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10 **BEFORE THE STATE WATER RESOURCES**
11 **CONTROL BOARD**

12 PART 2 - HEARING IN THE MATTER OF
13 CALIFORNIA DEPARTMENT OF WATER
14 RESOURCES AND UNITED STATES
15 BUREAU OF RECLAMATION REQUEST
16 FOR A CHANGE IN POINT OF DIVERSION
17 FOR CALIFORNIA WATER FIX

18 **SUR-REBUTTAL TESTIMONY OF**
19 **SUSAN PAULSEN IN SUPPORT OF**
20 **PROTEST OF THE CITY OF**
21 **ANTIOCH, PART 2.**

22 **(Exhibit: Antioch – 700)**

23 I, Susan C. Paulsen, declare as follows:

24 **QUALIFICATIONS**

25 My name is Susan Paulsen and I am a Registered Professional Civil Engineer in
26 the State of California (License # 66554). My educational background includes a Bachelor
27 of Science in Civil Engineering with Honors from Stanford University (1991), a Master of
28 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

1 Incorporated, in Pasadena, California, where I worked for 20 years, first as a consultant
2 (1994-1997), and then as an employee (1997-2014) in various positions, including
3 President. I have 25 years of experience with projects involving hydrology, hydrogeology,
4 hydrodynamics, aquatic chemistry, and the environmental fate of a range of constituents.

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

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

15 As before, I incorporate as part of my testimony my prior Reports and exhibits
16 submitted in support of Antioch's Part 1 case in chief, rebuttal, and sur-rebuttal and Part
17 2 case in chief, and rebuttal.

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SUMMARY OF TESTIMONY

My sur-rebuttal testimony focuses on addressing DWR's testimony as presented in
Opinion 5 of DWR-1217 (the testimony of Chandra Sekhar (Chandra) Chilmakuri).
Opinion 5 of DWR-1217 states "Applicable salinity requirements for City of Antioch's
M&I use will continue to be met" and comprises multiple sub-opinions. In response to
DWR-1217, I have developed the following opinions.

1 **TESTIMONY**

2 **Sur-Rebuttal Opinion 1: Because DWR’s own modeling shows significant water**
3 **quality degradation in the western Delta and at Antioch when WaterFix operations**
4 **do not include the Fall X2 requirement, the SWRCB should include the Fall X2**
5 **requirement (or an equivalent) as part of the flow criteria applicable to the**
6 **WaterFix project. The Fall X2 requirement should not be “independent of the CWF**
7 **change petition proceeding,” as asserted by DWR.**

8 Figure 5 of Opinion 5 of DWR-1217 presented 16-year monthly average EC at
9 Antioch’s intake location for the no action alternative (NAA) and the CWF H3+ scenario
10 and appears to be the primary basis for the statement that “applicable salinity
11 requirements for Antioch’s M&I use will continue to be met.” DWR also noted that “CWF
12 scenarios H3, H4, and B2 all indicate similar or better salinity conditions relative to NAA”
13 (DWR-1217, p. 12:13-14). DWR stated that “with the exception of Boundary 1 (B1)
14 scenario, all other scenarios presented are expected to provide similar or higher number
15 of compliance days compared to NAA ... Even the B1 scenario results from Dr.
16 Paulsen’s analysis indicate that 250 mg/L threshold is not met only 54 days compared
17 to the NAA (397 days compared to 343 days under NAA) resulting in an increase of only
18 1% relative to NAA over the 16-year DSM2 simulation period. ... Furthermore, this
19 relatively small increase in B1 scenario is a result of different assumptions in fall Delta
20 outflow requirements relative to NAA, as acknowledged by Dr. Paulsen in her
21 testimony.” (DWR-1217, p. 12:14-23)

22 WaterFix scenarios NAA, H3, H4, B2, and CWF H3+ and the existing conditions
23 scenario EBC2 include the Fall X2 requirement, while the Boundary 1 scenario does not
24 include the Fall X2 requirement. As shown in Table 1 below (reproduced from Antioch-
25 600), the Boundary 1 scenario (no Fall X2 requirement) results in the more days of
26 exceedance of the 250 mg/L chloride threshold at Contra Costa Canal Pumping Plant
27 No. 1 than all other scenarios (which include the Fall X2 requirement). Thus, the Fall X2
28 operations requirement is important to meeting the 250 mg/L chloride objective for

1 municipal and industrial (M&I) use in the western Delta.

2 Table 1. Number of days per water year that the D-1641 250 mg/L chloride water
 3 quality objective is **not** met (i.e., number of days it is exceeded) at Contra
 Costa Canal Pumping Plant No.1.

WY Type	WY	EBC2	NAA	Boundary 1				Boundary 2	
				CWF H3+	H3	BA H3+	H4		
Critical	1976	26	0	0	0	0	0	0	0
Critical	1977	0	23	0	0	0	0	0	0
Normal	1978	6	78	85	84	56	84	73	0
Normal	1979	0	7	57	0	0	0	0	0
Normal	1980	45	24	18	0	0	0	0	0
Dry	1981	0	0	0	0	0	0	0	0
Wet	1982	2	2	8	0	6	0	0	0
Wet	1983	21	0	0	0	0	0	0	0
Wet	1984	0	0	0	0	0	0	0	0
Dry	1985	0	0	8	0	0	0	0	0
Wet	1986	15	21	0	0	0	0	0	0
Dry	1987	0	0	38	0	0	0	0	0
Critical	1988	0	0	0	0	0	0	0	0
Dry	1989	55	80	88	87	55	53	51	0
Critical	1990	23	18	0	0	0	0	0	0
Critical	1991	17	91	95	99	52	52	34	0
sum		210	344	397	276	163	189	158	0

16 Perhaps most important for the City of Antioch, Table 2 (reproduced from
 17 Antioch-600) shows that, over the 16-year model period as a whole, the Boundary 1
 18 scenario results in **340 fewer days** (nearly a full year) of “useable water” at Antioch’s
 19 intake compared to the NAA scenario, and **430 fewer days** (more than 14 months) of
 20 “useable water” at Antioch’s intake compared to existing conditions (EBC2). Thus, it is
 21 clear that the Boundary 1 scenario has significant impacts on Antioch’s ability to use
 22 water at its intake, as a direct result of the fact that the Boundary 1 scenario does not
 23 include Fall X2 operations.¹

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 25 ¹ Note that DWR has stated that the operations of the proposed project will be bound by the
 26 Boundary 1 and Boundary 2 scenarios, even though those scenarios were not evaluated by DWR
 27 in their Part 2 case in chief. “A boundary analysis was presented in the Part 1 hearing, defined by
 28 Boundary 1 and Boundary 2, to provide a broad range of operational criteria anticipated to occur
 within the adaptive management process... Boundary 1 and Boundary 2, are not further
 discussed in the Part 2 hearing.” (DWR-1010, p.9:3-5, 9)

1 Table 2. Number of “useable” water days per year as defined by the 1968 Agreement.

2 WY Type	WY	EBC2	NAA	Boundary 1	CWF H3+	H3	BA H3+	H4	Boundary 2
3 Critical	1976	26	34	5	44	43	44	43	99
4 Critical	1977	0	0	0	0	0	0	0	0
Normal	1978	165	161	159	163	163	163	165	168
5 Normal	1979	145	145	104	146	146	146	146	149
6 Normal	1980	174	160	140	175	171	172	179	183
Dry	1981	97	85	74	85	76	81	79	100
7 Wet	1982	247	225	203	232	235	236	242	244
Wet	1983	365	320	300	300	319	318	312	331
8 Wet	1984	252	235	186	233	233	232	258	245
9 Dry	1985	85	95	39	113	112	124	109	178
Wet	1986	163	156	126	164	161	163	162	170
10 Dry	1987	68	79	54	90	87	87	88	119
Critical	1988	41	60	35	35	35	35	35	63
11 Dry	1989	77	74	66	71	69	71	69	79
12 Critical	1990	24	9	8	12	15	9	16	62
Critical	1991	39	40	39	40	39	39	39	40
sum		1968	1878	1538	1903	1904	1920	1942	2230

15 In addition, it is important to note that DWR included Fall X2 in both the future
 16 baseline condition developed for the WaterFix proceedings (NAA) and all project
 17 scenarios except Boundary 1. If the Fall X2 requirement is eliminated in the future for
 18 any reason, then none of the WaterFix model scenarios presented to and considered by
 19 the SWRCB in this proceeding (with the exception of the Boundary 1 scenario, which
 20 DWR-1217 appears to downplay) would be representative of the proposed project. In
 21 other words, with the exception of Boundary 1, the technical analyses DWR relies upon
 22 to support its WaterFix petition include operations to the Fall X2 requirement. If Fall X2
 23 were to be eliminated in the future through some separate, independent process, then
 24 the Boundary 1 scenario would be the only scenario presented by DWR in this
 25 proceeding that would be representative of future water quality. If the Fall X2
 26 requirement is not included in the flow criteria for the WaterFix project, then the SWRCB
 27 should not rely in this proceeding upon the other model scenarios to represent future
 28 water quality within the Delta.

1 As detailed in Antioch-500 Errata, municipal water suppliers in the Delta have
2 relied upon existing water quality objectives to plan capital improvements and treatment
3 facilities. Although the 1968 Agreement compensates Antioch for water it must
4 purchase from others when water quality at the City's intake is too saline for use as a
5 result of State Water Project operations, the fixed term of the agreement will expire
6 before WaterFix operations begin, and the agreement reimburses Antioch for only a
7 portion (one-third) of the purchases it must make and provides no mitigation for
8 pollutants other than chloride. Thus, the increased salinity caused by the WaterFix
9 project will have a material impact on the City.

10 Nonetheless, DWR asserts that the Fall X2 requirement "is a Delta smelt action
11 and subject to adaptive management" (DWR-1217 at p. 14:25) and that "the CWF
12 scenarios which include fall X2 requirement indicate no impacts to City of Antioch's
13 salinity conditions" (DWR-1217 at p. 14:26-27).² DWR's testimony misses the point.
14 DWR's own modeling clearly indicates that the Fall X2 requirement is an important
15 determinant of water quality in the western Delta and at Antioch's intake: the M&I water
16 quality objectives are met more often, and water at Antioch's intake is "useable" for
17 roughly a full year longer over the 16-year simulation period, as a direct result of the
18 implementation of the Fall X2 requirement.

19 Further, as acknowledged by DWR, decisions about Fall X2 operations will be
20 made through the adaptive management process and in consideration of the needs of
21 fish; the water quality requirements of municipal users of water in the Delta will not be
22 considered, and municipal users of water in the Delta will not be participants in the
23 adaptive management process.³

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25 ² DWR's testimony does not explain that, as shown in Table 2, WaterFix scenarios H3, BA H3+,
26 H4, and Boundary 2 all result in more days of useable water at Antioch's intake than Scenario
CWF H3+.

27 ³ "As part of the adaptive management process, DWR, Reclamation, CDFW, USFWS, NMFS,
28 and other appropriate agencies will coordinate with collaborative science workgroups to identify
(footnote continued)

1 This is precisely why it is important for the SWRCB to include Fall X2 as a
2 component of the flow criteria applicable to the WaterFix project.

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4 **Sur-Rebuttal Opinion 2: All of DWR’s model scenarios [EBC2, NAA, Boundary 1,
5 Boundary 2, H3, H4, and CWF H3+] exhibit salinity levels that are higher than
6 “natural” salinity levels.**

7 DWR-1217 states that “Dr. Paulsen’s alleged impacts to City of Antioch salinity
8 conditions are based on incorrect comparisons of CWF scenarios to the EBC2 scenario
9 and pre-1918 historic conditions.” (DWR-1217 at p. 12:24-25).

10 As discussed at length in Antioch-202 Errata, Antioch-300, and Antioch-500
11 Errata, the City of Antioch requested that I evaluate changes in water quality at the
12 City’s intake relative to existing conditions and relative to historical conditions observed
13 at Antioch’s intake since diversions of water began at this location prior to 1868.
14 Although DWR is correct in inferring that no direct EC measurements exist to describe
15 water quality at Antioch’s intake prior to about 1920, the historical record contains
16 abundant information indicating that water was “useable” at Antioch’s intake year-round,
17 at least at low tide, in all but the dry months of the driest years. Information on historical
18 salinity is described in detail in Antioch-500 Errata, Antioch-501, Antioch-216, Antioch-

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20 and prioritize potential changes to address uncertainties related to the effects of SWP and CVP
21 operations, including CWF, and other actions intended to **minimize or mitigate effects to**
22 **protected species.** (Exhibits SWRCB-108 and SWRCB-23 106.) Adaptive management will be
discussed in more detail in testimony by the biological experts.” (DWR-1010, p.8:18-24, emphasis
added)

23 I note also that the Bureau of Reclamation has, in recent years, requested reinitiation of the
24 consultation process with regard to the Fall X2 requirement. These requests have focused on
adaptive management and impacts to species, not on water quality for M&I uses in the Delta.
25 [See, for example, “Public Water Agency 2017 Fall X2 Adaptive Management Plan Proposal,”
August 30, 2017; Letter from the Bureau of Reclamation to the US Fish and Wildlife Service,
26 “Request for Reinitiation of Consultation on the 2008 Biological Opinion for the Coordinated Long-
term Operation of the Central Valley Project and State Water Project Biological Opinion for the
27 Proposed Change in Implementation of Reasonable and Prudent Alternative Component 3 –
Action 4 (Fall X2), September 7, 2017; and a memorandum from the Regional Director of the US
28 Fish and Wildlife Service to the Bureau of Reclamation, September 26, 2017.]

1 232, as well as in a report issued in 1931 by the California Department of Public Works
2 (the predecessor agency to DWR) (see Antioch-233). The information in these sources
3 is, in my opinion, reliable, and clearly indicates that water in the western Delta prior to
4 about 1918 was fresher than in all of the WaterFix model scenarios, including existing
5 conditions and the Boundary 2 scenario. The details of my analysis are not repeated
6 here. As discussed in Antioch-500 Errata, it is not possible to restore the Delta to its
7 historical condition and the City is not requesting that the SWRCB adopt flow criteria or
8 permit conditions that would restore natural salinity levels. Rather, the City provided
9 information on “natural” (pre-1918) water quality for the SWRCB’s use in the
10 development of flow criteria for the WaterFix project and for use by other parties in
11 evaluating the impacts of reduced flows and increased salinity on native species.

12 In contrast, I did explicitly and quantitatively use DWR’s model runs, including an
13 existing conditions model run (EBC2) prepared by DWR in 2013, the NAA, and the
14 WaterFix operations scenarios, to evaluate the impacts of the WaterFix project on the
15 quality of water at Antioch’s intake. As detailed in Opinion 1, if WaterFix project
16 operations do not include Fall X2 (i.e., if the WaterFix project is operated to the
17 Boundary 1 scenario, or if Fall X2 is removed from the other operations scenarios),
18 impacts to water quality at the City’s intake location will be severe, compared to both the
19 NAA and to existing conditions. DWR’s model runs demonstrate that, over the 16-year
20 simulation period, the City can expect to “lose” more than eleven months of useable
21 water relative to the NAA and more than fourteen months of useable water relative to
22 existing conditions. The testimony in DWR-1217 Opinion 5 regarding natural water
23 quality appears to be irrelevant to these conclusions and to Antioch’s request that the
24 SWRCB include Fall X2 in flow criteria to protect beneficial uses of water in the Delta.

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1 **Sur-Rebuttal Opinion 3: DWR’s statements regarding the C&H Sugar barge data**
2 **are irrelevant to my prior testimony and to Antioch’s proposed flow criteria for**
3 **the WaterFix project.**

4 DWR stated that “One specific source [Dr. Paulsen] mentioned was C&H Sugar’s
5 barge travel data. As cautioned by Dr. Hutton (DWR-1224), the data presented in
6 Exhibit Antioch-216 [CCWD 2010] is [sic] not appropriate to consider because it
7 appears to be shifted forward in time by half a month, resulting in biased reported
8 related to timing of initial and peak saltwater intrusion.” (DWR-1217 p.13:2-5)

9 As a primary matter, DWR’s statements regarding the C&H Sugar data are
10 irrelevant to my testimony. In Antioch-500 Errata, I offered four opinions:

- 11 • **Antioch-500 Errata Opinion 1:** Prior to about 1917, water within the Delta and
12 at Antioch’s intake location was historically fresh.
- 13 • **Antioch-500 Errata Opinion 2:** The Boundary 2 scenario is closest to “natural”
14 flow conditions.
- 15 • **Antioch-500 Errata Opinion 3:** Fall X2 is an important component to
16 establishing flow criteria that will not impair beneficial uses of water in the
17 western Delta.
- 18 • **Antioch-500 Errata Opinion 4:** At a minimum, flow criteria protective of
19 beneficial uses and public trust values at Antioch should include requiring D-1641
20 municipal and industrial water quality objectives be maintained at Antioch, as the
21 1968 Agreement is not protective of such beneficial uses at Antioch.

22 None of these opinions, nor the information used to support these opinions,
23 relates to or is reliant upon the “timing of initial and peak saltwater intrusion” in the
24 historical (pre-1918) time period, as DWR implies. None of these opinions would be
25 influenced if historical data were “shifted forward in time by half a month.” In my opinion,
26 the data collected by C&H Sugar are a valuable source of historical information
27 describing salinity in the western Delta, but Antioch’s requests regarding flow criteria for
28 the WaterFix project (see Antioch-500 Errata Opinions 3 and 4, reproduced above) are

1 based on DWR's DSM2 modeling for the WaterFix project.

2 Despite the lack of significance to my testimony, I reviewed the C&H Sugar barge
3 data presented in Antioch-216 (CCWD 2010), Antioch-232 (Means 1928) and Antioch-
4 233 (DPW 1931). I also reviewed DWR's Part 2 rebuttal testimony (DWR-1224 and
5 DWR-1217) and cross-examination responses related to the C&H Sugar barge data. I
6 did not find DWR's descriptions or explanations helpful in elucidating the issue, and I
7 was unable to identify the "half a month" shift or other signs of "biased" reporting. In any
8 case, a shift in the timing of peak salinity would not change the conclusions to be drawn
9 from the C&H Sugar data—i.e., the western Delta experienced significant increases in
10 salinity intrusion beginning around 1918 as a result of a number of factors, including
11 increased upstream agricultural development and in-Delta channelization. These factors
12 continue to influence salinity in the Delta today.

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14 Executed on September 21, 2018 in Pasadena, CA.

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Susan C. Paulsen, Ph.D., P.E., Principal
Scientist and Practice Director at Exponent

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