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BEFORE THE

CALIFORNIA STATE WATER RESOURCES CONTROL BOARD

HEARING IN THE MATTER OF THE 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 GREG KAMMAN

WRITTEN TESTIMONY OF GREG KAMMAN, HYDROLOGIST
PACIFIC COAST FEDERATION OF FISHERMEN'S ASSOCIATIONS (PCFFA) AND THE INSTITUTE FOR FISHERIES RESOURCES (IFR) FOR PART 2 OF THE CALIFORNIA WATERFIX CHANGE IN POINT OF DIVERSION HEARING BEFORE THE STATE WATER RESOURCES CONTROL BOARD

I, Greg Kamman, do hereby declare:

I. INTRODUCTION

My name is Greg Kamman. I am presenting this testimony on behalf of the PCFFA and IFR in this evidentiary hearing before the State Water Resources Control Board ("State Water Board") concerning the petition to change the point of diversion for the California WaterFix for the State Water Project ("SWP") and federal Central Valley Project ("CVP"), as specified in the licenses and permits of the US Bureau of Reclamation ("Reclamation") and the California Department of Water Resources ("DWR").

I am a hydrologist with over twenty-five years of technical and consulting experience in the fields of hydrology and hydrogeology. I have been providing professional hydrology and geomorphology services in California since 1991 and routinely manage projects in the areas of surface- and groundwater hydrology, water supply, water quality assessments, and water resources management. Much of my work is located in the Coast Range watersheds of California, including the Klamath/Trinity and Eel River systems. My areas of expertise include: characterizing and modeling watershed-scale hydrologic and geomorphic processes; evaluating surface- and ground-water resources/quality and their interaction; assessing hydrologic, geomorphic, and water quality responses to land-use changes in watersheds and causes of stream channel instability; assisting and leading in the development of CEQA environmental compliance documents and project environmental permits; and designing and implementing field investigations characterizing surface and subsurface hydrologic and water quality conditions. On behalf of Trinity County, I completed numerous water operations and temperature modeling studies related to alternative operations of Trinity and Lewiston Lake with a focus on effects on downstream temperatures in the Trinity River. These studies were completed from 1997 through 2004. I co-own and operate the hydrology and engineering consulting firm Kamman Hydrology & Engineering, Inc. in San Rafael, California (established in 1997). I earned a Master of Science in Geology, specializing in Sedimentology and Hydrogeology as well as a Bachelor of Arts in Geology from Miami University, Oxford, Ohio. I am a California registered Professional Geologist (PG) and Certified Hydrogeologist (CHg). My resume and list of professional reports and publications are provided in Exhibit PCFFA-127.

II. OVERVIEW OF TESTIMONY

The purpose of this testimony is to demonstrate that the Final EIS/R for the WaterFix is inadequate to support the Petition because it does not analyze or propose mitigation measures for reasonably foreseeable adverse impacts to fishery and aquatic resources of the Trinity River. These foreseeable impacts stem from insufficient carryover storage in Trinity Lake and planned CVP operations and releases to the Trinity River that are unable to meet water quality objectives stipulated in the California State Regional Water Quality Control Board's Water Quality Control Plan for the North Coast Region. The rationale for this conclusion is presented below.

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III. CVP OPERATIONS AND WATER QUALITY OBJECTIVES FOR THE TRINITY RIVER DIVISION

Under the WaterFix, CVP operations and resulting instream flows in the Trinity River will be managed pursuant to the 2000 Trinity River Record of Decision ("ROD")[1] (PCFFA-98). Releases from Lewiston Lake via water stored in Trinity Lake provide water to meet the ROD Flows in the Trinity River. Water is released from Trinity Lake to Lewiston Lake where it is diverted to both the Sacramento River (via Clear Creek Tunnel) and the Trinity River. Annual hydrographs of average weekly ROD Flows for designated water year types are presented on page 13 in the Trinity ROD (PCFFA-98). Annual volumes by water year type are presented on page 12 in the Trinity ROD. *Id*. The 2000 National Marine Fisheries Service ("NMFS") Biological Opinion for the Trinity River (PCFFA- 109) states that Trinity Reservoir (Trinity Lake) would be operated to maintain a minimum carryover storage of 600 thousand acre-feet (TAF) between water years (bottom page 4, PCFFA-109). Implementation of drawdowns below the 600 TAF minimum end-of-year carryover level in Trinity Reservoir shall be determined by Reclamation, U.S. Fish and Wildlife Service ("USFWS"), and NMFS on a case by-case basis in dry and critically dry water years and Reclamation shall be prepared to make use of the auxiliary bypass outlets on Trinity Dam as needed (page 49, PCFFA-109).

The North Coast Regional Water Quality Control Board and California State Water Resources Control Board approved Trinity River temperature objectives in 1991, which were approved by the United States Environmental Protection Agency in 1992. These temperature objectives are presented in the Water Quality Control Plan for the North Coast Region ("Basin Plan") (footnote 5 to Table 3-1, page 3-8.00, PCFFA-102). The temperature objectives stipulate that specified daily average river water temperatures should not be exceeded during specific periods of the year in selected reaches of river.

IV. TRINITY LAKE STORAGE AND COLD WATER POOL

Ordinarily in late summer, water temperatures in Trinity Lake are well stratified,

[1] Hereafter, the instream flow schedules for the Trinity River as specified in the ROD will be referred to as the "ROD Flows".

displaying a layer of warm water above a deeper pool of much colder water. During this time, releases from Trinity Lake to Lewiston Lake occur through a submerged powerhouse outlet. If the reservoir is drawn down to a relatively low level, the upper warm layer may intersect the powerhouse outlet, releasing warm water to Lewiston Lake. In turn, these warm temperatures are propagated through Lewiston Lake to the Trinity River. As presented herein, a number of studies have been completed to quantify the minimum October 1 carryover storage volume that is needed to protect against the introduction of warm summer water releases during various water year types and droughts. The main factors that affect and/or control the Trinity Lake storage volume and size of the cool water pool are: reservoir inflow temperatures and volumes; CVP diversions and operations; seasonal meteorological patterns; release schedules to the river; use of the auxiliary outlet and water year-types.

V. RESERVOIR OPERATION INFLUENCE ON RIVER RELEASE TEMPERATURES

Reclamation reports that CVP operators face seasonal challenges in meeting downstream temperature objectives on the Trinity River. It states, "The geometry, hydrodynamics, and incidence of direct solar radiation in Lewiston Reservoir can cause an increase in water temperature during travel of flows from Trinity Dam to Lewiston Dam, and into the Trinity River. This sometimes results in unsuitable mean daily temperatures for anadromous salmonids in the Trinity River below Lewiston Dam" (page 1, PCFFA-118). The rate of water flow through Lewiston Lake is controlled by releases to the Trinity River and diversions to the Sacramento River via the Carr power plant. When the Carr power plant diversions are at capacity, the rate of flow through Lewiston Lake is sufficient to displace its entire volume in about 2.5 days and water temperatures remain relatively cool (Section 4.2.1, page 9, PCFFA-127). On the other hand, when the Carr power plant is not operating, flow through Lewiston Lake stagnates and thermal stratification develops within days, typically leading to the warming of summer surface waters to between 60 and 70 degrees Fahrenheit (*ibid*). Water temperature modeling results suggest that total flow rates through Lewiston Lake (i.e. the sum of Carr power plant diversions and Trinity River releases) should be between approximately 800 cfs during the late summer/early fall months of normal year-types and up to 1900 cfs during the summer/fall months of critically dry year-types in order to comply with downstream temperature objectives on the Trinity River (*ibid*).

VI. TEMPERATURE COMPLIANCE OF THE ROD FLOWS AND 600 TAF CARRYOVER STORAGE

As part of the preparation of the environmental analysis leading up to the Trinity River ROD, Trinity County hired Kamman Hydrology & Engineering, Inc. (KHE) to collaborate with Reclamation and USFWS modelers to evaluate how the ROD Flows comply with Trinity River water temperature objectives under a variety of different water year types (e.g., wet, normal, dry year types) (pages 3-4, PCFFA-127). Thermal evaluation of the ROD Flows was completed using a series of models that simulate flow and water temperatures for sequential portions of the upper Trinity River system for an individual water year type. These models included: the Bureau of Reclamation's Temperature Model (RTM) which simulates release volumes and temperatures from Trinity Lake[2]; a reservoir temperature model of Lewiston Lake based on the Box Exchange Transport Temperature and Ecology of Reservoirs model (BETTER); and USFWS' Stream Network Temperature Model (SNTEMP) which simulates water temperatures on the mainstem Trinity River below Lewiston Lake.

The objective of the temperature modeling studies was to predict water temperatures on the mainstem Trinity River in response to CVP operations to meet the ROD Flows. Simulated river water temperatures were then compared to the temperature objectives in the Water Quality Control Plan for the North Coast Region. Modeling was initiated using PROSIM and RTM to estimate release volumes and temperatures from Trinity Lake into Lewiston Lake. These data were then used by KHE as input into the BETTER model to estimate release temperatures from Lewiston Lake into the upper Trinity River.

In order to determine how simulated Lewiston Lake releases fared in meeting the

[2] Input data for RTM comes from Reclamation's project simulation model (PROSIM) which is used to evaluate the CVP and State Water Project (SWP) systems. The close linkage between RTM and PROSIM means that PROSIM also plays an indirect role in the temperature analysis process.

downstream temperature objectives, a suite of Lewiston release rate and temperature relationships were developed by USFWS using the SNTEMP model that were determined necessary to meet downstream temperature objectives. Four sets of flow and release temperature relationships were developed for a variety of hydrometeorological year-type conditions, including: cold-wet; median; hot-dry; and extremely hot-critically dry. These relationships are presented Table 8 in (PCFFA-127).

Temperature compliance modeling results of CVP operations indicate that the ROD Flows with 600 TAF carryover storage achieve compliance with Trinity River temperature objectives during wet and normal water year types (Table 11, PCFFA-127). During dry year types, the ROD Flows achieve temperature objectives 86% of the time and only 36% of the time during critically dry year types (Tables 12 and 13, respectively; PCFFA-127). These results beg the question – how well do the ROD Flows achieve temperature objectives during a multi-year drought period when carryover storage is systematically reduced year-to-year?

VII. CARRYOVER STORAGE ANALYSIS: 1928-1934 DROUGHT PERIOD

In 1998, Trinity County retained KHE to evaluate how an intense multi-year drought would affect carryover storage in Trinity Lake (PCFFA-117). The study approach included an interannual accounting of Trinity Lake storage during a series of representative water year-types similar to those experienced during the 1928-1934 drought.[3] Water releases from Trinity Lake were based on the water year type Trinity Division operations[4] under the ROD Flows (page 13, PCFFA-98). A series of interannual Trinity Lake water budgets were developed with initial carryover storage volumes ranging from 750- to 2000-TAF. The results of this study are summarized in the table under the heading, “Flow Study Alternative” on page 2 of PCFFA-117.

Study results (page 2, PCFFA-117) indicate that under CVP operations to meet ROD Flows, there is a net annual increase in Trinity Lake storage during normal (1928) year-types, but decrease during dry (-17.5 TAF) and critically dry (-341 TAF) year-types. Thus, when starting

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[3] The interannual water budget accounting started in 1928, a normal water year type.

[4] It is likely that CVP operations would change during drought periods. However, we did not have the knowledge or expertise to define such changes. Thus, the analysis used operations consistent with the earlier PROSIM simulations.

with 750 TAF of storage, Trinity Lake storage would have dropped below 200 TAF after the third year of the drought, primarily driven by storage reductions experienced during critically dry years. Study results (page 2, PCFFA-117) also indicate that a starting storage volume of 1250 TAF is required to maintain a minimum carryover storage of 600 TAF through the drought. However, as presented above, even a 600 TAF does not fully achieve compliance with temperature objectives during dry and critically dry year types. This study suggests that a minimum carryover storage volume of between 1250- and 1500-TAF during the first year of drought is likely required in order to provide the necessary water release temperatures to the Trinity River to meet downstream temperature objectives.

VIII. OTHER RECOMMENDED CARRYOVER STORAGE VOLUMES

In addition to the work cited above, I am aware of two other studies focused on identifying the minimum Trinity Lake carryover storage necessary to provide the necessary cold water releases to satisfy river temperature objectives. In their 1992 testimony to the State Water Board, Finnerty and Hecht (PCFFA-116) concluded that Trinity Lake carryover storage of 900 TAF or slightly more may be needed to meet downstream temperature objectives during 90% of all years. Their conclusion was based on analysis of hydrology, reservoir operations and temperatures for 1991, a single critically dry year-type. The second study, completed by Deas in 1998 (PCFFA-128) on behalf of Trinity County, included water temperature simulations of Trinity Reservoir using the Water Temperature Simulation Model (WTSM). His analysis evaluated temperature compliance under 1990 dry year-type conditions assuming initial reservoir storage volumes of 750-, 1250- and 1500-TAF. Model simulation results indicated elevated water temperatures at the powerhouse intake elevation for the 750 TAF carryover storage scenario and minimal to no temperature concerns at initial carryover storage volumes of 1250- and 1500-TAF, respectively. Deas' findings of elevated temperatures associated with 750 TAF of carryover storage are corroborated in the 2012 report by Reclamation, which found that a September 30 carryover storage requirement of less than 750 TAF is "problematic" in meeting state and federal Trinity River temperature objectives protective of the fishery (PCFFA-115).

IX. TRINITY RIVER RESTORATION PROGRAM FLOW AND VOLUME MONITORING

Implementation of the ROD Flows on the Trinity River began in 2001. Table 1 presents a summary of Trinity Lake carryover storage volumes (on September 30 of each water year), annual changes in storage and flows directed to the Trinity River or diverted to the Central Valley.[5] Table 1 covers the 2001 through 2016 period. Table 1 also presents the annual combined total volume of water released to the river and diverted to the Central Valley along with the annual percentages of total releases to the river and diverted to the Central Valley. During the 2001-2016 period, the total volume of water moving through the Trinity Division was split relatively evenly between river releases and diversion to the Central Valley, with just slightly more water diverted to the Central Valley.

During the 2001-2016 period, there were two (2) three-year droughts experienced in the Trinity River watershed. The 2007 through 2009 drought consisted of three sequential dry years. The 2013 through 2015 drought consisted of a critically dry year-type sandwiched between dry water years. The carryover storage volumes at the start of each drought were 1800- and 1890-TAF, respectively. In contrast to the modeled decrease in annual Trinity Lake storage of 17 TAF during dry year types (see Section VII above), the measured decrease in reservoir storage ranged from approximately 60- to 497-TAF and averaged 286.5 TAF during all dry year types (2007-2009, 2013 and 2015). During the single critically dry year-type (2014) experienced during the 2001-2016 period, carryover storage was depleted by 697 TAF, a value over twice the modeled estimate of 341 TAF presented in Section VII, above.

At the end of the 2007-2009 drought, carryover storage was depleted to 919 TAF, a value similar to the minimum carryover storage volume established by Finnerty and Hecht and

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[5] Apart from the Trinity Lake storage values, the data in Table 1 comes from the "Flow Volume Summary" table found on the Trinity River Restoration Program website link at: http://www.trrp.net/restoration/flows/flow-volume-summary/. Trinity Lake (also known as Clair Engle Lake) storage volumes (USGS gauge # 11525400) for September 30 are provided at the USGS's National Water Information System: Web Interface website link at: https://waterdata.usgs.gov/ca/nwis/dv/?site_no=11525400&agency_cd=USGS&referred_module=sw.

discussed in Section VIII above. At the end of the second year (2014 critically dry year) of the 2013-2015 drought, carryover storage was depleted to approximately 606 TAF and further declined to approximately 546 TAF by the end of the three-year drought. With the exception of 2008 and 2015, more water was diverted to the Central Valley than released to the river, including during the critically dry year (2014), when diversion volumes to the Central Valley were nearly twice as high as water released to the Trinity River.

Table 1: Trinity River Restoration Program Flow and Volume Summaries: 2001-2016

Water Year (Oct. 1 through Sept. 30)	Water Year-Type	Trinity Lake End of Year (Sept. 30) Storage AF	Trinity Lake Change in Storage AF	Total Release to Trinity River (ac-ft)	Diversion to Central Valley (ac-ft)	Total River Release and Diversion to Central Valley (ac-ft)	% Total Release to Trinity River %	% Diversion to Central Valley %
2001	Dry	1,428,200		383,800	669,400	1,053,200	36%	64%
2002	Normal	1,500,100	71,900	482,700	629,000	1,111,700	43%	57%
2003	Wet	1,881,000	380,900	556,100	857,600	1,413,700	39%	61%
2004	Wet	1,591,000	(290,000)	768,300	987,500	1,755,800	44%	56%
2005	Wet	1,890,000	299,000	651,200	466,700	1,117,900	58%	42%
2006	Ext Wet	1,795,000	(95,000)	1,216,200	1,350,600	2,566,800	47%	53%
2007	Dry	1,461,000	(334,000)	457,800	614,400	1,072,200	43%	57%
2008	Dry	1,137,000	(324,000)	648,700	555,000	1,203,700	54%	46%
2009	Dry	919,000	(218,000)	456,600	539,200	995,800	46%	54%
2010	Wet	1,558,000	639,000	656,700	274,700	931,400	71%	29%
2011	Wet	2,167,000	609,000	732,600	473,100	1,205,700	61%	39%
2012	Normal	1,800,000	(367,000)	686,100	709,900	1,396,000	49%	51%
2013	Dry	1,303,000	(497,000)	480,500	852,200	1,332,700	36%	64%
2014	Crit Dry	605,600	(697,400)	435,300	618,600	1,053,900	41%	59%
2015	Dry	545,900	(59,700)	508,000	450,500	958,500	53%	47%
2016	Wet	969,400	423,500	748,000	278,900	1,026,900	73%	27%
Total 2001-2016 Averages				**616,788**	**645,456**	**1,262,244**	**49%**	**51%**
2007-2009 Drought Averages				**521,033**	**569,533**	**1,090,567**	**48%**	**52%**
2013-2015 Drought Averages				**474,600**	**640,433**	**1,115,033**	**43%**	**57%**

X. CONCLUSIONS

The study findings presented above indicate that initial October 1 carryover storage volumes of 600- and 750-TAF are not sufficient to satisfy Trinity River temperature objectives for a single dry/critically dry water year-type, let alone multi-year droughts. Thus, it is reasonable to foresee that current implementation of the ROD Flows without sufficient carryover storage will not achieve Trinity River temperature objectives during such year-types. Both modeling results and monitoring data (Table 1) indicate that critically dry water year-types deplete reservoir carryover storage volumes at much higher rates than occurs during dry years. Whether dealing with dry or critically dry year-types, reservoir storage has no chance of being replenished during multi-year droughts under the current CVP operations.

As determined by Finnerty and Hecht, a minimum baseline carryover storage volume of 900 TAF is required to meet Basin Plan temperature objectives on the Trinity River during a single dry year. Studies by Deas and Kamman suggest this baseline carryover storage volume is likely higher. Regardless, significantly higher carryover storage volumes over the baseline value are required to preserve the necessary reservoir cool water pool during multi-year drought periods, in order to achieve temperature objectives. The data presented in Table 1 indicates that the volume of diversions to the Central Valley are greater than water released to the Trinity River during drought periods. Reducing the volume of water diverted to the Central Valley during drought periods would preserve the necessary reservoir carryover storage required to meet Trinity River Basin Plan water quality objectives. Modeling studies suggest carryover storage volumes of around 1750 TAF are sufficient to maintain adequate carryover storage to meet temperature objectives during multi-year droughts. However, monitoring data of the 2013-2015 drought indicate a carryover storage volume of 1800 TAF is drawn down to insufficient levels after two years of drought. Thus, a single minimum carryover storage volume cannot be developed without revising CVP operations that focus on preserving Trinity Lake carryover storage, most likely by reducing water that is diverted out of the Trinity River basin.

I declare under penalty of perjury under the laws of the State of California that the above is true and correct, and that I executed this declaration on November 28, 2017, in San Rafel, California.

Greg Kamman, PG, CHG, Principal Hydrologist
Kamman Hydrology & Engineering, Inc.