

# APPENDIX D

## RESPONSE TO COMMENTS

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## PART I

### STAFF RESPONSE TO WRITTEN COMMENTS ON THE DRAFT STAFF REPORT AND PROPOSED BASIN PLAN AMENDMENT

(January 12, 2018)

We received four comment letters during the 45-day public comment period, which began on January 12 and closed on February 28, 2018. The comments and our responses are presented here in alphabetical order.

*Staff responses are shown in italic.*

Comment letters received:

1. Department of Water Resources (DWR, Cliff Feldheim)
2. Fairfield-Suisun Sewer District (FSSD, Meg Herston)
3. San Francisco Baykeeper (Baykeeper, Sienna Courter)
4. Suisun Resource Conservation District (SRCD, Steve Chappell)

## Comment Letter No. 1: Department of Water Resources (DWR)

**Comment:** The commenter is concerned that with the long timeframe the San Francisco Bay Mercury TMDL identifies to achieve the target concentrations in sportfish, that monitoring will be required for tidal wetland restoration sites for a long time. They specifically ask “Will project proponents need to monitor fish tissue for one hundred years in tidal wetland restoration sites? Since control sites may continue to show high fish tissue concentrations for one hundred years, how can one show that tidal restoration isn't significantly impacting the load to the system so that monitoring can cease? If fish tissue levels at tidal restoration sites are not significantly different from elevated fish tissue levels at control sites, is this enough evidence to cease monitoring? What if one does not meet target levels in Bay fish simply because of the large inventory of Hg in the Bay?”

**Response:** *We do not call for tidal wetland restoration project proponents to monitor individual restoration projects for 100 years in the Bay Mercury TMDL. The TMDL currently calls for pre- and post-restoration monitoring for tidal restoration projects. In recognition of the data collected by the North Bay Mercury Biosentinel Project, we are proposing that restoration proponents take a regional approach to monitoring the impacts of tidal wetlands and wetlands restoration on methylmercury (MeHg) production and bioaccumulation into the food web. This modification to the TMDL is reflected in the proposed Basin Plan amendment. We are proposing a regional approach so that we can adaptively manage monitoring requirements, inform restoration design to the extent possible, and collectively make decisions about the frequency and need for ongoing monitoring based on the observed trends. Coordinated monitoring among restoration projects can be used to provide context for interpreting local or site-specific MeHg exposure, or to explain larger regional or temporal trends. Measured concentrations can be compared to either TMDL targets or to ambient conditions.*

## Comment Letter No. 2: Fairfield-Suisun Sewer District (FSSD)

**Comment 2.1:** The Commenter requests a correction in the Staff Report (page 44) regarding the maximum allowable BOD discharge. They say the estimated BOD load of 545 kg/day is incorrect and provide an estimate based on their average monthly effluent limitation and their design flow. They also raise a concern about the estimates of BOD calculated as Dissolved Organic Carbon (DOC).

They comment that “The District does not sample effluent for Dissolved Organic Carbon (DOC), so the report should include a rationale for the estimates of DOC loading; otherwise, the estimates should be removed.”

They request that page 44 be corrected to read as follows:

“Although the maximum allowable discharge of BOD load from FSSD was approximately 900 kg/day ~~was at 545 kg/day or 204 kg/day as DOC~~, actual discharges are usually much lower. For example, in 2012, the average daily BOD load was less than 107 kg/day (~~DOC load of 40.1 kg/day~~) (NPDES discharge data).”

**Response:** *We have modified the text in the Staff Report to address the concerns raised:*

“Although the maximum allowable discharge of BOD load from FSSD was approximately 900 kg/day ~~was at 545 kg/day or 204~~ 346 kg/day calculated as DOC, the actual discharges are usually much lower. For example, in 2012, the average daily BOD load was less than 107 kg/day (calculated DOC load of 40.1 kg/day) (NPDES discharge data).”

*In order to compare FSSD’s BOD load to other sources, it is useful to express it as organic carbon. Since the FSSD does not sample for DOC, we approximated the DOC load using molecular weight ratios and the oxygen amount needed to burn carbon ( $O_2/C = (16 \times 2)/12 = 2.67$ ), which is commonly used in water quality models.*

**Comment 2.2:** “Be aware of limitations on the District’s ability to route “more FSSD discharges to Boynton and Peytonia Slough ... at times when low DO water is being discharged from managed wetlands.” (Page 77)

The District’s ability to increase discharges depends on influent flows to the plant as well as established recycled water demands.”

**Response:** *Comment noted.*

**Comment 2.3:** The Commenter requests that we revise the implementation language for the District’s DO receiving water limitation (Page 77).

“The District requests minor changes to the text to clarify that DO limits continue to apply within one foot of the surface and that the 3-month median will be removed from the NPDES Permit.

They request we revise page 77 to read as follows:

“The wasteload allocation for the FSSD wastewater treatment plant will continue to be implemented as receiving water limitations ( $\geq 5.0$  mg/L June 1-November 15, and  $\geq 7.0$  mg/L during all other times of the year and expressed as 30-day running average and within one foot of the surface). The requirement to maintain the median DO concentration for any three consecutive months at  $\geq 80\%$  of DO content at saturation will be removed from the NPDES Permit ~~not be required~~ as this objective does not apply.”

**Response:** *The text has been revised as follows:*

*“The wasteload allocation for the FSSD wastewater treatment plant will continue to be implemented as receiving water limitations ( $\geq 5.0$  mg/L June 1-November 15, and  $\geq 7.0$  mg/L during all other times of the year and expressed as 30-day running average and within one foot of the surface). Staff will recommend to the Water Board that the requirement to maintain the median DO concentration for any three consecutive months at  $\geq 80\%$  of DO content at saturation not be required, as this objective does not apply.”*

**Comment 2.4:** The Commenter requests that we revise text on Pages 77-78 to accurately reflect their operations as follows:

“Additionally, treated wastewater can be ~~redirected to storage ponds or irrigation conveyance and~~ used directly to flood up duck clubs located in the immediate vicinity of the ~~discharge distribution~~ pipeline. This would reduce the amount of water drawn from the sloughs, thereby reducing net upstream flows that had been associated with fish kills in the past. FSSD currently participates in the WQIF project, which tests the best ways to utilize treated effluent from its facility to improve DO conditions in the marsh.”

**Response:** *We have revised the text in the Staff Report as requested.*

### Comment Letter No. 3: San Francisco Baykeeper

**Comment 3.1:** “This TMDL was largely driven by DO depletion caused by releases of water from managed ponds, yet this TMDL contains no instantaneous minimum dissolved oxygen (DO) values, consistent with other TMDLs developed based on the ‘Virginia Province Approach’. Nor does the TMDL require implementation of recognized best management practices (“BMPs”) identified in the DO TMDL to improve water quality at managed wetlands. We ask the Regional Board to consider our requests to address the need for more active management of Suisun Bay duck clubs and their associated ponds.

Baykeeper is primarily concerned that the DO TMDL numeric targets are under-protective of aquatic life beneficial uses, and that the proposed Implementation and Monitoring Program for the DO TMDL lacks specificity to attain these targets. The Program, as proposed, relies on a status quo approach insufficient to determine the water quality attainment or the effectiveness of BMPs. This is in conflict with minimum TMDL requirements established in U.S. Environmental Protection Agency (“U.S. EPA”) guidance for TMDL development.”

**Response:** *We disagree that the TMDL is underprotective of aquatic life or that an instantaneous minimum DO value was required, as explained further in Comments 3.2 and 3.3. Contrary to the Commenter’s assertion, implementation of BMPs is required by applicants for the Regional General Permit 3, as explained in Comment 3.5. See generally responses to Comments 3.2 through 3.8 below.*

**Comment 3.2:** The Commenter cites DO criteria adopted for the Chesapeake Bay and raises a concern that while the numeric values in the DO TMDL are comparable to the standards implemented by the Chesapeake DO Criteria, the proposed sampling periods for DO numeric targets in Suisun Marsh are under-protective of Suisun Marsh’s beneficial uses and oversimplified in comparison to those found in the Chesapeake DO criteria.

Baykeeper comments that “The DO TMDL numeric targets do not include a multi-day short-term DO criteria, like the 7-day sampling criteria required in the Chesapeake DO Criteria (Table 2). This short-term monitoring period is more likely than a 30-day sampling mean to show signs of short-term DO impairment following managed wetland discharges. According to the Staff Report, a 2007 study showed that managed wetland drain events could decrease DO levels to 1.5 mg/L-0 mg/L, creating hypoxic and lethal conditions lasting multiple days. Based on information provided in the DO TMDL regarding the monitoring approach, it is not clear such events would be adequately detected or that the Acute CMC (1-day mean  $\leq 3.8$  mg/L) is protective of severe DO lags that may take place over hours rather than days. Although some aquatic life in Suisun Marsh may be naturally resilient to natural DO variation in wetland habitats, a multi-day period of extremely low DO values following a stagnant water discharge can severely impact fish growth, survival, and larval recruitment. A short-term lag in DO levels caused by managed wetland discharges could easily occur unnoticed when included within a mean taken from a cumulative 30-day sampling period.”

The Commenter requests that “the Regional Board revise the DO TMDL to establish a numeric target with a 7-day monitoring window to protect Suisun Marsh’s aquatic life from these previously observed multi-day DO lags.”

***Response:*** We disagree with the Commenter's conclusions that the proposed sampling periods are underprotective of Suisun Marsh's beneficial uses or oversimplified in comparison to those found in the Chesapeake DO criteria and that a 7-day monitoring window is necessary.

*In developing the site specific objectives (SSOs) for DO in Suisun Marsh, we followed the U.S. EPA methodology, which supports the derivation of region-specific DO criteria tailored to the species, habitats, and DO exposure regimes of varying estuarine, coastal, and marine waters. This specifically allows for setting the SSOs and the monitoring requirements as appropriate for a given aquatic system. The proposed SSOs and the sampling periods follow the in-depth evaluation of the types, life stages, and DO requirements of resident and migratory fish in Suisun Marsh, the available data, and the recommendations of the Science Advisory Panel, which provided full support for the SSOs.*

*Chesapeake Bay system is substantially larger and more complex than Suisun Marsh. In addition, its DO criteria derivation was driven by extensive eutrophication due to nutrient loading, which caused chronic widespread summer hypoxia lasting from spring to fall and affecting most of Chesapeake Bay. Chesapeake Bay also experiences thermally stratified conditions, which contribute to impairment. These adverse temperature regimes have not been observed in Suisun Marsh, nor is there evidence of excessive nutrient loads or DO stratification. Moreover, Chesapeake Bay 7-day mean  $\geq 4$  mg/L was established to protect open-water fish larvae. Since there is no spawning and/or larval stages of the DO sensitive species (Prof. Peter Moyle, pers. comm), and the acute objective (1-day mean  $\geq 3.8$  mg/L) is comparable in magnitude and somewhat more sensitive (1-day mean) than Chesapeake criterion (7-day mean), the proposed SSOs have an added level of protection for the juvenile and adult life stages of species present in Suisun Marsh. Since there is no spawning of migratory fish in Suisun Marsh, the 7-day mean  $\geq 6$  mg/L, which was established in Chesapeake Bay, is not necessary here.*

*Additionally, the Commenter's suggestion that the "managed wetlands discharges could easily occur unnoticed when included within a mean taken from a cumulative 30-day sampling period" is inaccurate. We require continuous data collection at regular intervals (every 15 to 60 minutes) to evaluate whether the objectives are met. All DO data at managed wetlands and in Suisun Marsh sloughs are collected with YSI sondes recording DO at 15-min increments. Specifically, we analyze and interpret all recorded data, not just the 30-day averages. The chronic objective ( $\geq 5$  mg/L) is evaluated as a running average, not a simple 30-day average, and the calculation of the running average is done with a 1-day time step, which makes it unbiased in detecting drops in DO during the averaging period. The purpose of the acute objective is, by design, to detect short-term drops in DO (1-7 days), and these drops become significant when the persistent low DO is observed on multiple days. Both acute and chronic objectives apply at all times and need to be evaluated concurrently.*

**Comment 3.3:** The Commenter requests the Regional Board revise the DO TMDL to include instantaneous minimum values.

They comment that "... the DO TMDL numeric targets also fail to establish an instantaneous minimum value for any criteria, falling short of the Chesapeake DO Criteria. Instantaneous minimums, or threshold values that cannot be exceeded in a single sampling event, identify exceedances of the TMDL. These values offer greater protection against fatal DO conditions



than would a mean of DO measurements taken over a 24-hour or 30-day time period. The Chesapeake DO Criteria includes instantaneous minimum values to protect aquatic life, including more stringent protections during salmonid migration and spawning season. Suisun Marsh has these same beneficial uses, and merits similar protections for its aquatic life. To account for natural variation, the Regional Board could establish a number of allowable exceedances of an instantaneous minimum value per sampling period, month, or year. However, natural variation cannot be an excuse for excluding instantaneous minimum values from the DO TMDL entirely.”

***Response:*** *The instantaneous minimum is not a prerequisite to establishing DO criteria, and it was not part of the U.S. EPA methodology for the Virginian Province. During the process of derivation of the SSOs, we discussed with the Expert Panel whether to include an instantaneous minimum DO threshold in the range of 1 to 2 mg/L, but this approach lacked a scientific basis, and it was not supported as a valid option for Suisun Marsh. In addition, the instantaneous minimum is not necessary for a system such as Suisun Marsh, which is not eutrophic. It was established in Chesapeake Bay to address the eutrophication problems causing huge daily swings in DO, against which minimum DO criterion helps to safeguard.*

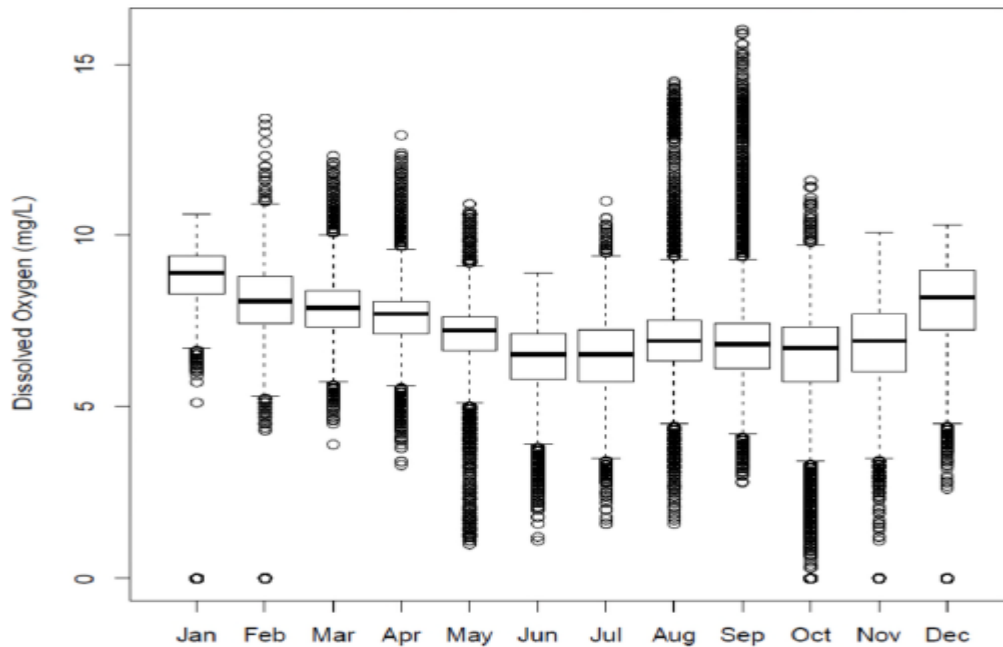
*Our SSOs include a more stringent chronic objective (6.4 mg/L) to protect sensitive juvenile salmonids and green sturgeon using the marsh for migration. This objective is protective of life stages of the sensitive species present in Suisun Marsh and reflective of their spatial and temporal extent. It also follows the findings issued by the National Marine Fisheries Service in its Biological Opinion for the Suisun Marsh Habitat Management, Preservation and Restoration Plan (NMFS 2013)<sup>1</sup>.*

*Moreover, establishing an instantaneous minimum criterion is not warranted since unexpected drops in DO concentrations are detected throughout the year and in locations without any discharges. Continuous DO concentrations measured in First and Second Mallard in 2008-2016 (see Figure below) show multiple incidences of low DO, despite the fact that these sloughs do not receive discharge from managed wetlands, are fully tidal, and considered minimally impacted.*

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<sup>1</sup> NMFS (National Marine Fisheries Service). 2013. *NMFS Biological Opinion on the proposed 30-year Suisun Marsh Habitat Management, Preservation, and Restoration Plan*.

*Dissolved Oxygen in First and Second Mallard Slough (combined) during 2008-2016*



**Comment 3.4:** The Commenter requests the Regional Board revise the DO TMDL to specify immediate actions that managed wetlands exceeding their DO load allocations must take to facilitate attainment of the DO TMDL.

They comment that “The DO TMDL fails to identify for managed wetlands any required response actions to a measured exceedance of the DO TMDL numeric targets during a sampling period. The model study discussed in Section 8.2 of the Staff Report showed that stable DO concentrations of 5 mg/L could be attained during managed wetland discharge events by reducing the volume of discharge or discharging a smaller load over a longer period of time. In response to any DO readings taken below the acute threshold (or instantaneous minimum) during a managed wetland discharge event, the managed wetland should be required to implement these or similar BMPs to immediately reduce the load until DO levels return to an appropriate threshold.”

**Response:** We disagree. Table 7.9.2-1 (Basin Plan amendment) specifies that discharges from managed wetlands shall not cause the DO concentrations in the sloughs to decrease below the SSOs, i.e., 3.8 mg/L (as daily average) and 5 mg/L (as 30-day running average). Since the load allocations are expressed as DO concentrations and are equal to the SSOs, the managed wetlands must take actions to meet these allocations. Immediate action is not feasible for Suisun Marsh; however, corrective actions are required to be identified. The vegetation and water quality BMPs identified in the Implementation Plan have been shown to improve DO conditions in the receiving waters. It is not appropriate to prescribe which specific BMPs should be implemented by any one of the 152 duck clubs. The specific actions implemented at each managed wetland will depend on the severity of the problem, hydrological configurations, existing control structures, access to different sloughs, and the understanding of the performance and effectiveness of past BMPs.

*As required by the 401 certification, the managed wetlands have to report back to the Executive Officer on the individual corrective actions they have taken and, if low DO was detected, which BMPs they intend to employ to prevent these drops from occurring in the future.*

**Comment 3.5:** The Commenter requests the Regional Board revise the DO TMDL Implementation and Monitoring Protocol to require managed wetlands to implement the full suite of recommended BMPs listed in Table 12-2 of the DO TMDL, to enhance the likelihood of full attainment of the DO targets, and to reduce activities that impair DO levels and/or implement new actions that will support attaining the TMDL. They also request that the Regional Board implement the DO TMDL through individual WDRs.

They comment that “The DO TMDL’s Implementation and Monitoring Protocol is insufficient to reduce the impact of managed wetlands on DO levels in Suisun Marsh. Sections 12.1.1 through 12.1.6 of the DO TMDL only summarize voluntary BMPs for managed wetlands and funding sources for landowners to develop their own water quality management programs. By failing to include additional required minimum BMPs, it is likely that managed wetlands will not implement additional BMPs, and will merely carry on the current status quo under the DO TMDL.

Moreover, the DO TMDL allows the Regional Board to defer the majority of its regulatory authority to other agencies, relying on the U.S. Army Corps of Engineers’ RGP3 Permit requirements for mandatory BMP implementation and DO Monitoring at managed wetlands. Section 12.1.6 of the Staff Report states the primary regulatory tool to implement the DO TMDL at managed wetlands is the 401 Water Quality Certification. Waste Discharge Requirements (“WDRs”) will only be issued to individual landowners if the TMDL is not achieved via voluntary compliance with the 401 Water Quality Certification. Baykeeper believes that it is highly unlikely that managed wetlands implementing their status quo BMPs will be able to voluntarily comply with the DO TMDL.

***Response:*** *The Commenter’s characterization of the Implementation Plan and the monitoring protocol is inaccurate. The TMDL Implementation Plan outlined in Section 7.9.1.5 of the proposed Basin Plan amendment and the implementation actions described in section 12.1 of the Staff Report are not self-implementing. The Implementation Plan provides examples of the types of management practices that will ensure adequate DO in managed wetland discharges and the mechanisms for requiring these management practices.*

*As described in Section 12.1.1 of the Staff Report and in the Basin Plan amendment, the primary mechanism for requiring BMPs to maintain adequate DO at managed wetlands is the Water Board’s 401 water quality certification of Regional General Permit 3. This certification, entitled “Water Quality Certification for the Reissuance of Regional General Permit 3 for Suisun Marsh Managed Wetlands Operations and Maintenance, Suisun Marsh, Solano County,” was issued on February 14, 2018. The requirements set forth in the TMDL are already included in the 2018 401 certification.*

*The TMDL Staff Report has been updated as follows to reflect that the 2018 401 certification has become final and to clarify the mechanism for BMP implementation. Section 12.1.1 has been edited to read:*

*This TMDL compels similar BMPs and monitoring provisions to be included in the reissued RGP3 (December 2017), informed by lessons learned during the current permit. (Page 71 of the Staff Report).*

*The 401 Water Quality Certification for Regional General Permit 3, issued on February 14, 2018, (2018 Water Quality Certification) implements the TMDL by requiring applicants to employ water management and vegetation BMPs identified in (1) the 2007 Conceptual Model for Managed Wetlands in Suisun Marsh; (2) the 2011 Strategies for Resolving Low Oxygen and Methylmercury Events in Northern Suisun Marsh; (3) the ongoing U.S. EPA Water Quality Improvement Pilot Project; and (4) the TMDL Staff Report. Applicants are required both to describe implemented actions and the effectiveness of BMPs and to report DO monitoring results in annual reports to the Water Board.*

*The 2018 Water Quality Certification also requires the Goodyear Slough Outfall to be cleaned as often as necessary to maintain dissolved oxygen objectives (as determined by continuous monitoring) and no less frequently than once per year.*

*It would be inappropriate to specify the numbers, types, and locations of implementation actions within the TMDL, because the BMPs need to be tailored to the specific conditions within each individual managed wetland. As stated in section 12.1.1, page 70 of the Staff Report, ... "different sloughs will require different BMP strategies due to variations in slough hydrology, watershed characteristics, managed wetland characteristics and property infrastructure, the amount and location of tidal marsh along the slough system, and other infrastructure considerations." Parties covered by the 401 certification and Regional General Permit 3 may select appropriate BMPs based on site-specific conditions and are responsible for demonstrating the effectiveness of these BMPs in their annual reports.*

*Implementing BMPs through the Water Quality Certification does not defer the Water Board's regulatory authority. To the contrary, the Water Quality Certification represents an exercise of the Water Board's authority under Clean Water Act section 401 (33 U.S.C. 1341). Similarly, contrary to Commenter's assertion, compliance with the Water Quality Certification is not voluntary. The Water Board may take enforcement against entities that have violated the conditions of their water quality certifications. (Wat. Code. § 13385, subd. (a)(5).). We included a reference to individual WDRs in the Implementation Plan so they could be considered as we adaptively implement the TMDL, in the event they are needed. We are confident the 401 certification is the appropriate mechanism, and efficient from a workload perspective, to address managed wetlands discharges at this time and this is supported by the results of early implementation actions taken under the 2013 401 certification.*

**Comment 3.6:** The Commenter requests the Regional Board revise the DO TMDL to require managed wetland discharges in winter and spring be sampled in the same manner as fall discharges to establish DO TMDL compliance.

They comment that "Section 2.1.2 of the Staff Report indicates that managed wetlands primarily discharge water into Suisun Marsh and surrounding sloughs during the "Fall Flood-Up" time period, but additional discharges also occur in winter and spring. According to Section 12.1.2 of the Staff Report, the Suisun Resource Conservation District ("SRCD") and

managed wetlands only monitor for DO before and during fall water discharges, “until mid-November, when, in general, water quality starts to improve in the sloughs receiving discharge from managed wetlands.” It is not enough to rely on the *assumption* that “water quality starts to improve in the sloughs [in mid-November]” in lieu of scientific monitoring to assure the DO TMDL is met. Furthermore, as discussed in Section 12.4.2 of the Staff Report, this limited monitoring of managed wetland discharges fails to meet the Water Board’s 401 Water Quality Certification requirement that “the sampling frequency and spatial extent be sufficient to determine ambient DO levels before the discharge occurs and to determine whether water quality objectives for DO in the receiving waters are met after the release of water from the managed wetlands.”

***Response:*** *It appears that the Commenter misread Section 12.1.2 as representing the current and only monitoring requirements. The text on page 72 of the Staff Report refers to the requirements and subsequent lessons learned from the 2013 401 certification.*

*The TMDL does require monitoring to be conducted in winter and spring, and the monitoring requirements are sufficient to determine compliance both spatially and temporally. In addition, DO data are currently collected throughout the year at three locations (two stations in Goodyear Slough, and one station in Montezuma Slough). We also have data from the two long-term ambient scientific monitoring stations in First and Second Mallard Slough maintained by the National Estuarine Research Reserve for comparison, and assessment of long-term trends.*

*As discussed in response to Comment 3.5 above, on February 14, 2018, the Water Board issued 401 water quality certification for the reissuance of Regional General Permit 3 for Suisun Marsh managed wetlands operations and maintenance. Provisions 7 through 9 of the certification (see below) specify monitoring conditions and require that the permittees prepare a Monitoring Workplan, acceptable to the Executive Officer, to be submitted each year. Therefore, we have an ability to evaluate, modify, and prioritize monitoring activities proposed by the applicants as needed.*

***Excerpts from the February 14, 2018, 401 Certification:***

*7. No later than May 1 of each year, the Applicants shall submit a DO Monitoring Workplan acceptable to the Executive Officer. The DO Monitoring Workplan shall describe water management and vegetation BMPs that will be implemented to attain water quality objectives for DO, the locations of monitoring stations, include an implementation schedule, and incorporate Conditions 8 and 9 below. The DO Monitoring Workplan shall be submitted via e-mail to RB2-401Reports@waterboards.ca.gov or by mail to the attention of 401 Certifications Reports at the Water Board (see the address on the letterhead). Any changes to the DO Monitoring Workplan shall be submitted, acceptable to the Executive Officer, two weeks prior to implementation.*

*8. Within the period of August through December of each year, the Applicants shall conduct continuous DO monitoring in the receiving sloughs to verify the effectiveness of BMPs and to demonstrate attainment of applicable water quality standards. Monitoring shall be conducted in Goodyear Slough and Boynton Slough and shall (1) be conducted for at least 90 days, and (2) include periods before, during, and after*

*discharge from the managed wetlands. The Applicants shall notify the Water Board of the start date for DO monitoring.*

*9. Within the period of January through April of each year, the Applicants shall conduct continuous DO monitoring in Montezuma Slough or Nurse Slough, or Denverton Sloughs to demonstrate that DO conditions ensure the protection of listed juvenile salmonids. Monitoring shall be conducted for at least 90 days. The Applicants shall notify the Water Board of the start date for DO monitoring.*

**Comment 3.7:** The Commenter requests the Regional Board revise the DO TMDL to clarify that individual managed wetland must submit individual reports, including monitoring data and updates to BMPs.

They comment that “The Staff Report states that SRCD is responsible for submitting a monitoring report to the Regional Board, including monitoring results, any implemented BMPs, and collaboration efforts between managed wetlands to meet the DO TMDL. It is unacceptable for the Regional Board to rely on a monitoring report from an external agency that only includes a portion of discharges into Suisun Marsh from managed wetlands, as these water discharges can cause substantial DO lags in receiving waters year-round.

**Response:** *It is not unusual for the Water Board to encourage a collaborative approach to monitoring, especially when discharges are generated by a number of small entities, or when a regional or coordinated approach would yield more comprehensive and better quality data. The “end-of-pipe”-like monitoring by individual managed wetlands will be of limited value, as it would not represent conditions in the receiving waters where the SSOs apply and likely be of low quality, while imposing high initial costs and subsequent maintenance costs. A single, new YSI sonde costs in excess of \$10,000, and it requires trained professionals to calibrate, deploy, troubleshoot, and retrieve data. The 2018 401 certification facilitates a meaningful monitoring program that builds upon preexisting knowledge and additional knowledge gained each year.*

*The 2018 401 certification requires SRCD, together with the managed wetland owners and other agencies (California Department of Fish and Wildlife, Department of Water Resources, U.S. Bureau of Reclamation) to conduct DO monitoring in the sloughs that receive discharges from managed wetlands, including continuous DO monitoring at compliance points, in order to evaluate whether they are achieving the load allocation and the SSOs.*

*We require that the BMP implementation is reported at individual managed wetlands but this information is compiled into a single annual report, which SRCD submits on behalf of landowners and agencies named in the 2018 401 certification. There is no water quality benefit in requiring separate BMP reports to be submitted by each managed wetland owner individually.*

*The Commenter did not provide any evidence to support the claim that “these [managed wetlands] water discharges can cause substantial DO lags in receiving waters year-round”. The discharges from individual managed wetlands occur for a fraction of the time during the year and largely in the fall. Our data show an almost instantaneous lowering of DO in the receiving slough after discharge begins, and similarly the DO increases are fairly rapid after the discharge ends. DO does not behave like a conservative tracer; therefore, it cannot be tracked to the source for extensive periods of time.*

**Comment 3.8:** The Commenter requests the Regional Board revise the DO TMDL to include more stringent monitoring requirements during the winter time period to ensure that this protective criterion is met.

They comment that “Baykeeper is extremely concerned about the impact of unmonitored winter and spring water discharges on spawning and migratory salmonids in Suisun Marsh, including endangered species. Monitoring requirements should be stringent during this season to ensure that beneficial uses (estuarine habitat, fish migration, preservation of rare and endangered species, fish spawning, and wildlife habitat) are appropriately protected. The proposed 30-day mean DO criterion of 5.0 mg/L is raised to 6.4 mg/L in Montezuma, Nurse, and Denverton Sloughs during the winter season (Jan-April) to protect migratory and endangered fish (Table 2).”

***Response:*** Here the Commenter notes that we raised the proposed 30-day mean DO criterion from 5.0 mg/L to 6.4 mg/L in Montezuma, Nurse, and Denverton sloughs to protect migratory and endangered fish but incorrectly assumes that the winter and spring discharges are not monitored and that they therefore adversely affect salmonids. See Response to Comments 3.6 and 3.7. The sampling location at Beldon Landing (Montezuma Slough) has been already established by the Department of Water Resources where DO data have been collected continuously since the beginning of December 2017. It is intended that this station will operate not only during January – April but will continue to measure DO throughout the year, so we can ensure protection of sensitive and endangered species. The cost of a single permanent monitoring station is considerable (see page 92 in the Staff Report); therefore, the TMDL attempts to balance the need for and value of data in assessing compliance against the cost to collect, compile, and store information.

**Comment 3.9:** The Commenter requests the Regional Board revise the DO TMDL to include required reductions and actionable monitoring requirements for managed wetlands to ensure that the Mercury TMDL is met.

They comment that “Section 7.6 of the Staff Report does not include any requirements or guidelines for monitoring Methylmercury (“MeHg”) discharge from managed wetlands in the Implementation Plan, despite naming managed wetlands as a substantial local source of MeHg. Section 11.1 of the Staff Report only includes tidal wetland restoration projects as subject to Bay Mercury TMDL requirements (through WDRs and Section 401 Certifications), failing to include any reduction requirements for managed wetlands. Relying on the gradual process of restoring tidal wetlands instead of requiring managed wetlands to reduce activities that promote Methylation will not result in attaining the Mercury TMDL. As stated in Section 12.1.6 of the Staff Report, if tidal marsh restoration projects “must ...include pre-and post-restoration monitoring [of methylmercury] to demonstrate compliance” with Section 401 Water Quality Certifications, managed wetlands should be subject to similar MeHg monitoring requirements to show they are not causing a “net increase in mercury or methylmercury loads to the Bay.”

***Response:*** The 303(d) listing of Suisun Marsh as impaired by mercury results from concerns about high concentrations of mercury in Bay biota and the fish consumption advisories issued for San Francisco Bay dating back to the early 1970s. Adding Suisun Marsh to the Bay

*Mercury TMDL is consistent with the plan for achieving reductions in fish tissue concentrations on a Bay-wide level.*

*Since MeHg loads generated by managed wetlands are highly variable and uncertain, there is a limited value in establishing numeric load reductions, which cannot be clearly measured or tracked. The relative magnitude of these loads compared to other sources of mercury to the Bay is also small. (see Section 7.6 of the Staff Report). The estimated MeHg fluxes from managed wetlands (0.122 to 0.46 g/day) are an order of magnitude smaller when compared to the load of MeHg carried by the tributaries to the Delta of 16.6 g/day, and they are likely to vary significantly depending on the water management system at individual wetlands. Preliminary data from Suisun Marsh also suggests that the MeHg flux is not unidirectional, which means that managed wetlands can act as sources or sinks of MeHg. The high temporal and spatial variability associated with the measured loads are likely to remain regardless of the amount of data being collected, because such variability is inherent in a biologically and hydrologically complex environment such as Suisun Marsh.*

*Nonetheless, we predict that implementation of actions to increase DO and to limit anoxic conditions at managed wetlands will simultaneously reduce methylation potential and, subsequently, mercury load from managed wetlands (Staff Report Section 11.1). Thus, our approaches to increase the DO levels to meet the requirements of the DO TMDL should result in improving Hg conditions. We have changed the text in Section 7.2.2.6 of the Basin Plan amendment to say:*

*Wetlands may contribute substantially to methylmercury production and biological exposure to mercury within the Bay. Plans for extensive wetland restoration in the San Francisco Bay region raise the concern that mercury methylation may increase, thereby increasing the amount of mercury entering the food web. Implementation tasks related to wetlands focus on managing existing wetlands and ensuring that new constructed wetlands are designed to minimize methylmercury production and subsequent transfer to the food web. Implementation actions identified in the Suisun Marsh TMDL for dissolved oxygen (Section 7.9.1) are expected to reduce methylmercury production and the overall load of mercury into the Bay.*

*Mercury monitoring at managed wetlands is not precluded as part of the Bay Mercury TMDL. The WQIF project is collecting data on methylmercury currently, and additional data collection plans or programs may be required during implementation or reissuance of the 401 certification.*



## Comment Letter No. 4: Suisun Resource Conservation District

**Comment 4.1:** “The Basin Plan amendment report and plan provide a comprehensive examination of water quality impairment issues. We appreciate the effort of the Water Board to work with the SRCD and landowners on development and implementation of Best Management Practices (BMPs) for managed wetlands to improve water quality in Suisun Marsh. In general, close coordination of wetland management with real-time monitoring will be most beneficial in meeting water quality objectives.”

**Response:** *We agree. Comment acknowledged.*

**Comment 4.2:** “Introduction (p. 1, para 3): “Salinity conditions in Suisun Marsh are to a great degree dependent on Delta water management regulations and decisions, and affected by the overall hydrology of the Central Valley watershed (ranging from wet to critically dry).” It should be noted that many wetland management practices in Suisun Marsh were initiated under conditions of lower salinity preceding changes in the Delta water management regulation.”

**Response:** *Comment noted that many wetland practices were initiated under conditions historically of lower salinity.*

**Comment 4.3:** The Commenter requests that we modify the Introduction (p. 1, para 4), as follows:

*“From 2009 to 2018, ~~Over the past two decades,~~ low DO concentrations ~~and fish kills in the fall~~ have been frequently observed in 4 out of 20 years in Peytonia, Boynton, Suisun, and Goodyear Sloughs in Suisun Marsh (O’Rear and Moyle, 2010, Schroeter and Moyle, 2004). Fish kills were documented in the fall seasons of 1999, 2001, ~~and~~ 2003, and 2004. In October 2004, a widespread fish kill was observed in Peytonia, Boynton, Goodyear, and Suisun Sloughs (Schroeter and Moyle, 2004). In October 2009, 100% mortality of fishes was observed in Goodyear Slough (O’Rear and Moyle, 2010). The fish kills were linked to the releases of low DO waters from managed wetlands. DO concentrations below 1-2 mg/L were measured in the marsh sloughs when discharges from the managed wetlands occurred, which can result in mortality to some species of fish.”*

Fish kills may occur under historical conditions or those without managed wetlands, but that rate is not known; hence, it is better to be specific here rather than suggest what is occurring “frequently.”

**Response:** *We edited the discussion in the Staff Report to remove the word “frequently.” However, we note that there have been significant fish kills in the marsh historically, and some may not have been documented.*

**Comment 4.4:** The Commenter requests that we make the following changes to Introduction (p. 2, para 2): “Two-thirds, or about 52,000 acres, of the Suisun Marsh wetlands are managed wetlands, meaning they are diked and managed to provide seasonal wetland habitat for resident and migratory wildlife focused on better waterfowl food resources. Accordingly, water control actions and vegetation management at managed wetlands play an important role in maintaining adequate DO levels of discharge water.”

**Response:** *The text has been revised.*

**Comment 4.5:** The Commenter requests that we make the following changes to Introduction (p. 2, para. 3): “...restoration of tidal action to at least ~~7,000~~ 5,000 acres of managed wetlands in Suisun Marsh (USFWS Tidal Marsh Recovery Plan, 2013).” The recovery plan and EIS report at least 5,000 acres.”

**Response:** *The amount of acreage has been revised.*

**Comment 4.6:** The Commenter requests that we make the following changes to section 2.1 Suisun Marsh Area (p.5, para 2): “*The majority of the marsh is used by over 150 private duck clubs today, which maintain diked seasonal wetlands for wintering waterfowl and hunting (Figure 2-2) as well as other resident and migratory wildlife species. In addition, some publicly owned portions of the marsh, including the Grizzly Island Wildlife Area, are managed as wetlands supporting public waterfowl hunting.*”

**Response:** *The text has been revised.*

**Comment 4.7:** The Commenter requests that we make the following changes to section 2.1.1 Hydrology: “*The hydrology of Suisun Marsh is affected by several factors, including Delta outflows, rainfall, tides, local creek inflow, and the Fairfield Suisun Sewer District (FSSD) Wastewater Treatment Plant discharge.*”

**Response:** *The text has been revised, and “Delta outflows” was added to the hydrological drivers.*

**Comment 4.8:** “2.1.2 Role of Managed Wetlands: while management is directed at wintering habitat for waterfowl, seasonal wetland management contributes a wide array of other beneficial ecosystem services that should be mentioned include enhancing biodiversity of species such as wintering shorebirds and other aquatic organisms, contributing invertebrate food resources for higher trophic level predators including fish, supporting breeding wildlife, sequestering carbon, and enriching cultural values.”

**Response:** *Comment noted. We do not dispute that the managed wetlands fulfill important ecological functions.*

**Comment 4.9:** “Figure 3-2, Causes of low DO in small tidal sloughs in Suisun Marsh: the key element requiring vegetation management is elevated salinity levels in waters linked to Delta water management regulations. The conceptual model should include a box that indicates Salinity is a primary External Source or Driver of wetland Vegetation Management. Without elevated salinities, leaching and discharge cycles would not be necessary.”

**Response:** *We disagree that Figure 3-2 needs revising. The location of Suisun Marsh in the center of the San Francisco Bay-Delta Estuary results in brackish salinity with strong salinity gradients and complex patterns of flow interactions. Historical records indicate that Suisun Marsh repeatedly experienced long periods of low freshwater inflows, which would make at least parts of the marsh experience high salinity (Historical Ecology Chapter in Moyle et al. 2014)<sup>2</sup>. Although upstream water diversions and other actions have affected salinity, Suisun*

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<sup>2</sup> Moyle, P.B., A.D. Manfree, and P.L. Fiedler. 2014. Suisun Marsh: Ecological History and Possible Futures. University of California Press.

*Marsh never functioned as a freshwater marsh, and the current salinity gradients are similar to those caused by the droughts in the past.*

**Comment 4.10:** “3.6 Mercury Effects and Impairment Assessment, p. 21, para 1: it would be good to note here that Mississippi silversides is a non-native species that forages in shoreline and shallow water habitats and exhibits greater potential for Hg methylation (p. 8, Sec 5.2.2).”

**Response:** *Comment noted. The references cited in the Staff Report (e.g., Grenier et al. 2010)<sup>3</sup> provide additional information on Mississippi silversides’ origin, distribution, and its importance as biosentinel species for mercury.*

**Comment 4.11:** The Commenter requests that we make the following changes to section “5.2.2 p. 39, para 1: correct “(California least tern)” ”

**Response:** *Corrected.*

**Comment 4.12:** “6.2.1 Surrounding Watersheds, p. 43, para 2: it may be relevant to note that runoff concentrations also have and will be affected by changes in watershed conditions following events such as wildfires.”

**Response:** *Comment noted.*

**Comment 4.13:** “Section 7.6 Managed Wetlands, p. 51, para 5: specify here that export will vary greatly with seasonal flooding and draining periods of pond management.”

**Response:** *Comment noted. It is implicit in the source analysis, and in the discussion of seasonal variations and critical conditions, that the loads and fluxes experience high temporal and spatial variability and that they may change (See, e.g., page 52).*

**Comment 4.14:** The Commenter requests that we make the following change to section 8.2 Impact of Discharge Timing and Volume on DO, p. 55: “*The HEC-RAS simulations demonstrated that changes to water management at the duck club properties, and specifically reductions in discharge by 40 to 60%, could result in a significant improvement in DO conditions in the receiving slough, but could have detrimental impacts to the managed wetland habitats. Similar improvements could be accomplished by allowing for discharge to occur over longer periods of time. This confirms implementation actions that improve water management, such as staggering discharges in individual sloughs, redirecting discharges to larger sloughs when possible, and coordinated release of FSSD high DO treated effluent, provide the best opportunity to improve DO and is the most efficient use of the available resources.*” Text was added to specify trade-offs. Also, it would be good to indicate when possible a rough idea of what “longer periods” of discharge will make a difference.”

**Response:** *The purpose of the modeling was to establish whether there was a link between the discharge from the managed wetlands and water quality in the sloughs. The HEC-RAS modeling by Tetra Tech did not evaluate if and how those discharge reductions would affect*

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<sup>3</sup> Grenier, L., B.Greenfield, D.Slotton, and S.Ayers. 2010. *North Bay Small Fish Mercury Monitoring with a Focus on Napa-Sonoma Managed Ponds and Sloughs V.2*. Contribution No. 620. Aquatic Science Center, Oakland, California.

*managed wetland habitats; therefore, the text has not been modified. We will continue to improve the modeling predictions as part of the work funded by the U.S. EPA's Water Quality Improvement Fund grant to better understand the effects of discharge timing and volume on DO conditions in the sloughs.*

**Comment 4.15:** “9.3. Seasonal Variations and Critical Conditions: was there any consideration of impending effects of climate change? Extended drought conditions with earlier runoff may result in warmer water temperatures and more likelihood of low DO events despite management best efforts.”

***Response:*** *The effects of climate change were not specifically evaluated, as we are addressing the water quality impairment given the current conditions in the marsh. We have already acknowledged in the Staff Report that the DO concentrations in the sloughs are affected by both natural and anthropogenic factors. If there is a change in conditions due to climate change, we will evaluate the impacts of the change on attainment of the TMDL as part of adaptive implementation.*

**Comment 4.16:** “12. Suisun Marsh DO TMDL Implementation Plan, p. 69, para 2: “*In developing the proposed implementation actions priority was given to those that were lower-cost and could be completed on-site now at managed wetlands.*” It would be good to have Water Board support for allocation of potential funding sources listed in the report directed to implementation of BMPs and continuous monitoring.”

***Response:*** *We do support SRCD's ongoing efforts to obtain additional funding to improve water quality in Suisun Marsh. In regards to funding and managing projects, all funding sources identified in Section 12.1.3 have their own individual criteria and application requirements.*

**Comment 4.17:** The Commenter provided perspective on a number of statements made in Section 12.1.1 of the Staff Report titled *Changes in Vegetation and Water Management at Managed Wetlands*, but did not request any changes to the Staff Report. They comment that they look forward to providing landowners with technical assistance to implement BMPs but acknowledge that landowner participation varies widely. They comment on the kinds of BMPs that have been implemented to date and state that the effective monitoring needs to be representative and aligned with adaptive BMPs for the best effect.

***Response:*** *Comments acknowledged.*

## PART II

### STAFF RESPONSE TO PEER REVIEWERS' COMMENTS ON THE STAFF REPORT AND BASIN PLAN AMENDMENT DRAFTS

Dated July 31, 2017

#### **Prof. Tim Essington: Specific Comments and Responses**

School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98195

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**E1:** “In accordance with the section 303(d) of the federal Clean Water Act, the San Francisco Bay Regional Water Quality Control Board seeks to set water quality criteria for Suisun Marsh. The Water Board already have criteria for downstream portions of San Francisco Bay but these are not appropriate for upstream reaches that contain tidal wetlands that are naturally lower in dissolved oxygen (DO). Moreover, fish kills have been observed in Peytonia, Boynton, Suisun and Goodyear Sloughs, primarily in Autumn. These appear to be related to timing of inundation and drainage of managed wetlands, principally those part of duck clubs.

The document “Establish water quality objectives and total maximum daily load for low dissolved oxygen/organic enrichment in Suisun Marsh and add Suisun Marsh to SF Bay mercury TMDL” describes the context, the system, and the methods used to set water quality criteria, identify acceptable nutrient loads, and set mercury criteria.

The report is well prepared and provides a thorough and rigorous review of the state of the system, the data that are available, and the alternative causes for low dissolved oxygen. These include carbon inputs, wastewater treatment, runoff from urban creeks, and flooding and drainage of managed wetlands. The report makes a convincing case that managed wetlands are the primary cause of extreme low dissolved oxygen events in autumn.”

*Response: Comment acknowledged.*

**[Conclusion] “1 The proposed SSOs for DO are fully protective of the resident sensitive aquatic organisms in Suisun Marsh sloughs.”**

**E2:** “Does the document and cited material provide sufficient information to address goal? The report assesses species that provide *beneficial uses*. These were defined as those that serve key ecological functions, are of commercial or recreational importance, or are threatened / endangered species. Non-native species are used when deemed an appropriate surrogate for native species. There is a good, rationale and transparent basis for selecting species. The Bailey et al. 2014 report provided the first compilation of species to be used in analysis, which was then revised following feedback from the Science Advisory Panel.

The process resulted in a collection of 17 fishes, and 5 invertebrates. The species list includes Chinook salmon and steelhead trout, and white sturgeon, which is relevant because they are

ESA listed. The species clearly meets the defined guidelines and represents a wide taxonomic diversity.”

*Response: We acknowledge the reviewer’s support for Conclusion 1 and appreciate the comment that the rationale for selecting species was sound and the process meets the guidelines for derivation of the DO criteria.*

**E3:** “For each species, LD50 values were obtained from review of laboratory experiments or, when available, field observations. When information was not available for a species, surrogate species of same genera, or same family were used. The [Tetra Tech] report failed to provide citations to the information sources used to create Table 8 in Tetra Tech (2017), and also failed to provide the method by which information was gathered. For instance, though Tetra Tech (2017) states that they identified new lab studies and field studies, a list of search terms and search databases were not provided. The report also failed to provide information on quality control on LD50 values e.g. minimum sample size, appropriate temperature, precision of estimate. For this reason it is not possible to assess the appropriateness, accuracy, or precision of the information used to generate the SSOs. In comparison, the EPA 2000 report provides some information on quality control (there, they removed studies that were conducted on temperatures out of range of the area being considered). I understand that many of the LD50 values used in the present report were based on those reported in the EPA 2000 report, yet it is not clear to me how information on additional species, or updated information collected over the past 15+ years were identified.”

*Response: The citations are Bailey et al (2014)<sup>4</sup> and U.S. EPA (1986)<sup>5</sup>. The search terms and additional details regarding the literature search are now provided on page 16 of the revised Tetra Tech report (dated October 23, 2017).*

*Neither Tetra Tech (2017)<sup>6</sup> nor the Water Board identified more recent laboratory toxicity data that were also suitable for inclusion in the criteria derivation. Therefore, the criteria for Suisun Marsh were calculated based on a number of studies, which underwent evaluation by the U.S. EPA and were already included in the U.S. EPA database for establishing criteria for Virginian Province. Table 8 summarizes the species identified by the scientific panel as present in Suisun Marsh and the LD 50 for each species or surrogate available in the U.S. EPA database. Text was added in the revised Tetra Tech report to clarify how the search for new data was conducted.*

**E4:** “The calculations of CMC and CCC are clearly laid out, in Tetra Tech 2017 and in Bailey et al. 2014. They apply the method to define minimum DO level needed to provide protection of 95% of all species. This method assumes a log-triangle distribution of LD50 levels, and assumes that LD05 is 1.38 times higher than LD50. The latter assumption comes from EPA

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<sup>4</sup> Bailey, H., C. Curran, S. Poucher, and M. Sutula. 2014. *Science Supporting Dissolved Oxygen Objectives for Suisun Marsh*. SCCWRP Report 830, March 10, 2014.

<sup>5</sup> U.S. EPA. 1986. *Ambient Water Quality Criteria for Dissolved Oxygen*. Office of Water Regulations and Standards. Criteria and Standards Division. Washington, DC. EPA 440/5-86-003.

<sup>6</sup> Tetra Tech, Inc. 2017. *DO Criteria Recommendations for Suisun Marsh*. Final Report. Revised October 23, 2017.

(2000). However, in Tetra Tech 2017 tables, a ratio of 1.43 is indicated (although the text refers to a 1.38 ratio). The ratio used needs to be clarified.”

*Response: Text was revised to clarify that the ratio of 1.43 was used in the calculations (page 20, revised Tetra Tech report). We agree with the reviewer’s suggestion (see comment E8) that this results in a more conservative (protective) value of CMC - 3.8 mg/L versus 2.3 mg/L as calculated in U.S. EPA (2000).*

**E5:** “The application of the EPA (2000) framework is clearly laid out. This framework considers effects on juvenile and adult survival, effects on juvenile and adult growth, and effects on egg / larval survivorship. The latter is based on a simple model that calculates degree of exposures and consequence as a function of spatio-temporal overlap of egg and larval periods with periods of low DO. Here, however, the Tetra Tech (2017) report provides little information regarding inputs to the model, or the sources for each.”

*Response: The step-by-step calculations of the criteria are shown in Tetra Tech (2017) (pages 29-32). Except when clearly noted (e.g., comment E4), the inputs to the model and the calculations of the criteria followed the U.S. EPA (2000)<sup>7</sup> methodology. The key effort in Tetra Tech (2017) was the refinement of the species list for which the laboratory data were available, such that they best represented the mixture of aquatic organisms present in Suisun Marsh (see Tables 7, 8 and 9 in Tetra Tech 2017). The inclusion of the species of ecological importance for Suisun Marsh and exclusion of the species associated with ecosystems outside of the marsh was done with recommendations from the Science Advisory Panel.*

**E6:** “In addition to the EPA (2000) method, the draft report sent to the Science Advisory Panel (Tetra Tech, 2017) also applies a second analysis to confirm that the resulting criteria are realistic given the natural biophysical conditions of affected water bodies. Here they used two reference areas, First and Second Mallard sloughs, where there has been minimal anthropogenic alteration of hydrology or nutrient loadings, and asked how commonly DO dropped below calculated CMC and CCC. This is a good approach, but a comparison table showing similarities and differences in temperature, salinity, tidal current velocities, etc. would be useful to judge the appropriateness of the reference areas. Apart from this omission, the data presented are clear and the analysis steps are transparent.”

*Response: Comment noted. We do not have the data necessary to provide a full comparison between the reference sloughs (First and Second Mallard sloughs) and the other sloughs in Suisun Marsh. More information about water quality in First and Second Mallard sloughs is provided in Appendix B to the Staff Report, Conditions in Minimally Impacted Sloughs (pages B-29-B-38).*

*The Science Advisory Panel also recognized the value of comparison of the DO thresholds to DO observed in First and Second Mallard sloughs. These sloughs do not fully meet the criteria for reference areas but are vital in gaining a better understanding of DO variability and daily ranges under semi-natural conditions.*

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<sup>7</sup> U.S. EPA. 2000. *Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras*. EPA-822-R-00-012. Washington, D.C.: Office of Water.

**E7:** “Are conclusions clearly linked to analyses, and readily follow from analyses? The resulting application of the Stephan et al. (1985) numerical method and the EPA (2000) framework yielded a criterion minimum concentration (daily average) of 3.8 mg / l, and a criteria chronic concentration that varies depending on location. This latter point was important because of spatial heterogeneity in the Suisun Marsh, particularly with respect to where and when salmonids are present. Salmonids are less tolerant of low DO and therefore areas that serve as juvenile rearing habitat need higher dissolved oxygen levels to protect them. Thus, all sloughs and channels, at all times, must maintain monthly averages greater than or equal to 5.0 mg / l, while Montezuma, Nurse, and Denverton sloughs must maintain monthly averages greater than or equal to 6.4 mg / l during January - April.

The species list is entirely appropriate, based on an extensive long term monitoring effort by UC Davis scientists (and with considerable input from one of California’s pre-eminent fish biologists). The conclusion that the species considered fully capture beneficial species is fully warranted.”

*Response: We appreciate the reviewer’s support for the proposed DO thresholds. We agree that setting a separate objective for salmonids is necessary to protect this DO sensitive fish.*

**E8:** “It is clear how the CRC follow from the application of Stephan et al. (1985) and related calculations. The Final Acute Value, calculated from the 4 most sensitive genera from 12 LD50 measurements was 2.67 mg / l, and this is multiplied by 1.42 (see Table 3.1.3 in Tetra Tech 2017) to translate into CMC. Note that this value is more precautionary than the 1.38 multiplier used in EPA 2000, though the text of the report claims that a 1.38 multiplier was used. The CCC follows from applying the Stephan et al. (1985) method with and without salmonids, to 7 measurements of chronic effects (again, using the 4 most sensitive genera). The report claims that CCC is based upon larval fish endpoints (Tetra Tech 2017, page34), but this seems inconsistent with the EPA 2000 framework. Some clarity on this point is needed.”

*Response: As noted in response to Comment E4, Tetra Tech (2017) used the 1.43 multiplier. Tetra Tech revised the report to make it clear. U.S. EPA (2000) for the CCC generally relies on “bioassays using larvae” (page 5, U.S. EPA 2000). Also see Table 2 of U.S. EPA (2000), which lists the type and the life stage of organisms used in the calculation of the criteria. The majority of the organisms represent embryonic to larval stages.*

**E9:** “The report concludes “The chronic 30-day mean DO  $\geq$ 5.0 mg/L will ensure survival, recruitment and growth of aquatic organisms as well as it will protect threatened and endangered species across Suisun Marsh habitats. According to the EPA methodology, exposures to DO concentrations above this level will not result in any adverse effects on growth as that value was derived by observing growth effects in the most sensitive larval and juvenile life stages. The 30- day averaging period is consistent with, and fully protects against the effects on larval recruitment greater than five percent. ”

I believe this is overstated and is not substantiated by evidence presented here. More accurately, the application of the EPA (2000) method produced a value of 5.0 mg / l as the value likely to ensure survival, recruitment, and growth of aquatic organisms. Whether or not this is correct depends on the degree to which this method accounts for all relevant effects of dissolved



oxygen and whether assumptions of underlying calculations are supported. The Science Advisory Panel wording was more careful and I believe more appropriate. In their review, they stated that ““The SAP finds that the use of the VP approach is considered as a viable and protective technical framework for setting DO criteria.” and that it is a “scientifically defensible” approach.”

*Response: The conclusions quoted above that the “chronic 30-day mean DO $\geq$ 5.0 mg/L will ensure survival, recruitment, and growth of aquatic organisms...” is a clear-language method of expressing the biological outcome of the criteria, and is necessary for the public to understand the expected consequences of implementing the new water quality standard. The U.S. EPA methodology considers larval stages as most sensitive and makes its determination about protection accordingly. This is because adverse impacts to early life stages are more likely to contribute to reductions in fish populations, and in many cases larvae have higher oxygen requirements than adults. In addition, fish eggs and larvae are considered more vulnerable to low DO due to their limited ability to avoid low DO conditions (Breitburg 2003)<sup>8</sup>. Since there is no spawning and/or larval stages of the DO sensitive species (prof. Peter Moyle, pers. comm), and the acute objective (3.8 mg/L) is higher than the U.S. EPA’s criterion of 2.3 mg/L, the proposed SSOs have an added level of protection for the life stages of species present in Suisun Marsh, and accounts for relevant DO conditions in the marsh. Therefore, we believe that our calculations have an additional margin of safety above the model assumptions, and, thus, the statement is accurate.*

**E10:** “Have the authors appropriately considered uncertainties and other factors that might influence the SSO calculations? The report carefully considers spatio-temporal patterns and salmonid habitat use (and considers uncertainty in chronic effects of low DO on salmonids). It is not clear how uncertainty in LD50 is incorporated e.g., when a range of LD50 values are provided, what value is used?”

*Response: Tetra Tech used a geometric mean when studies provided a range of LC50 values.*

**E11:** “More significantly, unlike the EPA (2000) report, the information used here to inform the CRC and CCC was limited. That is, EPA (2000) devoted considerable effort to explore non-lethal effects of low DO exposure that is not related to growth (e.g. increased predation risk through distributional shifts, physiological stress reflected in endpoints other than growth). Though EPA (2000) found that such field related work was not suited to numerical calculation, it was useful to consider these effects to evaluate whether the numerical solutions would provide protections for other kinds of effects.”

*Response: U.S. EPA does not clearly recommend a methodology to describe how these additional endpoints influence calculation of criteria. Therefore, U.S. EPA does not require states to alter DO criteria based on those parameters. Since these non-lethal effects of low DO were already evaluated by U.S. EPA, they were not re-evaluated extensively during this effort. It would be worthwhile in the future to establish a method*

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<sup>8</sup> Breitburg, D.L., A. Adamack, K.A. Rose, S.E. Kolesar, M.B. Decker, J.E. Purcell, J.E. Keister and J.H. Cowan. 2003. The pattern and influence of low dissolved oxygen in the Patuxent River, a seasonally hypoxic estuary. *Estuaries* 26: 280-297.

*for including these non-lethal endpoints in criteria calculation. Also see response to comment E15.*

**E12:** “Also, the temperature range of Suisun Marsh sloughs varies considerably during the period when low DO conditions are most likely to occur (by as much as 5 C), and these will alter the sensitivity to low DO (Pörtner and Knust 2007, Duetsch et al. 2015). It is not clear to me whether temperature-dependency of DO sensitivity was considered.

Finally, the CRC and CCC are based largely on lab studies, which may not account for local adaptation or acclimation (particularly for chronic sub lethal exposure) (Decker et al. 2003, Lefevre et al. 2017).”

*Response: Yes, temperature dependency was considered; the laboratory data used to calculate the site-specific objectives were generated at temperatures relevant to Suisun Marsh.*

*We concur that the U.S EPA Virginian Provenance Approach and our subsequent effort to use that approach in Suisun Marsh to set the CRC and CCC rely primarily on laboratory studies. As the reviewer stated in comment 9, this method is scientifically valid. In addition, the use of laboratory studies with aquatic organisms exposed to continuous low DO concentrations have been used as the primary data source for derivation of the criteria for a number of water bodies (primarily Long Island Sound, Delaware Bay, Chesapeake Bay, and marine waters in Florida). We agree that local adaptation could occur, an end result that would yield lower criteria, but still as protective. Therefore, we acknowledge that local acclimation and adaptation add to the required margin of safety.*

**E13:** “The report would have been strengthened had it explicitly noted these uncertainties and considerations that were not explicitly addressed. My suspicion is that the SSOs would be robust to these considerations, however. I base this on the reference site work that appeared in Tetra Tech (2017) that showed that areas that have been less directly altered have DO conditions that would satisfy the criteria.”

*Response: We agree. The proposed DO objectives are generally attained in minimally impacted sloughs. Also, see response to comment E12.*

**[Conclusion] “2. The derivation of the objectives is supported by sound scientific information and methods.”**

**E14:** “Is the information appropriate? Yes. This is largely attributable to the due diligence in maintaining species lists to be used in calculations. Use of surrogate species, and in particular including the non-native but well established Striped Bass is appropriate.”

*Response: We acknowledge the comment that the species list used in calculation of the DO criteria is scientifically sound.*

**E15:** “Is the information up to date? There is a large body of research of work on hypoxia effects on marine and brackish ecosystems that has been published since the EPA (2000) report, yet I see little evidence that this was used to inform or guide the process. Indeed, Tetra Tech (2017) contained only 3 citations to sources published in peer reviewed literature since 2000,

and the present document contains only a single citation since 2000 related to dissolved oxygen tolerance or effects of exposure. I am surprised that the recent work by Vaquer - Sunyer and Duarte (2008) is not used as an alternative source for thresholds inducing lethal and non-lethal effects.

In summary, I find that this report, and supporting documents fail to demonstrate that the dissolved oxygen criteria were based on best available science. I provide a semi annotated bibliography to highlight the scope of ecological effects of hypoxia, to identify papers that provide alternative methods to calculating DO thresholds, and to suggest papers that could be used to place findings in context because they are based on the same or related species as used in the report. These should serve to provide more context about ecological effects, sensitivity of species to low DO, and ultimately provide more strength to the claim that the fairly rigid application of the Virginia Criterion method (along with the Stephan et al. 1985 calculations) is capturing all relevant aspects of this ecosystem.”

*Response: Water Board staff reviewed the list of semi-annotated bibliography provided by the reviewer. In response to the reviewer’s comment, Vaquer-Sunyer and Duarte (2008)<sup>9</sup> has been added to the literature referenced in the Staff Report. The authors compiled the results of 872 published experiments to examine variability in DO thresholds for hypoxia across different benthic organisms. Although we do not consider this approach as suitable for setting the regulatory site-specific DO criteria for Suisun Marsh, we found the synthesis of the experimental data, and the resulting distribution of thresholds useful for comparison against the objectives proposed for Suisun Marsh. Except for the most sensitive species tested, which are not present in Suisun Marsh (e.g., the first larval zoea stage of the East Coast Cancer irroratus, or Atlantic cod Gadus morhua), our objectives are well above the median sublethal concentration of 2.24 mg/L. Interestingly, this median threshold equals the 24-hour acute criterion developed by U.S. EPA for the Virginian Province. Our objectives appear to be even more protective when time of exposure to low DO is considered. The estimated median lethal time of exposure to continuous acute hypoxia was over 116 hours (~ 5 days), whereas the hypoxic DO levels in Suisun Marsh sloughs usually last hours to a couple of days, and DO recovers to normoxic levels every day.*

*We recognize the importance of the ecological effects of hypoxia and alternative methods to establishing DO thresholds. We acknowledge there is a large body of research on direct effects (mortality, reduced biomass, abundance and diversity) and indirect effects (e.g., contracting of habitats, increased predation) of hypoxia. Many aspects of that research have been already reviewed as part of the larger effort to develop nutrient water quality objectives for the San Francisco Bay estuary of which Suisun Marsh is an integral part. The literature review and data gaps analysis for the San Francisco Bay nutrient project (McKee et al. 2011)<sup>10</sup> considered more than 400 publications, including research on hypoxia, and its ecological effects on seasonal composition and behavioral responses*

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<sup>9</sup> Vaquer-Sunyer, R. and C. M. Duarte. 2008. Thresholds of hypoxia for marine biodiversity. Proceedings of the National Academy of Sciences 105 (40):15452-15457.

<sup>10</sup> McKee, L.J., Sutula, Gilbreath, A.N., Beagle, J., Gluchowski, D., and Hunt, J. 2011 *Numeric nutrient endpoint development for San Francisco Bay- Literature review and Data Gaps Analysis*. Southern California Coastal Water Research Project Technical Report No. 644.

*of fish and benthic macrofauna. Additional research was also reviewed in support of setting the DO objectives for estuaries in California (Sutula et al. 2012)<sup>11</sup>. We had considered the conclusions and summaries of the literature studies when developing the objectives and associated Staff Report. However, we did not explicitly cite these resources. In response to the peer review comment we added text in the Staff Report (Section 4.2.1) to better explain our reliance on the published literature and to provide context for the Suisun Marsh project.*

*We were able to obtain and review 21 out of the 22 papers recommended by the reviewer. We also examined additional literature referenced in the recommended papers.*

*Although considerable amount of observations of physiological responses, feeding, and altered behavioral strategies in low oxygen habitats exist, population-level consequences of such conditions are very difficult to assess. So far, we cannot evaluate the sublethal effects in the same way as effects on growth and survival. However, the U.S. EPA does not believe that an additional margin of safety is needed to account for behavioral alterations following exposure to hypoxia because most of the effects observed occurred at DO levels below 2.3 mg/L, and therefore, the 24-hour acute criterion would be protective of those effects. In addition, the data reviewed by Breitburg (2003) clearly show that concentrations that have an effect on avoidance are nearly identical to those that affect growth. Therefore, criteria that protect growth should also be protective of habitat squeeze due to avoidance. Furthermore, information compiled by Vaquer - Sunyer and Duarte (2008) suggests that the proposed acute objective would be protective against the sublethal effects in Suisun Marsh.*

*Our review of the research suggested by the reviewer, related to dissolved oxygen tolerance and the effects of exposure, provided independent confirmation that the proposed chronic (5 mg/L), and acute (3.8 mg/L) site-specific objectives for Suisun Marsh will not affect mortality and growth of estuarine organisms. These objectives (especially the acute objective) are also more stringent than the U.S. EPA criteria for Virginian Province, which helps ensure they are protective against a slew of other potential effects.*

**E16:** “Are the methods used sufficient? Are there other methods and approaches that could have improved the calculations? The report uses the EPA (2000) “Virginia[n] Province” framework together with the Stephan et al. (1985) numerical method to calculate acute and chronic DO thresholds for Suisun Marsh. This framework has been applied in the U.S. East coast and elsewhere, and is advantageous because it is well known and transparent. It considers multiple types of population responses to low dissolved oxygen by looking at both mortality and growth responses and looking at juvenile / adults separate from early life history. The cited report (Tetra Tech, 2017) also used a reference system approach to described dissolved oxygen conditions in areas with similar biophysical characteristics but have protected lands in wetlands and surrounding uplands. That served as a useful “check” to evaluate whether the criteria values produced from the EPA (2000) framework are similar to water quality conditions that would naturally be expected in Suisun Marsh.”

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<sup>11</sup> Sutula, M., H. Bailey, and S. Poucher. 2012. *Science Supporting Dissolved Oxygen Objectives in California Estuaries*. Southern California Coastal Water Research Project Technical Report No. 684.

*Response: Comment acknowledged.*

**E17:** “There are important limitations to the methods used to generate dissolved oxygen criteria. The first is that the EPA (2000) was applied in a somewhat perfunctory manner, such that this report lacks the depth and rigor of the effects of dissolved oxygen that characterizes the EPA (2000) report. Indeed, a full six pages of the main text of the EPA (2000) report explores other information on behavioral effects and other effects that were not used explicitly in the calculation, and appendix materials provided further information and context.

In addition, the EPA (2000) framework has its limitations and requires many assumptions, many of which are not explicitly identified in the present report. A quick list of these include:

- The recruitment model, though scoring high for transparency, is not rooted in direct empirical evidence or shown to have predictive power.
- The calculation of FAV requires assumptions regarding probability density function of LD50s (a log - triangular distribution) that is not well supported by data.
- There is no explicit consideration of uncertainty. In fact, it is difficult to know what level of risk protection this method provides. Does it have a 90 percent chance of protecting 95% of species? 50% chance? There is no way to tell. This is particularly relevant given the very small sample sizes used to generate FAV values; 7 and 12 data points were used to generate CCC and CMC, respectively. A fixed ratio of LD50 to LD05 was used (with three significant figures!) although there is certainly a range of plausible values for this ratio. Consequently the precision of these estimates is not known and the report does not specifically consider this in making recommendations.

The EPA (2000) framework does not consider physiological affects that impair physiological processes necessary for reproduction (e.g (Wu 2009)), does not consider effects that increase mortality through predation (Mistri 2004, Eggleston et al. 2005, Long and Seitz 2008, Howard et al. 2017), and does not implicitly consider joint effects of temperature and dissolved oxygen on aquatic life (Pörtner and Knust 2007, Pörtner and Lannig 2009, Duetsch et al. 2015).”

*Response:*

*The U.S. EPA approach combines features of traditional water quality criteria with a new biological framework that integrates time and provides means to establish separate criteria for different life stages (larvae versus juveniles and adults). The U.S. EPA 2000 criteria document underwent internal and public reviews, and includes changes addressing comments from six peer reviewers. Despite the known limitations of this methodology, and all other methods to derive water quality criteria, the Science Advisory Panel found this approach as scientifically defensible, and a viable and protective technical framework for setting DO criteria. Also, the Panel provided full support for the derived acute and chronic DO thresholds proposed as the SSOs for Suisun Marsh. This methodology forms the basis for the criteria development in Chesapeake Bay, Florida, New Hampshire, and is being considered for other estuaries in California. The reviewer has not provided any compelling evidence or an alternative approach that would be better for setting the objectives for the Suisun Marsh sloughs.*

*We acknowledge that the U.S. EPA framework has uncertainties and are aware of the limitations that the reviewer describes. In order to clarify this point, we edited the Staff*

*Report to acknowledge uncertainties recognized by U.S. EPA and the reviewer. As explained in our response to comment E15, we anticipate that our site-specific objectives will be protective of non-lethal, behavioral effects of low DO.*

**E18:** “Finally, there appears to be an outstanding opportunity to use existing data to find site-specific thresholds. The report provides information on presence / absence and abundance of fish species within each site as a function of DO, which was very useful to evaluate the proposed SSOs. These data could be used in a much more rigorous way however, to statistically model the data to reveal acute and chronic DO levels associated with species presence / absence or abundance. Standard mixed effects generalized linear models could reveal water quality conditions that fish species avoid, while accounting for confounding effects of other environmental variables. This is standard practice and has been used elsewhere (e.g. (Schmitt and Osenberg 1996, McDonald et al. 2015)).”

*Response: Comment noted. The long-term data we had associated with the fish sampling although invaluable to better understand the conditions of the ecosystem, were grab-sample monthly data only. This limits the application of the data in a formal model for detecting change using continuous data. Here we presented the data as general validation of the Virginian Province approach, which showed that the thresholds were consistent with concentrations the fish avoid. In addition, we cannot identify species or the conditions in Suisun Marsh sloughs for which data are available or could be collected within a reasonable amount of time and effort, for which modeling and analysis similar to those in McDonald et al. 2015<sup>12</sup> would be warranted. However, application of probabilistic and Bayesian modeling may provide a tool for solving complex environmental problems in the future. We will pass these suggestions to the staff working on developing the nutrient objectives and the corresponding associations with dissolved oxygen for the San Francisco Bay Estuary, where more extensive data collection is being conducted.*

**[Conclusion] “3. The SSOs are appropriate targets for the Suisun Marsh TMDL for low DO/organic enrichment.”**

**[Conclusion] “4. The concentration-based TMDL is protective and supportive of aquatic life beneficial uses in Suisun Marsh sloughs.”**

**E19:** “The recommended SSO’s consider both acute (daily) and chronic (monthly) exposure to dissolved oxygen.:

Average daily dissolved oxygen  $\geq 3.8$  mg / l

Average monthly dissolved oxygen  $\geq 5$  mg / l

In addition, Winter / Spring average monthly dissolved oxygen criteria is  $\geq 6.4$  mg / l in Montezuma, Nurse, and Denverton sloughs to ensure adequate water quality conditions for salmonids present in those areas and times.

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<sup>12</sup> McDonald, P.S., T.E. Essington, J.P. Davis, A.W. E. Galloway, B.C. Stevick, G.C. Jensen, G. R. Vanblaricom, and D.A. Armstrong. 2015. Distribution, abundance, and habitat associations of a large bivalve (*Panopea generosa*) in a eutrophic fjord estuary. *Journal of Shellfish Research* **34**:137-145.

Based on the information that was presented in this report (estimates of acute lethal and chronic growth effects on species), these thresholds are well supported. Moreover, they are realistic, in that they account for natural fluctuations in dissolved oxygen in regions of Suisun Marsh that have lower tidal exchange and high biological productivity.”

*Response: We acknowledge the reviewer’s support for Conclusions 3 and 4 and acknowledge the comment that the proposed SSOs for DO are well supported and representative of natural conditions in Suisun Marsh.*

**E20:** “By applying the dissolved oxygen criteria to water that is discharged into the Suisun Marsh, the proposed SSO’s have a high likelihood of achieving water quality conditions that meet the criteria. The TMLD allocations in table 9-1 are appropriate and precautionary because they are equal to the marsh SSOs.

I therefore conclude that these are appropriate targets given the information that was provided. However, as noted above, attention to other information on low dissolved oxygen effects on aquatic life will strengthen the confidence in these SSOs.”

*Response: Comment acknowledged. See response to Comment E17.*

**E21: Editorial comments and minor corrections:**

“I note the following minor issues with the report:

Table 3-1 and 3.2 are inconsistent. Table 3-1 states that in 2004 "DO levels were recorded as low as 2.8 mg/L for three sites, and a low of 2.3 mg/L was recorded for Goodyear Slough", while Table 3-2 shows DO levels that are much lower than this. Please clarify

Figure 3-1. Legend needs to explain what the inset plots are showing. I think they are bar plots of measured DO through time, where each bar is a year. The bars are further color coded to indicate DO. It is confusing because the time axis is not specifically identified, and both bar height and bar color convey the same information. Also, are these annual averages? Minima?

Figure 3-2 is confusing, because the outcomes appear linked. For instance, the outcome of “growth of algae, macrophyte” is linked by an arrow into the outcome “Duck Club low DO and high BOD exports”. It is not clear that this refers to growth of algae and macrophyte within the managed wetland or something else. Some of the dotted areas have text labels, others do not. A more detailed figure legend is needed.

Figure 8.1 Denverton is misspelled on map, Union Creek is labeled as Laurel Creek.”

*Response: The report was revised to incorporate the editorial suggestions provided by the reviewer.*

**Prof. Jeremy Testa: Specific Comments and Responses**

Chesapeake Biological Laboratory

University of Maryland Center for Environmental Science, Solomons, MD 20688

“My review of this document is focused on the controls on dissolved oxygen sags within the marsh sloughs, including the simulations of dissolved oxygen in the Suisun Marsh sloughs and the relationships between oxygen and organic carbon, chlorophyll-a, and nutrient concentrations. I considered the physical, biological, and anthropogenic aspects of dissolved oxygen dynamics in the marsh sloughs and I comment on the relative role of anthropogenic eutrophication versus wetland pond management in controlling oxygen sags in the sloughs. In my review, I did not address the impacts of low dissolved oxygen on living resources or the TMDL for mercury because these topics are outside of my particular expertise. Although I read the entire documentation, I only provide review of Sections 1-3, 6, 8, 12 and 13, which are related to Conclusions 4, 5, 6, 7, and 9. My review addresses the primary findings and conclusions of the document, as well as specific aspects of the analysis and minor edits/corrections to the text. I also read Siegel et al. (2011) and Tetra Tech (2013, 2017) to support my review.”

**“Conclusion 4 – DO sags are triggered by discharges from managed wetlands. Hydrologic conditions and distance from the open bay contribute to low DO in back-end sloughs ”**

**T1:** “A considerable amount of information was synthesized to arrive at the conclusion that this unique system suffers dissolved oxygen sags due to the periodic discharge of low oxygen and high organic matter water from managed wetland ponds. The data and model simulations presented in this report, including extensive continuous oxygen records, clearly illustrate that the timing of discharges from managed wetlands correspond to oxygen sags in several of the Suisun Bay sloughs. Existing literature includes several examples of shallow, physically isolated creeks and canals displaying similar depleted oxygen conditions. The HEC-RAS modeling effort displayed that simulated wetland discharges can lead to oxygen depletion events associated with inputs of low oxygen, high DOC water to adjacent sloughs. These simulations are presently the most quantitative evidence to associate pond management with oxygen depletion. The association of the discharged water with high oxygen-demand potential is clearly made through the identification of high DOC concentrations in the wetland ponds, which should be expected to exist given high rates of organic production in the marsh. Therefore, targeting alternative wetland pond management approaches involving altered timing and asynchrony in the draining of managed wetland ponds seems achievable and appropriate to relieve oxygen depletion events in the sloughs. The report conclusions are drawn from an extensive review and analysis of a substantial and diverse amount of data, providing a solid basis for making recommendations for management of this system.”

*Response: We acknowledge the reviewer’s support for Conclusion 4 and appreciate the comment that the conclusions are based on extensive analyses and that the project is built on a solid scientific basis.*



**T2:** “In view of the provided oxygen time-series, the timing and nature of low dissolved oxygen seems to be tightly linked to the wetland pond management, justifying these activities as a target for dissolved oxygen remediation. The continuous dissolved oxygen data measured by the sensors in Denverton and Goodyear Sloughs in 2012 and Boynton and Peytonia Sloughs in 2007 clearly display that the sags (or minima) in oxygen occur in October when marsh flushing occurs. The report suggests that if anthropogenic eutrophication was the cause of the depleted oxygen, the oxygen minima would occur in summer when peak seasonal temperatures drive respiration of organic material that is being regularly produced via nutrient-fueled phytoplankton growth. Given the data provided, this appears to be a reasonable conclusion.”

*Response: Comment acknowledged that it is a reasonable conclusion that anthropogenic nutrient loading is not the cause of low DO.*

**T3:** “The fact that severe oxygen sags below 2 mg/l do not appear to routinely occur each year suggests that there is some interannual variability in these dynamics that is not fully addressed by the model and analysis. For example, oxygen sags clearly occur in Denverton and Goodyear sloughs in 2012 and Boynton and Peytonia sloughs in 2007 (Figures B15-B19), but there are other years where similar sags do not appear to occur. The dissolved oxygen time-series provided in the report and Appendix B do not allow for a clear interpretation of exactly when during the year that the low oxygen events occurred (the x-axis is too constrained), so I acknowledge that I lack a clear picture of a full annual cycle of dissolved oxygen for many of the creeks when I make this general conclusion.

Finally, this conclusion states that “Hydrologic conditions and distance from the open bay contribute to low DO in back-end sloughs” and while this could in fact be true, less quantitative analysis was performed to address these dynamics and the association of wetland management to oxygen sags is not necessarily dependent on the fact that these environments may be naturally susceptible to oxygen depletion.”

*Response: DO sags occur recurrently each fall in the north-west portion of the marsh following the discharges from the managed wetlands. However, the magnitude of the DO drops vary from year to year. Since 2012, when the most severe low DO concentrations were observed, we have been working with the landowners to implement changes to their water management practices and deploy BMPs to improve water quality. The trial implementation of BMPs and regional coordination of managed wetland operations appear to be successful at reducing impacts of the managed wetland discharges on slough water quality.*

*We agree that the model results are preliminary. Given the available data we could not fully study all factors contributing to the interannual variability in DO dynamics observed spatially and temporally in the sloughs. A hypothesis that adverse water quality conditions are amplified by longer distances from the tidal source and reduced hydraulic*

*connectivity to larger sloughs and channels is explained in Siegel et al. 2010<sup>13</sup>. The authors explore different spatial and temporal scales of hydrodynamic mixing and connectivity on chemical and biological habitat characteristics. The Suisun Marsh system is highly fragmented into discrete managed water bodies that are often disconnected from each other. The limited connectivity and reduced mixing have significant consequences for the cycling of organic carbon which, in turn, has an impact on DO.*

**“Conclusion 5 – Anthropogenic sources of nutrients are not associated with declines in DO in the sloughs”**

**T4:** “It is reasonable and justified to conclude that anthropogenic nutrient sources are not a primary driver of the majority of low dissolved oxygen in the sloughs, given the timing of oxygen depletion (fall, spring) and the moderate (but not low) chlorophyll-a levels reported. These types of wetland creeks are typically turbid, imposing light limitation of phytoplankton and benthic algae, which generally means that oxygen is less controlled by the production-respiration cycle that anthropogenic nutrients accelerate. However, nutrient concentrations can be extremely high in many of the sloughs (NO<sub>3</sub>- up to 12 mg/l and PO<sub>4</sub>- up to 3 mg/l), the highest nutrient levels are closest to the FSSD outfall (Figure B-25 and B-26), and some of the most impacted sloughs (with respect to low oxygen) are located in the region of the marsh near anthropogenic nutrient sources (Boynton Slough), suggesting some degree of eutrophication. Modeled photosynthesis rates also appear to be a large part of the oxygen budget (Figure 8-2), which would suggest that phytoplankton production rates are indeed high and likely supported by anthropogenic nutrient inputs. Phytoplankton blooms and fish kills have been reported in similar shallow creeks with low flushing and high nutrient concentrations. While the timing of the largest oxygen sags is most tightly linked to wetland pond discharges and the mechanistic link between discharges and the oxygen sags is scientifically sound, the sloughs are clearly not free from the influence of anthropogenic nutrient influence. Thus, although the discharges appear to be the primary contributor to oxygen sags in the sloughs, further investigation into the role of traditional eutrophication in these creeks might identify it as a secondary contributor to oxygen sags through diel oxygen consumption associated with autotrophic respiration.”

*Response: Nutrient studies in the marsh are ongoing as development of nutrient water quality objectives progresses. We agree that it would be worthwhile in the future to investigate further the role of nutrients and their influence on dissolved oxygen in the marsh. Parker et al. (2015)<sup>14</sup> evaluated available nutrient data and concluded that seasonal and spatial trends of nutrient-related indicators appear to be within the range*

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<sup>13</sup> Siegel, S., Enright, C., Toms, C., Enos, C. and J. Sutherland. 2010. Suisun Marsh Tidal Marsh and Aquatic Habitats Conceptual Model. **Chapter 1: Physical Processes**. Suisun Marsh Habitat Management, Restoration and Preservation Plan. Final Review Draft.

<sup>14</sup> Parker, A.E., M.C. Ferner, and E. Ceballos. 2015. *Initial Recommendations Regarding the Potential for Nutrient Impairment of Ecosystem Health in Suisun Marsh, CA*. A Report for the San Francisco Regional Water Quality Control Board (Region II). Agreement Number 12-135-250, 12 June 2015.

*likely to occur naturally. We acknowledge, though, that the assessment is based on limited data.*

**T5:** “I will specifically address the potential role of anthropogenic nutrient inputs in the text that follows. It is reported that nutrient concentrations are well above limiting levels (Table 6-4), so the observations of moderate chlorophyll-a are likely explained by either light limitation of phytoplankton growth or the physical flushing of phytoplankton biomass. One could suspect that CDOM concentrations are high in this type of environment, which attenuate light and limit photosynthesis, but no CDOM or light profile data are provided to evaluate light availability or its controls. Residence times are suggested to be high (but are not quantified so far as I can tell), so this high nutrient, high residence time environment should be expected to generate phytoplankton blooms, which the sensor data indicate to occur within the perimeter stations of some wetland ponds (Figure B-32). The HEC-RAS model simulations (Figure 8-2) reveal that photosynthesis is a large contributor to the slough oxygen dynamics, although these modeled rates were not directly validated with measured rates of phytoplankton metabolism or biomass. Figure 8.2 also indicates that photosynthesis is comparable in magnitude to CBOD, but the units of mg/l are difficult to interpret because they are not the traditional units used to express these rates (e.g., g O<sub>2</sub> m<sup>-2</sup> d<sup>-1</sup>). Figure 8-2 illustrates that the simulations are generating rates of photosynthesis that greatly exceed aerobic respiration which would explain why the model consistently overestimates dissolved oxygen concentrations in many of the sloughs (see response to **Conclusion 6** below for further detail).”

*Response: We appreciate the reviewer’s insight into the additional data and analysis to improve the understanding of nutrient dynamics in the marsh. As previously mentioned, we continue to collect data to support additional modeling, which will allow water managers to rapidly recognize and respond to worsening DO conditions. In particular, we support studies to collect chlorophyll a and CDOM data. New chlorophyll a measurements were conducted in the fall 2017 as part of the U.S. EPA’s WQIF Suisun Marsh BMP water quality improvement project. Additionally, our current data collection and analysis are focusing on water quality in the sloughs though, and not on the conditions in the managed wetland ponds, which remain disconnected from the slough network most of the time.*

**“Conclusion 6 – The analysis accurately identifies organic material and low dissolved oxygen waters as the main reason for declines in DO in slough water”**

**T6:** “Overall, I find the conclusion that discharges of high DOC, low oxygen water from managed marshes is the primary cause of oxygen depletion events in the sloughs to be supported by the available data. There is a direct mechanistic link between DOC availability and oxygen consumption rates and the largest observed oxygen sags in the sloughs clearly coincide with wetland pond draining activities during the fall. The numerical model that simulates wetland pond discharge of low oxygen, high-DOC successfully captures the seasonal and fortnightly depletion of oxygen in several of the sloughs. While all models are imperfect,

the model included here appears to consider the dominant processes and is an appropriate tool to address the questions posed in a quantitative and data-constrained way.”

*Response: We acknowledge the reviewer’s support for Conclusion 6 that discharges of high DOC, low oxygen water from managed marshes is the primary cause of oxygen depletion.*

**T7:** “I do, however, wish to address the shortcomings of the numerical models used to set management targets. The HEC-RAS model appears to capture the impact of wetland discharge events in time and (to some extent) in magnitude, but the baseline model simulations fail to capture the lower range of oxygen concentrations observed during wetland pond drainages. This inability to capture the lowest of the oxygen concentrations appears to be directly related to the model’s overall tendency to over-predict dissolved oxygen concentrations (e.g., Figure C-19, C-21, C-23). While the modeled oxygen minima clearly occur in October-December for Boynton and Peytonia Slough in 2007 and Goodyear and Denverton Slough in 2012, consistent with the observations, the oxygen concentrations predicted during the times beyond of the simulated discharge period are often too high. The numeric targets for the TMDL may be affected by these discrepancies between modeled and measured oxygen concentrations.

The model also appears to underestimate the sub-daily variations in dissolved oxygen in the marsh sloughs (e.g., Figure C-19, C-21). Although the data as presented are difficult to read from the graphs, it appears that the measurements indicate large diurnal or semi-diurnal variations in dissolved oxygen. The model generally fails to capture these large, short-term swings in oxygen, which could result from an underestimation of either (a) the diel cycling of oxygen associated with photosynthesis and respiration of the primary producers (e.g., phytoplankton) or (b) the tidal transport dynamics that flush the sloughs with water or conversely isolate them from adjacent waters. Figure 8-2 indicates that photosynthesis tends to be much greater than respiration in Boynton Slough, which would suggest that modeled diurnal variations in oxygen associated with daytime photosynthesis and nighttime respiration would favor oxygen production over consumption, leading to over-predicted oxygen concentrations. If the model-simulated photosynthesis and respiration rates were more comparable in magnitude (which is common in other shallow marsh creeks where observations are available), the diel cycle of oxygen would presumably span a larger range of concentration. In Figure 3-3 and 3-5, there are clear sub-daily variations in oxygen during the sag periods that are quite large, indicating that there could be a strong diel cycling of oxygen associated with phytoplankton that overlies the longer-term sag associated with high DOC and low oxygen water exported from the managed ponds. Figure C- 19, C-21 clearly show stronger sub-daily variation in the observations than is captured by the model. I cannot further investigate these dynamics without more information from model simulations, but it appears that there are secondary sources of variability in the oxygen data. Despite the extensive and useful modeling efforts, a more complete evaluation of the model simulations would have been possible if more extensive validation of the model variables was performed.”

*Response: The model results as presented in the Conceptual Model Impairment Assessment report (Tetra Tech 2013)<sup>15</sup> and referenced in the draft Staff Report were still preliminary and based on the limited observed data on flow exchanges and water quality from the tidal wetlands. The model application was primarily designed to support the linkage analysis. There are multiple duck clubs that may simultaneously discharge and/or draw water from any given slough. The schedules of flooding, circulation and discharge are controlled by the tidal stage, climatic conditions, need for vector control, presence of endangered species, and other factors, which change from season to season, and are difficult to model. Since the initial application of the HEC-RAS model, additional data have been collected on discharge rates from managed wetlands, with simultaneous measurements of water quality. The results of the updated modeling with calibration and validation supported by data collected in 2016 and 2017, will be presented in an upcoming report on the application of BMPs in Suisun Marsh. We expect to see an improved match of predicted to observed DO concentrations in the refined model. In the meantime, the model sufficiently demonstrates the relative contribution of duck clubs to dissolved oxygen sags in the sloughs and provides a tool to evaluate the effectiveness of the proposed BMPs.*

**T8:** “The report adequately describes validation efforts with respect to dissolved oxygen dynamics in the sloughs, which benefits from high-quality oxygen concentration time-series to allow for an assessment that the model prediction of oxygen is reasonable overall. However, a more complete evaluation of the numerical model would include validations of the model predictions of chlorophyll-a, dissolved organic carbon, nutrient availability, and primary production and respiration rates. Without an opportunity to review such validations (this material was not available for my review), it is difficult to fully evaluate the potential secondary roles of nutrient-induced phytoplankton production and respiration, as well as tidal flushing (or lack thereof) in contributing to oxygen concentration changes.”

*Response: Please see response to Comment T7 above. We acknowledge that a more extensive nutrient modeling, including primary production and respiration rates, could be useful in assessing conditions in Suisun Marsh. However, there were insufficient data available to perform a more comprehensive modeling at that time.*

**“Conclusion 7 – The Staff Report describes linkages and provides a valid description of the relationship between the desired DO conditions and sources of low DO”**

**T9:** “The report is comprehensive in the sense that it reviews, synthesizes, or estimates all relevant nutrient and BOD sources, addresses dissolved oxygen time-series in a large number of sloughs, adequately summarizes the management of the wetlands, and includes numerical model simulations of the marsh dynamics. Clear and justifiable links are made to describe the accumulation of high DOC and low oxygen water in marsh ponds that is seasonally discharged into the slough to drive oxygen sags, and continuous oxygen data are available to confirm these

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<sup>15</sup> Tetra Tech, Inc. 2013a. *Suisun Marsh Conceptual Model/Impairment Assessment Report for Organic Enrichment, Dissolved Oxygen, Mercury, Salinity and Nutrients*. Prepared for U.S. EPA Region IX and the San Francisco Bay Regional Water Board.

dynamics. Numerical model simulations clearly document that altering the discharge of high-DOC, low oxygen water from the managed marsh ponds into the adjacent sloughs will lead to depressed oxygen concentrations in the sloughs by limiting the input of not only low oxygen water, but also sources of oxygen demand.”

*Response: We acknowledge the reviewer’s support for Conclusion 7.*

**T10:** “I think the assessment of phytoplankton contributions to oxygen dynamics would benefit from better data on continuous chlorophyll-a time-series in the marsh, measures of current velocity and stage within the sloughs, and direct measurements of BOD and other metabolic rates in the sloughs at different times of year. All of these data are relatively easy to collect, but do require additional effort and funding.

The assessment of the influence of nutrient loading from the discharging streams (Page 43) is limited by small sample size (concentrations were measured during 2 storms + ~4 “dry weather” days) and combined with monthly discharge rates that were not clearly described. This small subset of samples would only allow for nutrient concentration estimates over roughly half of the months of a year, and it was not clear how exactly the data were converted into loads. While this particular source of nutrients was not high relative to others (Table 6-3), these inputs are not dismissible.”

*Response: We appreciate the comment. As mentioned by the reviewer, additional effort and funding is needed to further evaluate phytoplankton contributions to oxygen dynamics. We will consider adding phytoplankton to future monitoring efforts in the marsh. As mentioned in Response to Comment T.5, chlorophyll a monitoring began in 2017 as part of the U.S.EPA WQIF water quality improvement project. As mentioned in Response to Comment T.7, we are currently undertaking a study to collect data and refine modeling. The updated model and data will be used to enhance BMP implementation.*

*The load estimates were evaluated using the best available, albeit limited, data for the creeks. While the nutrient loads are not dismissible, the temporal linkage between managed wetland discharges and low DO events supports the wetlands as a more significant cause of the low DO problems in the receiving sloughs.*

**“Conclusion 9 – Actions proposed in the implementation plan will reasonably ensure progress towards attaining water quality objectives and supporting aquatic life beneficial uses.”**

**T11:** “The actions proposed in Section 12 provide a comprehensive summary of the options for meeting water quality objectives and focus on current actions that seem pragmatic and achievable for managing dissolved oxygen sags in the marsh sloughs.”

*Response: We acknowledge the reviewer’s support for Conclusion 9.*

**T12:** “Given the relative ease at which high quality, continuous dissolved oxygen measurements can be made – and given both the high and low frequency variation in oxygen already displayed – it is appropriate to make extended (e.g., year-round) deployments of oxygen

sensors in the western sloughs (at least). These data will not only help document improvements associated with marsh management, but will also continue to provide information concerning other possible features of oxygen depletion in the marsh sloughs, deriving from both natural and anthropogenic forces. The addition of sensors to measure or estimate turbidity and chlorophyll-a would greatly enhance the value of the oxygen time-series.”

*Response: We are considering year-round deployment of water quality sondes in the western portion of the marsh to evaluate compliance with the site-specific objectives and to help interpret and evaluate water quality.*

**T13:** “The adaptive implementation as described in 12.5 is a reasonable plan given that many of the BMPs proposed can be adaptively altered in a relatively short amount of time.”

*Response: We appreciate the reviewer’s support of our BMPs.*

**T14: “Summary Comments**

Overall, I was impressed by the comprehensive nature of the Draft Staff Report and the quality and clarity of the presentation. The report, assessments, and conclusions are based on a large volume of data and extensive analysis and modeling. Organic enrichment associated with marsh pond management appears to be the primary driver of the most severe oxygen depletion events observed in several of the marsh sloughs. My comments, where critical, are primarily aimed at improving the understanding and simulation of the natural variability in the marsh sloughs and the balance between physical replenishment and internal sources and sinks of oxygen beyond the discharges from managed ponds. Such an improved understanding will enhance the adaptive management proposed for this system, yield useful lessons for similar systems outside of the Delta, and help to further refine and maximize the efficacy of BMPs for the Suisun Bay sloughs.”

*Response: We appreciate the reviewer’s view on the comprehensiveness of the data and analyses presented in support of the project in the draft Staff Report.*

**Minor edits to the text:**

*Response: The report was revised to incorporate the editorial suggestions provided by the reviewer.*

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## PART III

### STAFF-INITIATED CHANGES TO DRAFT STAFF REPORT AND BASIN PLAN AMENDMENT

Water Board staff made insignificant editorial changes to the Staff Report, intended to clarify or correct the January 12, 2018, draft. These include correcting typographic errors and other minor changes to add clarity. Such changes to the Basin Plan amendment are shown in double underline/double strikeout in Appendix B.

Other staff-initiated changes to the Staff Report are described below:

1. A clarification was made in the introduction of the Staff Report as follows:

Staff Report Section 1, page 1, paragraph 1:

This Staff Report presents the supporting documentation for a proposed Basin Plan amendment to establish site-specific water quality objectives and a Total Maximum Daily Load (TMDL) for dissolved oxygen (DO) in Suisun Marsh wetlands, specifically in sloughs and channels (Suisun Marsh). The Report also provides the reasoning for the proposal to extend the San Francisco Bay Mercury TMDL to Suisun Marsh, which is also impaired by mercury.

2. The text was clarified to state that all elements of the Bay Mercury TMDL apply to Suisun Marsh.

Staff Report Section 1, page 3, paragraph 3:

This report follows the findings and recommendations of the Mercury TMDL for San Francisco Bay (Bay Mercury TMDL; SFBRWQCB 2006). The previously-established elements of the Bay Mercury TMDL, including source analysis, numeric targets, linkage analysis, TMDL, load and wasteload allocations, considerations of seasonal variations, and margin of safety, and implementation actions plan also apply to Suisun Marsh.

3. Text was revised to better explain applicability of the new statewide mercury objectives.

Staff Report Section 5, page 35, paragraph 1:

The statewide mercury water quality objectives approved by the State Water Board on May 2, 2017, apply to Suisun Marsh (Table 5-1). These objectives reflect the current scientific understanding of how mercury impairs humans, wildlife, and aquatic life by bioaccumulating in animal tissue. The mercury targets adopted by the Bay Mercury TMDL were established using the same assumptions and are equally protective of both human health and wildlife when compared to the statewide objectives. For example, the statewide objective for sport fish of 0.2 mg/kg in trophic level 3 or 4 fish is equal to the protection of human health target in the Bay Mercury TMDL. In addition, the statewide prey fish objective for the California Least Tern of 0.03 mg/kg similarly matches the target for protection of aquatic organisms and wildlife in the

Bay Mercury TMDL. The statewide mercury objectives in Table 5-1 include two possible objectives for prey fish; the Least Tern limit is more stringent than the general prey fish limit. The Bay Mercury TMDL includes the more stringent prey fish limit, which is protective of both objectives. Therefore, when the Bay Mercury TMDL targets are met, the waterbody will also be meeting the applicable water quality objectives.

**Table 5-1**  
**Water quality objectives currently applicable in Suisun Marsh**

| <b>Purpose</b>  | <b>Limit</b>                            | <b>Description</b>  |
|---|---|---|
| Sport Fish Water Quality Objective                      | 0.2 mg/kg wet weight in skinless fillet | Average mercury concentration measured in trophic level three (15-50 cm) or trophic level four fish (20-50 cm), whichever is the highest, measured in a calendar year |
| Prey Fish Water Quality Objective-                      | 0.05 mg/kg wet weight in whole fish     | Average mercury concentration measured in whole fish, 5–15 cm in length, measured in a calendar year  |
| California Least Tern Prey Fish Water Quality Objective | 0.03 mg/kg wet weight in whole fish     | Average mercury concentration measured in whole fish, < 5 cm in length, measured April 1 to August 31   |

The mercury water quality objectives currently applicable to Suisun Marsh should be updated because they are inconsistent with the San Francisco Bay Mercury TMDL, which applies to Suisun Bay and the portion of the West Delta directly connected to the Marsh. As it stands, the Marsh's current objectives, which derive from the Basin Plan, do not reflect the current scientific understanding of how mercury impairs humans, wildlife and aquatic life by bioaccumulating in animal tissue; instead they reflect water column concentrations, which evidence suggests does not directly bear a direct correlation to risk to ecological and human receptors (acute: 2.1 µg/L 1 hour average and chronic: 0.025 µg/L 4 day average). In 2006, the Bay Mercury TMDL vacated the outdated marine chronic objective in all Bay segments in favor of site-specific objectives expressed as fish tissue concentrations (Table 5-1), that are directly protective of wildlife and human health, and are consistent with the July 2017 statewide mercury water quality standards.

**Table 5-1**  
**Water quality objectives and numeric targets for Hg in San Francisco Bay**

| <b>Purpose</b>                               | <b>Limit</b>                        | <b>Description</b>  |
|--|-------------------------------------|---|
| Protection of human health                   | 0.2 mg/kg wet weight in fish tissue | Average mercury concentration measured in edible portion of TL3 <sup>+</sup> and TL4 fish |
| Protection of aquatic organisms and wildlife | 0.03 mg/kg wet weight in whole fish | Average mercury concentration measured in whole fish, 3–5 cm in length                    |

<sup>+</sup> TL—Trophic Level

4. Text was added to clarify the compliance locations for receiving water limitations.

Staff Report Section 12, page 77, paragraph 4:

The wasteload allocation for the FSSD will be implemented through the facility's NPDES permit (CA0038024), which already has receiving water limitations for DO and numeric effluent limits for biological oxygen demand and nutrients. The current permit specifies that the receiving water limitations have to be met in Boyton Slough and Ledgewood Creek and identifies monitoring locations to demonstrate compliance. These locations may change in the future.

5. We removed the addition of "Suisun Marsh" from the text of the proposed draft Basin Plan amendment Section 3.3.21 because as described in staff initiated changes number 3, above, the objectives that apply are from the statewide mercury objectives rather than the site-specific objectives in Table 3-3B. We deleted the reference to Section 3.3.21 in Appendix A. This text modification is shown below and in Appendix B.

Objectives for mercury that apply to San Francisco Bay ~~and Suisun Marsh~~ are listed in Table 3-3B.

6. The text below was added to the Basin Plan amendment Section 7.2.2.6 Mercury TMDL Implementation, for clarification.

Additionally, to demonstrate compliance with the provisions, projects must conduct mercury monitoring or cause such monitoring to be conducted, to determine how tidal wetlands and wetlands restoration impact net methylmercury production and/or bioaccumulation into the food web. Monitoring may be conducted on a project or regional basis. A regional approach to measuring and understanding patterns of mercury in biosentinel species (e.g., fish) conducted by a discharger-funded regional monitoring program is desirable and should be coordinated across individual restoration projects.

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