Appendix G3b

Delta Simulation Model II (DSM2) Methods and Results for the Proposed Voluntary Agreements

G3b.1 Introduction

To evaluate Delta water quality effects associated with the proposed Voluntary Agreements (VAs), the California Department of Water Resources' (DWR) Delta Simulation Model II (DSM2) was used to investigate whether occasional reductions in Delta inflow and alterations in Delta circulatory patterns might reduce water quality under some circumstances. DSM2 was run using inputs from the Sacramento Water Allocation Model (SacWAM) VA run to assess whether the following water quality effects might occur.

- Increases in electrical conductivity (EC) that might affect agriculture, drinking water, and attainment of EC standards at some locations.
- Potential for water stagnation that might result in harmful algal blooms (HABs) or growth of nuisance aquatic vegetation in some locations.

The effects of Delta conditions on fish, including X2,[1] were evaluated based on SacWAM results as described in Section 7.6.2, *Aquatic Biological Resources*, and not in this appendix.

Appendix A2, *Delta Simulation Model II (DSM2) Methods and Results,* contains background information pertinent to this appendix that is not repeated here, including:

- Description of the DSM2 model
- Description of DSM2 inputs
- Comparison of the DSM2 and SacWAM Delta water budgets
- Relationship between EC, chloride, and bromide
- Baseline conditions and processes

The SacWAM run used to generate input for DSM2 differs from baseline conditions due to a combination of regulatory changes and inclusion of VA assets from known, specified sources. In the SacWAM modeling, flows from the proposed VAs are added to the 2019 Biological Opinions (BiOps) condition, which differs from baseline conditions in that it does not include San Joaquin River inflow to export constraints for either the SWP or CVP to limit exports as a function of San Joaquin River flows. By contrast, the baseline incorporates the San Joaquin River inflow to export constraints as formulated in the 2020 Incidental Take Permit but applied to both SWP and CVP exports. Due to these differences in the inflow to export (I:E) constraints, the 2019 BiOps condition upon which the VA scenario is built results in higher south-of-Delta exports during April and May compared with baseline that can result in increases in net negative flows in Old and Middle Rivers. The regulatory

[1] X2 is the location in the Bay-Delta where the tidally averaged bottom salinity is 2 parts per thousand. It is expressed as the distance in kilometers from the Golden Gate Bridge.

changes primarily affect model results for April and May. Model results for other months are less affected by the change in regulatory conditions.

The proposed VAs include unspecified water purchases (Public Water Agency (PWA) Water Purchase Market Price Program and permanent state water purchases) from unspecified willing sellers, which could include inflow sources within the Sacramento/Delta watershed or reductions in exports, both of which could result in additional Delta outflows. As discussed in Section 9.5, *Changes in Hydrology and Water Supply*, the SacWAM run of tributary hydrology does not assume any additional Delta inflows from unspecified water purchases, given the unknown origin of these water purchases. The SacWAM run also does not include VA contributions from the San Joaquin River basin because approval of the Tuolumne River VA is being considered separately and the Friant VA may not move forward. Unspecified water purchases and VA contributions from the San Joaquin River basin would likely result in a combination of increased Delta inflow, increased Delta outflow, and reduction in Delta exports. The effects of unspecified water purchases and VA contributions from the San Joaquin River basin are presented in Section 9.5 as high and low flow bookends that were calculated through postprocessing of SacWAM results.

The main effect of increases in Delta inflow, increases in Delta outflow, and reductions in Delta exports compared with what is modeled for this appendix would be a reduction in seawater intrusion. Some additional smaller effects also could occur. Higher Delta inflow could slightly alter salinity in the Delta by altering the percent of water originating from the Sacramento River (lower EC) versus the San Joaquin River (higher EC). Reductions in Delta exports could reduce movement of Sacramento River water toward the southern Delta and reduce flow in channels conveying water to Delta exports. In addition, there could be shifting in the timing of effects. Unspecified water purchases would likely increase Delta outflow during spring, which could lead to reductions in flow during other times of the year. The SacWAM VA run and the associated DSM2 run include these types of effects, but the magnitude of these effects could be somewhat greater if unspecified water purchases and VA contributions from the San Joaquin River basin were included.

G3b.2 Methods

For this analysis, monthly water budget terms from SacWAM for water years 1976–1991 were used as DSM2 inputs. Detailed methods for translating SacWAM information into input for DSM2 were developed jointly by State Water Board staff and DWR, and are described in a DSM2 methods memo from DWR (Attachment 1 to Appendix A2, *Delta Simulation Model II [DSM2] Methods and Results*).

The comparison and evaluation of the changes in Delta flows and EC for the proposed VAs are based primarily on the monthly results for the 16-year sequences for the water years 1976–1991 DSM2 modeling period. Evaluation focuses on seawater intrusion effects, changes in flow that could affect harmful algal blooms, and changes in water quality at water quality compliance locations (Figure A2-1, Table A2-1).

Average monthly model results for the proposed VAs are compared with baseline conditions to evaluate EC effects and the attainment of water quality objectives for habitat, agriculture, and municipal water supply at the following locations in the Bay-Delta estuary.

- Suisun Marsh: Four compliance locations within Suisun Marsh and the Sacramento River at Collinsville, near where water enters the marsh at Montezuma Slough.

- Western Delta: Sacramento River at Mallard Slough and Emmaton; San Joaquin River at Antioch and Jersey Point.
- Interior Delta and exports (for convenience of discussion this extends from the SWP and CVP exports to the northern Delta): Barker Slough in the northern Delta, San Joaquin River at San Andreas Landing, Prisoners Point, and Stockton Intake; Mokelumne River at Terminous; Old River at Bacon Island (near Rock Slough) and Highway 4; Victoria Canal; and Clifton Court Forebay and Delta-Mendota Canal Intake.
- Southern Delta: San Joaquin River at Brandt Bridge and Vernalis, Old River near Middle River, and Old River at Tracy Boulevard.

A month-by-month comparison of the DSM2 EC values with water quality objectives can be used to verify compliance. However, because the DSM2 model uses monthly average flows from SacWAM, the variations in DSM2 EC values within each month reflect the spring-neap tidal cycle variations but do not include the daily changes in EC caused by changes in outflow that might be allowed to comply with “split-month” EC objectives. CVP and SWP operators adjust exports on a daily basis to maintain the daily average EC below the maximum-allowed EC at each of the EC objective locations. Although there potentially could be some occasions when the DSM2 monthly average EC would be greater than the EC objectives on a daily basis, EC exceedances (i.e., running-average EC greater than the EC objective) would not likely occur in actual Delta operations, because the CVP and SWP operators would increase the Delta outflow to reduce the daily average EC to less than the EC objectives at all locations. The comparison of the monthly EC patterns for the baseline and the proposed VAs can be used to identify the shifts in the monthly EC distribution from the baseline, which may indicate whether attainment of objectives could become more difficult.

Compliance is more difficult to evaluate for the agricultural EC objectives at Emmaton, Jersey Point, San Andreas Landing, and Terminous, which depend on water year type, may change within a month, and end on August 15 with no EC objective for August 16–31. When the EC objectives are not constant for a month, monthly EC objectives are approximated as the weighted average of the daily objectives. For example, at Emmaton in below-normal water years, the EC objective is 450 microSiemens per centimeter (μS/cm) from June 1 to June 20 and 1,140 μS/cm from June 21 to June 30. The estimated monthly EC objective would be (450*20+1,140*10)/30=680 μS/cm. In the case of the objectives that end on August 15, August monthly EC objectives are approximated as the weighted average of the August 1–15 objective and the highest objective (i.e., critical year) for August 16–31. Compliance with the X2 requirements described in Table 4 of State Water Board Water Right Decision 1641 are not evaluated here. SacWAM incorporates attainment of X2 objectives in the baseline and VA simulations.

G3b.3 Results

This section compares the DSM2 net monthly flows and monthly average EC at major Delta channels for the proposed VAs with baseline conditions. Changes in the Delta channel flows are caused by changes in inflows from the Sacramento River and Delta eastside tributaries and by changes in CVP and SWP exports. The following evaluation illustrates changes in monthly channel flows and monthly average EC values that were calculated with DSM2 for the proposed VAs relative to baseline.

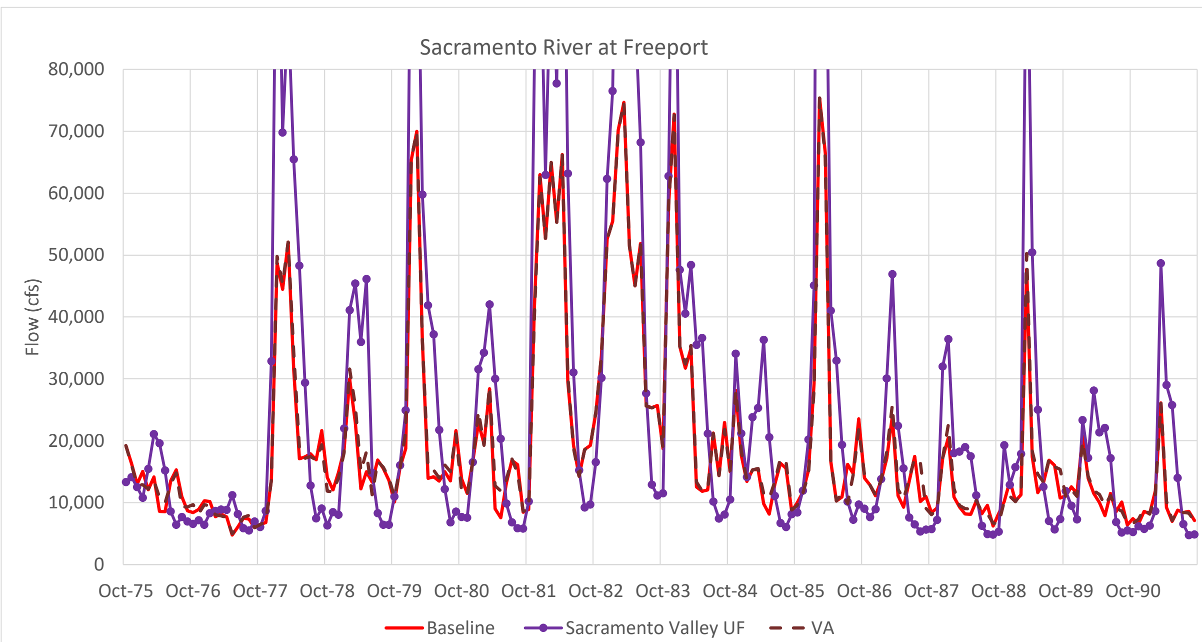
G3b.3.1 Changes in Flow

Delta channel flows are largely controlled by the Sacramento River, Yolo Bypass, and Delta eastside tributary inflows, and by the CVP and SWP exports in the southern Delta, all of which were modeled using SacWAM. San Joaquin River inflows are also important, but they do not vary between the proposed VAs and baseline as modeled in SacWAM. Changes in Delta inflow, exports, and outflow are described in detail in Chapter 9, *Proposed Voluntary Agreements*. This section provides a summary of those changes as well as changes in flow at some key interior locations within the Delta to inform the description of changes in EC within the Delta that were simulated by DSM2.

G3b.3.1.1 Flow at Locations Important for Delta Hydrodynamic Processes

Inflow

Figure G3b-1 shows the time series of flows in the Sacramento River at Freeport for the SacWAM baseline conditions and for the proposed VAs for water years 1976–1991. Seasonal variation and differences between years dominate hydrologic conditions. Sacramento River flows for the proposed VAs are similar to baseline flows, and differences are difficult to discern in cfs = cubic feet per second; UF = unimpaired flow; VA = proposed Voluntary Agreements Figure G3b-1. Tables presented in Chapter 9, *Proposed Voluntary Agreements*, show that average January–June flows at Freeport would increase (with an overall average increase of 200 thousand acre-feet, primarily during April and May) and average July–December flows would decrease (with an overall average decrease of 81 thousand acre-feet).

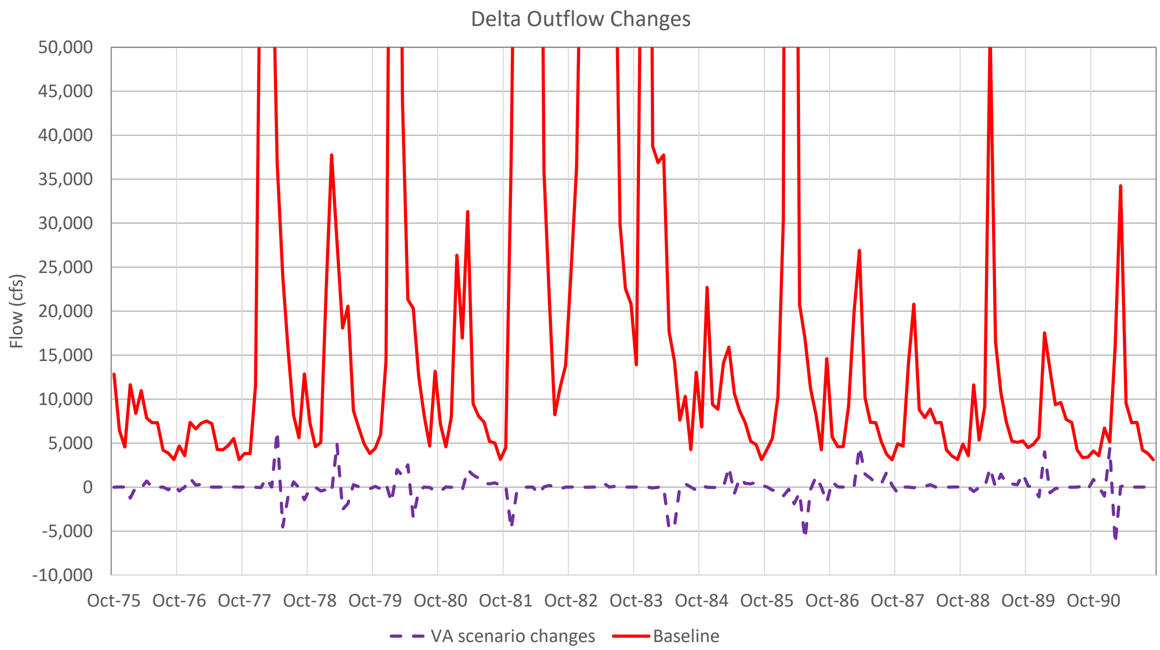


cfs = cubic feet per second; UF = unimpaired flow; VA = proposed Voluntary Agreements

Figure G3b-1. SacWAM Sacramento River Flow at Freeport – Baseline and Proposed VAs for Water Years 1976–1991

Outflow

Figure G3b-2 shows the baseline Delta outflows as simulated by SacWAM, and the changes in Delta outflows (increases or decreases) for the proposed VAs. In general, the most noticeable changes in outflow are operational shifts in timing of releases, such as shifts in which months water is released in spring or shifts in flood control releases. The more subtle changes in Delta outflow resulting from the proposed VA actions are not as apparent in this figure. Please see Chapter 9. *Proposed Voluntary Agreements*, for a discussion of changes in Delta outflow, including changes in Delta outflow that were not part of the DSM2 modeling such as unspecified water purchases and VA contributions from the Tuolumne River.

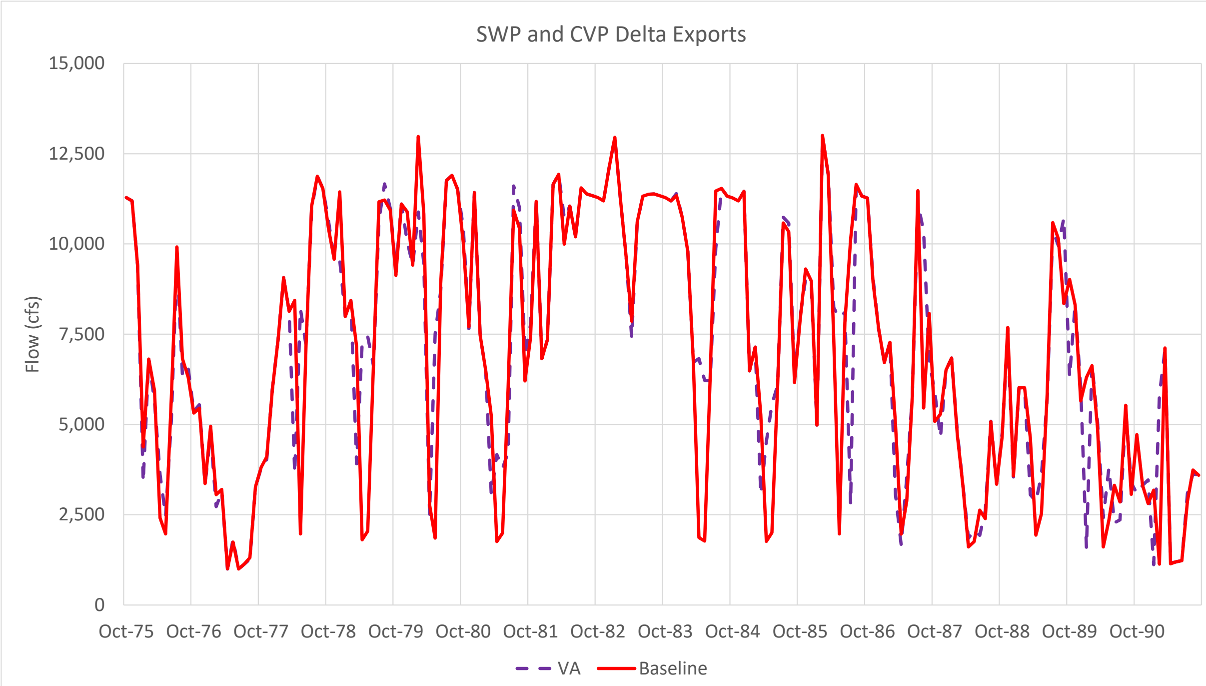


cfs = cubic feet per second
VA = proposed Voluntary Agreements

Figure G3b-2. Delta Outflow – Baseline and Changes from Baseline for the Proposed VAs for Water Years 1976–1991

Exports

Figure G3b-3 shows the CVP and SWP Delta exports calculated by SacWAM for baseline conditions and for the proposed VAs water years 1976–1991. These are inputs to the DSM2 model. Exports are highly variable from year-to-year and season-to-season. Differences between the proposed VAs and baseline are smaller than the annual and seasonal variation, making it difficult to see trends in the differences. Under baseline conditions, the lowest exports typically occur in April and May, when exports are limited by the San Joaquin River I:E ratio. April and May exports with the proposed VAs are also often lowest in April and May but can be substantially higher than under baseline conditions because the proposed VAs are built upon the regulatory conditions of the 2019 BiOps, which have no San Joaquin River I:E constraint. Another trend is for decreased exports in March associated with VA curtailment on Delta exports. The maximum combined exports are generally limited to less than 13,100 cubic feet per second (cfs) by the permitted capacities of the CVP and SWP pumping plants.

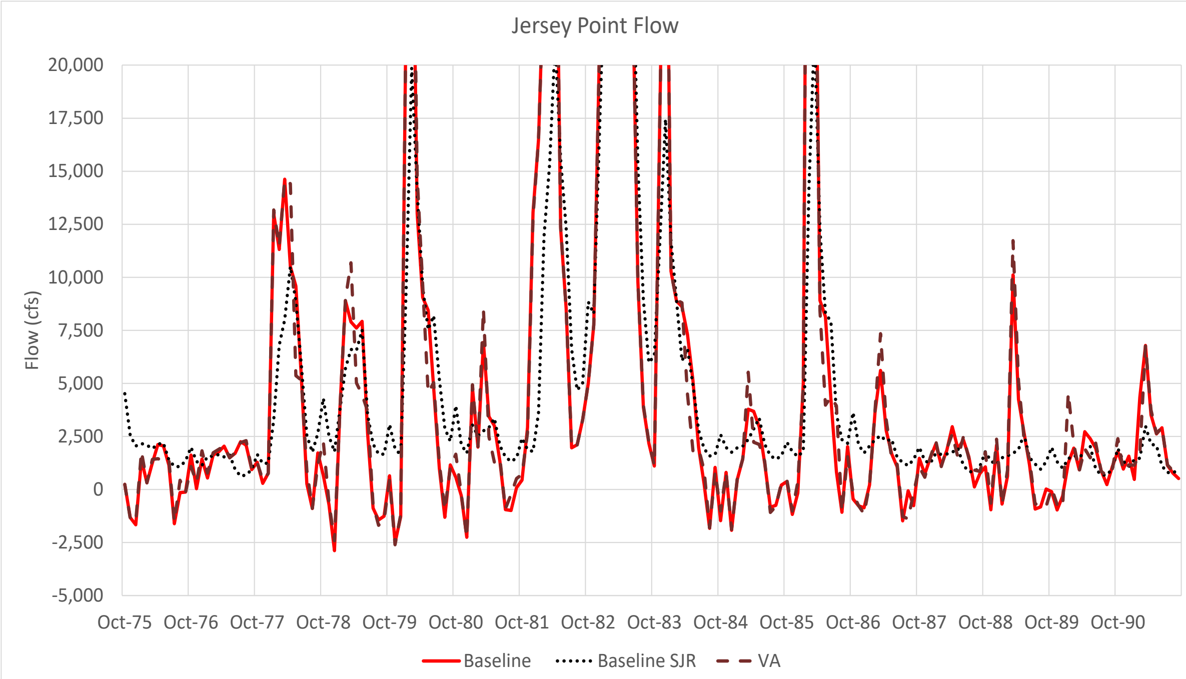


cfs = cubic feet per second
VA = proposed Voluntary Agreements

Figure G3b-3. SacWAM CVP and SWP Delta Exports – Baseline and the Proposed VAs for Water Years 1976–1991

San Joaquin River at Jersey Point

Flow at San Joaquin River at Jersey Point (Jersey Point) is important because reverse flow at this location is indicative of potential seawater intrusion into the interior Delta. Figure G3b-4 shows the monthly average flow at Jersey Point for baseline compared with the proposed VAs for water years 1976–1991. The baseline flows at Jersey Point are highest when the San Joaquin River inflows at Vernalis are high and additional flows are diverted from the Sacramento River through Georgiana Slough and Threemile Slough. The flows at Jersey Point are controlled by the Delta water balance between the sum of inflows from the San Joaquin River, Delta eastside tributaries, Delta Cross Channel (DCC), Georgiana Slough, and Threemile Slough compared with the CVP and SWP exports and the other water diversions in the southern and central Delta channels. Because Delta exports can represent a large fraction of total Delta inflows in summer months, the flows at Jersey Point are generally less than 2,500 cfs and are sometimes negative, indicating that water is moving upstream from Antioch and through False River to Franks Tract and Old River toward the CVP and SWP exports. The Jersey Point flows are sometimes negative (minimum of about -2,500 cfs) in summer and fall months for the baseline and the proposed VAs. Overall, the Jersey Point flows for the proposed VAs are generally similar to baseline but with some differences due to variation in the multiple flows that contribute to flow at Jersey Point. One trend, however, is for March flow at Jersey Point to sometimes be higher under the proposed VAs than under baseline conditions due to export curtailments associated with the proposed VAs. In April and May, the reverse can occur when the proposed VAs have higher exports due to reduced regulatory constraints on exports.



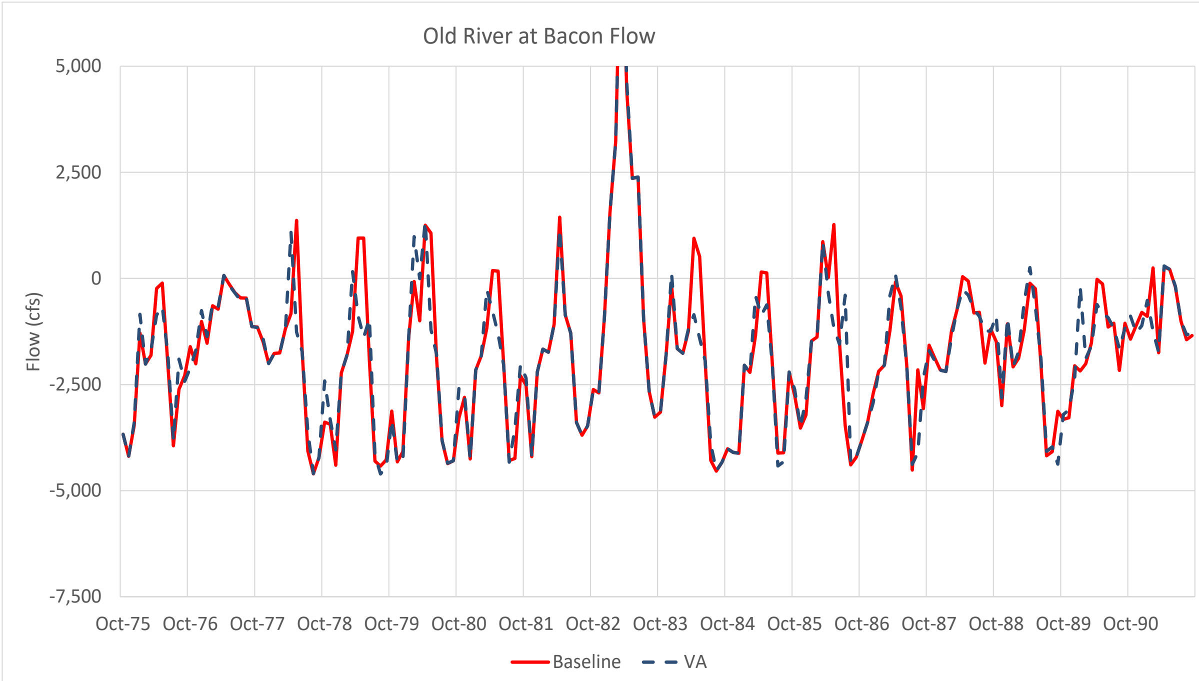
cfs = cubic feet per second; SJR = San Joaquin River; VA = proposed Voluntary Agreements

Figure G3b-4. San Joaquin River Flow at Jersey Point – Baseline and the Proposed VAs for Water Years 1976–1991

Old and Middle River

The Old River at Bacon Island and Middle River at Bacon Island flows together are known as Old and Middle River (OMR) flows. Reverse OMR flows indicate that San Joaquin River inflow to the southern Delta is not large enough to provide all the water for southern Delta exports and diversions; this indicates that little San Joaquin River water is reaching the ocean. It also indicates that some of the relatively low salinity water of the Sacramento River is flowing to the southern Delta. It may also indicate that any effect of seawater intrusion is being drawn into the southern Delta as well.

Figure G3b-5 shows the monthly average Old River flows at Bacon Island for baseline conditions compared with the proposed VAs for water years 1976–1991. The Old River at Bacon Island flows are about half of the OMR flows. These flows also represent the general pattern of flow effects seen in other southern Delta channels leading south to the Delta exports. Some flow is diverted into Rock Slough and Indian Slough, but most of the flow in Old River is measured at the Old River at Bacon station. The baseline Old River at Bacon Island flows are almost always negative, except when San Joaquin River inflows are higher than the CVP and SWP exports. The effect of the proposed VAs on flow in Old River is similar to the effect of the proposed VAs on flow at Jersey Point since flow at both locations is largely affected by the volume of Delta exports relative to San Joaquin River flows. OMR flows under the proposed VAs would generally be similar to but sporadically different from baseline flows, with the main trends being smaller negative flows in March and more negative flows in April and May.



cfs = cubic feet per second
VA = proposed Voluntary Agreements

Figure G3b-5. DSM2 Flow in Old River at Bacon Island – Baseline and the Proposed VAs for Water Years 1976–1991

G3b.3.1.2 Net Flow at Locations Representing Areas with Harmful Algal Blooms

Many factors affect the occurrence of HABs and aquatic vegetation (e.g., nutrients, temperature, motion of water). Low net flows and high agricultural diversions in some Delta channels may cause long water travel times that could allow algae (phytoplankton), floating aquatic vegetation (e.g., water hyacinth), and submerged aquatic vegetation (e.g., Brazilian waterweed) to grow and accumulate if other factors are conducive to growth.

Victoria Canal

The monthly net flows and corresponding water travel times (i.e., channel volume/net flow) in some southern Delta channels could be affected by the proposed VAs because occasional lower exports could reduce the negative (reversed) flow in the southern Delta. As an example of the possible changes in travel time caused by reduced CVP and SWP exports, the water travel times in Victoria Canal are calculated from the DSM2 flows for the baseline and the proposed VAs.

Victoria Canal carries about 40 percent of the reversed OMR flows. The volume of Victoria Canal is about 2,500 acre-feet, so the travel time in days is about 1,250/flow (cfs). Table G3b-1 gives the cumulative distribution of monthly travel times in Victoria Canal for the baseline and the proposed VAs. The monthly average flows in Victoria Canal were used to calculate travel time, and the resulting values were used to calculate the cumulative distribution of travel times. For most months, all the flows are negative and faster travel times are associated with increased flow toward the export pumps, but April and May are exceptions. The average travel times are less than a day in most months for the baseline flows but average about 5–6 days in April and May because CVP and SWP exports are usually reduced for fish protection during these months. Furthermore, these two months experience both positive and negative OMR flows. At the transition between positive and negative flows, there is little net flow and maximum travel time approaches 30 days under baseline conditions. Due to relatively cool conditions, these 2 months are not prime HAB months.

The DSM2 results indicate that average monthly baseline travel times through Victoria Canal are between 0.6 and 1.3 days during the June–October HAB season. Average travel time for the proposed VAs is not substantially different from baseline during the bloom period.

Table G3b-1. Cumulative Distribution of DSM2 Travel Times in Victoria Canal – Baseline and Changes from Baseline for the Proposed VAs for Water Years 1976–1991

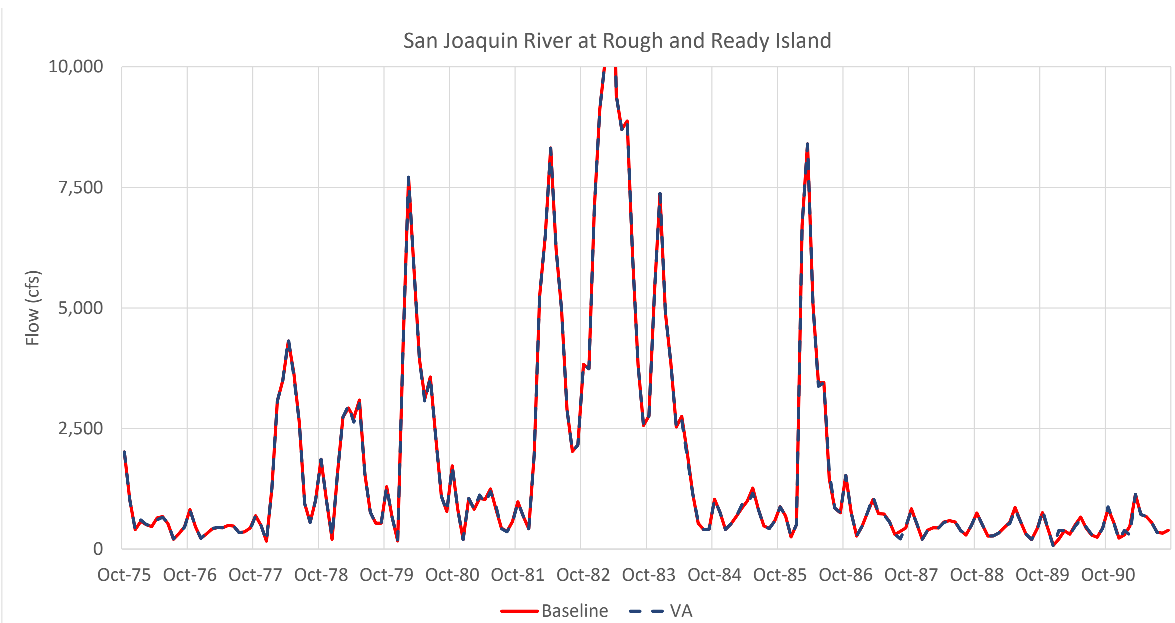
	Victoria Canal Travel Time (days)						Travel Time (days) is 1,250 / flow					
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Baseline												
10%	0.4	0.4	0.4	0.6	0.6	0.7	1.5	2.0	0.7	0.4	0.3	0.3
20%	0.4	0.4	0.4	0.6	0.6	0.8	2.5	2.3	0.7	0.4	0.3	0.3
30%	0.4	0.4	0.5	0.7	0.6	0.8	3.1	2.7	0.7	0.4	0.4	0.4
40%	0.4	0.4	0.5	0.7	0.7	0.9	3.5	3.0	0.7	0.4	0.4	0.4
50%	0.5	0.5	0.6	0.7	0.7	0.9	3.9	3.2	0.7	0.4	0.4	0.5
60%	0.5	0.5	0.7	0.7	0.7	0.9	4.6	3.6	0.8	0.4	0.5	0.6
70%	0.7	0.5	0.7	0.8	0.8	1.0	6.6	4.3	1.0	0.6	0.6	0.6
80%	0.8	0.7	1.0	0.9	1.0	1.0	8.6	8.7	1.5	1.3	0.7	1.0
90%	0.9	0.9	1.2	1.2	1.6	1.5	8.8	9.4	2.9	1.4	0.8	1.1
Average	0.6	0.6	0.7	0.9	1.3	1.0	6.1	5.2	1.3	0.7	0.6	0.6
Proposed VAs												
10%	0.0	0.0	0.0	0.0	0.0	0.0	-0.3	-1.1	0.0	0.0	0.0	0.0
20%	0.0	0.0	0.0	0.0	0.0	0.0	-1.2	-1.4	0.0	0.0	0.0	0.0
30%	0.0	0.0	0.0	0.0	0.0	0.0	-1.8	-1.7	0.0	0.0	0.0	0.0
40%	0.0	0.0	0.0	0.0	0.0	0.1	-2.1	-2.0	0.0	0.0	0.0	0.0
50%	0.1	0.0	0.0	0.0	0.0	0.6	-2.0	-1.7	0.0	0.0	0.0	0.0
60%	0.0	0.0	-0.1	0.0	0.0	0.7	-2.1	-1.9	0.0	0.0	0.0	0.0
70%	-0.1	0.0	0.0	0.1	0.0	0.8	-2.2	-2.6	0.3	0.4	0.0	0.0
80%	0.0	0.0	0.2	0.6	0.0	0.9	-1.0	-6.4	0.2	0.0	0.2	0.0
90%	0.3	0.1	0.0	1.6	0.0	0.5	9.7	-6.3	0.0	0.4	0.2	0.0
Average	0.1	0.0	0.0	0.3	-0.4	0.4	0.0	-2.4	0.1	0.1	0.0	0.0

VA = proposed Voluntary Agreements

Stockton

HABs have been particularly problematic near Stockton, especially near the Stockton Waterfront. The proposed VAs are expected to cause little change in San Joaquin River flow near Stockton during the June through October HAB season (Figure G3b-6, Table G3b-2). Correspondingly, the proposed VAs would cause little change in San Joaquin River travel time past the city of Stockton.

The Stockton Waterfront is located upstream of the Port of Stockton turning basin for cargo vessels in a dead-end slough that connects to the San Joaquin River at its west end. As described in Appendix A2, Section A2.3.3, *Tidal Slough Flow and Stagnation in the Southern Delta*, dead-end sloughs have limited tidal exchange and minimal net flow, resulting in stagnant water and long residence times, which are conducive to HAB formation. Net flow through the turning basin is negligeable and the flow scenarios are not expected to affect flow in and out of this slough (Figure G3b-7).



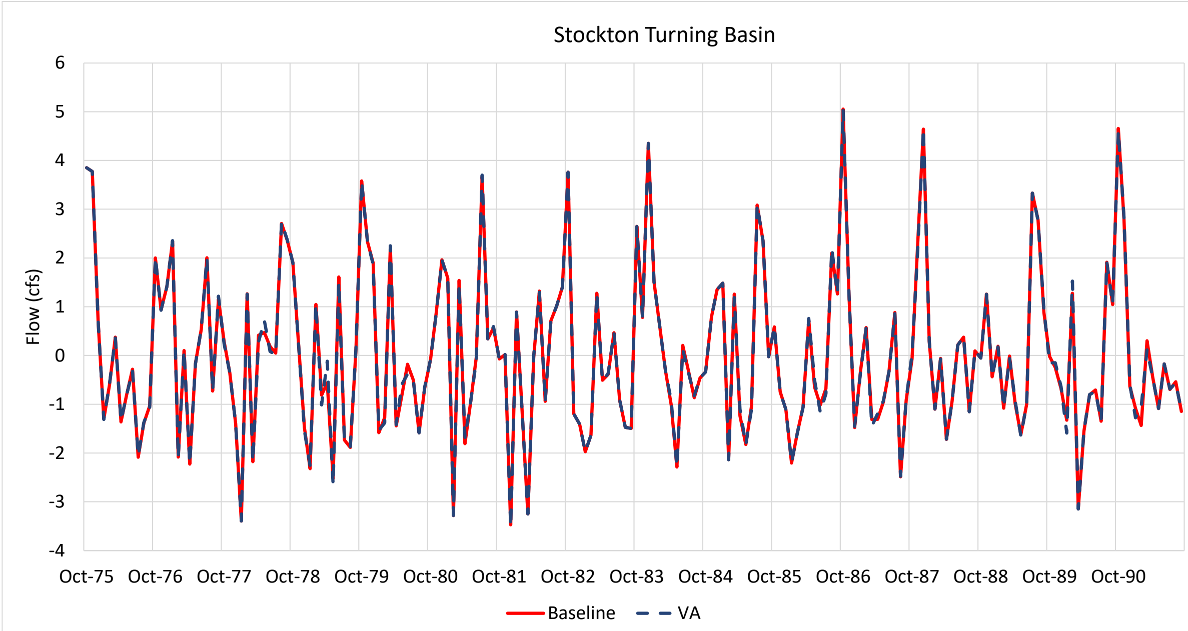
cfs = cubic feet per second
VA = proposed Voluntary Agreements

Figure G3b-6. DSM2 Flow in the San Joaquin River near Stockton – Baseline and the Proposed VAs for Water Years 1976–1991

Table G3b-2. Cumulative Distribution of DSM2 Flow Values for the San Joaquin River near Stockton – Baseline Compared with the Proposed VAs for Water Years 1976–1991

	San Joaquin River Flow near Stockton (cfs)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	751	480	166	284	397	442	528	626	500	296	268	417	445
20%	817	504	196	311	441	445	563	676	548	303	323	434	476
30%	837	539	204	433	491	659	681	702	562	343	343	437	598
40%	877	665	220	507	682	1,028	736	862	568	391	369	462	663
50%	1,007	680	239	550	793	1,094	1,014	1,255	832	458	386	514	792
60%	1,292	755	268	1,052	2,736	2,533	2,717	2,007	1,143	532	430	568	1,623
70%	1,627	797	337	1,417	3,462	3,210	3,343	3,106	2,095	850	544	667	2,281
80%	1,864	982	408	1,953	5,243	5,796	4,316	3,444	3,455	1,454	851	780	2,835
90%	2,386	2,377	3,749	4,570	7,207	7,444	6,698	4,935	4,266	2,585	1,561	1,587	3,208
Average	1,412	1,152	1,121	1,729	2,768	3,164	2,669	2,339	1,971	1,126	762	777	1,749
Proposed VA Change from Baseline													
10%	25	-1	12	72	-39	1	-28	-31	9	9	-36	-21	-3
20%	-7	6	0	78	-12	31	-8	-16	0	6	-30	-19	-2
30%	8	7	-2	0	-18	52	-20	-11	3	-3	-5	4	-3
40%	-2	0	4	0	0	63	8	-40	8	-5	-13	11	-5
50%	-4	5	19	14	0	34	-82	-81	31	-8	-5	-1	-8
60%	1	-2	1	0	0	0	-84	-96	0	30	-6	-24	-5
70%	-1	0	3	1	0	26	-36	-74	-2	2	-5	-1	2
80%	-2	0	0	0	0	8	45	-68	-4	131	4	0	-12
90%	0	0	0	0	3	0	-4	-33	-1	-1	-1	1	-2
Average	3	2	3	20	-10	20	-24	-43	7	11	-9	-6	-2

cfs = cubic feet per second
VA = proposed Voluntary Agreements



cfs = cubic feet per second
VA = proposed Voluntary Agreements

Figure G3b-7. DSM2 Flow in the Port of Stockton Turning Basin – Baseline and the Proposed VAs for Water Years 1976–1991

G3b.3.2 Changes in Delta Channel Salinity

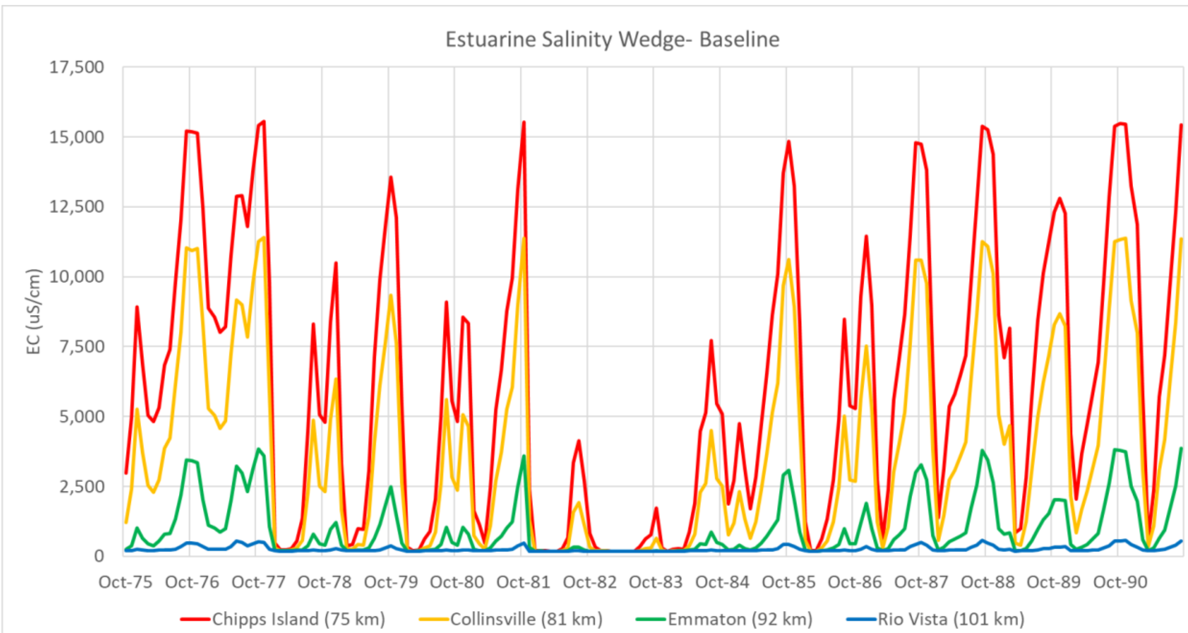
Changes in EC are evaluated at water quality compliance locations summarized in Table A2-1 in Appendix A2, *Delta Simulation Model II (DSM2) Methods and Results*. Because bromide and chloride are related to EC, the bromide and chloride objectives also are assessed here using the DSM2 EC results. SacWAM estimates net Delta outflow necessary to meet EC objectives for the Sacramento River at Collinsville, Sacramento River at Emmaton, San Joaquin River at Jersey Point, and Old River at Rock Slough. As a result, the hydrologic conditions transferred from SacWAM to DSM2 are expected to show attainment of EC objectives at these four locations. This section evaluates attainment of the objectives at all water quality compliance locations in Table A2-1, and shows the magnitude of expected changes in EC.

G3b.3.2.1 General Effect of Outflow on Seawater Intrusion

As described in Section G3b.3.1, *Changes in Flow*, there are some periods of reduced Delta inflow and outflow, which could occasionally affect EC in the Delta. Changes in Delta outflow, which do not always exactly follow the same pattern as changes in Delta inflow (due to changes in exports), have the greatest effect on seawater intrusion and EC at western locations—closer to the ocean, including the Sacramento River downstream of Rio Vista, the San Joaquin River downstream of San Andreas Landing, and in Suisun Bay and Suisun Marsh channels.

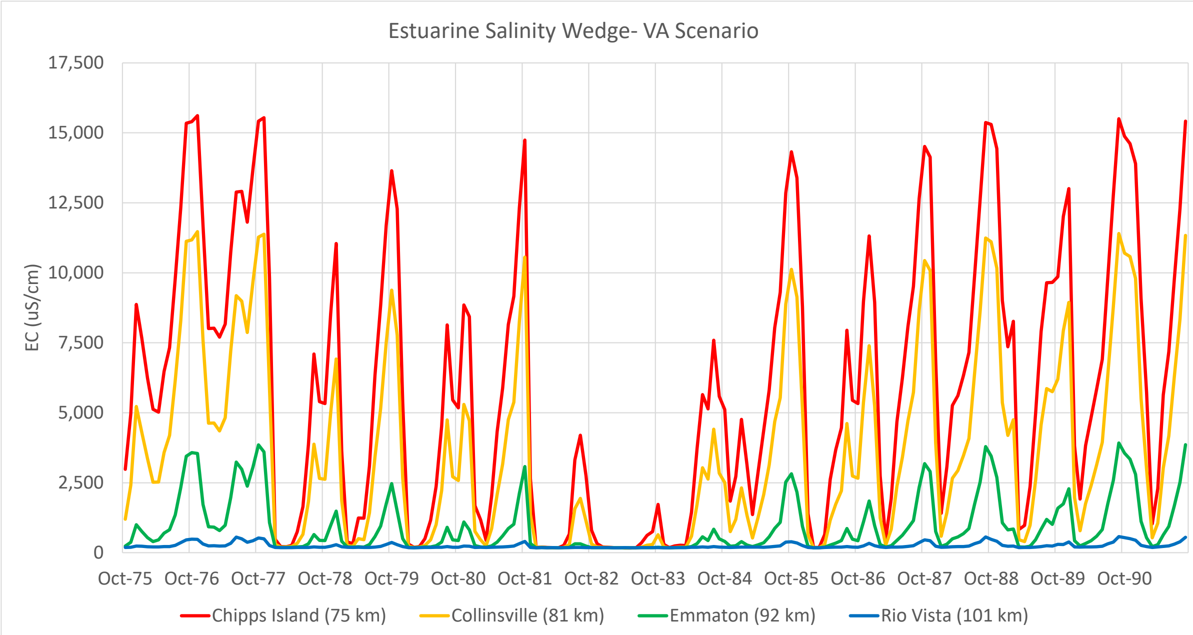
Appendix A2, Section A2.3.3, *Effects of Flow on Salinity*, describes the basic features of the estuarine salinity gradient that develops from the tidal mixing of seawater and freshwater (i.e., seawater intrusion). The salinity gradient moves upstream with lower Delta outflow and moves downstream with higher Delta outflow. µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer Figure G3b-8 and µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements Figure G3b-9, respectively, show changes in the salinity gradient between baseline conditions and the proposed VAs. These figures show DSM2 EC at Chipps Island (75 kilometers [km]), Collinsville (81 km), Emmaton (92 km), and Rio Vista (101 km) for water years 1976–1991.

Under baseline conditions, the upstream edge of the salinity gradient (1,000 µS/cm) is always downstream of Rio Vista and is often downstream of Emmaton; the baseline salinity gradient is sometimes downstream of Collinsville (>13,500 cfs Delta outflow) and is downstream of Chipps Island only in a few months with high Delta outflow (>17,000 cfs). The salinity gradient pattern for the proposed VAs is very similar to the baseline pattern.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer

Figure G3b-8. Time Series of DSM2 EC Values at Chipps Island (75 km), Collinsville (81 km), Emmaton (92 km), and Rio Vista (101 km) – Baseline for Water Years 1976–1991



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

Figure G3b-9. Time Series of DSM2 EC Values at Chipps Island (75 km), Collinsville (81 km), Emmaton (92 km), and Rio Vista (101 km) – Proposed VAs for Water Years 1976–1991

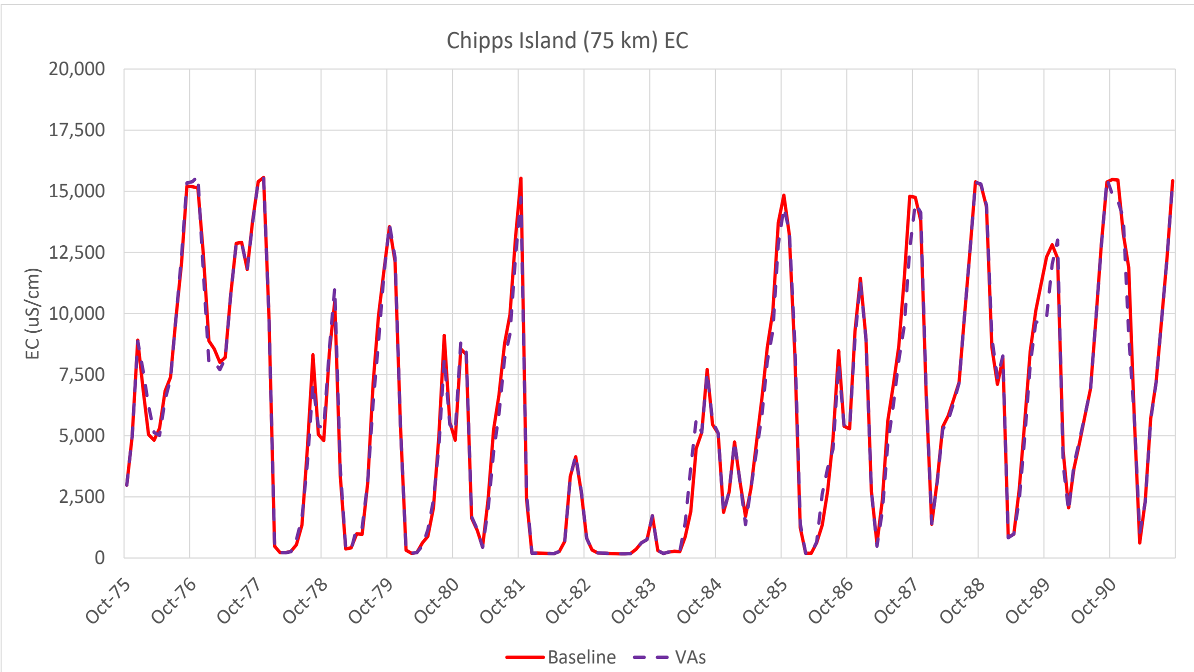
Specific information for particular locations with water quality objectives is summarized below in sections for Suisun Marsh and Delta fish and wildlife objectives, western and interior Delta agricultural objectives, municipal water supply objectives, and southern Delta agricultural objectives. The tables and figures used to evaluate DSM2 results for these locations provide specific information for the locations evaluated. The DSM2 results indicate that the proposed VAs would cause only small differences in EC from baseline conditions, with monthly average EC tending to be slightly less than baseline for most months.

G3b.3.2.2 Compliance with Suisun Marsh and Delta Fish and Wildlife EC Objectives

The Bay-Delta Plan includes fish and wildlife salinity objectives for five Suisun Marsh stations, one near the marsh entrance at Collinsville and four within the marsh (Table A2-1 in Appendix A2, *Delta Simulation Model II [DSM2] Methods and Results*). In addition, there are fish and wildlife objectives for the San Joaquin River reach between Jersey Point and Prisoners Point.

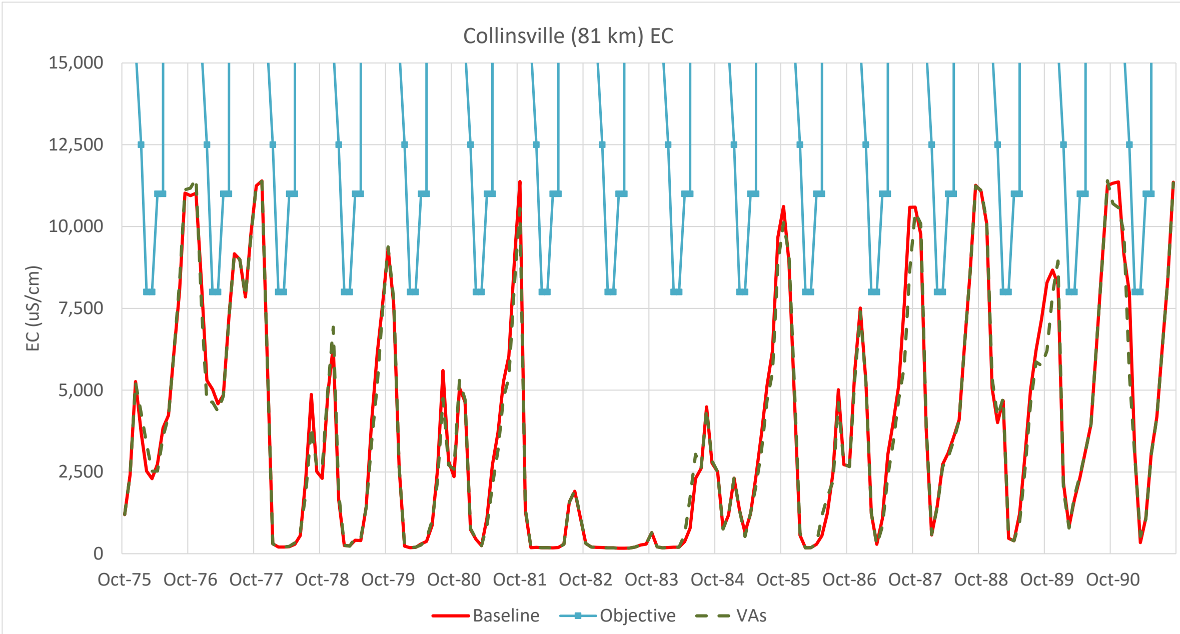
Tidal flows enter the Suisun Marsh channels at the mouth of Montezuma Slough and Suisun Slough, both located at the north end of Grizzly Bay. Because the Suisun Marsh channels are a network of dead-end tidal sloughs, the salinity generally decreases inland from Suisun Bay (for western marsh channels) and inland from the upstream end of Montezuma Slough (for eastern marsh channels). Fresh water enters the upstream end of Montezuma Slough at Collinsville, and the Montezuma Slough Salinity Control Gates (MSSCG) are operated (opened during ebb-tide, closed during flood-tide) from October through May each year to reduce salinity in Montezuma Slough and eastern marsh channels. In summer months, the gates are operated per California Department of Fish and Wildlife's Incidental Take Permit requirements.

As shown in Figure G3b-10 and Figure G3b-11, EC at Chipps Island and Collinsville under the proposed VAs is not expected to be substantially different from baseline conditions. In addition, Figure G3b-11 shows that the EC objective at Collinsville is expected to be satisfied for baseline and the proposed VAs. Table G3b-3 and Table G3b-4 quantify the simulated changes in EC at these two locations. At Chipps Island and Collinsville, percent change in EC between baseline and the proposed VAs would be low; generally, there would be more reductions in EC than increases (Table G3b-3 and Table G3b-4). Because the proposed VAs would cause little change in EC at Chipps Island and Collinsville, the proposed VAs would also cause little change in EC in Suisun Marsh during the October–May fish and wildlife objective period.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

Figure G3b-10. Time Series of DSM2 EC Values for Chipps Island – Baseline and the Proposed VAs for Water Years 1976–1991



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

Figure G3b-11. Time Series of DSM2 EC Values for Collinsville – Baseline and the Proposed VAs for Water Years 1976–1991 with EC Objectives for Reference

Table G3b-3. Cumulative Distribution of DSM2 EC Values for Chipps Island (75 km) – Baseline Compared with the Proposed VAs for Water Years 1976–1991

	Chipps Island EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	2,353	1,096	198	223	191	188	227	401	1,014	3,910	5,925	3,872	2,439
20%	4,805	2,415	2,704	319	192	215	619	889	2,045	4,881	8,312	5,393	4,580
30%	4,959	6,679	6,058	860	247	238	743	1,155	2,902	5,048	8,790	5,506	5,132
40%	5,286	8,554	8,323	1,383	368	411	978	1,893	4,480	7,138	9,915	11,232	5,141
50%	12,936	10,697	8,476	2,481	1,593	524	1,671	3,770	6,071	8,536	10,034	12,463	5,705
60%	14,754	12,815	8,913	4,369	2,728	617	2,382	5,244	6,671	8,650	10,119	13,713	7,358
70%	15,018	13,523	10,146	5,811	3,132	1,275	2,630	5,658	7,006	9,276	11,641	14,298	7,658
80%	15,269	14,369	11,444	7,104	5,043	3,666	4,713	5,824	7,183	9,780	12,048	15,209	8,543
90%	15,442	15,301	12,355	8,927	6,946	5,091	5,554	6,652	7,292	9,851	12,458	15,387	9,089
Average	9,867	9,288	7,455	3,866	2,580	1,733	2,420	3,754	5,125	7,310	9,472	10,299	6,097
Proposed VA Change from Baseline													
10%	2	-12	1	0	0	0	-7	104	144	-316	-277	196	129
20%	308	243	17	-4	2	0	-113	273	325	-421	-718	51	-64
30%	295	74	63	82	-1	0	72	650	486	-221	-745	17	-32
40%	44	296	108	27	11	-77	261	723	498	-807	-1,080	-1,573	43
50%	-1,183	-199	350	184	-43	-65	14	242	-334	-562	-798	-460	-258
60%	-430	-530	97	-552	21	212	-360	-877	-786	-571	-603	-1,065	-618
70%	-392	239	280	252	-24	-76	-50	-501	-428	-315	-913	-1,020	-38
80%	-394	67	-128	554	683	161	118	16	-28	19	250	136	-200
90%	-91	-224	5	-452	183	102	-238	-252	-39	15	9	5	-169
Average	-208	-7	134	-164	42	-5	-34	37	-20	-286	-480	-307	-108

µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

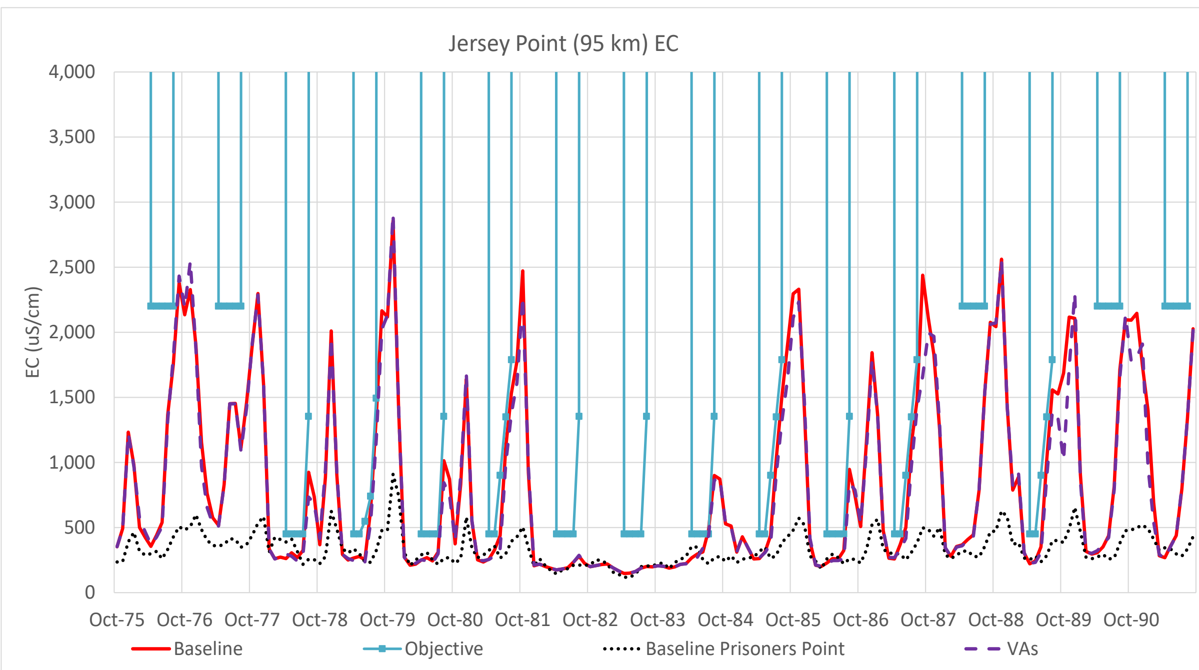
Table G3b-4. Cumulative Distribution of DSM2 EC Values for Collinsville (81 km) – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Fish and Wildlife Objectives Are Applicable (October – May)

	Collinsville EC (μS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	922	491	190	194	185	185	197	240	427	1,931	3,202	1,806	1,402
20%	2,305	1,306	1,182	235	186	198	291	380	865	2,463	4,870	2,725	2,730
30%	2,431	3,655	3,219	435	203	203	336	478	1,336	2,593	5,306	2,802	3,034
40%	2,679	5,073	4,639	574	253	243	397	784	2,298	4,047	6,043	7,169	3,127
50%	8,809	6,620	4,921	1,200	638	267	741	1,800	3,343	5,064	6,160	8,329	3,386
60%	10,591	8,673	5,263	2,167	1,229	340	1,091	2,716	3,710	5,144	6,229	9,681	4,452
70%	10,780	9,338	6,102	3,007	1,397	563	1,161	3,050	3,988	5,705	7,734	10,180	4,687
80%	11,078	10,096	7,510	4,011	2,528	1,664	2,327	3,149	4,092	6,304	8,015	11,024	5,475
90%	11,286	11,193	8,267	5,278	3,877	2,516	2,908	3,711	4,208	6,357	8,491	11,257	5,981
Average	6,675	6,209	4,582	2,212	1,375	917	1,238	2,062	2,932	4,404	6,004	6,937	3,796
Proposed VA Change from Baseline													
10%	1	-6	1	0	0	0	6	23	50	-231	-293	86	50
20%	201	71	11	-1	1	2	-24	82	142	-253	-459	-10	-75
30%	173	52	73	13	0	1	13	247	244	-168	-623	-12	-135
40%	-20	225	74	64	3	-10	106	380	291	-629	-891	-1,417	52
50%	-1,016	-48	255	115	-16	-11	-27	98	-254	-436	-701	-455	-161
60%	-469	-739	98	-197	13	128	-230	-638	-547	-432	-502	-1,023	-462
70%	-281	270	292	247	-16	-32	-6	-351	-308	-246	-869	-896	-58
80%	-374	74	-114	287	456	97	68	-15	-12	-14	269	106	-173
90%	-145	-215	11	-347	121	76	-174	-188	-24	31	-2	32	-138
Average	-206	-12	124	-141	23	3	-30	-35	-43	-214	-414	-299	-104

μS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

Jersey Point is located about 95 km upstream of the Golden Gate Bridge. Jersey Point has EC objectives for both fish and wildlife and for agriculture. The agricultural objectives are discussed in the next section, *Compliance with Western and Interior Delta Agricultural Objectives*. To meet the Jersey Point-Prisoners Point fish and wildlife objective, the 14-day running average EC during April and May must remain below 440 µS/cm for the San Joaquin River between Jersey Point and Prisoners Point. In general, EC at Jersey Point is much greater than EC at Prisoners Point (Figure G3b-12), so this discussion focuses on Jersey Point. The monthly objectives shown in Figure G3b-12 are the most restrictive of the fish and wildlife objectives for April and May and the agricultural objectives for April 1–August 15. The Jersey Point EC values for the proposed VAs are close to the baseline EC values. Both scenarios have some annual peaks exceeding 2,000 µS/cm, but neither of them exceed the April–May water quality objectives for fish and wildlife (Figure G3b-12).

Table G3b-5 gives the tabular summary of the DSM2 baseline EC and the changes in EC for the proposed VAs at Jersey Point for water years 1976–1991. This summary table clearly identifies the seasonal EC patterns and indicates that the EC generally will be slightly reduced for the proposed VAs relative to baseline. The changes during the April and May objective period are relatively small compared with the reductions later in the year. For example, under the proposed VAs, the average reduction in EC is 103 µS/cm in September but increases nominally during April (1 µS/cm) and is reduced by 15 µS/cm during May.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

The monthly objectives shown in the figure are the most restrictive of the fish and wildlife objectives for April and May and the agricultural objectives for April 1–August 15.

Figure G3b-12. Time Series of DSM2 EC Values for Jersey Point – Baseline and the Proposed VAs for Water Years 1976–1991 with EC Objectives for Reference

Table G3b-5. Cumulative Distribution of DSM2 EC Values for Jersey Point – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Fish and Wildlife Objectives Are Applicable (April 1–August 15)

Jersey Point EC (µS/cm)													
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	280	350	211	220	206	194	198	213	217	272	590	481	411
20%	368	511	312	272	211	219	228	261	253	324	924	743	651
30%	441	860	1,241	338	235	229	254	273	263	403	980	872	784
40%	528	922	1,393	391	260	250	259	296	313	639	1,112	1,461	800
50%	1,791	1,494	1,421	488	286	261	262	308	394	792	1,344	1,652	820
60%	2,043	2,116	1,599	788	317	272	265	328	439	820	1,480	1,906	902
70%	2,102	2,222	1,691	906	409	290	268	355	439	1,010	1,515	2,052	983
80%	2,118	2,328	1,843	981	501	304	307	371	443	1,115	1,535	2,096	1,077
90%	2,216	2,447	1,955	1,259	728	389	361	424	519	1,257	1,636	2,273	1,114
Average	1,337	1,480	1,280	653	381	282	275	336	420	750	1,196	1,469	822
Proposed VA Change from Baseline													
10%	0	0	3	0	0	0	2	-7	-8	-26	-79	-25	-10
20%	30	-8	0	-1	6	3	-4	-29	-19	-29	-82	5	-53
30%	31	63	11	2	-1	7	-12	-28	-19	-35	-126	-40	-31
40%	3	43	11	25	0	12	-8	-25	-6	-98	-23	-120	-29
50%	-393	-84	32	3	-1	5	-1	-28	-54	2	-102	-137	-28
60%	-134	-308	1	37	-6	0	1	-21	-67	-10	-136	-265	-19
70%	-68	-120	42	-16	2	7	15	-11	-20	-123	-132	-213	-35
80%	-7	-42	27	-16	40	2	15	2	-14	-136	-117	-71	-60
90%	-54	102	-20	-290	-115	19	4	-10	-47	-99	-42	-178	-73
Average	-80	-21	23	-37	-10	3	1	-15	-25	-52	-79	-103	-33

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

G3b.3.2.3 Compliance with Western and Interior Delta Agricultural Objectives

The Bay-Delta Plan EC objectives for the agricultural stations in the western and interior Delta (Sacramento River at Emmaton, San Joaquin River at Jersey Point, San Joaquin River at San Andreas Landing, and South Fork Mokelumne River at Terminous) are applicable April 1–August 15 and vary by month, water year type, and location. The actual objective is a 14-day running average EC that begins on April 1, but changes for some water year types to a second value on a specified date, which remains applicable through August 15. Because the DSM2 EC results are monthly averages, when the objective changes within a month, the EC objectives must be adjusted to "approximate" monthly average values (see Section A2.2.5, *Evaluating Compliance with Water Quality Objectives*, in Appendix A2 for a description of the method used for approximating monthly objectives). Because the EC objectives end on August 15, the average DSM2 monthly EC values could be greater than the August 1–15 EC objective but would still be in compliance with the EC objective.

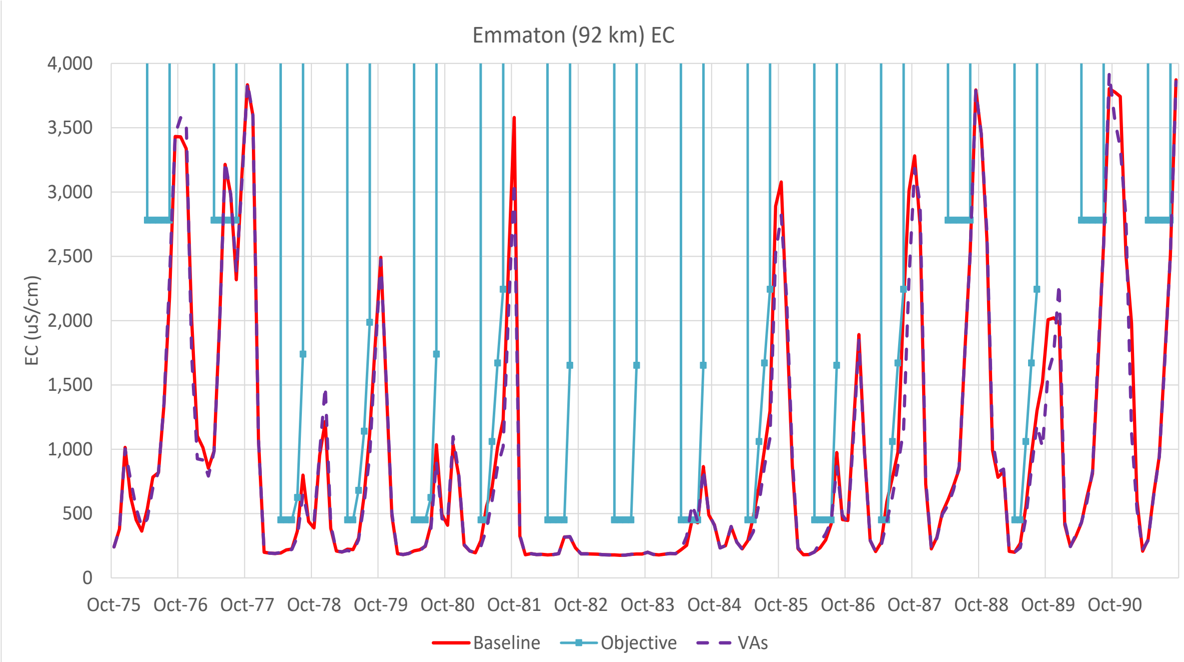
To check compliance with the agricultural EC objectives, monthly EC values were compared to the monthly EC objectives for all months simulated. There are no monthly exceedances of the San Andreas Landing or Terminous objectives under baseline conditions or under the proposed VAs. Minor exceedances at Emmaton and Jersey Point are discussed with the more detailed text that follows. The proposed VAs would not cause an increase in exceedances of the western and interior Delta agricultural objectives.

Emmaton

Figure G3b-13 compares the DSM2 Emmaton EC for the baseline and for the proposed VAs for water years 1976–1991. Emmaton is located about 92 km upstream of the Golden Gate Bridge. Outflow is likely controlled by the Emmaton EC objective when the DSM2 EC is close to the objective line, which tends to occur late in the objective period (e.g., July and August).

The Emmaton EC for the proposed VAs is close to the baseline EC. Table G3b-6 gives the tabular summary of the DSM2 baseline EC and the EC changes for the proposed VAs at Emmaton for water years 1976–1991. This summary table clearly identifies the seasonal EC patterns and indicates that the percent change in EC between baseline and the proposed VAs would be low, and in general, the proposed VAs would cause more reductions in EC than increases.

The increases in EC do not result in exceedances of water quality objectives beyond what is simulated for baseline conditions. There are six minor exceedances of the objectives for baseline conditions and three for the proposed VAs out of 80 months with objectives that are simulated (16 years times 5 months per year of objectives). It is likely that reservoir releases and exports would be controlled to provide sufficient Delta inflow and outflow to meet objectives more precisely than what was modeled by SacWAM.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

Figure G3b-13. Time Series of DSM2 EC Values for Emmaton – Baseline and the Proposed VAs for Water Years 1976–1991 with EC Objectives for Reference

Table G3b-6. Cumulative Distribution of DSM2 EC Values for Emmaton – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Agricultural Objectives Are Applicable (April 1–August 15)

	Emmaton EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	220	211	182	186	181	182	186	200	207	341	558	336	412
20%	389	325	250	188	182	188	200	219	245	412	865	454	633
30%	410	666	606	212	191	189	206	227	302	424	1,005	491	673
40%	447	1,036	798	227	209	195	219	254	452	640	1,126	1,520	761
50%	2,250	1,317	933	320	227	203	249	372	630	965	1,263	2,157	855
60%	3,078	2,013	1,015	398	278	207	289	554	708	1,002	1,298	2,891	1,014
70%	3,355	2,328	1,144	523	303	217	293	611	793	1,178	2,158	3,063	1,102
80%	3,453	2,736	1,892	782	450	323	428	651	818	1,686	2,319	3,433	1,412
90%	3,678	3,467	1,995	1,039	715	436	570	750	895	1,729	2,519	3,798	1,702
Average	1,951	1,626	1,023	520	347	275	332	510	704	1,011	1,462	2,003	980
Proposed VAs Change from Baseline													
10%	0	-1	0	0	0	0	2	-8	-2	-24	-71	5	-13
20%	19	7	1	0	0	0	0	-12	5	-30	-22	7	-13
30%	23	11	28	1	0	0	-2	-6	19	14	-117	2	-40
40%	-8	63	18	9	1	2	-5	23	17	-63	-170	-506	-74
50%	-219	-22	36	9	0	0	-18	-31	-57	-113	-210	-226	-36
60%	-259	-269	54	16	1	0	-37	-175	-106	-131	-149	-558	-85
70%	-225	99	138	75	-3	5	-8	-95	-67	-65	-397	-270	-41
80%	-1	167	-163	38	81	12	3	-9	11	-5	63	16	-17
90%	-109	-23	73	-94	-21	10	-58	-58	10	14	2	26	-53
Average	-81	-3	47	-51	-4	-1	-13	-37	-15	-36	-118	-120	-36

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

Jersey Point

Jersey Point EC values relative to the Bay-Delta Plan fish and wildlife objectives are discussed in the section above, *Compliance with Suisun Marsh and Delta Fish and Wildlife EC Objectives,* which includes a graphical comparison of DSM2 Jersey Point EC for the baseline and for the proposed VAs for water years 1976–1991 (Figure G3b-12, Table G3b-5). Jersey Point EC increases when the net flows at Jersey Point are reversed (negative, upstream), which is caused by higher Delta exports compared to San Joaquin River inflow plus Sacramento River diversions to DCC and Georgiana Slough. The monthly Jersey Point objectives in Figure G3b-12 show the most restrictive of the April-May fish and wildlife objective and the April–August agricultural objectives. In all but critical year types, the April–May fish and wildlife objective is slightly more stringent than the agricultural objective for April and May (440 µS/cm compared with 450 µS/cm). However, because EC increases through summer as Delta outflow decreases, an exceedance of the agricultural objective is more likely to occur than an exceedance of the fish and wildlife objective.

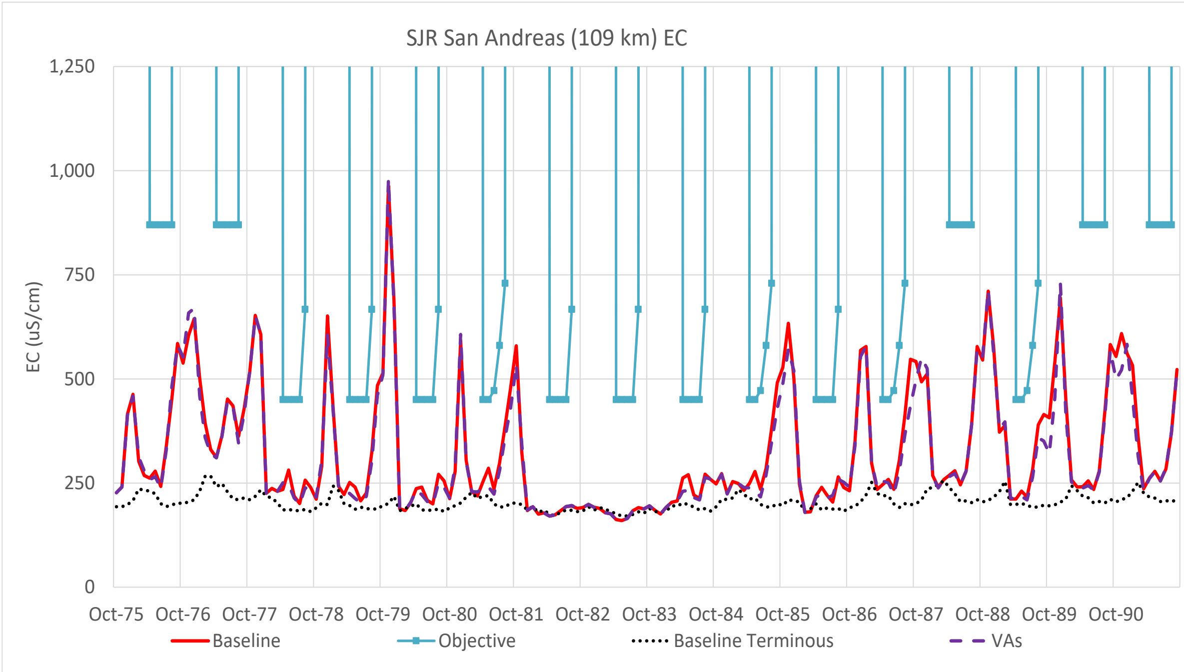
The agricultural EC objectives for Jersey Point were established in State Water Board Water Right Decision 1485 (1978). The 14-day running average EC must be less than the specified EC objectives during the April 1 to August 15 period; the EC objectives are different for each water year type. The EC objective is 450 µS/cm in wet and above-normal years, 2,200 µS/cm in critical years, begins at 450 µS/cm but increases to 740 on June 20 in below-normal years, and begins at 450 µS/cm but increases to 1,350 µS/cm on June 15 in dry years. The monthly average EC objectives are shown in Figure G3b-12 (see Section G3b.2 for a discussion of estimating objectives that change within a month).

The highest Jersey Point EC values are often in September through November (Table G3b-5), when there are no EC objectives at Jersey Point. The DSM2 results show that the proposed VAs would generally be similar to or slightly reduce EC at Jersey Point. In December, March, and April there are small increases in average EC; but more months have decreases, and the decreases are larger, with the largest reductions in average values occurring in September. During the April–August period for agricultural objectives, the largest reduction in monthly average EC under the proposed VAs is 79 µS/cm (in August).

There is one minor exceedance of the objectives for baseline conditions (by 31 µS/cm) and none for the proposed VAs out of the 80 months with objectives during the 16-year simulation period.

San Andreas Landing

Figure G3b-14 and Table G3b-7 compare the DSM2 San Andreas Landing EC for the baseline and for the proposed VAs for water years 1976–1991. San Andreas Landing is located on the San Joaquin River at the mouth of the Mokelumne River, about 109 km upstream of the Golden Gate Bridge. The San Andreas Landing EC for the proposed VAs is almost the same as the baseline EC. EC at San Andreas Landing is always less than April–August EC objectives for both baseline and the proposed VAs (Figure G3b-14).



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

Figure G3b-14. Time Series of DSM2 EC Values for San Andreas Landing – Baseline and the Proposed VAs for Water Years 1976–1991 with EC Objectives for Reference

Table G3b-7. Cumulative Distribution of DSM2 EC Values for San Andreas Landing – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Agricultural Objectives Are Applicable (April 1–August 15)

	San Andreas Landing EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	203	220	188	190	179	180	191	202	196	197	226	214	225
20%	213	272	225	193	184	203	219	240	208	201	265	239	283
30%	229	284	459	237	217	209	236	240	218	209	271	257	310
40%	248	324	512	253	237	219	241	255	221	226	325	415	315
50%	460	422	565	286	241	226	248	264	228	278	366	453	332
60%	517	541	575	372	249	232	251	278	235	281	380	484	346
70%	533	607	600	441	278	235	257	278	235	284	388	507	359
80%	542	633	644	463	302	240	262	279	242	298	390	547	379
90%	550	682	670	517	375	263	265	283	251	322	417	580	393
Average	390	459	487	337	258	227	240	257	236	263	334	405	324
Proposed VAs Change from Baseline													
10%	1	0	0	0	0	0	-1	-9	-3	0	-9	-2	-5
20%	4	-2	-1	0	0	1	-3	-22	-3	-1	-15	0	-15
30%	4	13	7	3	0	1	-8	-17	-6	5	-10	-1	-9
40%	1	16	13	2	-1	10	-8	-24	-6	-6	-22	-64	-11
50%	-56	-22	-8	-3	0	3	-10	-28	-12	-12	-19	-31	-2
60%	-20	-19	8	8	0	-1	-13	-34	-11	-5	-22	-54	-6
70%	-29	-46	7	-22	-2	4	-5	-29	-7	-5	-25	-59	-7
80%	-24	18	-37	-9	10	0	-4	-14	-4	-18	-17	-27	-14
90%	-6	4	3	-58	-38	5	-2	-8	0	-15	-18	-9	-18
Average	-15	-5	2	-10	-4	2	-5	-17	-5	-5	-13	-22	-8

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

Terminous

Table G3b-8 gives the tabular summary of the DSM2 baseline EC for South Fork Mokelumne River at Terminous for water years 1976–1991; the baseline time series for Terminous EC can be seen in Figure G3b-14. The agricultural EC objective at Terminous is only slightly more stringent than the objectives for San Andreas Landing. The lowest objective for both locations is 450 µS/cm. Because the baseline EC at Terminous (Figure G3b-14) is always less than 270 µS/cm and because the EC at Terminous would not change much under the proposed VAs, there would be no exceedances of the EC objectives.

Table G3b-8. Cumulative Distribution of DSM2 Baseline EC Values for South Fork Mokelumne River at Terminous for Water Years 1976–1991 with Highlighting to Indicate When Agricultural Objectives Are Applicable (April 1–August 15)

South Fork Mokelumne at Terminous Baseline EC (µS/cm)													
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10%	190	193	185	187	185	187	181	179	182	184	186	181	187
20%	190	194	198	194	189	194	196	186	185	185	188	182	192
30%	192	197	200	206	205	197	199	187	191	187	188	183	197
40%	193	198	204	212	227	200	200	198	192	188	189	188	200
50%	196	201	206	215	233	208	207	207	197	192	192	197	207
60%	197	205	209	218	236	223	216	214	200	192	193	200	208
70%	201	209	213	226	245	225	218	217	200	193	199	202	209
80%	202	210	216	230	252	232	220	220	202	205	202	209	212
90%	205	211	226	235	253	244	235	224	206	208	204	210	220
Average	196	202	206	214	224	214	208	204	196	193	194	195	204

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

G3b.3.2.4 Compliance with Municipal Water Supply Objectives

The municipal water quality objectives are given in units of chloride concentration in Table 1 of the Bay-Delta Plan (see Table A2-1 in Appendix A2, *Delta Simulation Model II [DSM2] Methods and Results*). Antioch was the original water supply pumping facility in the Delta, and the Contra Costa Canal began operations in 1950 as the first "Delta facility" of the U.S. Bureau of Reclamation's CVP. Chloride was the standard measure of salinity because chloride could be accurately determined with a chemical titration procedure. However, EC is now the primary measurement of Delta salinity.

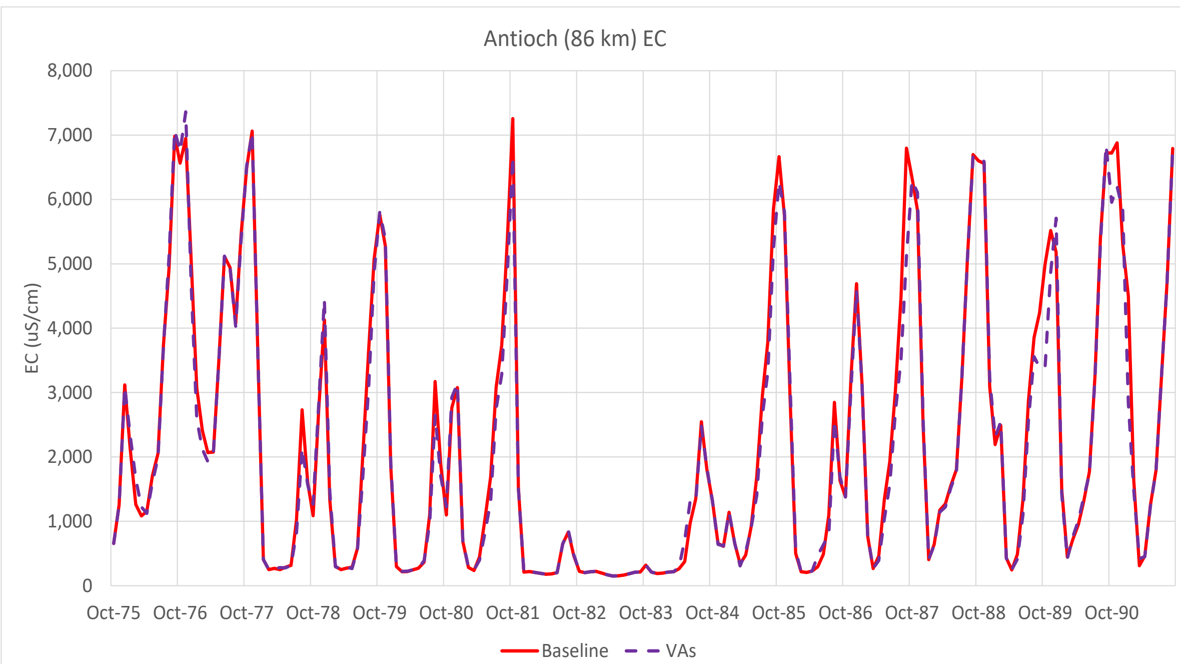
The chloride objective is generally 250 milligrams per liter (mg/L), with some periods (155 to 240 days during each calendar year, depending on the water year type) of 150 mg/L chloride at the Antioch intake or at the Contra Costa Water District (CCWD) Pumping Plant #1, which draws water from the western end of Rock Slough. Rock Slough connects with Old River downstream of the Old River at the Bacon Island EC station. In addition, there is a secondary drinking water maximum contaminant level of 250 mg/L for chloride that is applicable to all drinking water intakes. As described in Appendix A2, Section A2.2.4, *Relationship between EC, Chloride, and Bromide*, the 250-mg/L and 150-mg/L chloride objectives correspond to EC values of approximately 1,000 µS/cm and 700 µS/cm, respectively.

The 1,000-µS/cm surrogate chloride objective is conveniently in agreement with the agricultural EC objective at the CVP and SWP export locations (Table 3 in the Bay-Delta Plan and Table A2-1 in Appendix A2, *Delta Simulation Model II [DSM2] Methods and Results*). Due to this agreement, attainment of CVP and SWP water quality objectives for municipal and agricultural beneficial uses are assessed together in this section.

In general, the proposed VAs would have minimal effect on EC at each of the municipal water intakes and therefore would have little effect on the chloride and bromide concentrations at each water intake as well. More information for specific locations is provided below, starting with the more westerly sites and then moving inland.

Mallard Slough and Antioch

CCWD operates the Mallard Slough Pumping Plant for municipal water supply whenever the EC at Chipps Island (Figure G3b-10 above) is acceptable, and the City of Antioch operates the water supply pumping plant when the EC at Antioch (Figure G3b-15) is acceptable. Typically, EC at these locations is either too high for municipal intake or is well below the 1,000-µS/cm objective; these conditions would be similar under the proposed VAs.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

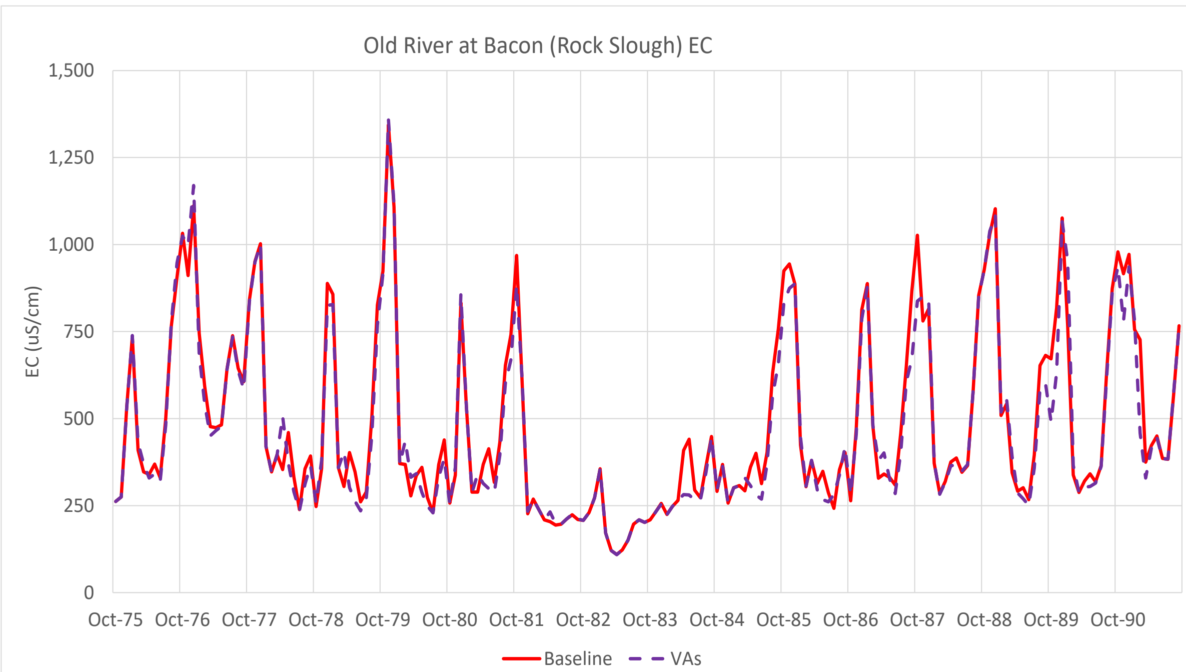
Figure G3b-15. Time Series of DSM2 EC Values for Antioch EC – Baseline and the Proposed VAs for Water Years 1976–1991

CCWD Pumping Plant #1 (Rock Slough)

Figure G3b-16 and Table G3b-9 compare DSM2 Old River at Bacon Island EC for the baseline and for the proposed VAs for water years 1976–1991. This is the "effective" EC compliance location for the CCWD Contra Costa Canal Rock Slough intake, located about 3 miles west of Old River.

The average monthly EC in Old River at Bacon Island is almost always less than 1,000 µS/cm, but there are some exceptions: 9 for baseline and 8 for the proposed VAs. In general, exceedances of the 250-mg/L objective at the Rock Slough intake are expected to be rare and the proposed VAs are not expected to cause an increase in exceedances of the objectives. The proposed VAs are expected to typically result in minimal change.

In addition, the proposed VAs are not expected to cause an increase in violations of the objective of having chloride less than or equal to 150 mg/L for a certain number of days depending on water year type. The annual requirement ranges from 155 days (about 5 months) for critically dry years to 240 days (about 8 months) for wet water years. One of the worst water years for salinity intrusion was 1977, which was critically dry (so chloride may exceed 150 mg/L for about 7 months out of the year). During this time, the DSM2 baseline results show only 5 months with average EC greater than 700 µS/cm, the EC surrogate for 150 mg/L chloride. For this same period, the proposed VAs have only 4 months with average EC greater than 700 µS/cm. Based on these results, neither baseline nor the proposed VAs are expected to cause a violation of the 150-mg/L objective.



µS/cm = microSiemens per centimeter; CCWD = Contra Costa Water District; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

Figure G3b-16. Time Series of DSM2 EC Values for Old River at Bacon Island (CCWD Rock Slough Intake) – Baseline and the Proposed VAs for Water Years 1976–1991

Table G3b-9. Cumulative Distribution of DSM2 EC Values for Old River at Bacon Island (CCWD Rock Slough Intake) – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Municipal Objectives Are Applicable (year-round)

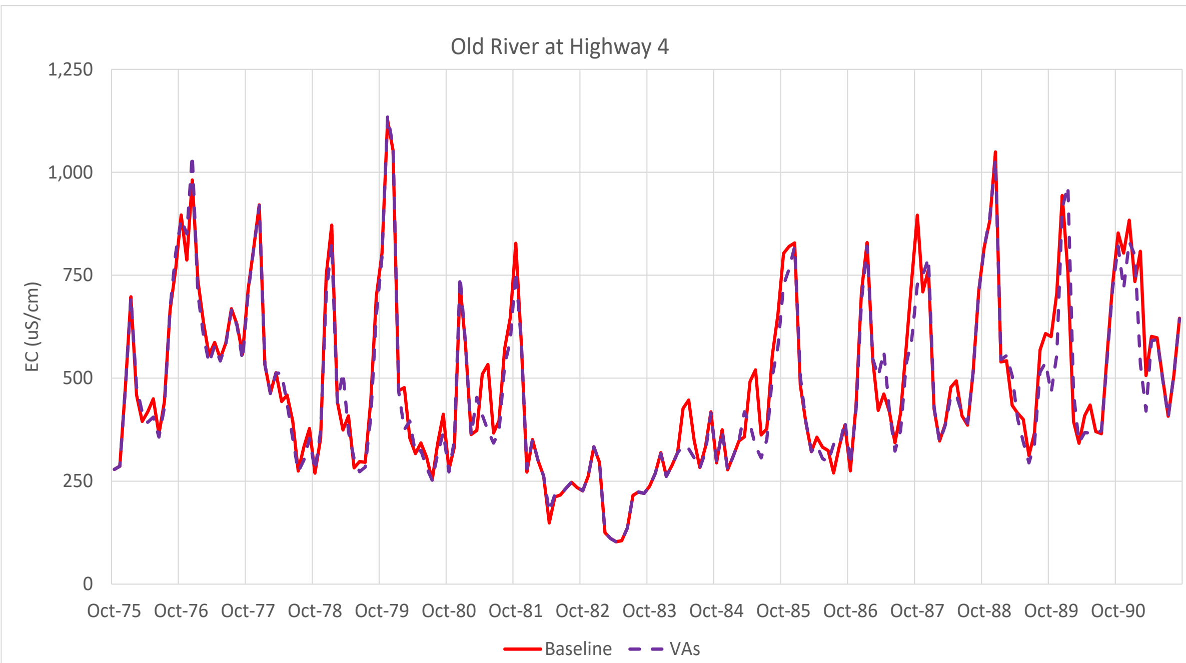
	Old at Bacon EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	228	254	257	285	243	237	248	248	229	221	288	301	309
20%	257	338	273	356	285	278	314	331	267	239	356	403	390
30%	263	362	675	371	297	288	329	344	280	258	365	444	463
40%	291	471	815	419	308	293	340	349	295	290	505	606	481
50%	756	691	860	467	343	312	347	365	311	365	573	712	496
60%	924	819	888	533	359	329	360	387	317	383	630	757	517
70%	926	914	987	740	389	346	372	407	324	399	640	796	538
80%	969	944	1,077	756	478	375	402	440	331	432	651	854	568
90%	1,003	991	1,105	811	567	388	415	455	366	480	653	870	614
Average	627	661	760	533	375	314	339	359	314	358	510	623	481
Proposed VAs Change from Baseline													
10%	3	0	-2	0	0	0	9	-17	-13	0	-20	-13	-16
20%	-1	22	0	0	-3	10	-27	-64	-18	-3	-24	-17	-32
30%	9	10	-15	0	0	35	-30	-69	-24	11	-24	-11	-23
40%	3	-17	10	1	0	37	-37	-68	-29	-8	-52	-21	-16
50%	-95	-70	-10	16	10	24	-37	-71	-35	-5	-5	-84	-6
60%	-88	-39	-1	2	7	42	-31	-81	-30	-15	-49	-88	-14
70%	-66	-52	-19	-28	44	35	-19	-74	-22	-23	-47	-79	-7
80%	-53	5	-11	25	-20	16	-1	-73	-10	-37	-46	-86	-21
90%	-71	27	-6	43	-56	12	25	-46	1	-38	-24	-14	-29
Average	-36	-11	-2	10	-12	18	-11	-53	-17	-11	-25	-36	-16

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

CCWD Old River Intake

CCWD constructed the Old River intake near the Highway 4 bridge in 1997 as part of the Los Vaqueros Project. Figure G3b-17 and Table G3b-10 compare DSM2 Old River at Highway 4 EC for the baseline and for the proposed VAs for water years 1976–1991.

Monthly average simulated EC at this location exceeds 1,000 µS/cm, the EC surrogate for 250 mg/L chloride, during only 3 months for the baseline simulation and only 4 months for the proposed VAs. The one extra exceedance with the proposed VAs is due to a small increase in EC that does not represent a general trend of higher values. On a daily basis, it is possible that EC could exceed 1,000 µS/cm more frequently. However, because the EC simulated for the proposed VAs is so similar to baseline EC and there are more slight reductions in EC with the proposed VAs than increases, the proposed VAs are not expected to cause a substantial change in the number of exceedances of the 250-mg/L daily objective.



µS/cm = microSiemens per centimeter; CCWD = Contra Costa Water District; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

Figure G3b-17. Time Series of DSM2 EC Values for Old River at Highway 4 (CCWD Old River Intake) – Baseline Compared with the Proposed VAs for Water Years 1976–1991

Table G3b-10. Cumulative Distribution of DSM2 EC Values for Old River at Highway 4 (CCWD Old River Intake) – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Municipal Objectives Are Applicable (year-round)

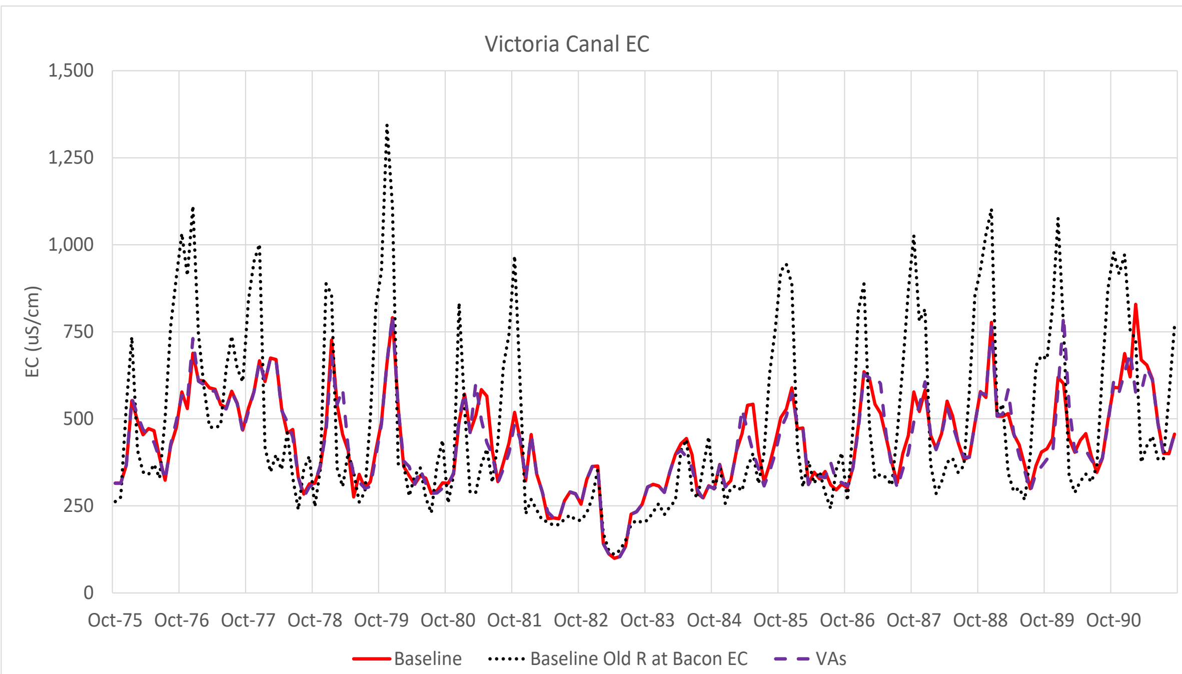
	Old River at Highway 4 EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	254	278	298	303	294	291	233	247	257	243	290	306	327
20%	275	334	333	351	348	322	356	332	308	270	333	386	410
30%	278	364	595	448	355	348	408	371	318	279	338	415	464
40%	295	434	728	484	394	357	415	417	343	296	448	558	473
50%	658	644	757	536	419	374	422	441	355	366	510	627	495
60%	802	710	828	581	459	388	443	450	364	377	549	647	520
70%	810	795	902	716	470	409	470	476	369	391	561	677	532
80%	828	815	944	737	542	434	492	520	396	408	572	710	550
90%	874	851	1,016	793	590	510	548	541	454	429	603	732	616
Average	567	597	706	555	433	377	411	411	352	353	462	550	481
Proposed VAs Change from Baseline													
10%	2	0	0	0	0	0	14	14	-12	0	-15	-11	-12
20%	1	16	0	0	-3	0	-20	-28	-25	3	-17	-18	-37
30%	6	8	-13	1	-1	17	-56	-44	-23	4	-11	-9	-14
40%	2	-11	-23	21	-19	39	-44	-83	-37	43	-41	-20	-12
50%	-72	-74	13	3	0	44	-32	-85	-41	-21	-3	-67	-4
60%	-76	7	-9	4	4	32	-42	-77	-22	-7	-36	-56	-12
70%	-66	-38	-30	-16	1	70	-36	-64	-13	-19	-38	-58	-9
80%	-34	-2	-25	61	-7	72	19	-82	-29	-17	-37	-58	-13
90%	-56	20	22	32	-39	4	23	-40	2	-12	-20	-20	-27
Average	-31	-9	-4	14	-19	24	-17	-45	-18	-5	-19	-28	-13

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

CCWD Middle River Intake (Victoria Canal)

CCWD constructed the Middle River intake on Victoria Canal in 2005. This location often has the lowest EC of the CCWD intakes. Victoria Canal connects Middle River with Old River and West Canal; the Middle River portion of the "reversed" OMR flows moves through Victoria Canal.

Figure G3b-18 and Table G3b-11 compare DSM2 Victoria Canal EC for the baseline and for the proposed VAs for water years 1976–1991. Because most of the Victoria Canal water originates from the Sacramento River diversions to the DCC and Georgiana Slough, the maximum baseline EC in Victoria Canal during summer and fall months of years with low outflow is considerably lower (e.g., some peaks 250 µS/cm less) than baseline EC in Old River at Bacon Island (Figure G3b-18). There is much less of an effect from seawater intrusion in Victoria Canal than in Old River at Bacon Island or at Highway 4. The Victoria Canal EC values for the proposed VAs are close to the baseline EC values. Under both baseline and the proposed VAs, monthly average EC is well below 1,000 µS/cm, the EC surrogate for 250 mg/L chloride.



µS/cm = microSiemens per centimeter; CCWD = Contra Costa Water District; EC = electrical conductivity; km = kilometer; VA = proposed Voluntary Agreements

Figure G3b-18. Time Series of DSM2 EC Values for Victoria Canal EC (CCWD Middle River Intake) for Baseline and for the Proposed VAs for Water Years 1976–1991

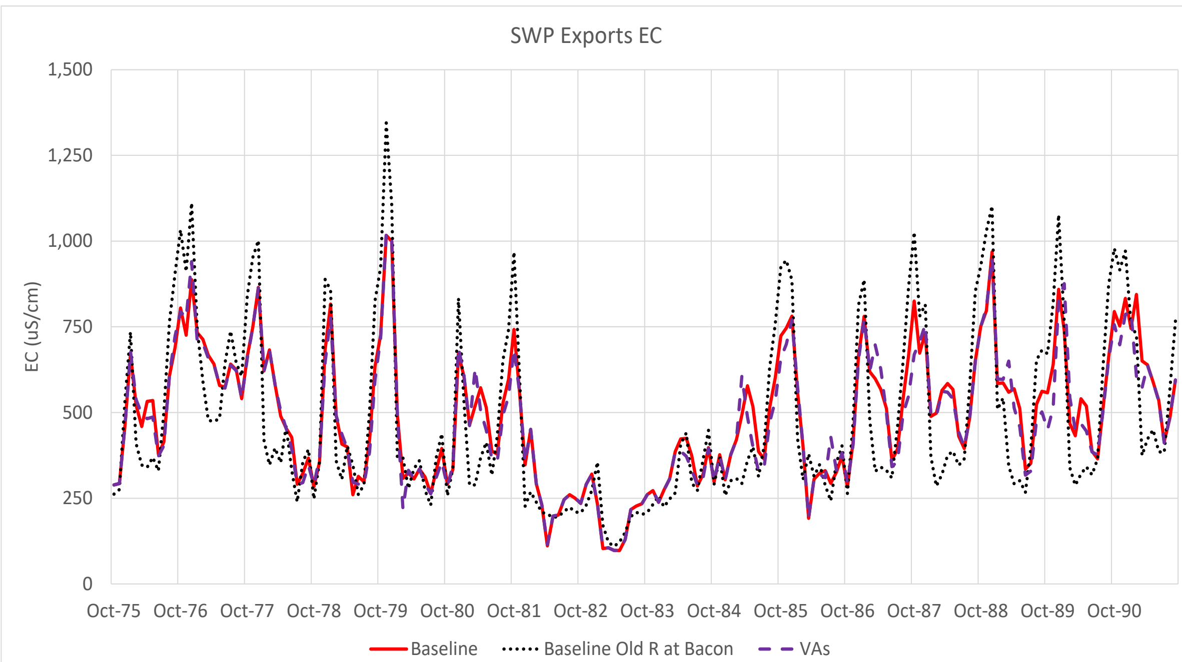
Table G3b-11. Cumulative Distribution of DSM2 EC Values for Victoria Canal EC (CCWD Middle River Intake) – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Municipal Objectives Are Applicable (year-round)

	Victoria Canal EC (µS/cm)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	301	320	315	343	345	301	263	246	271	275	278	296	331
20%	304	341	363	453	363	336	347	327	341	286	290	312	397
30%	315	361	423	463	412	401	419	381	357	300	295	314	406
40%	315	369	483	508	444	454	438	443	375	311	320	405	421
50%	452	441	537	543	468	456	464	451	391	317	367	420	434
60%	504	521	589	571	494	458	516	459	398	320	374	433	453
70%	524	529	643	604	524	512	535	487	407	328	388	454	467
80%	577	562	688	611	609	542	551	541	431	346	400	468	480
90%	578	583	733	628	645	629	584	553	479	392	411	481	540
Average	430	452	533	520	479	448	446	420	376	331	353	394	432
Proposed VAs Change from Baseline													
10%	2	0	3	0	0	0	9	29	-8	0	-6	-3	-5
20%	3	4	0	2	15	26	-10	12	-23	5	-3	-8	-21
30%	-2	1	-9	8	-2	1	-12	-8	-16	-3	3	-3	5
40%	1	-1	-10	0	17	0	-20	-49	-18	-9	1	-41	0
50%	-24	-22	1	2	25	43	-8	-45	-30	-6	-21	-23	-6
60%	-20	-14	-4	3	20	119	-50	-27	-16	3	-19	-32	3
70%	-35	16	-24	4	16	69	-24	-45	-16	18	-17	-24	0
80%	-56	8	-22	17	-33	44	-19	-59	1	29	-10	-6	-4
90%	-6	-6	15	58	-37	-16	6	-40	-12	2	3	5	-9
Average	-12	-1	-4	15	-8	24	-10	-21	-14	3	-7	-12	-4

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

SWP Exports

The agricultural and municipal EC objectives for the SWP exports are both 1,000 μS/cm (250 mg/L chloride) year round, although the municipal objective is somewhat more restrictive because it is a daily objective instead of a monthly objective (see Table A2-1 in Appendix A2, *Delta Simulation Model II [DSM2] Methods and Results*). Figure G3b-19 and Table G3b-12 compare DSM2 Clifton Court Forebay (SWP Export) EC for the baseline and for the proposed VAs for water years 1976–1991. The baseline peak SWP export EC values are slightly lower than the peak Old River at Bacon Island EC values (Figure G3b-19), indicating that lower Victoria Canal EC is mixed with the Old River EC in the SWP exports. The SWP export EC values for baseline and the proposed VAs are similar, with some instances of slightly higher and lower values for the proposed VAs. EC at the SWP exports is almost always less than 1,000 μS/cm. In 1 month under baseline conditions, monthly average EC exceeds the objective of 1,000 μS/cm, and in 2 months under the proposed VAs. The difference in simulated EC values that causes this difference in exceedances is very small and not indicative of the proposed VAs being likely to cause increased exceedances.



μS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

Figure G3b-19. Time Series of DSM2 EC Values for SWP Exports – Baseline and the Proposed VAs for Water Years 1976–1991 with Baseline Old River at Bacon Island EC for Reference

Table G3b-12. Cumulative Distribution of DSM2 EC Values for Clifton Court Forebay – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Agricultural and Municipal Objectives Are Applicable (year-round)

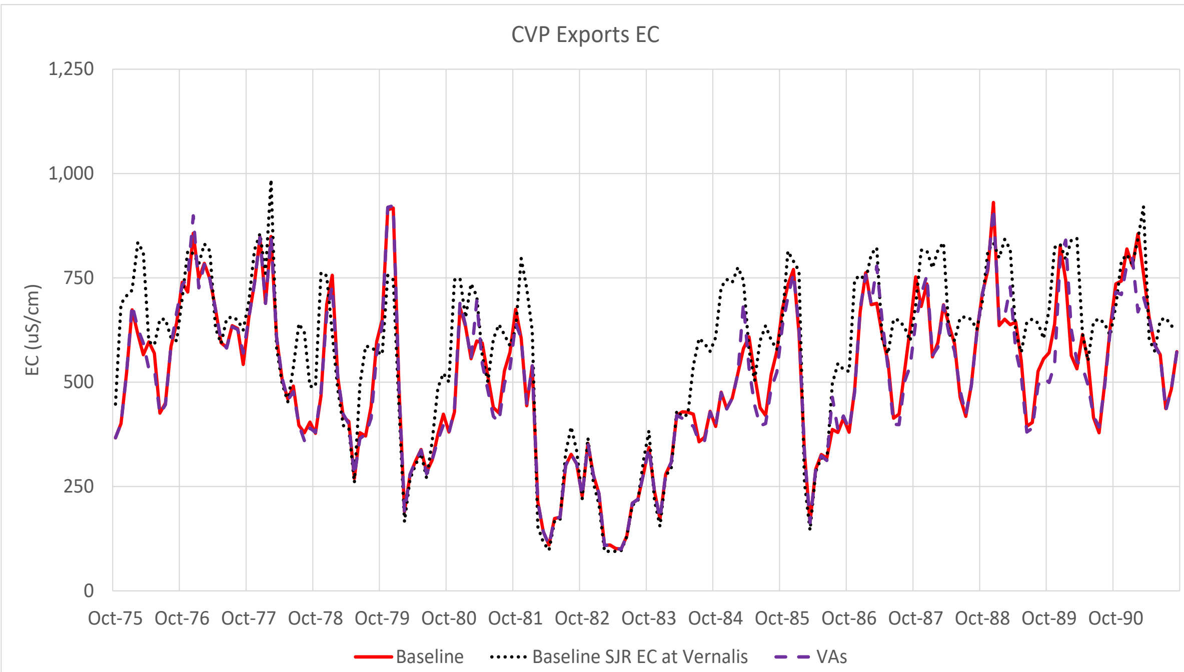
	Clifton Court EC (µS/cm)												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	272	292	312	326	299	212	209	228	256	255	290	309	327
20%	284	333	348	451	308	323	307	323	314	286	322	373	436
30%	290	366	565	492	411	397	411	380	333	292	328	396	447
40%	297	414	671	560	463	433	490	454	360	298	420	541	484
50%	611	599	708	595	480	476	536	512	376	358	484	578	488
60%	724	673	781	621	498	520	568	515	386	365	512	597	533
70%	734	736	846	702	554	562	570	518	387	386	519	618	550
80%	752	748	865	740	619	581	578	535	427	395	527	651	575
90%	800	775	928	763	698	625	612	573	484	415	574	664	624
Average	533	562	664	574	483	448	460	433	366	351	439	514	485
Proposed VAs Change from Baseline													
10%	1	0	-1	0	-44	0	3	19	-10	0	-11	-10	-7
20%	5	13	7	0	-2	8	1	-4	-22	2	-14	-16	-24
30%	2	6	-11	1	1	14	-21	-26	-19	-3	-7	-8	-3
40%	2	-8	-18	16	-2	16	-22	-54	-31	32	-35	-39	-13
50%	-57	-62	15	8	10	53	-52	-64	-38	-9	-10	-41	-6
60%	-65	24	-10	0	40	53	-63	-61	-21	-7	-27	-50	-7
70%	-57	-33	-40	-8	16	32	-61	-46	-9	2	-29	-46	-11
80%	-35	-1	-1	34	-13	47	-18	-36	-34	9	-30	-56	-12
90%	-47	16	18	22	-47	30	20	-13	5	6	-16	-12	-24
Average	-27	-7	-3	10	-15	26	-20	-26	-16	2	-16	-23	-10

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

CVP Exports

The EC objective for the CVP exports is the same as for SWP exports, 1,000 µS/cm. Figure G3b-20 and Table G3b-13 compare DSM2 CVP exports EC for the baseline and for the proposed VAs for water years 1976–1991. The EC at the Delta-Mendota Canal intake is largely San Joaquin River EC, with some Old River at Highway 4 EC and some Victoria Canal EC. The EC of CVP exports is often slightly lower than the EC in the San Joaquin River at Vernalis, indicating that some “reversed” OMR flow is mixed with the San Joaquin River EC in the CVP exports.

The EC objective of 1,000 µS/cm is satisfied for the baseline and for the proposed VAs. The CVP export EC values for the proposed VAs are close to the baseline EC patterns, with small differences following the same approximate pattern as the differences at the SWP exports.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

Figure G3b-20. Time Series of DSM2 EC Values for CVP Exports – Baseline and the Proposed VAs for Water Years 1976–1991 with Baseline San Joaquin River EC for Reference

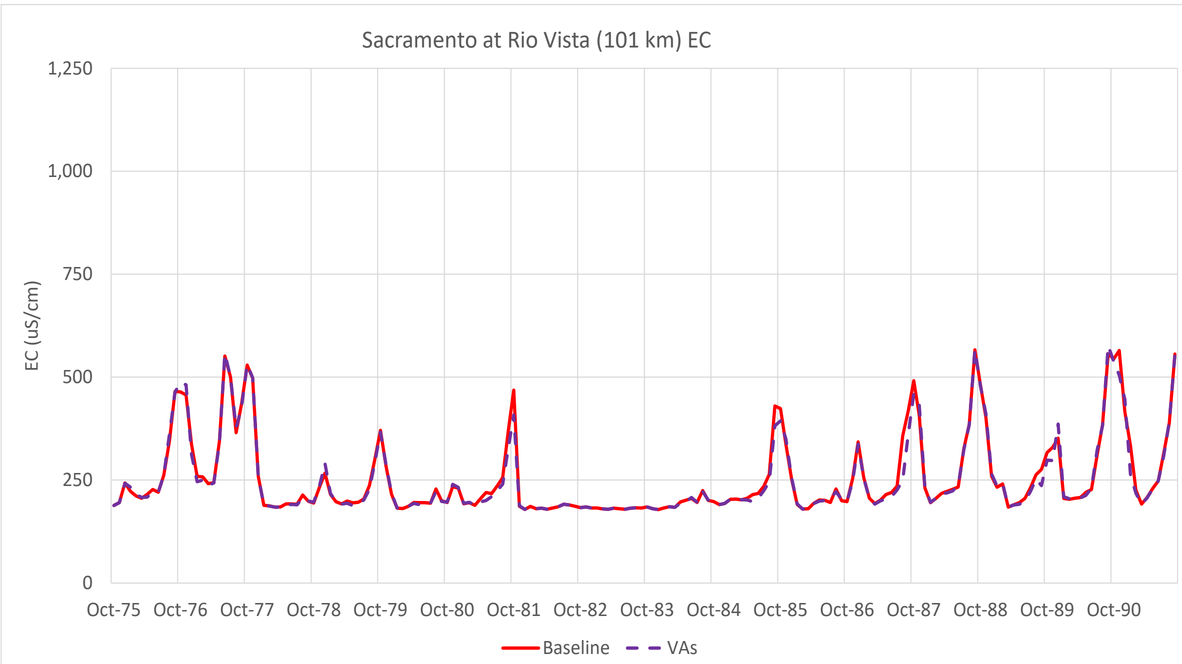
Table G3b-13. Cumulative Distribution of DSM2 EC Values for Delta-Mendota Canal Intake – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Agricultural and Municipal Objectives Are Applicable (year-round)

	Delta-Mendota Canal EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	355	377	357	371	202	152	201	221	231	307	347	354	342
20%	377	428	444	489	308	278	311	327	318	357	375	413	450
30%	380	472	595	550	421	419	417	383	387	375	379	427	465
40%	394	481	679	618	522	532	507	460	414	387	442	542	496
50%	610	622	711	635	560	573	595	516	419	400	488	564	532
60%	657	681	770	673	595	599	609	549	426	418	495	573	568
70%	675	724	823	717	633	623	613	552	439	422	522	585	583
80%	713	737	848	748	686	685	637	569	464	426	527	620	603
90%	737	756	887	759	817	718	649	591	528	443	556	629	642
Average	540	586	662	600	521	496	487	445	397	395	455	512	508
Proposed VAs Change from Baseline													
10%	0	0	0	0	-1	0	0	3	-2	0	-4	-7	-5
20%	0	8	6	0	0	1	0	-3	-5	0	-14	-16	1
30%	3	3	-3	2	0	3	-11	-15	-14	7	-5	-3	-6
40%	1	-4	-3	12	0	18	3	-14	-19	6	-28	-32	-15
50%	-43	-48	12	8	9	27	-62	-47	-22	-2	-4	-35	-5
60%	-19	22	-8	12	32	85	-73	-56	-8	-17	-6	-35	-4
70%	-33	-14	-33	-9	10	70	-53	-28	-18	-8	-30	-17	-8
80%	-57	0	-1	-18	-17	19	-20	-34	13	6	-30	-47	-8
90%	-24	8	21	17	-82	20	0	-9	-6	12	-12	-9	-18
Average	-18	-4	-1	6	-8	24	-21	-18	-9	1	-12	-15	-6

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

North Bay Aqueduct

Table G3b-14 provides a summary of the DSM2 EC for the North Bay Aqueduct intake on Barker Slough for the baseline only. EC values at the North Bay Aqueduct are very low compared with the 250-mg/l chloride objective (or the equivalent EC of 1,000 µS/cm) because the Cache Slough EC is dominated by Sacramento River water. The EC in Barker Slough would not change much because the Sacramento River EC is held constant (175 µS/cm) for both baseline and the proposed VAs, and there is little seawater intrusion upstream of Rio Vista (Figure G3b-21). For similar reasons, the EC at the Vallejo pumping plant on Cache Slough would not be affected by the proposed VAs.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

Figure G3b-21. Time Series of DSM2 EC Values for the Sacramento River at Rio Vista – Baseline and the Proposed VAs for Water Years 1976–1991

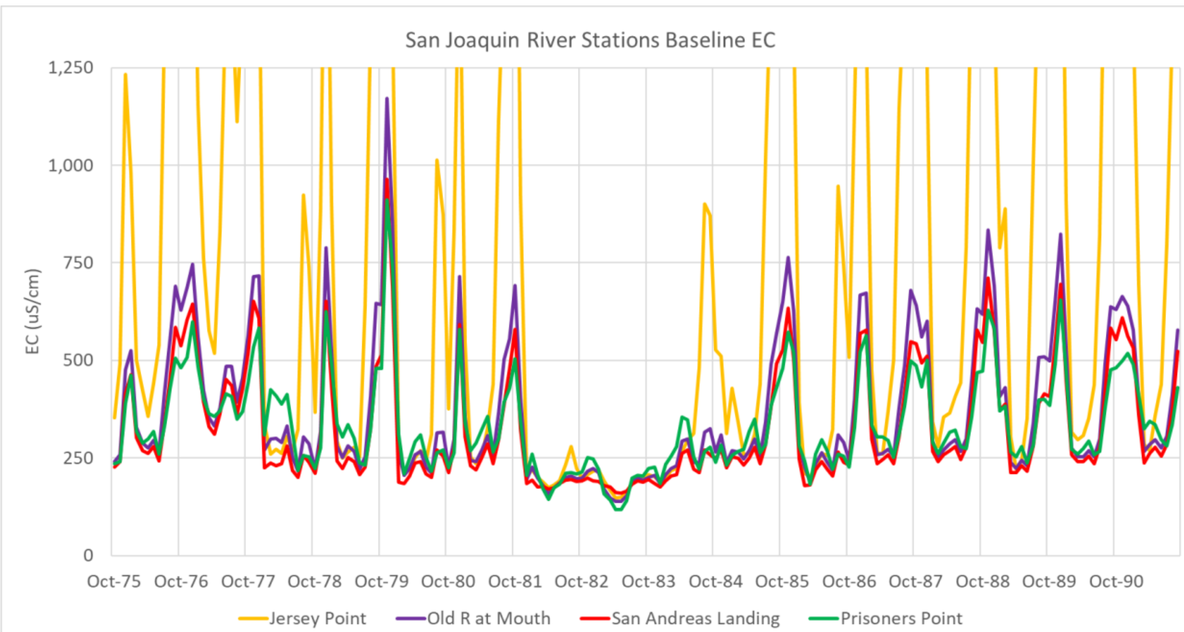
Table G3b-14. Cumulative Distribution of DSM2 EC Values for Barker Slough (North Bay Aqueduct Intake) – Baseline for Water Years 1976–1991 with Highlighting to Indicate When Municipal Objectives Are Applicable (year-round)

	Barker Slough EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10%	284	303	318	310	319	328	329	292	272	269	269	271	303
20%	289	308	322	325	352	336	335	293	276	271	269	274	304
30%	291	311	329	326	354	354	338	296	278	274	269	278	310
40%	292	315	333	331	356	362	340	297	279	275	270	279	314
50%	293	316	335	353	365	363	342	299	283	276	271	282	316
60%	294	320	339	354	367	365	343	301	287	277	273	285	317
70%	297	323	348	362	382	382	347	310	288	277	274	287	325
80%	303	328	354	365	389	388	367	330	320	317	313	336	333
90%	342	340	357	371	397	394	378	366	352	340	336	354	356
Average	302	320	338	343	361	364	348	313	296	290	287	297	322

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

City of Stockton Intake

The City of Stockton intake was constructed in 2012 at the southwest corner of Empire Tract, at the mouth of Disappointment Slough on the San Joaquin River about 5 miles upstream of Prisoners Point. Figure G3b-22 shows the DSM2 baseline EC for several San Joaquin River stations between Jersey Point and Prisoners Point. The Jersey Point EC is much higher than the EC at San Andreas Landing, the mouth of Old River, and Prisoners Point because of reduced seawater intrusion farther inland. Changes in EC at the City of Stockton intake will be similar to the changes in EC at Prisoners Point, approximately only 3.5 miles downstream. Baseline EC at Prisoners Point generally is expected to be similar to the proposed VAs. Table G3b-15 summarizes the DSM2 EC values for the San Joaquin River at Prisoners Point for the baseline. The Prisoners Point and Stockton Intake EC for the baseline and the proposed VAs would be much less than 1,000 µS/cm, the EC surrogate for 250 mg/L chloride.



µS/cm = microSiemens per centimeter
EC = electrical conductivity

Figure G3b-22. Time Series of DSM2 Baseline EC Values for San Joaquin River Stations for Water Years 1976–1991

Table G3b-15. Cumulative Distribution of DSM2 Baseline EC Values for the San Joaquin River at Prisoners Point near the City of Stockton Intake for Water Years 1976–1991 with Highlighting to Indicate When Municipal Objectives Are Applicable (year-round)

	San Joaquin River at Prisoners Point EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
10%	222	246	218	244	208	176	199	226	210	214	234	231	248
20%	224	264	247	261	242	249	260	293	237	218	260	255	298
30%	231	280	446	286	258	263	283	296	252	221	265	274	328
40%	240	328	518	310	267	273	299	300	254	232	323	369	340
50%	412	390	521	326	271	283	310	313	259	270	342	415	351
60%	473	490	580	370	318	288	317	321	263	281	354	430	360
70%	480	503	582	466	335	296	331	342	267	284	381	450	374
80%	481	533	598	483	383	304	345	349	279	299	384	476	379
90%	484	600	641	489	406	344	356	364	306	321	396	489	387
Average	362	424	480	364	297	274	293	304	261	266	324	372	335

µS/cm = microSiemens per centimeter
EC = electrical conductivity

G3b.3.2.5 Compliance with Southern Delta Agricultural Objectives

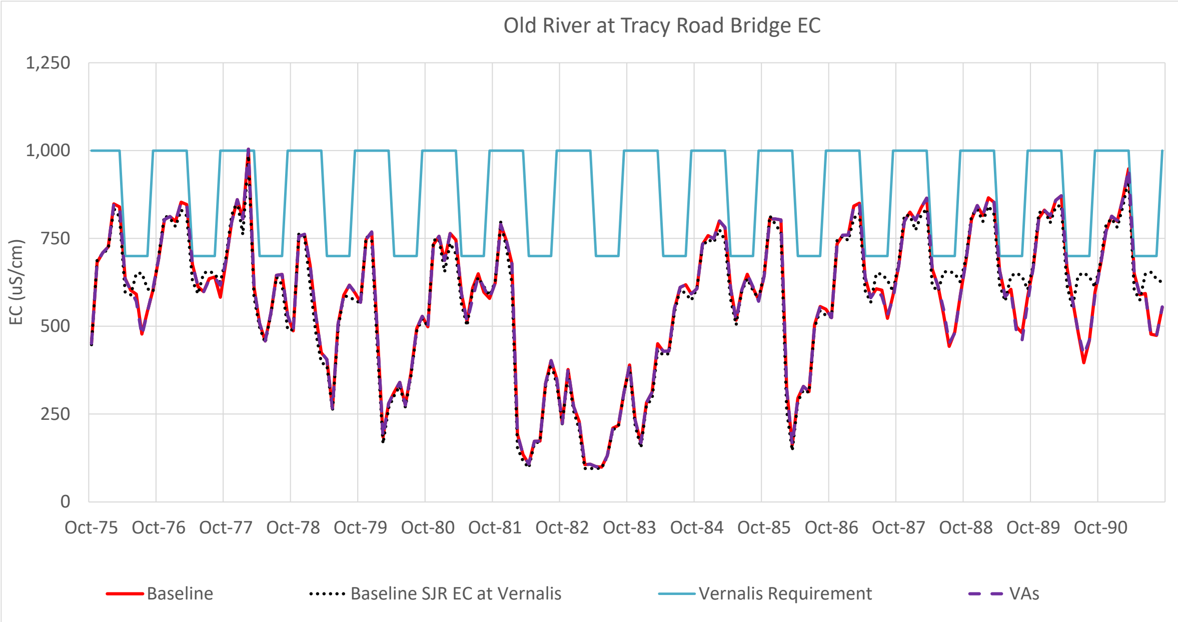
This section focuses on water quality compliance with the agricultural objectives for the southern Delta, the area near the San Joaquin River inflow to the Delta at Vernalis. Southern Delta objectives were modified in the 2018 Bay Delta Plan update to be 1,000 µS/cm year-round. The program of implementation in the 2018 Bay Delta Plan update continues the requirement for Vernalis salinity to be maintained at the older objective of 700 µS/cm for April through August to provide assimilative capacity downstream.

The 2018 Bay-Delta Plan update includes provisions to assess compliance with southern Delta salinity objectives at San Joaquin River at Vernalis and in three river segments (San Joaquin River from Vernalis to Brandt Bridge, Middle River from Old River to Victoria Canal, and Old River/Grant Line Canal from the head of Old River to West Canal). Because protocols to monitor compliance in river segments have not yet been established, compliance is evaluated in this appendix for the point locations specified in earlier versions of the Bay-Delta Plan. These include San Joaquin River at Brandt Bridge, Old River near Middle River, and Old River at Tracy Boulevard. Most of the water at these locations originates from the San Joaquin River, with water quality being similar to water quality in the San Joaquin River at Vernalis, but with some differences associated with accretions (e.g., agricultural return flows) and occasional influence of Sacramento River water. Although the San Joaquin River at Vernalis is a compliance location for agricultural salinity objectives, it is also a DSM2 model input and does not change between the scenarios and therefore is not one of the compliance locations evaluated. The boundary EC at Vernalis was estimated from an EC-flow regression equation (Suits and Wilde 2003).

Changes in EC in Old River at Tracy Boulevard for the proposed VAs relative to baseline EC illustrate the general effects of increased outflow and reduced exports on EC at the southern Delta agricultural compliance locations (Figure G3b-23, Table G3b-16). Old River at Tracy Boulevard was chosen because it historically has had the highest salinity.

The baseline EC in Old River at Tracy Boulevard is very similar to the baseline EC in the San Joaquin River at Vernalis because much of the water in Old River originates from the San Joaquin River at Vernalis when the head of Old River Barrier is not in place. Because the net flows in Old River at Tracy Boulevard are often small, small changes in the head of Old River flow, or the net flow past the temporary barrier, or the agricultural diversions and discharges may have moderate effects on the EC at Tracy Boulevard.

The proposed VAs generally would have relatively small effects on Delta exports and minimal effects on the agricultural diversions and discharges in the southern Delta. Consequently, as would be expected, EC results for Old River at Tracy Boulevard for the proposed VAs are very similar to the baseline results (Figure G3b-23, Table G3b-16). The DSM2 results indicate that the proposed VAs would not cause exceedances of the southern Delta agricultural salinity objectives.



µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

Figure G3b-23. Time Series of DSM2 EC Values for Old River at Tracy Boulevard – Baseline and the Proposed VAs for Water Years 1976–1991 with EC Objectives for Reference

Table G3b-16. Cumulative Distribution of DSM2 EC Values for Old River at Tracy Boulevard – Baseline Compared with the Proposed VAs for Water Years 1976–1991 with Highlighting to Indicate When Agricultural Objectives Are Applicable (year-round)

	Old River at Tracy Boulevard EC (µS/cm)												
Percentile	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Average
Baseline													
10%	421	529	490	383	188	148	201	219	224	352	431	440	407
20%	487	733	744	673	312	280	312	329	314	396	474	530	446
30%	512	734	757	683	427	437	417	385	495	460	482	551	529
40%	568	747	759	726	764	612	508	458	533	478	493	575	642
50%	615	763	765	755	819	763	602	515	544	501	533	581	655
60%	644	790	805	798	842	840	636	576	591	589	556	584	668
70%	670	798	813	800	851	848	644	583	596	607	603	589	671
80%	675	803	825	803	858	853	660	590	602	636	617	592	677
90%	684	805	837	807	866	868	666	607	606	646	629	596	687
Average	568	711	718	681	637	611	497	455	482	506	523	544	578
Proposed VAs Change from Baseline													
10%	0	0	0	0	0	0	0	0	0	0	0	0	0
20%	0	0	0	0	0	0	0	0	0	22	-14	0	0
30%	0	0	0	0	0	0	0	0	0	2	-6	1	0
40%	0	0	0	0	0	0	0	0	5	-5	0	-7	-2
50%	0	0	1	0	0	1	-2	-1	5	-8	4	-6	-1
60%	0	0	0	0	0	0	-2	-2	-20	-3	0	-5	-2
70%	0	-1	0	1	0	0	0	0	-10	-7	8	-1	1
80%	-1	0	0	0	0	2	-1	0	-5	-3	-1	0	2
90%	2	0	0	3	-2	0	-1	0	-4	-3	-1	7	-3
Average	0	0	0	1	0	0	-1	0	-3	-1	0	0	0

µS/cm = microSiemens per centimeter; EC = electrical conductivity; VA = proposed Voluntary Agreements

G3b.4 Summary

The DSM2 model of Delta hydrodynamics and water quality was used to simulate the effect of the proposed VAs on EC and flow in the Delta. The DSM2 results for EC and flow also were used to infer water quality effects for other Delta water quality constituents, including chloride, bromide, and HABs. Salinity-related water quality effects were evaluated for all water quality compliance locations within the Delta, except for X2. X2 position is calculated as part of SacWAM modeling and is evaluated in Chapter 9, *Proposed Voluntary Agreements*, based on SacWAM results.

DSM2 was run using a 15-minute time increment. However, the inputs to the model were monthly, with the Sacramento River and San Joaquin River inflows disaggregated to daily values to smooth the transition in flows between months. The analysis of effects is based on monthly values. The time increment of the surface water quality objectives described in the Bay-Delta Plan vary with the particular objective. For example, Bay-Delta Plan Table 1 objectives for municipal water quality use maximum mean daily values of the chloride concentration, whereas Bay-Delta Plan Table 2 objectives for agricultural water quality use maximum 14-day- or 30-day-running averages of the mean daily EC. If the time increment of an objective is less than monthly, it is possible that the objective could be exceeded even if the monthly results show no exceedances. However, operations are typically managed to meet objectives. In addition, even though the time increment for the water quality objectives does not always match the time increment of the DSM2 model, the model results still indicate whether changes in hydrology would hinder the ability to meet the water quality objectives by indicating whether EC is expected to increase versus decrease and whether any increases occur at a time when baseline EC is close to thresholds.

G3b.4.1 Salinity Effects by Region

The detailed results described above in Section G3b.3.2 are mostly organized by type of water quality objective (fish and wildlife, western and interior Delta agricultural objectives, municipal, and southern Delta agricultural objectives). Salinity and water quality in the Delta under the proposed VAs generally is expected to result in only small changes from baseline conditions, with more months showing average decreases in EC than months with increases in average EC. Water quality objectives generally are expected to be attained under baseline conditions, and the proposed VAs are not expected to increase exceedances of objectives. The following section describes changes in salinity by region.

G3b.4.1.1 Suisun Marsh

There are four fish and wildlife compliance locations within Suisun Marsh and one at Collinsville near the Montezuma Slough entry to Suisun Marsh. The proposed VAs would result in only small changes in EC at Chipps Island and Collinsville during the October–May fish and wildlife objective period. EC in Suisun Marsh is dominated by tidal flux from Suisun Bay. As such, the EC effects at Collinsville indicate that the proposed VAs would result in little change in EC in Suisun Marsh during the fish and wildlife objective period.

G3b.4.1.2 Western Delta

The western Delta has water quality compliance locations for agriculture (Sacramento River at Emmaton and San Joaquin River at Jersey Point) and municipal water supply (Sacramento River at Mallard Slough near Chipps Island and San Joaquin River at Antioch).

In the western Delta, the proposed VAs generally would result in only small changes in EC attributable to changes in seawater intrusion associated with changes in delta outflow. Any increases in EC do not result in exceedances of water quality objectives beyond what is simulated for baseline conditions. In addition, reservoir releases and exports generally are managed to ensure attainment of EC objectives in the western Delta; therefore, while EC may occasionally increase, it would not result in exceedances.

Water quality in the western Delta is suitable for municipal water supply only for parts of the year when EC is less than about 1,000 µS/cm. The proposed VAs would have little effect on the duration of water quality suitability for drinking water intakes in the western Delta at Mallard Slough and Antioch.

G3b.4.1.3 Interior Delta and Exports

As defined for this appendix, the interior Delta and export region includes water quality compliance locations for fish and wildlife (extending from the San Joaquin River at Jersey Point to the San Joaquin River at Prisoners Point), municipal water supply (Rock Slough, Barker Slough, Old River near Highway 4, Victoria Canal, City of Stockton intake on the San Joaquin River upstream of Prisoners Point, CVP exports at Jones Pumping Plant and SWP exports from Clifton Court Forebay), and agriculture (South Fork Mokelumne River at Terminous and San Joaquin River at San Andreas Landing).

Water in the interior Delta is a mixture of Sacramento River water, San Joaquin River water, Eastside tributary water, ocean water, and local accretions—with the ratios varying by location. For example, at one extreme, water in Barker Slough where the intake to the North Bay Aqueduct is located, originates primarily from the Sacramento River. The EC in Barker Slough would not change much under the proposed VAs because the Sacramento River EC is held constant (175 µS/cm) in each simulation and because there is minimal seawater intrusion upstream of Rio Vista into the Barker Slough area (Figure G3b-21).

In other portions of the interior Delta, water originating from other locations has more of an effect on water quality, but EC often is strongly influenced by the Sacramento River water that flows south through the DCC and Georgiana Slough. Because San Joaquin River inflow is generally less than the exports, most of the water in the interior Delta channels is Sacramento River water that is tidally mixed with some San Joaquin River water and occasional seawater intrusion.

If CVP and SWP exports are reduced substantially, the amount of water originating from the San Joaquin River may increase at some locations. San Joaquin River water is slightly saltier than Sacramento River water: 175 µS/cm for Sacramento River water compared to typically 250–750 µS/cm for San Joaquin River water. As a result, increases in San Joaquin River water can result in small increases in EC at some locations.

Because the proposed VAs have a limited effect on the factors affecting water quality in the interior Delta and Delta exports, the proposed VA EC values simulated for this region are similar to the baseline values, with more reductions than increases in EC due to effects from changes in exports and Delta outflow.

G3b.4.1.4 Southern Delta

Effects on southern Delta water quality compliance for agriculture was evaluated by considering EC at four locations: San Joaquin River at Vernalis and at Brandt Bridge, Old River near Middle River, and Old River at Tracy Boulevard. EC at Vernalis is a model input that does not change between baseline and the proposed VAs.

EC at these southern agricultural compliance stations is controlled primarily by the EC of the San Joaquin River and local drainage, which would not be affected by the proposed VAs. As a result, the proposed VAs would cause little change in EC in the southern Delta and are not expected to cause any exceedances in the southern Delta water quality objectives.

G3b.4.2 Chloride and Bromide

Because concentrations of chloride and bromide are correlated with salinity, the effects of the proposed VAs on chloride and bromide are similar to the salinity effects. Chloride and bromide are most relevant to drinking water quality because there are specific objectives for chloride at drinking water intakes listed in Table 1 of the Bay-Delta Plan and because the presence of bromide in water can result in harmful disinfection byproducts during water treatment. The proposed VAs generally are expected to produce minimal change in chloride and bromide at municipal intakes. There could occasionally be small increases or decreases in chloride and bromide at some locations, but these would be small and would not cause a trend of increased exceedances of water quality objectives. Small reductions in chloride and bromide associated with reductions in seawater intrusion would tend to be more common than small increases.

G3b.4.3 Harmful Algal Blooms

Many factors affect the occurrence of HABs and aquatic vegetation (e.g., nutrients, temperature, light, movement of water). HABs and invasive aquatic plants are affected by both tidal flows and net flows. Tidal back-and-forth flows would not be affected by the proposed VAs, but net flow in some Delta channels could be affected by the proposed VAs. Net flow is important because it controls residence time and can move harmful algae and floating invasive aquatic plants out of an area.

Victoria Canal was selected as a representative large channel that could be affected by changes in Delta exports and that already has experienced some limited formation of HABs (California Water Quality Monitoring Council 2018). Travel times through Victoria Canal were estimated using DSM2 results for the baseline condition and the proposed VAs (Table G3b-1).

The DSM2 results indicate that average monthly baseline travel times through Victoria Canal are between 0.6 and 1.3 days during the June–October HAB season. Model results indicate that average travel time would be minimally affected by the proposed VAs during the HAB season.

G3b.5 References

California Water Quality Monitoring Council. 2018. Cyanobacteria and Harmful Algal Bloom Network. Database on voluntarily reported harmful algal blooms. Available: https://mywaterquality.ca.gov/habs/where/freshwater_events.html. Accessed: October 15, 2018.

Suits, B. and J. Wilde. 2003. Delta Modeling Results in Proof of Concept of Forecasting California Aqueduct Water Quality. Technical Memorandum. Sacramento (CA). Bay-Delta Office. Delta Modeling Section. California Department of Water Resources. Available: https://rtdf.info/public_docs/Miscellaneous%20RTDF%20Web%20Page%20Information/Modeling%20Reports/proof_of_concept_delta_modeling_results_of_forecasting_california_aqueduct_water_quality_%28june_2003%29.pdf. Accessed: May 31, 2023.