Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh

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Chapter 4
Modeling Physical Barriers (Gates) as Engineering Solutions to Satisfy National Marine Fisheries Service Biological Opinion Reasonable Prudent Alternative Action IV.1.3

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4 Modeling Physical Barriers (Gates) as Engineering Solutions to Satisfy National Marine Fisheries Service Biological Opinion Reasonable Prudent Alternative Action IV.1.3

4.1 Introduction

This report provides detailed modeling information on the potential impact on flow, water quality, and water level throughout the Delta of physical barriers (gates) as engineering solutions to deter fish from entering the Delta. The modeling was performed to provide information to support decision-making for engineering solutions to satisfy the National Marine Fisheries Service Biological Opinion Reasonable and Prudent Alternative (NMFS BiOp RPA) Action IV.1.3 (Action). The Action objective is to prevent emigrating salmonids from entering into the interior of the Delta and southern Delta, and to reduce exposure to the Central Valley Project (CVP) and State Water Project (SWP) export facilities. Delta Simulation Model 2 (DSM2) was used to simulate gates on the Delta channels: Georgiana Slough, Head of Old River, Turner Cut, and Columbia Cut. The modeling results have been evaluated for impact analysis of flow, water quality, and water level throughout the Delta.

4.2 The Simulation Model

DSM2 is a one-dimensional hydrodynamic and water quality model used to simulate hydrodynamics, water quality, and particle tracking in the Sacramento-San Joaquin Delta. DSM2 represents the best available planning model for Delta tidal hydraulic and salinity modeling. It is appropriate for describing the existing conditions in the Delta, as well as performing simulations for the assessment of incremental environmental impacts caused by future facilities and operations.

DSM2 consists of three modules: HYDRO, QUAL, and PTM. HYDRO simulates flow, velocities, and water level, and provides the flow input for QUAL and PTM. DSM2-HYDRO outputs are used to predict changes in flow rates, water level, and their effects on Delta channels as a result of future facilities and operations.

The DSM2-QUAL module simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by DSM2-HYDRO. Outputs are used to estimate changes in salinity and their effects on Delta channels as a result of future facilities and operations.

The DSM2-PTM module, which was not used in this modeling analysis, simulates pseudo 3-D transport of neutrally buoyant particles based on the flow field simulated by DSM2-HYDRO. It simulates the fate and transport of individual particles traveling throughout the Delta. DSM2-PTM has multiple applications ranging from visualization of flow patterns to simulation of discrete organisms, such as fish eggs and larvae. Additional information on DSM2 can be found on the DWR Modeling Support Branch website: http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/models/dsm2/dsm2.cfm.

4.3 Methodology

There were several scenarios investigated during this analysis, ranging from full flow blockage to partial flow blockage at four key junctions in the Delta (Figure 4-1). An additional key junction, Threemile Slough, for which prior analysis had been conducted and is discussed in this report, is not shown in Figure 4-1. The purpose of the flow blockage is to simulate a gate blocking a junction to divert emigrating salmonids from entering into the Delta channels and to keep them in the Sacramento River

or San Joaquin River for their passage to the ocean. The 16-year (water year [WY] 1976-WY 1991) DSM2 model was used to simulate these scenarios. The 16-year DSM2 model simulations have also been used for the Bay Delta Conservation Plan (BDCP) Draft EIR/EIS, South Delta Improvements Program (SDIP), Franks Tract Project, and Storage Investigations and Operations Criteria and Plan (OCAP). The DSM2 model simulation of Existing Conditions for the BDCP Draft EIR/EIS was used as a baseline. The modeled or simulated flow water quality and water level were then compared with the baseline and the incremental changes were evaluated for impacts on various Delta locations.

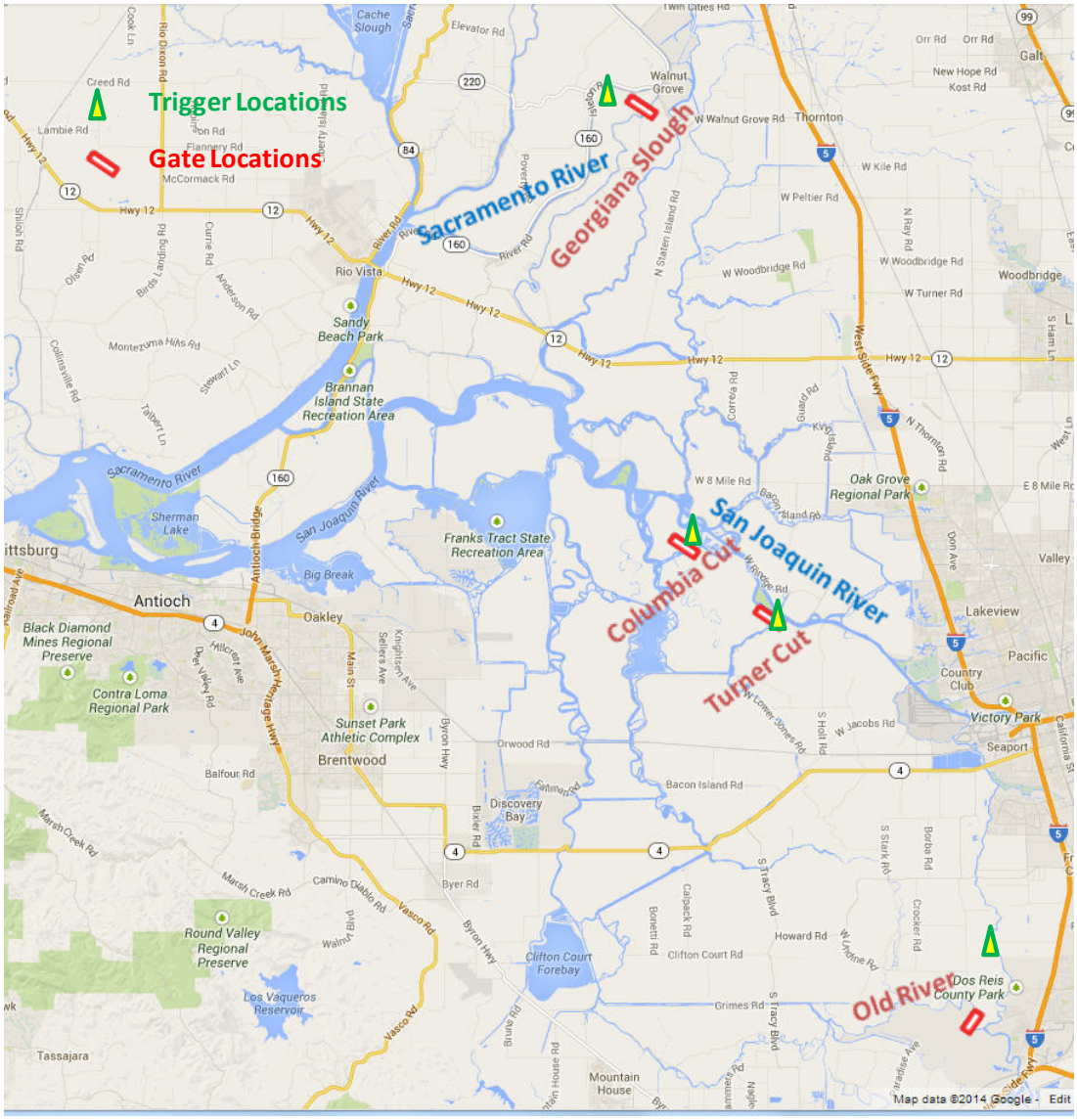

Figure 4-1 Gate Locations in the Delta Channels

4.3.1 Description of Existing Conditions

The existing conditions model simulation was developed assuming WY 2009-level of development and regulatory conditions. The existing conditions assumptions included how existing facilities and ongoing programs that existed as of February 13, 2009 (publication date of the BDCP Public EIR/EIS Notice of

Preparation and Notice of Intent) could affect or could be affected by implementation of the alternatives. The existing conditions assumptions also included assumptions related to the SWP and CVP, ongoing policies by governmental and nonprofit entities, and assumptions related to annual actions that vary every year. One exception was the NMFS BiOp on the Long-Term Central Valley Project and State Water Project Operations Criteria and Plan, released in June 2009, that was included in the development of the existing conditions simulation in the BDCP EIR/EIS (California Department of Water Resources 2013).

4.3.2 Description of Modeling Scenarios

The modeling scenarios were developed by adding a gate, or a combination of gates, to the existing conditions model simulation. The scenarios were divided into three categories: (1) full flow blockage to Delta channels, (2) partial flow blockage to Delta channels, and (3) flow blockage used in other projects. The gates in these scenarios were operated either by the flow trigger or the velocity trigger option to restrict flow to the Delta channels. The scenarios, which included Georgiana Slough or Head of Old River gate, had a gate operation trigger location either in the Delta channels containing the gates or in the river channels near the closure. The scenarios, which included the Turner Cut and Columbia Cut gates, had a trigger location only in the Delta channels. These channels are located in the Central Delta and are influenced by the tide. It was assumed that the impact from the trigger location in the rivers for these gates would be similar to that of the channels. Table 4-1 lists the categories with gate locations and operations for each of the scenarios.

Category	Location of Gate	Gate Operation Trigger	Trigger Location
Full Flow Blockage to Delta Channels	Georgiana Slough, Head of Old River, Turner Cut & Columbia Cut (Four Gates)	Closed on positive flow in channel & opened on reverse flow	Flow in Georgiana Slough, Head of Old River, Turner Cut & Columbia Cut
	Georgiana Slough	Closed on positive flow in channel & opened on reverse flow	Flow in Georgiana Slough
	Head of Old River	Closed on positive flow in channel & opened on reverse flow	Flow in Head of Old River
	Turner Cut	Closed on positive flow in channel & opened on reverse flow	Flow in Turner Cut
	Columbia Cut	Closed on positive flow in channel & opened on reverse flow	Flow in Columbia Cut

	Head of Old River, Turner Cut & Columbia Cut (Three Gates)	Closed on positive flow in channel & opened on reverse flow	Flow in Head of Old River, Turner Cut & Columbia Cut
	Georgiana Slough, Head of Old River, Turner Cut & Columbia Cut (Four Gates)	Closed on ebb & opened on flood	Flow in Sacramento River, San Joaquin River, Turner Cut & Columbia Cut
	Georgiana Slough	Closed on ebb & opened on flood	Flow in Sacramento River
	Head of Old River	Closed on ebb & opened on flood	Flow in San Joaquin River
	Head of Old River, Turner Cut & Columbia Cut (Three Gates)	Closed on ebb & opened on flood	Flow in San Joaquin River, Turner Cut & Columbia Cut
Partial Flow Blockage to Delta Channels	Georgiana Slough	Partial closed on ebb to block 50% net flow & opened on flood	Flow in Sacramento River
	Head of Old River	Partial closed on ebb to block 50% net flow & opened on flood	Flow in San Joaquin River
	Georgiana Slough	Closed on high velocity & Opened on low velocity	Velocity in Sacramento River
	Georgiana Slough	Partial closed on high velocity to block 50% net flow & opened on low velocity	Velocity in Sacramento River
	Head of Old River	Closed on high velocity & Opened on low velocity	Velocity in San Joaquin River
	Head of Old River	Partial closed on high velocity to block 50% net flow & opened on low velocity	Velocity in San Joaquin River
Flow Blockage Used in Other Projects	Threemile Slough (Franks Tract Project)	Franks Tract Project proposed operation, Seasonal operation for Fish and Water Quality	Flow in Sacramento and San Joaquin River or EC in Jersey Point

Table 4-1 Modeling Scenarios of Gate Location and Operation

4.3.2.1 Full Flow Blockage to Delta Channels

The gates were modeled to restrict flow from entering into the junctions. The gates at one site, or a combination of sites, were modeled in this category. The gates' operations were triggered by either flow in the Delta channels where the gates were placed, or flow in the rivers. The gates with a trigger location in Delta channels were closed on the positive flows in the channels and were opened on the reverse flows in the channels. The gates with a trigger location in the Sacramento or San Joaquin rivers are described below as flow trigger.

4.3.2.1.1. Flow Trigger

The gates were closed on the ebb tide when the water flowed toward the ocean from the rivers. The gates were opened on the flood tide when the water flowed from the ocean toward the rivers. The gate operation at Georgiana Slough was used to illustrate the flow trigger method. The trigger was based on the flow in the Sacramento River downstream of the gate. When the flow direction at the Sacramento River at the trigger location was toward the ocean, the Georgiana Slough gate was closed. The gate was opened during reverse flow periods. Figure 4-2 illustrates the gate closure in response to the flow trigger. The gate operation at the Head of Old River was based on the flow in the San Joaquin River downstream of the gate. The gate operation scenario was similar to the Georgiana Slough gate.

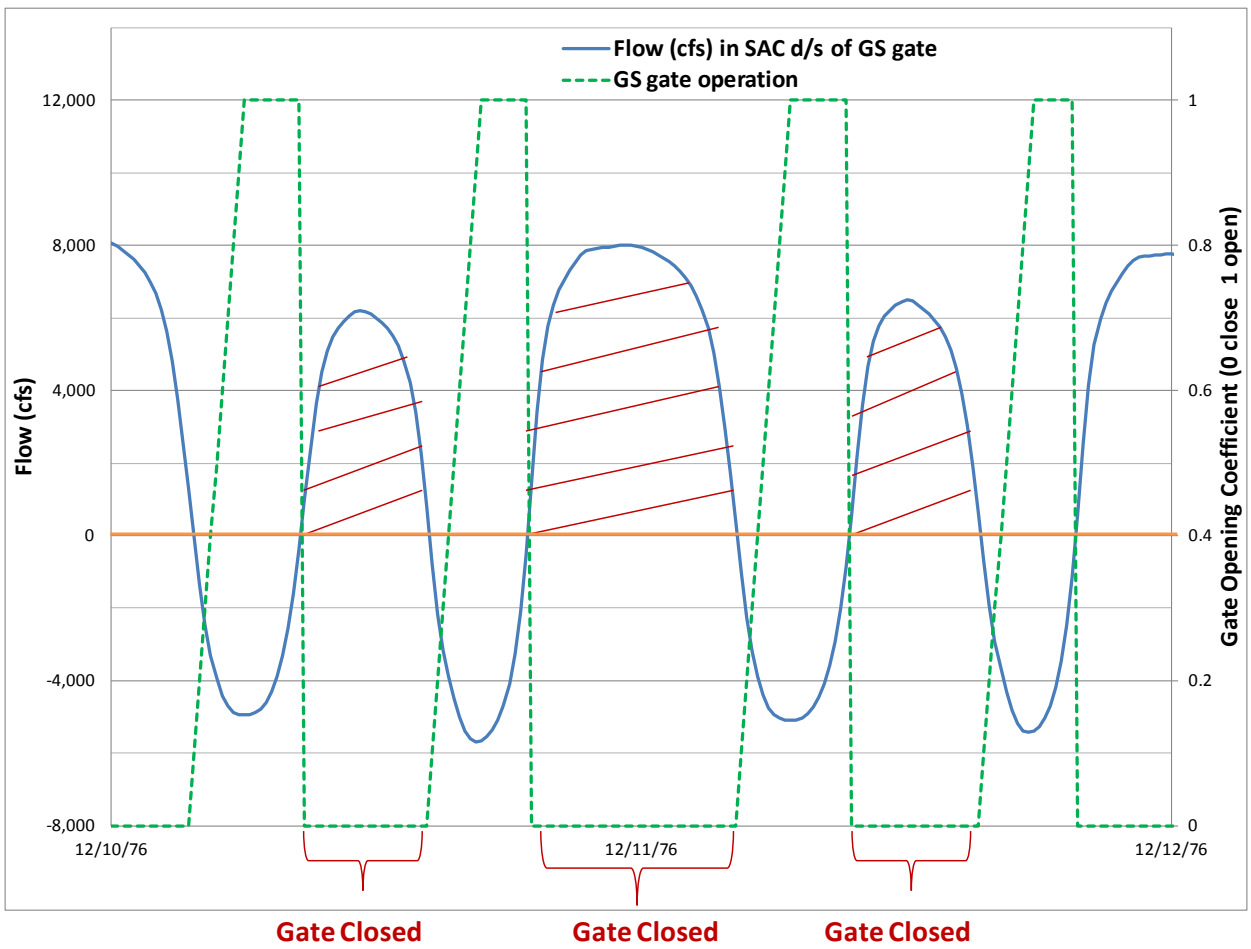

Figure 4-2 Flow Triggered Gate Operation (open/close)

4.3.2.2 Partial Flow Blockage to Delta Channels

The gates were modeled to restrict partial flow from entering into the junctions. The gates were placed in the junctions on Delta channels. In this category, flow was not fully blocked to enter into the channels from the rivers during the ebb tide. The gates' operations were triggered by either flow in the rivers, or velocity in the rivers. These triggers were described below.

4.3.2.2.1 Flow Trigger

During the ebb tide, the size of the gate was modified to attain an average flow blockage of about 50 percent during the 16-year model simulation period. The scenario was analyzed to evaluate incremental changes in water quality and water levels. The gates were closed on the ebb tide when the water flowed toward the ocean from the Sacramento or San Joaquin rivers. The gates were opened on the flood tide when the water flowed from the ocean toward the rivers. Figure 4-2 illustrates the flow trigger scenario for Georgiana Slough. The Head of Old River gate had similar operations.

4.3.2.2.2 Velocity Trigger

The gate operation was triggered by velocity in the rivers. The gate at a junction of a river and a channel operated based on velocity in the river downstream of the junction. The velocity in the Delta followed the tidal cycle and has two high and two low velocities occurring every 6 hours. When the velocity changed from high to low, the gate was closed, and when the velocity changed from low to high, the gate was opened. Figure 4-3 illustrates the gate closure in response to the velocity trigger. The gate at Georgiana Slough operated based on a velocity trigger in the Sacramento River downstream of the junction. Another scenario, which blocked about 50 percent of the flow during the gate closure period (Figure 4-3), was simulated. This modeling scenario was developed by modifying the size of the gate. The gate at the Head of Old River was operated on a similar velocity trigger formulation, but it was based on the velocity in the San Joaquin River downstream of the junction.

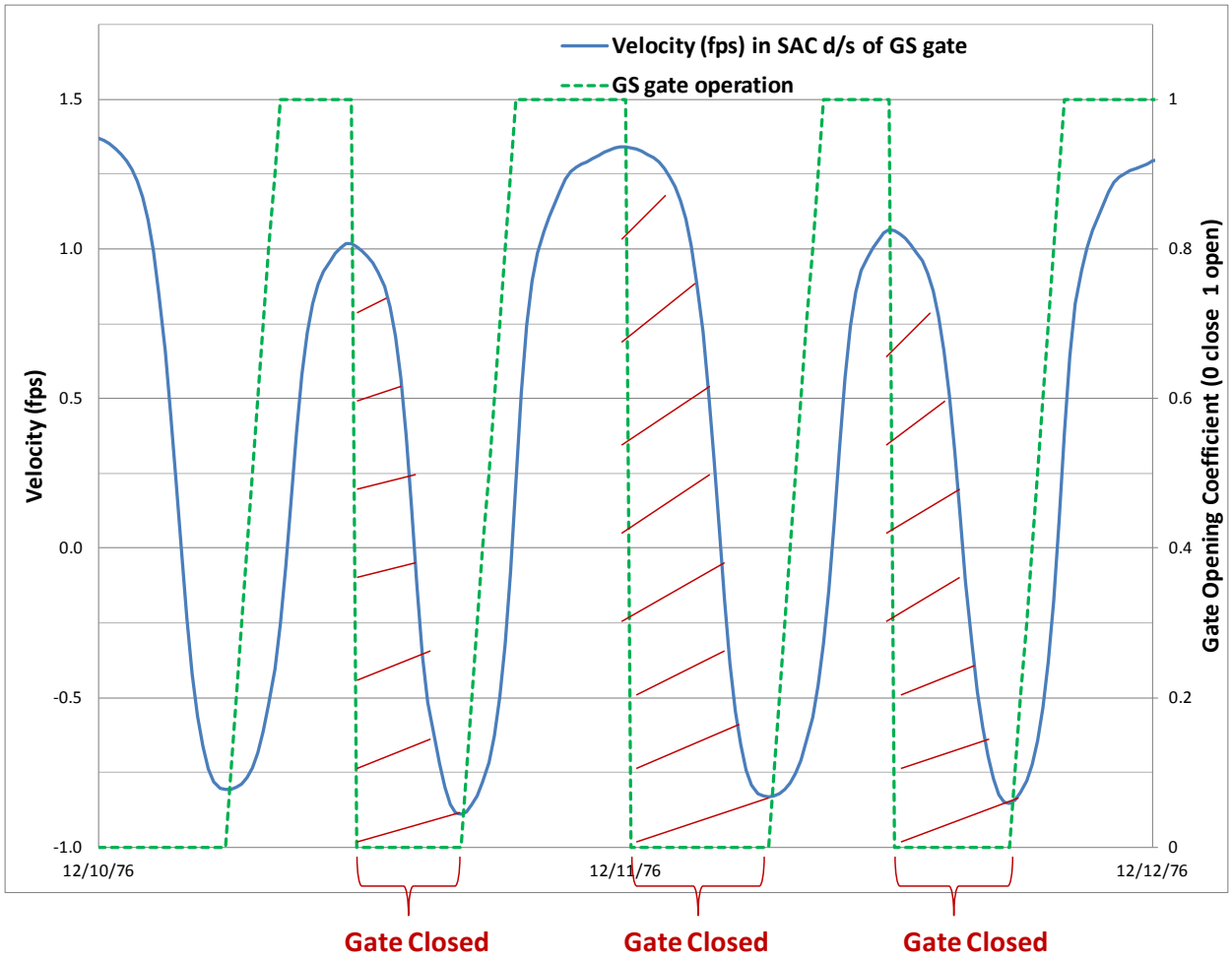

Figure 4-3 Velocity Triggered Gate Operation (open/close)

4.3.2.3 Flow Blockage used in Other Projects

As noted under section 4.3, Methodology, gate modeling analysis had already been conducted for Threemile Slough (Franks Tract Project). The Franks Tract Project objectives were different than the objective of NMFS BiOp RPA Action IV.1.3, but one of the objectives was to protect sensitive fish species and reduce seawater intrusion through modifications of flow conditions in the western Delta. The proposed Franks Tract Project includes a tidally operated gate located in the Threemile Slough. The Franks Tract DSM2 model was run again for this study analysis to simulate the proposed gate operations. The modeling results were analyzed for any impacts on the Delta.

4.4 Model Results

The DSM2 model was simulated for 16 years for existing conditions and all scenarios listed in Table 4-1. The model results were in 15-minute intervals and were processed to generate monthly average flow, monthly average EC (Electric Conductivity, used for salinity), and daily minimum water level. The percentage of time that the gates were closed throughout the simulation period is reported in Table 4-2 for all scenarios.

Category	Location of Gate	Gate Operation Trigger	Trigger Location	Percent of time gate was closed
Full Flow Blockage to Delta Channels	Georgiana Slough, Head of Old River, Turner Cut & Columbia Cut (Four Gates)	Closed on positive flows in channel & opened on reverse flows	Flow in Georgiana Slough, Head of Old River, Turner Cut & Columbia Cut	99, 99, 51 & 50
	Georgiana Slough	Closed on positive flows in channel & opened on reverse flows	Flow in Georgiana Slough	99
	Head of Old River	Closed on positive flows in channel & opened on reverse flows	Flow in Head of Old River	99
	Turner Cut	Closed on positive flows in channel & opened on reverse flows	Flow in Turner Cut	51
	Columbia Cut	Closed on positive flows in channel & opened on reverse flows	Flow in Columbia Cut	50
	Head of Old River, Turner Cut & Columbia Cut (Three Gates)	Closed on positive flows in channel & opened on reverse flows	Flow in Head of Old River, Turner Cut & Columbia Cut	99, 51 & 50
	Georgiana Slough, Head of Old River, Turner Cut & Columbia Cut (Four Gates)	Closed on ebb & opened on flood	Flow in Sacramento River, San Joaquin River, Turner Cut & Columbia Cut	80, 80, 51 & 50
	Georgiana Slough	Closed on ebb & opened on flood	Flow in Sacramento River	80
	Head of Old River	Closed on ebb & opened on flood	Flow in San Joaquin River	80
	Head of Old River, Turner Cut & Columbia Cut (Three Gates)	Closed on ebb & opened on flood	Flow in San Joaquin River, Turner Cut & Columbia Cut	80, 51 & 50

Category	Location of Gate	Gate Operation Trigger	Trigger Location	Percent of time gate was closed
Partial Flow Blockage to Delta Channels	Georgiana Slough	Partial closed on ebb to block 50% net flow & opened on flood	Flow in Sacramento River	80
	Head of Old River	Partial closed on ebb to block 50% net flow & opened on flood	Flow in San Joaquin River	80
	Georgiana Slough	Closed on high velocity & Opened on low velocity	Velocity in Sacramento River	46
	Georgiana Slough	Partial closed on high velocity to block 50% net flow & opened on low velocity	Velocity in Sacramento River	46
	Head of Old River	Closed on high velocity & Opened on low velocity	Velocity in San Joaquin River	45
	Head of Old River	Partial closed on high velocity to block 50% net flow & opened on low velocity	Velocity in San Joaquin River	45
Flow Blockage used in other Projects	Threemile Slough (Franks Tract Project)	Franks Tract Project proposed operation, Seasonal operation for Fish and Water Quality	Flow in Sacramento and San Joaquin River or EC in Jersey Point	12

Table 4-2 Gate Closure Frequency

The modeled flow for the scenarios was compared with existing conditions at downstream locations of the gates at Georgiana Slough, Head of Old River, Columbia Cut, and Turner Cut. The modeled EC was compared with EC at Sacramento River at Emmaton (Emmaton), San Joaquin River at Jersey Point (Jersey Point), Clifton Court Forebay (Clifton Court), and Old River at Tracy Road (Tracy Road). The modeled water level (stage) was compared with water levels at Old River at Tracy Road, San Joaquin River at Brandt Bridge (Brandt Bridge), and San Joaquin River at Prisoners Point (Prisoners Point) (Figure 4-4). The processed values are presented in Figures 4-5 to 4-41.

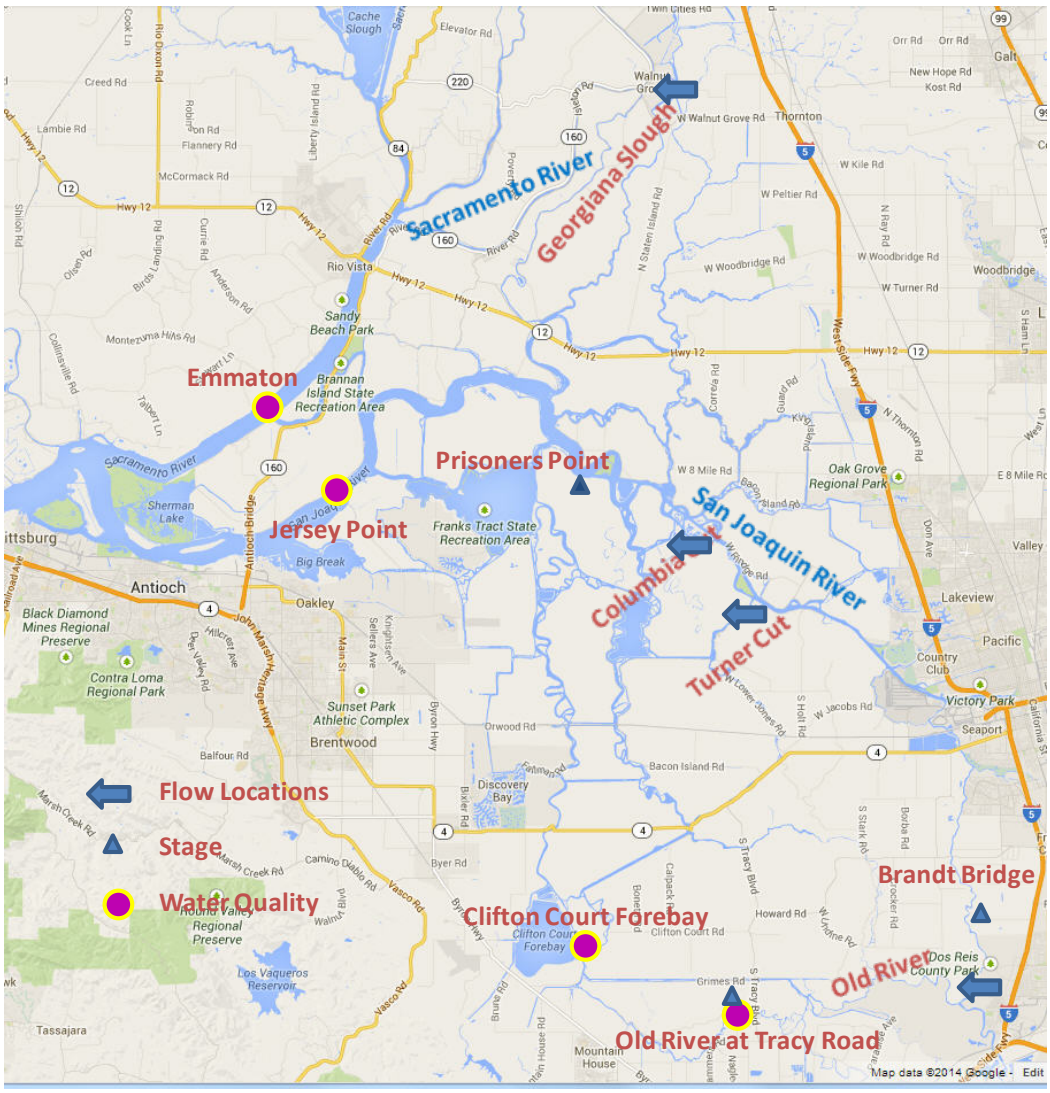

Figure 4-4 Model Output Locations

4.4.1 Full Flow Blockage to Delta Channels

The gates at Georgiana Slough and Head of Old River were closed 99 percent of the time for the flow in the Delta channels trigger scenarios. Consequently, little to no flow was going through these channels. The gates at Georgiana Slough and the Head of Old River were closed 80 percent of the time (Table 4-2) for the flow in the rivers trigger scenarios. The gates were closed less frequently than the previous scenarios, so little flow went through these channels. The gates at Columbia Cut and Turner Cut were closed or opened 50 percent of the time. Figure 4-5 to Figure 4-12 show monthly average flow in the Delta channels downstream of the gates. A positive flow direction in Columbia and Turner cuts refers to flow toward the San Joaquin River, and a negative flow direction refers to flow from the San Joaquin River into the cuts.

Figure 4-13 to Figure 4-20 show monthly average EC comparison bar plots. The Georgiana Slough gate and Four Gates scenarios (Table 4-1) blocked better quality Sacramento River flow from entering into

the interior of the Delta and southern Delta, and allowed more water to flow through the Sacramento River. This flow pattern had an impact on water quality. EC at Clifton Court and Jersey Point increased, and EC at Emmaton decreased. The Head of Old River gate and Three Gates scenarios (Table 4-1) had no impact on EC at Emmaton, Jersey Point, or Clifton Court.

The Delta Cross Channel (DCC) Gates were fully closed from February 1 through May 20 in accordance with the State Water Resources Control Board Decision 1641 (Bureau of Reclamation 2014). The DCC Gates were closed for 14 days, from May 21 through June 15. During those months, the model showed that the Head of Old River Gate and Three Gates scenarios resulted in deteriorated EC at Tracy Road, but EC improved or there were no impacts on EC for all the other months. The Four Gates scenario increased EC at Tracy Road. The Georgiana Slough gate scenario had no impact on EC at Tracy Road. The Columbia Cut gate and Turner Cut gate scenarios had no impact on EC. Consequently, no further modeling of partial flow blockage scenarios for Columbia Cut and Turner Cut gates were necessary.

Daily minimum water levels at the South Delta locations were evaluated (Figure 4-21 to Figure 4-26). The Head of Old River Gate dropped the water level by 1 foot or more during most years of the 16-year simulation period. The Head of Old River Gate restricted San Joaquin River flows from entering Old River and left more water in the San Joaquin River. As a consequence, the water level at Brandt Bridge increased by 1 foot or more 40 percent of the time. The water level at Prisoners Point, which is 45 miles downstream from the gate site, did not change. All of the other gate scenarios did not have an impact on water level in the South Delta.

4.4.2 Partial Flow Blockage to Delta Channels

For the flow trigger scenarios, with the 50 percent flow blockage on the ebb tide, more Sacramento River water went into Georgiana Slough, and more San Joaquin River water went into Old River (Figure 4-9 to Figure 4-12).

For the velocity trigger scenarios, the gates were closed 46 percent of the time in Georgiana Slough, and 45 percent of the time at Head of Old River (Table 4-2). As expected, flow was less restricted to these channels (Figure 4-27 to Figure 4-30).

EC at Clifton Court and Jersey Point increased in response to the Georgiana Slough gate operations. EC at Emmaton decreased, and there was no impact at Tracy Road. The velocity trigger scenarios had a smaller impact on EC (Figure 4-31 to Figure 4-34) than the flow trigger scenarios (Figure 4-17 to Figure 4-20).

The combined effects of the DCC Gate and the Head of Old River Gate closures deteriorated EC from February to May at Tracy Road. There were no impacts to EC at Emmaton, Jersey Point, and Clifton Court.

The Georgiana Slough gate did not have an impact on water level in the South Delta. The impacts on water level in the South Delta channels, because of the Head of Old River Gate, were similar in trends compared with the previous scenarios, but the magnitudes of changes were smaller. The velocity trigger scenarios had a smaller impact on water level (Figure 4-35 to Figure 4-37) than the flow trigger scenarios (Figure 4-24 to Figure 4-26).

4.4.3 Flow Blockage Used in Other Projects

The Franks Tract Project proposed gate at Threemile Slough was operated seasonally for water quality and fishery benefits. The gate improved water quality in Clifton Court and Jersey Point, and had no impact on water quality in Emmaton and Tracy Road. The gate had no impact on water level in the South Delta.

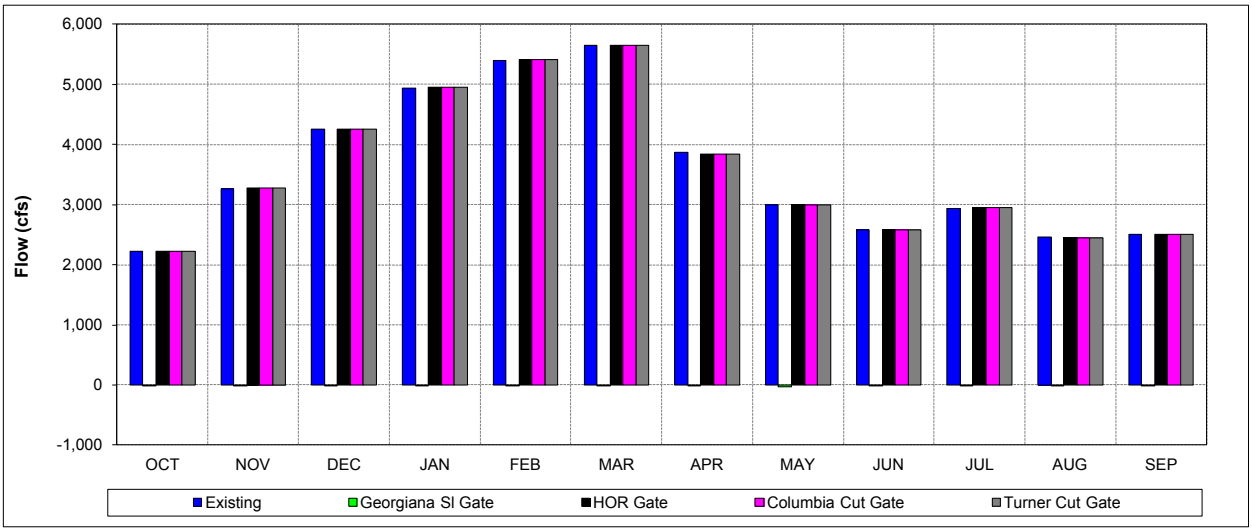

Figure 4-5 Monthly Average Flow at Georgiana Slough for Flow Trigger Location in Channels

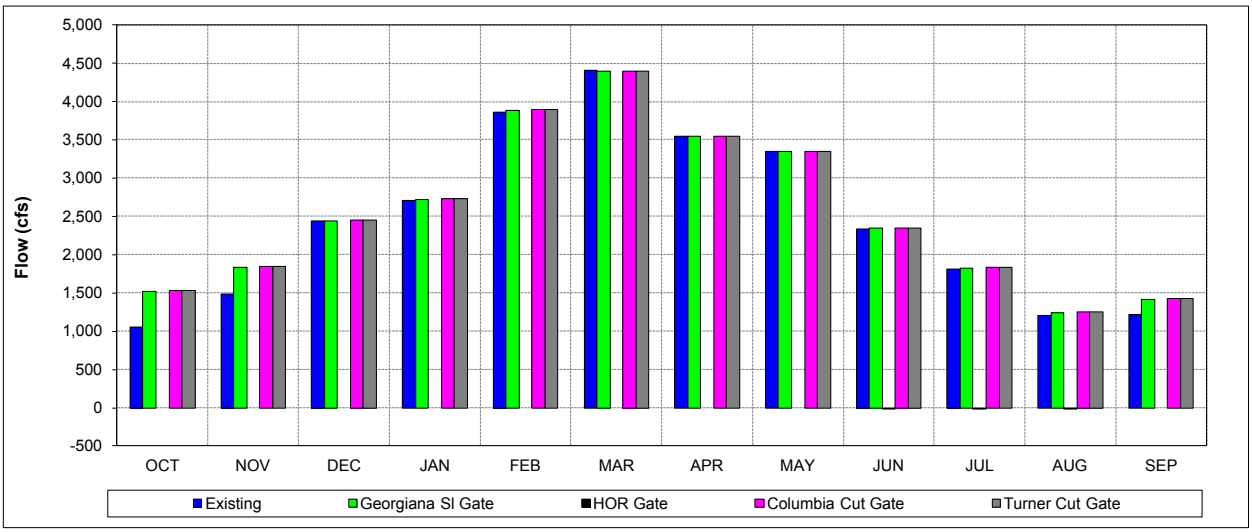

Figure 4-6 Monthly Average Flow at Head of Old River for Flow Trigger Location in Channels

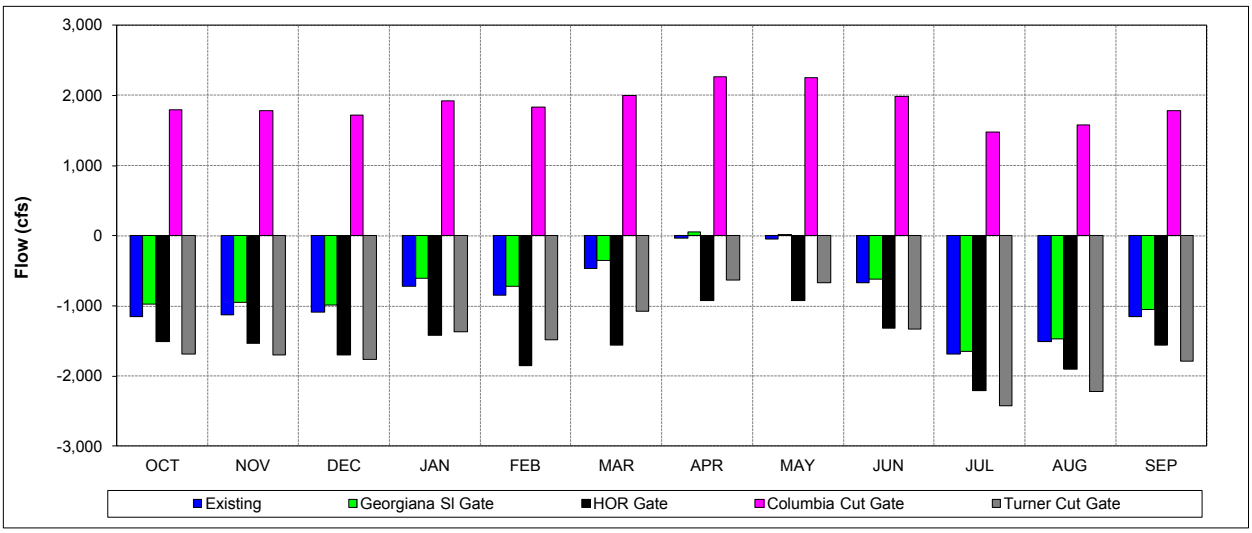

Figure 4-7 Monthly Average Flow at Columbia Cut for Flow Trigger Location in Channels

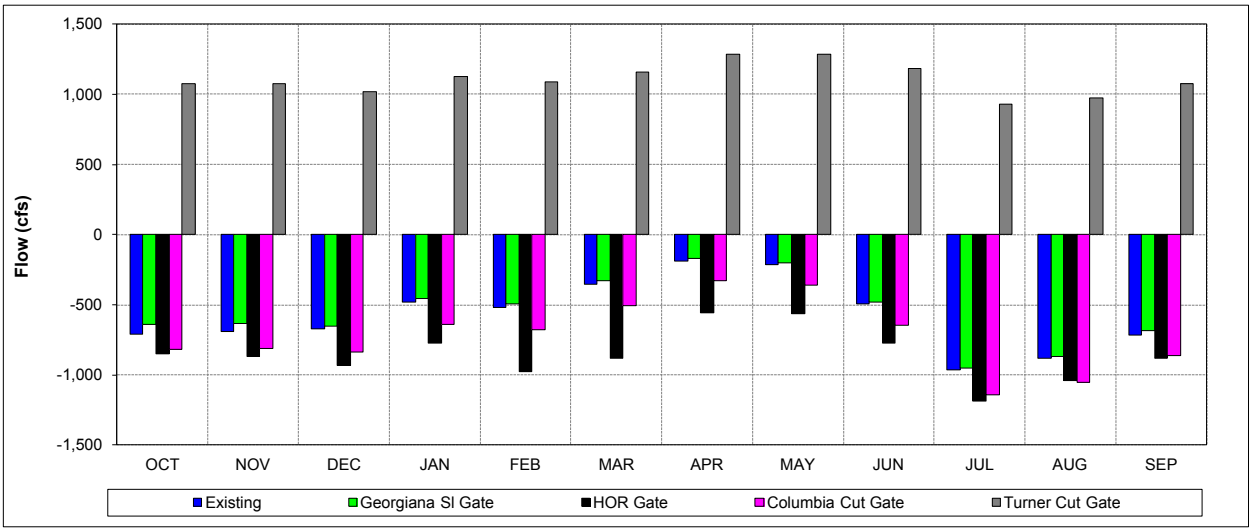

Figure 4-8 Monthly Average Flow at Turner Cut for Flow Trigger Location in Channels

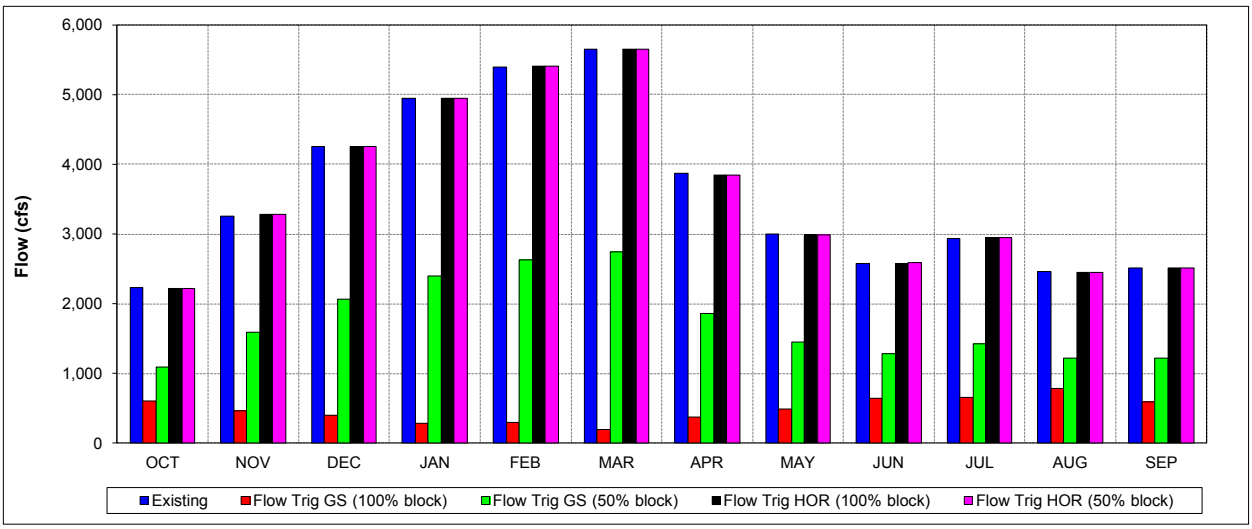

Figure 4-9 Monthly Average Flow at Georgiana Slough for Flow Trigger Location in Rivers

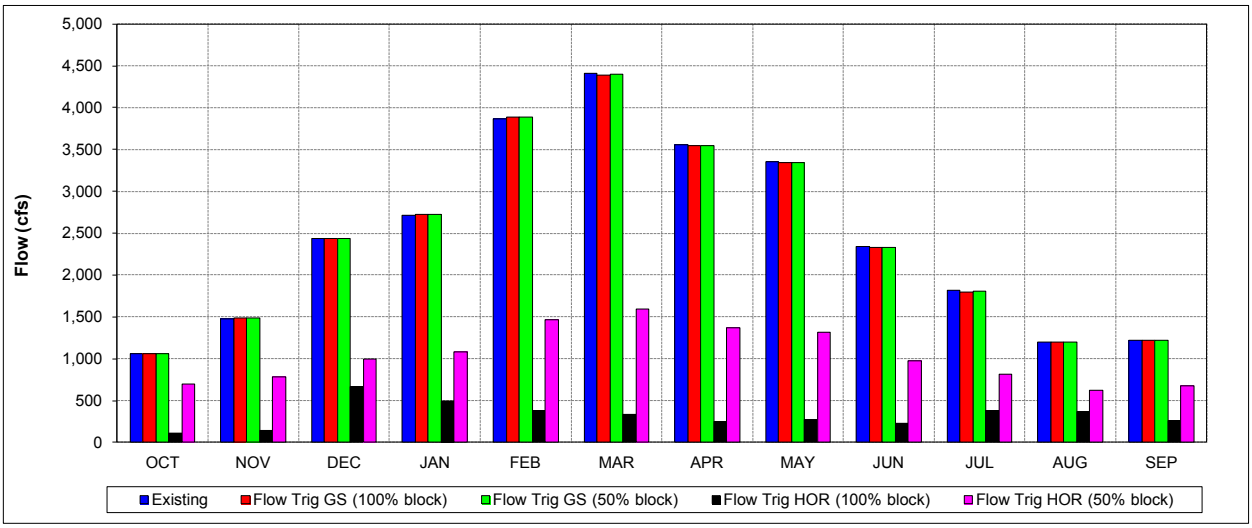

Figure 4-10 Monthly Average Flow at Head of Old River for Flow Trigger Location in Rivers

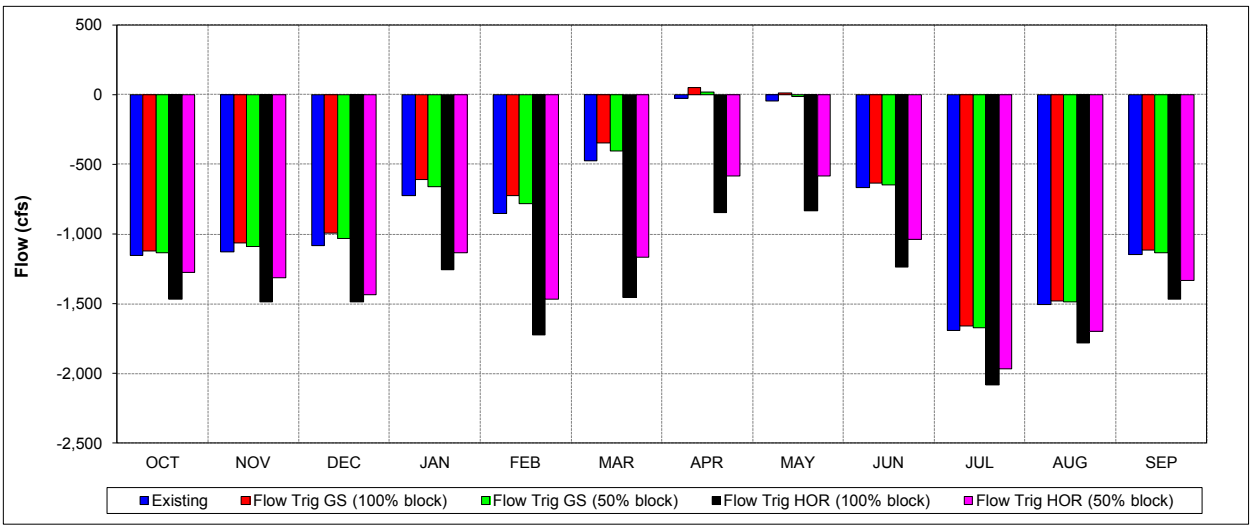

Figure 4-11 Monthly Average Flow at Columbia Cut for Flow Trigger Location in Rivers

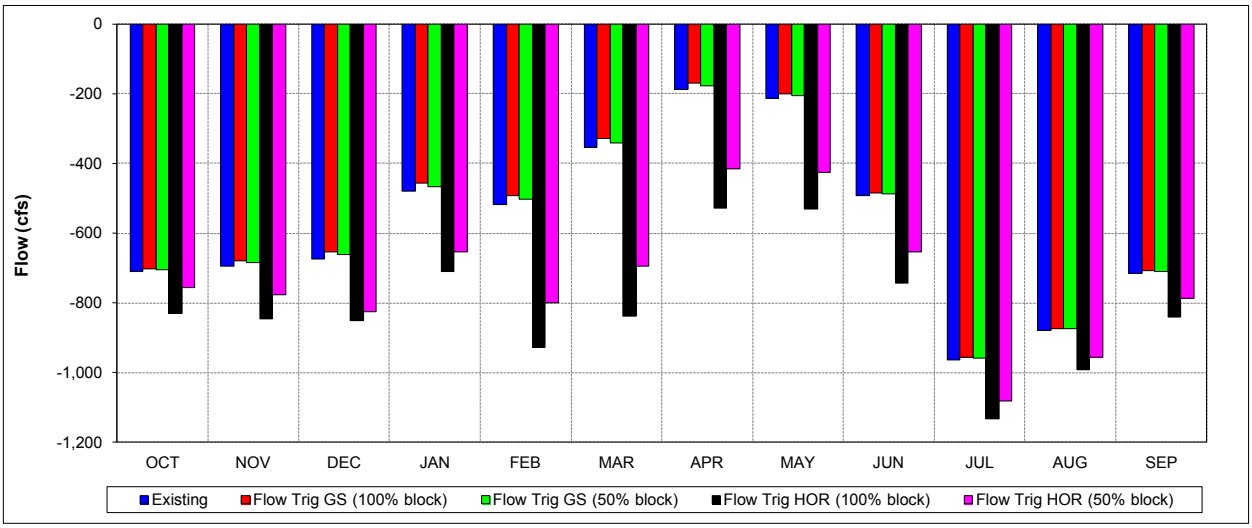

Figure 4-12 Monthly Average Flow at Turner Cut for Flow Trigger Location in Rivers

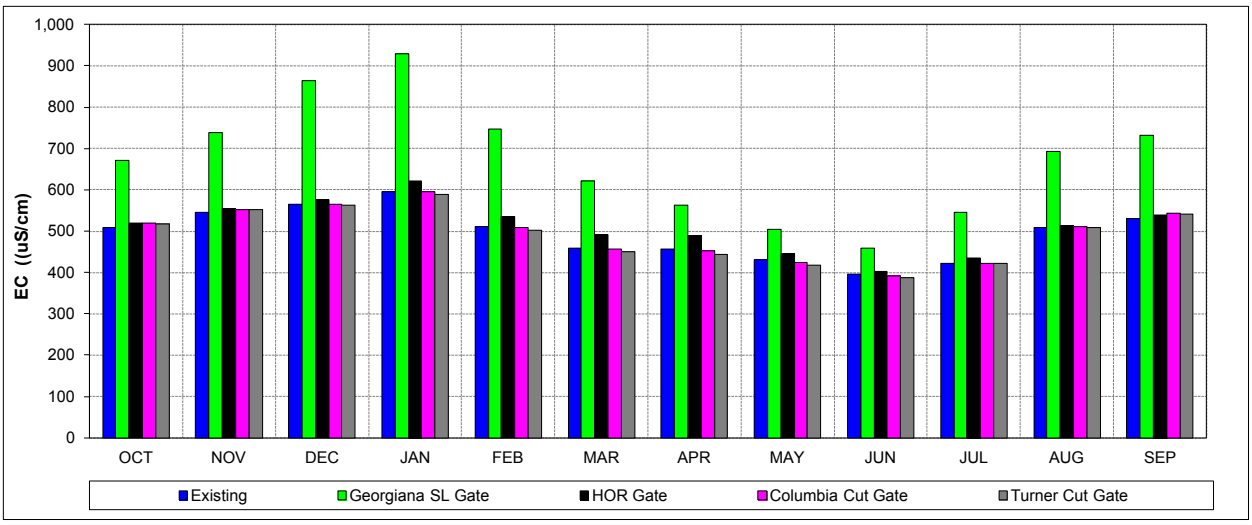

Figure 4-13 Monthly Average EC at Clifton Court Forebay for Flow Trigger Location in Channels

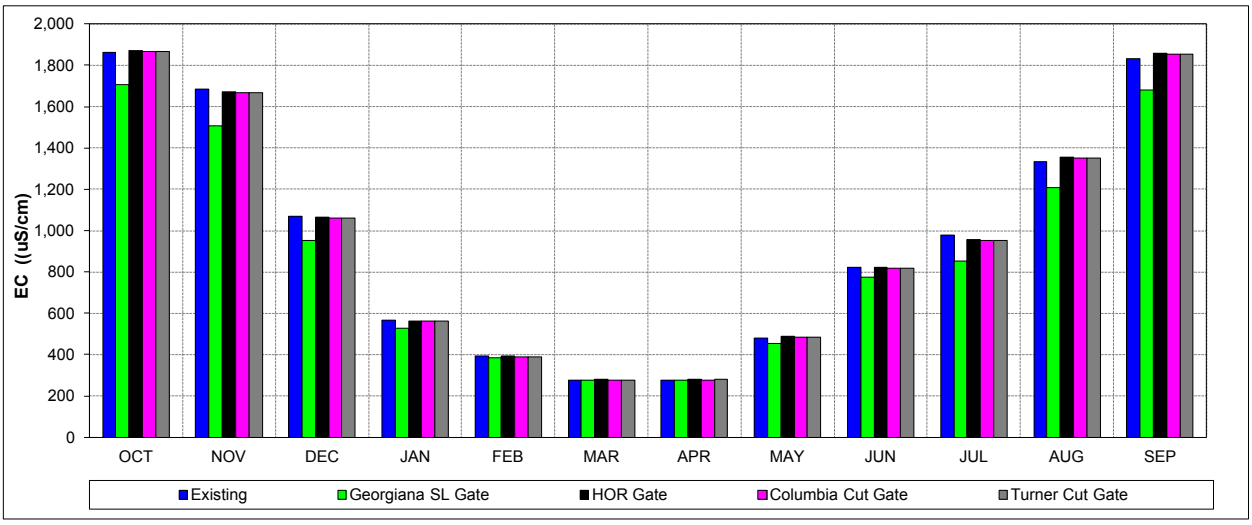

Figure 4-14 Monthly Average EC at Sacramento River at Emmaton for Flow Trigger Location in Channels

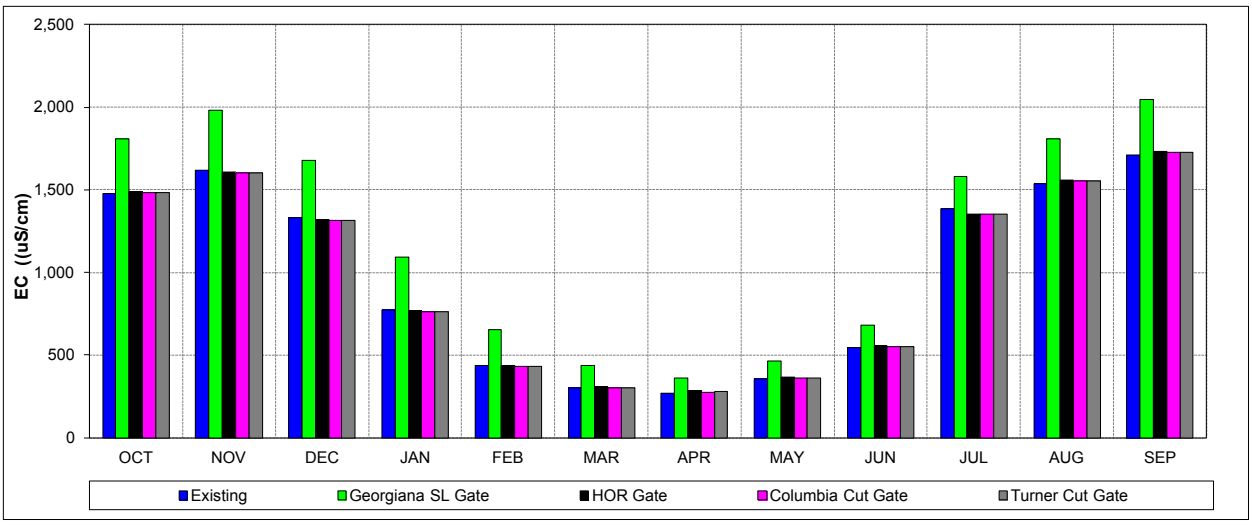

Figure 4-15 Monthly Average EC at San Joaquin River at Jersey Point for Flow Trigger Location in Channels

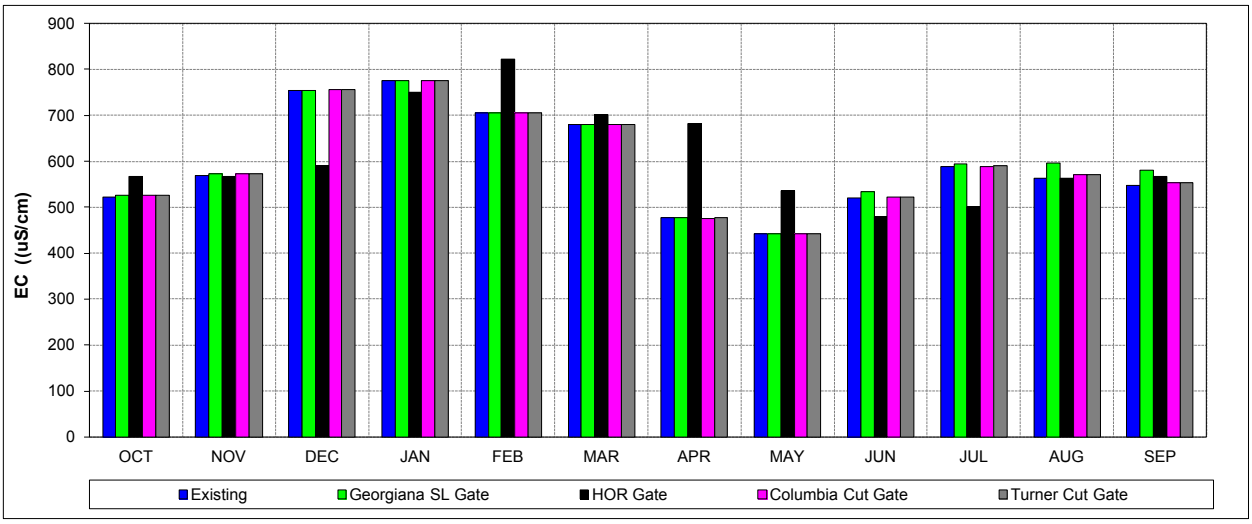

Figure 4-16 Monthly Average EC at Old River at Tracy Road for Flow Trigger Location in Channels

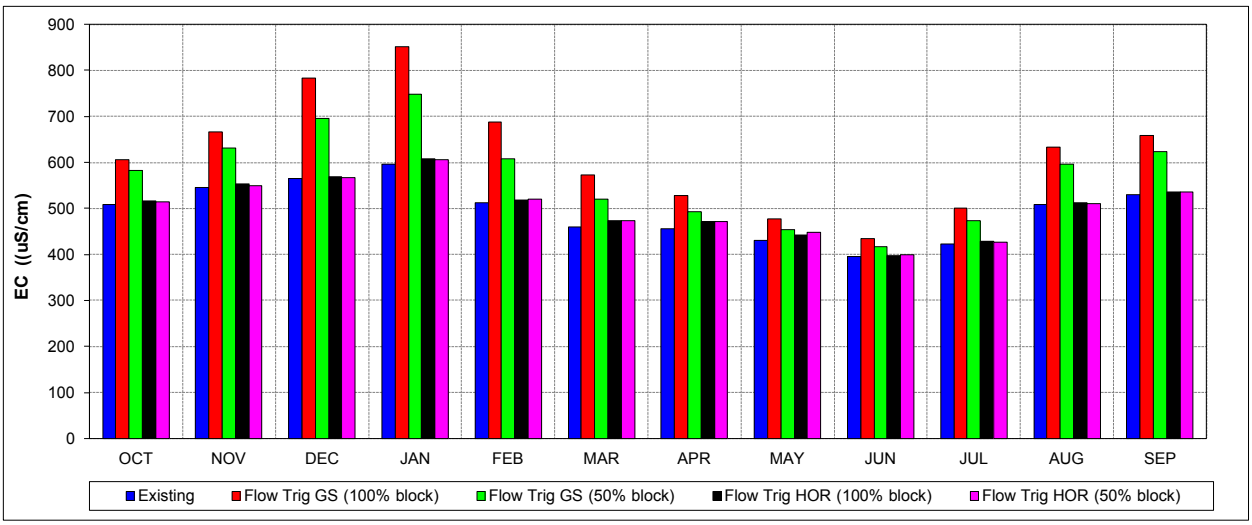

Figure 4-17 Monthly Average EC at Clifton Court Forebay for Flow Trigger Location in Rivers

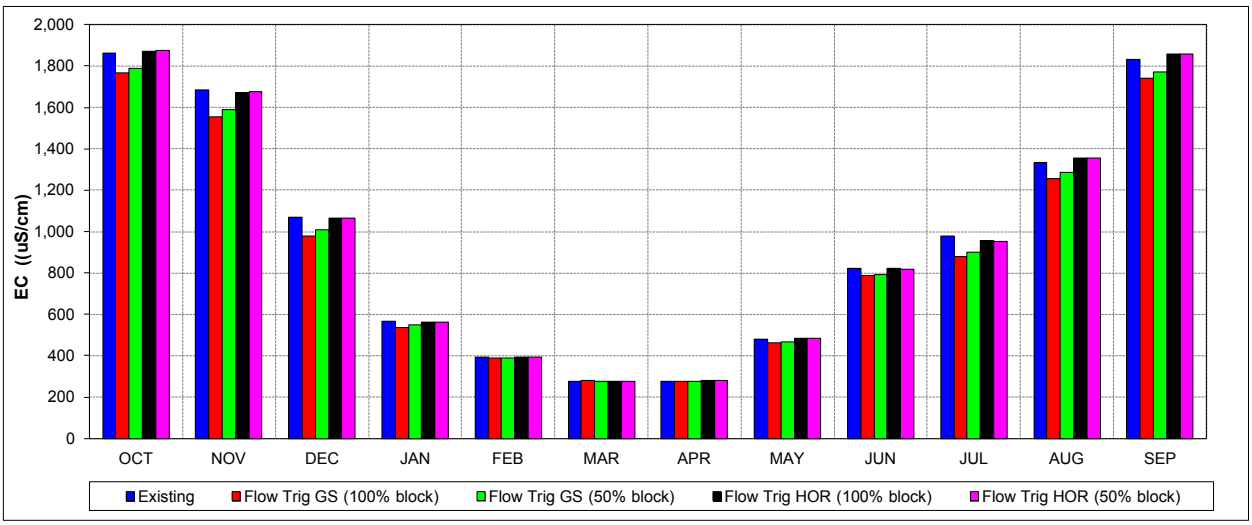

Figure 4-18 Monthly Average EC at Sacramento River at Emmaton for Flow Trigger Location in Rivers

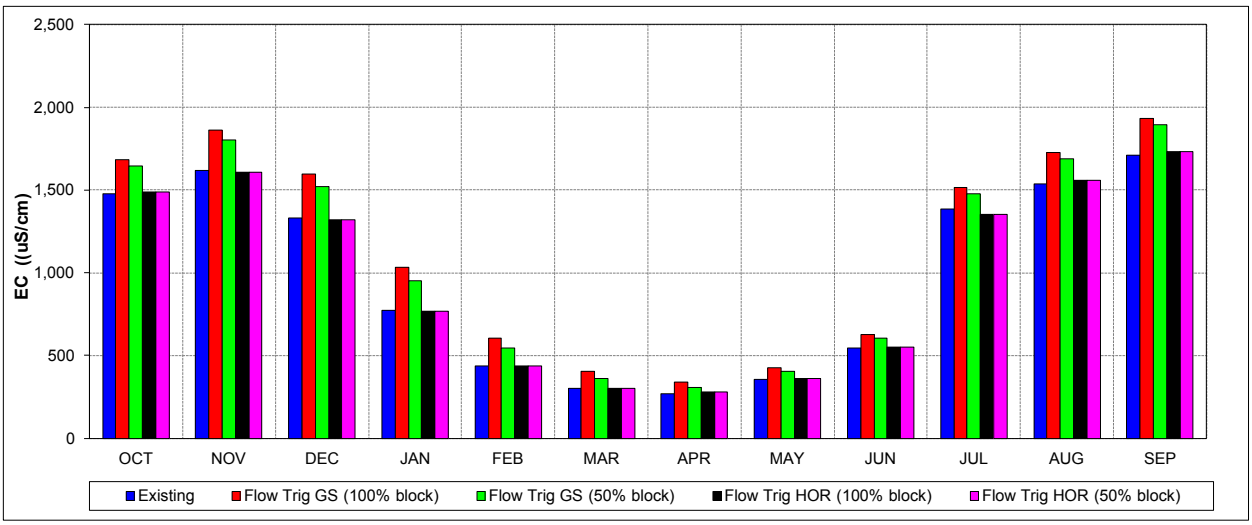

Figure 4-19 Monthly Average EC at San Joaquin River at Jersey Point for Flow Trigger Location in Rivers

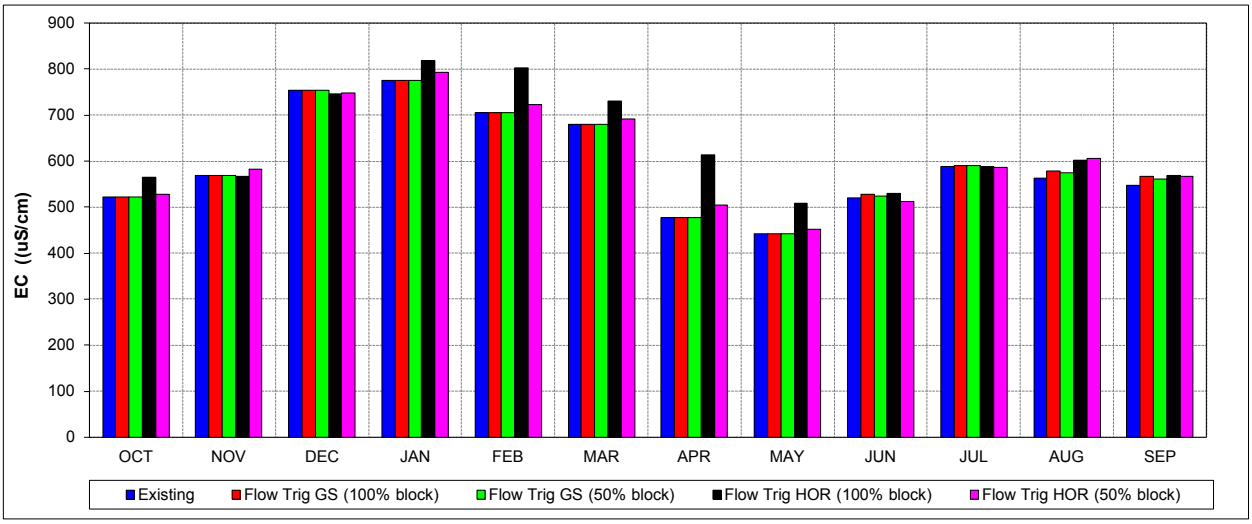

Figure 4-20 Monthly Average EC at Old River at Tracy Road for Flow Trigger Location in Rivers

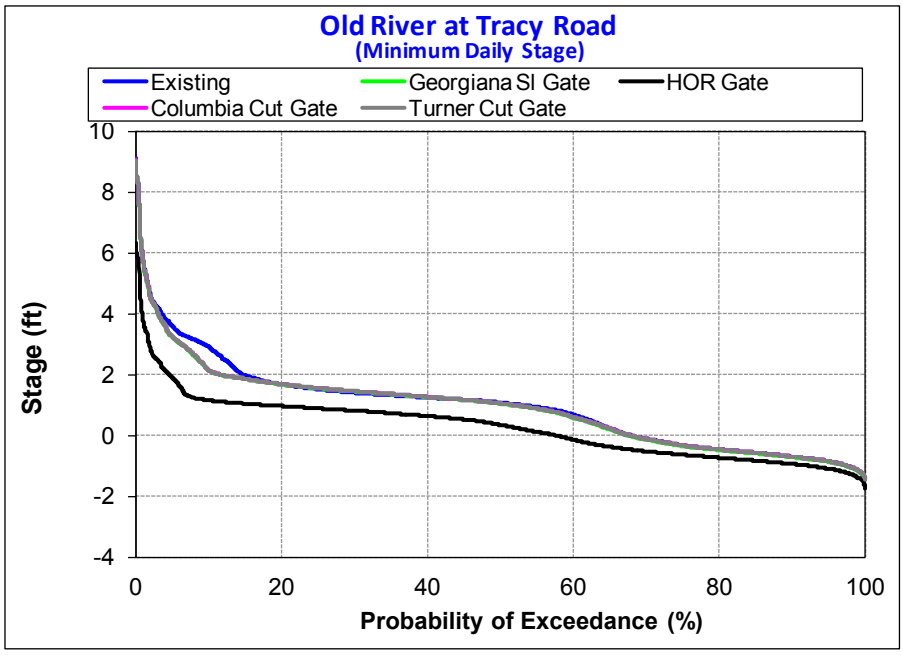

Figure 4-21 Daily Minimum Stage at Old River at Tracy Road for Flow Trigger Location in Channels

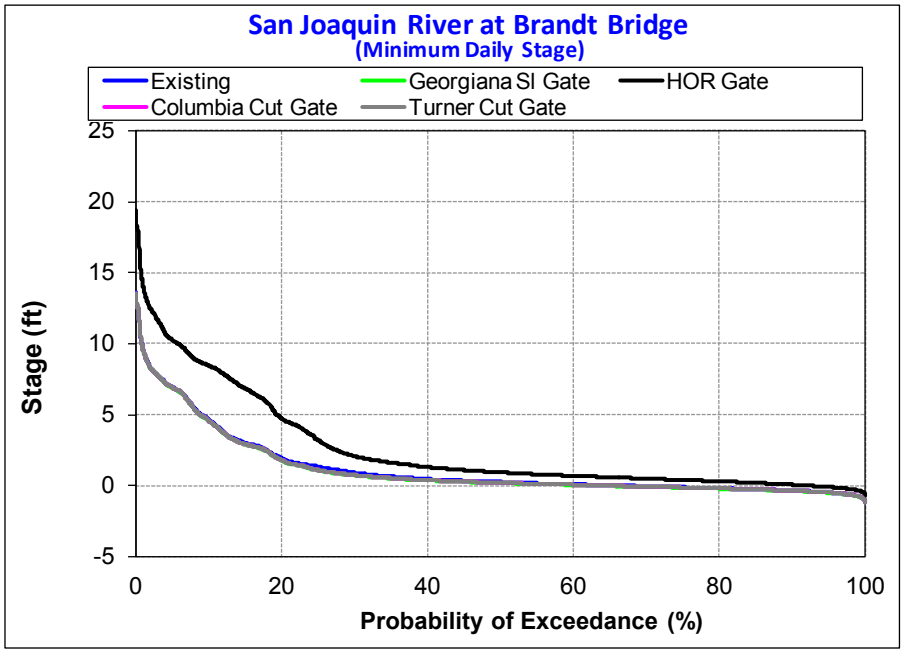

Figure 4-22 Daily Minimum Stage at San Joaquin River at Brandt Bridge for Flow Trigger Location in Channels

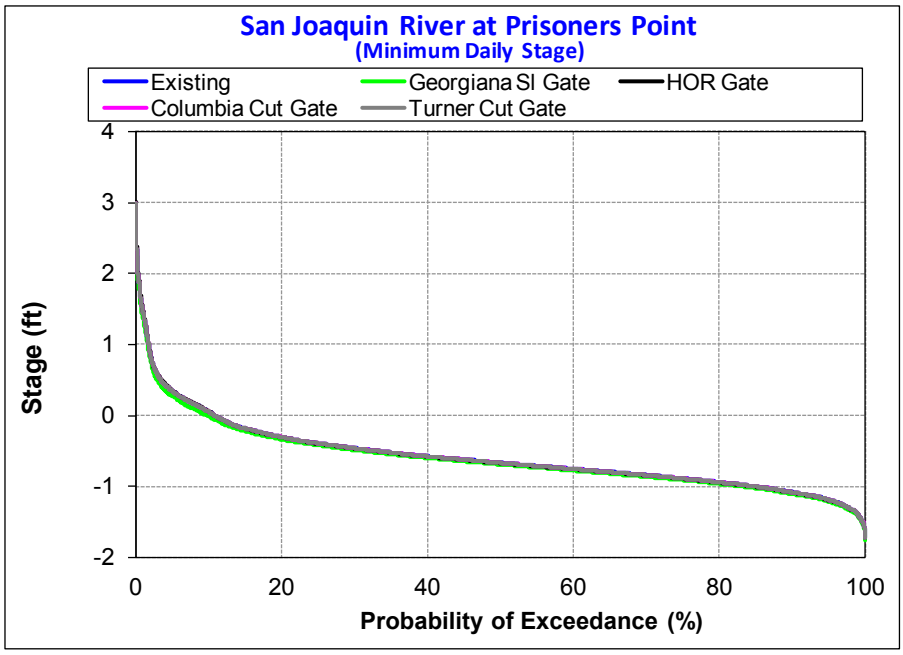

Figure 4-23 Daily Minimum Stage at San Joaquin River at Prisoners Point for Flow Trigger Location in Channels

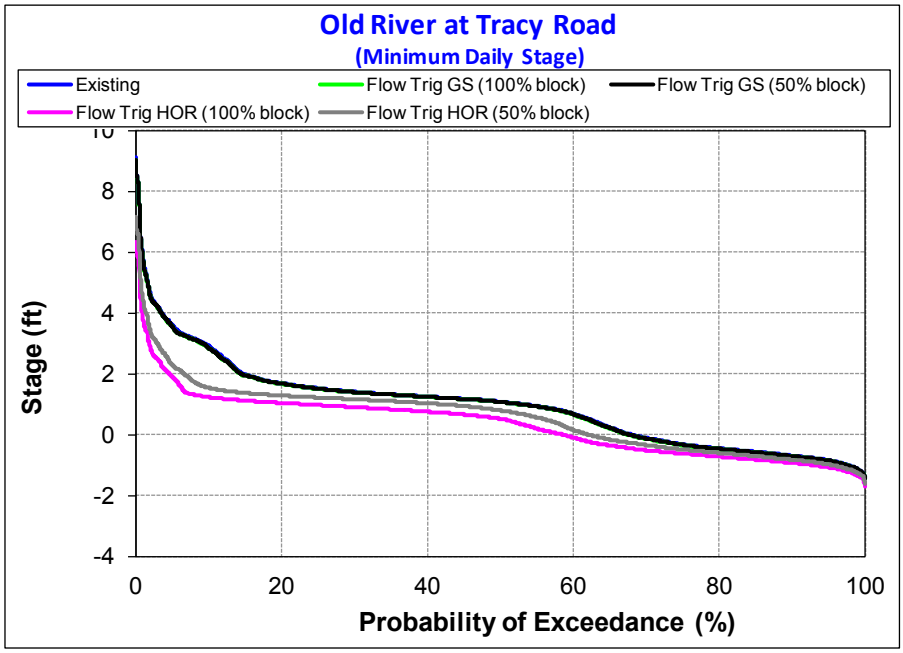

Figure 4-24 Daily Minimum Stage at Old River at Tracy Road for Flow Trigger Location in Rivers

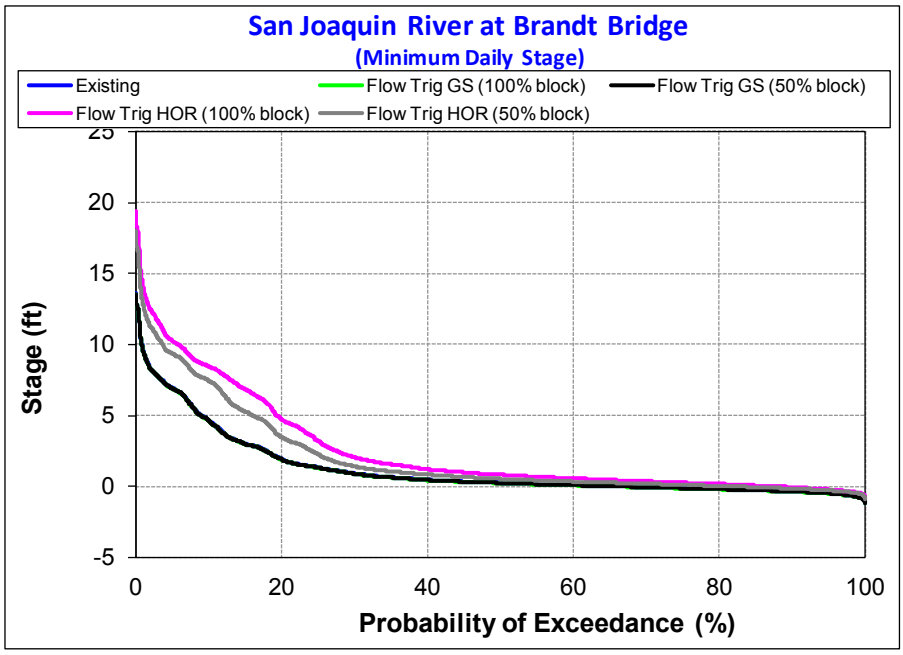

Figure 4-25 Daily Minimum Stage at San Joaquin River at Brandt Bridge for Flow Trigger Location in Rivers

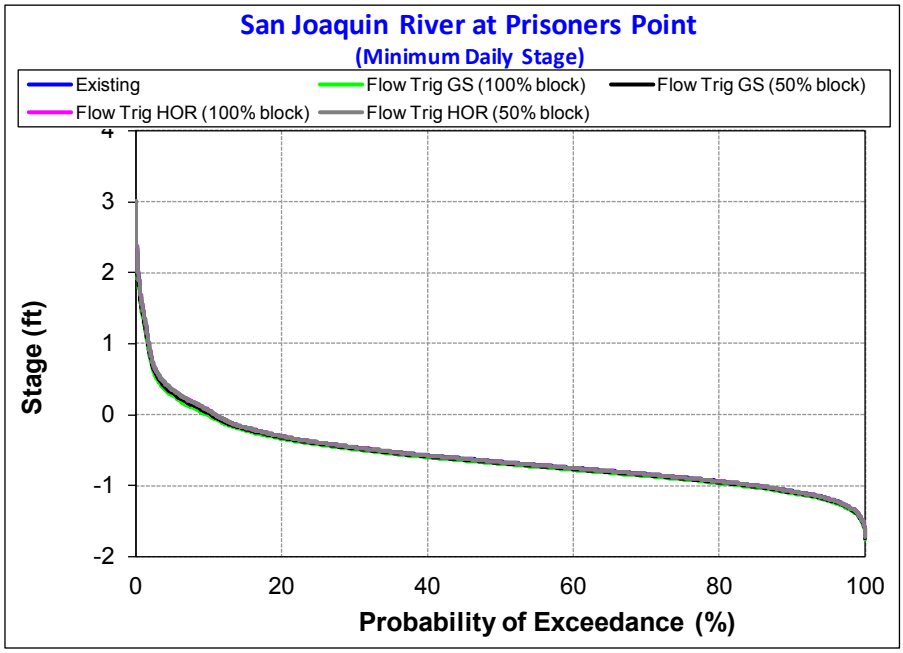

Figure 4-26 Daily Minimum Stage at San Joaquin River at Prisoners Point for Flow Trigger Location in Rivers

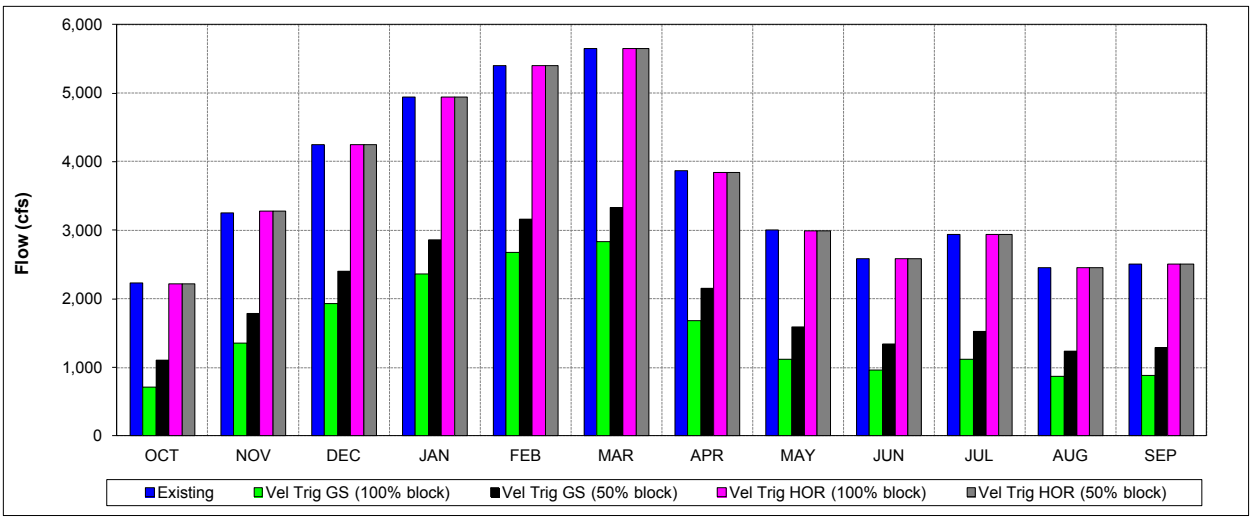

Figure 4-27 Monthly Average Flow at Georgiana Slough for Velocity Trigger Location in Rivers

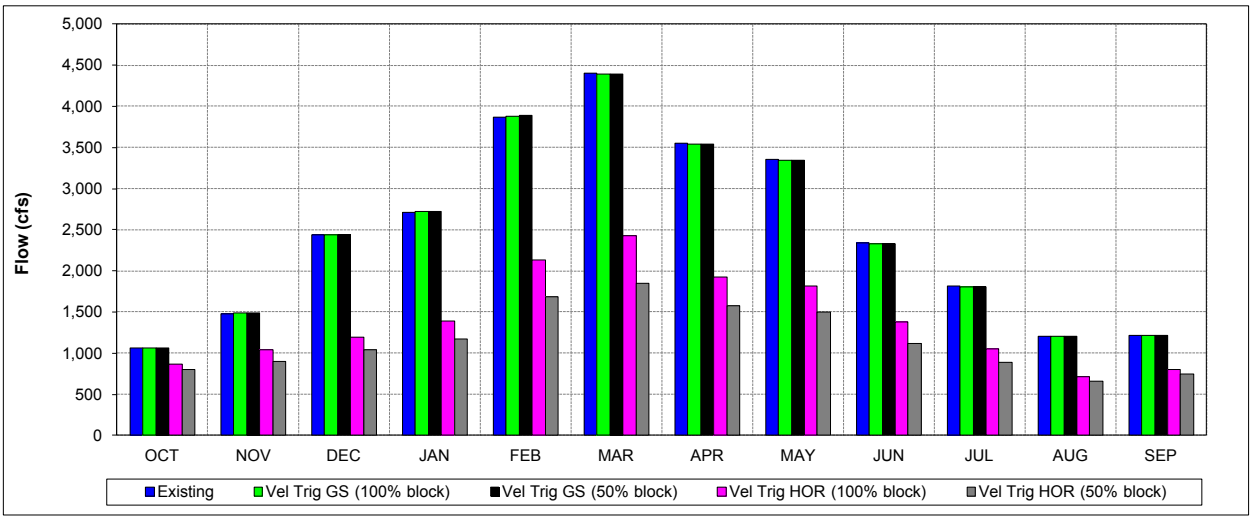

Figure 4-28 Monthly Average Flow at Head of Old River for Velocity Trigger Location in Rivers

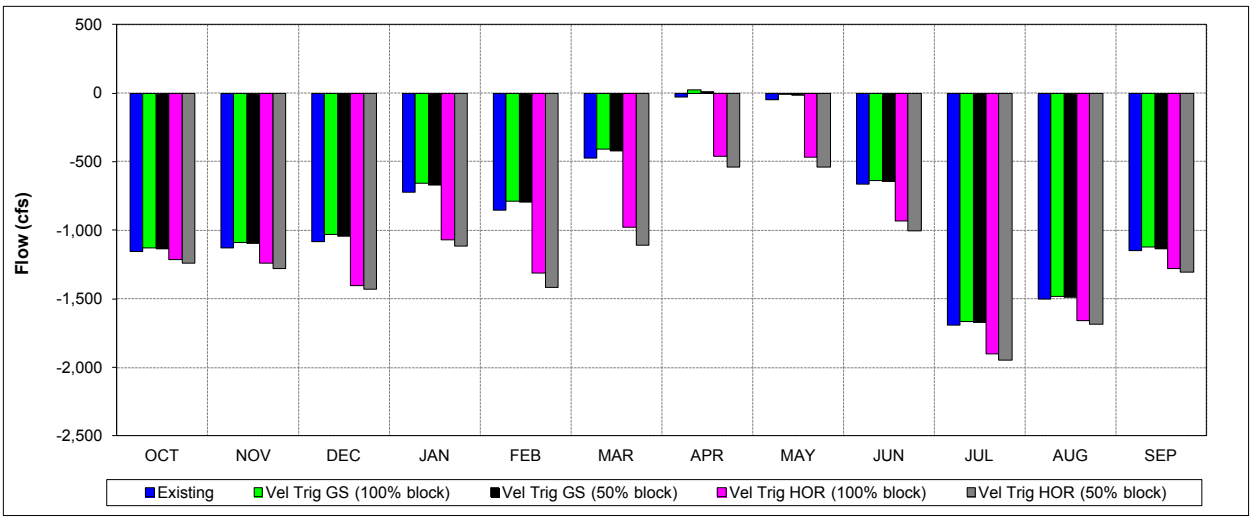

Figure 4-29 Monthly Average Flow at Columbia Cut for Velocity Trigger Location in Rivers

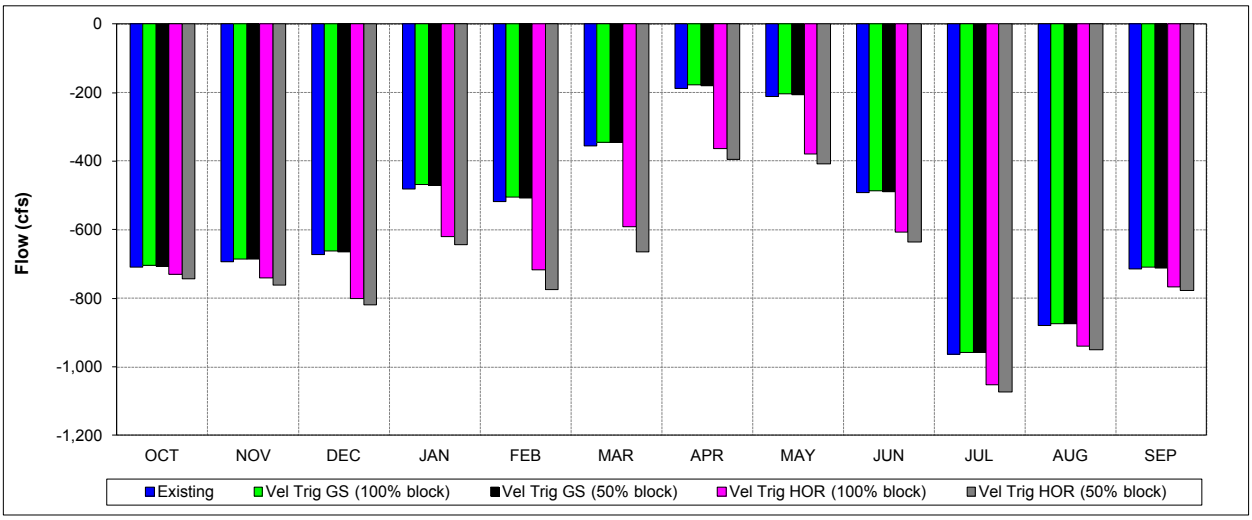

Figure 4-30 Monthly Average Flow at Turner Cut for Velocity Trigger Location in Rivers

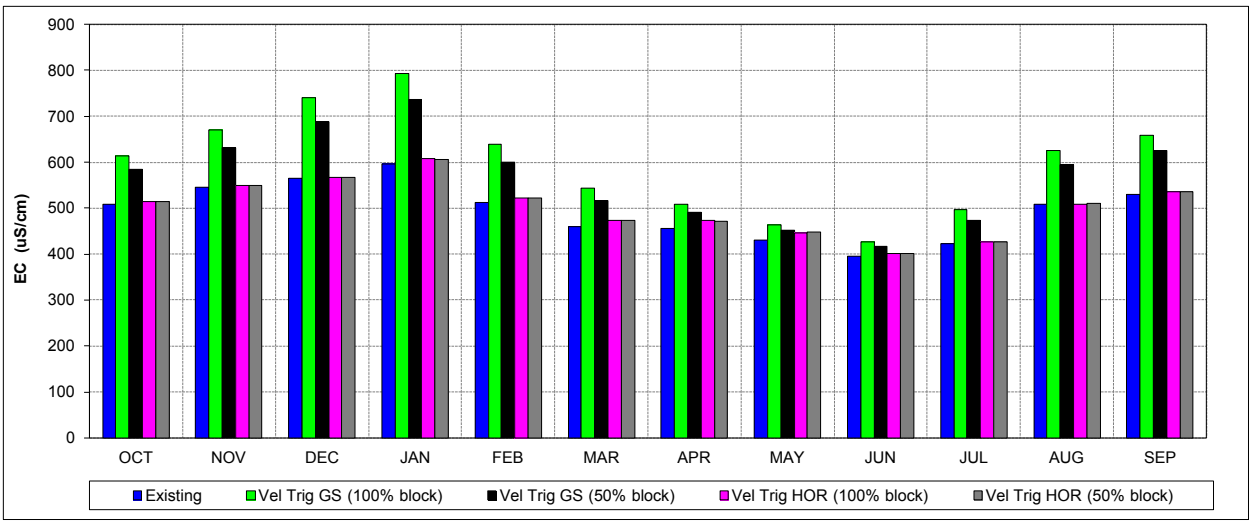

Figure 4-31 Monthly Average EC at Clifton Court Forebay for Velocity Trigger Location in Rivers

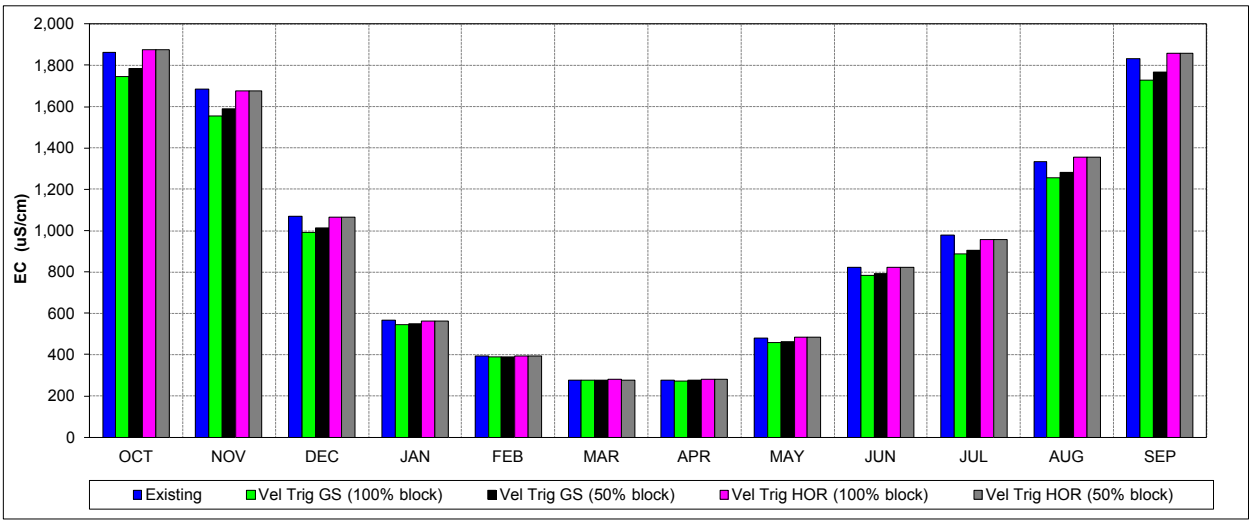

Figure 4-32 Monthly Average EC at Sacramento River at Emmaton for Velocity Trigger Location in Rivers

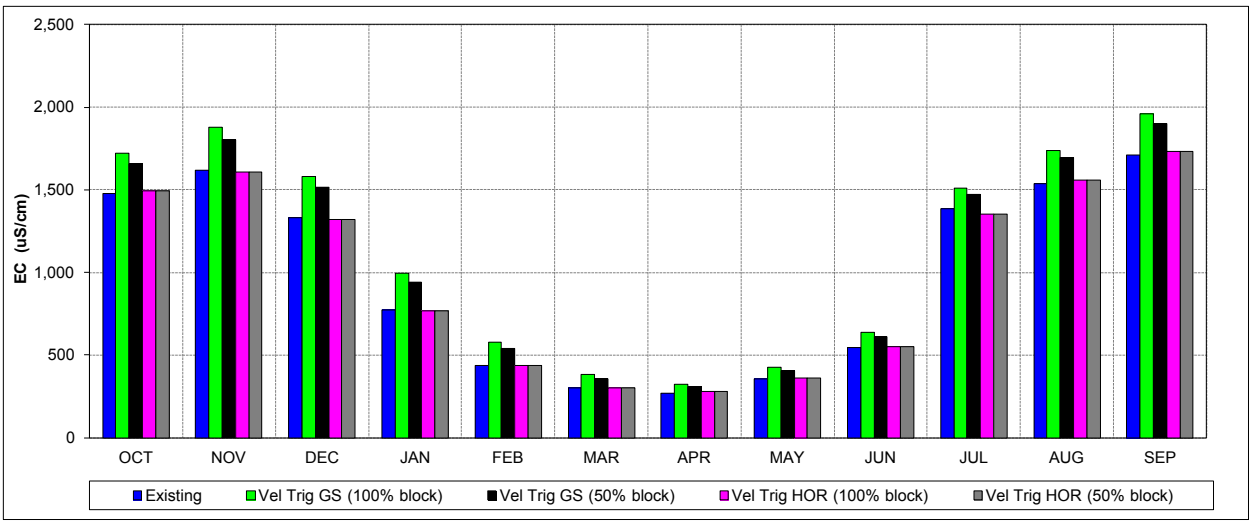

Figure 4-33 Monthly average EC at San Joaquin River at Jersey Point for Velocity Trigger Location in Rivers

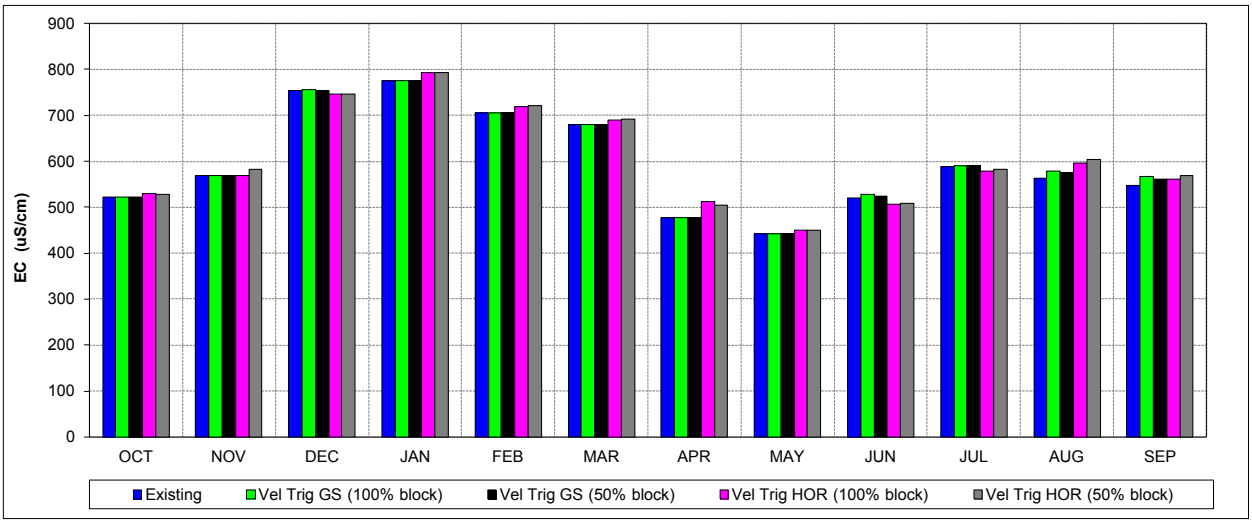

Figure 4-34 Monthly average EC at Old River at Tracy Road for Velocity Trigger Location in Rivers

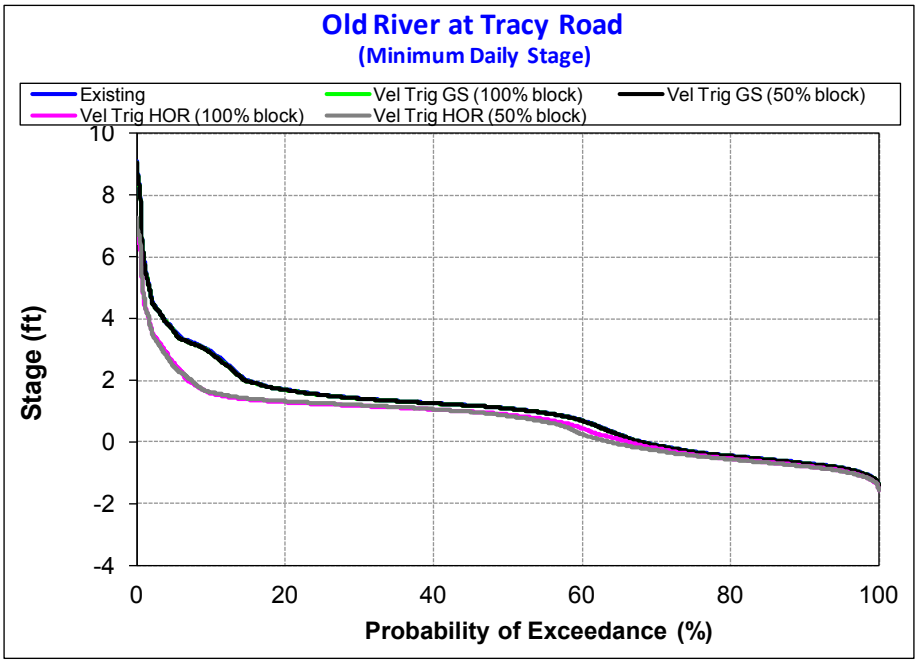

Figure 4-35 Daily Minimum Stage at Old River at Tracy Road for Velocity Trigger Location in Rivers

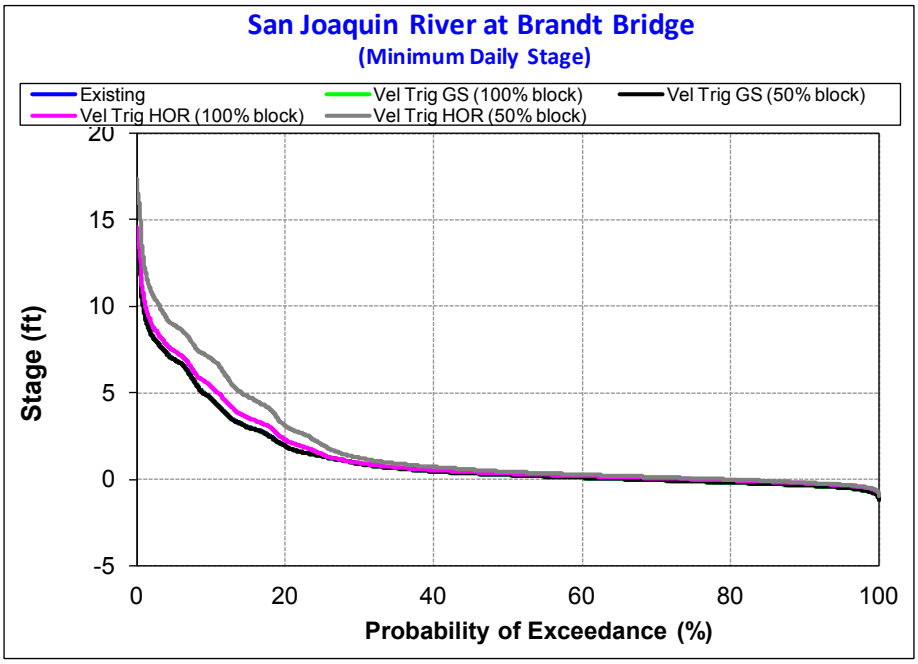

Figure 4-36 Daily Minimum Stage at San Joaquin River at Brandt Bridge for Velocity Trigger Location in Rivers

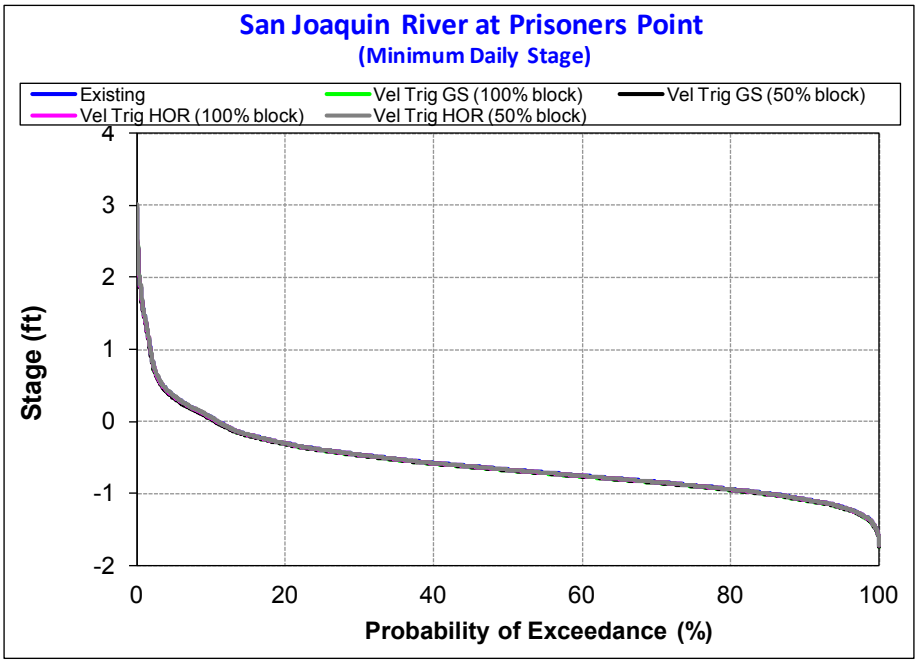

Figure 4-37 Daily Minimum Stage at San Joaquin River at Prisoners Point for Velocity Trigger Location in Rivers

4.5 Conclusion

The impacts of the Georgiana Slough, Head of Old River, Turner Cut, and Columbia Cut gates on water quality and water level varied. Figure 4-38 to Figure 4-41 represented incremental changes in water quality throughout the Delta for each of the gates. The figures also showed relative impacts among the four different gates. Table 4-3 summarizes the impacts on water quality for all scenarios.

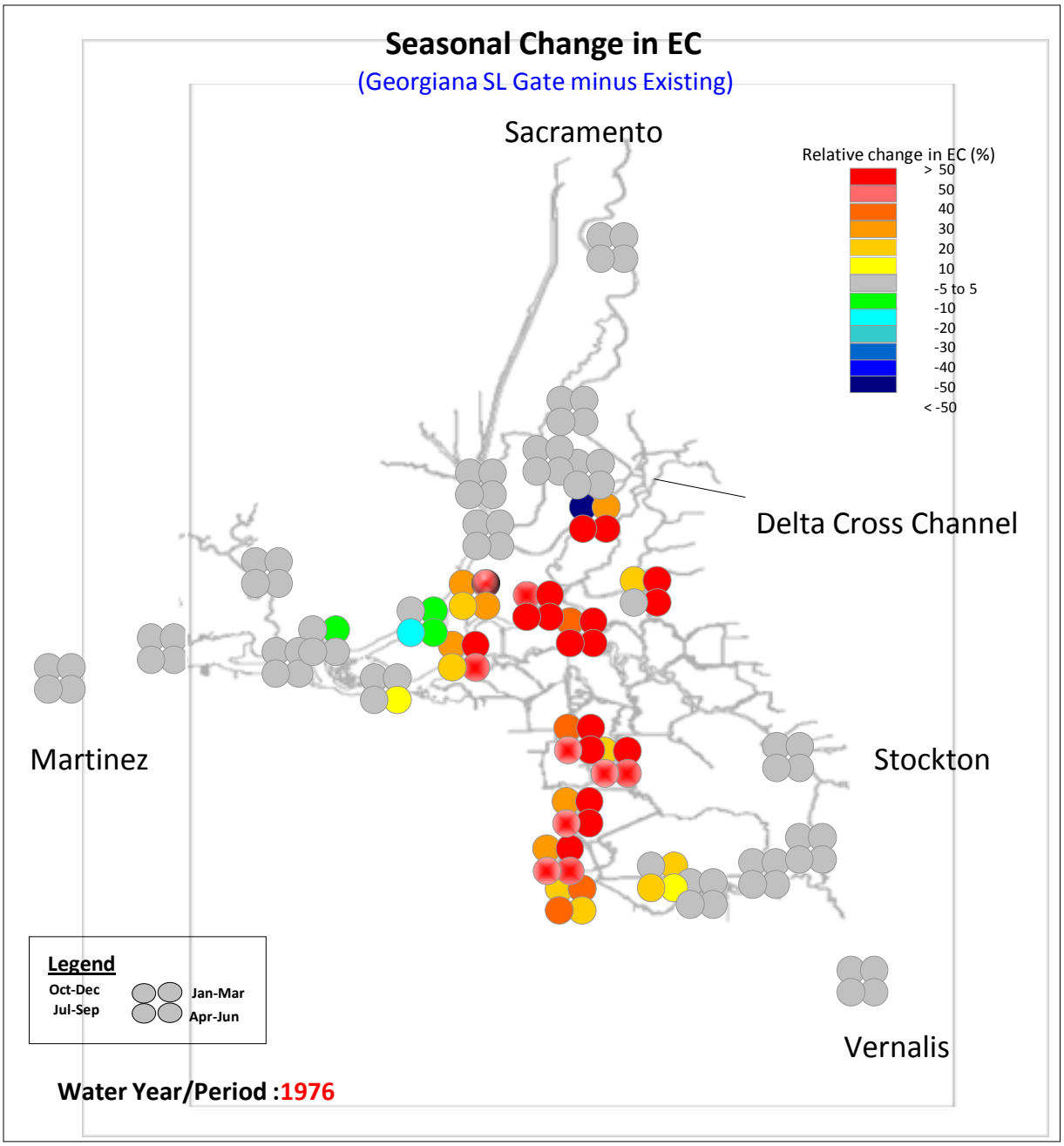

Figure 4-38 Impacts of Georgiana Slough Gate on Water Quality throughout Delta

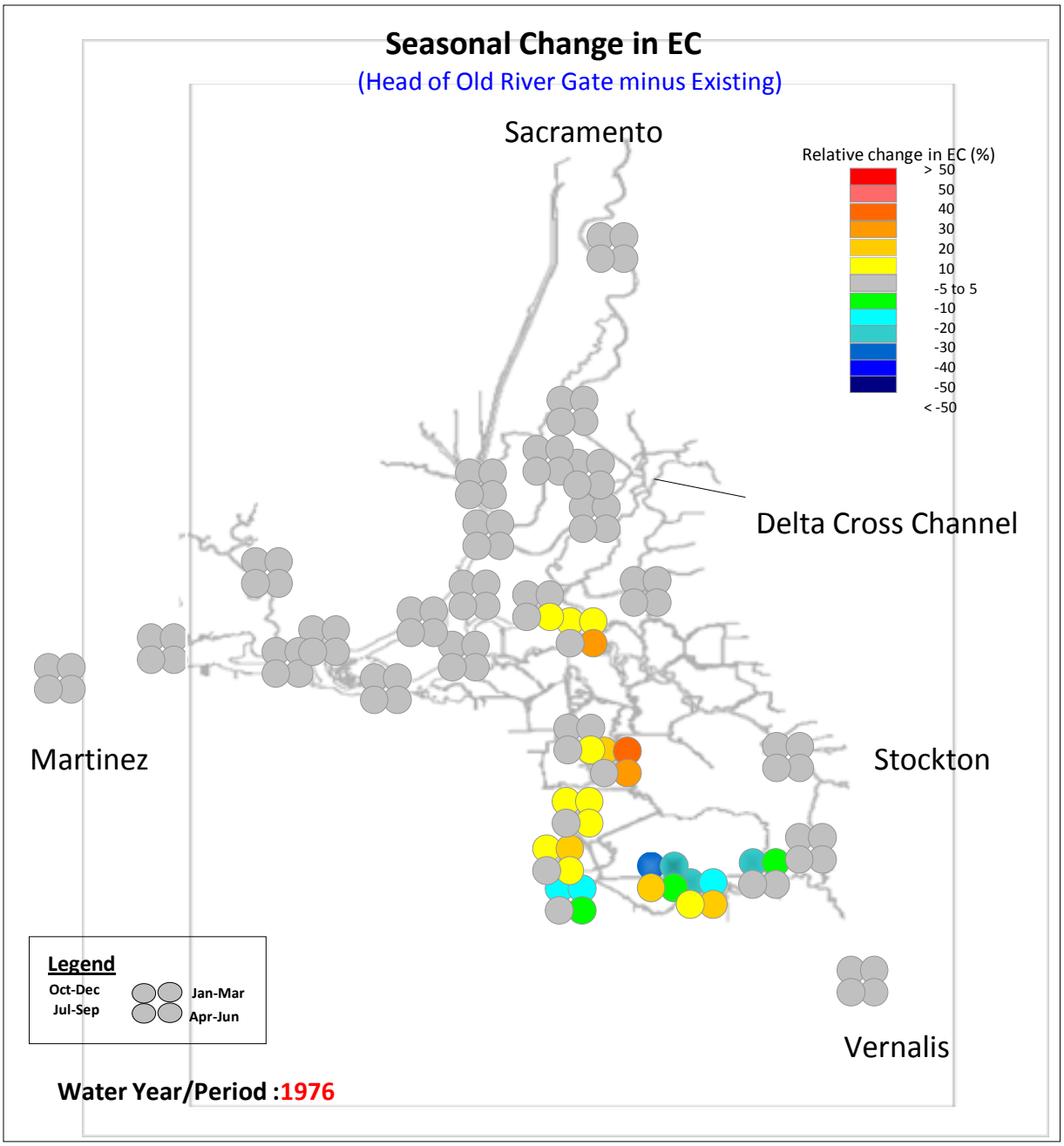

Figure 4-39 Impacts of Head of Old River Gate on Water Quality throughout Delta

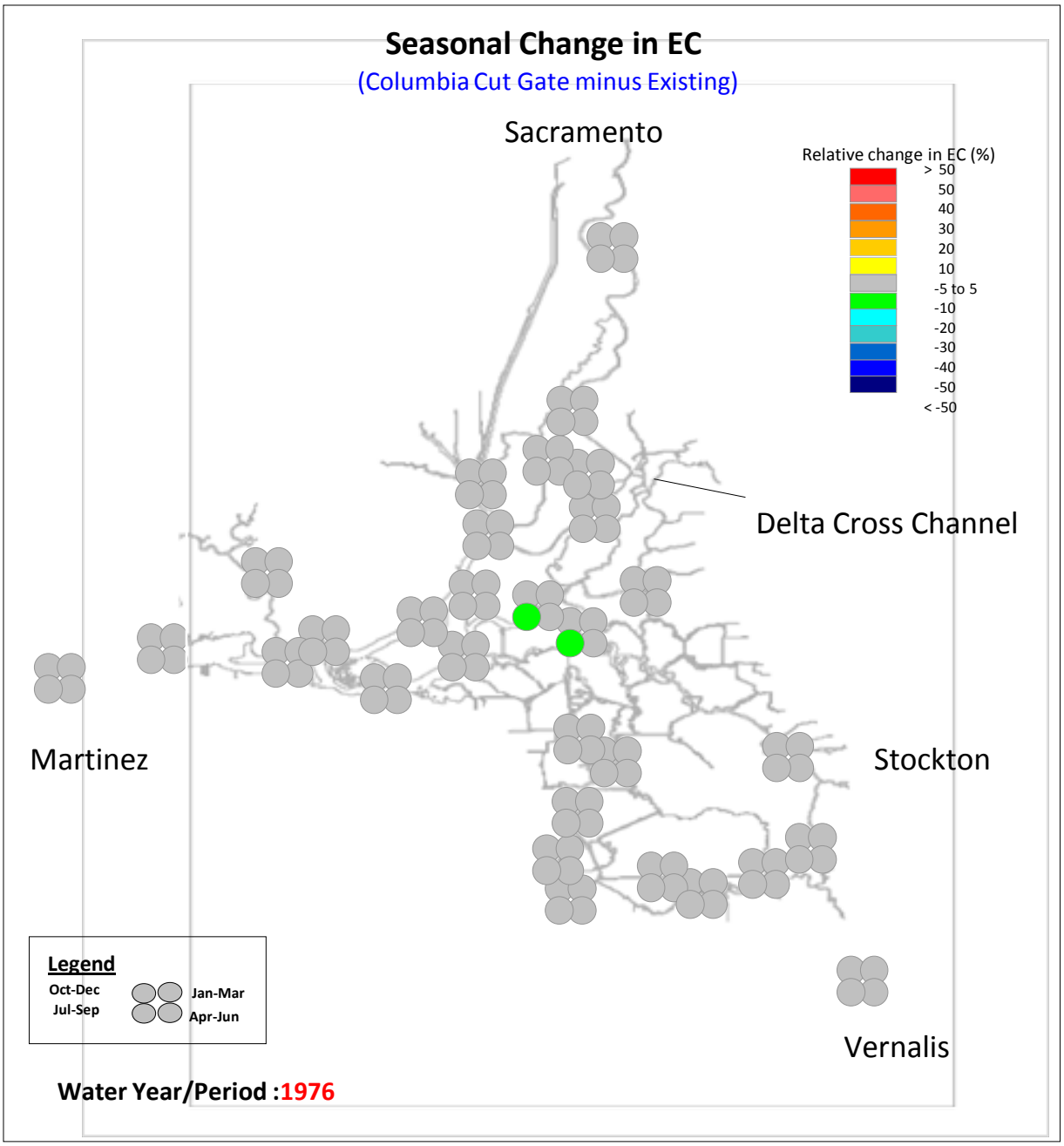

Figure 4-40 Impacts of Columbia Cut Gate on Water Quality throughout Delta

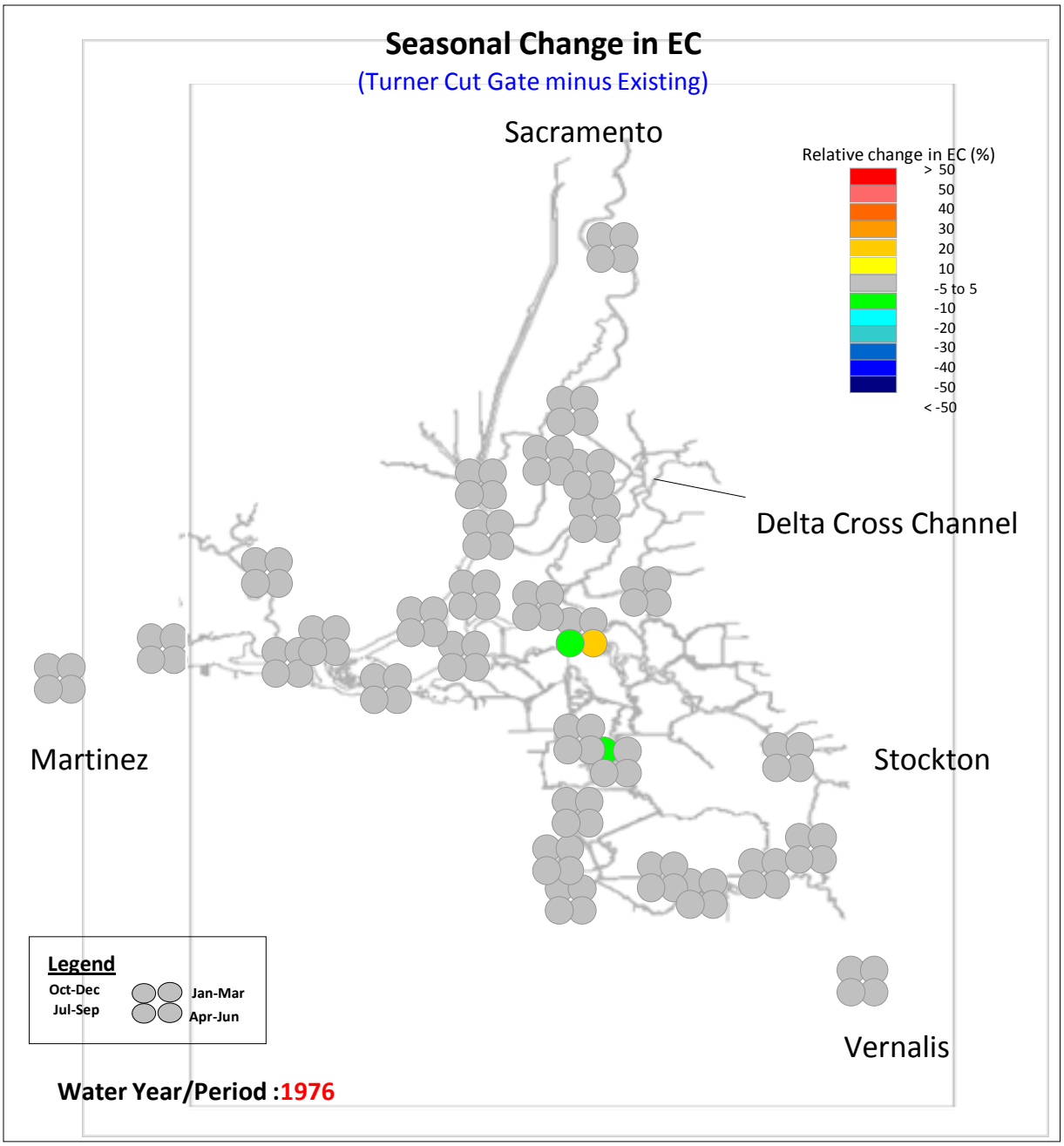

Figure 4-41 Impacts of Turner Cut Gate on Water Quality throughout Delta

			Impact on Water Quality (EC)			
Category	Location of Gate	Gate Operation Trigger	Clifton Court	Emmaton	Jersey Point	Tracy Road
Full Flow Blockage to Delta Channels	Georgiana Slough, Head of Old River, Turner Cut & Columbia Cut (Four Gates)	Closed on positive flow in channel & opened on reverse flow	Deteriorated	Improved	Deteriorated	Deteriorated*
	Georgiana Slough	Closed on positive flow in channel & opened on reverse flow	Deteriorated	Improved	Deteriorated	No/Minimal
	Head of Old River	Closed on positive flow in channel & opened on reverse flow	No/minimal	No	No	Deteriorated*
	Turner Cut	Closed on positive flow in channel & opened on reverse flow	No	No	No	No
	Columbia Cut	Closed on positive flow in channel & opened on reverse flow	No	No	No	No
	Head of Old River, Turner Cut & Columbia Cut (Three Gates)	Closed on positive flow in channel & opened on reverse flow	No/minimal	No	No	Deteriorated*

			Impact on Water Quality (EC)			
Category	Location of Gate	Gate Operation Trigger	Clifton Court	Emmaton	Jersey Point	Tracy Road
	Georgiana Slough, Head of Old River, Turner Cut & Columbia Cut (Four Gates)	Closed on ebb & opened on flood	Deteriorated	Improved	Deteriorated	Deteriorated*
	Georgiana Slough	Closed on ebb & opened on flood	Deteriorated	Improved	Deteriorated	No/Minimal
	Head of Old River	Closed on ebb & opened on flood	No	No	No	Deteriorated*
	Head of Old River, Turner Cut & Columbia Cut (Three Gates)	Closed on ebb & opened on flood	No/Minimal	No	No	Deteriorated*
Partial Flow Blockage to Delta Channels	Georgiana Slough	Partial closed on ebb to block 50% net flow & opened on flood	Deteriorated	Improved	Deteriorated	No/Minimal
	Head of Old River	Partial closed on ebb to block 50% net flow & opened on flood	No	No	No	Minimal*
	Georgiana Slough	Closed on high velocity & Opened on low velocity	Deteriorated	Improved	Deteriorated	No/Minimal

			Impact on Water Quality (EC)			
Category	Location of Gate	Gate Operation Trigger	Clifton Court	Emmaton	Jersey Point	Tracy Road
	Georgiana Slough	Partial closed on high velocity to block 50% net flow & opened on low velocity	Deteriorated	Improved	Deteriorated	No/Minimal
	Head of Old River	Closed on high velocity & Opened on low velocity	No	No	No	Minimal*
	Head of Old River	Partial closed on high velocity to block 50% net flow & opened on low velocity	No	No	No	Minimal*
Flow Blockage used in other Projects	Threemile Slough (Franks Tract Project)	Franks Tract Project proposed operation, Seasonal operation for Fish and Water Quality	Improved	No	Improved	No

*EC deteriorated at Tracy Road when both DCC and Head of Old River gates were closed.

Table 4-3 Impacts of Modeling Scenarios on Water Quality

The modeling analysis conclusions are:

- The impacts on water quality and water level decreased as gate closure time decreased.
- The Georgiana Slough Gate deteriorated water quality in the Central and South Delta, as well as in the SWP and CVP export facilities.
- The Georgiana Slough Gate improved water quality at Emmaton.

- The Head of Old River Gate deteriorated water quality locally, and caused lower water level in the South Delta.
- The Columbia and Turner Cut Gates had no impact on water quality or water level.

4.6 References

California Department of Water Resources. 2013. *Draft Environmental Impact Report/Environmental Impact Statement Bay Delta Conservation Plan* Appendix 3D. "Defining Existing Conditions, No Action Alternative, No Project Alternative, and Cumulative Impact Conditions." Sacramento (CA): California Department of Water Resources. November. 112 pp.

Bureau of Reclamation. "Delta Cross Channel Gates." Sacramento (CA): Bureau of Reclamation Central Valley Operations Office [website]. Viewed online at:.http://www.usbr.gov/mp/cvo/vungvari/xcgtxt.html . Accessed: September 18, 2014.