

1 Spencer Kenner (SBN 148930)
 James E. Mizell (SBN 232698)
 2 **DEPARTMENT OF WATER RESOURCES**
 Office of the Chief Counsel
 3 1416 9th St.
 Sacramento, CA 95814
 4 Telephone: +1 916 653 5966
 E-mail: jmizell@water.ca.gov

5 Attorneys for California Department of Water
 6 Resources

7
 8 **BEFORE THE**
 9 **CALIFORNIA STATE WATER RESOURCES CONTROL BOARD**

10 HEARING IN THE MATTER OF CALIFORNIA
 DEPARTMENT OF WATER RESOURCES
 11 AND UNITED STATES BUREAU OF
 RECLAMATION REQUEST FOR A CHANGE
 12 IN POINT OF DIVERSION FOR CALIFORNIA
 WATER FIX
 13

TESTIMONY OF PARVIZ NADER-
 TEHRANI

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 15
 16 I, Parviz Nader-Tehrani, do hereby declare:

17 I. INTRODUCTION

18 I am a supervising Engineer. I am employed by the Department of Water Resources
 19 (DWR). I received a Bachelor of Science degree in Civil Engineering from California State
 20 University in Fresno (1981), a Master of Science degree (1985) and PhD (1989) in Civil
 21 Engineering from UC Davis. I am a registered Civil Engineer in the State of California. I
 22 have over 26 years of experience in numerical modeling in hydrodynamics, water quality,
 23 and particle tracking in the Sacramento San Joaquin Delta mostly using DSM2. My duties
 24 include directing staff to conduct computer modeling in support of various programs within
 25 the DWR and reviewing the computer modeling done by DWR engineers and the
 26 consultants in support of the California WaterFix (CWF). A copy of my statement of
 27 qualifications has been submitted as Exhibit DWR-26¹.

28 ¹ Exhibit DWR-26 is a true and correct copy of the document.

1 In my testimony, I explain the water quality model and modeling results based on the
2 analytical framework described in Ms. Pierre's testimony. The boundary analysis provides
3 a range of operational criteria that are sufficiently broad so as to assure the State Water
4 Board that any operations considered within this change petition proceeding have been
5 evaluated with regard to effects on legal users of water.

6 More specifically this testimony in conjunction with Mr. Munévar's separate
7 testimony is provided to present the modeling results (CalSim II and DSM2) for the
8 boundary analysis that show the effects on legal users of water with respect to expected
9 changes in water supply, water quality, water levels, and end of September reservoir
10 storage. I rely on testimony provided by Mr. Munévar, specifically the CalSim II output that
11 feeds into the DSM2 model. The focus of my testimony is on possible changes to water
12 quality and water levels. The modeling done in support of the information presented in this
13 testimony was performed by the engineers from CH2M and DWR. The modeling done by
14 CH2M was directed by DWR and I have reviewed the model results. The modeling
15 conducted by DWR was done at my direction. It is my opinion that the modeling results are
16 accurate and consistent with this testimony.

17 II. OVERVIEW OF TESTIMONY

18 This testimony provides an overview of the computer modeling performed to
19 evaluate changes in the water quality and water levels associated with the CWF and any
20 possible effects on legal users of water. This modeling provides information in support of
21 how the CWF can be operated while continuing to meet DWR and Reclamation's
22 responsibilities under the Water Rights Decision 1641 objectives (D-1641). Delta
23 Simulation Model (DSM2) is the primary state of the art tool utilized in this analysis. The
24 modeling results are shown in Exhibit DWR-513².

25 The model results comparing the operational scenarios to the No Action Alternative
26 (NAA) show the following with respect to water quality changes:

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28 ² Exhibit DWR-513 is a true and correct copy of the document.

- 1 • The simulated water quality in the Delta is presented in terms of monthly average
2 bar graphs for Electrical Conductivity (EC) and chloride concentration. The water
3 quality is shown to meet the water quality objectives assigned to DWR and
4 Reclamation under D-1641. The water quality results compared to the NAA are
5 varied at locations and show seasonal variations. The water quality results at some
6 locations are better and some are worse as compared to the NAA.
- 7 • Operations under D-1641 are modeled in CalSim II. Model results at times show
8 modeling anomalies. A small fraction of these anomalies represent modeled
9 exceedances at some locations.
- 10 • Changes in minimum water levels are shown for locations throughout the Delta.
11 (See DWR-513, pp. 11-15, Figures W1-W5). The highest changes to water levels
12 correspond to locations close to the proposed North Delta Diversion (NDD) intakes
13 and can be up to 1.2 ft (during high flows) to 0.5 ft (during low flows). The modeled
14 daily minimum water level for Boundary 1, which results in the most NDD diversions,
15 drops below the lowest water level under the NAA only during 73 days out of the 16
16 years simulated, which represents less than 5 days in a year. Furthermore, the
17 modeled minimum water levels occur only for a short period of time throughout the
18 day. It is my opinion that there will not be negative effects to legal users of water
19 due to water level changes.

20 III. DSM2

21 DSM2 is a one-dimensional hydrodynamic and water quality simulation model used
22 to simulate hydrodynamics and water quality in the Sacramento-San Joaquin Delta. DSM2
23 represents the best available planning model for Delta tidal hydrodynamics and salinity
24 modeling. It is appropriate for describing the existing conditions in the Delta, as well as
25 performing simulations for the assessment of incremental changes caused by future
26 facilities and operations. The DSM2 HYDRO simulates velocities and water surface
27 elevations and its output provides the flow input for QUAL, which is a module that simulates
28 fate and transport of conservative and non-conservative water quality constituents,

1 including salts, given a flow field simulated by HYDRO.

2 All DSM2 model runs (hydrodynamics and water quality) were based on 16 years of
3 record (1976-1991). The years 1976-1991 contain a similar spectrum of year types as
4 those reflected in the 82 years (1922-2003) included in the CalSim II simulations. The
5 DSM2 16-year simulation period has an ample amount of data, provided in 15 minute
6 increments, to look at the finer details of the physical system. The 16-year period contains
7 the driest two-year drought on record and an extended drought period (1987–1991). There
8 is adequate variation of year types and drought periods to evaluate the physical system
9 and the effects of operational and structural changes to that system. (Exhibit DWR-511³.)

10 Estimates for all the Delta river inflows and Delta diversions (including SWP/CVP)
11 from CalSim II are used to drive the DSM2-Hydro and QUAL for predicting tidally-based
12 flows, stage, velocity, and salt transport within the estuary. The results from DSM2 are
13 used to inform the understanding of the overall effects of the CWF including changes in
14 water quality and water levels in the Delta.

15 IV. DELTA WATER QUALITY

16 The testimony that follows assesses the quantitative changes in water quality as
17 measured by chloride concentration and Electrical Conductivity (EC) based upon a
18 comparison of the DSM2 water quality results for all operational scenarios with the NAA.
19 This allows for an isolation of direct project effects. These data are presented in terms of
20 monthly average bar graphs for locations throughout the Delta. Later testimony will
21 describe whether these data show a modeled exceedance of D-1641. (see Exhibit DWR-
22 513, pp. 5-10, Figures C1-C6.)

23 In general, H3 and H4 operational scenarios result in very similar water quality
24 results as measured in EC or chloride at most locations, and the EC values are typically
25 (but not always) somewhere in between the results for Boundary 1 and Boundary 2
26 scenarios. Where these results do not fall within the boundary analysis, I explain why

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28 ³ Exhibit DWR-511 is a true and correct copy of the document.

1 below. Because Boundary 2 has an operational scenario that results in higher outflow this
2 generally results in lower EC and chloride. It should be noted that Boundary 1 does not
3 include Fall X2 in its operational assumptions, and in general may reflect higher EC results,
4 especially for the months of September through November, and mostly for areas in the
5 Western and Central Delta.

6 Exhibit DWR-513, Figures EC1- EC4 show the monthly average EC concentrations
7 at Sacramento River at Emmaton, San Joaquin River at Jersey Point, South Fork
8 Mokelumne River at Terminous, and San Joaquin River at San Andreas Landing. D-1641
9 water quality objectives at these locations are specified April 1 to August 15, with actual EC
10 thresholds varying depending on water year types. CalSim II prioritizes meeting the
11 D-1641 water quality objectives for all scenarios, and therefore it is no surprise that the
12 water quality results for all alternatives at these locations are similar during the period in
13 which the SWP/CVP operate to meet their responsibilities for D-1641. For the months of
14 April through June, the monthly average EC values for all scenarios are very similar to the
15 NAA for all locations shown.

16 For all scenarios except Boundary 2, in the months of July and August there is an
17 increase in EC at Emmaton of about 18-19 percent when compared to the NAA. (Exhibit
18 DWR-513, p. 1, Figure EC1.) DWR-EC values for Boundary 2 are higher than those for
19 NAA for the month of July by about 5 percent and are lower than those for NAA for the
20 month of August by about 19 percent. (Exhibit DWR-513, p. 1, Figure EC1.)

21 At Jersey Point (see DWR-513, p. 1, Figure EC2), there is a reduction of EC for the
22 months of July (19%-34%) and August (5%-41%) when compared to the NAA, with
23 Boundary 2 scenario resulting in the lowest EC. At San Andreas Landing (see Exhibit
24 DWR-513, p. 2, Figure EC3), there is a reduction of EC for the months of July (10%-15%)
25 and August (7%-26%) when compared to the NAA, with Boundary 2 scenario resulting in
26 the lowest EC. At Terminous, the EC results are very similar for all alternatives and are
27 well below the D-1641 water quality objectives.

28 Figure EC5 shows the simulated EC results for Old River at Tracy Road. (Exhibit

1 DWR-513, p. 3.) The D-1641 South Delta agricultural water quality objective (based on 30-
2 day running average) is 700 EC for the months April through August and 1000 EC for all
3 other months. For all months except March through May, EC results are very similar to
4 those for the NAA. For the months of March through May, Boundary 2 scenario results in
5 higher EC than all alternatives, while all other scenarios result in similar EC compared to
6 the NAA. (Exhibit DWR-513, p. 3.) It is my opinion that the increase in EC for Boundary 2
7 is most likely due to the assumption that there will be full closure of Head of Old River
8 through the operable gate for the months of March through May.

9 Figure EC6 shows the simulated EC results for San Joaquin River at Brandt Bridge.
10 At this location the EC results for all scenarios are very similar to the NAA. (Exhibit DWR-
11 513, p. 3.)

12 V. Delta Water Quality (Chloride)

13 For chloride, this water quality assessment applies a relationship between EC and
14 chloride that were developed based on historical water quality data to the DSM2 output for
15 EC. This relationship was developed based on data at Mallard Island, Jersey Island, and
16 Old River at Rock Slough. (Exhibit DWR-509.) The relationship was: $Cl = \max(0.15 \cdot EC - 12 \text{ and } 0.285 \cdot EC - 50)$. In the equation above, Cl is the chloride concentration in mg/L, and
17 EC is in $\mu\text{S}/\text{cm}$. The chloride regression method was developed using data for the west
18 Delta and is thus valid for that area. (Exhibit DWR-509.) The chloride regression method
19 has not been validated for other areas of the Delta.
20

21 Exhibit DWR-513, Figures CL1 to CL3 show the simulated chloride concentrations at
22 Contra Costa Canal, Old River near Clifton Court, and Barker Slough/ North Bay Aqueduct.
23 (Exhibit DWR-513, pp.4-5.) At all these locations there is year round D-1641 chloride
24 concentration objective to be at or below 250 mg/l. Model results show that the monthly
25 average chloride concentrations for all alternatives at these locations stay below this
26 threshold.

27 At Contra Costa Canal the results are mixed. (Exhibit DWR-513, p. 4, Figure CL1.)
28 For Boundary 1, chloride concentrations are higher than those for the NAA for the months

1 of October through March, while for other months the chloride concentrations are similar or
2 lower than the NAA. In fact, for the months of April through May, Boundary 1 results in the
3 lowest chloride concentration among all alternatives. It is my opinion that this is most likely
4 due to the higher negative Old and Middle River (OMR) flows assumed under this scenario.
5 Chloride concentration for alternatives H3 and H4 are similar or lower than the NAA for all
6 months except June. (Exhibit DWR-513, p. 4, Figure CL1.) Chloride concentration for
7 Boundary 2 is similar or lower than the NAA for all months except February through April
8 and June. (Exhibit DWR-513, p. 4, Figure CL1.) Boundary 2 results in the lowest chloride
9 concentration among all scenarios for the months of August through January. (Exhibit
10 DWR-513, p. 4, Figure CL1.) Surprisingly, Boundary 2 results in the highest chloride
11 concentration among all scenarios for the months of March and April. It is my opinion that
12 this is most likely to due to the lower South Delta diversions assumed under this scenario.

13 There is a relationship between bromides and chlorides and there is a formula that
14 calculates bromides based on chloride concentration. The chloride to bromide relationship
15 is approximately the same in many areas in the Delta, (Contra Costa Water District 1997).
16 (Exhibit DWR-509⁴.) The relationship used is $Br=0.0035*Cl$.

17 There are three municipal diversion locations where bromides may be of concern.
18 Two of which DWR has contracts that address SWP operations. (Exhibits DWR-303,
19 DWR-310, DWR-304.) The third point is the North Bay Aqueduct at Barker Slough. Based
20 on the chloride results shown in Figure CL-3 which show little to no change in chloride, it is
21 my opinion there will be no change in bromide. (Exhibit DWR-513, p. 5.)

22 Also I have had my staff review the CCWD agreement for potential water quality
23 changes in the Delta and based on this analysis it is my opinion there would be minimal
24 changes in water quality. (Exhibit- DWR-512⁵.)

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27 ⁴ Exhibit DWR-509 is a true and correct copy of the document.

28 ⁵ Exhibit DWR-513 is a true and correct copy of the document.

1 VI. D-1641 Compliance

2 As mentioned earlier, D-1641 objectives are implemented in CalSim II, but due to
3 many factors, including the difference in time-step size between the models, DSM2 may
4 show exceedances that are more related to the differences in the assumptions within each
5 model. In addition, the models do not reflect the ability of the SWP/CVP operators to meet
6 those water quality objectives.

7 Exhibit DWR-513, Figures C1 through C5 show the modeled probability of meeting
8 D-1641 water quality objectives at Emmaton, Jersey Point, San Andreas Landing,
9 Terminous, and Contra Costa Canal. (Exhibit DWR-513, pp. 5-9.) The information shown
10 is based on DSM2 water quality analysis. Based on the model results, in general all
11 scenarios including the NAA meet D-1641 water quality objectives most of the time. The
12 data shows a similar or an increased ability for all operational scenarios (compared to the
13 NAA) to meet D-1641 water quality objectives at all locations except Emmaton. At
14 Emmaton there is only a slightly lower ability to meet D-1641 water quality objectives. At
15 San Andreas Landing (see Exhibit DWR-513, p. 7, Figure C3) all scenarios (except the
16 NAA) meet the D-1641 water quality objectives at all times. At Terminous (see Exhibit
17 DWR-513, p. 8, Figure C4) all scenarios meet the D-1641 water quality objectives at all
18 times.

19 Exhibit DWR-513, p.10, Figure C6 shows the number of days in a year meeting the
20 150 mg/l mean daily chloride concentration at the Contra Costa Canal Intake. DSM2
21 Results indicate that Boundary 2 meets D-1641 water quality objectives for all water years.
22 All other scenarios (including the NAA) meet D-1641 for all years except 1977. It should be
23 noted that in general, all scenarios except Boundary 1 meet the 150 mg/l mean daily
24 chloride concentration for a greater number of days, beyond what is required, compared to
25 the NAA.

26 Exhibit DWR-513, p. 10, Figure C6 does not reflect actual chloride experienced in
27 1977 drought. Due to severe drought conditions, barriers were installed at six different
28

1 locations in the Delta in 1977, in order to help reduce ocean salinity intrusion and to raise
2 water levels. These barriers are not reflected in the modeled results. (Exhibit DWR-510⁶.)

3 VII. Water Levels

4 Exhibit DWR-513, pp. 11-15, Figures W1 through W5 show the probability of
5 exceedance for daily minimum water levels for locations throughout the Delta. For
6 example, the 10% exceedance represents the top 10% minimum daily water levels, which
7 most likely occur during high flow periods. Similarly, the 90% exceedance represents the
8 bottom 10% minimum water levels, which most likely occur during low flow periods. Results
9 show in general that all scenarios (except the NAA) result in a similar frequency distribution
10 for water levels.

11 As expected, the largest changes in water levels occur in the vicinity of the proposed
12 intakes along Sacramento River. Figure W1 shows the probability of exceedance for daily
13 minimum water levels at Sacramento River downstream of the proposed intakes. (Exhibit
14 DWR-513, p. 11.) The results show the maximum reduction of about 1.0-1.2 ft, occurring at
15 the 0-10% exceedance levels (highest changes expected during high flow periods periods).
16 This is consistent with the highest changes occurring at times when the three proposed
17 NDD are utilized at or near maximum capacity (9,000 cfs), typically occurring at high flow
18 periods. At highest probability levels (i.e., lowest range in water levels), the results show
19 the reduction in water levels is about 0.5 ft. This is consistent with the lowest changes in
20 water levels occurring during low flow periods when the total flow diverted through the three
21 proposed NDD is at its lowest range. On average, the minimum water levels in the vicinity
22 of the proposed NDD drop below the lowest minimum water level under the NAA only
23 during less than 5 days in a year.

24 Furthermore, the minimum water levels occur only for a short period of time
25 throughout the day. DSM2 results show that under the lowest minimum water levels the
26 tidal range at Sacramento River downstream of the proposed intakes is between 2 to 4 ft.

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28 ⁶ Exhibit DWR-510 is a true and correct copy of the document.

1 Which means for most of the day, the water level would be well above the minimum value.
2 During low flow periods, the total amount of water diverted from the proposed NDD is much
3 lower than the 9,000 cfs capacity. Modeled results were not refined on an hourly basis for
4 meeting specific water elevations. For this reason, the modeled results are showing a
5 more conservative outcome.

6 Similarly, Figure W2 shows the probability of exceedance for daily minimum water
7 levels at Sacramento River downstream of Georgiana Slough. (Exhibit DWR-513, p. 12.)
8 The results show the highest changes of about 0.9 ft, occurring at the 0-10% exceedance
9 levels, and the lowest changes of about 0.3 ft occurring at 90-100% exceedance levels.

10 As expected, the results show smaller changes in water levels at locations that are
11 farther from the three proposed NDD. In fact, according to Figures W3 to W5, there is very
12 little change in water levels at Sacramento River at Rio Vista, Mokelumne River at
13 Terminous, and Old River at Tracy Road. (Exhibit DWR-513, pp. 13-15.)

14 It is my opinion that for all of these reasons there will not be negative effects to legal
15 users of water due to these water level changes.

16 VIII. SUMMARY

17 Delta Water quality (based on EC and chloride) results are mixed. During the period
18 which Agricultural D-1641 water quality objectives for Western and Interior Delta applies
19 (April through August), water quality at most locations in the Delta are somewhat similar
20 amongst all operational scenarios. (Exhibit DWR-513, pp. 1- 5.) In general, the EC values
21 overall are expected to be higher at Emmaton for all alternatives except for Boundary 2,
22 and lower or similar for most other locations. (Exhibit DWR-513, pp. 1-5.) This is as
23 expected since Boundary 2 operational scenario has the highest Delta outflow among all
24 alternatives which results in lower EC.

25 Results for all operational scenarios including the NAA show modeled exceedances
26 in D-1641 water quality objective (agricultural, municipal, and industrial). (Exhibit DWR-
27 513, 5-10.) However, as explained earlier, the exceedances are mostly a result of
28 differences in model assumptions, such as the time-step issue described previously. In

1 reality, and as testified to by Mr. Leahigh, SWP/CVP project operators have been able to
2 meet their regulatory obligations to prevent most exceedances. (Exhibit DWR-61.)

3 The largest reduction in water levels is expected to occur in the vicinity of the NDD
4 and mostly during high flow periods. (Exhibit DWR-513, p. 11.) However, during low flow
5 periods, the expected reduction in daily minimum water levels is about 0.5 ft near the three
6 intakes and are much smaller at other areas farther from the three intakes. On average,
7 the minimum water levels in the vicinity of the proposed NDD drop below the lowest
8 minimum water level under the NAA only during less than 5 days in a year, and only for a
9 short period of time during the day. Furthermore, the modeled results are showing a more
10 conservative outcome. It is my opinion that for all of these reasons there will not be
11 negative effects to legal users of water due to water level changes.

12 The modeling shows the expected changes to water quality and water levels within
13 the Delta for the operational scenarios as compared to the NAA. Any changes that occur,
14 either structurally or operationally, within the Delta affects areas throughout the Delta.
15 Through careful planning and analysis, many areas of the Delta benefit and any negative
16 water quality and water level changes have been minimized. It is my opinion that the
17 modeling cannot completely mimic operational decisions but it does show that D-1641
18 water quality objectives can be met.

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Executed on 27 day of May, 2016 in Sacramento, California.



Parviz Nader-Tehrani

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