Master Response 3.3
Southern Delta Water Quality

Overview

The southern Sacramento–San Joaquin Delta represents many things to many people. It is recognized for its thousands of acres of fertile farmland, a diverse ecosystem, and a system of channels and waterways that are vital to California water management. To protect these and other beneficial uses, it is imperative to maintain good water quality. One of the primary water quality concerns in the southern Delta is salinity concentration, particularly for agricultural water users. Using irrigation water with high salinity can cause buildup of salts in the soil that could potentially injure crops and reduce yield.

The current southern Delta salinity objective in the 2006 *Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta Estuary* (2006 Bay-Delta Plan) requires that during the summer irrigation season (April through August), salinity levels, measured as electrical conductivity (EC), must be maintained below 0.7 deciseimens per meter (dS/m)[1] based on the salt sensitivity and growing season of the most salt-sensitive crop, which is beans. Additionally, during the winter irrigation season (September through March), salinity levels must be maintained below 1.0 dS/m based on the growing season and salt sensitivity of alfalfa during the seedling stage. Compliance with the objective is measured at four stations within the southern Delta: San Joaquin River at Vernalis, CA; San Joaquin River at Brandt Bridge; Old River at Middle River; and Old River at Tracy Road Bridge. The Department of Water Resources (DWR) and the U.S. Bureau of Reclamation (USBR) are currently responsible for meeting these objectives. The 0.7 dS/m EC objective, however, is frequently not achieved in the interior southern Delta.

Several challenges make it difficult to control salinity in the southern Delta. The San Joaquin River (SJR), which flows into the southern Delta, carries a heavy salt load from upstream, primarily associated with discharges from agricultural lands on the west side of the river, served with Central Valley Project (CVP) water. In addition, due to upstream water infrastructure development, flows in the SJR are lower than they were historically. Agriculture uses much of the water that enters the southern Delta, but then returns most of the salts that were in that water back to southern Delta waterways, thus increasing salt concentrations in the waterways. Complex southern Delta circulation issues, shallow saline groundwater, the export pumps of the State Water Project (SWP) and CVP, and hundreds of diversions further complicate the salinity issues.

During the 2006 Bay-Delta Plan Update, the State Water Resources Control Board (State Water Board) identified southern Delta salinity as a key issue. Prior to and after 2006, there have been many different opinions regarding the southern Delta salinity objective. Various parties support

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[1] *Electrical conductivity* (EC), an indirect measure of salinity, is generally expressed in this SED as deciSiemens per meter (dS/m). Other units used include millimhos per centimeter (mmhos/cm). The conversion is 1 mmhos/cm = 1 dS/m. Measurement of EC is a widely accepted indirect method to determine the salinity of water, which is the concentration of dissolved salts (often expressed in parts per thousand or parts per million). EC and salinity are therefore used interchangeably in this document. The current objective in the 2006 Bay-Delta Plan is in units of mmhos/cm. As part of the Bay Delta Plan Update, the objective will be changed to be in dS/m, the international unit for EC.

raising the existing salinity objectives, while others advocate maintaining or lowering the objectives. These parties all have different views as to what salinity levels are reasonable to attain in the southern Delta given the complexity of the Delta system. Per the 2006 Bay-Delta Plan, the State Water Board commenced a process in January 2007 to review the salinity requirements of the beneficial uses of water in the southern Delta. Under the Clean Water Act, the Board is required to adopt water quality criteria that protect designated beneficial uses. (40 C.F.R. 131.12.) Similarly, under Water Code section 13241, the Board is required to establish water quality objectives as in its judgment will ensure the reasonable protection of beneficial uses, while recognizing that it may be possible for water quality to be changed to some degree without unreasonably affecting beneficial uses. The section also requires the consideration of certain factors in establishing water quality objectives, including, but not limited to, the past, present, and probable future beneficial uses of water and potential economic effects.

In the 2010 report on *Development of Flow Criteria for the Sacramento-San Joaquin Delta Ecosystem*, the State Water Board determined that 60% unimpaired flow would be protective of fish and wildlife beneficial uses in the SJR (State Water Board 2010); however, this was based on a narrow analytical framework that did not consider competing uses of water. In contrast, the SED provides information to consider the reasonableness of such a flow requirement and its alternatives, the effects on other beneficial uses, and the potential economic impacts that it could cause, among other information. In light of the information in the SED, the proposal is for a flow objective range from 30 to 50% of unimpaired flow on the Eastside tributaries, with 40% of unimpaired flow as a starting point; analysis in the SED shows that this flow proposal is still protective of fish and wildlife beneficial uses, but takes into account the other factors required to be considered under Water Code section 13241.

Similarly, the SED analyses of southern Delta water quality and crop salinity requirements considers all factors that contribute to crop salt tolerance and shows that existing salinity conditions in the southern Delta are suitable for all crops. The analyses also show that the existing April through August salinity objective of 0.7 dS/m EC is actually lower than what is needed to reasonably protect agriculture. Specifically, a key conclusion in the SED's Appendix E, *Salt Tolerance of Crops in the Southern Sacramento–San Joaquin Delta* (prepared by Dr. Glenn J. Hoffman; "Hoffman Report") is that the water quality objective "could be increased to as high as 0.9 to 1.1 dS/m, and all of the crops normally grown in the South Delta would be protected." The proposal is to amend the current salinity objective throughout the southern Delta during the summer irrigation season and adopt a year-round objective of 1.0 dS/m EC, based on analysis in the SED. Although changing the water quality objective from 0.7 dS/m to 1.0 dS/m EC would constitute a 43% increase in the objective itself, as several commenters have asserted, actual salinity levels in the southern Delta would not change from the current conditions. This is because the program of implementation in the plan amendments proposes to continue USBR's responsibility to maintain the 0.7 dS/m at Vernalis. This would provide assimilative capacity[2] for salinity in the southern Delta during the irrigation season.

Furthermore, rather than determining compliance with the salinity objective at specific compliance points (i.e., the fours stations), as identified in the current objectives, compliance is proposed to be assessed over larger river segments that better characterize southern Delta salinity conditions. These reaches include: the SJR from Vernalis to Brandt Bridge, Middle River from the confluence

[2] Assimilative capacity of a water body represents its ability to absorb a pollutant, in this case salinity, without exceeding the objectives. For the interior southern Delta, higher flows at Vernalis provide more water for dilution at downstream stations and thus more assimilative capacity to take on salt loading from upstream on the SJR.

with Old River to Victoria Canal, and Old River/Grant Line Canal from the Head of Old River to West Canal. Specific compliance points may not be reflective of conditions in the larger area of the southern Delta. Under the program of implementation, DWR's and USBR's water rights will be conditioned to require the development of information that will be used to determine the appropriate locations and methods to assess attainment of the salinity objective in the interior southern Delta.

The amendment to the salinity objective has been viewed as a separate, single issue by many commenters. However, while it is correct that the update of the salinity objective is an element of the State Water Board's proposed update to the 2006 Bay-Delta Plan, the salinity and flow objectives are connected components of the proposed plan amendments. The Lower SJR (LSJR) flow objectives complement the southern Delta salinity objective of the plan amendments by augmenting flow in the southern Delta, particularly during the February through June timeframe. Increased flows under the LSJR flow objectives would have the incidental benefit of providing low salinity irrigation water supply that would flush salts early in the irrigation season and, thus, provide better salinity conditions during germination of crops in the springtime, which is generally the most salt sensitive time. The complementary nature of both objectives (i.e., salinity and flow) allows the plan amendments to provide a comprehensive solution for maximizing the beneficial uses of water.

This master response addresses comments raised regarding the amendments to the southern Delta salinity objective to protect agricultural beneficial uses and other comments regarding southern Delta water quality. Justification and analysis for the southern Delta salinity objective is presented in Appendix E. Additional analysis of potential water quality impacts of the plan amendments is presented in Chapter 5, *Surface Hydrology and Water Quality,* and Chapter 23, *Antidegradation Analysis.*

Several commenters have called into question some of the assumptions that underpin the analysis in Appendix E. In particular, questions have been raised regarding what the leaching fractions of southern Delta soils are, and how leaching fractions, if determined to be different than assumed in Appendix E, could affect what irrigation water salinity level is needed to protect crops grown in the southern Delta. The *leaching fraction* can be considered a measure of how well water passes through that soil when it is applied for irrigation. In Appendix E, leaching fractions were estimated based on the salinity of tile drain[3] discharges from several drainage systems at various locations in the southern Delta. The commenters asserted that the tile drain discharge data used in Appendix E are affected by shallow saline groundwater and that the calculated leaching fractions are, therefore, too high and not representative of southern Delta soil conditions. These commenters say, therefore, that the conclusion of Appendix E—that all of the crops normally grown in the South Delta would be protected with an irrigation supply of 1.0 dS/m—is incorrect.

In 2013 and 2014, a separate study was commissioned by the Southern Delta Water Agency and performed by Dr. Leinfelder-Miles on production alfalfa fields to analyze southern Delta leaching fractions, resulting soil salinity, and crop yield. The results of the Leinfelder-Miles study show several sites with extremely low leaching fractions—approximately 3 percent. This is far lower than the leaching fractions evaluated in Appendix E. Lower leaching fractions indicate that it is harder for irrigation water to pass through the soil, thus making it harder to flush salts from the root zone.

[3] *Tile drains* are subsurface drains installed to provide drainage for soils that otherwise do not drain adequately to support irrigated agriculture. They are installed to lower shallow groundwater below the root zone of crops and to remove high salinity water.

Despite the low leaching fractions observed in the Leinfelder-Miles study, alfalfa yields associated with these low leaching fractions are the same or higher than statewide average yields, and not correlated with soil salinity. This shows that even with low leaching fractions, current water quality conditions are adequate to support the agricultural production in the southern Delta. As further discussed in this master response, the overarching conclusion of Appendix E—that the crops normally grown in the southern Delta would be protected with an EC of 1.0 dS/m—is correct even in light of site-specific information that shows some soils in the southern Delta have extremely low leaching fractions. In addition, Appendix E bases its determinations on additional considerations beyond the single issue of leaching fractions.

The State Water Board reviewed all comments related to the southern Delta water quality, southern Delta salinity objectives, and the SDWQ alternatives evaluated in the SED and developed this master response to address recurring comments and common themes. For ease of reference, a table of contents is provided after this *Overview* section in order to help guide readers to specific subject areas based on recurring comments and comment themes. Commenters have expressed concern regarding a wide range of issues related to the plan amendments for the southern Delta salinity objective. This master response addresses, but is not limited to, the following topics raised by commenters.

- Reasoning and justification for updating the southern Delta salinity objectives.
- Discussion of Appendix E and southern Delta leaching fractions.
- Responsibilities of DWR and USBR.
- Measuring salinity compliance in the interior delta.
- Indirect effects of the LSJR alternatives on southern Delta salinity.
- Methodology and area evaluated.

For responses to comments regarding water quality in relation to disadvantaged communities, please see Master Response 2.7, *Disadvantaged Communities*. For responses to comments regarding potential impacts of the plan amendments on wastewater treatment plants/publicly owned treatment works in the southern Delta, please see Master Response 3.6, *Service Providers*. For information regarding Harmful Algal Blooms (HABs) and Toxic Algal Blooms, please see Master Response 1.1, *General Comments*, under the topic of *Resources*. For information regarding the reasonable range of alternatives evaluated in the SED, the overall approach to selecting the feasible alternatives evaluated, and the feasibility of commenter-suggested plans and proposals please see Master Response 2.4, *Alternatives to the Water Quality Control Plan Amendments*. And for information regarding the justification of SDWQ Alternative 2, please see Master Response 2.1, *Amendments to the Water Quality Control Plan*.

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Justification for Updating the Southern Delta Salinity Objective

Several commenters have said that the basis for updating the southern Delta salinity objective is not adequately explained in the SED. The *Executive Summary* explains why changes to the salinity objective for the southern Delta are proposed. This section further explains the process and justification for why it is being proposed that the salinity objective in the southern Delta be changed from 0.7 dS/m to 1.0 dS/m during the April through August time period (the summer irrigation season).

Salinity problems in the southern Delta primarily result from a complex interaction of factors, including low flows; tidal action; diversions by the CVP, SWP, and local water users; agricultural return flows; poor circulation; and channel capacity. As early as 1991, the State Water Board recognized in its 1991 Bay-Delta Plan the need to meet the salinity objectives largely through regulation of water flow. The current southern Delta salinity objectives were established in the 1995 update to the Bay-Delta Plan, and they were implemented through Water Rights Decision 1641 (D-1641) (revised March 15, 2000) (State Water Board 2000). The water rights of DWR and USBR are currently conditioned to meet the salinity water quality objectives in the southern Delta.

Attainment of these salinity objectives proved difficult because of the complex interaction of the factors that affect salinity levels in the southern Delta and use of compliance locations in the interior Delta that are not optimally located to assess salinity over a wide area. Temporary barriers that are used to maintain water levels have also been identified as a measure to help benefit water quality in the southern Delta by improving circulation in null zones (areas with little or no circulation) where salts tend to collect. Both D-1641 and the 2006 Bay-Delta Plan envisioned permanent operable barriers as one of the solutions to salinity problems in the southern Delta. Due to concern regarding the impact such barriers could have on migratory fish, implementation of any such barrier project has been postponed indefinitely. As a result, salinity concentrations at the interior Delta stations (San Joaquin River at Brandt Bridge; Old River at Middle River; and Old River at Tracy Road Bridge) continue to sometimes exceed current objectives.

Per the 2006 Bay-Delta Plan, the State Water Board commenced a process in January 2007 with a workshop to review the salinity requirements of the beneficial uses of water in the southern Delta. Another public workshop was held on May 16, 2007, to discuss study tasks for a potential salinity consultant. A consultant was identified, and a study commenced with a workshop on November 4, 2008. One of the tasks to be performed by the consultant was to "provide a recommendation to the SWRCB [State Water Board] as to a salinity objective that would provide full protection of the most salt sensitive crop type on drainage-impaired soils in the study area." The product of this charge, vetted through a series of public workshops, is Appendix E, *Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta*.

Among other conclusions, Appendix E states that "the water quality standard could be increased to as high as 0.9 to 1.1 dS/m and all of the crops normally grown in the South Delta would be protected." This means that the current salinity objective of 0.7 dS/m is more protective than is needed for crops normally grown in the southern Delta and that crop yields could still be protected with an objective of 1.0 dS/m. This conclusion was based on thorough literature review of southern Delta salinity conditions and the effects of salinity on crops, as well as detailed steady-state modeling of how irrigation water salinity could reduce yield. Some commenters questioned the results of Appendix E due to concerns about the data used to determine the leaching fractions in the analysis; however, this does not invalidate the report's conclusions. The salinity objectives are not intended to provide absolute protection for every field in the southern Delta regardless of management practices, but rather are intended to provide general protection for agriculture in the region so that current levels of production can be maintained. With proper agricultural management, a 1.0 dS/m objective would generally protect bean and alfalfa production, two of the most salt-sensitive crops. For more discussion on Appendix E and leaching fractions in the southern Delta, please see the following section of this master response.

Maintaining a salinity objective lower than is needed to protect agricultural beneficial uses would have no negative effect on agricultural beneficial uses in the southern Delta. However, it would make meeting the objective more difficult than necessary for those entities (DWR and USBR) who are responsible. USBR controls salinity at Vernalis primarily by releasing dilution flows from New Melones Reservoir on the Stanislaus River. A lower objective would require additional releases, which would reduce the amount of water available for delivery to agricultural water users and for reservoir storage. In addition, the ability of DWR to control salinity concentrations in the southern Delta is limited as it has no facilities on the SJR or its tributaries that can be used to release dilution flows, so most of the burden would fall on USBR. Source control programs for salt discharges upstream of Vernalis have improved water quality conditions in the SJR, but there is a limit to how much can be achieved through those programs. The nature of the salinity issue in the SJR and southern Delta is that water is diverted and consumptively used, leaving behind all the salts in the residual water, some of which returns back to the river, thereby increasing the salt concentration further.

The results of the No Project Alternative show the implications of maintaining the 0.7 dS/m salinity objective at the interior Delta stations. Under the No Project Alternative, which represents compliance with the 2006 Bay-Delta Plan as implemented through D-1641, USBR is required to maintain the salinity objective at each of the interior Delta stations by making releases from New Melones Reservoir. The additional releases from the Stanislaus River further dilute the salt load at Vernalis and provide assimilative capacity to account for salt input between Vernalis and the interior Delta stations. On average, this requires about 60 thousand acre-feet (TAF) of additional releases from New Melones Reservoir each year, primarily between June and August. In a few very dry years, the results indicate that the salinity objectives are unachievable, even with increased releases from New Melones Reservoir (see Table D-3 in Appendix D, *Evaluation of the No Project Alternative [LSJR Alternative 1 and SDWQ Alternative 1]*). Many of these releases would be in addition to the flow releases that are proposed in the SED to protect fish and wildlife during the February through June time period under the LSJR alternatives. This modeling scenario shows that a large quantity of water would need to be released from New Melones Reservoir to meet an overprotective salinity objective.

The proposed update to the southern Delta salinity objective would not cause degradation in water quality because the current objective was never fully attained and the program of implementation for the plan amendments would ensure that there would be no change from the current conditions. USBR's water right for New Melones Reservoir would remain conditioned to meet the current objective of 0.7 dS/m at Vernalis. Maintaining the lower salinity at Vernalis would provide assimilative capacity for the evapoconcentration of salts and additional loads that occur downstream of Vernalis and help maintain the 1.0 dS/m objective at interior stations. The recent historical record shows that EC at Vernalis has almost never exceeded 0.7 dS/m (see Figure 23.1 in

Chapter 23, *Antidegradation Analysis*) because USBR is able to control it with releases from New Melones Reservoir. As such, salinity would not increase above current conditions, and there would be no degradation of water quality at Vernalis. Furthermore, because salt loading downstream of Vernalis would not change as a result of the plan amendments and because USBR's requirement to meet 0.7 dS/m at Vernalis would remain unchanged, there would be no change in overall salinity concentrations at the interior stations and, thus, no water quality degradation would occur because of the plan amendments.

Finally, though the LSJR alternatives are intended to provide higher flows for the protection of fish and wildlife from February to June, the additional flow would provide incidental benefit to salinity conditions in the southern Delta. The program of implementation for the salinity objective includes implementation of the objective in part through the LSJR flow objectives. The higher flows would come from the three eastside tributaries, which are characterized as having relatively low salinity concentrations. The additional low salinity water would help dilute salts in the SJR compared to the current conditions, reducing the salinity concentration of water flowing into the southern Delta. These higher flows would occur during the February through June time period, which represents the early planting season. Low salinity water can be used to pre-irrigate fields and provide leaching for salts prior to planting. Pre-plant irrigation is especially beneficial in years when there is low rainfall during the winter and natural leaching was low or did not occur. Furthermore, lower salinity irrigation water during the early growing season may benefit seedlings of salt-sensitive crops during germination and emergence. (Ayers and Westcot 1985)

Discussion of Appendix E and Southern Delta Leaching Fractions

Several commenters have questioned the adequacy of Appendix E, *Salt Tolerance of Crops in the Southern Sacramento-San Joaquin Delta,* to serve as a scientific basis for updating the southern Delta salinity objectives. Some commenters believe that Appendix E overestimates typical soil leaching fractions in the Southern Delta and, in turn, underestimates potential effects of a 1.0 dS/m salinity objective. Commenters also cite to the recent work of Dr. Leinfelder-Miles, who estimated lower leaching fractions than suggested in Appendix E, at a few sites in the southern Delta. In addition, commenters questioned the validity of Appendix E's peer review status because only one of five reviewers tasked with the peer review commented on the report. This section establishes why Appendix E is a valid analysis for determining a protective salinity objective for agriculture in the southern Delta.

As stated earlier, the Hoffman Report was already subject to a public review process. Dr. Hoffman prepared the final Hoffman Report after a public process following the release of a draft of the report in July 14, 2009. After public release of the draft report, the State Water Board held two public workshops—the first to discuss the draft report and solicit public comments and the second to discuss responses to comments received and how they will be addressed in the final report. On January 5, 2010, the State Water Board released the final Hoffman Report, in which Dr. Hoffman addressed comments and responded to written comments. The Hoffman Report serves as the scientific basis for the proposed salinity objective.

Leaching Fractions in Appendix E

Appendix E contains the Hoffman Report in which Dr. Hoffman reviewed soil salinity conditions and leaching fractions in the southern Delta. The leaching fraction is the ratio of the depth of water leached below the root zone to the depth of water applied to the surface. The leaching requirement represents how much additional applied water, above what is needed for plant consumptive use, must be passed through the root zone to leach salts and other constituents from the soil. A leaching requirement of a crop represents the leaching fraction needed to avoid yield reductions based on crop salt tolerance and irrigation water EC. If the data is available, leaching fractions can be calculated as the ratio of the irrigation water EC to the root zone drainage EC. In Appendix E, leaching fractions were estimated based on the salinity data of tile drain discharge from a large number of drainage systems and a few soil samples taken at various locations in the southern Delta. The tile drainage EC data was used to represent the root zone drainage EC, and the irrigation water salinity was assumed to be 0.7 dS/m (equal to the current salinity objective). Based on the calculated leaching fractions, it appeared that the leaching fractions in the southern Delta, with some exceptions, averaged between 21 and 27 percent. Minimum leaching fractions ranged from 11 to 22 percent. Dr. Hoffman included analysis of crop yield over a range of leaching fractions for a few different crops, including beans with leaching fractions ranging from 15 to 25 percent, almond trees with leaching fractions ranging from 10 to 20 percent, and alfalfa with leaching fractions ranging from 7 to 20 percent.

Some commenters asserted that the calculation methods were not adequate for estimating effects of salinity on southern Delta agriculture. They did not agree with the estimation methods for leaching fractions and suggested that it would have been more appropriate to measure actual leaching fractions in the field. These commenters are ultimately disagreeing with the Hoffman Report's approach and conclusion that the water quality objective could be increased to as high as 0.9 to 1.1 dS/m and all of the crops normally grown in the south Delta would be protected. However, Appendix E is based upon sound scientific knowledge, methods, and practices. Field testing, such as the one recommended by Dr. Hoffman in Appendix E, could be informative, but it is not necessary in light of the overall conclusion of the Hoffman Report. Dr. Hoffman also agreed that the salinity water quality objectives could be increased even in the absence of field studies. For example, in response to comments by DWR that field experiments are not necessary to modify the salinity water quality objectives, Dr. Hoffman responded, "I agree that the results of this report give adequate justification for the State Board to change the water quality objective. A field study like the one I am recommending will take 3 to 5 years to conduct. If the results of the field experiment are significantly different than the conclusions of this report the State Board could certainly change the water quality objective based on the field results." (Appendix E, Response to Comment #2.1.) Thus, field studies and experiments are not necessary to support the proposed change to the salinity objectives. Moreover, while the Board did not conduct any additional field testing in light of Dr. Hoffman's conclusion, other field studies have been conducted (i.e., Leinfelder-Miles's study), which the Board has considered, and they reinforce the Hoffman's conclusion that salinity conditions in the southern Delta are suitable for all crops, as further discussed below.

Commenters have raised two perceived issues with the calculation of leaching fractions in Appendix E.

1. The EC of supply water in the Delta is higher than the 0.7 dS/m Dr. Hoffman used to calculate leaching fractions.

2. The tile drain discharge data used in the calculation of the leaching fractions could have contained shallow saline groundwater and may not have represented the portion of irrigation water draining through the root zone.

Some commenters said that actual water quality data should have been used to calculate leaching fractions, instead of the assumed water quality of 0.7 dS/m. However, assuming applied water quality of 0.7 dS/m was a conservative assumption to help avoid overestimating leaching fractions. This assumption is conservative because it would mean that less irrigation water passed through the root zone to achieve the salt concentration seen in the drainage data. If a higher irrigation water salinity was assumed and used with the tile drain data, the estimated leaching fractions would have been larger. In addition, using EC observations from some other source, such as the California Data Exchange Center (CDEC), would have been speculative as the precise point of diversion for the irrigation water that could have ended up in the tile drains is unknown. Please see Appendix E, Section 3.13.2, *South Delta Situation*, which was expanded during initial preparation of the document in response to similar comments received on the draft report (see comments in Appendix E), for more discussion of how different assumptions would affect the estimates of leaching fractions.

There was little information available on shallow groundwater, surface runoff, and subsurface drainage to go with the tile drain data used to calculate leaching fractions in the southern Delta. The groundwater quality and elevated root zone water level are the product of field conditions and water management (i.e., low permeability soil and a high regional water table), and this specific information is not needed to draw the correct conclusions drawn in Appendix E. Focusing exclusively on the data and methods used to estimate leaching fractions misses the relevant point of the report. Based on available scientific literature, Appendix E shows how crops are affected by salinity, based on a number of factors, including crop salt tolerance thresholds, irrigation water salinity, and leaching fractions. The analysis and steady-state modeling were intended to show how these factors influence crop productivity and yields. The analysis does not consider all the agricultural management practices that must be employed to maintain crop yields in areas with very low leaching fractions or shallow groundwater. In response to similar comments regarding shallow groundwater during preparation of Appendix E, Dr. Hoffman stated:

> If no leaching occurs, the soil will become saline and no crops can be grown. If 'normal' irrigation practices will not result in leaching, then other methods must be found or the land will have to be abandoned. As pointed out, a drainage system may need to be utilized to maintain crop productivity. (Appendix E, p. 128)

Results in the Leinfelder-Miles Study

In *The Leaching Fractions Achieved in South Delta Soils under Alfalfa Culture, Project Report Update December 2016*, by Dr. Leinfelder-Miles (Leinfelder-Miles 2016), several alfalfa fields in the southern Delta were found to have very low leaching fractions. Leaching fractions were calculated by measuring the EC of applied water and estimating the EC of water draining out of the root zone at seven study locations for both 2013 and 2014. Some commenters have pointed to the results of this study as proof that leaching fractions in the southern Delta are much lower than those determined by Dr. Hoffman in Appendix E. However, Dr. Hoffman never suggested that leaching fractions at specific fields in the southern Delta could not be lower than what he had calculated. Even if some individual fields have very low leaching capabilities this does not mean they are representative of the overall southern Delta.

The results can be produced for lower leaching fractions using the equations presented in Appendix E. Figure 3.3-1 in this master response shows the theoretical relative yield of alfalfa as a function of irrigation water salinity (ECi) assuming a leaching fraction of 3 percent, as estimated by Dr. Leinfelder-Miles (results produced using two models for crop water uptake, the 40-30-20-10 model and Exponential model; see Section 4.1 of Appendix E for details). At an ECi of 0.7 dS/m the theoretical model shows there is a 5 percent decrease in yield under median rainfall and an 8 percent decrease in yield under minimum rainfall. At an ECi of 1.0 dS/m, there is a 13 percent decrease in yield under median rainfall and a 17 percent decrease in yield under minimum rainfall. Increasing ECi from 0.7 to 1.0 dS/m, with a leaching fraction of 3 percent, decreases yield by 8 to 9 percent. Please note that these results are theoretical and do not consider the benefits of employing agricultural management practices.

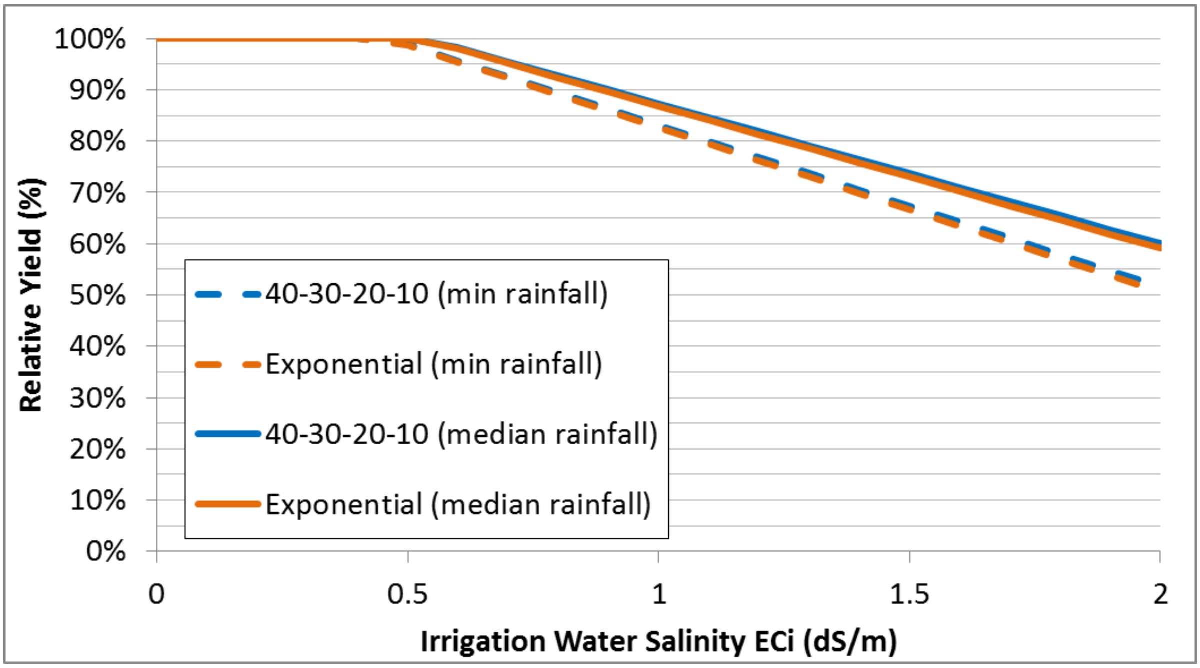

Figure 3.3-1. Relative Yield of Alfalfa vs. Irrigation Water Salinity (for Soil with Leaching Fraction = 3 percent)

The assertion that the observed low leaching fractions cited in the Leinfelder-Miles study invalidates the conclusions in Appendix E is unfounded because the data presented in the Leinfelder-Miles study itself shows that alfalfa yields can and are maintained at very high levels in spite of low leaching fractions. Though the theoretical model results of Appendix E suggest that there would be impacts on yield, the yield results presented by Dr. Leinfelder-Miles do not show a correlation between leaching fractions and yield. Figure 3.3-2 plots Dr. Leinfelder-Miles's estimates for leaching fraction versus estimated yield for the seven sites in both 2013 and 2014. As noted by Dr. Leinfelder-Miles, other factors, such as pest pressure and irrigation management techniques, may have had more influence on alfalfa yield than the irrigation water salinity. Yields were also relatively high despite both years of the study being part of a severe drought. In 2013, yield at all sites met or exceeded annual average alfalfa yields for California, (8 to 10 tons/acre [Orloff 2007]) and in 2014 yields at three of the sites still met or exceeded the annual average. The lowest yield, of just over 4 tons per acre, occurred on a site in 2014, with a leaching fraction of 18 percent. The highest yield of 12 tons per acre occurred at a site in 2013, with a leaching fraction of 3 percent. Leaching fractions are not the only factor that determine the success of alfalfa and other crop production; in particular, management methods will have a significant effect on how well fields perform.

Per Dr. Leinfelder-Miles testimony, the three soil series representing the seven sites in the study "represent about a third of the irrigated land in the south Delta." Leaching fractions vary spatially and temporally because soil conditions are not uniform, and weather conditions are always changing. As the Leinfelder-Miles study shows, there are sites with the same soil series in the southern Delta with leaching fractions ranging from 2 percent to above 20 percent. Drought conditions may also influence leaching fractions. During droughts, "the combination of less than normal rainfall and deficit irrigation may contribute to higher than normal salinity levels in the root zone" (Cahn and Bali 2015). This means that high salinity levels in root zone drainage and associated lower estimates of leaching observed during the drought years of 2013 and 2014 of Leinfelder-Miles' study are reflective of worst case conditions during drought.

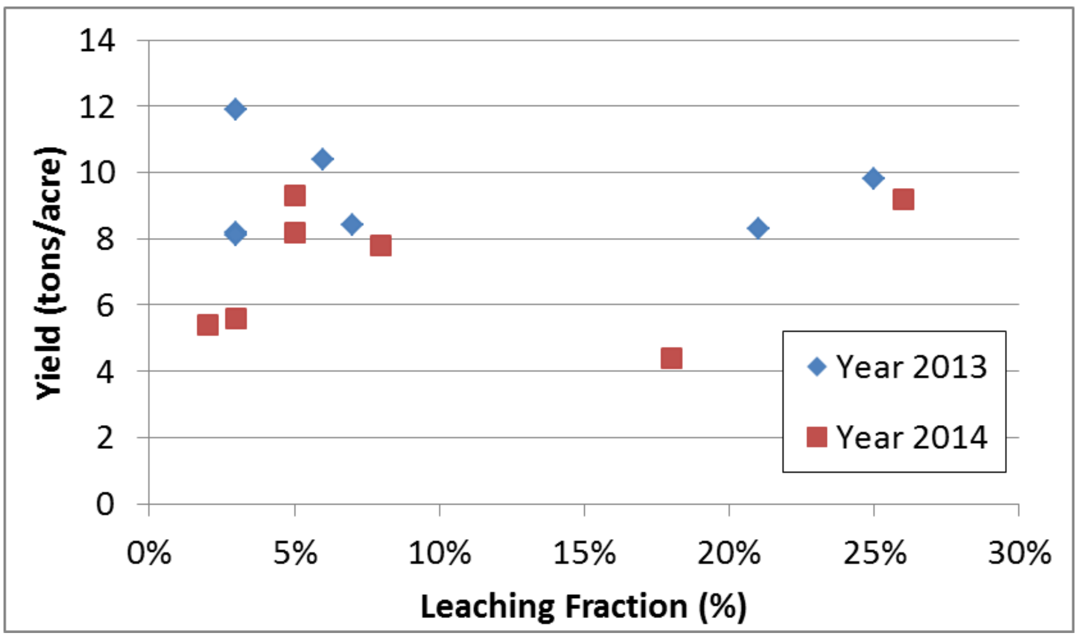

Figure 3.3-2. Estimated Annual Alfalfa Yield (tons/acre) vs. Leaching Fractions (Estimated by Dr. Leinfelder-Miles)

Though the proposed salinity objective is intended to be protective of the most salt-sensitive crop, beans, beans are not typically grown on low permeability soils such as those identified in the Leinfelder-Miles study. Beans do not grow well on low permeability soil that can remain saturated for a long period of time because the high water content can hinder root growth and increase susceptibility to fungus infection and damage (Long and Temple 2010). The leaching fractions considered for beans in Appendix E are, therefore, appropriate to evaluate potential yield reductions. The report found that the maximum yield loss of 11 percent would occur with irrigation water salinity of 1.0 dS/m, assuming a relatively low leaching fraction of 15 percent. The yield losses would be reduced to 7 and 3 percent, respectively, for leaching fractions of 20 and 25 percent. Given the intolerance of beans to low permeability soils, they are more likely to be grown on soils with the higher leaching fractions.

Alfalfa performs better than beans on low permeability soils and, with proper management, is often grown on soils with low infiltration rates (Leinfelder-Miles 2016). Recent history shows a trend in southern Delta agriculture away from beans, while alfalfa acreage has increased. Furthermore, development of more salt tolerant varieties of alfalfa will improve options for growers facing salinity issues (Miller 2014). For soils with extremely low permeability, very little water percolates below the root zone, and salt accumulates in the soil even with irrigation water salinity much lower than 0.7 dS/M. In such circumstances the steady-state model assumptions Dr. Hoffman used would not work. In this case, no matter where the salinity objective was set, it would not prevent salt buildup in the soil profile and, as a result, eventually other management practices would need to be applied or else the soil would become unusable.

Validity of the Appendix E Peer Review

The scientific portions of the proposed plan amendments are based on peer-reviewed scientific knowledge and literature, sound methods and practices, and detailed data evaluation. The peer review requirements for the State Water Board require such documents to enter into an agreement with the "National Academy of Sciences, the University of California, the California State University, or any similar scientific institution of higher learning, any combination of those entities, or with a scientist or group of scientists of comparable stature and qualifications that is recommended by the President of the University of California, to conduct an external peer review." (Health & Saf. Code, § 57004, subd. (b) (emphasis added).) The Board is further required to submit the scientific portions of the proposed rules, such as Appendix E, to the external scientific peer review entity (not *entities*) for its evaluation (*Id*. at subd. (d)(2).).

The State Water Board has a rigorous external peer review process designed to provide high-quality independent review of the State Water Board's scientific work, and all peer review requirements were satisfied. Dr. Mark E. Grismer, PhD., P.E., provided external peer of Appendix E and supported its conclusions. While some commenters expressed concern that he was the only peer reviewer evaluating Appendix E, as set forth in the above requirements, only one is required. Consistent with statutory requirements, the California Environmental Protection Agency's *External Scientific Peer Review Guidelines* states, "For Water Board proposals, the number of reviewers has ranged from one to eight" (CalEPA 2006: p. 8). Furthermore, some commenters referenced the Delta Stewardship Council regulations for the *Council's* definition of best available science, suggesting that the State Water Board peer review process did not satisfy these requirements. However, these regulations are not applicable to the State Water Board because they pertain to how the Delta Stewardship Council carries out the policies in its Delta Plan.

In addition to being peer-reviewed according to legal requirements, Appendix E was subject to numerous opportunities for public review and modification. The final report addressed questions raised during and after preparation of the draft report. Please see the final section of Appendix E, titled "Appendix A: Summary of Public Comments Received by September 14, 2009 and Written Responses", for comments received on the draft version of Appendix E and responses to those comments.

Responsibilities of DWR and USBR

Some commenters questioned assigning responsibility to DWR and USBR for complying with the southern Delta salinity objectives. At issue is the responsibility of DWR and USBR for causing the increased salinity within the southern Delta. In addition, commenters also questioned including installation of temporary barriers and completion of a comprehensive operations plan (COP) as conditions in the water rights of DWR and USBR. This section describes the proposed responsibilities of DWR and USBR and the reasoning for why they are or would be assigned these responsibilities.

Maintaining Southern Delta Salinity Requirements

In D-1641, the State Water Board found that "the actions of the CVP are the principal cause of salinity concentrations exceeding the objectives at Vernalis" and that "USBR, through its activities associated with operating the CVP in the San Joaquin River basin, is responsible for significant deterioration of water quality in the southern Delta" (State Water Board 2000: p. 83). It determined that salinity exceedances at Vernalis are caused by highly saline discharges to the SJR, originating from agricultural land on the west side of the San Joaquin Valley served by the CVP. In addition, diversion of high quality water by the CVP in the Upper SJR at Friant also contribute to the issue by reducing the capacity of the LSJR to assimilate the agricultural return flows. Therefore, D-1641 amended USBR's CVP permits requiring that it meet the Bay-Delta Plan's EC objectives at Vernalis.

At interior southern Delta stations, in D-1641, the State Water Board found both DWR and USBR partially responsible for the salinity problems because of hydrologic changes caused by export pumping. Specifically, the State Water Board found:

> …export pumping by the SWP and the CVP and in-Delta diversions in the southern Delta . . . cause null zones, areas with little or no circulation. These zones have little assimilative capacity for locally discharged salts. The lack of circulation prevents better quality water that is otherwise available from the main channels from freshening the water in these channels" (State Water Board 2000: p.87).

Though agricultural activities within the Delta do increase the salt concentration in Delta channels, they do not add to the overall salt load; SWP and CVP do add to the overall salt load by bringing water from other areas into the southern Delta and delivering it to lands that drain into the SJR. Therefore, D-1641 also amended both DWR's and USBR's export permits to require implementation of the EC objectives in the interior southern Delta stations.

D-1641 remains in effect and USBR and DWR are responsible for meeting the salinity water quality objectives. The proposed updates to the 2006 Bay-Delta Plan continue USBR's responsibility over salinity problems at Vernalis and in the interior southern Delta. The program of implementation for the plan amendments requires USBR to maintain EC levels of 0.7 dS/m from April through August at Vernalis in order to implement the salinity objectives for the interior southern Delta. With respect to DWR's responsibility over salinity exceedances in the interior Delta, the proposed plan amendments continue DWR's responsibility to address salinity exceedances for which it is partially responsible, as determined in D-1641. Some commenters argued that DWR does not have responsibility for salinity exceedances in the southern Delta. Although DWR facilities do not deliver water to the west side of the SJR and, therefore, do not contribute salt loads directly to lands that drain to the SJR, SWP and CVP are sometimes jointly operated. Per D-1641: "The DWR and the USBR are partially responsible for salinity problems in the southern Delta because of hydrologic changes that are caused by export pumping" (State Water Board 2000: p. 88).

Some commenters argued that water quality degradation due to salinity in the southern Delta is caused by in-Delta discharge of high salinity agricultural return flow and that DWR and USBR cannot control it. These commenters referenced a recent ICF report, *Evaluation of Salinity Patterns and Effects of Tidal Flows and Temporary Barriers in South Delta Channels* (ICF 2016) to show that DWR and USBR are not responsible for the salinity degradation. However, as the State Water Board made clear in its correspondence to DWR and USBR dated November 9, 2017, the report, while informative, is not dipositive (State Water Board 2017). Commenters also pointed to Delta Simulation Model 2 (DSM2) results produced by DWR and USBR which suggest that SWP and CVP Delta operations cannot control salinity at the interior Delta compliance points. These results are also informative, but not dispositive. As acknowledged in DWR's testimony during the 2006 CDO hearing, there is no simple relationship between SWP export operations and water quality improvement in the Delta (DWR 2005). Therefore, the impacts of the DWR's and USBR's operations on salinity in the interior southern Delta will be further evaluated through the development and implementation of the Comprehensive Operations Plan (COP), as set forth in the program of implementation. With respect to in-Delta discharges of high agricultural return flow, the program of implementation includes other efforts to assist in implementing the southern Delta salinity objective, such as requiring the Central Valley Regional Water Board to regulate in-Delta discharges of salts by agricultural dischargers and describing ongoing efforts to control and manage salinity discharges.

Some commenters stated water right conditions cannot be determined in a program of implementation as part of a water quality control plan proceeding, but must instead be established through an adjudicatory proceeding, which affords due process. However, these commenters are incorrect. Water Code section 13242 requires a program of implementation for achieving water quality objectives, which must include a description of the nature of actions that are necessary to achieve the objectives. (Wat. Code, § 13242, subd. (a).) Consistent with this requirement, the proposed implementation program for the plan amendments sets forth the actions necessary to achieve the salinity objectives; specifically, it states that through water right actions, USBR and DWR would be required to continue complying with salinity requirements as conditions of their water rights. The State Water Board has been granted a "'broad,' 'open-ended,' and 'expansive' authority to undertake comprehensive planning and allocation of water resources." (*National Audubon Society v. Superior Court* (1983) 33 Cal.3d 419, 449.) This includes the authority to enact rules and regulations that condition water rights. (*Light v. State Water Resources Control Board* (2014) 226 Cal.App.4th 1463, 1484-1487 [the Board's broad adjudicatory and regulatory authority is coincident with that of the Legislature and includes the power to enact regulations governing the reasonable use of water] *citing California Trout, Inc. v. State Water Resources Control Board* (1989) 207Cal.App.3d 585.) Moreover, it has long been established that a legislative act, like a regulation or rulemaking, such as the proposed plan amendments, can dictate the outcome that would otherwise be decided in a later evidentiary hearing. (See, e.g., *U.S. v. Storer Broadcasting* (1956) 351 U.S. 192.)

Commenter claims about the denial of due process are equally unavailing. While due process principles require reasonable notice and opportunity to be heard before governmental deprivation of a significant property interest, only adjudicative decisions, and not legislative actions, are subject to procedural due process principles. (*Horn v. County of Venture* (1979) 24 Cal.3d 605, 612.) Moreover, here, USBR, DWR, and those affected by CVP and SWP operations had both the notice and opportunity to comment and participate in the proposed plan amendment proceeding.

Comprehensive Operations Plan and Additional Monitoring Studies

As part of the proposed updates to the 2006 Bay-Delta Plan, DWR and USBR would be required to continue addressing the impacts of their operations on interior southern Delta salinity levels.

Specifically, DWR's and USBR's water rights would be conditioned to require development of a COP and additional monitoring reports. As described in more detail in the section *Measuring Compliance with the Salinity Objective in the Interior Delta* in this master response, salinity in the southern Delta is currently assessed at three monitoring locations that are not necessarily representative of overall salinity conditions in the southern Delta. Under the proposed amendments, the interior southern Delta salinity compliance locations would be comprised of three river segments rather than three specific point locations so that compliance with the southern Delta salinity objective can be better determined in a Delta environment subject to alternating tidal flows. The intent of the COP and associated special studies is to determine the appropriate locations and methods to better assess attainment of the salinity objective in the interior southern Delta, as well as the efficacy of measures to improve salinity levels. Per the proposed program of implementation, the COP must fulfill the following requirements.

- Describe the actions that would fully address the impacts of SWP and CVP export operations on water levels and flow conditions that may affect salinity conditions in the southern Delta, including the availability of assimilative capacity for local sources of salinity.
- Include detailed information regarding the configuration and operations of any facilities relied upon in the plan.
- Identify specific performance goals (i.e., water levels, flows, or other similar measures) for these facilities.

Goals in the COP are to be supported by a special study to characterize how salinity varies spatially and temporally in the southern Delta. The special study is intended to analyze the dynamics of the southern Delta and identify where solutions, such as salt load reductions and improvements to circulation, can be applied. Furthermore, methods for assessing attainment of the southern Delta salinity objective are to be determined as part of a long-term monitoring and reporting plan. This plan is to set monitoring protocols for measuring representative salinity conditions in the southern Delta.

Finally, Contra Costa Water District (CCWD) requested that a requirement be added to include a water quality management plan in the COP to ensure that export operations avoid or minimize any water quality degradation at its water intakes. The requested change has not been made. As stated above, the COP must include "actions that would fully address the impacts of SWP and CVP export operations on water levels and flow conditions that may affect salinity conditions in the southern Delta" and identify performance goals for the facilities. In addition, Appendix K has been revised to add that USBR and DWR consult with CCWD, among other stakeholders, to develop and implement the COP.

Addressing Impacts of SWP and CVP Export Operations

DWR's and USBR's water rights would also be conditioned to address the impacts of SWP and CVP pumping on southern Delta salinity conditions. The agencies would be required to continue operation of the agricultural barriers at Grant Line Canal, Middle River, and Old River at Tracy *or* enact some other reasonable measure to control water levels and flow conditions and provide assimilative capacity for local sources of salinity. Several commenters interpreted these conditions as requiring continued operation of the temporary barriers, but the actual requirement is for DWR and USBR to address export operations on water levels and flow conditions that might affect southern Delta salinity conditions. The barriers are one possible tool for controlling water levels and flow conditions. DWR began installing the temporary barriers in 1990 as part of a settlement agreement with South Delta Water Agency to maintain water levels suitable for agricultural diversions in southern Delta channels. At times, the barrier's culverts can be operated to help benefit water quality in the southern Delta by improving circulation in null zones where salts tend to collect.

Measuring Compliance with the Salinity Objective in the Interior Delta

Several commenters requested clarity on how compliance with the salinity objective for the interior Delta would be measured given that the compliance locations are comprised of river segments rather than discrete locations. This section explains why the salinity objective would be applied over entire river segments and how the method for assessing compliance would be determined.

As mentioned previously in this master response, compliance with the salinity objective in the interior southern Delta is currently determined based on the EC readings at three specific locations: San Joaquin River at Brandt Bridge, Old River at Middle River, and Old River at Tracy Road Bridge. However, due to complex salinity conditions in the southern Delta, simply measuring EC at the three current monitoring locations may not give an accurate depiction of the true salinity conditions. For example, the southern Delta is a wide area with many different sources of salinity and complex hydrodynamics related to tidal reverse flows. In addition, some areas of the southern Delta are especially problematic in terms of salinity because they have poor circulation or are located near high salinity discharges. In particular, the Tracy Road Bridge location has uncharacteristically high salinity for the southern Delta because of its proximity to Paradise Cut and Sugar Cut, two upstream tidal sloughs that contain high salinity agricultural runoff.

The proposed updates to the 2006 Bay-Delta Plan seek to improve the methods for determining compliance with the southern Delta salinity objectives by looking at salinity over entire river segments rather than specific points. These segments include: the San Joaquin River from Vernalis to Brandt Bridge, Middle River from the confluence with Old River to Victoria Canal, and Old River/Grant Line Canal from the Head of Old River to West Canal. Some commenters have incorrectly interpreted this requirement to mean that compliance with the salinity objective would be assessed based on the average salinity over the river segment. Determining compliance through river segments rather than specific points is to better assess compliance with the salinity objective, not average away salinity problems as commenters asserted. The appropriate locations and methods to assess attainment with the salinity objective will be informed by the COP, special studies, modeling and the monitoring and report plan that DWR and USBR will be required to produce (with stakeholder input). Until then, USBR's and DWR's compliance with the salinity objective would continue to be assessed at the three current monitoring locations.

Indirect Effects of the LSJR Alternatives on Southern Delta Salinity

As discussed above, the additional flow in the SJR associated with the LSJR alternatives is expected to provide incidental benefit to salinity conditions in the southern Delta during the February through June time period. Chapter 23, *Antidegradation Analysis*, concludes: "The LSJR and SDWQ alternatives, as well as their implementation, are not expected to reduce water quality; rather, water quality will be maintained and generally improved." However, some commenters were concerned that the indirect effects of the LSJR alternatives on water quality in the southern Delta were not adequately presented. These commenters requested that the average annual change in salinity under different unimpaired flow requirements for the southern Delta compliance locations shown in Table 23-2 of Chapter 23 be broken down into monthly average changes. These results are shown below in Tables 3.3-1 through 3.3-3, with each table corresponding to the different compliance locations. Table 3.3-2 represents both the change in salinity in the SJR at Brandt Bridge and in Old River near Middle River. As discussed in Chapter 23 and shown in Figures 23-5 through 23-7, about 10 to 20 percent of months show a minor increase in EC over baseline conditions under each of the alternatives, while other months show much more substantial decreases in salinity. The minor increases primarily occur in the months of January and December and merely represent shift in variable salinity concentration as water is moved from one period to another. Overall, however, salinity concentrations would improve.

Table 3.3-1. Monthly Average EC for the SJR at Vernalis under Modeled Baseline Conditions and the Change in Value based on Percent of Unimpaired Flow

	Monthly Average EC (dS/m)					
		Change from Baseline EC				
Month	Baseline	20% UF	30% UF	40% UF	50% UF	60% UF
January	0.70	0.00	0.01	0.04	0.05	0.05
February	0.66	0.01	0.00	-0.01	-0.04	-0.08
March	0.59	0.02	-0.01	-0.04	-0.08	-0.12
April	0.44	-0.01	-0.06	-0.09	-0.13	-0.16
May	0.41	-0.05	-0.12	-0.16	-0.20	-0.23
June	0.51	-0.09	-0.14	-0.19	-0.23	-0.27
July	0.58	0.00	0.02	-0.01	0.00	0.02
August	0.54	0.00	0.01	0.00	0.01	0.01
September	0.52	-0.01	0.00	-0.03	-0.02	-0.02
October	0.49	0.00	0.00	-0.05	-0.05	-0.05
November	0.60	0.00	0.00	-0.03	-0.03	-0.03
December	0.77	0.01	0.02	0.04	0.04	0.04
Annual Avg.	0.57	-0.01	-0.02	-0.04	-0.06	-0.07

EC (dS/m) = electrical conductivity (salinity) as measured in deciSiemens per meter
UF = unimpaired flow

Table 3.3-2. Monthly Average EC for the SJR at Brandt Bridge and for Old River near Middle River under Modeled Baseline Conditions and the Change in Value based on Percent of Unimpaired Flow

	Monthly Average EC (dS/m)					
		Change from Baseline EC				
Month	Baseline	20% UF	30% UF	40% UF	50% UF	60% UF
January	0.74	0.00	0.01	0.04	0.05	0.05
February	0.69	0.01	0.00	-0.01	-0.04	-0.08
March	0.62	0.02	-0.01	-0.04	-0.08	-0.13
April	0.46	-0.01	-0.06	-0.10	-0.14	-0.18
May	0.44	-0.06	-0.13	-0.18	-0.22	-0.25
June	0.56	-0.10	-0.16	-0.21	-0.25	-0.29
July	0.64	0.00	0.02	-0.01	0.00	0.02
August	0.60	0.00	0.02	0.00	0.01	0.01
September	0.57	-0.01	0.00	-0.03	-0.03	-0.02
October	0.53	0.00	0.00	-0.05	-0.05	-0.05
November	0.65	0.00	0.00	-0.03	-0.03	-0.03
December	0.82	0.01	0.02	0.04	0.04	0.04
Annual Avg.	0.61	-0.01	-0.02	-0.05	-0.06	-0.08

EC (dS/m) = electrical conductivity (salinity) as measured in deciSiemens per meter
UF = unimpaired flow

Table 3.3-3. Monthly Average EC for Old River at Tracy Blvd. Bridge under Modeled Baseline Conditions and the Change in Value based on Percent of Unimpaired Flow

	Monthly Average EC (dS/m)					
		Change from Baseline EC				
Month	Baseline	20% UF	30% UF	40% UF	50% UF	60% UF
January	0.82	0.00	0.01	0.04	0.05	0.06
February	0.75	0.01	0.00	-0.01	-0.04	-0.08
March	0.68	0.02	-0.01	-0.05	-0.09	-0.14
April	0.52	-0.01	-0.07	-0.12	-0.16	-0.20
May	0.49	-0.07	-0.15	-0.20	-0.25	-0.28
June	0.66	-0.12	-0.19	-0.25	-0.30	-0.35
July	0.77	0.00	0.02	-0.01	0.00	0.02
August	0.73	0.00	0.02	0.00	0.01	0.02
September	0.67	-0.01	0.00	-0.03	-0.03	-0.03
October	0.61	0.00	0.00	-0.06	-0.06	-0.06
November	0.75	0.00	0.00	-0.04	-0.04	-0.04
December	0.91	0.01	0.02	0.04	0.04	0.05
Annual Avg.	0.70	-0.01	-0.03	-0.06	-0.07	-0.09

EC (dS/m) = electrical conductivity (salinity) as measured in deciSiemens per meter
UF = unimpaired flow

Methodology and Area Evaluated

Some commenters were concerned that the methodology for determining water quality effects and the area evaluated for the effects were inadequate. More specifically, commenters asserted that the SED's plan area failed to include all areas that could be affected by the project and did not evaluate potential water quality impacts in the Delta outside of the south Delta compliance points. Furthermore, commenters were concerned that the SED only analyzed potential degradation in terms of compliance with the objectives, while assuming flow shifting would be present, which could not be implemented as modeled. They also commented that the SED did not evaluate how Delta operations might change for water users, including the CVP and SWP.

Salinity Effects in the Southern Delta

The SED identifies and evaluates drinking water quality effects at intake facilities, including those outside of the plan area in Chapter 2, *Water Resources* (Section 2.7.2, *Water Diversions*); Chapter 5, *Surface Hydrology and Water Quality* (Section 5.2.8, *Southern Delta: Flows and CVP/SWP Exports*); and Chapter 13, *Service Providers* (Section 13.2.3, *Southern Delta*; Section 13.3.2, *Regulatory Background [State]*; Section 13.4.3, *Impacts and Mitigation Measures*. The SED also discusses expected water quality changes in the Delta as it relates to habitat/fish in Chapter 7, *Aquatic Biological Resources*, under Impact AQUA-12, and in Chapter 13 under Impact SP-2a.

The antidegradation analysis in Chapter 23 evaluates the potential for the plan amendments to result in the degradation of water quality in the southern Delta due to increased salinity; the analysis models water quality at the SJR near Vernalis and the three interior southern Delta compliance locations: Old River at Tracy Boulevard Bridge, Old River near Middle River, and SJR at Brandt Bridge. The analysis determined that the plan amendments would not cause a degradation in water quality; overall, there would be an improvement in water quality. Changes to the magnitude and timing of flow releases could, however, sometimes cause slight increases in salinity. This slight increase is due to the inverse relationship between flow and salinity in the SJR (see Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*). This means that when SJR flows are low, salinity is relatively high, and when SJR flows are high, salinity is low. Under the LSJR alternatives, increased releases from rim reservoirs on the eastside tributaries during the February through June time frame sometimes results in more open storage in the reservoirs following June. The additional open storage changes the magnitude and timing of reservoir flood control releases because the reservoir is able to capture additional water that would have otherwise been spilled. This change in flood spills could reduce flow at Vernalis under the LSJR alternatives relative to baseline and slightly increase salinity concentrations.

The relationship between flow and salinity continues at and beyond the three interior southern Delta compliance locations, although the relationship is complicated by other factors, such as tidal effects, evapoconcentration of salts, and the comingling of Sacramento River water in the southern Delta. Water quality was not explicitly modeled at other locations beyond the interior southern Delta compliance locations; however, the same relative effects are expected in other parts of the Delta, except to the extent that they are also affected by Sacramento River water. Under current conditions, there is often insufficient SJR flow to meet the consumptive demand of all the diversions in the southern Delta. The result is that Sacramento River water is drawn across the Delta into channels of the southern Delta where it mixes with the SJR flow. To the extent that flows are reduced, and salinity in the southern Delta is higher, and more Sacramento River water is drawn across the Delta, further limiting the ability of the SJR flows from having an effect on areas outside the southern Delta.

Flow Shifting and its Inclusion in the Analysis of Potential Impacts

Some commenters were critical that the State Water Board included flow shifting in the analysis of potential water quality degradation impacts because the analysis asserts that flow shifting through adaptive management is not mandated by the plan amendments. Flow shifting (from the spring to summer and fall) was included in model runs of 40 percent and higher unimpaired flow to analyze the likely real-world operations that would occur with these higher unimpaired flow requirements. Flow was shifted to other months, as needed, to obviate negative temperature effects of releasing much higher than baseline quantities of water February through June and, therefore, less water in the fall months. While the plan amendments do not explicitly include a flow shifting requirement, some shifting will be needed to avoid significant adverse temperature impacts on fish in the summer and fall and meet the narrative flow objective. The specific amount of flow shifting cannot be known; however, the SED analyzes reasonable operations to protect up migrating salmon consistent with the plan amendments. The use and timing of flow shifting to obviate negative temperature effects would also generally align with times when the shifted flows would have a positive effect on other measures of water quality, including salinity. As tables 3.3-1, 3.3-2, and 3.3-3 show, flow shifting is not likely to occur in December and January, which is why those months show a small increase in salinity over baseline. In addition, as the tables show, the reduction in salinity during the rest of the year is overall much larger than the increase in salinity during December and January.

Evaluating the plan amendments without flow shifting would not satisfy CEQA's requirement to analyze the environmental impacts of a project. To implement the narrative flow objective, the program of implementation in Appendix K, *Revised Water Quality Control Plan*, states that when implementing the LSJR flow objectives, the State Water Board will include minimum reservoir carryover storage targets or other requirements to ensure that providing flows to meet the flow objectives will not have significant adverse impacts on fish and wildlife. Appendix K provides for adaptive implementation, which allows some flow from the February through June time period to be shifted to other times of the year to prevent adverse impacts to fisheries, including temperature impacts, that would otherwise result from implementation of February to June flow requirements. Without flow shifting, there could be unintended, adverse temperature impacts during the summer as a result of higher flows during the February through June time period. Such adverse impacts are antithetical to the purpose and requirements of the plan amendments to reasonably protect fish and wildlife beneficial uses. As such, flow shifting is part of the plan amendments and was, therefore, included in the modeling.

Potential Changes in Delta Operations

Two of the principal drivers of water quality in the southern Delta are the state and federal water projects (SWP and CVP, respectively). The plan amendments do not include additional operational requirements on the SWP and CVP; therefore, the effects of the water projects on other areas of the southern Delta will remain unchanged and the plan amendments will not cause additional impacts that were not analyzed. Future amendments to the Bay-Delta Plan that do affect project operations would have to address the environmental impacts associated with those operational changes. Additionally, all salinity and chloride standards in the southern Delta and at intake facilities in the southern Delta, including at intakes to SWP and CVP, would have to be met.

The SED is a programmatic document and it is not reasonably feasible to describe all possible operational changes that could be adopted by specific entities in response to the proposed change in the salinity objective. The SED analyzed the reasonably foreseeable environmental effects of the plan amendments, including adaptive implementation, and disclosed all that it reasonably can. Please see Master Response 1.1, *General Comments*, for discussion of the programmatic nature of the SED and why project-level analysis is not required at this time.

Groundwater Pumping and the Historical Flow–EC Relationship at Vernalis

Some commenters suggested that the SED improperly assumes a historical flow–EC relationship at Vernalis despite increased groundwater usage in the plan area. The most likely way increased groundwater usage in the plan area could cause a change in the salinity concentrations at Vernalis would be if the salinity of agricultural return flows increased substantially. While it is true that there are some localized issues, such as selenium and other constituents being present in some areas of the San Joaquin Watershed (e.g., from tile drained areas on the west side of the SJR, for which there are currently load reduction programs in place), groundwater quality is fairly good within the plan area. Please see Chapter 9, *Groundwater Resources*, and Chapter 13, *Service Providers*, for discussion of groundwater quality in the plan area. There is no evidence indicating that small changes in the ratio of groundwater use to surface water use for agriculture in the plan area would significantly affect the salinity of agricultural return flow and cause significant changes in salinity on the SJR at Vernalis.

Potential for Displacement of Sacramento River Flow

Some commenters expressed concern that increased flow from the SJR could actually decrease the water quality in certain areas of the southern Delta if it displaced better quality Sacramento River water. The hydrodynamics of the southern Delta are complex, and the exact effect of the LSJR alternatives would depend on multiple factors, including SJR flow, SWP and CVP exports, tidal flow, Head of Old River Barrier status, and Delta outflow. However, the overall effect of the plan amendments would be a reduction in EC (Chapter 5, *Surface Water Hydrology and Water Quality*). Salinity objectives would continue to be met within the southern Delta and outside the southern Delta, and no new facilities would need to be constructed to maintain southern Delta water quality.

Lower salinity Sacramento River water could possibly be displaced by increased flow from the SJR in the southern Delta under some circumstances when SWP and CVP exports and other diversions are low. As discussed under *Salinity Effects in the Southern Delta* in this master response, Sacramento River water is drawn across the Delta into channels of the southern Delta by the export pumping of the SWP, CVP, and to a lesser extent, other diversions in the southern Delta. If the ratio of SJR water to Sacramento River water were to increase in the southern Delta, it is possible that there might be a slight increase in EC in the southern Delta under limited circumstances; however, these potential EC increases would be limited as the difference between Sacramento River EC and SJR EC is relatively small when SJR flow is higher. Sacramento River EC is typically 125 – 250 uS/cm, whereas SJR EC at Vernalis usually ranges from 250–1,000 uS/cm, with the lower values occurring at higher flows (Appendix F.2, *Evaluation of Historical Flow and Salinity Measurements of the Lower San Joaquin River and Southern Delta*, Section F.2.4, *Southern Delta Salinity Patters, Southern Delta Salinity (EC) Increments*). Sacramento River flow could only be displaced when the flows from the SJR are very high and, therefore, its EC near the bottom of the range and closer to the Sacramento River EC.

There would be multiple stronger effects associated with the plan amendments that would reduce EC in the southern Delta and Delta as a whole. Higher inflows of low salinity water from the eastside tributaries would reduce EC in the SJR. In turn, greater February through June flows from the SJR would reduce salinity in the southern Delta. Overall reductions in salinity would be much larger than any episodic slight increases in salinity. Furthermore, higher inflow to the Delta from the SJR would dilute high salinity local accretions. As an additional benefit, the plan amendments would help protect against seawater intrusion. There is a substantial difference between SJR EC (250–1,000 uS/cm) and ocean water EC (approximately 50,000 uS/cm). Greater flow from the SJR would increase Delta outflow and limit seawater intrusion. This would be of particular benefit to drinking water providers whose intakes are in areas of the Delta where the effects of seawater intrusion are more pronounced. Overall, under the plan amendments, the distribution of EC values in the southern Delta and at drinking water intakes and agricultural diversions would shift such that EC would be generally lower.

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