conducted using the RMA Bay-Delta model for flow and salinity. The model utilizes the finite element method to simulate 2-D depth averaged / 1-D cross-sectionally averaged flow and salinity for a 7.5-minute computational time step.

Electrical Conductivity (µmhos/cm or µSiemens/cm), or EC, was modeled as a surrogate for salinity. The reference to "EC" in this document is in keeping with some past conventions, and is used as a stand-in for the more precise term of Specific Conductance (SC) for the electrical conductance corrected to 25° C.

Hydrodynamic and EC simulations were performed for the periods of January – December, 2018 and January – December 2020. According to DWR's hydrologic classification index, the 2018 water year was classified as below normal and the 2020 water year was classified as dry.

To assess potential impacts associated with the CSMB Project, simulations were performed for scenarios examining Base and Future conditions and With Project and Future with Project conditions. The Base condition includes recently constructed projects or projects in construction. The Future condition includes planned restoration projects at Prospect Island, McCormack Willamson Tract and LEMBP.

Results were post-processed to evaluate relative impacts, potential for violation of D-1641 standards and impacts on X2. X2 is the location along the primary axis of the estuary where tidally averaged bottom salinity is two parts per thousand, which is a Bay-Delta Plan standard. Daily and monthly average salinity changes were assessed at D-1641 compliance locations and water export locations. Spatial plots of relative salinity change were provided for summer and fall months.

EC results were converted to chloride for analysis of D-1641 standards at the water intakes. Additionally, bromide impacts were assessed based on conversion of modeled EC to bromide. Simulations of Martinez volumetric source fraction were performed to provide additional information for estimation of chloride and bromide concentrations at the water intakes.

To assess DOC impacts, a CSMB areal source tracer with age was simulated for the current and future conditions. Results of these simulations allow visualization of the fate of any DOC that will potentially be produced on the Project site, as well as the age and relative amount at locations of interest.

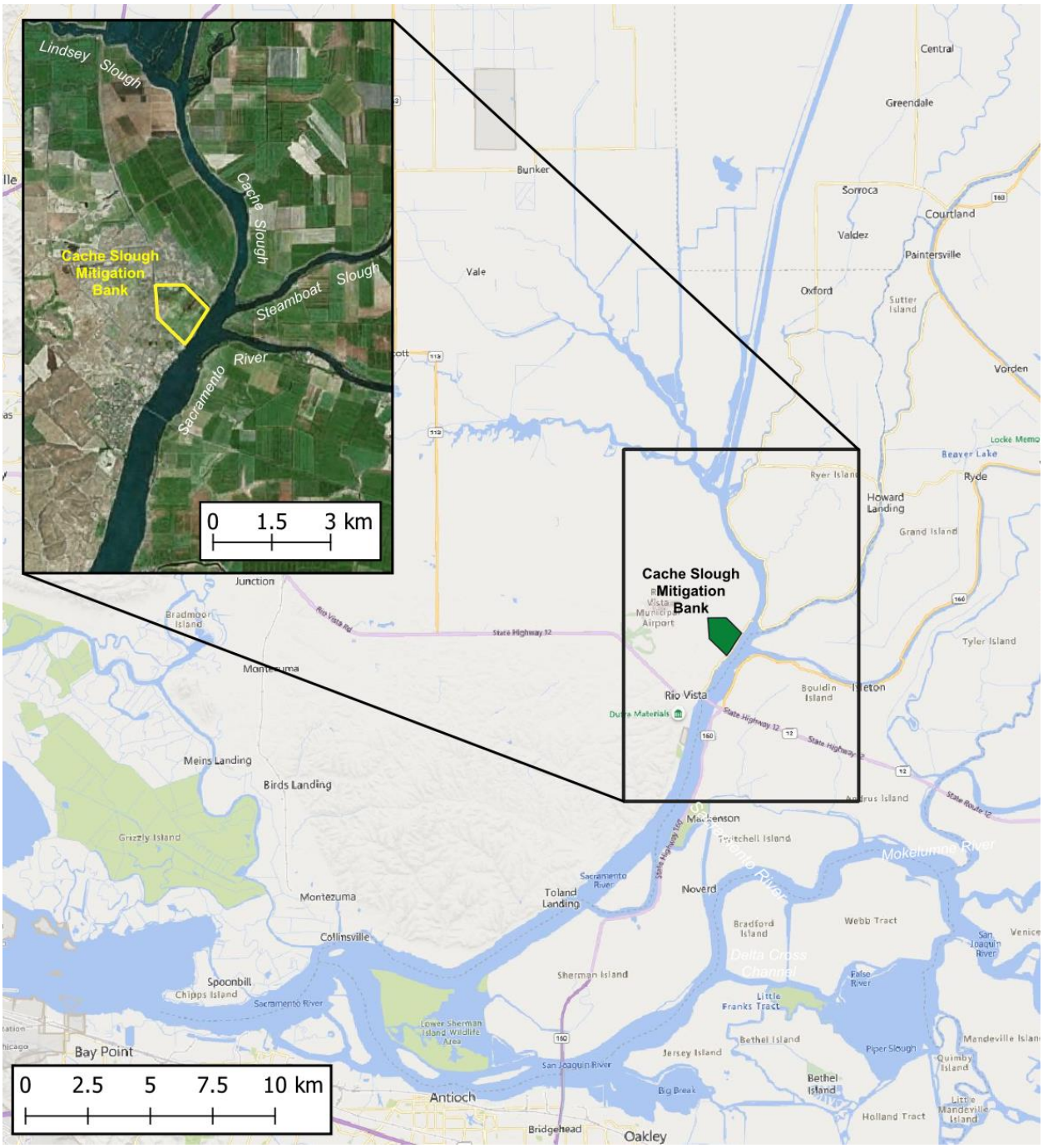


Figure 2 Location of the CSMB Project site in the northern Delta.

Model Configuration

Geometric Extents

RMA's San Francisco Bay, Sacramento–San Joaquin Delta network was developed using an in-house GIS-based graphical user interface program (RMA, 2003) and the Janet commercial grid generation program (smile consult GmbH). The programs allow for development of the finite element mesh over layers of bathymetry points and bathymetry grids, GIS shapefiles and aerial images.

The RMA Bay-Delta model, shown in Figure 3 for the With Project condition and Figure 4 for the Future with Project condition, extends from the Golden Gate to the Sacramento River above the confluence with the American River, and to the San Joaquin River near Vernalis. A two-dimensional depth-averaged approximation is used to represent the San Francisco Bay, Suisun Bay region, the Sacramento-San Joaquin confluence area, Sherman Lake, the Sacramento River up to Rio Vista, Cache Slough, Liberty Island, Shag Slough, Lindsey Slough, the Sacramento River Deep Water Ship Channel (DWSC) and Miner Slough, Big Break, the San Joaquin River up to its confluence with Middle River and in the vicinity of Turner Cut, False River, Franks Tract and surrounding channels, Mildred Island, Old River south of Franks Tract, the Old River – Doughty Cut – Paradise Cut junction, the Delta Cross Channel area, Nurse Slough and Hunter Cut in Suisun Marsh, and all existing and future restoration areas (e.g. Lookout Slough, Dutch Slough, etc.). The model has undergone continuous development through dozens of projects since 1997 (e.g., RMA, 2012, 2015b).

The other Delta and Suisun Marsh channels and tributary streams are represented using a one-dimensional cross-sectionally averaged approximation. A detail view of the Cache Slough Complex (CSC) is shown in Figure 5 for the With Project condition and Figure 6 for the Future with Project condition.

The size and shape of elements are dictated by changes in bottom elevation and other hydraulic and salinity considerations. Wetting and drying of the tidal mudflats has been represented in sufficient detail to provide a good definition of change in the tidal prism with change in tidal stage.

The With Project grids include detailed representation of the proposed CSMB Project configuration, while the Base and Future model networks do not include CSMB (it is assumed to be dry).

All the model networks include the following recently constructed or underway projects (see Figure 7):

- Lower Yolo Ranch tidal restoration
- Yolo Flyway Farms tidal habitat restoration
- Lindsey Slough tidal restoration
- Decker Island tidal habitat restoration
- Liberty Island Conservation Bank
- RD 2093 North Delta Fish Conservation Bank
- Lookout Slough tidal restoration
- Dutch Slough tidal restoration

The Future condition grids include, in addition to the above (see Figure 8):

- Prospect Island restoration
- Little Egbert Multi-Benefit Restoration Project
- McCormack-Williamson Tract Habitat Restoration

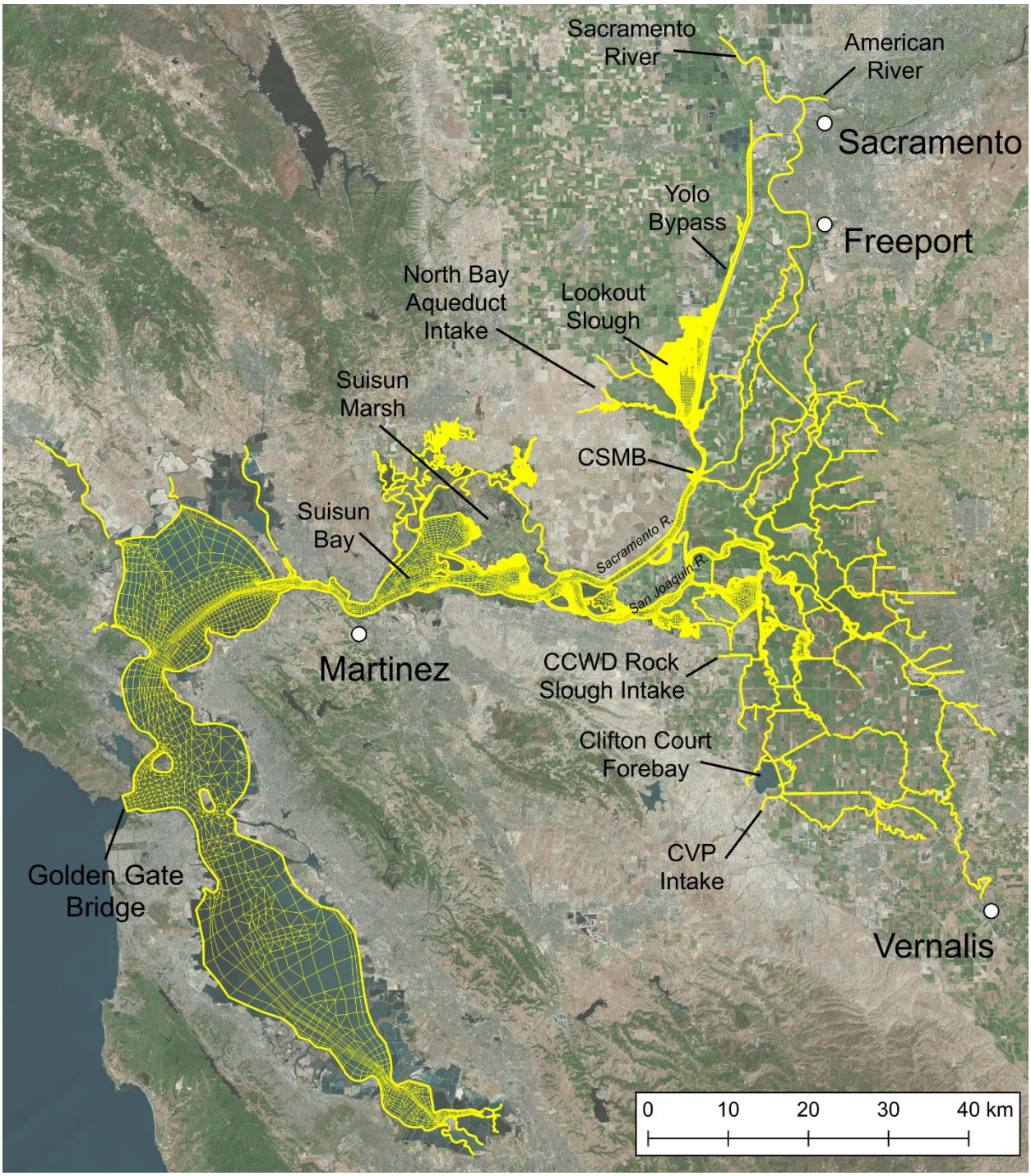


Figure 3 Extents of the RMA Bay-Delta model for the CSMB Project analysis (With Project).

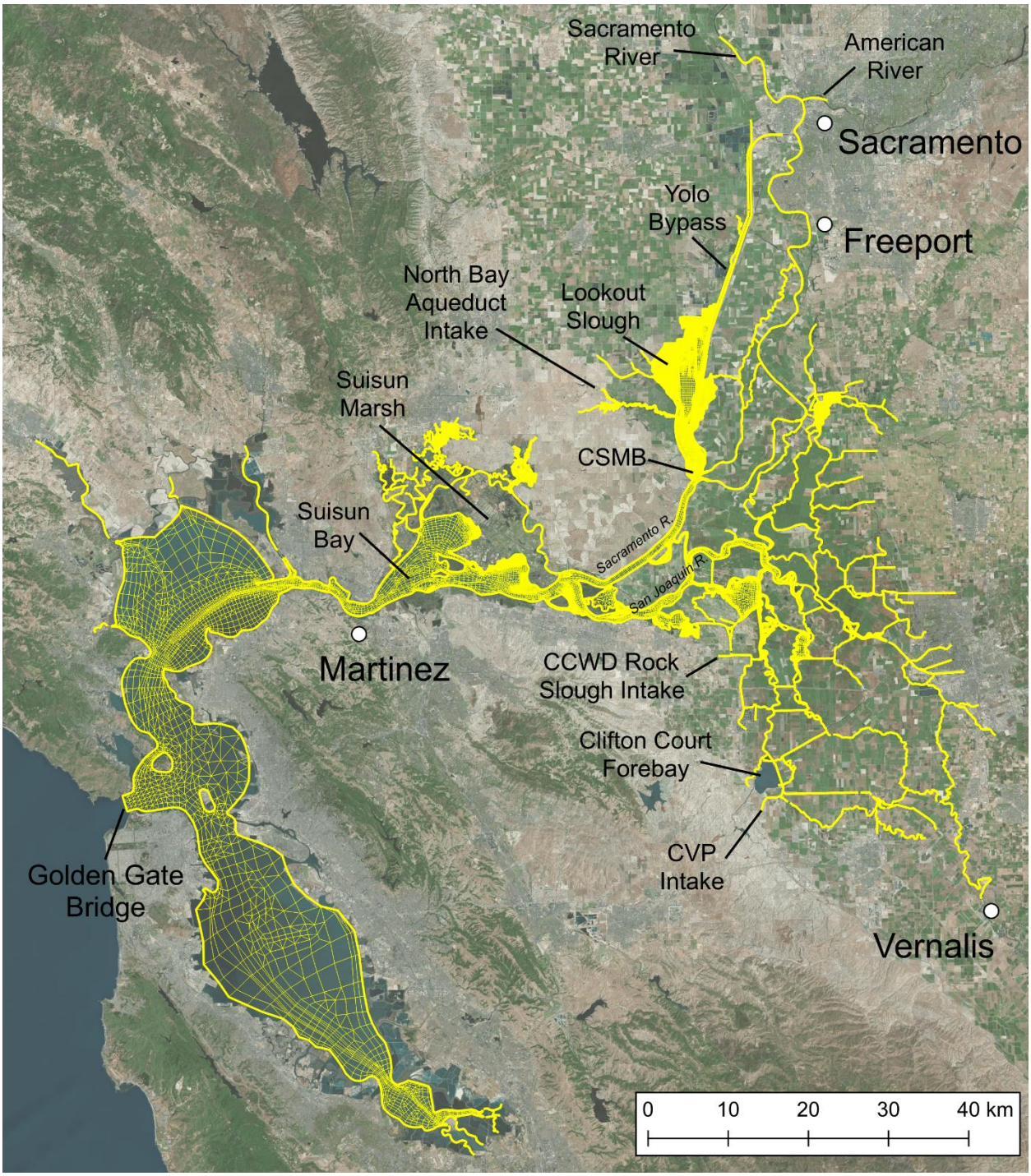


Figure 4 Extents of the RMA Bay-Delta model for the CSMB Project analysis (Future with Project).

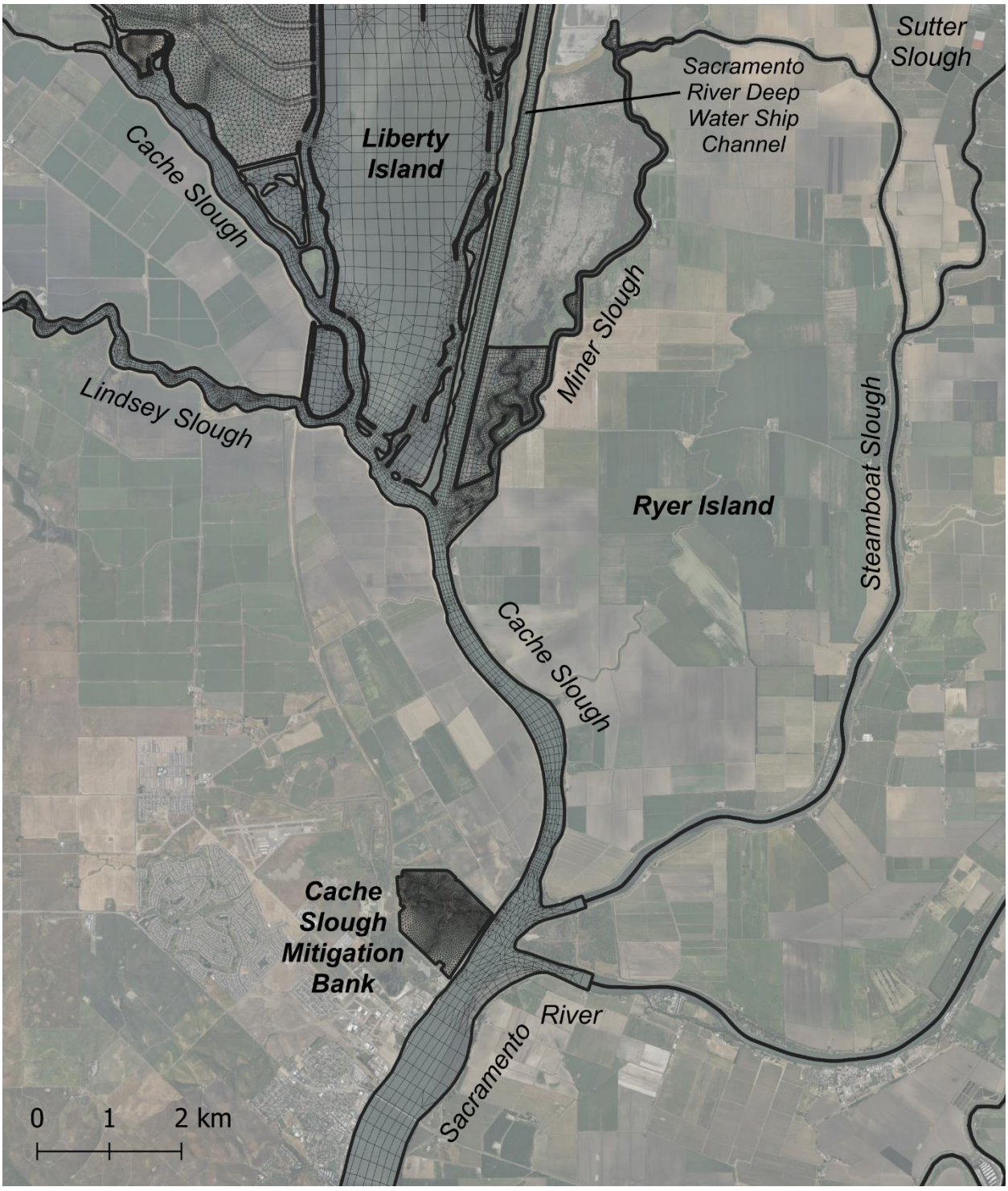


Figure 5 Detail view of the With Project model configuration.

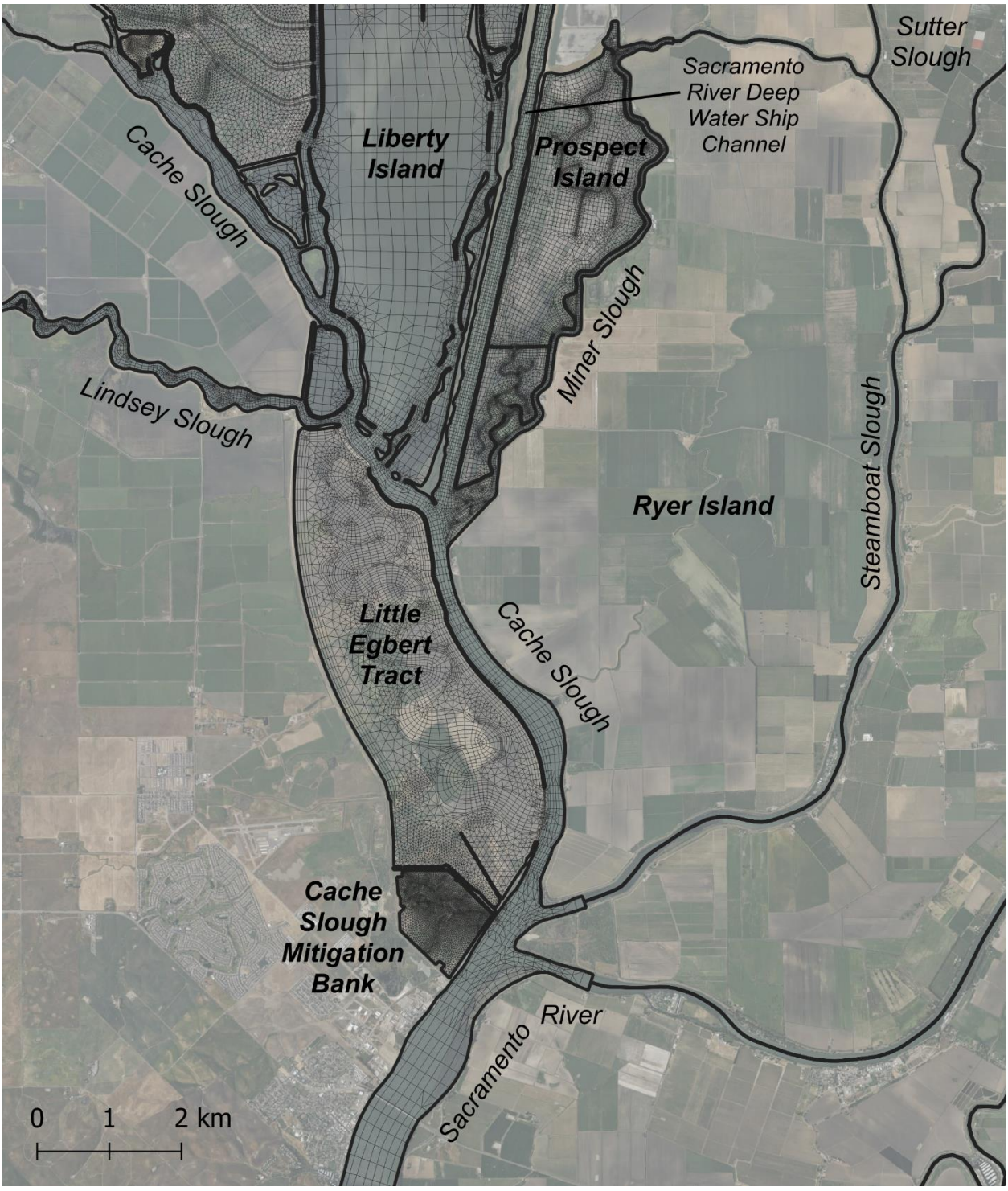


Figure 6 Detail view of the Future with Project model configuration.

Bathymetry

The RMA Bay-Delta model grid and bathymetry has been continually updated over the years as new and better bathymetry data becomes available. For all areas of the model grid, the most current, best quality bathymetric data were used to set grid elevations (Figure 9) as follows.

- Most recently, elevations were set using data collected in the CSC during 2015, 2017 and 2018 by the USGS[2].
- Deepwater Ship Channel and Miner Slough elevations were set using data collected by DWR (DWR, 2012).
- Elevations in the portions of the Ship Channel upstream of the DWR survey were set using 2005 USACE data (USACE, 2005).
- In Cache Slough and Sutter Slough elevations were set using data collected by Environmental Data Solutions (EDS) 2012.
- For the San Francisco Bay and Suisun Bay, DWR's 2012 10m San Francisco Bay and Sacramento – San Joaquin Delta DEM version 3[3] were used.
- The model grid includes elevations based on the multi-beam bathymetry surveys performed by DWR for selected Suisun Marsh and Delta channels and posted on the DWR Delta Bathymetry websites[4,5]. The sites provide a documentation of the multi-beam and single-beam data sources.
- For all areas not covered by more recent data sets listed above, bottom elevations and the extent of mudflats were based on bathymetry data collected by NOAA, DWR, USACE and USGS. These datasets have been compiled by DWR and can be downloaded from DWR's Cross Section Development Program (CSDP) websites[6] and;
- The Lower Yolo Ranch tidal restoration grid was based on data provided by cbec.
- The Lower Flyway Farms tidal restoration grid was based on data provided by cbec.
- The Decker Island tidal restoration grid was based on data provided by Stillwater Sciences.
- The Liberty Island Conservation Bank grid was based on USGS[7] topography data.
- The RD 2093 North Delta Fish Conservation Bank tidal restoration grid was based on data provided by cbec.

[2] https://www.sciencebase.gov/catalog/item/5d781129e4b0c4f70d020cdd
[3] https://data.cnra.ca.gov/dataset/san-francisco-bay-and-sacramento-san-joaquin-delta-dem-v3
[4] https://data.cnra.ca.gov/dataset/san-francisco-bay-and-sacramento-san-joaquin-delta-dem-for-modeling-version-4-2
[5] https://data.cnra.ca.gov/dataset/san-francisco-bay-and-sacramento-san-joaquin-delta-dem-for-modeling-version-4-1
[6] https://data.ca.gov/dataset/cross-section-development-program-navd88-update
[7] https://www.sciencebase.gov/catalog/item/5d7810e1e4b0c4f70d020cdb

- The Lookout Slough planned tidal restoration grid was based on design data provided by ESA.
- The Dutch Slough tidal restoration grid was based on data provided by DWR.
- The Prospect Island planned tidal restoration grid was based on data provided by Stillwater Sciences.
- The McCormack Williamson Tract planned tidal restoration grid was based on design data provided by cbec.
- The LEMBP restoration grid was based on design data provided by MBK Engineers

Four versions of the model grid were developed:

1. Base – current conditions with restoration projects that are in construction
2. Future – Base with LEMBP, Prospect Island and McCormack-Williamson Tract Habitat Restoration
3. With Project – Base with CSMB Project restoration
4. Future with Project – Future with CSMB Project restoration

A DEM of the CSMB restoration design feature was provided by Westervelt. A spatial plot of model bathymetry in the vicinity of CSMB is shown in Figure 11. All features of the restoration design are represented in the model using 2D grid elements.

Model Boundary Conditions

Figure 12 shows the location of the model boundary conditions. A detail view of the Cache Slough Complex is shown in Figure 13. Figure 14 shows the DCD (Delta Channel Depletion) locations and major control structures through the Delta and Suisun Marsh. Each model inflow boundary condition requires a corresponding EC value be specified (see Appendix A: Model Boundary Conditions). The model boundary conditions are:

Tidal stage boundary at the Golden Gate (from NOAA, see 2018 Model Boundary conditions - Figure 107 and 2020 Model Boundary conditions - Figure 122)

Inflows:
Sacramento River above American River
American River near Sacramento
San Joaquin River near Vernalis
Yolo Bypass and Yolo Bypass Toe Drain
Fremont Weir Big Notch flows (project in construction)
Mokelumne River near Thornton
Cosumnes River
Calaveras River near Stockton
Ulatis Creek

Campbell Lake
Agricultural return flows (from Delta Channel Depletion - DCD[8])
Precipitation

Exports/Diversions:
State Water Project (SWP), Clifton Court Forebay gates
Central Valley Project (CVP) Tracy Pumping Plant
Contra Costa Water District (CCWD) intakes at Rock Slough, Old River and Victoria Canal
North Bay Aqueduct (NBA), Barker Slough Pumping Plant
Delta Channel Depletion (DCD), throughout Delta
Cache Slough Complex agricultural diversions
Evaporation in the Cache Slough Complex and restoration areas

Major Control Structures:
Delta Cross Channel gates
Suisun Marsh Salinity Control Gate (SMSCG)
South Delta Temporary Barriers

- Old River near Tracy (DMC) temporary barrier
- Old River at Head temporary barrier
- Middle River temporary barrier
- Grant Line Canal temporary barrier

Time series plots of model boundary conditions for the model analysis periods of January – December 2018 and January – December 2020 are provided in Appendix A: Model Boundary Conditions.

[8] https://data.ca.gov/dataset/dsm2

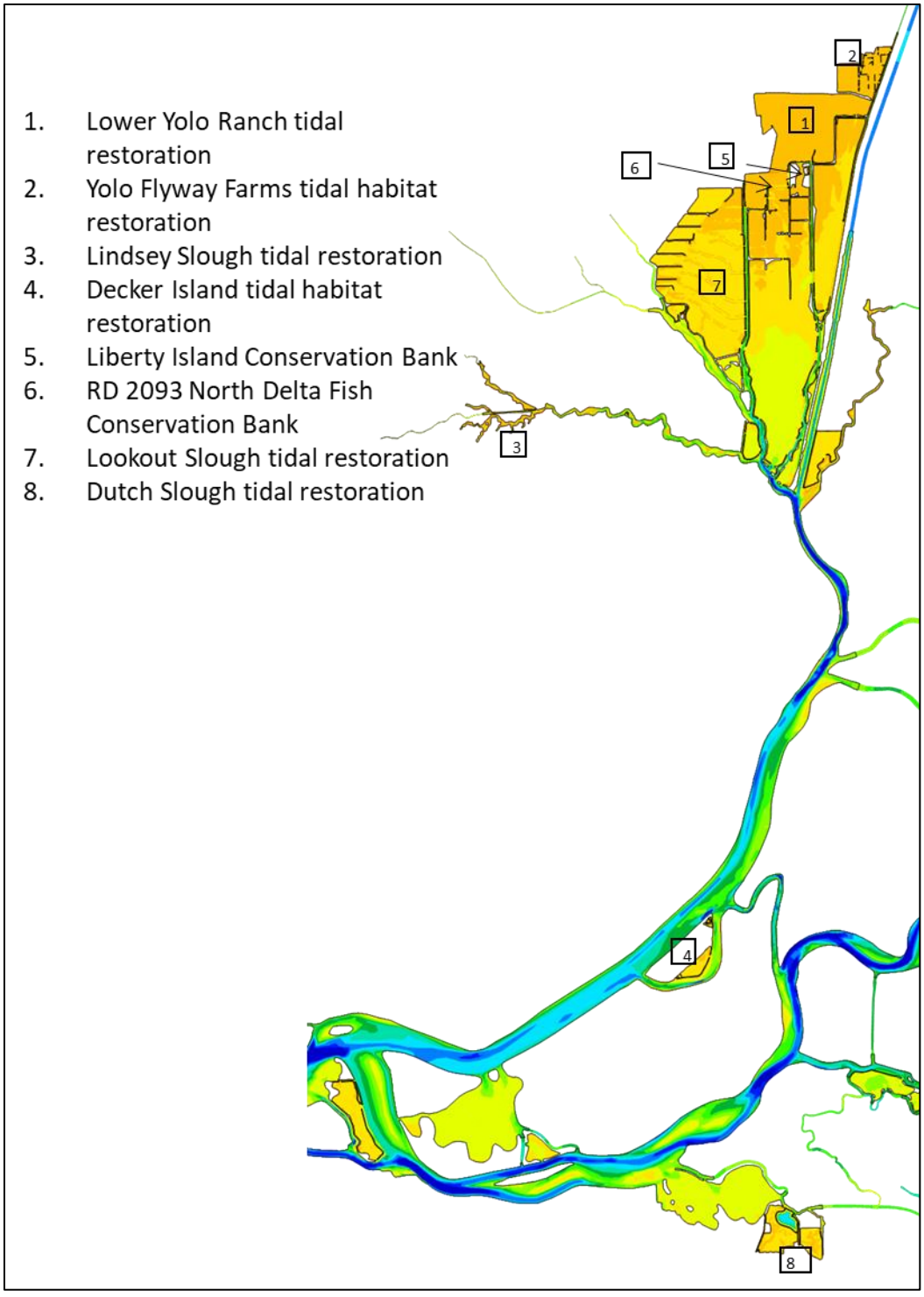


Figure 7 Recently constructed or planned tidal restoration projects included in model grids for all simulations.

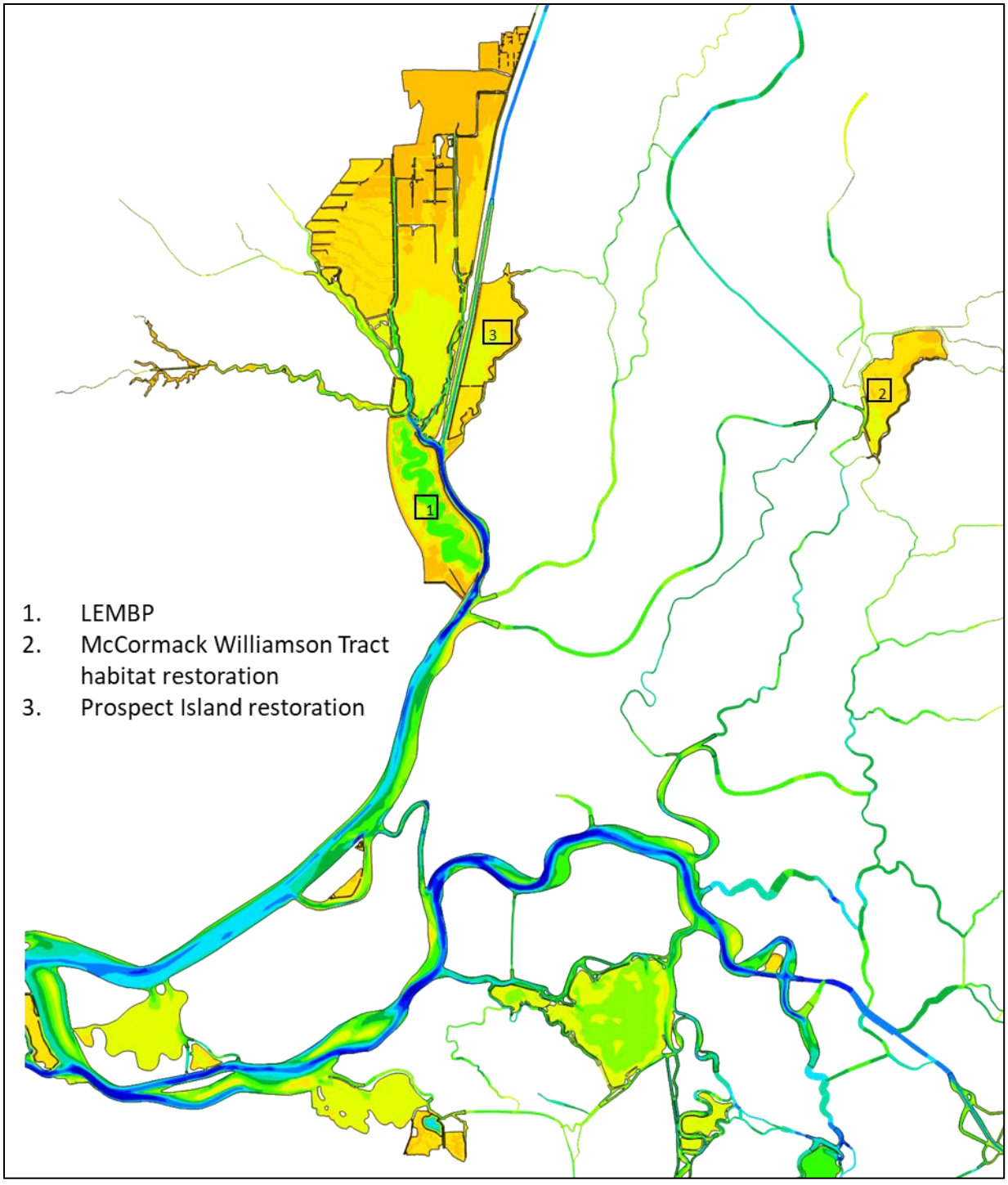


Figure 8 Tidal restoration projects included in Future model grids.

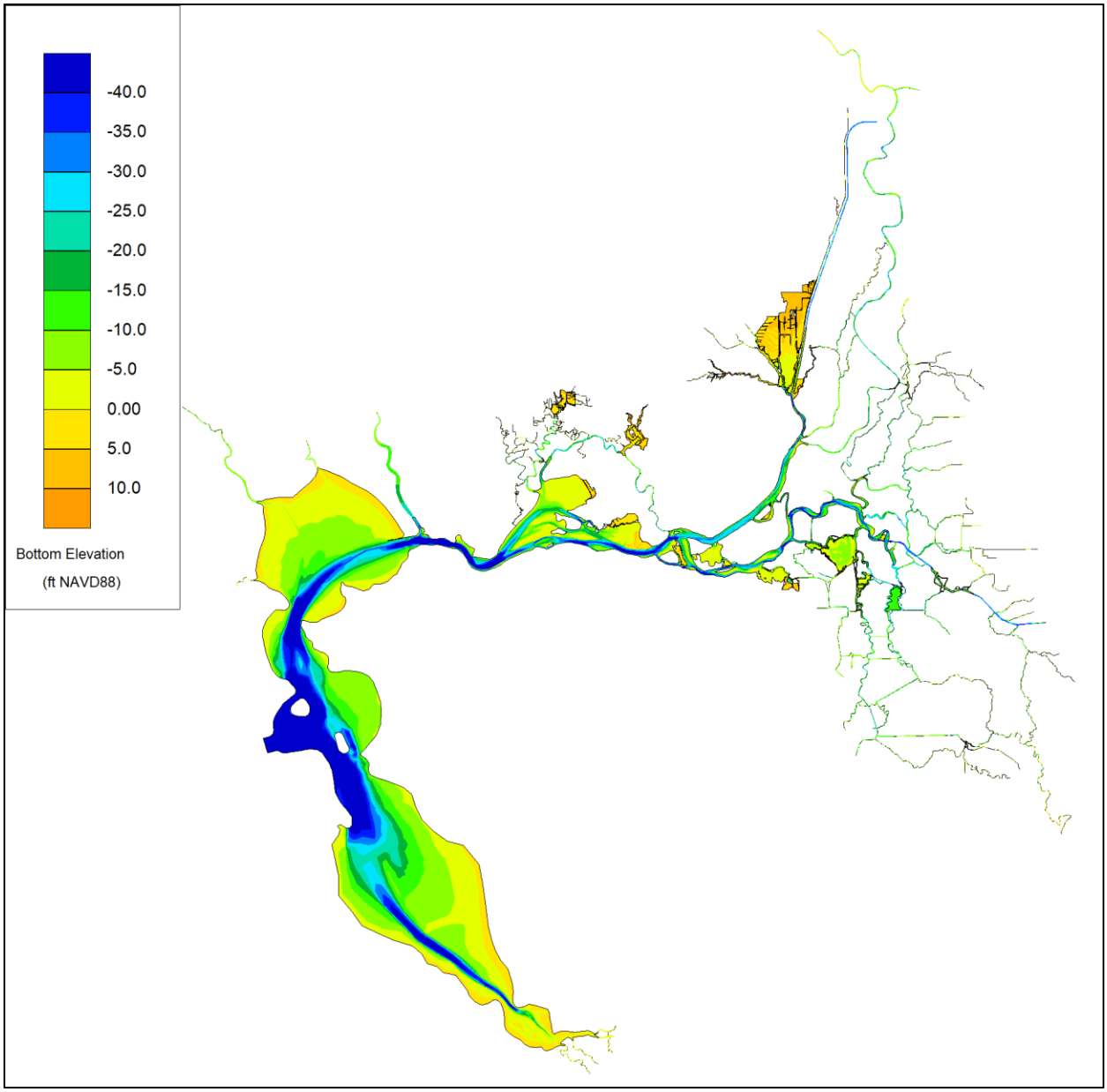


Figure 9 RMA Bay-Delta Base model bathymetry.

Figure 10 CSMB restoration design.

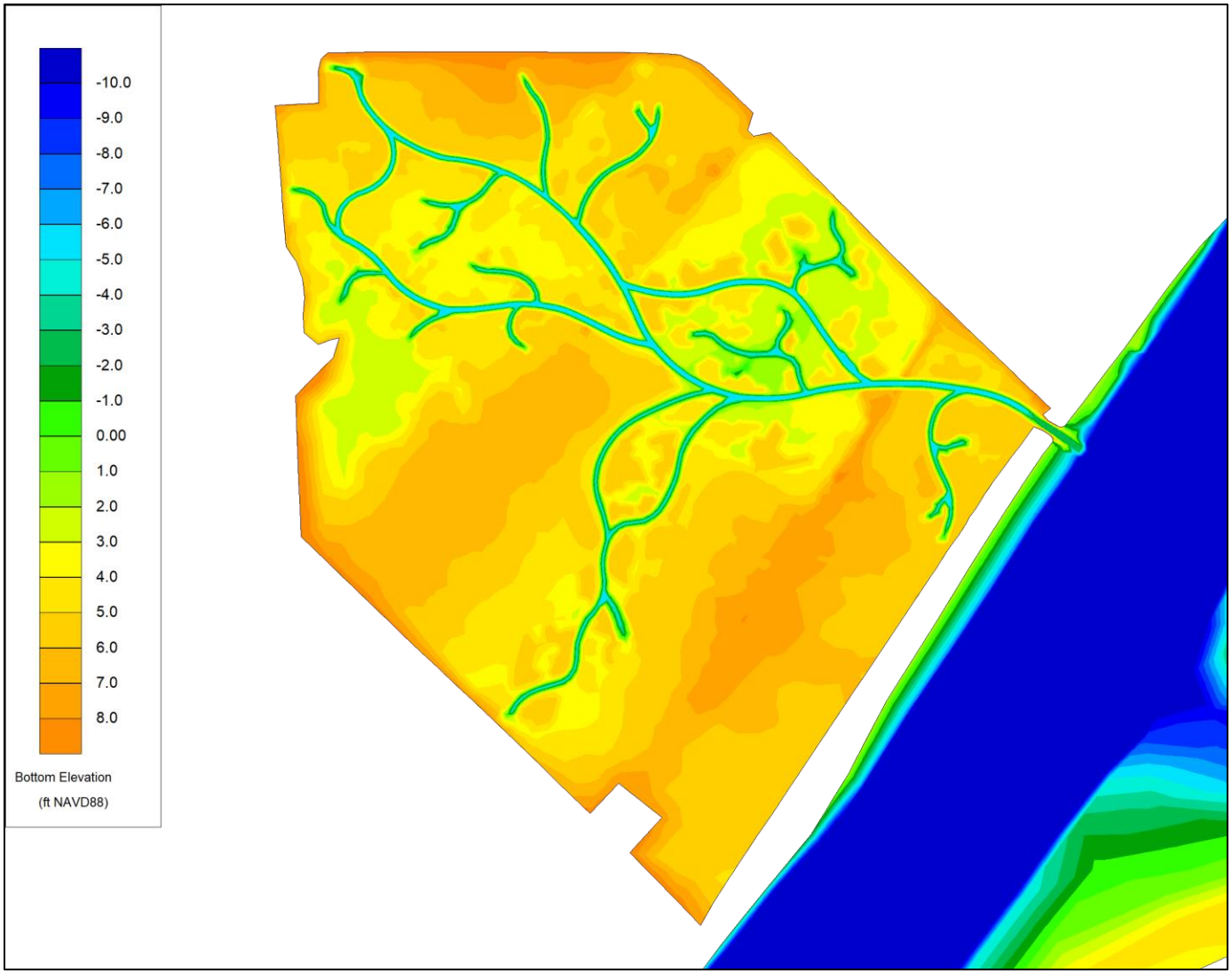


Figure 11 CSMB restoration model bathymetry

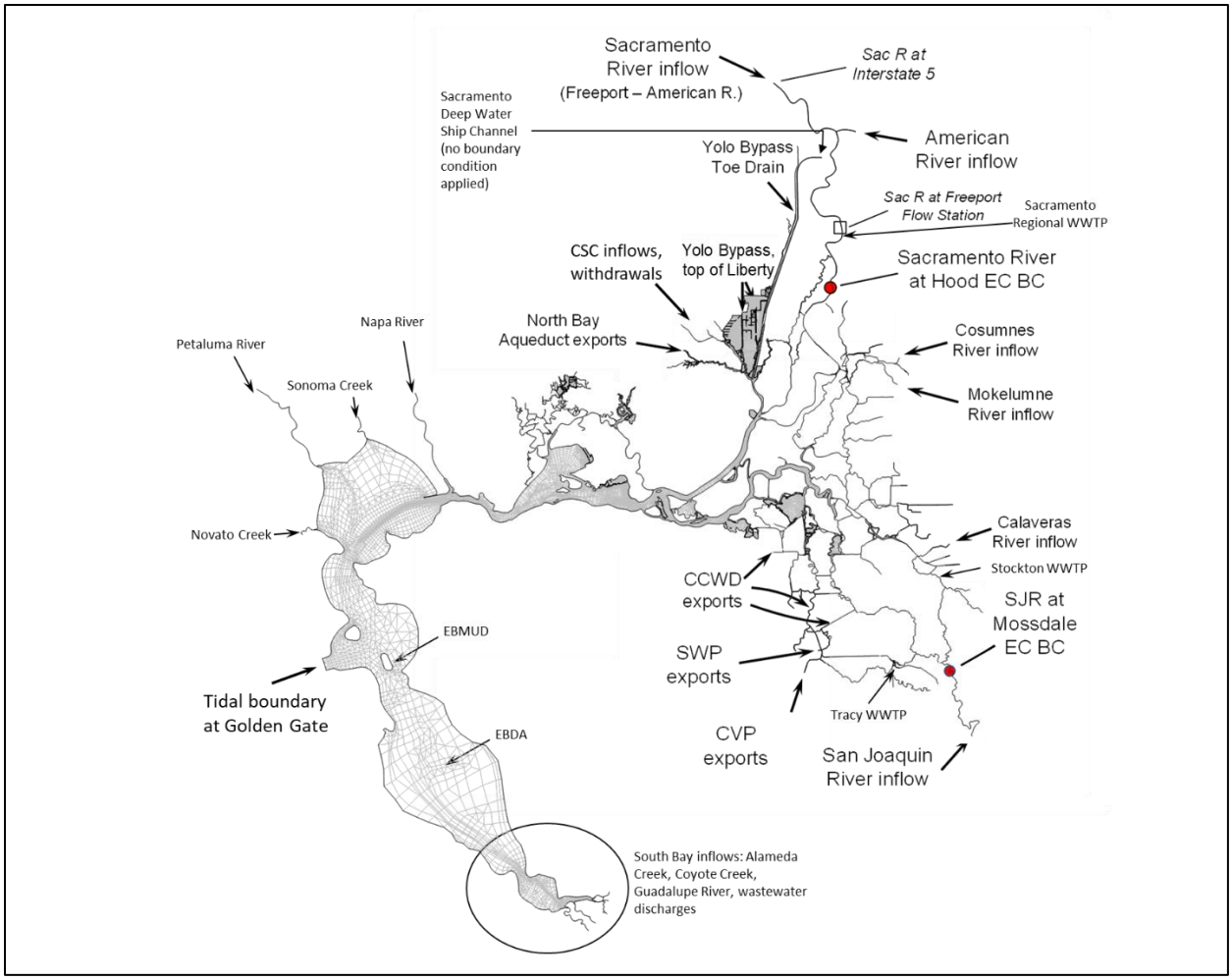


Figure 12 Model boundary condition locations. Internal EC boundary conditions are set for the Sacramento River at Hood and for the San Joaquin River at Mossdale.

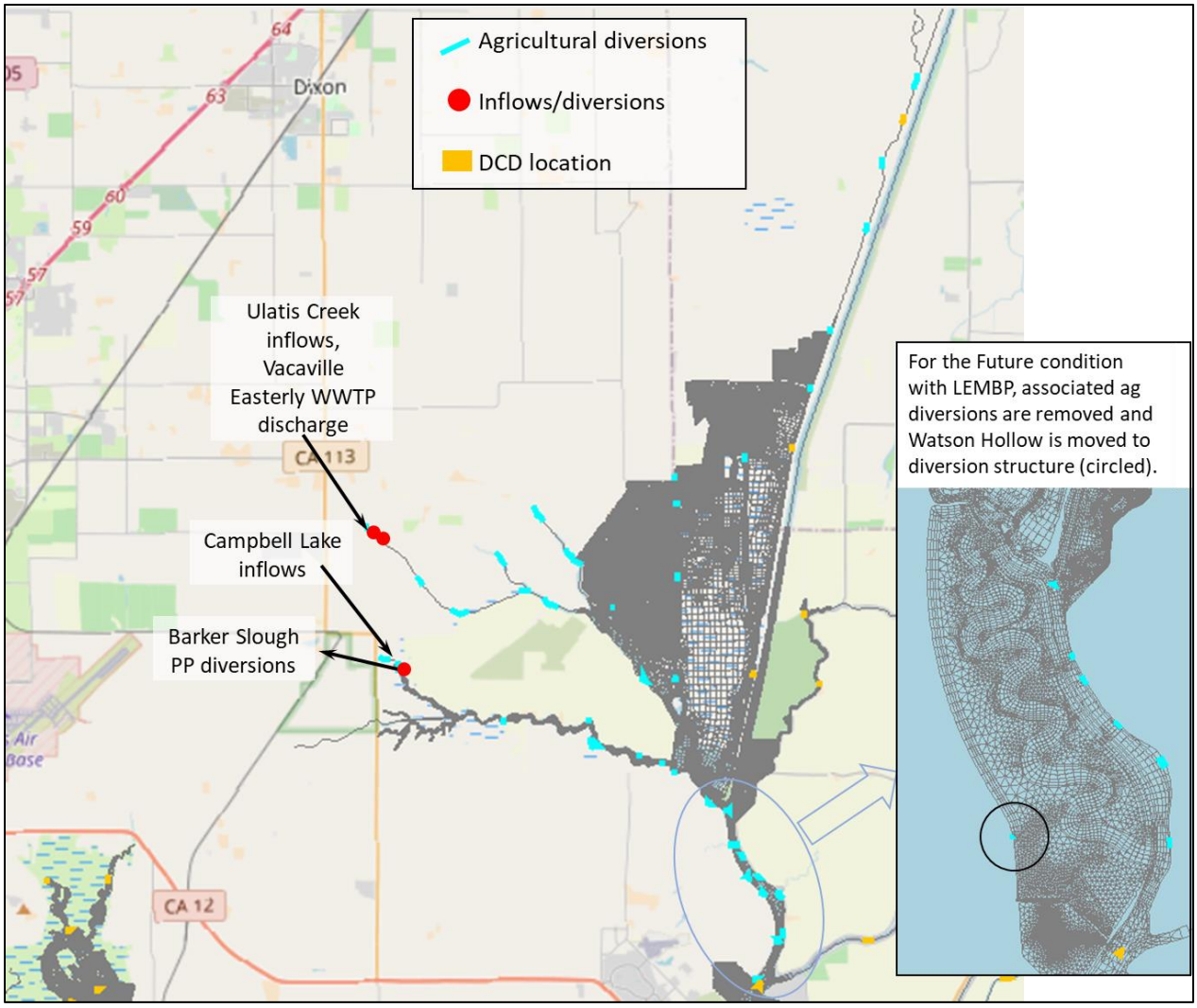


Figure 13 Cache Slough Complex model boundary condition locations

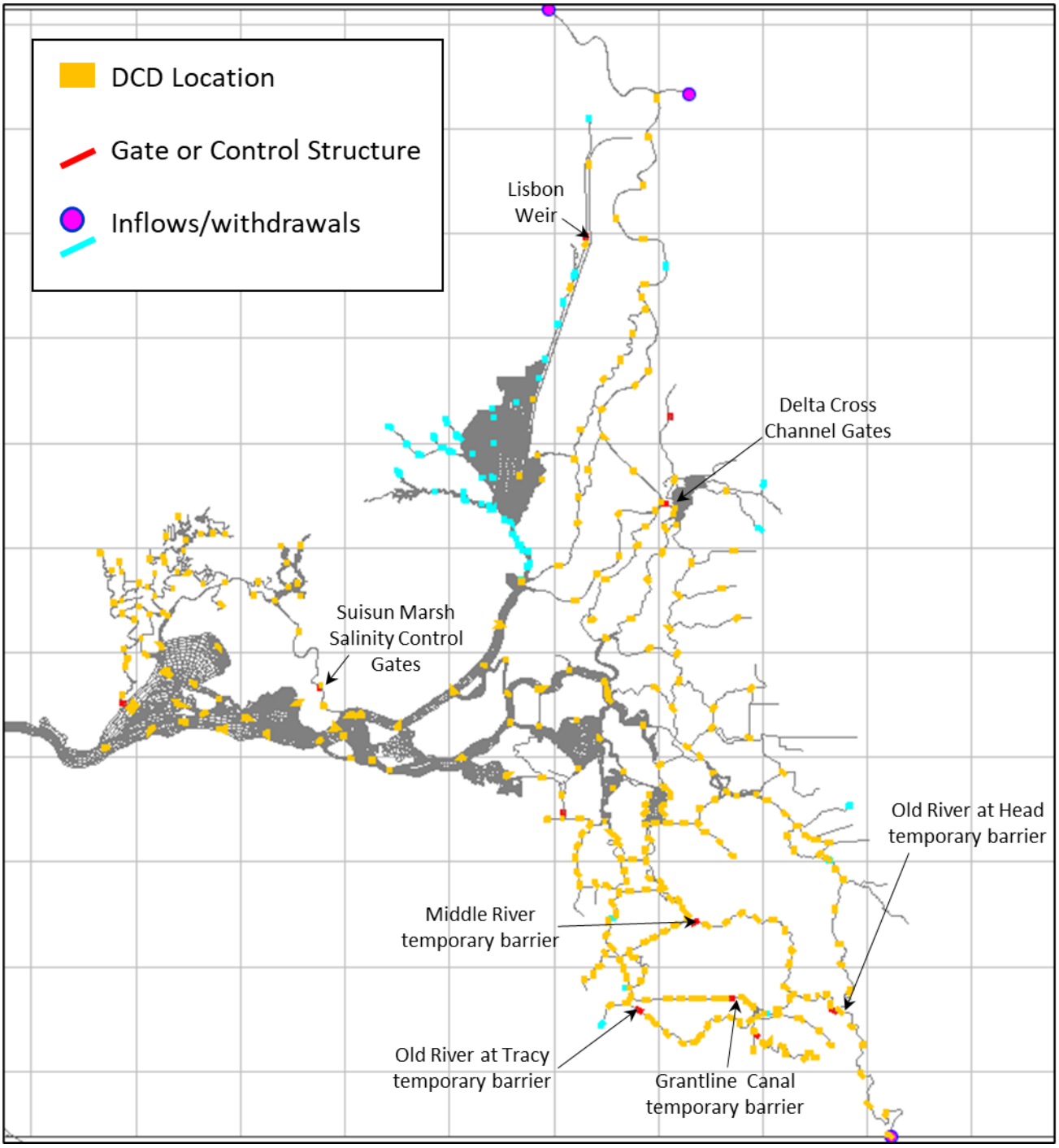


Figure 14 Location of DCD diversions and returns, and the major Delta control structures. DCD diversions in the Cache Slough Complex are replaced with estimated ag diversion flows provided by Solano County Water Agency.

Modeling Evaluation Process

Introduction

This section provides a description of the model configurations for the current and Future Base and CSMB restoration and describes and discusses the selected model simulation period for the analysis.

Model Configurations

The Base configuration represents the current condition at CSMB, with no flow onto the Project site. The CSMB Project restoration configuration (With Project) case is compared to the Base. The Future condition includes planned future tidal marsh restoration projects at Prospect Island, McCormack Williamson Tract and LEMBP. The Future with Project configuration combines the Future restoration projects with the CSMB Project restoration.

The proposed CSMB Project restoration configuration design is shown in Figure 10. The restoration design includes construction of a breach to Cache Slough on the east side and interior channels.

All of the model networks include the following recently constructed or underway projects (see Figure 7):

- Lower Yolo Ranch tidal restoration
- Yolo Flyway Farms tidal habitat restoration
- Lindsey Slough tidal restoration
- Decker Island tidal habitat restoration
- Liberty Island Conservation Bank
- RD 2093 North Delta Fish Conservation Bank
- Lookout Slough tidal restoration
- Dutch Slough tidal restoration

The Fremont Weir Big Notch flows were included. This project is in construction.

The Future configuration grids additionally include (see Figure 8):

- McCormack Williamson Tract habitat restoration
- Prospect Island restoration
- LEMBP

Analysis Period

The two one-year model analysis periods are January through December 2018 and January through December 2020. The hydrologic conditions for 2018 were classified as below normal (BN) and conditions for 2020 were classified as dry for the Sacramento Valley and San Joaquin Valley[9]. For reference, Figure 15 and Figure 16 present the overall Delta hydrologic conditions for 2008-2020. Figure 15 shows the major Delta inflows. The salinity intrusion in the western Delta over the 2008-2020 period is illustrated with the plot of the observed EC for the San Joaquin River at Jersey Point location in Figure 16.

The water year effectively begins with the freshening of the Delta with the rise of the winter/spring inflows. This was late-March for 2018. There was no significant freshening event in 2020.

The model runs were initialized from observed Delta EC values for January 1, 2018 and January 1, 2020. The high Delta inflows of the winter months generally flush the Delta and reduce the effects of the initial EC condition, however for 2020 this did not occur.

The salinity impacts of CSMB restoration are examined on a relative basis in terms of the change and percentage change from the Base and Future condition values. The model analysis also examines the potential for non-compliance to the D-1641 water quality objectives. For this, model predicted values are compared to numerical thresholds. The model overestimates or underestimates EC at some locations at times during the simulation period, as seen in the verification results. When comparing the computed EC values to the water quality compliance standards, these discrepancies can be taken into account by including observed data on the plots.

Time series plots of the major inflows, diversions and EC boundary conditions are provided for reference in Appendix A: Model Boundary Conditions.

[9] https://cdec.water.ca.gov/reportapp/javareports?name=wsihist

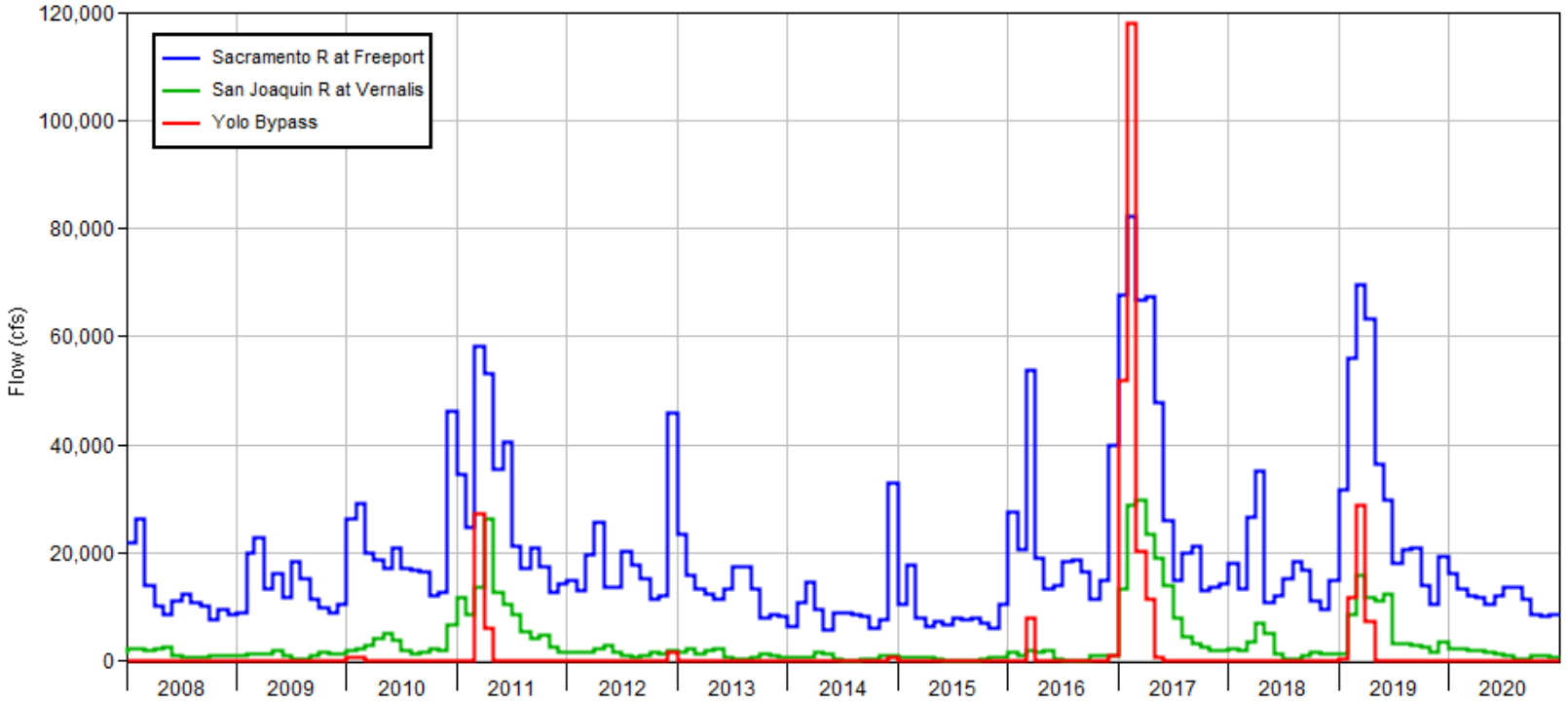


Figure 15 Monthly averaged Delta inflows for the Sacramento River, Yolo Bypass and San Joaquin River for 2008-2020.

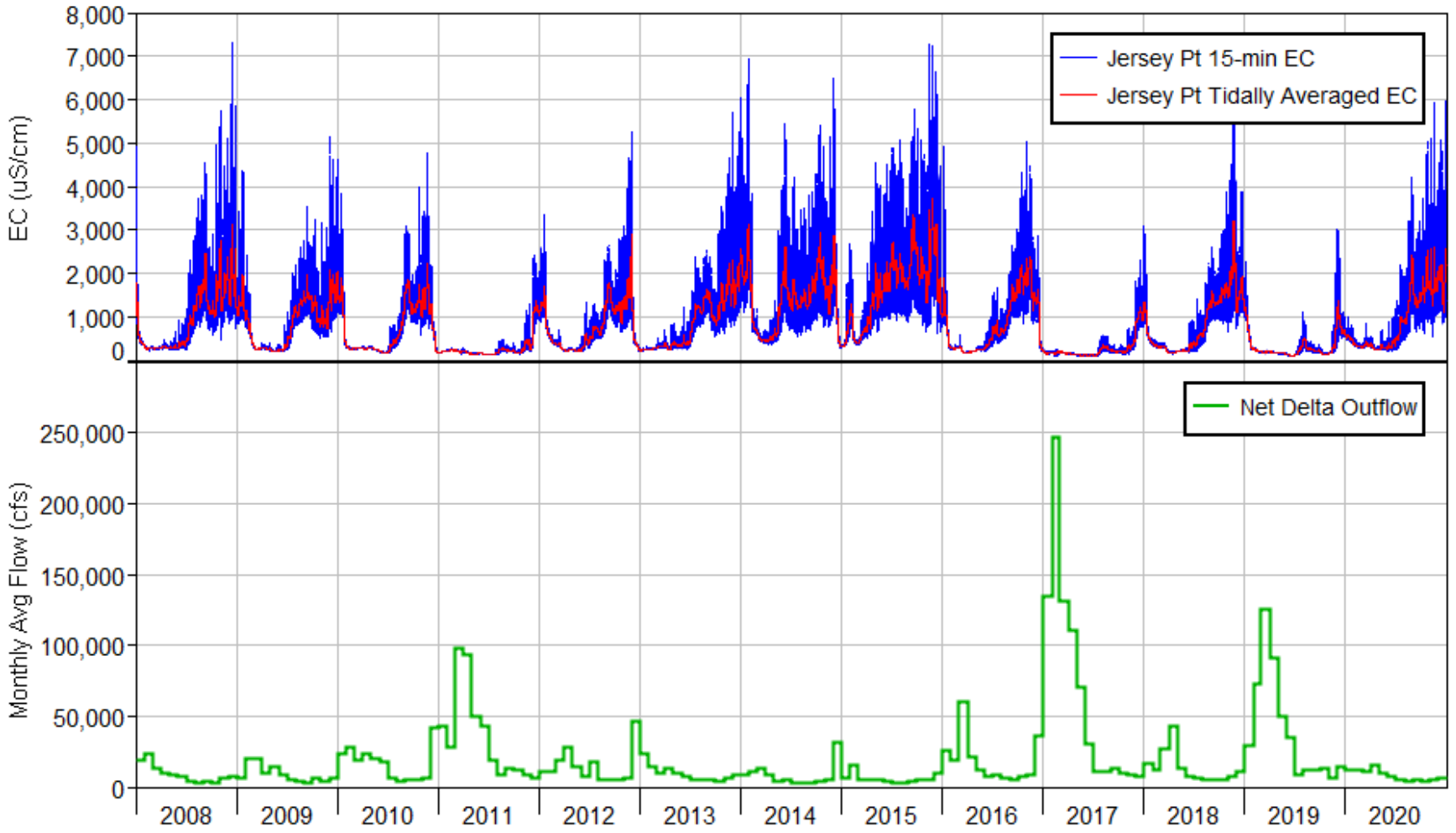


Figure 16 Observed San Joaquin River at Jersey Point EC and monthly averaged Net Delta Outflow (from DAYFLOW) for 2008-2020. The plots illustrate the dry season salinity intrusion into the western Delta with low NDO and the response of the Jersey Point EC to variations in the NDO over the different water years.

Evaluation of Water Quality Changes at Select D-1641 Compliance Stations and CCWD Intake Locations

Introduction

The salinity (EC) transport component of the RMA Bay-Delta model was utilized to evaluate the potential salinity changes at select D-1641 compliance locations and Contra Costa Water District intake locations listed in Table 1 (see Figure 1 for map). Chloride and bromide changes at the water intakes were evaluated as well as changes to X2.

The analyses were performed for both a below normal and a dry water year.

Table 1 D-1641 Compliance Stations to be used for Project salinity evaluation.

D-1641 Station ID	Location
D22	Sacramento River at Emmaton
D15	San Joaquin River at Jersey Point
D29	San Joaquin River at Prisoners Point
C5	Contra Costa Canal at Pumping Plant 1
C9	West Canal at mouth of Clifton Court Forebay
DMC1	Delta-Mendota Canal at Tracy Pumping Plant
SLBAR3	Barker Slough NBA Intake
C19	City of Vallejo Intake Cache Slough
C2	Sacramento River at Collinsville
D12	San Joaquin River at Antioch
	CCWD Intake at Mallard Slough
	CCWD Intake at Old River
	CCWD Intake at Victoria Canal

The modeling evaluation criteria were:

1) Evaluate the salinity impacts by quantifying the With Project percentage change from the Base and Future conditions at the Table 1 locations.
2) Examine if the Project has the potential to result in non-compliance with the D-1641 water quality objectives for EC and chloride for the Table 1 locations.
3) Examine Project impacts on X2.
4) Examine Project impacts on bromide.

EC Changes at Compliance Locations

Salinity (EC) model results were computed for the periods January 1, 2018 to December 31, 2018 and January 1, 2020 to December 31, 2020. The year 2018 is characterized as a near "average" year (below normal) and 2020 as a dry year. The results were stored at 15-minute intervals for all model computational points allowing both temporal and spatial analysis. The primary metrics chosen for the Project impacts analysis were the percentage change from Base and Future conditions of monthly averaged EC at the Table 1 locations. Table 2 provides the monthly average computed Base and Future EC and the incremental and relative (%) EC change with the CSMB restoration Project (With Project) at each of the compliance locations listed in Table 1. For each compliance location, daily average Base, Future, With Project and Future with Project EC time series are plotted with absolute change and percent change in Figure 17 through Figure 23.

The general observations for the monthly average EC results are:

1) The CSMB Project has very small impacts on regional salinity in the Delta. The largest increases are 0.4%, occurring at Emmaton during the summer of 2020. The largest decreases are less than 0.1%, occurring at Antioch during the fall of 2018 and beginning of 2020.
2) Salinity increases at North Bay Aqueduct and City of Vallejo intakes are less than 0.1%.
3) Salinity increases at south Delta exports and CCWD water intakes are 0.1% or less.

Spatial plots of monthly average computed Base condition EC and absolute EC change from Base for the CSMB restoration Project are provided in Figure 43 for June 2018. Percent change from Base EC plots are provided for June through November of 2018 in Figure 44 through Figure 49. Monthly average computed Future condition EC and absolute EC change from Future for the With Project scenario are provided in Figure 50 for June 2018. Percent change from Base EC plots are provided for June through November of 2018 in Figure 51 through Figure 56.

Monthly average computed Base condition EC and absolute EC change from Base for the CSMB restoration are provided in Figure 57 for June 2020. Percent change from Base EC plots are provided for June through November of 2020 in Figure 58 through Figure 63. Monthly average computed Future condition EC and absolute EC change from Future for the With Project scenario are provided in Figure 64 for June 2020. Percent change from Base EC plots are provided for June through November of 2020 in Figure 65 through Figure 70.

These plots provide a spatial illustration of the EC impacts occurring in the summer and fall, when impacts are the greatest. Salinity increases are very small throughout the system. The

largest changes tend to occur around Emmaton and into the eastern side of Montezuma Slough. There is almost no change in the Cache Slough Complex.

Table 2 Monthly average Base and Future EC and percent change from Base and Future EC with the CSMB restoration Project at select D-1641 compliance stations and CCWD water intakes for the 2018 simulation period. The darkest blue cells indicate the largest decreases for the simulation period and the darkest red cells indicate the largest increases.

	SLBAR3 – Barker Slough NBA Intake						C19 – City of Vallejo Intake Cache Slough					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2018	341	0.0	0.01%	342	0.0	0.01%	710	0.4	0.05%	728	0.4	0.05%
Feb-2018	348	0.1	0.01%	346	0.1	0.02%	794	0.6	0.08%	824	0.6	0.07%
Mar-2018	500	0.1	0.01%	498	0.1	0.01%	673	0.3	0.04%	685	0.3	0.04%
Apr-2018	568	0.2	0.03%	571	0.2	0.03%	658	0.4	0.06%	674	0.4	0.06%
May-2018	290	0.1	0.04%	287	0.1	0.04%	369	0.2	0.07%	376	0.3	0.07%
Jun-2018	180	0.0	0.01%	178	0.0	0.02%	302	0.1	0.05%	308	0.2	0.05%
Jul-2018	156	0.0	0.02%	155	0.0	0.03%	292	0.2	0.06%	299	0.2	0.07%
Aug-2018	157	0.0	0.01%	155	0.0	0.01%	307	0.2	0.06%	314	0.2	0.06%
Sep-2018	187	0.0	-0.01%	185	0.0	0.00%	325	0.2	0.05%	331	0.2	0.05%
Oct-2018	200	0.0	0.01%	197	0.0	0.01%	421	0.4	0.09%	434	0.4	0.08%
Nov-2018	194	0.1	0.04%	192	0.1	0.04%	478	0.4	0.09%	498	0.4	0.09%
Dec-2018	265	0.1	0.04%	265	0.1	0.05%	532	0.4	0.07%	548	0.4	0.07%

	C2 – Sacramento River at Collinsville						D22 – Sacramento River at Emmaton					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2018	2390	2.8	0.12%	2451	2.3	0.09%	546	0.9	0.16%	562	0.7	0.13%
Feb-2018	1001	1.2	0.12%	1028	1.0	0.10%	257	0.1	0.03%	258	0.1	0.04%
Mar-2018	672	1.0	0.15%	699	0.9	0.13%	204	0.0	0.02%	206	0.1	0.03%
Apr-2018	167	0.0	0.02%	168	0.0	0.02%	142	-0.1	-0.04%	141	0.0	-0.03%
May-2018	848	1.1	0.13%	871	0.9	0.10%	224	0.3	0.12%	228	0.2	0.10%
Jun-2018	2634	3.1	0.12%	2699	2.6	0.10%	503	1.7	0.33%	523	1.4	0.27%
Jul-2018	4026	4.3	0.11%	4106	3.6	0.09%	687	2.3	0.34%	710	2.0	0.28%
Aug-2018	4545	4.9	0.11%	4633	3.9	0.08%	599	1.7	0.29%	611	1.5	0.25%
Sep-2018	4384	3.8	0.09%	4426	3.0	0.07%	622	1.3	0.21%	623	1.2	0.19%
Oct-2018	6228	3.9	0.06%	6245	3.0	0.05%	1246	3.2	0.26%	1230	2.6	0.22%
Nov-2018	8539	5.8	0.07%	8633	4.6	0.05%	2078	6.1	0.30%	2122	5.0	0.24%
Dec-2018	3620	4.8	0.13%	3726	4.0	0.11%	560	1.3	0.22%	582	1.2	0.20%

	D-12 – San Joaquin River at Antioch						D15 – San Joaquin River at Jersey Point					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2018	1715	-0.7	-0.04%	1684	-0.5	-0.03%	848	-0.3	-0.04%	837	-0.2	-0.02%
Feb-2018	585	-0.3	-0.05%	571	-0.2	-0.03%	360	-0.1	-0.03%	357	0.0	-0.01%
Mar-2018	452	-0.1	-0.03%	446	-0.1	-0.01%	297	0.0	-0.01%	296	0.0	0.00%
Apr-2018	191	0.0	0.00%	191	0.0	0.00%	200	0.0	0.00%	200	0.0	0.00%
May-2018	416	-0.1	-0.02%	409	0.0	-0.01%	233	0.0	0.01%	234	0.0	0.01%
Jun-2018	1301	-0.2	-0.02%	1294	-0.1	0.00%	362	0.0	0.00%	371	0.1	0.03%
Jul-2018	2289	-0.4	-0.02%	2285	0.0	0.00%	725	0.3	0.05%	767	0.6	0.08%
Aug-2018	2920	-1.2	-0.04%	2883	-0.8	-0.03%	1167	-0.3	-0.02%	1188	0.1	0.00%
Sep-2018	2950	-1.6	-0.06%	2884	-1.2	-0.04%	1351	-0.6	-0.04%	1360	-0.3	-0.02%
Oct-2018	3724	-1.7	-0.05%	3662	-1.3	-0.04%	1352	-0.1	0.00%	1396	0.1	0.01%
Nov-2018	5121	-1.5	-0.03%	5073	-1.0	-0.02%	1713	0.1	0.01%	1777	0.5	0.03%
Dec-2018	2401	-0.9	-0.04%	2364	-0.4	-0.02%	1092	-0.4	-0.03%	1105	0.1	0.01%

	D29 – San Joaquin River at Prisoners Point						C5 – Contra Costa Intake at Rock Slough					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2018	391	0.0	0.00%	381	0.0	0.01%	842	0.0	0.00%	840	0.0	0.00%
Feb-2018	311	0.0	0.01%	307	0.0	0.01%	621	0.0	0.00%	618	0.0	0.01%
Mar-2018	296	0.0	0.01%	293	0.0	0.01%	503	0.0	0.00%	502	0.0	0.01%
Apr-2018	235	0.0	0.01%	234	0.0	0.01%	463	0.0	0.01%	463	0.0	0.01%
May-2018	231	0.0	0.01%	229	0.0	0.01%	470	0.1	0.02%	472	0.1	0.01%
Jun-2018	191	0.0	0.01%	192	0.0	0.01%	388	0.1	0.01%	390	0.1	0.01%
Jul-2018	193	0.1	0.05%	204	0.1	0.07%	404	0.1	0.02%	417	0.1	0.03%
Aug-2018	294	0.3	0.10%	321	0.4	0.13%	530	0.2	0.04%	561	0.4	0.07%
Sep-2018	363	0.4	0.11%	400	0.6	0.14%	773	0.1	0.02%	809	0.3	0.04%
Oct-2018	316	0.3	0.11%	354	0.5	0.13%	759	0.2	0.03%	799	0.3	0.04%
Nov-2018	373	0.3	0.08%	415	0.4	0.10%	740	0.3	0.04%	798	0.4	0.05%
Dec-2018	449	0.3	0.07%	468	0.5	0.10%	840	0.3	0.04%	891	0.5	0.05%

	C9 – Clifton Ct Forebay Intake						DMC1 – Delta Mendota Canal at Tracy PP					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2018	590	0.0	-0.01%	586	0.0	0.00%	591	0.0	-0.01%	588	0.0	0.00%
Feb-2018	506	0.0	0.00%	503	0.0	0.00%	544	0.0	0.00%	542	0.0	0.00%
Mar-2018	479	0.0	0.00%	478	0.0	0.00%	519	0.0	0.00%	519	0.0	0.00%
Apr-2018	269	0.0	0.01%	269	0.0	0.00%	269	0.0	0.00%	269	0.0	0.00%
May-2018	220	0.0	0.00%	220	0.0	0.00%	229	0.0	0.00%	229	0.0	0.00%
Jun-2018	282	0.0	0.01%	283	0.0	0.01%	294	0.0	0.01%	295	0.0	0.01%
Jul-2018	293	0.1	0.03%	306	0.1	0.04%	302	0.1	0.02%	313	0.1	0.04%
Aug-2018	393	0.2	0.05%	419	0.3	0.08%	377	0.2	0.04%	399	0.3	0.07%
Sep-2018	550	0.2	0.05%	585	0.4	0.07%	501	0.2	0.04%	528	0.3	0.06%
Oct-2018	519	0.2	0.05%	557	0.4	0.06%	484	0.2	0.04%	515	0.3	0.06%
Nov-2018	532	0.2	0.04%	570	0.3	0.05%	511	0.2	0.03%	542	0.2	0.04%
Dec-2018	622	0.2	0.03%	653	0.4	0.06%	647	0.2	0.02%	671	0.3	0.04%

	CCWD Intake at Old River						CCWD Intake at Victoria Canal					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2018	608	-0.1	-0.01%	603	0.0	-0.01%	542	0.0	-0.01%	537	0.0	0.00%
Feb-2018	464	0.0	0.00%	460	0.0	0.00%	482	0.0	0.00%	477	0.0	0.01%
Mar-2018	428	0.0	0.00%	427	0.0	0.01%	511	0.1	0.01%	510	0.1	0.01%
Apr-2018	321	0.0	0.00%	320	0.0	0.00%	343	0.0	0.00%	343	0.0	0.00%
May-2018	300	0.0	0.01%	301	0.0	0.01%	307	0.0	0.00%	307	0.0	0.00%
Jun-2018	277	0.0	0.01%	279	0.0	0.01%	272	0.0	0.01%	272	0.0	0.01%
Jul-2018	312	0.1	0.04%	328	0.2	0.05%	252	0.0	0.01%	257	0.1	0.02%
Aug-2018	453	0.2	0.05%	484	0.4	0.08%	264	0.2	0.06%	280	0.3	0.09%
Sep-2018	639	0.2	0.03%	678	0.4	0.06%	341	0.3	0.08%	367	0.4	0.11%
Oct-2018	590	0.3	0.04%	634	0.4	0.06%	350	0.2	0.06%	375	0.3	0.08%
Nov-2018	617	0.3	0.05%	672	0.4	0.06%	382	0.1	0.02%	407	0.2	0.04%
Dec-2018	661	0.2	0.04%	700	0.4	0.06%	469	0.2	0.03%	490	0.3	0.06%

	CCWD Intake at Mallard Slough					
	Base			Future		
	EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2018	5223	1.1	0.02%	5229	0.6	0.01%
Feb-2018	3025	0.3	0.01%	3023	0.1	0.00%
Mar-2018	1975	0.7	0.04%	1997	0.5	0.03%
Apr-2018	366	0.0	0.00%	364	0.0	0.00%
May-2018	2541	0.3	0.01%	2539	0.1	0.01%
Jun-2018	5855	0.6	0.01%	5864	0.4	0.01%
Jul-2018	8141	0.7	0.01%	8156	0.4	0.00%
Aug-2018	9217	0.7	0.01%	9233	0.1	0.00%
Sep-2018	8892	-0.1	0.00%	8860	-0.5	-0.01%
Oct-2018	11247	-1.0	-0.01%	11177	-1.4	-0.01%
Nov-2018	14149	-0.7	0.00%	14101	-1.2	-0.01%
Dec-2018	8085	1.4	0.02%	8094	0.8	0.01%

Table 3 Monthly average Base and Future EC and percent change from Base and Future EC with the CSMB restoration Project at select D-1641 compliance stations and CCWD water intakes for the 2020 simulation period. The darkest blue cells indicate the largest decreases for the simulation period and the darkest red cells indicate the largest increases.

	SLBAR3 – Barker Slough NBA Intake						C19 – City of Vallejo Intake Cache Slough					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2020	358	0.0	0.01%	360	0.1	0.02%	672	0.3	0.04%	685	0.3	0.04%
Feb-2020	340	0.1	0.02%	337	0.1	0.04%	756	0.4	0.05%	772	0.3	0.04%
Mar-2020	355	0.0	0.01%	348	0.1	0.02%	675	0.2	0.03%	684	0.2	0.03%
Apr-2020	343	0.1	0.03%	338	0.1	0.04%	498	0.4	0.07%	511	0.4	0.07%
May-2020	231	0.1	0.03%	227	0.1	0.03%	331	0.2	0.05%	336	0.2	0.06%
Jun-2020	188	0.0	0.01%	186	0.0	0.02%	289	0.1	0.04%	293	0.1	0.04%
Jul-2020	166	0.0	0.01%	165	0.0	0.02%	282	0.2	0.06%	287	0.2	0.06%
Aug-2020	168	0.0	0.01%	167	0.0	0.01%	314	0.2	0.06%	321	0.2	0.06%
Sep-2020	196	0.0	0.00%	195	0.0	0.01%	369	0.2	0.06%	379	0.2	0.07%
Oct-2020	199	0.0	0.03%	198	0.1	0.03%	386	0.3	0.08%	399	0.3	0.08%
Nov-2020	187	0.1	0.07%	188	0.2	0.09%	586	0.5	0.08%	608	0.5	0.08%
Dec-2020	217	0.1	0.05%	217	0.1	0.07%	404	0.2	0.05%	413	0.2	0.04%

	C2 – Sacramento River at Collinsville						D22 – Sacramento River at Emmaton					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2020	1613	2.2	0.14%	1659	2.0	0.12%	303	0.3	0.10%	309	0.5	0.17%
Feb-2020	1063	1.6	0.15%	1099	1.3	0.12%	261	0.1	0.05%	262	0.2	0.06%
Mar-2020	1440	2.2	0.16%	1499	1.9	0.13%	275	0.4	0.13%	283	0.4	0.13%
Apr-2020	1228	1.7	0.14%	1270	1.4	0.11%	248	0.3	0.12%	255	0.3	0.11%
May-2020	2370	3.3	0.14%	2457	2.8	0.11%	409	1.4	0.33%	438	1.2	0.28%
Jun-2020	3031	3.9	0.13%	3118	3.4	0.11%	549	2.1	0.38%	579	1.9	0.32%
Jul-2020	4925	5.6	0.11%	5033	4.8	0.09%	921	3.9	0.42%	960	3.4	0.35%
Aug-2020	6821	6.0	0.09%	6920	4.9	0.07%	1320	4.9	0.37%	1352	4.1	0.31%
Sep-2020	6559	4.5	0.07%	6595	3.6	0.05%	1240	3.5	0.28%	1236	2.9	0.23%
Oct-2020	8450	5.0	0.06%	8514	3.8	0.04%	1933	6.0	0.31%	1966	4.8	0.25%
Nov-2020	7796	5.6	0.07%	7916	4.2	0.05%	1675	5.3	0.31%	1749	4.3	0.24%
Dec-2020	6831	6.4	0.09%	7008	5.1	0.07%	1364	4.2	0.31%	1442	3.4	0.24%

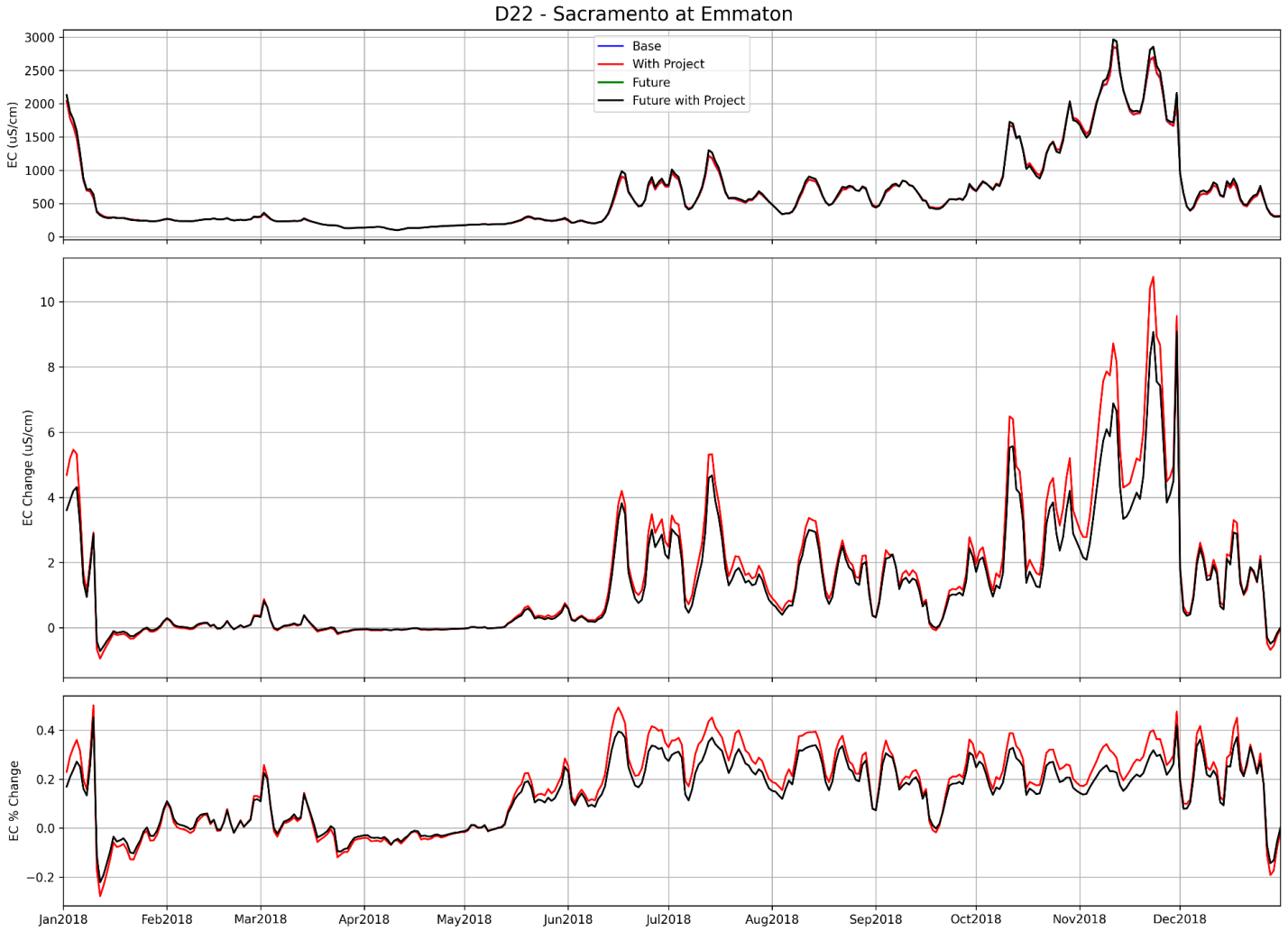
	D-12 – San Joaquin River at Antioch						D15 – San Joaquin River at Jersey Point					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2020	994	-0.7	-0.07%	963	-0.4	-0.04%	488	-0.3	-0.06%	479	-0.1	-0.01%
Feb-2020	578	-0.4	-0.07%	561	-0.2	-0.04%	336	-0.2	-0.05%	331	-0.1	-0.02%
Mar-2020	735	-0.4	-0.06%	718	-0.2	-0.03%	340	-0.1	-0.03%	338	0.0	-0.01%
Apr-2020	623	-0.4	-0.06%	604	-0.2	-0.04%	300	-0.1	-0.03%	298	0.0	-0.01%
May-2020	1113	-0.4	-0.04%	1091	-0.2	-0.02%	334	-0.1	-0.02%	334	0.0	0.01%
Jun-2020	1452	-0.4	-0.03%	1441	-0.1	-0.01%	385	0.0	-0.01%	392	0.1	0.03%
Jul-2020	2641	-0.8	-0.03%	2631	-0.4	-0.02%	696	0.1	0.02%	732	0.4	0.05%
Aug-2020	4132	-1.6	-0.04%	4094	-1.1	-0.03%	1341	-0.1	0.00%	1392	0.3	0.02%
Sep-2020	3878	-1.8	-0.05%	3830	-1.3	-0.04%	1349	0.3	0.02%	1429	0.6	0.04%
Oct-2020	4929	-2.1	-0.04%	4859	-1.6	-0.03%	1534	0.1	0.00%	1611	0.4	0.03%
Nov-2020	4600	-1.6	-0.04%	4529	-1.0	-0.02%	1438	-0.1	-0.01%	1489	0.5	0.04%
Dec-2020	4075	-1.2	-0.03%	4014	-0.6	-0.01%	1375	-0.4	-0.03%	1395	0.3	0.02%

	D29 – San Joaquin River at Prisoners Point						C5 – Contra Costa Intake at Rock Slough					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2020	308	0.0	0.01%	304	0.1	0.02%	484	0.0	0.00%	483	0.0	0.00%
Feb-2020	302	0.0	0.00%	299	0.0	0.01%	449	-0.1	-0.02%	446	0.0	0.00%
Mar-2020	315	0.0	0.01%	311	0.1	0.02%	503	0.0	0.00%	502	0.0	0.01%
Apr-2020	280	0.0	0.01%	277	0.0	0.01%	407	0.0	0.00%	407	0.0	0.01%
May-2020	281	0.0	0.01%	279	0.1	0.02%	387	0.0	0.00%	388	0.0	0.01%
Jun-2020	239	0.0	0.01%	240	0.0	0.02%	361	0.0	0.01%	363	0.1	0.02%
Jul-2020	195	0.1	0.03%	202	0.1	0.05%	373	0.1	0.03%	388	0.2	0.04%
Aug-2020	274	0.2	0.09%	301	0.4	0.12%	540	0.2	0.04%	576	0.3	0.06%
Sep-2020	323	0.3	0.11%	361	0.5	0.14%	798	0.4	0.05%	866	0.6	0.07%
Oct-2020	324	0.3	0.10%	369	0.5	0.13%	709	0.5	0.07%	787	0.6	0.08%
Nov-2020	366	0.2	0.05%	396	0.4	0.10%	742	0.4	0.05%	815	0.6	0.07%
Dec-2020	441	0.1	0.03%	463	0.4	0.09%	868	0.1	0.02%	913	0.4	0.05%

	C9 – Clifton Ct Forebay Intake						DMC1 – Delta Mendota Canal at Tracy PP					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2020	444	0.0	-0.01%	442	0.0	0.00%	495	0.0	0.00%	494	0.0	0.00%
Feb-2020	497	0.0	-0.01%	495	0.0	0.00%	534	0.0	0.00%	533	0.0	0.00%
Mar-2020	501	0.0	0.00%	499	0.0	0.00%	518	0.0	0.00%	517	0.0	0.00%
Apr-2020	504	0.0	0.00%	504	0.0	0.00%	534	0.0	0.00%	534	0.0	0.00%
May-2020	399	0.0	0.01%	399	0.0	0.01%	410	0.0	0.00%	411	0.0	0.01%
Jun-2020	355	0.0	0.01%	357	0.1	0.02%	355	0.0	0.01%	356	0.1	0.01%
Jul-2020	310	0.1	0.03%	322	0.1	0.04%	314	0.1	0.02%	325	0.1	0.04%
Aug-2020	401	0.2	0.05%	431	0.3	0.07%	393	0.2	0.04%	420	0.3	0.06%
Sep-2020	576	0.4	0.07%	631	0.5	0.09%	571	0.3	0.06%	620	0.5	0.08%
Oct-2020	512	0.3	0.06%	565	0.4	0.08%	515	0.3	0.05%	563	0.4	0.07%
Nov-2020	578	0.2	0.04%	623	0.4	0.06%	570	0.2	0.03%	607	0.3	0.05%
Dec-2020	696	0.1	0.01%	724	0.3	0.04%	720	0.0	0.01%	742	0.2	0.03%

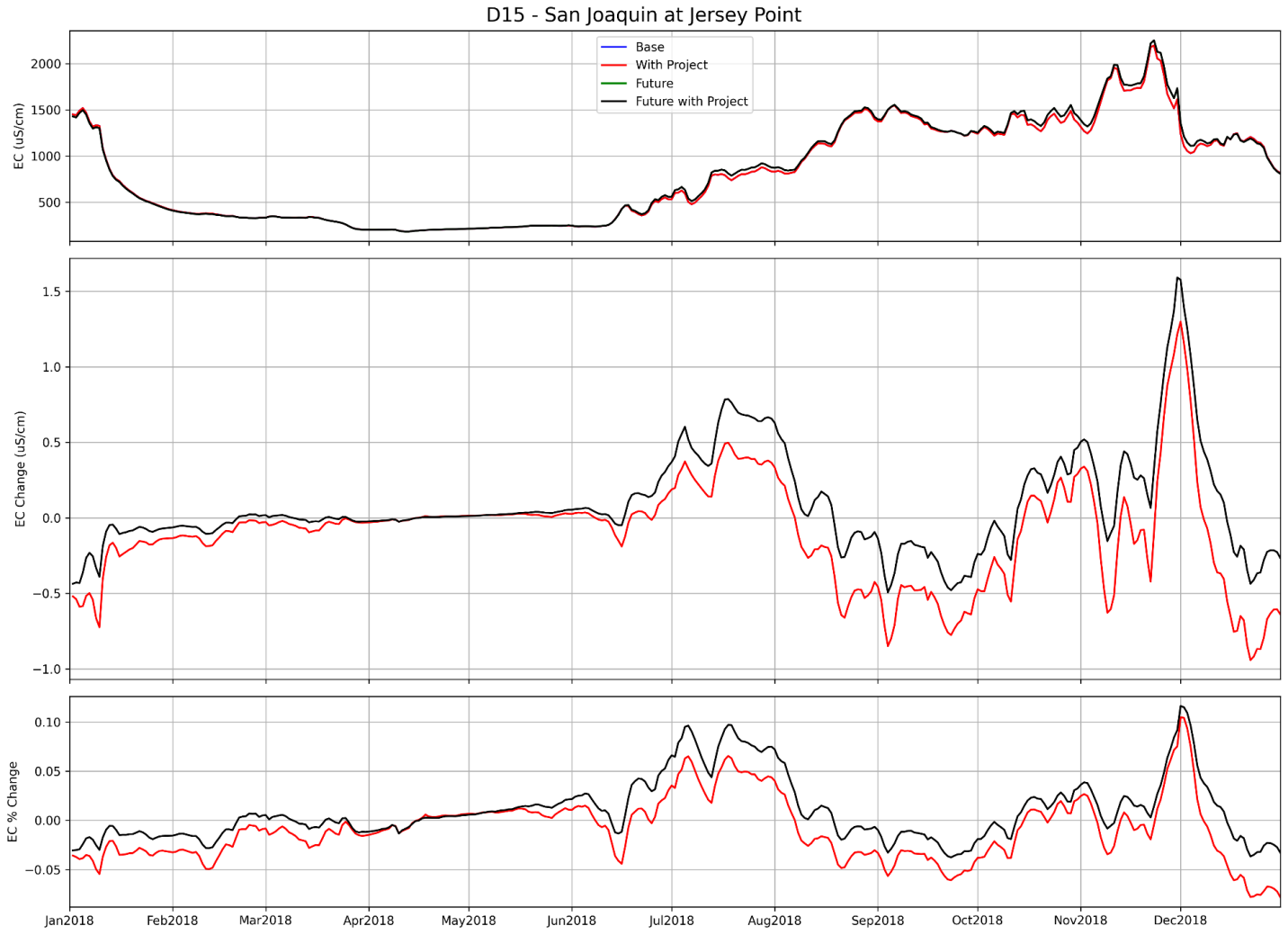
	CCWD Intake at Old River						CCWD Intake at Victoria Canal					
	Base			Future			Base			Future		
	EC	With Project EC change		EC	With Project EC change		EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2020	421	0.0	-0.01%	419	0.0	0.00%	389	0.0	0.00%	387	0.0	0.00%
Feb-2020	422	-0.1	-0.02%	419	0.0	0.00%	446	0.0	0.00%	443	0.0	0.01%
Mar-2020	425	0.0	0.00%	423	0.0	0.01%	484	0.0	0.01%	484	0.1	0.01%
Apr-2020	405	0.0	0.00%	404	0.0	0.01%	445	0.0	0.01%	445	0.1	0.01%
May-2020	405	0.0	0.01%	406	0.1	0.01%	426	0.1	0.02%	427	0.1	0.02%
Jun-2020	350	0.0	0.01%	353	0.1	0.02%	363	0.1	0.02%	365	0.1	0.02%
Jul-2020	326	0.1	0.03%	343	0.2	0.05%	272	0.0	0.01%	277	0.1	0.02%
Aug-2020	472	0.2	0.05%	511	0.4	0.07%	272	0.1	0.02%	285	0.1	0.05%
Sep-2020	678	0.5	0.07%	745	0.6	0.08%	362	0.2	0.05%	390	0.3	0.08%
Oct-2020	602	0.4	0.07%	672	0.5	0.08%	371	0.2	0.04%	405	0.3	0.07%
Nov-2020	650	0.3	0.05%	713	0.5	0.08%	461	0.1	0.02%	496	0.3	0.05%
Dec-2020	698	0.1	0.02%	738	0.4	0.06%	546	0.0	0.00%	570	0.2	0.04%

	CCWD Intake at Mallard Slough					
	Base			Future		
	EC	With Project EC change		EC	With Project EC change	
	µS/cm	µS/cm	%	µS/cm	µS/cm	%
Jan-2020	4451	0.5	0.01%	4443	0.2	0.01%
Feb-2020	3228	0.6	0.02%	3237	0.4	0.01%
Mar-2020	4026	0.9	0.02%	4055	0.6	0.01%
Apr-2020	3560	0.6	0.02%	3569	0.3	0.01%
May-2020	5651	1.1	0.02%	5678	0.8	0.01%
Jun-2020	6544	1.0	0.02%	6568	0.7	0.01%
Jul-2020	9241	1.0	0.01%	9267	0.5	0.01%
Aug-2020	11854	0.1	0.00%	11847	-0.5	0.00%
Sep-2020	11681	-0.8	-0.01%	11618	-1.3	-0.01%
Oct-2020	14046	-1.4	-0.01%	13969	-1.8	-0.01%
Nov-2020	13532	-0.6	0.00%	13479	-1.3	-0.01%
Dec-2020	12533	0.9	0.01%	12547	0.2	0.00%



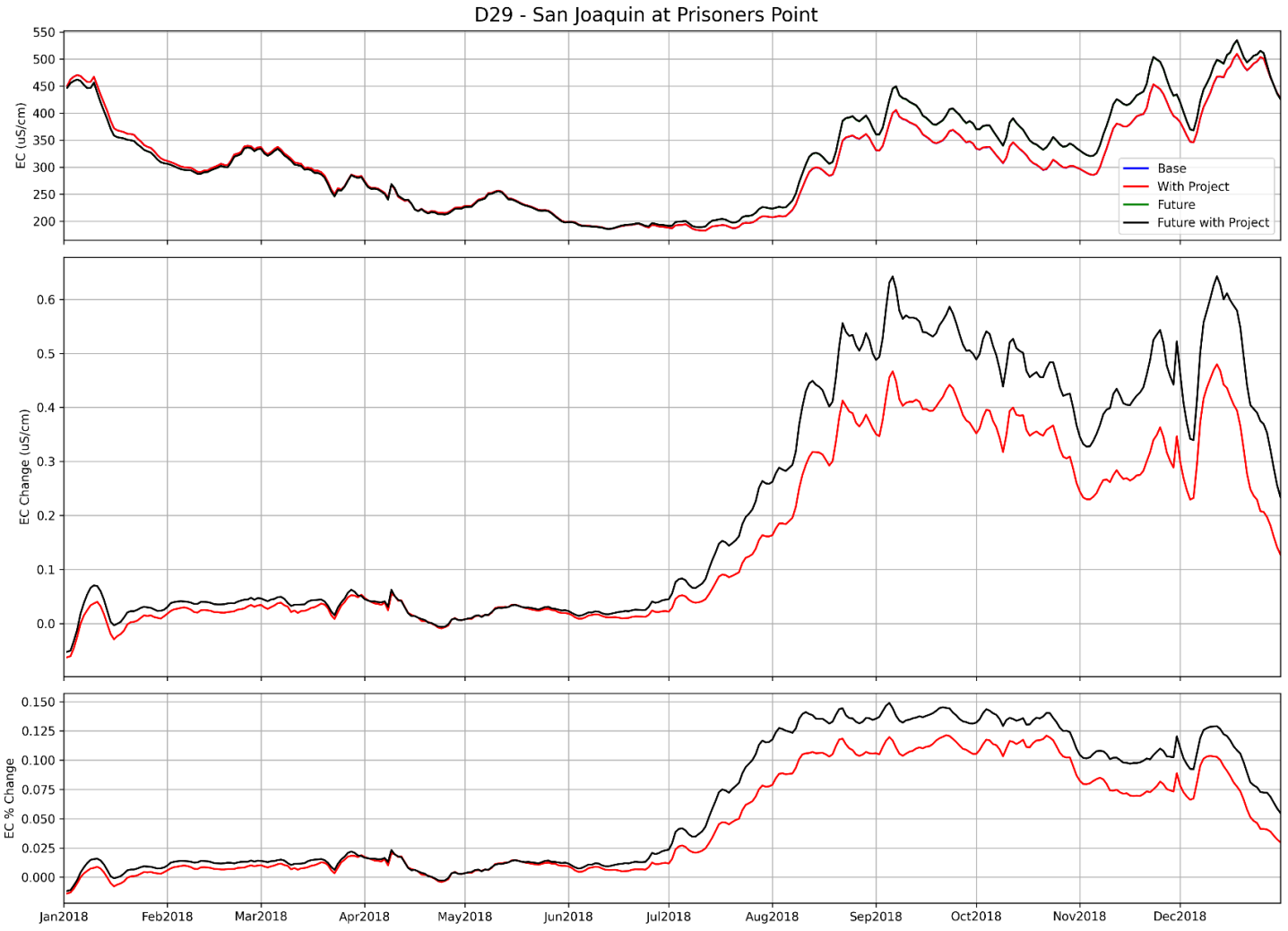
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 17 Daily average EC at station D22 – Sacramento River at Emmaton for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



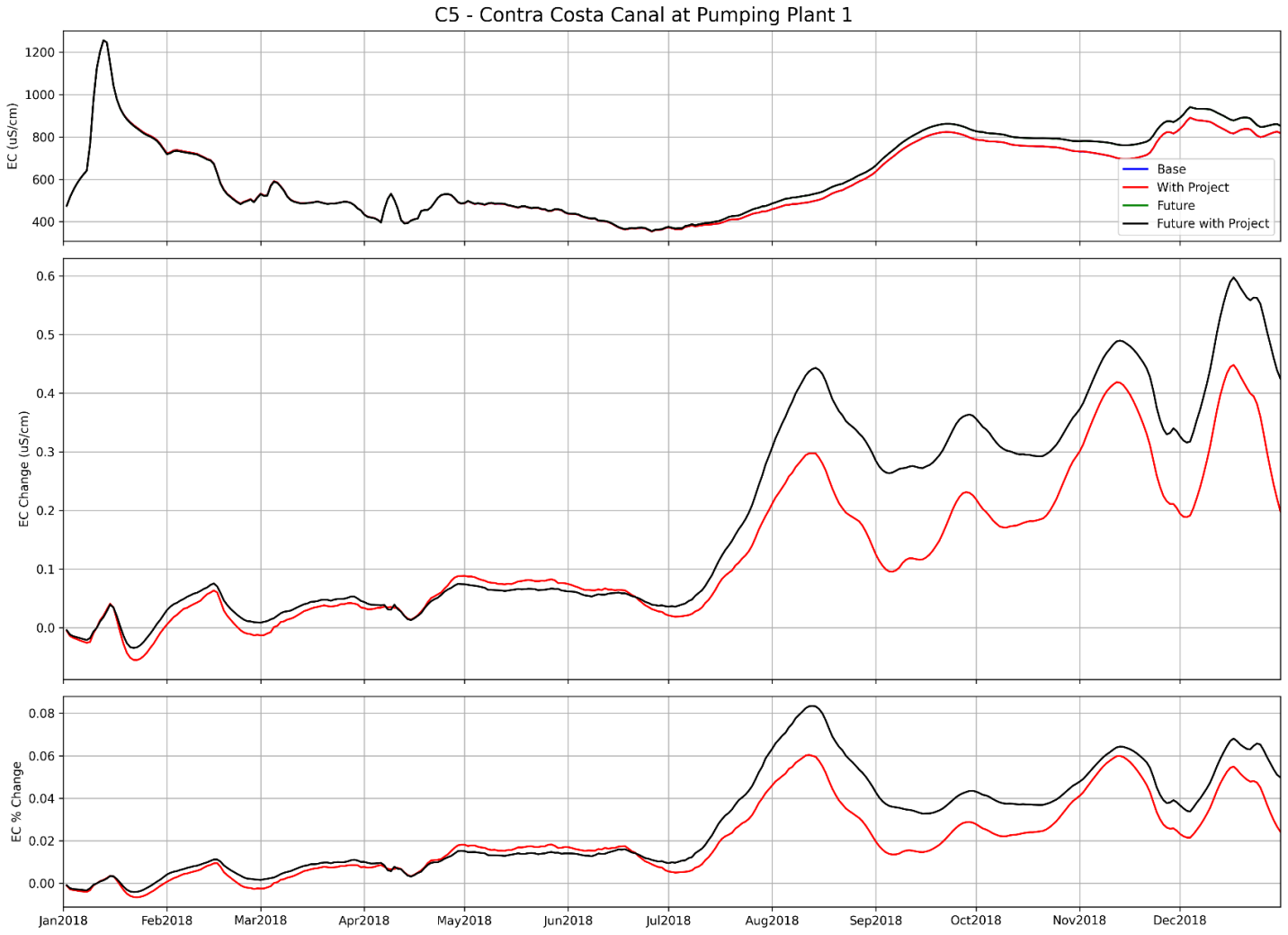
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 18 Daily average EC at station D15 - San Joaquin River at Jersey Point for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



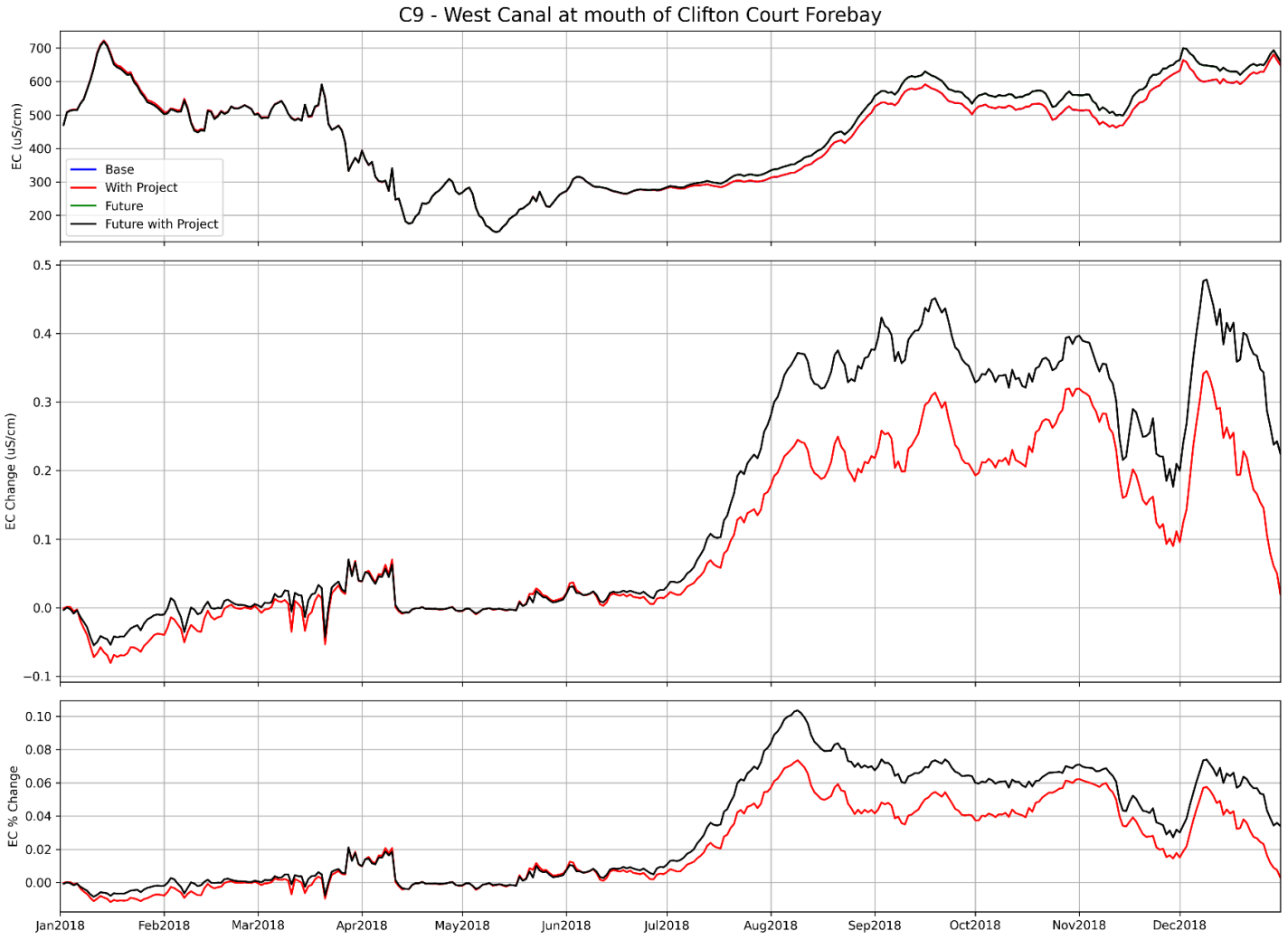
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 19 Daily average EC at station D29 - San Joaquin River at Prisoners Point for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



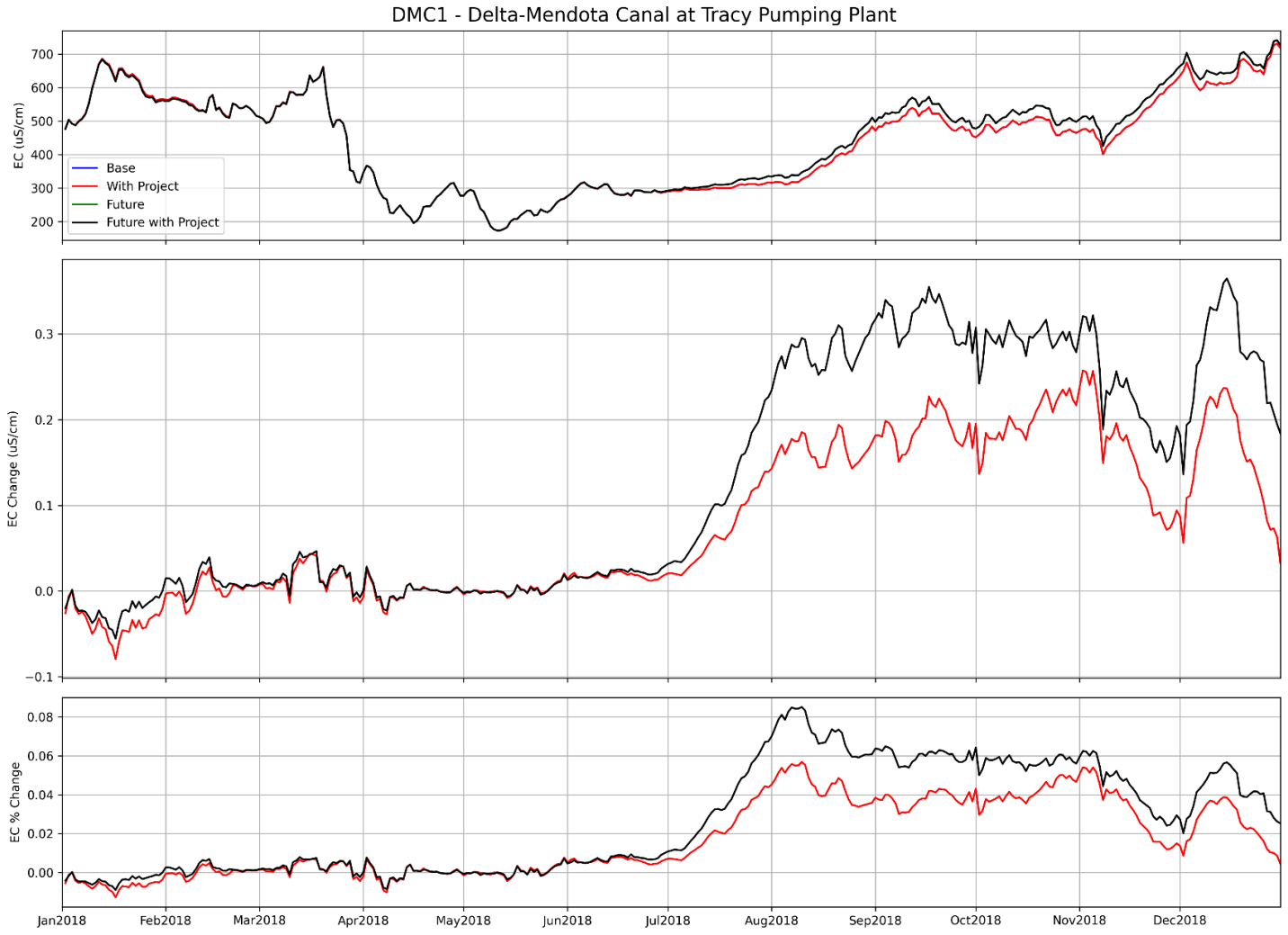
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 20 Daily average EC at station C5 - Contra Costa Canal at Pumping Plant 1 for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



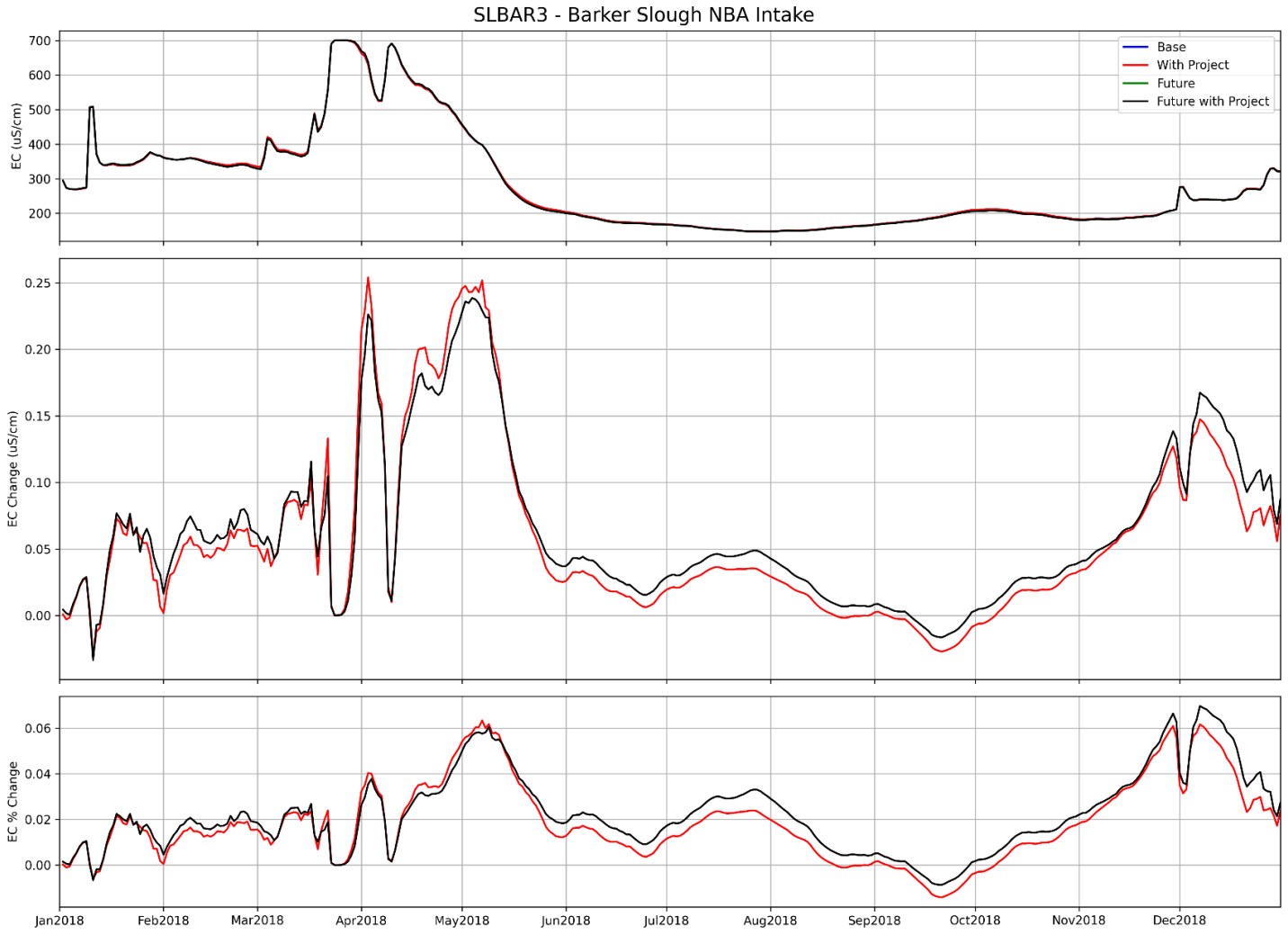
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 21 Daily average EC at station C9 – West Canal at Clifton Court Forebay for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



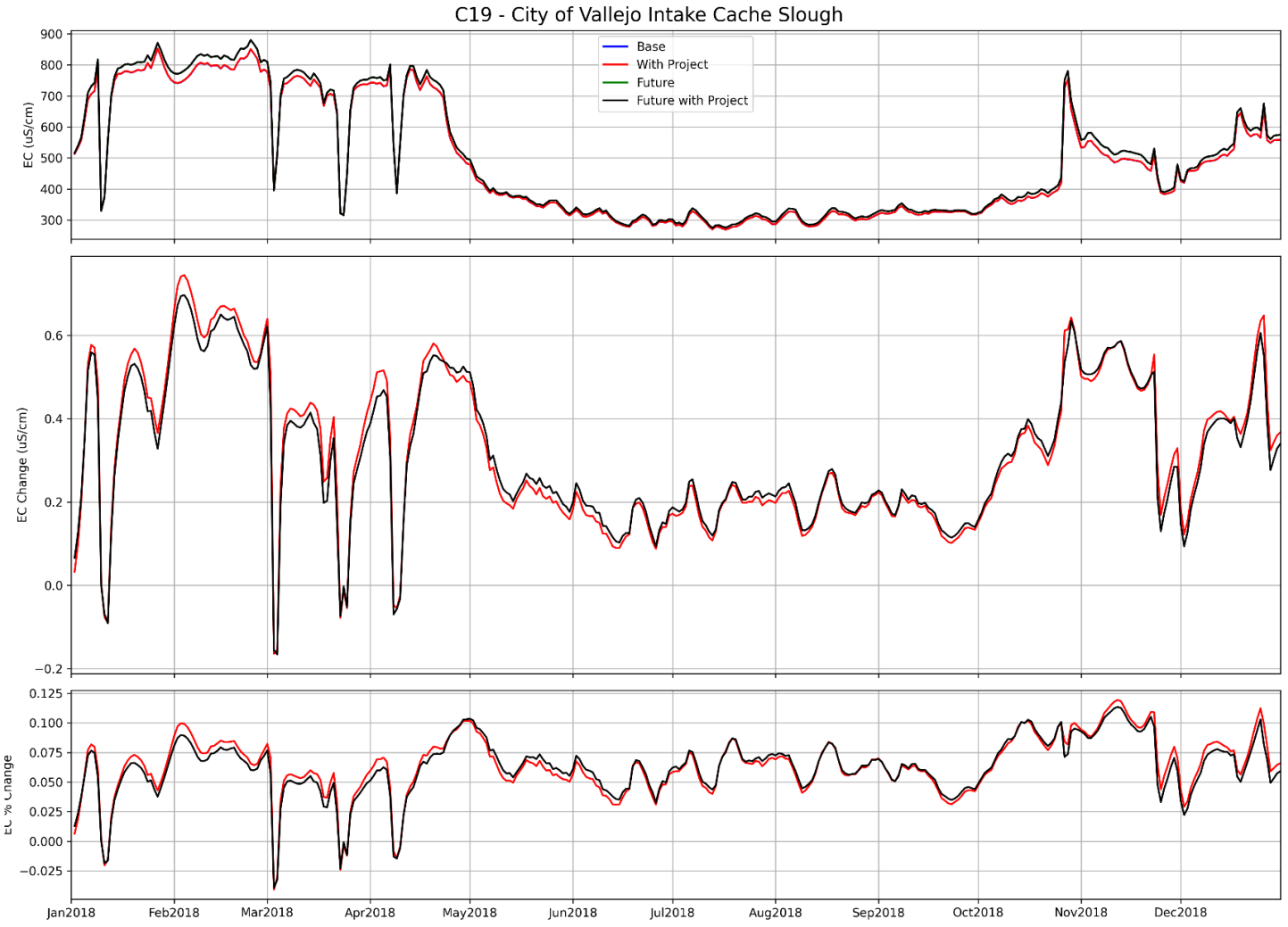
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 22 Daily average EC at station DMC1 – Delta-Mendota Canal at Tracy PP for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



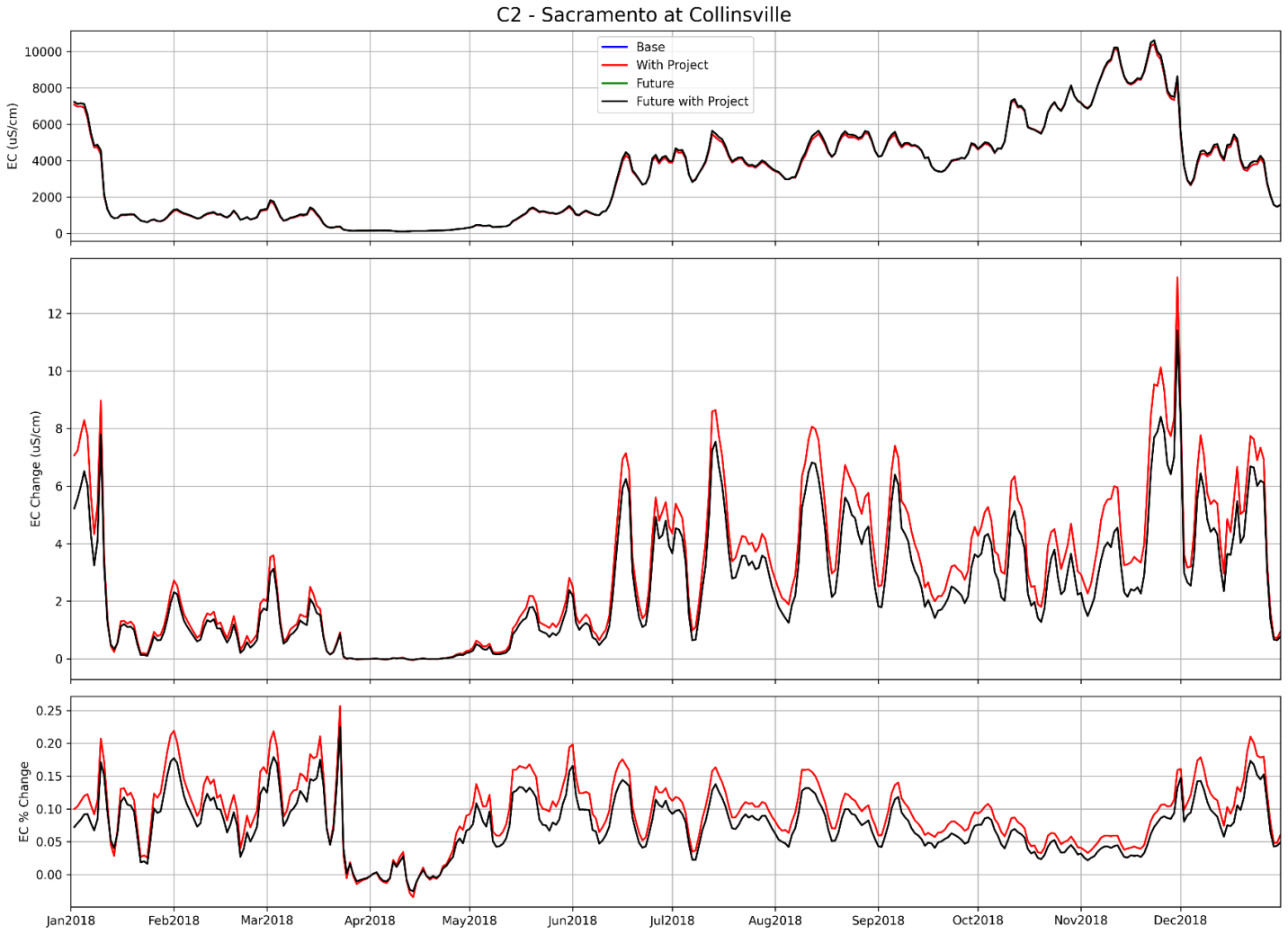
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 23 Daily average EC at station SLBAR3 – Barker Slough at NBA Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



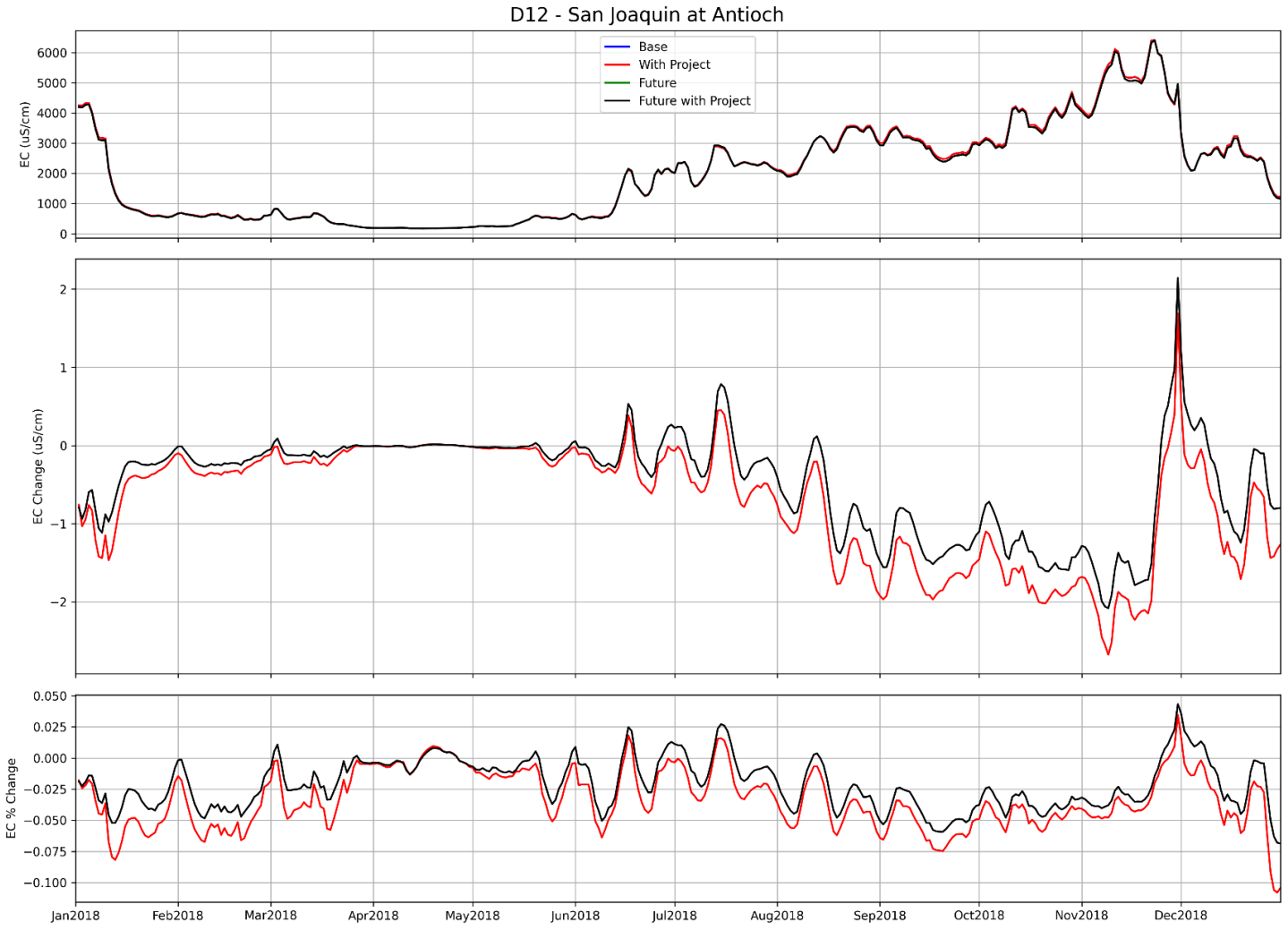
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 24 Daily average EC at station C19 – Cache Slough at City of Vallejo Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



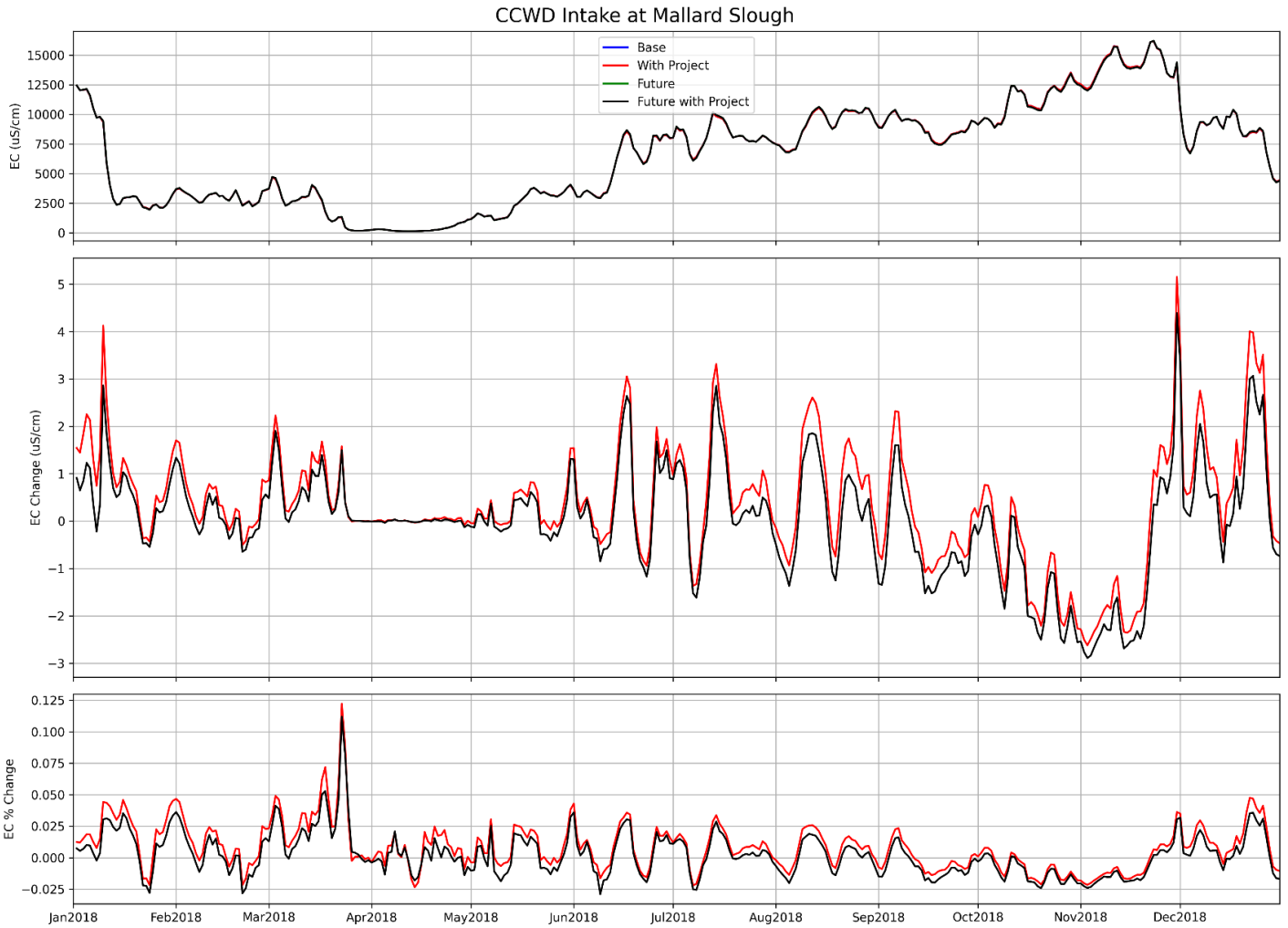
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 25 Daily average EC at station C2 – Sacramento River at Collinsville for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



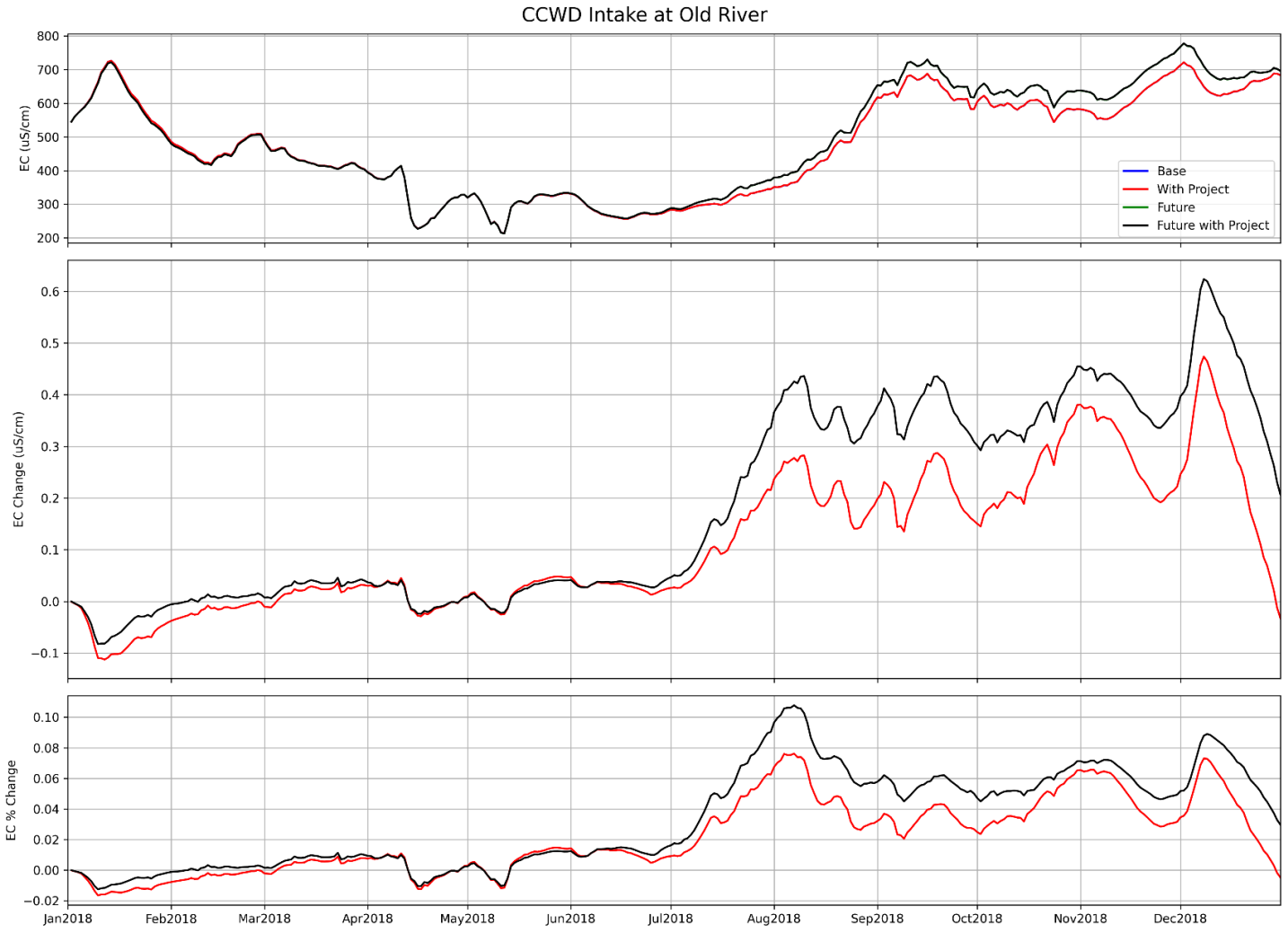
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 26 Daily average EC at station D12 – San Joaquin River at Antioch Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



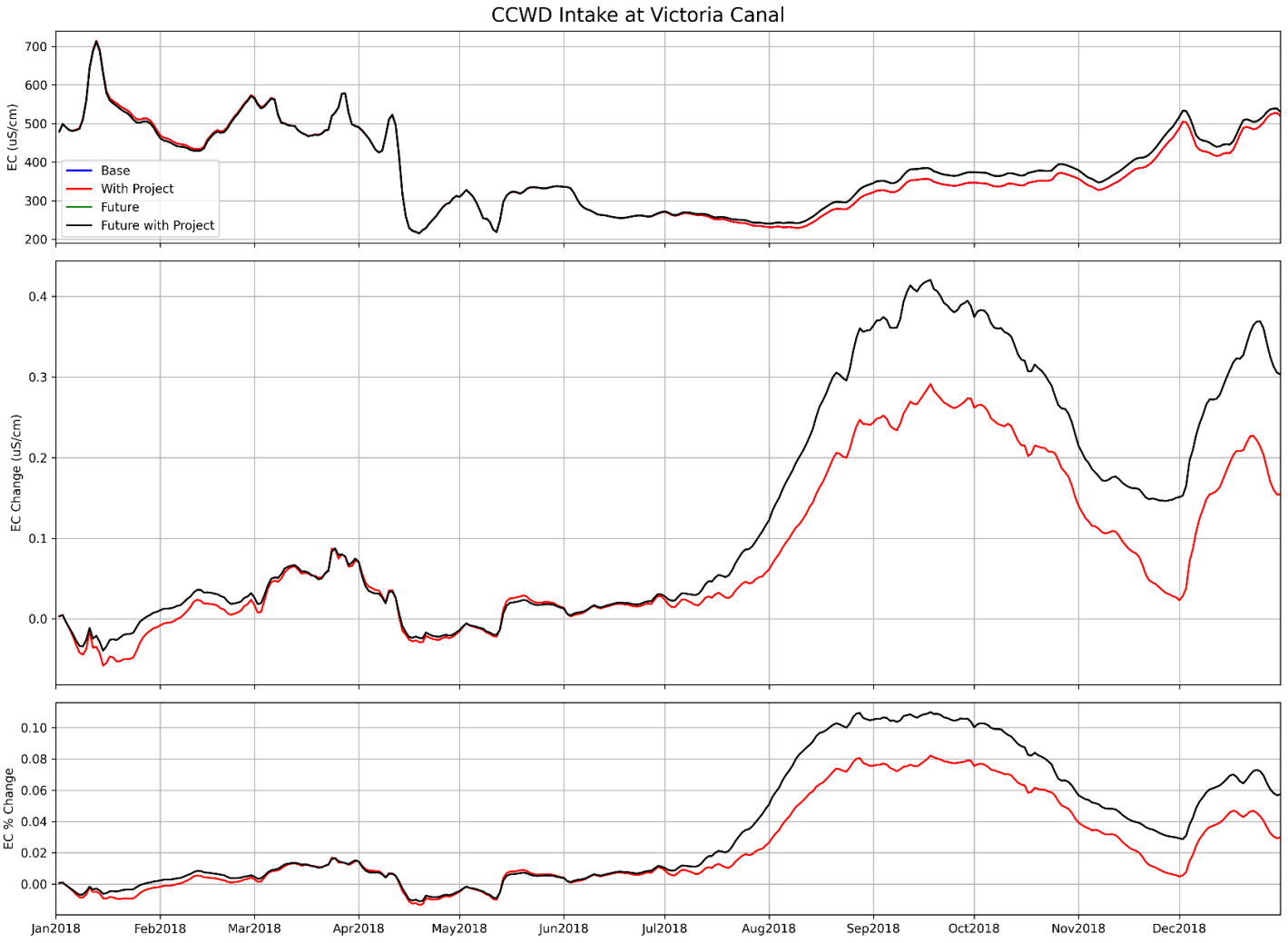
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 27 Daily average EC at station for Contra Costa Water District – Mallard Slough Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



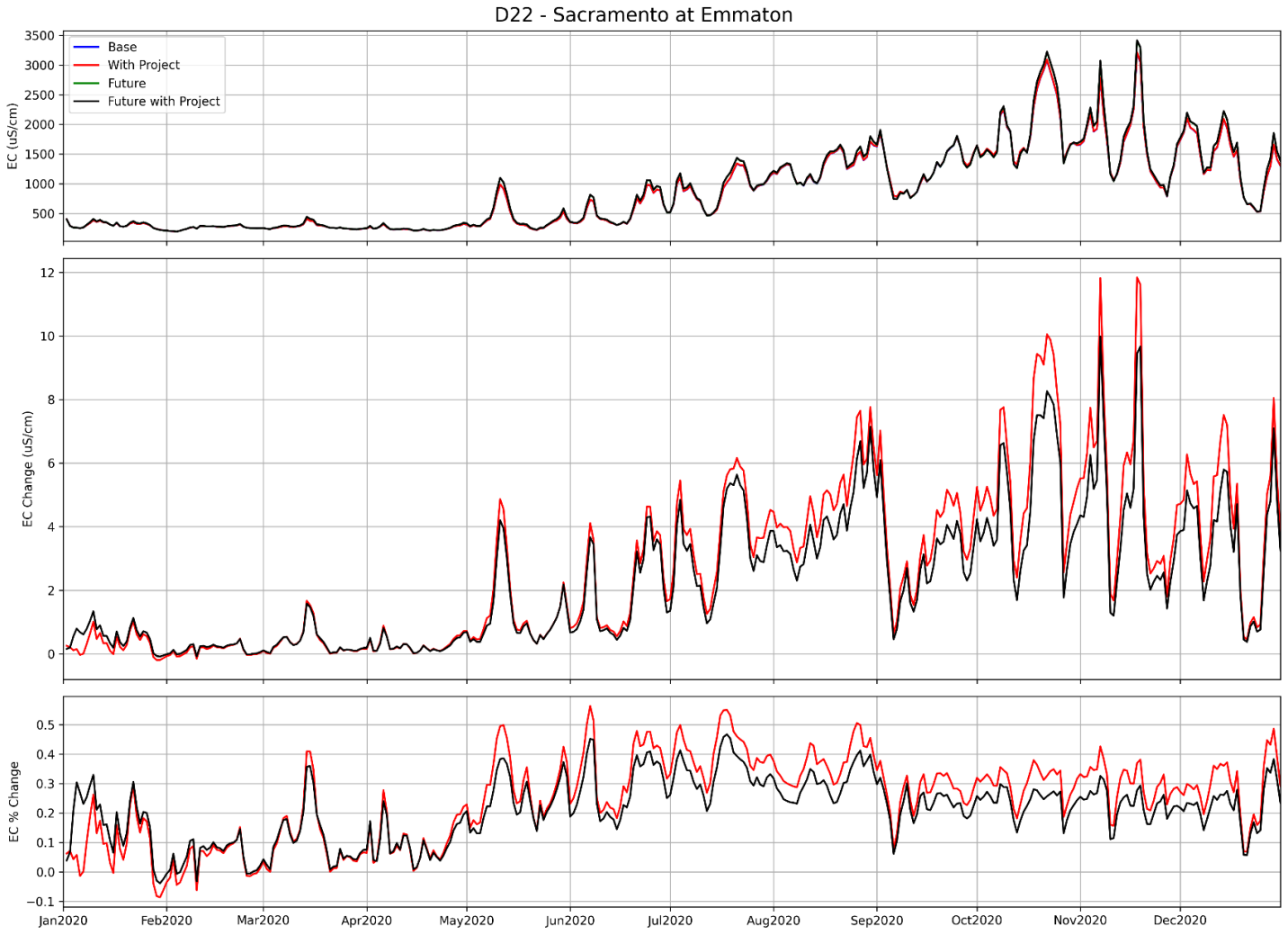
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 28 Daily average EC at Contra Costa Water District – Old River Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



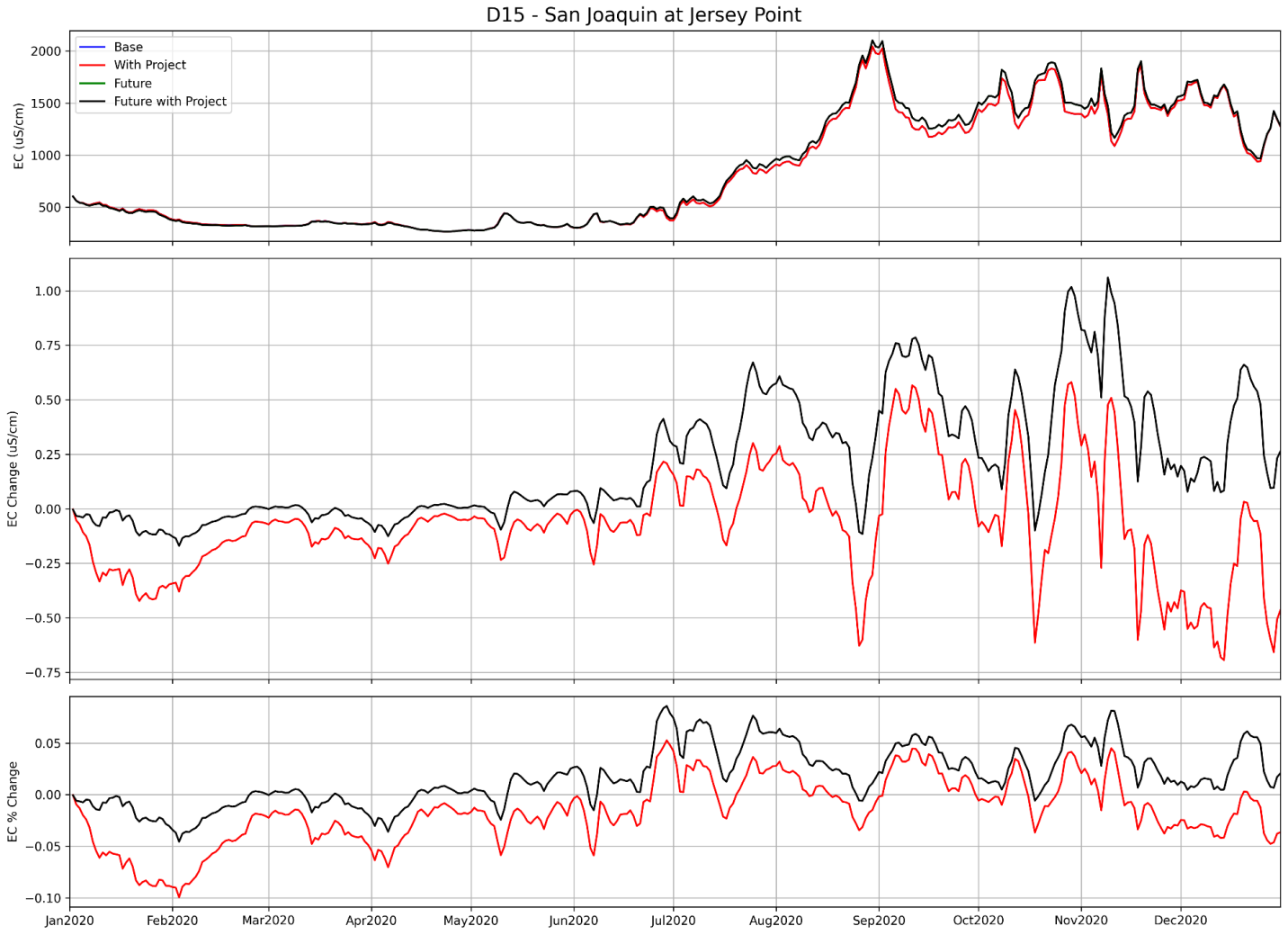
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 29 Daily average EC at Contra Costa Water District – Victoria Canal Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2018 simulation period.



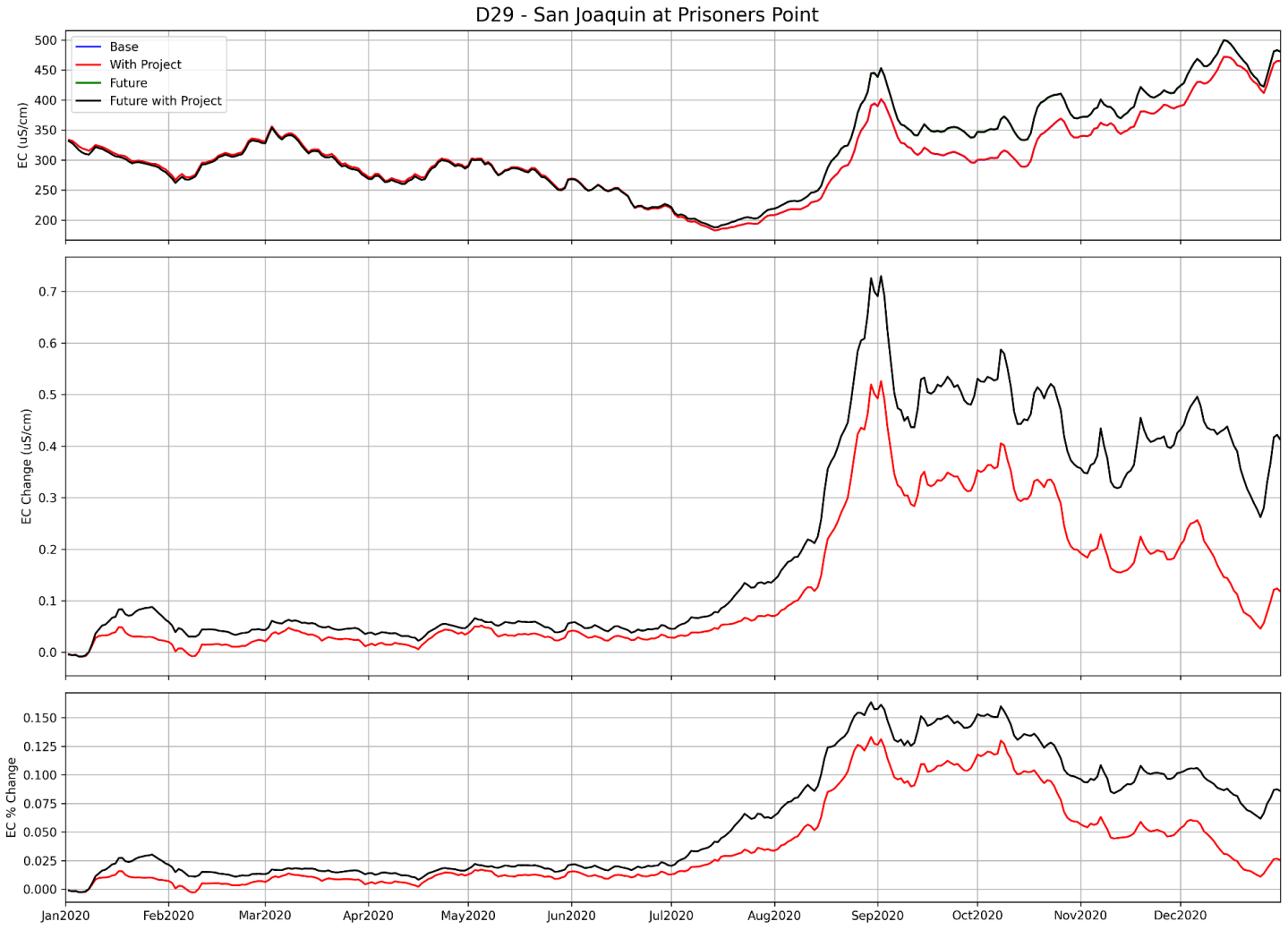
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 30 Daily average EC at station D22 – Sacramento River at Emmaton for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



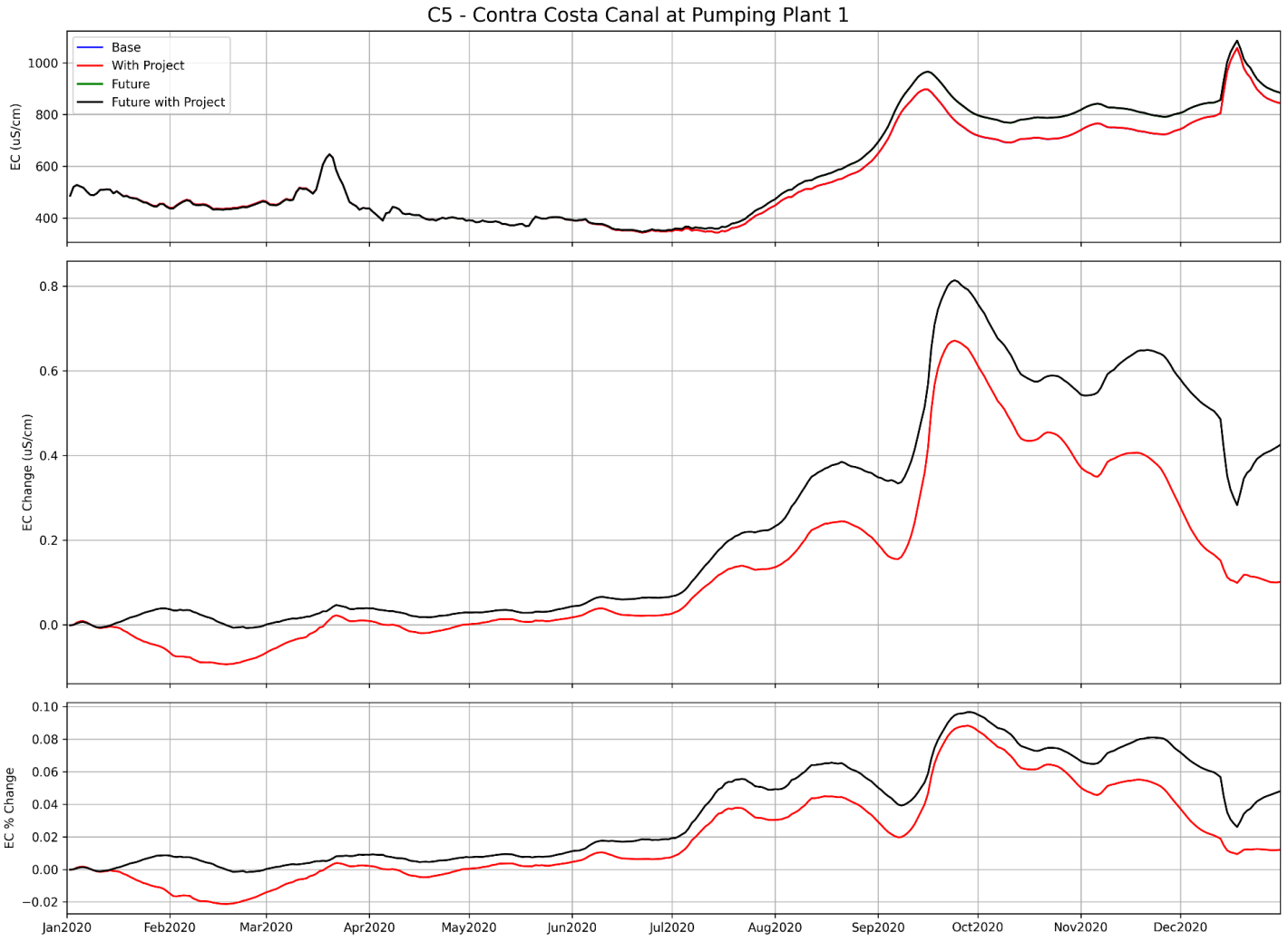
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 31 Daily average EC at station D15 - San Joaquin River at Jersey Point for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



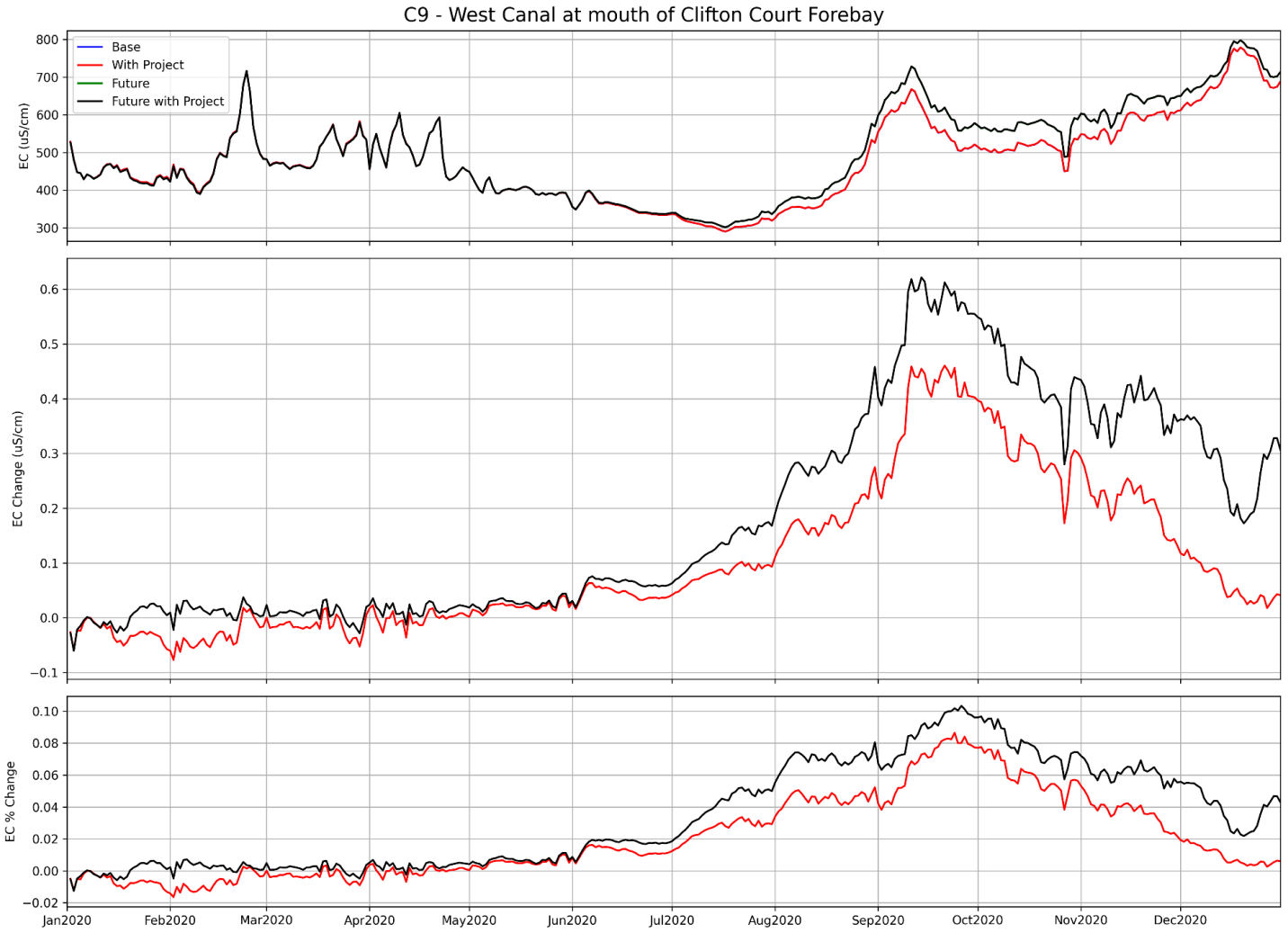
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 32 Daily average EC at station D29 - San Joaquin River at Prisoners Point for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



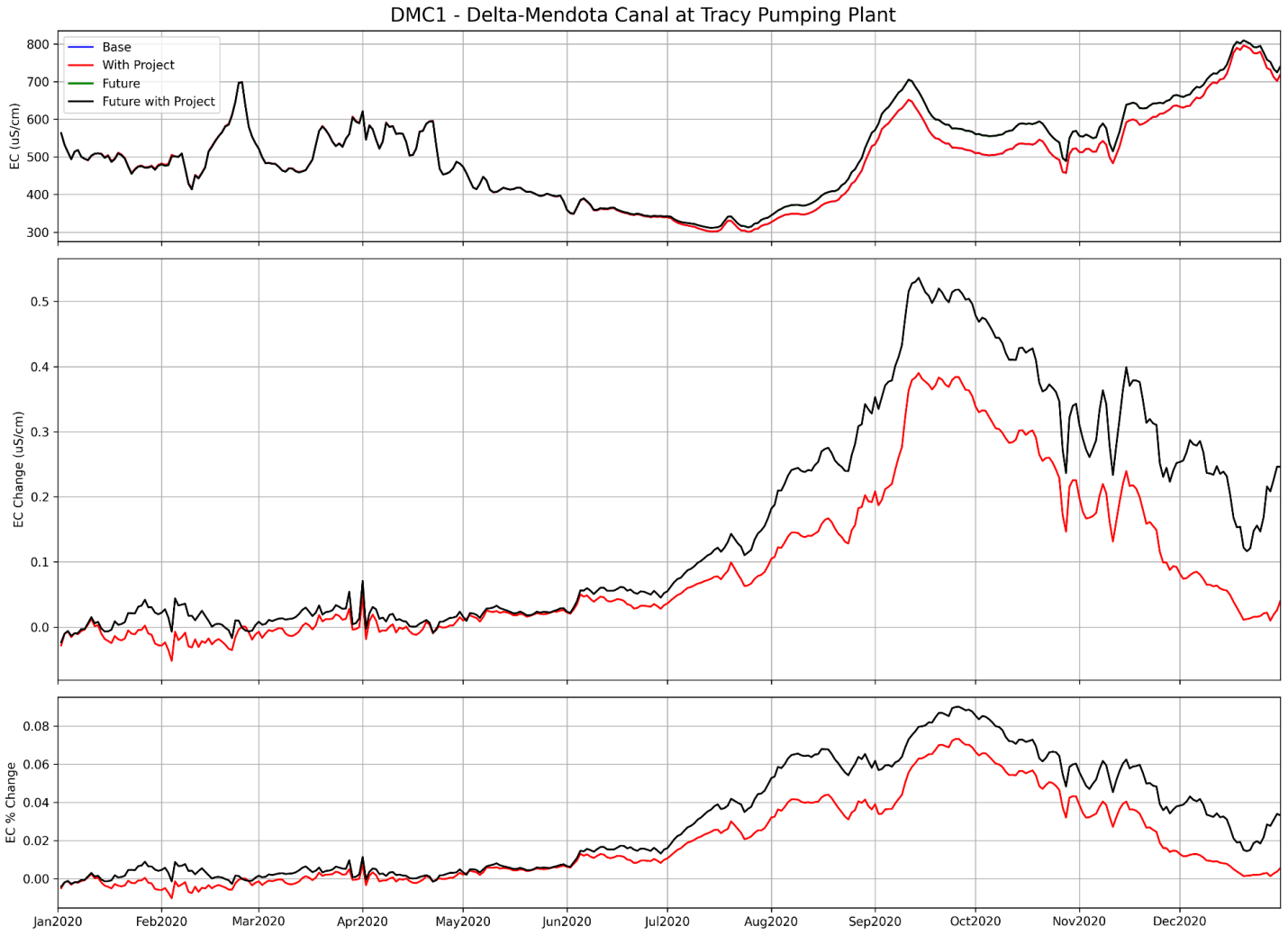
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 33 Daily average EC at station C5 - Contra Costa Canal at Pumping Plant 1 for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



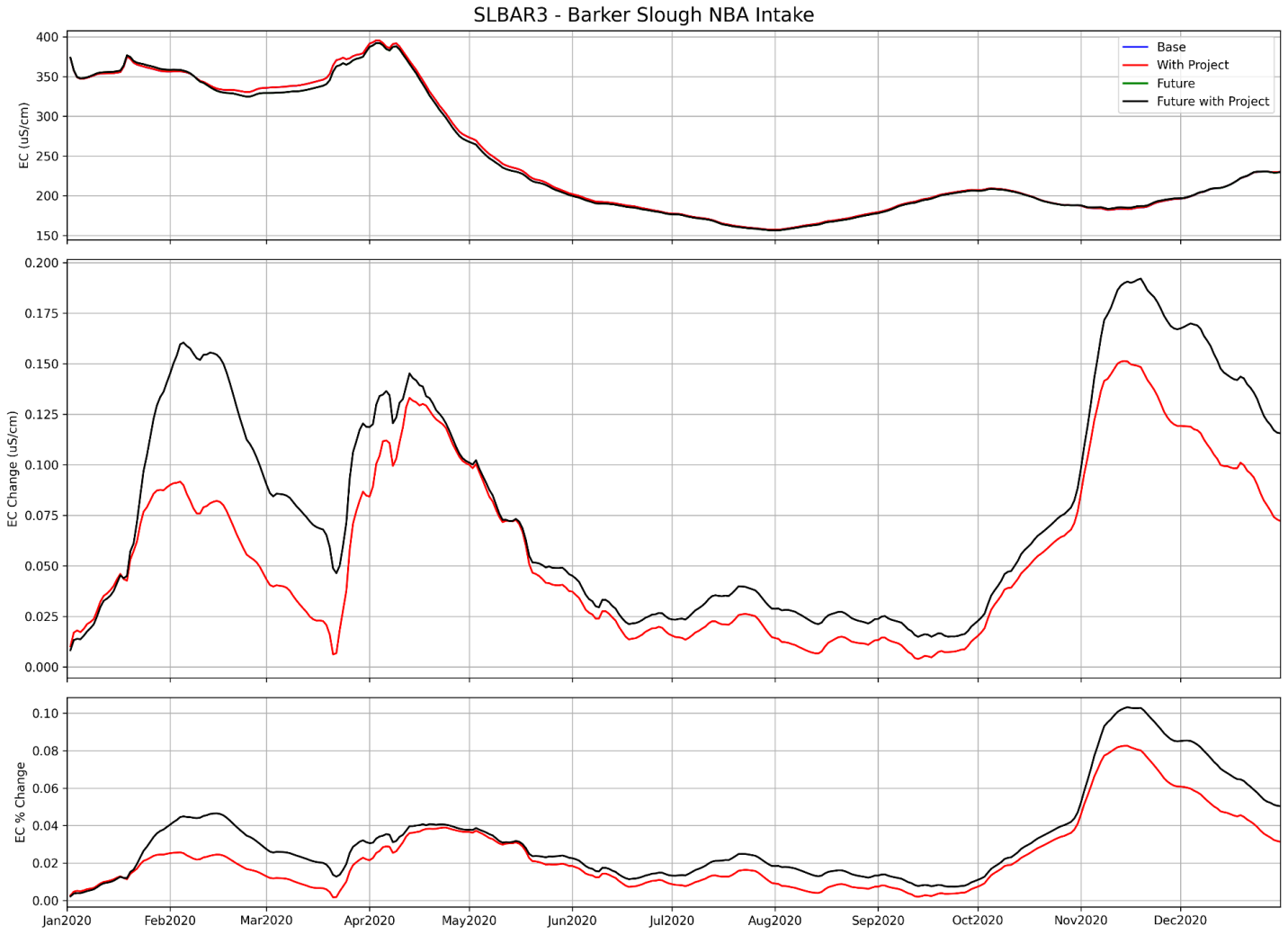
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 34 Daily average EC at station C9 – West Canal at Clifton Court Forebay for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



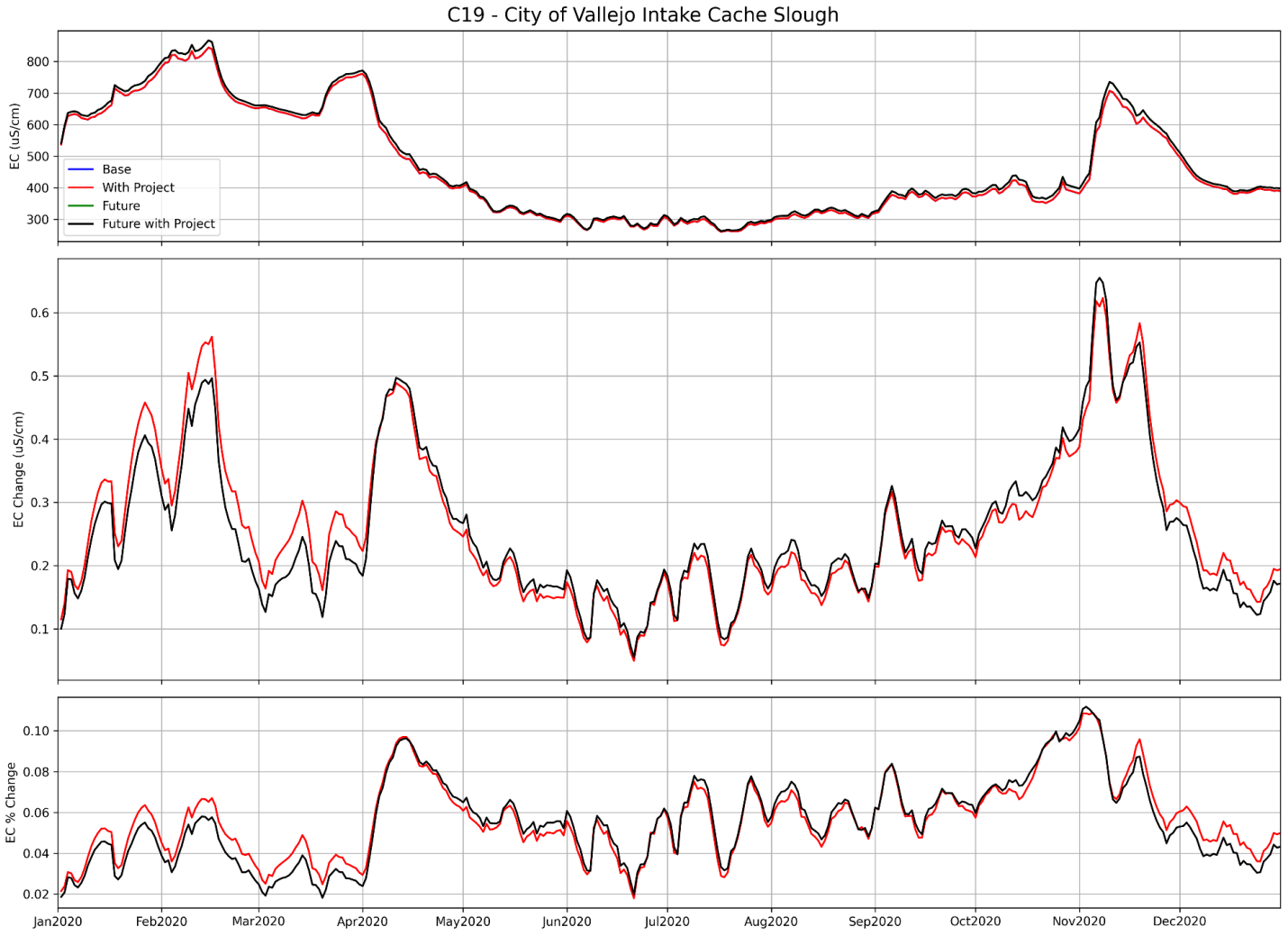
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 35 Daily average EC at station DMC1 – Delta-Mendota Canal at Tracy PP for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



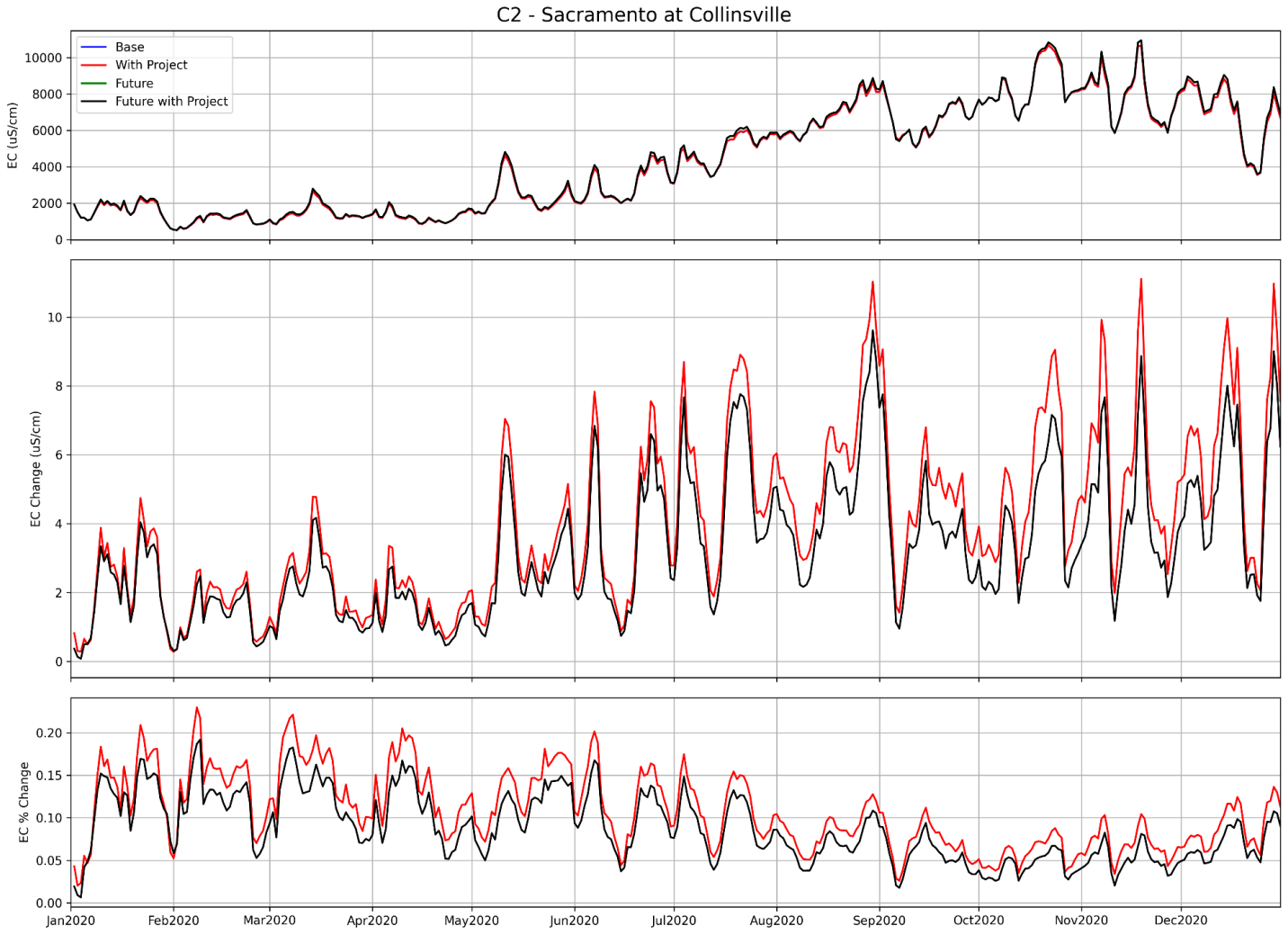
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 36 Daily average EC at station SLBAR3 – Barker Slough at NBA Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



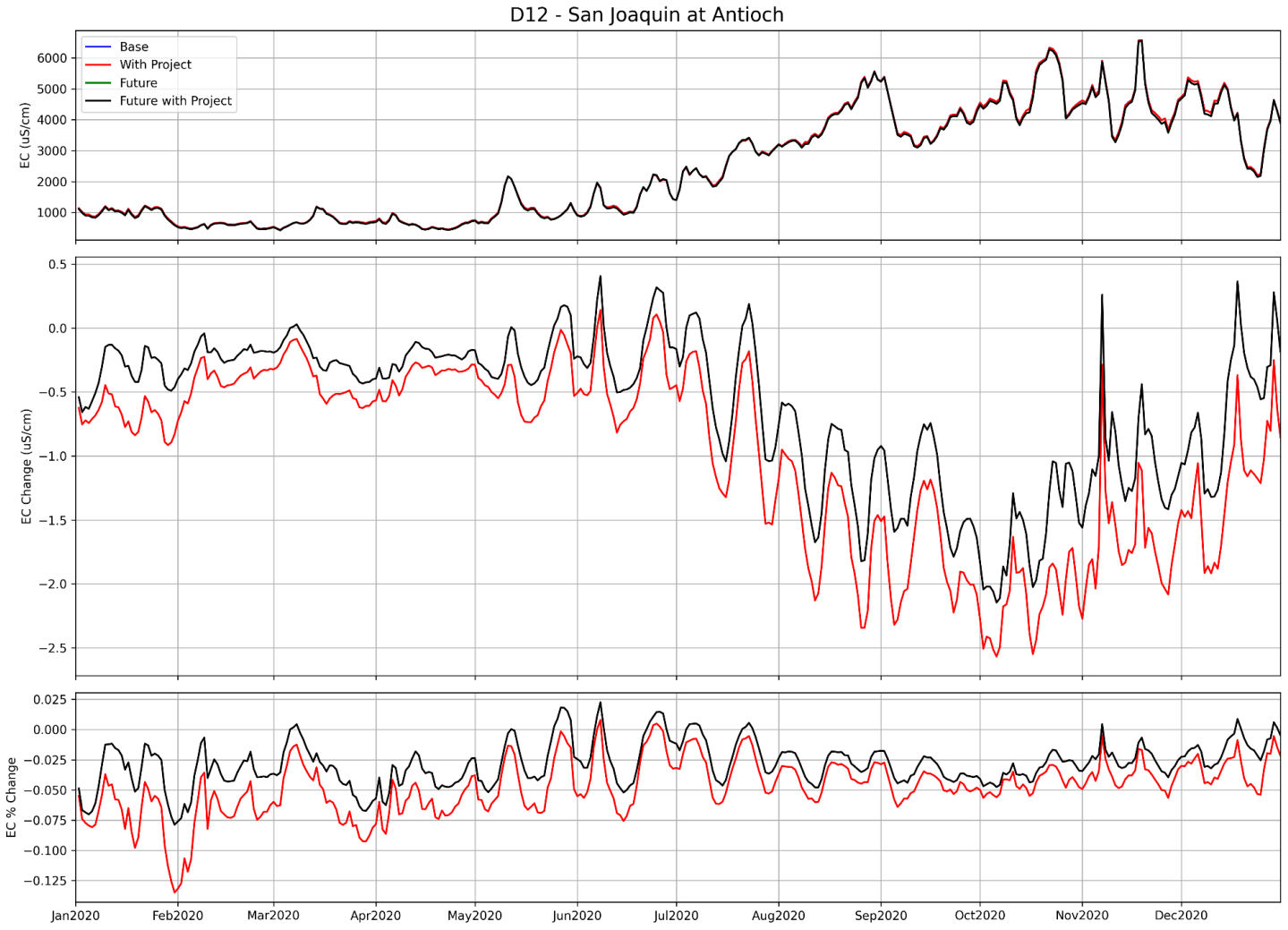
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 37 Daily average EC at station C19 – Cache Slough at City of Vallejo Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



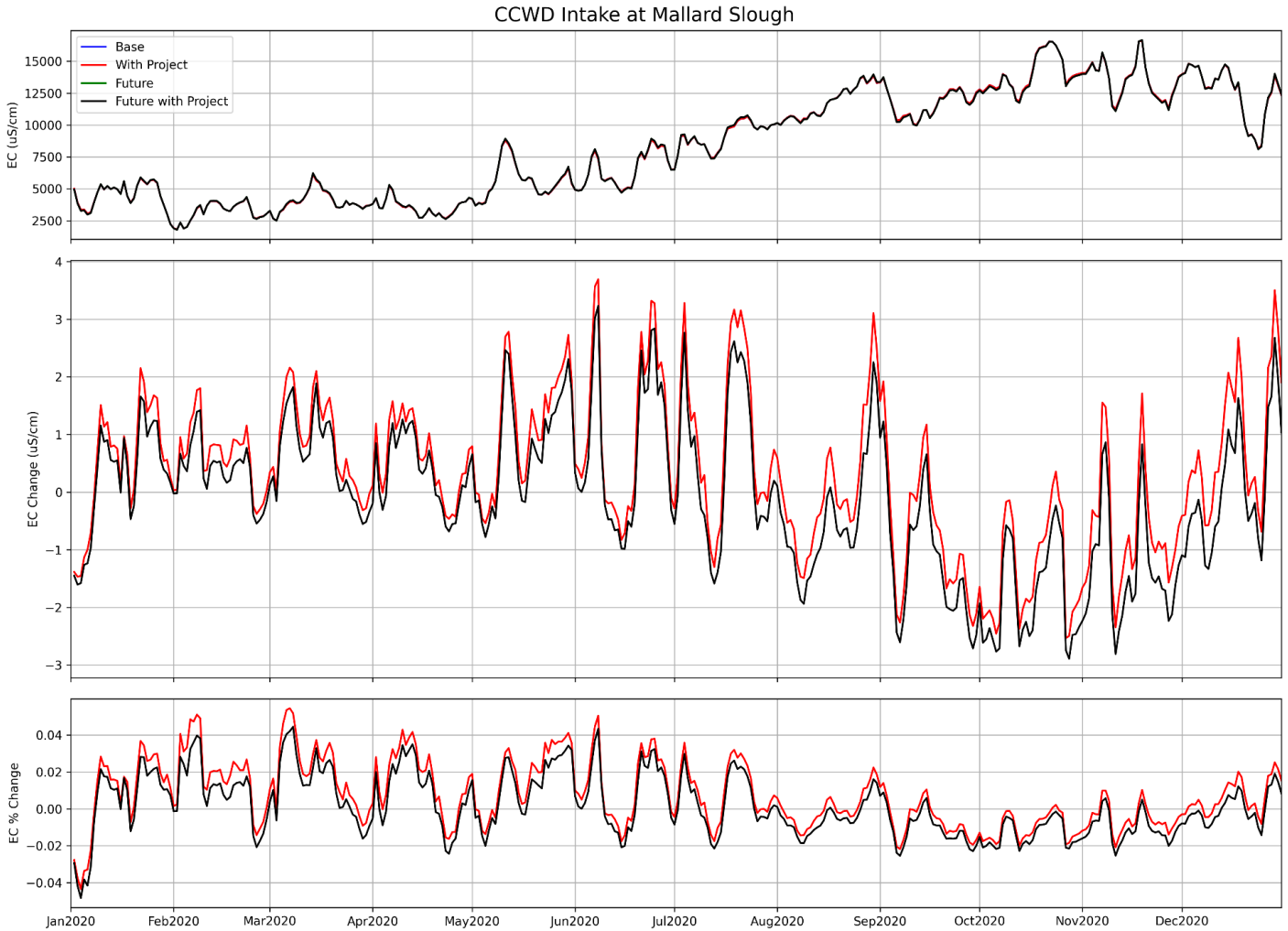
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 38 Daily average EC at station C2 – Sacramento River at Collinsville for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



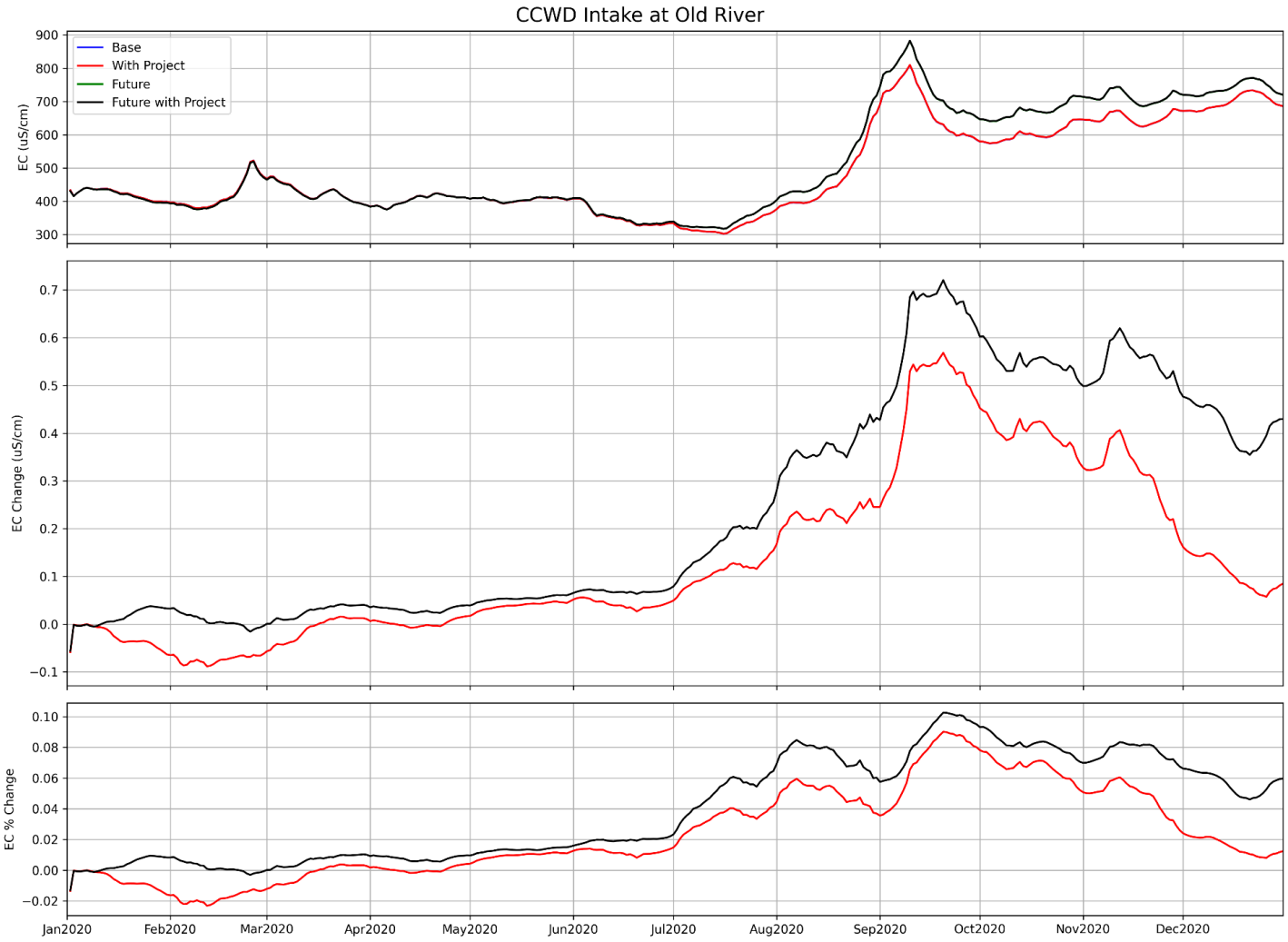
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 39 Daily average EC at station D12 – San Joaquin River at Antioch Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



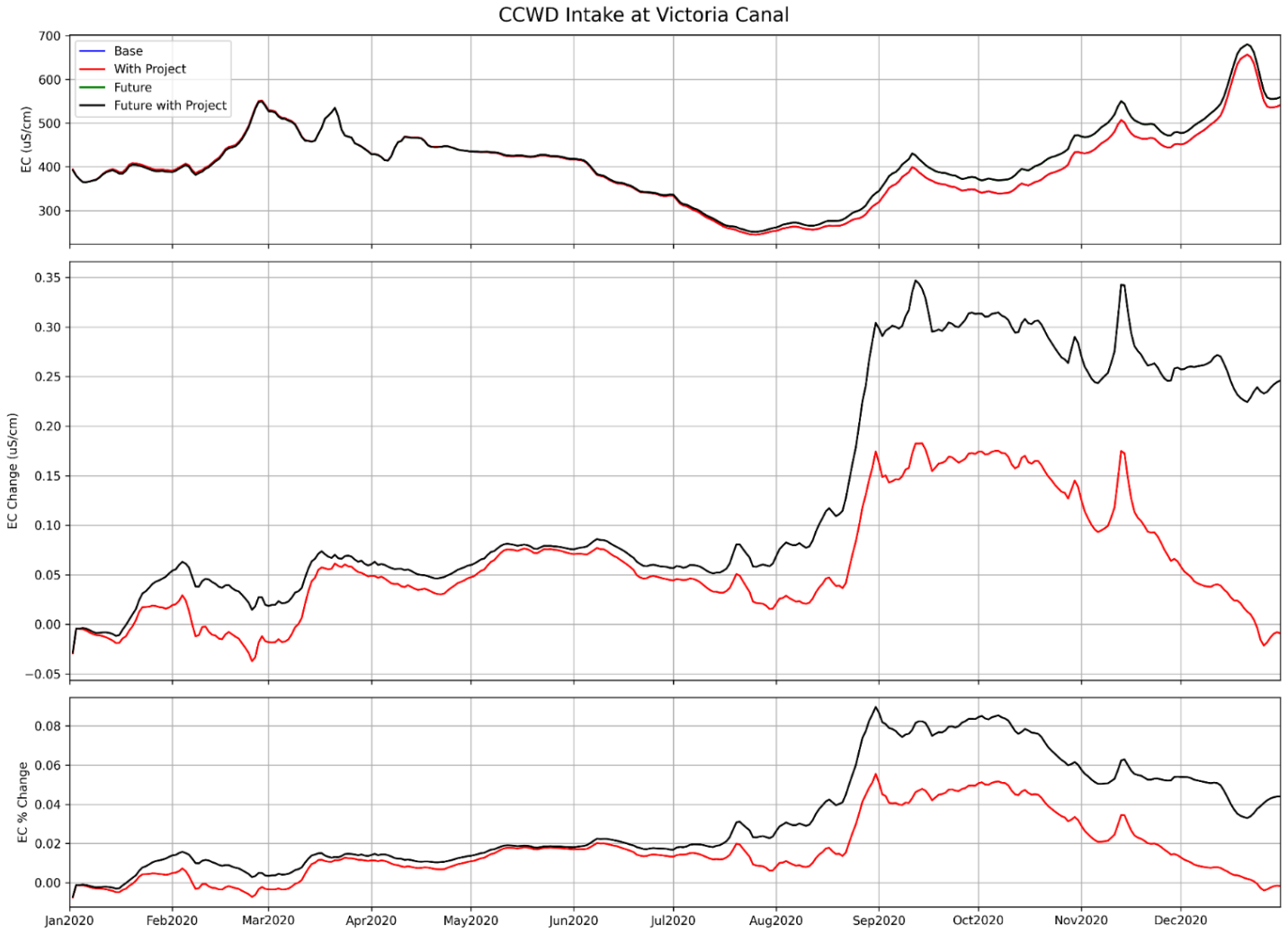
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 40 Daily average EC at station for Contra Costa Water District – Mallard Slough Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 41 Daily average EC at Contra Costa Water District – Old River Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.



Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 42 Daily average EC at Contra Costa Water District – Victoria Canal Intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) EC change with the Project for the 2020 simulation period.

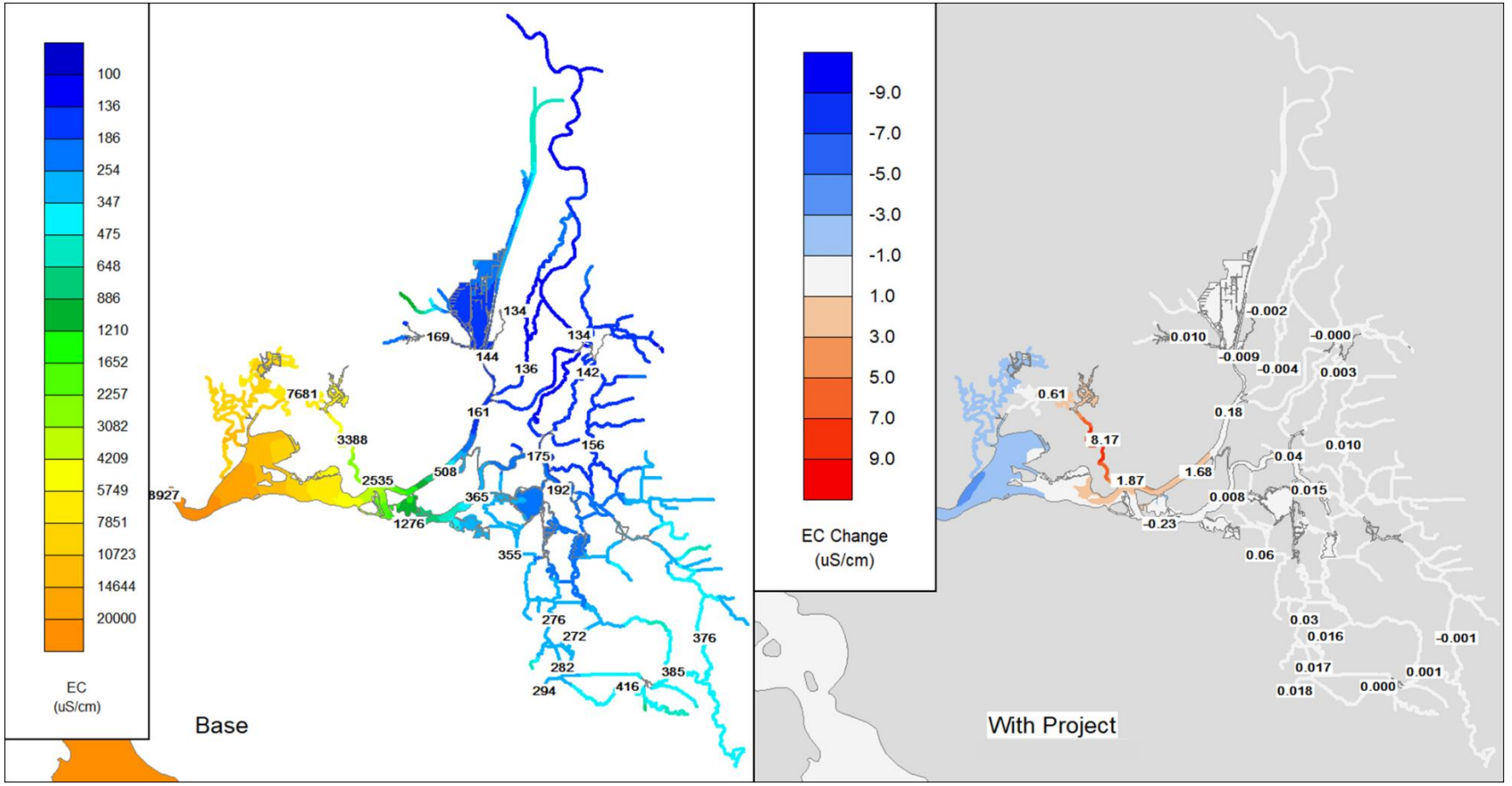


Figure 43 June 2018 (left) average Base condition EC and (right) With Project change from Base condition average EC.

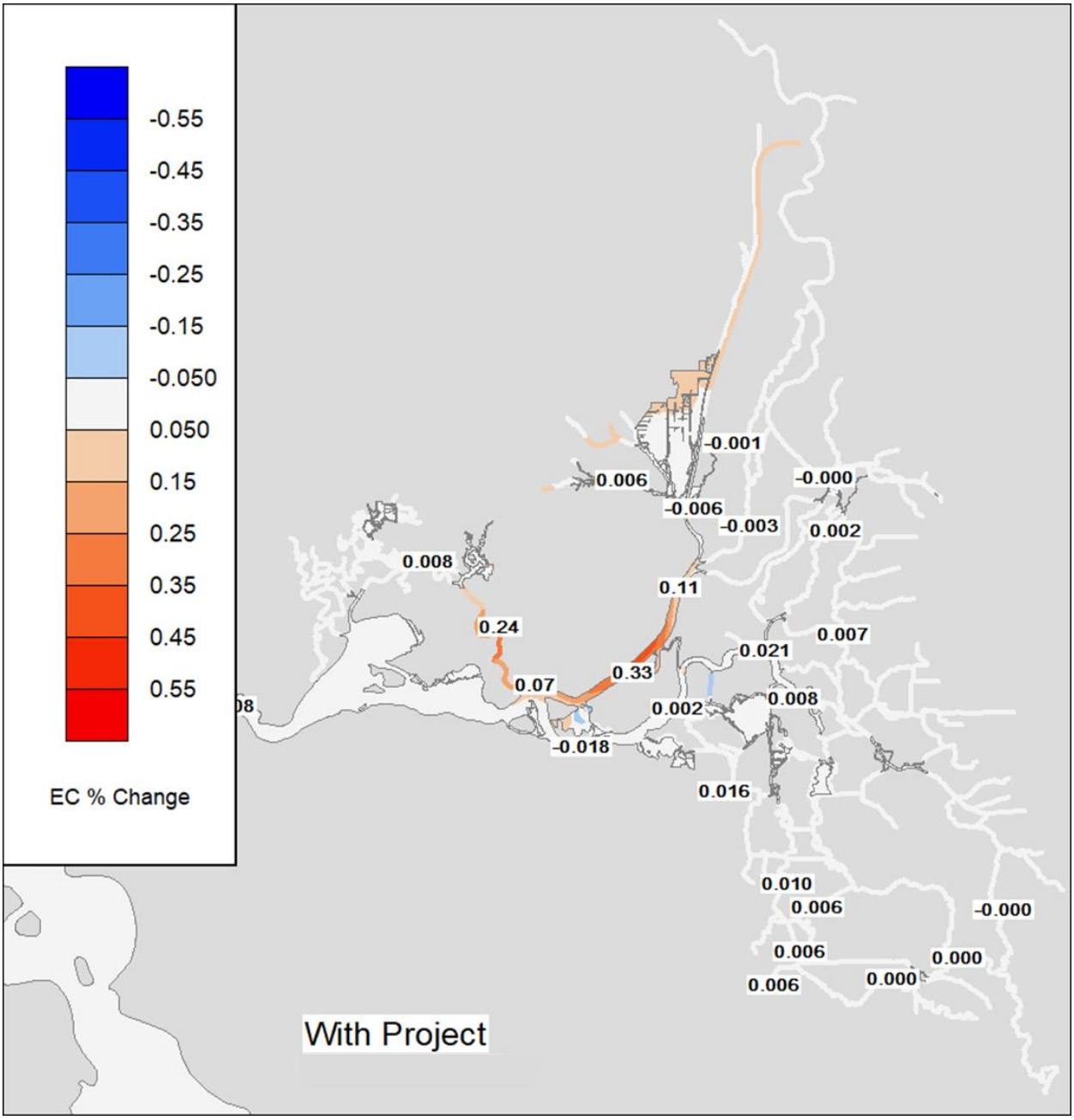


Figure 44 With Project average percent change from Base EC for June 2018.

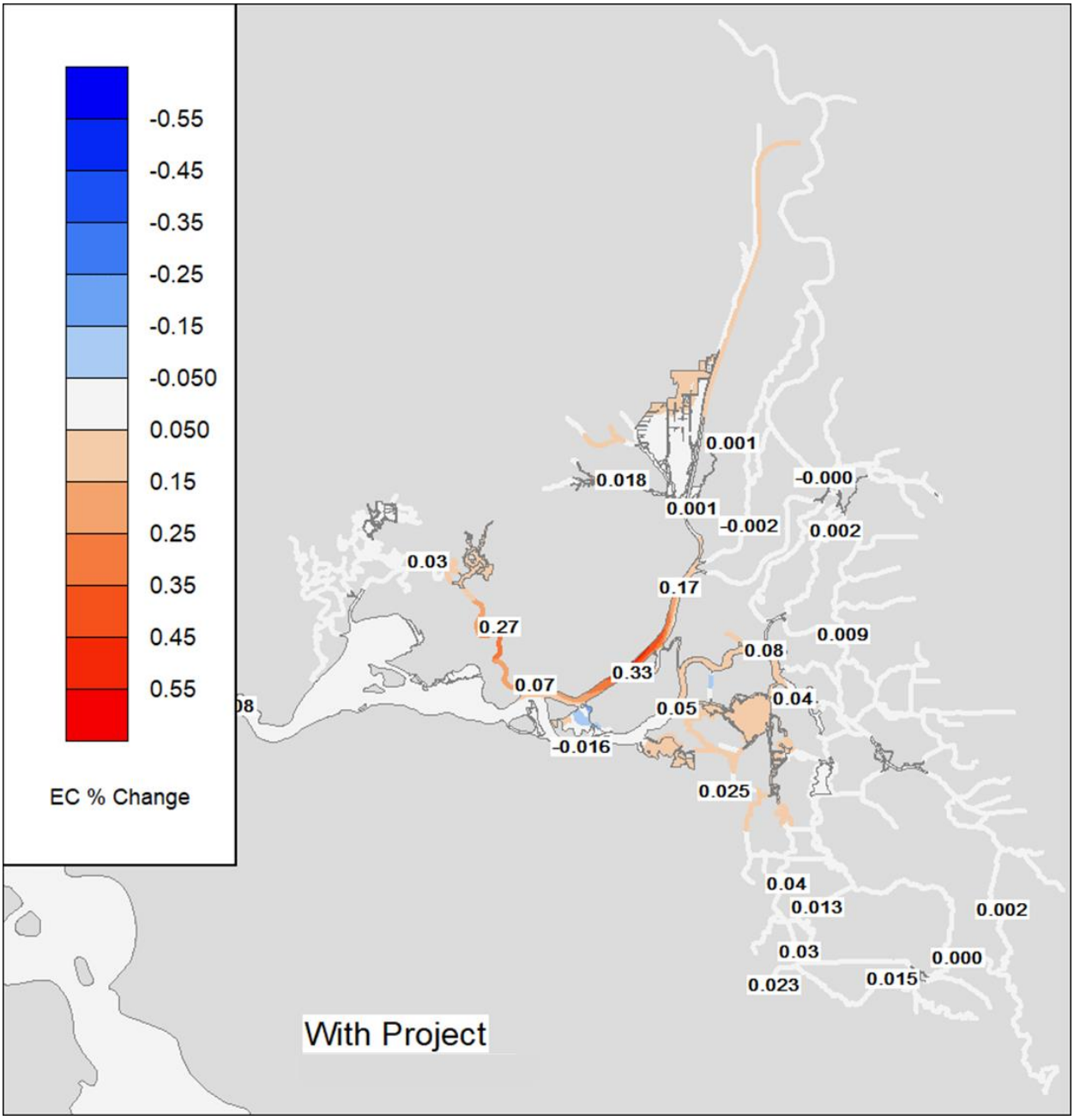


Figure 45 With Project average percent change from Base EC for July 2018.

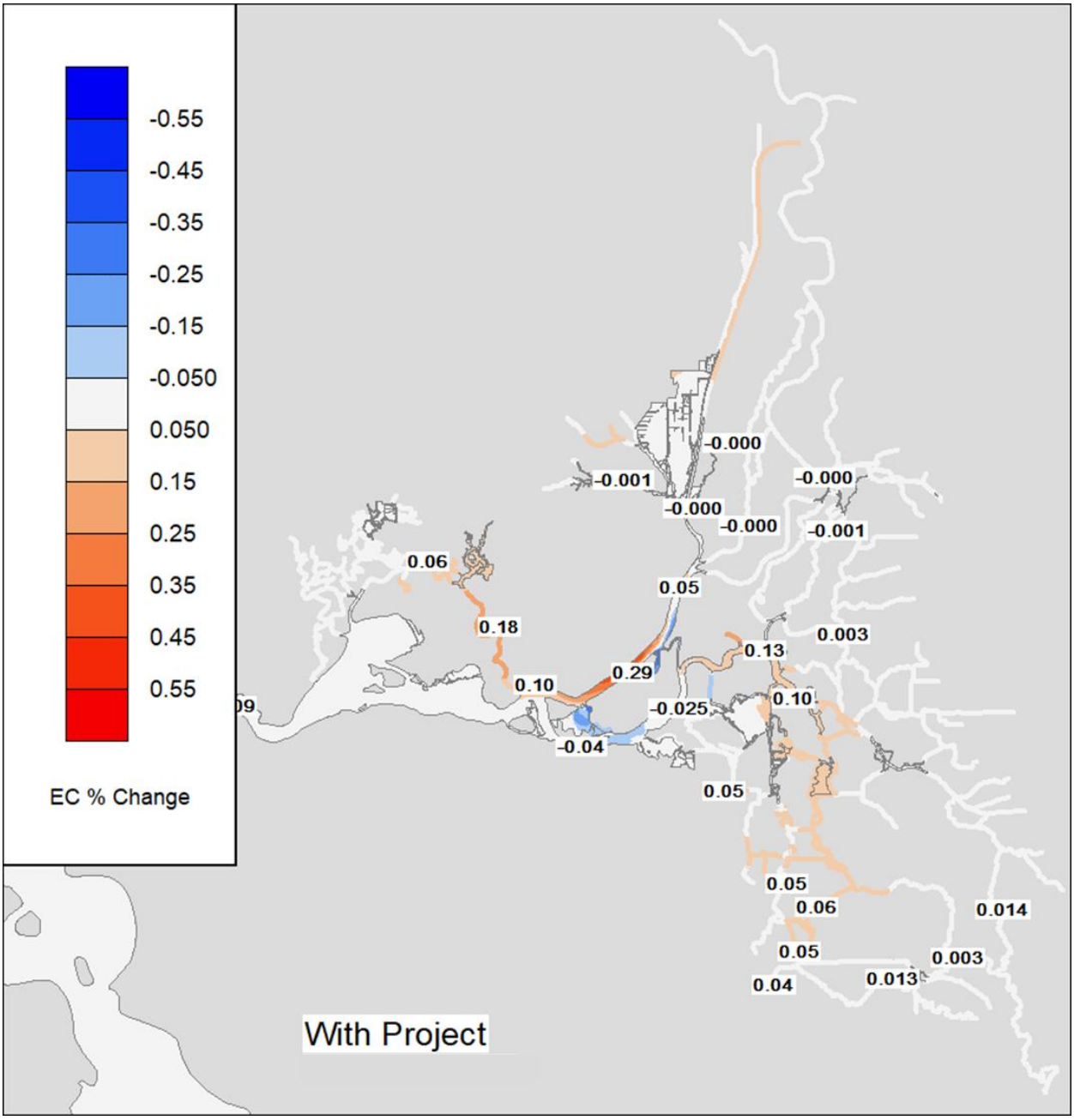


Figure 46 With Project average percent change from Base EC for August 2018.

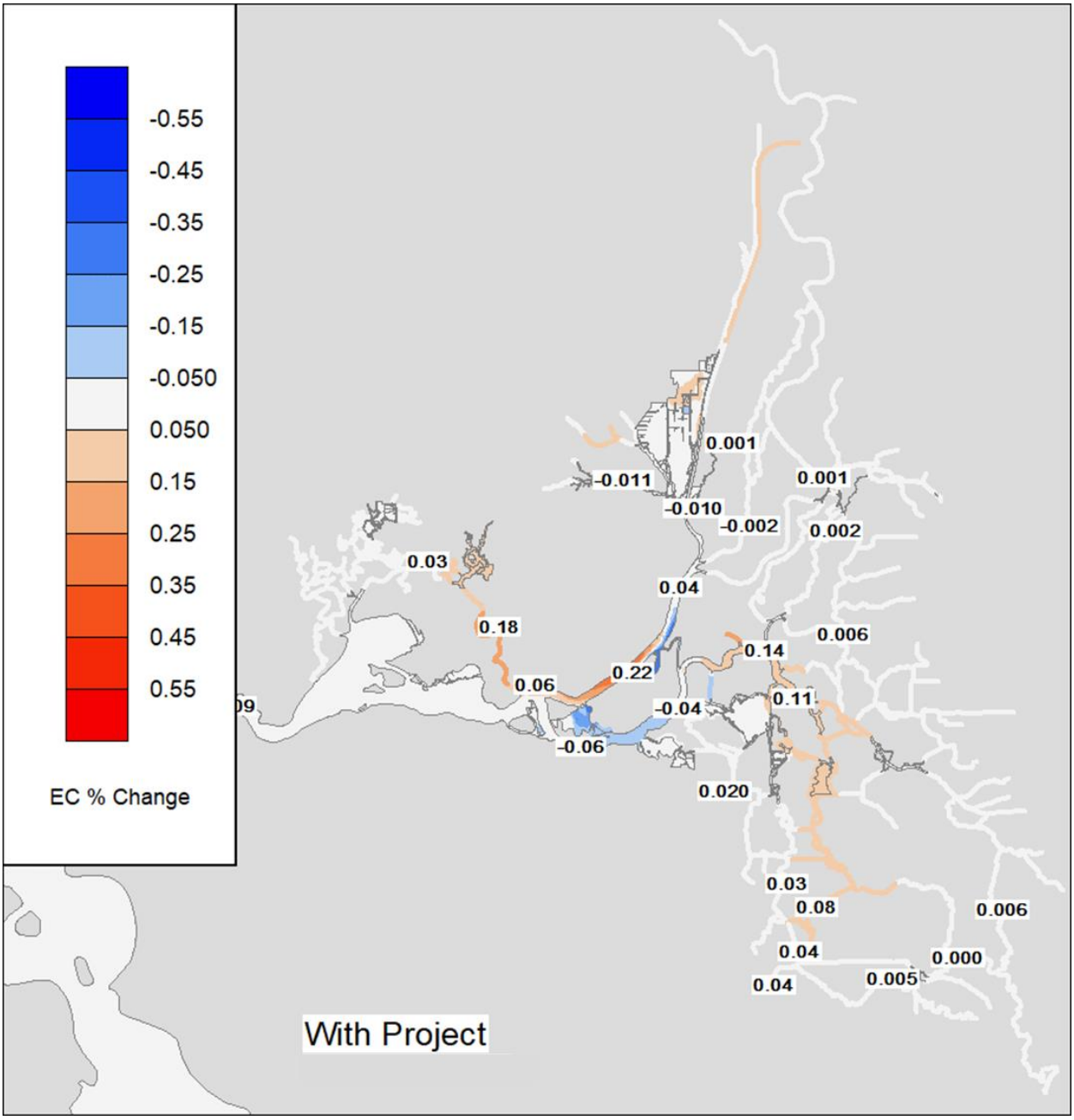


Figure 47 With Project average percent change from Base EC for September 2018.

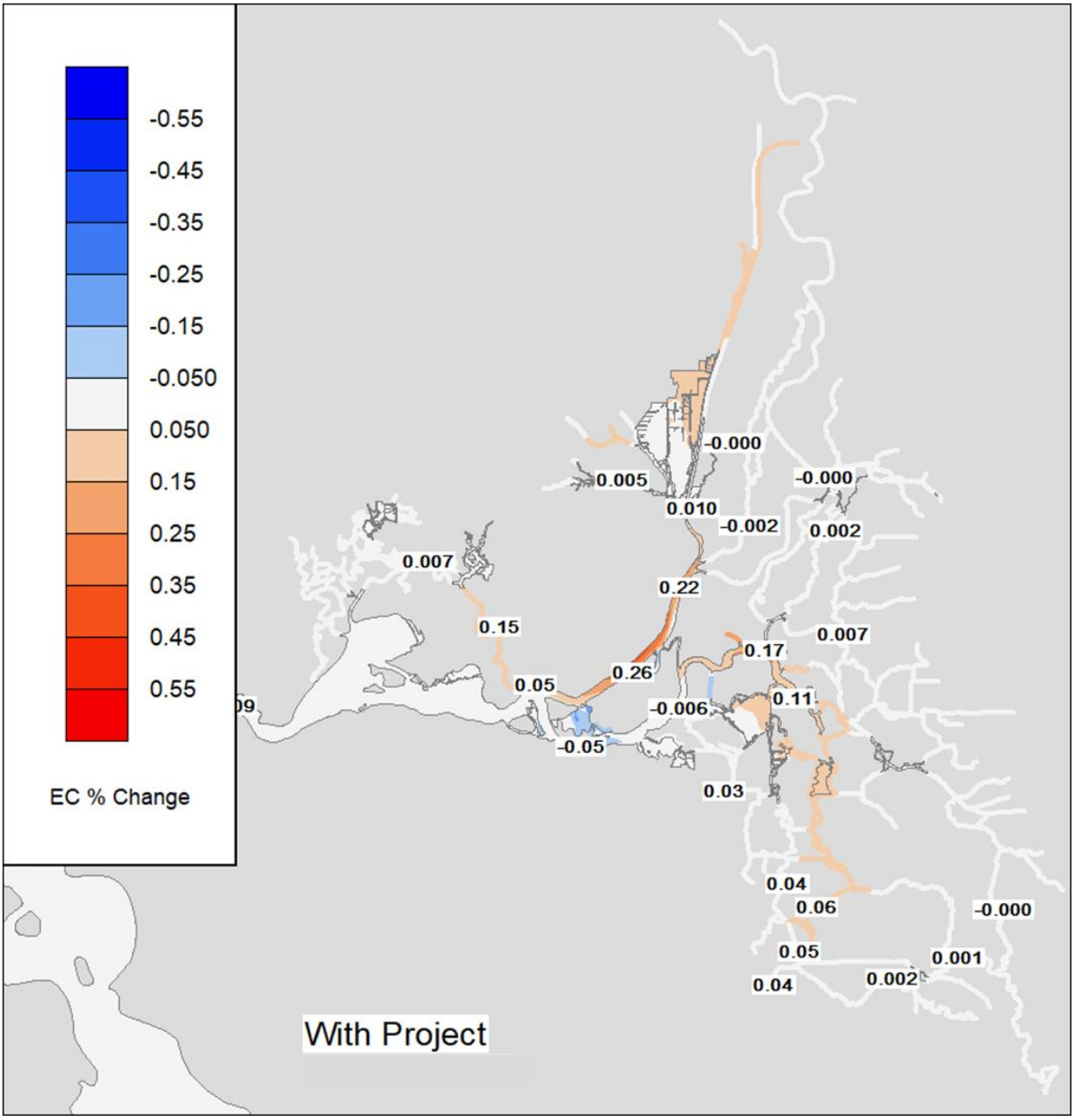


Figure 48 With Project average percent change from Base EC for October 2018.

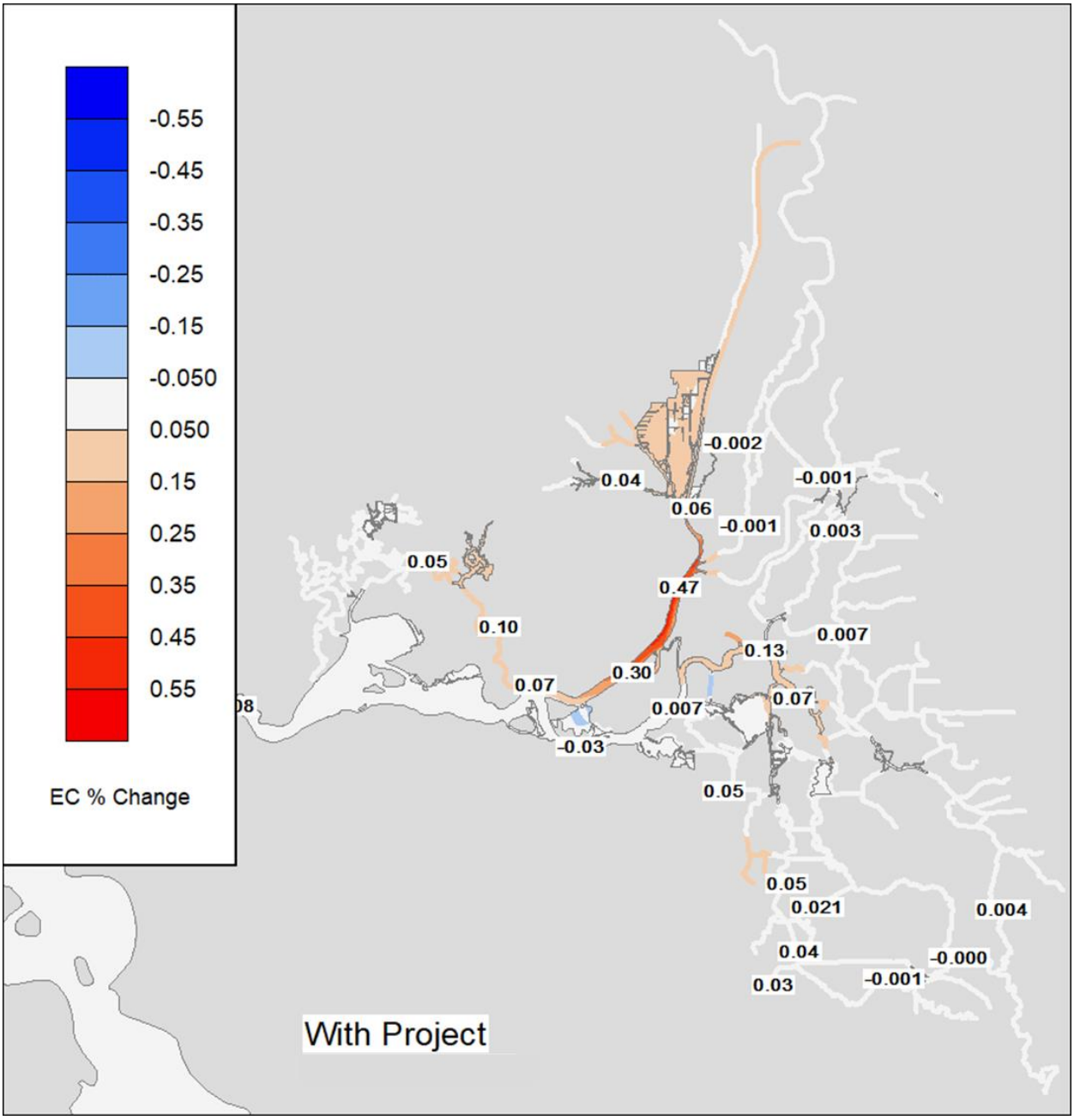


Figure 49 With Project average percent change from Base EC for November 2018.

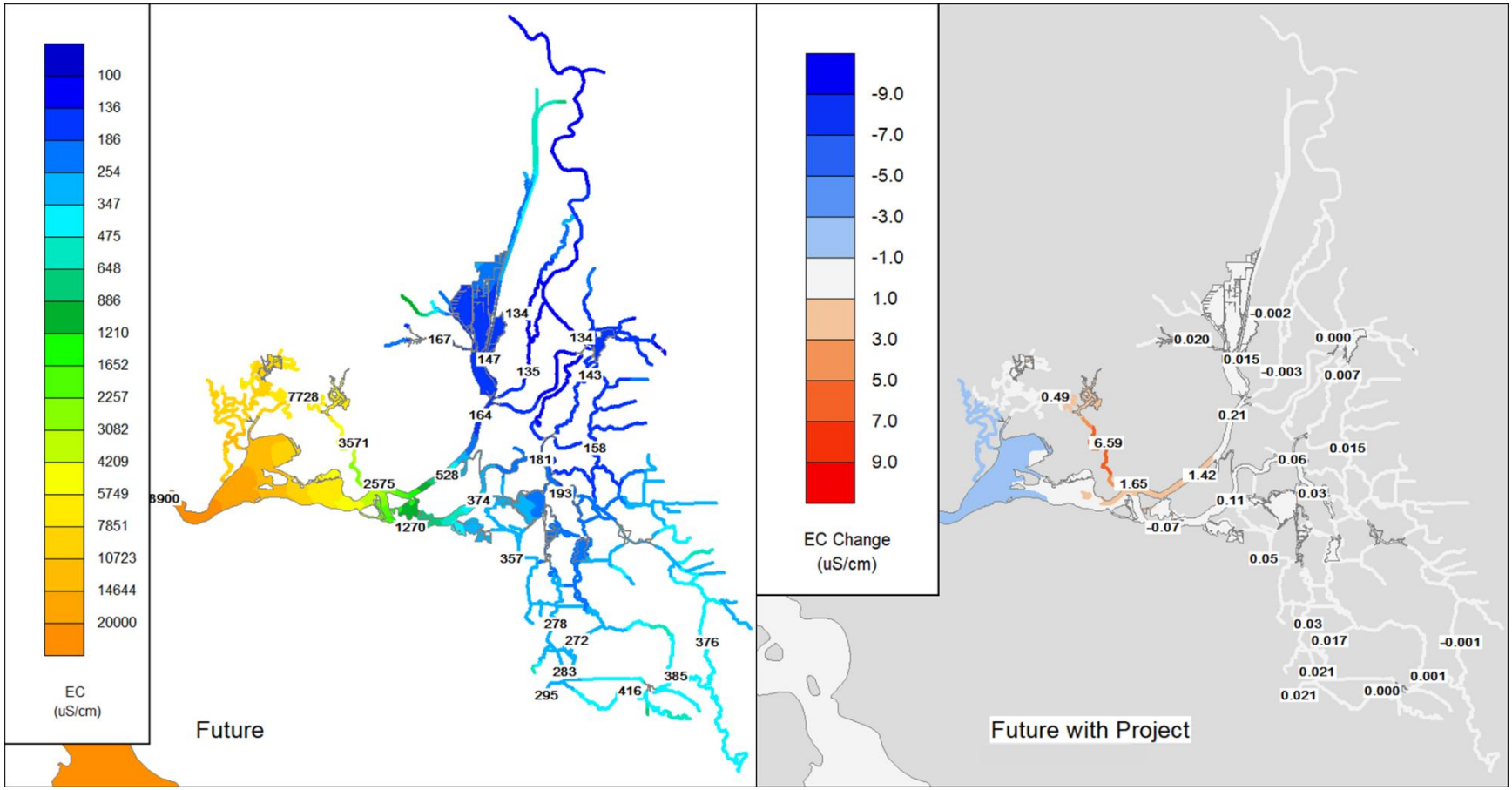


Figure 50 June 2018 (left) average Future condition EC and (right) Future with Project change from Base condition average EC.

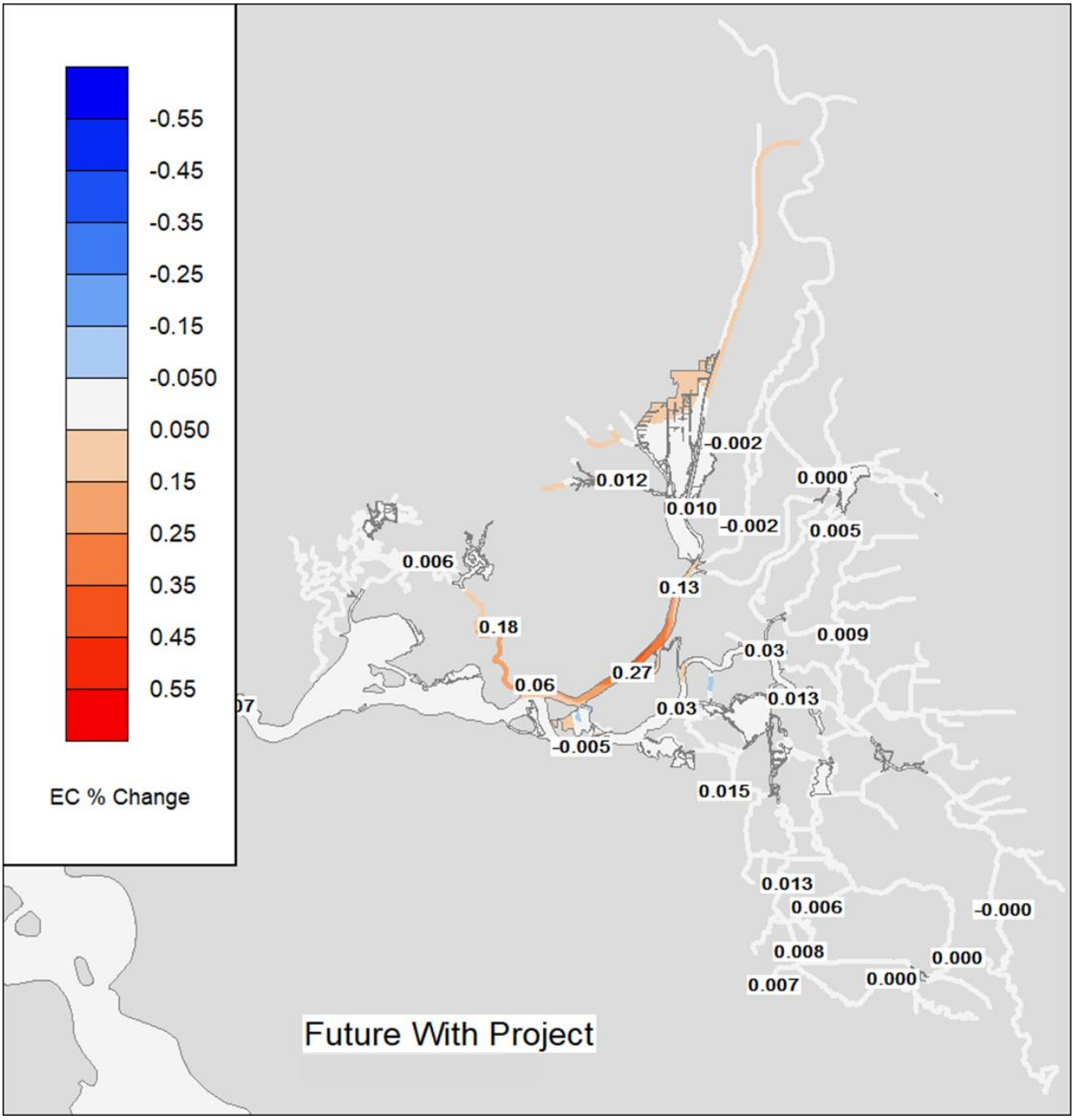


Figure 51 Future with Project average percent change from Future EC for June 2018.

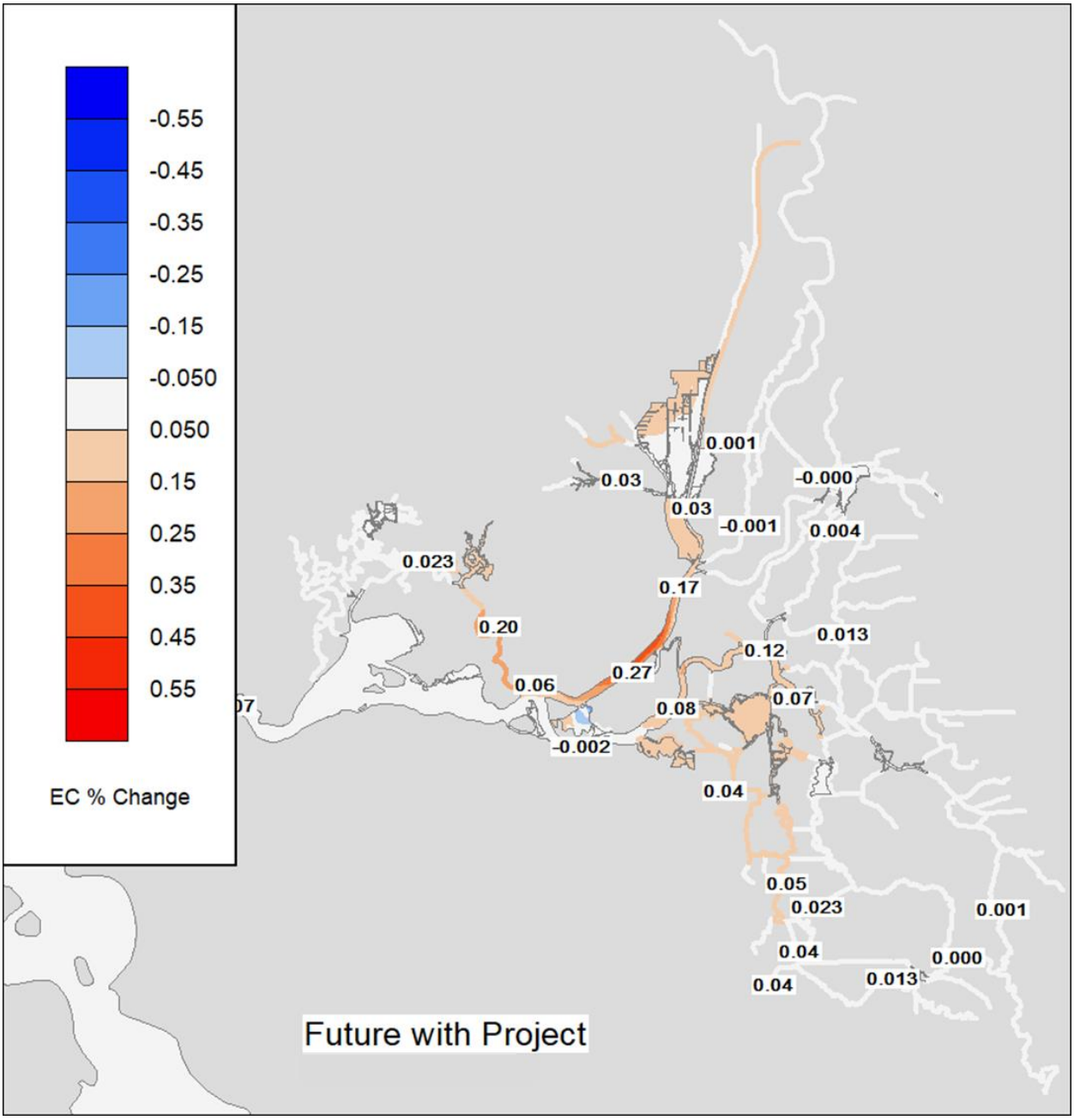


Figure 52 Future with Project average percent change from Future EC for July 2018.

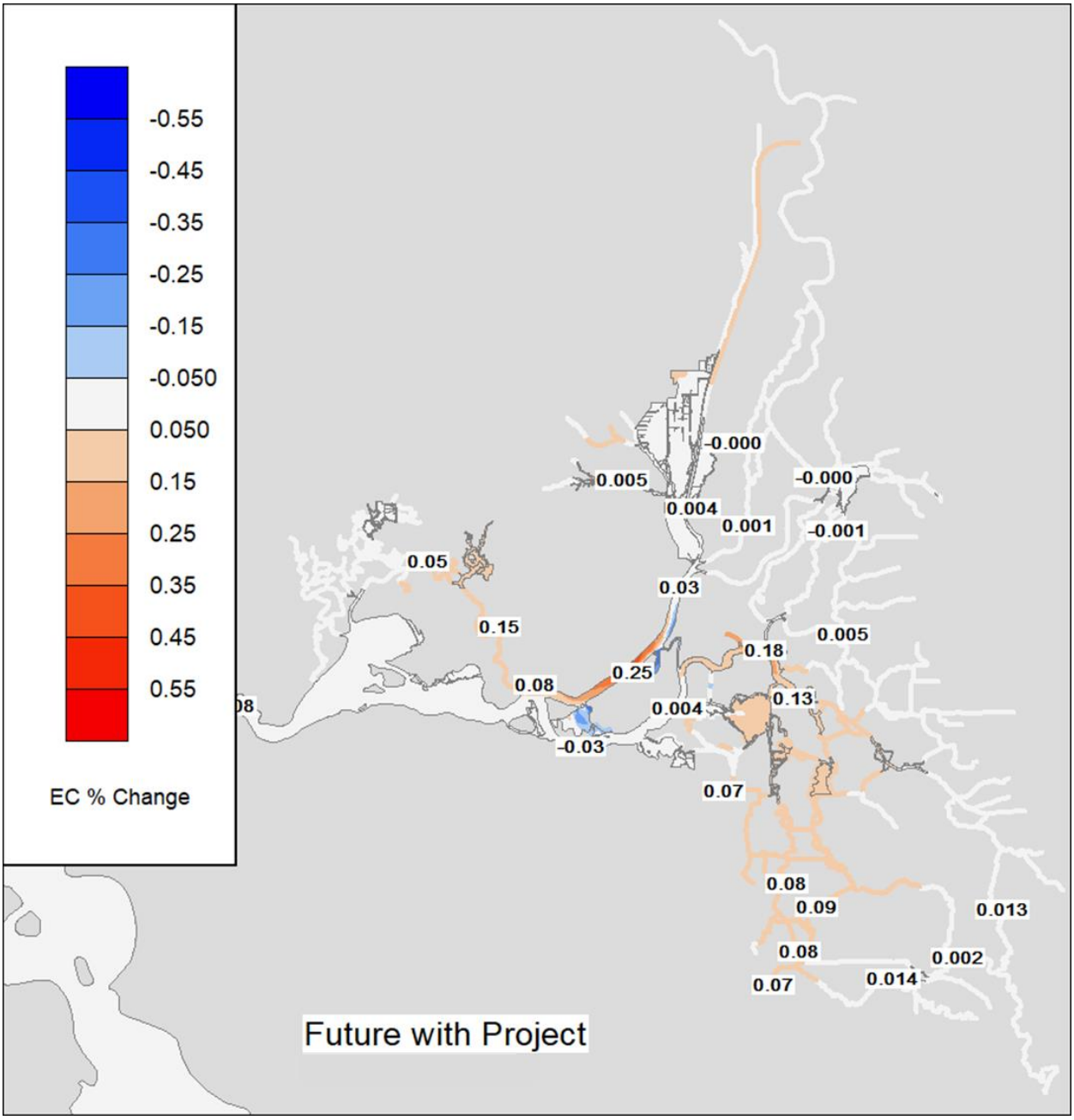


Figure 53 Future with Project average percent change from Future EC for August 2018.

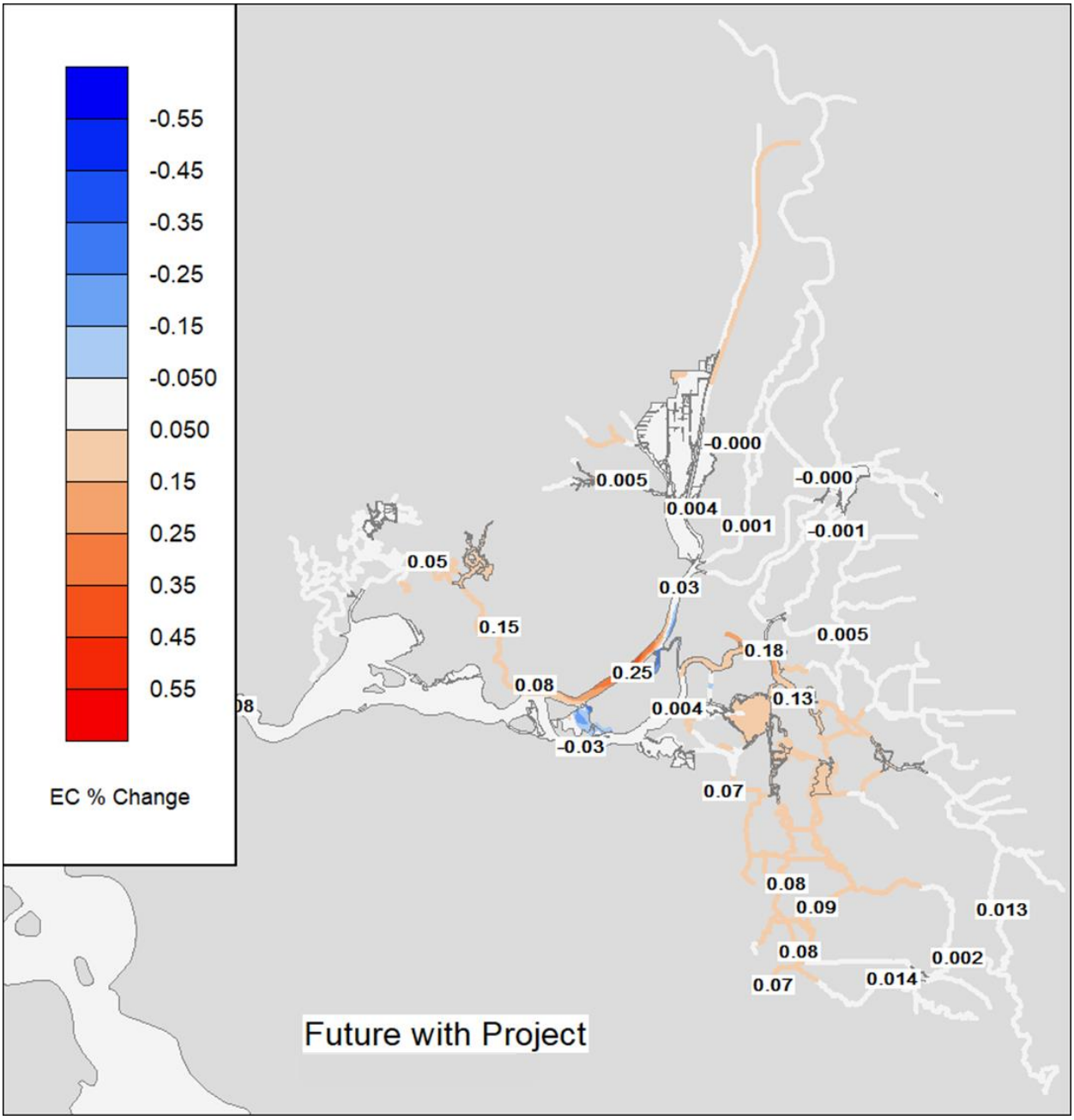


Figure 54 Future with Project average percent change from Future EC for September 2018.

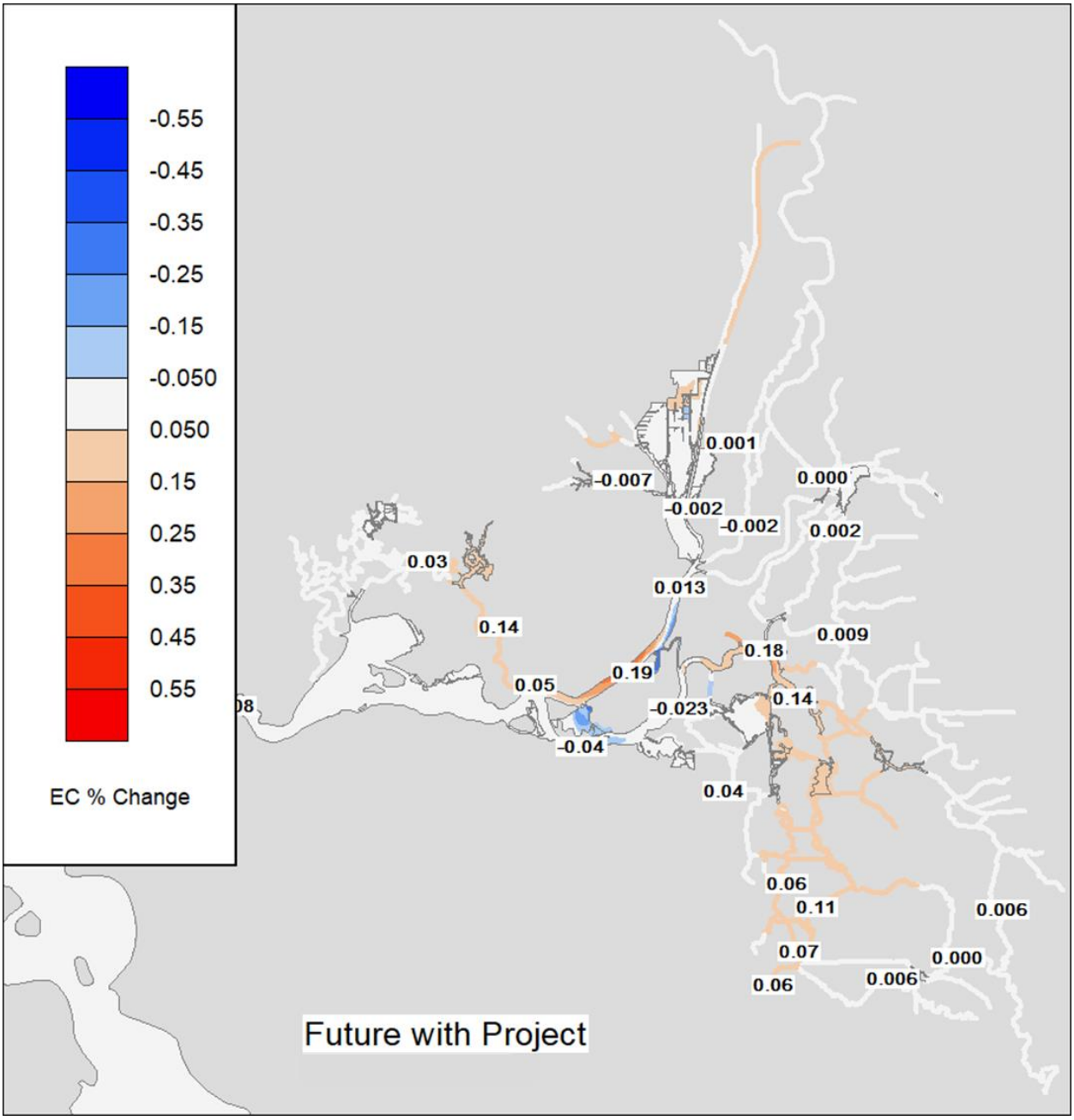


Figure 55 Future with Project average percent change from Future EC for October 2018.

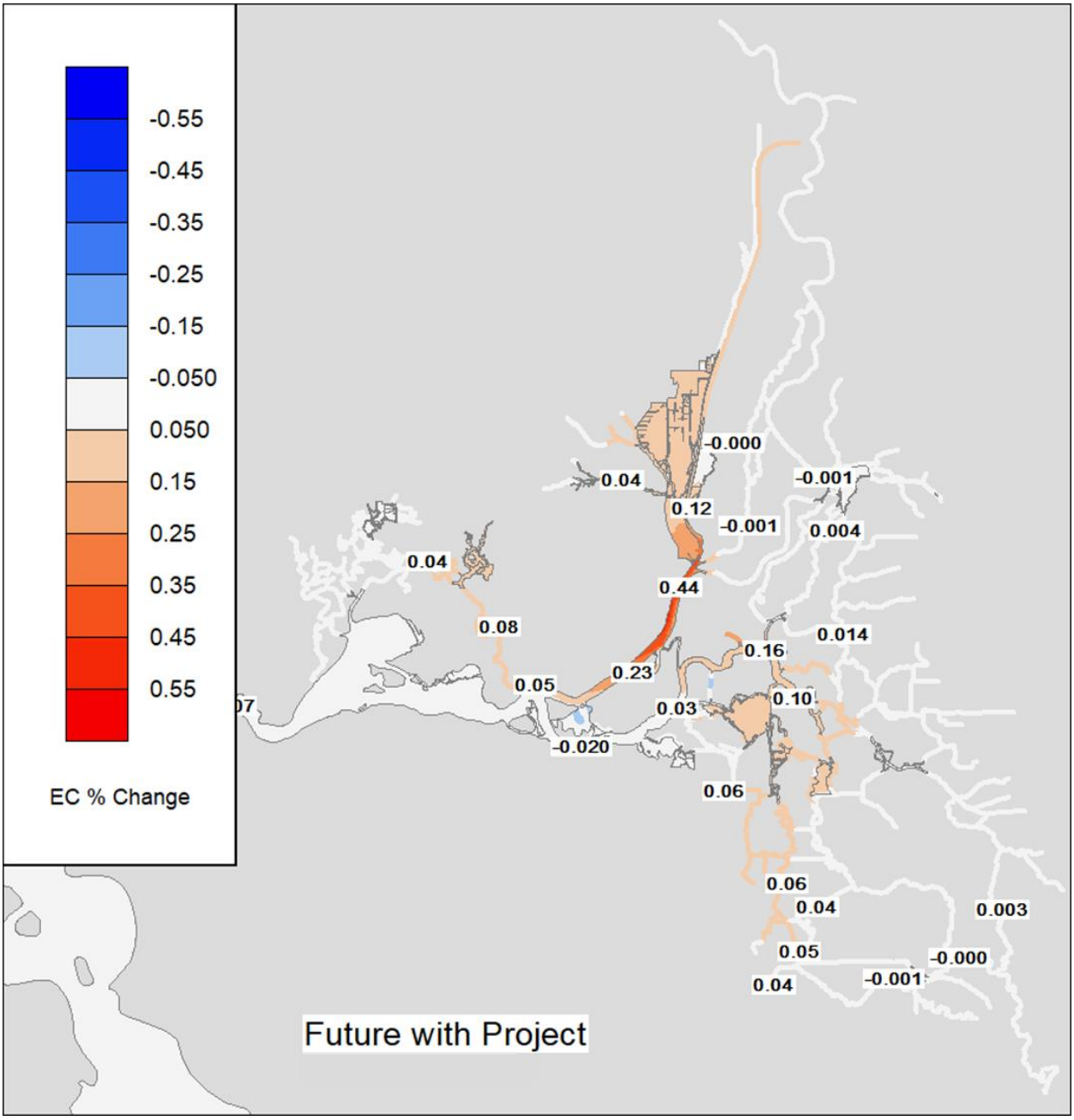


Figure 56 Future with Project average percent change from Future EC for November 2018.

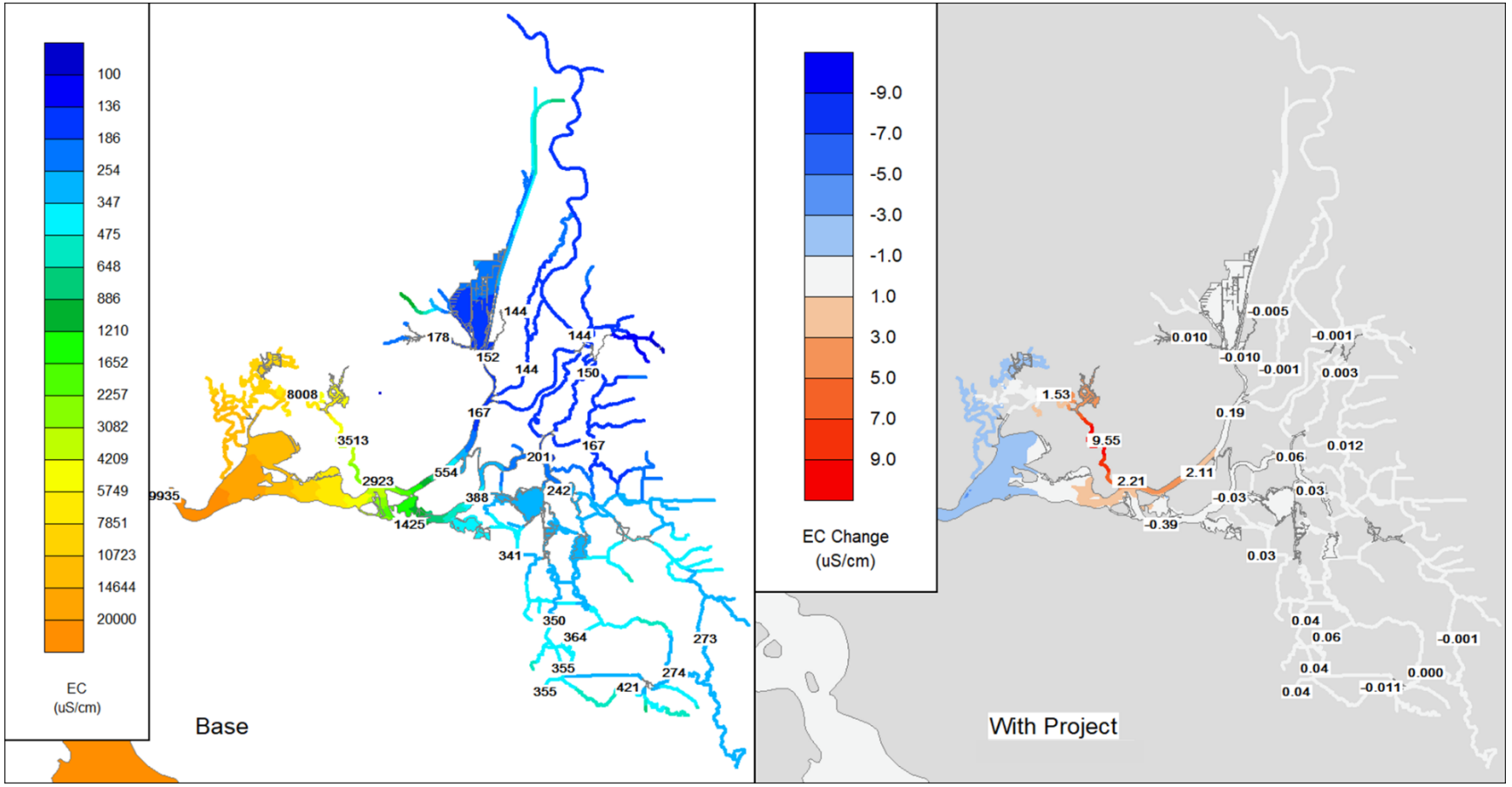


Figure 57 June 2020 (left) average Base condition EC and (right) With Project change from Base condition average EC.

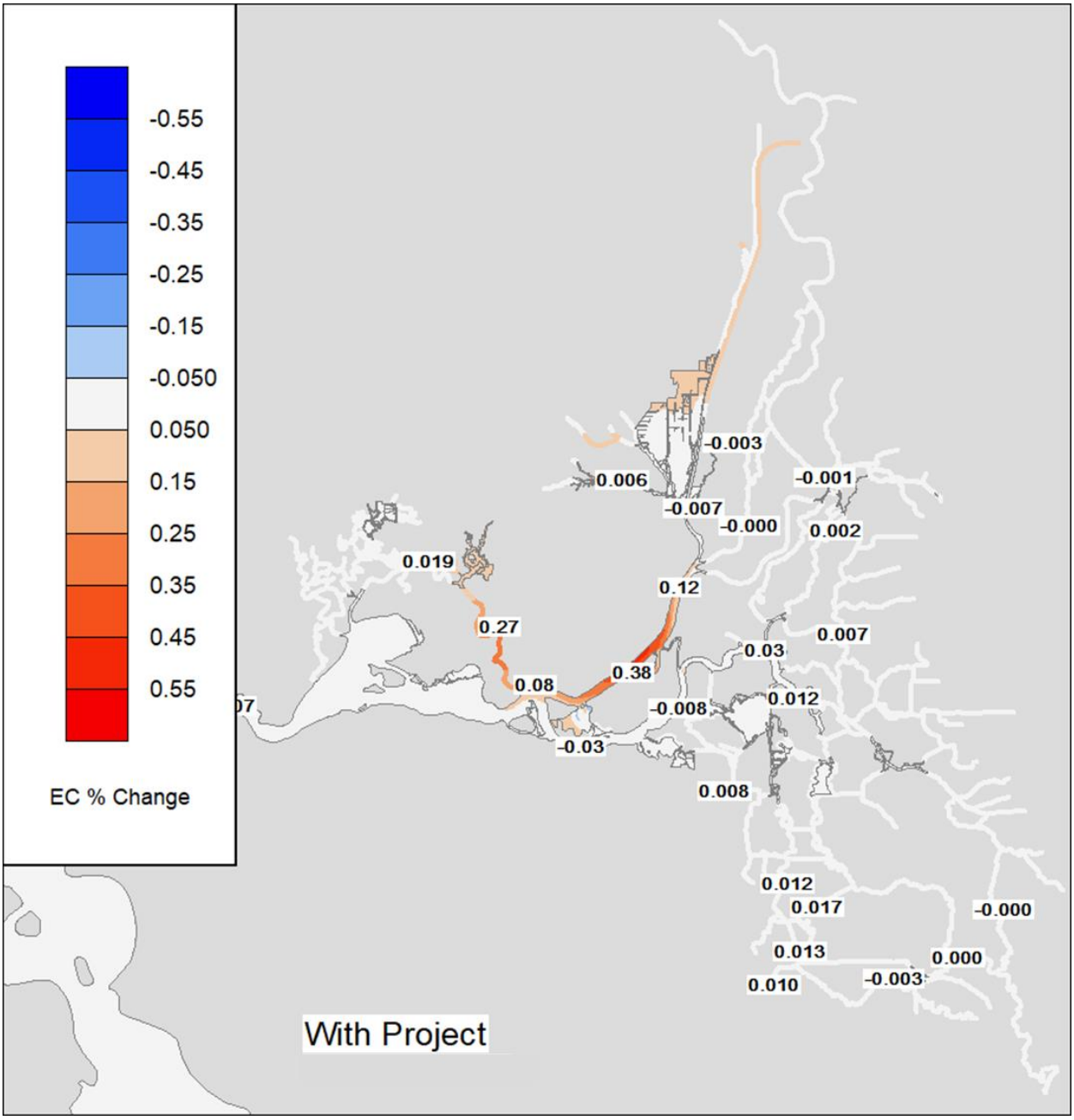


Figure 58 With Project average percent change from Base EC for June 2020.

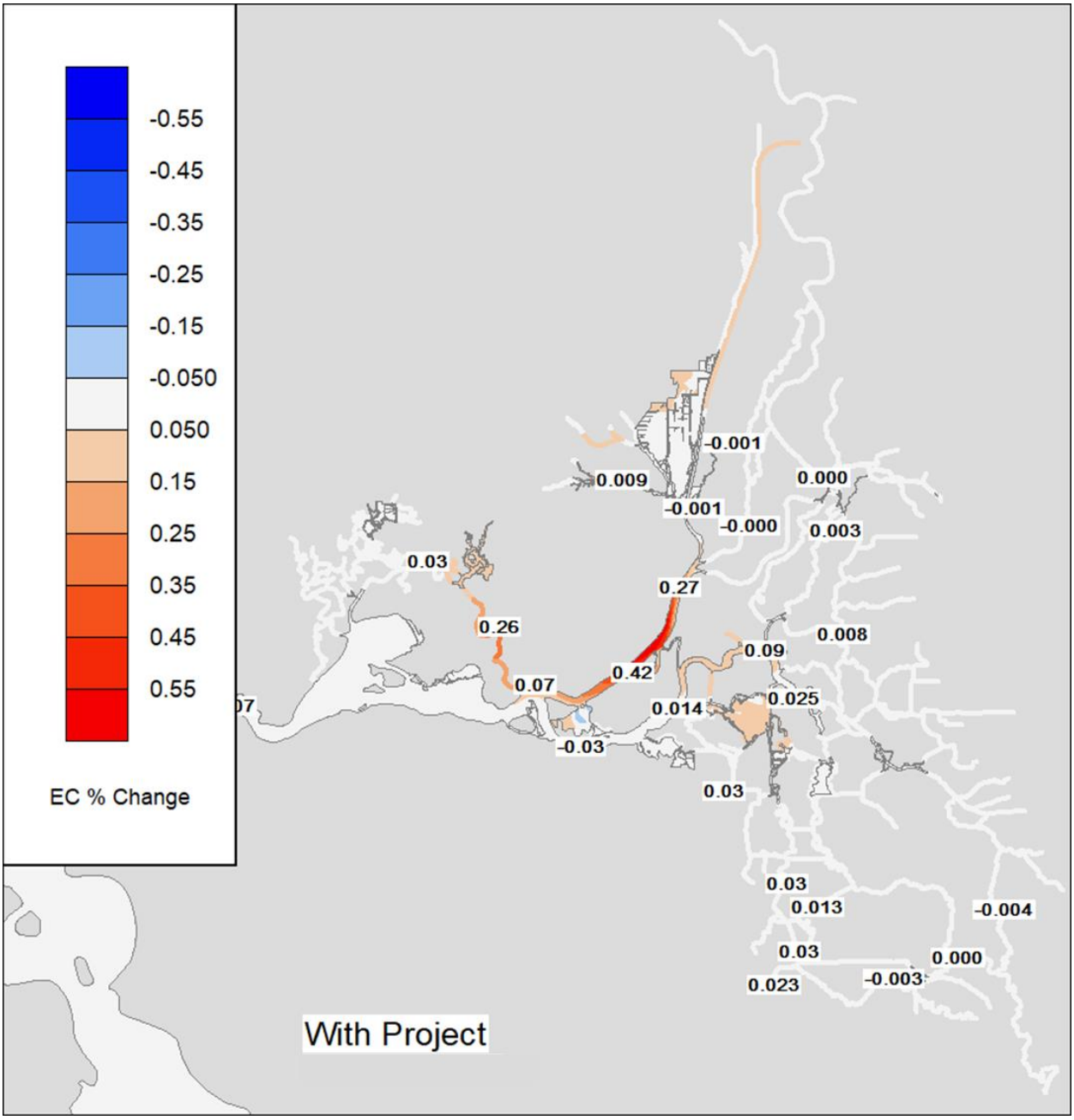


Figure 59 With Project average percent change from Base EC for July 2020.

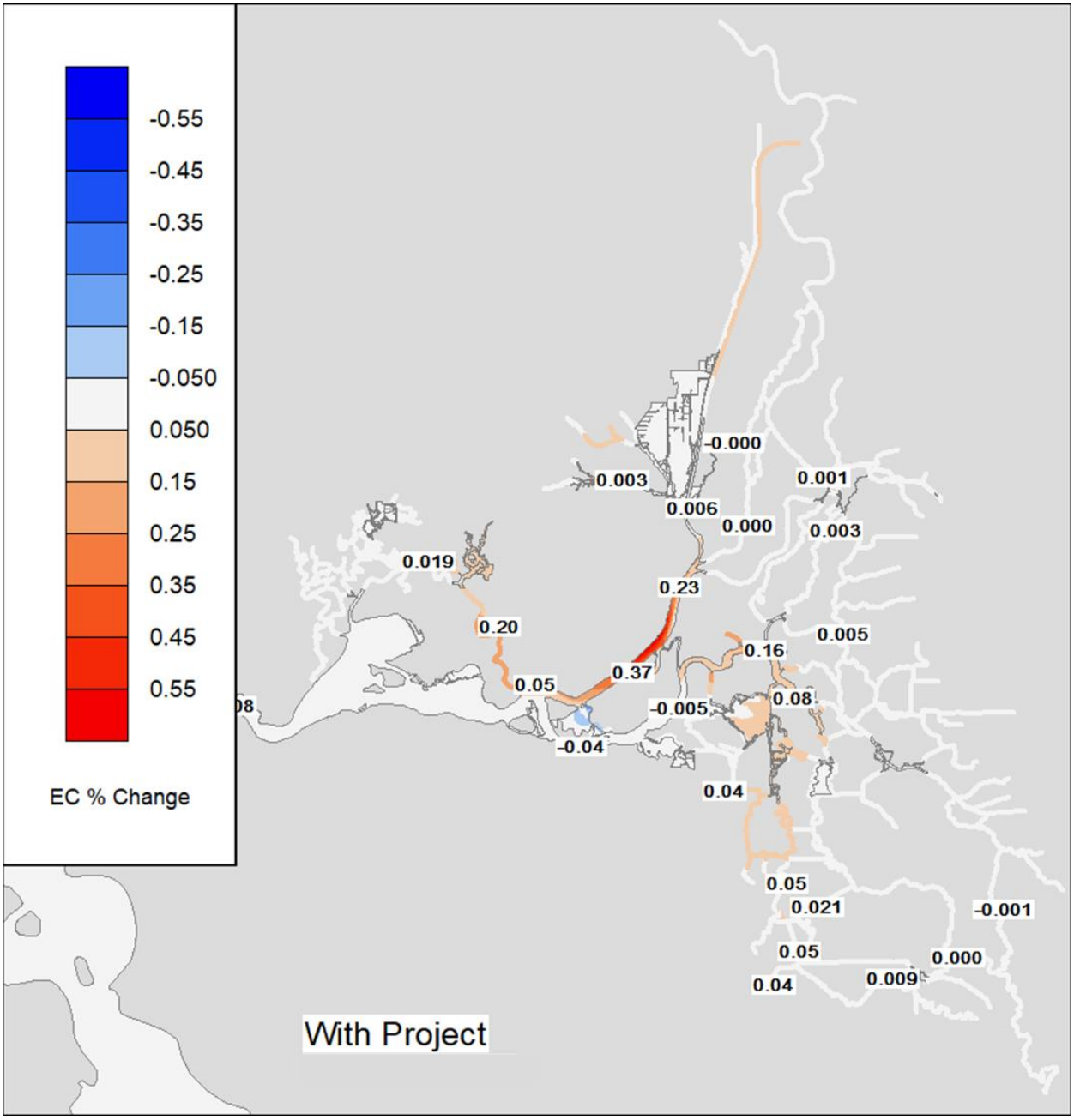


Figure 60 With Project average percent change from Base EC for August 2020.

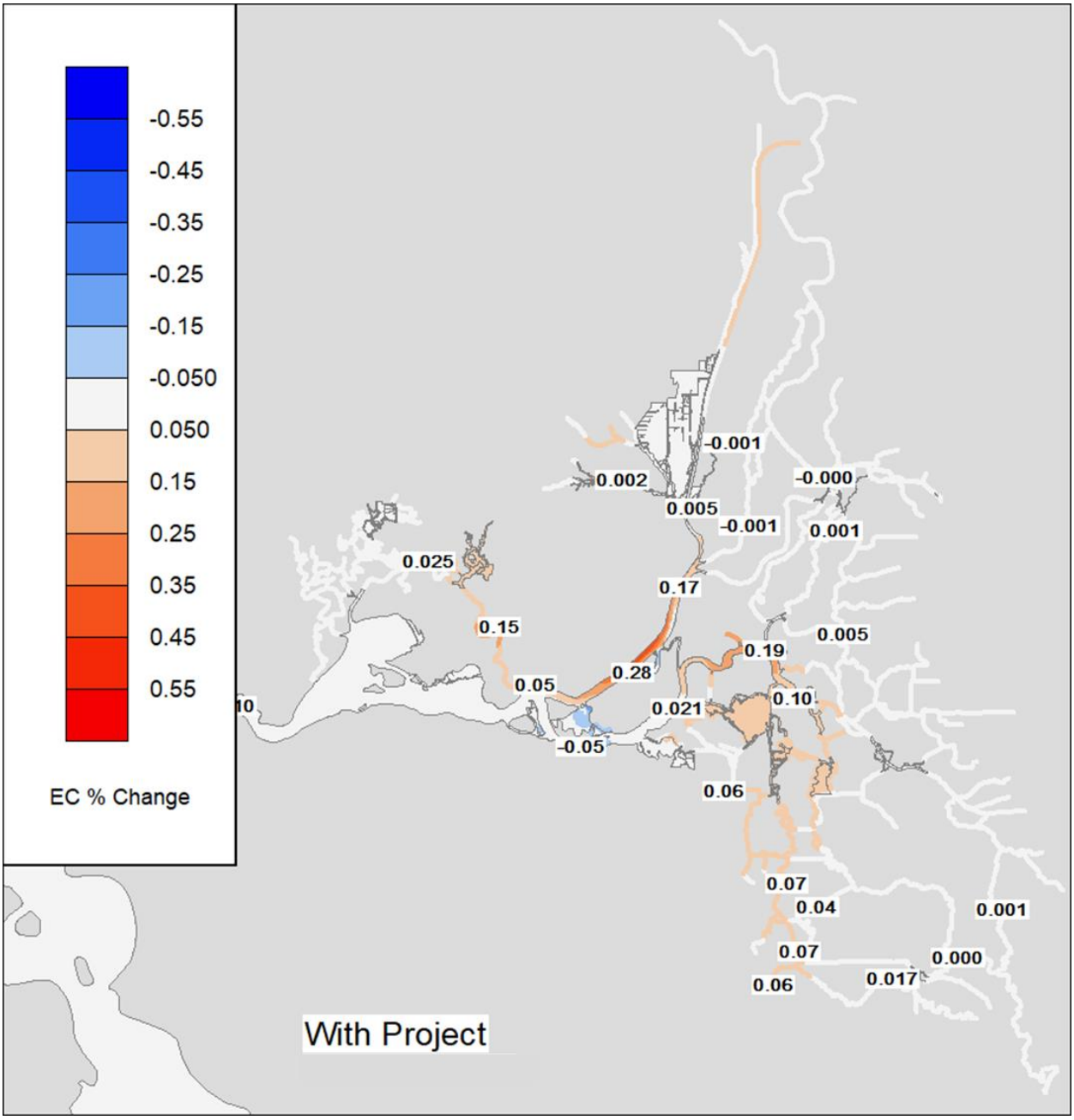


Figure 61 With Project average percent change from Base EC for September 2020.

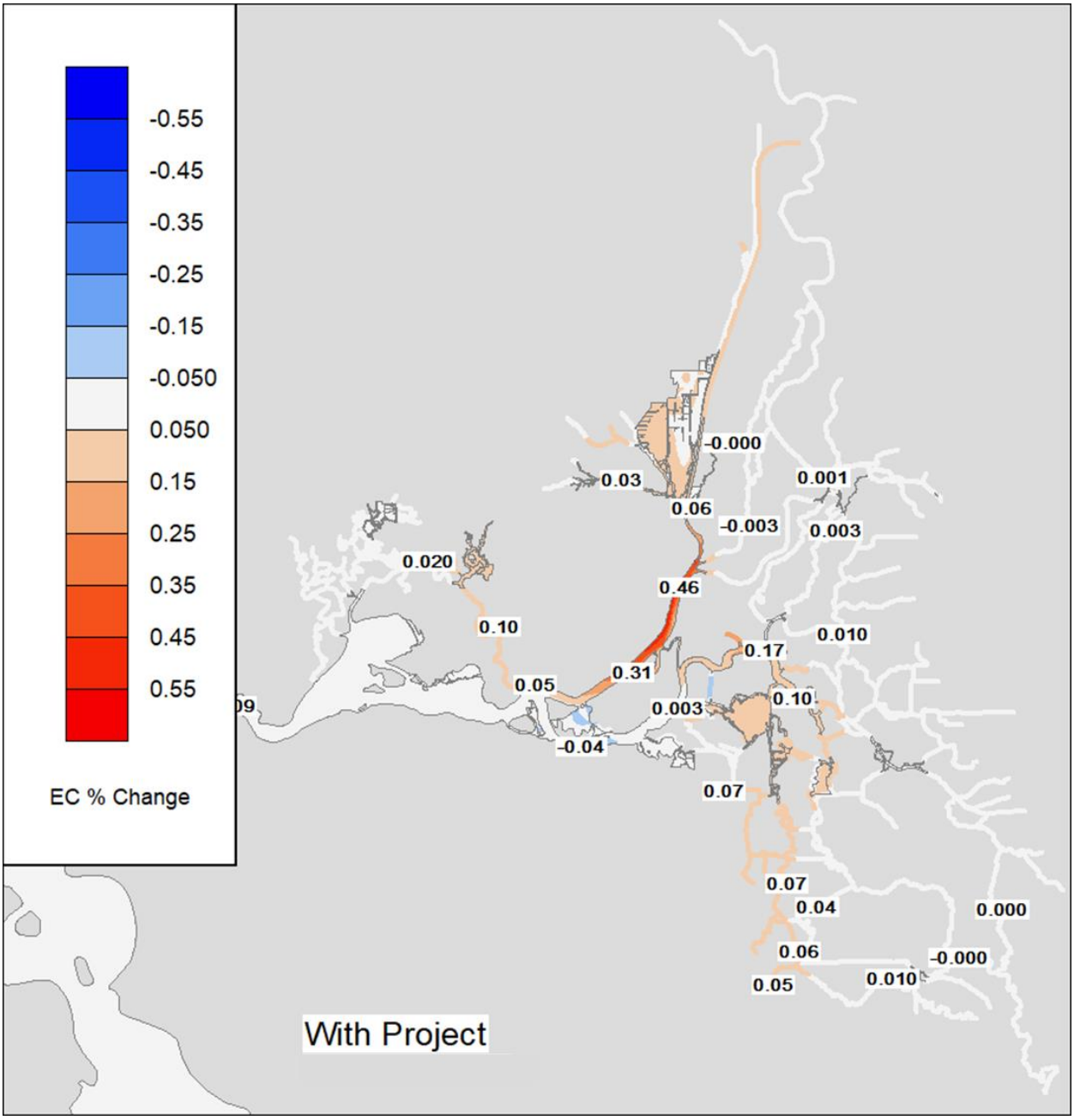


Figure 62 With Project average percent change from Base EC for October 2020.

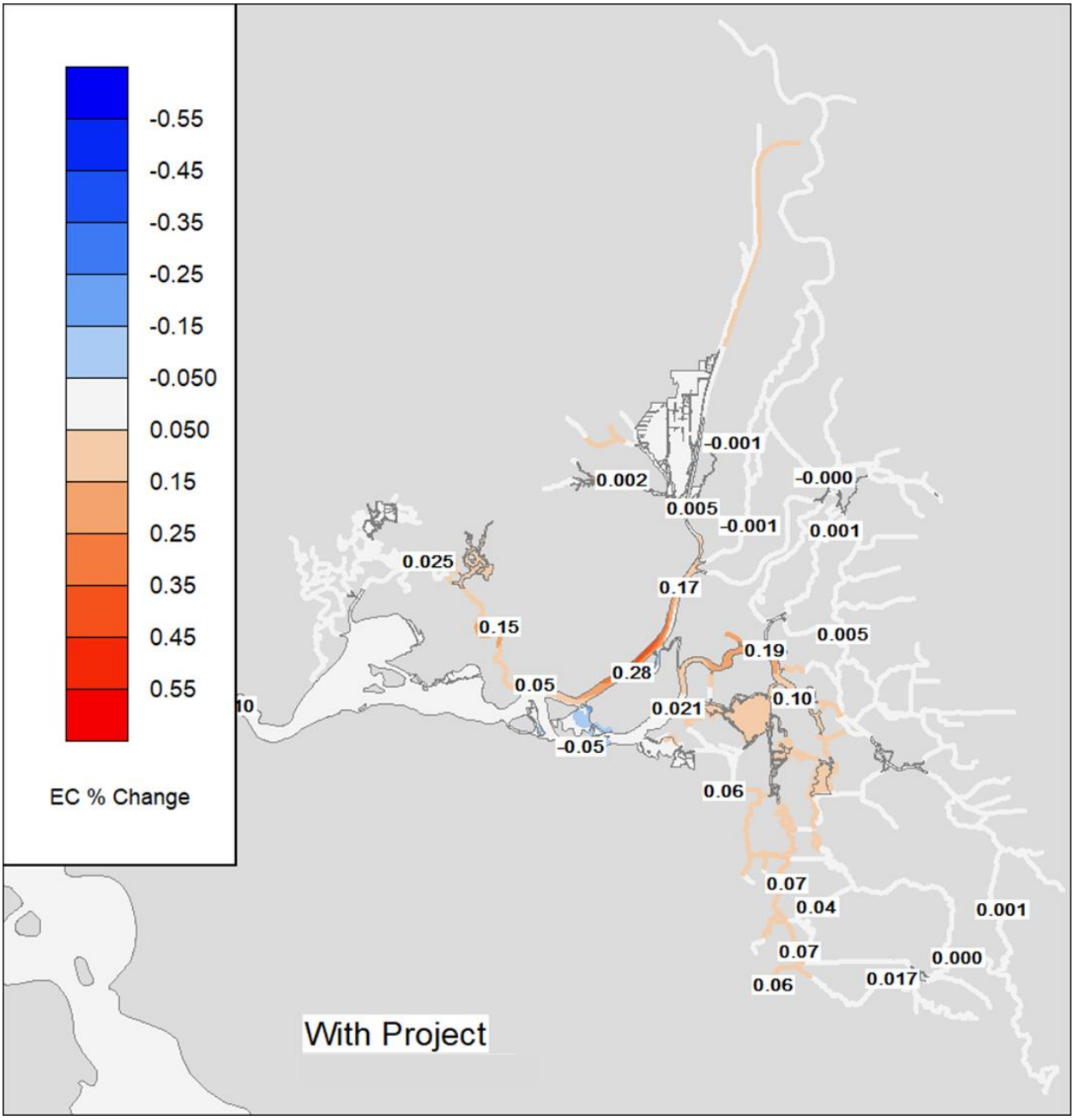


Figure 63 With Project average percent change from Base EC for November 2020.

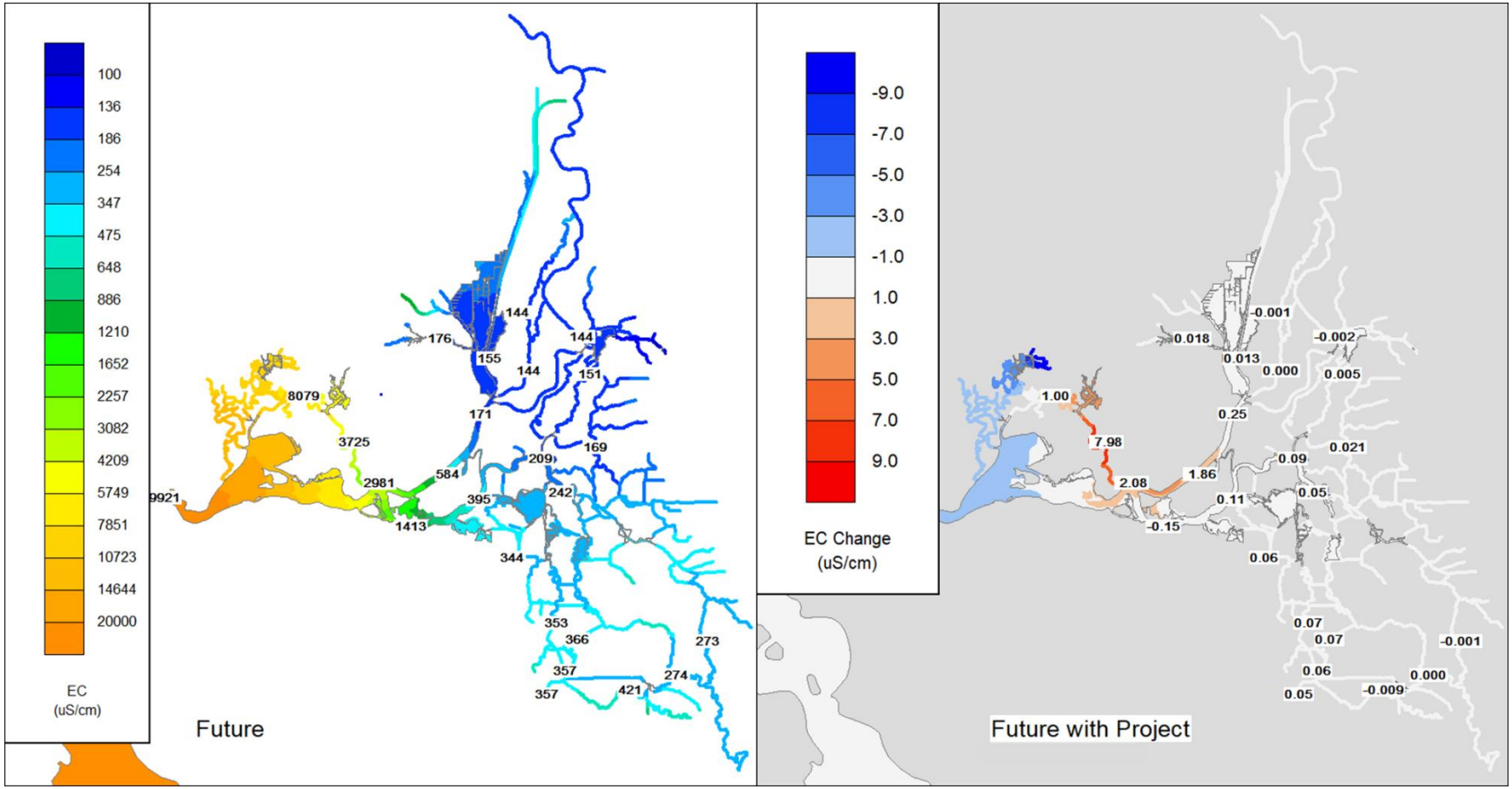


Figure 64 June 2020 (left) average Future condition EC and (right) Future with Project change from Base condition average EC.

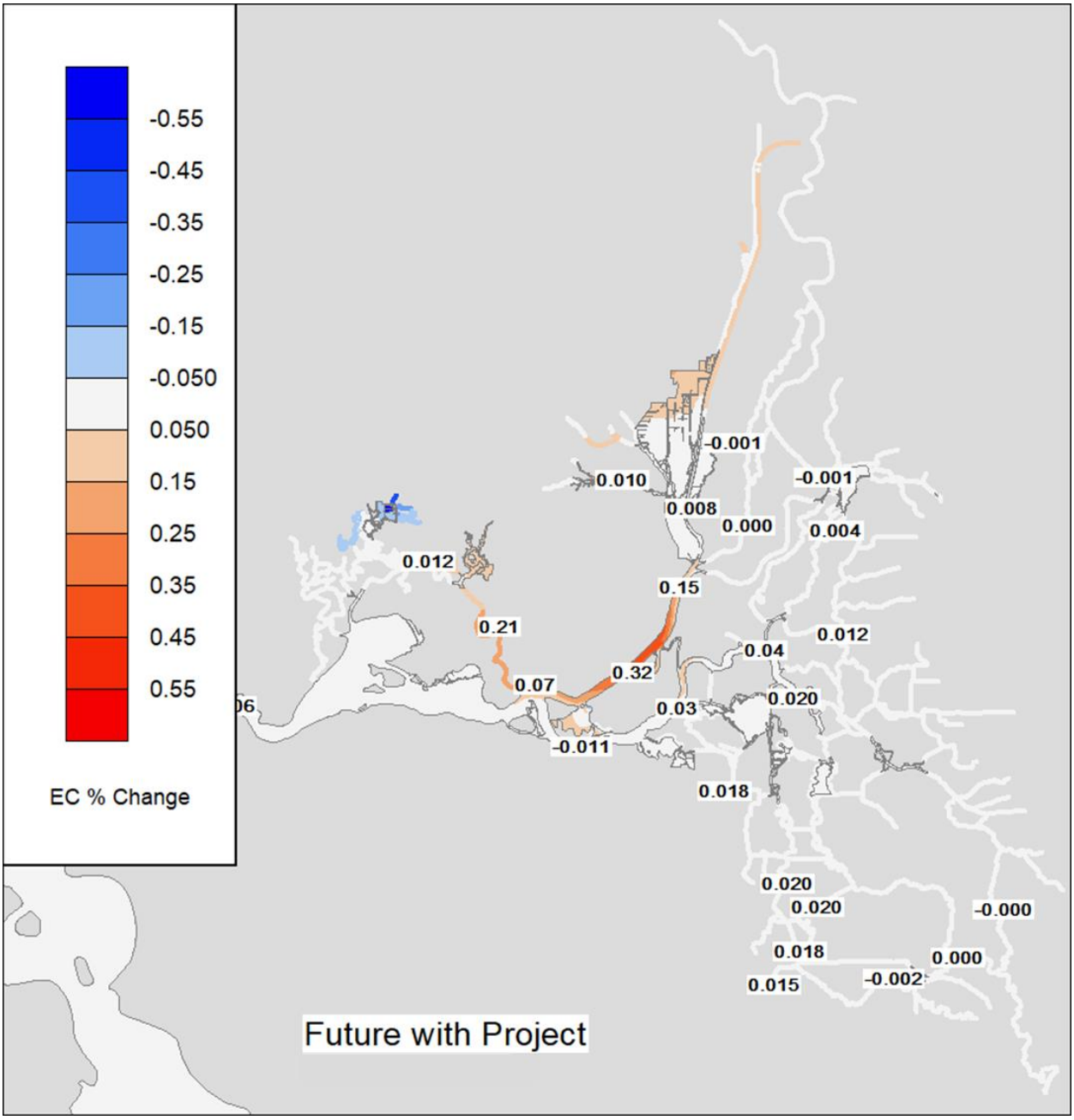


Figure 65 Future with Project average percent change from Future EC for June 2020.

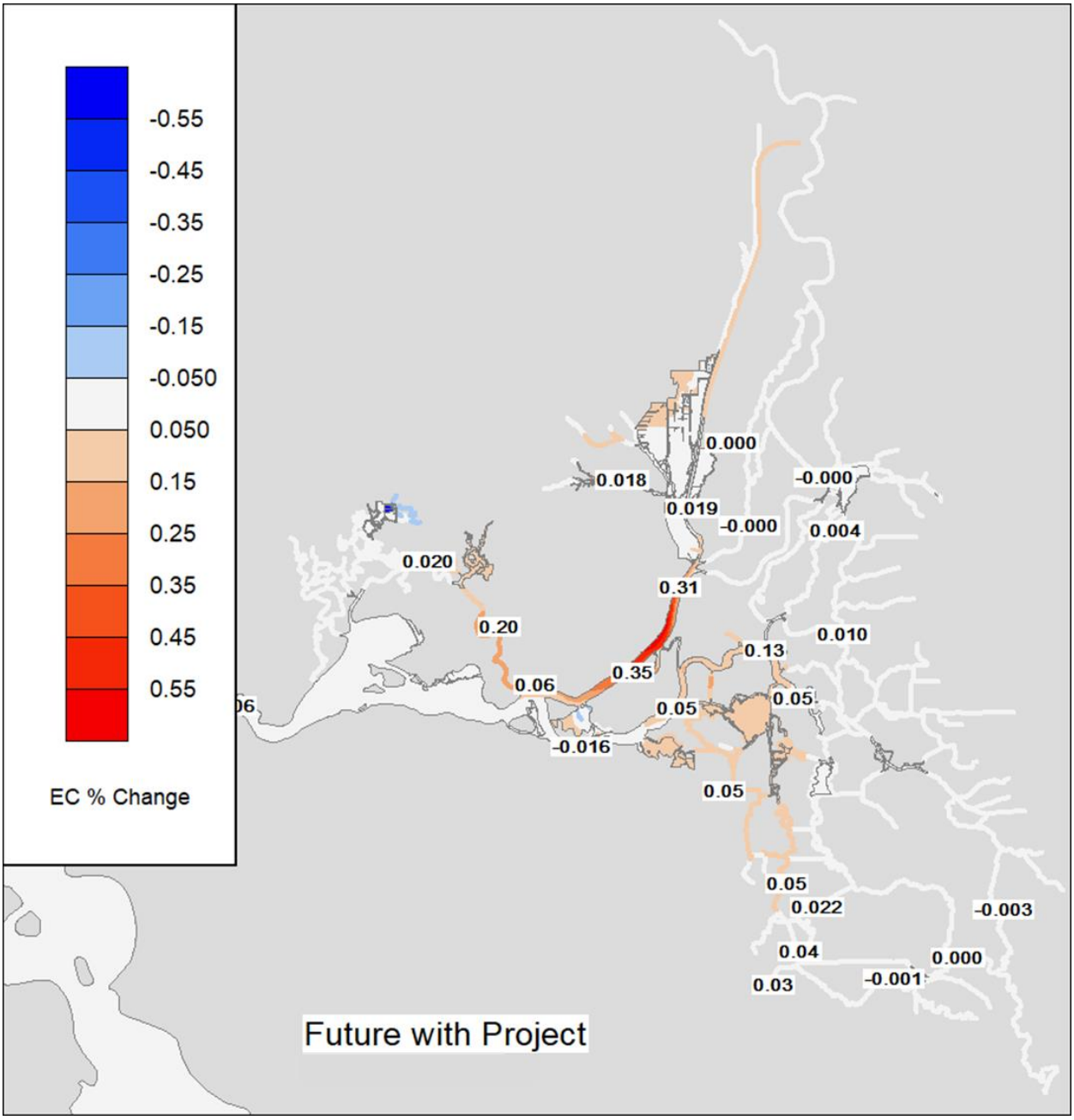


Figure 66 Future with Project average percent change from Future EC for July 2020.

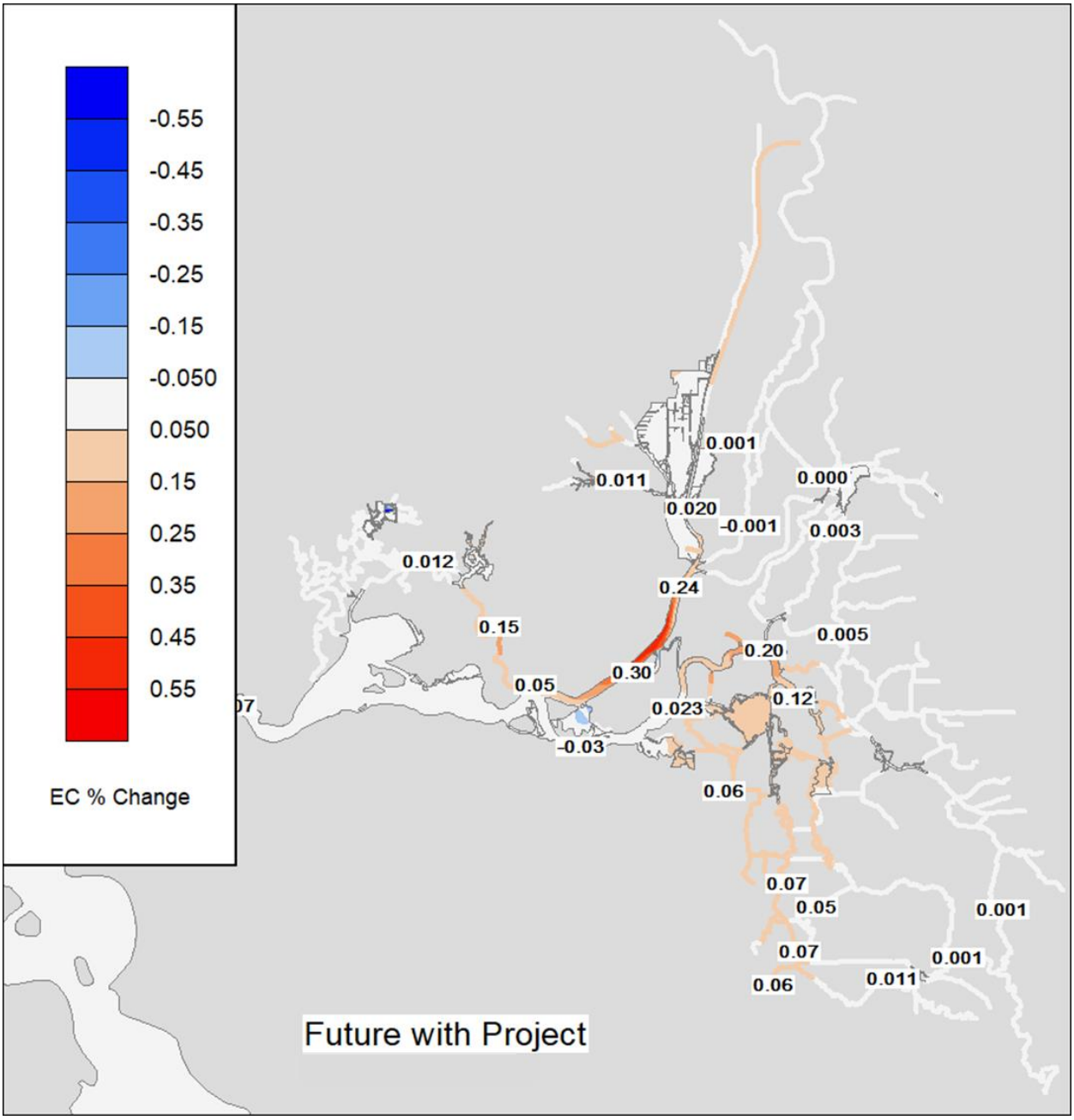


Figure 67 Future with Project average percent change from Future EC for August 2020.

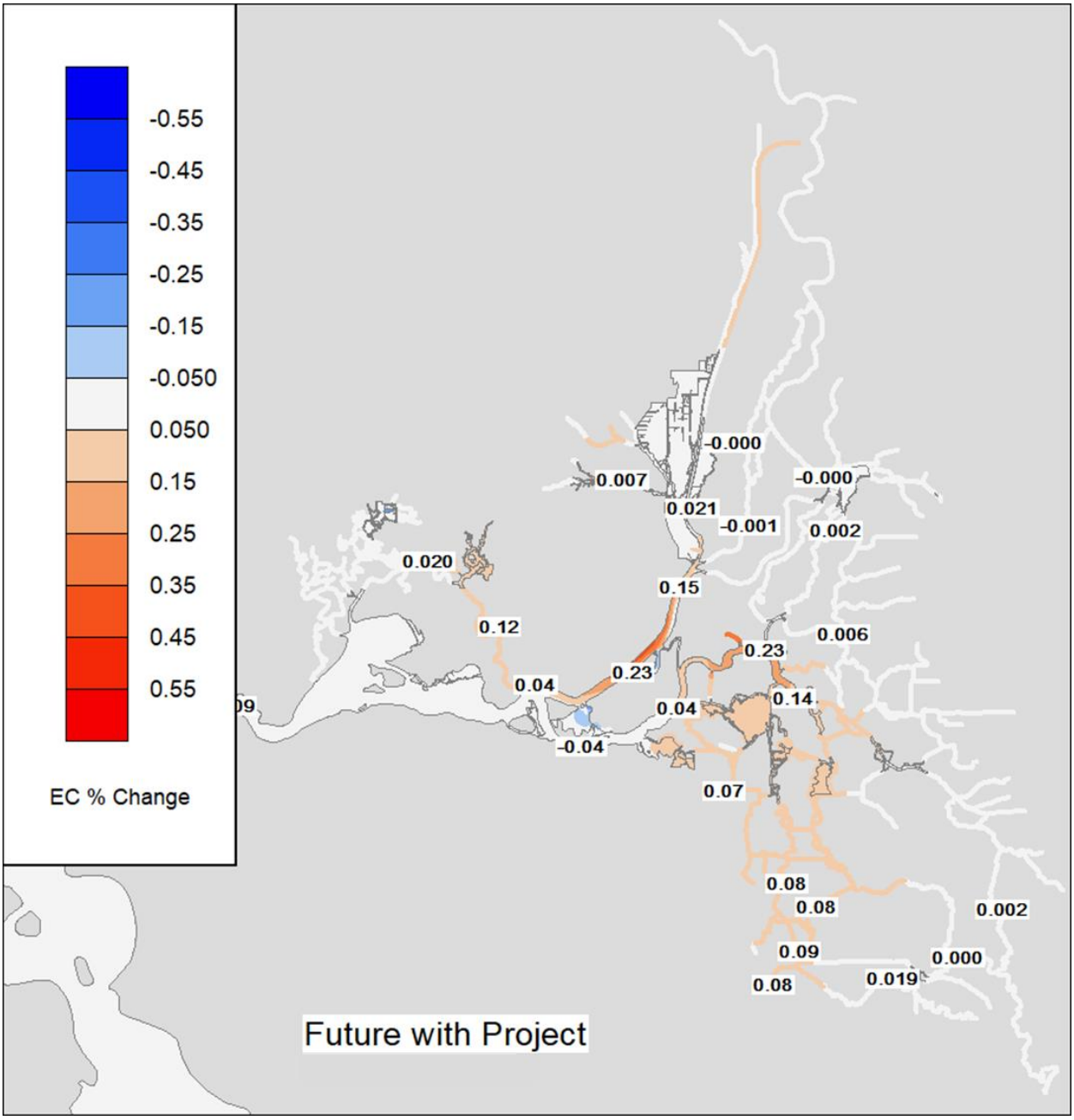


Figure 68 Future with Project average percent change from Future EC for September 2020.

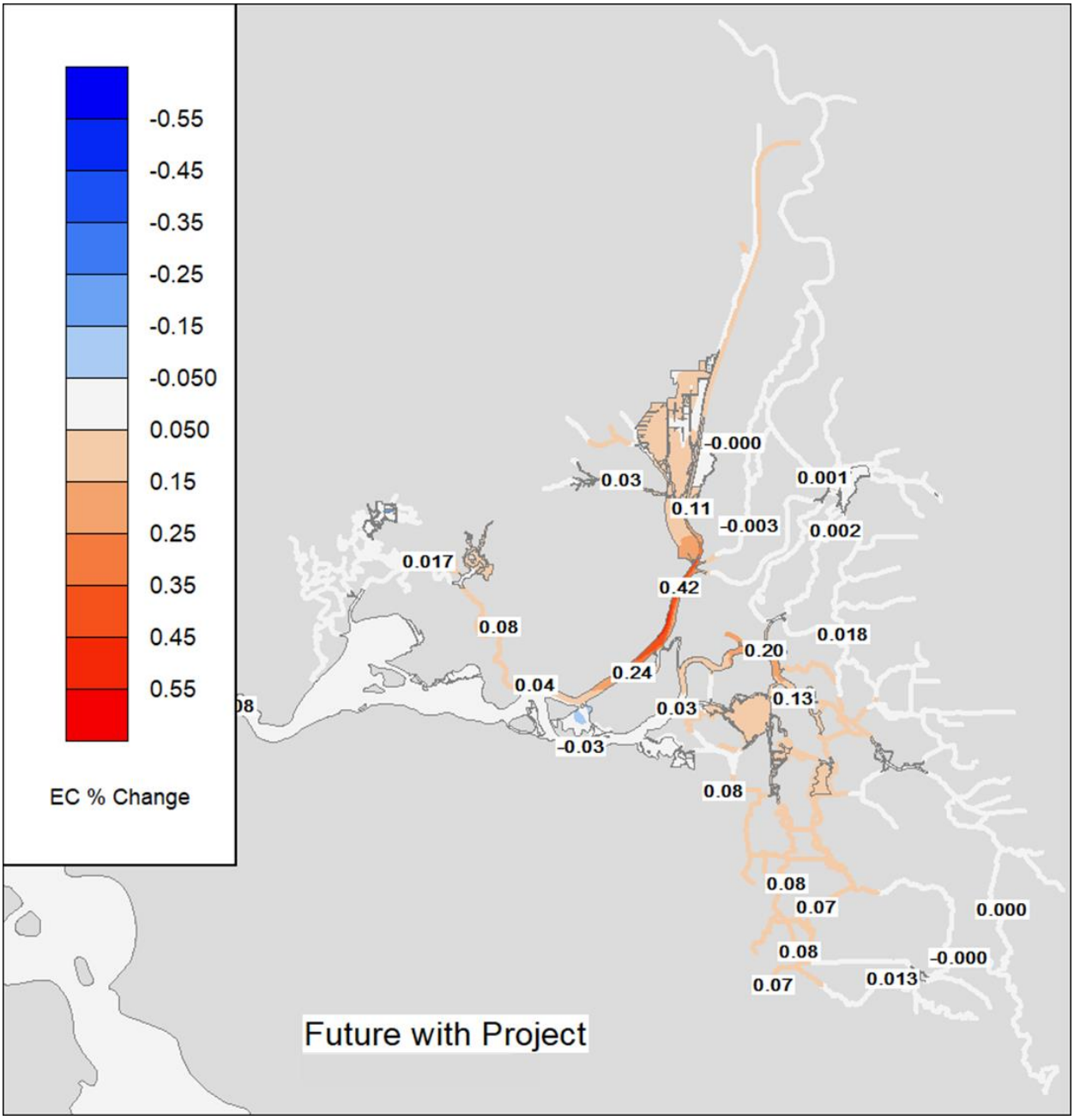


Figure 69 Future with Project average percent change from Future EC for October 2020.

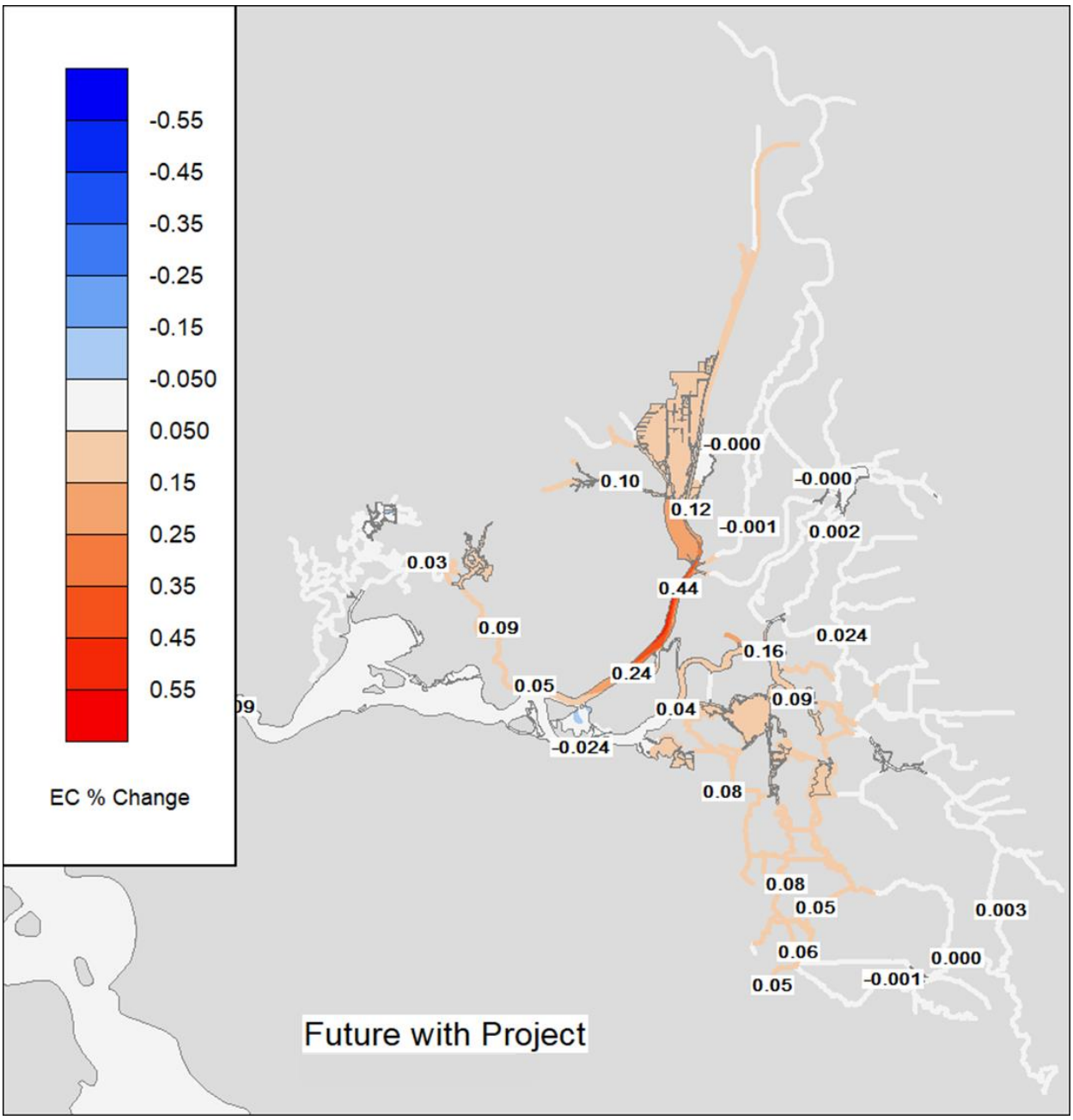


Figure 70 Future with Project average percent change from Future EC for November 2020.

Evaluation of Potential Non-Compliance at Select D-1641 Stations

The second goal of the salinity modeling analysis was to evaluate the potential for the Project to cause non-compliance with the D-1641 water quality objectives. The compliance stations with salinity (EC) water quality objectives for agriculture, and fish and wildlife are listed in Table 4 and chloride objectives for municipal and industrial or water intakes are listed in Table 5. The water quality objectives applied for 2018 are for the "Below Normal" Sacramento Valley hydrologic year type. The water quality objectives used for the 2020 evaluation are for a "Dry" hydrologic year type.

For the D-1641 locations analyzed below, time series plots are provided that include modeled EC results for the Base, With Project, Future and Future with Project scenarios (see Figure 71 through Figure 78). For reference, observed data are also provided. While the Base condition model geometry does not exactly represent historical conditions in 2018 and 2020, in some cases the computed Base EC deviates from observed data due to model inaccuracies. When larger discrepancies occur, the incremental differences between Base and With Project EC should be considered relative to the observed value to determine if compliance standards violations might be expected to occur. However, at all D-1641 locations, the Project did not impact EC values enough to cause any new non-compliance with water quality standards. While four modeled results are provided in each of the plots below, only two are visible because the With Project results plot on top of the respective Base and Future results. EC for the Future scenario tends to be higher than the Base EC.

Table 4 D-1641 Station Salinity Water Quality Objects – Fish and Wildlife and Agriculture. Standards are presented in mmhos/cm (1 mmho/cm = 1000 µS/cm).

Station	Water Year Type[1]	Fish and Wildlife		Agriculture			
		Value[2]	Time Period	Value[2]	Time Period	Value[2]	Time Period
D22 - Sacramento at Emmaton	Wet	not applicable		0.45	Apr 1 – Aug 15		
	Above Normal			0.45	Apr 1 – Jun 30	0.63	Jul 1 - Aug 15
	Below Normal			0.45	Apr 1 – Jun 19	1.14	Jun 20 - Aug 15
	Dry			0.45	Apr 1 – Jul 14	1.67	Jul 15 - Aug 15
	Critical			2.78	Apr 1 – Aug 15	not applicable	
D15 - San Joaquin at Jersey Point	Wet	0.44	Apr 1 – May 31	0.45	Apr 1 – Aug 15	not applicable	
	Above Normal	0.44	Apr 1 – May 31	0.45	Apr 1 – Aug 15	not applicable	
	Below Normal	0.44	Apr 1 – May 31	0.45	Apr 1 – Jun 19	0.74	Jun 20 - Aug 15
	Dry	0.44	Apr 1 – May 31	0.45	Apr 1 – Jun 14	1.35	Jun 15 - Aug 15
	Critical	not applicable		2.2	Apr 1 – Aug 15	not applicable	
D29 - San Joaquin at Prisoners Point	Wet, Above Normal, Below Normal, Dry	0.44	Apr 1 – May 31	not applicable			
C2 - Collinsville[3]	not applicable	19.0	Oct	not applicable			
		15.5	Nov-Dec				
		12.5	Jan				
		8.0	Feb-Mar				
		11.0	Apr-May				

[1] Sacramento Valley Water Year Hydrologic Classification
[2] Maximum 14-day running average of mean daily EC (mmhos/cm)
[3] Maximum monthly average of both daily high tide EC values (mmhos/cm)

Table 5 D-1641 water quality objectives for water intakes.

Compliance Location	Station Number	Criteria Description	Water Year type	Value
CCWD at Rock Slough or Antioch Intake	C5 or D12	Maximum mean daily Chloride of 150 mg/L for required number of days	Wet Abv Norm. Blw Norm. Dry Critical	# of days*[10] each calendar year ≤ 150 mg/L Cl 240 190 175 165 155
CCWD at Rock Slough -and- West Canal at Clifton Court -and- DMC Canal at Tracy PP -and- Barker Sl -and- Vallejo PP	C5 C9 DMC1 SLBAR3 C19	Maximum mean daily Chloride	All	250 mg/L

[10] # of days must be met in intervals not less than two weeks

Agriculture, Fish and Wildlife Compliance Stations

Compliance for Emmaton (D22), Jersey Point (D15) and Prisoners Point (D29) is determined from the 14-day running average of mean daily EC. The compliance period begins on April 1 and ends August 15 for the Emmaton (D22) and Jersey Point (D15) stations, and ends May 31 for the Prisoners Point (D29) station. Collinsville (C2) compliance is based on the maximum monthly EC value of the daily average of the two high tides. The compliance periods are January through May and October through December. Specific details are provided in Table 4.

Sacramento River at Emmaton (D22)

No potential compliance issues for the Sacramento River at Emmaton (D22) are expected during the periods analyzed (2018 and 2020). The 14-day average observed, Base, With Project, Future and Future with Project results are compared in Figure 71 for 2018 and Figure 72 for 2020. While Base and Future EC values rise above the compliance limits briefly during both simulation periods, this is likely due to model overestimation of EC. There are no incremental EC increases resulting from the Project at this location.

San Joaquin River at Jersey Point (D15)

The D-1641 compliance period for the Jersey Point location extends from April 1 to August 15. Figure 73 shows that the model predicts non-compliance for Base, With Project, Future and Future with Project results from mid-July through August 15, 2018, however a comparison with observed data shows that the model overpredicts EC during this time. There are no incremental EC increases resulting from the Project at this location. During 2020, shown in Figure 74, no compliance standard violation is predicted.

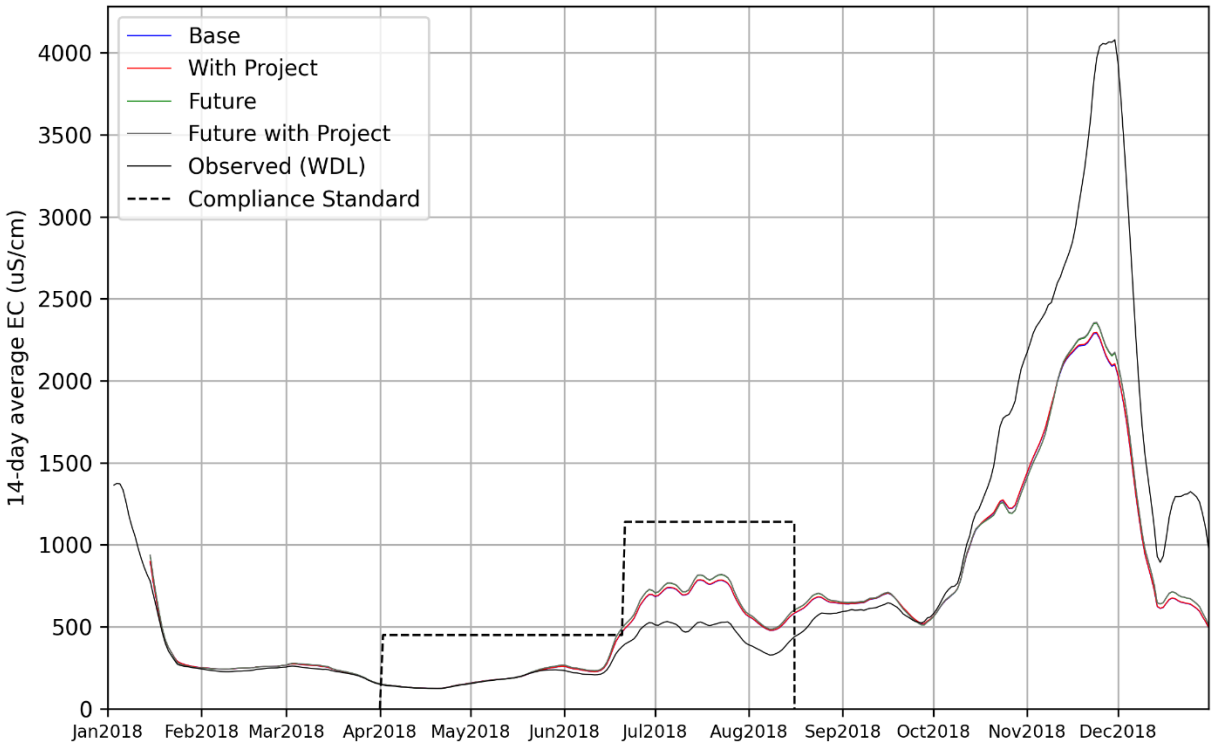
San Joaquin River at Prisoners Point (D29)

Maximum computed 14-day average Prisoners Point EC results for Base, With Project, Future and Future with Project are plotted in Figure 75 and Figure 76 for the 2018 and 2020 simulation periods. There are no incremental EC increases resulting from the Project at this location and all results fall well below the compliance standard.

Sacramento River at Collinsville (C2)

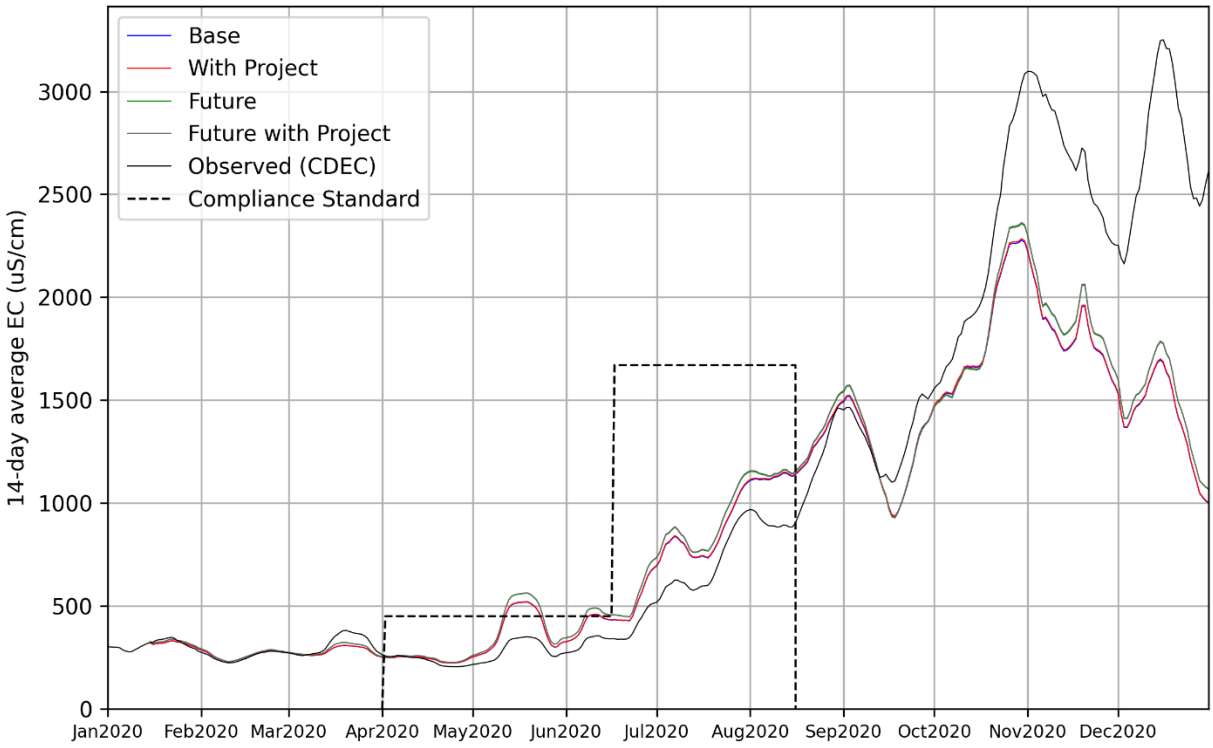
At Collinsville, EC compliance is based on the maximum monthly EC value of the daily average of the two high tides. These values are plotted for observed CDEC EC, Base, With Project, Future and Future with Project EC in Figure 77 for 2018 and Figure 78 for 2020, along with the EC compliance standard. There are no incremental EC increases resulting from the Project at this location and all computed EC values are below the standard during the compliance periods. In November 2018, the observed data violates the standard. The model likely underpredicts EC

during the fall of 2018 and it is likely that all scenarios would also be non-compliant in November 2018, however the Project would not exacerbate any non-compliance.



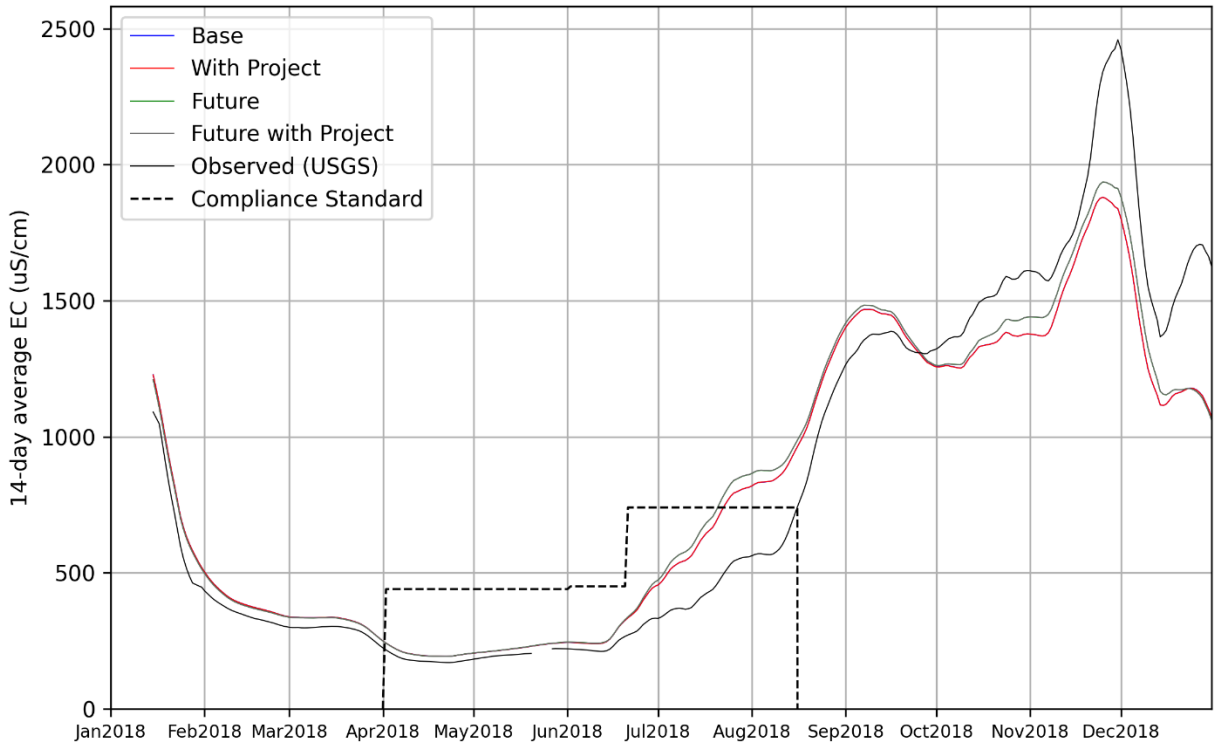
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 71 14-Day running average EC for the Sacramento River at Emmaton (D22). Base, With Project, Future, and Future with Project computed results are plotted with the D-1641 standard and observed Emmaton EC for the 2018 simulation period.



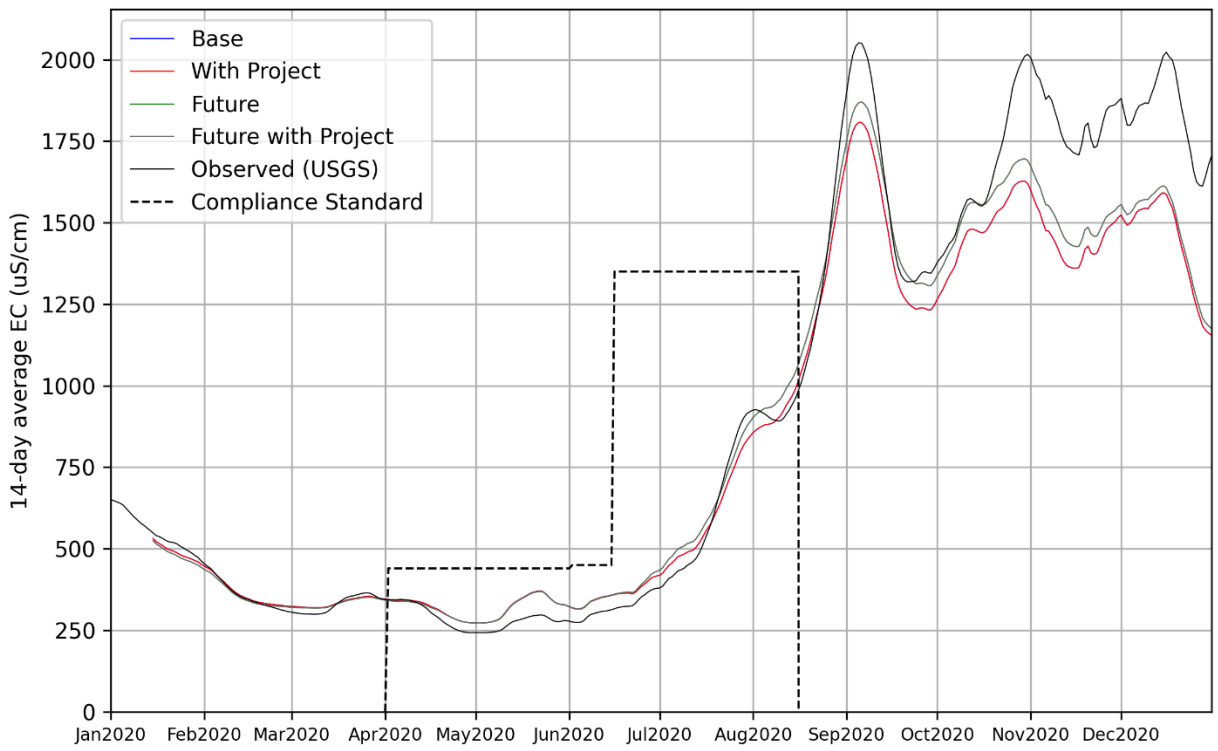
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 72 14-Day running average EC for the Sacramento River at Emmaton (D22). Base, With Project, Future, and Future with Project computed results are plotted with the D-1641 standard and observed Emmaton EC for the 2020 simulation period.



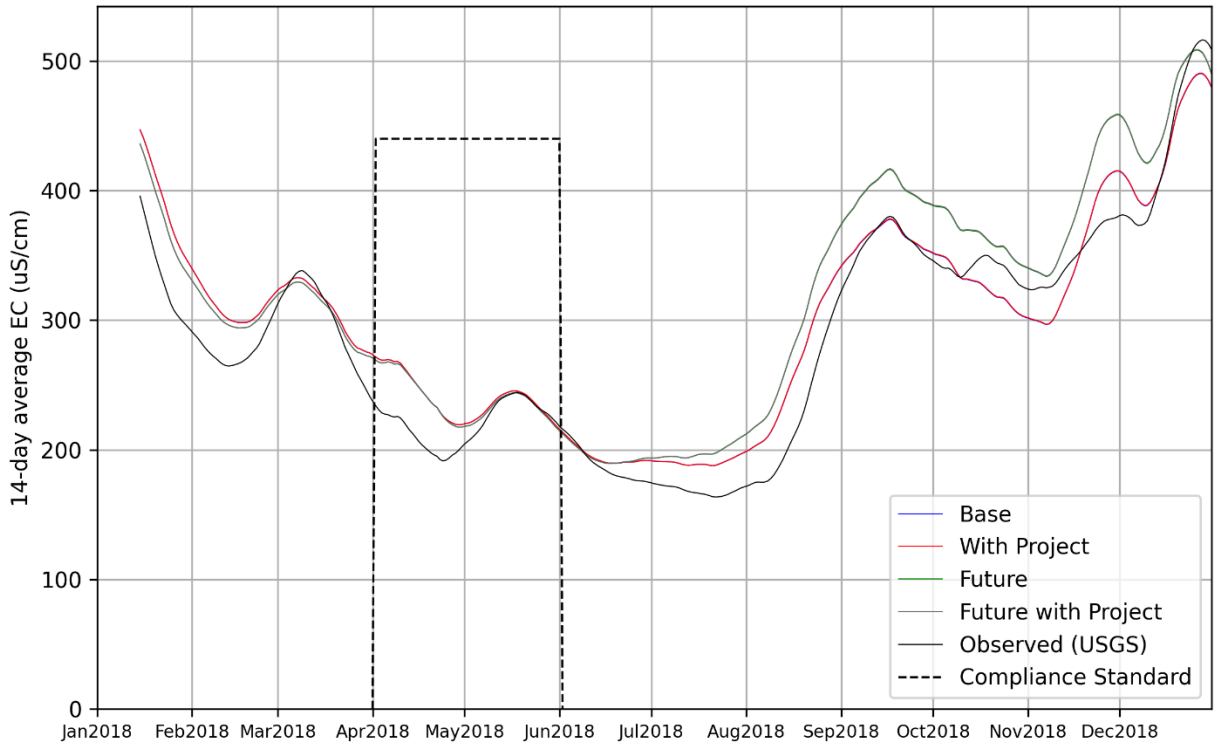
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 73 14-Day running average EC for the San Joaquin River at Jersey Point (D15). Base, With Project, Future, and Future with Project computed results are plotted with the D-1641 standard and observed Jersey Point EC for the 2018 simulation period.



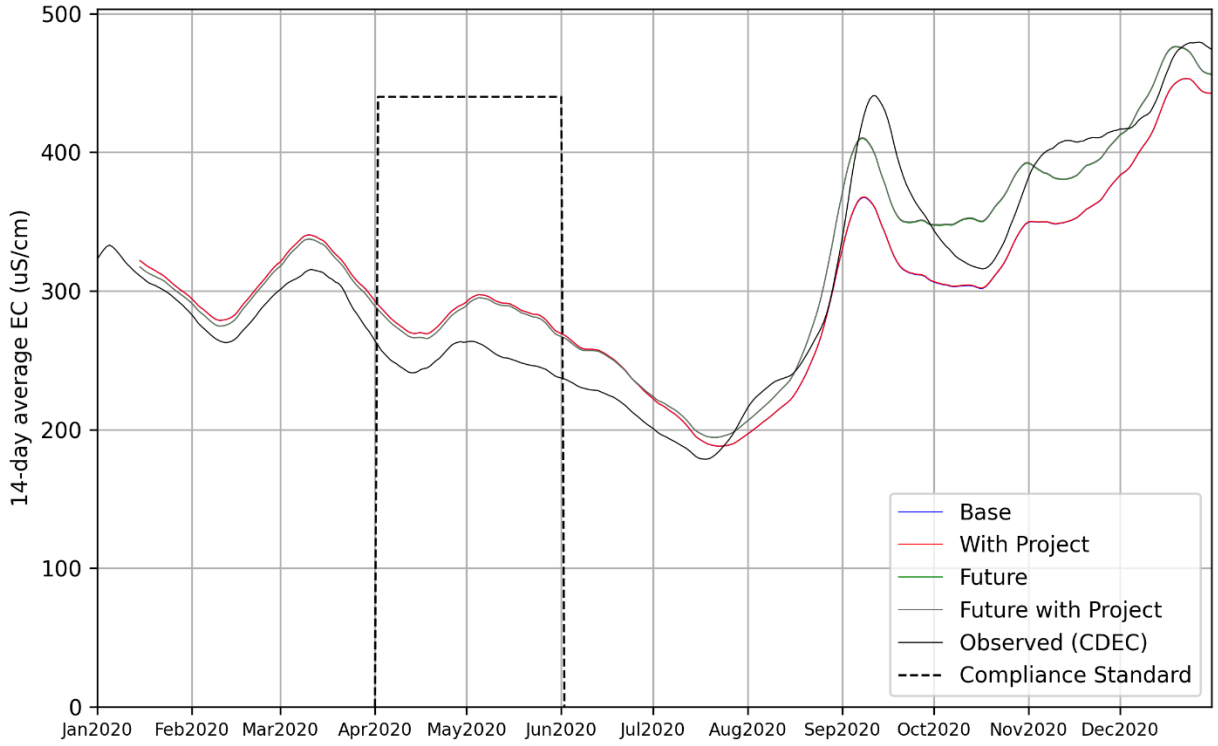
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 74 14-Day running average EC for the San Joaquin River at Jersey Point (D15). Base, With Project, Future, and Future with Project computed results are plotted with the D-1641 standard and observed Jersey Point EC for the 2020 simulation period.



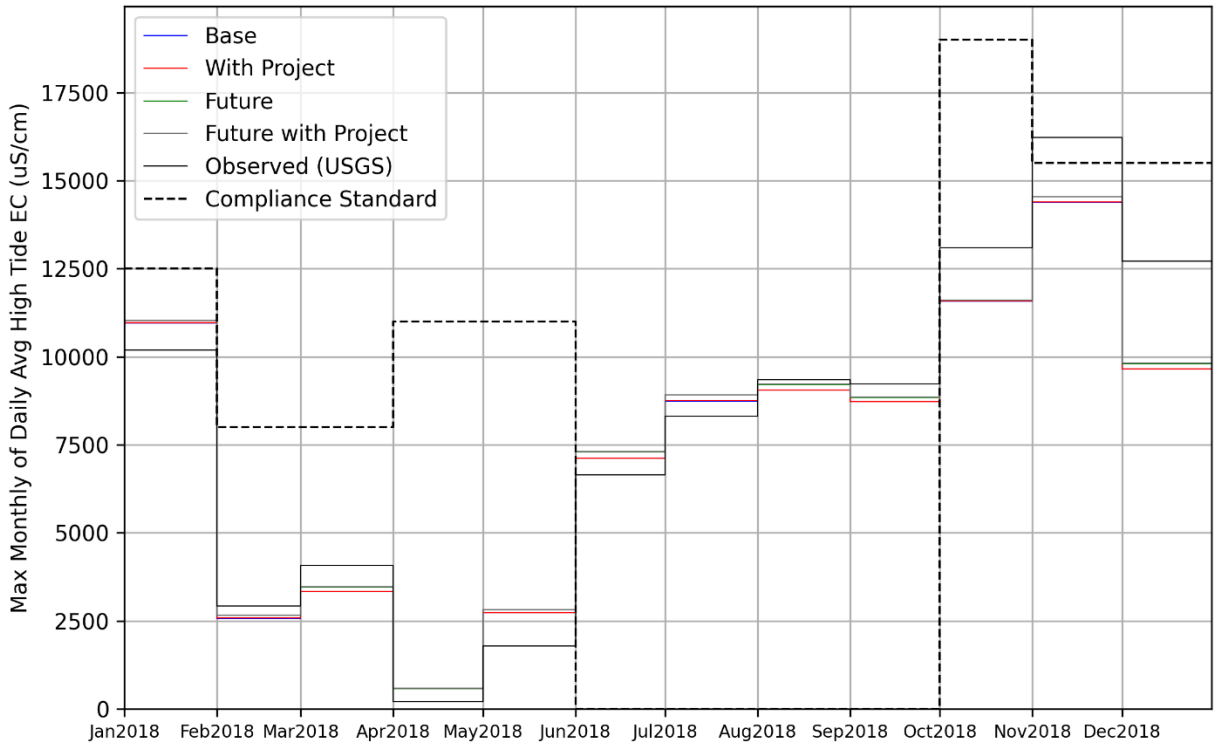
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 75 14-Day running average EC for the San Joaquin River at Prisoners Point (D29). Base, With Project, Future, and Future with Project computed results are plotted with the D-1641 standard and observed Prisoners Point EC for the 2018 simulation period.



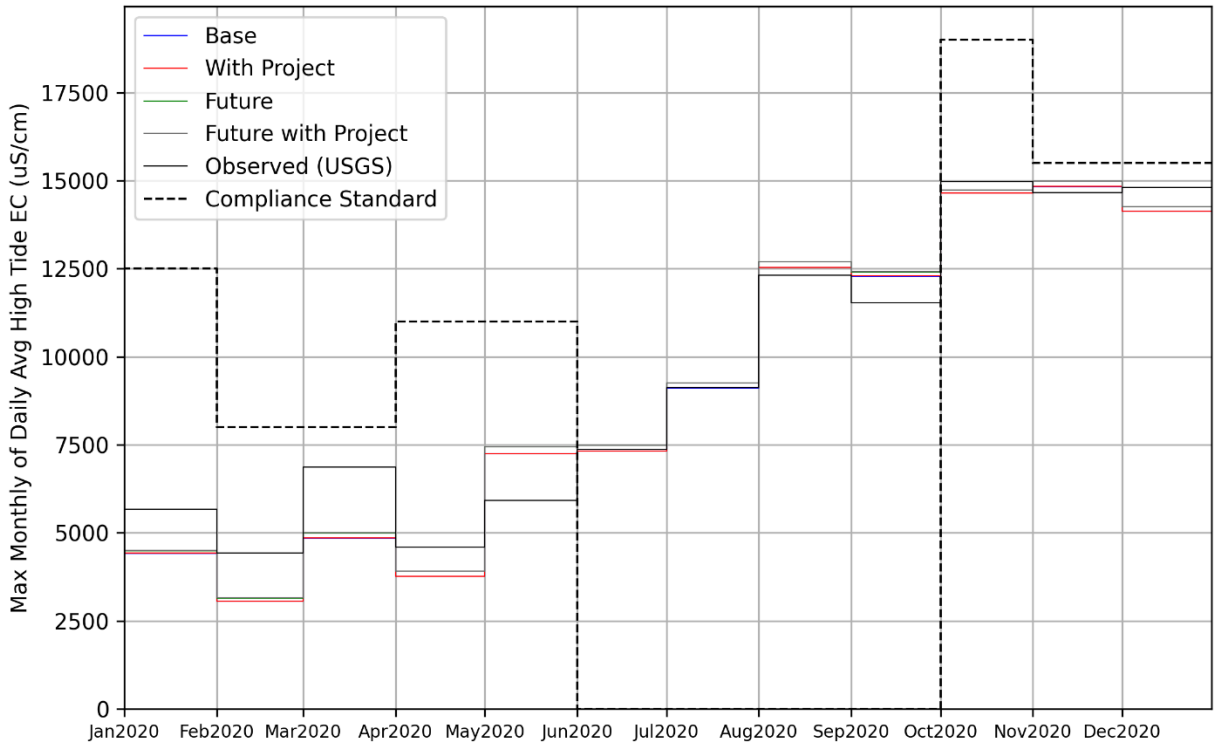
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 76 14-Day running average EC for the San Joaquin River at Prisoners Point (D29). Base, With Project, Future, and Future with Project computed results are plotted with the D-1641 standard and observed Prisoners Point EC for the 2020 simulation period.



Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 77 Max monthly of daily average of high tide EC for the Sacramento River at Collinsville (C2). Base, With Project, Future, and Future with Project computed results are plotted with the D-1641 standard and observed Collinsville EC for the 2018 simulation period.



Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 78 Max monthly of daily average of high tide EC for the Sacramento River at Collinsville (C2). Base, With Project, Future, and Future with Project computed results are plotted with the D-1641 standard and observed Collinsville EC for the 2020 simulation period.

Water Intakes

D-1641 water quality objectives at the water intakes are based on chloride, which can be estimated from the modeled EC results along with volumetric source fraction from Martinez. To determine the volumetric source fraction, Martinez fingerprinting simulations were performed for all scenarios and time periods. For these simulations, a tracer was applied at Martinez and the fraction of tracer was output at each water intake location. Martinez volumetric source fraction is an indication of fraction of seawater.

Chloride (mg/L) was estimated from modeled EC (µS/cm) in conjunction with volumetric Martinez fraction based on the following equations (USBR, 2010).

When volumetric Martinez source fraction is greater than or equal to 0.4%:

$Cl = 0.285(EC) - 50$

When volumetric Martinez source fraction is less than 0.4%:

$Cl = 0.15(EC) - 12$

Chloride criteria, based on the maximum mean daily chloride value, are summarized in Table 5. Results for 2018 and 2020 are summarized in Table 6 and Table 7, respectively. Relative to the Base and Future conditions, the CSMB restoration Project had no impact on the maximum mean daily chloride values used to determine compliance. Antioch does not meet the criteria for number of days below a threshold for any of the scenarios, but the Project does not make this worse.

Table 6 Chloride results at D-1641 water intakes for 2018.

Intake Location	Base	With Project	Future	Future with Project
	# days < 150 mg/L (175 days req'd at Rock Slough or Antioch)			
C5–CC at Pumping Plant 1[11]	212	212	210	210
D12–SJR at Antioch	139	139	139	139
	Max mean daily chloride, mg/L (req'd < 250 mg/L)			
C5–CC at Pumping Plant 1	115	115	121	121
CCWD intake Old River	81	81	86	86
CCWD intake Victoria Canal	52	52	54	54
C9–West Canal at Clifton Ct	54	54	56	56
DMC1–DMC Canal Tracy PP	69	69	72	72
SLBAR3–Barker Slough PP	30	30	30	30
C19–Vallejo intake	61	61	63	63

Table 7 Chloride results at D-1641 water intakes for 2020.

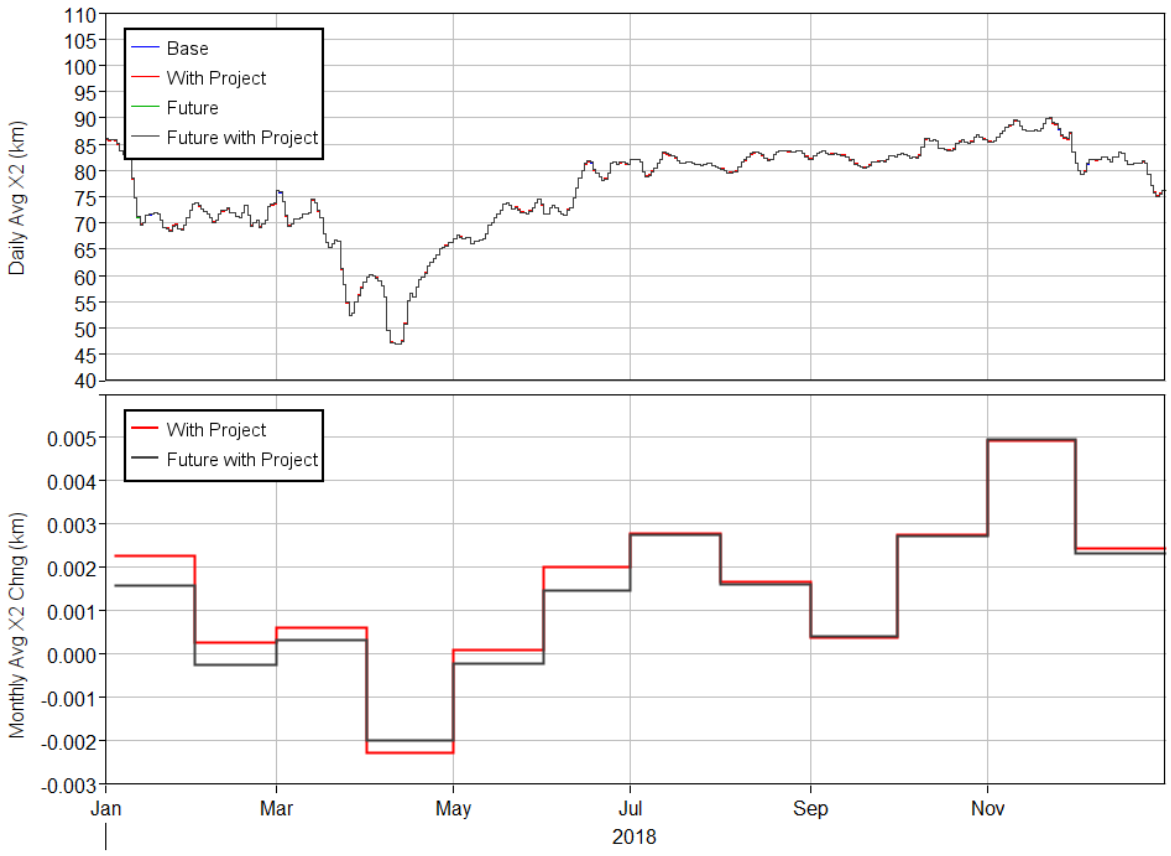
Intake Location	Base	With Project	Future	Future with Project
	# days < 150 mg/L (165 days req'd at Rock Slough or Antioch)			
C5–CC at Pumping Plant 1[12]	253	253	245	245
D12–SJR at Antioch	61	61	62	62
	Max mean daily chloride, mg/L (req'd < 250 mg/L)			
C5–CC at Pumping Plant 1	102	102	109	109
CCWD intake Old River	84	84	91	91
CCWD intake Victoria Canal	58	58	61	61
C9–West Canal at Clifton Ct	78	78	83	83
DMC1–DMC Canal Tracy PP	80	80	84	84
SLBAR3–Barker Slough PP	25	25	25	25
C19–Vallejo intake	57	57	59	59

[11] # of days are consecutive, meeting the requirement that criteria must be met in intervals of not less than two weeks

[12] # of days are consecutive, meeting the requirement that criteria must be met in intervals of not less than two weeks

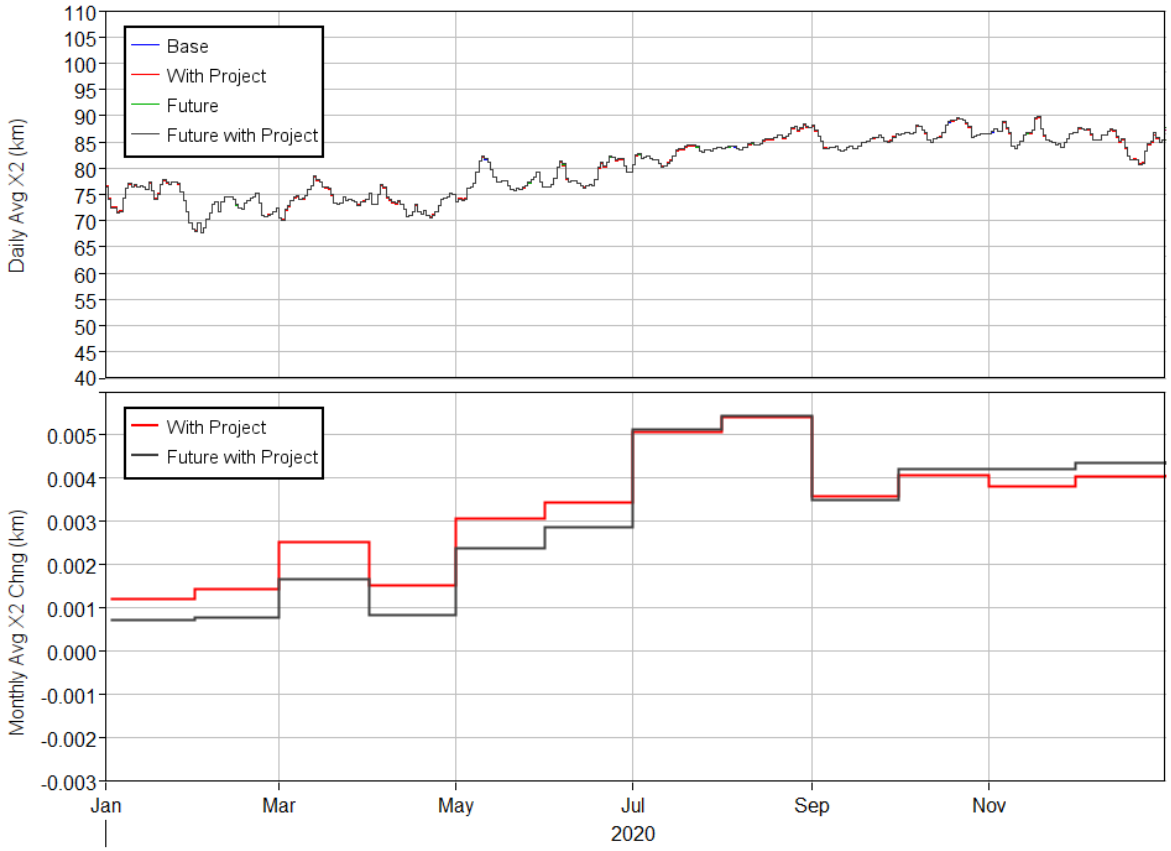
X2

Base, With Project, Future and Future with Project X2 distances are plotted with monthly averaged differences in Figure 79 for 2018 and in Figure 80 for 2020. The CSMB restoration Project results in changes in X2 of less than 0.01 km. The maximum monthly averaged increase of 0.005 km occurs in August 2020.



Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 79 Base, With Project, Future and Future with Project daily average X2 location (top) and monthly average change from Base X2 location for current and Future conditions (bottom) for the 2018 simulation period.



Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 80 Base, With Project, Future and Future with Project daily average X2 location (top) and monthly average change from Base X2 location for current and Future conditions (bottom) for the 2020 simulation period.

Evaluation of Bromide Impacts at Drinking Water Intakes

Bromide can be estimated from the modeled EC results along with volumetric source fraction from Martinez. To determine the volumetric source fraction, Martinez fingerprinting simulations were performed for all scenarios and time periods. For these simulations, a tracer was applied at Martinez and the fraction of tracer was output at each water intake location. Martinez volumetric source fraction is an indication of fraction of seawater.

Bromide (mg/L) was estimated from modeled EC (µS/cm) in conjunction with volumetric Martinez fraction based on the following equations (USBR, 2015).

When volumetric Martinez source fraction is greater than or equal to 0.4%:

$Br = 0.000827(EC) - 0.112$ (1)

When volumetric Martinez source fraction is less than 0.4%:

$$Br = 0.000552(EC) - 0.073 \quad (2)$$

These equations were developed based on whether water at any location is seawater or riverine dominant. Seawater is typically the primary source of bromide in the Delta, so equation (1) is appropriate for estimating bromide from EC in the central and south Delta where EC variations from the CSMB restoration project are predominantly due to changes in the seawater fraction. In the north Delta where seawater fractions are very small and salinity is from local sources (neither seawater nor riverine), the USBR (2015) equations may not be appropriate. While the USBR equations have been applied to the Barker Slough and Vallejo water intakes with results reported below, they should be interpreted with caution. The direction of bromide change likely follows the direction of EC change in the north Delta, however, there is uncertainty in the predicted magnitude of change based on the USBR equations.

These values are also monthly averaged and summarized in tabular format in Table 8 for 2018 and in Table 9 for 2020. Tabular results are provided with sufficient detail to provide reader with information about small changes. While this level of precision is available from the water quality (EC) model, the model's accuracy is likely only one to two significant digits with further uncertainty in the EC to bromide conversions. Although there is uncertainty in the results, as reflected by the effective significant digits, the model is considered sufficient for assessing potential impacts, particularly for the direction of change and small % change. Additionally, the USBR (2015) equations are considered sufficient for converting EC to bromide for assessing potential impacts when EC change is primarily due to changes in seawater fraction.

The general observations for CSMB Project impacts on bromide are:

- Project impacts on Bromide are very small throughout the model domain. The largest increases occur at the NBA intake in Barker Slough during the fall of 2020. Changes at this location range from -0.02% to 0.3%
- Bromide increases of up to 0.2% occur in the fall at the south Delta water intakes.
- The largest percent bromide decreases of less than 0.1% occur at Antioch.

Daily averaged bromide results are provided at the water intake locations as time series of bromide and absolute and relative (%) change from Base/Future bromide in Figure 81 through Figure 88 for 2018 and in Figure 89 through Figure 96 for 2020.

Although results based on published relationships between EC and bromide predict increases in bromide at C19 and at times in Barker Slough, there is uncertainty in the magnitude of these changes because the EC to bromide conversion equations were not developed specifically for the conditions occurring in this area, where local inflows are the primary source of salinity.

Table 8 Monthly average Base and Future Bromide and percent change from Base and Future Bromide with the CSMB restoration Project at water intakes for the 2018 simulation period. The darkest blue cells indicate the largest decreases for the simulation period and the darkest red cells indicate the largest increases.[13,14]

	SLBAR3 – Barker Slough NBA Intake						C19 – City of Vallejo Intake Cache Slough					
	Base			Future			Base			Future		
	Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change	
	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%
Jan-2018	0.12	0.000	0.01%	0.12	0.000	0.02%	0.32	0.000	0.07%	0.33	0.000	0.06%
Feb-2018	0.12	0.000	0.02%	0.12	0.000	0.03%	0.37	0.000	0.10%	0.38	0.000	0.09%
Mar-2018	0.20	0.000	0.02%	0.20	0.000	0.02%	0.30	0.000	0.05%	0.31	0.000	0.05%
Apr-2018	0.24	0.000	0.04%	0.24	0.000	0.04%	0.29	0.000	0.08%	0.30	0.000	0.08%
May-2018	0.09	0.000	0.08%	0.09	0.000	0.08%	0.13	0.000	0.10%	0.13	0.000	0.11%
Jun-2018	0.03	0.000	0.04%	0.03	0.000	0.06%	0.09	0.000	0.09%	0.10	0.000	0.09%
Jul-2018	0.01	0.000	0.13%	0.01	0.000	0.19%	0.09	0.000	0.12%	0.09	0.000	0.12%
Aug-2018	0.01	0.000	0.04%	0.01	0.000	0.08%	0.10	0.000	0.11%	0.10	0.000	0.11%
Sep-2018	0.03	0.000	-0.02%	0.03	0.000	-0.01%	0.11	0.000	0.08%	0.11	0.000	0.09%
Oct-2018	0.04	0.000	0.02%	0.04	0.000	0.04%	0.16	0.000	0.12%	0.17	0.000	0.12%
Nov-2018	0.03	0.000	0.12%	0.03	0.000	0.13%	0.19	0.000	0.13%	0.20	0.000	0.12%
Dec-2018	0.07	0.000	0.08%	0.07	0.000	0.09%	0.22	0.000	0.10%	0.23	0.000	0.09%

[13] Results are provided with sufficient detail to provide reader with information about small changes. While this level of precision is available from the model, the model's accuracy is likely only one-two significant digits.

[14] Equations converting EC to bromide may be less accurate at the SLBAR3 and C19 locations than for other areas in the Delta, given that these equations were not developed for conditions where local inflows are the primary salinity source, as is the case at these locations.

	D-12 – San Joaquin River at Antioch						C5 – Contra Costa Intake at Rock Slough					
	Base			Future			Base			Future		
	Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change	
	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%
Jan-2018	1.31	-0.001	-0.04%	1.28	0.000	-0.03%	0.58	0.000	0.00%	0.58	0.000	0.00%
Feb-2018	0.37	0.000	-0.06%	0.36	0.000	-0.04%	0.39	0.000	0.01%	0.38	0.000	0.01%
Mar-2018	0.25	0.000	-0.04%	0.25	0.000	-0.02%	0.20	0.000	0.01%	0.20	0.000	0.01%
Apr-2018	0.03	0.000	-0.01%	0.03	0.000	-0.01%	0.18	0.000	0.01%	0.18	0.000	0.01%
May-2018	0.23	0.000	-0.03%	0.22	0.000	-0.01%	0.19	0.000	0.02%	0.19	0.000	0.02%
Jun-2018	0.96	0.000	-0.02%	0.96	0.000	-0.01%	0.14	0.000	0.02%	0.14	0.000	0.02%
Jul-2018	1.78	0.000	-0.02%	1.78	0.000	0.00%	0.19	0.000	0.04%	0.21	0.000	0.06%
Aug-2018	2.30	-0.001	-0.04%	2.27	-0.001	-0.03%	0.33	0.000	0.06%	0.35	0.000	0.09%
Sep-2018	2.33	-0.001	-0.06%	2.27	-0.001	-0.05%	0.53	0.000	0.02%	0.56	0.000	0.04%
Oct-2018	2.97	-0.001	-0.05%	2.92	-0.001	-0.04%	0.52	0.000	0.03%	0.55	0.000	0.05%
Nov-2018	4.12	-0.001	-0.03%	4.08	-0.001	-0.02%	0.50	0.000	0.05%	0.55	0.000	0.06%
Dec-2018	1.87	-0.001	-0.04%	1.84	0.000	-0.02%	0.58	0.000	0.05%	0.63	0.000	0.06%

	C9 – Clifton Ct Forebay Intake						DMC1 – Delta Mendota Canal at Tracy PP					
	Base			Future			Base			Future		
	Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change	
	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%
Jan-2018	0.37	0.000	-0.01%	0.37	0.000	-0.01%	0.34	0.000	0.01%	0.34	0.000	0.00%
Feb-2018	0.22	0.000	-0.02%	0.22	0.000	0.00%	0.23	0.000	-0.01%	0.23	0.000	0.00%
Mar-2018	0.19	0.000	0.00%	0.19	0.000	0.01%	0.21	0.000	0.00%	0.21	0.000	0.00%
Apr-2018	0.08	0.000	0.01%	0.08	0.000	0.01%	0.08	0.000	0.00%	0.08	0.000	0.00%
May-2018	0.05	0.000	0.01%	0.05	0.000	0.00%	0.05	0.000	0.00%	0.05	0.000	0.00%
Jun-2018	0.08	0.000	0.01%	0.08	0.000	0.01%	0.09	0.000	0.01%	0.09	0.000	0.01%
Jul-2018	0.11	0.000	0.06%	0.12	0.000	0.11%	0.11	0.000	0.05%	0.12	0.000	0.13%
Aug-2018	0.21	0.000	0.08%	0.23	0.000	0.12%	0.20	0.000	0.08%	0.22	0.000	0.11%
Sep-2018	0.34	0.000	0.06%	0.37	0.000	0.09%	0.30	0.000	0.05%	0.32	0.000	0.08%
Oct-2018	0.32	0.000	0.06%	0.35	0.000	0.08%	0.29	0.000	0.06%	0.31	0.000	0.08%
Nov-2018	0.33	0.000	0.05%	0.36	0.000	0.06%	0.31	0.000	0.05%	0.33	0.000	0.06%
Dec-2018	0.40	0.000	0.04%	0.43	0.000	0.07%	0.40	0.000	0.03%	0.43	0.000	0.08%

	CCWD Intake at Old River						CCWD Intake at Victoria Canal					
	Base			Future			Base			Future		
	Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change	
	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%
Jan-2018	0.39	0.000	-0.01%	0.39	0.000	-0.01%	0.33	0.000	-0.01%	0.32	0.000	0.00%
Feb-2018	0.22	0.000	-0.02%	0.22	0.000	0.02%	0.19	0.000	0.00%	0.19	0.000	0.01%
Mar-2018	0.16	0.000	0.01%	0.16	0.000	0.01%	0.21	0.000	0.01%	0.21	0.000	0.02%
Apr-2018	0.10	0.000	0.00%	0.10	0.000	0.00%	0.12	0.000	0.00%	0.12	0.000	0.00%
May-2018	0.09	0.000	0.01%	0.09	0.000	0.01%	0.10	0.000	0.00%	0.10	0.000	0.00%
Jun-2018	0.08	0.000	0.02%	0.08	0.000	0.02%	0.08	0.000	0.01%	0.08	0.000	0.01%
Jul-2018	0.15	0.000	0.09%	0.15	0.000	0.10%	0.07	0.000	0.03%	0.07	0.000	0.05%
Aug-2018	0.29	0.000	0.07%	0.29	0.000	0.11%	0.09	0.000	0.18%	0.11	0.000	0.20%
Sep-2018	0.45	0.000	0.04%	0.45	0.000	0.07%	0.17	0.000	0.13%	0.19	0.000	0.17%
Oct-2018	0.41	0.000	0.06%	0.41	0.000	0.07%	0.18	0.000	0.10%	0.20	0.000	0.13%
Nov-2018	0.44	0.000	0.06%	0.44	0.000	0.07%	0.20	0.000	0.04%	0.22	0.000	0.06%
Dec-2018	0.47	0.000	0.05%	0.47	0.000	0.08%	0.28	0.000	0.05%	0.29	0.000	0.08%

Table 9 Monthly average Base and Future Bromide and percent change from Base and Future Bromide with the CSMB restoration Project at water intakes for the 2020 simulation period. The darkest blue cells indicate the largest decreases for the simulation period and the darkest red cells indicate the largest increases.[15,16]

	SLBAR3 – Barker Slough NBA Intake						C19 – City of Vallejo Intake Cache Slough					
	Base			Future			Base			Future		
	Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change	
	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%
Jan-2020	0.12	0.000	0.02%	0.13	0.000	0.03%	0.30	0.000	0.06%	0.31	0.000	0.05%
Feb-2020	0.11	0.000	0.03%	0.11	0.000	0.07%	0.34	0.000	0.06%	0.35	0.000	0.05%
Mar-2020	0.12	0.000	0.02%	0.12	0.000	0.04%	0.30	0.000	0.04%	0.30	0.000	0.03%
Apr-2020	0.12	0.000	0.05%	0.11	0.000	0.06%	0.20	0.000	0.10%	0.21	0.000	0.10%
May-2020	0.05	0.000	0.06%	0.05	0.000	0.07%	0.11	0.000	0.09%	0.11	0.000	0.09%
Jun-2020	0.03	0.000	0.04%	0.03	0.000	0.05%	0.09	0.000	0.08%	0.09	0.000	0.08%
Jul-2020	0.02	0.000	0.06%	0.02	0.000	0.10%	0.08	0.000	0.11%	0.09	0.000	0.11%
Aug-2020	0.02	0.000	0.03%	0.02	0.000	0.07%	0.10	0.000	0.10%	0.10	0.000	0.10%
Sep-2020	0.04	0.000	0.01%	0.03	0.000	0.03%	0.13	0.000	0.10%	0.14	0.000	0.10%
Oct-2020	0.04	0.000	0.08%	0.04	0.000	0.09%	0.14	0.000	0.12%	0.15	0.000	0.12%
Nov-2020	0.03	0.000	0.25%	0.03	0.000	0.31%	0.25	0.000	0.10%	0.26	0.000	0.10%
Dec-2020	0.05	0.000	0.12%	0.05	0.000	0.17%	0.15	0.000	0.07%	0.15	0.000	0.06%

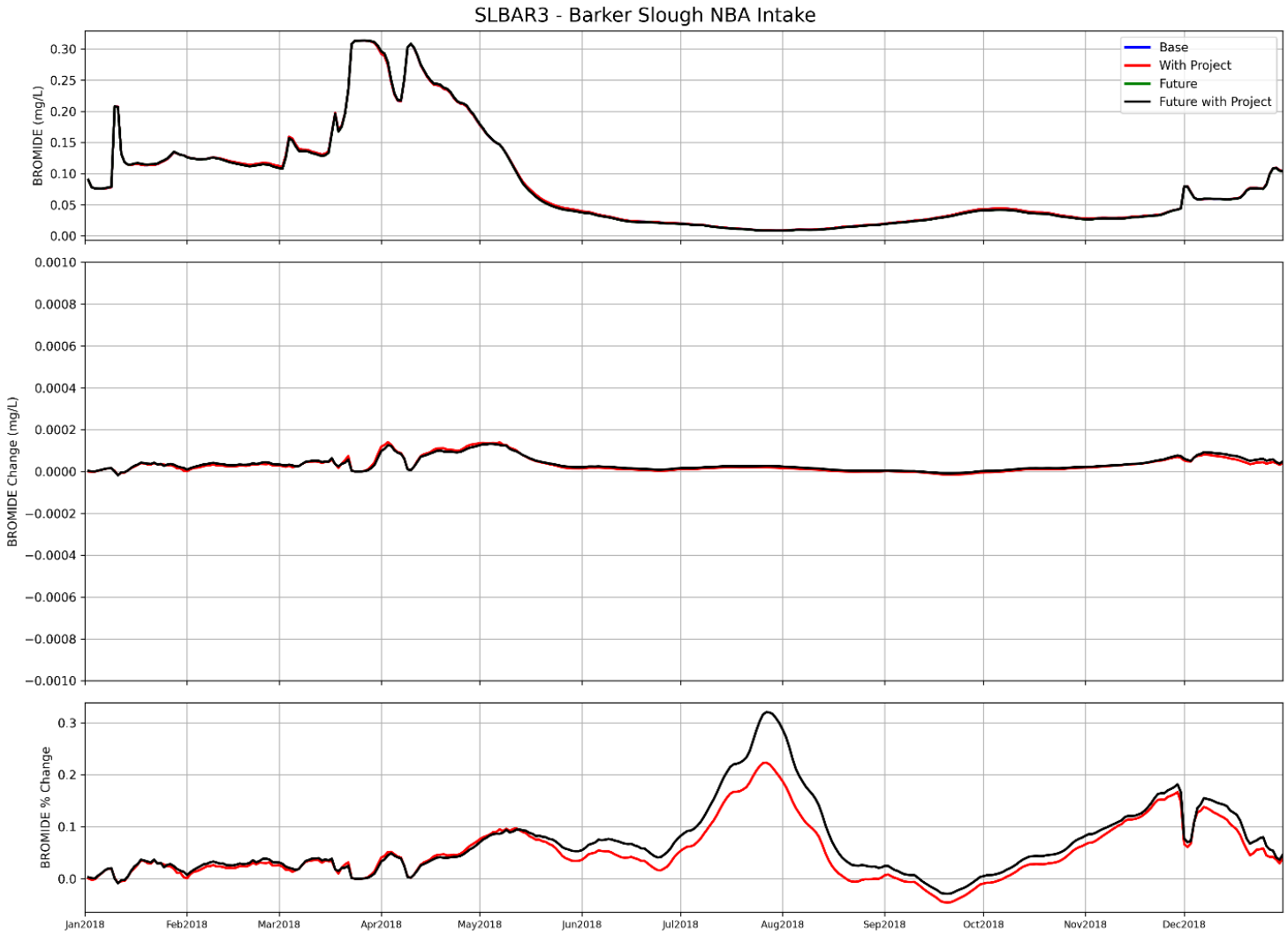
[15] Results are provided with sufficient detail to provide reader with information about small changes. While this level of precision is available from the model, the model's accuracy is likely only one-two significant digits.

[16] Equations converting EC to bromide may be less accurate at the SLBAR3 and C19 locations than for other areas in the Delta, given that these equations were not developed for conditions where local inflows are the primary salinity source, as is the case at these locations.

	D-12 – San Joaquin River at Antioch						C5 – Contra Costa Intake at Rock Slough					
	Base			Future			Base			Future		
	Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change	
	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%
Jan-2020	0.71	-0.001	-0.08%	0.68	0.000	-0.04%	0.29	0.000	-0.01%	0.29	0.000	0.00%
Feb-2020	0.37	0.000	-0.09%	0.35	0.000	-0.05%	0.26	0.000	-0.03%	0.26	0.000	0.00%
Mar-2020	0.50	0.000	-0.07%	0.48	0.000	-0.04%	0.23	0.000	0.00%	0.23	0.000	0.01%
Apr-2020	0.40	0.000	-0.08%	0.39	0.000	-0.05%	0.15	0.000	0.00%	0.15	0.000	0.01%
May-2020	0.81	0.000	-0.05%	0.79	0.000	-0.02%	0.14	0.000	0.00%	0.14	0.000	0.01%
Jun-2020	1.09	0.000	-0.03%	1.08	0.000	-0.01%	0.13	0.000	0.01%	0.13	0.000	0.03%
Jul-2020	2.07	-0.001	-0.03%	2.06	0.000	-0.02%	0.17	0.000	0.05%	0.19	0.000	0.07%
Aug-2020	3.31	-0.001	-0.04%	3.27	-0.001	-0.03%	0.33	0.000	0.05%	0.36	0.000	0.08%
Sep-2020	3.10	-0.002	-0.05%	3.06	-0.001	-0.04%	0.55	0.000	0.06%	0.60	0.000	0.08%
Oct-2020	3.96	-0.002	-0.04%	3.91	-0.001	-0.03%	0.47	0.000	0.08%	0.54	0.001	0.09%
Nov-2020	3.69	-0.001	-0.04%	3.63	-0.001	-0.02%	0.50	0.000	0.06%	0.56	0.001	0.09%
Dec-2020	3.26	-0.001	-0.03%	3.20	0.000	-0.01%	0.61	0.000	0.02%	0.64	0.000	0.06%

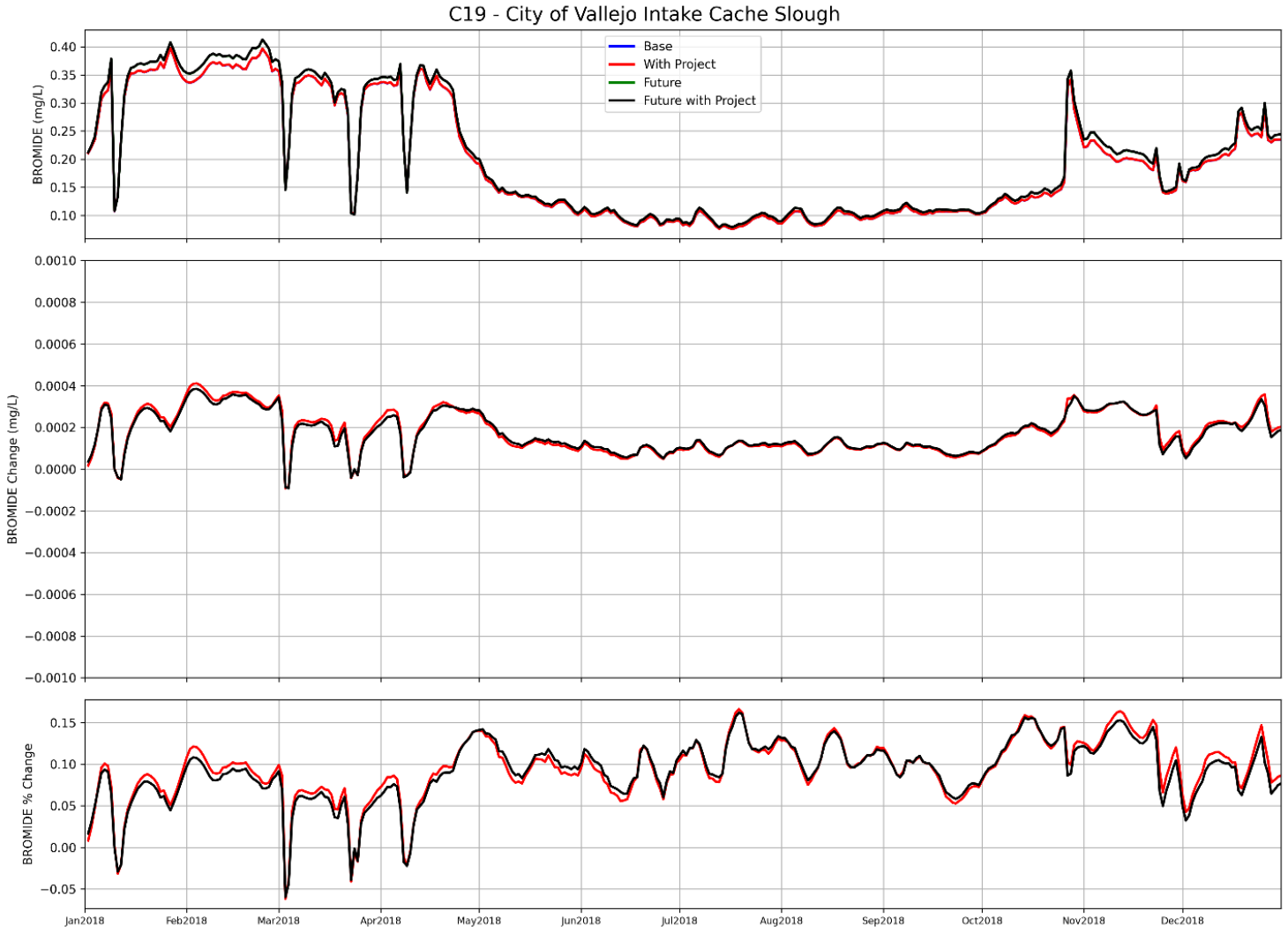
	C9 – Clifton Ct Forebay Intake						DMC1 – Delta Mendota Canal at Tracy PP					
	Base			Future			Base			Future		
	Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change	
	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%
Jan-2020	0.25	0.000	-0.01%	0.25	0.000	0.00%	0.28	0.000	0.00%	0.27	0.000	0.00%
Feb-2020	0.24	0.000	-0.01%	0.23	0.000	0.00%	0.24	0.000	-0.01%	0.24	0.000	0.00%
Mar-2020	0.20	0.000	0.00%	0.20	0.000	0.00%	0.21	0.000	0.00%	0.21	0.000	0.01%
Apr-2020	0.21	0.000	0.00%	0.21	0.000	0.00%	0.22	0.000	0.00%	0.22	0.000	0.00%
May-2020	0.15	0.000	0.01%	0.15	0.000	0.01%	0.15	0.000	0.01%	0.15	0.000	0.01%
Jun-2020	0.12	0.000	0.02%	0.12	0.000	0.03%	0.12	0.000	0.02%	0.12	0.000	0.02%
Jul-2020	0.12	0.000	0.05%	0.13	0.000	0.07%	0.11	0.000	0.04%	0.12	0.000	0.06%
Aug-2020	0.22	0.000	0.07%	0.24	0.000	0.10%	0.21	0.000	0.06%	0.24	0.000	0.09%
Sep-2020	0.36	0.000	0.09%	0.41	0.000	0.11%	0.36	0.000	0.08%	0.40	0.000	0.10%
Oct-2020	0.31	0.000	0.08%	0.36	0.000	0.10%	0.31	0.000	0.07%	0.35	0.000	0.09%
Nov-2020	0.37	0.000	0.05%	0.40	0.000	0.08%	0.36	0.000	0.04%	0.39	0.000	0.06%
Dec-2020	0.46	0.000	0.01%	0.49	0.000	0.05%	0.48	0.000	0.01%	0.50	0.000	0.04%

	CCWD Intake at Old River						CCWD Intake at Victoria Canal					
	Base			Future			Base			Future		
	Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change		Bromide	With Project Bromide change	
	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%	mg/L	mg/L	%
Jan-2020	0.24	0.000	-0.01%	0.23	0.000	0.00%	0.21	0.000	0.00%	0.21	0.000	0.00%
Feb-2020	0.23	0.000	-0.03%	0.23	0.000	0.00%	0.23	0.000	0.00%	0.21	0.000	0.01%
Mar-2020	0.18	0.000	0.00%	0.18	0.000	0.01%	0.19	0.000	0.01%	0.19	0.000	0.01%
Apr-2020	0.15	0.000	0.00%	0.15	0.000	0.01%	0.17	0.000	0.01%	0.17	0.000	0.02%
May-2020	0.15	0.000	0.01%	0.15	0.000	0.02%	0.16	0.000	0.02%	0.16	0.000	0.03%
Jun-2020	0.12	0.000	0.02%	0.12	0.000	0.03%	0.13	0.000	0.03%	0.13	0.000	0.03%
Jul-2020	0.14	0.000	0.06%	0.15	0.000	0.09%	0.08	0.000	0.03%	0.08	0.000	0.04%
Aug-2020	0.28	0.000	0.07%	0.31	0.000	0.10%	0.08	0.000	0.05%	0.10	0.000	0.10%
Sep-2020	0.45	0.000	0.09%	0.50	0.001	0.10%	0.19	0.000	0.07%	0.21	0.000	0.12%
Oct-2020	0.39	0.000	0.09%	0.44	0.000	0.10%	0.19	0.000	0.07%	0.22	0.000	0.11%
Nov-2020	0.43	0.000	0.06%	0.48	0.000	0.09%	0.27	0.000	0.03%	0.30	0.000	0.07%
Dec-2020	0.47	0.000	0.02%	0.50	0.000	0.07%	0.34	0.000	0.01%	0.36	0.000	0.06%



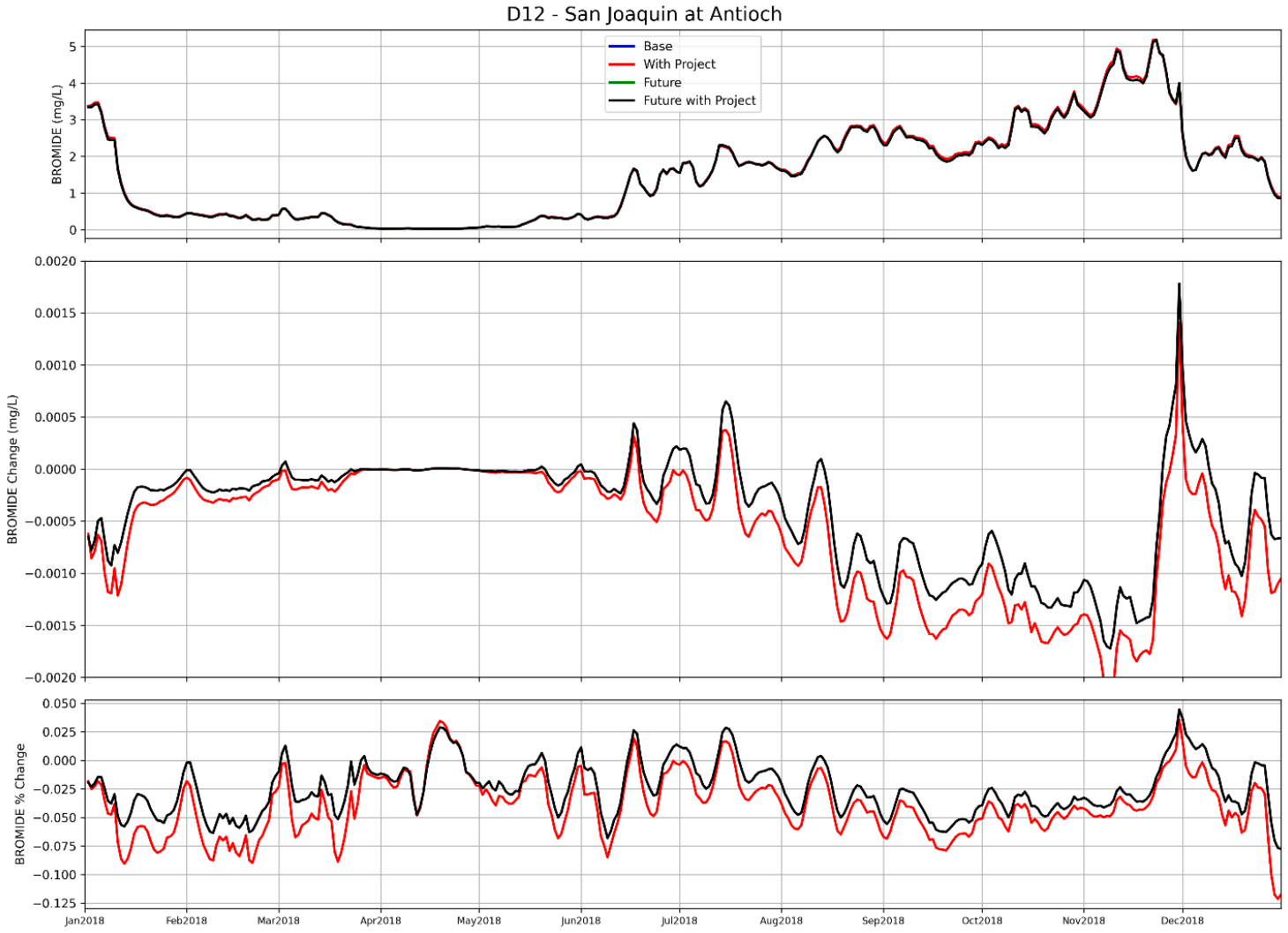
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 81 Daily average Bromide at station SLBAR3 – Barker Slough at NBA for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2018 simulation period.



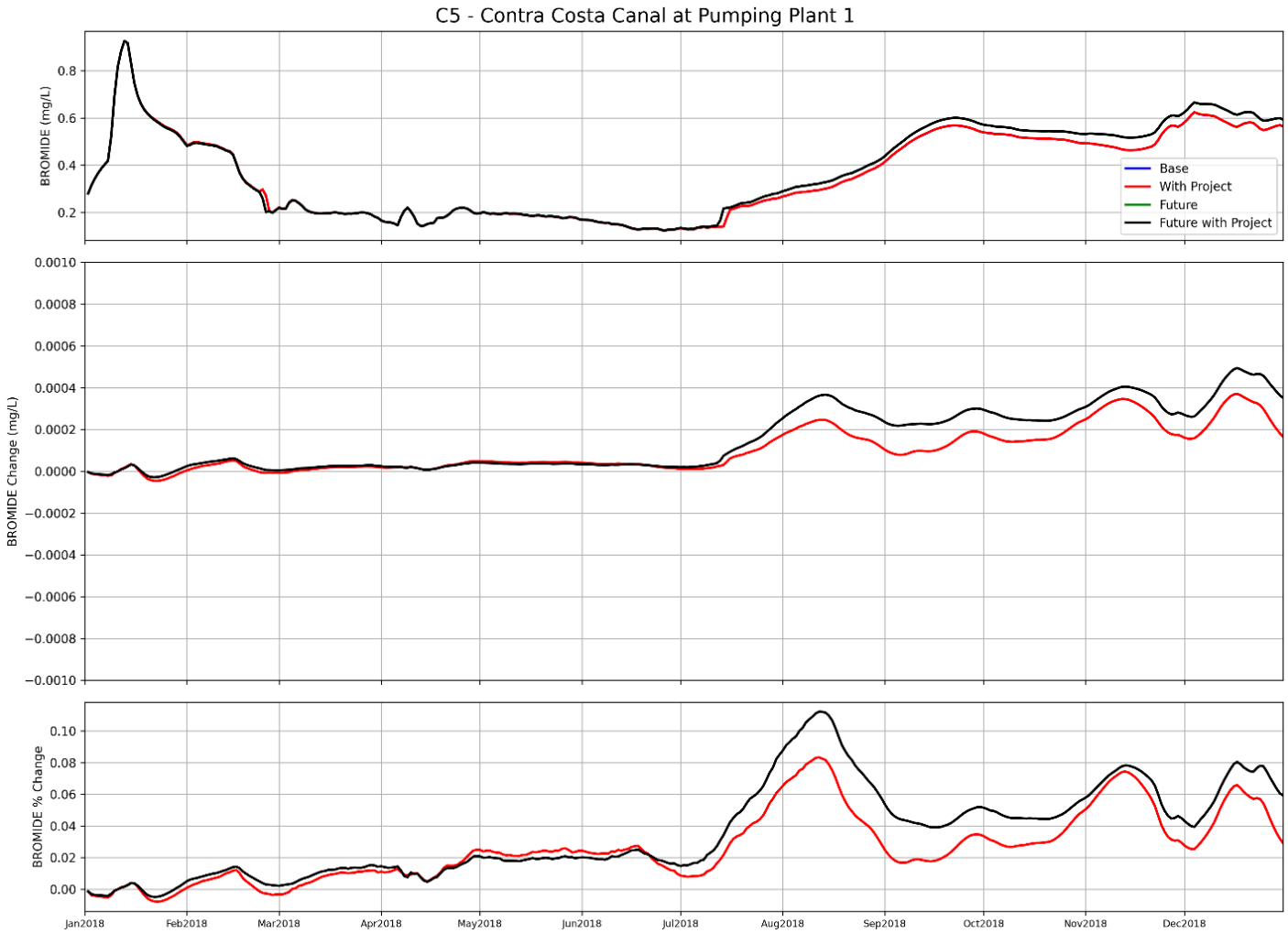
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 82 Daily average Bromide at station C19 – City of Vallejo intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2018 simulation period.



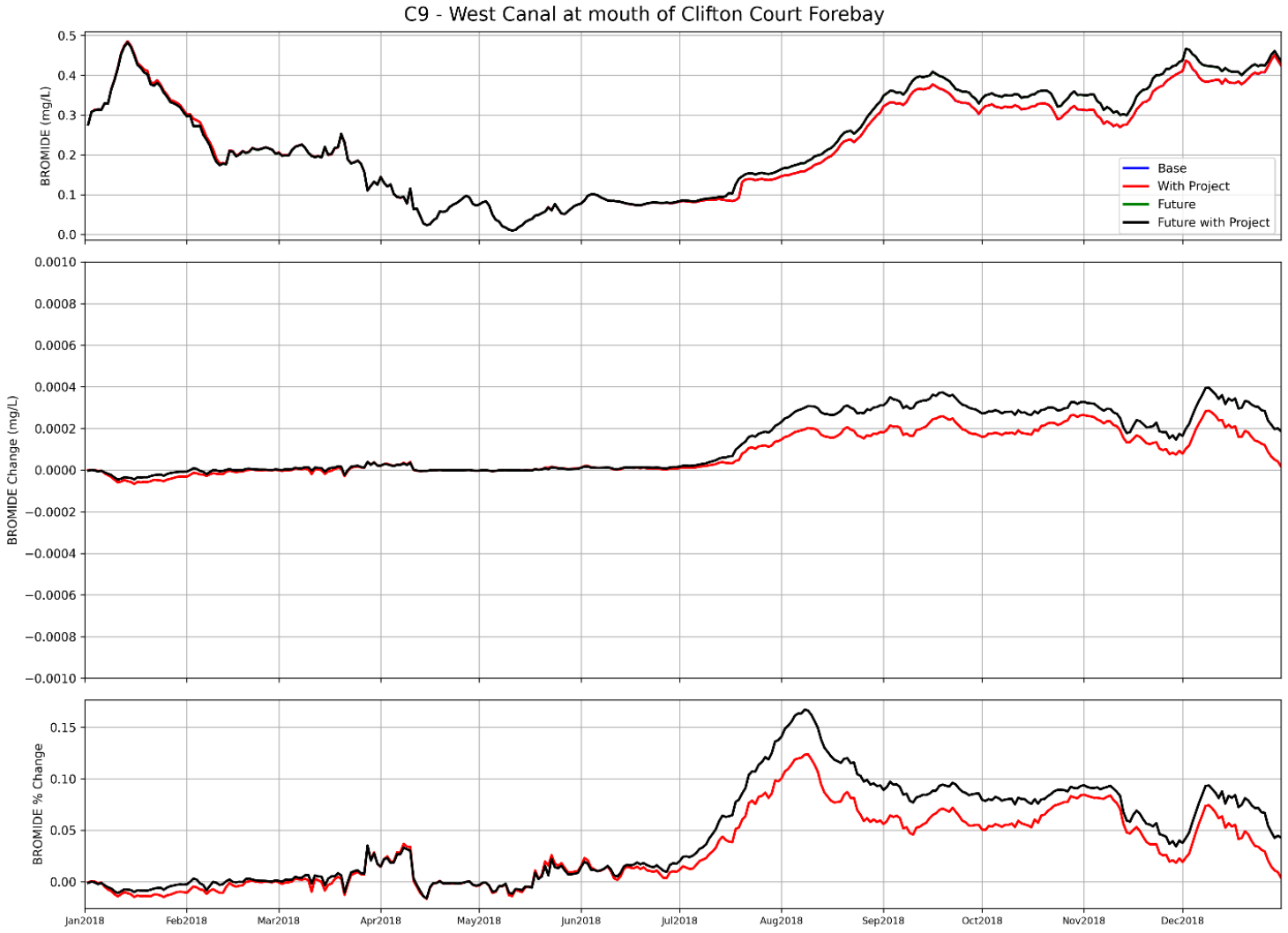
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 83 Daily average Bromide at station D12 – San Joaquin at Antioch for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2018 simulation period.



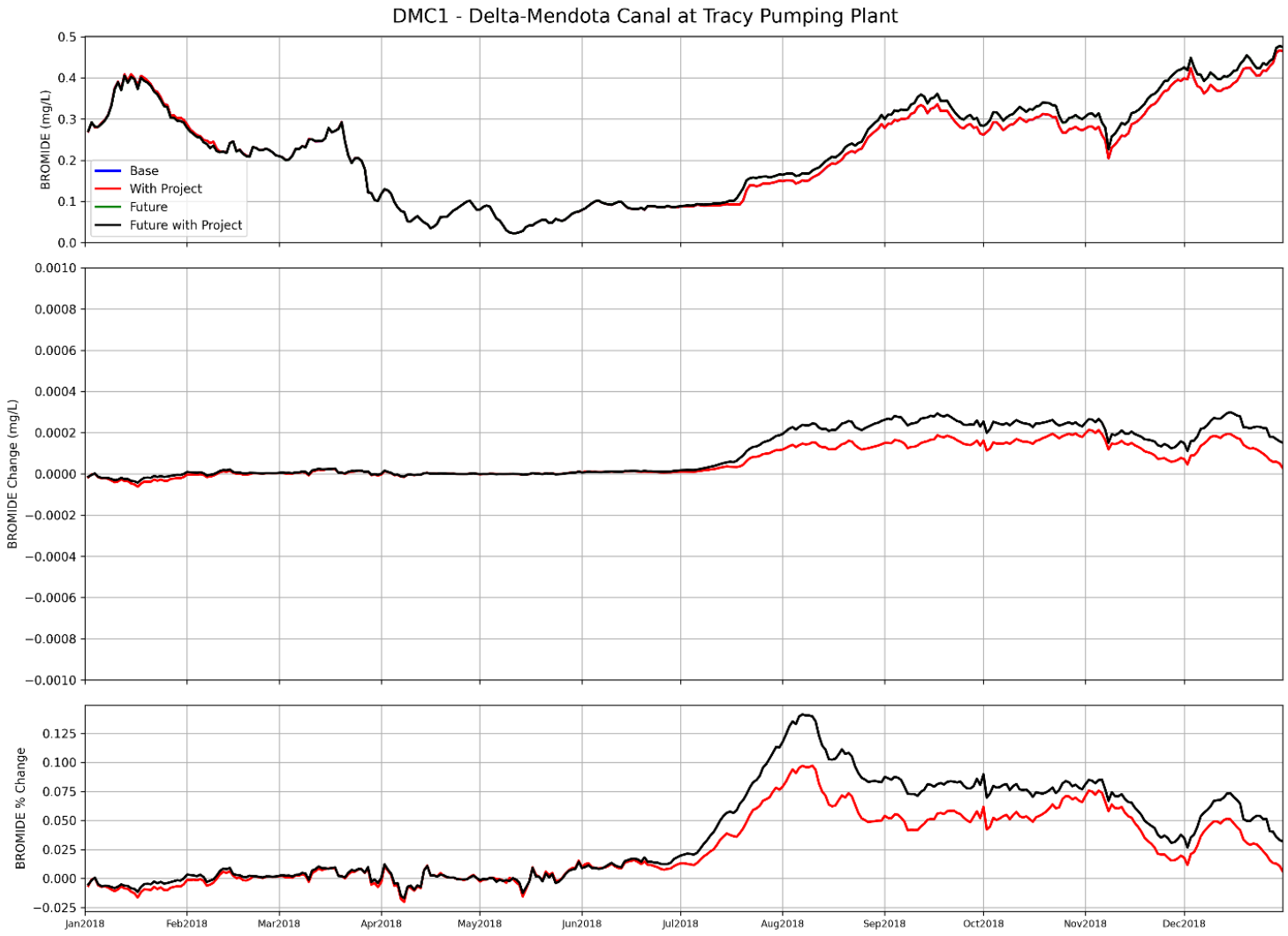
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 84 Daily average Bromide at station C5 – Contra Costa Canal at Pumping Plant 1 at NBA for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2018 simulation period.



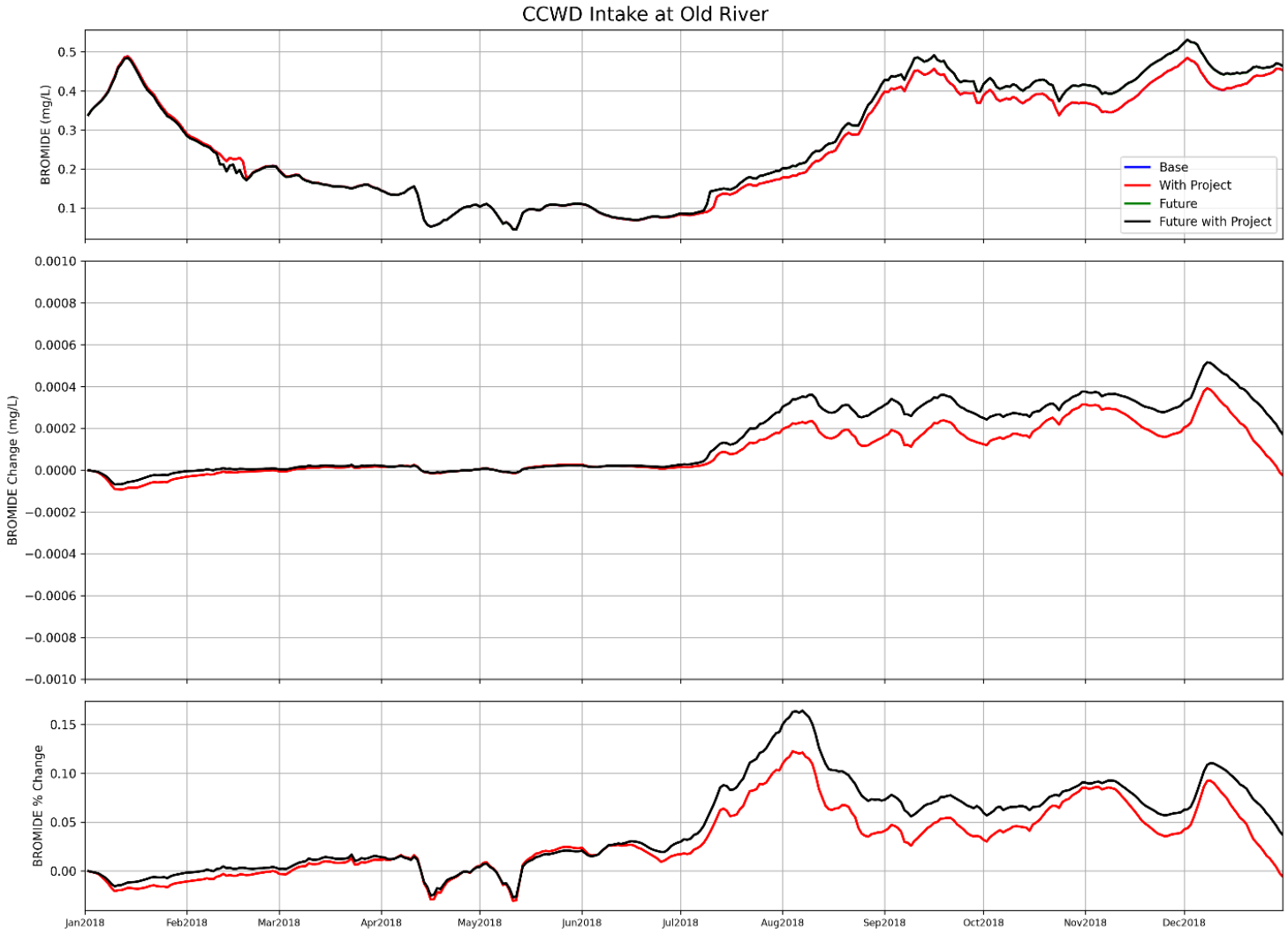
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 85 Daily average Bromide at station C9 – West Canal at Clifton Court for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2018 simulation period.



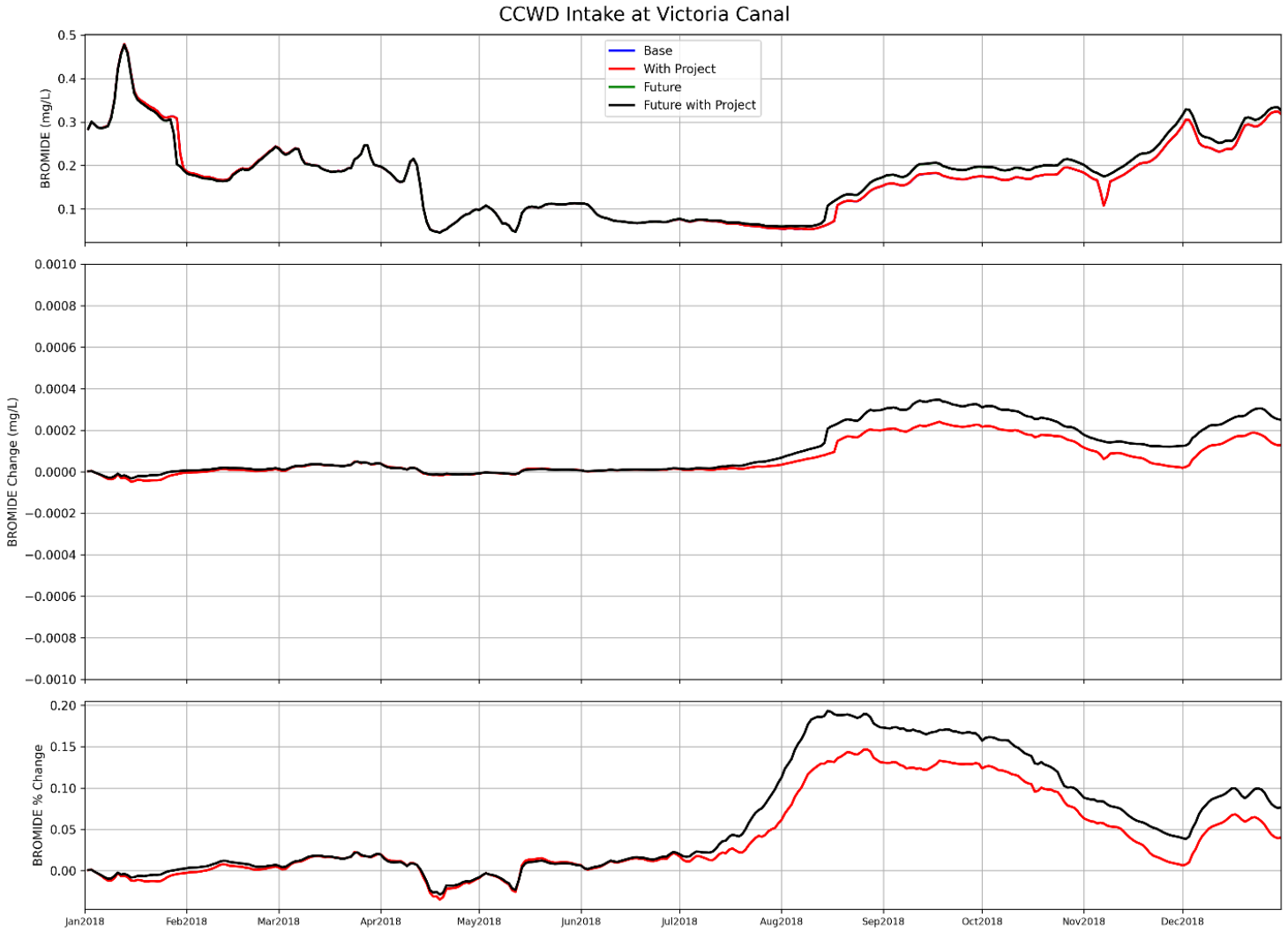
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 86 Daily average Bromide at station DMC1 – Delta Mendota Canal at Tracy for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2018 simulation period.



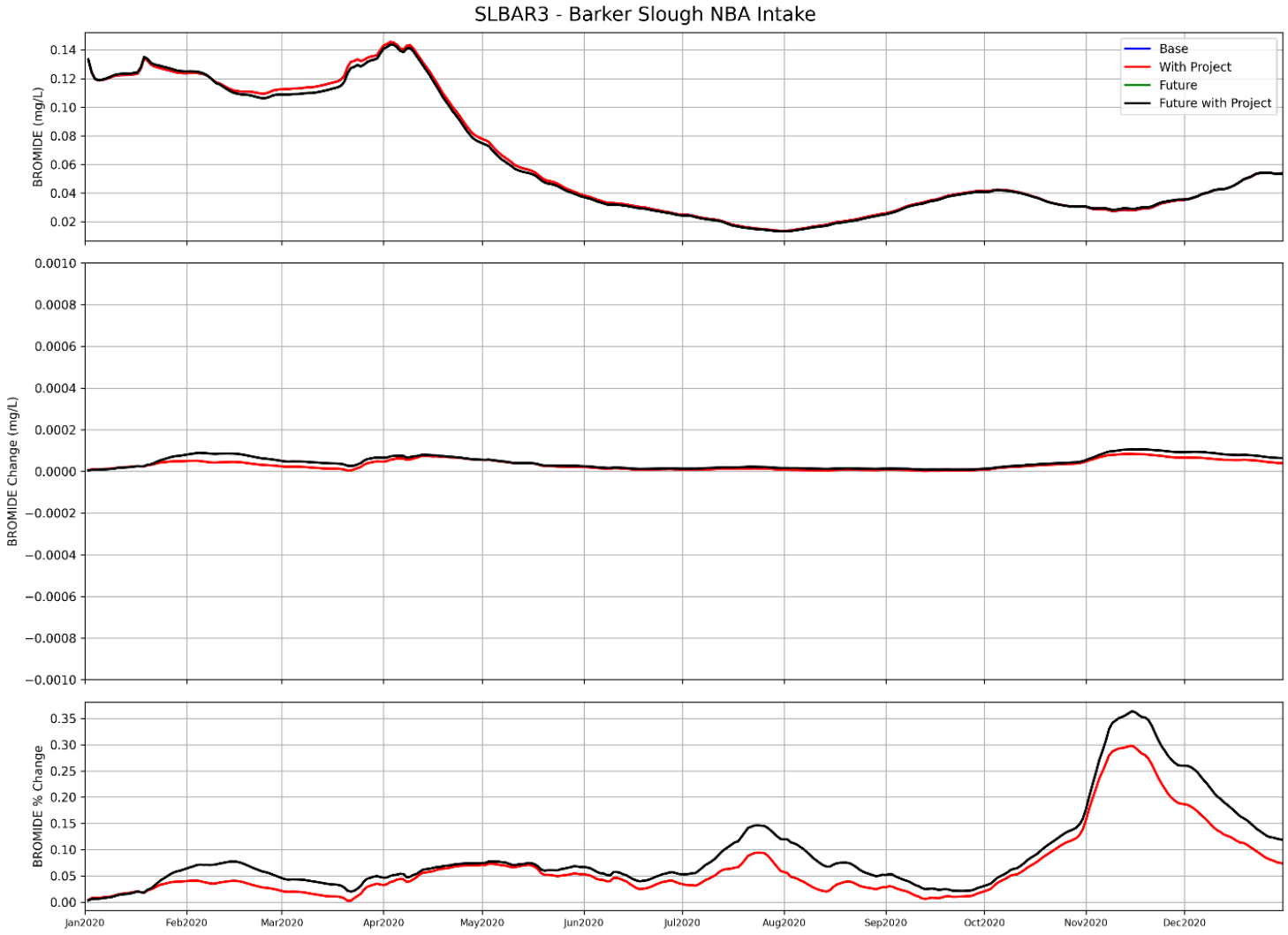
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 87 Daily average Bromide at CCWD intake at Old River for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2018 simulation period.



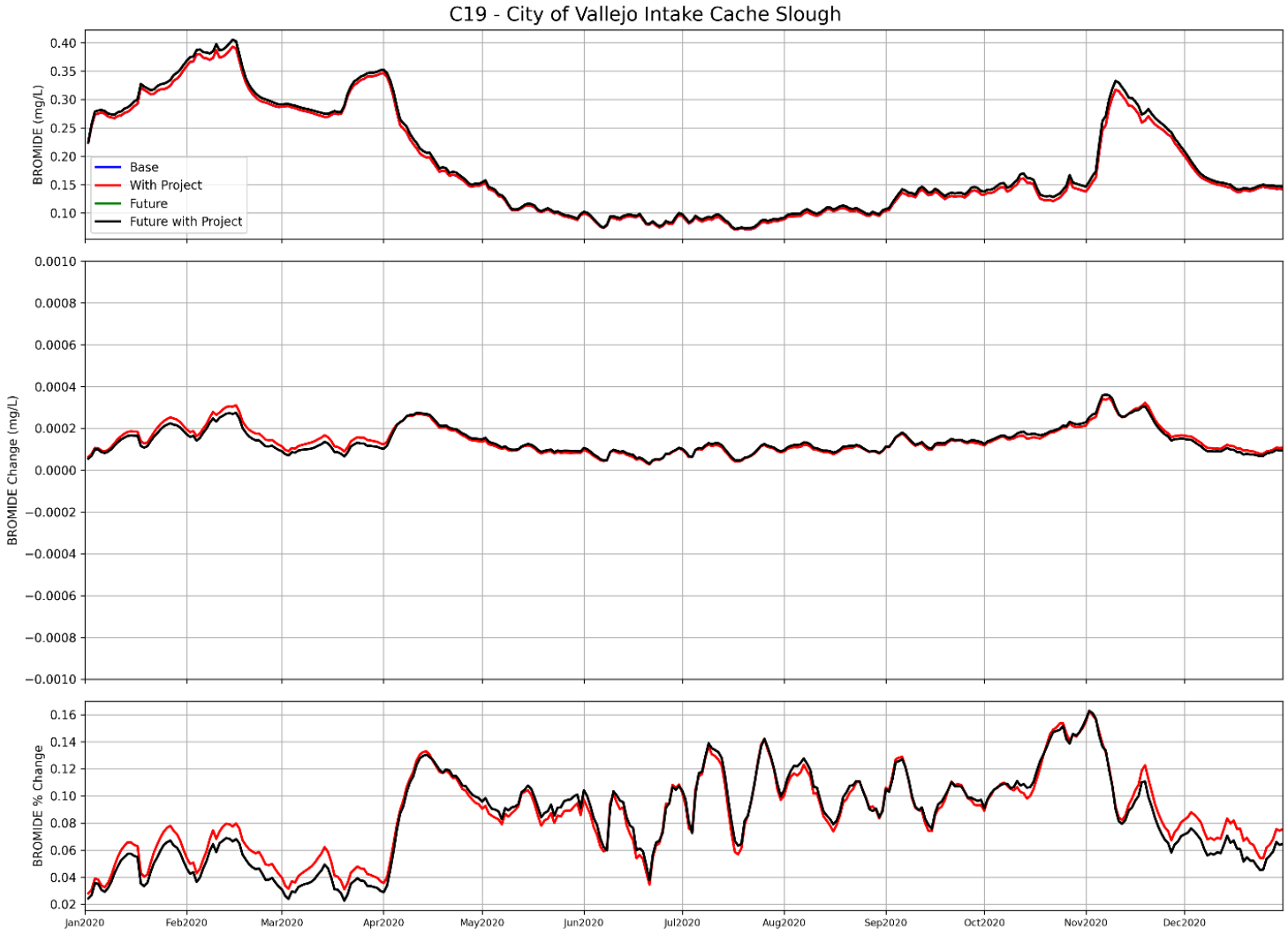
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 88 Daily average Bromide at station CCWD intake at Victoria Canal for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2018 simulation period.



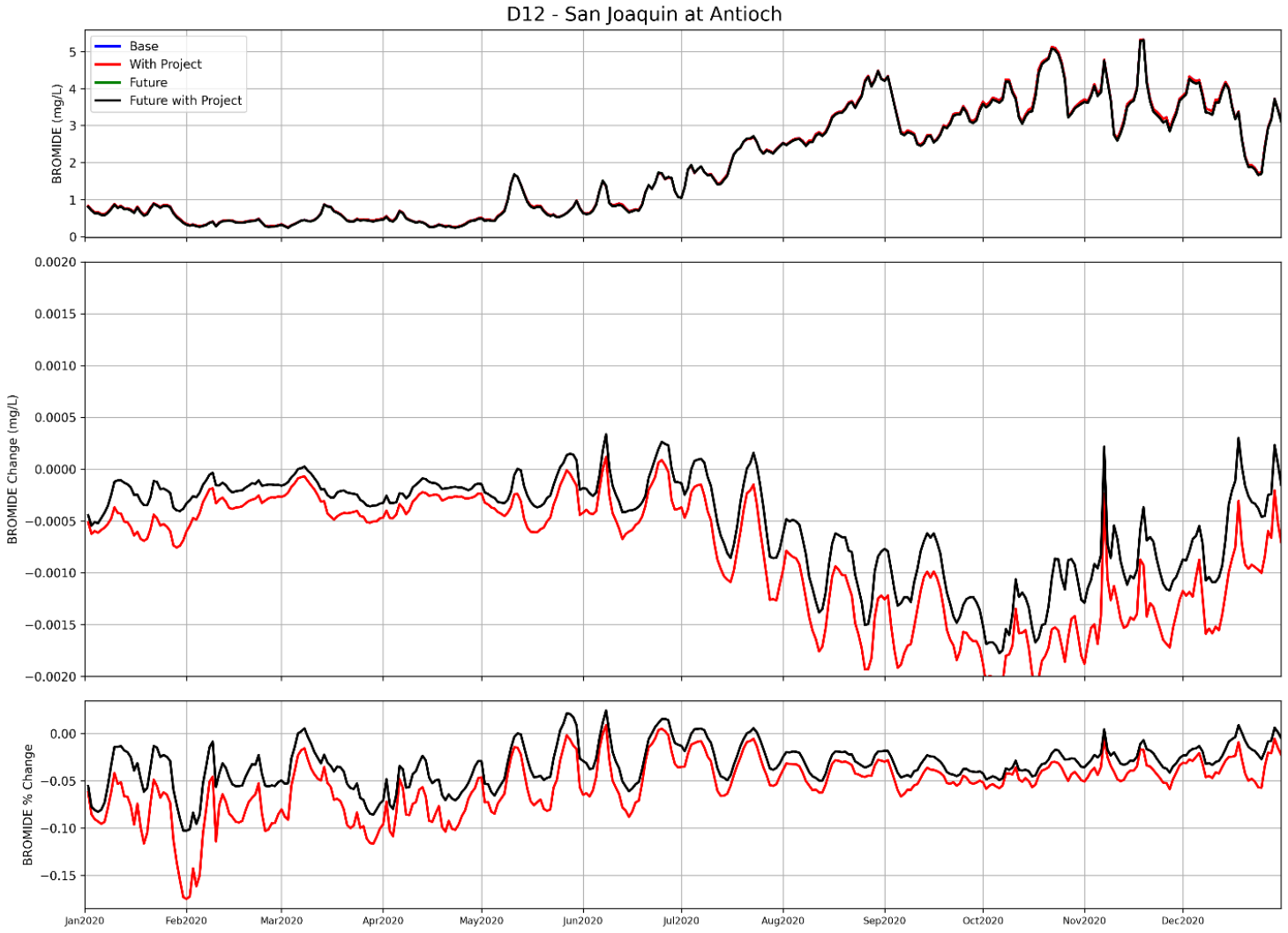
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 89 Daily average Bromide at station SLBAR3 – Barker Slough at NBA for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2020 simulation period.



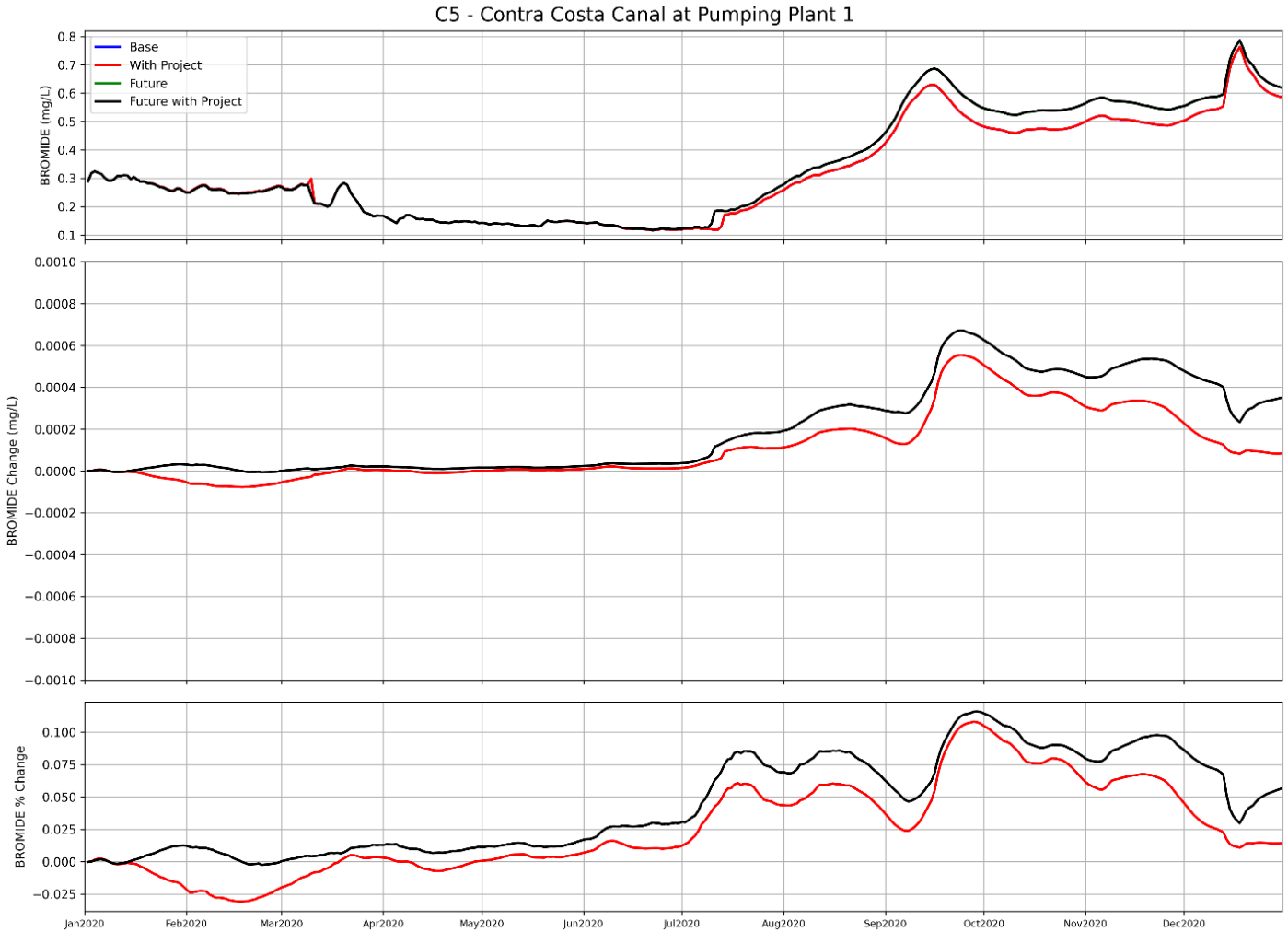
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 90 Daily average Bromide at station C19 – City of Vallejo intake for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2020 simulation period.



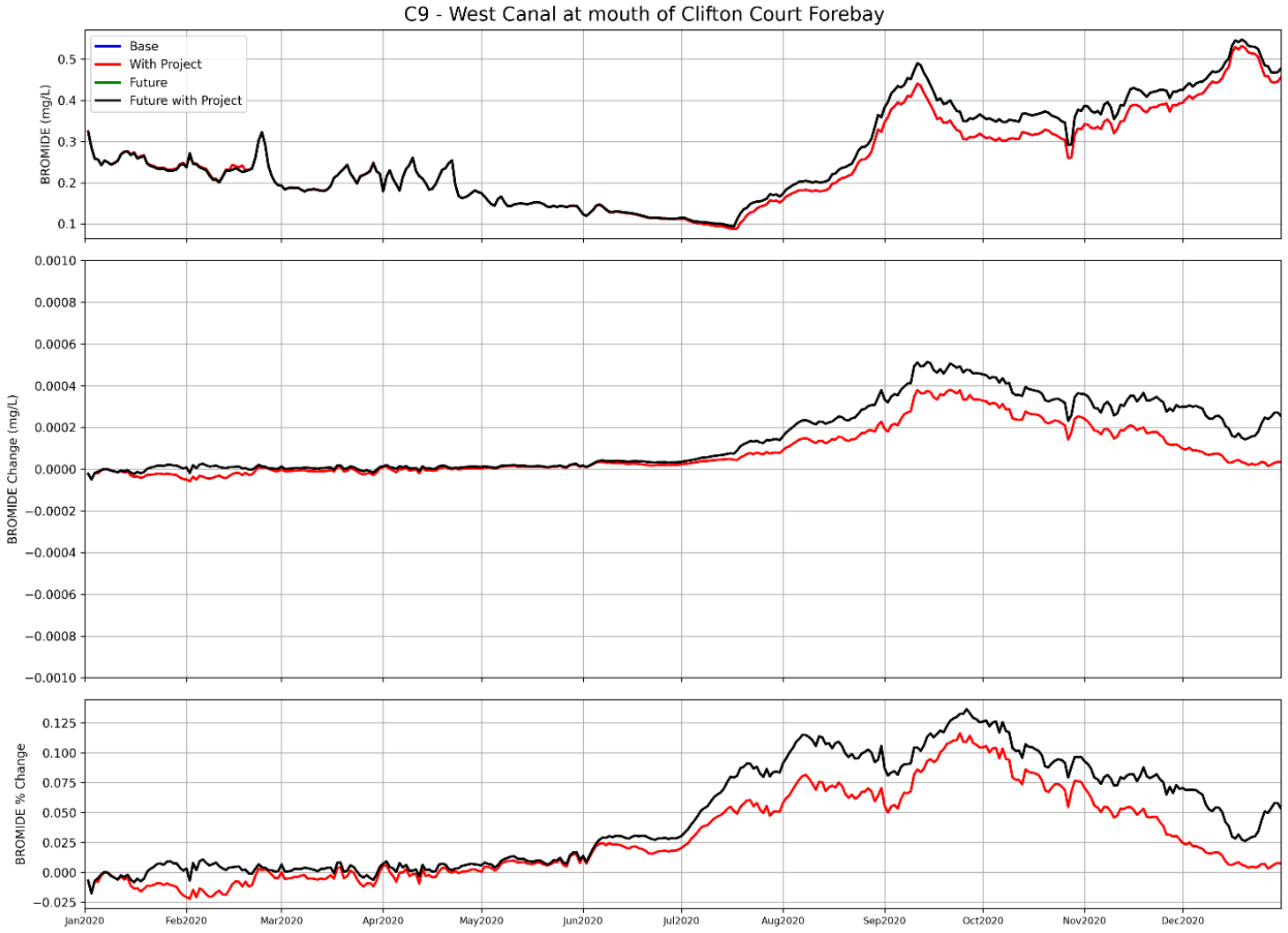
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 91 Daily average Bromide at station D12 – San Joaquin at Antioch for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2020 simulation period.



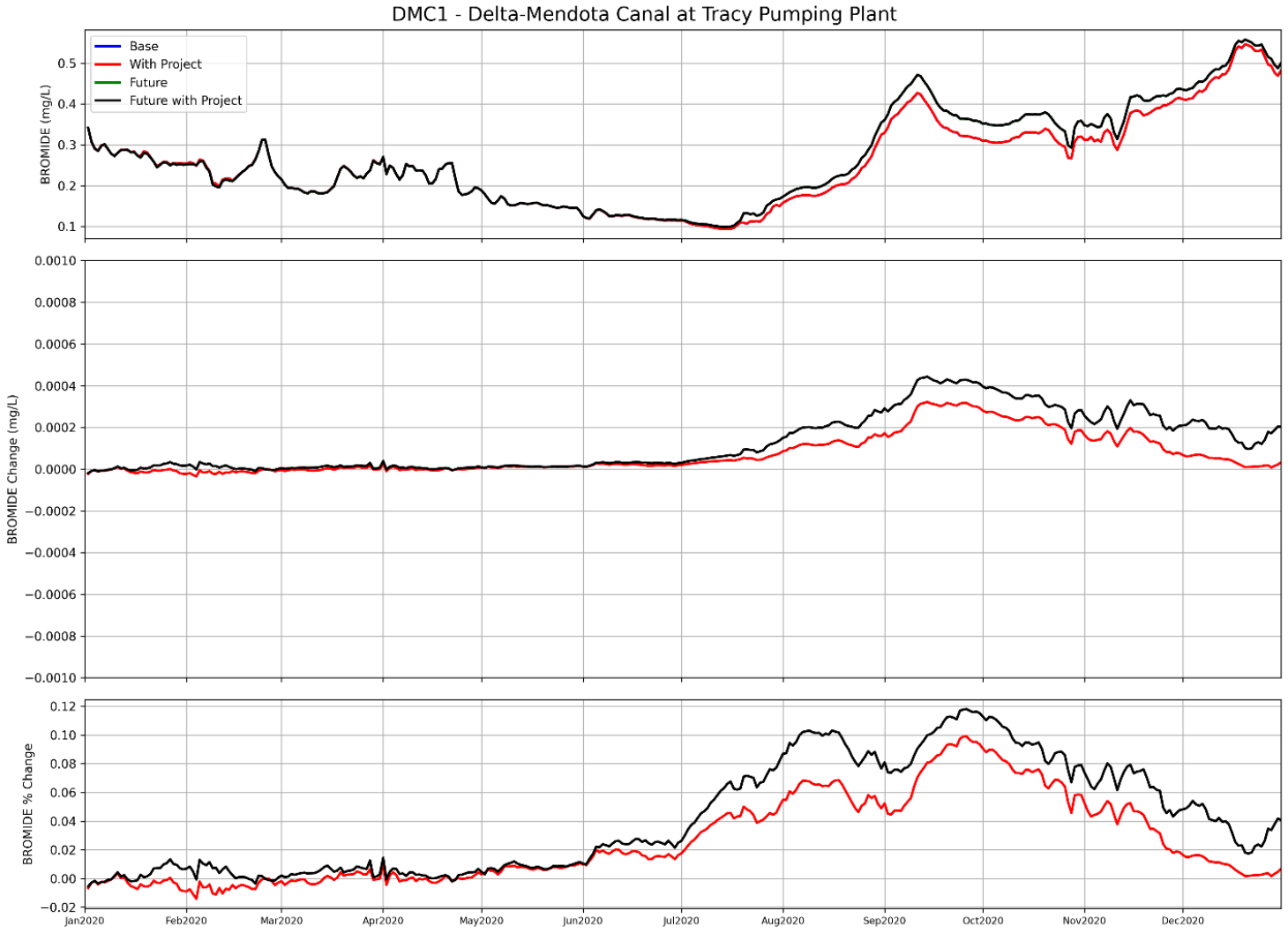
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 92 Daily average Bromide at station C5 – Contra Costa Canal at Pumping Plant 1 at NBA for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2020 simulation period.



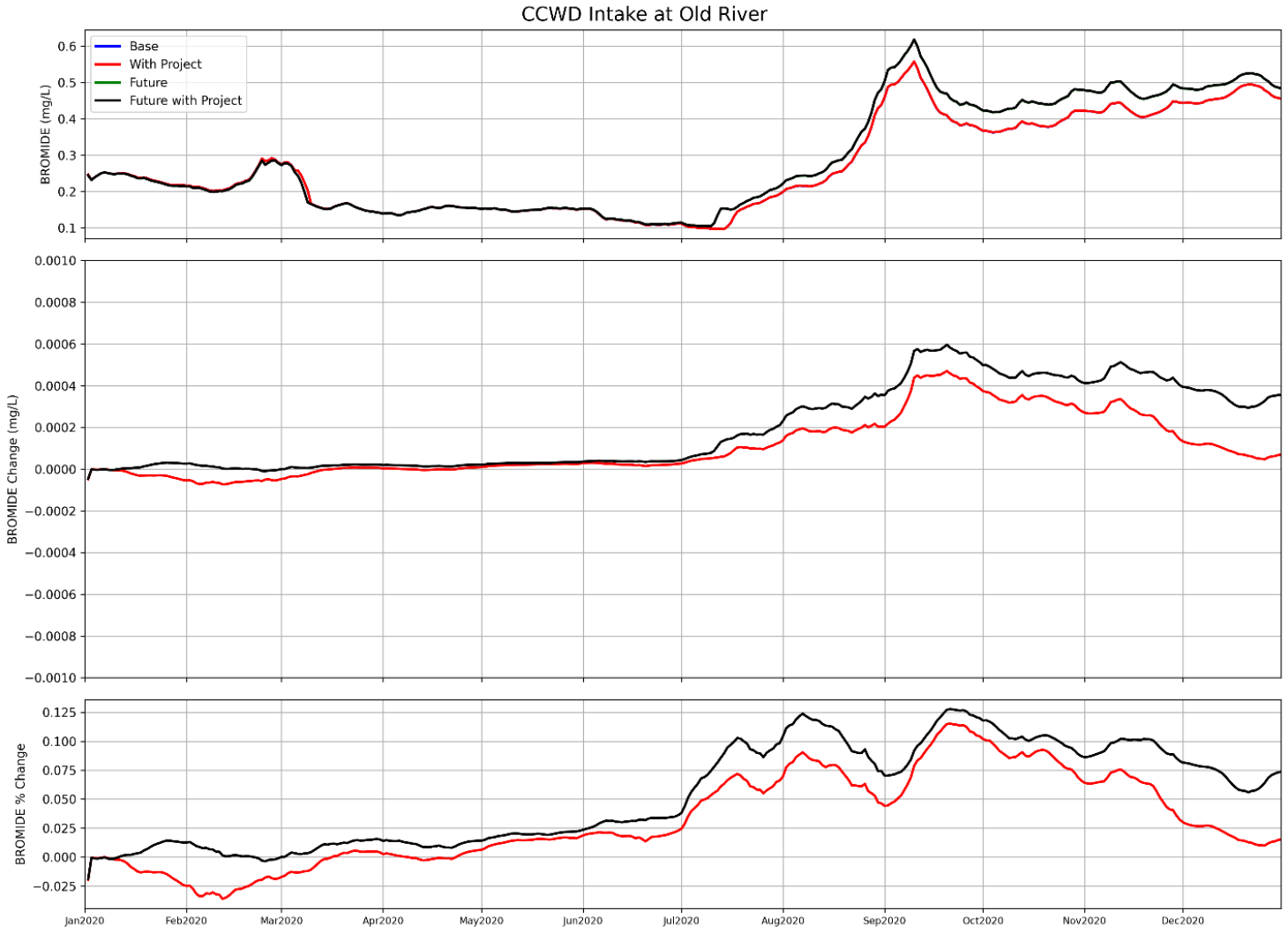
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 93 Daily average Bromide at station C9 – West Canal at Clifton Court for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2020 simulation period.



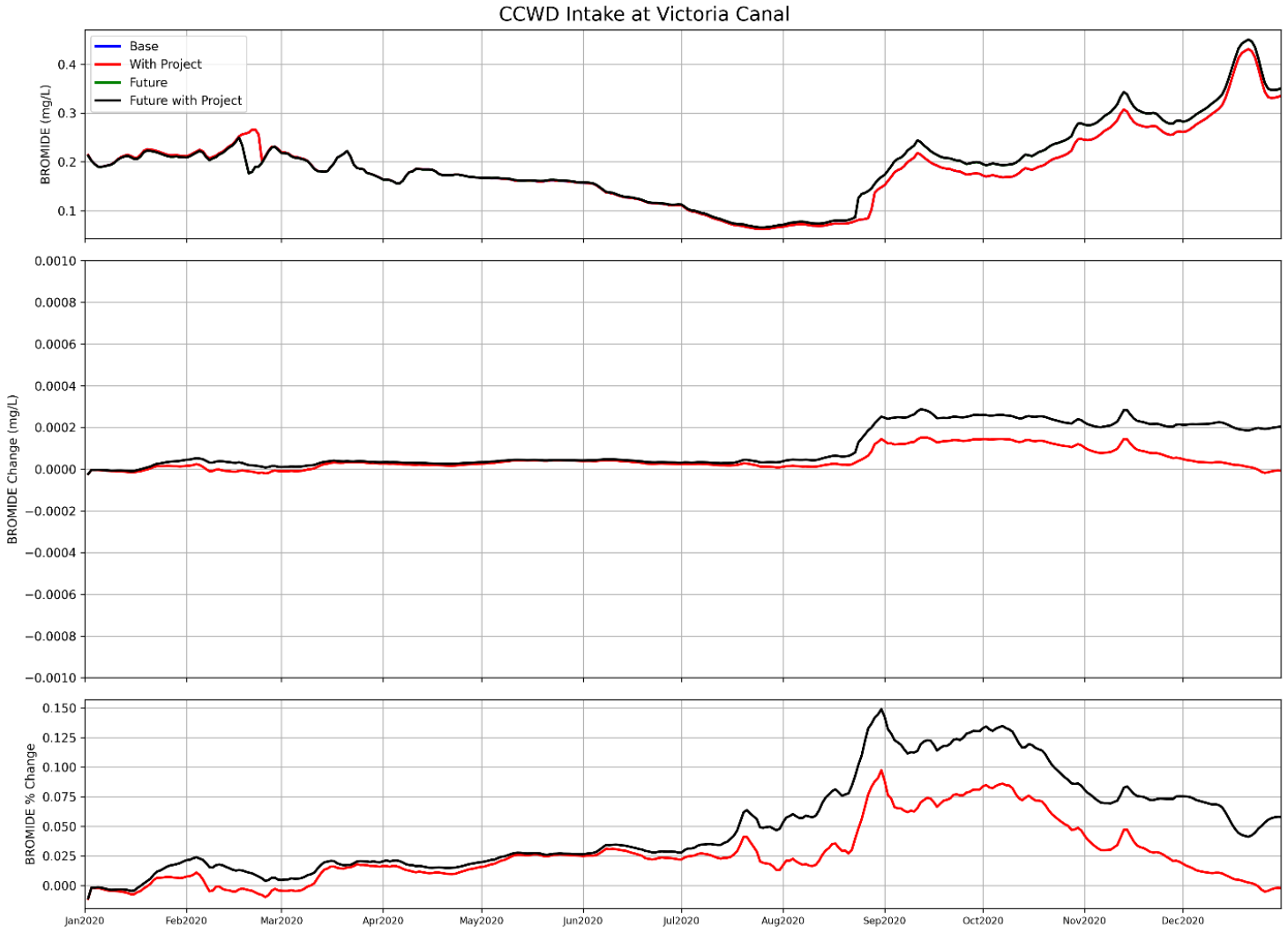
Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 94 Daily average Bromide at station DMC1 – Delta Mendota Canal at Tracy for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2020 simulation period.



Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 95 Daily average Bromide at CCWD intake at Old River for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2020 simulation period.



Note that in the top panel With Project results plot on top of Base results, and Future with Project results plot on top of Future results because the differences are so small.

Figure 96 Daily average Bromide at station CCWD intake at Victoria Canal for Base, With Project, Future, and Future with Project, plotted with daily average absolute and relative (%) Bromide change with the Project for the 2020 simulation period.

CSMB Tracer

CSMB tracer and tracer age Simulations were performed for the With Project and Future with Project conditions over the 2018 and 2020 simulation periods to examine the fate of DOC that could potentially be produced in the marsh plain on the Project site.

The tracer was applied to the CSMB marsh plain as an area source rate of $1/m^2$ per day when water depth was greater than 1 cm. Results can be interpreted as a factor that could be applied to a known marsh source rate of dissolved organic carbon (DOC). For example, if the marsh produced 1 g DOC/m^2 per day, the results would be interpreted directly as g/m^3 or mg/L DOC attributable to the CSMB marsh.

An age tracer was also simulated and age results were clipped to the minimum plotted tracer value of 0.05.

Color contour plots of CSMB tracer and age under current and Future conditions are provided at times of greatest flood and ebb tide tracer excursion during the 2018 and 2020 simulations in Figure 97 through Figure 104. The minimum tracer concentration plotted is 0.05. This minimum value was chosen to best illustrate the fate of the tracer plume. Tracer concentrations of 0.1 and above occur only within the CSMB Project site and just outside the breach.

Results are similar for the current and Future conditions. In November 2018, on flood tide, the tracer moves upstream in Cache Slough and just into the Deepwater Shipping Channel and Liberty Island, where the tracer age is approximately 6 days. On ebb tide, the tracer moves downstream in Sacramento River to Chipps Island, where the age is over 30 days. In November 2020, on flood tide, the tracer moves upstream in Cache Slough, reaching Shag Slough, and slightly further into the Deepwater Shipping Channel and Liberty Island, where the tracer age is approximately 8 days. Additionally, due to the dryer conditions of 2020, tracer accumulates in Montezuma Slough and Nurse Slough in Suisun Marsh, where the age is 40 to 50 days. On ebb tide, the tracer moves downstream in Sacramento River, just downstream of Chipps Island, where the age reaches 40 days. There is a small amount of 50-day-old tracer in Nurse Slough for the current condition only.

Tracer concentrations of 0.05 or higher do not reach the NBA intake in Barker Slough or the City of Vallejo intake in Cache Slough. Time series plots of daily maximum tracer at these two locations for 2018 (Figure 105) and 2020 (Figure 106) show that tracer concentrations never exceed 0.03 at the NBA intake and never exceed 0.02 at the Vallejo intake, and thus a very small fraction of any DOC potentially produced on the Project site would end up at these intakes.

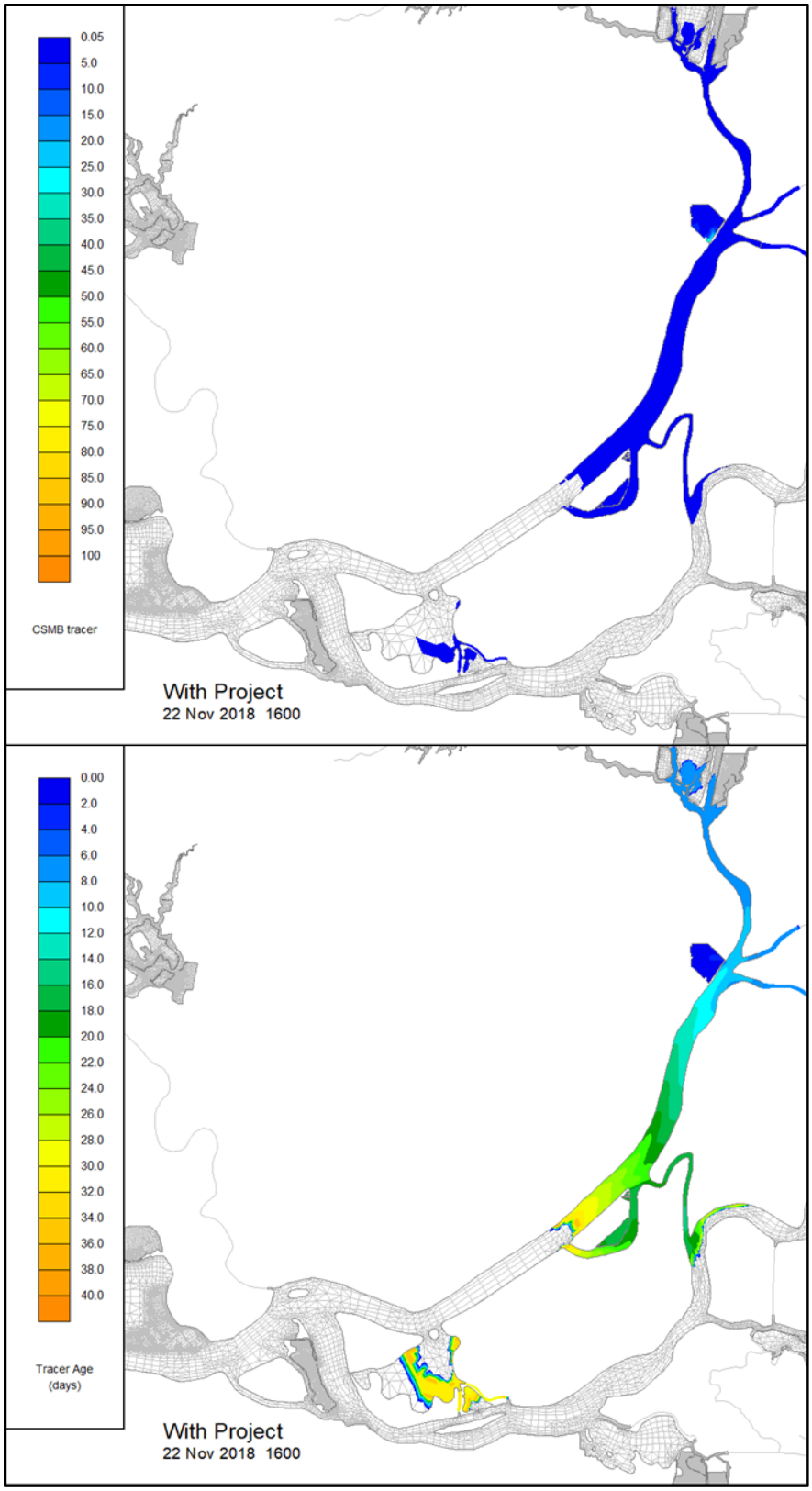


Figure 97 Contours of CSMB tracer concentration (top) and age (bottom) at flood tide on November 22, 2018 for the current With Project condition.

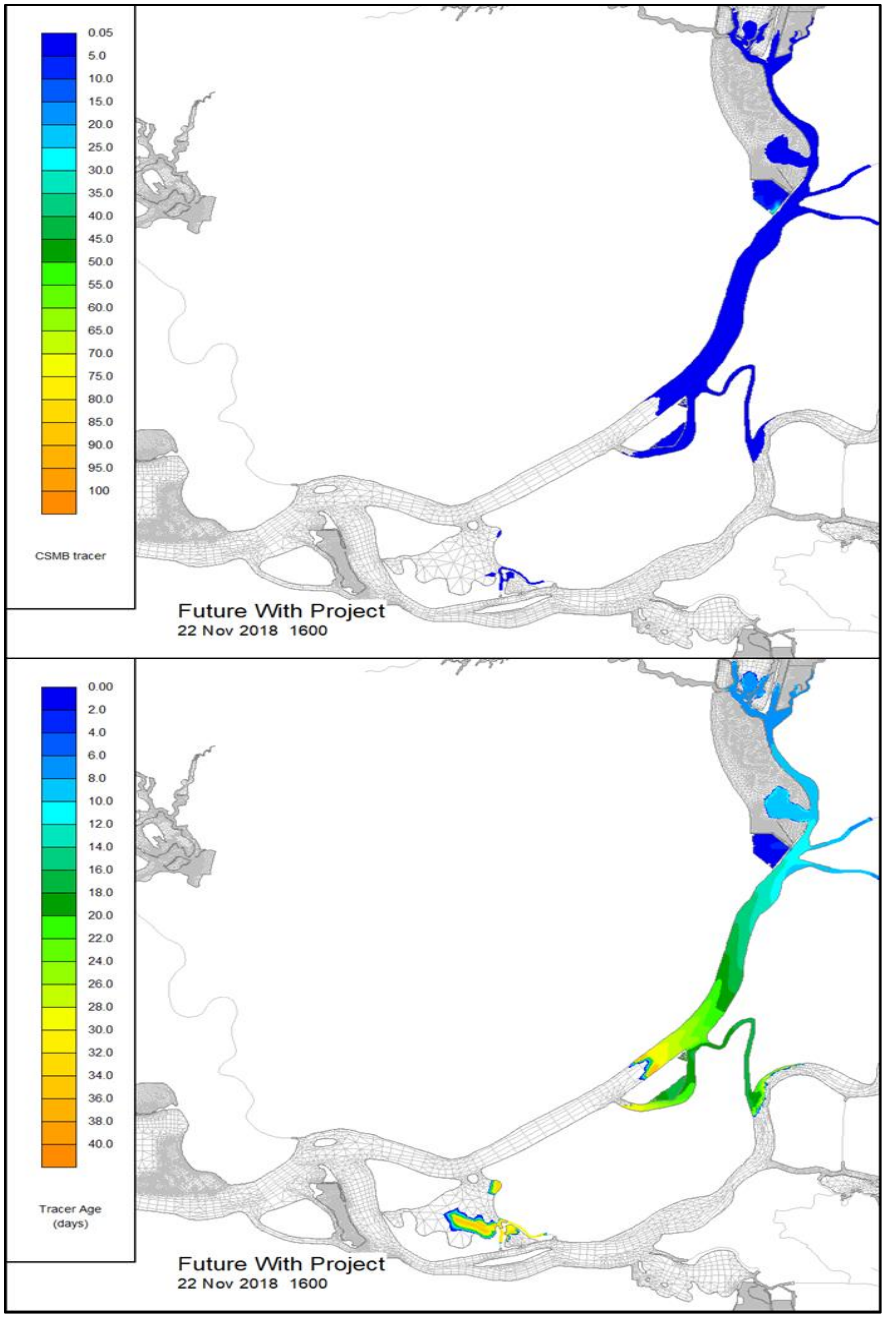


Figure 98 Contours of CSMB tracer concentration (top) and age (bottom) at flood tide on November 22, 2018 for the Future with Project condition.

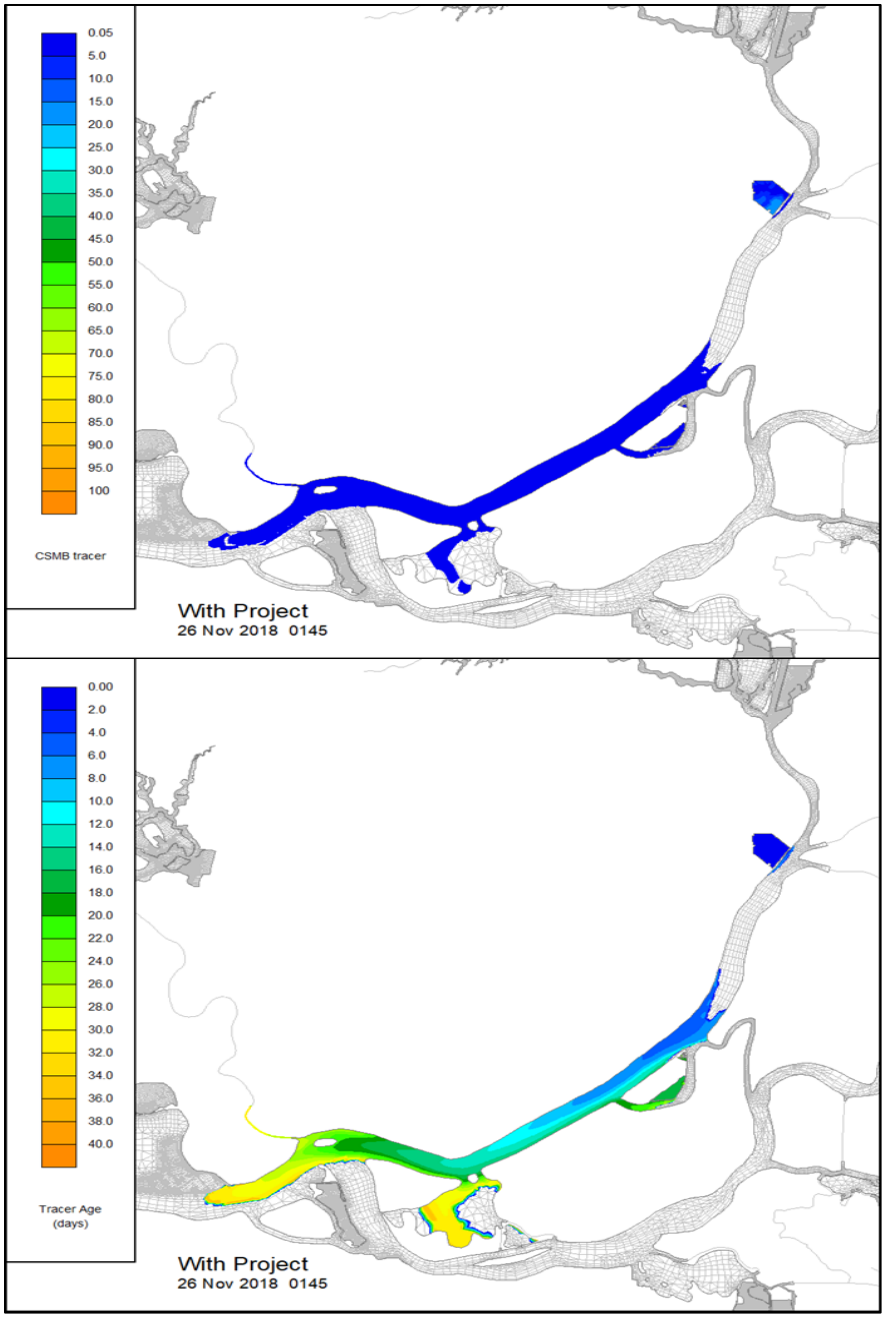


Figure 99 Contours of CSMB tracer concentration (top) and age (bottom) at ebb tide on November 26, 2018 for the current With Project condition.

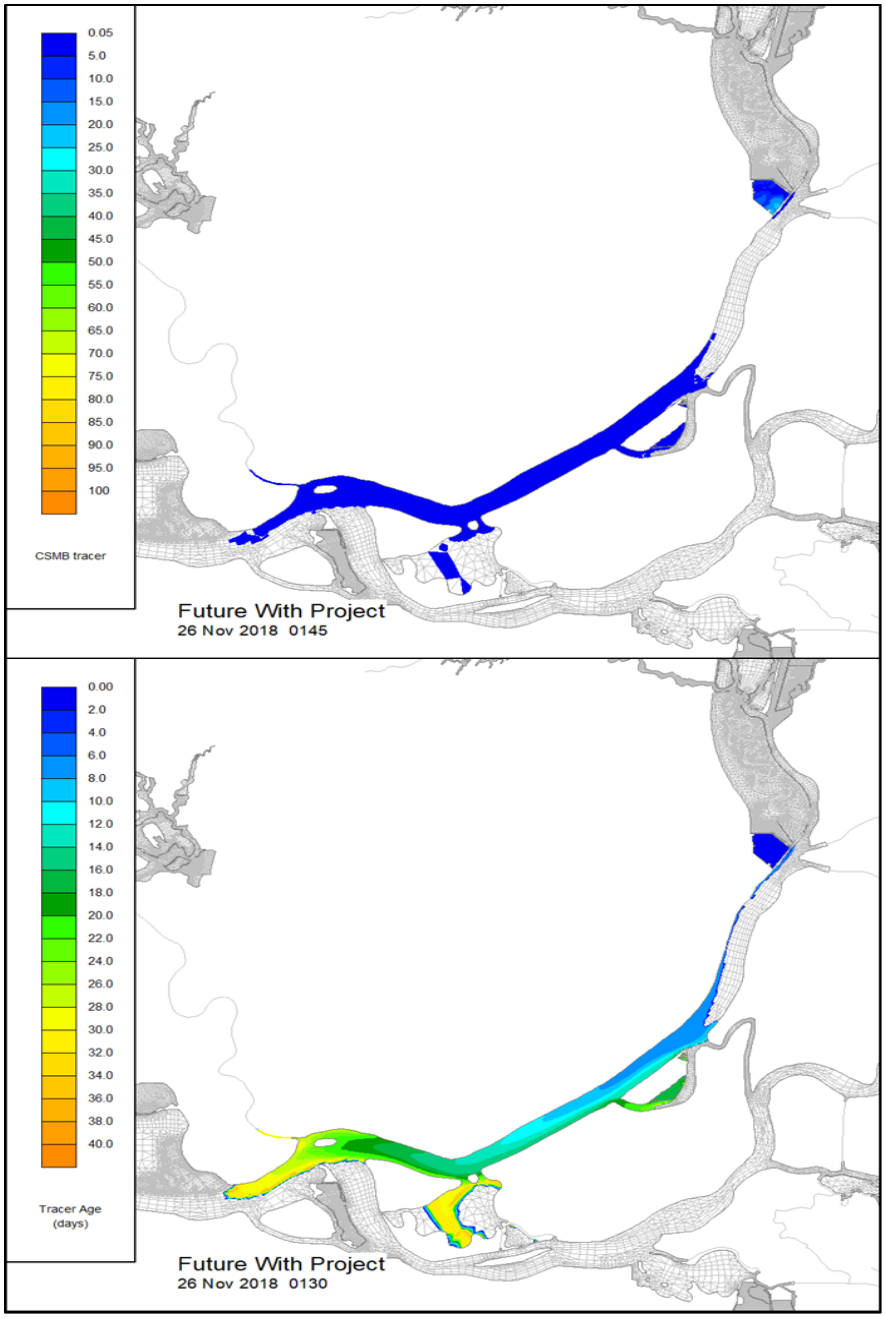


Figure 100 Contours of CSMB tracer concentration (top) and age (bottom) at ebb tide on November 26, 2018 for the Future with Project condition.

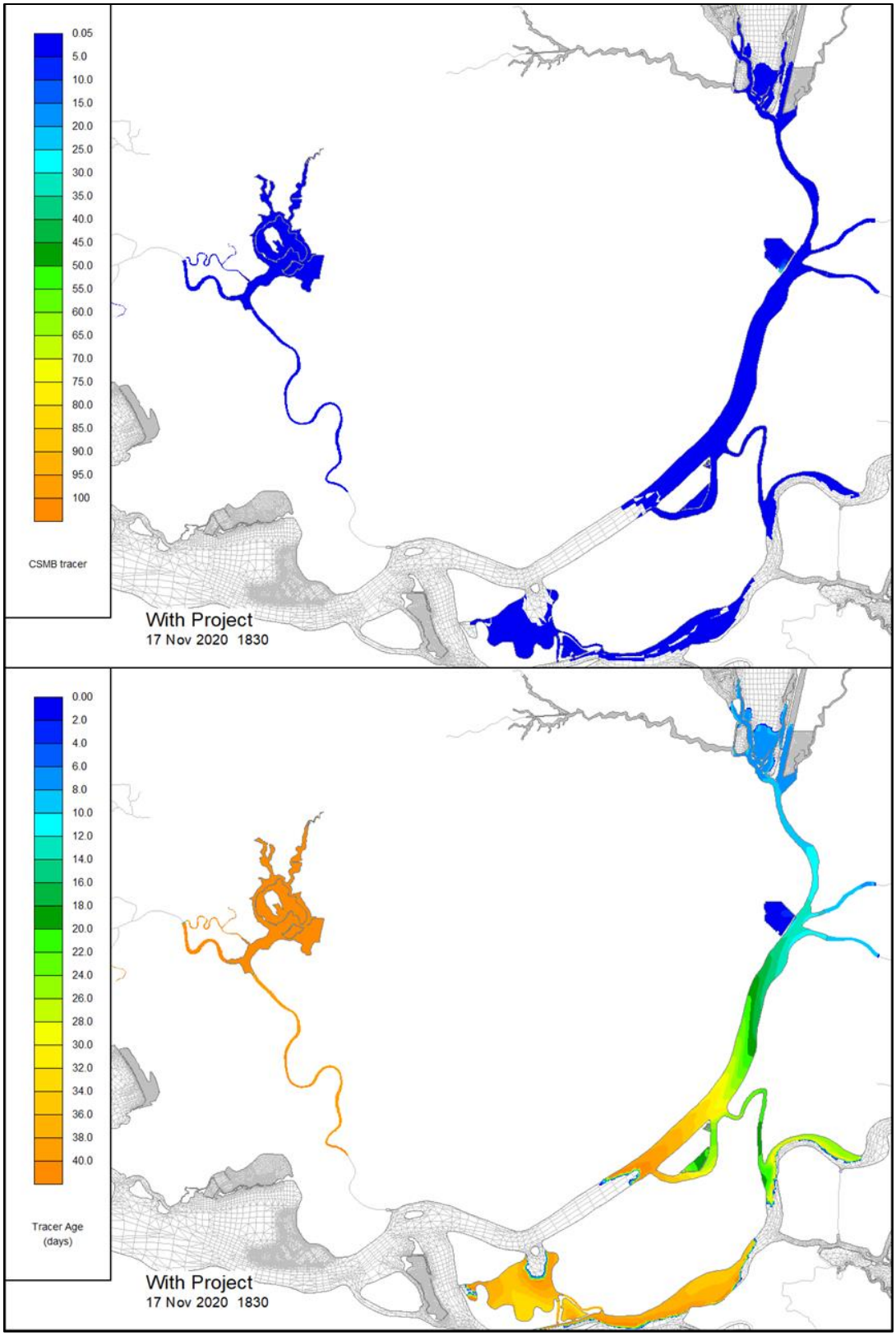


Figure 101 Contours of CSMB tracer concentration (top) and age (bottom) at flood tide on November 17, 2020 for the current With Project condition.

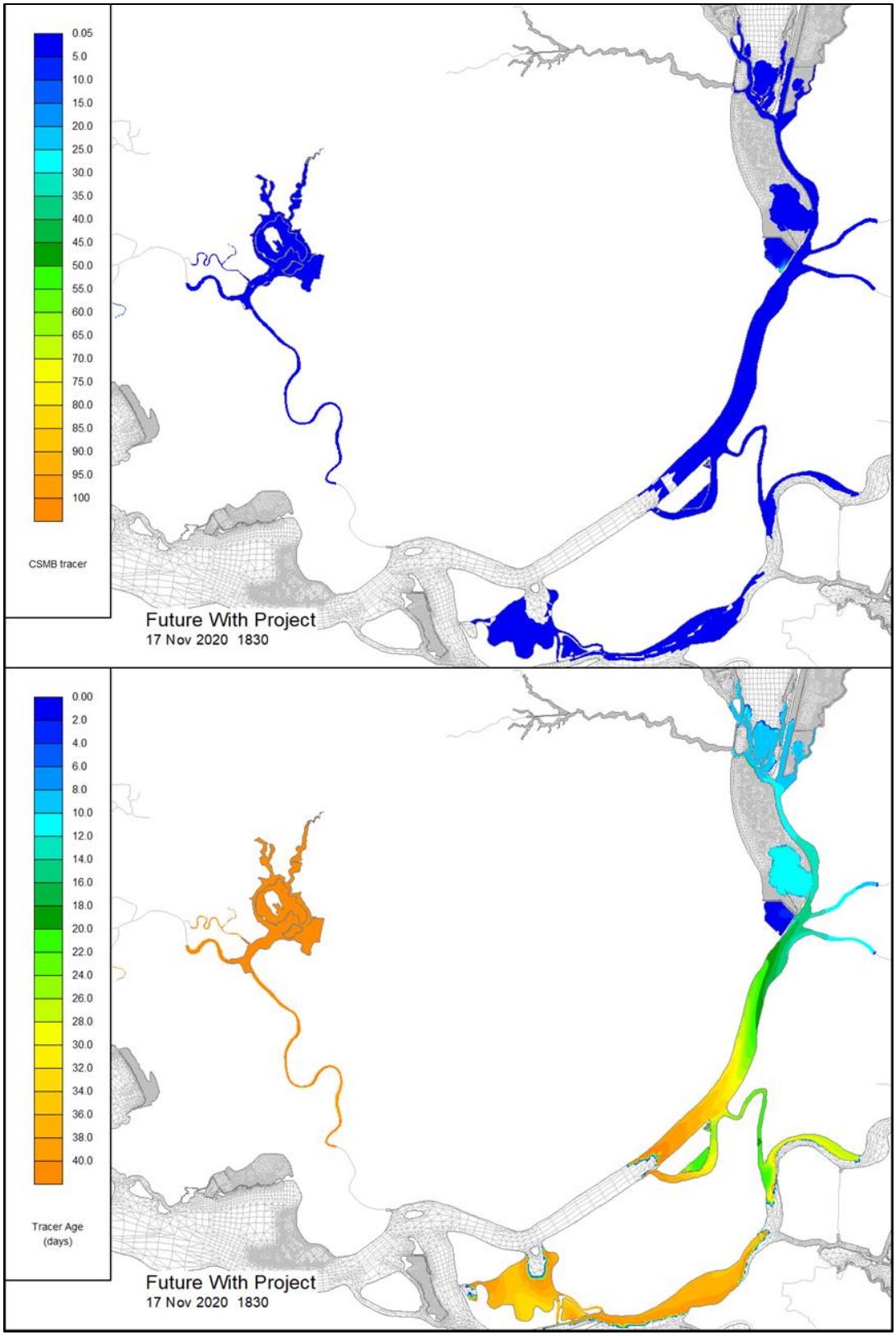


Figure 102 Contours of CSMB tracer concentration (top) and age (bottom) at flood tide on November 17, 2020 for the future with Project condition.

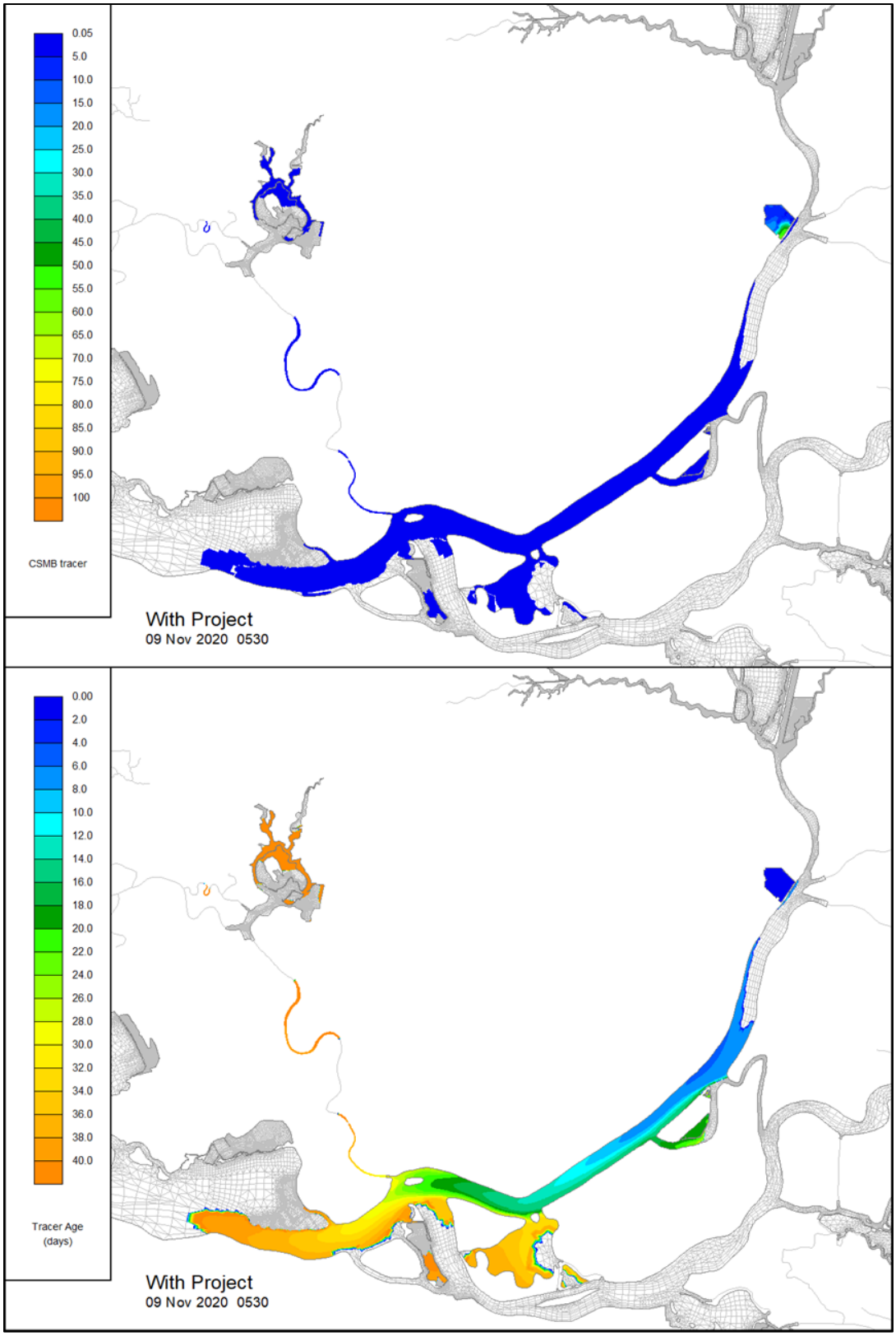


Figure 103 Contours of CSMB tracer concentration (top) and age (bottom) at ebb tide on November 9, 2020 for the current With Project condition.

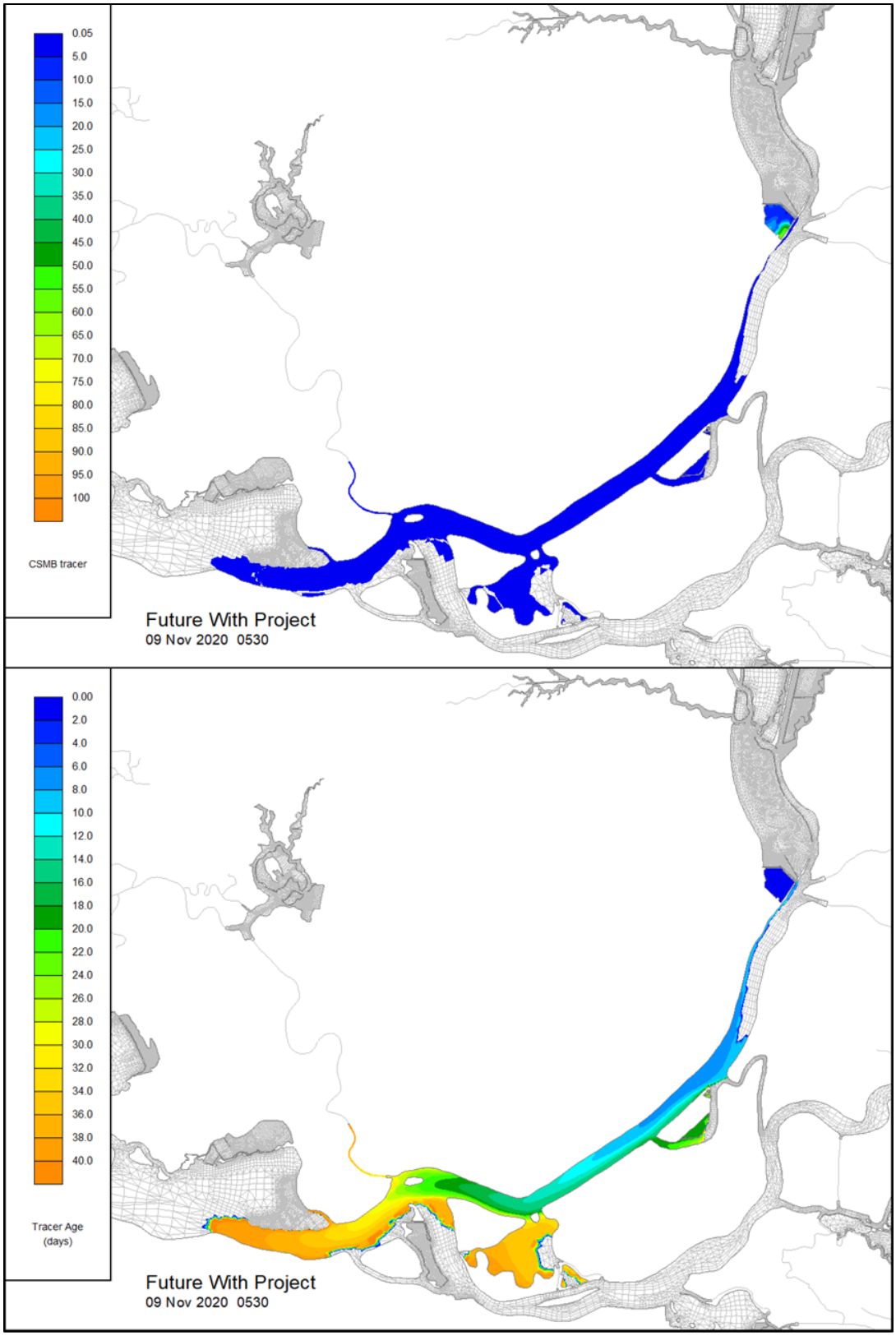


Figure 104 Contours of CSMB tracer concentration (top) and age (bottom) at ebb tide on November 9, 2020 for the Future with Project condition.

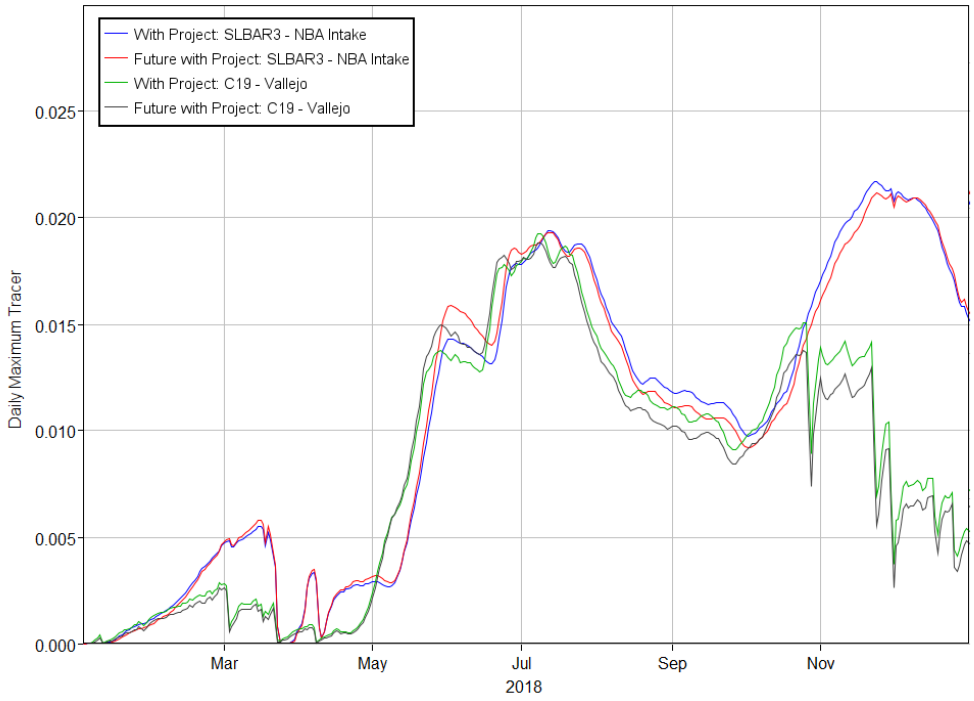


Figure 105 Time series of daily maximum tracer at SLBAR3 - NBA intake in Barker Slough and C19 - City of Vallejo intake in Cache slough for the With Project and Future with Project scenarios in 2018.

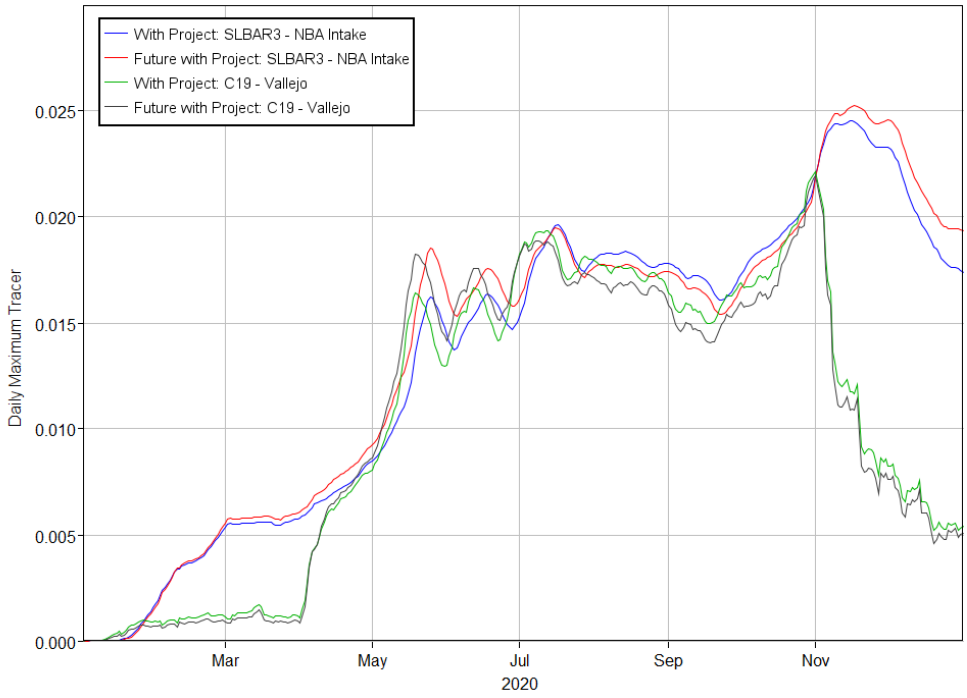


Figure 106 Time series of daily maximum tracer at SLBAR3 - NBA intake in Barker Slough and C19 - City of Vallejo intake in Cache slough for the With Project and Future with Project scenarios in 2020.

Summary and Conclusions

The RMA Bay-Delta model was applied to evaluate the proposed Cache Slough Mitigation Bank Project water quality impacts relative to Base and Future conditions. The Base condition networks include recently constructed or underway projects. The Future condition networks additionally include planned future tidal marsh restoration projects at Prospect Island, McCormack Williamson Tract and LEMBP. The Base and Future condition networks represent the current state of CSMB (no tidal action and not included in the grid). The proposed CSMB Project design includes construction of a breach to Cache Slough on the east side and interior channels. For the With Project and Future with Project scenarios, the CSMB Project is represented in the model in sufficient detail to achieve the modeling goal of assessing regional salinity impacts.

Four scenarios were evaluated:

1. Base – current conditions with restoration projects that are in construction
2. Future – Base with LEMBP, Prospect Island and McCormack-Williamson Tract Habitat Restoration
3. With Project – Base with CSMB Project restoration (evaluated relative to Base)
4. Future with Project – Future with CSMB Project restoration (evaluated relative to Future)

To evaluate Project impacts on water quality, modeled EC for all four scenarios was monthly averaged and compared for select D-1641 compliance locations and water exports. The modeling results showed that the CSMB Project has very small impacts on regional salinity in the Delta, relative to Base and Future conditions. The largest increase is 0.4%, occurring at Emmaton during the summer of 2020. The largest decrease is less than 0.1%, occurring at Antioch during the fall of 2018 and beginning of 2020. Salinity increases at North Bay Aqueduct and City of Vallejo intakes are less than 0.1% and salinity increases at south Delta exports and CCWD water intakes are 0.1% or less.

Model results were processed to determine the potential for the CSMB Project to cause non-compliance with the D-1641 water quality objectives. Seasonal EC standards apply to Agriculture, Fish and Wildlife compliance stations at the Sacramento River at Emmaton (D22), Sacramento River at Collinsville (C2), and the San Joaquin River at Jersey Point (D15) and Prisoners Point (D29) and chloride standards at the water intakes. The Project did not cause any EC changes at the D-1641 stations that were large enough to impact compliance.

Modeled EC and Martinez volumetric source fraction results were post-processed to produce chloride concentrations to assess compliance at the water intakes. No violations of the

maximum mean daily chloride objectives occurred at any of the intakes under any of the modeled configurations or time periods. Relative to the Base and Future conditions, the CSMB restoration Project had no impact on these values. Antioch does not meet the criteria for number of days below a threshold for any of the scenarios, but the Project does not make this worse.

Evaluation of changes to X2 indicated that the Project would generally increase monthly averaged X2 by less than 0.01 km.

Bromide concentrations were estimated from modeled EC and Martinez volumetric source fraction. Project impacts on Bromide were very small throughout the model domain. The largest increases occurred at the NBA intake in Barker Slough during the fall of 2020. Changes at this location ranged from -0.02% to 0.3%. Bromide increases of up to 0.2% occurred in the fall at the south Delta water intakes. The largest percent bromide decreases of less than 0.1% occurred at Antioch.

CSMB marsh tracer and tracer age Simulations were performed for the With Project and Future with Project conditions over the 2018 and 2020 simulation periods to examine the fate of DOC that could potentially be produced in the marsh plain on the Project site. Modeled tracer concentrations were very low outside the project site and the tracer excursion was predominantly downstream. Low concentrations of tracer reached Chipps Island on peak ebb tide with an age of over 30 days. On flood tide, the same low concentration of tracer moved upstream, just into Liberty Island with an age of around 6 to 8 days. Results were similar for the current and Future conditions. Tracer concentrations remained extremely low at the NBA intake in Barker Slough or the City of Vallejo intake in Cache Slough, indicating that a very small fraction of any DOC potentially produced on the Project site would end up at these intakes.

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Appendix A: Model Boundary Conditions

2018 Model Boundary conditions

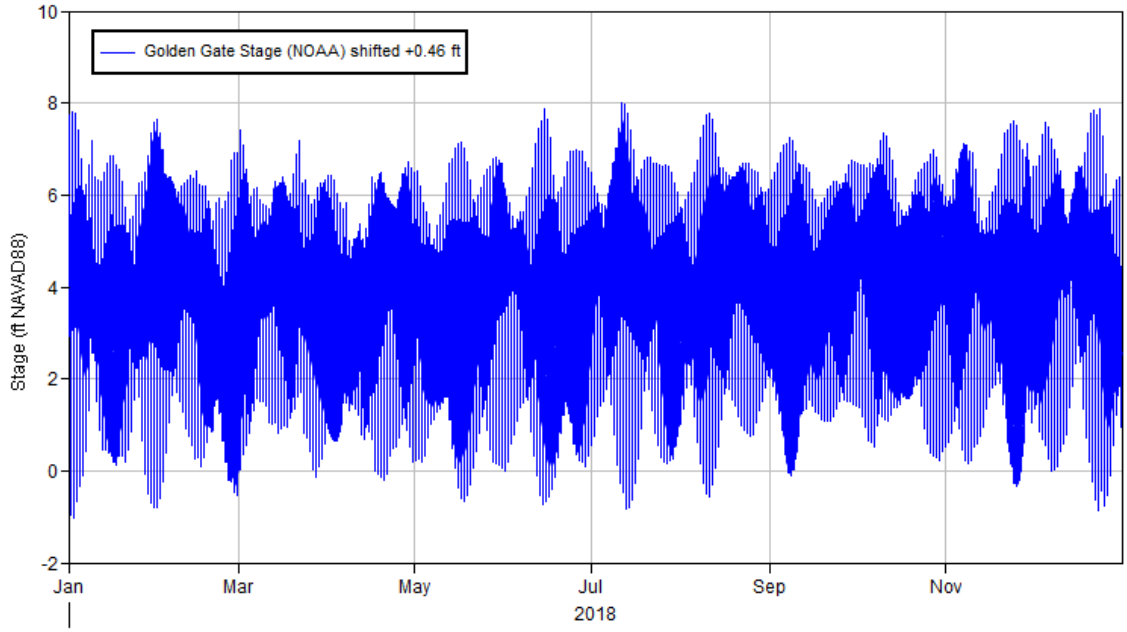

Figure 107 Golden Gate stage boundary for 2018 (data source: NOAA, shifted +0.46 ft). EC set constant at 50,000 µS/cm.

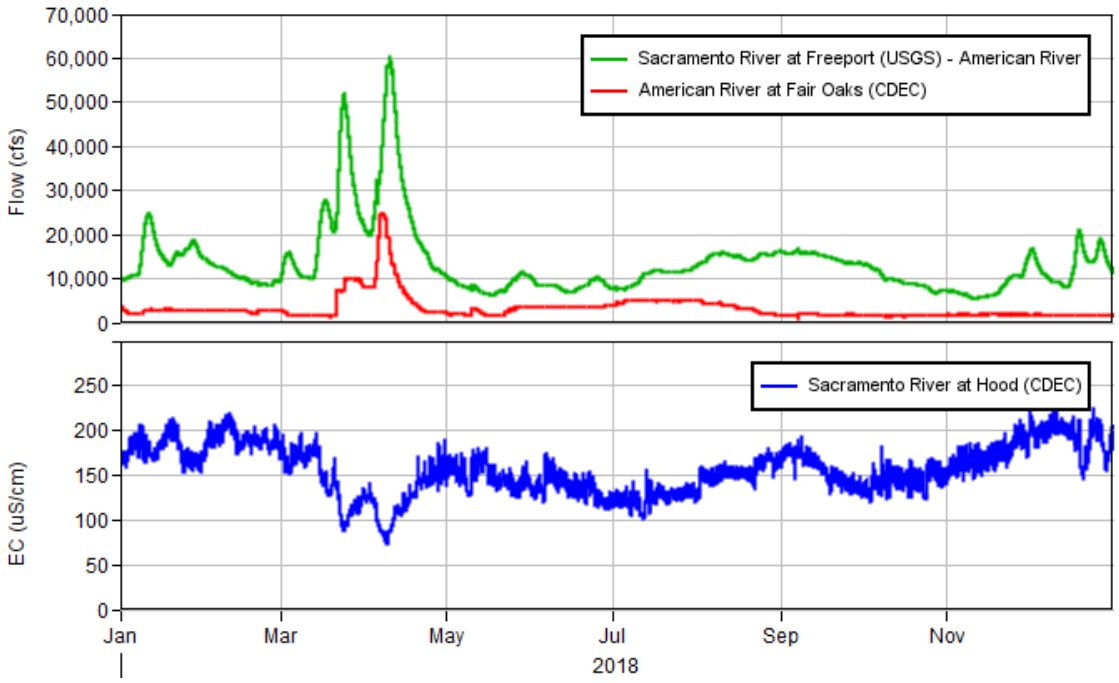

Figure 108 Flow and EC boundary conditions for the Sacramento River and American River for 2018. An internal EC boundary condition is applied in Sacramento River at Hood.

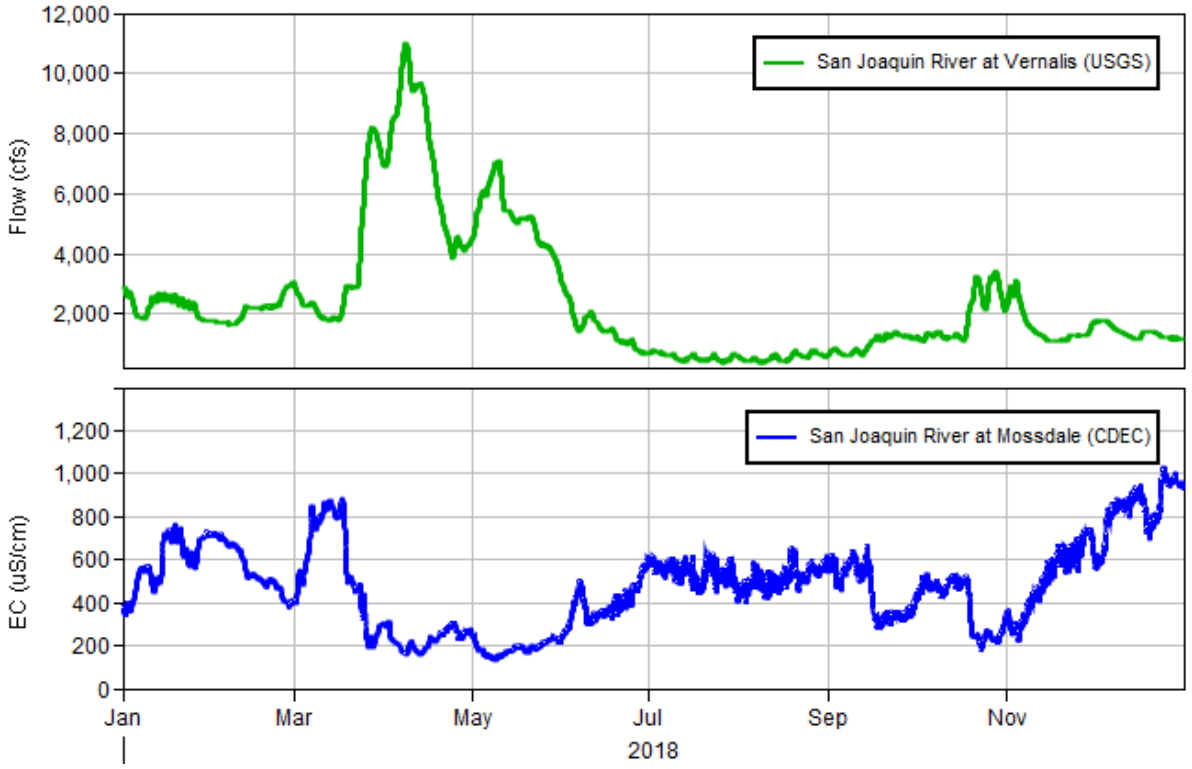

Figure 109 Flow and EC boundary conditions for the San Joaquin River for 2018. An internal EC boundary condition is applied in San Joaquin River at Mossdale.

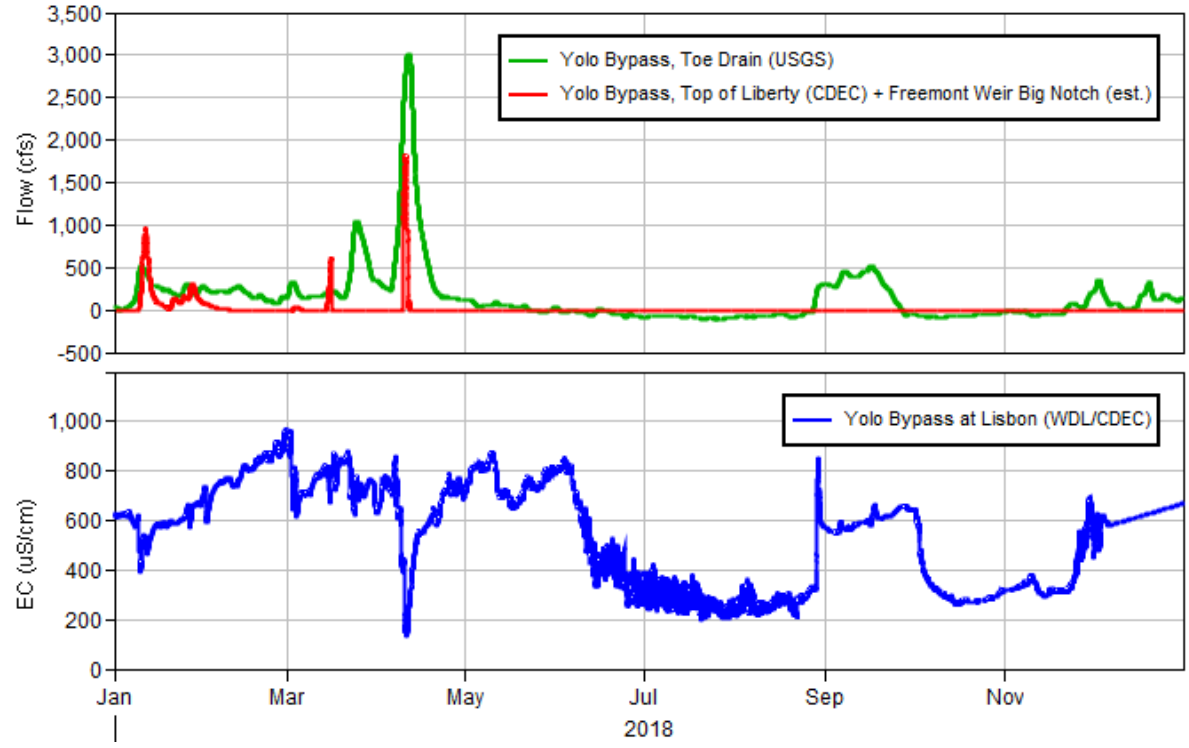

Figure 110 Flow and EC boundary conditions for the Yolo Bypass for 2018.

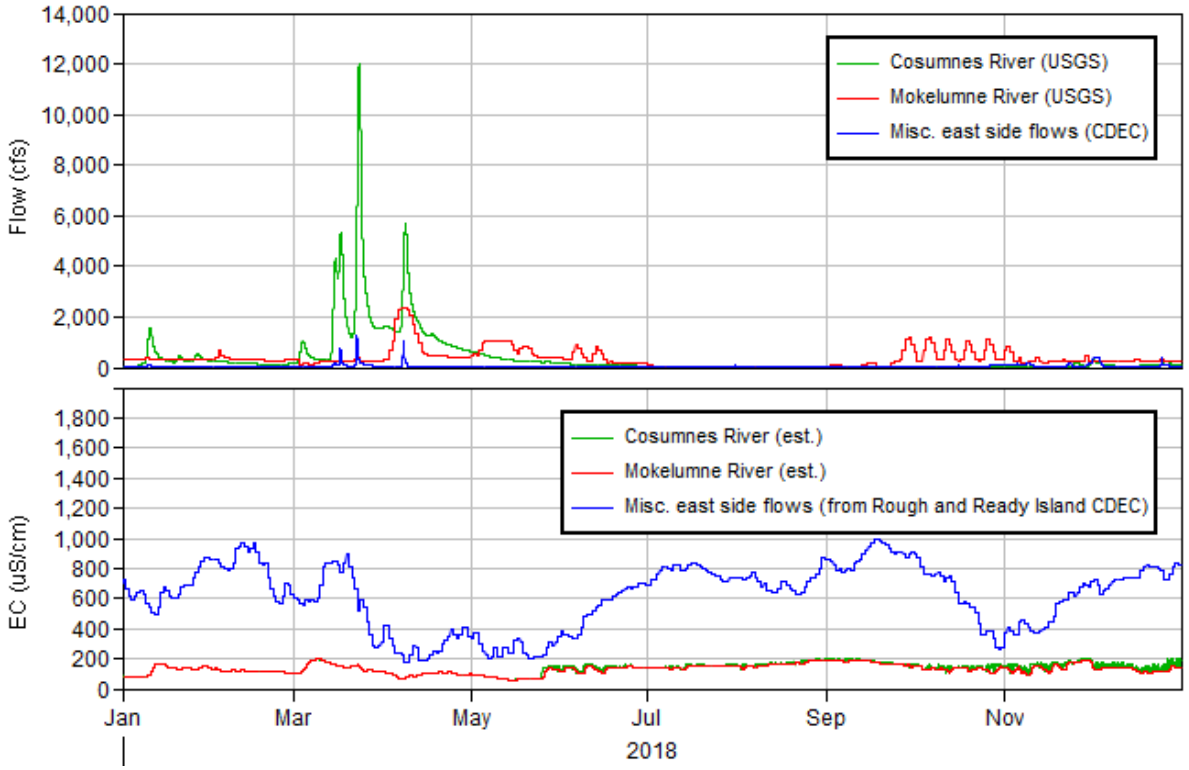

Figure 111 Flow and EC boundary conditions for east side inflows for 2018.

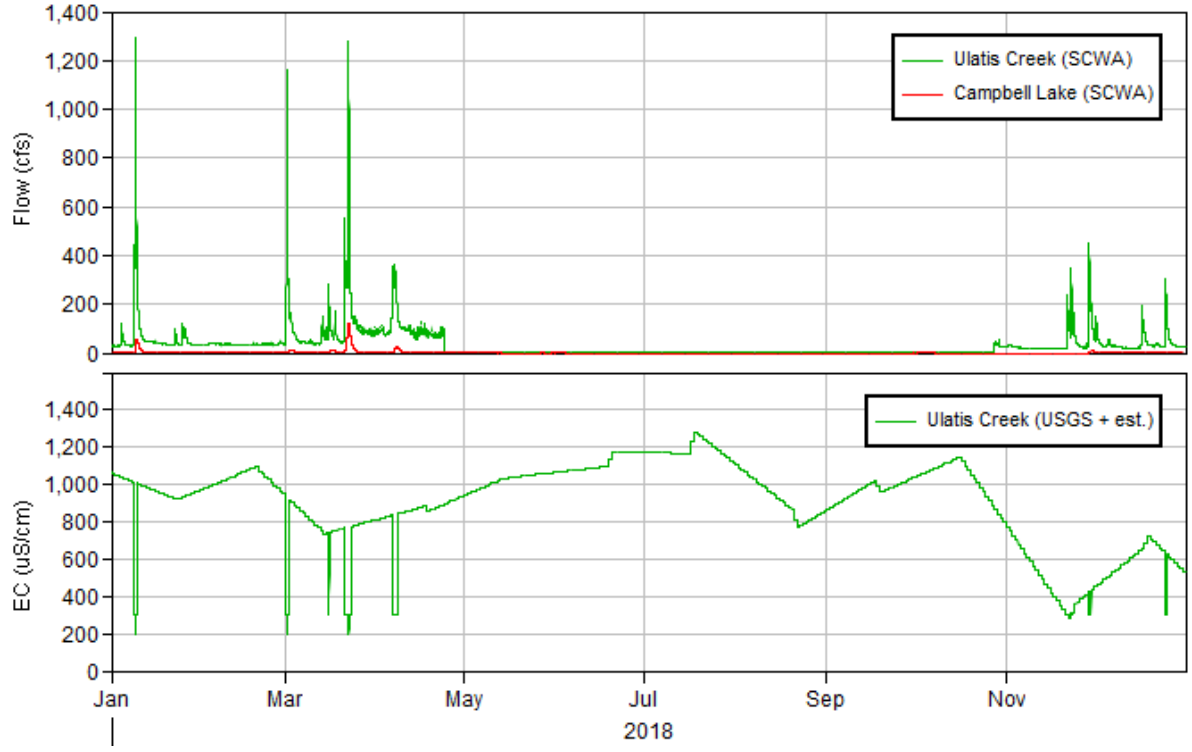

Figure 112 Flow and EC boundary conditions for Ulatis Creek and Campbell Lake for 2018 (EC set constant at 700 µS/cm for Campbell Lake).

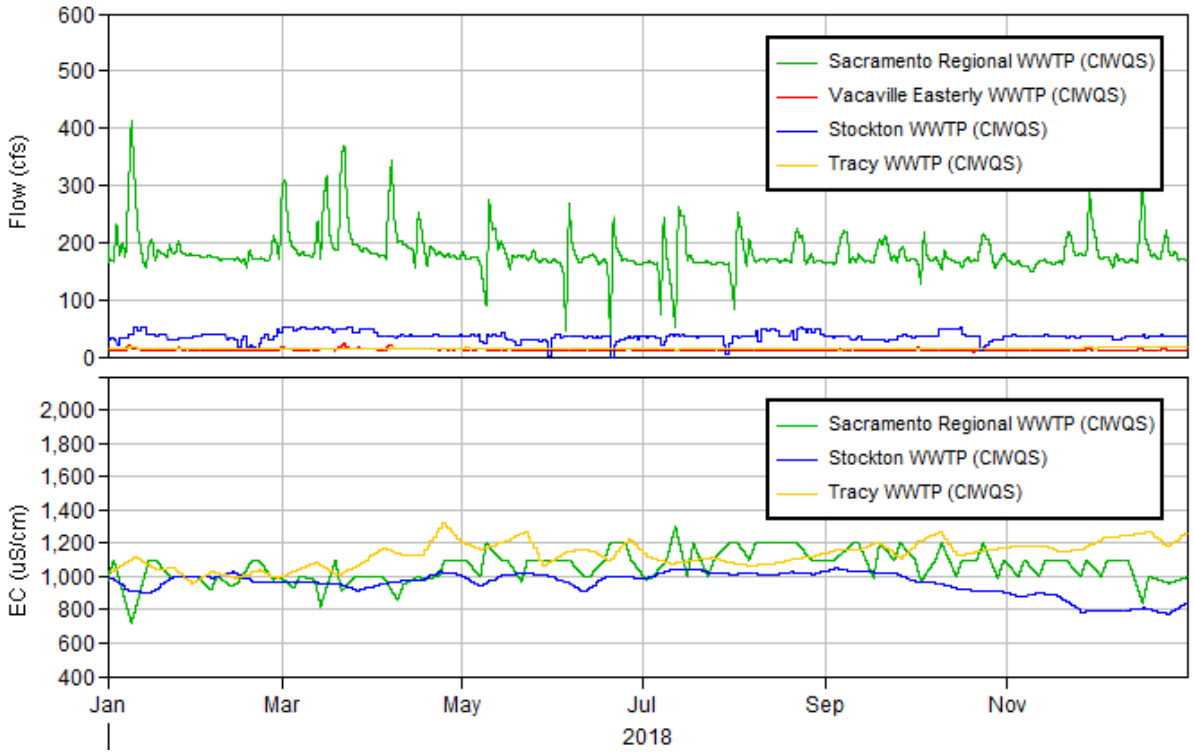

Figure 113 Flow and EC for Delta Wastewater Treatment Plants (WWTP) for 2018. Vacaville Easterly WWTP EC was set constant at 1050 µS/cm.

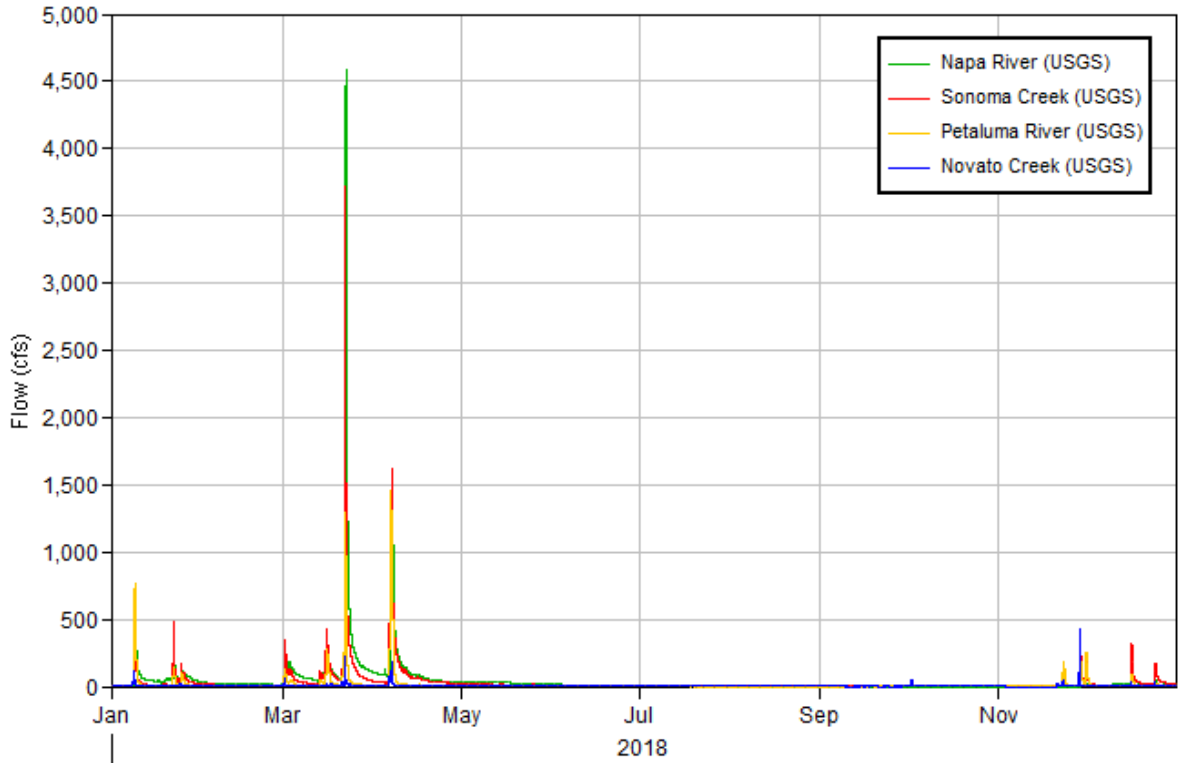

Figure 114 San Pablo Bay region inflows for 2018. EC set constant at 120 µS/cm.

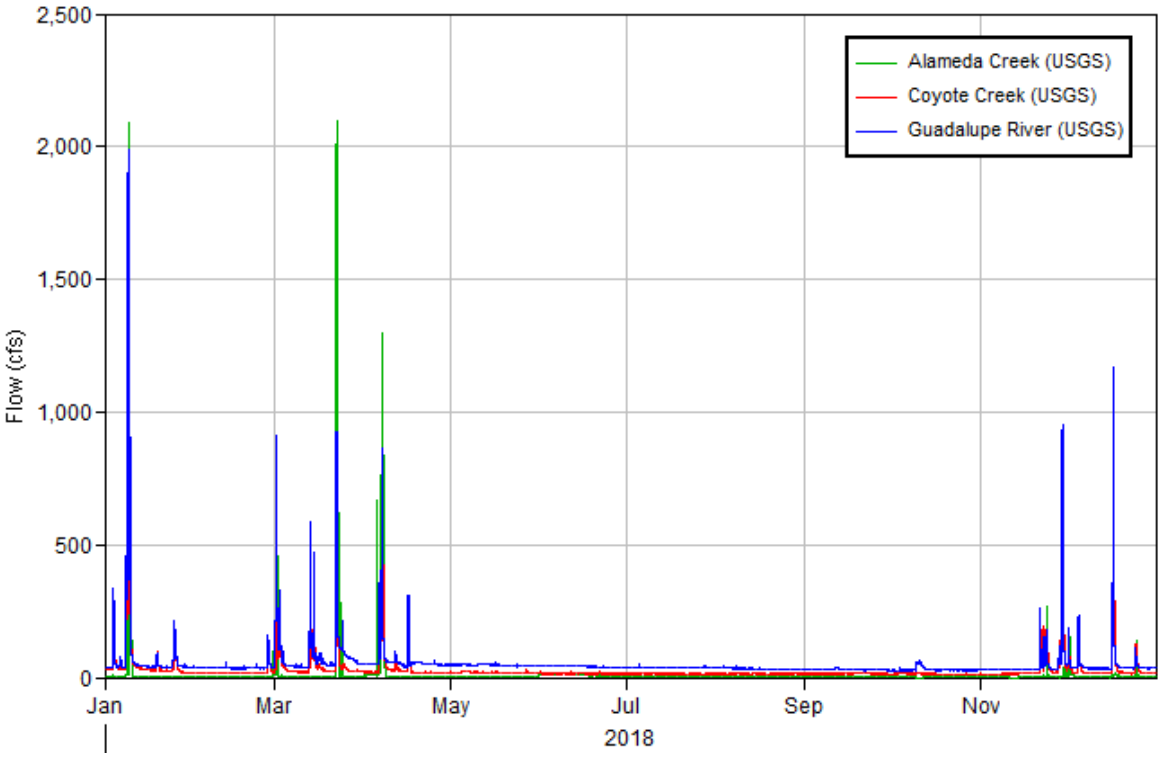

Figure 115 South Bay inflows for 2018. EC set constant at 120 µS/cm.

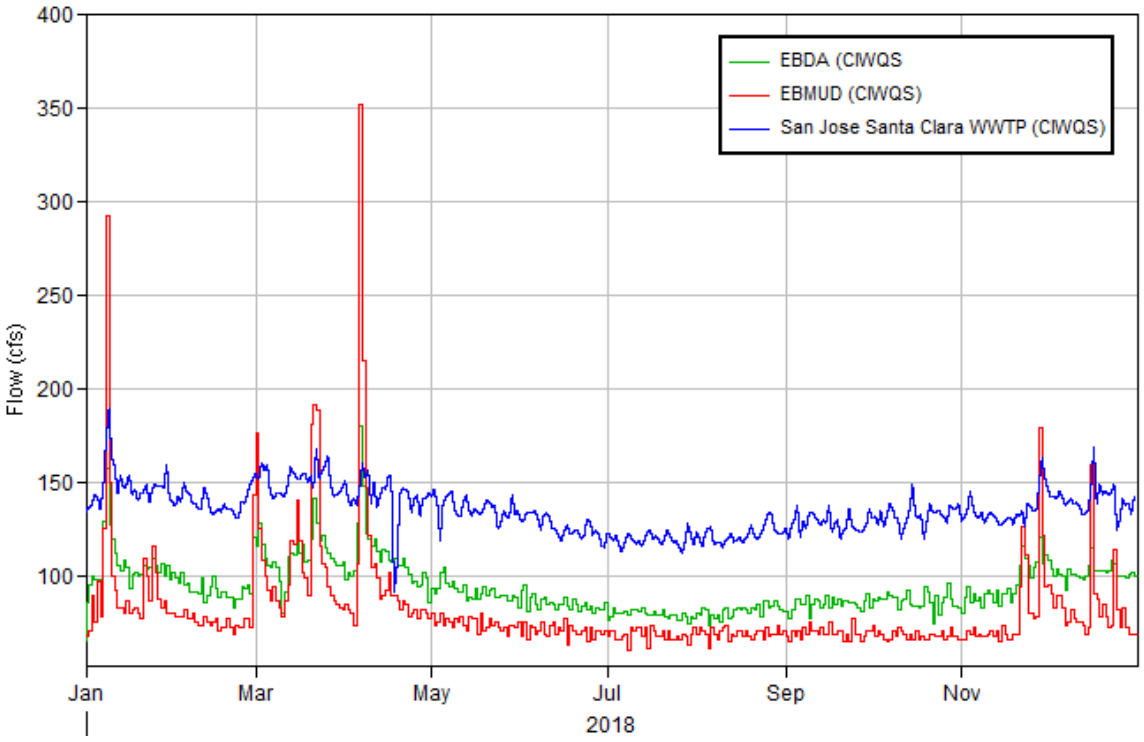

Figure 116 Wastewater Treatment Plant discharge flows in the south Bay region for 2018. EC set constant at 950 µS/cm.

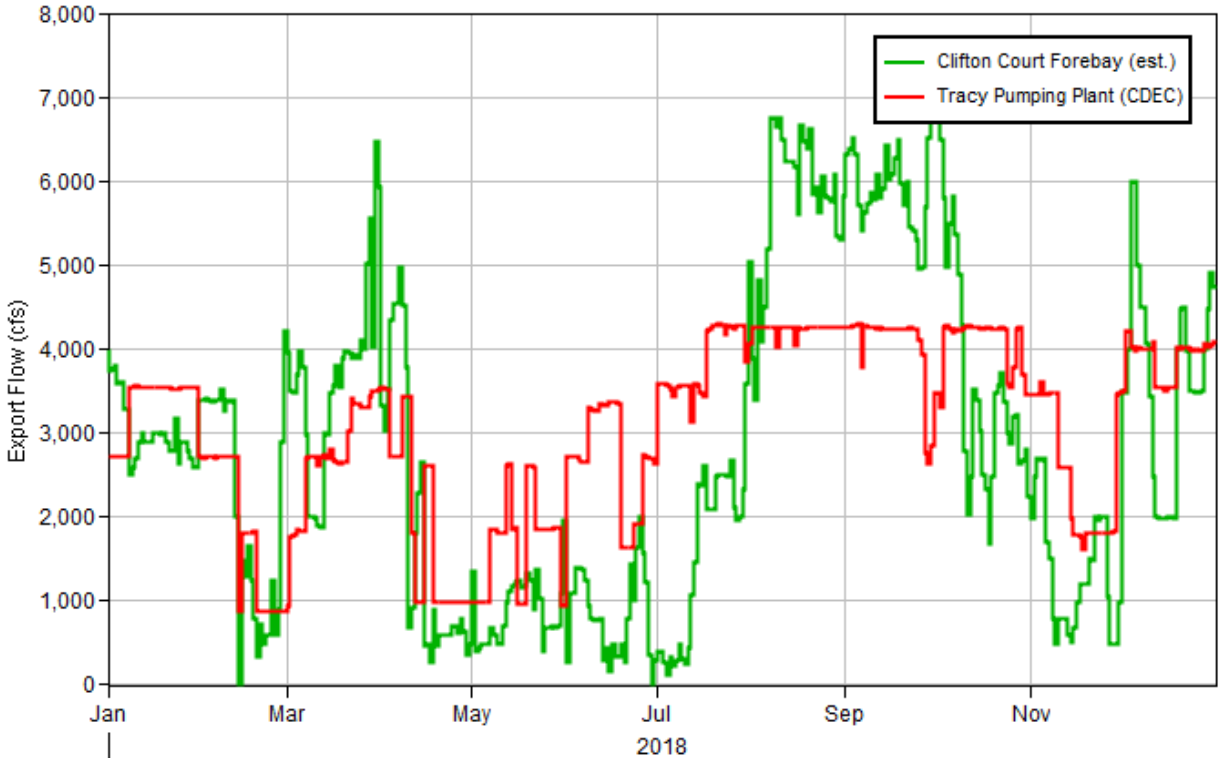

Figure 117 SWP (Clifton Court) and CVP (Tracy Pumping Plant) exports for 2018.

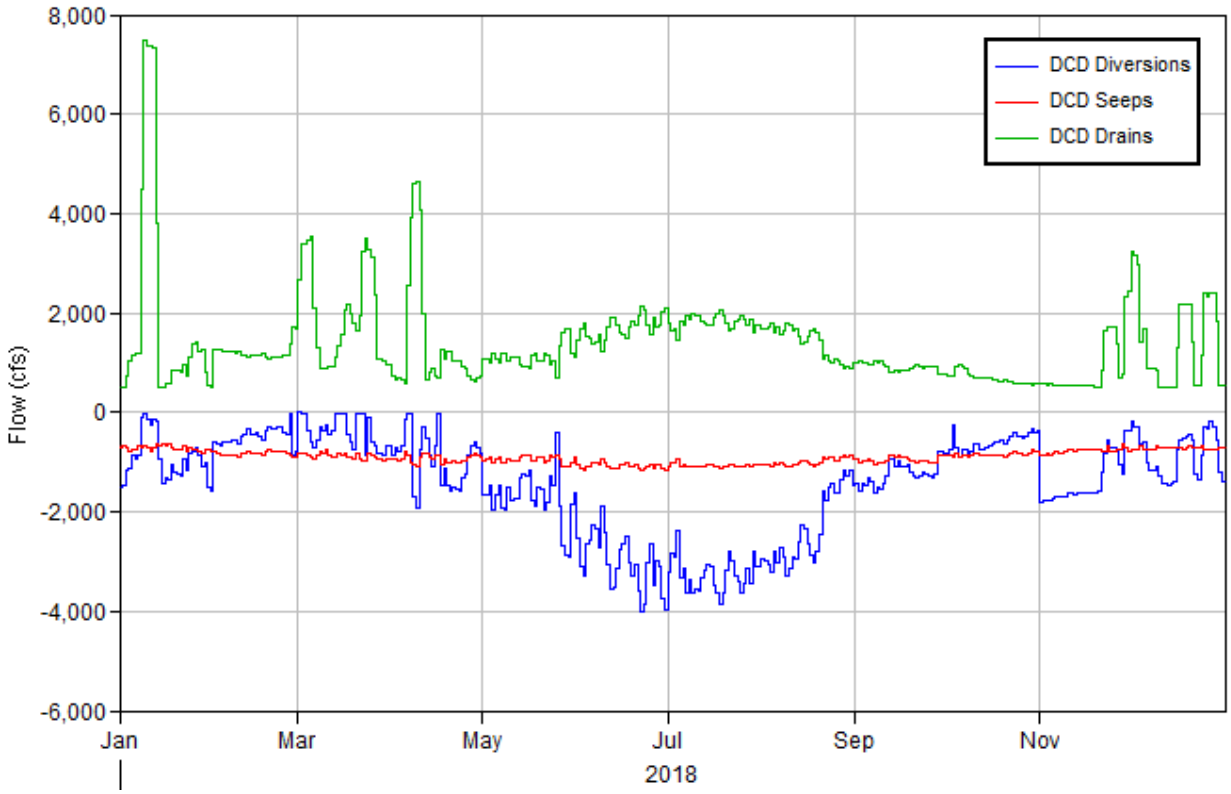

Figure 118 Sum of Delta DCD diversions, seeps and drains for 2018.

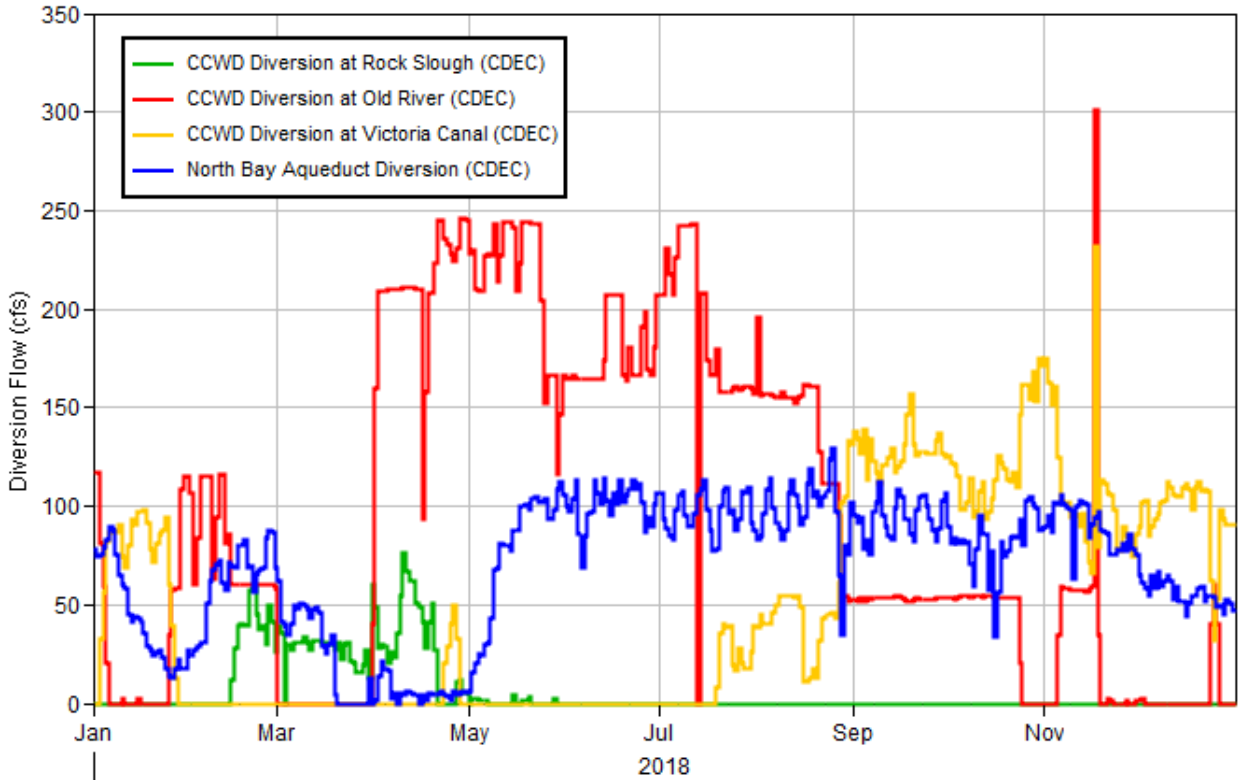

Figure 119 CCWD and North Bay Aqueduct diversions for 2018.

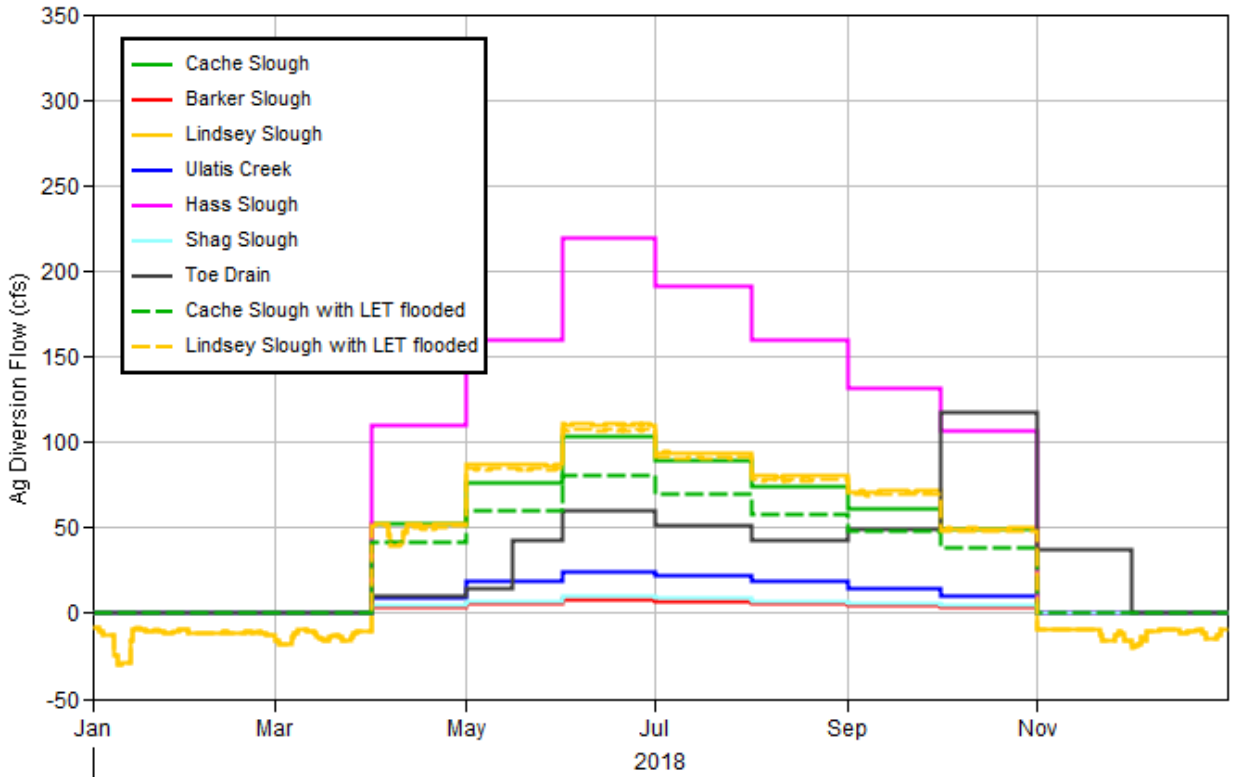

Figure 120 Agricultural diversions in the Cache Slough Complex channels for 2018.

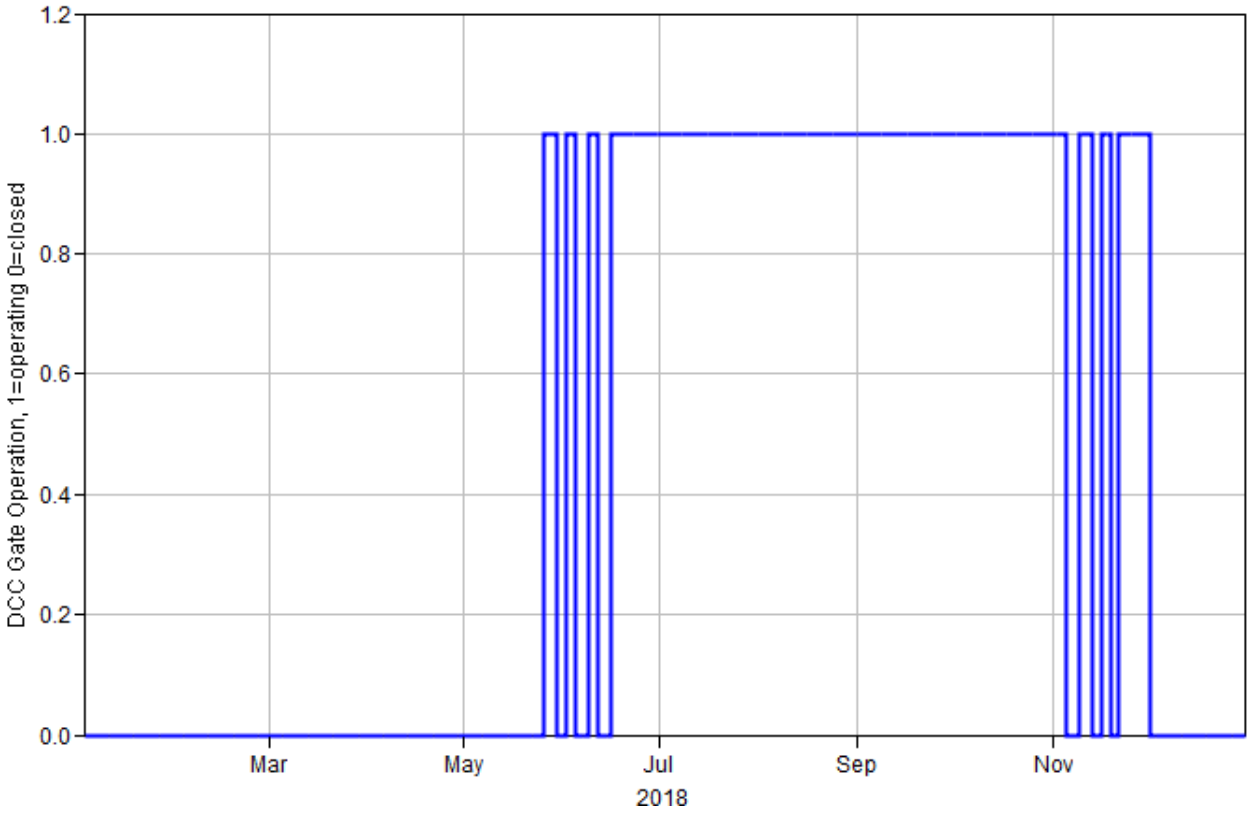

Figure 121 Delta Cross Channel operation schedule for 2018.

2020 Model Boundary conditions

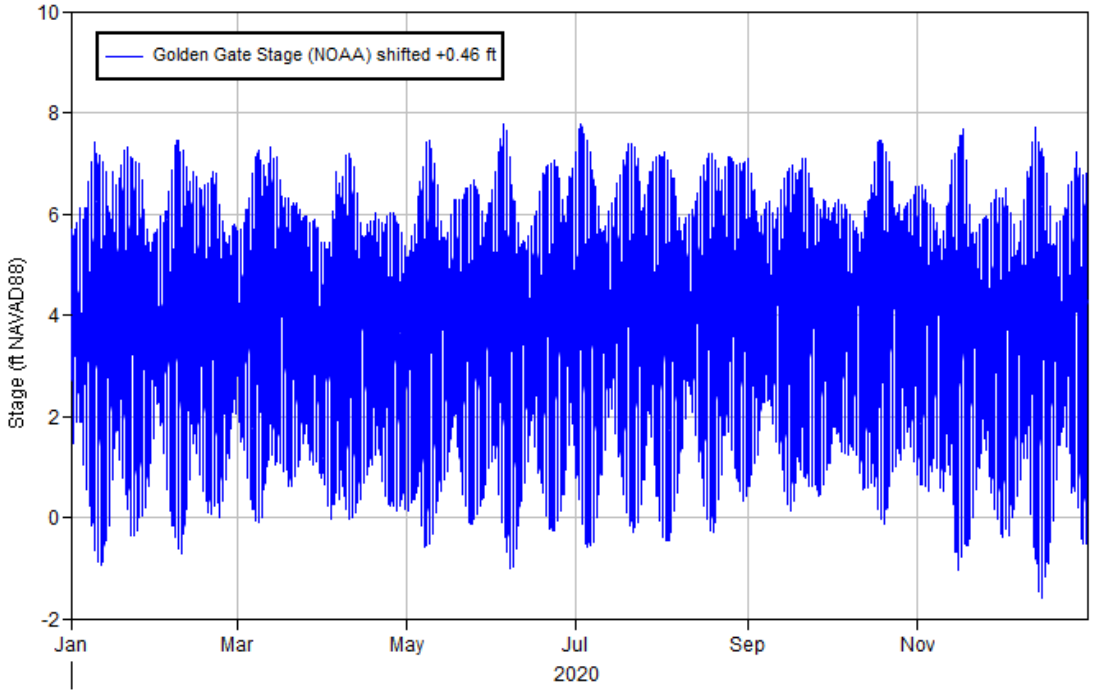

Figure 122 Golden Gate stage boundary for 2020 (data source: NOAA, shifted +0.46 ft). EC set constant at 50,000 µS/cm.

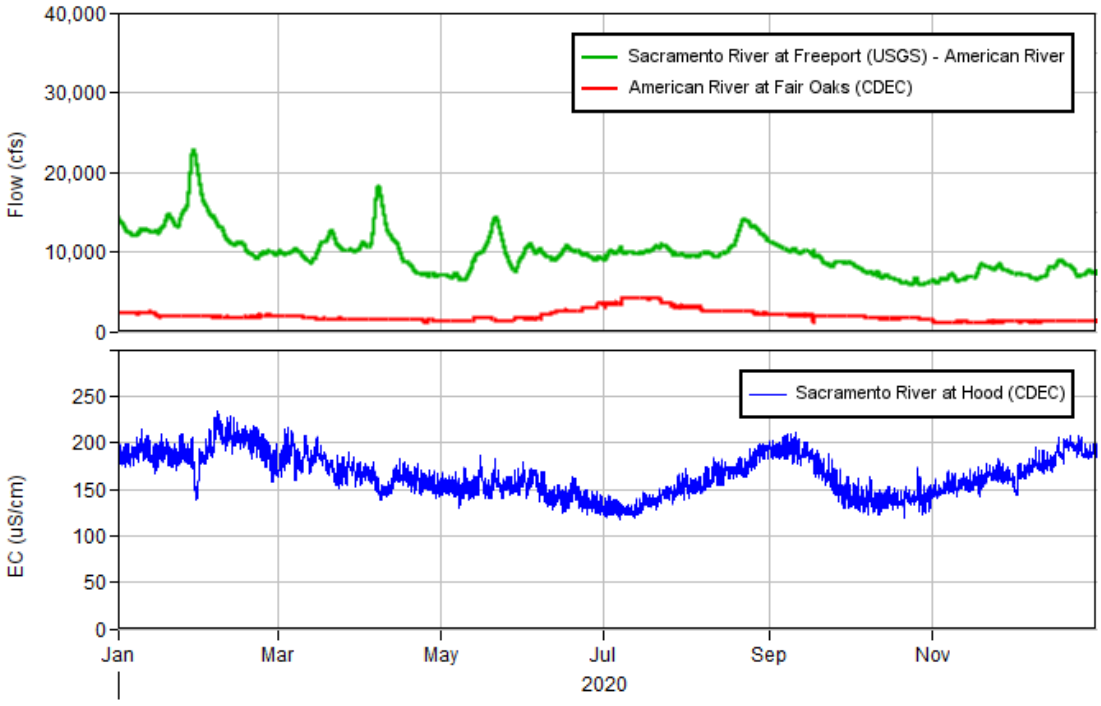

Figure 123 Flow and EC boundary conditions for the Sacramento River and American River for 2020. An internal EC boundary condition is applied in Sacramento River at Hood.

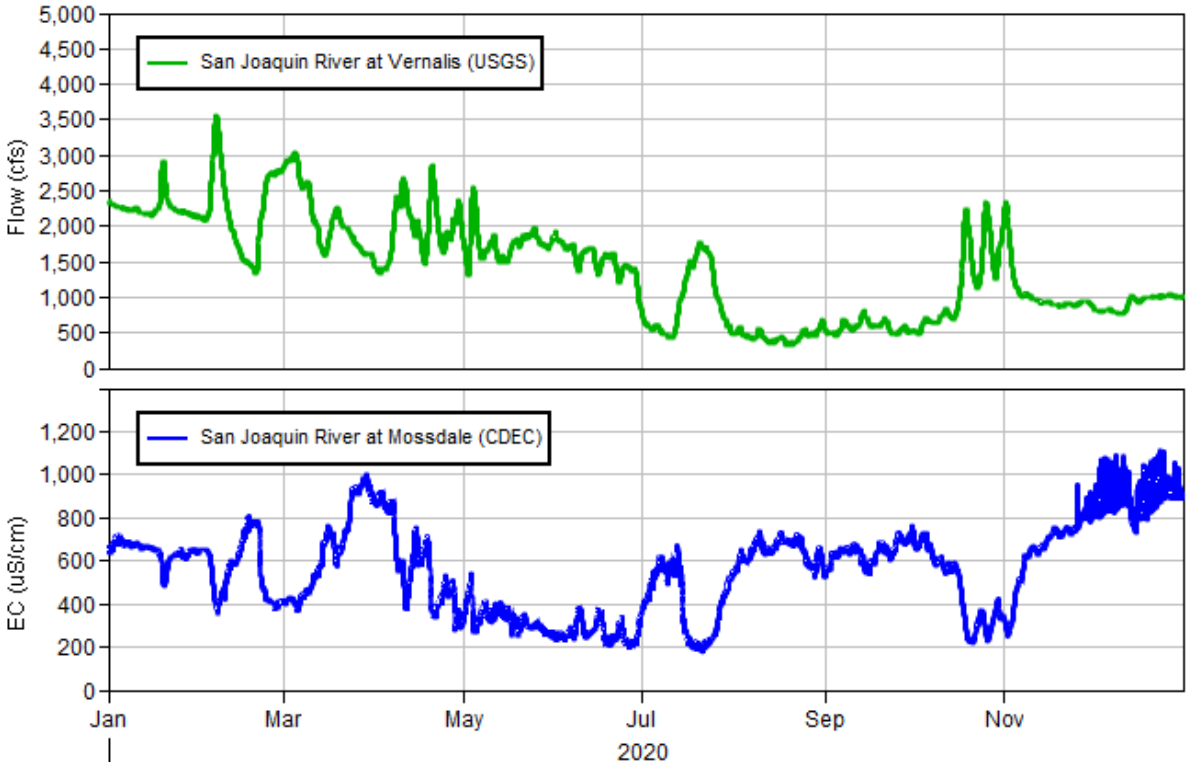

Figure 124 Flow and EC boundary conditions for the San Joaquin River for 2020. An internal EC boundary condition is applied in San Joaquin River at Mossdale.

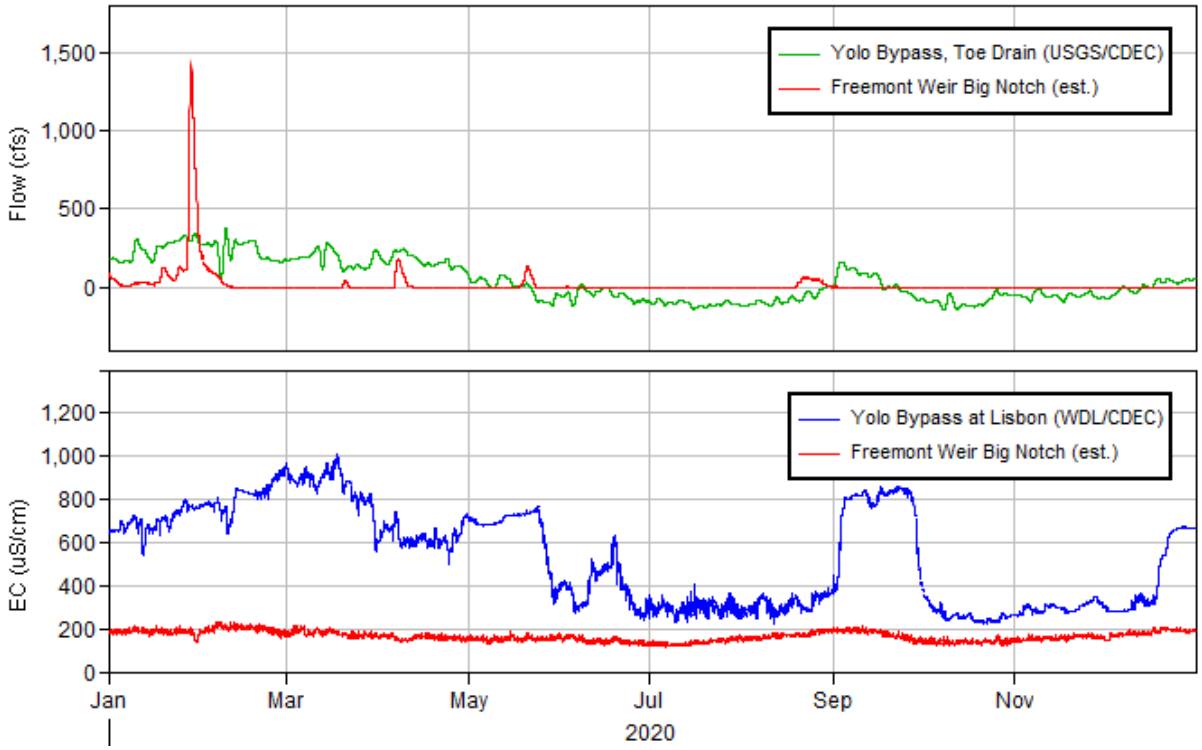

Figure 125 Flow and EC boundary conditions for the Yolo Bypass for 2020.

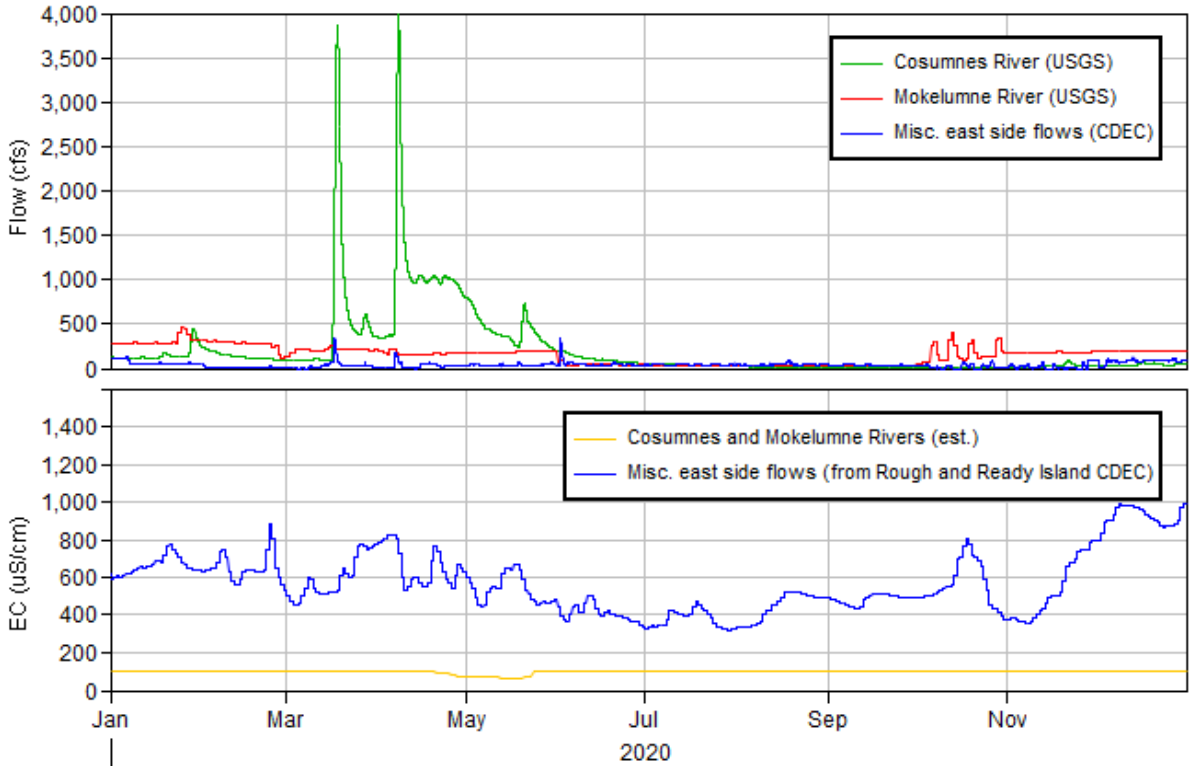

Figure 126 Flow and EC boundary conditions for east side inflows for 2020.

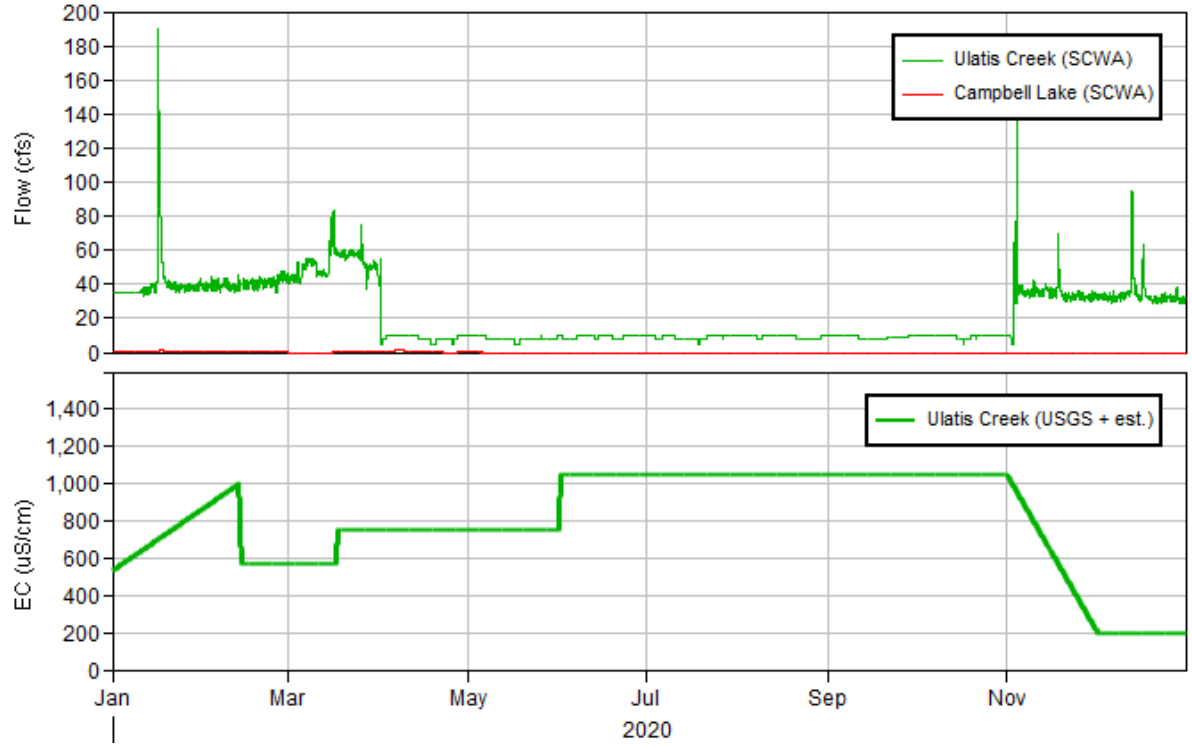

Figure 127 Flow and EC boundary conditions for Ulatis Creek and Campbell Lake for 2020 (EC set constant at 700 µS/cm for Campbell Lake).

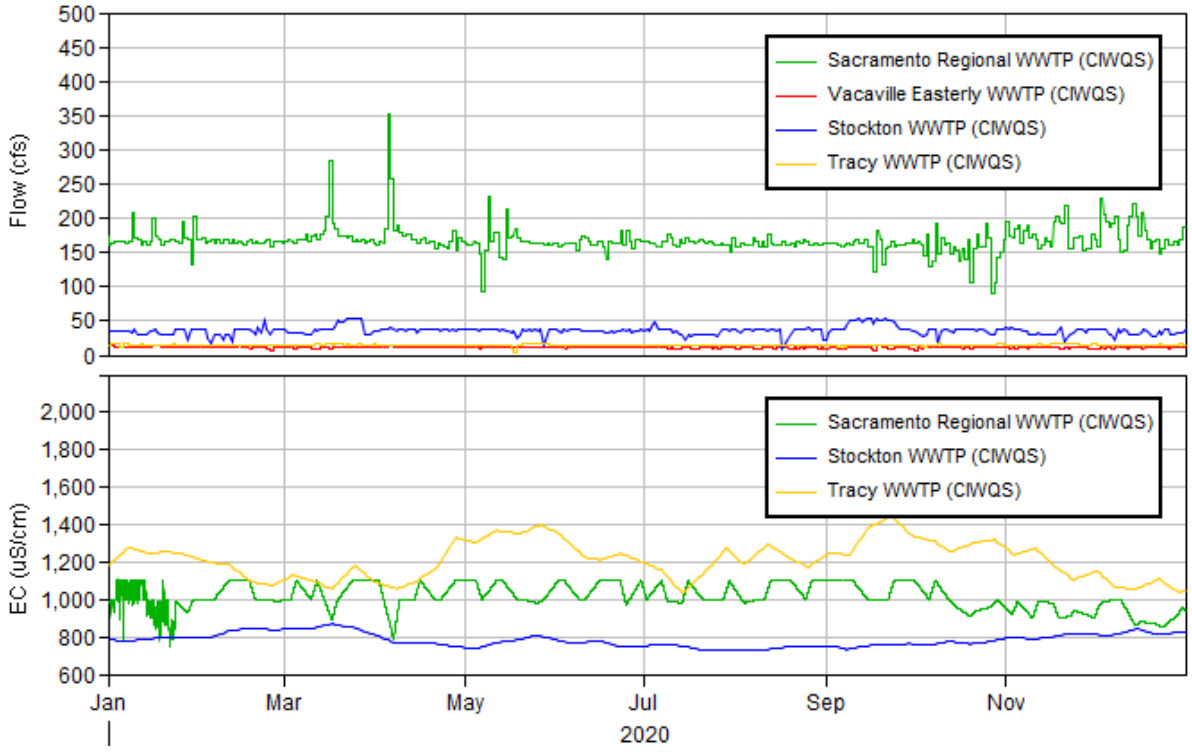

Figure 128 Flow and EC for Delta Wastewater Treatment Plants (WWTP) for 2020. Vacaville Easterly WWTP EC was set constant at 1050 µS/cm.

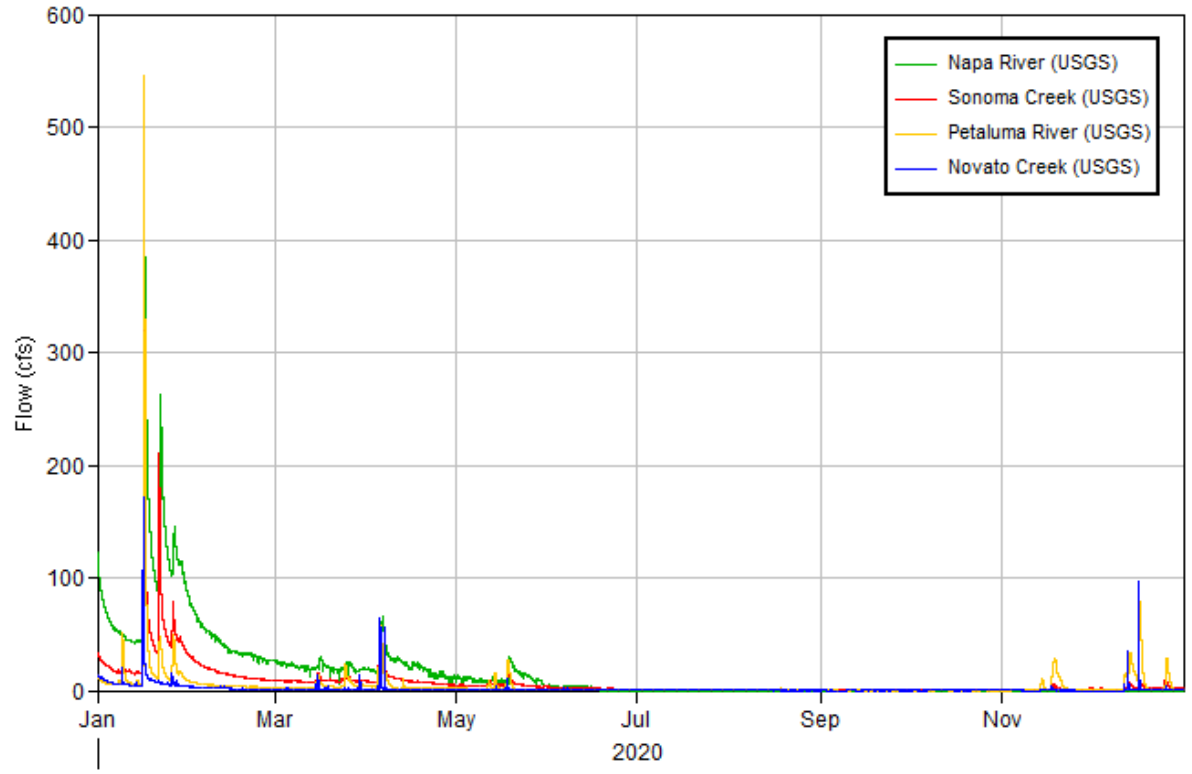

Figure 129 San Pablo Bay region inflows for 2020. EC set constant at 120 µS/cm.

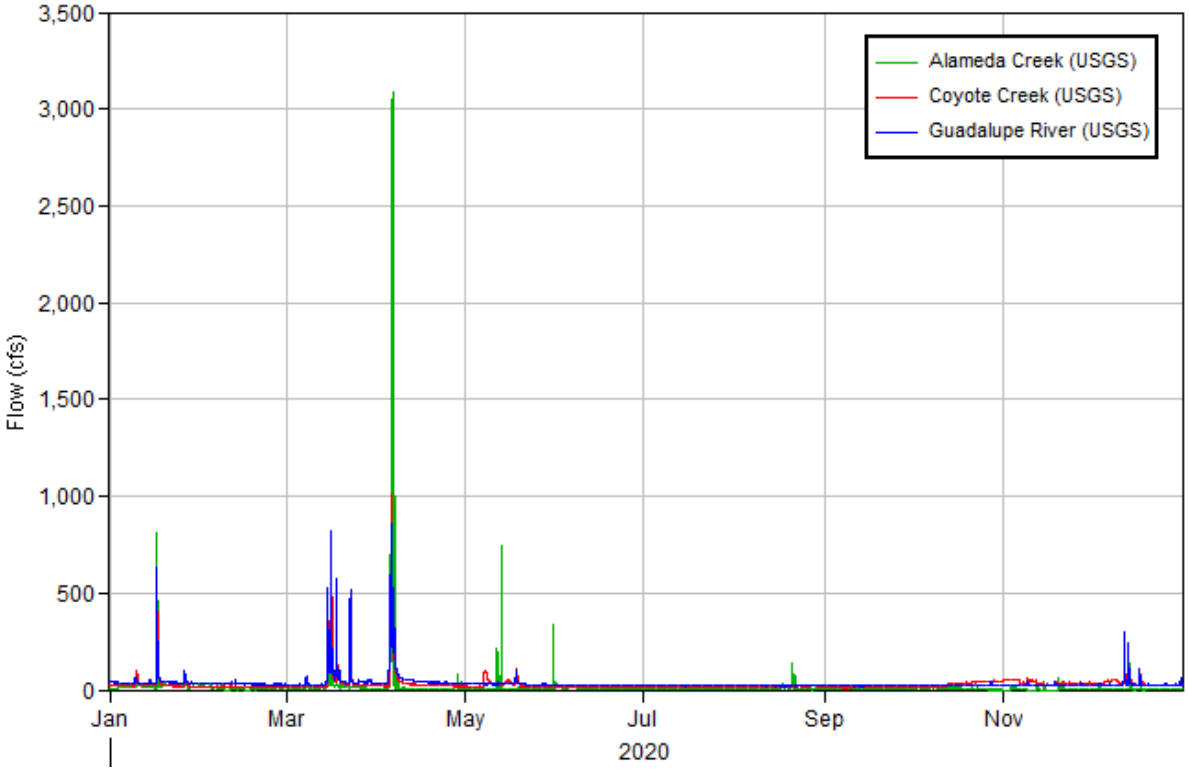

Figure 130 South Bay inflows for 2020. EC set constant at 120 µS/cm.

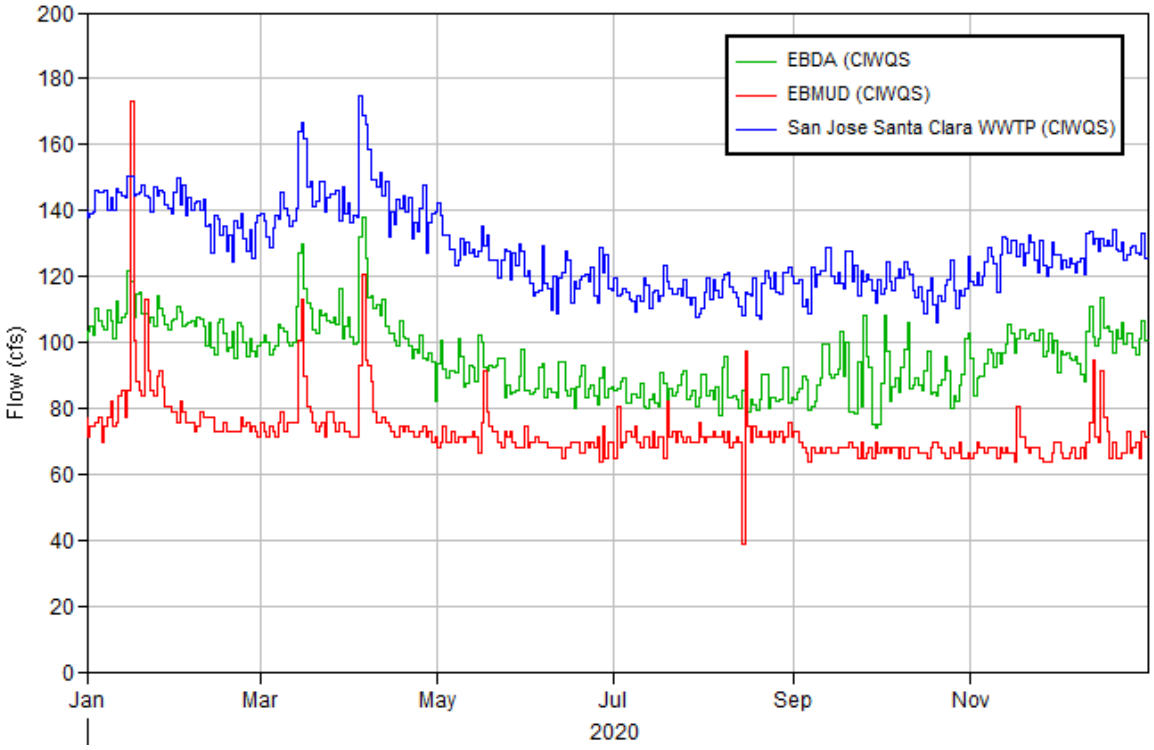

Figure 131 Wastewater Treatment Plant discharge flows in the south Bay region for 2020. EC set constant at 950 µS/cm.

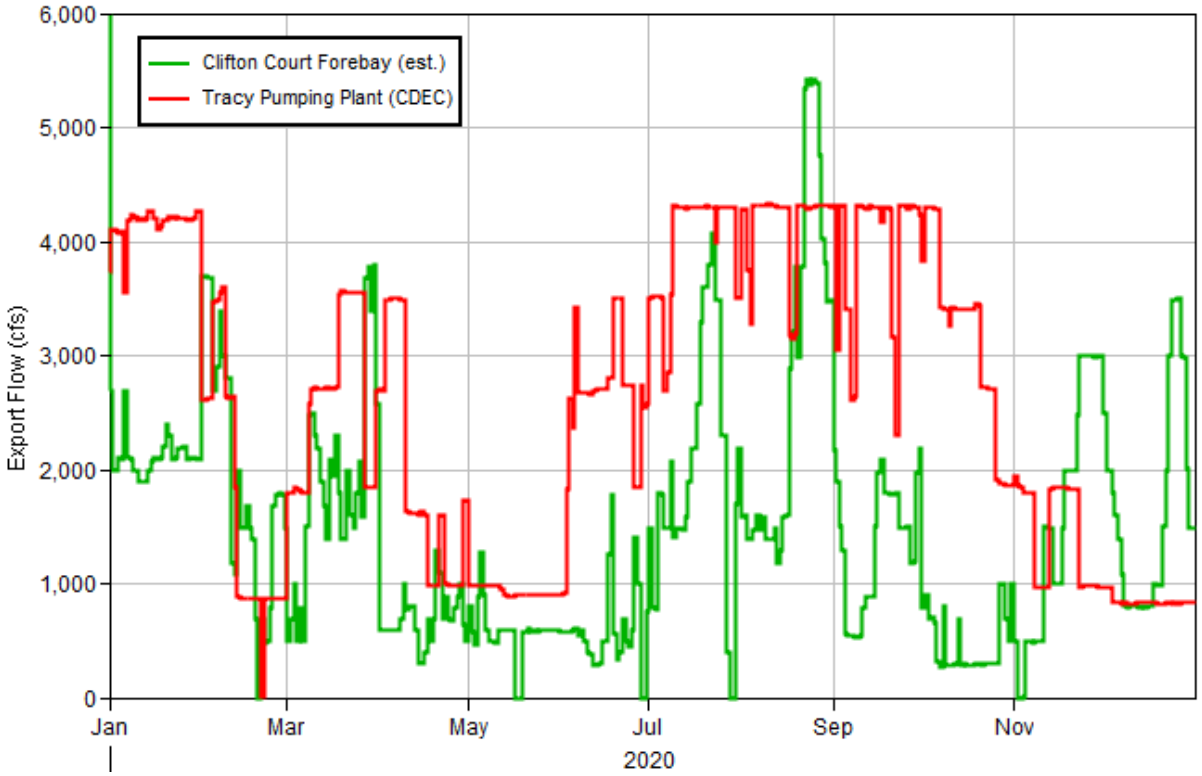

Figure 132 SWP (Clifton Court) and CVP (Tracy Pumping Plant) exports for 2020.

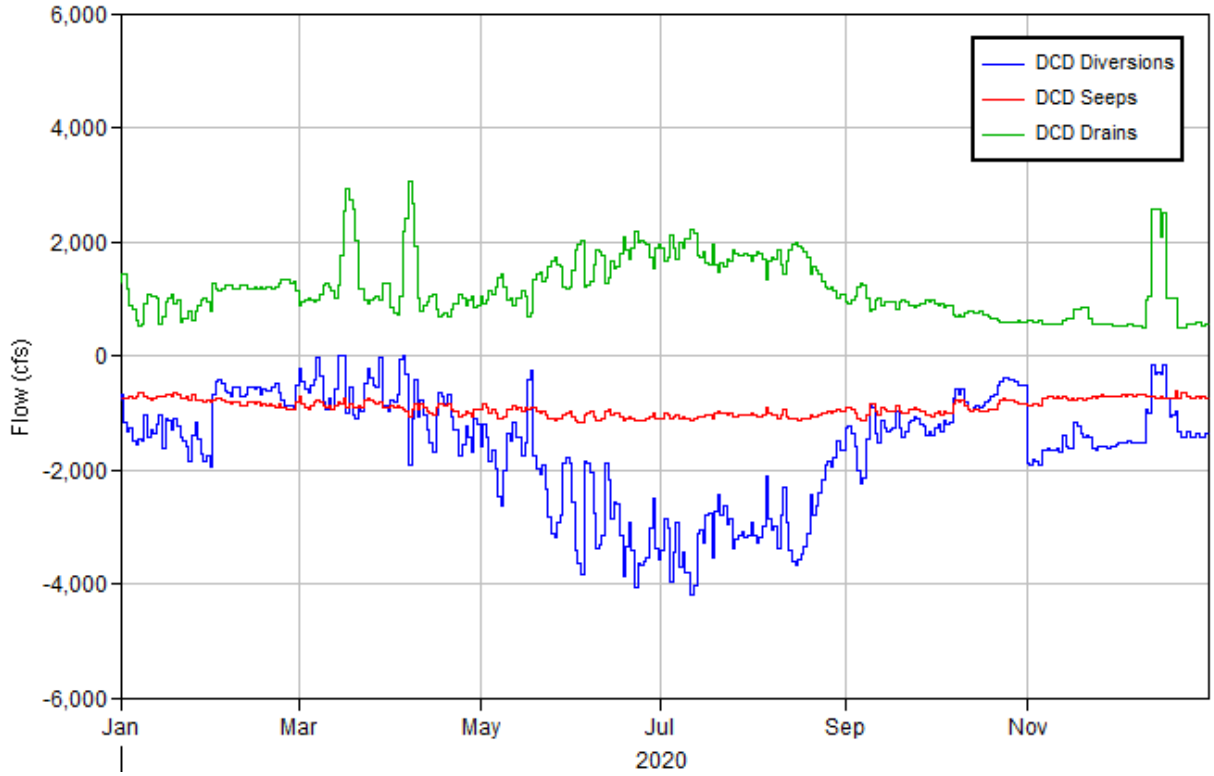

Figure 133 Sum of Delta DCD diversions, seeps and drains for 2020.

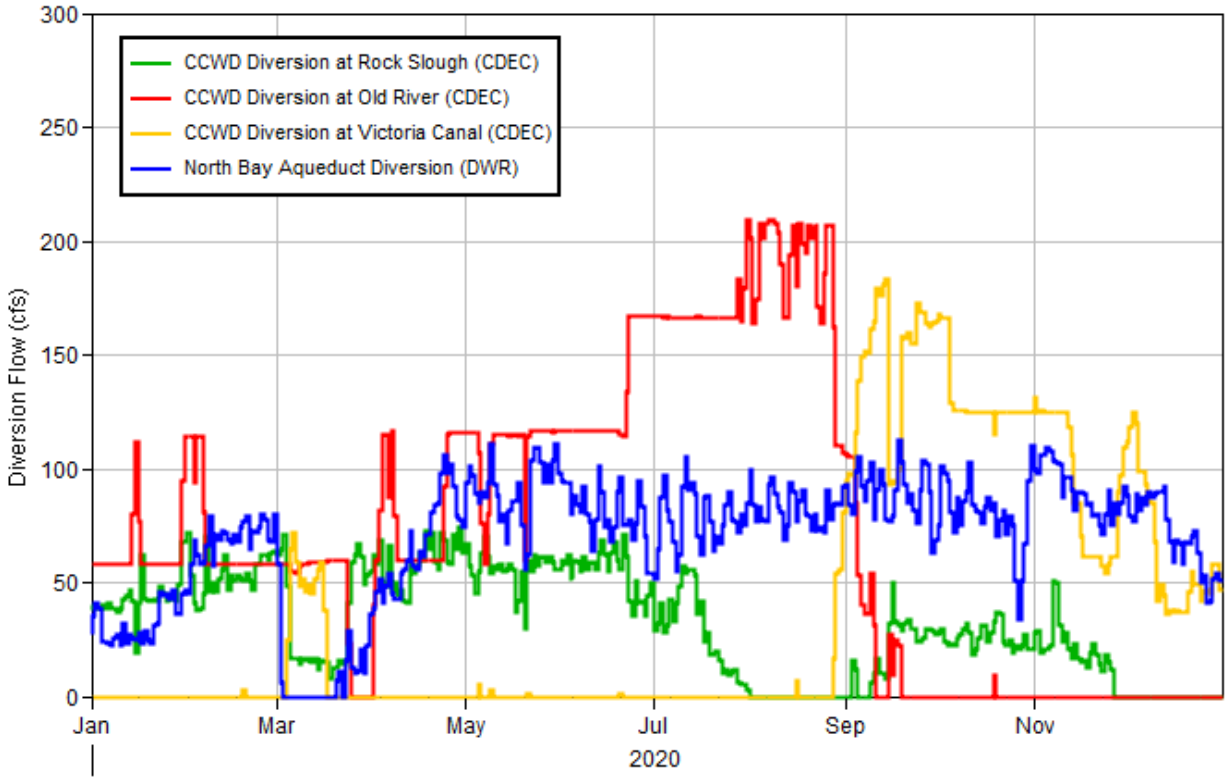

Figure 134 CCWD and North Bay Aqueduct diversions for 2020.

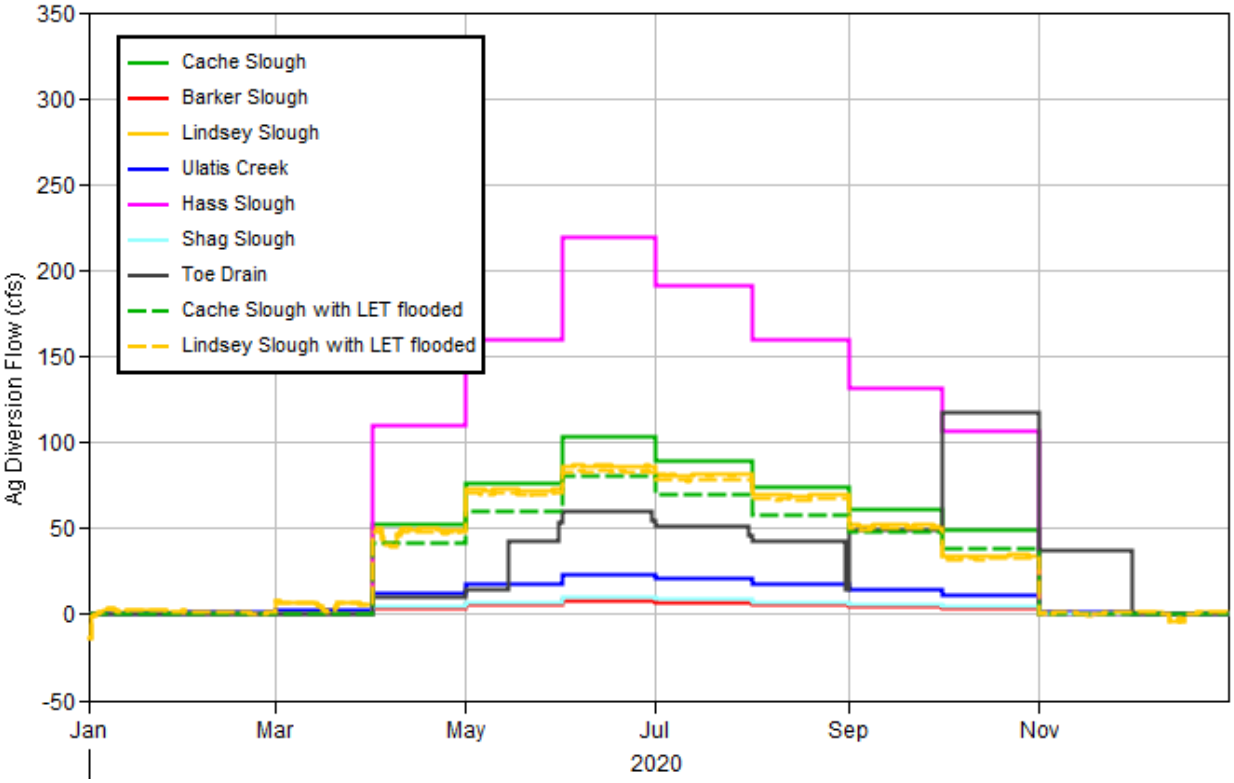

Figure 135 Agricultural diversions in the Cache Slough Complex channels for 2020.

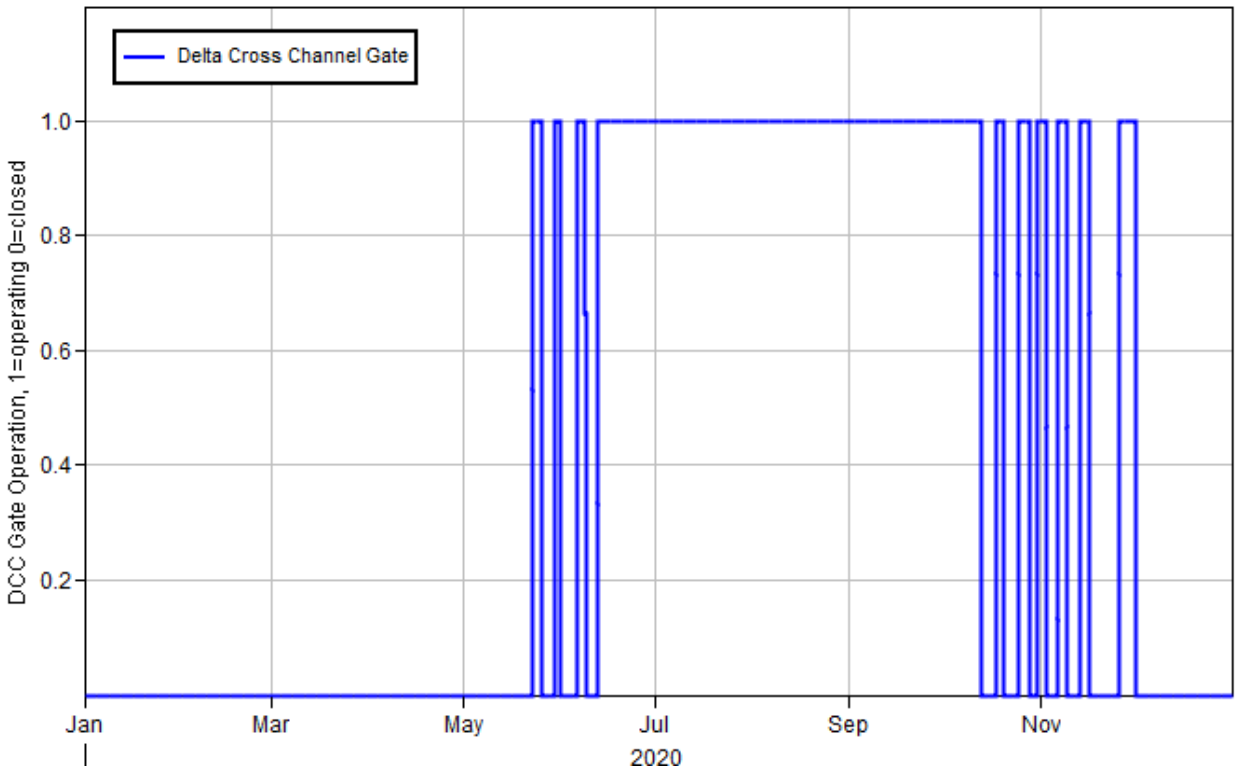

Figure 136 Delta Cross Channel operation schedule for 2020.