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BEFORE THE STATE WATER RESOURCES

CONTROL BOARD

PHASE 2 - HEARING IN THE MATTER OF CALIFORNIA DEPARTMENT OF WATER RESOURCES AND UNITED STATES BUREAU OF RECLAMATION REQUEST FOR A CHANGE IN POINT OF DIVERSION FOR CALIFORNIA WATER FIX	**TESTIMONY OF SUSAN PAULSEN IN SUPPORT OF PROTEST OF THE CITY OF ANTIOCH, PHASE 2.** **(Exhibit: Antioch – 500)**

I, Susan C. Paulsen, declare as follows:

QUALIFICATIONS

My name is Susan Paulsen and I am a Registered Professional Civil Engineer in the State of California (License # 66554). My educational background includes a Bachelor of Science in Civil Engineering with Honors from Stanford University (1991), a Master of Science in Civil Engineering from the California Institute of Technology ("Caltech") (1993), and a Doctor of Philosophy (Ph.D.) in Environmental Engineering Science, also from Caltech (1997). My education included coursework at both undergraduate and graduate levels on fluid mechanics, aquatic chemistry, surface and groundwater flows, and hydrology, and I served as a teaching assistant for courses in fluid mechanics and hydrologic transport processes.

I currently am a Principal and Director of the Environmental and Earth Sciences practice of Exponent, Inc. ("Exponent"). Prior to that, I was employed by Flow Science

Incorporated, in Pasadena, California, where I worked for 20 years, first as a consultant (1994-1997), and then as an employee (1997-2014) in various positions, including President. I have 25 years of experience with projects involving hydrology, hydrogeology, hydrodynamics, aquatic chemistry, and the environmental fate of a range of constituents.

My Ph.D. thesis was entitled, “A Study of the Mixing of Natural Flows Using ICP-MS and the Elemental Composition of Waters,” and the major part of my Ph.D. research involved a study of the mixing of waters in the Sacramento-San Joaquin Bay-Delta (the Delta) using source water fingerprints. I also directed model studies that used chemical source fingerprinting to validate volumetric fingerprinting simulations using Delta models (including the Fischer Delta Model (FDM) and the Delta Simulation Model II (DSM2)). I have designed and directed numerous field studies within the Delta using both elemental and dye tracers, and I have designed and directed numerous surface water modeling studies within the Delta.

As before, I incorporate my prior Report and exhibits submitted in support of Antioch’s Part 1 case in chief, rebuttal, and sur-rebuttal as part of my testimony.

A copy of my curriculum *vitae* can be found in Exhibit Antioch-201.

SUMMARY OF TESTIMONY

Sacramento-San Joaquin Delta (Delta) flow criteria must “include the volume, quality, and timing of flows necessary to protect public resources in the Delta”[1] and are a critical component of achieving the co-equal goals detailed in the Delta Reform Act. Water quality in the Delta is a complex function of hydrology managed by upstream controls (e.g., water storage and release), interior Delta controls (e.g., gates and barriers), and diversions/exports and return flows, among other factors. The complexity of Delta hydrodynamics, the uncertainty regarding how the Central Valley Project (CVP) and State

[1] SWRCB (2015). Notice of Petition and Notice of Public Hearing and Pre-Hearing Conference to Consider the Petition. State Water Resources Control Board. October 30, 2015.

Water Project (SWP) will be operated under the Department of Water Resources (DWR) California WaterFix Plan (WaterFix) and the uncertainty of future Delta conditions under climate change together make establishing appropriate flow criteria a challenging task. In addition, the State Board recently released the Phase II update of the Bay-Delta Plan,[2] specifically addressing the need for revised Delta inflow and outflow criteria. While I understand that the WaterFix hearings and the Bay-Delta Plan proceedings are separate actions, the Bay-Delta Plan flow criteria will affect inflows to and outflows from the Delta generally, including future WaterFix operations, and thus have the potential to impose flow criteria more stringent than DWR has anticipated and modeled for WaterFix operations.

I was asked by the City of Antioch to evaluate the relationship between Delta flow and salinity at the City's intake location on the San Joaquin River. For reasons described above, salinity at Antioch's intake is not a simple function of Delta inflows or Delta outflow; rather, salinity at the City's intake is a complex function of a large number of factors, particularly given the residence time and large volume of water in the Delta. Rather than suggesting specific flow criteria, I evaluated existing and proposed Delta operations to identify representative historical conditions and conditions that would be protective of municipal and industrial beneficial uses at Antioch's intake location. In addition, I revisited historical data and information that describe natural conditions at Antioch's intake location. My opinions are as follows:

- Opinion 1: Prior to about 1917, water within the Delta and at Antioch's intake location was historically fresh.
- Opinion 2: The Boundary 2 scenario is closest to "natural" flow conditions.
- Opinion 3: Fall X2 is an important component to establishing flow criteria that will not impair beneficial uses of water in the western Delta.

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[2] SWRCB (2017). Phase II Update of the Bay-Delta Plan: Inflows to the Sacramento River and Delta and Tributaries, Delta Outflows, Cold Water Habitat and Interior Delta Flows. State Water Resources Control Board. October 4, 2017.

- Opinion 4. At a minimum, flow criteria protective of beneficial uses and public trust values at Antioch should include requiring D-1641 municipal and industrial water quality objectives be maintained at Antioch, as the 1968 Agreement is not protective of such beneficial uses at Antioch.

TESTIMONY

Opinion 1: Prior to about 1917, water within the Delta and at Antioch's intake location was historically fresh.

In considering the adoption of Delta flow criteria, in my opinion it is important to understand historical salinity and flow conditions within the Delta, and to understand how the WaterFix operations scenarios compare to both historical and current conditions. The State Board has stated that "third-party water right holders are only entitled to the natural flows necessary to provide adequate water quality for their purposes of use; they are not entitled to better water quality than would exist under natural conditions."[3] Thus, it is important to understand what "natural conditions" means, even if "natural conditions" will not be attained in the future. It is also important to correct the record, as DWR has provided testimony in this proceeding that may leave the SWRCB with the mistaken impression that the salinity intrusion that occurred in the 1920s and 1930s is the appropriate "baseline" or natural condition of the Delta.[4]

Antioch is one of the oldest cities in California, established in 1850 and incorporated in 1872,[5] prior to the channelization and development that defines the present day Delta. Because of Antioch's historical significance, there is a substantial

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[3] DWR (2017). Re: August 31, 2017 Ruling Regarding Scheduling of Part 2 and Other Procedural Matters. Letter from Tripp Mizell and Amy Aufdemberge to Chair Marcus and Board Member Doduc. Department of Water Resources. September 8, 2017.

[4] See DWR-53, p.15:1-2: "historical salinity was at times greater than current conditions [citing 1931, a critically dry year], particularly during drier periods." DWR's testimony does not appear to discuss salinity conditions within the Delta prior to the 1920s.

[5] "California Cities by Incorporation Date*." California Association of* Local Agency Formation Commissions*. Archived from* the original *(Word) on November 3, 2014*. Retrieved March 27, 2013*.*

record of historical data and information regarding water quality at the City's location on the San Joaquin River, which makes it possible to determine what "natural conditions" actually looked like.

The California Department of Public Works (DPW), the predecessor agency to the current Department of Water Resources (DWR), authored a report in 1931 entitled "*Variation and Control of Salinity in Sacramento-San Joaquin Delta and Upper San Francisco Bay*," which has been entered into evidence as Antioch-233. The DPW 1931 report documented the fact that salinity intrusion was generally not an issue prior to 1917: "From early days, Antioch has obtained all or most of its domestic and municipal water supply from the San Joaquin River immediately offshore from the City… However, conditions were fairly satisfactory in this respect until 1917, when the increased degree and duration of saline invasion began to result in the water becoming too brackish for domestic use during considerable periods in the summer and fall" (Antioch-233, p. 60). The DPW noted that "the dry years of 1917 to 1919, combined with increased upstream irrigation diversions especially for rice culture in the Sacramento Valley, had already given rise to invasions of salinity into the upper bay and lower delta channels of greater extent and magnitude than had ever been known before" (Antioch-233, p. 22). A separate report authored in 1928 by Thomas H. Means and titled "*Salt Water Problem San Francisco Bay and Delta of Sacramento and San Joaquin Rivers*" which has been entered as Antioch-232, confirms that salinity intrusion began to increase markedly in about 1918, when "the urge of war had encouraged heavy plantings of rice and other crops in the Sacramento Valley, result[ing] in the penetration of salt water into the Delta for a longer time and to a greater distance upstream than ever known before" (Antioch-232, p. 57).

In the 1920 lawsuit of *Town of Antioch [Plaintiff] v. Williams Irrigation District et al. [Defendants]* (1922, 188 Cal. 451), Antioch testified that upstream diversions were the cause of increasing salinity intrusion at Antioch (Antioch-231, p. 11), and that prior to 1918, freshwater was available at Antioch even during dry years and in the fall (Antioch-231, p. 12). The State Supreme Court record on file at the State archives documents that the Defendants in this case testified that water at Antioch was apparently fresh at low tide at least until around 1915 (Antioch-231, p.11).

In contrast, between about 1917 and the late 1930s, drought conditions, upstream water diversions, and channelization increased the salinity of water at Antioch's intake location. With the development of the CVP beginning in the late 1930s[6] and the SWP beginning in the 1960s[7], salinity in the Delta was also influenced by reservoir storage and release.

Additional information can be found in Antioch-216 (CCWD, 2010), which provides an in-depth analysis of historical conditions in the Western Delta using additional reports and evidence. Antioch-216 demonstrates that, among other things, conditions in the Delta in the early 1900s were much fresher than current conditions, and the Delta is now managed at a salinity level that is higher than would have occurred under pre-1900 conditions. See also Antioch-231, which was prepared for the SWRCB 2010 flow criteria proceedings, and which presents additional information demonstrating generally low salinity levels at Antioch prior to about 1917.

The historical record clearly demonstrates that "natural conditions" at Antioch were predominantly fresh, and that water was available for diversion year-round, at least during low tide, in all but the driest years.

It is not, of course, possible to restore the Delta to its historical condition, and the City is not requesting that the historical condition be used as a baseline for flow criteria moving forward. However, it is instructive when evaluating the potential permit conditions that could be applied to the WaterFix Project to consider water quality in the western Delta under a range of conditions and potential project operations. In addition to supporting municipal and industrial beneficial uses in the western Delta, the native species the State

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[6] Source: https://www.usbr.gov/mp/cvp/

[7] Source: http://www.water.ca.gov/swp/docs/Timeline.pdf

Board aims to protect with revised new flow criteria are adapted to these historical conditions. While I do not offer an opinion on appropriate flow criteria for fish and wildlife, numerous scientific studies support the idea that the native species in the Delta require freshwater flows.[8] Thus, the information in Opinion 1 is provided to the State Water Board for its use in the development of flow criteria for the WaterFix project, and for use by other parties in evaluating the impacts of reduced flows and increased salinity on native species.

Opinion 2. The Boundary 2 scenario is closest to "natural" flow conditions.

In Part 1 of the WaterFix hearings, I evaluated the availability and usability of water at Antioch's intake for the various WaterFix scenarios. For Part 2, I have chosen to supplement this analysis by evaluating how the salinity levels of the WaterFix scenarios compare to the "natural" or historical (pre-1918) condition.

As part of my 2010 evaluation of salinity conditions at Antioch's intake, I previously compared salinity at low tide for historical (pre-1918) conditions to salinity over a measured period of record (1985-2009) (see Figure 1 [reproduced from Antioch-231, p. 21]). The analysis in Figure 1 was prepared using salinity measured at Antioch's intake for the period of 1985-2009; data were obtained from California Data Exchange Center (CDEC). The colored bars representing historical (pre-1918) conditions were constructed based on information in the historical record, as described in Opinion 1 above, and using

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[8] William E. Fleenor, William A. Bennett, Peter B. Moyle, and Jay R. Lund (2010). On Developing Prescriptions for Freshwater Flows to Sustain Desirable Fishes in the Sacramento-San Joaquin Delta. Delta Solutions Center for Watershed Sciences. UC Davis. February 15, 2010; San Francisco Estuary Institute Aquatic Science Center (2014). A Delta Transformed: Ecological functions, spatial metrics, and landscape change. Prepared for California Department of Fish and Wildlife. October 2014; NOAA (2014). Central Valley Chinook Salmon & Steelhead Recovery Plan. National Oceanic and Atmospheric Administration. Summer 2014. http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/california_central_valley/california_central_valley_recovery_plan_documents.html; CA DFG (2010). Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta. Prepared pursuant to the Sacramento-San Joaquin Delta Reform Act of 2009. California Department of Fish and Game. November 23, 2010.

information from Antioch-216 (CCWD 2010), Antioch-232 (DPW 1931), and Antioch-233 (Means 1928). The seven-day running average of salinity measurements taken at lower low tide each day was computed for each day in the measurement period; values from each day (e.g., 25 values for January 1 in the 25-year measurement period) were then arranged by electrical conductivity (EC) values, from smallest to largest. Percentile values were then calculated (as shown on Figure 1) to characterize the salinity at Antioch over the period and plotted by date to create the figure in Antioch-231, p. 21.

As discussed in Opinion 1 and as detailed in Antioch-231, available data and information indicates that water with a chloride concentration below 250 mg/L (corresponding to an EC of 976 uS/cm, shown in Figure 1 as a light blue horizontal line) would have been available at low tide in all but about three months of the driest years under natural conditions (pre-1918).

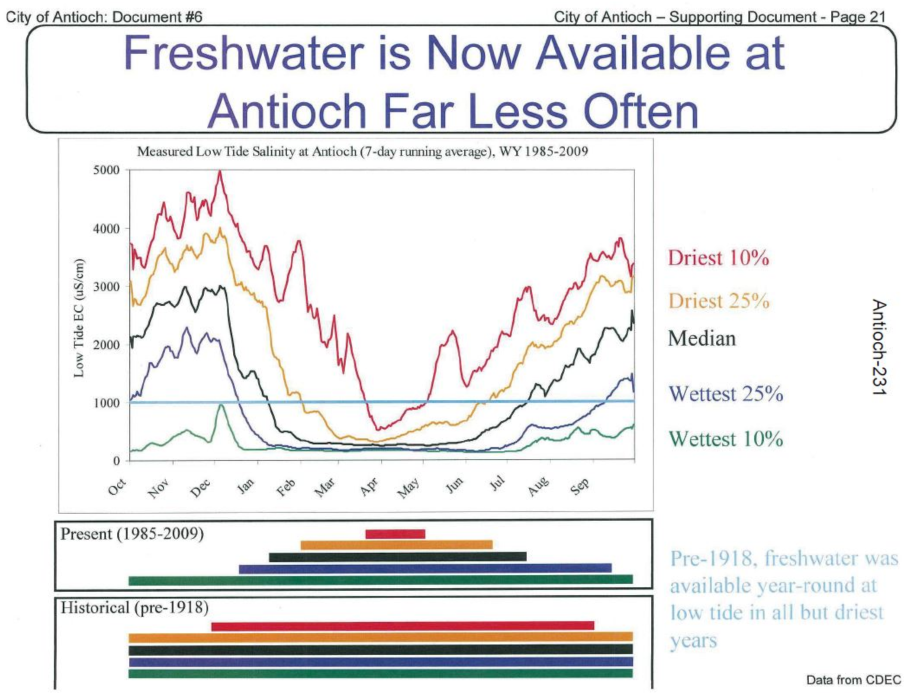

Figure 1. Antioch-231, p. 21. Analysis of freshwater availability during historical (pre-1918) conditions and during modern (1985-2009) conditions.

Exponent reproduced this analysis for the six model simulations performed by DWR to characterize existing conditions (EBC2), the no action alternative (NAA), and the four WaterFix scenarios (Boundary 1, H3, H4, and Boundary 2) for the simulation period of 1976-1991. Exponent also adjusted the bars describing salinity in the natural (pre-1918) condition in recognition of the fact that critical years occur more frequently in the 1976-1991 simulation period (in 5 of 16 years, or about 31 percent of the simulation period) than in the historical period for which water year type classifications are available (1906-2016) (16 of 111 years, or about 14 percent of the historical record). Exponent created plots similar to those shown in Figure 1 to characterize both the salinity at low tide (see Antioch-501, pp. 3-8) and the salinity at slack current after higher high tide (corresponding to the salinity threshold used to evaluate the 1968 Agreement between the City of Antioch and the State; see Antioch-501, pp.10-15). Figures 2 and 3 were created from these analyses and show, using colored bars, time periods when chloride concentrations are simulated to be below 250 mg/L. All the simulated scenarios, including the existing condition and "high outflow" Boundary 2 scenario, show that chloride concentrations are simulated to be below 250 mg/L less frequently than pre-1918 (natural) conditions. The extent and duration of the exceedances of 250 mg/L differs substantially for the different WaterFix model scenarios.

For the 1976-1991 time period under natural conditions, it is estimated that low-tide chloride concentrations would be below 250 mg/L on all days of the year in all but critical years (i.e., below 250 mg/L about 69 percent of the time). In contrast, the Boundary 2 scenario shows that water would have a low-tide chloride concentration below 250 mg/L year-round only about 25 percent of the time, while water is not simulated to have a year-round, low-tide chloride concentration below 250 mg/L for the remaining scenarios (EBC2, NAA, H3, H4 or Boundary 1). Thus, while the Boundary 2 scenario is closest to natural conditions, it still exhibits higher salinity levels than natural conditions for significant periods of time. The remaining five scenarios exhibit higher salinity levels than the Boundary 2 scenario. Tabulated results are shown in Table 1.

As shown in Figure 2 and Table 1, the Boundary 2 scenario, which is the DWR model scenario with the highest Delta outflow[9], will have salinity levels comparable to the pre-1918 condition between 25 and 50 percent of the 16-year model simulation period, but will be drier than the natural condition more than 50 percent of the time. As shown in Table 1, summary statistics for the H3 and H4 scenarios are generally lower salinity (better water quality) than the EBC2 and NAA scenarios, and the Boundary 1 scenario shows the greatest level of water quality impact, with the lowest number of days when low-tide chloride concentrations are below 250 mg/L. As shown in prior testimony (see Antioch-200), the increases in salinity are greatest at Antioch in dry, "normal" and wet water years.

[9] As noted in Antioch-202 at p. 22, DWR has provided testimony noting that the Boundary 2 was evaluated "primarily to consider increases in outflow, without consideration of water supply benefits, and as such, an alternative that included this operational scenario would likely not meet the project objectives or purpose and need statement." (See Antioch-220 or DWR-51 at p. 11.)

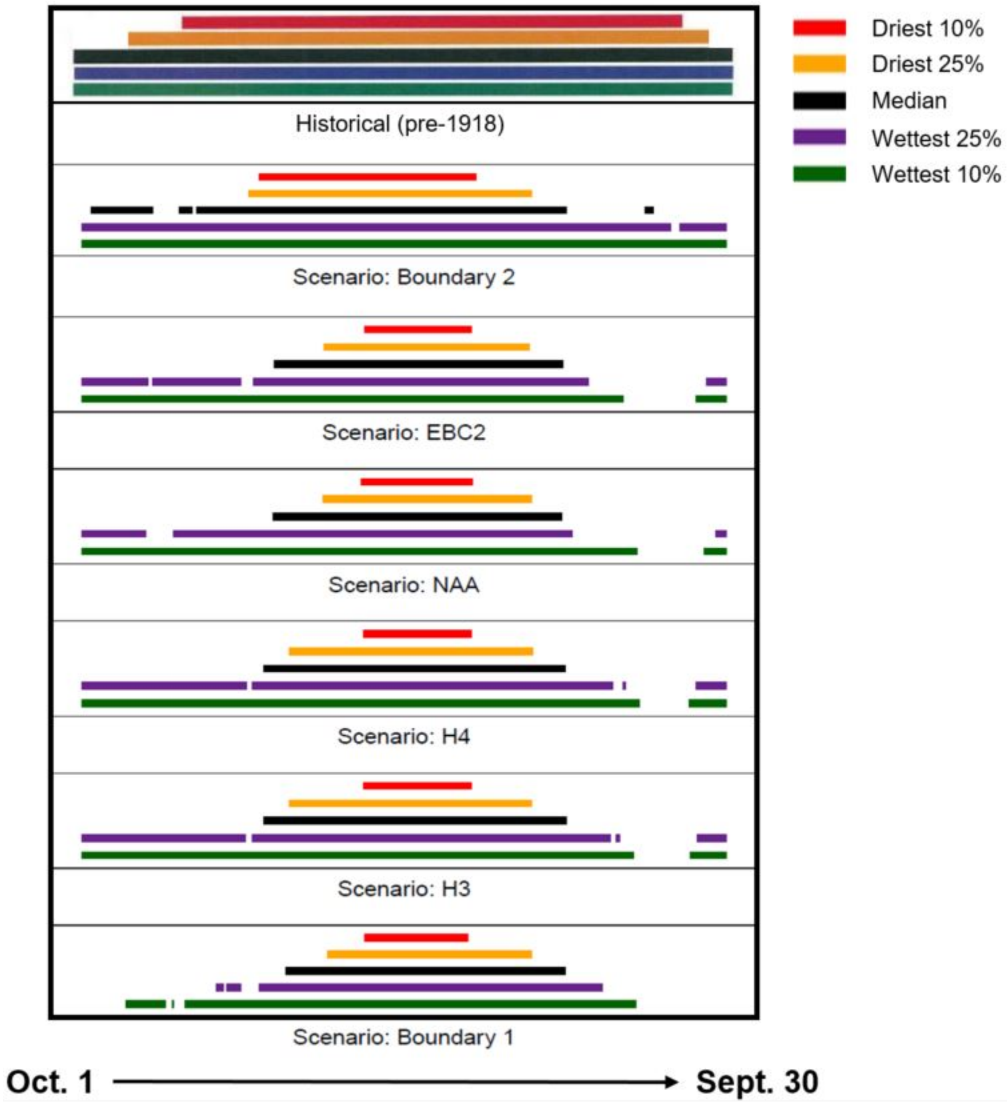

Figure 2. Water availability at Antioch's intake as determined using modeled salinity at Antioch's intake at low tide (seven-day running average salinity at low tide). Colored bars indicate simulated chloride concentrations below 250 mg/L at the exceedance probability shown in the plot. Note that the results for the natural (pre-1918) condition differ from those shown in Figure 1 in recognition of the fact that critical water years occur more frequently in the 1976-1991 simulation period (31 percent of the time) than in the longer 1906-2016 time period (14 percent of the time).

Table 1. Number of days per year chloride is below 250 mg/L at Antioch during low-tide for different hydrologic conditions and different exceedance levels (calculated from DSM2 model results for 1976-1991).

	EBC2 (days)	NAA (days)	B1 (days)	H3 (days)	H4 (days)	B2 (days)	Historical [pre-1918] Condition[a]
Driest 10 %	61	64	59	62	62	124	275
Driest 25 %	117	119	116	138	139	161	320
Median	164	164	159	172	171	260	365
Wettest 25 %	291	270	209	317	319	361	365
Wettest 10 %	325	328	281	334	338	365	365

[a] Historical information indicates that during the driest 25 percent of historical (pre-1918) water years, chloride remained below 250 mg/L year-round (see Figure 1). Exceedance estimates for historical conditions (pre-1918) were adjusted for the 1976-1991 period because critical years occurred 31 percent of the time in 1976-1991 but less frequently in the historical record (e.g., only 14 percent of the time from 1906 to 2016).

Figure 3 presents similar results generated using simulated salinity levels on each day at slack current after higher high tide—i.e., at the time of day when water is determined to be "useable" per the 1968 Agreement. Results are also tabulated in Table 2. Note that Figure 3 and Table 2 do not include "natural conditions," as the data and information used to compile Figure 2 (at lower low tide) were derived directly from historical information that characterized salinity at low tide, and historical information does not include a similar level of detail for slack current after higher high tide. [Note, however, that it has long been known that highest salinity occurred at slack current after higher high tide. As noted in DPW (1931) (Antioch-233) at p. 22, "it was discovered that the highest degree of salinity usually occurred about one and one-half to two hours following high-high tide…"]

Figure 3 and Table 2 show that, as would be expected, salinity levels at slack current after higher high tide exceed salinity levels at low tide. As with low tide conditions, the Boundary 2 scenario exhibits longer time periods where chloride levels are below 250 mg/L than the Boundary 1 scenario, and the remaining scenarios generally fall between these endpoints. In all WaterFix scenarios, the 10% driest probability conditions indicate that chloride concentrations at slack current after higher high tide will not be below 250 mg/L at any point during the year, as indicated by the absence of the red bar in Figure 3. In the Boundary 1 scenario, the 25% driest probability conditions show no "useable water" during the entire year, whereas water would be useable at the 25% driest probability level for about two months in the Boundary 2 scenario and for 10-14 days in the remaining scenarios.

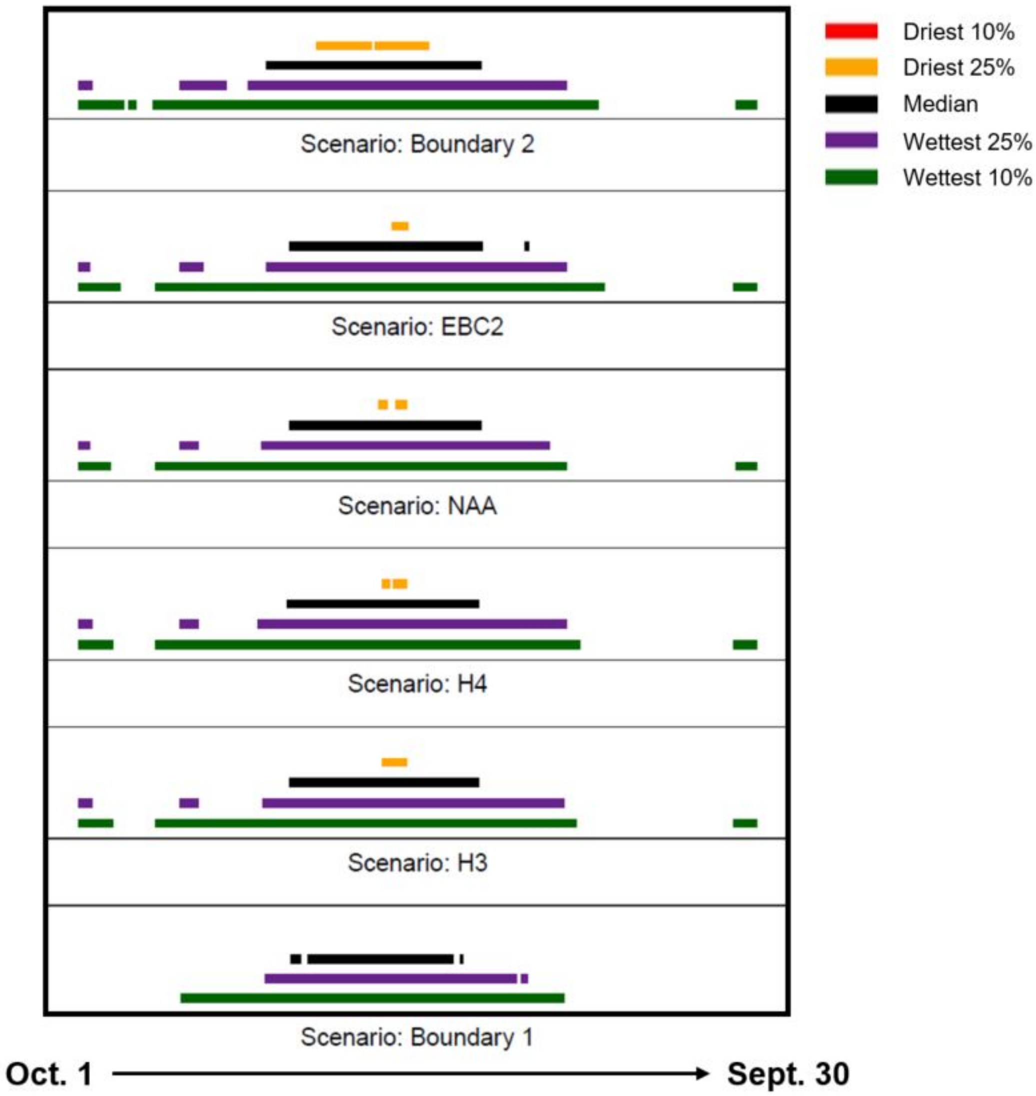

Figure 3. The presence of "useable water" at Antioch's intake as determined using modeled salinity at two hours after higher high tide for the simulation period 1976-1991. Colored bars indicate simulated chloride concentrations below 250 mg/L at the exceedance level as indicated in the plot.

Table 2. Number of days per year chloride is below 250 mg/L at Antioch 2 hours after higher-high tide for different hydrologic conditions for different exceedance levels (calculated from DSM2 model results for 1976-1991)

	EBC2 (days)	NAA (days)	B1 (days)	H3 (days)	H4 (days)	B2 (days)
Driest 10 %	0	0	0	0	0	0
Driest 25 %	10	13	0	14	13	60
Median	108	104	87	103	104	116
Wettest 25 %	183	174	140	182	186	206
Wettest 10 %	278	252	207	259	261	282

Simulation results indicate that the water with a chloride concentration less than 250 mg/L will be available less often for all WaterFix scenarios than in "natural" (pre-1918) conditions. The greatest increase in salinity is predicted to occur for the Boundary 1 scenario, which results in a significant loss of "useable" water at Antioch's intake. Although salinity levels are lowest in the Boundary 2 scenario (i.e., salinity under the Boundary 2 scenario is closest to "natural" (pre-1918) conditions), Boundary 2 salinity levels are significantly higher than in "natural" (pre-1918) conditions.

Opinion 3: Fall X2 is an important component to establishing flow criteria that will not impair beneficial uses of water in the western Delta.

The Boundary 1 scenario will result in both higher salinity and changes in water composition at Antioch's drinking water intake in all water year types relative to existing conditions (EBC2). As discussed in detail in Section 7.2 of Antioch-202 Errata, the proposed north delta diversion (NDD) intakes are located on the Sacramento River in the northern part of the Delta. The water exported from the NDD intakes will consist almost entirely of Sacramento River water, thereby reducing the amount of Sacramento River water that enters the Delta and that will be available for use by other water users located downstream of the NDD intakes. In the Boundary 1 scenario, the composition of water available for use in the Delta downstream of the NDD intakes will change, generally including less Sacramento River water and higher proportions of water from other, lower-quality sources of water, such as the San Joaquin River and agricultural return flows. As discussed in Section 7.2 of Antioch-202, the San Joaquin River typically has higher concentrations of salinity, bromide, and other chemicals than water from the Sacramento River or eastside streams. Agricultural return flows also have poorer water quality than Sacramento River water as a result of the concentration of salts from soils, from fertilizers used within the Delta, and from evaporation of water applied for irrigation (Exhibit SWRCB-27).

Figure 6 of Antioch 202-Errata (reproduced below) shows the volumetric percent of water from the Sacramento River at Antioch's intake for the Boundary 1 scenario and for the existing condition (EBC2) and no action alternative (NAA) scenarios for different water year types. For all water year types, the Boundary 1 scenario generally results in less Sacramento River water at Antioch's intake compared to NAA or EBC2.

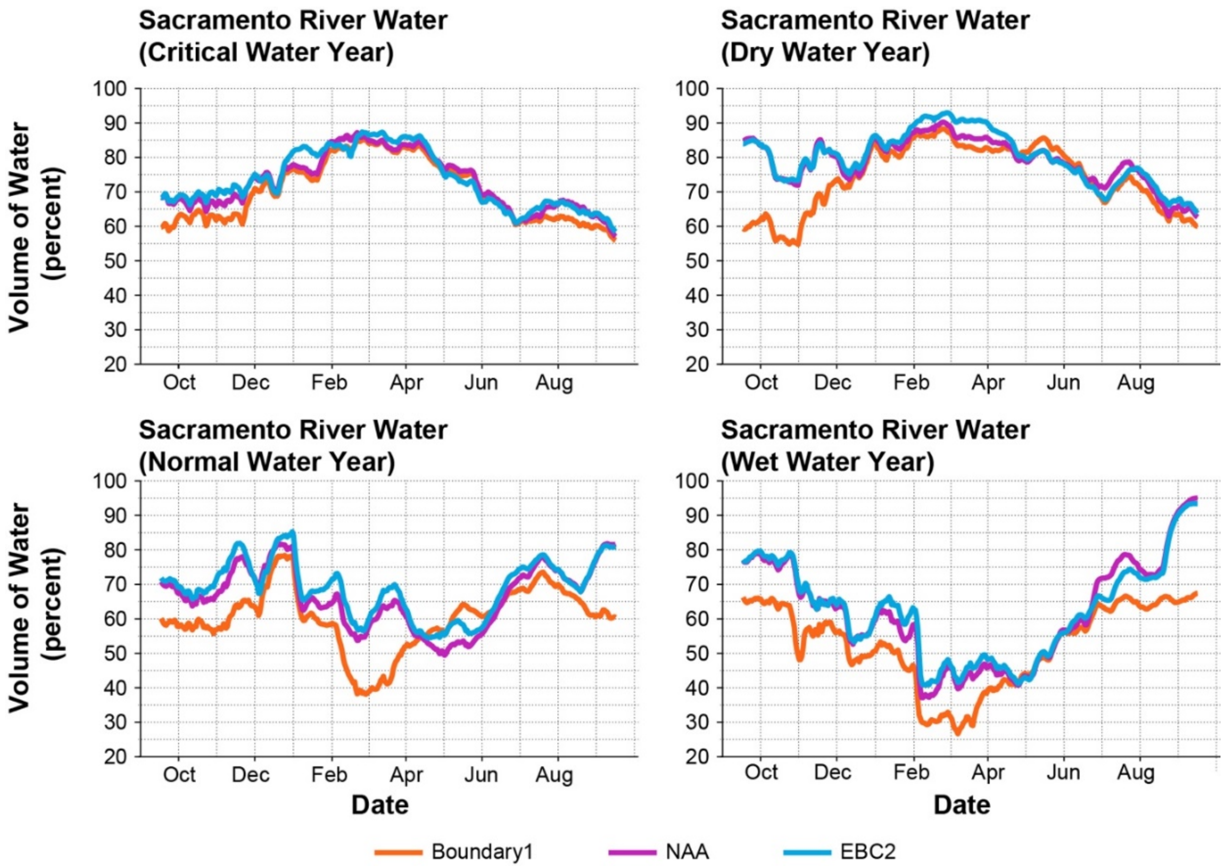

Figure 6 Antioch 202-Errata. Source fractions of Sacramento River water at Antioch's intake as modeled by DSM2, averaged by water year type.

Within the Delta, water of lesser quality will replace Sacramento River water exported by the NDD intakes that otherwise would have flowed into the Delta. As a result, salinity will increase at Antioch's intake location, and, as detailed in Opinion 2, "useable water" (water with a chloride concentration less than 250 mg/L) will be present less frequently at Antioch's intake under the Boundary 1 scenario.

Thus, WaterFix operations under the Boundary 1 scenario are expected to impact the municipal and industrial beneficial use in the western Delta and cause more frequent exceedances of applicable water quality objectives.[10] The modeled exceedances of the 250 mg/L chloride D-1641 water quality objective for municipal and industrial beneficial uses at Contra Costa Canal at Pumping Plant #1 (PP#1) are shown in Table 3[11] for all WaterFix scenarios. DWR's modeling shows that Boundary 1 scenario will result in 397 days of exceedance of the 250 mg/L chloride objective over the 16-year modeled period, while the Boundary 2 scenario will not result in any exceedances of this objective.

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[10] See Antioch-202 Section 9.2 for additional detail.

[11] Table 3 of this document is a corrected version of Antioch-202 Errata Table 8 and Brentwood-102 Table 5, which presented the number days of exceedance of the 250 mg/L chloride D-1641 water quality objective using an incorrect electrical conductivity to chloride concentration conversion factor. The appropriate conversion factor (station ROLD021) for Contra Costa Canal at Pumping Plant #1 was used to develop Table 3 of this document. See http://www.water.ca.gov/suisun/facts/salin/index.cfm for further detail.

Table 3. Number of days in each water year that the 250 mg/L chloride threshold for municipal and industrial beneficial uses is not met at PP#1 based on DWR model results.

Water Year	Year Type	Total Days	EBC2	NAA	B1	H3	H4	B2
1976	Critical	366	26	0	0	0	0	0
1977	Critical	365	0	23	0	0	0	0
1978	Normal	365	6	78	85	55	73	0
1979	Normal	365	0	7	57	0	0	0
1980	Normal	366	45	23	18	0	0	0
1981	Dry	365	0	0	0	0	0	0
1982	Wet	365	2	2	8	0	0	0
1983	Wet	365	21	0	0	0	0	0
1984	Wet	366	0	0	0	0	0	0
1985	Dry	365	0	0	8	0	0	0
1986	Wet	365	15	21	0	0	0	0
1987	Dry	365	0	0	38	0	0	0
1988	Critical	366	0	0	0	0	0	0
1989	Dry	365	55	80	88	53	51	0
1990	Critical	365	23	18	0	0	0	0
1991	Critical	365	17	91	95	52	33	0
		sum	**210**	**343**	**397**	**160**	**157**	**0**

As detailed in testimony by Dr. Nader-Tehrani,[12] the Boundary 1 scenario results in higher salinity in part because the Boundary 1 scenario is not operated to meet Fall X2 requirements. Fall X2 was adopted for regulatory purposes because this measure has been linked to the success of various pelagic organisms and provides a link to fish habitat.[13,14] When freshwater flows into the Delta are high and the Fall X2 position is pushed seaward, the "abundance of numerous taxa increases… implying that the quantity

[12] See DWR-66, p. 5:2-5. "It should be noted that Boundary 1 does not include Fall X2 in its operational assumptions, and in general may reflect higher EC results, especially for the months of September through November, and mostly for areas in the Western and Central Delta."

[13] Kimmerer, W. J. 2002a. Physical, biological, and management responses to variable freshwater flow into the San Francisco Estuary. Estuaries 25: 1275-1290; Kimmerer, W.J. 2002b. Effects of freshwater flow on abundance of estuarine organisms: physical effects or trophic linkages. Marine Ecology Progress Series 243:39-55.

[14] Baxter et al. (2010). Interagency Ecological Program – 2010 Pelagic Organism Decline Work Plan and Synthesis of Results. December 6, 2010. Available at http://water.ca.gov/iep/docs/pod/2010_POD_Workplan.pdf

or suitability of estuarine habitat increases when outflows are high."[15]

From this, I conclude that operating to meet Fall X2 is an important component of flow criteria to protect not only the municipal and industrial beneficial use of water in the Delta, but also to protect public trust uses in the Delta.

Opinion 4. At a minimum, flow criteria protective of beneficial uses and public trust values at Antioch should include requiring D-1641 municipal and industrial water quality objectives be maintained at Antioch, as the 1968 Agreement is not protective of such beneficial uses at Antioch.

D-1641 includes water quality objectives that are intended to protect the municipal and industrial beneficial use. D-1641 requires that the "Licensee/Permittee shall ensure that the water quality objectives for municipal and industrial beneficial uses and agricultural beneficial uses for the western Delta, interior Delta and export area as set forth in Tables 1 and 2…" are met.[16]

As discussed in detail in Antioch 202-Errata Section 9.3, D-1641 provides that the 150 mg/L chloride water quality objective can be met either at Antioch or at PP#1 (also called "Rock Slough"). DWR has indicated that they "don't attempt to meet it [at Antioch] because it's – for one, it's not required to meet it per D-1641. The requirement is at either location [CCPP#1/Rock Slough or Antioch]. And typically, it would be much less costly in terms of water – water supply for the entire system if we meet it at Rock Slough."[17] Thus, the D-1641 150 mg/L chloride water quality objective for municipal and industrial beneficial uses, as currently applied, is not protective of water quality at Antioch. The lack of action to protect Antioch's water supply was recognized by DWR when the 1968

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[15] Jassby, A. D., W. J. Kimmerer, S. G. Monismith, C. Armor, J. E. Cloern, T. M. Powell, J. R., Schubel, and T. J. Vendlinski. 1995. Isohaline position as a habitat indicator for estuarine populations. Ecological Applications 5: 272-289; Kimmerer 2002a, 2002b (footnote 13).

[16] SWRCB D-1641 p.146.

[17] Part 1A, Testimony Volume 11, p. 94, lines 19-24.

Agreement was adopted, as that agreement was intended to mitigate the City of Antioch for degradation in water quality caused by the operation of the State Water Project.[18]

However, the fixed term of the 1968 Agreement will expire on September 30, 2028 (see Antioch-102), prior to the commencement of WaterFix operations; after the end of the fixed term, either party may terminate the 1968 Agreement with twelve months' notice. Thus, Antioch stands to be harmed twice: first, if the 1968 Agreement is terminated by the State, as the City would no longer be reimbursed for water purchases it must currently make as a result of degraded water quality at its intake, as caused by the SWP; and second, WaterFix operations are expected to cause additional degradation to water quality at Antioch's intake, which would further reduce the amount of time Antioch can use water from its intake and increase the amount of water that must be purchased from other sources, and which would adversely impact public trust uses. As discussed previously, the Boundary 1 WaterFix operations scenario is expected to significantly reduce the number of days water is "useable" at the City's intake[19] and impair public trust uses due to the failure to operate to meet Fall X2. Without some form of compensation or mitigation provided by the State, the WaterFix project will worsen water quality at Antioch, such that beneficial uses are not protected.

Thus, the City requests that DWR either (1) enter into new agreement (or modify the existing agreement) to mitigate the City for the impacts of the WaterFix project or (2) require that DWR (a) operate to D-1641 <u>at Antioch</u> and (b) operate to meet Fall X2 requirements.

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[18] The 1968 Agreement (Antioch-101) provides at p. 2 that "in the future the average number of days per year that usable river water will be available to the City will be caused to decrease, and such decrease will be due in part to the operation of the State Water Resources Development System." The Agreement applies only to chlorides and only to municipal and industrial use by the City. The Agreement contains no standards or mitigation specifically protective of public trust or recreational uses. At the time of the 1968 Agreement, Water Rights Decision 990 (adopted on February 9, 1961, and predecessor to D-1641) was the primary document governing water use in the Delta.

[19] The Boundary 1 scenario will reduce the number of days of "useable water" by an average of 31 days per year in wet years, 21 days per year in normal years, 25 days per year in dry years, and 11 days per year in critical years, relative to existing conditions [EBC2]. See Antioch-202 Errata Table 4.

Executed on November 29, 2017 in Pasadena, CA.

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