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BEFORE THE CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

IN THE MATTER OF

CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION FOR A PETITION FOR CHANGE FOR CALIFORNIA WATERFIX

TESTIMONY OF BONNY L. STARR (EXHIBIT CITY SAC - 8)

I, Bonny L. Starr, do hereby declare:

## INTRODUCTION & SUMMARY

1. I am a registered Civil Engineer with the State of California. I have worked as a consulting engineer in source water protection, drinking water quality, and drinking water treatment since 1994. I offer my testimony in this proceeding on behalf of the City of Sacramento (Sacramento). A true and correct copy of my resume is attached to this written testimony as Exhibit City Sac - 9. My resume accurately describes my education, professional registration, and work experience.

2. At times in my testimony I refer to the California WaterFix, arising from the Petition for Change submitted on or about August 25, 2015 by the California Department of Water Resources (DWR) and the United States Bureau of Reclamation (Reclamation), which I refer to at times as the Proposed Project. Without a credible analysis of the Proposed Project impacts on Municipal and Domestic Supply (MUN) water quality upstream of the Delta, the

Proposed Project proponents have not demonstrated that the Proposed Project will not materially reduce Sacramento's MUN source water quality, which in turn impacts Sacramento's treated drinking water supply. Based upon what has been provided regarding the Proposed Project in the below-referenced documents, it appears that the Proposed Project has the potential to cause material adverse impacts on Sacramento's source water quality and hence MUN supply.

**BACKGROUND**

3. Sacramento's E.A. Fairbairn Water Treatment Plant (EAFWTP) uses the Lower American River for MUN supply, consistent with its beneficial use designation. The raw water is treated to meet all drinking water standards using conventional filtration processes with chlorine disinfection. Historically, there have been no constituents or characteristics consistently present in the raw water that necessitate additional or advanced treatment processes. Folsom Reservoir stores water from the upper watershed, which influences the quantity and quality of the water in the Lower American River. Water temperature varies greatly by season, with cold water from late fall through spring and warmer water during the summer and early fall. Turbidity and total organic carbon (TOC) levels in the raw water are relatively low for surface water, and levels have historically peaked during the winter storm season. The source water level of *E. coli* is primarily impacted by winter storm events and first flush events. The source water quality is evaluated by Sacramento every five years as part of the American River Watershed Sanitary Survey, most recently conducted in 2013 (Exhibit City Sac - 25).

4. Sacramento's Sacramento River Water Treatment Plant (SRWTP) uses the Sacramento River for MUN supply, consistent with its beneficial use designation. The raw water is treated to meet all drinking water standards using conventional filtration processes and chlorine disinfection. Historically, there have been no constituents or characteristics consistently present in the raw water that necessitate additional or advanced treatment processes. Shasta and Oroville reservoirs store large amounts of runoff from the upper watershed and largely control the flows in the Sacramento and Feather Rivers. The SRWTP is located just downstream of the confluence with the Lower American River, therefore the source water quality can also be highly influenced by the Lower American River. The water quality trends are similar to the American River, but

with higher levels of solids loading, increased organic, bacterial, and metals content, and warmer water temperatures. The SRWTP intake is approximately 650 feet upstream of the 'I' Street Bridge, which is the furthest upstream legal boundary of the Delta on the Sacramento River. The source water quality is evaluated by Sacramento every five years as part of the Sacramento River Watershed Sanitary Survey, most recently conducted in 2015 (Exhibit City Sac - 26).

5. The MUN water supplies of the Lower American River and the Sacramento River are heavily influenced by upstream reservoir operations of Folsom, Oroville, and Shasta reservoirs. Storage and releases impact the quantity and flow of water in the rivers, as well as the overall water quality (including temperature and concentrations of constituents).

6. The SRWTP and EAFWTP must comply with all federal and state primary and secondary drinking water standards, including the Surface Water Treatment Rules and Disinfectant/Disinfection By-Products Rules. These are all described in the California Code of Regulations (Title 22, Division 4, Chapters 15 through 17.5). Also, California Notification Levels and Archived Advisory Levels, as shown on the Division of Drinking Water (DDW) website[1], must be met if any of the constituents regulated by these standards are detected in the source water. For detectable constituents with no regulatory threshold, such as cyanotoxins, Sacramento must consider compliance with USEPA Health Advisories[2], if they exist, or other human health guidance values for drinking water. The SRWTP and EAFWTP are conventional filtration drinking water treatment plants as described in the direct testimony of James Peifer, P.E., Principal Engineer at the City of Sacramento Department of Utilities. (Exhibit City Sac - 1.)

7. Sacramento's treated water demands vary seasonally, as described in the direct testimony of James Peifer, P.E., Principal Engineer at the City of Sacramento Department of Utilities. (Exhibit City Sac - 1.) Water demands begin to increase in late spring, with peaks during summer, and taper off in the fall with timing dependent on rainfall.

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[1] http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/NotificationLevels.shtml

[2] http://www.epa.gov/dwstandardsregulations/drinking-water-contaminant-human-health-effects-information

8. Specialty water quality investigations were conducted by Sacramento in 2015 and 2016 regarding unusual water quality conditions in the source water related to drought conditions as described in the direct testimony of Pravani Vandeyar, Water Quality Superintendent at the City of Sacramento, Department of Utilities. (Exhibit City Sac - 6.) This included evaluation of algae and cyanotoxins in the source water. Sacramento did not identify the presence of cyanotoxins in 2015, but did have low level detects of microcystin and anatoxin in the source water in 2016. In addition, algal concentrations were higher than historic levels and present at levels sufficient to complicate operation and maintenance at the water treatment plants and necessitate special efforts to ensure protection of public health. Algae, including cyanobacteria, can cause numerous complications to a MUN supply, including; taste and odor concerns, acute health impacts, increased organic carbon levels, and interference with treatment processes (such as filter clogging and increased disinfection requirements).

**IMPACTS TO WATER QUALITY AT CITY OF SACRAMENTO INTAKES**

9. The evaluation of impacts to water quality included herein is based on the assumption that operation of the proposed North Delta Diversion (NDD) Intakes is represented by Alternative 4A of California WaterFix and the Partially Recirculated Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement (RDEIR/SDEIS), with operational scenario Alternative 4 H3 or H4 as defined and evaluated in the Draft Environmental Impact Report/Environmental Impact Statement (Draft EIR/EIS)[3] for the Bay Delta Conservation Plan (BDCP). This determination was based on:

- The Petition for Change (SWRCB-1 and SWRCB-2) and page 4 of the SWRCB October 30, 2015 Notice of this proceeding, which state that the California WaterFix Project is Alternative 4A, the CEQA preferred alternative.
- The purpose defined in the RDEIR/SDEIS (Section 1.2) as selecting Alternative 4A as the preferred alternative.

[3] BDCP Draft EIR/EIS, Chapter 3, Page 3-15, Table 3-1

- Notation in Section 3.3.1 of the RDEIR/SDEIS that the Water Supply and Climate Change analyses from the Draft EIR/EIS were not substantively changed,
- Table 4.1-1 of the RDEIR/SDEIS identifying a hybrid operational scenario of H3 and H4 with reference to the Draft EIR/EIS, and
- Confirmation in Section 4.1.6 of the RDEIR/SDEIS that what is referred to in that document as "physical modeling" for Alternative 4 of the Draft EIR/EIS accurately predicts the effects of Alternative 4A.

10. The Proposed Project NDD Intakes will add almost nine thousand cubic feet per second (9,000 cfs) of diversion capacity on the Sacramento River. There is no specific proposal as part of the Proposed Project to limit or clearly define how that capacity will be used. The lack of information provided about project operations undermines the ability to understand project impacts. However, there are some aspects of project impacts that can be gleaned from the information provided, upon which this testimony is based.

11. Operation of the NDD Intakes will alter the Sacramento River water system operations, hydraulics, and water quality. It is my understanding that modeling assessments were performed by other parties as described and presented in the direct testimony of Walter Bourez, P.E., of MBK Engineers. While some hydraulic and limited water quality effects upstream of the Delta associated with operation of the NDD Intakes are documented in the BDCP and Draft EIR/EIS documents and California WaterFix and RDEIR/SDEIS, the hydraulic and water quality effects upstream of the proposed NDD Intakes in the vicinity of Sacramento's intakes are not adequately evaluated or quantified in the BDCP, Draft EIR/EIS, California WaterFix, or RDEIR/SDEIS. Therefore, a review of the available information was conducted for this testimony to allow for identification of upstream hydraulic effects, subsequent water quality impacts, and their significance to the MUN supply for Sacramento.

12. The key potential water quality impacts from the NDD Intakes operation to Sacramento MUN supply presented in this testimony include:

- Reservoir operation changes causing increased source water temperatures contributing to blue-green algae growth in the source water and treated water DBP formation, and

- Increases in residence time/water column stability caused by changing river flows and associated lower river velocities, resulting in increased presence of blue-green algae in the source water.

13. First presented below is evidence of impacts to Sacramento's MUN supply, for both temperature effects and residence time effects, shown in the BDCP and the Draft EIR/EIS documents. This evidence of impacts is presented for the information and analysis that are only presented in these documents, not re-evaluated in the RDEIR/SDEIS, or referred to in the RDEIR/SDEIS. Next follows a presentation of evidence of impacts to Sacramento's MUN supply, for both temperature effects and residence time effects, shown in the California WaterFix and RDEIR/SDEIS documents.

***<u>Evidence of Impacts to Water Quality in the BDCP and Draft EIR/EIS</u>***

14. The BDCP and the Draft EIR/EIS describe the hydraulic changes to the Sacramento River system indirectly through model results presented in various technical appendices (Draft EIR/EIS Appendices 5A and 11C). Hydraulic changes include revised reservoir storage and changes to downstream river flows based on operations of the NDD Intakes. The BDCP and the Draft EIR/EIS identified, in various technical appendices, impacts to water temperature (BDCP Appendix 5A and Draft EIR/EIS Appendices 11D and 29C) and to residence time (BDCP Appendix 5C), based on both of these hydraulic conditions.

15. Although no specific operations plan for the NDD Intakes is articulated in the BDCP or the Draft EIR/EIS, aspects of various potential operational scenarios were presented. The operation of the NDD Intakes on the Sacramento River near Clarksburg will necessitate different Sacramento River inflows to the Delta at different times of the year to meet downstream water quality objectives. Operational scenarios H3 and H4 include higher spring or fall outflows from the Delta (Draft EIR/EIS Chapter 3.6.4.2), including the Sacramento River system inflows. The foregoing documents state that this could be met through a variety of conditions, including;

increased upstream reservoir releases, purchasing water rights, and preferential seasonal use of the south Delta diversions.[4]

16. Higher spring outflow from the upstream reservoirs as part of Operational scenarios H2 and H4 is projected to result in lower reservoir storage in the Sacramento Valley and downstream river flows through the summer and fall months as compared to Existing Conditions.[5] The BDCP and Draft EIR/EIS documents show that under some of the NDD intake proposed operational scenarios there are significant increases in water temperature and reductions in river flow (discussed later), over longer periods of time. These changes could contribute to increases in the presence of blue-green algae in the MUN supply for Sacramento's intakes and increased levels of treated water DBPs.

17. While climate change has been represented as a significant factor in hydraulic and temperature changes (as part of the No Action Alternative [NAA][6,7]), to correctly evaluate impacts of the proposed NDD Intakes, climate change should be considered in light of the cumulative impacts. Climate change is projected to impact water quality but it does not eliminate the impacts of the proposed NDD Intakes; it changes the context in which they will occur. Climate change and its management have been evaluated in the Watershed Sanitary Surveys (Exhibits City Sac - 25 and 26) as a potential impact on source water quality. The modeling for the BDCP and Draft EIR/EIS did not include any mitigation or other adaptive measures that would likely be implemented to address the climate change effects. It is not reasonable to assume that no mitigation or adaption would be implemented by water system managers to minimize impacts. DWR is currently planning Climate Change Adaptation and Mitigation strategies in their operational programs[8], and the USBR and USACE are revising the Folsom Water Control

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[4] BDCP/California Water Fix RDEIR/SDEIS Appendix A, Chapter 4, Section 4.1.2.2, Page 4.1-6, Lines 23-25 and 28-33

[5] BDCP/California Water Fix RDEIR/SDEIS Appendix A, Chapter 5, Section 5.3.3, Page 5-22, Table 5-7

[6] BDCP/California Water Fix RDEIR/SDEIS Appendix A, Chapter 5, Section 5.3.3.1, Page 5-3, Lines 25-27

[7] Draft EIR/EIS Appendix 11D, Section 11.D.4, Miscellaneous Tables

[8] http://www.water.ca.gov/system_reop/

Manual[9]; these strategies need to be articulated and included in the Project proposal and evaluated so that the resulting water quality impacts can be known.

*Temperature Effects and Impacts on MUN Supply*

18. In the BDCP and Draft EIR/EIS, the project proponents: (a) asserted that the primary concern of water temperature was related to fish and aquatic organisms (Draft EIR/EIS, Chapter 8.2), (b) only prepared temperature impacts for aquatic life (Draft EIR/EIS, Chapter 8.4.1), and (c) omitted temperature impacts evaluation on the MUN beneficial use (Draft EIR/EIS Table 8-5). No water quality assessments were completed with regard to temperature impacts of the Project on the MUN supply, and temperature evaluations were only conducted relative to aquatic life (Draft EIR/EIS Chapter 11).

19. The failure to evaluate the Proposed Project impacts on water temperature for MUN is a significant error, because temperature is a key driving water quality constituent to the MUN beneficial use, affecting source water quality, drinking water treatability, and treated water quality. Even small increases in water temperature can impact MUN uses by altering source water quality (such as increasing pathogen or algal growth), changing treated water quality (such as accelerating DBP formation), and impacting treatment facilities (such as altering existing processes or potentially requiring additional or alternative processes). Without such analysis the Proposed Project proponents cannot demonstrate that the operation of the NDD Intakes will not injure Sacramento's MUN water quality and supply.

20. Water temperature is a critical driver for many source water quality constituents. This is documented in general science and summarized by the United States Geological Survey (USGS)[10]. Temperature impacts the growth of biological and aquatic constituents (increased growth at increased temperatures) and the presence and concentration of other types of water quality constituents.

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[9] http://www.spk.usace.army.mil/Portals/12/documents/civil_works/JFP/Water%20Control%20Manual%20Update/FolsomWCMUpdate_BriefingMemo_18JUL12.pdf

[10] http://water.usgs.gov/edu/temperature.html

21. As noted by USGS, water temperature is strongly influenced by dam operations for lakes and reservoirs. I prepared two graphics to relate historic water temperature at Sacramento's two drinking water treatment plants to the upstream reservoir storage for the period 2010 through 2015. These graphics are attached as Exhibits City of Sac - 27 and 28. They accurately depict the described conditions for purposes of this testimony. DWR water year hydrologic classifications for the period are as follows: 2010 – below normal, 2011 – wet, 2012 – below normal, 2013 – dry, 2014 – critical, 2015 – critical[11]. The first three years of this period are used in this testimony to represent more typical historic reservoir storage operations, while the last three years are used in this testimony to represent lower volume reservoir storage operations, such as those that are projected to occur more frequently if the California WaterFix Project is implemented under Operational Scenario H3 or H4.[12]

22. The chart of the raw water temperature at the EAFWTP on the Lower American River and the storage volume of Folsom Reservoir from 2010 through 2015 shows that as reservoir storage volume decreases, the downstream water temperature increases significantly (Exhibit City Sac - 27). Lower reservoir levels resulted in water temperatures greater than 20°C in the summer and fall at the EAFWTP. The peak temperatures (up to 24°C) and duration of those peaks (over four months) were higher in consecutively low storage volume years. During the months of June through October, for the period 2010 through 2012, 97 percent of temperature samples were less than 20°C at the EAFWTP. For the period 2013 through 2015, when Folsom Reservoir storage levels were much lower and potentially representative of lower storage levels which will result from the NDD Intakes operation, only 29 percent of temperature samples were less than 20°C. The chart of the raw water temperature at the SRWTP on the Sacramento River and the percent of storage volume of Shasta, Oroville, and Folsom reservoirs from 2010 through 2015 shows a similar trend (Exhibit City Sac - 28). The peak temperatures were even higher (up to 28°C) and lasted even longer, more than six months. For the summer and fall months of June

[11] http://cdec.water.ca.gov/cgi-progs/iodir/wsihist
[12] BDCP/California Water Fix RDEIR/SDEIS Appendix A, Chapter 5, Section 5.3.3, Page 5-22, Table 5-7

through October, for the period 2010 through 2012, 45 percent of temperature samples were less than 20°C at the SRWTP. For the period 2013 through 2015, when reservoir storage levels were much lower and potentially representative of more frequent years under the NDD Intakes operation, only 15 percent of temperature samples were less than 20°C.

23. utilities, had a Technical Memorandum prepared by Palencia Consulting Engineers on Cyanotoxins in the Sacramento River Watershed (Exhibit City Sac - 29) at the request of the DDW. The memorandum presents information on the potential presence and risk of cyanobacteria, and possibly cyanotoxins, in the Sacramento River watershed. It was noted that water temperatures below 15°C, or 59°F, are not conducive to significant growth of algae and cyanobacteria, and temperatures above 20°C, or 68°F, can result in strong growth. The presence of algae and cyanobacteria are of concern for drinking water safety because they are a source of organic carbon in the water as well as a source of cyanotoxins. The memorandum also discussed Sacramento's 2015 special algae monitoring results as described in the direct testimony of Pravani Vandeyar (Exhibit City Sac - 6). This data, as well as additional cyanotoxin data collected in 2016, is presented in Exhibit City Sac - 30. No cyanotoxins were detected in the source water in 2015, but there were low level detects of anatoxin a in the Lower American River in July and August 2016 and low level detects of microcystin YR in the Lower American River and Sacramento River in August 2016. The above-described conditions that generated the algae, and associated cyanotoxins, are of major concern to utilities providing drinking water such as Sacramento.

24. Increases in water temperature also affect the water treatment process. Higher temperature water results in reduced viscosity related to sedimentation and increased kinetic reactions related to coagulation/flocculation and disinfection as described in Water Quality and Treatment[13], presented in scientific journals[14], and summarized by the

[13] Frederick W. Pontius, ed., *Water Quality and Treatment; A Handbook of Community Water Supplies* (New York, New York, McGraw-Hill, Inc., 1990), 306, 420, and 757.
[14] Zhang, X.l et al., "Formation of disinfection by-products: Effect of temperature and kinetic modeling," *Chemosphere* 90 (2013): 634-639.

USEPA (https://iaspub.epa.gov/tdb/pages/treatment/treatmentOverview.do?treatmentProcessId=1934681921). Of particular concern is the possibility of disinfection reaction rates increasing two to three-fold when associated with water temperature increases of 10˚F.

25. An increase in water temperature, and the resultant increased disinfection reaction rates, necessitates an increase in chlorine feed to oxidize matter in the source water and ensure sufficient residual chlorine in the treated water. Increased disinfection reaction rates result in increased treated water levels of DBPs (of concern are total Trihalomethanes [TTHM] and haloacetic acids [HAA5]) as described in Integrated Design of Water Treatment Facilities, Section 7.4.1. [15] Disinfection kinetics and disinfection by-product formation are complex, including temperature as a driving factor, as described in the World Health Organization Environmental Health Criteria 216 for Disinfectants and Disinfection Byproducts, Chapter 2 (Exhibit City Sac - 31). The American River Watershed Sanitary Survey 2013 Update, Section 3 (Exhibit City Sac - 25) investigated impacts of water temperature increases at Folsom Reservoir on treated water DBP levels for a local water agency, San Juan Water District, and found that a 5˚F increase in water temperature resulted in a treated water TTHM average increase of 37 percent and a treated water HAA5 average increase of 20.6 percent.

26. In the Draft EIR/EIS, modeling results were presented with regard to reservoir storage and downstream river flows (Appendix 5A and 11C), and temperature impacts (Appendix 11D and 29C). The BDCP also presented model results for temperature in Appendix 5A.

27. Reservoir storage and downstream river flow model projections for the Proposed Project were reviewed in preparation of this testimony to identify conditions that would result from changes in historical operations caused by operation of the NDD Intakes, which may impact Sacramento's source water quality, specifically temperature increases. BDCP Appendix 5A (Section 5.A.2.3.4.2) and the Draft EIR/EIS Appendix 29C (Section 29.C.2.2) document impacts

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[15] Susumu Kawamura, *Integrated Design of Water Treatment Facilities* (New York, New York: John Wiley & Sons, Inc., 1991), 518-520.

of reservoir operations on water temperature, that reflect similar water quality impacts as those seen in the historic information presented above for Sacramento's two water treatment plants.

> *"The seasonal releases from the power plant intakes (generally low in the reservoir) will cause the temperatures in the deeper water to slowly increase throughout the summer months. The release temperatures usually reach a maximum in September or October, prior to the fall cooling and mixing of the reservoir. The seasonal release temperatures at each reservoir will depend on the annual hydrology (i.e., filling and summer drawdown) and the reservoir geometry and outlet elevations (or selective withdrawal facilities)."*[16]

28. BDCP Appendix 5A documents that downstream river temperatures increase with lower storage volumes in each reservoir in the fall (September/October). When Shasta storage volume is less than 2,500 thousand acre-feet (TAF), temperature effects are seen; when the volume is less than 1,500 TAF there is a 5˚F increase, and temperature further increases as volume decreases[17]. When Oroville storage volume is less than 1,000 TAF temperature effects are seen downstream, with an increase of 5˚F or more[18]. When Folsom storage volume is less than 300 TAF temperature effects are seen downstream with an increase of 5˚F or more[19]. Due to the shallow depth of Folsom Reservoir, the most profound temperature impacts occur at this reservoir and the downstream Lower American River.[20] The Project documents state that the only way to remedy the higher temperatures is to have a higher carryover storage volume[21].

29. A review of Shasta, Oroville, and Folsom storage volumes from CDEC for 2010 through 2015 was conducted in preparation of this testimony (Exhibit City Sac - 32). This data shows that Shasta storage volume was at or less than 1,500 TAF on 9.6 percent of days (21 percent of September and October), Oroville storage volume was at or less than 1,000 TAF on 4.5

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[16] BDCP Draft EIR/EIS, Appendix 29C, 29.C.2.2, page 29C-2, lines 26-32
[17] BDCP, Appendix 5A, 5.A.2.5.2, page 5A.2-54, lines 19-21
[18] BDCP, Appendix 5A, 5.A.2.5.3, page 5A.2-64, lines 19-21
[19] BDCP, Appendix 5A, 5.A.2.5.4, page 5A.2-72, lines 22-24
[20] BDCP, Appendix 5A, 5.A.2.5.4, page 5.A.2-73, lines 21-23
[21] BDCP, Appendix 5A, 5.A.2.5.4, page 5A.2-72, lines 35-37

percent of days (2.2 percent of September and October), and Folsom storage volume was at or less than 0.3 TAF on 15.2 percent of days (17.6 percent of September and October).

30. The Draft EIR/EIS Appendix 29C also presents information on the warming of the rivers downstream of the reservoirs, citing the importance of equilibrium temperatures, heat exchange, and river flow[22].

31. The Draft EIR/EIS presented model results for reservoir storage and downstream river flows in Appendix 5A. Some of this data was revised in the RDEIR/SDEIS, and is discussed later. Under Alternative 4 H4 (most closely representing the Proposed Project), the storage volumes in all three major reservoirs are projected to be more frequently at lower volumes than existing conditions for the end of May and the end of September. Shasta Reservoir volumes for Alternative 4 are shown in Figures C-2-1 and C-2-2. Shasta end of September storage volume is projected to be 1,500 TAF approximately 10 percent of the time under existing conditions (similar to the historic data presented above) and Alternative 4 H4 will increase that to approximately 17 percent of the time. Alternative 4 H4 tracks closely to the No Action Alternative (NAA), but has reduced frequency of higher storage volumes, especially end of September volumes greater than 2,500 TAF.

32. Oroville Reservoir volumes for Alternative 4 are shown in Figures C-3-1 and C-3-2. Oroville end of September storage volume is projected to be 1,000 TAF approximately 10 percent of the time under existing conditions and Alternative 4 H4 will increase that to approximately 17 percent of the time. Alternative 4 H4 end of May storage volumes are vastly different (more frequently much lower) than the NAA, primarily due to the planned high spring outflow conditions from March through May. The end of September storage volumes are similar to the NAA, due to the very low releases during the summer months to the Feather River.

33. Folsom Reservoir volumes for Alternative 4 are shown in Figures C-4-1 and C-4-2. Folsom end of September storage volume is projected to be 300 TAF less than 10 percent of the time under existing conditions and Alternative 4 H4 will increase that to more than 20 percent

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[22] BDCP Draft EIR/EIS, Appendix 29C, 29C.2.3, page 29C-2, lines 37-39

of the time. Alternative 4 H4 tracks closely to the No Action Alternative (NAA), but has reduced frequency of higher storage volumes, especially end of May volumes greater than 800 TAF and end of September volumes greater than 500 TAF.

34. These reductions in end of September storage volume at all reservoirs due to the operation of the Proposed Project, and increased frequency of low storage volume, indicate that the Proposed Project will cause water temperatures to increase in the reservoirs north of the Delta more frequently during summer and fall periods.

35. The reservoir operations and resultant storage volumes are affected by the downstream river flow demands. Alternative 4 H4 includes only minor projected flow differences for the Sacramento River between Keswick and Verona, with the long-term average flows in Figures C-15-1 and C-16-1 showing that Alternative 4 H4 will result in higher winter flows (January and February) and lower fall flows (October and November) as compared to both the existing conditions and NAA. The impacts on the Feather River are more profound, with the long-term average flows in Figure C-17-1 showing that Alternative 4 H4 will result in much higher flows in the spring (March through May) and much reduced flows in the summer (July and August) as compared to both the existing conditions and NAA. The impacts on the American River shown in Figure C-19-1 show higher winter flows (January through March) and lower flows in summer and fall (July through November).

36. Evaluations presented in the Draft EIR/EIS Appendix 11C exemplify the flow variabilities. Table 18 in Section 11C.4.1.9 indicates that for Alternative 4 H4 there are significantly (noted as greater than 5 percent) increased flows in the Feather River at the confluence with the Sacramento River in the spring months and vastly reduced summer flows, up to 50 percent lower compared to both existing conditions and the NAA. Table 20 in Section 11C.4.1.10 indicates that for Alternative 4 H4 reduced flows will occur in the American River at Nimbus in the summer and fall months, up to 45 percent lower compared to existing conditions and 14 percent lower compared to the NAA. Table 8 in Section 11C.4.1.4 indicates that for Alternative 4 H4 reduced flows in the Sacramento River at Verona in the summer and fall months, especially in November, will occur up to 15 percent more frequently compared to

existing conditions and the NAA. These reductions in summer and fall river flows indicate that water temperatures will be further increased in the downstream rivers more frequently and water velocities may be reduced as well.

37. Since analysis performed for the Proposed Project does not include any modeling conducted to evaluate impacts to MUN supply upstream from the Proposed Project's NDD Intakes, I reviewed the Draft EIR/EIS Appendix 11D, which presents temperature impacts associated with the fish analysis. In the BDCP and Draft EIR/EIS temperature modeling for the Sacramento River was conducted using the Sacramento River Water Quality Model, but the modeling only evaluated locations between Shasta and Knights Landing/Hamilton City.[23] No temperature evaluation was provided for the Lower Sacramento River between Hamilton City and the Delta where the SRWTP is located[24]. The temperature modeling for the Trinity, Feather, and American rivers was conducted using the Recreation Temperature Model.[25]

38. Draft EIR/EIS Appendix 11D presents mean monthly temperature model results comparing Alternative 4 H3 and H4 to both the existing conditions and the NAA. The use of mean monthly results masks peak temperatures that may occur. The Sacramento River at Hamilton City (Section 11D.4.5, Table 2) shows increased temperatures from July through October. The increase is significant as compared with existing conditions, as much as 7˚F, and as much as 1.2˚F compared to the NAA. The Feather River at the confluence with the Sacramento River (Section 11D.4.14, Table 2) shows increased temperatures from July through December. The increase is significant as compared with existing conditions, as much as 6.4˚F, and as much as 1.9˚F compared to the NAA. The most pronounced temperature increases in the Feather River for Alternatives 4 H3 and H4 over the NAA are seen in July through September. The American River at Watt Avenue (Section 11D.4.16, Table 2) shows increased temperatures throughout the year. The increase is significant as compared with existing conditions, as much as 8.3˚F, and as much as 1.3˚F compared to the NAA.

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[23] BDCP, Appendix 5C, 5C.4, page 5C.4-6, Table 5C.4-2
[24] BDCP, Appendix 5A, 5.A.2.5.2, page 5A.2-53 through 5A.2-55
[25] BDCP, Appendix 5C, 5C.4, page 5C.4-5, Table 5C.4-2

39. The Proposed Project's changes to reservoir storage operations and subsequent changes to downstream river flows, especially in the summer and fall, will result in increased water temperatures in the Sacramento and American River in the vicinity of Sacramento's intakes. The increased temperature and reduced flows would result in conditions that support increased algae and cyanobacteria in the source water. Increased temperature will also cause increased formation of DBPs in the treated water. Both the presence of algae or cyanobacteria and potential for increased levels of DBPs in treated water would alter the water quality at Sacramento intakes materially, resulting in impacts to the treatability of Sacramento's MUN supply from the Sacramento River and American River.

*Residence Time Effects and Impacts on MUN Supply*

40. Residence time effects were presented in the BDCP (Chapter 5.3.3.2 and Appendix 5C.5) as modeled by the DSM2 Particle Tracking Model, but the information provided was largely limited to those impacts identified in the Delta (since the model does not include areas upstream of the Delta) and were based upon the larger BDCP project, including all the originally proposed habitat restoration measures. No residence time effects were provided for the presently proposed California WaterFix project only. The document does acknowledge:

41. *"It is generally believed that an increase in residence time will cause an increase in primary production because the phytoplankton population will spend more time integrating light and nutrients within Delta channels and growing."*[26]

42. North Delta impacts presented in the BDCP are in the area located closest to City of Sacramento's intakes. The BDCP determined that the longest residence times are in the summer/fall[27]. The analysis also noted that under the high outflow scenario (HOS), which represents Delta outflow conditions similar to the high spring outflow that is identified in

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[26] BDCP, Chapter 5, 5.3.3.2.2, page 5.3-35 line 42 through page 5.3-36 line 2
[27] BDCP, Appendix 5C, 5C.5.4.4.1, page 5.C.5.4-83, lines 21-23

California WaterFix[28], there was a 10 percent increase in the average residence time difference for the North Delta region[29].

43. An increase in residence time is important to the water quality of the MUN supply because it represents reduced water velocity and increased stability of the water column, each of which contributes to the increased growth potential for algae and cyanobacteria. Increases in residence time in the North Delta region may result in propagating impacts up the Sacramento River to Sacramento's MUN supply.

***Evidence of Impacts to Water Quality in the California WaterFix and RDEIR/SDEIS***

44. The RDEIR/SDEIS Section 4 presents additional model results for Alternative 4A in the Early Long Term (ELT) for operational scenarios H3 and H4. Hydraulic data includes reservoir storage and downstream river flows. New information was provided regarding potential *Microcystis* impact to the MUN use in the Delta in Revisions to the Draft EIR/EIS Chapter 8, but not to the upstream areas. The RDEIR/SDEIS asserts that hydrodynamic conditions of upstream rivers are not conducive to bloom formation (Section 8.1.3.18). However, based on real data and conditions at Sacramento intakes this assertion is incorrect. The RDEIR/SDEIS did not make any changes to BDCP Appendix 5A or 5C and Draft EIR/EIS Technical Appendices 5A, 11C, 11D, or 29C.

45. Algal and aquatic macrophyte growth factors in the Delta are currently under evaluation through the development of the Delta Nutrient Research Plan[30] led by the Central Valley Regional Water Quality Control Board (CVRWQCB). Work products to date produced through this process include reports commissioned by the CVRWQCB summarizing the current state of knowledge regarding potential drivers of hazardous cyanobacteria (predominantly

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[28] BDCP, Appendix 5C, 5C.0, pages 5C.0-1 through 5C.0-3
[29] BDCP, Appendix 5C, 5C.5.4.4.2, page 5.C.5.4-90, lines 5-8
[30] http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/index.shtml

*Microcystis*)[31] and invasive, non-native aquatic macrophytes[32] in the Delta. Water temperature and residence time were identified as key drivers of both hazardous algal blooms and nuisance populations of aquatic macrophytes in the reports, which supports the concern about the impact of the Proposed Project's operation of the NDD Intakes.

46. Through its effects on water temperature and residence time in Sacramento's source waters, the Sacramento and American Rivers, operation of the Proposed Project's NDD Intakes will exacerbate the risk of hazardous cyanobacteria and elevate costs associated with treatment and maintenance caused by other algae and aquatic macrophytes. These impacts are discussed later in this testimony.

*<u>Temperature Effects and Impacts on MUN Supply</u>*

47. There was no supplemental evaluation provided for temperature impacts on the MUN beneficial use in the California WaterFix or RDEIR/SDEIS.

48. The RDEIR/SDEIS acknowledges the key drivers for *Microcystis* as follows:

49. *"Water temperatures greater than 19°C, low water velocities, and high water clarity are necessary for Microcystis levels to reach bloom-forming scale (Paerl 1988; Lehman et al. 2008; Lehman et al. 2013). The water temperature requirement is considered the primary factor that restricts bloom development to the months of June through September (Lehman et al. 2013). Sufficiently high water temperature (i.e., 19°C), low flow and thus sufficiently long residence time, and increased clarity enable bloom formation, which occurs in the San Joaquin*

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[31] Berg, Mine and Sutula, Martha. *Factors Affecting Growth of Cyanobacteria With Special Emphasis on the Sacramento-San Joaquin Delta.* Southern California Coastal Water Research Project Technical Report 869. August 2015 http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/science_work_groups/2015_08_cyano_wp_final.pdf

[32] Boyer, Katharyn and Sutula, Martha. *Factors Controlling Submersed and Floating Macrophytes in the Sacramento-San Joaquin Delta*. Southern California Coastal Water Research Project Technical Report 870. October 2015 http://www.waterboards.ca.gov/centralvalley/water_issues/delta_water_quality/delta_nutrient_research_plan/science_work_groups/2015_10_macro_whitepaper.pdf

*River, Old River, and Middle River earlier, and to a greater extent, than other areas of the Delta." (RDEIR/SDEIS at p. 8-45)*

50. As acknowledged by the RDEIR/SDEIS, water temperatures at or above 20˚C are generally considered conducive for *Microcystis* blooms. Temperature in the Sacramento and American Rivers at the EAFWTP and SRWTP intakes was discussed previously, and can exceed 20˚C during the summer and fall. The data review presented in this testimony indicates that the frequency and duration of water temperatures exceeding 20˚C at both EAFWTP and SRWTP is strongly influenced by upstream reservoir storage. California WaterFix, through operation of the NDD Intakes, will result in reservoir storage pattern and volume changes, especially at Oroville Reservoir, and river flow changes, especially in the late summer and fall period. Reduced upstream reservoir storage during this period will contribute to longer periods of temperature exceeding 20˚C in the vicinity of Sacramento's intakes and extend periods of increased risk of *Microcystis* growth in the vicinity of the EAFWTP and SRWTP intakes.

51. The RDEIR/SDEIS provided selected updates for figures of end of September reservoir storage and downstream river long-term average flows in Chapter 4, for the new Alternative 4A. The main difference was the time period as being the early long-term (ELT) rather than the late long-term (LLT) presented in the Draft EIR/EIS, which significantly reduces the projected duration of impacts as well as the level of impacts. These model results for Shasta, Oroville, and Folsom reservoirs (shown in Figures 4.3.1-6, 4.3.1-8, and 4.3.1-10) demonstrate similar trends as the original model results. In all cases, reservoir storage volume under Alternative 4A will more frequently be less than existing conditions; especially for the larger storage volumes, which are important to provide cooler water temperatures. The modeled river flows were also updated for selected downstream locations. The results for the American River at Nimbus (Figure 4.3.2-12), the Feather River at Thermalito Dam (Figure 4.3.2-14), and the Sacramento River at Freeport (Figure 4.3.2-4) all display similar trends as the original model results. These indicate higher winter flows (January and February) and lower summer and fall flows (June through November) at the EAFWTP and SRWTP intakes. Both lower summer and fall reservoir storage and river flows will contribute to increased water temperature at

Sacramento's intakes, which can contribute to increased algae growth in the source water and treated water DBP levels.

*Residence Time Effects and Impact on MUN Supply*

52. Information about NDD intakes effects on mean residence time in the Delta is presented in the RDEIR/SDEIS Section 8 in the context of the Proposed Project's potential to increase the geographic extent and abundance of the hazardous cyanobacterium *Microcystis*. Residence time was modeled using the DSM2 particle tracking model and the results presented in Table 8-60a (Section 8, page 8-83) represent the time it took for 50 percent of particles released from various starting points in the Delta (e.g., "North Delta", "South Delta") to exit the project area (i.e., through downstream movement past Martinez, or via entrainment in export facilities). The model results predict increases in mean residence time (as defined above) in the North Delta year-round, with significant increases in the fall. Table 8-60a reveals that Alternative 4 H3 (note that Alternative 4 H4 was not included in the table) is expected to increase residence time during the fall in the North Delta by 14 percent compared to the No Action Alternative (via an increase in residence time from 50 to 57 days) or by 16 percent compared to Existing Conditions (via an increase in residence time from 49 to 57 days). The SRWTP intake is immediately upstream from the North Delta boundary, and would likely be affected by this residence time increase. Increases in residence time in the North Delta increases the probability that *Microcystis* blooms may occur upstream in locations where resulting cyanobacteria, or their cyanotoxins, could enter the SRWTP and/or EAFWTP intakes.

53. Contributing to the increased residence time, the proposed NDD intakes will alter Sacramento River hydraulics such that "reverse flow" and tidal effects will be amplified compared to both Existing Conditions and the No Action Alternative. As specified in Section 8.3.3.9 of the RDEIR/SDEIS, the Proposed Project will decrease annual Delta outflow and amplify sea water intrusion into the Delta independent of climate-change-related sea level rise, leading to a projected decrease in annual Delta outflow of five thousand acre-feet (TAF) under Alternative 4A H4 based on operations changes only:

54. “*Long-term average annual Delta outflow is anticipated to decrease under Alternative 4 by between 864 (scenario H1) and 5 TAF (scenario H4) relative to the No Action Alternative, due only to change in operations. The result of this is increased sea water intrusion in the west Delta.*” (RDEIR/SDEIS at p. 8-205)

55. In addition to higher residence times and high water temperatures suitable for algal growth, lower turbidity also elevates the risk of *Microcystis* blooms in the vicinity of Sacramento’s intakes. The American River has much lower average turbidity than the Sacramento River and the location of the SRWTP intake, just downstream of the confluence with the American River, ensures lower turbidity conditions than is typical for the Sacramento River cross section at that location. These conditions favor cyanobacteria growth compared to the more turbid Sacramento River and lower Delta.

**OTHER POTENTIAL IMPACTS NOT QUANTIFIED BY BDCP OR CALIFORNIA WATERFIX**

56. Sacramento has numerous other water quality concerns as described in their comments on the BDCP and the Draft EIR/EIS (Exhibit City Sac - 33) and California WaterFix and the RDEIR/SDEIS (Exhibit City Sac - 34), which are largely related to insufficient analyses that prevent quantifiable impacts to Sacramento from being accurately identified and assessed. Other potential impacts to the MUN supply for Sacramento’s intakes, for which no analysis has been performed or provided by the Project proponents, include:

- High spring outflow releases from Oroville Reservoir in March through May will result in discharge of water with less holding detention time and therefore higher in solids loading. This would increase the treatment requirements at the SRWTP and solids handling.
- High outflow spring met by buying water rights from willing sellers could result in a shift to increased groundwater use in the Sacramento Valley basin. This shift could result in more groundwater return, as agricultural drainage, to the Sacramento River contributing higher levels of metals, minerals, bromide, and temperature than the

surface water. This could result in increased treatment requirements at the SRWTP or an increase in DBP levels in the treated water.

- Lower reservoir levels through the summer and fall months could result in discharge of water from, or mixing with, the lower reservoir pool that may have increased concentration of dissolved species (organic carbon and metals). This could result in increased treatment requirements at either water treatment plant and/or an increase in DBP levels in the treated water.
- Lower reservoir levels in the fall could result in more exposed shoreline resulting in more significant first-flush storm effects (higher solids, microbial, and organic content) to the downstream source water. This could result in increased treatment requirements at either water treatment plant and/or an increase in DBP levels in the treated water.

**INJURY TO SACRAMENTO CAUSED BY CALIFORNIA WATERFIX**

57. The operation of the Proposed Project's NDD Intakes will result in changes to reservoir storage operations and changes to downstream river flows, especially in the summer and fall. The summer and fall are currently the period of highest water temperature at the EAFWTP and SRWTP and typically exhibit the lowest flows in the Sacramento and American Rivers. This is also the period of maximum water demand requiring highest production from both water treatment plants. The Proposed Project environmental documents show that storage at Shasta, Oroville, and Folsom reservoirs will be reduced more frequently to lower volumes in the summer and fall. River flows in the Sacramento, Feather, and American Rivers also are projected to be lower more frequently in the summer and fall.

58. Reductions in reservoir storage volumes and river flows will result in injury to Sacramento by impacting the water quality of the American and Sacramento River source waters. The three major categories of injury are reduced availability of sufficient source water quality; increased operation and maintenance costs to treat water to potable standards; and costs associated with installation of new capital improvements as targeted treatment technologies.

***Reduced Availability of Sufficient Source Water Quality***

59. Projected reductions in storage volume and river flow caused by operation of the Proposed Project will increase water temperature and residence time in the rivers downstream of the major reservoirs, including the Sacramento and American Rivers in the vicinity of Sacramento's intakes.

60. Increased water temperatures in the summer and fall will cause water quality impacts at Sacramento's drinking water treatment plants in two major ways: increased presence of algae (which is organic matter and may potentially include cyanobacteria) and increased rate of disinfection byproduct reaction kinetics leading to increased levels of DBPs in the treated water.

61. Increased residence time in the North Delta region, which reflects reduced water velocity and increased stability of the water column, has the potential to propagate upstream to Sacramento's intakes. Similar to increases in water temperature, increased residence time also contributes to the increased growth potential for algae, potentially including cyanobacteria.

62. An increased frequency of algae blooms, including cyanobacteria such as *Microcystis,* in the fall and summer at the EAFWTP and SRWTP intakes would have a direct impact on Sacramento's available periods of adequate quality supply water. Since pre-chlorination can make the presence of cyanotoxins worse in treated water, Sacramento would need to further investigate and monitor the treated water to verify levels. If cyanotoxins could not be removed to levels below the USEPA Health Advisories, Sacramento would need to evaluate the continued use of the source water during the algae bloom. Since the summer and fall are peak demand periods, it could be very difficult for Sacramento to meet system demands without one or both of its surface water treatment plants. Thus the water quality impact becomes a water supply impact.

63. Increased water temperature and increased algae, thus organic carbon, in the source water in the summer and fall months both contribute to increased DBP formation potential in the treated water. This could reduce the ability of Sacramento to utilize the surface water during seasonal periods and continue to meet DBP regulations using current treatment processes, thus causing a water supply impact.

***Increased Operations and Maintenance Costs***

64. An increased frequency of algae blooms, including cyanobacteria such as *Microcystis*, in the fall and summer at the EAFWTP and SRWTP intakes would have direct impacts on Sacramento's monitoring requirements and treatment required. If the source water quality degrades and/or changes significantly, Sacramento may need increased monitoring or enhanced treatment to meet federal and state drinking water quality standards and protect public health.

65. If any cyanobacteria were detected in Sacramento's MUN supply from the American or Sacramento River, due to Proposed Project caused water quality and hydraulic conditions (warm water and low flows), then additional monitoring would need to be conducted to verify the potential presence of cyanotoxins in the water. This would increase laboratory costs.

66. Factors increasing the risk to Sacramento's MUN water supply from *Microcystis* (lower river flows and increased residence time, higher temperatures), are also factors that will favor growth of phytoplankton, benthic algae (which drift), and floating macrophytes. Macrophyte and algae removal from Sacramento's intakes and treatment plants incurs incremental costs to Sacramento through increased intake maintenance, increased disinfectant dosing, increased filter cleaning, and increased solids removal, handling, and disposal. Decreased river flows and source water quality will result in the increased intake screen biofouling and the need to clean the intake screens, using divers. This will increase operations and maintenance costs. Decreased source water quality will require Sacramento to evaluate, and possibly increase, its needs and usages of coagulants, polymers, and other chemicals used in the treatment process. This may increase operations and maintenance costs. Decreased source water quality from algae blooms would require Sacramento to increase in-plant management by increasing chlorine disinfection and filter backwashing procedures. This would increase operations and maintenance costs. Decreased source water quality, from increased solids loading or algae blooms, will result in the need for additional processing of residual solids, trucking, and landfill utilization. This will increase operations and maintenance costs.

***New Capital Improvement Costs***

67. Both the SRWTP and EAFWTP are conventional filtration plants with chlorine disinfection. The selection of treatment processes is based on historic and current source water quality. The facilities are not designed to address specialty contaminants, such as cyanotoxins, or waters with high levels of temperature or organic carbon.

68. An increased frequency of algae blooms, including cyanobacteria such as *Microcystis,* in the fall and summer at the EAFWTP and SRWTP intakes would have the following direct impacts on Sacramento's water treatment required. Cyanobacteria, and their associated cyanotoxins, have variable treatment effectiveness as described in the Cyanotoxins in the Sacramento River Watershed Technical Memorandum (Exhibit City Sac - 29). The effectiveness of conventional filtration depends on the cellular nature of the cyanotoxins (intracellular versus extracellular). There is significant risk of pre-chlorination to cyanotoxin presence, since the chlorine breaks open the bacteria cells and releases the cyanotoxins, so it is discouraged from use during blooms. Currently, Sacramento implements pre-chlorination at both the EAFWTP and SRWTP. This would need to be revised to an alternate disinfectant strategy if algae blooms became regular or more frequent. This may require Sacramento to plan, construct, and operate new disinfection facilities.

69. Increased water temperature and increased algae, thus organic carbon, in the source water in the summer and fall months both contribute to increased DBP formation potential in the treated water. The increases in these factors could lead to longer periods of high DBP formation, which may result in higher compliance values. If compliance values approach the drinking water standards for DBPs, then Sacramento would need to investigate the necessity of implementing an alternative disinfection strategy at its water treatment plants, and potentially its entire water supply system, to ensure that standards are met and public health is protected. Sacramento has considered future addition of intermediary alternative disinfection, such as UV or ozone, as a primary disinfectant. The conversion to an alternate primary disinfectant would require significant capital costs for the construction of new plant facilities and increased operation and maintenance costs. Implementation of an alternative disinfection strategy would require

careful evaluation and planning to prevent distribution system water quality issues for Sacramento and its wholesale agencies. Depending on the water quality impacts, other pre-oxidants and secondary disinfection alternatives may need to be considered.

Executed on this 31st day of August, 2016 in Sacramento, California.

Bonny Starr

Bonny L. Starr, P.E.