Millerton Lake CE-QUAL-W2 Temperature Modeling Supplemental Report by Merlynn D. Bender

1. Introduction and Summary of Supplemental Opinions:

I have been identified as an expert by the U.S. Department of Justice to provide testimony in *NRDC v. Rodgers*. I have been asked to express my opinions on flow and water temperature mathematical modeling of Millerton Lake and Friant Dam outlet releases and potential effects and uncertainties on a proposed downstream riverine cold water salmonid fishery.

I wrote a Millerton Lake CE-QUAL-W2 (W2) temperature modeling expert report and that expert report was submitted during August 2005. Two additional sensitivity modeling runs (S06 and S07) for this supplemental report have been completed since the expert report was submitted. I have prepared this supplemental report based on the expert report written by Dr. Michael L. Deas, Ph.D., P.E. and the Millerton Lake W2 two-dimensional (2D) water temperature modeling runs S06 and S07.

As a result of the Millerton Lake hydraulic and temperature modeling studies and review of the expert report written by Dr. Deas, I have reached the following supplemental conclusion, the basis for which is discussed in supplemental conclusions SC1 and SC2 as follows:

> SC1) W2 Modeling indicated that Dr. Moyle's proposed dry (5^{th} to 20^{th} percentile years) and normal-dry (20^{th}-50^{th} percentile years) outflow hydrographs, which release more water to the San Joaquin River and less water to the Madera and Friant-Kern canals and were proposed by National Resources Defense Council (NRDC) experts (see expert reports by Peter B. Moyle, Ph.D. and G. Mathias Kondolf, Ph.D.), would warm releases to the San Joaquin River about 2.8 to 3.0 °C (5.0 to 5.4 °F). The normal-dry outflow hydrograph will significantly reduce the reservoir volume by a third by mid-November during modeled calendar year 2004, drop water surface elevations over 28.4 feet (8.7 meters), and deplete the cold water volume that is less than 12 °C (53.6 °F) and is not in dead storage.
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> SC2) Tailwater "thermal refugia" are cold water areas where a few salmon currently "hang out" or exist during harsh warm conditions at other locations in the tailwater downstream of Friant Dam. Releasing more and warmer flow to the San Joaquin River could warm some of the thermal refugia and destroy cool water habitat for existing salmon. The larger warmer volume released under proposed NRDC dry and normal-dry outflow hydrographs to the San Joaquin River may dilute the cool water thermal refugia. This proposed phenomenon requires more data and investigation under a range of hydrologic conditions.

Based on the above SC1 and SC2 conclusions, in my expert opinion, without further Millerton Lake (W2), riverine (HEC5Q), habitat, fishery, and system operational modeling studies, it is unknown if there is enough existing cold water volume to seasonally sustain cool Friant Dam

release temperatures due to uncertainties in this hydraulically-dynamic and thermally-dynamic water resource. Based on the supplemental preliminary Millerton Lake W2 modeling temperature sensitivity study runs S06 and S07, sufficient cold water for a sustainable salmonid fishery downstream of Friant Dam during dry and normal-dry conditions is problematic as discussed above.

2. Data and Other Information Considered by Merlynn D. Bender in Forming Opinions:

In forming the opinions set forth herein and in preparing this supplemental report, I reviewed or used the following additional material:

1) Expert reports by Michael L. Deas, Ph.D, P.E., Peter B. Moyle, Ph.D., G. Mathias Kondolf, Ph.D., and Donald J. Smith and data and references that support the expert reports.

3. Discussion:

The focus of this supplemental report is Millerton Lake temperature modeling of proposed San Joaquin River dry hydrograph and normal-dry hydrograph releases proposed by the National Resources Defense Council (NRDC). The primary indicator is release temperature to the San Joaquin River just downstream of Friant Dam.

The roughly calibrated Millerton Lake CE-QUAL-W2 model was used for sensitivity simulations. Two additional sensitivity scenarios, runs S06 and S07, were run using 2004 hydrologically dry calendar year data to assess the affects of releasing more water out the river outlet works for a cold water fishery. The following describes the S06 and S07 scenarios that were run by the W2 model to assess river outlet temperatures to the San Joaquin River:

S06: Release more bottom water by increasing San Joaquin River outlet works flows (centerline elevation 115.82 meters (380.0 ft)) as proposed by the ***NRDC dry hydrograph*** for modeled calendar year 2004. Less water is released to the Madera and Friant-Kern canals. The dry hydrograph is 350 cfs (9.91 m3/s) with a two week flow of 500 cfs (14.16 m3/s) during the first two weeks in March, with a two week flow of 1500 cfs (42.48 m3/s) during the last two weeks in March, and with a two week flow of 700 cfs (19.82 m3/s) during the first ten days in November. Releasing the larger flows through the bottom outlet warmed summer and autumn river outlet release temperatures to the San Joaquin River due to a thicker mixed floating warm surface layer. The warm pan of surface water deepens due to wind mixing from the top and convective mixing from the bottom (due to the large interflows caused by canal withdrawals). When compared to modeled historical conditions observed during 2004, this scenario also will cause the water

surface of Millerton Lake to decrease by about 4.2 feet (1.3 meters) by November 11 since more water is released from Millerton Lake. Modeled release temperature at 15.3 °C (59.5 °F) on October 27, 2004 was 2.8 °C (5.0 °F) warmer than modeled historical 2004 conditions.

S07: Release more bottom water by increasing River outlet works (centerline elevation 115.82 meters (380.0 ft)) flows as proposed by the ***NRDC normal-dry hydrograph*** for modeled calendar year 2004. Less water is released to the Madera and Friant-Kern canals. The normal-dry hydrograph is 350 cfs (9.91 m3/s) with a two week flow of 500 cfs (14.16 m3/s) during the first two weeks in March, with a two week flow of 1500 cfs (42.48 m3/s) during the last two weeks in March, with a 2500 cfs (70.79 m3/s) flow spike during the first two weeks in April, and with a two week flow of 700 cfs (19.82 m3/s) during the first ten days in November. Releasing the larger flows through the bottom outlet warmed summer and autumn river outlet release temperatures to the San Joaquin River due to a thicker mixed floating warm surface layer. The warm pan of surface water deepens due to wind mixing from the top and convective mixing from the bottom (due to the large interflows caused by canal withdrawals). When compared to modeled historical conditions observed during 2004, this scenario also will cause the water surface of Millerton Lake to decrease by about 28.4 feet (8.7 meters) by November 11 since more water is released from Millerton Lake. This is problematic because the backwater transition (inflow mixing zone) is pushed downstream and autumn cool inflows will be forced to mix through the epilimnetic (warm surface) layer. Modeled release temperature on October 27, 2004 at 15.5 °C (59.9 °F) was 3.0 °C (5.4 °F) warmer than modeled historical 2004 conditions.

It has been hypothesized that a sustainable cold water salmonid fishery could be developed downstream of Friant Dam. However, the existing water resource does not appear to have the flexibility to accommodate the existing extensive water deliveries and a cold water fishery (salmonid) in Friant Dam tailwater. Additional investigation is required to define the bounds of the proposal and to determine if a technically-feasible and cost-effective salmonid tailwater fishery is possible.

4. Supplemental Conclusions

Based on supplemental preliminary Millerton Lake CE-QUAL-W2 modeling results and based on the derived 2004 NRDC dry and NRDC normal-dry Friant Dam outflow hydrographs input to the W2 model which indicated a loss of water and therefore a drop in Millerton Lake water surface under the dry and normal-dry outflow hydrographs, releasing more water to the San Joaquin River through the river outlet works under dry and normal-dry hydrographs could warm summer and autumn Friant Dam releases by about 2.8 to 3.0 °C (5.0 to 5.4 °F). The NRDC normal-dry outflow hydrograph will significantly reduce the reservoir volume by a third by mid-November during modeled calendar year 2004, drop water surface elevations over 28.4 feet (8.7 meters), and deplete the cold water volume that is less than 12 °C (53.6 °F) and is not in dead storage. Additional data should continue to be collected in support of future modeling efforts. Additional modeling is required to confidently answer the questions associated with Millerton Lake temperature characteristics such as cold water volume storage capacity, running out of cold water, and the inability to pull a cold water autumn inflow through Millerton Lake due to excessive mixing at the inflow area where the log jam develops.

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Merlynn D. Bender