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19 Mokelumne River Water and Power Authority

20 [ADDITIONAL COUNSEL LISTED ON FOLLOWING PAGE]

21 **BEFORE THE**
22 **CALIFORNIA STATE WATER RESOURCES CONTROL BOARD**

23 HEARING IN THE MATTER OF
24 CALIFORNIA DEPARTMENT OF WATER
25 RESOURCES AND UNITED STATES
26 BUREAU OF RECLAMATION
27 REQUEST FOR A CHANGE IN POINT OF
28 DIVERSION FOR CALIFORNIA WATER
FIX

TESTIMONY OF ERIK RINGELBERG

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1 I, Erik Ringelberg, do hereby declare:

2 **I. INTRODUCTION**

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

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

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

21 **II. OVERVIEW – MICROCYSTIS IN THE DELTA**

22 My testimony is intended to provide scientific analysis and conclusions about the likely
23 project impacts on toxic algal growth, colony formation, and toxic byproduct formation because
24 of the proposed diversions on the Sacramento River near Clarksburg. The proposed project
25 influences flow and water quality within Sacramento San Joaquin Delta as a result of this
26 diversion, and those factors further influence the formation of Hazardous Algal Blooms (“HABs”
27 or CyanoHABs).
28

1 ***Cyanobacteria and Hazardous Algal Blooms***

2 ***Summary***

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

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

16 There is information provided on one genus of HABs (*Microcystis*) in Exhibits SWRCB-
17 3, SWRCB-4, and SWRCB-5, despite molecular biologists identifying the HABS in the Delta
18 (and elsewhere) could contain or be caused by multiple genera, and identifying that genus
19 being less dominant in the Delta, potentially being replaced by the toxic *Aphanizomenon*
20 *flosaquae*. (SJC-045 Kurobe et al. 2013) I have analyzed information provided in Exhibits
21 SWRCB-3, SWRCB-4, and SWRCB-5 in detail as a part of my comments on the project
22 previously. (Exhibit SCWRB-3 RESIRC 2622 Pg. 14-20)

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

27 The Project documentation states: "...beneficial uses in the Delta will not be negatively
28 impacted by operations with the new point of diversion." (SWRCB-1, Pg. 19) The scientific

1 question of how the project could affect the environment is not evident because of the
2 inadequacies in analysis and water quality modeling of the proposed project. Because of the
3 lack of supporting information provided by the Petitioners, I looked at relevant information
4 available from other sources that could be used as surrogates for the proposed action and
5 extrapolated from existing conditions that were the most similar to project operations. Contrary
6 to the project's analysis in SWRCB-3, there are several scales of models available for HAB
7 formation, including for the Sacramento-San Joaquin Delta (Delta) (Attachment Figure 4).
8 There is a detailed Delta food web model, as well as predictive models used for the Potomac
9 and Lake Eire¹. (SJC-046 Durand, 2008, SJC-047 Tango 2009) The project failed to apply any
10 of those models to this project. Finally, since there was no HAB modeling provided for me to
11 review any technical basis of their conclusion of no injury, I examined how the proposed
12 project impacts could be assessed by the last remaining metric, the Basin Plan itself. The
13 following is an analysis of the Project's potential impacts on these beneficial uses:

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

19
20 The beneficial uses relevant to project impacts to water quality are identified in the 2006
21 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta Estuary
22 (Basin Plan) as follows:
23

24 Municipal and Domestic Supply; Recreation-Contact; Agriculture- Irrigation and Stock
25 Watering, and including although not expanded upon in detail in this analysis,
26 Freshwater Habitat- Warm and Cold, and Wildlife.
27
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¹ <http://lakeeriealgae.com/forecast/>

1 (SWRCB-27.)

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

12 From the limited summary flow data provided in these two sources, it appears that the
13 flows immediately downstream of the intakes would be altered in the following manner, at
14 5,000 cfs, 900 cfs would be diverted, leaving 4,100 cfs in the river. At 15,000 cfs, 3,000 cfs
15 would be diverted, leaving 12,000 cfs in the river. At 22,000 cfs, 9,000 cfs would be diverted,
16 leaving 13,000 cfs in the river. These flow rules result in a flow reduction of 18% to 41%. Under
17 these rules, the flow would for the vast majority of the time would be constrained from 4,100
18 cfs to 13,000 cfs, removing most of the flow variability (except in flood) and regulating the flow.

19 These flows are directly equivalent to the range of flows at Freeport during critically dry
20 year (mean 9,345 cfs 1922) to a dry year (mean 16,003 cfs 1989). (SJC-049 ICF 2016, Pg. 2-
21 3). In plain language, the project rules create a drought equivalent condition on the
22 Sacramento River. Notwithstanding those rules, the scenarios that were provided as illustration
23 of the project modeling analysis for 1978, which was also classified as a dry year, is modeled
24 with a flow in the river of 14,000 cfs, and a 6,000 cfs diversion, leaving 8,000 cfs in the river
25 with a 43% flow reduction. The same modeling shows that even in an above normal year
26 (1993), at a flow of 11,000 cfs, 8,000 cfs is diverted, leaving 3,000 cfs in the river, a reduction
27 of 73% (DWR 5 errata, Pg 25-6). These rules and their associated modeling illustrate that the
28 project will reduce flows to the same as occur in critically dry and dry years. The ecological

1 effects will be the same as what occurs in equivalent drought periods, but, potentially, even
2 worse, since the frequency of these periods is likely to increase in comparison to recent
3 history.

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

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

19 The degree of impact on human health and drinking water supplies from the project's
20 impacts on blue-green algae is not adequately assessed or mitigated in the material submitted
21 in support of the Petition. The testimony and supporting material submitted in support of the
22 Petition all but ignores the project diversion's relationship to flow, nutrients and their associated
23 environmental impacts. The limited analysis instead looks at a single dimension of algal
24 dynamics, nutrient availability and ratio, and states that the data for nutrients are equivocal.
25 Juxtaposing the current analysis with the CVP/SWP Contractors' 2010 comments on
26 Sacramento Regional County Sanitation District's wastewater discharges, the data on algal
27 bloom relationships appear to have gone from certain to uncertain when the Tunnels are the
28

1 source of the impact. (SJC-050, Alameda, 2010. See also DWR-3, RDEIR/S Section 8.1.3.18
2 Microcystis (p. 8-45 lines 15-42 and p. 8-46, lines 1-22))

3 **II. CYANOBACTERIAL ECOLOGY AND PUBLIC HEALTH THREATS**

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

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

18 As was first documented in the Sacramento-San Joaquin River Delta in 1999, blooms of
19 cyanobacteria have spread for miles throughout the Delta during periods of warmer
20 temperatures and low flows (SJC-052, Berg and Sutula, 2015). This threat of increasing algal
21 blooms and the formation of algal toxins 'appears to increase' as the drought goes on (SJC-
22 052, Berg and Sutula, 2015).

23 Phytoplankton, the entire aquatic microbial 'plant' community, have been extensively
24 studied in the Delta and elsewhere. An existing transition point or shift in dominance from
25 benthic diatoms to phytoplankton has been noted below the I-80 Bridge, as well as the
26 Stockton Deep Water Ship Channel. (SJC-053, Kimball, 2011; SJC-054, Brunell, Litton and
27 Borglin, 2008; SJC-055, Müller-Solger, Jassby, and Müller, 2002. Pg.1474). These ecological
28 shifts on both the Sacramento River and the San Joaquin River, respectively, are associated

1 with a number of physical factors, including strong flows above I-80 and Mossdale, and
2 reduced flows and tidal mixing below those locations. These shifts are the discernable point
3 where higher flow, dominant riverine processes transition to slower, tidal systems with naturally
4 longer residence times, and differing water quality and temperature regimes. Without
5 modeling, it is difficult to say if the project will make the upstream transition between the
6 benthic diatom and the phytoplankton community more abrupt, or move it upriver, or create
7 some new unknown dynamic. In any case, the natural hydrologic conditions would be amplified
8 below the new point of diversion, as identified by the project- river stages, and other project
9 changes to the environment that will occur, each of which can be more favorable to the
10 formation of HABs than the current conditions.

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

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

26 Cyanobacteria have growth rate increase of 100 to 400 percent every 10 degree C rise
27 in temperature. (SJC-052, Berg and Sutula, 2015, p. 32.) As with most microorganisms, they
28 have a logarithmic response to the appropriate ecological conditions, responding very rapidly

1 to what can appear to be subtle differences in factors such as temperature or sunlight. (See
2 Figures 1, 2, and 3 attached hereto) A couple of degrees of increased temperature can lead to
3 HABs in just a few days. Higher temperatures also prompt higher levels of toxins. (SJC-057
4 Brutemark, 2015.) Increased salinity levels (up to 10 parts per trillion) do not significantly harm
5 these organisms, as they survive in brackish water. (SJC-052 Berg, 2015.) Blooms of
6 cyanobacteria also reduce the dissolved oxygen content in a water body, and block sunlight
7 needed by other living organisms. (SJC-052 Berg, 2015.) For this reason, cyanobacteria's
8 role was investigated as a potential correlate with the pelagic organism decline in the Delta.
9 (SJC-058 Lehman, 2005.)

10 Cyanobacteria present public health issues because of the potent toxins found in many
11 different genera of cyanobacteria cause symptoms in both animals and humans, ranging from
12 vomiting, rashes, headaches, and diarrhea to liver failure, and even death. (SJC-059 Office of
13 Environmental Health Hazard Assessment, 2009; SJC-060 U.S. EPA, 2015.) The International
14 Agency for Research on Cancer lists the toxin found in cyanobacteria as possibly carcinogenic
15 to humans. (SJC-061 Cogliano, 2010.) Similar to mercury and other bioaccumulative toxins,
16 cyanobacteria toxins are known to build up in the bodies of fish and shellfish; it also can
17 contaminate food crops when present in irrigation water. (SJC-061 Cogliano, 2010, p. 357-
18 358.)

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

23 The "Do not boil" advisory is an important consideration, because (as distinct from
24 responses to many other dangerous bacterial species, such as fecal coliforms) boiling
25 microcystin contaminated water will not render the contaminant harmless. A species related to
26 the cyanobacteria that contaminated Ohio drinking water has been detected in the Delta,
27 *Microcystis aeruginosa*. (SJC-045 Kurobe, 2013.) Traditional methods of killing algae, such as
28 algaecide, can actually increase the presence of the cyanobacteria toxin, which releases upon

1 the death of the organism. (SJC-060, U.S. EPA, 2015, p. 41.) Conventional water treatment
2 systems do not remove the toxins; therefore, U.S. EPA recommends that drinking water
3 systems affected by a cyanobacteria bloom change the location of their intakes, purchase well
4 water from a neighbor, or add expensive additional treatments such as reverse osmosis.
5 (SJC-060, U.S. EPA, 2015, pp. 41-43.)

6 **III. HARMFUL ALGAL BLOOMS IN THE DELTA, CURRENTLY**

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

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

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

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

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

28

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

1 Upon ingestion, toxic microcystins are actively absorbed by fish, birds and
2 mammals;

3 People swimming, waterskiing, or boating in contaminated water can be exposed
4 to microcystins;

5 Microcystins may also accumulate in fish that are caught and eaten by people;

6 Finally, pets and livestock have died after drinking water contaminated with
7 microcystins.³

8 Moreover:

9 Microcystins are toxic to fish at concentrations as low as a few micrograms per
10 liter ($\mu\text{g/L}$) or possibly even fractional $\mu\text{g/L}$. Finally, Blooms of cyanobacterial
11 species that produce microcystins and/or anatoxin-a have coincided with the
12 deaths of ducks, gulls, songbirds, pheasants and hawks, as well as several other
13 bird species. The severity of such bird kills have ranged from a few individuals to
14 several thousand birds per incident.

15 (*Ibid.*)

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

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

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³ <http://oehha.ca.gov/ecotox/documents/Microcystin031209.pdf>

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

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

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

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

1 protecting, restoring, and enhancing the delta ecosystem” (SJC-062, Delta Stewardship
2 Council, 2013). Documenting how these changes affect flows in the delta is important.
3 The proposed flooding of Sherman Island, for example, could affect hydrodynamics and
4 transport processes, including salinity intrusion, throughout the delta. Withdrawing water
5 from the system into an isolated water-conveyance facility, such as the currently
6 proposed twin tunnels, would also alter transport throughout the delta. If built, net flows
7 throughout the north and western Sacramento–San Joaquin River Delta would be
8 proportionately reduced by the amount withdrawn into the conveyance facility,
9 increasing the influence of the tides throughout the delta. If the conveyance facility is
10 built, the north-to-south draw of water across the delta that has existed for decades
11 would likely be reduced as a result of compensatory reductions in pumping from the
12 south delta, creating much longer average residence times. Longer residence times are
13 associated with higher rates of algal growth, which could fuel eutrophication in some
14 regions, including increased blooms of nuisance algae, such as *Microcystis*, which is
15 toxic to humans and other organisms (Lehman and others, 2013). In the coming
16 decades, the flow-station network can provide data that address uncertainty concerning
17 the location of proposed water-conveyance facilities and that, after they are built,
18 document the effects of these new water-conveyance facilities, management actions,
19 and habitat-restoration efforts.”

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

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

24 For example, the conditions in the Sacramento River created by the proposed project
25 operations are the very same conditions -- reduced flow, longer retention times, and likely
26 localized higher temperatures -- identified in the basic ecology discussion provided above
27 known to promote cyanobacterial blooms. Furthermore, flow reduction also directly affects
28 velocity, which maintains particles in suspension, leading to “drop out” of sediment, and this

1 loss of sediment related turbidity, which is further compounded by the project's removal of
2 sediment at the intakes, and flow reversals. (SJC-054, Brunell, Litton, and Borglin, 2008, Pg.2-
3 3, 12)

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

8 ***Potential Impacts of Climate Change on HABs in the Delta***

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

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

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

24 The project's operational effects of locally increasing water temperature, reducing flows
25 into the Delta to levels similar to known conditions that create HAB formations in the Delta from
26 the Sacramento River would worsen the HABs problems in the Delta. Moreover, project
27 induced increased dominance of cyanobacterial blooms can significantly disrupt the aquatic
28

1 food chain (zooplankton) reducing both diversity and food quality of these resources for fish
2 and piscivorous wildlife. (SJC-065, Reichwaldt, Song, and Ghadouani, 2013.)

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

8 **IV. CONCLUSION**

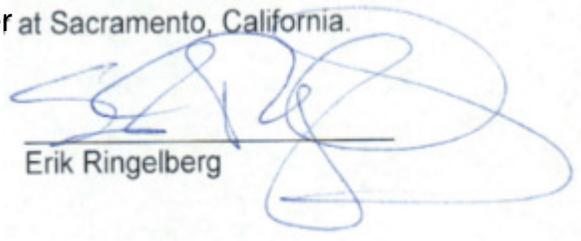
9 The project has direct impacts on flows by removing significant portions of Sacramento
10 flow, the primary freshwater source of the Delta. The combined project operations associated
11 with this diversion also directly manipulates the source waters through dam releases, and
12 controls the remaining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

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

26 The Petition fails to demonstrate how the project will protect beneficial uses, or protect
27
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1 legal users of the water from HABs created or made more made more likely to occur across a
2 variety of water years by the project.

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

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5 Erik Ringelberg
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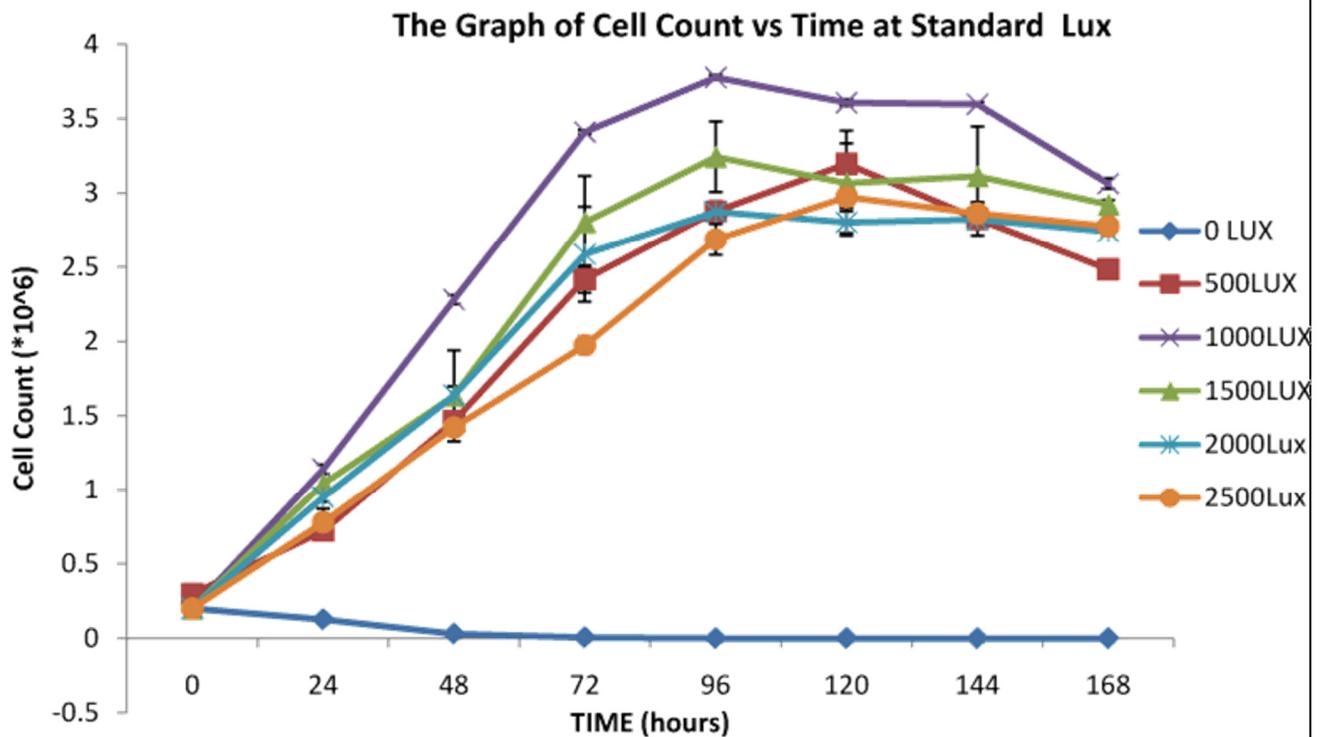
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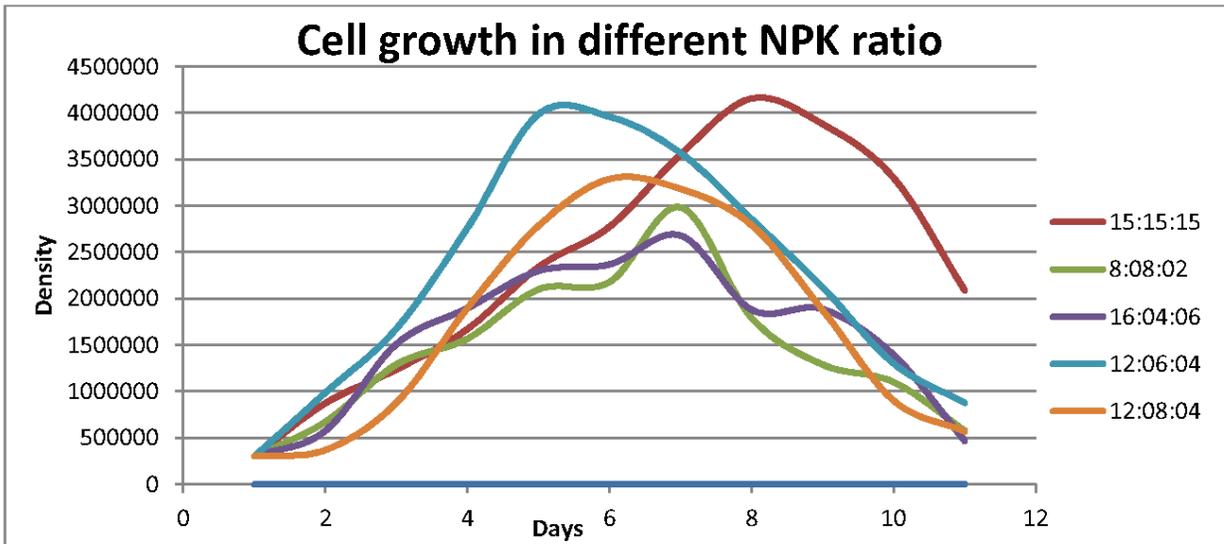
1 **Attached Figures**

2 *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 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)

Figure 3.

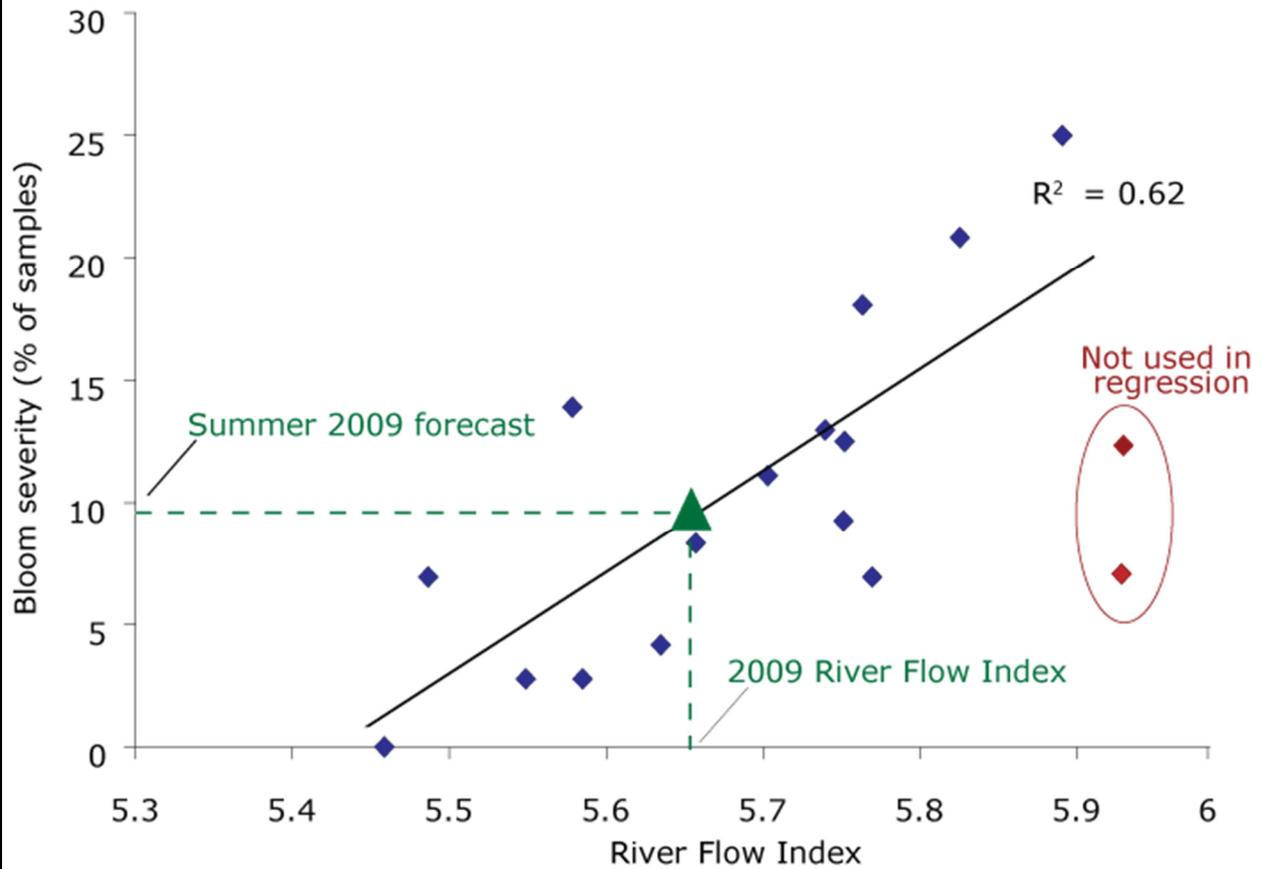


Figure 1. Regression relationship between river flow index at Point of Rocks, Potomac River, MD and Bloom Severity Index as % of samples in a summer season where bloom levels of *Microcystis* were detected. 2008 Summer Forecast is shown here.

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

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