Master Response 4 Water Quality

Overview

Commenters raised multiple concerns regarding the methods of evaluation and impact analyses related to water quality, as well as reservoir water quality management and operation of the I/O Works for reservoir releases to preserve downstream water quality. This master response addresses the following common topics raised by commenters:

- Concerns about metals and metalloids other than mercury associated with high inflow concentrations, evapoconcentration, anoxic conditions, shoreline erosion, additive effects of different metals combined, and effects on beneficial uses.
- Use of the I/O tower to control releases of constituents.
- Adequacy of mitigation.

This master response includes, for ease of reference, a table of contents on the following page to help guide readers in finding where the topics of their concern are addressed. The table of contents is based on general recurring and common themes found in the comments that were received.

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Introduction

Construction of Sites Reservoir would increase water supply for municipalities, agriculture, and environmental purposes (e.g., refuges and Yolo Bypass flow augmentation). Potential water quality impacts are evaluated in Chapter 6, *Surface Water Quality*. Surface water quality is a common concern for reservoirs in California, and issues can include elevated methylmercury and other metal concentrations, harmful algal blooms (HABs), anoxic conditions in the deepest parts of the reservoirs, and release temperatures that do not meet objectives. The detailed analysis in Chapter 6 determined that a number of water quality impacts would be less than significant, including water temperature; salinity; nutrients, organic carbon, and dissolved oxygen; HABs and invasive aquatic vegetation; and pesticides and metals (with the exception of methylmercury) in most water bodies in the study area. The analysis further found that certain Project impacts would be significant, including methylmercury, metals in Stone Corral Creek, and metals and pesticides in the Yolo Bypass. The analysis in Chapter 6 includes mitigation measures for these significant impacts—Mitigation Measures WQ-1.1, WQ-2.1, and WQ-2.2. These mitigation measures would reduce the metals and pesticides impacts to a less-than-significant level, but the analysis acknowledges that methylmercury impacts would remain significant and unavoidable after mitigation. In addition to the mitigation measures, as described in Chapter 2, *Project Description and Alternatives*, Chapter 6, and Appendix 6D, *Sites Reservoir Discharge Temperature Modeling*, water quality in Sites Reservoir will be managed by the RMP). The draft RMP, which is described in Appendix 2D, *Best Management Practices, Management Plans, and Technical Studies*, includes water quality monitoring for the reservoir and downstream locations, fisheries management (i.e., managing the reservoir to minimize accumulation of mercury and other metals in stocked fish), and invasive aquatic plant and invertebrate species management. The RMP will continue to be revised throughout the operation of the reservoir in consultation with resource agencies. Future revisions to the RMP will include ongoing analysis of water quality and account for and analyze changes to operations, site-specific conditions, adaptive management actions and decisions, and future changes to regulations or methodologies for evaluating water quality constituents. Water quality would also be monitored and managed through the Stone Corral Creek and Funks Creek Aquatic Study Plan and adaptive management, described in Chapter 2 and Appendix 2D. All of these efforts are designed to ensure that water quality impacts are appropriately minimized during Project operations.

Best Available Data

Some commenters stated that the analysis of water quality impacts did not make use of the best available scientific information. Chapter 6 describes the data that were used for the surface water quality analysis in the EIR/EIS, and information is included below describing the modeling results and the data that were used in the Final EIR/EIS. Additional information about modeling and data sources can be found in Appendix 6B1, *Sacramento–San Joaquin Delta Modeling, Salinity Results*; Appendix 6B2, *Sacramento–San Joaquin Delta Modeling, Chloride Results*; Appendix 6B3, *Sacramento–San Joaquin Delta Modeling, X2 Results*; Appendix 6C, *River Temperature Modeling*; Appendix 6D, *Sites Reservoir Discharge Temperature Modeling*; Appendix 6E, *Water Quality Data*; and Appendix 6F, *Mercury and Methylmercury*. Chapter 6 and the preceding appendices use sources of publicly available, peer-reviewed data and model results for multiple periods. This approach supports a robust impact analysis because it combines multiple sources of information and provides both spatial variability (e.g., different locations along the Sacramento River) and temporal variability (e.g., multiple months, multiple years, or specific seasons). For information about the use of best available scientific information in the EIR/EIS, please refer to Master Response 1, *CEQA and NEPA Process, Regulatory Requirements, and General Comments,* regarding general methods and modeling.

Modeling Modifications

Various refinements to the hydrologic modeling are described in Master Response 2, *Alternatives Description and Baseline*, and Master Response 3, *Hydrology and Hydrologic Modeling*. Refinements described in Master Response 3 include adjustments made in the CALSIM II modeling to better represent the most up-to-date modeling procedures and real-time operations. Refinements described in Master Response 2 include refinements to Project operations. The refinements to operations most likely to affect water quality are a reduction in operational dead pool storage from 120 TAF to 60 TAF and new diversion criteria, including an October–June minimum flow requirement of 10,700 cubic feet per second (cfs) for the Sacramento River at Wilkins Slough. These changes result in occasional periods of lower storage and increased evapoconcentration. New CALSIM II results and their effect on water quality have been incorporated into Chapter 6 of the Final EIR/EIS. As described in Chapter 6, the refined modeled results do not change the impact determinations or conclusions disclosed in the chapter.

The effect of these modeling refinements on CALSIM II results are described in Master Response 2 under *Refinements to Project Operations* and Master Response 3 under *Modeling Modifications*. CALSIM II results are used quantitatively in the water quality analysis of water temperature (input to temperature models), evapoconcentration, dilution in the Sacramento River, metal concentrations, and Delta water quality (input to DSM2). From a water quality perspective, the largest change in model results is increased peak evapoconcentration and more frequent low storage in Sites Reservoir. This master response describes how evapoconcentration is used in the water quality analysis. The effect of higher peak evapoconcentration is covered in Chapter 6 of the Final EIR/EIS. More frequent low storage could affect use of the I/O Tower, which is discussed in this master response.

Metals and Metalloids Other Than Mercury

Multiple commenters stated concerns about metal concentrations; the methodologies used to evaluate metal concentrations in inflow to the reservoir, in the reservoir, and releases from the reservoir; the fate of metals in the reservoir due to anoxic conditions and shoreline erosion; the effect of metals on beneficial uses; and the consideration of additive effects from different metals in combination with one another. Commenters also stated concerns about the measured datasets used and the specific metals evaluated. In some instances, comments indicated that the presentation of the methods of evaluation in Chapter 6 was not clear. The text in this section addresses these comments by summarizing, clarifying, and providing additional detail for the approach described in Chapter 6. In the EIR/EIS, mercury is evaluated separately from other metals and metalloids. The text in this section focuses on metals and metalloids other than mercury.

Methods of Analysis

The metals analysis methodology includes consideration of multiple factors. This section provides information regarding the methodology to facilitate understanding of all the factors that were considered in the analysis. The factors discussed are based on the most common topics and themes raised by commenters regarding the methodology.

Regulatory Standards for Evaluation

Metal concentrations were compared to regulatory standards to determine which metals would most likely cause potential violations of regulatory standards under the alternatives. The table titled *Metals Water Quality Standards* in Chapter 6 shows the primary standards considered in the evaluation: California Maximum Contaminant Levels (MCLs) for drinking water and freshwater chronic standards for aquatic life protection. The State Water Resources Control Board (State Water Board) provides guidance on selection of water quality objectives for protection of beneficial uses and a table of objectives suggested based on this guidance (State Water Resources Control Board 2016, 2017a). In this State Water Board table, MCLs and standards for aquatic life protection are the primary standards recommended for evaluation of metal concentrations for municipal water supply and protection of aquatic life and consumption of aquatic life. The metals evaluation focused on the more conservative standards, which was generally the standard for aquatic life protection.

The State Water Board guidance on selection of water quality objectives includes some very low concentrations for public health goals for protection against municipal toxicity for particularly toxic metals (State Water Resources Control Board 2017a). Some of the particularly stringent public health goals are not used by agencies as MCL regulatory standards due to infeasibility of control due to economic or technological constraints (State Water Resources Control Board 2016, p.11). Particularly stringent California drinking water public health goals that are less than the MCLs include those for arsenic (0.004 microgram per liter [µg/L]), cadmium (0.04 µg/L), and lead (0.2 µg/L). These public health goals are less than the standards for aquatic life protection. The arsenic and cadmium goals are particularly low, with the arsenic goal being less than minimum measured values in the Sacramento River and the cadmium goal generally being less than detection limits. There are also some secondary MCLs that are less than the standards for aquatic life protection. These include the secondary MCL for aluminum (200 µg/L) and iron (300 µg/L). These secondary MCLs and public health goals were not included in the impact analysis in Chapter 6 for the following reasons:

- They all pertain to drinking water quality and, as disclosed in Chapter 6, dilution from the Sacramento River and Feather River flows would occur prior to water being diverted for drinking water purposes and thus reduce potential effects of Sites Reservoir releases.
- The secondary MCLs for aluminum and iron are not health related.
- Cadmium is not evaluated because measured values were very low, with most values below detection limits. The detection limits for the cadmium measurements were usually

0.10 µg/L, substantially below the California MCL of 5 µg/L and the standard for aquatic life protection of 0.45 µg/L.

- Arsenic is evaluated under Impact WQ-2 by focusing on whether there would be a substantial increase in concentration. Arsenic is unique because concentrations do not increase in response to winter flows, but do increase from upstream to downstream along the Sacramento River.
- For lead, the standard for aquatic life protection is more appropriate due to its regulatory nature and applicability to beneficial uses most likely to be affected by the Project. The standard for aquatic life protection is more stringent than the drinking water MCL, although less stringent than the public health goal. Public health goals are not regulatory standards even though the State Water Board must consider them when setting drinking water MCLs. In addition, as mentioned above, drinking water would be greatly diluted by Sacramento and Feather River flow.

The table titled *Metals Water Quality Standards* in Chapter 6 and the table titled *Metals Water Quality Standards* in Appendix 6E, *Water Quality Data*, have been modified to include water quality standards for agriculture, which are all, with the exception of arsenic, substantially greater than the standards evaluated in Impact WQ-2. These tables have also been modified to show the dissolved concentration standards for aquatic life protection for those standards that are permitted to be evaluated using dissolved concentrations. Showing both the dissolved and total standards illustrates that the standards that assume total concentrations would only be slightly greater than the dissolved concentrations. The measured data, however, show much larger differences between the dissolved and total concentrations than what was assumed for the standards. As a result, the standards for total concentrations chosen for the evaluation performed in Chapter 6 and Appendix 6E conservatively overestimate exceedances of standards.

For the metals selected for detailed evaluation (see below), the water quality standards used in the evaluation were conservative because of the following:

- The standards chosen for the evaluation of copper and lead could have been higher and easier to meet, but more conservative values were chosen instead. The evaluations of copper and lead were based on the dissolved concentration standards for aquatic life protection that were translated to total concentrations based on agency-estimated differences between dissolved and total concentrations. Because dissolved concentrations are lower than total concentrations, the standards for total concentrations are higher than the standards for dissolved concentrations. However, the agency assumptions for the differences between the dissolved and total concentrations are smaller than the actual differences between the measured and dissolved concentrations observed in the Sacramento River.
- The aluminum standard for aquatic life protection depends on pH and dissolved organic carbon (DOC). The Sacramento River water quality values for pH and DOC used to calculate the U.S. Environmental Protection Agency aluminum standard for aquatic life protection were based on the low end of values measured in the Sacramento River, resulting in lower, more stringent, standards (footnote c in the Chapter 6 table titled *Metals Water Quality Standards*).

Selection of Metals for Detailed Evaluation

The metals evaluated with detailed quantitative estimates (aluminum, copper, iron, and lead) in Chapter 6 were those most likely to experience a potential increase in exceedance of water quality standards (see the section titled *Pesticides and Metals other than Mercury* in Chapter 6) and therefore provide a reasonable representation of the potential water quality impacts associated with operational effects of the Project on metal concentrations in and downstream of Sites Reservoir. The metals evaluated in most detail in Chapter 6 have Sacramento River measurements that show seasonal changes in concentration with some concentrations above standards during late fall through early spring. Other metals (e.g., manganese, nickel, zinc) may experience similar types of processes as the metals selected for detailed evaluation. The concentrations of these other metals would be lower relative to water quality standards because the measured concentrations of these other metals in the Sacramento River were typically well below applicable water quality standards (Appendix 6E). Therefore, these other metals would be much less likely to cause exceedances of water quality objectives than the ones selected for detailed evaluation.

Measured Data and Estimation of Metal Concentrations in Sites Reservoir Inflow

To evaluate potential impacts, Chapter 6 used best available measured metals data from multiple locations to develop equations of the inflow metals concentrations to Sites Reservoir as a function of Sacramento River flow and the percent of flow from tributaries. Equations allow the estimated inflow concentration to change as a function of changes in hydrology. The equations for estimating inflow concentrations are conservative because they were adjusted upward to be more responsive to increases in river and percent tributary flow, they allow estimated concentrations to exceed the maximum measured values, and they assume no settling of suspended sediment in the conveyance system on the way to Sites Reservoir.

Measured data were not used directly in the quantitative evaluation in Impact WQ-2. Instead, the measured data were used to develop equations to estimate concentrations over a range of flows and percentages of tributary contributions to flow. The range of flows and percentages of tributary contributions to flow include conditions that sometimes result in estimated concentrations above the maximum measured values. Estimated inflow concentrations that respond to changes in hydrology ultimately allow the impact analysis to reflect the range of hydrologic conditions that may occur and are better than selecting a single value.

Historical measurements of metal concentrations at the proposed Sacramento River diversion locations at Red Bluff and the GCID Main Canal at Hamilton City were collected by the California Department of Water Resources (DWR) on a schedule and did not specifically target high-flow events, but, as illustrated in Appendix 6E, multiple scheduled measurements occurred during higher flows. As described in *Pesticides and Metals other than Mercury* in Chapter 6, the metals analysis for developing the equations for inflow concentrations relied on best available data provided by DWR’s Water Data Library. These data were collected intermittently over multiple years, with measurements representing a wide range of flow conditions near the proposed Red Bluff and Hamilton City diversion locations on the Sacramento River. Although water quality measurements did not target high flows, multiple measurements were taken during higher flows.

Metals concentrations measured at Red Bluff and Hamilton City were similar to each other (described in *Metals other than Mercury* in Chapter 6 and shown in Appendix 6E), which allowed the data to be pooled to maximize the number of measurements collected during high-flow events. November through May measurements were used in the assessment to maximize the number of measurements collected during high flows that were not due to upstream reservoir releases for water supply purposes. There is no strict definition of "high flow," but Sacramento River flows at Keswick greater than 10,000 cfs during November through May likely indicate rainfall runoff or flood control releases and represent conditions when Sites Reservoir might make diversions. Keswick flows greater than 10,000 cfs that occur during other times of year likely represent upstream reservoir releases for water supply. Of the 120 sets of data points represented in this collection of data (November–May measurements taken from the Sacramento River near Red Bluff and Hamilton City), 19 were collected when Sacramento River flow at Keswick was between 10,000 and 48,800 cfs. This set of 120 data points was sufficient to develop exponential equations to estimate metal concentrations as functions of tributary input and river flow as described above.

As described in *Methods of Analysis* in Chapter 6, total metal concentrations are correlated with flow in the Sacramento River and the fraction of river flow originating from tributaries downstream of Lake Shasta. The concentrations of metals diverted from the Sacramento River for storage in Sites Reservoir were estimated with an exponential equation dependent on flow metrics that depend on both Sacramento River flow (flow at Keswick) and the fraction of Sacramento River flow originating from tributaries such as Cottonwood Creek (estimated as 1 – Keswick Flow / Bend Bridge Flow). Maximum calculated concentrations were capped at two times the maximum measured value. The use of an exponential equation means that flow or fraction of water originating from tributaries beyond what was associated with measured concentrations leads to substantial increases in the estimated concentration of metals. Exponential equations for total aluminum, copper, iron, and lead were developed with measured data that included all the highest measured concentrations available. Furthermore, the fitted equations were modified upward to estimate even higher concentrations to ensure substantially elevated concentrations at the highest values of the flow metric. The nature of the exponential increases in estimated values and the upward adjustment in the estimated concentrations can be seen in the figure titled *Relationships between Flow Metric and Total Aluminum Concentrations* in Chapter 6. This approach, for example, produces estimated Sites Reservoir inflow concentrations with maximum values that are 1.2 to 2.0 times the maximum measured values for Alternative 3 (2.0 for aluminum, 1.2 for copper, 1.8 for iron, and 1.6 for lead).

The metals methodology includes the following assumptions that would lead to an overestimate of the concentration of metals entering Sites Reservoir:

- The exponential equations for estimating Sites Reservoir inflow concentrations were adjusted upward, which allows an estimate of higher inflow metal concentrations.
- Estimates of Sites Reservoir inflow concentration assumed no settling of suspended sediment in the conveyance facilities. In reality, much of the suspended sediment contributing to elevated concentrations of metals during the high-flow diversion period is expected to settle during conveyance before reaching Sites Reservoir and would be removed from canals during regular maintenance.

Time-Series Estimates of Inflow Concentration, Evapoconcentration, and Dilution Using CALSIM II Results

Some comments stated that the approach taken to estimate metal concentrations through time was not clear. For example, some commenters thought that evapoconcentration was not considered. In addition, some commenters thought that a combination of worst-case assumptions should be made (e.g., constant maximum inflow concentration, no settling of metals, maximum evapoconcentration, minimum dilution). In reality, conditions would fluctuate over time. Metal concentrations entering and in Sites Reservoir and effects from Sites Reservoir releases on Sacramento River metal concentrations were estimated using CALSIM II results as input. This enabled metal concentrations to be estimated for the entire water year 1922–2003 CALSIM simulation period, which allows an assessment of how conditions would fluctuate over time. Use of the CALSIM II results provides a large range of conditions that allow an assessment of frequency and interaction between factors that would affect metal concentrations (e.g., co-occurrence of high evapoconcentration and low dilution in the Sacramento River).

As described in this response in the section titled *Measured Data and Estimation of Metal Concentrations in Sites Reservoir Inflow*, exponential equations were developed to estimate metal concentrations in the Sacramento River at the points of diversion for Sites Reservoir. These equations depend on flow in the Sacramento River at Keswick and the portion of river flow originating from tributaries (estimated as 1 – Keswick Flow / Bend Bridge Flow). Estimates of these values came from CALSIM II results for flow below Keswick Dam and flow at Bend Bridge. Flow at Keswick is an indicator of the magnitude of flow in the Sacramento River, and the difference between flow at Bend Bridge and Keswick provides an estimate of tributary inflow.

Concentration of metals within Sites Reservoir was adjusted to account for evapoconcentration (*Evapoconcentration* in Chapter 6). Evapoconcentration calculations relied on water balance information from CALSIM II (i.e., Sites Reservoir inflow from the Sacramento River, storage, and outflow). Dilution of metal concentrations from Sites Reservoir in the Sacramento River was calculated with CALSIM II results (*Dilution of Sites Discharges in the Sacramento River* in Chapter 6). When Sites Reservoir would release water to the Sacramento River, it would constitute 6%–7% of the Sacramento River flow on average and 14%–15% when discharges are relatively high compared to river flow (i.e., 90th percentile values), depending on which alternative was evaluated.

Settling of Suspended Sediment

When water is first pumped into Sites Reservoir, concentrations of suspended sediment may be relatively high, causing concentrations of total metals to also be high. Eventually, based on empirical data from other reservoirs (Brune 1953), most suspended sediment entering Sites Reservoir would settle, falling to the bottom of the reservoir, which would cause substantial reductions in total metal concentrations. Metal concentrations were estimated both with and without settling of suspended sediment (*Pesticides and Metals other than Mercury* in Chapter 6). This range of assumptions provides a range of estimated concentrations, including those that may occur when water first enters Sites Reservoir and those that may occur after diversions to storage have stopped. Most releases from Sites Reservoir would occur after settling of suspended sediment.

The settling analysis acknowledges the uncertainty associated with it. Most of the sediment entering Sites Reservoir is expected to settle in the reservoir. Several conservative assumptions were made in the evaluation of settling of suspended sediment that may result in underestimation of the effect of settling on metal concentrations, as follows:

- Settling of suspended sediment was assumed to only affect total concentration if estimated total concentration was greater than the 80th percentile of measured values.
- If estimated total concentration was greater than the 80th percentile of measured values, only the portion of the estimated value above the 80th percentile of measured values would experience settling.
- The analysis assumes that settling would only affect the non-dissolved concentrations.

Underestimation of the effect of settling on metal concentrations means the estimated metal concentrations in the reservoir and its releases would be higher than what might actually occur.

Shoreline Erosion

Some commenters expressed concern that resuspension of sediment would cause substantial increases in metal concentrations. Resuspension of sediment along the shoreline due to wind, rain, and wave action would be unlikely to substantially change concentrations in Sites Reservoir because the amount of sediment involved would represent a small fraction compared to the suspended sediment concentrations diverted from the Sacramento River during high flows. Most of the sediment entering the reservoir would settle at depths where there would be no erosion due to wind, rain, and wave action. If large quantities of sediment remained in suspension due to wind, rain, and wave action, reservoirs would not be the sediment sinks that they are. As described in *Pesticides and Metals other than Mercury* in Chapter 6, based on empirical data (Brune 1953), reservoirs with inflow and storage capacity similar to Sites Reservoir experience settling of 95% or more of the sediment entering the reservoir.

Effect of Anoxic Conditions on Metals Other Than Mercury

Some commenters expressed concern that anoxic conditions at the bottom of Sites Reservoir could lead to the release of metals from reservoir sediment that would reduce water quality. This section addresses this concern by describing general processes that can occur in reservoirs under anoxic conditions and reaeration, anoxic effects considered in Chapter 6, and more detail regarding the possible fate of metals that may be released under anoxic conditions in Sites Reservoir. Due to the limited likelihood that metals released under anoxic conditions would be carried downstream from Sites Reservoir at times when metal concentrations would otherwise be low, this more detailed consideration of the potential release of metals from reservoir sediment in this section does not result in any change in impact conclusions described in Chapter 6.

This text focuses on metals other than mercury. Although some processes are relevant to mercury such as formation of low-quality water (i.e., formation of methylmercury) under anoxic conditions and fate of anoxic water in the reservoir, the chemical reactions differ, and mercury is evaluated separately in Chapter 6 with a different approach.

Effect of Low Oxygen and Reaeration on Metal Concentrations in Reservoirs in General

Low dissolved oxygen occurs in deep portions of many reservoirs and could occur in Sites Reservoir. Low oxygen or anoxic (no oxygen) conditions are likely to form if substantial organic material accumulates and decays at the bottom of a reservoir in the absence of mixing with oxygenated surface water. Respiration by benthic organisms (e.g., bacteria, insect larvae, worms, crustaceans), which require oxygen, contributes to low oxygen. In addition, low light can contribute to low oxygen deep in reservoirs as a result of less generation of oxygen through photosynthesis. Low oxygen is most likely to occur in the hypolimnion, the deep portion of a stratified reservoir with uniformly cool temperatures. The epilimnion, the upper layer of a stratified reservoir with relatively uniform warmer temperatures, is generally well aerated due to oxygenation at the water surface. The metalimnion is the transition zone, with conditions intermediate between the hypolimnion and epilimnion.

Low oxygen conditions may lead to chemical reduction processes in sediment that can cause phosphates, ammonia, sulfides, and metals to be dissolved and released into the water column (Beutel 2003:208). The metals most commonly associated with this process are iron and manganese (Langmuir et al. 2004:39). Metals other than iron and manganese may also be released from sediment in response to anoxic conditions. For example, if iron and manganese oxides present in sediment become reduced and dissolve due to low oxygen concentrations, other metals and phosphorus that may be bound to the iron and manganese oxides may also be released from the sediment (Giles et al. 2015:2; Pachana et al. 2010:6).

Not all metals present in sediment enter the water column under anoxic conditions. For example, a study of remobilization of manganese, iron, copper, and lead in anoxic sediments found release of manganese and iron, but not copper and lead (Sakata 1985:1033). Physical location and molecular structure may also limit release of metals into the water column under anoxic conditions. Metals attached to buried sediment have limited ability to diffuse into the water column. Also, some metal atoms may become bound in a crystalline form that is unlikely to dissolve (Namiesnik and Rabajczyk 2010:7).

High concentrations of dissolved metals deep in a reservoir typically do not affect various aquatic species because most aquatic organisms are unlikely to use low-oxygen habitat, as they require oxygen to survive. High concentrations of metals typically do not move up into the more aerated portion of the water column and are typically not released from a reservoir. Once a year, when reservoir surface temperatures cool sufficiently, the reservoir may experience “turnover,” meaning that the top and anoxic bottom water may become mixed. Once water is mixed into the upper portions of a reservoir during fall or early winter turnover, or released to downstream waterways, it becomes aerated. The presence of oxygen can reverse the process that causes metals to dissolve, which can cause metals to precipitate out of solution (Ashby et al. 2004:65; Giles et al. 2015:3; Namiesnik and Rabajczyk 2010:17). Elevated dissolved metal concentrations leaving an anoxic zone may also come out of solution by adsorption to particulates or oxidation through bacterial action (e.g., manganese; Ashby 2000:xii).

Discussion of Anoxic Conditions in the RDEIR/SDEIS

The RDEIR/SDEIS considers the effect of anoxic conditions in several places. For example, for methylmercury, it describes that in lakes and reservoirs that thermally stratify, oxygen in the hypolimnion can be depleted due to respiration and organic carbon decomposition, and the resulting anoxic conditions stimulate mercury methylation. Due to this stratification, reservoir releases from the warmer epilimnion during the summer are less likely to have elevated methylmercury concentrations compared to releases from the deeper hypolimnion. In fall, as ambient temperatures cool, thermal stratification breaks down, and methylmercury that has built up in the hypolimnion will mix throughout the water column. Water chemistry management actions may be taken under Mitigation Measure WQ-1.1, and these could include the addition of an oxidant (e.g., dissolved oxygen, ozone, nitrate) to the reservoir bottom waters (near the sediment-water interface) to reduce anoxia as one possible mitigative action.

All actions identified for Mitigation Measure WQ-1.1 are included in the RMP. The RMP also includes possible measures to counteract anoxic conditions to reduce the release of bottom-sediment nutrients that may contribute to HAB formation, if HABs become a consistent problem near the I/O tower.

In addition, anoxic conditions are described as one reason metal concentrations may be elevated at the bottom of Sites Reservoir. Releases of this potentially lower quality water to Stone Corral Creek is the reason impacts of other metals on aquatic life in Stone Corral Creek are considered to be potentially significant as discussed in the *Impact Analysis and Mitigation Measures* section of Chapter 6. Implementation of Mitigation Measure WQ-2.1 is expected to reduce this impact to a less-than-significant level.

Possible Effects of Anoxic Conditions on Concentrations of Metals Other Than Mercury in Releases from Sites Reservoir

With respect to anoxic conditions, Sites Reservoir is expected to behave like other reservoirs as described above. During spring through fall, anoxic water at the bottom of the reservoir could cause the release of metals from sediment. Upon late fall/early winter turnover of the reservoir, which would occur after Sites Reservoir releases for water supply are finished for the year, metals released under anoxic conditions may mix within the whole reservoir, temporarily causing increased concentrations of metals at the top of the reservoir and decreased concentrations at the bottom of the reservoir. Eventually concentrations of dissolved metals are expected to decline after turnover due to presence of oxygen and adherence to particulates in the water column. Because there would be no reservoir present under the No Project Alternative, the effect of metals on aquatic organisms within the reservoir would affect water quality in the reservoir, but would not represent an impact of the Project on the environment relative to the No Project Alternative. This paragraph has focused on conditions in Sites Reservoir that are pertinent to the following text regarding releases from Sites Reservoir.

Anoxic water is unlikely to be released through the I/O tower, including under conditions of low storage. At high storage levels, multiple ports on the I/O tower will be available for use. As the reservoir storage level drops, water will need to be released from lower elevations. When reservoir storage is low, a greater percentage of the water column would be in the epilimnion and transition zone (the metalimnion). The vertical extent of the epilimnion and metalimnion depend on multiple factors including temperature (both in the water and the air) and wind speed.

Sites Reservoir water temperature was simulated with CE-QUAL-W2, a 2-dimensional water quality model used frequently for water temperature simulations. The model and model results are described in Appendix 6D, *Sites Reservoir Discharge Temperature Modeling*. Water temperature profiles from CE-QUAL-W2 results indicate the possible vertical extent of the epilimnion, metalimnion, and hypolimnion under various conditions. Figures MR4-1 and MR4-2 show CE-QUAL-W2 temperature profiles for Alternative 3 under moderately low reservoir storage, 1924 (Figure MR4-1), and very low storage, 1932 (Figure MR4-2). In 1924, simulated storage started at 500 TAF in January and dropped to 76 TAF by September. In 1932, simulated storage started at 62 TAF in January (close to operational dead pool of 60 TAF) and dropped to 52 TAF by October.

CE-QUAL-W2 results for Alternative 3 indicate that the reservoir is well mixed during colder months (December–February), with temperature profiles being almost vertical (Figures MR4-1 and MR4-2). Cold hypolimnion water tends to extend farther up in the reservoir when reservoir storage is higher and in the spring, when the reservoir starts to warm from the surface. Under low storage conditions, when water surface elevation is below 340 feet, the middle of the bottom tier (opening) of the I/O tower, reservoir releases would be limited to the low-level intake, which has a centerline at 311 feet. At these low storage levels, the metalimnion, and sometimes the epilimnion (e.g., October 1932 in Figure MR4-2), extends down to the low-level intake. Under these low storage conditions, anoxic hypolimnetic water is expected to be limited to a small volume at the bottom of the reservoir, and releases from the low-level intake would likely draw from the more aerated metalimnion. These results show that release of anoxic water is unlikely because either there would be options for upper-level release points from the I/O tower or, if low storage would restrict releases to the low-level intake, aerated water would extend down to the low-level intake.

If high metal concentrations associated with anoxic conditions cannot be avoided in the reservoir discharge, such releases would be temporary, and the metal concentrations would be expected to decline as the water moves downstream due to reaeration. Implementation of Mitigation Measure WQ-2.1 will protect Stone Corral Creek from releases of low-quality water from the bottom of the reservoir, making this impact less than significant. To ensure impacts remain less than significant, water quality in Stone Corral and Funks Creeks will be monitored as part of the RMP and the Stone Corral Creek and Funks Creek Aquatic Study Plan and managed through adaptive management. Eventually, water from the creeks would mix with other water sources, reducing the water quality signature from Sites Reservoir; approximately 7.6 miles from Sites Dam, Stone Corral Creek would mix with water from GCID and become integrated with the water management system, and, approximately 1.8 miles from Golden Gate Dam, Funks Creek would mix with TCCA water at Funks Reservoir.

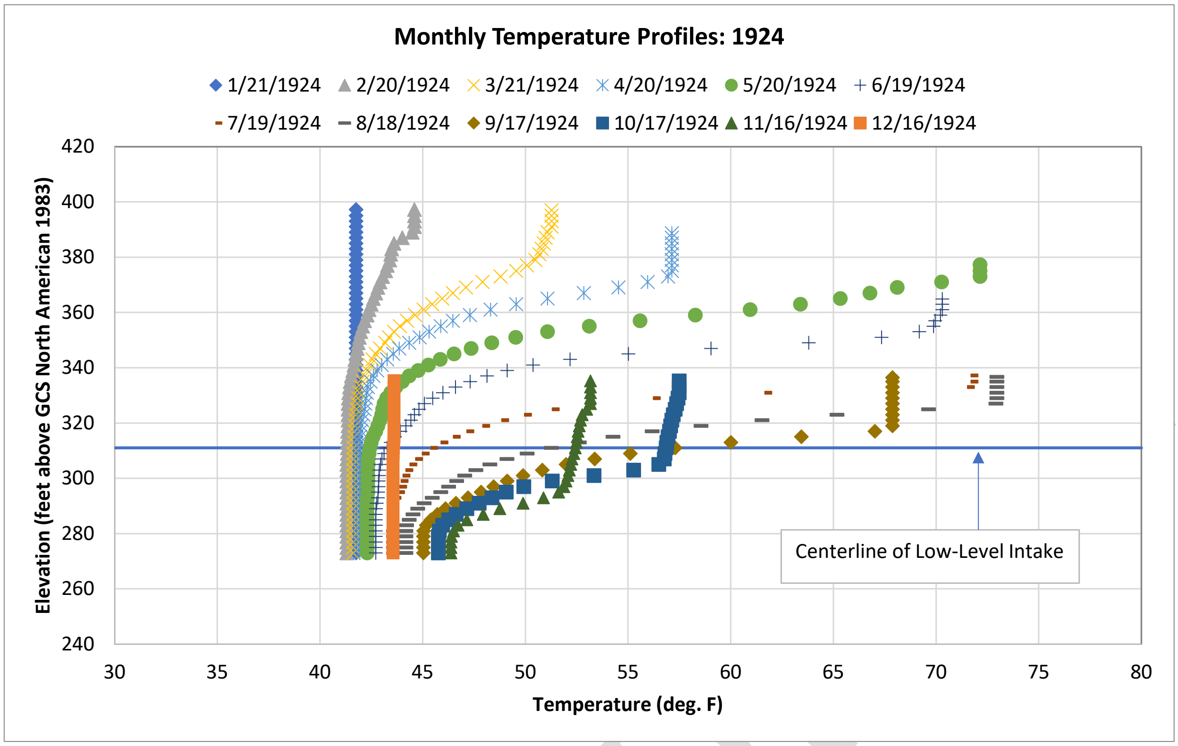

Figure MR4-1. Sites Reservoir Water Temperature Profiles for 1924 Hydrologic Conditions as Simulated with CE-QUAL-W2

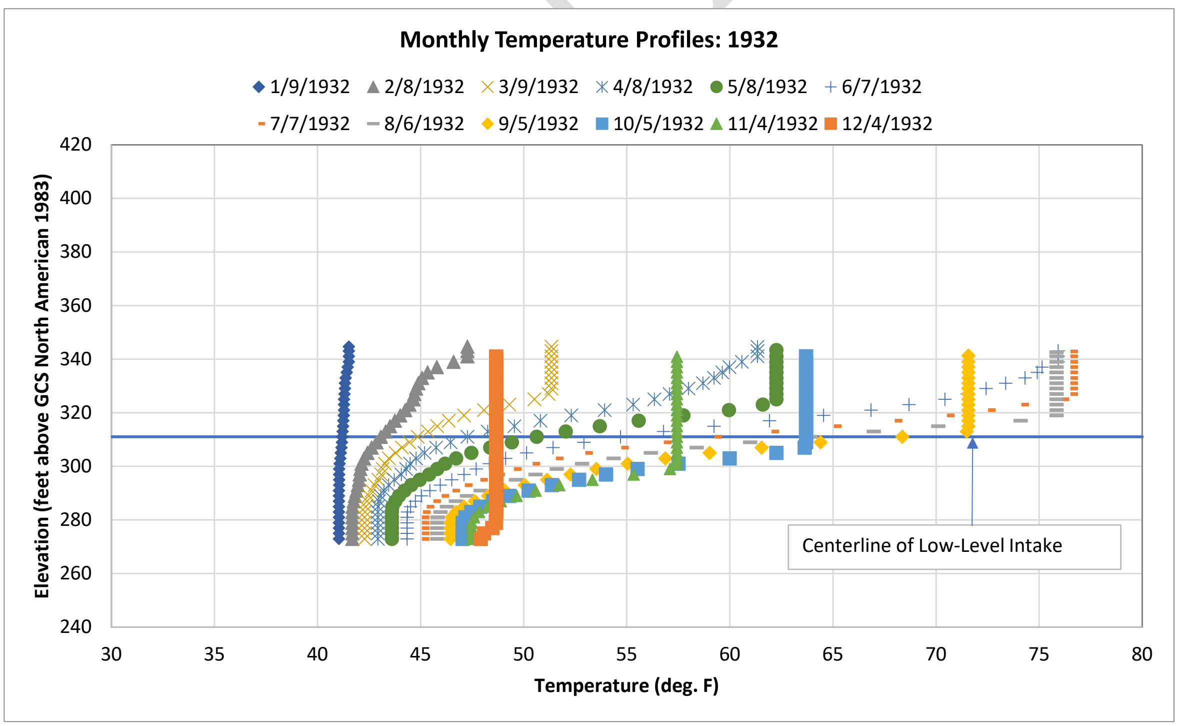

Figure MR4-2. Sites Reservoir Water Temperature Profiles for 1932 Hydrologic Conditions as Simulated with CE-QUAL-W2

Consideration of Effect of Metals Other Than Mercury on Beneficial Uses

Some commenters expressed concern that elevated metal concentrations would harm multiple beneficial uses of water. As described in the RDEIR/SDEIS discussion for Impact WQ-2, the analysis indicates that while some metal concentrations in Sites Reservoir may temporarily be elevated and similar to high concentrations in the Sacramento River, these concentrations are likely to decline substantially as a result of settling of suspended sediment. As a result of this decline in concentrations and mixing with downstream waterways, beneficial uses are unlikely to be affected beyond impacts identified in Chapter 6 of the RDEIR/SEIS, as well as the Final EIR/EIS. The following section provides a summary of potential beneficial uses affected by elevated metal concentrations, focusing on those beneficial uses and waterbodies most likely to be affected. Estimated concentrations of metals are described in Chapter 6 for Impact WQ-2. Table MR4-1 provides a summary of these concentrations for use in summarizing effects on beneficial uses here.

The table provides a general assessment of metal concentrations in Sites Reservoir and changes in concentration in CBD and the Sacramento River. Concentrations are generally expected to be similar or reduced in CBD, and no increases in exceedances of water quality standards are expected in the Sacramento River. For comparison purposes, the first column in the table presents the water quality standards used in the evaluation for assessing protection of beneficial uses.

Fish Consumption

This discussion focuses on consumption of fish from the reservoir or the creeks that are supplied with water from the reservoir because the highest metal concentrations associated with the Project are expected to occur in Sites Reservoir, Stone Corral Creek, and Funks Creek. Consumers of aquatic organisms are not likely to be affected by elevated metal concentrations for several reasons, as discussed below.

Water quality standards for protection of aquatic life are often used as surrogates for protection of fish consumers (State Water Resources Control Board 2017a). These surrogate standards may be overly protective for the purposes of applying them to fish consumption because many of these standards were developed to protect sensitive aspects of fish physiology (e.g., gill function, growth, mobility, and fertility), not to protect fish consumers. Metal concentrations in Sites Reservoir and the creeks may be higher than concentrations in the Sacramento River during spring through fall. Concentrations during these times are generally not expected to regularly exceed standards for aquatic life, with the possible exception of aluminum.

If a metal does not bioaccumulate, then it is unlikely to occur at elevated levels that might be harmful to consumers of fish. Aluminum is the most likely metal to be at concentrations above the aquatic life standard for substantial amounts of time, but aluminum is already widely present in food, medicine, and water and does not bioaccumulate to a high degree (U.S. Department of Health and Human Services 2008:175, 177, 190, 223). In fish, measured concentrations of lead and the essential metals copper and iron indicate low bioaccumulation (U.S. Department of Health and Human Services 2022:188–189; Olayinka-Olagunju et al. 2020:12, 13; Rahayu et al. 2020:2, 5, 6).

Terrestrial wildlife such as birds that consume aquatic organisms from Sites Reservoir are likely to ingest food with metal concentrations that would be lower or similar to concentrations found in the Sacramento River during the winter or in CBD. Due to the timing of water supply releases from Sites Reservoir (generally May–November), most suspended sediment that enters Sites Reservoir would settle on the way to Sites Reservoir or in the reservoir prior to discharge. Once some settling of suspended sediment has occurred in Sites Reservoir, metal concentrations in Sites Reservoir are likely to be similar to or less than concentrations in CBD. Median measured concentrations in CBD are similar to or higher than the median values estimated to occur in Sites Reservoir after settling of suspended sediment (Table MR4-1). The high concentration of metals in CBD are shown in Appendix 6E, in the sections titled *Metals Data by Month* and *Metals Data Tables*.

Table MR4-1. Measured and Alternative 3 Metal Concentrations (µg/L)

Metal	Median Estimated Sites Reservoir Concentration Assuming No Settling of Suspended Sediment Alternative 3	Median Estimated Sites Reservoir Concentration Assuming Some Settling of Suspended Sediment Alternative 3	Median Measured Concentration in Colusa Basin Drain During the Primary Sites Discharge Season[a] (May–September)	Median Measured Concentration in Sacramento River Receiving Water During the Primary Sites Discharge Season (May–September)	Maximum and Average Estimated Concentration in Sacramento River when Sites Discharge is Mixed with Median Sacramento River Concentration[b] Alternative 3	95th Percentile of Measured Concentrations in Sacramento River Receiving Water During the Primary Sites Discharge Season (May–September)	Maximum and Average Estimated Concentration in Sacramento River when Sites Discharge is Mixed with 95th Percentile Sacramento River Concentration[b] Alternative 3
Total Aluminum (Standard = 620)	1,018	614	882	110	Max=253 Avg=144	838	Max=874 Avg=825
Total Copper (Standard = 5.2)	4.91	4.24	5.09	1.66	Max=2.43 Avg=1.83	3.75	Max=4.13 Avg=3.79
Total Iron (Standard = 1,000)	1,372	605	1,242	126	Max=257 Avg=158	809	Max=835 Avg=798
Total Lead (Standard = 1.3)	0.60	0.28	0.68	0.08	Max=0.13 Avg=0.09	0.42	Max=0.42 Avg=0.41

[a] Discharges to the Sacramento River could occur any time of the year but are unlikely to occur during wet conditions. As modeled by CALSIM (see Chapter 5 of the EIR/EIS), there would be almost no releases to the Sacramento River from December–March. Receiving-water concentrations for the No Project Alternative were calculated based on historical May–September measurements because these months would be within the primary months of release and measurements under wet conditions should not be included (because releases would not typically occur under wet conditions). The receiving-water assessment could have included October and November, but this would make little difference in the characterization of receiving-water quality, especially if measurements during wet conditions were not included.

[b] Assuming some settling of suspended sediment in Sites Reservoir.

µg/L = microgram per liter; EIR/EIS = environmental impact report/environmental impact statement

Aquatic Life in Funks and Stone Corral Creeks

The portions of Funks and Stone Corral Creeks between Sites Reservoir and downstream inputs would be the only two stream reaches expected to be supplied directly by water from Sites Reservoir without dilution with other water. As described in Chapter 6 and summarized in Table MR4-1, the estimated concentrations of non-mercury metals in the Sites Reservoir discharges to these creeks are not expected to continually exceed aquatic life standards. Exceedances of aquatic life standards would most likely occur when metal concentrations in Sites Reservoir are elevated due to high concentrations of suspended sediment associated with active filling of the reservoir. During these wet conditions, flows in these creeks would also likely be high under the No Project Alternative and, therefore, likely have concentrations of metals similar to the higher concentrations measured in Stone Corral Creek (Appendix 6E), which are higher than the standards for protection of aquatic life. In other words, aquatic life in these creeks is already exposed to elevated metal concentrations and would also be exposed to elevated metal concentrations under the No Project Alternative.

Metal concentrations released to the creeks could be higher than the estimated values if water is released from near the bottom of the reservoir under anoxic conditions (see *Anoxic Conditions* above). During Project operation, Funks Creek downstream of Sites Reservoir would receive discharges of Sites reservoir water from releases from the I/O tower. The multiple ports of the I/O tower would offer options for optimizing the withdrawal location within the water column and would help avoid withdrawal of high concentrations of metals that might be associated with anoxic conditions at the bottom of the reservoir (see *Use of the I/O Tower to Control Releases of Constituents* below for a discussion regarding the improbability of conflicting port selection goals). Potentially elevated concentrations of metals in the releases to Stone Corral Creek due to possible anoxic conditions at the bottom withdrawal from Sites Dam have been acknowledged as a significant impact in Chapter 6 under Impact WQ-2 and are addressed with Mitigation Measure WQ-2.1, which provides a suite of possible methods for avoiding release of low-quality water from the bottom of the reservoir.

In addition to this mitigation, as part of the RMP, metal concentrations will be measured in Stone Corral Creek downstream of Sites Reservoir and in the release from the I/O tower, which would provide water to Funks Creek. In addition, the Stone Corral Creek and Funks Creek Aquatic Study Plan (Appendix 2D) includes additional water quality measurements, benthic macroinvertebrate and algae surveys, and fish species and abundance surveys occurring before reservoir construction and during operation. The fish surveys and benthic macroinvertebrate and algae surveys will indicate if there are unexpected toxic effects. Furthermore, the Authority will develop an adaptive management plan as part of its operation of the Project in consultation with fish and wildlife agencies to maintain fish in good condition consistent with California Fish and Game Code Section 5937. The adaptive management plan will include actions to be taken in response to any concerns raised during implementation of the Stone Corral Creek and Funks Creek Aquatic Study Plan.

The plan for discharges to Stone Corral Creek and Funks Creek will be finalized with input from permitting agencies (Chapter 2 and Appendix 2D). Using information from these field studies, along with currently available information, the Authority would prepare a Stone Corral Creek and Funks Creek flow schedule that would be incorporated into the Reservoir Operations Plan that would identify the approach for releases, including release schedules and volumes; a monitoring plan; and an adaptive management plan (Chapter 2). Discharges to Stone Corral Creek and Funks Creek are expected to range from 0 to 100 cfs, with larger pulse flows to emulate natural flood conditions and lower flows in the drier months (Chapter 7, *Fluvial Geomorphology*). Flows measured by the U.S. Geological Survey in Stone Corral Creek near Sites (station 11390672) from 1958–1985 show no flow during August–October and almost no flow during June and July (see the table titled *Stone Corral Creek Daily and Monthly Flows Near Sites, USGS 11390672* in Chapter 11, *Aquatic Biological Resources*). As described in Chapter 5, *Surface Water Resources*, flow in Funks Creek has not been measured through time, but is expected to be similar to flow in Stone Corral Creek based on proximity and watershed size. Creek flows under the No Project Alternative would likely be similar to historical values. When the creeks would be dry under the No Project Alternative, there would be no basis of comparison for evaluating water quality impacts associated with the Project.

CBD and Sacramento River

Sites Reservoir releases are unlikely to increase metal concentrations in CBD because concentrations in CBD tend to be similar or higher than concentrations expected in Sites Reservoir at the time water would be released for water supply (Table MR4-1 and Chapter 6, Impact WQ-2). Water would be released for water supply after time has allowed settling of suspended sediment that might enter the reservoir during filling.

After settling of suspended sediment, metal concentrations may still increase due to evapoconcentration. The highest estimates of evapoconcentration occur when Sites Reservoir would be drawn down to operational dead pool and exposed to continued evaporation (during 1931–1934 in the CALSIM simulation). Under these circumstances, reservoir storage would be below operational dead pool and the reservoir would not be capable of releasing water for water supply purposes. Water would not be released for water supply purposes until there would be substantial increases in storage from fresh inflow that would reduce concentrations (see figure titled *Estimated Sites Reservoir Storage and Water Supply Releases during Period of Peak Evapoconcentration* in Chapter 6).

Sites Reservoir releases are unlikely to have substantial effects on metal concentrations in the Sacramento River due to dilution with Sacramento River flows. Table MR4-1 shows the maximum and average of the estimated metal concentrations in the Sacramento River downstream of the Sites Reservoir discharge location for Alternative 3 for two different concentrations upstream of the discharge location (median and 95th percentile concentrations). The results are similar for the other alternatives. If Sites Reservoir water were added to Sacramento River when concentration in the river is at median concentrations, the estimated maximums of the resulting concentrations are substantially less than water quality standards for aquatic life.

Increases in concentration in the Sacramento River would likely not cause standards to be exceeded, even if Sacramento River concentrations were higher. When Sacramento River concentrations are high, the Sites Reservoir discharge has little effect on concentrations. For example, if Sites Reservoir water is added to Sacramento River water when concentration in the river is high (e.g., 95th percentile or the values measured in the Sacramento River during May–

September), the effect of Sites Reservoir releases would be small due to similarity between Sites Reservoir concentrations and the river concentrations (Table MR4-1). In some such cases, the Sites Reservoir discharge could cause small reductions in Sacramento River concentrations (Chapter 6, Impact WQ-2). These reductions explain why some of the averages of the resulting combined concentrations shown in the last column of Table MR4-1 show a slight reduction in concentration relative to the 95th percentile values for the Sacramento River. Further, the scenario of Sites Reservoir releases into moderately high Sacramento River concentrations is unlikely to occur because high metal concentrations during the May–September period used to characterize measured concentrations occur mostly when river flows are high due to late-season storm runoff. In these wet-condition circumstances, there would be little demand for release of Sites Reservoir water for water supply.

Yolo Bypass

Under Alternatives 1, 2, and 3, some of the Sites Reservoir releases may pass through CBD and through the Yolo Bypass for habitat purposes during August–October. The Yolo Bypass flow pulses have been proposed because there is evidence that these flows could increase phytoplankton abundance downstream of the Yolo Bypass and food supply for fish in the North Delta, including delta smelt. This conclusion is based on evaluation of flow pulses that occurred through the Yolo Bypass during 2011–2019 as described in Chapters 6 and 11. The magnitude of effect has been variable, and the methodology for maximizing primary production has not been determined. There is some concern that flow pulses could relocate contaminants and reduce the expected benefits of the pulses (e.g., Davis et al. 2022:2,3).

As described in Chapter 6 for Impact WQ-2, re-direction of CBD flow to the Yolo Bypass could cause relocation of CBD water, which has high concentrations of several metals, into the Yolo Bypass. Few measurements exist for metal concentrations in the Yolo Bypass, so it is unclear whether discharge of CBD water to the bypass would cause exceedances of water quality standards for protection of aquatic life.

As described in Chapter 6, Mitigation Measure WQ-2.2 for Impact WQ-2 would reduce potential Yolo Bypass impacts associated with increased pesticides and metals other than mercury to a less-than-significant level. As part of this mitigation measure, metal measurements would be taken to quantify the effect of flow pulses on metal concentrations in the Yolo Bypass. Yolo Bypass habitat flow releases are is expected to provide net benefit to fisheries, but if they cannot be made to provide this benefit, the program would be discontinued, and the water could be used for more beneficial environmental purposes.

Drinking Water

Sites Reservoir releases to the Sacramento River would be greatly diluted and would not affect beneficial uses in the Sacramento River such as drinking water. Dilution would occur both at the location of Sites Reservoir discharge as described in Chapter 6, section entitled *Dilution of Sites Discharges in the Sacramento River,* and when the Feather River joins the Sacramento River.

Agriculture

Except for arsenic, water quality standards for agriculture are substantially higher than water quality standards for aquatic organisms (Chapter 6 table titled *Metals Water Quality Standards*).

All the agricultural standards would be met by the water from Sites Reservoir. The Chapter 6 Impact WQ-2 discussion includes a discussion of arsenic and estimated arsenic concentrations in Sites Reservoir and the releases. Arsenic concentrations would continue to be substantially less than regulatory standards for agriculture (Chapter 6 table titled *Arsenic Concentrations in the Sacramento River, Sites Reservoir, and Regulatory Standards*) because concentrations in the Sacramento River are so low and because the arsenic concentrations in the inflow to Sites Reservoir would not be high relative to the concentrations in the Sacramento River at the time and location of discharge from Sites Reservoir (because concentrations are higher farther downstream on the Sacramento River and are fairly uniform through the year). Chapter 15, *Agriculture and Forestry Resources*, in the section titled *Methods of Analysis*, also includes an evaluation of water quality for agricultural uses, and no impacts are identified.

Refuges

Sites Reservoir would not be the sole water source for any refuges. No substantial effects would be anticipated on the Delevan or Colusa National Wildlife Refuges (NWRs). Delevan NWR receives water from CBD, several agricultural drains, and Stone Corral Creek more than 3 miles downstream of its confluence with Funks Creek. The main water inputs to Colusa NWR are from the CBD and Powell Slough. Because Project effects on metal concentrations in the Sacramento River are expected to be less than significant, refuges supplied by water from the Sacramento River and the Delta would also be less than significant. In addition, an increase in incremental level 4 water supply to the refuges is an ecosystem benefit of the Project as it provides an additional water source.

Recreation

People who engage in water contact activities in Sites Reservoir would not be affected because very little metal would pass through skin or accidentally be ingested during various water contact activities.

Consideration of Additive Effects

Multiple commenters stated concerns about the additive effects of metals. They considered the evaluation in Chapter 6 to be insufficient and suggested use of methodology described in the State Water Board Water Quality Goals document (State Water Resources Control Board 2016). As described in Chapter 6, determination of the combined effects of metals on aquatic resources is difficult due to the variable nature of the interaction of effects:

> Toxicity studies have been conducted to attempt to determine whether various metals together may have additive, antagonistic, or synergistic (greater than additive) physiological effects. In lethality tests on the nematode, *Caenorhabditis elegans*, results indicated that copper had a synergistic effect with cadmium, lead, mercury, zinc, and nickel, whereas zinc had a neutralizing effect on the toxicity of other metals (e.g., aluminum, cadmium) (Chu and Chow 2002:58). Copper and cadmium appear to have a synergistic effect in inhibiting cell division in the freshwater alga *Chlorella* sp., while combinations of copper and zinc, cadmium and zinc, and the three metals were less than additive or antagonistic (Franklin et al. 2002:2412).

As summarized in Lynch et al. (2016:446), "Metal mixture toxicity has been studied for decades. However, the results are not consistent, and thus ecological risk assessment and regulation of mixtures has been difficult." Many studies evaluate only small subsets of the total suite of metals that may occur in water. Furthermore, the nature of interaction depends on factors such as the particular physiological process evaluated, duration of exposure (Feng et al. 2018:97), whether the metal is dissolved, and other water quality conditions (e.g., pH, hardness, and dissolved organic matter) (Niyogi and Wood 2004:6177; Rüdel et al. 2015:5; Smith et al. 2015:57–60; Arienzo et al. 2022:48–49).

To evaluate additive effects of metals, it is necessary to understand bioavailability of metals and how metals affect particular physiological processes. Biotic ligand models have been developed to estimate availability of metals for binding to biotic ligands (sites of toxic action in organisms). Generally, higher concentrations of cations (e.g., calcium ions, sodium ions, magnesium ions, and hydrons) and abiotic ligands (e.g., dissolved organic matter, chloride, carbonates and sulfides) can diminish the severity of toxic metal effects on fish (Niyogi and Wood 2004:6177; Smith et al. 2015:57–60) and the effect of these water quality constituents depends on the specific toxic metal, metal mixtures, and taxa (Smith et al. 2015:57–60). Fish gills are a common biotic ligand evaluated. Many metals can bind to fish gills, disrupting their proper function (Niyogi and Wood 2004:6177).

Biotic ligand models for fish gills can be used to estimate bioavailability of metals, but do not allow for full consideration of additive effects. The effect of metals on fish gills has been studied extensively, and biotic ligand models have been developed to evaluate toxicity for small sets of metals, but not the combined effect of all metals that could be detrimental to fish-gill function. A partial list of metals that potentially could interfere with fish-gill functionality includes aluminum, cadmium, chromium, copper, iron, lead, nickel, silver, and zinc (Niyogi and Wood 2004:6177; Rüdel et al. 2015:1; Smith at al. 2015:57).

Commenters suggested that additive effects of all chemicals having similar toxicologic effects be evaluated and cited to the State Water Board Water Quality Goals document (State Water Resources Control Board 2016). There is great uncertainty in evaluating additive effects and a lack of accurate tools to do so, but the State Water Board Water Quality Goals document offers one possible approach to assess the additive effects of a large group of metals (State Water Resources Control Board 2016:44–45). This approach is implemented using the following equation:

$$\sum_{i=1}^{n} \frac{[Concentration\ of\ Constituent]i}{[Toxicologic\ Threshold\ in\ Water]i} < 1.0$$

This approach for evaluating additive effects can allow a full suite of metals to be evaluated. However, as described below, the use of this approach to assess fish-gill toxicity illustrates some key inadequacies. This approach was used to assess possible effects associated with the subset of metals listed above that could affect fish gills (aluminum, cadmium, chromium, copper, iron, lead, nickel, silver, and zinc). When the average total concentrations of these metals measured in the Sacramento River at Red Bluff are used with the water quality standards for total concentrations of these metals (values presented in Appendix 6E and below in Table MR4-2), the resulting additive toxicity risk value is 1.67, which, according to the water quality goals document, (State Water Resources Control Board 2016:44–45), indicates that on average the Sacramento River provides an unacceptable level of risk to fish. This conclusion is less likely indicative of an additive effect and more likely indicative of the difficulty in estimating additive effects of metals on fish in the Sacramento River. First, not all the water quality standards used in the calculation were developed specifically with effects on fish gills in mind, nor do they all incorporate consideration of water quality parameters such as pH, hardness, and DOC that would affect the bioavailability of these metals. In addition, some of the metals included in the calculation, such as copper, iron, and zinc (Lall and Kaushik 2021:1) are essential nutrients. This linear calculation that assumes even low levels of essential metals contribute towards deleterious effects is likely overly simplistic. Furthermore, while all the metals evaluated may affect fish gills, they do not all have exactly the same effect on fish gills. For example, copper and silver may affect sodium uptake pathways, whereas zinc and lead may affect calcium uptake pathways (Niyogi and Wood 2004:6177).

Because of the difficulty and speculative nature of estimating additive toxicity effects of multiple metals, the analysis in Chapter 6 focuses on whether there would be substantial increases in constituent concentrations or exceedances of water quality standards as evaluated for Impact WQ-2. The metals analysis in Chapter 6 indicates minimal effect of Sites Reservoir on metal concentrations in the Sacramento River and potential improvements in CBD. The most likely waterbodies that could experience increases in metal concentrations are the Yolo Bypass (due to inflow from CBD) and Stone Corral Creek during drier parts of the year (when metal concentrations would not naturally be elevated under the No Project Alternative as a result of increased suspended sediment associated with higher flows and rainfall runoff).

Stone Corral Creek and the Yolo Bypass will be protected by Mitigation Measures WQ-2.1 and WQ-2.2, as described further below. In addition to these mitigation measures, as part of the RMP, which is described in Appendix 2D in the section titled *Reservoir Management Plan*, metal concentrations will be measured in Stone Corral Creek and the release from the I/O tower, which would provide water to Funks Creek. In addition, the Stone Corral Creek and Funks Creek Aquatic Study Plan (Appendix 2D) will include additional water quality measurements, benthic macroinvertebrate and algae surveys, and fish species and abundance surveys. The fish surveys and benthic macroinvertebrate and algae surveys will indicate if there are unexpected additive toxic effects. Furthermore, the Authority will develop an adaptive management plan in consultation with fish and wildlife agencies to maintain fish in good condition consistent with California Fish and Game Code Section 5937 as part of its operation of the reservoir. The adaptive management plan will include actions to be taken in response to any concerns raised during implementation of the Stone Corral Creek and Funks Creek Aquatic Study Plan.

Table MR4-2. Estimation of Average Additive Toxicity Effects of Metals on Fish-Gill Function in the Sacramento River near Red Bluff

Metal	Average Measured Total Concentration (µg/L)	Water Quality Standard for Total Concentration (µg/L)	Average Measured Value Divided by Standard
Aluminum	283.6	620	0.46
Cadmium	0.0443	0.45	0.10
Chromium (III)	1.1	49	0.02
Copper	2.10	5.2	0.40
Iron	297.0	1000	0.30
Lead	0.166	1.3	0.13
Nickel	1.8	29	0.06
Silver	0.0178	0.12	0.15
Zinc	3.66	67	0.05
			Sum = 1.67

Notes: Values from Appendix 6E and approach from State Water Resources Control Board 2016:44–45
µg/L = microgram per liter

Use of the I/O Tower to Control Releases of Constituents

Multiple commenters expressed concern that the optimal I/O tower port for reservoir discharge may vary by water quality constituent and that this could lead to a conflict in optimal port opening and difficulty avoiding “poor” water quality in the reservoir discharge. Presence of HABs/cyanotoxins would be an indication for use of deeper ports for reservoir releases, whereas avoidance of potentially high concentrations of methylmercury and other metals, or desire for warmer water for rice production, could be an indication for use of higher ports. If HABS near the I/O tower occurred at the same time as particularly high metal concentrations at the bottom of the reservoir, for example, it might be difficult to select a port opening that could avoid release of elevated concentrations of both constituents. The text that follows describes how use of selective withdrawal from the I/O tower would avoid release of lower quality water in most circumstances and thereby avoid conflict between water quality objectives.

Some control of the water quality of Sites Reservoir releases would be provided by selective use of the multiple tiers in the I/O tower (centerlines at 340, 370, 390, 410, 430, and 450 feet elevation, with an additional outlet at 470 feet for Alternatives 1 and 3) and the low-level intake (centerline at 311 feet). At each tier in the I/O tower, there would be three ports on alternating faces of the hexagonally shaped tower. Ports are estimated to be 7 feet high, pending final design. Measurements of metal concentrations, HABs/cyanotoxins, and water temperature, as described in the draft RMP, would indicate optimal port depth.

Because presence of HABs/cyanotoxins would be the only reason for releasing water from deeper in the reservoir, potential conflicts with regard to I/O tower tier selection to avoid releasing multiple water quality constituents of concern would not occur unless HABs/cyanotoxins were present at the I/O tower. If HABs/cyanotoxins were present at the I/O tower at the same time relatively high metal concentrations (including methylmercury) or water too cold for agriculture was deep in the reservoir, there might be no I/O tower tier available for discharging relatively high-quality water. However, as described below, this scenario would be uncommon, and additional measures listed below would protect against the consequences of such a scenario.

Studies have shown that cyanotoxins from planktonic cyanobacteria may be located at depths up to 33 feet from the water's surface. If reservoir levels are moderate to high, it would be possible to withdraw water from 33 feet or more below the surface, where cyanotoxin concentrations would be lower relative to closer to the water's surface, and above the hypolimnion where water may be cold, and metals and methylmercury concentrations might be elevated due to anoxic conditions. For example, if water surface elevation was greater than 410 feet (reservoir storage of approximately 545 TAF), providing a 40-foot buffer to avoid higher concentrations of cyanobacteria/cyanotoxins could still allow use of the tiers centered at 340 and 370 feet, which would be well above the deepest portions of the reservoir. Even if reservoir water surface elevation were as low as 380 feet (reservoir storage of approximately 320 TAF), the ports with centerline at 340 feet could likely withdraw water that is not affected by anoxic conditions or substantially high concentrations of cyanobacteria or cyanotoxins (if present).

On rare occasions during periods of low water availability, reservoir storage may be drawn down and approach the operational dead pool of 60 TAF (water surface elevation of 323 feet). Releases for water supply could be made if storage is above operational dead pool, and releases to the creeks potentially could occur even when storage is below operational dead pool. If reservoir levels approach operational dead pool, it may be necessary to make all releases from the low-level intake. The CE-QUAL-W2 water temperature profiles shown and described above in the section above titled *Possible Effects of Anoxic Conditions on Concentrations of Metals other than Mercury in Releases from Sites Reservoir* show the position of the hypolimnion, metalimnion, and epilimnion relative to the low-level intake when reservoir levels would be low. Based on simulated temperature profiles for the reservoir, when reservoir levels are low, it is likely the hypolimnion would be very small and the more well-aerated metalimnion would extend to the low-level intake, especially during the warmer parts of the year when HABs are more likely to form. This reduces the likelihood of elevated metal concentrations in the reservoir release, but would increase the importance of monitoring and controlling HABs near the low-level intake.

The only locations downstream of Sites Reservoir where aquatic life would experience undiluted water from the reservoir would be the sections of Stone Corral Creek and Funks Creek between the reservoir release points and integration with the agricultural conveyance system. As described above (in the section titled *Aquatic Life in Funks and Stone Corral Creeks*), there is almost no flow in Stone Corral Creek during June–October, and flow in Funks Creek is likely similar. While reservoir release patterns to these creeks have not been finalized, it is anticipated that the releases will be managed to reflect the historical hydrograph and seasonal conditions. Sites Reservoir releases will thus likely occur in late fall, winter, and early spring, at times when HABs are less likely to occur in the reservoir.

At low storage levels, water temperatures released from the reservoir could be quite warm depending on meteorological conditions. Warm releases would be acceptable for the warm-water fish of Stone Corral Creek and Funks Creek and for agriculture. Warm-water releases are also not expected to cause downstream impacts. As shown in the Final EIR/EIS in Chapters 6 and 11, results from the blending model, which estimates the effect of Sites Reservoir releases on downstream water temperatures, indicate that low storage would not cause substantial increases in Sacramento River temperatures or impacts to cold water fisheries.

The flexibility offered by multiple ports In the I/O tower is one of several tools for monitoring and managing water quality including:

- Mitigation Measures WQ-1.1 and WQ-2.1. Mitigation Measure WQ-1.1, Methylmercury Management, includes actions to monitor mercury concentrations, protect public health, and reduce methylmercury concentrations as described in the RMP. Actions to reduce methylmercury concentrations would be according to methods proven feasible and effective at reducing mercury methylation by pilot tests undertaken in other mercury-impaired reservoirs, as determined by the State Water Board's program review at the conclusion of the Phase 1 pilot tests for the Statewide Mercury Control Program for Reservoirs. Mitigation Measure WQ-2.1, Prevent Metal Impacts in Stone Corral Creek Associated with Sites Reservoir Discharge, includes monitoring for exceedances of standards for the protection of aquatic life and actions such as drawing releases from higher in the reservoir to reduce metal concentrations in Stone Corral Creek if warranted.
- Stone Corral Creek and Funks Creek Aquatic Study Plan and Adaptive Management. A draft plan to study conditions in Stone Corral Creek and Funks and Creek is described in Appendix 2D of the FEIR/FEIS. Water quality is one component of these studies. Using information from these field studies, along with currently available information, the Authority will prepare a Stone Corral Creek and Funks Creek flow schedule that could be incorporated into the Reservoir Operations Plan that will identify the approach for releases, including release schedules and volumes, a monitoring plan, and an adaptive management plan to maintain fish in good condition consistent with California Fish and Game Code Section 5937 in Stone Corral Creek and Funks Creek.
- Reservoir Management Plan. The RMP will describe the management of water resources in Sites Reservoir, including monitoring water quality. A preliminary RMP is provided in Appendix 2D of the FEIR/FEIS. The final RMP will be prepared after meetings and consultation with regulatory agencies and other stakeholders. The RMP will include monitoring for HABs, cyanotoxins, methylmercury, other metals, and water temperature. In addition, the RMP will include actions to be taken if the monitoring raises concerns regarding particular water quality constituents. Some of these actions will be designed to protect people who potentially could be exposed to HABs or fish with high methylmercury concentrations in the reservoir. The RMP will also include actions that could be taken to improve water quality in the reservoir. For example, if HABs become a consistent problem near the I/O tower, additional measures may be implemented, such as oxygenation of the hypolimnion to reduce the release of nutrients from bottom sediment. Reducing reservoir nutrients may help reduce the potential for the formation of HABs and/or the production of cyanotoxins at concentrations exceeding the trigger levels.

Adequacy of Mitigation

Some commenters questioned the adequacy or effectiveness, as well as the feasibility, of the proposed mitigation measures for impacts on surface water quality. Significant impacts and mitigation were identified in Chapter 6 to address effects on water quality related to mercury/methylmercury concentrations in Sites Reservoir, metals other than mercury in Stone Corral Creek, and metals other than mercury and pesticides in the Yolo Bypass. The following mitigation measures were identified as feasible and effective for reducing the magnitude of the water quality impacts related to methylmercury, metals other than mercury, and pesticides:

- Mitigation Measure WQ-1.1, *Methylmercury Management*
- Mitigation Measure WQ-2.1, *Prevent Metal Impacts in Stone Corral Creek Associated with Sites Reservoir Discharge*
- Mitigation Measure WQ-2.2, *Prevent Net Detrimental Metal and Pesticide Effects Associated with Moving Colusa Basin Drain Water Through the Yolo Bypass*

Actions included in Mitigation Measure WQ-1.1, for example, will either help reduce the methylation of mercury in Sites Reservoir and thus in reservoir releases, and/or will reduce the potential magnitude of mercury bioaccumulation in fish in the short and long term. The potential effectiveness of actions included in the mitigation measure, such as removing vegetation in the inundation area prior to filling the reservoir and managing reservoir fisheries to reduce methylmercury bioaccumulation, for example, are supported by scientific research (State Water Resources Control Board 2017b). These actions and other actions identified in this mitigation measure are also actions recommended by the State Water Board and the Regional Water Quality Control Boards (State Water Resources Control Board 2017b). Further, aqueous and fish tissue monitoring for methylmercury within the reservoir under this mitigation measure will allow the Authority to track and measure changes in methylmercury concentrations and thus will provide flexibility to change or revise actions to more effectively reduce in-reservoir mercury methylation over time. As acknowledged in the Chapter 6 impact analysis (Impacts WQ-1 and WQ-2), the effectiveness of the actions to be implemented under Mitigation Measure WQ-1.1 to reduce reservoir methylmercury concentrations such that there would be no substantial measurable increase in aqueous and fish tissue methylmercury concentrations in the reservoir and at downstream locations is not known at this time. Accordingly, the impact is determined to be significant and unavoidable even with mitigation.

With regard to the concentration of metals in Stone Corral Creek, Mitigation Measure WQ-2.1 will be implemented to determine which specific action would be needed to ensure that Sites Reservoir releases do not cause exceedances of water quality standards in the creek. Potential actions identified in the measure include possible measures to release water to Stone Corral Creek from higher in the reservoir where metals concentrations are anticipated to be lower.

With regard to the concentration of metals and pesticides in Yolo Bypass, Mitigation Measure WQ-2.2 will be implemented to prevent net detrimental metal and pesticide effects. If flow augmentations to the Yolo Bypass are determined to increase pesticide concentrations to a level that could be detrimental to fish or if the metal measurements indicate that the Project habitat flows could cause Yolo Bypass concentrations of metals to exceed water quality standards for aquatic life protection, the augmented flows could be stopped entirely, and Project operations could continue without these flows, thereby eliminating the adverse impact as a result.

As described in the Chapter 6 analysis for Impacts WQ-1 and WQ-2, conditions resulting from operation of Sites Reservoir would be conducive to the formation of HABs, which could result in exposure of the public to cyanotoxins. If cyanobacteria and cyanotoxins were present in reservoir releases, potential substantial downstream effects on water quality would not be expected because concentrations of cyanobacteria and cyanotoxins would be diluted in CBD and greatly diluted when eventually discharged into the Sacramento River, and cyanotoxins would undergo biodegradation and, to some degree, photodegradation. In addition, releases could be made from lower in the water column (e.g., through the low-level intake) to reduce the potential for higher concentrations of cyanobacteria and cyanotoxins to be released downstream. As a result, the impacts are anticipated to be less than significant without the need for mitigation.

Further, the RMP, which is part of the Project, includes measures to protect against adverse effects associated with HABs. Most of the measures that would be implemented under the RMP are focused on detecting HABs and protecting recreationists at the reservoir from direct and indirect exposure to cyanotoxins at concentrations of concern to public health. These RMP measures are based on recommended actions for recreational inland waters from the California CyanoHAB Network (CCHAB Network), which includes the State Water Board, Office of Environmental Health Hazard and Assessment, and the California Department of Public Health. The RMP would utilize the key resources recommended by the CCHAB Network (e.g., Visual Guide to Observing Blooms, Site Reconnaissance Guide Standard Operating Procedures) (Cyanobacteria and Harmful Algal Bloom Network of the California Water Quality Monitoring Council 2022), and require posting of advisory HABs warning signs, as necessary, which is generally standard procedure at inland reservoirs with confirmed HABs. The RMP will be adaptively managed over time to allow flexibility to appropriately respond to changes in reservoir water quality as well as evolving state and local guidelines. The content of the RMP is based on best available state and local guidelines and actions regarding HABs.

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