REBUTTAL EXPERT REPORT OF PROFESSOR W. MICHAEL HANEMANN, PH.D.

QUALIFICATIONS AND EXPERIENCE

A summary of much of my experience and publications in the field of water-related economics is provided below. For a more complete description of my qualifications, experience and publications, please refer to the attached curriculum vitae.

SUMMARY OF WATER-RELATED EXPERIENCE

Member, Scientific Oversight Panel, California Department of Water Resources San Joaquin Valley Hydrologic-Economic Modeling Study, 1980-1983.

Member, National Academy of Sciences Committee to Review the Glen Canyon Dam Environmental Studies Program (1986-91).

Consultant, Alaska Department of Fish & Game, statewide economic model to value sport fishing in Alaska (1986-1991).

Economic staff for the California State Water Resources Control Board's regulation of salinity and selenium in the San Joaquin River (1986-87) and for its Bay/Delta Water Rights/Water Quality Hearings (1987-90).

Independent member of negotiating committee for Memorandum of Understanding on Urban Water Conservation in California (1990-1991).

Consultant, San Joaquin Valley Inter-Agency Drainage Program, environmental benefits study of San Joaquin Valley fish and wildlife resources (1989-91).

Consultant, California State Water Resources Control Board, responsible for the economic component of the Board's EIR for its Mono Lake Decision, including water demand forecasting and public trust valuation (1991-93).

Technical Adviser on water rate design, Mayor of Los Angeles' Blue Ribbon Committee on Water Rates (1992-95).

Consultant on water rates, demand forecasting, and integrated resource planning for Blue Ribbon Task Force established by the Directors of the Metropolitan Water District of Southern California (1993).

Consultant on water rate design, conservation planning, and cost-effectiveness assessment to the California Urban Water Conservation Council (1992-97).

Consultant to US Bureau of Reclamation on economic analysis of urban water supply and environmental benefits, Programmatic EIS for the Central Valley Project Improvement Act (1994-97).

Consultant to the National Commission of Water, Mexico on water pricing and reform of water allocation (1995-99).

Adviser to the UK Department of the Environment on valuation of environmental damages from pollution (1998-2001).

Chair of the Board, National Ocean Economics Project (1999-present)

Member, EPA Science Advisory Board, Environmental Economics Advisory Committee (2000 - present).

Member, EPA Science Advisory Board, Drinking Water Arsenic Rule Review Panel (2001).

Consultant to URS Corporation for review of analyses to assess potential for water market purchases and to assess economic impact of various supply alternatives for Friant Water Users Authority Service area (2001-02)

Organizer, Second World Congress of Environmental & Resource Economists, Monterey CA June 24-27, 2002.

Member, EPA Science Advisory Board, Environmental Economics Advisory Committee on Affordability Criteria for Small Drinking Water Systems (2002).

Member, CALFED Urban Drinking Water Quality Advisory Committee (2002 - present).

Consultant to the Spanish Ministry of the Environment, to review the Spanish National Hydrological Plan (2002).

Consultant to California Energy Commission for peer review of California climate change impact assessment report (2002-3).

Consultant to the Hopi Tribe on claim for water rights in connection with the adjudication of the Little Colorado River (2003 – present).

Consultant to Imperial Irrigation District on outdoor urban water use in Southern California (2003).

Director, California Climate Change Center at UC Berkeley (2003 – present)

Peer Reviewer, Central Valley Regional Water Quality Board Report on Economic Analysis for the Implementation of a Control Program for Salt and Boron Discharges to the Lower San Joaquin River.

Consultant to Hobbs, Ong & Associates for study of the economic impact of water-based growth limitation in Southern Nevada (2003-04)

Member, CALSIM Technical Peer Review Committee, California Bay-Delta Authority (2003).

Consultant to Malaysia Foreign Ministry on the pricing of long-run water supply contracts with Singapore (2003-4).

Member, California Bay-Delta Authority Finance Advisory Panel (2003-4).

Consultant to the California Urban Water Conservation Council on environmental costing for water supply in California (2004 – present).

Consultant to Imperial Irrigation District for evaluation of methods for the equitable apportionment of water (2005)

Member, National Research Council Committee on Propsective Benefits of DOE's Energy Efficiency and Fossil Energy R&D Program (Phase Two), July 2005 –

SUMMARY OF PUBLICATIONS ON THE ECONOMICS OF WATER

Lake, Elizabeth, W. Michael Hanemann, and Sharon Oster. *Who Pays for Clean Water? The Distribution of Water Pollution Control Costs*. Boulder, Colorado: Westview Press, 1979.

Erlenkotter, Donald, W. Michael Hanemann, Richard E. Howitt, and Henry J. Vaux, Jr. "The Economics of Water Development and Use." In *California Water Planning and Policy: Selected Issues*, edited by Ernest Engelbert. Davis: University of California, Water Resources Center, June, 1979.

Bockstael, Nancy E., W. Michael Hanemann, and Ivar Strand. *Measuring the Benefits of Water Quality Improvements Using Recreation Demand Models*. Washington, D. C.: U. S. Environmental Protection Agency, October, 1986.

Bockstael, Nancy E., W. Michael Hanemann, and Catherine L. Kling. "Estimating the Value of Water Quality Improvements in a Recreational Demand Framework." *Water Resources Research*, Vol. 23 (May, 1987), pp. 951-960. Reprinted in *Environmental Valuation*, ed. by Kenneth G. Willis, Cheltenham, U.K.: Edward Elgar (2000).

Hall, C. H.; Lichtenberg, E. R.; Patton, S. E.; Layton, D. W.; Hanemann, W. M.; and Stuermer, D. H. *Costs of Alternative Treatment Technologies for 1,2-Dibromo-3- Chloropropane (DBCP) in California Groundwater Supplies*. Livermore, California: Lawrence Livermore National Laboratory, May, 1987.

Hanemann, Michael, Erik Lichtenberg, David Zilberman, David Chapman, Lloyd Dixon, Greg Ellis, and Janne Hukkinen. "Economic Implications of Regulating Agricultural Drainage to the San Joaquin River." *Regulation of Agricultural Drainage to the San Joaquin River*. SWRCB Order No. W.Q. 85-1, Technical Committee Report. Appendix G (two vols.). Sacramento, California: State Water Resources Control Board, August, 1987, 443p.

Strong, David, W. Michael Hanemann, and L. Tim Wallace. "Private and Public Sector Economic Impacts Resulting from Regulation of Agricultural Drainage to the San Joaquin River." *Regulation of Agricultural Drainage to the San Joaquin River*. SWRCB Order No. W.Q. 85-1, Technical Committee Report. Appendix J, Indirect and Induced Economic Impacts. Sacramento, California: State Water Resources Control Board, August, 1987, 207p.

Committee to Review the Glen Canyon Environmental Studies. *The Canyons of the Colorado: A Review of the Glen Canyon Environmental Studies*. Washington, D.C.: National Academy Press, 1987. 203p.

Carson, Richard T., W. Michael Hanemann, and Thomas C. Wegge. *Final Report: Southcentral Alaska Sport Fishing Economic Study*. Prepared for the Alaska Department of Fish and Game. Jones and Stokes Associates, Sacramento, California, December, 1987.

Hanemann, W. M., and L. Dale. *Reasonable Municipal and Industrial Use in 2010 by SWP Contractors in Southern California* and *Reasonable Municipal and Industrial Use in 2010 in the Central Coast and San Francisco Bay HSAs.* Consultant's report submitted to the State Water Resources Control Board, Berkeley, 1988.

Dale, L.; and Hanemann, W. M. *The Cost of Re-Operating New Don Pedro Reservoir to Increase Spring Flow to the San Joaquin River*. Department of Agricultural and Resource Economics, University of California. Berkeley, June, 1990.

Dale, L.; and Hanemann, W. M. *Sizing of A Groundwater Bank*. Department of Agricultural and Resource Economics, University of California. Berkeley, June, 1990.

Jones & Stokes Associates, Inc. *Environmental Benefits Study of San Joaquin Valley's Fish and Wildlife Resources*. (JSA 87-150) Sacramento, California. Prepared by J. B. Loomis, W. M. Hanemann, and T. C. Wegge, September, 1990.

Fisher, Anthony C., W. Michael Hanemann, and Andy Keeler. "Integrating Fishery and Water Resource Management: A Biological Model of a California Salmon Fishery." *Journal of Environmental Economics and Management*, Vol. 20 (1991), pp. 234-261.

MacDougall, Neal, W. Michael Hanemann, and Zilberman, David. *The Economics of Agricultural Drainage* Report submitted to the Central Valley Regional Water Quality Control Board, Standard Agreement No. 0-132-150-0. June, 1992.

Hanemann, W. Michael. "Natural Resource Damages for Oil Spills in California." In Kevin M. Ward and John W. Duffield, *Natural Resource Damages: Law and Economics*, New York: John Wiley & Sons, Inc., 1992, pp. 555-580.

Hanemann, W. Michael. "Designing New Water Rates for Los Angeles." *Water Resources Update*, The Universities Council on Water Resources, Issue No. 92, Carbondale, IL, (Summer, 1993).

Hanemann, W. Michael; McCann, Richard. "Economic Impacts on the Northern California Hydropower System" in *Integrated Modeling of Drought and Global Warming, Impacts on Selected California Resources*. National Institute for Global Environmental Change, University of California, Davis. pp. 55-68. March, 1993.

Dumas, Christopher; and Hanemann, W. Michael. "Simulating Impacts on the Sacramento River Fall Run Chinook Salmon Population" in *Integrated Modeling of Drought and Global Warming, Impacts on Selected California Resources*. National Institute for Global Environmental Change, University of California, Davis. pp. 69-95. March, 1993.

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Dumas, Christopher F., and Hanemann, W. Michael. *Economic Benefits of the United States Environmental Protection Agency's Proposed Bay-Delta Standards*. Report for United States Environmental Protection Agency, Water Management Division, San Francisco, California, November,1993.

Mitchell, David L., and W. Michael Hanemann. *Setting Urban Water Rates for Efficiency and Conservation: A Discussion of Issues*. Sacramento, CA: California Urban Water Conservation Council, October 1994.

Hewitt, Julie A., and W. Michael Hanemann. "A Discrete/Continuous Choice Model of Demand Under Block Rate Pricing." *Land Economics*, Vol. 71, No. 2 (May, 1995), pp. 173-192.

Pekelney, David M., Thomas W. Chesnutt, and W. Michael Hanemann. *Guidelines to Conduct Cost-Effectiveness Analysis of Best Management Practices for Urban Water Conservation*. Sacramento CA: California Urban Water Conservation Council, September, 1996.

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Baumann, Duane, John Boland, and W. Michael Hanemann (eds.) *Urban Water Demand Management and Planning*. New York: McGraw Hill, 1998.

Hanemann, W. Michael. "Determinants of Urban Water Use." Chapter 2 in *Urban Water Demand Management and Planning,* edited by Duane Baumann, John Boland, and Michael Hanemann. New York: McGraw Hill, pp. 31–75, 1998.

Hanemann, W. Michael. "Price and Rate Structures." Chapter 5 in *Urban Water Demand Management and Planning,* edited by Duane Baumann, John Boland, and Michael Hanemann. New York: McGraw Hill, pp. 137–179, 1998.

Hanemann, W. Michael. Arsenic Rule Benefits Panel of the US EPA Science Advisory Board, *Arsenic Rule Benefits Analysis: An SAB Review*. EPA-SAB-EC-01-008, Washington DC, August 2001.

Cavanagh, Sheila M., W. Michael Hanemann, and Robert N. Stavins "Muffled Price Signals: Household Water Demand Under Increasing-Block Prices" Fondazione Eni Enrico Mattei Working Paper 40. February, 2002.

W. Michael Hanemann, "The Central Arizona Project", Department of Agricultural and Resource Economics Working Paper No. 937, University of California, Berkeley, October 2002.

Horne, Alexander, John Dracup, Michael Hanemann, Ignacio Rodriguez-Iturbe, Edward Means and James Roth, *A Technical Review of the Spanish National Hydrological Plan (EbroRiver Out-of-Basin Diversion)*. Submitted to Fundacion Universidad Politecnica de Cartagena, Spain, January 7, 2003.

Carson, R.T., R.C. Mitchell, W.M. Hanemann, R. J. Kopp, S. Presser, P. A. Ruud. "Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill." *Environmental and Resource Economics*, July 2003, Volume 25, Issue 3, pp. 257-286.

Carson, Richard T., Michael B. Conaway, W. Michael Hanemann, Jon A. Krosnick, Robert C. Mitchell and Stanley Presser, *Valuing Oil Spill Prevention: A Case Study of California's Central Coast* Kluwer Academic Publishers, 2004.

Hanemann, W. Michael, Linwood Pendleton, and Craig Mohn, *The Effect of Coastal Water Quality on the Value of Beach Recreation in Southern California* University of California, Berkeley, May 2004.

Katherine Hayhoe et al. "Emissions Pathways, Climate Change, and Impacts on California," *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* August 2004; 101 (34).

Schlenker, W., W. M. Hanemann and A. C. Fisher. "Will U.S. Agriculture Really Benefit from Global Warming? Accounting for Irrigation in the Hedonic Approach," *American Economic Review* (March 2005) 395-406.

Sethi, G., C. Costello, A. Fisher, W.M. Hanemann and L. Karp, "Fishery Management Under Multiple Uncertainty," *Journal of Environmental Economics & Management* (in press).

Schlenker, W., W. M. Hanemann, and A. C. Fisher, "Water Availability, Degree Days, and the Potential Impact of Climate Change on Irrigated Agriculture," *Climatic Change* (in press).

Schlenker, W., W. M. Hanemann, and A. C. Fisher, "The Impact of Global Warming on US Agriculture: An Econometric Analysis of Optimal Growing Conditions," *Review of Economics and Statistics* (in press).

Hanemann, W. M. "The Economic Conception of Water" in P. Rogers & R. Llamas (eds.) *Water Crisis: Myth or Reality*. Taylor & Francis (in press).

Albiac, J. M. Hanemann, J. Calatrava, and J. Uche. "Evaluating Alternatives to the Spanish National Hydrological Plan" under review at *Natural Resources Journal.*

1. SUMMARY OF OPINIONS

I was asked by the Natural Resources Defense Council (NRDC) to review and analyze the economic analyses of Dr. Robert McKusick, including the expert reports of Dr Charles Burt and Dr. Kenneth Schmidt from which several of Dr. McKusick's key economic assumptions derive, and to provide my opinion thereof.

In the case of Dr McKusick's report,[1] my opinion is that, because of flaws in the economic analysis, the estimate of the economic costs to agriculture in the San Joaquin Valley and to the California economy generally of increased restoration releases from Friant Dam are seriously overstated. This is so even if one accepts the Spring Release scenario used in the report; it is even more so if one adopts the release scenario developed by Dr. Kirby and Professor Kondolf. The report is also inadequate as an economic assessment because it entirely ignores potentially substantial economic benefits from the restoration of flows in the San Joaquin River to the people of California and the California economy.

Dr. McKusick's analysis relies on the expert report of Dr. Burt for his estimate of the amount of groundwater being pumped by the Friant unit districts. In my opinion, Dr. Burt's estimate of groundwater pumping lacks a solid empirical foundation and understates the current level of groundwater pumping that occurs.

Dr. McKusick's analysis relies on the expert report of Dr. Schmidt for his estimate of the impact on the future depth to groundwater pumping of any increased groundwater pumping. In

[1] Dr. McKusick submitted two reports: Expert Report of Dr. Robert McKusick on the Economic Impact of Reduced Surface Water Deliveries in the Friant Division of the Central Valley Project (Aug. 22, 2005); and Friant Power Authority Economic Impact Assessment (Aug. 18, 2005). I have reviewed both reports, but am primarily responding here to the former, and am referring to the former throughout this report unless otherwise specified.

my opinion, Dr. Schmidt's analysis is unreliable. His analysis of the impact of groundwater pumping by the Friant districts on their depth to groundwater is flawed both because he uses Dr. Burt's estimate of groundwater pumping by these districts (which I believe underestimates the true amount of groundwater pumping) and also because he ignores the known fact that groundwater overdraft in some of the farming areas adjacent to the Friant districts contributes to the decline in their water table.

The basis for these opinions is set forth in the remainder of this report.

2. IMPACT ON FARM ECONOMY

2.A The Impact of Friant Dam on the Regional Agricultural Economy

Dr McKusick begins his report with an overview of the regional economy, emphasizing the contribution made by the delivery of water from Friant Dam to the region's economic prosperity. His preliminary observations set the context for the specific results from his economic production model (FDPM) presented later in his report.

To highlight the contribution of Friant Dam to the regional economy, Dr. McKusick presents data in Tables 4 and 5 on employment and crop and livestock production in the local region today, and data in Tables 6 and 7 on the change in crop production and gross revenue from farming in the Friant districts between the time just before the delivery of Friant water and now. The latter tables focus on 18 districts for which data on pre-Friant farming is available from the Bureau of Reclamation's Factual Reports. Table 6 appears to show that the total irrigated acreage in these districts increased from 559,462 acres before Friant to 829,840 acres today, and the proportion of irrigated acreage devoted to permanent crops rose from 25% before Friant to 62% today.

This information is somewhat misleading. First, there is a numerical error in the calculation of the total acreage for 2004; the correct total in Table 6 should be 684,958 acres, not 829,840 acres.[2] This aside, the information in Table 6 is misleading because it appears to imply that the entire economic change between the late 1940s and now is due solely to the delivery of water from Friant Dam. In fact, deliveries from Friant commenced in Madera County in the 1940s and in Tulare County in the early 1950s. As shown in Table 1, in most of the Friant districts except Gravelly Ford and Arvin-Edison deliveries of water from Friant Dam were in full

[2] The error also affects the estimate of the share of irrigated acreage planted to permanent crops, which is 58% rather than 62%.

swing by the mid-1960s. For each district, I reviewed the history of Friant deliveries as tabulated in USBR (1992) and made a judgment as to when deliveries had ramped up to their normal level – this is shown as the date for the beginning of substantial deliveries in the fourth column of Table 1. I conclude that, for all the districts covered by Dr. McKusick's Table 6 except Arvin Edison, the delivery of water from Friant Dam had been effectively completed by about 1963 or 1964; in the case of Arvin Edison, it occurred by about 1969. Therefore, in order to form a correct assessment of the economic contribution provided by Friant water, one should the compare the farming economy in the region around that time (1963-1964) with what it was pre-Friant. Economic changes after about 1963/64 are *not* due to the creation of Friant Dam because the regional economy had already adjusted to that factor; they must, for the most part, be due to other factors, including the development of *other* water supply infrastructure in the region.[3]

The comparison of agricultural production in the Friant districts pre-Friant and post-Friant (1963-64) is presented in Table 2. This shows that the total irrigated acreage in the Friant districts grew from 559,463 acres pre-Friant to 613,425 acres post-Friant. This is less than half of the increase in irrigated acreage that ultimately occurred between pre-Friant and today; the larger share of the increase in acreage (57%) occurred *after* 1963/64. The data also show that almost all of the shift in the Friant districts from annual crops to permanent crops occurred *after* 1963/64 – the share of permanent crops in total acreage in 1963-64 (26%) was very close to what it had been pre-Friant (25%). Factors other than the arrival of water from Friant Dam were primarily responsible for the change from the pre-Friant cropping pattern to today's cropping pattern.

[3] In fact, a substantial development of water supply infrastructure took place after 1963/64 including the California Aqueduct, completed in 1971; the Cross Valley Canal, completed in 1975; Hidden Dam on the Fresno River, completed in 1975; and Buchanan Dam on the Chowchilla River, also completed in 1975. In addition, in 1963/64 Terminus Dam on the Kaweah River and Success Dam on the Tule River had just come on line a few years earlier, in 1961.

TABLE 1: DELIVERY OF WATER FROM FRIANT DAM

COUNTY	District	CVP Contract	Beginning of substantial deliveries	Table 6 district?	Factual Report year
Madera	Chowchilla WD	1950	1952	Y	1949
	Madera ID	1951	1954	Y	1948
	Gravelly Ford WD	1981			1949
Fresno	Garfield WD	1961	1963		
	International WD	1963	1966		
	Fresno ID	1964	1965		
	Orange Cove	1955	1952	Y	1946
Tulare	Orange Cove ID	1955	1952	Y	1946
	Stone Corral ID	1959	1953	Y	1949
	Ivanhoe ID	1949	1953	Y	1946
	Exeter ID	1950	1956	Y	1948
	Tulare ID	1950	1953	Y	1948
	Lewis Creek WD	1965	1969		
	Lindsay Strathmore ID	1948	1954	Y	1948
	Lindmore ID	1949	1953	Y	1946
	Lower Tule River ID	1957	1953	Y	1951
	Porterville ID	1952	1962	Y	1949
	Teapot Dome ID	1958	1964	Y	1956
	Saucelito ID	1951	1952	Y	1949
	Terra Bella ID	1950	1954	Y	1946
	Delano-Earlimart ID	1951	1955	Y	1949
Kern	Delano Earlimart ID	1951	1955	Y	1949
	Southern San Joaquin MUD	1957	1954	Y	1946
	Shafter-Wasco ID	1955	1962	Y	1948
	Arvin Edison WSD	1962	1969	Y	1950

TABLE 2: A CORRECTED AND AMPLIFIED VERSION OF DR. MCKUSICK'S TABLE 6

District	Pre-Friant crop acreages		1963-64 crop acreages		2004 crop acreages	
	Annual	Permanent	Annual	Permanent	Annual	Permanent
Arvin-Edison WSD	85,351	16,038	81,910	21,582	55,822	54,932
Chowchilla WD	46,435	1,116	48,826	1,635	38,814	30,099
Delano-Earlimart ID	21,552	21,111	22,886	25,494	3,832	44,395
Exeter ID	566	9,769	831	8,306	287	11,514
Ivanhoe ID	1,687	7,259	466	7,653	-	10,185
Lindmore ID	4,885	14,572	9,705	13,133	3,058	20,049
Lindsay-Strathmore ID	373	8,206	948	9,929	441	11,565
Lower Tule River ID	66,654	2,720	79,625	3,802	78,941	10,333
Madera ID	56,527	24,758	53,001	30,553	12,929	89,731
Orange Cove ID	991	8,017	5,728	10,788	1,163	25,691
Porterville ID	12,094	1,710	10,466	2,930	5,968	6,436
Saucelito ID	8,431	5,109	12,947	5,278	5,831	9,967
Shafter Wasco ID	30,354	1,518	28,739	1,873	15,266	15,130
Southern San Joaquin MUD	28,919	7,314	35,743	8,792	7,892	35,056
Stone Corral ID	1,010	738	2,823	1,612	687	4,958
Tea Pot Dome WD	571	1,252	286	1,506	25	2,950
Terra Bella ID	178	2,226	1,701	2,885	799	9,039
Tulare ID	55,524	3,928	56,439	2,604	53,988	7,185
Total	422,102	137,361	453,070	160,355	285,743	399,215
Percent of District	75%	25%	74%	26%	42%	58%
Total Annual and Permanent	559,463		613,425		684,958	

Source: Pre-Friant and 2004 from Table 6 of Dr. McKusick's report.
The data for 1963/64 is an average of the annual crop reports submitted by each of the districts to the Bureau of Reclamation in those two years.

There are many possible factors that could have contributed to the increase in farming prosperity in the Friant region after Friant was completely operational – for example, advances in agronomy, the development of new seed varieties, the introduction of new crops, the improvement in crop yield, the development and adoption of newer irrigation technologies, changes in commodity prices, changes in markets and marketing, changes in federal farm programs, and, as previously noted, expansion of other water supplies. For example, over the past fifty years, the average yield of oranges grown in the Tulare County has risen from 7.96 tons per acre in 1959-1961 to 13.94 tons per acre in 2000-2002.[4] California farmers are highly market-driven and respond quickly to changes in market conditions, whether these be commodity markets or financial markets. By way of illustration, with the recent decline in grape prices, in the last year or two there has been a reduction in acreage planted to permanent crops in some of the Friant districts compared to what the situation was in 2003 and earlier.[5] As another illustration, in recent years the federal farm subsidies to agricultural producers in Kern County increased from about $6 million in 1995 to nearly $55 million in 2003.[6] This is but one of many economic changes that have occurred in the region, and that are entirely unrelated to the completion of Friant Dam. Economic conditions are constantly changing, and Friant area farmers are resourceful and energetic in responding to them.

An unwary reader might infer from Dr. McKusick's report that, during the 1950s, the only substantial expansion of irrigated acreage in the Friant area occurred in the Friant districts themselves. In fact, this is not correct. There was a tremendous expansion of irrigated acreage in neighboring portions of these counties outside the Friant service area, as shown in Table 3. Here I omit Fresno County because it is extremely heterogeneous but, in addition to Madera, Kern, and Tulare Counties, I also include Kings County. Several water districts in Kings County, including the Kaweah Delta WCD and Kings County WD, are operationally highly connected

[4] Tulare County Agricultural Commissioner Reports, various years.
[5] California Agricultural Statistics Service (2005, Tables 8,9,10, and 11)..
[6] http://www.ewg.org/farm/regiondetail.php?fips=06029&summlevel=2, visited on 9/8/05.

with the Friant districts and sometimes exchange water with them;[7] therefore I believe an analysis of developments in Kings County is relevant. Table 3 shows the irrigated acreage in each county pre-Friant, in 1963-64, and in 2004. It also breaks the acreage down between acreage in the county within the Friant districts and acreage outside those districts.[8] The table shows that, while the irrigated acreage in the Friant districts considered here increased from 546,050 acres pre-Friant to 595,751 acres in 1963-64, an increase of 49,701 acres (9.1%), the irrigated acreage outside these districts increased from 1,101,221 acres to 1,548,064 acres, an increase of 446,843 acres (40.5%). [9]

[7] Tulare ID lies within the Kaweah Delta WCD (KWCD) service area. KDWCD and other districts in Kings County have purchased water from the CVP or from Friant districts under exchange or short-term agreements. CVP water can be diverted from the Friant-Kern Canal into KDWCD from three turnouts. CVP water has been released into Cottonwood Creek, and also into the Kings River channel for delivery through canal systems in the western portion of the KWWCD area (Provost and Pritchard, 2004).

[8] This is intended as only a rough comparison, not an exact one, because of differences in the timing of data. For 1948-49, the county data are taken from the Agricultural Commissioners' reports for 1948 and 1949, averaged over those two years. The Friant districts' data are for whatever year the Bureau of Reclamation Factual Report was prepared, which is often neither 1948 nor 1949. For 1963-64, both the county data and the Friant districts data are for those years exactly, averaged over the two years. For 2004, the county data are from the Commissioners' reports for that year; the Friant Districts data are for whatever year Dr. McKusick reports in his Table 6. Orange Cove and Delano Earlimart each straddle two counties; I allocated their cropped acreage between the counties in proportion to the allocation of their service areas.

[9] The total Friant district acreage in Table 3 is smaller than that shown in Table 2 because the data in Table 3 exclude the portion of Orange Cove lying in Fresno County.

TABLE 3 AGRICULTURAL DEVELOPMENT IN THE FRIANT REGION

	1948-49 crop acreages			1963-64 crop acreages			2004 crop acreages		
	Annual	Permanent	Total	Annual	Permanent	Total	Annual	Permanent	Total
Kern County	466,444	28,507	494,951	626,232	50,153	676,385	607,919	283,605	891,523
Kings County	271,944	13,562	285,506	449,817	8,486	458,303	543,127	38,294	581,421
Madera County	287,764	24,987	312,751	304,727	44,278	349,005	119,132	193,838	312,970
Tulare County	401,053	152,344	553,396	471,736	188,387	660,123	939,612	319,069	1,258,680
4-county Total	1,427,205	219,399	1,646,604	1,852,511	291,304	2,143,815	2,209,789	834,806	3,044,594
			-			-			-
Friant districts in Kern*	62,397	11,916	74,312	67,793	14,389	82,182	20,330	79,347	99,677
Arvin Edison WSD	85,351	16,038	101,389	81,910	21,582	103,492	55,822	54,932	110,754
	-	-	-	-	-	-	-	-	-
Friant districts in Madera	94,248	25,654	119,902	92,668	31,868	124,536	49,433	113,473	162,907
Friant districts in Tulare	170,882	79,564	250,446	198,685	86,856	285,541	151,171	136,229	287,400
Friant Total	412,878	133,172	546,050	441,056	154,695	595,751	276,756	383,981	660,738
			-			-			-
Rest of Kern County	318,696	553	319,249	476,529	14,182	490,710	531,766	149,326	681,092
Rest of Kings County	271,944	13,562	285,506	449,817	8,486	458,303	543,109	38,291	581,399
Rest of Madera County	193,516	-	193,516	212,059	12,410	224,469	69,698	80,365	150,063
Rest of Tulare County	230,170	72,779	302,950	273,051	101,531	374,581	788,441	182,839	971,280
Total Non-Friant	1,014,327	86,894	1,101,221	1,411,455	136,609	1,548,064	1,933,014	450,821	2,383,835

In some cases, Tulare County for example, much of the increase in the irrigated acreage outside the Friant districts between the late 1940s and 1963-64 was supported by the use of groundwater.[10] In several cases, this caused a significant lowering of the water table in the Friant

10 County of Tulare (1979)

districts. DWR Bulletin 118-80 classified all the groundwater basins in these areas as subject to critical conditions of overdraft. For example, it refers to heavy groundwater pumping in the Chowchilla Basin in the areas to the southwest and north of Chowchilla WD and states: "ground water lowering in these areas of heavy pumping is expected to induce greater subsurface flows from the Chowchilla Water District area and cause levels there to drop" (DWR 1980 page 45). There are similar observations with regard to heavy groundwater pumping adjacent to Madera Irrigation District (page 45) and west of Fresno Irrigation District (page 46). It should be noted that these problems with groundwater had been anticipated when the CVP's Friant Division was being planned. A Bureau of Reclamation planning document issued in 1949 states: "A major problem will be to restrict water use to average water supply; if this is not solved, the present overdraft of groundwater may continue on an enlarged scale." It further states: "If the advantages of a stable supply are to be achieved, there is an imperative need for the application of groundwater controls, either by passage of special legislation or under the framework of present law" (Bureau of Reclamation, 1949). Neither of these actions seems to have been taken. These facts place the issues of potential groundwater overdraft raised by Dr. McKusick in the broader temporal and spatial context.

2.B Economic model analysis of impact on Friant District agricultural economy

Dr. McKusick relies for many of his specific estimates of the economic impact of increased releases from Friant Dam on a new economic model, the Friant Division Production Model (FDPM). This is a brand new model being used in his expert report for the first time. In its broad approach it resembles the Department of Water Resources' Central Valley Production Model (CVPM), which Dr. McKusick had employed in his report "Analysis of the Impacts of Surface Water Reductions on the Eastern San Joaquin Valley of California" (McKusick, 1997). Like the CVPM, the FDPM uses what is known as the *positive mathematical programming* approach. However, it is different in many of the specific details. It has a much narrower spatial coverage than CVPM. Whereas the CVPM covers the entire Central Valley, FDPM is narrowly restricted to the service areas of the Friant Districts and excludes all farming areas in Madera, Tulare, Fresno, Kings or Kern counties lying outside the Friant districts; in effect, it assumes that the Friant districts are entirely isolated and exist in a separate universe from the rest of the San Joaquin Valley agricultural economy.[11] Also, whereas CVPM assumes that Central Valley farmers face downward sloping demand curves for their products, FDPM assumes perfectly elastic demand curves for the Friant producers, which are unaffected by production outside their own acreage.

In any economic model, the details matter greatly, whether these are details of model parameters or details of model assumptions. These details can significantly influence the output of the model. It is not uncommon in economics to find that what appears to be a conclusion stemming from a detailed scientific modeling exercised is, in fact, the product of specific assumptions incorporated into the analysis without rigorous examination or justification. The positive mathematical programming approach is especially prone to this, because it ascribes all differences between what the base model predicts and what is happening in reality to errors in the slope of the marginal cost production – not to errors in the intercept of the cost curve, in the demand curve, in the specification of a cropping choice set or the production constraints, or in the selection of parameter values. As I discovered when running FDPM, this is by no means a sound or innocuous assumption, but has a substantial impact on the model's output. Consequently, I believe that some of Dr. McKusick's conclusions are indeed driven by specific assumptions that he makes in his use of FDPM.

First, it should be noted that some of the specific values used for parameters in the model appear unjustified by the data or internally inconsistent. I will mention a couple of examples. The first example is the assumed cost of water. FDPM assumes that, in each group of districts,

[11] This assumption is unreasonable and biases Dr. McKusick's analysis in the direction of exaggerated economic costs, as I explain below.

surface water costs the same, regardless of whether it comes from Friant Dam or any other source. Moreover, these costs vary in some distinctive ways; for example, FDPM assumes that all surface water costs $25/acre-foot in Garfield ID, International ID and a small piece of Fresno ID ("FresnoB") but $60.91/acre-foot in the rest of Fresno ID. Moreover, there are inevitable problems of aggregation. For example, Dr McKusick's own survey data show that Saucelito ID charges $50/acre-foot, Tea Pot Dome WD charges vary from $90 to $115/acre-foot, and Terra Bella ID charges vary from $70.04 to $120.87/acre-foot; FDPM assumes that these districts all uniformly charge $74.81/acre-foot. A second example is producer prices. When the FDPM model is run, it employs commodity prices developed by UC Cooperative Extension for use over broad aggregates of the San Joaquin Valley; but when Dr. McKusick converts the model output into estimates of gross producer revenue, he employs the commodity prices published by the County Agricultural Commissioners for particular counties. There is often a substantial difference between the two sets of prices. Thus, for example, FDPM uses a price of $8.84/carton for oranges when determining the production of oranges in Fresno County, but when calculating gross revenue impacts Dr. McKusick uses the Fresno County Agricultural Commissioner price of $6.84/carton.

Besides these questions about details of the data, which might have been resolved if FDPM had the same extensive history of use by a variety of researchers as CVPM, or any prior peer review at all, there are some fundamental methodological issues concerning the economic metric used by Dr. McKusick to characterize the economic impact changes in Friant water availability, and the specific assumptions about how water is used in the Friant districts that Dr. McKusick built into FDPM.

The standard metric for measuring impacts to producers in economic analysis is net income, or profit: this is the difference between gross income (revenue) and the cost of production. It is a fundamental principle in economics that any change in a producer's welfare is measured in monetary terms by the change in his net income: if I have a business which I have to shut down, and I have production costs of $100 that I can avoid if I shut down, and I earn revenues of $120 when I do produce, what should be compensated is my loss of *net* income – in this case, $20, not $120. This is a standard precept, and it is recognized by FDPM when it determines the allocation of agricultural production, which is based on the criterion of maximizing farmers' net income. But Dr McKusick sets this aside when he presents the results of the FDPM analysis, which he characterizes in terms of impact on gross revenue, not net revenue.[12]

The choice of metric makes a substantial difference in analyzing potential impacts to the agricultural economy. Dr. McKusick's major conclusion on page 57 of his report is: "It is expected that total agricultural value will decline by $372.5 million." This is misleading for two reasons. First, and most fundamentally, what Dr. McKusick presents in his conclusion is an estimate of the change in *gross* revenue, whereas FDPM is actually driven by the maximization of *net* revenue, which is the correct measure of economic loss. If Dr. McKusick consistently followed the logic of FDPM and expressed the economic loss from his Spring Run Release scenario in terms of the reduction in *net* revenue as calculated by his own FDPM model run, he would report an economic loss of $37.8 million, not $372.5 million. Second, the $372.5 million figure is *not* the actual estimate of gross revenue change that is generated by FDPM. FDPM uses Cooperative Extension commodity prices to calculate crop revenue, but, without explanation, Dr. McKusick abandons these prices when presenting his conclusion and switches instead to commodity prices from the County Agricultural Commissioners.

Further, as Dr. Kirby notes in his rebuttal report, the Spring Run release scenario analyzed by Dr. McKusick demands considerably more water for restoration than what Professor Kondolf recommends in his report. If one runs FDPM exactly as Dr. McKusick has run it, but with the release scenario recommended by Professor Kondolf instead, and if one characterizes

[12] Also, as noted above, this gross revenue is calculated with different prices from those used by FDPM to actually determine the allocation of agricultural production.

the results in terms of the net revenue loss calculated using the exact commodity prices used by FDPM, the average annual loss is not $37.5 but $27.6 million.

There are two additional key assumptions in FDPM dealing with (i) groundwater pumping by farmers in the Friant area; and (ii) water exchanges both among Friant districts and also between them and other districts in the Valley, both of which affect the model's results.

The treatment of groundwater pumping in FDPM is problematic for two reasons. First, FDPM assumes that, when Friant deliveries are reduced in order to increase flows in the Upper San Joaquin River, farmers in the Friant districts make up the shortfall on a one-for-one basis by pumping groundwater without restriction, thereby causing groundwater levels to fall. Unrestrained groundwater pumping continues through 2024. In 2025, however, the FDPM assumes that Friant districts' pumping of groundwater pumping is constrained so as to not exceed the level of groundwater pumping today with no fish restoration releases. Given the history of groundwater usage in the region, this is not a plausible assumption.[13]

Even if one accepts the constraint that FDPM imposes on groundwater pumping – i.e., the assumption that a restriction on groundwater pumping appears overnight in the region in 2025 – the groundwater table may indeed have fallen prior to 2025 with reduced deliveries from Friant Dam, depending on how the Friant districts respond.[14] It is necessary therefore to determine what

[13] The treatment of groundwater pumping is an artifact of Dr. McKusick's methodology. He implicitly acknowledges that there is nothing to stop Friant area farmers from increasing their groundwater pumping if they decide to do so, but when he conducts his economic analysis for the year 2025 he imposes that assumption in order to raise the estimated cost of a reduction in deliveries from Friant Dam.

[14] As discussed below, it is not a sound economic assumption to presume the Friant districts will raise their groundwater pumping one-for-one with the reduction in Friant deliveries. Instead, basic economic theory suggests that a profit maximizing producer will consider the full range of options available and will choose the option that is most profitable. Similarly, it is reasonable to assume that water managers in the Friant area will consider the full range of options available to them, such as purchasing water from other water districts in the Valley, expanding groundwater

level to set for the depth to groundwater going in to 2025. In FDPM, this is based on the Spring Run release scenario combined with Dr. Kenneth Schmidt's analysis regarding the change in depth to groundwater per acre-foot increase in groundwater pumping by the Friant districts. Both parts of the calculation are questionable. Professor Kondolf has shown that the Spring Run release scenario overstates the amount of water needed to restore a salmon fishery in the Upper San Joaquin River. And, for reasons described below, Dr. Schmidt's estimate of the change in depth to groundwater per acre-foot increase in groundwater pumping is overstated. Nevertheless, to be overly conservative, I continue to employ Dr. Schmidt's estimate of the impact of groundwater pumping on groundwater depth, but I have adjusted the 2025 depth to groundwater to conform to the Kondolf releases. The adjustment is based on the ratio of the Kondolf releases to the Spring Run releases. For example, if Dr. McKusick had estimated that groundwater levels in a zone would decline 300 feet by year 2025 as a result of the reduction in Friant deliveries, and if the Kondolf delivery decrease was 50% of the Spring Run decrease, then I assumed that the groundwater level in the zone would decline by 150 feet instead of 300 feet.[15] With this adjustment to 2025 groundwater depth, the economic impact calculated by FDPM for the Kondolf release scenario, is a net revenue loss averaging $14.5 million per year, compared to the estimated loss of $27.6 million per year with the same Kondolf release scenario, but using Dr. McKusick's groundwater depth.[16]

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banking, or re-circulating San Joaquin River flows somewhere downstream on the Lower San Joaquin River. These are discussed further in Dr. Kirby's Expert and Supplemental Reports.

[15] In zones with more than one district, the adjustment ratio was calculated as a weighted average using the district's irrigated acreage as the weights. This adjustment is certainly consistent with the type of linear proportional relationship employed by Dr. Schmidt (personal communication with Dr. Deverel).

[16] This analysis exaggerates the true economic impact not only because it employs Dr. Schmidt's estimate of the relation between groundwater pumping and change in groundwater depth but also because it assumes that, during the period prior to 2025, there is a one-to-one substitution of groundwater for the reduction in surface water delivered from Friant Dam. However, when FDPM is run for the year 2025, it allows economic optimization to determine the level of water use, and the outcome is much less than a one-to-ones substitution of groundwater. The inconsistency between the behavior assumed prior to 2025 and the behavior modeled in 2025 is another artifact of Dr. McKusick's methodology. It should be noted that this methodology was not employed, and these artifacts were not present, in his 1997 analysis; he then treated the different years consistently (McKusick, 1997)

Another shortcoming in FDPM concerns exchanges of water: FDPM is programmed so that it permits adjacent and nearby Friant districts to trade water with one another if they wish, but *not* with more distant Friant districts. Dr. McKusick explains that FDPM divides the Friant districts into 8 zones, and trading is allowed within zones but not across zones.[17] For example, Chowchilla ID is allowed by FDPM to exchange water with Madera ID, which is in its zone, but not with Fresno ID, say, Orange Cove ID, or Arvin-Edison WSD which are in different zones. This is an arbitrary and illogical restriction – given that all the districts are physically connected by Millerton Lake and the Friant-Kern and Madera Canals, it is physically possible to exchange water throughout the Friant unit. Moreover, the restriction flies in the face of reality: the fact is that Chowchilla ID *has* exchanged water with Fresno ID, and with Orange Cove ID, and with Arvin-Edison WSD.[18] This information in well known to Dr. McKusick since it was solicited by him in a survey that he conducted. Besides his own survey, there is no shortage of information from many other sources corroborating the fact that irrigation districts in California now engage in buying and selling water, the Friant districts included, all of which confirm the unreasonableness of the assumption programmed into FDPM that there can be no exchange of water across artificial boundaries within the Friant unit.[19]

In short, the decision to incorporate an assumption of no trading between zones in FDPM is baffling. On theoretical grounds, one knows that it will bias the results: any impediment to exploiting potential gains from trade automatically boosts the estimated economic cost of any supply impairment. To test this prediction, FDPM was re-programmed so as to permit water exchanges between any of the Friant districts. When this is done, the net economic loss

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[17] Here I am quoting from the description on page 150 of Dr. McKusick's report. In actuality, the Friant Districts are divided into 9 zones, with Garfield ID, International ID and about 2,500 acres of Fresno ID in a separate zone from the remainder of Fresno ID.

[18] See the handwritten notation on the 16th page of Chowchilla's response to the Survey of Friant Division Member Districts on the Impacts of Reduced Surface Water Supplies. More generally, Table 7 in Mr. Richard Moss' report shows that, between 1990 and 2003, Friant districts in aggregate transferred in (purchased) and transferred out (sold) substantial quantities of water.

[19] See, for example, Hanak (2002).

calculated by FDPM for the Kondolf release scenario is reduced slightly from $14.5 million per year without trading to $13.5 million per year with water exchanges among the Friant districts.

The historical experience has been that not only do the Friant districts exchange water among themselves, but they also exchange water with other districts outside the Friant unit. Indeed, they not only transfer water *in* from other districts, but they also transfer water *out* to other districts, both agricultural and urban. None of this is recognized in FDPM. In my view it is essential to incorporate exchanges between Friant districts and the outside world into FDPM not only because this has occurred extensively in the past but also because it is likely to occur even more frequently in the future, even without any change in the operation of Friant Dam. For example, the San Joaquin River Exchange Contractors Water Authority recently conducted an EIS/EIR on a plan which includes transferring up to 70,000 acre-feet in any year into the Friant districts.[20] Moreover, in the event of any reduction in deliveries from Friant Dam, the Friant districts will look to purchasing water from outside the Friant unit to make up part of the deficiency. This is precisely what they told Dr. McKusick they would do. It is quite simply unreasonable to assume this away in FDPM.[21][22]

To obtain a meaningful assessment of the economic impact of a reduction in deliveries from Friant Dam, it is essential to integrate FDPM with the rest of the San Joaquin Valley. Only

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[20] URS Corporation (2004), page 2-18. This is discussed further in Dr. Kirby's Supplemental Report.

[21] The explanation provided by Dr. McKusick is that a permanent reduction in water available from Friant Dam will make water exchanges infeasible. This is incorrect. Economic theory teaches that, whenever agents have different relative comparative advantages, there exist gains from trade no matter how limited the total endowment of resources. Only if all farmers in Friant were identical – with the same soils, the same climate, the same production costs and the same marketing opportunities – would there be no gains from trade; only in that case could water markets not mitigate the effects of a reduction in water supply. But the data in FDPM indicate clear difference in comparative advantage, which is why FDPM generates gains from trade as soon as this is permitted in the model.

[22] It is important to note another of the district's responses to Dr. McKusick 's survey. When asked how they would be willing to pay to up to $125/acre-foot to obtain water from other Friant contractors, and up to $175/acre-foot for water from outside the Friant unit. This information is not factored into FDPM.

then can one account for exchanges of water into and out of the Friant unit. With the limited time and resources available to me, it was not possible for me to do this. However, I can offer the following sketch of what might happen – it is intended merely as a rough illustration. I decided to integrate the Friant unit with farming in the rest of Madera, Tulare, and Kern Counties, as well as with Kings County. I therefore created four additional economic zones defined as the non-Friant parts of the three counties plus the whole of Kings County. I represented the surface and groundwater supplies in these new zones, and the costs of surface and groundwater, in the same way as FDPM does for the corresponding Friant districts. I estimated the cropping patterns in the new zones by subtracting the Friant districts' acreage for 1999-2003 from the average total County acreage for the same period. (the data are summarized in Table 3), and I calibrated the expanded FDPM to these cropping patterns in exactly the same way that FDPM is calibrated to the cropping patterns within the Friant districts. I then ran the expanded FDPM both with the existing operation of Friant Dam and then with the Kondolf release scenario and groundwater levels. Opening the Friant unit up to exchanges with its neighbors in the non-Friant zones reduces the net economic loss associated with the Kondolf release scenario from $13.5 million to $10.3 million per year.[23]

[23] Details of these and the other scenarios are summarized in Tables 4 – 8.

TABLE 4: PROFIT VARIATION ACROSS SCENARIOS

		Existing Release	Spring Run-Kondolf Hydrology	
		Profit	Profit	% Reduction
No Trading	Dry	468,477,896	447,409,503	4%
	Normal-Dry	475,221,967	456,793,588	4%
	Normal-Wet	482,641,663	470,278,557	3%
	Wet	487,707,502	482,378,587	1%
	Average	478,596,155	464,079,269	3.0%
Trading within Friant	Dry	473,749,600	455,381,806	4%
	Normal-Dry	481,403,771	465,230,517	3%
	Normal-Wet	492,909,150	480,457,356	3%
	Wet	503,597,995	497,283,871	1%
	Average	487,763,393	474,239,496	2.8%
Trading with Larger Area	Dry	479,339,952	466,550,901	3%
	Normal-Dry	484,895,988	471,626,807	3%
	Normal-Wet	493,682,892	483,648,542	2%
	Wet	499,351,558	495,660,432	1%
	Average	489,311,976	479,024,871	2.1%

TABLE 5: ANNUAL CROP VARIATION ACROSS SCENARIOS

		Existing Release	Kondolf Hydrology	
		Acres	Acres	% Reduction
No Trading	Dry	300,757	261,442	13%
	Normal-Dry	300,750	265,262	12%
	Normal-Wet	301,808	267,612	11%
	Wet	303,471	278,262	8%
	Average	301,613	267,803	11.2%
Trading within Friant	Dry	273,320	252,494	8%
	Normal-Dry	269,808	242,854	10%
	Normal-Wet	298,116	277,638	7%
	Wet	332,781	312,311	6%
	Average	291,597	269,109	7.7%
Trading with Larger Area	Dry	302,164	306,414	-1%
	Normal-Dry	305,982	298,087	3%
	Normal-Wet	299,191	292,608	2%
	Wet	311,997	295,938	5%
	Average	304,384	297,679	2.2%

TABLE 6: PERMANENT CROP ACREAGE VARIATION ACROSS SCENARIOS

	Existing Release	Kondolf Hydrology	
	Acres	Acres	% Reduction
No Trading	507,615	489,991	3.5%
Trading within Friant	469,720	459,678	2.1%
Trading with Larger Area	472,360	471,859	0.1%

TABLE 7: PROFIT LOSS DUE TO KONDOLF RELEASES

		Kondolf Hydrology	
		Profit Loss	% Reduction
No Trading	Dry	21,068,393	4%
	Normal-Dry	18,428,379	4%
	Normal-Wet	12,363,107	3%
	Wet	5,328,915	1%
	Average	14,516,886	3.0%
Trading within Friant	Dry	18,367,794	4%
	Normal-Dry	16,173,253	3%
	Normal-Wet	12,451,794	3%
	Wet	6,314,124	1%
	Average	13,523,897	2.8%
Trading with Larger Area	Dry	12,789,051	3%
	Normal-Dry	13,269,181	3%
	Normal-Wet	10,034,350	2%
	Wet	3,691,126	1%
	Average	10,287,105	2.1%

Table 8: Difference in Profit Across Year Type Under Existing Releases

		Profit
No Trading	Dry	468,477,896
	Normal-Dry	475,221,967
	Normal-Wet	482,641,663
	Wet	487,707,502
	Average	478,596,155
Trading within Friant	Dry	473,749,600
	Normal-Dry	481,403,771
	Normal-Wet	492,909,150
	Wet	503,597,995
	Average	487,763,393
Trading with Larger Area	Dry	479,339,952
	Normal-Dry	484,895,988
	Normal-Wet	493,682,892
	Wet	499,351,558
	Average	489,311,976

In summary, I disagree with Dr. McKusick's assertion that restoring fish in the Upper San Joaquin River will generate a loss of $372.5 million to local farmers. His estimate is inflated because it focuses on gross revenue rather than the economically correct net revenue, because it uses an inflated release scenario instead of the Kondolf release scenario, because it relies on flawed groundwater pumping assumptions, and because it unreasonably assumes no water exchanges both among the Friant districts and between them and other districts outside the Friant unit. When these flaws are fixed, the correct estimate of economic loss to farmers in the Friant unit is at most $14.5 million, and probably less.

I regard the figure of $14.5 million as an overestimate not only because it ignores the established fact of water exchanges into and out of the Friant unit, but also because it is still impaired by two other restrictions built into the FDPM model. First, FDPM assumes irrigation efficiencies that in some cases are overstated. Second, while it accounts for the farmer's response to changes in water availability, it makes no attempt to account for the *water managers'* responses.

Taking the latter point first, not only are water exchanges a likely response by water district managers to reduced deliveries from Friant Dam, but also there are other potential responses not accounted for in FDPM. Examples include: increased groundwater banking; re-operation and coordinated operation of Friant Dam with other CVP and local reservoirs; the pump-in of flood flows from Tulare Basin or Eastside rivers into the Friant Kern Canal, and the recirculation of San Joaquin River flows somewhere downstream on the Lower San Joaquin River.[24] None of these is allowed for in FDPM. I believe that, to the extent that some of these options will make water available at a cost which is lower than the profit from farming in the Friant unit, they are very likely to be adopted over time.

My last observations on Dr. McKusick's analysis of farm economics in the Friant unit concern irrigation efficiency, groundwater pumping, and his estimate of the rate at which the groundwater table falls as farmers pump groundwater in the Friant area. To measure the latter, Dr. McKusick relies on the analysis by Dr. Kenneth Schmidt in his expert report, which contains

[24] These are discussed in Dr. Kirby's Expert and Supplemental Reports.

a set of (implicit) regression equations for groundwater pumping depth as a function of groundwater pumping volume, one for each Friant district. In my opinion, these regression relationships are not reliable because one or more relevant explanatory variables are being omitted, and the sole explanatory variable that is included is measured with systematic measurement error. In those circumstances, the regression coefficient – the estimate of groundwater decline per unit groundwater pumped – is biased.[25] The variable that is omitted is groundwater pumping by farmers in adjacent areas outside the district. As noted above, DWR Bulletin 118-75 draws attention to this phenomenon and identifies groundwater pumping outside Friant districts as a cause of the decline in their water table. The measurement error arises because Dr. Schmidt uses an estimate of groundwater pumping by farmers in each Friant district over the period 1987-1998 developed by Dr. Charles Burt which is also systematically biased and unreliable.

Dr. Burt develops his estimate of annual groundwater pumping volume through an indirect procedure involving two steps: (i) He takes the annual known cropping pattern in each district and applies to this assumed, crop-specific water application rates; this yields his estimate of total irrigation water use in the district. (ii) He subtracts from this total the known annual delivery of surface water, and he takes the residual as his estimate of groundwater pumping volume. This measurement approach is notoriously unreliable. The Achilles heel of this approach is the crop-specific water application rates. These, in turn, are typically derived from crop-specific estimates of ET requirements that are adjusted (divided) by an assumed irrigation application efficiency. The problem is that there is a tendency to exaggerate irrigation application efficiency levels and, if the irrigation efficiency is overstated, the volume of groundwater pumping will be underestimated.[26]

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[25] A similar point is made by Dr. Steven Deverel in his Supplemental Report.

[26] The converse is also true: if the irrigation efficiency were underestimated, the volume of groundwater pumping will be overstated. In this particular case, however, Dr. Burt (page B-3) agrees with my conclusion and concedes that his efficiency estimates are "high" and therefore understate groundwater pumping.

In this particular case, there are a couple of reasons to believe that the volume of groundwater pumping is being underestimated by Dr. Burt. First, there is not any solid empirical evidence, such as observations from a field survey, to support his estimates of irrigation application efficiency, and they appear in some cases to be implausibly high.[27] Second, in this case there is an alternative and more substantial source of data on groundwater pumping. This arises because the Department of Water Resources and the Bureau of Reclamation have recently conducted a lengthy and systematic study of groundwater pumping on the eastside of the San Joaquin Valley for use in CALSIM.[28] The CALSIM groundwater study overlaps with Dr. Burt's estimates for Chowchilla ID and Madera ID. Over the period 1987-1998, the CALSIM groundwater data show groundwater pumping in Chowchilla averaging 140,245 acre-feet per year, while Dr. Burt's estimate is 106, 396 acre-feet. For Madera, the CALSIM estimate is 203,028 acre-feet, while Dr. Burt's estimate is 140,291 acre-feet. Dr. Burt's estimates of groundwater pumping are about 31% lower than the CALSIM estimates.[29]

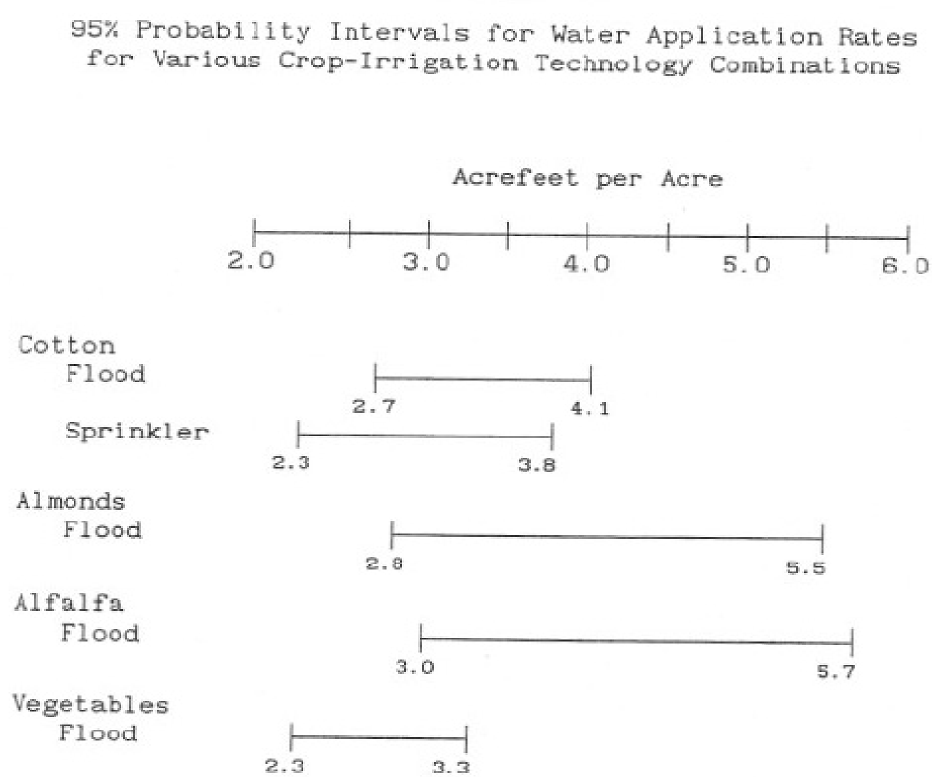
There is an additional reason why I distrust the indirect approach to the estimation of groundwater pumping volume. This is because it implicitly assumes that, for each combination of a particular crop and a particular irrigation technology, what farmers do can be represented by a single number, as though all farmers are alike and apply exactly the same amount of irrigation water, without any variation among them. In fact, whenever I have seen empirical data with individual-level observations on farmer behavior, there is tremendous variation even among farmers growing exactly the same crop on the same type of soil with the same method of irrigation. Not only is there a distribution of water use, but the distribution tends to be skewed with a long right tail. It is misleading in these circumstances to analyze crop water use as though it takes on a single value.

[27] See the expert report of Dr. Peter Gleick.
[28] US Bureau of Reclamation, 2005.
[29] Dr. Deverel makes a similar finding in his Supplemental Report.

By way of illustration, Figure 1 shows the results of a survey of 35 farmers in Kern County farmers conducted in 1988 by my student Dr. Lloyd Dixon for his Ph.D dissertation.[30] Lloyd conducted structured, in-depth interviews with farmers who farmed in 14 districts in Kern County, with a total acreage of 43,980 acres; four of the respondents farmed in Arvin Edison. In part of the interview he asked them about their water use, broken down by crop and by irrigation method. The results are shown in Figure 1, where the bars represent 95% confidence intervals for the distribution of responses regarding the amount of water applied. For example, among farmers in Kern County growing cotton with surface irrigation, the amount of water applied ranged from 2.7 to 4.1 acre-feet per acre, with a mean of 3.4 acre-feet per acre. According to Dr. Burt, the ET for cotton in Kern County is 2.47 acre-feet per acre, and there is a 75% irrigation efficiency with surface irrigation. Therefore, all of these farmers should be using 3.29 acre-feet/ per acre (= 2.47/.75); nobody should have been applying as little as 2.7 acre-feet or as much as 4.1 acre-feet – yet they were. The conclusion I draw from this and other such data is that Dr. Burt's method of estimating water is not always reliable in practice. If one wants to estimates to estimate irrigation water use and groundwater pumping, there is no adequate substitute for direct observation.

[30] This is copied from Figure 5 in Dixon (1988).

FIGURE 1


95% Probability Intervals for Water Application Rates
for Various Crop-Irrigation Technology Combinations
Acrefeet per Acre
2.0
3.0
4.0
5.0
6.0
Cotton
Flood
2.7
4.1
Sprinkler
2.3
3.8
Almonds
Flood
2.8
5.5
Alfalfa
Flood
3.0
5.7
Vegetables
Flood
2.3
3.3

2.C Economic Impact on the Dairy Industry

In his report, Dr. McKusick states that dairies within the Friant service area will suffer an economic loss because their costs will increase by almost $7 million per year, consisting of an increased groundwater pumping cost of $737,000, and an increased expenditure on forage of $6,225,000 due to the reduction in the acreage alfalfa, corn silage, and small grain silage that his FDPM analysis predicts will be grown within the Friant Districts under his Spring Run release scenario. Both losses are overstated

With regard to groundwater, Dr. McKusick's estimate of the increased cost of pumping is inflated by his use of the Spring Run release scenario as compared to Professor Kondolf's release scenario, and by his reliance on Dr. Schmidt's analysis of the reduction in groundwater table per acre-foot of increased groundwater pumping which, as mentioned above, is seriously flawed. If both errors were corrected, the increased cost of groundwater pumping would be much lower, probably by a factor of four or more; in fact, if the Friant districts manage their groundwater in the future as carefully and creatively as they have over the past two decades, there could be only a minimal increase in the dairies' groundwater pumping cost.

With regard to the reduction in the production of forage, Dr. McKusick's analysis rests on his assessment of (i) the reduction in the production of alfalfa, corn silage, and small grain silage within the Friant districts as a consequence of his FDPM model analysis of the Spring run release scenario, and (ii) his assessment of the source of a replacement supply for forage. His FDPM analysis exaggerates the overall reduction in cropped acreage within the Friant districts both because it uses the Spring run release scenario and also because it ignores exchanges of water both within the Friant service area and outside. For example, when FDPM is re-configured to permit trading within the Friant districts, and the Kondolf release scenario is applied, there is a smaller reduction in the overall acreage of forage crops, as follows:

Acreage reduction	Dr. McKusick's analysis	My analysis
Alfalfa	15,773	16,163
Corn silage	6,615	885
Small grain silage	3,932	289

The difference in the acreage changes roughly halves Dr. McKusick's estimate of the impact on forage production shown in his Table 27.

Given a reduction in locally grown forage crops, Dr. McKusick proceeds on the premise that "dairy farmers will be forced to ship in a greater proportion of their feed supplies from outside the region." He specifically mentions Imperial Valley as a possible source, and he calculates an estimate of the increased shipping cost from outside the region. He appears to overlook the fact that these same crops are grown closer at hand, namely in other parts of the *same* counties where the Friant districts are located and in Kings County. In 2003, for example, about 55,000 acres were planted to alfalfa in Madera and Tulare counties outside the Friant Districts, about 170,000 acres were planted to corn silage in Madera, Tulare, Fresno, Kings and Kern counties outside the Friant districts, and about 133,000 acres were planted small grain silage in those counties outside the Friant districts. Given the availability of feed supplies from non-Friant farming areas in these counties, I doubt that the cost of obtaining forage from local dairies will increase by anything like Dr. McKusick's estimate.

2.D Impact on Urban Water Users

Several municipalities receive Friant water either directly as contractors or indirectly as purchasers from Cross Valley Contractors. Dr. McKusick assumes that, in the event of a reduction in the supplies available from Friant, the municipalities would modify their behavior and turn to the next most economic alternative.[31] His Table 29 shows an estimated cost of the reduction in supply for the cities of Fresno, Lindsay, and Orange Cove totaling $326,340 per year. Beyond this direct impact, Dr. McKusick states that "the communities themselves will be unable to grow at the rates anticipated because of limited water supplies." I disagree with both conclusions.

Dr. McKusick's estimate of the reduction in water supply available to municipalities is exaggerated because of his reliance on the Spring run release scenario, and also because his FDPM analysis does not consider the possibility that the municipalities might be able to purchase water from some of the Friant agricultural districts at a cost that is lower than that of the management alternatives he identifies. The cost increase due to fishery restoration in the Upper San Joaquin River is likely to be small in relation to the overall cost of municipal water supply.

It is implausible that the municipalities will be unable to grow because of the limitation in water supplies from Friant Dam. For the last century, the experience in California has been that urban residents have a higher net willingness to pay for water than farmers, and they can afford to buy water from agricultural areas of the state. There is every reason to believe that this will continue to hold for municipalities in the Friant area.

Another point should be noted about urban water use. While Dr. McKusick alludes to the likelihood of population growth in the Friant area, he does not factor it into his FDPM analysis of

[31] This contrasts with his FDPM analysis of the irrigation districts in the Friant service area, which does not consider the Cross Valley Contractors and ignores water resource management options that would constitute the next most economic alternative of water supply.

agricultural water use, as though it had no effect on the agricultural demand for water. In fact, future urban expansion is likely to cause a significant reduction in the cropped acreage with the Friant counties. A recent study by Tietz et al. (2005) predicts that about 500,000 acres of prime farmland will become urbanized by 2040, mainly in Tulare, Fresno, and Kern counties. Depending on how water managers and land use planners manage this expansion it could have a significant effect on future water demand in those counties.[32] Whatever the future trajectory of urban development in the Friant counties, I do not believe it will be constrained by the reduction in deliveries from Friant Dam.

[32] Residential water use in new housing is greatly influenced by the type of fixtures and landscaping. As Dr. Gleick notes in his expert report, there is a great potential for reducing water use in new housing if this were encouraged by the water districts and land use planners (see also Gleick et al., 2003). Moreover, housing density affects the balance of indoor and outdoor residential water use. Outdoor water use is partly lost to the system through evapotranspiration from lawns and other plantings while indoor water use is retained within the system and is available for through the re-use of treated wastewater.

2.E Impact on Power Generation

Dr. McKusick concludes that there will be a reduction in net power generation due to the fishery restoration releases from Friant Dam. He does not consider the possibility to expand generation capacity for releases into the river. As noted by Dr. Kirby in his Supplemental Report, this has the potential to offset any losses due to reductions in power generation on the canals.

3. ECONOMIC BENEFITS TO CALIFORNIANS

It is a standard axiom of economists that public actions should be subjected to a cost-benefit assessment to determine whether, in the language employed by Congress, "the benefits to whomsoever they may accrue are in excess of the estimated costs" (33 USC 701a). However, a noteworthy feature of Dr. McKusick's Report is that it considers only the economic costs of increased releases from Friant Dam, and it makes no effort to consider the potential economic benefits and to assess how these might compare with the costs. An unwary reader of his Report might assume that jobs are only lost in agriculture and none are created by the proposed fish restoration changes in the operation of Friant Dam, that there are only costs and no benefits from these changes. But this is incorrect: there are significant benefits from the increase in releases from Friant Dam and, as shown below, these have substantial economic value. From an economic perspective, such benefits need to be considered along with the costs in forming an assessment of whether or not increased releases are in the public interest.

3A.1 Impact on water-dependent outdoor recreation along the San Joaquin River

The first component of economic benefits I shall consider is the impact on water-dependent outdoor recreation along the San Joaquin River. The 2005 California Water Plan identifies this type of recreation as "an important consideration for water managers" and goes on to state: “Water management, and water infrastructure, can have significant effects on recreation. By considering recreation during the planning process, water managers can take advantage of opportunities to enhance recreation, and can guard against actions that would limit recreation.” The Water Plan adds: “As trustee to public resources, the state must consider the benefit and use of land and water resources for recreational opportunities. As discussed in Chapter 2 of Volume 1[of the Water Plan], the Public Trust Doctrine recognizes recreation as one of the public trust uses that state agencies must take into account when managing tidelands and navigable waters and their tributaries.”[33]

For most people, including residents of California, bodies of water provide a natural focus for their outdoor recreation, whether on the shoreline of an ocean, bay or lake, or along the banks of a river or stream. These activities are typically classified in two categories. *Water-based* recreation activities are those involving actual use of water, such as swimming, boating, sailing, rafting, canoeing, and fishing. In addition, many other outdoor recreation activities tend to be pursued alongside bodies of water, including picnicking, hiking, walking, jogging, biking, and viewing nature and wildlife (Cordell et al., 2004, p. 248). These activities are enhanced by the presence of water and are sometimes referred to as *water-related.* The combined set of water-based and water-related activities are referred to as *water-dependent* recreation.

There is clear evidence of the importance of water-dependent recreation to people in California. For example, the California Department of Parks and Recreation has conducted statewide surveys of public opinions and attitudes on outdoor recreation in California every five years since 1987. The results consistently indicate the great importance to Californians of outdoor recreation, and water-dependent recreation in particular. In the most recent survey, conducted in 2002, 84.1% of those surveyed responded that outdoor recreation areas and facilities were important or very important to them and their families (California Department of

[33] California Department of Water Resources, 2005, Volume 2, page 24-1.

Parks and Recreation, 2003). When respondents were asked to consider their favorite recreation activity and to assess the importance of various factors to their overall enjoyment of this activity, 67.4% said that being outdoors was a very important factor for them, and 43.8% said that the availability of water (lakes, reservoirs, rivers, wetlands) was very important for them. When asked about their attitude to various issues, 76.2% of respondents strongly agreed with the statement that “maintaining the natural environment in outdoor recreation areas is important to me;” 49.8% strongly agreed with the statement that “more recreation and open space lands are needed in or close to urban areas;” and 45.8% strongly agreed with the statement that “more outdoor recreational facilities are needed at lakes and reservoirs, such as picnic and camping sites.”

With regard to participation, 75.1 % of respondents had participated at least once in 2002 in wildlife viewing, bird watching and/or viewing natural scenery; 46.7% had participated in swimming in freshwater lakes, rivers and/or streams; 34% had participated in freshwater fishing; 29.1% had participated in motor boating; and 23% had participated in kayaking, rowing, canoeing and/or rafting. Water-dependent recreation activities are clearly very popular in California.

The survey also assessed the *latent* demand for recreation activities that Californians would do more often if opportunities were available; of the 55 activities considered, wildlife viewing had the fourth highest latent demand index, while freshwater fishing came in ninth. The survey asked respondents for their opinion regarding spending priorities for state and federal agencies with regard to outdoor recreation facilities and services outside their local community. The top priority was protecting natural resources; 71.4% of the respondents said that government agencies should give more emphasis to spending on this.

Using the data from this survey, the 2005 California Water Plan estimates that, in 2002, adult Californians spent about 150 million participation-days on water-based recreation (California Department of Water Resources, 2005, loc cit); in the case of water-related recreation, it estimates that there were 55 million adult participation-days for wildlife viewing, and 36 million adult participation-days for hiking. In addition, it notes, "water recreation is a large draw to tourists, helping to attract 20 million visitors." With regard to the economic impact of water-dependent recreation in California, the most specific information available is for sportfishing. The 2005 Water Plan presents data showing that freshwater fishing alone generates over $3 billion per year of economic output in California.[34] The economic activity generated by other components of water-dependent recreation, including water-related tourism, exceeds that associated with freshwater fishing by a very substantial margin. Thus, water-dependent outdoor recreation by both residents and tourists is now an important part of the California economy.

Stepping back for a moment, two long-term trends are evident in California over the past five decades: there has been a substantial increase in participation in several forms of water-dependent recreation, fueled in part by rapid growth in population, while at the same time the natural resources needed to support water-dependent recreation in California have shrunk significantly due to urban and agricultural development. In 1950, when the CVP Friant Unit was coming on line, there were about 10,650,000 people living in California; today there are over 36,800,000. By 2040 the population will likely exceed 50 million. Moreover, while per capita participation in fishing has declined somewhat over this period, per capita participation in forms of water-dependent recreation has increased substantially. The best data on participation in water-dependent recreation are available only for the U.S. as a whole, and for a more recent period, and are derived from the National Survey of Recreation. For example, the percentage of Americans 16 years or older participating in swimming in a river, lake or ocean increased from 30.1% in 1982-83 to 36.2% in 1994-95; the percentage participating in motorboating increased from 17.9% to 21.8% over the same period; the percentage participating in bird watching more

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[34] When saltwater sportfishing is added, the total economic activity generated by sportfishing in California rises to about $5 billion annually (McWilliams and Goldman, 1994 as cited in the California Department of Water Resources, 2005).

than doubled from 11.3% to 25.0% over this period; and the percentage participating in canoeing and kayaking increased from 2.0% in 1960 to 8.1% in 1994-95.[35]

Both in California and elsewhere, the volume of participation in most water-dependent activities is projected to increase in the future faster than the population. According to Cordell et al. (1999), between 1995 and 2050 the number of days spent canoeing is expected to increase about 12% faster than the rate of population growth in the Pacific region (an 80% increase versus a 60.4% increase in population). The number of days of rafting/floating in the Pacific region is expected to grow a third faster than the rate of population growth in the region, while the number of days of motorboating is expected to grow by almost double the rate of population growth in the region. The number of days spent visiting beaches and watersides in the Pacific region is expected to grow almost 20% faster than the rate of population growth, while the number days spent on nonconsumptive wildlife activities (which includes birdwatching, photography, and other forms of wildlife viewing) in the region is expected to grow a third faster than the rate of population growth. The main exceptions to these trends are swimming in a river, lake or ocean, which will slightly trail the rate of population growth in the Pacific region, and sportfishing, which will grow at a rate about 10% lower than the rate of population growth in the region.[36]

Meanwhile over the past 50 years, wetland areas in California have declined and sections of the San Francisco Bay and Delta have become more polluted, as have rivers in some other parts of California. In addition, the completion of Friant Dam by 1950 left 60 miles of the river almost completely dry.

This contrast of a growing statewide population and a growing public interest in participation in water-based and water-dependent relation, combined with a steady reduction in the availability and quality of water-related outdoor recreation in California, provides the context

[35] Cordell et al., 1999, pages 237-240.
[36] Cordell et al., 1999, pages 324,329-336.

for the California Water Plan's current emphasis on the importance of outdoor recreation for water resource managers in California.

3A.2. Existing Water-Related Recreation Resources along the Upper San Joaquin River

The pressing need for water-related outdoor recreation in California is certainly a relevant consideration for the San Joaquin River, both as it exists today and as it could exist if more water were released from Friant Dam.

My analysis of the issue considers the potential impacts on water-related recreation both at Millerton Lake along the entire 167 stretch of the San Joaquin River (see the map in Figure 2).

FIGURE 2

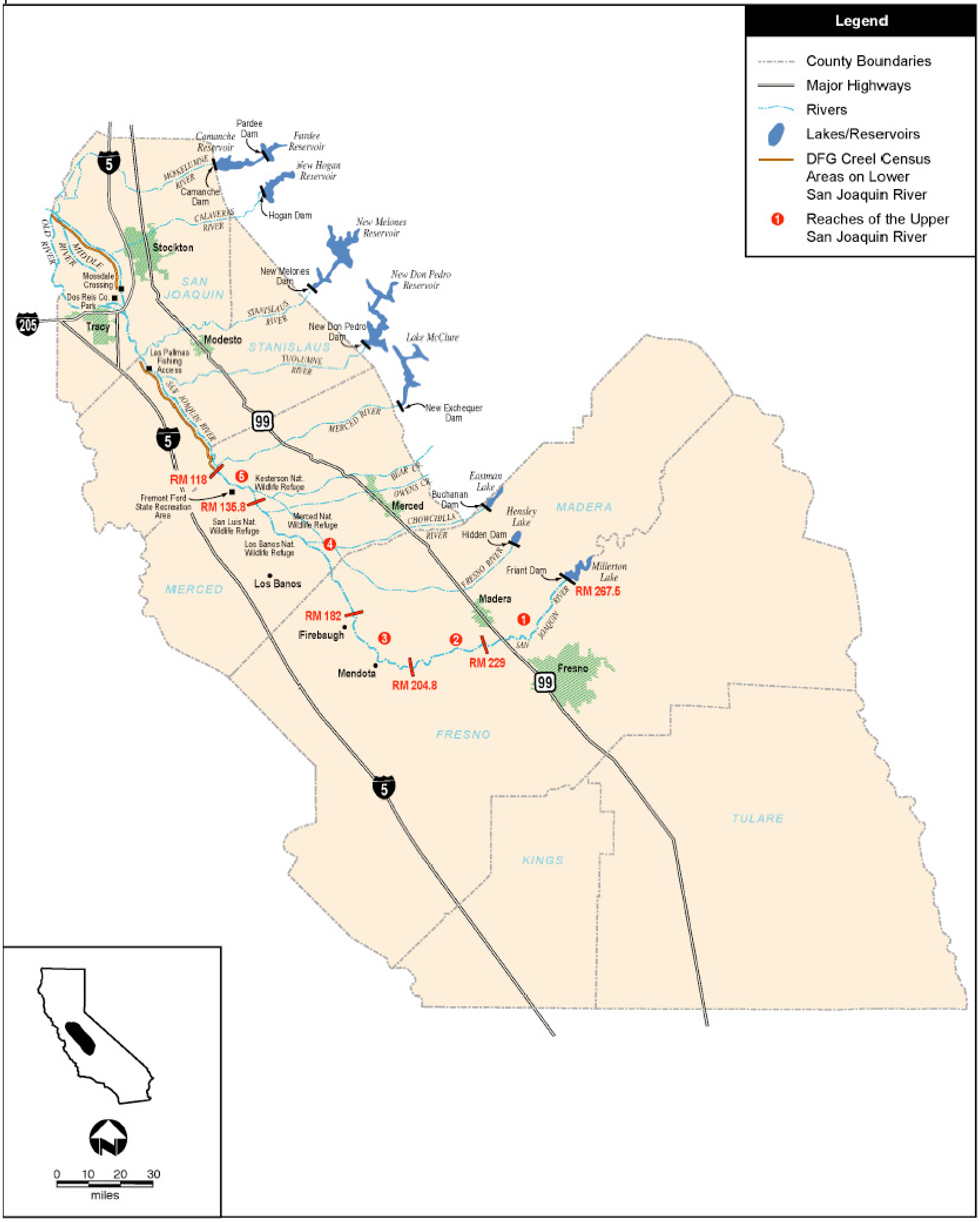

Figure 1
San Joaquin River Study Area

Millerton Lake, created with the closing of Friant Dam, supports a variety of recreation activities, including fishing, swimming, boating, waterskiing, picnicking, camping and trail use. It is a popular recreation destination for residents of Fresno, Madera and Merced Counties, and regularly experiences heavy use during the peak summer season; approximately three quarters of all recreational use occurs between April and September. Annual use averaged about 609,000 visitor-days over the period 1983-1990, and presumably has increased somewhat since then with the growth in county populations.[37]

The Upper San Joaquin River is divided into five primary reaches that exhibit similar flows, geomorphology, and channel morphology. Most recreation currently occurs in just two of these reaches, Reaches 1 and 3.

Reach 1 runs from Friant Dam to Gravelly Ford, and is subdivided into Reach 1A (the upper section) and Reach 1B (the lower section), where the dividing line is State Route 99. Both subreaches have flowing water all year.

Reach 1A has been the focus of considerable planning and restoration activity because of its role as a focal point of the San Joaquin River Parkway, a planned 6,000-acre greenbelt along

[37] Data on freshwater-related recreation *by location* in California are generally very sparse and incomplete, in contrast to the data on water-related participation. This is because the three major outdoor recreation surveys – by the California Department of Parks and Recreation, the National Survey of Fishing, Hunting and Wildlife Associated Recreation, and the National Survey of Recreation – collect data on respondents' total participation in a given activity within the state, but they do not ask *where* in the state the activity occurred. The National Marine Fisheries Service's Marine Recreational Fishing Survey does ask respondents about the location where they fished, but these surveys are restricted to saltwater fishing and thus provide no information about freshwater-based recreation in California. Location-specific data on outdoor recreation in California generally come from one of two sources: (i) records of attendance at developed sites based on a count of people or vehicles entering the site, and (ii) on-site surveys conducted occasionally by agencies at specific locations, including creel censuses conducted by the California Department of Fish and Game, surveys of Delta recreation by the Department of Water Resources, occasional surveys by the Department of Boating and Waterways, and sporadic surveys by individual researchers and organizations. These surveys are at best intermittent, and they typically are not consistent over time.

the reach, with natural areas, recreation areas and open space connected by the Lewis S. Eaton multi-purpose trail plus several smaller trails that allow users closer access to the river. As of 2001, 3,500 of the planned 6,000 acres had been preserved for public access and use. In addition to the trail system, other existing features of the Parkway include Lost Lake County Park, Woodward Park, Camp Pashayan, and Sycamore Island Ranch, which is a privately-owned recreation area on the north side of the San Joaquin River. Based on a survey of users of the Parkway, it was estimated that approximately 220,000 visits were made to the parkway in 2000 (Houser and North 2001). The vast majority of the users of the parkway are residents of Fresno County (92%) with Madera residents accounting for 3% of users. 61% of users are residents of the City of Fresno and 14% are residents of Clovis.

Results from the 2000 user survey indicate that use of the trail system for jogging, walking, and bicycling is a primary activity. Seventy-eight percent of the users interviewed were intercepted on the Eaton Trail. More than half of the users at Lost Lake County Park and more than a third of users at Camp Pashayan were engaged primarily in fishing. Guided canoe trips are a popular activity on the river, accounting for more than 1 percent of the visitors who participated in the user surveys.

In Reach 1B, the flows are lower than in Reach 1A and the primary land use is gravel mining and agriculture. It appears likely that there is a limited level of recreation use along this reach.

Reach 2, from Gravelly Ford to Mendota Dam, has little or no flow, and little or no riparian vegetation. The surrounding land use is agricultural. It is unlikely that there is recreational use along this reach.

Reach 3, from Mendota Dam to Sack Dam, is wet most of the year with water imported from the Delta via the Delta-Mendota Canal. Agriculture is the primary land use in this reach, and the river is confined by local dikes and canals on both sides. However, the City of Firebaugh is located to the west of Reach 3, and it has completed a section of trail along the San Joaquin River, along with riparian vegetation plantings in the parkway. There is therefore some level of recreational use in this reach, but a specific estimate is not available.

Sack Dam diverts the flow of the river at Reach 4, from Sack Dam to Bear Creek. The water in this reach comes from irrigation return flow and groundwater accretion. Agriculture is the primary land use in the entire reach. However, several national wildlife refuges and wildlife areas are located in proximity to this reach, including the San Luis National Wildlife Refuge, Kesterson Nation Wildlife Refuge, Merced National Wildlife Refuge, and the Los Banos Wildlife Area. The City of Merced is located to the east and the City of Los Banos is located to the west. No recreation use information is available for Reach 4; however, it appears that recreation activity is minimal.[38]

Reach 5, from Bear Creek to the confluence with the Merced River, flows continuously. Although recreation use information specific to Reach 5 could not be identified, some recreation use at the Fremont Ford State Recreation Area (which is now part of the Great Valley Grasslands State Park) was reported in the CVPIA Programmatic Environmental Impact Statement (USDI 1997).

The river from the confluence with the Merced River to Vernalis at the southern edge of the Delta is known as the Lower San Joaquin River. This section of the river is characterized by a combination of flows from tributary streams, major rivers, groundwater accretions, and agricultural drainage water. Major tributaries along this stretch of the river include the

[38] It is worth noting that the Grasslands ecological area was named a “Wetlands of International Importance” this year under the Ramsar convention -- see http://www.fws.gov/pacific/sacramento/ea/news_releases/2005%20News%20Releases/Grasslands_award_draft.htm.

Tuolumne River and the Stanislaus River. All of these tributaries support a variety of water-related recreation, including fishing and boating.

Past Vernalis, the river splits into the Deep Water Channel that passes the City of Stockton, Middle River, and the Old River. Based on creel census data from the California Department of Fish, Gallo (2002) estimates that the reach of the river between Mossdale Landing near Tracy in San Joaquin County and the Delta (from the confluence with the Sacramento River) and accounted for 49,580 angler hours during the months of April and May in 2000, and angler activity along the reach of the San Joaquin River between the Stanislaus River and Merced River accounted for about 30,070 angler hours during April and May in 2000. Information from the CVPIA Environmental Impact Statement (Bureau of Reclamation, 1997) indicates that use at three recreations areas along the Lower San Joaquin River (Dos Reis County Park and Mossdale Landing County Park, both in San Joaquin County, and Las Palmas Fishing Access Site located in Stanislaus County) plus a fourth recreation area located in Merced County accounted for 157,000 visitor days in 1992.

With this as background information, the question I will now address is the likely consequences of the releases recommended by Professor Kondolf in his report for water-related recreation along the San Joaquin River.

3A.3 Increase in Water-Related Recreation along the San Joaquin River Associated with NRDC Restoration Scenario.

While I believe there will be some significant changes in recreation activities along the San Joaquin River if flows are increased as specified in Professor Kondolf’s expert report, I do not believe it is possible for anybody to predict with precision how these changes will play out over time. Restoring water to 60 miles of river that has been dry most of the last 55 years is a profound change. Three generations of anglers have grown up in the San Joaquin Valley knowing only a dewatered stretch of river; what was a focal point for an active sportfishing pastime vanished, and with it some of the physical and social infrastructure to support that activity. With the restoration of flows to the river, water-dependent recreational activities will re-emerge, but the timing is difficult to predict. To accommodate this uncertainty, I will frame my analysis in terms of likely recreational use twenty years from now, in 2025. By then, of course, there will be a larger population living in California and in the San Joaquin Valley than today. To deal with this, I will analyze a 2025 world as it might be with *today's* population, and then adjust for the expected growth in population between now and then.

My analysis accounts separately for (1) the impact on recreation at Millerton Lake; (2) the impact on recreation along the Upper San Joaquin River; and (3) the impact on recreation along the Lower San Joaquin River.

In the case of Millerton Lake, it is unlikely that there will be any effective impact on recreation. The pattern of releases from Friant proposed by Professor Kondolf may result in a slight reduction in lake levels compared to current operations,[39] but this would mostly affect the level of the lake in the *early* part of the important summer recreation season when the lake levels are still high from the spring run-off. In August and September, the average lake level with the releases proposed by Professor Kondolf would likely be similar to what is experienced now with current operations. In June, the releases proposed by Professor Kondolf could reduce the average lake level from 561 to 551 feet above mean sea level (msl), and in July the lake level could be reduced from 537 to 529 feet above msl. However, at these levels, nearly all of the facilities at Millerton Lake would still be operational, so the drawdown would be unlikely to affect recreation opportunities or levels of recreation activity.

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[39] Whether reservoir levels would be reduced from historical levels depends on a variety of factors, including the amount and timing of canal diversions from the reservoir and the amount and timing of flows upstream of Millerton Lake, which are regulated by a vast upstream hydropower complex. This analysis assumes that upstream flows reflect historical flows and canal diversions reflect the reductions analyzed by Dr. Kirby.

Future recreation along the Upper San Joaquin River can be extrapolated from what is currently occurring in Reach 1A now with the San Joaquin River Parkway in place. Information on recreational activity along the Parkway comes from a survey conducted by Houser and North (2001). As noted earlier, most of the visitors come from Fresno and Madera Counties – these can be regarded as the *local* market for the Parkway. In addition, some visitors come from elsewhere in the San Joaquin Valley, outside Fresno and Madera Counties, which I take as the *non-local* market for the Parkway. From the data provided by Houser and North, one can calculate the local and non-local *rates* of visitation at the Parkway, as a function of respective County populations. Given the length of the area currently visited, one can then estimate local and non-local visitation participation rates per mile of river. These form the basis for my analysis of the other reaches of the Upper River.[40]

The participation estimates for the other reaches are keyed off the local and non-local markets for water-related recreation. For Reach 1B, I define the local market as the population of Fresno and Madera Counties minus 25% of the population of the City of Fresno; for Reach 2, it is defined as the population of Fresno and Madera Counties minus 50% of the population of the City of Fresno; for Reach 3, it is defined as the population of Fresno and Madera Counties minus 67% of the population of the City of Fresno; for Reach 4, it is defined as the population of Merced County plus 15% of the population of Fresno and Madera Counties; and for Reach 5 it is defined as the population of Merced County. The non-local market is defined as the other counties in the San Joaquin Valley excluding Kern County, on the theory that the Kern River may function as a substitute to the San Joaquin River for Kern County residents. It should be emphasized that these market areas are intended to be rough estimates based on geographic proximity.

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[40] I believe this analysis is conservative because the Houser and North survey did not cover all of the sites used for recreation along the Parkway, and therefore is likely to understate total recreation participation there.

For my forecast of water-related recreation in 2025 I employ the Department of Finance's forecast of the populations of these Counties, and of the City of Fresno, in 2025. However, I discount the participation rates in several reaches because, even in 2025, it is likely that access to recreation along the river will be inferior to what exists now along Reach 1A. Specifically, by 2025, access to the river along Reaches 3 and 4 is likely to be comparable to what exists now along Reach 1A, but, even by 2025, the trail use component of river-based recreation in Reach 1B will likely be only a half of what it is now in Reach 1A; in reaches 2 and 5, I assume it will be only a quarter of what it is now in Reach 1A.[41] [42] I make two further assumptions. I assume that, by 2025, the fishing component of recreation activity along Reach 1A increases by 25% because of the introduction of salmon fishing opportunities. I also assume that the share of non-local participation in recreation along the Upper River rises from the 5% observed currently on Reach 1A to a level of 15% by 2025 to reflect the wider appeal of the restored river both regionally and statewide.

It is worth pointing out what is *not* being assumed. I am assuming no change in the rate at which Californians participate in water-related recreation, despite the evidence cited above that

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[41] As noted above, there is some limited recreational use along Reach 3 at present. The City of Firebaugh is located nearby and there already is a section of trail along the river. With improved water quality the reach would be a natural focal point for increased recreation. Existing recreational activity on Reach 4 is minimal, but this reach has considerable potential because of the proximity to several national wildlife refuges and wildlife areas, as well as proximity to urban populations in Merced and Los Banos.

[42] It is important to emphasize that the current poor state of access to much of the Upper River is not something that is immutable. If the river became a more attractive place for recreation activities, public agencies and environmental NGOs would have an incentive to acquire easements and develop improved access in order to satisfy unmet public needs for attractive outdoor recreation. An example is the activities of The Nature Conservancy which has been an active participant in implementing a restoration program to guide riparian habitat management along the Sacramento River and its tributaries. This program has involved acquiring (both fee simple and conservation easements) and restoring lands within the riparian zone, focused primarily on the 100-mile reach of the Sacramento River from Red Bluff to Colusa. About 60 percent of the lands within the river corridor zone are in private ownership, with about 50 percent of these lands in agricultural production.

this participation is expected to rise. And my estimate of recreation activity does not include recreation visits for viewing salmon along the Upper San Joaquin River. This activity, which could generate significant tourism and revenue, does not now occur and is therefore difficult to estimate. For these reasons, I believe my analysis of recreation impacts on the Upper River is conservative.

The Upper San Joaquin River supports fewer than 250,000 recreation trips today, almost all of them along Reach 1A. I estimate that, with increased releases from Friant Dam under 2025 conditions, but with today's population, it would support about 778,000 recreation trips annually. With increased releases from Friant and the expected 2025 population, it would support about 1,350,000 trips annually.

Increased releases from Friant Dam will benefit recreation along the Lower San Joaquin River in at least two ways: establishing a sport fishery for salmon on the Upper River will also enhance salmon fishing on the Lower River; and, as explained in greater detail in the following section, increasing releases from Friant Dam will improve water quality in the Lower River and that, in turn, improves conditions for recreation there. The basis for my analysis of these recreation impacts is a creel census of sportfishing conducted by the Department of Fish and Game in 1999 along two sections of the Lower San Joaquin River, between the Delta and Mossdale Crossing and from the confluence with the Stanislaus River to the confluence with the Merced River (California Department of Fish and Game, 2001a,b). These two segments account for about 80% of the rivers length, while the middle section, between Mossdale Crossing and the confluence with the Stanislaus, accounts for about 20%. I assume, therefore, that the middle segment accounts for about 20% of the sport fishing, and the other two segments account for 80%. I also assume that sport-fishing accounts for about 40% of all water-related recreation activity along the Lower San Joaquin River, based on the fact that it is this proportion of total recreation activity along the Lower Sacramento River (Department of Water Resources, 1980). This yields a baseline estimate of recreation along the Lower San Joaquin today. I assume that

90% of this sportfishing is local, by residents of San Joaquin and Stanislaus Counties, and 10% is non-local, by residents of Fresno, Madera, Kings, Tulare, Merced, Contra Costa, and Sacramento Counties.

To predict recreation along the Lower San Joaquin River in 2025, I make several modifications. First, I adjust the baseline estimate of recreation by the predicted growth in the population of the relevant counties, using the Department of Finance's forecasts. Second, I adjust for the improvement in salmon fishing and in water quality due to the increased releases from Friant Dam. I assume that salmon fishing would account for 25% of the total fishing activity along the Lower River, based on the proportion observed on the Sacramento River and its tributaries, where there is good salmon fishing now. I also assume that the improvement in water quality in the Lower River leads to a 10% increase in other recreation activities along the river. I also assume that the non-local share of recreation activity along the Lower San Joaquin River rises from 10% at present to 20% by 2025.

The Lower San Joaquin River supports about 275,000 recreation trips today, consisting of about 110,000 fishing trips and 165,000 other recreation trips. I estimate that, with increased releases from Friant dam under 2025 conditions, but with today's population, it would support about 320,000 trips annually, consisting of about 138,000 fishing trips and 182,000 other recreation trips. With increased releases from Friant and the expected 2025 population, it would support about 572,000 trips annually, consisting of 247,000 fishing trips and 325,000 other recreation trips.[43]

These estimates of recreation activity along the Upper and Lower San Joaquin Rivers seem modest when compared to water-related recreation elsewhere in California. The Sacramento River, at 300 miles the only river in California longer than the San Joaquin River,

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[43] Again, I am not assuming any change in the rate at which Californians participate in water-related recreation. I am also not considering water quality benefits to in-river fisheries other than salmon.

was estimated in 1980 to support more than 2 million recreation visits annually. With the growth in population since then and the growth in participation in water-related outdoor recreation noted above, the level of recreation activity along the Sacramento River probably now exceeds more than 3 million visits. More than 5 million visitors are believed to use the American River Parkway annually. Thus, an increase in recreation along the Upper and Lower San Joaquin River from a present level of about 525,000 visits to a level of about 1,100,000 visits if there were increased releases from Friant Dam under 2025 conditions, but with today's population, seems entirely plausible.

3A.4. Economic Value and Impact of Increased Recreation along the San Joaquin River

The gross monetary value of an item to an individual, such as being able to go fishing on the Upper San Joaquin River, is defined by economists to be the amount of money that the individual is willing to exchange for the item. This exchange can be framed in one of two ways as either the maximum amount that the individual would be willing to pay (WTP) to have the item rather than go without it, or as the minimum amount that the individual would be willing to accept (WTA) as compensation in exchange for foregoing the item. I will focus here on the WTP measure. The *net* economic value of an item is defined as the gross value minus the cost of the item – i.e., it is the excess of the maximum amount that the consumer would be willing to pay for the item over what he actually does pay. This net value is used by economists to measure the gain from an increase in the availability of an item, or the loss from a reduction in its availability. In the recreation context, it is the economic measure of the use and enjoyment that the public obtains from having the opportunity to engage in recreation at some location.

This net value is also known as the *consumer's surplus*. It can be measured from the demand curve the item in question as the area lying under the demand curve but above the current price – what is known as the Marshallian triangle; or, it can be measured from an interview technique called contingent valuation, to described in a later section. When consumer’s surplus is estimated for recreation site, the price that enters the demand curve is based in part on the cost of traveling to the recreation site – hence the method of calculating consumer’s surplus from a demand curve is sometimes called the travel cost method. It is important to note that the travel cost is not itself a measure of economic welfare: it is an ingredient to the estimation of a demand curve, from which the measure of welfare – consumer’s surplus – is subsequently derived.

There have been many recreation demand studies in California and elsewhere that have developed demand curves for various types of recreation at various locations from which an estimate of consumer’s surplus is obtained. There is one study in the literature that deals specifically with water-related recreation on the Upper San Joaquin River. This is the study by Houser and North (2001) who surveyed recreation visitors along the San Joaquin River Parkway specifically for the purpose of fitting a demand function for this recreation and estimating the consumer’s surplus derived from it. Their estimate of consumer’s surplus came to about $36 per trip in 2000 dollars. To be conservative, I propose to use a lower value of $25 per trip (in today’s dollars) for general recreation along the Upper San Joaquin River, allowing for the large potential increase in trips under 2025 condition.

With regard to the other types of recreation – salmon fishing along the Upper San Joaquin, and general fishing, salmon fishing, and other recreation activities along the Lower San Joaquin River, I am not aware of any existing studies conducted specifically on those activities in this area. To value these other activities, I use estimates of consumer’s developed for such benefits transfer purposes by Walsh, Johnson and McKean (1992). Their consumer’s surplus values, all in 1987 dollars, are as follows: salmon fishing (on the Upper and Lower San Joaquin), $46.24/trip; general fishing (on the Lower River) $22.50/trip; other recreation (i.e., motorized boating and other activities on the Lower River) $25.67/trip. These values are converted to present day dollars using the consumer price index (CPI) US city average for all urban consumers.

The recreation activities along the Upper and Lower San Joaquin River will generate significant economic activity among local businesses. To measure the impact on the local and regional economy I use estimates of the expenditures per recreation trip. For this purpose I employ the expenditure data from Houser and North (2001) and from surveys conducted in 1997 for the Trinity River Mainstem Fishery Restoration Study (US Department of the Interior, 2002). The expenditure data is as follows. On the Upper River, the expenditure trail use is $6.73/trip (Houser and North, 2000$); expenditure on both salmon fishing and other fishing is $21.14/day (Trinity River study, 1997$); expenditure on other recreation activities is $16.21/day (Houser and North, 2000$). On the Lower River, spending by locals on salmon fishing and other fishing, and other recreational activities is estimated at $26.05/day (Trinity River study, 1997$). Spending by non-locals is estimated at $21.14/day for salmon fishing and other fishing, and $20.50/day for other recreational activities (Trinity River study, 1997$) To be compatible with the expenditure analysis from McKusick, these values are all converted to 2003 dollars.

Using the estimates of consumer's surplus per trip, I conclude that recreation opportunities on the Upper San Joaquin River would generate additional net benefits to recreationists, in terms of an increase in aggregate consumer's surplus, amounting to about $14.3 million annually (an increase from $6.3 million to $20.6 million in aggregate consumer's surplus), assuming 2025 resource conditions but today's population. With the population actually expected by 2025, net benefits will rise to about $35.8 million per year, an increase of about $29.5 million compared to 2000 values. On the Lower San Joaquin River, the additional releases from Friant Dam will generate additional recreation benefits in terms of consumer's surplus of about $3.1 million per year (an increase from $10.6 million to $13.7 million), assuming 2025 resource conditions but today's population. With the population actually expected by 2025, these benefits would rise to about $26.3 million in annual consumer' surplus, an increase of about $15.7 million compared to 2000 values. With regard to the impact on the local and regional economy, the infusion of spending by people from outside the region who are visiting the river can be expected to generate more than $14 million in local spending in the Upper San Joaquin

River region by 2025 and more than $15 million in local spending in the Lower San Joaquin River region. This spending will create employment opportunities and generate income for residents of these areas; this is described further in section 4..

3B. Impact on water quality along the San Joaquin River

3B.I. Existing Water Quality Conditions

From a water quality perspective, the San Joaquin River is a river in trouble. The Upper San Joaquin River, from Friant Dam to the confluence with the Merced River, does not currently support a continuous natural riparian and aquatic ecosystem.[44] From Mendota Pool to Vernalis (i.e., Reaches 3, 4 and 5 of the Upper San Joaquin River and the entire Lower San Joaquin River), the San Joaquin River is listed by the State of California as an impaired water body under the federal Clean Water Act Section 303(d). And downstream of Vernalis, the Delta itself is a notoriously troubled water body. The Delta supplies drinking water for approximately two thirds of the people living in California, and problems associated with its poor water quality have been the focus of almost continuous deliberations by the State Water Resources Control Board and the Central Valley Regional Quality Board (CVRWQB) for more than 30 years. For the last decade, they have also been the central concern of CALFED (now the California Bay/Delta Authority).

The San Joaquin River and diversions by units of the Central Valley Project in the San Joaquin Valley are major contributors to California's Bay/Delta problem: Any action that degrades water quality in the San Joaquin River harms the Delta; any action that raises water quality in the San Joaquin River benefits the Delta.[45] Given the billions of dollars that have already been spent in the past on improving Delta water quality, and the additional billions of dollars that will need to be spent in the future, improvements in San Joaquin River water quality

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[44] US Bureau of Reclamation (2005a), page ES-4.

[45] See the expert report of Edgar A. Imhoff.

associated with increased releases from Friant Dam could have a significant economic benefit by virtue of reducing the expenditures that California will otherwise have to incur in order to improve water quality in the San Joaquin River and the San Franco Bay/Delta.

At this time, I do not have sufficient information that would permit me to quantify this economics benefit in a precise manner. Instead, I will outline the issue in general terms.

The existing impairments of water quality in the Upper and Lower San Joaquin River are listed in Table 9, taken from Table 3-5 of the Upper San Joaquin River Basin Storage Investigation. The impairments involve elevated concentrations of salinity and boron, selenium, organophosphate pesticide (diazinon and chlorpyrifos), Group A Pesticides, DDT, and mercury, and also, in the Stockton Ship Channel, depressed levels of dissolved oxygen. The CVRWQB has currently developed TMDLs for two of these items: salt and boron, and dissolved oxygen, from which some cost information is available.

TABLE 9

SAN JOAQUIN RIVER WATER QUALITY IMPAIRMENTS BY SEGMENT

Waterbody / Reach	Pollutant/Stressor	Affected Area / Reach Length	Information Source
Mendota Pool[1]	Selenium	3,045 acres	2002 Clean Water Act §303(d) List
San Joaquin River: Mendota Pool to Bear Creek	Boron	67 miles	2002 Clean Water Act §303(d) List
	Chlorpyrifos		
	DDT		
	Diazinon		
	Electrical Conductivity		
	Group A Pesticides		
	Unknown Toxicity		
San Joaquin River: Bear Creek to Mud Slough	Boron	14 miles	2002 Clean Water Act §303(d) List
	Chlorpyrifos		
	DDT		
	Diazinon		
	Electrical Conductivity		
	Group A Pesticides		
	Mercury		
	Unknown Toxicity		
San Joaquin River: Mud Slough to Merced River	Boron	3 miles	2002 Clean Water Act §303(d) List
	Chlorpyrifos		
	DDT		
	Diazinon		
	Electrical Conductivity		
	Group A Pesticides		
	Mercury		
	Selenium		
	Unknown Toxicity		
San Joaquin River: Merced River to South Delta Boundary	Boron	43 miles	2002 Clean Water Act §303(d) List
	Chlorpyrifos		
	DDT		
	Diazinon		
	Electrical Conductivity		
	Group A Pesticides		
	Mercury		
	Unknown Toxicity		
Delta Waterways: Stockton Ship Channel	Chlorpyrifos	952 acres	2002 Clean Water Act §303(d) List
	DDT		
	Diazinon		
	Group A Pesticides		
	Mercury		
	Organic Enrichment / Low Dissolved Oxygen		
	Unknown Toxicity		

Notes:
[1] Includes 3-mile reach of San Joaquin River and 8-mile reach of Fresno Slough upstream of Mendota Dam.

In the case of salt and boron, the TMDL document notes that, since the 1940s, mean annual salt concentrations in the Lower San Joaquin River at Vernalis have doubled and boron levels have increased significantly.[46] This impairment has occurred in large part as a result of an extensive expansion in the irrigated acreage in the basin combined with large-scale water resource development, including the upstream diversion and diminution of river flows, and the replacement of natural river water with poorer quality (higher salinity) imported water. The Staff Report on a TMDL for salinity and boron considers several alternative methods to meet these water quality objectives. It estimates that the cost to nonpoint source dischargers in the basin of the cheapest alternative would amount to about $27-38 million annually.[47] In addition, the cost to point source dischargers (the Cities of Turlock and Modesto) could be as high as approximately $6 million per year.

With regard to dissolved oxygen (DO), the San Joaquin River experiences regular periods of low DO concentrations in the first few miles of the Stockton Deep Water Ship Channel downstream from the City of Stockton due in part to reduced river flow. The Staff Report on a TMDL for DO considers several alternatives. The preferred alternative requires agricultural and municipal dischargers to perform various studies, estimated to cost about $15.6 million. The preferred alternative also includes a prohibition of discharge if water quality objectives are not achieved by December 31, 2011. The estimated cost to cease discharge of water from irrigated lands ranges from $95 to $113 million per year. The estimated cost to provide the amount of additional water needed to meet the minimum flow requirement in the channel (370,000 acre-feet of water per year) is estimated at $37 million per year, using a cost of $100 per acre-foot to acquire purchased water; this would eliminate the need for a prohibition of discharge of water from irrigated lands.[48] The cost of construction of an aeration device of adequate capacity to

[46] CVRWQB, 2004a, Appendix 1, page 1-5.

[47] The report notes that this represents a high cost estimate because the analysis aims to be conservative (CVRWQB, 2004a, Appendix 4, page 4-15.

[48] This is based on the observation that recent purchases of water to provide flows for fishery protection, conducted as part of the Environmental Water Account, have had a sale price of $75 to $180 per acre-foot (CVRWQB, 2004b, pages 74-75).

eliminate the impairment, in conjunction with point source load reductions already in place, is estimated to be $10 million, with yearly operation and maintenance costs of $200,000 per year.

However, these costs are only a part of the overall water quality picture. The CVRWQB has not yet issued TMDLs for the other impaired water quality parameters listed in Table 9. And, there are other impacts on communities in the San Joaquin Valley besides those associated with the Stockton Ship Channel. In Mendota, for example, the poor water quality in the San Joaquin River means that the city is compelled to obtain its water supply from groundwater which requires costly treatment. Cities with sewage treatment plants like Turlock, Modesto, Manteca, Newman and Stockton are being forced to take extraordinary measures to manage their wastewater, at great expense, largely because the San Joaquin River has so little clean water that it cannot assimilate even highly treated wastewater. These are costs that could be lowered if there were increased freshwater flow in the San Joaquin River. Moreover, without some relief through increased freshwater flow in the San Joaquin River, the costs of the poor water quality in the river to the neighboring urban communities will only increase as the urban population in the San Joaquin Valley expands over time.

It is not only those who use water from the San Joaquin River who bear the economic cost of its poor water quality. Others who divert water from its tributary rivers are also affected, because they are sometimes compelled to limit their diversions in order to ensure that the flow downstream in the San Joaquin River meets water quality objectives. These other water users are paying the price of inadequate releases from Friant Dam.

Corroboration for this assertion comes from the fact that some water users have brought suits against the Bureau of Reclamation protesting the fact that it changed the operation of New Melones Dam on the Stanislaus River, diverting water from the dam at certain times for use in fish habitat downstream on the San Joaquin River which otherwise would have been delivered to them by the Bureau under their contracts to receive CVP water. In one case, Central Delta Water

Agency et al., v. United States of America, the ruling by the US Court of Appeals for the Ninth Circuit observes that

> "plaintiffs have at the very least raised a material question of fact with respect to the issue whether they suffer a substantial risk of harm as a result of the Bureau's policies. The plaintiffs base their showing of threatened harm on modeling prepared by the Bureau itself. As part of its planning for the reservoir's current operational plan, the Bureau prepared a forecast of future violations of the Vernalis standard that would result from various alternatives. In a modeling exercise based on data about water conditions over the past 71 years, a Bureau engineer concluded that under the plan now in effect, the Vernalis standard will be violated at least one month a year in 41% of the next 71 years. Moreover, the majority of the months during which the standard would be exceeded are projected to be peak-irrigation months during the plaintiffs' growing season. According to the Bureau model, under the 1999 operations plan, about 16% of the months during the time when plaintiffs depend on New Melones water for irrigation will see salinity higher than permitted by the applicable [SWRCB] permits."

In finding evidence creating a material question of fact as to whether the Bureau's violation of the Vernalis standard would cause harm to the plaintiffs, the Court took note of their allegation that their crops had in the past been damaged by excessively saline water."[49]

I am not qualified to judge the legal issues in this case, but it illustrates two important non-legal points. First, the water supply systems of the entire Central Valley – Bay/Delta system are highly interconnected and cannot be considered in isolation.[50] Second, from an economic perspective, it supports my observation that some of the economic costs associated with the poor water quality in the San Joaquin River are likely to be borne by users of water from *other* rivers in the San Joaquin Valley, although this is not at all considered by Dr. McKusick.

In summary, for many agricultural and urban water users in the San Joaquin Valley downstream of the Friant Unit, and for taxpayers around California, the poor water quality in the

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[49] Central Delta Water Agency v. United States, 306 F.3d 938 (9th Cir. 2002)

[50] See also the expert report of Edgar A. Imhoff.

San Joaquin River downstream of Friant Dam is both an important and an expensive economic burden. I believe that increasing the releases from Friant Dam would alleviate this economic burden, although at this time I am not in a position to give a specific numerical estimate.

3C. Benefit to the General Public in California

3C. 1 Overview

In addition to the economic benefits through reduced expenditures required to meet water quality objectives on the San Joaquin River and the San Francisco Bay/Delta, and in addition to the possibility of being able to benefit from enhanced water-related recreation opportunities, it is likely that some Californians will benefit because, as citizens of California, they place a positive value on protecting the natural environment and restoring past environmental degradation in California. Economists recognize the possibility of such a value and have given it several names, of which the most common are “existence value,” “non-use value” and “passive-use” value.

The concept was first clearly enunciated by John Krutilla (1967) who observed that people may value the natural environment out of considerations *unrelated* to their own immediate and direct use of it. Krutilla identified two reasons why this might occur. With bequest value, some people would be willing to pay to protect a national park, say, from destruction or irreversible damage because they want to preserve it for future generations. With existence value, some people would be willing to pay to protect it even if they knew that neither they nor their children would ever visit it; in Krutilla’s phrase, these people may “obtain satisfaction from mere knowledge” that it exists. Both of these are legitimate sources of economic value, Krutilla argued, but they would not be captured by a conventional market economic analysis, including the demand analysis based on travel cost that was applied above to the valuation of outdoor recreation.

The method used to measure non-use value is to interview people directly and elicit their willingness to pay. This method, now known as contingent valuation, was first proposed in 1947 by Professor Ciriacy-Wantrup, my predecessor in the Department of Agricultural Economics at UC Berkeley. Ciriacy-Wantrup was discussing soil conservation, and he noted that several of the benefits such as reduced siltation of rivers or reduced impairment of scenic resources were what he called "collective goods." He characterized the problem as being one of measuring the demand curve for a collective good, and he suggested the following solution: "[Individuals] may be asked how much money they are willing to pay for successive additional quantities of a collective extra-market good. The choices offered relate to quantities consumed by all members of a social group. If the group interrogated is only a sample ... the modal schedule of the sample is obtained, and each point on this schedule is then multiplied by the number of individuals in the whole social group being investigated." What was thus obtained could be taken as the analog of a market demand schedule for the collective good.

The first significant application of this approach was by Davis (1963) which dealt with the economic value of outdoor recreation in the Maine woods; to measure this Davis interviewed a sample of hunters and recreationists and asked how much more they would be willing to pay to visit the area.[51] Davis characterized his goal as being to "approximate a market" in a survey by "describing alternative kinds of areas and facilities to make available to the public" and then simulating market behavior.[52] The next application was by Ridker (1967); to measure the damages from air pollution, Ridker included some questions in a survey about people's willingness to pay to avoid soiling from air pollution. Over the next eight years, researchers conducted about 20 contingent valuation studies on a wide variety of topics, including the valuation of improving visibility in the Four Corners region of the Southwest and the valuation of improving water quality at beaches in the Boston area. In 1975, the National Survey of

[51] Probably the first contingent valuation study was actually conducted in 1958 for the US National Park Service, which hired a market research company to survey residents of the Delaware River basin about their willingness to pay entrance fees for national parks.
[52] Davis, personal communication, June 16, 1986, quoted in Carson and Hanemann (in press)

Fishing, Hunting and Wildlife-Associated Recreation included a version of a contingent valuation question to value outdoor recreation. Further official recognition occurred in 1979, when the US Water Resources Council listed contingent valuation as a recommended method of non-market valuation in the revised edition of the “Principles and Standards for Water and Related Land Resources Planning” that sets forth guidelines for project evaluation by federal agencies.

At this time, the U.S. Army Corps of Engineers began to make extensive use of the contingent valuation method to assess the benefits of water projects. By 1986, the Corps had conducted almost twenty contingent valuation studies of varying degrees of sophistication and, as a consequence, published for Corps personnel the first government handbook on how to undertake contingent valuation studies (Moser and Dunning, 1986). Contingent valuation was also recognized as an approved method for measuring benefits and damages under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (Superfund), according to the final rule promulgated by the Department of the Interior in 1986.

During the 1980s, contingent valuation studies were being conducted in many European countries and also by the World Bank, the Inter-American Development Bank, and USAID in a variety of developing countries. In this decade, contingent valuation were being conducted around the world at an average rate of about 50 per year. During the 1990s, the rate of production grew to an average of about 300 per year. A current bibliography of contingent valuation contains citations to over 6,000 papers and studies.

In the United States, contingent valuation has played a key role in several important assessments of water pollution and water quality improvement, including the California State Water Resource Control Board’s 1994 Mono Lake Decision, and the US Department of the Interior’s 1995 re-assessment of the operation of Glen Canyon Dam on the Colorado River.

In the case of Mono Lake, a statewide contingent valuation survey was conducted in which respondents were presented with simulated photographs showing what Mono Lake would look like in the no-action condition and what it would like in three of the alternative conditions being considered in the EIR. They were told that, if the no-action alternative was to be avoided, Los Angeles' water supply would still be preserved because the Mono Lake water would be replaced using funds from a state bond dedicated to financing water supply from new sources. This bond would be repaid from an increase in state taxes to all residents in California. For each of the three alternatives, respondent were told how much they could expect the annual cost to their household to be in terms of their increased state tax over the next 20 years, and they were asked "if program A were the only measure on the California ballot today and it cost your household $X each year for the next 20 years, would you vote for it or against it?" The dollar cost, X, was actually varied across respondents, although they did not know this. For each dollar amount, the percent of respondents saying they would support the program was calculated. At lower dollar amounts a larger percentage of respondents would support a given program, while at higher amounts fewer respondents would support it; the survey results trace out a form of demand curve for the "collective good."[53] For the purposes of analysis, the dollar amount that 50% of the respondents would be willing to pay – the median willingness to pay of the surveyed population – was used as the summary statistic representing the estimate of the California public's willingness to pay for each alternative. The results showed that the non- and recreation benefits significantly exceeded the value of the loss of water supply and hydropower for Los Angeles for two of the three alternatives. The recommended alternative resulting coming from this economic analysis coincided with that ultimately chosen by the State Board (Wegge *et al.*, 1996).

[53] This type of survey format is known as the discrete-response format because respondents are asked to state "yes" or "no" to a specific tradeoff confronting them: pay X and get the item, or don't pay X and don't get the item. The alternative format in which respondents are asked directly what is the maximum amount they would be willing to pay for an item, known as the continuous-response format and used originally by Davis (1963) and other early researchers, has gone out of favor since the mid-1980s.

In the case of Glen Canyon Dam, on the recommendation of a National Research Council's Committee to Review the Glen Canyon Environmental Studies (GCES) a contingent valuation study was conducted in 1995 to examine the nonuse values placed by the public on three main alternatives for modifying the operation of the dam. The nonuse values were found to be significant when compared to both the recreational values and the foregone power revenues associated with modified dam operations. For all three alternatives, the combined recreation and nonuse benefits of modifying dam operations greatly exceed the foregone power revenues. The National Research Council Committee found that "The GCES nonuse value studies are one of the most comprehensive efforts to date to measure nonuse values and apply the results to policy decisions. The studies were subject to extensive scrutiny by the interests (agencies, advocacy groups) participating in GCES and also to intensive review by a panel of professional economists with no stake in the outcome of the studies." The Committee concluded that "the nonuse value results are an important contribution of GCES and deserve full attention as decisions are made regarding dam operations." [54]

Contingent valuation of water quality impairment also played a prominent role in law suits brought by the State of Alaska and the federal government for compensation to for natural resource damages following the *Exxon Valdez* oil spill. Following the settlement of these claims, the U.S. National Oceanic and Atmospheric Administration (NOAA) convened a Blue Ribbon Panel co-chaired by two Nobel Prize winners (Arrow *et al.*, 1993) to consider whether passive use (i.e., nonuse) values should be included in natural resource damage assessment and whether they could reliably be measured by contingent valuation (CV). The Panel held hearings in the summer of 1992 and reviewed a large volume of evidence. In its report, it concluded that passive use values should be included in natural resource damage assessment and that "CV studies can produce estimates reliable enough to be the starting point for a judicial or administrative determination of natural resource damages-including lost passive-use value."

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[54] National Research Council (1996), pages 133-136.

3C.2 The Nonmarket Valuation Study conducted for the SJVDP

Another important contingent valuation survey touching on improvements of water quality was conducted in 1989 as part of a larger survey conducted for the Inter-Agency San Joaquin Valley Drainage Program (SJVDP). The SJVDP was conducting research on the economic benefits of three types of programs that could improve environmental conditions in the San Joaquin Valley. The programs considered concerned managed wetlands, agricultural drainage evaporation ponds, and restoration of flows in the Upper San Joaquin River. To value the potential benefits of such program, scenarios were developed to represent the range of potential management for each resource, and these scenarios were presented to respondents in a contingent valuation survey conducted in May 1989.[55]

Respondents were told: "The California and federal governments are studying ways to protect and improve fish and wildlife populations and habitats in the San Joaquin Valley. This section describes different programs under consideration and provides you with an opportunity to vote on them. At present, the California and federal governments do not have sufficient funds to implement these programs. However, a special wildlife trust fund could be established with funds spent on one or more of the programs."

In the case of wetlands and drainage ponds, the respondents were told that if no new action is taken environmental conditions in the San Joaquin Valley will deteriorate: the wetlands habitat that supports wildlife in the San Joaquin Valley will decrease, and it will not be possible to maintain current populations of wildlife, and the exposure of some wildlife in the San Joaquin

[55] Jones and Stokes Associates, Inc. (1990). The main version of the survey involved contacting people by phone using random digit dialing, asking them to participate in a study, mailing them an information brochure, and then contacting them again by phone to interview them about obtain their response to items in the brochure. A second version of the survey just mailed a questionnaire in the form of a longer version of the information brochure to a random sample of individuals together with a pre-paid envelope for returning the completed questionnaire. In the case of the mail survey, the survey population was adult residents of California; in the case of the telephone survey, it also included residents of Oregon, Washington, and Nevada.

Valley, especially the southern part of the Valley, to contaminated agricultural drainage stored in evaporation ponds will also increase. For wetlands and drainage ponds there were two possible levels for each program. The first would *maintain* current conditions for wetlands habitat and wildlife, or for exposure of wildlife to contamination). The second level of program would *improve* on current conditions by improving habitat to increase wildlife populations, or by reducing wildlife exposure to contaminated waters.

In addition to these four programs (maintain current conditions for wetlands; improve on current conditions for wetlands; maintain current conditions for exposure to contaminated drainage; improve on current conditions for exposure to contaminated drainage), a fifth program dealt with the San Joaquin River and salmon improvement. Here there was a single program. Respondents were told: "Since the construction of Friant dam near Fresno in the 1940s, flows in the upper San Joaquin River from the Dam to the river's junction with the Merced River have been much reduced. This affects fish and wildlife populations and vegetation along the river banks. This program would increase flows and fish populations along this stretch of the river."

The information brochure sent to respondents then provided some more specific detail on each of the five programs in turn. The following is the text for the San Joaquin River and salmon improvement program:

> **"If no action is taken**, water flows and salmon populations in the upper San Joaquin River between Friant Dam (near Fresno) and the Merced River would remain at reduced levels. This improvement program would **increase** flows and salmon populations in the river. Water would be allowed to flow down the river channel to the Delta and then would be pumped back through canals for eventual use by farmers in the southern San Joaquin Valley. The program would increase Chinook salmon populations in the river, the number of salmon caught by sport and commercial anglers, streamside vegetation and wildlife, and river recreation opportunities.
>
> Total populations of Chinook salmon returning to spawn in the upper San Joaquin River would average 15,000 fish annually. This compares with current average annual populations of less than 100. The salmon population would consist of both hatchery produced and wild fish.

> The total number of salmon from Sacramento Valley and San Joaquin rivers that are caught annually by sport anglers would increase by an estimated 7,500 annually, or about 6% above current levels, from 124,000 to 131,500 fish. The total caught by commercial fishermen would increase by 23,000 fish annually, or about 5% above current levels, from 439,000 to 462,000 fish.
>
> Streamside vegetation and numbers of wildlife species would be enhanced in the upper river. Resident populations of herons, egrets, and other waterbirds would increase. Increases in wintering wildlife populations would also occur.
>
> Opportunities for viewing bald eagles and spawning salmon along the river would increase. Scenic values would be improved along the river. The increased flows also would provide opportunities for rafting, canoeing, and kayaking on the upper river."

For each of the five programs separately, respondents to the survey were asked: "If this program was the only program you had an opportunity to vote on and this program cost every household $X each year in additional taxes, would you vote for it?" This was followed by a second question: "What if the cost were $Y?" where Y was a lower amount than X if the initial response was "no," and a higher amount if it was "yes."[56] After proceeding through each of the five programs in this manner, the survey continued by presenting five specific program *packages* consisting of various combinations of action or no action for wetlands, drainage ponds and the San Joaquin River, with a particular price tag attached to each program.[57] The respondents were told: "The program packages would have different costs to you as a taxpayer. For the five program packages described below, please check how you would vote for each package at the cost shown if it were the only program you had an opportunity to vote on."

The responses to the survey were analyzed in a report published by Jones and Stokes (1990) and in journal articles by Hanemann, Loomis and Kanninen (1991) and Hoehn and Lomis (1993). The 1991 paper received considerable attention in the literature because it introduced what was a new variant of the discrete-response survey format using the second follow-up

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[56] The second question was asked in the telephone survey, but not in the mail version of survey. The quantities X and Y were chosen randomly in each interview from a small number of pre-selected alternative values.

[57] Different sets of five program packages were assigned at random to different respondents.

valuation question. This has become known as the double-bounded format and has since been quite widely adopted by contingent valuation researchers.

For present purposes what is relevant is the results with regard to the San Joaquin River and salmon improvement program. Hanemann, Loomis and Kanninen (1991) show the double-question (double-bounded) format yields more precise and reliable results than the single-question format. Since the mail survey used the single-question format, the Jones and Stokes report focused mainly on the results from the telephone survey. The analysis showed that California households had an estimated mean (and median) willingness to pay for the San Joaquin River and salmon improvement program of about $183 per year.[58] Subsequently, Hoehn and Loomis (1993), using the mail survey, showed that when the responses for the individual program evaluations are combined with those for the program packages, there are some significant interaction effects indicating that government action on wetlands, contaminated drainage and the San Joaquin River are seen by people as substitutes to some degree, so that the stand alone value of any one is lower when the possibility of action on the others is accounted for. Their estimate of the stand-alone value of the San Joaquin River program was about $96 per household for California households.

3C. 3 A New Valuation Study of the Restoration of the San Joaquin River

It is clear from the 1989 SJVDP study that many Californians place a positive monetary value on increasing flows and fish populations in the Upper San Joaquin River. However, the SJVDP study is now 16 years old, and it is possible that attitudes to the environment have changed somewhat since that survey was conducted.

[58] This estimate was based on combining the responses of households in the San Joaquin Valley with those of households living elsewhere in California. The mean willingness to pay of households living in the San Joaquin Valley when taken alone was slightly higher; that for households living outside the Valley when taken alone was $181.

For this reason, I decided that it would be desirable to repeat the SJVDP survey now. Given the confines of time and budget and the issue at hand, I decided to focus specifically on the San Joaquin River component of the 1989 study. Because the resulting questionnaire would be far shorter than in the 1989 survey, I decided that it was appropriate to conduct the survey entirely by telephone, using random digit dialing, and also to confine it to California households.

The questionnaire used in the survey is contained in Appendix 1. The questionnaire starts with some attitudinal questions regarding the environment which replicate those used in the 1989 SJVDP survey, in order to determine whether these attitudes have changed since then. After a few more such questions, the text continues:

> "Now, I would like to ask you a couple questions regarding a potential bond measure that may be on the ballot in an upcoming election.
>
> The San Joaquin River, one of four major rivers in the San Joaquin Valley, is the second longest river in California. Since the late 1940s most of the water that once flowed in, almost 150 miles of the San Joaquin River downstream of the Friant Dam (near Fresno), has been diverted – and 60 miles of the river now go completely dry in most years. Whereas there used to be tens of thousands of salmon in this stretch of river, these salmon runs have been completely destroyed, along with much of the river habitat for other fish, birds, and wildlife.
>
> There is currently a proposal to increase water flows in the San Joaquin River in order to restore the salmon runs, which would include sufficient water to maintain a continuous flowing river in almost all years. Additional benefits would include increased habitat for other San Joaquin Valley fish and wildlife, and increased recreational opportunities such as canoeing and rafting."

Note that this text was designed to inform respondents that the San Joaquin River is one of several major rivers in the San Joaquin Valley. In this way, I ensured that respondents would be aware of possible substitutes for the resources of the San Joaquin River; I wanted to make sure that the valuation responses were not for "river services" in general in California, but specifically for the portion of the San Joaquin River described in the survey.[59] The valuation question was

[59] Note that, in order to be conservative, I deliberately confined the description of potential improvements to benefits associated with wildlife and recreation, and omitted any reference to improvements in water quality downstream in the Lower San Joaquin River and the Delta.

then posed using a slight variation of the double-bounded format used in 1989: "The salmon and river improvement bond would cost every household in California somewhere between X and Y dollars in extra taxes per year. If the cost were [randomly select X or Y] dollars per year would you vote for the measure?" where X and Y were two different dollar amounts, with Y larger than X, chosen at random for each respondent from 4 pre-selected pairs of values.[60] Suppose that Y (the larger amount) was selected by the computer (this was a computer-assisted telephone interview). If the respondent answered "yes", there was no further valuation question since Y was the maximum amount that we had told him the program could cost; but, if the respondent said "no" he was then asked: "If the cost were X dollars per year, would you vote for the measure?" Conversely, if X was the amount selected for the first valuation question and the respondent answered "no", no further valuation question was asked because X was the minimum amount that we had told him the program could cost; but, if the respondent said "yes" he was then asked: "If the cost were Y dollars per year, would you vote for the measure?" After the valuation question there was then a follow-up question on reasons for saying "would not vote" or "no" similar to a follow-up question used in the 1989 survey, and then some demographic questions also similar to those employed in the 1989 survey.

The survey was conducted by PA Consulting, a survey company whose work I have known and held in high regard for many years, over a three week period at the end of July and the beginning of August. The instrument was pre-tested by PA who conducted 10 interviews These surveys went well, and the survey instrument appeared to work as intended. Nobody who had agreed to participate in the survey stopped mid-way, and the respondents all listened to the questions attentively and then answered them. Given the

[60] The pairs, chosen on the basis of a rough assessment of possible distributions of willingness to pay, were [45, 90], [90, 135],[135,225], and [225,335]. These values were obtained by inflating the dollar values used in the 1989 survey by 50%, which is approximately corresponds to the change in consumer prices between then and now. I consider this variant of the double-bounded format preferable to the original version, and have found that it maintains most of the benefits of the original version in terms of statistical efficiency while providing a slightly more comfortable setting for survey respondents (Cooper, Hanemann and Signorello, 2003).

satisfactory outcome of the pre-test, I decided to go ahead and have the survey implemented as planned.

The plan was to conduct 1,350 telephone interviews broken down by specific geographic areas within the state: 350 surveys in the San Joaquin Valley, 500 surveys in Northern California outside the San Joaquin Valley (Santa Barbara being the dividing line); and 500 surveys in Southern California outside the San Joaquin Valley. The intent was to sample the full range of households across the state, as well as to have a concentration of households living in proximity to the San Joaquin River. PA Consulting was able to meet these interview targets within the time period.[61] The cooperation rate varied by region; it was 48.8% in the San Joaquin Valley, 40.3% in Northern California, and 35.8% in Southern California.[62] Starting with the 1,351 completed surveys, respondents who said that "they would not vote" were set aside, leaving a total of 1,280 responses to the valuation question, consisting of 332 from the San Joaquin Valley, 465 from Northern California, and 483 from Southern California.[63] Table 10 shows the demographic characteristics of these respondents and compares them to the general California population. The distributions of income and education in the survey are similar to those of the general population.

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[61] Actually, there were 1,351 completed survey responses.

[62] The co-operation rate is defined as the ratio of the number of surveys completed divided by the number of households contacted. The difference between households contacted and households completing the survey consists of households who were contacted but who refused to participate in the survey. The refusals occurred prior to asking the first question (Q1a) either as hang-ups or as stated refusals. What survey companies do in this case is to call the number back and attempt to persuade the respondent to participant using interviewers trained for this purpose. This process, known as "refusal conversion,' takes time and the shortness of the interview period meant that it was extremely limited. Had there been an extra week for refusal conversion, the overall cooperation rate would have been much closer to 50%, which is roughly what was achieved with the 1989 SJVDP survey. Two major factors account for the difference in cooperation rates between then and now: the 1989 survey was identified as being conducted for "state and federal agencies" while no sponsor was identified for this survey; and there has been a precipitous decline over the past decade in the willingness of people to participate in telephone surveys because of abuses associated with telemarketing. Southern California in particular is a notoriously difficult location for conducting telephone surveys.

[63] The dollar valuation amounts were randomly distributed across respondents and were well balanced across each of the three regions.

The survey respondents are slightly older, on the whole and, as was the case with the 1989 survey, ethnic minorities are under-represented in the survey relative to the general population.

Table 10: 2005 Survey Demographics

	Survey	California Population
Average age of respondents 18 years of age or older	51.9	50
Average years of education of respondents 18 years of age and older	15	13.3
Median household income	$60,000 (rough estimate)	$48,900
Ethnicity		
White	79.40%	46.70%
Black	3.40%	6.70%
Hispanic	7.30%	32.40%
Asia/Pacific	2.90%	10.90%
Other	7%	3.30%

Table 11 shows the responses to the attitudinal questions, and these indicate a significant shift in attitudes since 1989. For example, in 1989, 51.0% of San Joaquin Valley residents, and 55.2% of California residents outside the Valley, said that "even if never see them, just knowing that fish and wildlife exist is extremely important." In 2005, those percentages had declined to 34.4% and 48.5%, respectively. Given the shift in attitudes, I would expect to find a somewhat lower willingness to pay for environmental restoration in California now than in 1989.

Table _11: Response to Attitudinal Questions (2005 and 1989)

1. Being able to see wildlife is…	San Joaquin Valley Sample		Other CA Sample	
Attitude	2005 Study	1989 Study	2005 Study	1989 Study
Not Important	6.3%	.9%	6%	2.8%
Slightly Imp.	11.1%	9.3%	9.5%	6.5%
Important	46.4%	50.7%	41.1%	49.7%
Very Important	36.1%	39.1%	43.3%	41%
2. Protecting habitat for fish and wildlife is…	San Joaquin Valley Sample		Other CA Sample	
Attitude	2005 Study	1989 Study	2005 Study	1989 Study
Not Important	5.2%	.9%	3.7%	.7%
Slightly Imp.	13.5%	4%	7.8%	3.7%
Important	45.6%	39.7%	39.4%	34%
Very Important	35.8%	56.4%	49%	61.5%
3. Just knowing fish and wildlife exist is…	San Joaquin Valley Sample		Other CA Sample	
Attitude	2005 Study	1989 Study	2005 Study	1989 Study
Not Important	4.2%	.9%	4.6%	1.2%
Slightly Imp.	10.9%	3%	5.7%	3%
Important	50.5%	45%	41.1%	40.6%
Very Important	34.4%	51%	48.6%	55.2%

The responses to the valuation question were analyzed in two ways both of which employ the same parametric specification for the response probability distribution, based on a logistic model for willingness to pay, that was also employed in Jones and Stokes (1990). In both cases the response probability distribution is estimated by maximum likelihood, using GAUSS.

One approach uses socioeconomic and attitudinal covariates; the resulting response equation is presented in Table 12 for the subsamples of San Joaquin Valley residents and residents of

California outside the Valley, and then for all California residents combined.[64] The signs of the coefficients on these variables are as expected. As in the 1989 survey, *existimp* has a significant positive effect on willingness to pay to increase flows in the San Joaquin River.

To generate an overall statewide estimate of willingness to pay for the environmental scenarios, the Jones and Stokes (1990) report relied on a simple bivariate regression of the survey response on the dollar amount used in the valuation question with no other covariates. Here, for the same purpose, I used the *full* sample of 1,351 survey responses and, to be conservative, I treated any response of "would not vote" as equivalent to "vote no." The estimation results are shown in Table 13 together with the corresponding estimates of median WTP to increase flows in the San Joaquin River

[64] The variables are as follows. *Bid* refers to the dollar amount in the valuation question; *existimp* is the coded response to the attitudinal question about "just knowing that fish and wildlife exist;" *fish* is 1 if the respondent has done any fishing in California in the past 12 months, and 0 otherwise; *tknow* is 0 if the respondent had *not* read, seen or heard anything about fish and wildlife issues in the San Joaquin Valley in the past 12 months; it is 1 if the person *has* read, seen, or heard something, and it incremented by 1 for each source of information where the respondent has heard this information, for a maximum value of 6; *age* and *income* are the respondent's age and income. In order to use these covariates, it was necessary to omit observations lacking these variables. 392 observations were deleted, leaving a total of 888 observations distributed as follows across the geographic areas: 245 in the San Joaquin Valley; 318 in Northern California outside the San Joaquin Valley; and 325 in Southern California outside the San Joaquin Valley.

Table 12: Multivariate Regression Results for Response to Valuation Questions on Willingness to Pay to Increase Flows in the San Joaquin River

	Whole Sample	Northern & Southern California	San Joaquin Valley
Constant	-1.958 (-4.15)***	-1.44 (-2.71)***	-3.1210 (-2.98)***
Bid	-0.0063 (-12.58)***	-.0068 (-11.29)***	-.0050 (-5.84)***
Existimp	**0.9400** **(8.80)*** **	**.8760** **(7.13)*** **	**1.0660** **(5.10)*** **
age	-0.0062 (-1.37)	-.0087 (-1.67)*	.0004 (.04)
fish	0.1558 (.91)	.1494 (.73)	.2165 (.65)
income	2.11E-06 (1.35)	1.22E-06 (.68)	4.5E-06 (1.23)
tknow	0.0844 (1.42)	.1903 (2.33)**	-.0347 (-.33)
# of observations	888	643	245

t-statistics in ( )

*= significant at 90%, **=significant at 95%, ***= significant at 99%

To deal with the survey non-response another version of the bivariate logistic model was estimated in which the observations in the sample are *re-weighted* so that they correctly match the distributions of ethnicity and age in the corresponding California population. For this purpose I continued to use the full sample of 1,351 survey responses treating any response of “would not vote" as equivalent to "vote no." The results of this estimation are shown in Table 14, together with the corresponding estimate of median WTP to increase flows in the San Joaquin River. The weighted estimation slightly raises the estimate of WTP, from a statewide median of $137 to .

Table _13: Bivariate Equation Results (Full Sample: "would not vote" equals "no")

Sample	# of obs.	Constant	Bid	Median WTP
All California	1351	.7952 (10.99)	-.0058 (-15.39)	$137
Northern & Southern California	1001	.9143 (10.66)	-.0062 (-13.64)	$147
San Joaquin Valley	350	.4734 (3.488)	-.0050 (-7.15)	$95

Table _14: Bivariate Equation Results Weighted Sample (Full Sample: "would not vote" equals "no")

Sample	# of obs.	Constant	Bid	Median WTP
All California	1351	.9253 (12.8)	-.0057 (-16.07)	$162
Northern & Southern California	1001	1.1239 (12.98)	-.0064 (-14.92)	$176
San Joaquin Valley	350	.4336 (3.29)	-.0042 (-6.70)	$103

$162. Both of these values are somewhat lower than those measured in the 1989 survey once one adjusts for inflation.[65]

To translate from these values from the survey sample to the population of California one can extrapolate from either the separate sub-state samples (San Joaquin Valley versus rest of Northern & Southern California) or the combined statewide sample. The results are similar. To be conservative, I use the lower WTP estimates from Table 13. There are 11.9 million households in California, of which about 1.0 million households live in the San Joaquin Valley, and the rest live outside. If one uses the median WTP value corresponding to the combined statewide sample, aggregate annual willingness to pay of California households to increase flows in the San Joaquin River amounts to about $1.6 billion. If one uses the separate sub-samples, the aggregate annual willingness to pay amounts to about $1.7 billion.

In the non-market valuation literature, the type of contingent valuation survey I conducted is commonly referred to as a "referendum format" study because it places respondents in the position of voters responding to spending proposition on a ballot. In California, that is not a hypothetical situation, because we frequently face spending propositions on the California Ballot. Moreover, many of these propositions have involved taxing ourselves to raise funds for environmental improvements. Thus, my survey involved something that was essentially familiar to the survey population.[66]

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[65] The California CPI had increased by 57% between 1989 and June 2005.

[66] Table 15 shows the 17 ballot initiatives that have been approved in California since 1982 that allocated state money for environmental purposes. Measured in today's dollars Californians have approved almost $16.5 billion in new environmental programs over the past 25 years. These programs have ranged from protecting Lake Tahoe to the purchase of additional open space for wildlife protection to numerous projects that protect and improve California's drinking water supply.

Table _15: Environmental Initiatives Passed in California 1982-2005

Date	Measures Passed	Description	Cost
Nov. 2, 1982	Proposition 4: Lake Tahoe Acquisitions Bond Act	This act provided funding for the purchase of property in the Lake Tahoe Basin to prevent the environmental decline of this unique natural resource, to protect the waters of Lake Tahoe from further degradation, and to preserve the scenic and recreational values of Lake Tahoe.	$85 M
June 5, 1984	Proposition 18: California Park and Recreational Facilities Act of 1984	This act provided funding for the acquisition, development, rehabilitation, and restoration of real property by state, counties, cities and districts for park, beach, recreational, or historical preservation purposes.	$370 M
	Proposition 19: Fish and Wildlife Habitat Enhancement Act of 1984	This act provided funding for appropriation to the Wildlife Conservation Board and the State Coastal Conservancy for specified acquisition, enhancement, and development of habitat areas.	$35M
Nov. 6, 1984	Proposition 25: Clean Water Bond Law	This act provided funding for water pollution control, water conservation, and water reclamation projects and activities.	$325 M
	Proposition 28: California Safe Drinking Water Bond Law of 1984	This act provided funding for improvement of domestic water systems to meet minimum drinking water standards	$75 M
June 3, 1986	Proposition 43: Community Parklands Acts of 1986	This act provided funds for acquiring, developing, improving, rehabilitating, or restoring urgently needed local and regional parks, beaches, recreational areas and facilities, and historical resources.	$100 M
	Proposition 44: Water Conservation and Water Quality Bond Law of 1986	This act provided funds for water conservation, groundwater recharge, and drainage water management.	$150 M
Nov. 4, 1986	Proposition 55: California Safe Drinking Water Bond Law of 1986	This act provided funds for the improvement of domestic water systems to meet minimum drinking water standards.	$100 M
June 7, 1988	Proposition 70: Wildlife, Coastal, and Park Land Conservation Bond Act	This act provided funds for the acquisition, development, rehabilitation, protection, or restoration of park, wildlife, coastal, and natural lands in California including lands supporting unique or endangered plants or animals.	$776 M
Nov. 8, 1988	Proposition 81: California Safe Drinking Water Bond Act of 1988	This act provided funds for the improvement of domestic water systems to meet minimum drinking water standards.	$75 M
	Proposition 82: Water Conservation Bond Law of 1988	This act provided funds for a local water projects assistance program, water conservation programs, and groundwater recharge facilities.	$60 M
	Proposition 83: Clean Water And Water Reclamation Bond Act of 1988	This act provided funding for water pollution control and water reclamation projects.	$65
Nov. 5, 1996	Proposition 204: Safe, Clean, And Reliable Water Supply Act	This act provided funds to ensure safe drinking water, increase water supplies, clean up pollution	$995 M

		in rivers, streams, lakes, bays, and coastal areas, protect life and property from flooding, and protect fish and wildlife and makes changes in the Water Conservation and Water Quality Bond Law of 1986 and the Clean Water and Water Reclamation Bond Law of 1988 to further these goals.	
Mar. 7, 2000	Proposition 12: Safe Neighborhood Parks, Clean Water, Clean Air, and Coastal Protection Bond Act of 2000	This act provided funds to protect land around lakes, rivers, and streams and the coast to improve water quality and ensure clean drinking water; to protect forests and plant trees to improve air quality; to preserve open space and farmland threatened by unplanned development; to protect wildlife habitats; and to repair and improve the safety of state and neighborhood parks.	$2,100 M
	Proposition 13: Safe Drink Water, Clean Water, Watershed Protection, and Flood Protection Bond Act	This act provided funds for a safe drinking water, water quality, flood protection, and water reliability program.	$1,970 M
Mar. 5, 2002	Proposition 40: The California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002	This act provided funds to protect rivers, lakes, and streams; to improve water quality and ensure clean drinking water; protect beaches and coastal areas threatened by pollution; improve air quality; preserve open space and farmland threatened by unplanned development; protect wildlife habitat; restore historical and cultural resources; repair and improve safety of state and neighborhood parks.	$2,600 M
Nov. 5, 2002	Proposition 50: Water Quality, Supply and Safe Drinking Water Projects. Coastal Wetlands Purchase and Protection.	This act provided funds for a variety of water projects including: specified CALFED Bay-Delta Program projects including urban and agricultural water use efficiency projects; grants and loans to reduce Colorado River water use; purchasing, protecting and restoring coastal wetlands near urban areas; competitive grants for water management and water quality improvement projects; development of river parkways; improved security for state, local and regional water systems; and grants for desalination and drinking water disinfecting projects.	$3,440 M
Total:	17 Propositions		$16.460 B ($2005)

4. CONCLUSIONS

The foregoing analysis is based on the information that is presently available to me. I have made every effort to obtain the best information possible, but my analysis is inevitably limited by any gaps in what was available. In particular, I relied heavily for my data on the farming economy of the Friant districts on the economic information embedded in the FDPM model. Where I could, I attempted to check this against other sources of information. But, a significant portion of the data in FDPM was obtained through the Friant districts' cooperation with Dr. McKusick, and I did not have the same access to them. If it turns out that there are errors in Dr. McKusick's data, this could affect my own analysis too.

Using the FDPM model developed by Dr. McKusick, I conclude that the release schedule recommended by Professor Kondolf will impose a cost on the farmers of the Friant districts that is unlikely to exceed $14.5 million annually in lost net revenue, and could be significantly lower if the Friant districts continue to show the same energy and imagination in managing their water resources as they have displayed in the past two decades.

I conclude that the release schedule will bring significant benefits to the people of California through improved water quality and through enhanced recreation opportunities along the length of the San Joaquin River and in the San Francisco Bay/Delta. I estimate that, by 2025, the economic value of the increased use and enjoyment from water-related recreation in the Upper San Joaquin River will amount to about $29.5 million per year, and in the Lower San Joaquin River to about $15.7 million per year. I do not have a specific estimate for the economic benefit to municipalities and agricultural water users from improved water quality in the Lower San Joaquin River and the Delta, but I believe this will not be inconsequential.

Furthermore, I conclude that many Californians who will not themselves benefit directly from the improved water quality and enhanced recreation opportunities will nevertheless benefit from the Kondolf release scenario because they place a significant monetary value on restoring fisheries and wildlife habitat in one of the major rivers of California. I conclude that if there were a bond measure on the California ballot to raise upwards of a billion dollars for such restoration, it would be likely to be approved.[67] Given the public interest in environmental restoration in the Upper San Joaquin River and the modest economic cost, I conclude that such a measure would be reasonable, and it would pass..

In his report, Dr. McKusick presents an estimate of the spillover effects on the regional economy from the cost imposed on Friant district farming. He estimates that the statewide loss of personal income resulting from the Spring run release amounts to $190.6 million annually, and the statewide loss of jobs amounts to 7,340 jobs (Tables 33, 34). Using the Kondolf release scenario and allowing for water exchanges among the Friant districts, while using the same six county IMPLAN model, I estimate that economic losses to agriculture and associated spillover effects will result in a $20 million reduction in personal income and a loss of 1,605 jobs

Furthermore, I estimate that the increased recreational expenditures in the region resulting from the enhanced recreation opportunities along the San Joaquin River will have direct and indirect spillover effects that increase personal income by $14.5 million annually, and increase employment by 475 jobs. In addition, I find that new construction activities associated with increased San Joaquin flows will increase personal income by $33 million and increase the employment by 820 jobs.[68]

Two qualifications need to mentioned. The first concerns timing. Dr. McKusick frames his economic analysis around the year 2025 and I have followed him in this. In any individual year, the costs and benefits will be different than those estimated for 2025. In years prior to 2025 the economic costs to agriculture will be smaller, because in our analyses these are affected by

[67] I do not intend to imply this is what restoration will cost – the Expert Report of Scott English estimates the cost of physical restoration at $50-100 million.

[68] With regard to construction-related economic impacts, these are temporary and will be spread over the years during which the restoration of the Upper River basin is conducted. The estimated economic impact is based on an assumed cost of $50 million.

the depth to groundwater. Dr. McKusick assumes that the groundwater table will fall without restraint between now and 2024; I have adopted the same assumption for simplicity, but I actually do not believe that the groundwater table will fall anywhere near as much as Dr. McKusick assumes because I do not believe that reduced surface water deliveries will be replaced one-for-one with increased groundwater pumping. With regard to recreation and water quality benefits, which are not considered by Dr. McKusick, these will be small at first as people adjust to the new recreation opportunities that have opened up. They will grow over time not only because of the rising awareness of an improved river but also because of population growth and also the growth in the relative importance of water-related outdoor recreation to Californians.

The second qualification is that all these estimates of job impacts and impacts on personal income are likely to be overstated. They rest on the assumption that the resources and workers affected by the spillover effects of a reduction in agricultural acreage will not find employment elsewhere in the economy In the case of the San Joaquin Valley, a more plausible assumption is that job growth in the non-farm sectors of the economy will absorb the indirect and induced job losses caused by decreased agricultural revenue. At worst, the only long-term jobs impact may be the decline in direct farm employment. I estimate that direct job losses in the agricultural sector in the Friant area will be 796 jobs. This is less than one percent of the total current agricultural employment in the six county region. These job losses are also very small relative to the annual fluctuations in on farm employment; in any given year in the San Joaquin Valley these fluctuations average over 8,000 jobs.[68]

W. Michael Hanemann
September 21, 2005

[68] California Statistical Abstract (2002, p. 52).

PREVIOUS TESTIMONY IN THE LAST FOUR YEARS

In July 2002, I was asked by the California Attorney General Office to serve as an expert witness in the PGE Bankruptcy proceedings, testifying on the potential adverse environmental impacts of PGE's proposed spin-off to an unregulated private entity of its hydropower generating facilities and related land holdings in the Sierra Nevada mountains. The issue became moot when PGE's other creditors announced their opposition to this aspect of the bankruptcy reorganization plan.

In March 2003, I was retained by the Hopi Tribe to serve as its expert witness on economic issues relating to its claim for water rights in *In re the General Adjudication of All Rights to Use Water in the Little Colorado River System and Source* now pending before Arizona Superior Court for Apache County. I produced an initial expert report and am engaged in further work to extend and revise it.

In the summer of 2003, I was retained by the Foreign Minister of Malaysia as a technical expert to assist him in his negotiations with Singapore regarding the revision of the long-term contracts under which Malaya sells raw water to Singapore.

On August 11 2004, I testified at an Informational Hearing on the Climate Change Crisis in Santa Monica City Hall arranged by the California State Assembly Select Committee in Air & Water Quality.

STATEMENT OF COMPENSATION

I am being compensated at a rate of $375/hour for my work in this proceeding.

INFORMATION CONSIDERED

Expert Reports of Professor Kondolf, Dr. Kirby, Dr. Deverel, Dr. Gleick, Mr. Imhoff and Mr. English.

Supplemental Reports of Dr. Kirby, Dr. Deverel

Expert Reports of Dr. Burt, Dr. Schmidt, Dr. McKusick, Mr. Moss

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