Common Response 4.1
Harmful Algal Blooms

Introduction

This introduction provides important context to this common response. A similar introduction is provided in each common response to ensure that the reader has the appropriate context when reviewing common responses. For ease of reference, a table of contents is included after this introduction to guide readers to specific subject areas.

Protecting the San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta) watershed and its many beneficial uses of water is one of the State Water Resources Control Board's (State Water Board) primary responsibilities and top priorities. In response to declines of several native aquatic species since the Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Watershed (Bay-Delta Plan or Plan) was last comprehensively updated, the State Water Board commenced a process to update the Bay-Delta Plan for the Sacramento River and its tributaries, Delta eastside tributaries (including the Calaveras, Cosumnes, and Mokelumne Rivers), and Delta for the reasonable protection of fish and wildlife beneficial uses, referred to as the Sacramento/Delta Update to the Bay-Delta Plan. The Bay-Delta Plan identifies beneficial uses of water to be protected in the Bay-Delta watershed, water quality objectives and program of implementation to achieve the reasonable protection of those beneficial uses, monitoring, evaluation, and special study provisions. The State Water Board's proposed action to update the Bay-Delta Plan is supported by a Staff Report/Substitute Environmental Document (Staff Report), which provides an evaluation of the environmental impacts and economic effects in support of consideration of different alternatives to update the Bay-Delta Plan to achieve reasonable protection of fish and wildlife beneficial uses in the Sacramento/Delta. The Staff Report is functionally equivalent to an Environmental Impact Report under the California Environmental Quality Act (CEQA) but also provides the additional analyses that support the State Water Board's consideration of the action under the Clean Water Act and Porter-Cologne Water Quality Control Act.

Development of the final Staff Report and final draft Bay-Delta Plan were informed by several opportunities for public comment over multiple years. This common response may address issues that were raised during any of those public comment periods. In September 2023, the State Water Board released the 2023 draft Staff Report evaluating different alternatives for the Sacramento/Delta Update to the Bay-Delta Plan for public review and comment. Following release of the 2023 draft Staff Report, the State Water Board released draft amendments to the Bay-Delta Plan in October 2024 (2024 draft Plan) for public review and comment that incorporated alternatives identified in the 2023 draft Staff Report with revisions based on public comments. The State Water Board released revised draft Plan updates in July 2025 (July 2025 revised draft Plan), but delayed public comment on that version of the Plan pending further updates, though some parties did submit public comments on the July 2025 draft that are part of the State Water Board's response to comments. In December 2025, the State Water Board released Chapter 13, *Revised Proposed Plan Amendments*, as a limited recirculation of the 2023 draft Staff Report (2025 partially recirculated draft Staff Report) together with the December 2025 revised draft Plan for public review and comment. These documents reflect the updated proposed project, referred to as the revised proposed Plan amendments, which brings together in the Bay-Delta Plan program of implementation a voluntary agreement (VA) pathway that incorporates commitments identified in the Healthy Rivers and Landscapes (HRL) proposal and would apply to specified HRL water rights, and a regulatory pathway based on the revised proposed Plan amendments that would apply to other water rights and to any HRL water rights no longer covered under the VA pathway. In August 2026, the State Water Board released a final draft Bay-Delta Plan that included refinements to the revised proposed Plan amendments based on public comments received on the December 2025 revised draft Plan. At the same time, the State Water Board released this final Staff Report, including responses to comments previously received on the draft Staff Report. The final Staff Report informs the State Water Board's consideration of adoption of the Sacramento/Delta updates to the Bay-Delta Plan.

With respect to the CEQA impact conclusions, it is important that they be understood in the context of the overall nature of the proposed project, which is intended to be an environmental restoration action. CEQA only considers changes that could negatively impact the existing environment and does not recognize or offset negative changes with improvements that could result from an environmentally beneficial project. Here, the impacts that could potentially result from implementation of the restoration action occur in a system that has been highly altered, and the project would be expected to improve conditions for native fish and wildlife in the Sacramento/Delta watershed over time. However, the project will also result in changes in hydrology and changes in water supply that could result in some potentially significant adverse environmental impacts at certain times and locations that must be analyzed under CEQA. These potentially significant environmental impacts should be viewed in light of the overall purpose and goals of the Sacramento/Delta update to the Bay-Delta Plan.

The State Water Board reviewed and considered all comments and developed common responses to address recurring comments and common themes. This common response addresses comments raised regarding harmful algal blooms (HABs) as discussed in the 2023 draft Staff Report and 2025 partially recirculated draft Staff Report Chapter 13*, Revised Proposed Plan Amendments*. The State Water Board reviewed and considered all comments related to HABs and developed this common response to address recurring comments and common themes. In particular, this common response addresses, but is not limited to, the following topics:

- Background on HABs in the Delta
- Instream flows and HABs
- State Water Board commitments to address HABs in the Delta
- Water quality standards for cyanotoxins
- Nutrient discharge and HABs
- HABs effects on air quality
- Economically disadvantaged communities and HABs
- California Native American Tribes and HABs

This common response references related common responses, as appropriate, where recurring comments and common content themes overlap with other subject matter areas. See Common Response 10.1, *Economically Disadvantaged Communities*, for responses to comments on economically disadvantaged communities (DACs). See also Common Response 11.1, *Tribal Engagement and Tribal Beneficial Uses,* for more information on tribal outreach and engagement and

Tribal Beneficial Uses. For responses to comments related to the water quality control planning process, please refer to Common Response 1.2, *Water Quality Control Planning Process*. For further discussion of the new HAB monitoring requirements in the revised proposed Plan amendments, see Common Response 1.3, *Revised Proposed Plan Amendments*. For consideration of drought and climate change effects on HABs in the Staff Report, see Common Response 4.2, *Drought and Climate Change*. For discussion of the use of best available science and the addition of new literature to the Staff Report, please see Common Response 3.1, *Fish Protection*. See also Common Response 7.1, *General CEQA and Approach to the Analysis*, regarding use of the Staff Report to meet CEQA requirements.

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Background

Cyanobacteria harmful algal blooms have become a regular occurrence in the Sacramento-San Joaquin Delta (Delta) since 1999 (Lehman et al. 2005; ^Lehman et al. 2013) consistent with global increases in freshwater HABs (^Kudela et al. 2023). HABs most frequently occur in backwaters, dead-end sloughs, and other waterways with poor water circulation in the central and southern Delta. The magnitude and frequency of HABs are influenced by several environmental factors that are becoming more common in the Delta. These include higher water temperature, low flows and longer water residence time, increased water clarity, salinity, and high nutrient concentrations (^Kudela et al. 2023). HABs can appear in the Delta during spring, summer, and fall months, with primary HAB activity occurring between June through October, though HABs can occur as early as May and persist until as late as November depending on local water temperature (Preece et al. 2024a). HABs are associated with water temperature above approximately 19°C, long water residence time, intensification of water column stratification, high irradiance, and elevated nutrient (nitrogen and phosphorous) concentrations (Jacoby et al. 2000; ^Lehman et al. 2013; ^Berg and Sutula 2015; ^Kudela et al. 2023).

HABs can adversely affect water quality, humans, and domestic animals. Blooms can reduce dissolved oxygen when they decompose, produce surface scum that interferes with contact recreation, cause drinking water taste and odor problems, and HABs that occur near the water's surface can block sunlight from reaching organisms deeper in the water column. Some cyanobacteria species produce toxins (cyanotoxins) that can affect the nervous system, liver, skin, stomach, or intestines. Cyanotoxins are bioaccumulative and can also have toxic effects on aquatic species, as discussed in Chapter 4, *Other Aquatic Ecosystem Stressors*, of the Staff Report (CDC 2017). Currently, there are no federal or state regulatory standards for cyanotoxins.

The State Water Board acknowledges the increasing occurrence and prevalence of HABs statewide and has established the Freshwater and Estuarine Harmful Algal Bloom (FHAB) Program to protect water quality and public health from HABs pursuant to Assembly Bill 834.[1] The State Water Board also acknowledges that HABs are disproportionately affecting DACs in the Delta. However, the Sacramento/Delta Update to the Bay-Delta Plan is intended to provide for the reasonable protection of native fish and wildlife. The current updates to the Bay-Delta Plan are not expressly intended to manage the occurrence of HABs in the Delta. The goals of the Bay-Delta Plan updates are identified in Section 7.1.3, *Purpose and Goals of the Sacramento/Delta Update to the Bay-Delta Plan.* The flow scenarios and other alternatives will be evaluated for their ability to meet the purposes and goals of updating the Bay-Delta Plan, feasibility, and ability to avoid significant impacts on the environment. The Staff Report fulfills the requirements of CEQA and the State Water Board's CEQA regulations (Cal. Code Regs., tit. 23, § 3775 et seq.) to analyze the environmental effects of the proposed regulatory activity (i.e., updating the Bay-Delta Plan), as well as requirements of the Porter-Cologne Water Quality Control Act (See also Common Response 7.1, *General CEQA and Approach to the Analysis*). CEQA does not compel the State Water Board to provide a solution to this existing environmental problem with HABs in its Sacramento/Delta Update to the Bay-Delta Plan, although it

[1] Assembly Bill 834 mandates the following FHAB Program Objectives: (1) Coordinate immediate and long-term even response; communicate notifications and risks broadly; (2) Conduct monitoring and assessment at the state, regional, and water body scales to track status and trends and help identify "at-risk" waterbodies; (3) Conduct applied research and tool development; and (4) Provide outreach, education, centralized website, and data management.

is possible that a future update to the Plan could occur in the future. The specific causes and potential solutions to HABs are under development and more investigation is needed.

The occurrence of HABs in the Sacramento/Delta watershed and statewide is of significant concern to the State Water Board, and therefore, the State Water Board is committed to supporting actions to address HABs moving forward. These actions include supporting science, research, monitoring, and special studies that are needed to develop HAB-predictive models and identify possible management and mitigation measures that could be used to control HABs in the Delta, in addition to supporting incident response and other actions to address HABs. The State Water Board's commitments to addressing HABs are described in the Staff Report Section 5.6.1.3, *Proposed Changes to Monitoring, Assessment, Special Studies, and Reporting* and below in the section, *State Water Board Commitments to Address HABs in the Delta*, of this common response. Staff Report Section 13.3.9.2, *Harmful Algal Blooms,* describes new monitoring requirements for HABs in the Delta as part of the Sacramento/Delta Update to the Bay-Delta Plan (see Common Response 1.3, *Revised Proposed Plan Amendments*, for more information).

Many new scientific articles have been included in this common response and in relevant sections within the final Staff Report. New literature was considered through specific recommendations by commenters and through additional literature review by staff to include recent papers, studies, and reports that provide supplementary context to the scientific content regarding HABs included in the 2023 draft Staff Report. More recent scientific literature often serves to reinforce or complement the scientific knowledge found in the 2023 draft Staff Report but does not significantly alter the findings or scientific basis on which the revised proposed Plan amendments or any alternatives are built. Specific to HABs, information in the Staff Report was updated to reflect recently evolving science. Many new scientific studies on HABs specific to environmental conditions in the Delta have been published since release of the 2023 draft Staff Report, and inclusion of this new information provides a better basis for understanding how changes proposed in the Bay-Delta Plan may affect HABs. For additional discussion on the use of best available science and the addition of new literature to the Staff Report, please see Common Response 3.1, *Fish Protection*.

Instream Flows and HABs

This section addresses comments received regarding the influence of instream flows on the development of HABs, the concern that the 35, 45, and 55 scenarios in drought years would result in the proliferation of HABs in the Delta, and that the 2023 draft Staff Report should have included a discussion of how increasing flows could be used as a mitigation strategy to manage HABs in the Delta. Several commenters expressed concern that 55 percent of unimpaired flow would be inadequate to prevent or limit the occurrence of HABs in the Delta, and they asserted that the State Water Board should adopt requirements for 65 or 75 percent of unimpaired flow. Also addressed are comments asserting that summertime flow thresholds for the Sacramento and San Joaquin Rivers should be considered to limit HABs in the Delta, and the frequency of these flows during the spring to fall months, when HABs are most likely to form, should be analyzed in the Staff Report.

Flow Changes and HABs Under the Flow Scenarios

Several commenters expressed concern that 55 percent of unimpaired flow would be inadequate to prevent or limit the occurrence of HABs in the Delta and asserted that the State Water Board should adopt requirements for 65 or 75 percent of unimpaired flow. However, implementing requirements for a higher percent of unimpaired flow will not solve the existing problem of HABs in reservoirs and in the Delta. Under the 65 or 75 scenario, increases in winter and spring outflows, and reduced inflows for the summer and early fall that could cause incremental increases in HABs would be even more pronounced than under the 35, 45, or 55 scenarios. As discussed below, winter and spring flows may play a role in determining bloom patterns through the following summer and fall, but additional research is needed to fully understand this dynamic, and flow is not the only environmental variable controlling HABs.

Winter flood peaks and spring snowmelt runoff from Delta tributaries have been greatly reduced by the creation of upstream storage reservoirs, and current water operations for regulated tributaries consist of large reservoir releases during the summer months, leading to increased flows in summer and early fall (as discussed in Staff Report Section 2.4.1, *Delta Inflows*). While increased flow requirements under the revised proposed Plan amendments would increase Delta outflow in the winter and spring to reflect a more natural hydrograph to the possible benefit of reducing HABs, summer and early-fall Delta inflows would be reduced to some extent for Central Valley Project (CVP) and State Water Project (SWP) tributaries, such as the Sacramento, Feather, and American Rivers, where, under existing conditions, substantial storage releases to downstream diversions create artificially high summer and early fall flows. This reduction of summer and early-fall flows with implementation of the flow requirements would occur because increased winter and spring outflows would require greater releases from upstream reservoirs earlier in the water year, thereby lowering reservoir storage levels and limiting the volume of water available for release during the summer and early fall.

Changes in hydrology due to implementation of the flow scenarios may result in an incremental increase in HABs in some reservoirs and at some Delta locations (see Staff Report Section 7.12.1, *Surface Water*). Hydrological changes may cause lower storage levels in some reservoirs at certain times, leading to shallower, warmer, and more stable water column conditions. These conditions could promote more frequent HABs. In addition, in some Delta channels, net flow, which controls water residence time, could be reduced during the June through October bloom period due to changes in hydrology. These reductions, which would be greater under the 55 and 65 scenarios, are more likely in channels that convey Sacramento River water to the export pumps, such as Victoria Canal, and could incrementally increase the chances of HAB formation and bloom size. Appendix A2, *Delta Simulation Model II (DSM2) Methods and Results,* of the Staff Report considers how the flow scenarios may impact environmental hydrodynamics that can influence bloom formation. Certain locations in the Delta, such as the Stockton Waterfront, where HABs regularly occur due to limited tidal exchange and minimal net flow, are not expected to be affected by the flow scenarios.

Implementation of the proposed VAs, which include a combination of proposed flow and non-flow habitat restoration measures, is unlikely to increase the probability of HAB formation or severity in the Delta. However, as discussed in the Staff Report, Chapter 9, *Proposed Voluntary Agreements*, changes in hydrology under the proposed VAs could result in lower reservoir storage levels and in associated shallower, warmer, more stable water column conditions in those reservoirs. These conditions could lead to increased reservoir HABs. Changes in storage would generally be expected to be smaller than would occur under the flow scenarios.

The revised proposed Plan amendments described in Chapter 13, *Revised Proposed Plan Amendments* provide for both a voluntary agreement pathway, and a regulatory pathway that would apply in the absence of an approved VA and for non-VA water rights. As described in Section 13.7.12, *Hydrology and Water Quality*, the effects of the revised proposed Plan amendments on HABs would be similar to the effects of the proposed project as described in Section 7.12.1, *Surface Water,* with reduced HAB impacts due to the water supply adjustments under the starting point for the regulatory pathway and the VA pathway at the outset of Plan implementation. An additional analysis added to Section 13.7.12, *Hydrology and Water Quality*, of the final Staff Report to evaluate the effects of the 2025 Record of Decision and 2025 Incidental Take Permit (2025 ROD/ITP) for operations of the Central Valley Project and the State Water Project, show that the 2025 ROD/ITP could interact with the revised proposed Plan amendments to further increase the incidence of HABs in the Delta under the regulatory pathway and the VA pathway. See Common Response 1.1, *General Comments*, regarding comments about the 2025 ROD and 2025 ITP.

In addition to the effects of flow on HABs, Staff Report Chapter 4, *Other Aquatic Ecosystem Stressors*, describes how the magnitude and frequency of HABs in the Delta are positively influenced by several other environmental factors, including elevated water temperatures, high nutrient concentrations, and high degrees of thermal stratification (^Kudela et al. 2023). Recent literature shows that many of these factors become increasingly common and more important during drought years (Bouma-Gregson et al. 2024), which may partially explain the recent increase in HAB reports throughout the Delta given that 15 of the last 20 years have been classified as Below Normal, Dry, or Critical water years.

Additionally, certain site-specific factors such as tidal and net flows, which influence water residence time, can also affect the occurrence of HABs. Dead-end channels, marinas, and some flooded islands with long water residence times maintain the highest overwintering densities of *Microcystis* cells in the sediment, potentially due to less frequent sediment-scouring flow events in those regions (Preece et al. 2025a). Benthic cells seed water column *Microcystis* blooms during the summer, and regions with the highest benthic seedstock have the greatest bloom severity (Preece et al. 2025a). Winter and spring flows may reduce the density of overwintering benthic *Microcystis* cells (Preece et al. 2025a). Ongoing research that seeks to explain patterns of overwintering sediment seedstock density and cell movement is expected to offer more insight into the interplay between winter and spring flows on sediment seedstock and *Microcystis* blooms during the summer.

Due to the nature of the timing of flows under the revised proposed Plan amendments, there may be less Delta inflow during the summer and fall months, coinciding with the typical HAB season in the Delta. Conversely, the flow scenarios would provide more flows during the winter and spring months with potential “flushing” influence for the subsequent HAB season. It is unknown what the overall effect of the revised proposed Plan amendments may be on HABs in the Delta, though modeling indicates very minimal flow changes under the flow scenarios for Victoria Canal and on the San Joaquin River near Stockton. Under higher flow scenarios, such as the 65 and 75 scenarios, the seasonal differences in flow would become more pronounced and further research is needed to understand how low flows in the summer and fall versus higher flows in the winter and spring may influence current-season and subsequent-season HAB dynamics. However, the existing science that is relied upon in the Staff Report analyses described above, demonstrates that higher flow scenarios will not solve the existing problem of HABs in reservoirs and in the Delta because flow requirements would result in lower reservoir storage levels and lower flows during the bloom season, and the flow scenarios would not affect HABs in dead-end channels like the Stockton Waterfront where tidal exchange and water circulation are limited.

Regarding the flow scenarios and drought, some commenters questioned whether the 35, 45, and 55 scenarios in drought years would result in the proliferation of HABs in the Delta, and other commenters questioned whether the modeling and analyses in the Staff Report underestimated the effects of climate change on HABs. However, the existing modeling and analyses in the Staff Report already account for the effects of drought and climate change on HABs. DSM2 modeling utilized in Appendix A2, *Delta Simulation Model II (DSM2) Methods and Results,* of the Staff Report was run using inputs from the Sacramento Water Allocation Model (SacWAM) to evaluate hydrologic changes in the Delta associated with the proposed Plan amendments. The hydrologic record utilized for SacWAM simulations incorporated many drought years and changes in climatic conditions. Therefore, outputs from DSM2 and SacWAM that were used to evaluate flow effects on HABs inherently contain considerations for drought and climate change. Please see Common Response 4.2, *Drought and Climate Change*, for further discussion on the inclusion of drought and climate change within SacWAM and the consideration of climate change effects on HABs.

Environmental Mediation of HABs

Many commenters suggested that the Staff Report should consider flow thresholds and more thoroughly discuss flow as a mitigation strategy for HABs in the Delta. While some flow thresholds for HABs have been identified in the scientific literature, flow is not the only controlling variable for HABs in the Delta, and different areas of the Delta would be influenced differently by changes in flow, as further discussed below. Staff Report Section 4.3.2, *Harmful Algal Blooms*, provides an overview of HABs in the Delta, including a discussion of important environmental drivers, such as flow and water residence time.

Increases in *Microcystis* abundance in the Delta are correlated with low flow in the San Joaquin River, Sacramento River, and central Delta (^Lehman et al. 2013) as well as low flows in general through the Delta as indicated by X2 values (Lehman et al. 2022). Summer-fall flow thresholds limiting *Microcystis* blooms were identified for the upper San Joaquin River (approximately 2,825 cfs) and lower Sacramento River near Rio Vista (approximately 10,594 cfs) (^Lehman et al. 2013). Recent research suggests that flows above these levels limit bloom severity but do not prevent bloom formation when temperature and other conditions are right for *Microcystis* growth (Lehman et al., 2022).

Evidence suggests that the position of the low salinity zone (as indexed by X2) as a proxy for water residence time, is also predictive of *Microcystis* bloom magnitude (Lehman et al. 2022). One study found that the X2 index and water temperature accounted for most of the variation in *Microcystis* bloom abundance in the Delta (Lehman et al. 2022). However, the strength of the relationship between X2 and bloom magnitude may differ across areas of the Delta, because X2 is more strongly correlated with water residence time in the northern and western parts of the Delta than in south and central Delta where HABs most frequently occur (Preece and Hartman 2024). In the central and south Delta, where water residence time is heavily influenced by San Joaquin River flow and SWP and CVP exports (Hammock et al. 2019), X2 is a poor predictor of water residence time and *Microcystis* bloom magnitude (Preece and Hartman 2024). Several studies have found that water exports are strongly correlated with *Microcystis* blooms in the Delta (Hartman et al. 2022; Bouma-Gregson et al. 2024; Preece and Hartman 2024). Accordingly, San Joaquin River flow and water exports are better predictors of *Microcystis* biovolume in the south and central Delta (Preece and Hartman 2024). As described above under *Flow Changes and HABs Under the Flow Scenarios*, the Staff Report already evaluates the potential effects of changes in Delta inflows, outflows, and exports on changes in net flow and HABs in Delta channels. In addition, the Staff Report already discloses that changes in hydrology resulting from the flow scenarios could cause incremental increases in

HABs in reservoirs and Delta channels, and that the VAs would be unlikely to change net flows in Delta channels where HABs regularly occur.

In addition, flow is just one of many drivers which may influence bloom formation and severity and may interact with other factors, including annual hydrologic context, nutrient concentrations, light availability, and water temperature that have been identified as important controlling factors for freshwater HABs in general and for *Microcystis* blooms in the Delta (Preece and Hartman 2024; Preece et al. 2024a). For example, research investigating drought impacts on HABs found that SWP and CVP exports, temperature, and Secchi depth (a measure of water clarity) together best explained the probability of *Microcystis* observations in the south Delta, Franks Tract, lower San Joaquin River, and Old River regions, demonstrating that several environmental factors affect HAB formation (Bouma-Gregson et al. 2024). Under combined conditions of reduced SWP and CVP exports, higher Delta water temperatures, and increased water clarity, the probability of observing higher levels of *Microcystis* blooms in the Delta increases. These conditions, prevalent during dry years, also encourage phytoplankton to more fully utilize the high springtime nutrient supply that can accumulate during droughts, further driving HAB formation (Bouma-Gregson et al. 2024).

Temperature can also mediate the effects of flow on *Microcystis* blooms. A temperature threshold of 19°C has been documented for initiating *Microcystis* blooms in the Delta, although optimal growth occurs above 25°C when cyanobacteria begin to outcompete other phytoplankton (^Lehman et al. 2013; ^Kudela et al. 2023). Additional research demonstrates that although higher San Joaquin River inflow and higher Sacramento Valley index values for water year type are correlated with decreased bloom magnitude, increasing summertime flows may be less effective at controlling HABs when temperatures are high (Preece and Hartman 2024). Accordingly, climate change is expected to increase the duration of the bloom season as temperatures increase (^Lehman et al. 2013), and climate change is a primary factor contributing to increasing frequency and severity of HABs in the Delta and globally (^Kudela et al. 2023).

Additional research is needed to understand the specific ways in which drivers interact. However, the existing evidence shows that flow alone cannot control HABs, and addressing climate change extends beyond the scope of the Board's regulatory authorities. Though flow is a known driver for HAB formation in the Delta, the ways in which flow may influence HAB formation in different Delta waterways have yet to be quantified. Conceptually, dead-end channels and marinas are the least influenced by flow and therefore, HABs in these areas may be least affected by increased amounts of flow. Flows may be more influential for main channel areas, but this would not address the many other drivers of HABs, such as high temperature and replete nutrients. See below on *State Water Board Commitments to Address HABs in the Delta* for a discussion of monitoring and research that the Board is supporting to better understand the role of flow versus temperature and other environmental conditions on HABs.

State Water Board Commitments to Address HABs in the Delta

Some commenters asserted that the State Water Board's commitments to addressing HABs in the Sacramento/Delta were limited to new monitoring requirements and that this constitutes an inadequate response to the problem. Monitoring is needed to understand how drivers of HABs under the State Water Board's regulatory authorities (e.g., flow and nutrients) may interact with other drivers, to develop effective management and mitigation measures to control HABs and provide the necessary information to develop predictive models. In addition to new monitoring, the State Water Board is continuing existing monitoring, reporting, and public notification of HAB events through the Statewide FHAB Program, as well as supporting new coordination, research, and special studies through the Cyanobacteria Harmful Algal Bloom Monitoring Strategy for the Sacramento-San Joaquin Delta (Delta CHAB Monitory Strategy [Preece et al. 2024c]), developing new statewide water quality objectives for HABs (see *Water Quality Standards for Cyanotoxins*), and continuing ongoing efforts to control nutrients (see *Nutrient Discharge and HABs*).

To date, monitoring and assessment of HABs in the Delta have been inadequately coordinated and have relied on intermittent monitoring, special studies, and utilized established water quality programs that were not designed to monitor HABs and their drivers. Staff Report Section 5.6.1.3, *Proposed Changes to Monitoring, Assessment, Special Studies, and Reporting*, describes some of the current gaps related to monitoring HABs in the Delta. Regarding the influence of instream flow on HABs in the Delta, current monitoring should be extended both spatially and temporally beyond individual bloom incidents and should occur before, during, and after the cyanobacteria bloom season. Additionally, monitoring water residence time, nutrients, temperature, turbidity, and other water quality parameters can help inform how different environmental conditions interacting with flow may contribute to HAB formation. The Delta CHAB Monitoring Strategy developed through the Delta Science Program identifies additional monitoring, data, and knowledge gaps related to HABs. Gaps include a lack of coordinated monitoring in areas of the Delta known for experiencing low flows and exhibiting the most severe HABs, such as dead-end sloughs and backwaters. The Delta CHAB Monitoring Strategy also states that while environmental factors that drive HABs (e.g., warm water temperatures, sufficient nutrients) are generally understood, the potential interactions between these factors, annual environmental variations, site-specific processes, climate change, and anthropogenic activities remain in question and require additional data gathering (Preece et al. 2024c).

Key data gaps remain in understanding how to best manage HABs in the Delta. The Delta CHAB Monitoring Strategy identifies needs for additional special studies and the establishment of a coordinated Delta-wide HAB monitoring program to help fill these gaps. Monitoring recommendations from the Delta CHAB Strategy include: 1) identifying prioritized geographic areas for monitoring, such as static peripheral areas like dead-end channels or marinas; 2) selecting appropriate spatial and temporal coverage along with monitoring frequency to better understand the conditions leading up to a bloom as well as the spatial coverage of a bloom both within the water column or across a shoreline; and 3) choosing suitable metrics/parameters, sampling techniques, and analysis methods to respond to directed management questions (Preece et al. 2024c). Special studies that can fill data gaps and further inform monitoring needs may focus on the environmental processes surrounding HABs, including their development and decline, the various methods of conducting monitoring such as field data versus remote sensing, the toxicity of HABs, and the effectiveness of different mitigation options (Preece et al. 2024c).

As outlined in the Delta CHAB Monitoring Strategy, special studies which identify practicable Delta HAB mitigation options should be conducted to better understand the monitoring and management needs for the different Delta HAB environments. Due to the complex hydrology of the Delta, many HAB mitigation options may not be practical or may only be suited for certain environments. After identifying mitigation options which may be feasible for the Delta, these options can be further refined to address different habitat types (e.g., flowing channels, backwater areas, channel margins). Considering the large size of the estuary, identifying the potential costs of implementing applicable mitigation measures with associated pilot studies at different scales can help to inform management decisions (Preece et al. 2024c).

Section 7.12.1.3, *Impact Analysis*, of the Staff Report identified mitigation measures for HABs in the Delta. Technologies such as gene-silencing agents, chemical management measures like algaecides, or physical measures such as dredging could all act to reduce HAB biomass or toxicity. Various mitigation measures have been or are currently being explored by different agencies involved in Delta HAB research. The U.S. Army Corps of Engineers is evaluating projects which propose to apply technologies to effectively detect, prevent, manage, or eliminate HABs with the Sacramento-San Joaquin Delta as an identified focus area for these proposals (ERDC 2024). Additionally, a private pilot program utilizing hydrogen peroxide to combat blooms in the hotspot location of Discovery Bay is also being explored by the Discovery Bay Community Foundation (Fehr 2024). Although there is no current proven mitigation or management method for HABs in the Delta, additional monitoring and gathering of site-specific data can better inform the selection and testing of possible mitigation methods.

As described in Section 13.3.9.2, *Harmful Algal Blooms*, the State Water Board is committed to helping to implement the Delta CHAB Monitoring Strategy to improve coordination and science, research, and monitoring for HABs in the Delta. The State Water Board will coordinate with the Delta Stewardship Council, the Divisions and Offices at the State Water Board and the Central Valley and San Francisco Bay Water Boards, Department of Water Resources (DWR), US Geological Survey (USGS), and others, including tribes, Delta community groups, and other interested entities to implement the Delta CHAB Strategy. In addition, Section 13.3.9.2 describes new HAB monitoring requirements at locations in the Delta that are included in the Bay-Delta Monitoring and Evaluation Program of the revised proposed Plan amendments. Requirements would include monitoring for cyanotoxins in the Delta following a tiered monitoring approach with enhanced monitoring during bloom events, as well as monitoring for HAB drivers throughout the bloom season to ensure the necessary data are collected to understand HAB drivers and develop HAB mechanistic and predictive models. Additional requirements include a special study to evaluate the effects of HABs on native estuarine fish species, and requirements for the VA parties to conduct monitoring for HABs in the Sacramento/Delta tributaries with approved VAs and to contribute to implementing the Delta CHAB Monitoring Strategy. Moreover, the revised proposed Plan amendments reiterate the State Water Board's commitment to continuing to implement the California Water Boards' Framework and Strategy for Freshwater Harmful Algal Bloom Monitoring (FHAB Strategy) produced pursuant to Assembly Bill 834 (FHAB Program) within the Bay-Delta watershed. See Common Response 1.3, *Revised Proposed Plan Amendments*, for further discussion of the HAB monitoring requirements.

The State Water Board is also pursuing special studies and synthesis of HABs research in the Delta in collaboration with USGS, DWR, the Central Valley Water Board, and others, to help fill gaps in knowledge about how flows and other environmental conditions contribute to HABs. As part of these efforts, the State Water Board funded the development of a Delta CHAB monitoring designs report prepared by the USGS (Bouma-Gregson et al. 2025). The report recommends possible monitoring designs that could be implemented as part of a coordinated Delta-wide CHAB monitoring program, consistent with recommendations from the Delta CHAB Monitoring Strategy (Preece et al. 2024c), and these recommendations informed the design of the tiered HAB monitoring requirements in the revised proposed Plan amendments. For more information about these commitments to addressing HABs in the Delta, see Staff Report Sections 5.6.1.3, *Proposed Changes to Monitoring, Assessment, Special Studies, and Reporting* and 13.3.9.2, *Harmful Algal Blooms*.

Water Quality Standards for Cyanotoxins

The State Water Board received several comments related to the development of water quality standards for HABs. Specifically, commenters asserted that numeric objectives or criteria for cyanotoxins for the protection of beneficial uses, including recreation, domestic supply, and TBUs, should be developed and added to the Bay-Delta Plan as part of the Sacramento/Delta Update. Furthermore, commenters indicated that recreational and drinking water criteria for cyanotoxins should be based on U.S. Environmental Protection Agency's (USEPA's) recommended recreational ambient water quality criteria or swimming advisories (Table CR 4.1-1a) and drinking water health advisories for cyanotoxins (Table CR 4.1-1b), respectively.

Table CR 4.1-1a. U.S. Environmental Protection Agency's Recommended Values for Recreational Criteria and Swimming Advisories for Cyanotoxins

Cyanotoxin	Concentration (μg/L)	Duration	Frequency
Microcystins	8	1 in 10-day assessment period across a recreational season	Not more than 3 excursions in a recreational season in more than one year [a]
Cylindrospermopsin	15		

Source: USEPA 2019
μg/L = microgram(s) per liter.
[a] An excursion is defined as a ten-day assessment period with an observed toxin concentration higher than the criteria magnitude. When more than three excursions occur within a recreational season and that pattern reoccurs in more than one recreational season (i.e., in more than one year for most areas, although some recreational seasons may straddle two calendar years), it is an indication the water quality is not supporting its recreational use.

Table CR 4.1-1b. U.S. Environmental Protection Agency's Drinking Water Health Advisories (10-day) for Cyanotoxins

Cyanotoxin	Bottle-Fed Infants and Pre-School Children (μg/L)	School-Age Children and Adults (μg/L)
Microcystins	0.3	1.6
Cylindrospermopsin	0.7	3.0

Source: USEPA 2015a and 2015b
μg/L = microgram(s) per liter.

The Staff Report references some of the numeric guidelines which have been developed for cyanotoxins in Section 4.3.2, *Harmful Algal Blooms*, such as those for microcystin from the Office of Environmental Health and Hazard Assessment (OEHHA) and the World Health Organization (WHO). In referencing those guidelines, the Staff Report acknowledges that dissolved microcystin concentrations in the Delta can occasionally exceed the levels designated in these guidelines. Importantly, there are currently no federal or state regulatory standards for cyanotoxins in recreational waters or drinking water. Microcystin is the most commonly detected cyanotoxin in the Delta (^Kudela et al. 2023). Accordingly, many of the thresholds and guidance levels set for cyanotoxins in the Bay-Delta system focus on microcystin. The State Water Board, OEHHA, and the California Department of Public Health have developed voluntary guidance for responding to HABs in recreational inland waters, which includes health-based cyanotoxin "trigger levels" or concentrations of three cyanotoxins in water, microcystin, anatoxin-a, and cylindrospermopsin. The California Cyanobacteria and Harmful Algal Bloom (CCHAB) Network under the California Water Quality Monitoring Council adopted these trigger levels as voluntary guidance in 2016. Based in part on OEHHA's risk assessment and action levels[2], these trigger levels prompt increasing public health warnings through advisory signage to users of recreational waterbodies and increased monitoring as cyanotoxin concentrations increase. Table CR 4.1-2 identifies the CCHAB Network's trigger levels for posting advisory signs for planktonic HABs. OEHHA action levels were developed as voluntary guidance and the CCHAB Network recommends their use to promote consistency in public notification and risk communication throughout California.

Table CR 4.1-2. Cyanobacteria and Harmful Algal Bloom Network's Trigger Levels for Human and Animal Health

Criteria [a]	No Advisory [b]	Caution (Tier 1)	Warning (Tier 2)	Danger (Tier 3)
Total Microcystins [c]	< 0.8 µg/L	0.8 µg/L	6 µg/L	20 µg/L
Cylindrospermopsin	< 1 µg/L	1 µg/L	4 µg/L	17 µg/L
Anatoxin-a	Non-detect [d]	Detected [d]	20 µg/L	90 µg/L
Cell Density of Potential Toxin Producers	< 4,000 cells/mL	4,000 cells/mL	_____	_____
Site-specific indicator(s)	No site-specific indicators present	Discoloration, scum, algal mats, soupy or paint-like appearance. Suspected illness	_____	_____

Source: California Water Quality Monitoring Council 2020.
µg/L = microgram per liter.
[a] Action levels are met when one or more criteria are met.
[b] For de-posting, all criteria for no advisory must be met for a minimum of 2 weeks. General awareness signs may remain posted and healthy water habits are still recommended.
[c] Microcystins refers to the sum of all measured Microcystin congeners.
[d] Using an analytical method that detects ≤ 1 µg/L anatoxin-a.

The WHO has also set a recreational guideline level for microcystin of 24 µg/L (WHO 2021). USEPA has established a water quality guideline threshold of 8 µg/L for microcystins (Table CR 4.1-1a).

USEPA, WHO and OEHHA have also established recommended drinking water thresholds for cyanotoxins. OEHHA recommends health-based acute (one day) notification levels and short-term (up to three months) notification levels for microcystins, cylindrospermopsin, saxitoxin, and anatoxin-a in drinking water. The acute notification level for microcystins is 3 micrograms per liter (µg/L) and the short-term notification level is set at 0.03 µg/L (OEHHA 2022b). The WHO has placed a provisional guideline value[3] for life-long consumption at 1 µg/L and 12 µg/L for short-term exposure[4] (WHO 2022). The USEPA health advisory thresholds for microcystins for adults and

[2] For recreational waters, OEHHA identified human health-based water concentration levels or "action levels" for microcystins, anatoxin-a and cylindrospermopsin as follows: microcystin = 0.8 µg/L; anatoxin-a = 90 µg/L; and cylindrospermopsin = 4 µg/L (OEHHA 2012). Cyanotoxin concentrations at or below these action levels are not expected to lead to adverse health effects.

[3] These guideline values are considered provisional due to uncertainties in the health database (WHO 2022).

[4] The provisional short-term drinking-water guideline value is intended to indicate the extent to which the lifetime value can be exceeded for periods of up to about 2 weeks until water treatment can be augmented to bring the concentration of microcystins down. It is not intended to allow repeated seasonal exceedances of the lifetime value (WHO 2022).

school-age children, based on a 10-day exposure period is 1.6 µg/L and 0.3 µg/L, respectively (Table CR 4.1-1b).

The guidelines, action levels, and recommendations described above are examples of the widely varying protective thresholds for microcystin and other cyanotoxins. The guideline thresholds developed by OEHHA and recommended for use across the state are the most conservative.

Commenters requested that numeric objectives or criteria for cyanotoxins should be developed and added to the Bay-Delta Plan as part of the Sacramento/Delta Update, utilizing the USEPA's recommended recreational ambient water quality criteria or swimming advisories and drinking water health advisories as a reference. As detailed above, there are currently no federal or state regulatory standards for cyanotoxins in recreational waters or drinking waters; however, OEHHA guidelines are recommended for use by the CCHAB network and are commonly used for public notification and risk communication throughout the state. Data gathering, including research into exposure pathways, and risk assessment are needed to develop regulatory numeric criteria for cyanotoxins. To gain a better understanding of cyanotoxins in the Delta and to inform efforts at developing numeric thresholds, proposed monitoring actions are discussed in Section 5.6.1.3, *Proposed Changes to Monitoring Assessment, Special Studies, and Reporting*. This section also includes a commitment to coordination on the public health risks associated with HABs and suggests the use of information from USEPA on measures that should be implemented to prevent and respond to HABs in surface waters and drinking water supplies. As described in Section 13.3.5.1, *Bay-Delta Monitoring and Evaluation Program*, new monitoring requirements for HABs in the Delta as part of the revised proposed Plan amendments would improve status and trends monitoring of cyanotoxin concentrations, as well as monitoring for public health risks and notification at six common HAB hotspot locations where HABs regularly occur during the bloom season and at other locations throughout the Delta.

In addition to the new monitoring requirements for HABs in the Delta, the State Water Board Division of Water Quality is developing statewide water quality objectives for HABs and cyanotoxins and a program of implementation under the Harmful Algal Blooms and Cyanotoxins Provisions project. The primary project objective is to protect beneficial uses impacted by harmful algal blooms and cyanotoxins by establishing a statewide water quality control plan and associated state policy for water quality control to:

1. Establish numeric water quality objectives for cyanotoxins applicable to all inland surface waters, enclosed bays, estuaries, and coastal lagoons for the protection of municipal and domestic water supply (MUN) and water contact recreation (REC-1) beneficial uses.
2. Establish a narrative water quality objective for HABs applicable to all inland surface waters, enclosed bays, estuaries, and coastal lagoons.
3. Establish a program of implementation to achieve both the numeric and narrative water quality objectives and reduce the occurrence of HABs.

In support of the statewide HABs water quality objectives, the State Water Board Division of Water Quality is consulting with OEHHA on updating the science for the action levels described above. These action levels were developed in 2012 for three cyanotoxins: microcystin, anatoxin-a, and cylindrospermopsin. These action levels are being refined based on the current science and literature for adequate public health protection and are also being updated to include action levels for the cyanotoxin saxitoxin. This project will evaluate current CCHAB Network recreational advisory action levels and the OEHHA Drinking Water Action Levels for cyanotoxins to determine if these numbers can be adapted or updated based on more recent scientific evidence for water contact recreation beneficial use (REC-1) protection for the four cyanotoxins produced by planktonic blooms. This project will also provide guidance as to information necessary to perform a risk assessment to adapt the recreational advisory action levels to protect Tribal Tradition and Culture (CUL) beneficial uses.

Nutrient Discharge and HABs

This section addresses commenters' concerns that nutrient loading to the Delta needs to be reduced as part of an effort to control the formation and proliferation of HABs. Also addressed is the concern that Delta nutrient monitoring and the development and implementation of nutrient TMDLs, as well as the potential development of numeric water quality objectives for nutrients[5], are measures that are unlikely to mitigate potential HAB impacts from implementation of the flow scenarios.

Staff Report Sections 4.3.2, *Harmful Algal Blooms* and 7.12.1, *Surface Water,* discuss the role of nutrients in the establishment and proliferation of HABs in the Delta. While *Microcystis* can utilize all forms of nitrogen, ammonium is considered the preferred source, and elevated concentrations of nitrogen are associated with increased bloom toxicity (^Kudela et al. 2023). The Staff Report acknowledges that ammonia concentrations may have negative effects on algal community composition, such as shifting species composition from diatoms to blue-greens, though these conclusions remain under question and additional research is needed (Senn et al. 2016). Additional discussion on the role of nutrients in the Delta can be found in Staff Report Section 4.3.1.4, *Ammonia/Ammonium*.

The Delta is a nutrient-enriched system in which nutrients are generally not limiting for HAB growth, making other environmental factors—particularly water flow and temperature—more influential in controlling bloom formation and persistence (^Kudela et al. 2023). Recent research in the Delta using nutrient addition bioassay experiments along the Stockton Waterfront and Deep Water Ship Channel confirms that nutrients are generally present in excess of phytoplankton growth needs, with cyanobacteria outcompeting other algal groups in June but not in September (Preece et al. 2024b). This research also aligns with earlier studies indicating that phytoplankton—particularly cyanobacteria—tend to prefer ammonium over nitrate as a nitrogen source (Preece et al. 2024b). Both point and non-point source discharges contribute to high nutrient concentrations in the Delta, but HAB hotspot locations like the Stockton Waterfront are also characterized by large nutrient pools stored in the sediment and pore waters, which maintain internal nutrient loading processes (Preece et al. 2024b).

Recent research suggests that high volumes of winter and spring precipitation and runoff, combined with large and prolonged snowmelt events, can generate sufficient summertime nutrient dilution to control and limit the growth of HABs in hotspot locations (Preece et al. 2025b). In the Stockton Waterfront, wet years with high flow exhibit low nutrient concentrations and cyanobacteria can experience nutrient limitation during summer and fall months, despite elevated nutrient loading (Preece et al. 2025b). Regardless of hydrologic year type, long-term nutrient control may be the most effective approach for limiting HAB events. However, because nutrients in the Delta are currently nonlimiting, other drivers of cyanobacterial HABs, such as flow and circulation patterns,

[5] See Mitigation Measure MM-SW-a,f: 4, *Avoid or Reduce Harmful Algal Blooms and Invasive Aquatic Weeds*, in Section 7.12.1, *Surface Water*.

light availability, and temperature are thought to presently control the presence and severity of HABs in the Delta and may, along with physical, chemical and other mitigation strategies, be the most promising variables to consider in the near-term when developing HABs management actions (^Kudela et al. 2023; Preece et al. 2024b; Bouma-Gregson et al. 2024; Preece et al. 2025b).

As indicated in Section 7.12.1, *Surface Water,* of the Staff Report, the Sacramento Regional Wastewater Treatment Plant (SRWTP) completed upgrades in 2023 which substantially reduced nutrient loads into the Sacramento River. Increased winter and spring flow would be expected to dilute nutrients and may decrease the effects of remaining excess nutrients in the system (Preece et al. 2025b). However, it is unknown whether upgrades to the SRWTP, aimed at reducing ammonium to undetectable levels, could induce shifts in the cyanobacterial community. As ammonium becomes less available, conditions may favor other toxin-producing cyanobacteria that are nitrogen fixers, such as *Dolichospermum*, over *Microcystis*, though additional monitoring and research is needed to test this hypothesis. *Dolichospermum* dominated the cyanobacterial bloom in Franks Tract during the summer of 2022 (DWR 2024), which may indicate potential for shifting community dynamics.

The Central Valley Water Board is currently overseeing implementation of the Delta Nutrient Research Plan which is meant to assess the need for numeric nutrient objectives for the Delta and determine the potential benefits of nutrient reductions on existing water quality concerns (Central Valley Regional Water Quality Control Board 2018).

The State Water Board acknowledges the role that nutrients play in creating conditions that are conducive to HAB formation and is engaged in various efforts aimed at better understanding nutrient dynamics in the Bay-Delta and reducing and limiting the effects of nutrients. As described above in the section, *State Water Board Commitments to Address HABs in the Delta*, the State Water Board has committed to coordinating with other agencies, tribes, and other interested parties in implementing the Delta CHAB Monitoring Strategy to improve coordination on HABs monitoring and support special studies that can fill data gaps and further support monitoring needs. Special studies identified in the Delta CHAB Monitoring Strategy include those targeted towards developing effective mitigation measures specific to Bay-Delta environmental conditions, encompassing considerations for drivers like flow and nutrients. In addition, the revised proposed Plan amendments include monitoring provisions related to HABs, including monitoring at six Delta HAB hotspot locations. These new monitoring requirements would ensure that necessary data are collected to better understand HAB drivers, including nutrients, and their potential interactions with other drivers, to inform and develop models as well as possible management and mitigation measures for controlling HABs.

Actions to address nutrient-related HAB concerns also include substantial efforts to reduce nutrient loads in the San Francisco Bay (Bay). In 2022 there was a large-scale HAB that caused widespread negative environmental impacts throughout the Bay. In response, the San Francisco Bay Regional Water Quality Control Board adopted the San Francisco Bay Nutrients Watershed Permit, requiring an aggregate 40 percent reduction in total inorganic nitrogen nutrient loads to the Bay by 2034 (San Francisco Bay Regional Water Quality Control Board 2024). The permit is expected to significantly reduce the likelihood of large HABs and will protect beneficial uses. As the Bay is tidally connected with the larger Sacramento-San Joaquin Delta, nutrients deposited in the Bay can flow upstream with the tides.

Air Quality

Several comments summarized recent research conducted by the University of North Carolina (UNC) that studied the interaction between HAB incidents and air pollution. The comments concluded that the UNC research demonstrates that HABs can lead to aerosol formation in the atmosphere, forming particulate matter (PM) that can contribute to regional and localized pollution. Based on the findings of the recent UNC research, some comments asserted that the analysis presented in Section 7.5, *Air Quality* is deficient because it does not specifically identify potential HAB impacts on air quality and human health.

The Staff Report acknowledges that HABs can have potentially severe impacts on human health and safety in Section 4.3.2, *Harmful Algal Blooms* and Section 5.6.1.3, *Proposed Changes to Monitoring, Assessment, Special Studies, and Reporting*. Section 7.12.1, *Surface Water*, identifies HABs and the proliferation of invasive aquatic plants that affect surface waterbodies in the Delta under existing conditions; Plan implementation could incrementally increase the chances of HAB formation and bloom size and the production of invasive aquatic plants in some Delta channels at some times, particularly in the southern Delta. Section 7.18, *Recreation*, discusses how HABs, due to release of cyanotoxins, as well as invasive aquatic plants, can limit recreational opportunities in and adjacent to surface waterbodies in the Delta.

Recent research indicates that freshwater HABs may be associated with elevated PM2.5 mass concentrations as aquatic cyanobacteria, associated cyanotoxins, or other secondary metabolites may be aerosolized at high rates during periods of rapid bloom growth. However, additional work is needed to more comprehensively characterize the composition of airborne emissions from HABs (Plaas et al. 2022). HABs may also produce secondary organic aerosols via atmospheric oxidation of volatile organic compounds (VOC) emitted by HABs (Plaas et al. 2023). The concentration of microcystin within PM2.5 can be highly variable depending on local meteorology and aerosol spray generation mechanisms, such as high wind speeds, the presence of aeration systems, or the passing of water over a spillway (Shi et al. 2023). Additionally, further research is needed to understand the inland transportation of aerosolized toxins from affected water bodies. As reviewed by Plaas and Paerl (2021), sea spray aerosol, a prominent source of airborne cyanobacteria, can be transported up to 1000 kilometers (km) inland at concentrations of 10^3 particles per cubic meter, indicating aerosolized cyanotoxins may travel significant distances. Less information is available for transport distances of aerosolized cyanotoxins in freshwater and estuarine systems.

Though many knowledge gaps remain when considering the aerosolization of cyanotoxins, it is known that cyanotoxins are diverse and exposure by people or pets can produce a variety of adverse health outcomes including neuromuscular failure, liver damage, skin irritation, and respiratory symptoms. The most common routes of exposure occur during water recreation, when individuals may have skin contact with contaminated waters, inadvertently ingest HAB waters, or inhale aerosolized cyanotoxins (^Kudela et al. 2023). Individuals with decreased lung function, such as asthmatics, may be particularly at risk of experiencing symptoms through inhalation exposure (Plaas and Paerl 2021). However, current data suggest that acute intoxication via microcystin inhalation is unlikely in recreational waters and less likely in surrounding areas, but additional research into chronic health impacts is needed (Plaas and Paerl 2021).

The research summarized in this section confirms that the potential for HABs to contribute to elevated ambient air pollution through aerosolization of cyanotoxins depends on interconnected biological, chemical, and physical processes. Receptors must be exposed to and inhale the aerosolized cyanotoxins to be at increased risk of developing adverse health effects from exposure to elevated air pollution from HABs. The likelihood of exposure depends on the physical receptor location relative to the waterway, as well as the potential transport distances of aerosolized cyanotoxins. Correlating the flow scenarios to air quality or associated human health impacts from HABs would require the State Water Board to speculate on dynamic conditions and rely on incomplete or ongoing research. Such an analysis would not produce accurate or meaningful results based on currently available information, precluding any material conclusions. For the reasons discussed above, no revisions to the Staff Report are required.

While no changes to the environmental analysis are required, the State Water Board recognizes that as HABs increase in the Bay-Delta system, additional research and monitoring is needed to produce actionable management information that can reduce and mitigate HAB impacts on human health.

Economically Disadvantaged Communities

The following section is intended to address comments about HABs and environmental justice communities and DACs. Comments generally state that HABs disproportionately impact DACs and that the analysis of HABs in the Staff Report is insufficient. Commenters stated that the HABs analysis favors water exports over the environment and DACs, and that this is discriminatory and ignores the importance of beneficial uses to Delta residents. Comments indicate that assigning a less than significant impact conclusion for HAB effects to recreation is evidence of discrimination, and that the Staff Report does not propose sufficient mitigation measures for HABs. Commenters stated that the effects of HABs on environmental justice communities and DACs should be analyzed.

HABs are a statewide water quality issue that exists independently of potential incremental effects from changes in hydrology under the proposed Plan amendments. The Sacramento/Delta updates to the Bay-Delta Plan are intended to provide for the reasonable protection of fish and wildlife beneficial uses and are not expressly intended to manage the occurrence of HABs in the Delta or in reservoirs. However, the State Water Board recognizes that HABs are a growing concern. Below is information describing how HABs are analyzed in the Staff Report, including an explanation of CEQA impact thresholds. To address commenters concerns, the *CEQA Thresholds and Recreation Impacts* section below describes additional information in the final Staff Report on the benefits that increased instream flows would be likely to have for DACs and California Native American Tribes.

Existing HABs Effects on DACs

Multiple commenters stated that the effects of HABs on environmental justice communities and DACs should be analyzed in the Staff Report. This section is intended to address the general claim that HABs have disproportionately affected these communities.

State Water Board Staff evaluated the recent occurrence of HABs in disadvantaged communities in the Delta for this common response. Staff utilized SB535 data to identify DACs. SB535 gave CalEPA the responsibility to identify DACs based on geographic, socioeconomic, public health, and environmental hazard criteria. Census tracts were designated as DACs based on data from CalEnviroScreen and requests from federally recognized tribes to designate land under their authority as DACs (OEHHA 2022a). Using HAB incident report data from the California Water Quality Monitoring Council HAB Report Maps, managed by the State Water Board, State Water Board staff mapped the number of reported HABs during the June to October bloom season from 2016 to

2023 that overlap with DACs in the legal Delta (California Water Quality Monitoring Council n.d.)(Figure CR 4.1-1, 2016-2023 Reported Harmful Algal Blooms [HABs]). The HABs incident reports consist of online submissions to report HAB occurrences, reports to the State Water Board about HAB incidents by Partners and other organizations, and water monitoring data submitted to the Water Boards by other entities. Staff recognize that incident report data does not reflect conditions in the entire Delta, rather it reflects conditions reported through the FHAB website when visual indicators were present. Only reports for which HABs were confirmed through laboratory testing for cyanotoxins or visual confirmation by FHAB program coordinators that were subsequently assigned to a CCHAB network recreational advisory level were considered for this evaluation. Other HAB indicators, such as the *Microcystis* visual index were considered for mapping HABs; however, the visual index data only covers the main channels of the Delta. Therefore, incident report data were used instead as indicators of HABs.

The analysis shows that HABs occur regularly in areas of the legal Delta inside and outside of DAC regions. However, the highest number of reported incidents are in the Stockton region where DACs are present and where community members may engage in recreation and subsistence fishing.

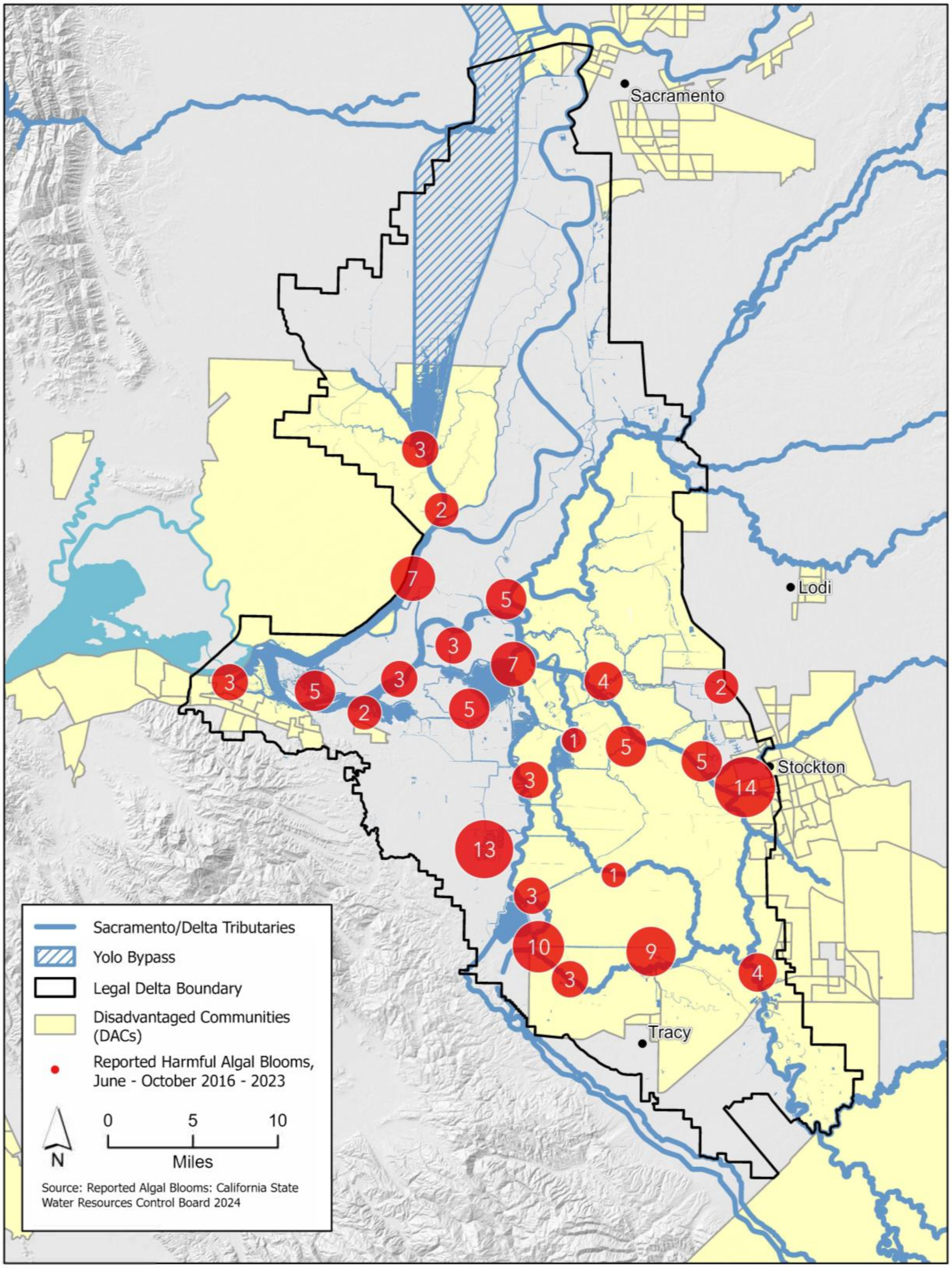

Figure CR 4.1-1. 2016-2023 Reported Harmful Algal Blooms (HABs)

HABs also occur in other areas of the South and Central Delta that overlap with DACs. The analysis suggests that HABs could also affect these communities.

HABs are an existing water quality impairment. The State Water Board acknowledges this and recognizes their effect on DACs. The impacts that could potentially result from implementation of the Bay-Delta Plan update occur in a system that has been highly altered, and the updates would be expected to improve conditions for native fish and wildlife in the Sacramento/Delta watershed over time. The Staff Report contains analyses that show that in some cases increased flows result in water quality impacts, such as for HABs and temperature. Under the flow scenarios, summer and early-fall Delta inflows would be reduced to some extent for tributaries such as the Sacramento, Feather, and American Rivers, where, under existing conditions, substantial storage releases to downstream diversions create artificially high summer and early fall flows. The occurrence of HABs in the Sacramento/Delta watershed and statewide is of significant concern to the State Water Board, and as described above in the following sections: *State Water Board Commitments to Address HABs in the Delta*, *Water Quality Standards for Cyanotoxins*, and *Nutrient Discharge and HABs*, the State Water Board is committed to supporting actions to address HABs and reduce their effects on DACs. More information on these actions can also be found in Section 5.6.1.3, *Proposed Changes to Monitoring Assessment, Special Studies, and Reporting* and Section 13.3.9.2, *Harmful Algal Blooms* of the final Staff Report.

HABs in Reservoirs

Comments state that the analysis of HABs in the Staff Report focuses on how HABs relate to reservoirs and water exports and neglects the effect of HABs on Delta communities, including DACs. The following section summarizes the Staff Report's analysis of the effect of HABs on reservoirs, including mitigation measures, so that readers can better understand how the Staff Report has evaluated possible HAB related impacts. More information on HABs in the Delta, and information on recreation impacts, can be found in the sections following this one.

Comments assume that increasing requirements for unimpaired flows, such as adopting 65 or 75 percent of unimpaired flow, will help reduce HABs, but these comments ignore the potential adverse impacts that increased flow scenarios could have on HAB formation, including HABs in reservoirs that could result from lower reservoir levels. As discussed in Staff Report Section 6.3.1.1, *Sacramento River Region and Delta Eastside Tributaries,* the flow scenarios evaluated in the Staff Report are generally expected to increase instream flows over baseline from late winter through spring. These instream flows would be the result of the narrative inflow objective and numeric inflow requirements and would be subject to the inflow-based outflow objective which states that required inflows are required as outflows. The resulting changes in supply and reservoir storage evaluated in the Staff Report would primarily be due to the instream flow requirements and not due to increases in water exports.

The flow scenarios have the potential to reduce rim reservoir storage in Sacramento/Delta reservoirs at the beginning of the irrigation season and lead to less total water being released in the summer months (Staff Report Section 7.12.1.3, *Changes in Hydrology: Sacramento River Watershed and Delta Eastside Tributaries Regions: Harmful Algal Blooms*.) These changes in hydrology could lead to reduced storage levels in some reservoirs at some times and in shallower, warmer, more stable water column conditions in those reservoirs. These conditions could lead to increased reservoir algal bloom formations and with lower storage levels, could lead to blooms being exposed to reservoir outlets, affecting supplies from the reservoir for downstream releases and water supply purposes. This is not intended to suggest that increased instream flows do not offer benefits to fish and wildlife or the environment, but rather, that a range of environmental factors influence HAB formation and that some of the changes in hydrology and supply that could result from the flow scenarios have the potential to increase the production of HABs.

Similar to the potential impacts in the Sacramento/Delta reservoirs, and as described in Staff Report Section 7.12.1*, Surface Water,* reduced Sacramento/Delta supply to export reservoirs could lower reservoir storage and could result in increased algal growth in export reservoirs.

Staff Report Section 13.4, *Changes in Hydrology and Water Supply*, describes that the revised proposed Plan amendments are expected to result in similar or lower magnitude changes in Sacramento/Delta reservoir storage and export reservoir storage compared to the flow scenarios evaluated in Staff Report Chapter 6, *Changes in Hydrology and Water Supply*. Accordingly, the potential reductions in reservoir storage will be similar or less than what was analyzed Staff Report Section 7.12.1, *Surface Water*, which could result in similar or lower impacts on reservoir HABs.

Given the potential increase in HAB formation resulting from the flow scenarios, the Staff Report identifies mitigation measures for reducing potential HAB impacts in reservoirs, including through implementation of Mitigation Measures MM-SW-a,f: 1 and 3 through 5. Mitigation Measure MM-SW-a,f:1 targets water quality contaminants and regulates waste discharges. Mitigation Measure MM-SW-a,f: 5 protects municipal water quality by requiring public water systems to comply with regulations to implement the Safe Drinking Water Act, commits the State Water Board to continue implementing funding programs for assistance projects, including technical assistance programs and operation and maintenance programs for DACs, and recommends that service providers modify water treatment procedures or mix water sources to retain adequate drinking water quality and to comply with drinking water permits.

Impacts on water temperature from the flow scenarios would be mitigated through Mitigation Measure MM-SW-a,f: 3, which will avoid or reduce temperature impacts in the Sacramento/Delta rim reservoirs and would implement Mitigation Measure MM-AQUA-a,d:1. Mitigation Measure MM-AQUA-a,d:1 focuses on temperature control and reservoir management to ensure that water quality is maintained in reservoirs and in streamflows below reservoirs and that temperature impacts are avoided or reduced, including impacts to recreation resources, which as described above, may be affected by increased incidence of HABs.

Mitigation Measure MM-SW-a,f: 4.i and ii aim to avoid or reduce HABs and invasive aquatic weeds through continued HABs monitoring under the Surface Water Ambient Monitoring Program, and continued monitoring through permitting for nutrients such as nitrate and ammonia. Mitigation Measure MM-SW-a,f: 4.iii describes the Harmful Algal Blooms and Cyanotoxins Provisions project by the State Water Board Division of Water Quality, which includes consideration of statewide water quality objectives for cyanotoxins and HABs and a program of implementation to achieve the objectives. In addition, Mitigation Measure MM-SW-a,f: 4.iv describes HAB management technologies under development by other agencies. More information about these mitigation measures can be found in Staff Report Section 7.12.1.4, *Mitigation Measures*.

HABs in the Delta

Comments state that the analysis of HABs in the Staff Report focuses on how HABs relate to reservoirs and water exports and neglects the effect of HABs on Delta communities, including DACs.

The following sections summarize the Staff Report's analysis of HABs in the Delta and how increased flow scenarios could affect HAB formation in the Delta.

Comments generally assume that the flow scenarios, and in particular, the high flow alternative, will reduce HAB formation in the Delta. However, the flow scenarios analyzed in the Staff Report also present potentially adverse impacts on HAB formation, including HAB growth in the summer and fall due to lower flows. Net flow in some Delta channels could be affected by changes in hydrology. As presented in Section 7.12.1, *Surface Water,* and Appendix A2, *Delta Simulation Model II (DSM2) Methods and Results*, the flow scenarios may cause either little change in flow or increases in flow in the San Joaquin River near Stockton during the HAB season. This change in hydrology would have minimal effect on HABs in the San Joaquin River or could cause the San Joaquin River to be slightly less suitable for HAB formation. Additionally, the flow scenarios would increase spring runoff and could result in increased overbank flows (Staff Report Section 7.12.1.3, *Changes in Hydrology: Sacramento River Watershed and Delta Eastside Tributaries Regions: Nutrients, Organic Matter, and Harmful Algal Blooms*). This may lead to more nutrients and organic material transported into the Delta, which could result in increased algal growth. The bigger HAB problem, however, for the city of Stockton occurs near the Stockton Waterfront, which is located upstream of the Port of Stockton turning basin for cargo vessels in a dead-end slough that connects to the San Joaquin River at its west end. Dead-end sloughs have limited tidal exchange and minimal net flow, resulting in stagnant water and long residence times, which are conducive to HAB formation. The flow scenarios would not affect HABs in the Stockton Waterfront slough because, as shown in Appendix A2, *Delta Simulation Model II (DSM2) Methods and Results,* the proposed Plan amendments would not affect flow in and out of this slough.

Flow effects on HAB formation are more likely in channels that convey water to the export pumps. Travel times through Victoria Canal were estimated using DSM2 results for baseline conditions and proposed Plan amendments (Section 7.12.1, *Surface Water,* and Appendix A2, *Delta Simulation Model II (DSM2) Methods and Results*). Victoria Canal was selected as a representative large channel that could be affected by changes in Delta exports and that already has experienced some limited formation of HABs. Travel times through Victoria Canal could increase, which could incrementally increase the frequency of HABs and bloom size in Victoria Canal and other channels neat the export pumps. These travel times would increase due to lower exports during the summer under the flow scenarios. However, travel times would decrease during the winter and spring, which could provide some benefits for decreasing HABs in some Delta channels due to the sediment-scouring effects of higher flows that could reduce sediment cyanobacterial seedstock that can initiate summer blooms (see *Instream Flows and HABs* above).

Staff Report Section 13.4, *Changes in Hydrology and Water Supply*, describes that the revised proposed Plan amendments are expected to result in similar or lower magnitude changes in hydrology and water supply compared to the flow scenarios evaluated in Chapter 6, *Changes in Hydrology and Water Supply*. Accordingly, the potential changes in hydrology in the Delta will be similar or lower than what was analyzed Staff Report Section 7.12.1, *Surface Water*, which could result in similar or lower impacts on HABs in the Delta. Potential HAB impacts in the Delta can be reduced through implementation of Mitigation Measures MM-SW-a,f: 1, 4, and 5, which are described above in the section *HABs in Reservoirs*.

CEQA Thresholds for Recreation Impacts

Some commenters indicated that DACs face significant impacts from HABs and that identifying potential increases in HABs as a less than significant impact on recreation in the Staff Report is discriminatory. Commenters state that this is an example of how the 2023 draft Staff Report favors water exporters over communities. Additionally, commenters stated that the mitigation measures for recreation identified in the 2023 draft Staff Report are inadequate. The following section addresses these comments and discusses why the 2023 draft Staff Report analysis identified the proposed plan amendments as having a less than significant impact on recreation and how this is a reflection of CEQA thresholds for recreational impacts. This section also describes the changes to the impact conclusion for recreation in Chapters 7, *Environmental Analysis*, 9, *Proposed Voluntary Agreements*, and 13, *Revised Proposed Plan Amendments*, of the final Staff Report.

The Staff Report identifies HABs as a statewide water quality issue that exists independently of potential incremental impacts from the proposed Plan amendments or the revised proposed Plan amendments. The 2023 draft Staff Report Section 7.18, *Recreation*, under Impact REC-a identified that under the proposed Plan amendments, changes in hydrology could lead to increased HAB production in reservoirs and Delta channels and could interfere with recreation, including causing temporary closures to recreation in some waterbodies. Section 7.18 concluded that these changes would not exceed the recreation threshold for a potentially significant impact because the potential increased frequency of closures would not be expected to result in a substantial number of recreationists moving to alternate recreational locations to the extent that it would substantially physically deteriorate those alternate locations.

Reduced recreational opportunities are not by themselves physical impacts on the environment requiring CEQA analysis (Staff Report Section 7.18, *Recreation*). Rather, the CEQA impact thresholds for recreation focus on whether a project would cause substantial physical deterioration of recreation facilities or would require the construction or expansion of recreational facilities and thereby cause an adverse physical effect on the environment. Because of these CEQA recreation impact criteria, the 2023 draft Staff Report identified potential increases in HABs as having a less than significant impact on recreation. Impact REC-a evaluates whether the project would increase the use of existing neighborhood and regional parks or other recreation facilities such that substantial physical deterioration of the facility would occur or be accelerated. Impact REC-b considers whether the project includes recreational facilities or requires the construction or expansion of recreational facilities that could cause an adverse physical effect on the environment. Potential increases in HABs from changes in reservoir levels would not constitute a significant impact under the REC-b criterion. HABs do, however, have potential to close recreation in waterbodies, which could result in an impact under the REC-a criterion. These potential closures could cause recreationists to move to alternate recreational locations, where increased use could result in physical deterioration of those alternate locations. However, based on the number of available recreational facilities and the temporary nature of waterbody closures due to HABs, any redirection of recreationists would likely be insufficient in scale or duration to result in significant physical deterioration at alternate sites. Accordingly, Section 7.18 in the 2023 draft Staff Report concluded that these impacts would be less than significant and no mitigation was identified. Section 9.7.18, *Recreation*, reached the same impact conclusion.

Potential impacts from HABs do not meet the CEQA-defined significance thresholds for recreation. This impact significance determination was not intended to convey that HABs have not impacted recreational opportunities or that communities, including DACs, have not been impacted by HABs.

This impact significance determination was also not intended to prioritize the concerns of water exporters over communities. The State Water Board does recognize that HABs are a growing concern in the Delta and that they can disproportionately affect DACs. In response to public comments, and in recognition of recreation as an important public use of these Delta channels and reservoirs and as a beneficial use of water in the Bay-Delta Plan and other basin plans, this impact conclusion is revised to potentially significant in Sections 13.7.18, *Recreation*, 7.18, and 9.7.18, of the final Staff Report. Mitigation measures are identified to reduce or avoid impacts on recreation.

Mitigation Measure MM-REC-a: 3 incorporates measures to avoid or reduce harmful algal blooms and invasive aquatic weeds (Mitigation Measures MM-SW-a,f: 1, 3 through 5, and 7, described above under HABs in Reservoirs). Several ongoing activities to address HABs, such as those coordinated by the FHAB Program, also could be employed to mitigate the impacts of the proposed Plan amendments or the revised proposed Plan amendments. The most immediate response efforts include public education and notification efforts to minimize exposure of pets and people to waterbodies containing HABs. The California Water Quality Monitoring Council maintains a website for the CCHAB Network that tracks HABs and provides information about how to respond to HABs, including information from USEPA on measures that should be implemented to prevent and respond to HABs in surface waters and drinking water supplies. The State Water Board and regional water boards also regulate discharges of nitrogen and phosphorus, which help control these discharges that contribute to HAB formation. While the State Water Board and others are engaged in efforts to address HABs, those efforts will take time and may not fully resolve HAB issues.

As previously stated, the flow scenarios may increase HAB formation. HAB formation is complex and the drivers for them are still being determined. Please see the *Instream Flows and HABs* section above for more information on the influence of flow on HAB formation and proliferation. While it is unclear the extent that increased instream flow alone would help address HABs, increased instream flow does present benefits for DACs and tribal communities. See Common Response 10.1, *Economically Disadvantaged Communities*, for a discussion the benefits of increased flow to DACs.

California Native American Tribes

The following section is intended to address comments on HABs and their impact on California Native American Tribes. Comments stated that tribes face disproportionate impacts from environmental degradation, including HABs, and that HABs, and other water quality issues, impact Tribal Beneficial Uses (TBUs) and the ability for tribes to pass on traditional ecological knowledge (TEK). Commenters indicated that HABs create unique harm for tribes. This includes preventing traditional, religious, and cultural practices and ceremonies from occurring and preventing TEK from being passed on. Tribes are culturally connected to ceremonial sites, and relocating to alternate locations is not an option.

As discussed in the introduction and the *Economically Disadvantaged Communities* section above, the proposed updates to the Bay-Delta Plan analyzed are not expressly intended to manage the occurrence of HABs in the Delta but are intended to provide for the reasonable protection of fish and wildlife beneficial uses. The State Water Board does, however, recognize that HABs have negatively impacted California Native American Tribes, Tribal Beneficial Uses, the ability of tribes to conduct traditional and cultural practices and pass on TEK.

As discussed in the sections above on *State Water Board Commitments to Address HABs in the Delta*, *Water Quality Standards for Cyanotoxins*, and *Nutrient Discharge and HABs*, that State Water Board is committed to supporting actions to address HABs. These include supporting science, research, monitoring, and special studies that are needed to develop HAB-predictive models and identify possible management and mitigation measures that could be used to control HABs, developing statewide policy to address HABs, and controlling drivers of HABs such as nutrients, in addition to supporting incident response and other actions. These commitments are described in Staff Report Section 5.6.1.3, *Proposed Changes to Monitoring, Assessment, Special Studies, and Reporting* and Section 13.3.9.2, *Harmful Algal Blooms*, including new HABs monitoring requirements on the Sacramento/Delta tributaries and in the Delta under the revised proposed Plan amendments.

The State Water Board Division of Water Quality is considering statewide water quality objectives for cyanotoxins and HABs. This project includes efforts to evaluate existing cyanotoxin advisory action levels and determine if they can be adapted or updated for protection of REC-1 beneficial uses and to help determine what information is necessary to perform a risk assessment to adapt the recreational advisory action levels to protect Tribal Tradition and Culture (CUL) beneficial uses. Please see the *Water Quality Standards for Cyanotoxins* section of this common response for more information. Common Response 11.1, *Tribal Engagement and Tribal Beneficial Uses*, has additional information on TBUs.

References Cited

^Berg, M. and M. Sutula. 2015. Factors Affecting the Growth of Cyanobacteria with Special Emphasis on the Sacramento–San Joaquin Delta. *Southern California Coastal Water Research Project.* Technical Report 869:i-100. Available: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/RestoretheDelta/RTD_236.pdf.

Bouma–Gregson, K., D. H. Bosworth, T. M. Flynn, A. Maguire, J. Rinde, and R. Hartman. 2024. Delta Blue(green)s: The Effect of Drought and Drought-Management Actions on Microcystis in the Sacramento–San Joaquin Delta. San Francisco Estuary and Watershed Science, 22(1):1-39. Available: https://doi.org/10.15447/sfews.2024v22iss1art2.

Bouma-Gregson, K., L.V. Lucas, A. Jaegge, D. Avouris, E. Richardson, J.A. Zwart, and T.E.C. Kraus. 2025. Designs for Cyanobacterial Harmful Algal Bloom Monitoring in the Sacramento–San Joaquin Delta, California. ESS Open Archive.

California Department of Water Resources (DWR), 2024. *2021-2022 Comprehensive Emergency Drought Barrier Effectiveness Report*. Prepared by California Department of Water Resources. Available: https://cawaterlibrary.net/wp-content/uploads/2024/06/EDB-Effectiveness-Rpt_2021-2022_June2024.pdf. Accessed: July 16, 2026.

California Water Quality Monitoring Council. n.d. HAB Reports Map. Last Revised: 2026. Available: https://mywaterquality.ca.gov/habs/resources/reports-map/. Accessed August 6, 2025.

California Water Quality Monitoring Council. 2020. Trigger Levels for Human and Animal Health. Available: https://mywaterquality.ca.gov/habs/docs/trigger-levels-and-response-decision-tree-for-planktonic-blooms.pdf. Accessed: February 12, 2025.

Centers for Disease Control and Prevention (CDC). 2017. Harmful Algal Bloom (HAB)-Associated Illness. Last Revised: November 17, 2017. Available: https://www.cdc.gov/harmful-algal-blooms/about/index.html. Accessed: August 15, 2025.

Central Valley Regional Water Quality Control Board. 2018. Delta Nutrient Research Plan. Prepared by the California Environmental Protection Agency. Available: https://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/2018_0802_dnrp_final.pdf. Accessed: August 6, 2025.

Fehr, D. 2024. Summer Returns, but so Does Toxic Blue-Green Algae in Delta: Blue-Green Algae Blooming, but No One Knows Who's to Blame. Last revised: July 15, 2024. Available: https://www.thepress.net/news/summer-returns-but-so-does-toxic-blue-green-algae-in-delta/article_ae26d052-3faa-11ef-82f1-5f3f5396d54b.html. Accessed: October 17, 2024.

Hammock, B. G., S. P. Moose, S. S. Solis, E. Goharian, and S, J. Teh. 2019. Hydrodynamic Modeling Coupled with Long-term Field Data Provide Evidence for Suppression of Phytoplankton by Invasive Clams and Freshwater Exports in the San Francisco Estuary. Environmental Management, 63(6), 703–717. Available: https://doi.org/10.1007/s00267-019-01159-6.

Hartman, R., N. Rasmussen, D. Bosworth, M. Berg, E. Ateljevich, T. Flynn, B. Wolf, T. Pennington, and S. Khanna. 2022. Temporary Urgency Change Petition of 2021 and Emergency Drought Salinity Barrier; Impact on Harmful Algal Blooms and Aquatic Weeds in the Delta. Report to the State Water Resources Control Board. Sacramento, CA.

Jacoby, J. M., D. C. Collier, E. B. Welch, F. J. Hardy, and M. Crayton. 2000. Environmental Factors Associated with a Toxic Bloom of *Microcystis aeruginosa*. *Canadian Journal of Fisheries and Aquatic Science*, 57:231-240. Available: https://doi.org/10.1139/f99-234.

^Kudela, R. M., M. D. A. Howard, S. Monismith, and H. W. Paerl. 2023. Status, Trends, and Drivers of Harmful Algal Blooms Along the Freshwater-to-Marine Gradient in the San Francisco Bay–Delta System. *San Francisco Estuary and Watershed Science*, 20(4):1-51. Available: https://doi.org/10.15447/sfews.2023v20iss4art6.

Lehman, P. W., G. Boyer, C. Hall, S. Waller, and K. Gehrts. 2005. Distribution and Toxicity of a New Colonial Microcystis aeruginosa Bloom in the San Francisco Bay Estuary, California. Hydrobiologia, 541:87–99. Available: https://doi.org/10.1007/s10750-004-4670-0.

^Lehman, P. W., K. Marr, G. L. Boyer, S. Acuna, and S. J. Teh. 2013. Long-term trends and causal factors associated with *Microcystis* abundance and toxicity in San Francisco Estuary and implications for climate change impacts. *Hydrobiologia*, 718(1):141–158. Available: https://doi.org/10.1007/s10750-013-1612-8.

Lehman, P. W., T. Kurobe, and S. J. Teh. 2022. Impact of extreme wet and dry years on the persistence of Microcystis harmful algal blooms in San Francisco Estuary. Quaternary International, 621: 16–25. Available: https://doi.org/10.1016/j.quaint.2019.12.003.

Office of Environmental Health Hazard Assessment (OEHHA). 2012. Toxicological Summary and Suggested Action Levels to Reduce Potential Adverse Health Effects of Six Cyanotoxins. Sacramento, CA. Prepared by California Environmental Protection Agency. Available: https://oehha.ca.gov/media/downloads/fish/document/cyanotoxins053112.pdf.

Office of Environmental Health Hazard Assessment (OEHHA). 2022a. SB 535 Disadvantaged Communities. Last Revised: May 2024. Available: https://oehha.ca.gov/calenviroscreen/sb535. Accessed: August 6, 2025.

Office of Environmental Health Hazard Assessment (OEHHA). 2022b. Recommendations for Acute Notification Levels for Anatoxin-a, Cylindrospermopsin, Microcystins and Saxitoxins. Memorandum from Lauren Zeise, Director of the California Office of Environmental Health Hazard Assessment, to Darrin Polhemus, Deputy Director, Division of Drinking Water, State Water Resources Control Board. Available: https://oehha.ca.gov/sites/default/files/media/downloads/water/document/acutenlrecommendationsmemo061522.pdf

Plaas, H. E., and H. W. Paerl. 2021. Toxic Cyanobacteria: A Growing Threat to Water and Air Quality. Environmental Science & Technology, 55(1):44–64. Available: https://dx.doi.org/10.1021/acs.est.0c06653. Accessed: August 14, 2025.

Plaas, H. E., R. W. Paerl, K. Baumann, C. Karl, K. J., Popendorf, M. A. Barnard, N. Y. Chang, N. P. Curtis, H. Huang, O. L. Mathieson, J. Sanchez, D. J. Maizel, A. N. Bartenfelder, J. S. Braddy, N. S. Hall, K. L. Rossignol, R. Sloup, and H. W. Paerl. 2022. Harmful cyanobacterial aerosolization dynamics in the airshed of a eutrophic estuary. *Science of The Total Environment*, 852, 158383:1-10. Available: https://doi.org/10.1016/j.scitotenv.2022.158383.

Plaas, H. E., J. Yan, C. Christensen, S. Chang, C. Cortez, S. Fern, L. Nelson, A. Sabo, N. C. Armstrong, B. J. Turpin, Y. Zhang, H. W. Paerl, and J. D. Surratt. 2023. Secondary Organic Aerosol Formation from Cyanobacterial-Derived Volatile Organic Compounds. ACS Earth and Space Chemistry, 7(9):1798–1813. Available: https://doi.org/10.1021/acsearthspacechem.3c00177.

Preece, E. P. and R. Hartman. 2024. Exploring factors that affect Microcystis abundance in the Sacramento San Joaquin Delta. Harmful Algae, 102682:1-11. Available: https://doi.org/10.1016/j.hal.2024.102682.

Preece, E. P., T. G. Otten, and J. Cooke. 2024a. Use of multiple sampling techniques for cyanobacteria and cyanotoxin monitoring in the Sacramento-San Joaquin Delta under different hydrologic regimes. Marine Pollution Bulletin, 205, 116585:1-11. Available: https://doi.org/10.1016/j.marpolbul.2024.116585.

Preece, E. P., J. Cooke, H. Plaas, A. Sabo, L. Nelson, and H. W. Paerl. 2024b. Managing a cyanobacteria harmful algae bloom “hotspot” in the Sacramento – San Joaquin Delta, California. Journal of Environmental Management, 351, 119606:1-11. Available: https://doi.org/10.1016/j.jenvman.2023.119606.

Preece, E., M. Berg, T. Lee, K. Odkins, and J. Rinde. 2024c. Cyanobacteria Harmful Algal Bloom Monitoring Strategy for the Sacramento-San Joaquin Delta. Delta Stewardship Council Final Report. Available: https://deltacouncil.ca.gov/pdf/science-program/2024-10-21-final-delta-chabs-monitoring-strategy.pdf.

Preece, E. P., T. G. Otten, J. Cooke, and K. V. Cook. 2025a. Role of benthic overwintering cyanobacteria seed stock on estuarine bloom dynamics. Harmful Algae, 143,102807:1-13. Available: https://doi.org/10.1016/j.hal.2025.102807.

Preece, E. P., H. W. Paerl, H. E. Plaas, and J. Cooke. 2025b. From drought to deluge: hydrologic extremes alter nutrient-driven harmful cyanobacterial blooms. Environmental Pollution, 382,126731:1-10. Available: https://doi.org/10.1016/j.envpol.2025.126731.

San Francisco Bay Regional Water Quality Control Board. 2024. Staff Summary Report. Available: https://www.waterboards.ca.gov/sanfranciscobay/board_info/agendas/2024/July/6_ssr.pdf.

Senn, D. B., Spotswood, E., and A. Malkassian. 2016. Synthesis of Current Science: Influence of Nutrient Forms and Ratios on Phytoplankton Production and Community Composition. San Francisco Estuary Institute Contribution No. 862. Prepared for San Francisco Bay Nutrient Management Strategy. Available: https://www.sfei.org/sites/default/files/biblio_files/2016_suisunsynthesis2_final.pdf.

Shi, J. H., N. E. Olson, J. A. Birbeck, J. Pan, N. J. Peraino, A. L. Holen, I. R. Ledsky, S. J. Jacquemin, L. C. Marr, D. G. Schmale, III, J. A. Westrick, and A. P. Ault. 2023. Aerosolized cyanobacterial harmful algal bloom toxins: microcystin congeners quantified in the atmosphere. *Environmental Science & Technology,* 57:21801-21814. Available: https://doi.org/10.1021/acs.est.3c03297.

U.S. Army Engineer Research and Development Center (ERDC). 2024. Harmful Algal Bloom Demonstration Program. Available: https://www.erdcwerx.org/harmful-algal-bloom-demonstration-program/. Accessed: April 23, 2025.

U.S. Environmental Protection Agency (USEPA). 2015a. Drinking Water Health Advisory for the Cyanobacterial Toxin Cylindrospermopsin. EPA-820R15101. Washington, DC. Prepared by USEPA, Office of Water. Available: https://www.epa.gov/sites/default/files/2017-06/documents/cylindrospermopsin-report-2015.pdf.

U.S. Environmental Protection Agency (USEPA). 2015b. Drinking Water Health Advisory for the Cyanobacterial Microcystin Toxin. EPA-820R15100. Washington, DC. Prepared by USEPA, Office of Water. Available: https://www.epa.gov/sites/default/files/2017-06/documents/microcystins-report-2015.pdf.

U.S. Environmental Protection Agency (USEPA). 2019. Recommended Human Health Recreational Ambient Water Quality Criteria or Swimming Advisories for Microcystins and Cylindrospermopsin. EPA 822-R-19-001. Washington, DC. Prepared by USEPA, Office of Water. Available: https://www.epa.gov/sites/default/files/2019-05/documents/hh-rec-criteria-habs-document-2019.pdf.

World Health Organization (WHO). 2021. Guidelines on Recreational Water Quality. Volume 1: Coastal and Fresh Waters. License: CC BY-NC-SA 3.0 IGO. Available: https://iris.who.int/bitstream/handle/10665/342625/9789240031302-eng.pdf?sequence=1.

World Health Organization (WHO). 2022. Guidelines for Drinking-Water Quality. Fourth edition incorporating the first and second addenda. License: CC BY-NC-SA 3.0 IGO. Available: https://www.who.int/publications/i/item/9789240045064.