THOMAS H. KEELING (SBN 114979)
FREEMAN FIRM
1818 Grand Canal Boulevard, Suite 4
Stockton, CA 95207
Telephone: (209) 474-1818
Facsimile: (209) 474-1245
Email: tkeeling@freemanfirm.com

J. MARK MYLES (SBN 200823)
Office of the County Counsel
County of San Joaquin
44 N. San Joaquin Street, Suite 679
Stockton, CA 95202-2931
Telephone: (209) 468-2980
Facsimile: (209) 468-0315
Email: jmyles@sjgov.org

Attorneys for Protestants County of San Joaquin,
San Joaquin County Flood Control and
Water Conservation District, and
Mokelumne River Water and Power Authority

[ADDITIONAL COUNSEL LISTED ON FOLLOWING PAGE]

BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

HEARING IN THE MATTER OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATER FIX	**TESTIMONY OF ERIK RINGELBERG**

JENNIFER SPALETTA (SBN 200032)
SPALETTA LAW, PC
P.O. BOX 2660
LODI, CA 95241
Telephone: (209) 224-5568
Facsimile: (209) 224-5589
Email: jennifer@spalettalaw.com

Attorneys for Protestants North San Joaquin Water Conservation District

OSHA R. MESERVE (SBN 204240)
SOLURI MESERVE, A LAW CORPORATION
1010 F Street, Suite 100
Sacramento, CA 95814
Telephone: (916) 455-7300
Facsimile: (916) 244-7300
Email: osha@semlawyers.com

Attorneys for Protestants
Local Agencies of the North Delta
Bogle Vineyards / Delta Watershed Landowner Coalition
Diablo Vineyards and Brad Lange / Delta Watershed Landowner Coalition
Stillwater Orchards / Delta Watershed Landowner Coalition

I, Erik Ringelberg, do hereby declare:

I. INTRODUCTION

I am an environmental scientist with technical and managerial experience in developing, planning, and permitting large projects, assessing their environmental impacts, and, where necessary, developing mitigation measures. I have applied scientific experience in the assessment of water quality in both the field and in the laboratory, and experience managing multi-disciplinary teams in the assessment of ecological baseline conditions and assessing the results of managed hydrologic regimes leading to water quality impacts.

As an environmental scientist, I have completed analyses of the Bay Delta Conservation Plan (BDCP) and its various permutations since 2008. Over those eight years, I have been asked to provide oral and written comments by the Local Agencies of the North Delta with particular emphasis on the technical considerations of project features that would impact water quality, terrestrial and aquatic ecology, and the rural agricultural community. Prior to those efforts, I provided support to the Pyramid Lake Paiute Tribe on the Truckee River Operating Agreement and its management of Pyramid Lake habitat and water quality. That work included managing a sampling team and a water quality laboratory that completed algal chlorophyll, nutrient, and other water quality analyses to assess the condition of the lake and the Truckee River.

My educational background and other qualifications are summarized in the Statement of Qualifications submitted concurrently herewith. (SJC-003)

II. OVERVIEW – MICROCYSTIS IN THE DELTA

My testimony is intended to provide scientific analysis and conclusions about the likely project impacts on toxic algal growth, colony formation, and toxic byproduct formation because of the proposed diversions on the Sacramento River near Clarksburg. The proposed project influences flow and water quality within Sacramento San Joaquin Delta as a result of this diversion, and those factors further influence the formation of Harmful Algal Blooms ("HABs" or CyanoHABs).

Cyanobacteria and Harmful Algal Blooms

Summary

I was asked to assess the proposed California Water Fix Petition for Change before the State Water Resources Control Board (SWRCB) to determine from a scientific perspective whether the project, as proposed by the Petitioners, would be likely to affect the conditions that promote the incidence of harmful algal blooms and, if so, to identify those likely effects. I was asked, also, to: (1) review the adequacy of the analysis, if any, of HABs presented in the Petition, (2) explain the conditions that promote the development of HABs and the effects of HABs on legal users of water in the Delta.

Upon review of the Petition (SWRCB-1, and the associated errata, SWRCB-2), there are no analyses of any kind analyzing the project's potential to create or exacerbate the formation of HABs or their toxic byproducts. During my review of the relevant portions of the direct testimony in support of this project, I did not hear analysis of any kind associated with HABs and their toxic byproducts. Furthermore, there were no experts on HABs were provided in support of the project.

There is information provided on one genus of HABs (*Microcystis*) in Exhibits SWRCB-3, SWRCB-4, and SWRCB-5, despite molecular biologists identifying the HABS in the Delta (and elsewhere) could contain or be caused by multiple genera, and identifying that genus being less dominant in the Delta, potentially being replaced by the toxic *Aphanizomenon flosaquae*. (SJC-045, Kurobe et al. 2013) I have analyzed information provided in Exhibits SWRCB-3, SWRCB-4, and SWRCB-5 in detail as a part of my comments on the project previously. (Exhibit SCWRB-3 RESIRC 2622 Pg. 14-20)

For a variety of reasons described in my prior analysis, and repeated for context in this analysis, the Petitioners' prior analyses fail to adequately describe the likely project impacts on the ecological drivers for HAB formation created or exacerbated by the project, and further fail to provide scientific substantiation that the project will not create HABs and their toxins.

The Project documentation states: "…beneficial uses in the Delta will not be negatively impacted by operations with the new point of diversion." (SWRCB-1, Pg. 19) The scientific question of how the project could affect the environment is not evident because of the inadequacies in analysis and water quality modeling of the proposed project. Because of the lack of supporting information provided by the Petitioners, I looked at relevant information available from other sources that could be used as surrogates for the proposed action and extrapolated from existing conditions that were the most similar to project operations. Contrary to the project's analysis in SWRCB-3, there are several scales of models available for HAB formation, including for the Sacramento-San Joaquin Delta (Delta). There is a detailed Delta food web model, as well as predictive models used for the Potomac and Lake Eire[1]. (SJC-046, Durand, 2008; SJC-047, Tango 2009) The project failed to apply any of those models to this project. Finally, since there was no HAB modeling provided for me to review any technical basis of their conclusion of no injury, I examined how the proposed project impacts could be assessed by the last remaining metric, the Basin Plan itself. The following is an analysis of the Project's potential impacts on these beneficial uses:

> State law defines beneficial uses of California's waters that may be protected against quality degradation to include (and not be limited to) "...domestic; municipal; agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife, and other aquatic resources or preserves" (Water Code Section 13050(f)).

The beneficial uses relevant to project impacts to water quality are identified in the 2006 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary (Basin Plan) as follows:

> Municipal and Domestic Supply; Recreation-Contact; Agriculture- Irrigation and Stock Watering, and including although not expanded upon in detail in this analysis, Freshwater Habitat- Warm and Cold, and Wildlife.

[1] http://lakeeriealgae.com/forecast/

(SWRCB-27.)

There is simply no scientific debate that HABs and their toxic byproducts are by definition injurious to legal users of waters applying their water for beneficial uses. The toxins harm and can kill people, pets, stock animals, wildlife, and can impair other agricultural uses. As explained in greater detail below, I have concluded that the proposed project diversion in the North Delta under certain project scenarios will establish essentially the equivalent of drought conditions, and their associated lower flows, in the Delta by removing significant flow of the Sacramento River during ecologically critical periods (summer and early fall) for algal bloom formation. (DWR-515 and DWR 5 errata, Pg 25-6). Moreover, because of the current drought conditions, spring is now an important period for bloom formation. (SJC-048, Glibert et al. 2014)

From the limited summary flow data provided in these two sources, it appears that the flows immediately downstream of the intakes would be altered in the following manner, at 5,000 cfs, 900 cfs would be diverted, leaving 4,100 cfs in the river. At 15,000 cfs, 3,000 cfs would be diverted, leaving 12,000 cfs in the river. At 22,000 cfs, 9,000 cfs would be diverted, leaving 13,000 cfs in the river. These flow rules result in a flow reduction of 18% to 41%. Under these rules, the flow would for the vast majority of the time would be constrained from 4,100 cfs to 13,000 cfs, removing most of the flow variability (except in flood) and regulating the flow.

These flows are directly equivalent to the range of flows at Freeport during critically dry year (mean 9,345 cfs 1922) to a dry year (mean 16,003 cfs 1989). (SJC-049, ICF 2016, Pg. 2-3). In plain language, the project rules create a drought equivalent condition on the Sacramento River. Notwithstanding those rules, the scenarios that were provided as illustration of the project modeling analysis for 1978, which was also classified as a dry year, is modeled with a flow in the river of 14,000 cfs, and a 6,000 cfs diversion, leaving 8,000 cfs in the river with a 43% flow reduction. The same modeling shows that even in an above normal year (1993), at a flow of 11,000 cfs, 8,000 cfs is diverted, leaving 3,000 cfs in the river, a reduction of 73% (DWR 5 errata, Pg 25-6). These rules and their associated modeling illustrate that the project will reduce flows to the same as occur in critically dry and dry years. The ecological effects will be the same as what occurs in equivalent drought periods, but, potentially, even worse, since the frequency of these periods is likely to increase in comparison to recent history.

The project's impacts associated with, and related to, algae in general and cyanobacteria specifically, leading to the formation of concentrations of these organisms (blooms [mats or scum]), include: lower flows compared to the same period in the Sacramento River below the intakes, with the resulting lower dilution potential, reduced assimilative capacity, and longer residence times, amplification of the flow split from Delta Cross-channel (lowering flows further in the Sacramento River sloughs and Cache Slough complex), and increased temperatures.

The project operational control of flows, and the removal of flow within the North Delta is not the only project operation that can induce or maintain HABs. The project analysis includes a brief and non-specific analysis for potential impacts associated with riparian and tidal habitat creation, providing locally increased nutrients. (DWR-3; RDEIR, App. A, p. 28-16 (Environmental Justice).) Where there is any project analysis regarding HABs, the project impacts are largely ignored, and, instead, what limited analysis exists is solely and incorrectly focused on the nutrient data, and their relationship to the blooms of a single species, *Microcystis aeruginosa*. (SCWRB-3 RESIRC 2622 Pg. 14-20)

The degree of impact on human health and drinking water supplies from the project's impacts on blue-green algae is not adequately assessed or mitigated in the material submitted in support of the Petition. The testimony and supporting material submitted in support of the Petition all but ignores the project diversion's relationship to flow, nutrients and their associated environmental impacts. The limited analysis instead looks at a single dimension of algal dynamics, nutrient availability and ratio, and states that the data for nutrients are equivocal. Juxtaposing the current analysis with the CVP/SWP Contractors' 2010 comments on Sacramento Regional County Sanitation District's wastewater discharges, the data on algal bloom relationships appear to have gone from certain to uncertain when the Tunnels are the source of the impact. (SJC-050, Alameda, 2010. See also DWR-3, RDEIR/S Section 8.1.3.18 Microcystis (p. 8-45 lines 15-42 and p. 8-46, lines 1-22))

II. CYANOBACTERIAL ECOLOGY AND PUBLIC HEALTH THREATS

Cyanobacteria or blue-green algae are a 'simple' form of microscopic photosynthetic bacteria that lives in water. While they are simple structurally, Cyanobacteria are widely distributed in aquatic and terrestrial environments, globally important primary producers for the global nitrogen oxygen and carbon budgets. It is generally accepted that the chloroplasts of true algae and plants and are derived from a cyanobacterial ancestor. (SJC-051, Tomitani et al. 2006)

They are typically green, from the chlorophyll, but they also can make a number of pigment chemicals, which have different colors. An algal bloom forms when the numbers of algal cells increase rapidly to reach concentrations dense enough to be visible. The bloom typically looks like a colored cloud in the water and can form very thick layers of scum. Many genera of algae form blooms, some are important for the ecology of the system, and not all algal blooms are toxic, even if the species can create toxicity. The toxin itself is not visible and can exist long after the cell is dead. As noted, the toxic blooms are called "Harmful Algal Blooms" and can be found in many environments from lakes to the ocean.

As was first documented in the Sacramento-San Joaquin River Delta in 1999, blooms of cyanobacteria have spread for miles throughout the Delta during periods of warmer temperatures and low flows (SJC-052, Berg and Sutula, 2015). This threat of increasing algal blooms and the formation of algal toxins 'appears to increase' as the drought goes on (SJC-052, Berg and Sutula, 2015).

Phytoplankton, the entire aquatic microbial 'plant' community, have been extensively studied in the Delta and elsewhere. An existing transition point or shift in dominance from benthic diatoms to phytoplankton has been noted below the I-80 Bridge, as well as the Stockton Deep Water Ship Channel. (SJC-053, Kimball, 2011; SJC-054, Brunell, Litton and Borglin, 2008; SJC-055, Müller-Solger, Jassby, and Müller, 2002. Pg.1474). These ecological shifts on both the Sacramento River and the San Joaquin River, respectively, are associated with a number of physical factors, including strong flows above I-80 and Mossdale, and reduced flows and tidal mixing below those locations. These shifts are the discernable point where higher flow, dominant riverine processes transition to slower, tidal systems with naturally longer residence times, and differing water quality and temperature regimes. Without modeling, it is difficult to say if the project will make the upstream transition between the benthic diatom and the phytoplankton community more abrupt, or move it upriver, or create some new unknown dynamic. In any case, the natural hydrologic conditions would be amplified below the new point of diversion, as identified by the project- river stages, and other project changes to the environment that will occur, each of which can be more favorable to the formation of HABs than the current conditions.

Within the phytoplankton community, the dynamics between phyla become important in terms of which predominate under which conditions. This is why it is difficult to assert a specific outcome for a particular environmental change or series of changes without modeling. The model identifies under which conditions one or the other phyla predominate. That dynamic interaction is quantifiable through a series of correlations to documented HABs, and if calibrated iteratively can become a relatively precise, *predictive* model.

Cyanobacterial blooms have been extensively studied in the lab, field trials, and even in whole lake manipulations in Canada. These experimental studies show that if phytoplankton is entrained in the turbulent flow and redistributed vertically over the entire depth, green algae and diatoms outcompete (colonial) cyanobacteria due to a higher growth rate and reduced sedimentation losses. The advantage of buoyant cyanobacteria to float up to the illuminated upper layers is eradicated in a well-mixed system. (SJC-056, Visser, 2015) Lower flows also increase blooms because lower flows can reduce water column mixing. (SJC-052 Berg, 2015) Said another way, increased flows can control conditions cyanobacterial blooms both mechanically by breaking up the bloom, and also through ecological, competitive controls.

Cyanobacteria have growth rate increase of 100 to 400 percent every 10 degree C rise in temperature. (SJC-052, Berg and Sutula, 2015, p. 32.) As with most microorganisms, they have a logarithmic response to the appropriate ecological conditions, responding very rapidly to what can appear to be subtle differences in factors such as temperature or sunlight. (See Figures 1, 2, and 3 attached hereto) A couple of degrees of increased temperature can lead to HABs in just a few days. Higher temperatures also prompt higher levels of toxins. (SJC-057 Brutemark, 2015.) Increased salinity levels (up to 10 parts per trillion) do not significantly harm these organisms, as they survive in brackish water. (SJC-052 Berg, 2015.) Blooms of cyanobacteria also reduce the dissolved oxygen content in a water body, and block sunlight needed by other living organisms. (SJC-052 Berg, 2015.) For this reason, cyanobacteria's role was investigated as a potential correlate with the pelagic organism decline in the Delta. (SJC-058, Lehman, 2005.)

Cyanobacteria present public health issues because of the potent toxins found in many different genera of cyanobacteria cause symptoms in both animals and humans, ranging from vomiting, rashes, headaches, and diarrhea to liver failure, and even death. (SJC-059 Office of Environmental Health Hazard Assessment, 2009; SJC-060 U.S. EPA, 2015.) The International Agency for Research on Cancer lists the toxin found in cyanobacteria as possibly carcinogenic to humans. (SJC-061, Cogliano, 2010.) Similar to mercury and other bioaccumulative toxins, cyanobacteria toxins are known to build up in the bodies of fish and shellfish; it also can contaminate food crops when present in irrigation water. (SJC-061, Cogliano, 2010, p. 357-358.)

The presence of cyanobacteria toxins, notably microcystins, can shut down drinking water supplies. Nationally, there have been "do not drink or boil" advisory for their water when a cyanobacterial bloom near Toledo's drinking water intake on Lake Erie caused microcystin to spike in samples in 2014. (SJC-060, U.S. EPA, 2015, p. 14.)

The "Do not boil" advisory is an important consideration, because (as distinct from responses to many other dangerous bacterial species, such as fecal coliforms) boiling microcystin contaminated water will not render the contaminant harmless. A species related to the cyanobacteria that contaminated Ohio drinking water has been detected in the Delta, *Microcystis aeruginosa.* (SJC-045 Kurobe, 2013.) Traditional methods of killing algae, such as algaecide, can actually increase the presence of the cyanobacteria toxin, which releases upon the death of the organism. (SJC-060, U.S. EPA, 2015, p. 41.) Conventional water treatment systems do not remove the toxins; therefore, U.S. EPA recommends that drinking water systems affected by a cyanobacteria bloom change the location of their intakes, purchase well water from a neighbor, or add expensive additional treatments such as reverse osmosis. (SJC-060, U.S. EPA, 2015, pp. 41-43.)

III. HARMFUL ALGAL BLOOMS IN THE DELTA, CURRENTLY

As described, the current drought conditions provide context for observing the impacts of the project; these are the effects of reduced freshwater flows from the Sacramento River, leading to resulting increased residence times and localized increased water temperatures. These are the conditions that lead to HAB formation in the Delta. (SJC-058, Lehman, 2005.)

The serious and increasing incidence of HABs in San Joaquin County, and State and local government's awareness of, and efforts to respond to the hazards HABs pose in San Joaquin County are amply illustrated in the Testimony of Linda Turkatte, submitted concurrently herewith. (See Exh. SJC-002.)

Even Sacramento had a recent (October 5, 2015) death of a dog in the Sacramento River at a public beach directly attributed to cyanobacteria.[2] Per the Sacramento Bee article, the Sacramento County environmental health division chief said he expects more blue-green algae events if the state's four-year drought continues: "That's because droughts create more pockets of slow-moving warm water in rivers, a situation that triggers more algal blooms." The identical conditions will be created or exacerbated by the proposed project.

The testimony and other material submitted in support of the Petition fails to consider the readily-available literature provided by the CalEPA's Office of Environmental Health Hazard Assessment ("OEEHA"), which documents these issues, which directly relate back to the defined beneficial uses, in great detail:

> Many cyanobacteria species produce a group of toxins known as microcystins, some of which are toxic;

---

2 http://www.sacbee.com/news/local/environment/article38250372.html

> Upon ingestion, toxic microcystins are actively absorbed by fish, birds and mammals;
>
> People swimming, waterskiing, or boating in contaminated water can be exposed to microcytins;
>
> Microcystins may also accumulate in fish that are caught and eaten by people;
>
> Finally, pets and livestock have died after drinking water contaminated with microcystins.[3]

Moreover:

> Microcystins are toxic to fish at concentrations as low as a few micrograms per liter (µg/L) or possibly even fractional µg/L. Finally, Blooms of cyanobacterial species that produce microcystins and/or anatoxin-a have coincided with the deaths of ducks, gulls, songbirds, pheasants and hawks, as well as several other bird species. The severity of such bird kills have ranged from a few individuals to several thousand birds per incident.

(*Ibid.*)

The OEEHA report identifies that it is not just one genus, *Microcystis*, but several, that create the toxins. People, agricultural and domestic animals, birds and fish are at direct and acute risk. The risk to fish is exceptionally high. And, the report further explains that conditions that are not classically considered favorable for bloom formation can still lead to toxicity sufficient to kill even mammals.

The project will cause changes to water operations and creation of project-required tidal and floodplain restoration areas that change water residence times within Delta channels, and increases in Delta water temperatures. "The data do not represent the length of time that water in the various subregions spends in the Delta in total, but do provide a useful parameter with which to compare generally how long algae would have to grow in the various subregions of the Delta." (DWR-3, RDEIR/S, Section 8.3.1.7, p. 8-82, p. 31-43.)

---

[3] http://oehha.ca.gov/ecotox/documents/Microcystin031209.pdf

In the RDEIR/S, much is made regarding Redfield ratios associated with historic nutrient levels, but there is no evidence provided that nutrients are limiting, indeed research demonstrates the opposite is likely, the nutrients are at more than sufficient levels for algal blooms and one or more factors, namely light deficiency and velocity-induced mixing are controlling near the proposed intakes. (SJC-053, Kimball, 2011; SJC-054, Brunell, Litton and Borglin, 2008; SJC-055, Jassby, and Müller, 2002.) Water clarity, temperature and nutrients that support blue-green algal growth needs and HAB formation in the Delta and its waterways are already sufficient to support the toxic blooms since they have already occurred in both places.

IV. IMPACTS OF THE PROPOSED WATERFIX PROJECT ON CONDITIONS CONDUCIVE TO FORMATION OF HARMFUL ALGAL BLOOMS.

Based on the flow description and operational rules provided in SWRCB-3, and the failure to present any scientific supporting information to the contrary, the proposed changes in the point of diversion will have obvious consequences for water quality, quantity and more subtle, yet equally profound effects on the ecology of the Delta. Because the Delta and its tributaries and sloughs are subject to significant tidal influence from the Pacific Ocean and through the San Francisco Bay, they are also subject to multiple physical processes and thus ecological processes ranging from river-like to lake-like (fluvial to lacustrine), twice a day. This hydrologic condition of tides slowing the rate of downstream transport, is exacerbated by the Project's removal of significant fractions of flow, which change the hydraulic head of the river (advection) and increase the residence time downstream of the intakes, and within each of those proximate sloughs. Some of these potential project impacts have already been identified by federal scientists:

> "Uncertainty about New Facilities and Habitats Decades of hydrodynamics monitoring, modeling, and special studies indicate that restoration or changes in water conveyance in one area can substantially affect basic hydro-dynamic processes and transport in others. Many changes are proposed for the Sacramento–San Joaquin River Delta to meet the State's goals of "providing a more reliable water supply for California and

protecting, restoring, and enhancing the delta ecosystem" (Delta Stewardship Council, 2013). Documenting how these changes affect flows in the delta is important. The proposed flooding of Sherman Island, for example, could affect hydrodynamics and transport processes, including salinity intrusion, throughout the delta. Withdrawing water from the system into an isolated water-conveyance facility, such as the currently proposed twin tunnels, would also alter transport throughout the delta. If built, net flows throughout the north and western Sacramento–San Joaquin River Delta would be proportionately reduced by the amount withdrawn into the conveyance facility, increasing the influence of the tides throughout the delta. If the conveyance facility is built, the north-to-south draw of water across the delta that has existed for decades would likely be reduced as a result of compensatory reductions in pumping from the south delta, creating much longer average residence times. Longer residence times are associated with higher rates of algal growth, which could fuel eutrophication in some regions, including increased blooms of nuisance algae, such as Microcystis, which is toxic to humans and other organisms (Lehman and others, 2013). In the coming decades, the flow-station network can provide data that address uncertainty concerning the location of proposed water-conveyance facilities and that, after they are built, document the effects of these new water-conveyance facilities, management actions, and habitat-restoration efforts."

(SJC-063, USGS Fact Sheet 2015-3061. 2016)

Yet, despite what seem obvious to ecologists, aquatic chemists, and geomorphologists, the project documentation submitted by Petitioners fails to take the aquatic environmental changes created by the proposed project and their likely consequences into account.

For example, the conditions in the Sacramento River created by the proposed project operations are the very same conditions -- reduced flow, longer retention times, and likely localized higher temperatures -- identified in the basic ecology discussion provided above known to promote cyanobacterial blooms. Furthermore, flow reduction also directly affects velocity, which maintains particles in suspension, leading to "drop out" of sediment, and this loss of sediment related turbidity, which is further compounded by the project's removal of sediment at the intakes, and flow reversals. (SJC-054, Brunell, Litton, and Borglin, 2008, Pg.2-3, 12)

The significant reduction of sediment, thus influencing turbidity, results in greater sunlight penetration of the water column. This light is likely to support phytoplankton, which get their energy from sunlight, and is understood to be one of the key controlling factors for HAB formation in the Delta.

Potential Impacts of Climate Change on HABs in the Delta

The drought has demonstrated the link between lower flows and HAB formation within the Delta. This is not unexpected, as science has well identified that under appropriate nutrient conditions, lower flows and longer retention time are directly associated with HAB formation.

The uncertainties that climate change can create does not necessarily mean that climate change by itself will induce more HABs. For example, increased precipitation and greater flushing flows could occur under scenarios for the Delta. (SJC-064, Cloern et al. 2014) Increased temperature is of course a driver, but significant improvements in water quality through nutrient control have been and continue to be implemented by the SWRCB and the CVRWQCB. These controls if done strategically may countervail the HAB temperature response to some degree.

Given the wide range of uncertainty regarding the ultimate climate change trajectory, and the temporal difference between when the project is proposed and the more significant impacts of that change in the Delta, the project should use or develop a model for HABs and their formation processes in the Delta, and then provide model support to demonstrate how it will not induce HABs through its operations over the next 20 years.

The project's operational effects of locally increasing water temperature, reducing flows into the Delta to levels similar to known conditions that create HAB formations in the Delta from the Sacramento River would worsen the HABs problems in the Delta. Moreover, project induced increased dominance of cyanobacterial blooms can significantly disrupt the aquatic food chain (zooplankton) reducing both diversity and food quality of these resources for fish and piscivorous wildlife. (SJC-065, Reichwaldt, Song, and Ghadouani, 2013.)

In any case, the Petitioners are obligated to demonstrate scientifically why the project would not induce or sustain these HABs, and to describe the effects of these induced HABs on the beneficial uses of water for both short-term impacts and potential climate change scenarios. Petitioners case in chief fails to do so, and indicates that water uses will in fact be injured by HABs should the Petition be granted.

IV. CONCLUSION

The project has direct impacts on flows by removing significant portions of Sacramento flow, the primary freshwater source of the Delta. The combined project operations associated with this diversion also directly manipulates the source waters through dam releases, and controls the remaining (bypass) flows within the Delta through operation of the Delta Cross Channel, which directs the flows to the east; and, then through operations of the South Delta pumps, which control regional circulation. The new intakes will also remove sediment, which allows for more light to enter the water column and exacerbates algal growth.

As most Delta agriculture, and many municipalities are reliant on pumping directly from rivers and sloughs, HABs and their toxic microcystins can lead to many problems ranging from illness to mortality as a result of direct and indirect environmental conditions exacerbated or created by the project both in the near-term and cumulatively. Removing significant fractions of the flow of the Sacramento River and concentrating that effect in a river corridor profoundly changes the downstream channel flow (velocity). The flow-related dilution and water column mixing, as well as the induction of flow reversals which serve to lengthen residence time, are further exacerbating conditions that lead to HAB formation and maintenance. These project-caused ecological conditions can amplify natural conditions that are suitable for HABs and create the tipping point for bloom expression.

The Petition fails to demonstrate how the project will protect beneficial uses, or protect legal users of the water from HABs created or made more made more likely to occur across a variety of water years by the project.

Executed on the 1st Day of September at Sacramento, California.

Erik Ringelberg

CITED REFERENCES

Alameda County Water District, Alameda County Flood Control and Water Conservation District, Zone 7, Contra Costa Water District, Metropolitan Water District of Southern California, Santa Clara Valley Water District, State Water Contractors (Alameda). 2010. Comments on Drinking Water Supply and Public Health Issues Concerning the Sacramento Regional Wastewater Treatment Plant NPDES Permit Renewal. Letter to Ms. Kathy Harder, Central Valley Region Regional Water Quality Control Board. See pg 57 footnote for averages.

Berg, M. and M. Sutula. 2015. *Factors Affecting Growth of Cyanobacteria With Special Emphasis on the Sacramento-San Joaquin Delta.* Central Valley Regional Water Quality Control Board: Southern California Coastal Water Research Project. Technical Report No. XXX (DRAFT).

Brunell, M. S., G.M. Litton and S. Borglin. 2008. An Analysis Of Grazing And Phytoplankton Communities In The Lower San Joaquin River Above The Stockton Deep Water Ship Channel. San Joaquin Valley Drainage Authority, San Joaquin River, Up-Stream DO TMDL Project, ERP - 02D - P63 Task: 9

Brutemark, A. E.-Ö. 2015. Growth, toxicity and oxidative stress of a cultured cyanobacterium (*Dolichospermum* sp.) under different CO2/pH and temperature conditions. *Phycological Research*, 63: 56–63.

Cloern. JE.., Knowles N., Brown L.R., Cayan D., Dettinger M.D., et al. 2013. Projected Evolution of California's San Francisco Bay-Delta-River System in a Century of Climate Change. PLoS ONE 6(9): e24465. doi:10.1371/journal.pone.0024465

Coetsee, R. 2015. Delta water weed problems called the worst in years . *Contra Costa Times* 20 January 2015. http://www.contracostatimes.com/breaking-news/ci_27358409/delta-water-weed-problems-called-worst-years

Cogliano, V. J. 2010. Volume 94: Ingested Nitrate and Nitrite, and Cyanobacterial Peptide Toxins. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans* (p. 422). Lyon, France: World Health Organization.

Cohen, A. N. and Moyle, P. B. 2004. Summary of data and analyses indicating that exotic species have impaired the beneficial uses of certain California waters. http://www.sfei.org/sites/default/files/biblio_files/2004-ImpairedCalWaters382.pdf

Department of Boating and Waterways. 2002. *Environmental Impact Report Excerpt*. 9 July 2002. http://www.dbw.ca.gov/PDF/Egeria/WHSciProbsExcerpts.pdf

Durand, J. 2008. Delta Foodweb Conceptual Model. Sacramento (CA): Delta Regional Ecosystem Restoration Implementation Plan.

Glibert, P.M. et al. 2014. Major – but rare – spring blooms in 2014 in San Francisco Bay Delta, California, a result of the long-term drought, increased residence time, and altered nutrient loads and forms. / Journal of Experimental Marine Biology and Ecology 460 (2014) 8–18

Kassim, Z., Akbar J., Lim K. C., Nur F. Z. and Nur H. A. 2014. Sustainable Technique for Selected Live Feed Culture in: "Sustainable Aquaculture Techniques", book edited by Martha Patricia Hernandez- Vergara and Carlos Ivan Perez-Rostro, ISBN 978-953-51-1224-2, (Figure. Cellular Growth at Different Nutrient Levels)

Kimball, J. W. 2011. Freshwater Ecosystems. In Biology Pages. http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/F/Freshwater.html

Kurobe, T. E. 2013. Identification of Harmful Cyanobacteria in the Sacramento-San Joaquin Delta and Clear Lake, California by DNA Barcoding. *SpringerPlus 2*, 491.

Lehman, P. W., G. Boyer, C. Hall, S. Waller, and K. Gehrts. 2005a. *Microcystis biomass and toxicity.* Sacramento: Interagency Ecological Program Pelagic Organism Decline Work Group.

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.

Lehman, P. W., G. Boyer, M. Satchwell, and S. Waller. 2008a. The Influence of Environmental Conditions on the Seasonal Variation of Microcystis Cell Density and Microcystins Concentration in San Francisco Estuary. *Hydrobiologia* 600(1):187–204.

Lopez, C.B., Jewett, E.B., Dortch, Q., Walton, B.T., Hudnell, H.K. 2008. Scientific Assessment of Freshwater Harmful Algal Blooms. Interagency Working Group on Harmful Algal Blooms, Hypoxia, and Human Health of the Joint Subcommittee on Ocean Science and Technology. Washington, DC.

Müller-Solger, A.B., A.D. Jassby, D.C. Müller. 2002. Nutritional Quality of Food Resources for Zooplankton (Daphnia) in a Tidal Freshwater System (Sacramento-San Joaquin River Delta): Limnology and Oceanography, Vol. 47, No. 5 (Sep., 2002), pp. 1468-1476.

Office of Environmental Health Hazard Assessment. 2009. *Microcystis: Toxic Blue-Green Algae.* http://oehha.ca.gov/ecotox/pdf/microfactsheet122408.pdf deadlink

Pal S. W., N. K. Singh and K. Azam. 2013. Evaluation of Relationship between Light Intensity (Lux) and Growth of *Chaetoceros muelleri*. School of Marine Studies, Faculty of Science, Technology and Environment, University of the South Pacific, Fiji. (Figure Microalgae response to light.)

RWQCB [California Central Valley Regional Water Quality Control Board] 2006.The Water Qality Control Plan (Basin Plan) for the California Regional \ Water Quality Control Board Central Valley Region. Fourth Edition. Rev Apr. 2006. The Sacramento River Basin and the San Joaquin River Basin(,) California.

Reichwaldt E.S., H.Song, A. Ghadouani. 2013. Effects of the Distribution of a Toxic Microcystis Bloom on the Small Scale Patchiness of Zooplankton http://dx.doi.org/10.1371/journal.pone.0066674

Sabalow, R. 2015. Unusual Delta Algae Bloom Worries Researchers. *Sacramento Bee*, pp. http://www.sacbee.com/news/state/california/water-and-drought/delta/article32394438.html.

Tomitani A., A.H. Knoll, C. M. Cavanaugh, and T. Ohno. 2006. The evolutionary diversification of cyanobacteria: Molecular–phylogenetic and paleontological perspectives. Proceedings of the National Academy of Sciences. 5442–5447, doi: 10.1073/pnas.0600999103.

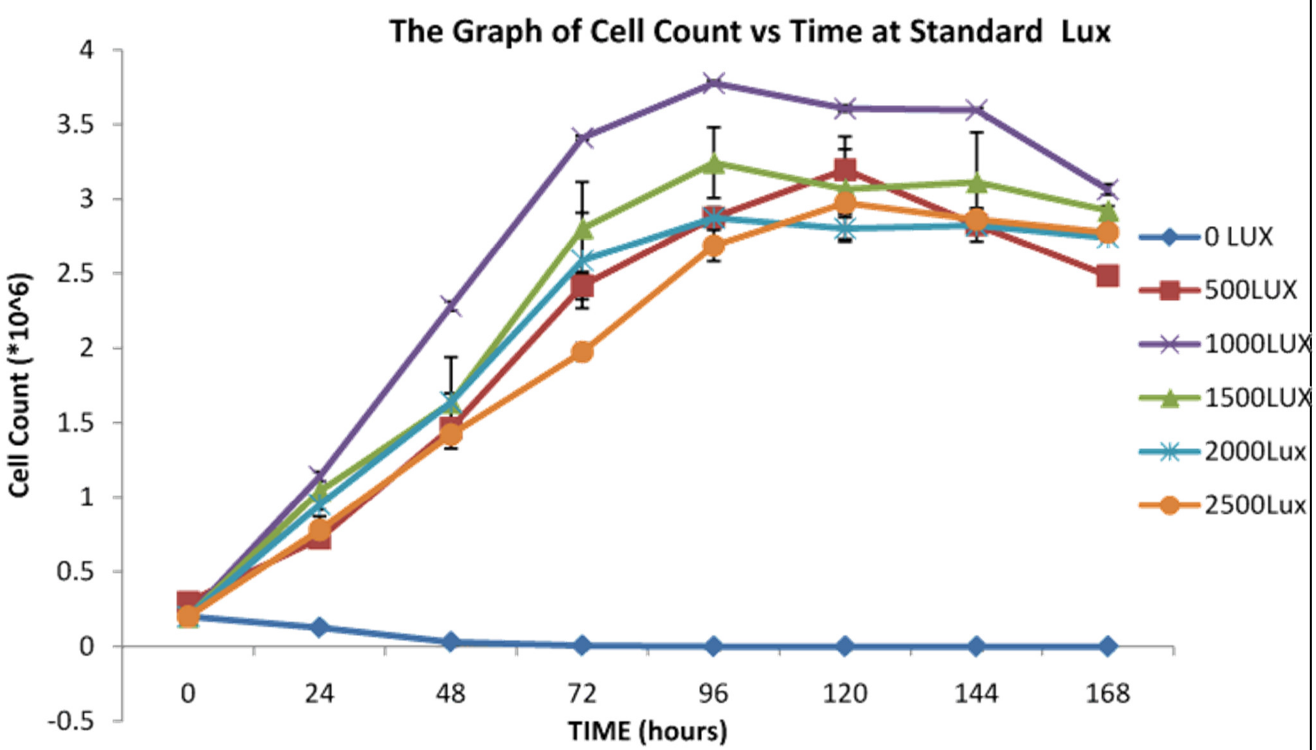
U.S. EPA. (2015). *Drinking Water Health Advisory for the Cyanobacterial Microcystin Toxins.* Washington, DC: U.S. Environmental Protection Agency.

U.S. Geologic Survey [USGS] 2016. Innovation in Monitoring: The U.S. Geological Survey Sacramento–San Joaquin River Delta, California, Flow-Station Network. Fact Sheet 2015-3061.

Visser, P.M., B.W, Ibelings, M., Bormans, and J. Huisman. 2015. Aquatic Ecology doi:10.1007/s10452-015-9537-0

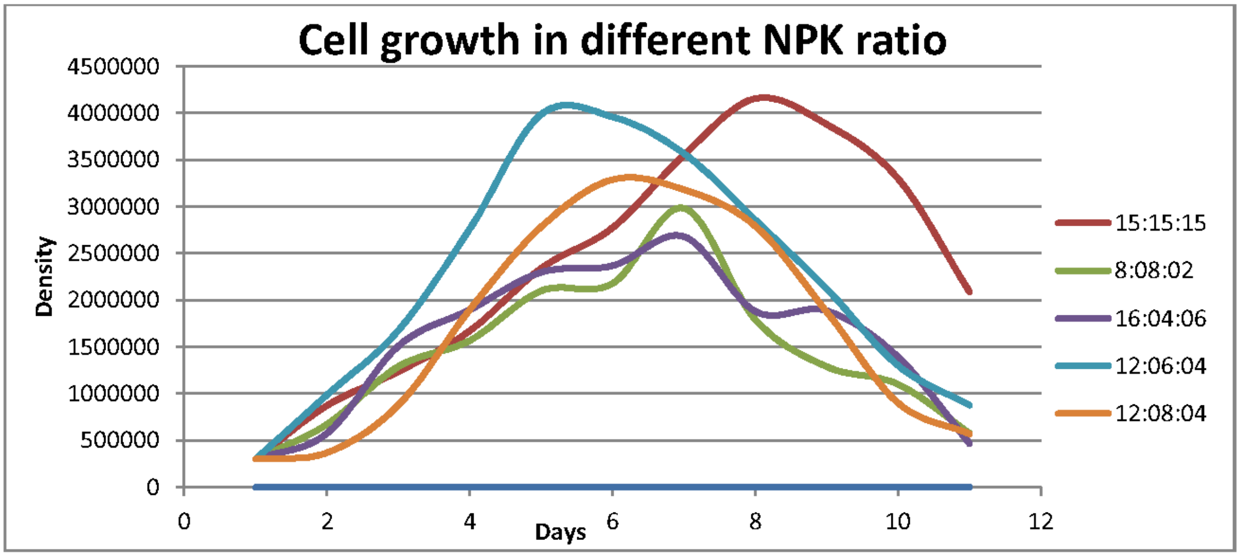
Attached Figures

Figure 1. Chaetoceros Cell Counts at Varying Light Levels



SJC-066 Pal S. W., N. K. Singh and K. Azam. 2013. Evaluation of Relationship between Light Intensity (Lux) and Growth of *Chaetoceros muelleri*. School of Marine Studies, Faculty of Science, Technology and Environment, University of the South Pacific, Fiji. (Figure Microalgae response to light.)

Figure 2. Chlorella Growth Rate at Varying Nutrient Ratios



SJC- 067 Kassim, Z., Akbar J., Lim K. C., Nur F. Z. and Nur H. A. 2014. Sustainable Technique forSelected Live Feed Culture in: "Sustainable Aquaculture Techniques", book edited by Martha Patricia Hernandez- Vergara and Carlos Ivan Perez-Rostro, ISBN 978-953-51-1224-2, (Figure. Cellular Growth at Different Nutrient Levels)

Figure 3.

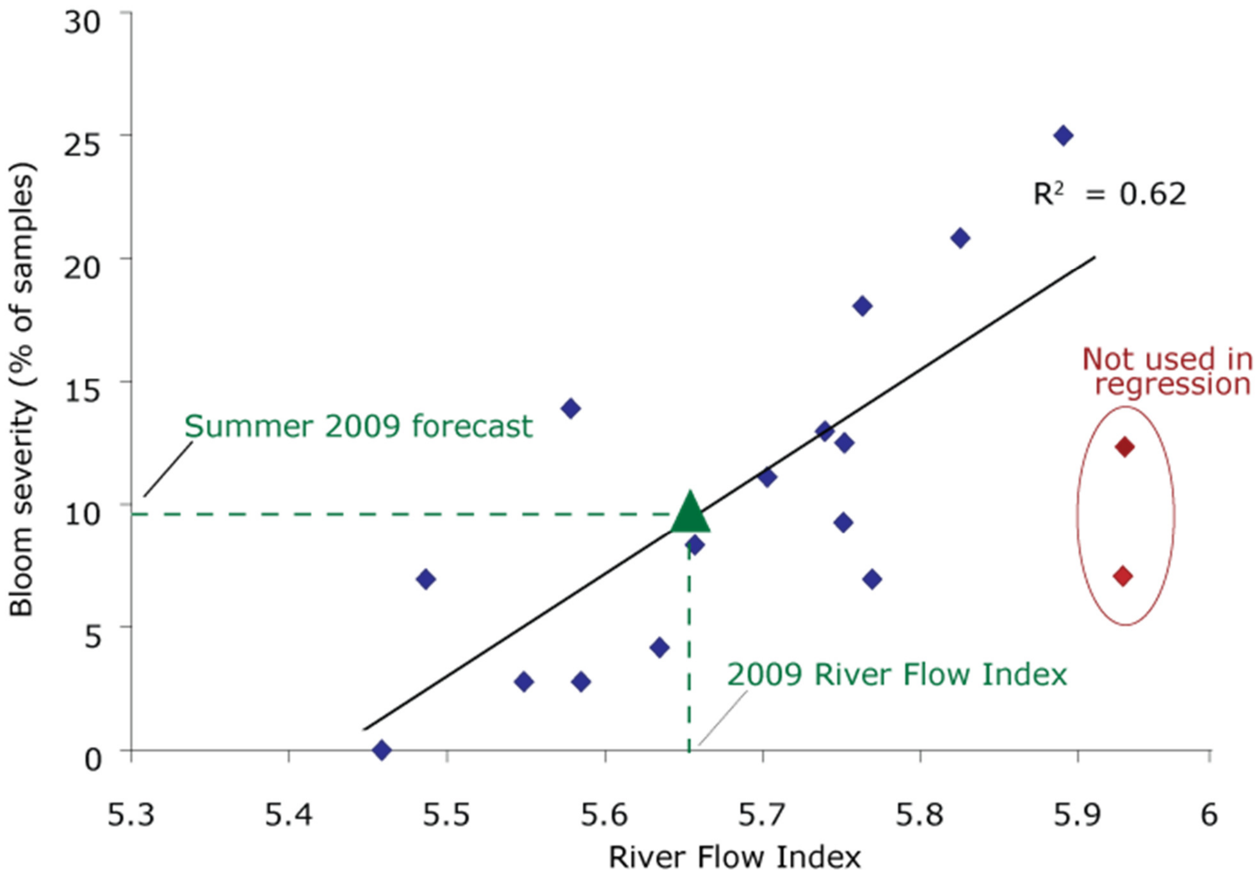


Figure 1. Regression relationship between river flow index at Point of Rocks, Potomac River, MD and Bloom Severity Index as % of samples in a summer season where bloom levels of *Microcystis* were detected. 2008 Summer Forecast is shown here.

X-axis: River Flow Index = Log_{10}(Cumulative 17 month flow in cubic feet/$(1 * 10^{-6})$)
Y-axis: Bloom Severity Index = % Summer Potomac samples at bloom level

SJC-047 Tango, P. 2009. HAB. USGS. (Microcystis) Growth Model, Potomac Algal Bloom http://ian.umces.edu/ecocheck/forecast/chesapeake-bay/2009/indicators/microcystis#_Methodology