SOMACH SIMMONS & DUNN
A Professional Corporation
DANIEL KELLY, ESQ. (SBN 215051)
MICHAEL E. VERGARA, ESQ. (SBN 137689)
LAUREN D. BERNADETT, ESQ. (SBN 295251)
500 Capitol Mall, Suite 1000
Sacramento, California 95814-2403
Telephone: (916) 446-7979
Facsimile: (916) 446-8199

Attorneys for Petitioner/Plaintiff
BYRON-BETHANY IRRIGATION DISTRICT

BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

In the Matter of ENFORCEMENT ACTION ENF01951 – ADMINISTRATIVE CIVIL LIABILITY COMPLAINT REGARDING UNAUTHORIZED DIVERSION OF WATER FROM THE INTAKE CHANNEL TO THE BANKS PUMPING PLANT (FORMERLY ITALIAN SLOUGH) IN CONTRA COSTA COUNTY	SWRCB Enforcement Action ENF01951 WRITTEN TESTIMONY OF SUSAN C. PAULSEN

I, Susan C. Paulsen, declare:

1. I submit this written testimony at the request of counsel for: (1) Byron-Bethany Irrigation District (BBID) in Enforcement Matter No. 01951 (ENF01951); and (2) West Side Irrigation District (WSID) in Enforcement Matter No. 01949 (ENF01949). ENF01951 and ENF01949 (collectively, Enforcement Proceedings) are pending before the State Water Resources Control Board (SWRCB).

2. If called as a witness, I can and would competently testify to the following facts, analyses, findings, and conclusions stated herein, and to the information contained in the report produced as Exhibit BBID384 (Exponent Report), which is incorporated herein by reference as part of my written testimony.

Qualifications: Education and Professional Background

3. I am a Registered Professional Civil Engineer (License # 66554) and have been

since 2003.

4. In 1991, I received a Bachelor of Science in Civil Engineering with Honors from Stanford University.

5. In 1993, I received a Master of Science in Civil Engineering from the California Institute of Technology (Caltech).

6. In 1997, I obtained my Doctor of Philosophy (Ph.D.) in Environmental Engineering Science, also from Caltech.

7. 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. A more detailed explanation of my educational experience is contained in my curriculum *vitae* attached as Appendix G to the Exponent Report.

8. 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.

a. As part of this work, I collected composite samples of water at multiple locations within the Delta, and used the elemental "fingerprints" of the three primary inflow sources (the Sacramento River, the San Joaquin River, and the Bay at Martinez), together with the elemental "fingerprints" of water collected at two interior Delta locations (Clifton Court Forebay and Franks Tract) and a simple mathematical model, to establish the patterns of mixing and distribution of source flows within the Delta during the 1996–1997 time period.

b. After my thesis was completed, I directed model studies to use the chemical source fingerprinting to validate volumetric fingerprinting simulations using Delta models (including the Fischer Delta Model (FDM) and the Delta Simulation Model (DSM)).

9. I currently am a Principal and Director of the Environmental and Earth Sciences practice of Exponent, Inc. ("Exponent").

10. Prior to joining Exponent, I was the President of Flow Science Incorporated, in Pasadena, California. I worked with Flow Science for 20 years, first as a consultant (1994-1997),

and then as an employee in various positions, including President (1997-2014).

11. I have 25 years of experience with projects involving hydrology, hydrogeology, hydrodynamics, aquatic chemistry, and the environmental fate of a range of constituents.

12. I have extensive knowledge of California water supply issues, including expertise in California's Bay-Delta estuary. I have expertise in designing and implementing field and modeling studies to evaluate groundwater and surface water flows, and contaminant fate and transport.

13. I have designed studies using one-dimensional hydrodynamic models, three-dimensional computational fluid dynamics models, longitudinal dispersion models, and Monte Carlo stochastic models. I have directed modeling studies and have utilized the results of numerical modeling in my work, including for evaluation of surface water flows.

14. I also have expertise in analyzing the fate and transport of organic and inorganic pollutants, including salinity, DDT, PCBs, PAHs, copper, lead, selenium, and indicator bacteria, in surface water, and groundwater, and sediment.

15. I have designed and implemented field studies in reservoir, river, estuarine, and ocean environments using dye and elemental tracers to evaluate the impact of pollutant releases and treated wastewater, thermal, and agricultural discharges on receiving waters and drinking-water intakes.

16. I have also designed and managed modeling studies to evaluate transport and mixing, including the siting and design of diffusers, the water quality impacts of storm water runoff, irrigation, wastewater and industrial process water treatment facilities, desalination brines and cooling water discharges.

17. 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, including in the south Delta in the vicinity of the WSID and BBID intakes. A more detailed explanation of my professional experience is contained in my curriculum *vitae* attached as Appendix G to the Exponent Report.

18. I am the author of multiple reports describing the history and development of

water quality regulations and have provided testimony on regulatory issues, water quality, and water rights matters. These reports and other relevant publications are set forth in detail in my curriculum *vitae*, under "Selected Publications and Presentations." (*See*, Appendix G to Exponent Report, p. 2.)

Scope of Retention and Testimony

19. I was retained by counsel for BBID to assist them and counsel for WSID as an expert in the Enforcement Proceedings to: (1) describe flow and salinity conditions within the Sacramento-San Joaquin River Delta (Delta) over time; (2) review the historical diversion practices of BBID and WSID; (3) analyze the "availability" of water to satisfy BBID's intake demands in June 2015 according to its pre-1914 appropriative water rights; and (4) analyze the "availability" of water to satisfy WSID intake demands through the irrigation season according to its post-1914 appropriative water rights. As used herein, the term "availability" refers to both the quantity and quality of water available for diversion.

Description of Tasks and Evaluations Performed

20. To perform the analysis required for the scope of my retention, I evaluated the following information, as further described in the Exponent Report:

a. The history, evolution, and existing conditions of the Delta:

i. *Geography*: Review and analysis of the size of the Delta and its network of channels as impacted by the natural processes of sediment erosion and deposition, and human activities such as dredging and historical levee construction.

ii. *Hydrodynamics*: Review and analysis of Delta hydrodynamics, freshwater inflows and outflows, and the tidal behavior of and influences on flow.

iii. *Variations in Hydrology*: Review, analysis, and comparisons of hydrologic conditions, runoff, water year indices, and water year classifications in the Sacramento and San Joaquin Valleys during multiple drought periods.

SOMACH SIMMONS & DUNN
A Professional Corporation

iv. *Residence Time of Water in the Delta*: Review and analysis of "residence time" of water in the Delta (i.e., a measure of the amount of time that water spends within a system), which is a function of the amount of water present in the system and the flow rate of water into or out of the system.

v. *Variations in Salinity within the Delta*: Review and analysis of sources of salinity (e.g., agricultural return flows, wastewater treatment operations, sea water) and the effects of activities on salinity levels (e.g., releases of freshwater from upstream reservoirs by the Central Valley Project (CVP) and the State Water Project (SWP), and effects of the deep water ship channels).

vi. *Source Fingerprints*: Review and analysis regarding the location and time at which freshwater flows enter the Delta by using water samples collected throughout the Delta or by modeling, including review and analysis of information in the DSM2 model widely used by the California Department of Water Resources (DWR). This review and analysis further included modeling and evaluation of volumetric fingerprinting regarding how the distribution of water has changed within the Delta over time.

b. Historical hydrodynamics, salinity intrusion, and pumping practices relating to BBID's and WSID's diversions in the Delta during three pertinent time periods: 1) the pre-1917 Delta conditions, 2) drought periods after 1917 but prior to construction of the SWP and the CVP (i.e., post-1917/pre-SWP and CVP), and 3) drought periods after construction of SWP and CVP (i.e., post-SWP and CVP).

i. *Pre-1917 Conditions*: Review and analysis regarding the salinity levels and monitoring data (and a comparison of those conditions to other time periods), the physical changes in the Delta landscape, and early water management, export, storage, and diversion activities upstream of and within the Delta.

BBID Exh. 388

ii. *Post-1917 and Pre-CVP/SWP Conditions*: Review and analysis regarding the determination of "full natural flow," the historical diversion operations of BBID and WSID and their water diversions from Old River, and the salinity in the Delta between 1917 and 1944.

iii. *Post-CVP/SWP Conditions*: Review and analysis regarding the determination of "full natural flow," the relationship between reservoir releases and "full natural flow," and the historical diversion operations of BBID and WSID, specifically comparing the diversions between 2011 and 2015 against the diversions in 1977 for BBID, and comparing the diversions for 2014 and 2015 against the diversions in 1977 for WSID.

c. Hydrodynamic and water quality modeling was conducted to understand the source of the water and its distribution within the Delta during the conditions that occur in critically dry years. For this analysis, I used the DSM2 model and performed simulations for two conditions: (1) water year (WY) 1931, the driest year on record, according to the Sacramento Valley water index, prior to the construction of the SWP and CVP; and (2) WY 2015 with input data corresponding to actual conditions. The DSM2 model results were validated by comparing modeled salinity (modeled as EC and converted to chloride concentration) to measured chloride results for 1931, and by comparing measured and modeled EC for 2015. The results of the 1931 and 2015 model runs, together with historical information and measurements describing salinity within the Delta, were used to develop opinions regarding the conditions that would have existed during WY 2015 if the CVP and SWP had not been operating. The DSM2 model was used for three primary purposes: to understand the movement of water within the Delta estuary; to simulate salinity levels throughout the estuary, including salinity intrusion from the Bay; and to determine the source of water within the Delta. The source of water analysis was used to assess the fraction of water at the BBID intake in June 2015, and at the WSID intake during the summer of 2015, that originated from the Sacramento River, the San Joaquin River, and other sources, and to calculate when that water entered the Delta.

i. *Hydrodynamics, Salinity, and Source Fingerprints Using a Critically Dry, Pre-Project Year of 1931*: I reviewed and analyzed a simulation representative of the conditions that would likely have occurred during WY 2015 had the CVP and SWP not been constructed—i.e., WY 1931 is the pre-Project water year most hydrologically similar to WY 2015. Measured salinity data were used to understand model outputs for salinity, and the DSM2 was used to calculate source fingerprints for water at key locations within the Delta for 1931.

ii. *Hydrodynamics, Salinity, and Source Fingerprints for 2015*: As with the WY 1931 run, salinity measurements from key locations within the Delta were compared to DSM2 model output for WY 2015 to understand and interpret model results. The 2015 model runs were used to calculate hydrodynamics and salinity as a function of time, to evaluate Delta conditions during June 2015 and during the summer of 2015, and to determine both the location and the time at which water in the interior of the Delta entered the estuary.

iii. *Conditions in the Delta in 2015 Without the CVP and SWP*: I reviewed and analyzed modeling results for the WY 1931 and the WY 2015 runs to develop an opinion regarding the conditions that would have existed during WY 2015 if the CVP and SWP had not been operating.

Summary of Key Findings

21. The above referenced tasks and evaluations (as further described in the Exponent Report) yielded the following key findings:

a. *Delta and Water Availability*:

i. The Delta is the transition zone between the San Francisco Bay and its watershed. The salinity of water within the Delta results primarily from the balance between freshwater flows into the Delta and higher salinity water that enters the Delta from San Francisco Bay as a result of tidal action; freshwater flows into San Francisco Bay and agricultural return flows within the Delta also affect Delta salinity. Freshwater flows into the Delta typically peak in winter and spring in response to precipitation and snowmelt. Freshwater flows into the Delta are lowest, and exports and diversions of water from the Delta are highest, during the summer and fall months when weather is warmest and water demands are highest.

ii. Because Delta channels are below sea level, water is always present within the Delta. Because water will always be present in the Delta, the analysis of availability focused on the quality of water, specifically the salinity of water, and the source of water within the Delta.

iii. Flows within the Delta are strongly tidal. During dry conditions, tidal variations in stage and bi-directional ("sloshing") flows occur throughout the Delta, including at the upper extent of the Delta (e.g., in the Sacramento River at Sacramento). Tidal variations in flow rate, particularly in the western Delta, are often much larger than the net outflow, and large volumes of water enter and leave the Delta on a single tidal cycle.

iv. Water quality within the Delta is a function of the complex hydrodynamics and the geometry of the system, and salinity intrusion from the Bay into the Delta is greatest during the dry season of dry years.

v. The volume of water within the Delta is large (the Delta contains approximately 1.2 million acre-feet (MAF) of water), and the residence time, or length of time water remains in the Delta before it flows out of or is pumped from the Delta, varies greatly. The residence time of water within the Delta varies from a few days during the winter of wet years to as long as three months during the summer and fall of dry years.

vi. DWR computes a "water year index" that is used to classify the hydrologic condition in each water year (the period from October through the following September). DWR also calculates the unimpaired runoff, also known as "full natural flow." The full natural flow is defined as "the natural water production of a river basin, unaltered by upstream diversions or storage, or by export or import of water to or from other watersheds."

vii. WY 2015 was the seventh driest year on record in terms of the full natural flow, the fourth driest year on record in terms of the Sacramento Valley water year index, and the driest year on record in terms of the San Joaquin Valley index.

viii. In terms of the amount of full natural flow, water years 1977, 1924, 1931, 2014, 1976, and 1994 were drier than 2015.

b. *Pre-1917 Conditions*:

i. An abundance of evidence indicates that, prior to the early 1900s, water in the Delta was predominantly fresh.

ii. Changes in the Delta landscape since the mid-1800s have included the reclamation and removal of freshwater tidal marshes and levee construction, both of which increased salinity within the Delta.

iii. Freshwater diversion projects for storage and irrigation also increased salinity within the Delta, particularly during the summer and fall irrigation seasons.

iv. Salinity intrusion began to increase markedly in about 1918, when heavy plantings of rice and other crops occurred in the Sacramento Valley, which resulted in the penetration of salt water into the Delta for a longer time and to a greater distance upstream than known before. Prior to that point in time, water within the Delta had been sweet (fresh).

v. Historical data indicates that prior to about 1917, water at the (future) location of the BBID and WSID intakes would have been fresh year-round during all hydrologic year types.

c. *Historical data: 1917 to 1944*: Based on the salinity levels reflected in the historical measurements collected by DWR and its predecessor -

i. The data indicate that BBID and WSID diverted water from the Delta in the months of March through October of all years beginning in 1917 (BBID) and around 1919 (WSID), including during the months of March through October of the critically dry water years of 1924, 1929, 1931, and 1934.

ii. WY 1931 was the year with the lowest Sacramento River flow index in the historical record; because this year occurred during the pre-CVP/SWP time period, conditions during 1931 are most representative of the conditions that would occurred during WY 2015, if the CVP and SWP did not exist.

iii. Both BBID and WSID (along with other diverters in Old River) diverted water during the months of June, July and August 1931; the amount of water diverted did not vary appreciably from the months of June, July, and August of other years in this time period.

iv. Salinity measurements made near the BBID intake indicate that water at this location remained fresh throughout the month of June 1931, began to rise in July 1931, reached a level of 1000 mg/L as chloride in early September 1931, peaked at about 1300 mg/L chloride in late September 1931, and fell below 1000 mg/L in late October 1931. Measured chloride data also demonstrate that chloride concentrations of 1000 mg/L or greater were observed at the BBID intake location only twice (in the fall of 1931 and 1934) at the WSID intake only once (in the fall of 1931). Both BBID and WSID diverted water from Old River throughout this period.

///

v. Available data show that between June 13-25, 1931 (i.e., during critically dry conditions without the operation of the CVP and SWP, and without curtailment orders issued by the SWRCB or another agency), water was present at the BBID intake location, water was of suitable quality for use (i.e., was "fresh"), and water was diverted by BBID. Similarly, for WSID, throughout the irrigation season of 1931, water was present at the WSID intake location, water was of suitable quality for use, and water was diverted by WSID. Thus, by any measure, water was "available" to BBID and WSID during a critically dry year, even without the influence of the CVP and SWP (which had not been constructed in 1931), and even without curtailment of diversions within and upstream of the Delta (as occurred during 2015).

d. _Historical data: 1944 to present_:

i. The CVP and SWP have changed the timing of freshwater inflows to the Delta, generally reducing winter and spring inflows and increasing summer and fall inflows. In addition, water is exported by the CVP and SWP from the South Delta, which has changed both the flow rates in Delta channels and the distribution of water and salinity within the Delta.

ii. Available data demonstrate that BBID and WSID diverted water throughout the summer of WY 1977, which by most measures was drier than WY 2015, and that water remained fresh at the BBID and WSID intake locations during this time period. Additionally, measured salinity data demonstrate that water at the BBID and WSID intake locations remained fresh during WY 2015.

e. _Model Simulations: Source of water in the Delta in 1931_: Although it has been asserted that the operations of the SWP and the CVP are responsible for the presence of freshwater in the south Delta during the summer of 2015, neither historical data (from the even drier pre-Project year of 1931) nor model results support this view.

i. The DSM2 model was able to simulate the intrusion of salinity from the Bay into the Delta well (as shown by comparisons of model results to measured salinity at Antioch).

ii. In the south Delta, the model captured the timing of salinity increases well but showed differences in the magnitude of concentration, a common occurrence with DSM2 that is likely due to difficulties in accurately simulating salinity impacts from agricultural return flows.

iii. Both measured and modeled chloride data indicate that fresh water was present at the BBID intake between June 13-25, 1931 (maximum chloride concentration of about 120 mg/L), and that water of suitable quality for use was present at the WSID intake during the irrigation season in WY 1931 (maximum chloride concentration of about 1000 mg/L).

iv. The analysis and the source fingerprinting shows that Sacramento River water present at the BBID intake from June 13-25, 1931, entered the Delta during the months of February-May 1931. Similarly, Sacramento River water present at the WSID intake during the irrigation season in 1931 originated primarily from the Sacramento River (and consisted of water that entered the Delta between February and May 1931) and from agricultural return flows.

f. _Model simulations: 2015_:

i. The impact of the CVP and SWP have changed the distribution of water within the Delta markedly, such that the Sacramento River is the primary source of water in the Delta year-round, and not just during the summer months.

ii. Approximately 65% or more of the water present throughout 2015 at Clifton Court Forebay, just upstream of the BBID intake located in the intake channel to the Banks Pumping Plant, originated from the

Sacramento River. It is important to note that the Project reservoirs upstream of the Delta captured and stored a portion of the runoff that occurred during the wet months of 2015; had this water not been captured by the Projects, that water would have entered the Delta and some fraction of this water would have remained in the Delta in subsequent months.

iii. During the period of June 13-25, 2015, water at the BBID intake consisted primarily of Sacramento River water that entered the Delta during the months of February-May 2015.

iv. It can be estimated that water that entered the Delta from the Sacramento River consisted of full natural flow prior to about April 20, 2015, and consisted of both full natural flow and stored water beginning on about April 20, 2015 (when the flow rates released from Shasta Dam surpassed than the full natural flow in the Sacramento River at Bend Bridge).

v. Less than 20% of the water at Clifton Court Forebay in late June 2015 flowed into the Delta from the Sacramento River after April 20, 2015, and only a fraction of that water would have been stored water released from reservoirs upstream of the Delta.

vi. Source fingerprinting performed using the DSM2 model demonstrates that the majority of the water diverted by BBID between June 13-25, 2015, consisted of the full natural flow of the Sacramento River that entered the Delta many months prior to that time.

vii. Approximately 65% to 75% or more of the water present at the WSID intake during the irrigation season in 2015 originated from the Sacramento River or from agricultural return flows (i.e., return flows from irrigation water diverted from Old River). During the irrigation season, the majority of the Sacramento River water at the WSID intake had entered the Delta during the months of February through May 2015. As was the case

BBID Exh. 388

at the BBID intake, source fingerprinting indicates that the majority of the Sacramento River water diverted by WSID during the irrigation season in 2015 consisted of the full natural flow of the Sacramento River that entered the Delta in the months prior to that time.

viii. Because the residence time of water in the Delta is several months during dry flow conditions, it takes a significant amount of time for river water to flow into and to propagate through the system. Because full natural flows are determined far upstream of the Delta, they would not be available for diversion for weeks to months—i.e., for the time required for water to travel from full natural flow measurement locations into and through the Delta, and to diversion locations in the south Delta—and in the meantime, water in the Delta would consist of flows that had entered the Delta in prior months. Although the relationship between full natural flow and "availability" within the Delta could be determined using model simulations, it would be inappropriate to use full natural flow as a real-time indicator of water availability in the Delta.

Conclusions

22. Based on the information and analyses contained herein and detailed in the Exponent Report, I conclude:

a. BBID Water Availability: Water was available both in terms of sufficient quantity and quality for diversion by BBID between June 13-25, 2015, and the availability of water to BBID at these times was independent of the operations of the SWP and CVP.

b. WSID Water Availability: Water was "available" both in terms of sufficient quantity and quality for diversion by WSID throughout the irrigation season of 2015, and the availability of water to WSID at these times was independent of the operations of the SWP and CVP.

///

c. Availability of Natural Flow: Although the relationship between full natural flow and "availability" within the Delta could be determined using model simulations, it would be inappropriate to use full natural flow as a real-time indicator of water availability in the Delta.

23. I formed the foregoing conclusions in consideration of the configuration, hydrodynamics, residence time, and quality of water within the Delta; the historical record that describes the diversion practices of BBID and WSID, and the quality of water available at the intakes of BBID and WSID; and an analysis of the salinity of water, and the source, both in terms of location and time, of water available for diversion by BBID and WSID.

I declare under penalty of perjury under the laws of the State of California that the foregoing is true and correct.

Executed on this 18th day of January, 2016, at Pasadena, California.

Susan C. Paulsen

Susan C. Paulsen

SOMACH SIMMONS & DUNN
A Professional Corporation

BBID Exh. 388