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10 January 2008

Delores Brown
Chief, Office of Environmental Compliance
California Department of Water Resources
901 P Street
Sacramento, CA 95814

Re: Draft Environmental Impact Report, Monterey Amendment, SCH#: 200301118

Dear Ms. Brown:

Please accept the attached comments in behalf of the Citizens Planning Association of Santa Barbara County (CPA), one of the original plaintiffs in the matter of **PCL et al v. DWR.** The comments have been prepared by Mr. Arve R. Sjovold, our representative to the plaintiffs' committee and a participant in the EIR process. Although Mr. Sjovold participated in many of the EIR committee meetings, he is distressed that virtually none of the comments and suggestions made in the long tenure of this committee were recognized or adopted in the preparation of the document. Accordingly, he regrets that his name is listed as one of the committee responsible for preparing this document. Nonetheless, he will honor his pledge to be of service to the committee and to DWR in this matter.

The comments are divided up into several distinct sections. The first deals with what Mr. Sjovold shows are critical flaws in the CALSIM II model, which was used as the primary analytic tool for the impact analyses. Based on Mr. Sjovold's review of the model, CPA finds this Draft EIR is seriously deficient. The CALSIM II review presents several analytic findings that are seminal with regard to this model's flaws; they should be addressed by DWR before this process continues. The CALSIM II review also points to critical failures in the application of the CALSIM II results in the analysis.

The second section addresses other areas of the impact analyses while the third section is an attachment of comments and criticisms of the DWR paper on incorporating climate change in to CALSIM II. Since DWR made this report central to their analyses of climate change impacts in the EIR, it is entirely appropriate to include such comments.

Finally, there are two appendices which support the CALSIM II analysis presented by Mr. Sjovold. They point to constructive changes that should be included in CALSIM II before it is used again.

These comments do not reach all the analyses presented in the Draft; there was not sufficient time to do so. However, because of the central importance of CALSIM II to the Draft's analyses, the flaws that have been shown by Mr. Sjovold are sufficient to render the entire Draft as inadequate.

We appreciate your serious consideration of these significant concerns.

Sincerely,

Steve Dunn, CPAPresident Arve Sjovold, CPA Board Member & Plaintiff Representative

CC: Attorney General Edmund G. Brown, Department of Justice
Secretary Mike Chrisman, California Department of Resources
Assemblymember Pedro Nava, California State Assembly

AN ANALYSIS OF CALSIM II
AS USED IN THE DRAFT EIR
By: Arve R. Sjovold

Introduction

The draft EIR uses CALSIM II as its primary methodology in analyzing the impacts of the Monterey Amendments (with Settlement additions) and therefore deserves detailed scrutiny as to its accuracy and appropriateness as a tool for environmental impact analysis. The accuracy problem is paramount given that the Appellate Court found that the original Monterey EIR had not considered the ramifications of the SWP's inability to deliver anywhere near the full entitlement values prescribed in the SWP contracts. A consequence of this finding is the acknowledgement that any entity relying on full entitlements as actual deliveries that cannot be fulfilled is dealing with "paper water". To quantify how much water the project can deliver reliably requires a model with a high degree of absolute accuracy. And the degree to which the project falls short of delivering reliably against expected full entitlements is the measure of "paper water". DWR's analyses of reliability of delivery rely totally on the use of its CALSIM II model; thus the accuracy of CALSIM II is essential.

DWR has not properly calibrated CALSIM II so its accuracy is still in question. The EIR does not reference any calibration exercise of CALSIM II and assumes that it delivers accurate estimates of delivery given the assumptions that are made in its development and use.

CALSIM II is referred to as a "simulation model" though in fact it is an optimization model, which is designed to determine the maximum amount of water that can be exported given the constraints of hydrology and SWRCB rules that govern the project's operations. There are troubling features of CALSIM II, which in all likelihood render the model as unsuitable as an estimator of project deliveries. The troubling features include:

- Its water year indices
- The lack of statistical rigor in characterizing the hydrology
- The inability to use environmental parameters as inputs to study impacts
- The lack of calibrations

Model Suitability for Environmental Impact Analyses

The fact that the model is an optimization model and not a simulation as purported, misleads the analysis of environmental impact. This is particularly true considering that **the optimization objective is maximizing export of water from the Delta and not the maximizing of environmental qualities.** Admittedly, quantifying environmental qualities for a mathematical model is an extremely difficult task. However, the model should at least allow ready testing of various proposals to improve the environmental health of the Delta. Instead, the model treats the existing set of water

rights rules and regulations as hard-coded constraints within the model code such that it is very cumbersome to change them for use in environmental studies**. Furthermore, the constraints coded in the model are only those that the SWRCB has promulgated as regulations on the project that reflect the past history of the project and its observed impacts on the Delta. It is a tenuous proposition to pretend that those constraints are adequate to protect the environment as we move forward with this project.** For example, DWR admits that the model does not include within its code any sense of Endangered Species Act requirements, which given the current state of the Delta should be its primary focus. Furthermore, the last 12 months have seen several court rulings that acknowledge the inadequacy of the current operations and regulations to protect endangered species. As a result of these rulings, Delta exports have been dramatically reduced. As currently configured, CALSIM II is not well suited to help solve these problems.

The SWRCB constraints that are most limiting on exports are the salinity constraints in the Delta and these operate to control salinity mostly in the western Delta. **In fact, it is fair to say that the model assumes that as long as it meets the salinity constraints in the Delta it has met its requirement for environmental protection in the Delta.**

For example, there are no routines in the model to deal with reverse flows in the San Joaquin River and the consequent mortality of Delta Smelt in the project pumps. Yet there is sufficient data to provide a competent predictor based on flow and pumping conditions to predict when reverse flows are likely to occur. It could be used as a constraint on Delta pumping in order to protect the fish. (See Appendix A)

Even in the case of modeling the salinity, the model uses a predictive equation that relies on one position in the western Delta, is dependent only on Delta outflow, and is independent of project pumping. Yet the historical sense on this issue is the knowledge that heavy pumping in the South Delta can affect the position and variability of the salinity gradient in the Delta. With the relationship that presently exists in the model, the prediction of the salinity appears to be unaffected by export operations.

Furthermore, it is a tenuous scientific proposition that a single point for measuring the affects of the project on salinity in the Delta is sufficient given the magnitude and complexity of the Delta. For example, the Delta Smelt is a species that lives entirely within the brackish water of the Delta and its movements to and fro in the Delta are largely dependent on the salinity variations. DWR should use its modeling talents to predict salinity gradients throughout the Delta and how they vary under different hydrologic and pumping scenarios. The EIR is largely silent on this matter and yet it would seem, given the present dire state of the Delta, that analyses of this sort would be a primary focus of the EIR.

The presently used systems of modeling the Delta by DWR rely on CALSIM II in concert with DSM2, a more detailed model that is intended to calculate the flows throughout the myriad Delta channels. It depends on CALSIM II to provide the input and export flows to and from Delta using the CALSIM II calculations for the Sacramento and San Joaquin valleys; in effect CALSIM II provides the boundary conditions for the operation of DSM2. Thus, DSM2 is limited in the scope of its calculations by the CALSIM II constrained inputs. The limitations of CALSIM II as an export optimization

model are visited upon the DSM2 calculations independent of the capability of DSM2 to investigate salinity variations more broadly.

It would be extremely useful to the analysis of the environmental impacts of the project if first model calculations could be obtained for a scenario without regulation of input flows and no exports to establish the conditions in the Delta for which the Delta Smelt are adapted. From this baseline it may be possible to determine the degree to which project operations affect Delta habitat and hence the species that rely on it.

The Problem With Water Year Indices in CALSIM II

CALSIM II uses as a primary input to its calculations a designation called "Water Year Type", which can take on one of five discreet values corresponding to whether the year in question is "wet", "above normal", "below normal", "dry", or "critical". These designations are used as input data to govern project operations in the model (and in practice), particularly in setting environmental constraints and are developed from the historical record spanning 73 years, 1922-1994, the basic hydrologic record used to drive CALSIM II.

Water year type is derived from a "Water Year Index" which is in turn developed from a runoff index. There are two sets of runoff indices, one for the Sacramento Basin runoff and one for the San Joaquin basin runoff. The basin runoff indices are calculated from the measured runoffs from the four major rivers in the Sacramento Basin and the four major rivers in the San Joaquin. These major rivers capture about 80% of the total runoff in the respective basins and are believed to be reliable surrogates for runoff. This runoff data is available on a monthly basis.

For each water year (October through September) a water year index is calculated as the weighted sum of 40% of the current forecast for the upcoming April to July runoff, plus 30% of the current October through March runoff, plus 30% of the previous year's water index. Thus the weighted formulation necessarily spans parts of two water years although it purports to represent the current water year. Depending on the value of the index for a given water year an assignment into one of the water year types is made. For project operations, the index is set by the first of the month forecast beginning in February and continues until the final determination based on the May forecast of runoff.

For use in CALSIM II a water-year type and a water year index are provided as fixed assignments for a given year in a "look-up table" for use in the calculations. **Because of the way in which these two attributes are derived they in effect provide the simulation with "perfect" information as to the upcoming runoff season (December through May) for a given water year, a circumstance that is not possible for making decisions for real time operations.** Also there is the fundamental question posed by the derivation of the water year index in that it combines the runoff from two successive water years. **There is no scientific merit to the notion that the previous year's runoff should affect the subsequent year's runoff, which is precisely what the 40-30-30 weighting does.** A simple serial correlation of the annual runoff record shows that there is no significant correlation, meaning that the current water year's runoff is independent of the previous water year. The water index is without any scientific merit and it should not be used, as is the case for the dependent parameter, water year type.

How the use of these indices biases the CALSIM II calculations and the actual project operations is difficult to deduce, but it is sufficiently clear to state that none of the calculations can be considered useful in the analyses of the EIR.

The additional fact that the indices as they are used are provided to the calculations in a fashion that gives the calculations "perfect information" ahead of the unfolding water year run-off is also sufficient to discredit any claim that this model is a simulation of system hydrology. In a simulation, one tries to replicate the decision structure that faces the system in real time. Knowing how the water year is going to end well before it is experienced allows CALSIM II to begin pumping early in the water year when at times little runoff has materialized. In effect, the early pumping borrows water from the Delta in the knowledge that it will be made up during the spring runoff. However, in real time the system operators do not know that spring runoff will be ample and therefore must restrict early pumping until events on the ground dictate that it is safe to pump.

Environmental Inputs

The object of environmental impact analyses is to evaluate the degree to which project operations and requirements affect what is broadly referred to as the environment. Because environmental attributes are difficult to quantify a good approach is to develop quantitative methods that at least allow ready evaluation of various alternatives intended to both achieve environmental protection and project operations. The present form of CALSIM II focuses only on project operations. It limits its treatment of the environment to what can be hard coded into the model as purported environmental constraints. Even in this regard no attempt has been made to have the model address important environmental questions such as that posed by the dangerous declines in Delta fish species.

A peer review panel of nationally recognized experts was convened to review the CALSIM II model as a tool to support water planning (See Appendix G of the EIR). However, that panel "did not specifically address the manner in which CALSIM II represents the environmental regulations and objectives established for the Central Valley water system", as stated in a study(1) by the National Heritage Foundation. That study builds on the peer review study to examine just how CALSIM II treats environmental constraints and objectives in the model.

The NHI study found that CALSIM II and actual operations are not faithful to the constraints and requirements that have been levied on the projects to protect the environment and the Delta. The study also attempts to examine what would be required in terms of additional changes and requirements that might be necessary to restore Delta health. The EIR does not address the current lack of compliance nor what additional measures might be necessary to begin to restore the Delta. Given the current state of the Delta this deficiency is deplorable and the EIR is again deficient.

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(1) Jeffrey T. Payne et al, "**<u>An Environmental Review of CalSim-II</u>** : Defining "Full Environmental Compliance" and "Environmentally Preferred" Formulations of the CalSim-II Model, Natural Heritage Institute, November 2005

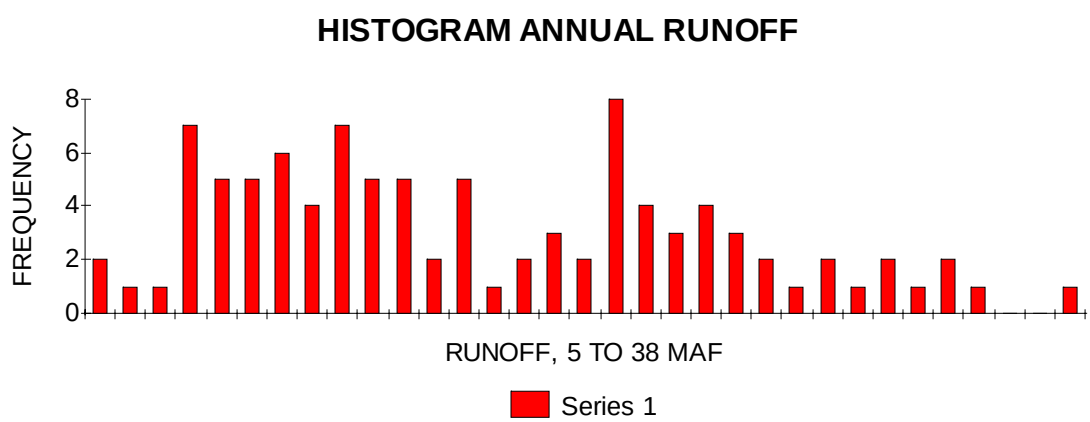
Lack of Statistical Rigor in Characterizing the Hydrology

CALSIM II uses a 73-year historical record of runoff as the primary input to the model. The variation evident in this record is assumed to be an accurate representation of the variation to be expected in the future and this assumption is relied on in characterizing the likelihood of the various output results. For the estimate of reliability of delivery, the model arranges the outputs in ascending order and ranks them in terms of the percentage of outputs exceeding a particular level of delivery. This percentage is used as an indicator of how well the project can meet its delivery requirements. Used in this way the frequency of occurrence takes on the quality of probability. But before any notion of probability can be assigned, the underlying stochastic character of the input variable, runoff, must be ascertained. In fact this information must be available to adequately design the model in the first place. This seems not to have taken place in the development of CALSIM II.

A careful examination of the statistical character of Central Valley runoff (using the 8-river runoff index--the combination of Sacramento and San Joaquin runoff) shows that runoff comprises two distinct groupings, a group that can be described as dry years and the other as wet years. Figure 1 presents a crude histogram of the 98-year runoff record for the 8-river index and it is quite clear that there are two distinct modes (central tendencies). These two tendencies

Figure 1

Runoff Distribution in the Central Valley
8-River Index
(Frequency of occurrence of annual flows-98 year record)



comprise two independent probability distributions and must be treated as such. The overall average runoff for the record (the 8-river index) is 18.04 million acre-feet, which is located in the minimum between the two central tendencies. Accordingly, the average is a relatively unlikely event, certainly not representative of what is normally referred to as “normal.” Thus to characterize individual water years as “normal”, “above normal”, or “below normal” conveys no real meaning. Another characteristic of the dry side

distribution is that the only sense of a threshold that could be described as "critical" are the lowest four years in the distribution, which are all 7 MAF or less.

There are 55 years (56% of the record) that comprise the dry year distribution and 43 years (44%) that are in the wet year distribution. These characterizations are based on total annual runoff. Since project operations cannot know at the beginning of the water year in September what the eventual runoff for the year will be, and the previous year is no indicator for what may happen in the current water year, it is of interest to examine the monthly runoff variations to establish when, in a given water year, a reliable conclusion can be drawn as to the likely amount of total runoff. This is where the look-up table of water year index and water year type bias the calculations by in effect telling CALSIM II what the water year will be before it is fully experienced. (Typically, runoff in the first few months of the water year is not very high and appreciable runoff does not occur until significant rain occurs.) **This is very important to the environmental management of the Delta because it could be extremely detrimental to the fisheries if massive pumping was initiated before a reasonable forecast could be made of the amount of water to be made available.** Since in general significant runoff seldom occurs before December, prudence would dictate reduced pumping rates in the fall until runoff is sufficient to provide exports and assure a healthy Delta habitat. Of necessity the project has to be operated this way because it cannot pump water that is not really available. **However, that level of early year pumping that can both protect the Delta environment and provide for exports has not been ascertained, either for operations or for CALSIM II calculations and the EIR fails to show as much.**

Significant runoff can occur in December and generally runoff increases going into winter and peaks in the spring when snowmelt becomes the major source of runoff. However, the record shows that December and even January and February have widespread variations in runoff. Figures 2, 3, and 4 present the histograms of runoff for those months respectively based on the 98-year runoff record. What is remarkable about these histograms is that they are highly skewed to dry months, so much so that the most likely (mode) runoff is approximately 1/3 of the average runoff for either December or January. More than half the data points in December are in the first three bars of the histogram, which means that for most of the years it is very unlikely that even modest export levels should be entertained. The same is true for January and even February. Again it must be observed that the average values of monthly runoff are not very representative of anything and can be very misleading. The likelihood of an average runoff is about 1/3 that of the most likely runoff. If pumping operational decisions were to be dictated by the average level of runoff, in most years there would be insufficient water for Delta health. This may in fact be the central reason in explaining the current declines in several of the threatened and endangered species in the Delta.

Given the above characteristics for monthly runoff, it is of great interest to establish when at the earliest the overall character of the year can be discerned. To this end some illuminating regression analyses have been performed to see how well earlier monthly runoff can predict total annual runoff (See Appendix B). A fairly good predictor is obtained by taking the sum of December and January runoff as an independent variable and regressing total runoff against that variable. Figure 5 is a scatter-plot of this data and shows distinctly that the Dec-Jan variable divides the data set into wet and dry domains. (There is a gap in the scatter-plot that demarks the two domains.) All the dry year totals

except one are delimited when the Dec-Jan sum is 3.9 MAF or less. That threshold also captures approximately 5 years that belong to the wet year group. The mean of the sum of December and January is 4.46 MAF so a sum of 3.9 or less signifies a dry winter as well. The average annual runoff (8-river index) is 18.04 MAF and the scatter-plot shows few data points surrounding this total, further confirmation that the average does not confer any sense of "normal."

CALSIM II needs to be revised to correctly account for the bi-modal statistical distribution of runoff. The analysis presented in Appendix B shows one possible direction. That direction would lead to a decision framework that would restrict pumping significantly in the fall and early winter until the amount of runoff that has materialized in combination with whatever snow-pack measurements indicate that more pumping can resume. And if that decision framework were put in place it would most likely eliminate the notion that there is any surplus water in January, February, and possibly March, to be used to implement Article 21, Carryover, or Turnback pool provisions in the Monterey Amendments.

Figure 2
Histogram of Dec Flow
Frequency vs. MAF

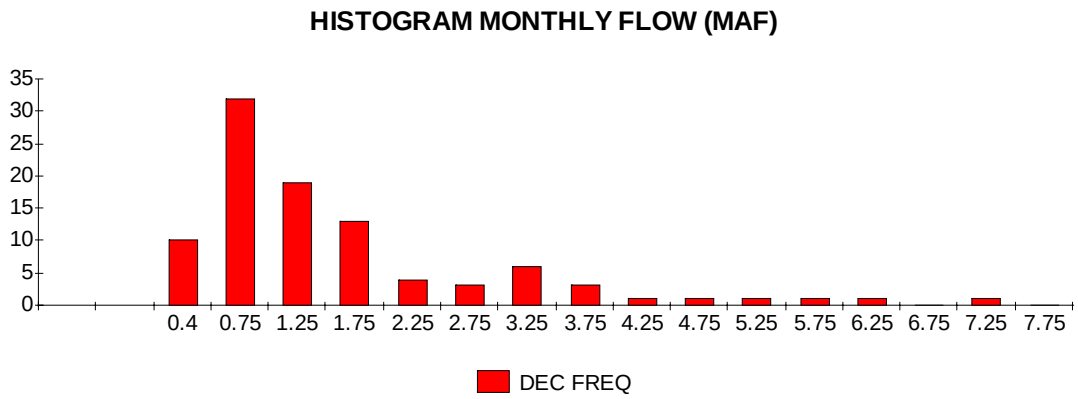


Figure 3
Histogram of Jan Flow
Frequency vs. MAF

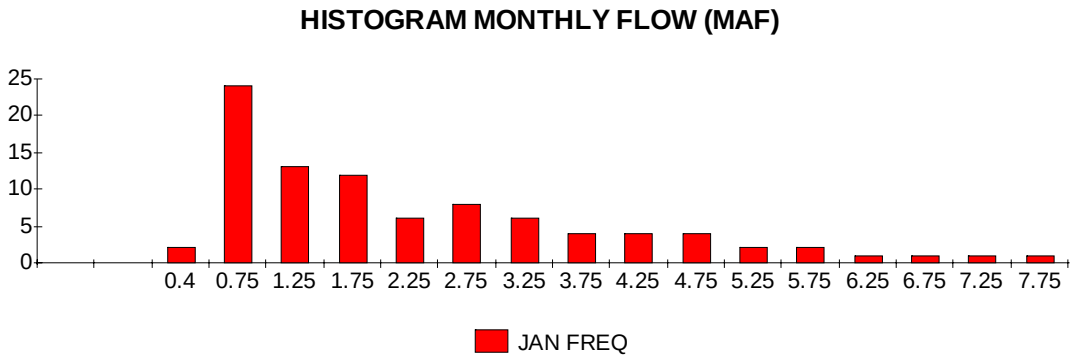


Figure 4
Histogram of Feb Flow
Frequency vs. MAF

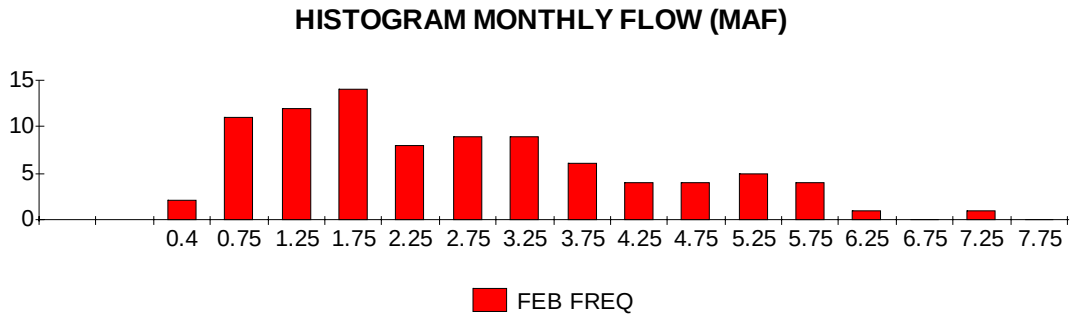
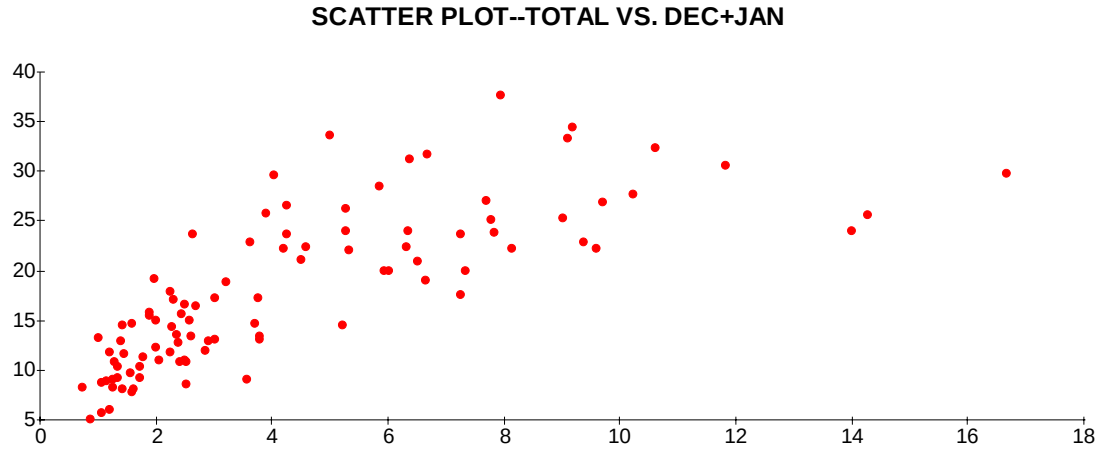


Figure 5

Total 8-River Flow vs. Dec+Jan, (MAF)



The Lack of Calibration of CALSIM II

It was stated above that it is necessary that CALSIM II be calibrated if it is to serve any useful function in environmental assessment or in assessing delivery reliability. DWR claims that its model gives reasonable answers and that it can be relied on for relative accuracy. A peer review of the model strongly recommended that the model be calibrated, especially if it is to be used where absolute accuracy is required and even if it is used for relative accuracy, as in comparisons of cases, given that it is an optimization model. **Calibrating an optimization model is essential in order to establish that whatever optima are calculated are real or possible solutions. This has not been done for CALSIM II and there can be no assurance of how well its calculated values represent reality.**

On the other hand, from the data at hand and with an understanding of how CALSIM II works it is possible to develop some estimates of its accuracy. What is required are CALSIM II estimates for a sequence of years for which there is also actual delivery data and which can be reasonably asserted are for the same conditions assumed for the CALSIM II estimates.

The EIR and the Reliability Report (Final 2005 Report) use CALSIM II estimates for a record that spans 1922-1994 and studies cases for levels of development corresponding to the years 2001, 2003, and 2021. The EIR reports in Table 6-7 the requests and subsequent actual Table A deliveries for the years 1996-2005, a period that spans the assumed level of development for year 2001 but there are no CALSIM II results for those years. The EIR also identifies the water year types associated with the actual deliveries.

Because the CALSIM II runs noted above do not include in its record the years 1996-2005 it is not possible to perform a direct comparison of estimates with deliveries. However, an examination of the CALSIM II results reported in the Reliability Report for the 73-year record shows two sequences of 10 years that are very similar to the 1996-2005 period, as judged by water year type. Those sequences are 1940-1949 and 1978-1987.

Table 1 presents the actual deliveries for the 1996-2005 period, along with the water year type and the contractor requests as reported in the EIR. Also shown are the reported actual deliveries as reported in the DWR reliability report, which show some disagreement from the EIR. Table 2 presents the water year type, assumed level of demand, and the CALSIM II deliveries for the selected 10-year sequences judged equivalent to the 1996-2005 period. The estimated deliveries are from Table B-3 of the reliability report as is the level of assumed demand, year 2001, or roughly the midpoint of the 10-year span. Water year types for these two sequences were taken from the input data file assembled for CALSIM II.

Table 1
SWP Actual Deliveries
Table A as reported (TAF)

		(From EIR)		(2005 Rel Rep)
YEAR	**YR TYPE**	**REQ**	**DEL**	**DEL**
1996	W	2676	2515	2206
1997	W	2976	2326	2308
1998	W	3335	1726	1595
1999	W	3147	2738	2521
2000	AN	3617	3201	2703
2001	D	4124	1547	1374
2002	D	3914	2573	2511
2003	AN	4126	2901	2964
2004	BN	4128	2600	2312
2005	AN	4127	2828	
	AVG	**3617**	**2495.5**	**2277.1**

It is assumed that "Requests" as reported in Table 6-7 of the EIR is a reasonable representation of the "demand" as used in the CALSIM II runs. Table 1 shows quite clearly that deliveries fall far short of requests. There is also the troubling observation that the EIR and Reliability Report do not agree; there is a little more than a 200 TAF difference in the averages. The EIR and the Reliability Report both profess to provide a detailed tabulation of actual deliveries. Since actual deliveries should be a matter of record there should be no discrepancy.

Table 2

Estimated CALSIM II Deliveries
Table A (TAF)
(From 2005 Reliability Report)

YEAR	TYPE	DEMAND	DEL	YEAR	TYPE	DEMAND	DEL
1940	AN	3713	3544	1978	AN	3126	3036
1941	W	3013	3036	1979	BN	3527	3509
1942	W	3583	3599	1980	AN	3197	3208
1943	W	3632	3545	1981	D	3834	3532
1944	D	3563	3449	1982	W	3451	3471
1945	BN	3612	3479	1983	W	3007	3036
1946	BN	3710	3724	1984	W	3692	3706
1947	D	3954	2652	1985	D	3753	3540
1948	BN	3959	2681	1986	W	3345	3023
1949	BN	3864	2568	1987	D	3905	2894
AVG		**3660**	**3227**			**3483.7**	**3295**

For both of the sequences presented in Table 2, looking at just the averages, CALSIM II estimates deliveries that are nearly equal to the assumed level of demand. For either sequence the level of demand is very nearly the same as the level of requests shown in Table 1 above. However, the level of estimated deliveries for each of these sequences is substantially higher than was shown as actual deliveries for the period 1996-2005. The estimated averages are roughly 700 TAF or 950 TAF above the actual average deliveries as reported by the EIR and the Reliability Report respectively for the period 1996-2005.

The two sequences are not perfect reproductions of the hydrologic sequence shown in Table 1 for the period 1996-2005. However, the balance of wetter than normal and drier than normal years is comparable. In fact, there are fewer drier years in the actual delivery sequence than in the two CALSIM II sequences. If there were to be any bias due to this difference it should reduce the estimated delivery level, which is already too high in comparison to the actual.

Based on these comparisons, one must conclude that either the level of demand assumed for the CALSIM II estimates is without foundation or that the model is seriously biased. In fact, until the source of this difference can be discovered and corrected the model is too inaccurate to be used for either absolute or relative accuracy in any study. It should be noted here that the list of contractor requests, which are used to drive CALSIM

II, does include some unrealistic requests. For example, a full Table A request of 25,000 acre-feet is shown for San Luis Obispo County which would be impossible to fulfill since the pipeline to San Luis Obispo County is sized to pass only 4800 acre-feet. What the model does with this excess water is a mystery.

One may conjecture that the bias is due to the difference between the operations implicit in an optimization model and the operations in actual practice. The model is given perfect information concerning the hydrology and only considers constraints that are promulgated by the SWRCB while actual operations must always be governed by the uncertainties of the hydrology ahead and environmental conditions as they materialize, of which the ESA actions are the most important. The optimization model is not really a good simulator of actual operations.

Other Comments on the Utility of CALSIM II in the EIR

<u>Use of Averages in Reporting</u>

Because the EIR relies so strongly on CALSIM II wherever it makes quantitative findings, it is questionable if such findings are of any merit given the deficiencies in the model. Even the methodology for reporting the model's calculations is misleading. First, because the model construction has ignored the underlying stochastic character of the input hydrology, the use of averages everywhere in the report give little insight as to the effects of project operations. For example, many lengthy tables are presented showing average flows throughout the system as calculated by CALSIM II. Table 7.1-2 of chapter 7 of the EIR presents tables that show average monthly flows for a number of stations over a fairly lengthy record. It is not certain what this table is intended to demonstrate since the record spans the period with CVP-only operations up to and including the period when both the SWP and the CVP are operating. What would be more interesting is to show the typical changes in these flows as the projects mature to maximum entitlements. **Furthermore, given the highly skewed character of the monthly flow distributions as shown above, it is more important to show what the flows are for the dry as well as wet domains. We have already shown that the average monthly flow is an uninteresting statistic and lends no meaning to the analysis.**

OTHER COMMENTS ON THE DRAFT MONTEREY + EIR

Use of Partial Hydrologic Records in Some Impact Analyses

In several instances the analysis relies on restricted hydrologic records in quantifying a particular point. The analysis of the effects of "borrowing" from lakes Castaic and Perris is a particular egregious example of distorting the impact by use of a restricted record. The analysis tries to show that the borrowing has little or no impact by comparing operations at these lakes before and after the Monterey amendments. Central to this analysis are the recorded data of operations from 1974 through 1994 for the before and the recorded data of operations from 1995 through 2003. The problem with this comparison is that the before record has an embedded 6-year drought and the after is an acknowledged wet period. Thus borrowing under Monterey occurred during a wet period while the basis for comparison has a mixed hydrologic record. Given the variations in lake parameters over ordinary operations those records are also too short to give confidence to the conclusions drawn.

If CALSIM II did not have so many flaws, this would have been a good example for its use to establish over the variation of a 98-year record the relative changes in lake levels due to borrowing. This would be standard practice for a study of this kind for which a large simulation had been developed. Unfortunately, CALSIM II is not a simulation and is not an appropriate tool. This leaves the analysis of the impact of borrowing resting on comparisons of a very restricted record.

In section 7.1, which characterizes the environmental setting in the major rivers and the Delta, data is presented which comprises significant variations in record lengths. Some data records span the period of SWP start-up but stop before full maturation of project contract entitlements. Only averages over these periods are reported so it is puzzling to discern just what the EIR is attempting to portray. Clearly, what would be much more informative would be to show the trends in stream flows as the project matures. Also, because the data represent several different sources, there are inconsistencies in the data. Inflows do not necessarily add up to Delta outflow (Table 7.1-2), as one would expect from the ensemble of rivers represented. The same can be said of the presentation of pre-project water quality data. If the environmental setting is to serve as a basis for comparison in impact analysis, the presentations leave much to be desired, especially when more informative presentations could have been prepared.

Use of frequency charts

Another reporting method is the use of the "frequency of return" charts that appear throughout the EIR. They purport to give the sense of probability of occurrence. However, because there are really two underlying probability distributions for the hydrology ("dry period" and "wet period" as we show above) the frequency charts are misleading and give an optimistic picture of the project's capabilities. They should not be used in the EIR

Article 21, Carryover, and Turn-back Pool Deliveries

These three categories of contractual water deliveries raise serious questions regarding pumping and Delta health. All are deliveries to be made in January, February, or March when certain conditions prevail. Article 21-water is termed surplus water but the only definition for it comes from the SWP contracts. There is certainly no test of whether it is surplus to the Delta. **DWR must develop a definition of surplus water that is properly constrained by considerations of Delta ecological health. This constraint must supersede the definition of surplus water in the master contract. The EIR must be considered deficient until such a requirement has been met.**

The Monterey Amendments eliminates all the conditions and constraints on delivery of surplus water that were in the original contract and substituted a new Article 21. One of the original provisions was the responsibility to determine that surplus water not be used in any manner that would constitute the development of a permanent-like economy due to its use. The new definition would seem to allow much more latitude to the use of surplus water for M&I uses that might not be allowed under the original contract. The EIR should analyze the impact of this provision in creating still more paper water.

Carryover and Turn-back Pool water are also contractual definitions and, together with Article 21 water, all three definitions have been modified by the Monterey Amendments. Carryover water is strictly a consequence of the difference between the definitions of contract year and water year. "Carryover" as used in the contract does not deal at all with reserving water in one water year to make it available in a subsequent water year, which is the normally intended meaning of the word. Instead, at the end of December when a new contract year starts, whatever Table A amounts that were scheduled but not delivered in the old year may be delivered in the new contract year even though it is in the same water year. The demand for this delivery occurs in the same months as for Article 21 water when, as we have shown, there is great uncertainty as to how the water year will turnout. The same is basically true for Turn-back Pool water. It too is a creation of the difference between contract and water years. Both "Carryover" and "Turn-back Pool" create opportunities for the contractors to "game" the system to get more Table A deliveries, all under the guise of strict adherence to the contracts. Because these categories are basically contractual creations of Monterey, invocation of them to cause deliveries in the first three months of the contract year should be carefully scrutinized in the EIR for impacts on Delta health. In fact, it would be extremely useful to examine project operations without these provisions. Furthermore, an alternative scenario for full EIR examination should be generated which requires the contract year to be coincident with the water year.

EWA operations

The EIR's discussions of the Environmental Water Account (EWA) do not help the reader understand how the EWA is supposed to work. On one hand it sounds like it is intended to reserve water to be made available for fish in the Delta when circumstances indicate that more flow into the Delta is necessary. On the other hand the EIR talks about

storing EWA water in the San Luis Reservoir. If it is in the San Luis Reservoir how is it made available to the fish when needed? The obvious question is could the water be kept above the Delta so that its release for fish is direct and to the point? Why must the water be delivered to San Luis Reservoir if it is anticipated that it will be needed for the EWA? Are those who are selling their water south of the Delta making a profit on it? And if it is a project obligation to adhere to the ESA why doesn't DWR act cautiously to make sure that it keeps enough water above the Delta to assure their ESA obligations? All of these questions should be addressed in the EIR.

Energy Impacts

Since the SWP is a very large net consumer of power, and given the present urgency about energy use and global warming, the analysis of the project's energy impacts is very important. Probably the most important direct energy effect of the Monterey Amendments per se is the transfer of 130 TAF of water from agriculture in the San Joaquin to urban users, most of which are outside the San Joaquin Valley. For those transfers to Southern California the transferred water must be pumped over the Tehachapi Mountains, which constitutes a net increase of pumping energy over and above that which would have been required if the water was used in the Southern San Joaquin as originally called for in the contracts. However, there are many more facets to the impacts of energy requirements associated with this project.

First and foremost, because the project has rarely delivered close to full Table A allotments, there is the question of how the energy required for pumping will be supplied when the project deliveries approach the full allotments. Since the SWP is at present a net energy consumer, any additional deliveries must be presumed to require more pumping energy, which must necessarily come from commercial power from the grid. Given the difficulties that California has in meeting peak demands in the most recent years, it is not at all certain that additional pumping energy can be had without significant impacts on the competing demands of California residents. It may be argued that this particular problem would attend the SWP without Monterey, but we should point out that all of DWR's calculations with CALSIM II predict increased deliveries, so much so that they have made those calculations the basis of their reliability analyses. The same CALSIM II calculations also are used to claim that the amended SWP now has much less "paper water". In any event, to make their calculations consistent they should assess the net increase in pumping energy demands associated with their claim that they can deliver more water than in the past.

A correct reckoning and portrayal of the energy impacts should use the actual record of deliveries as a basis for comparison instead of the CALSIM II generated numbers for year 2020. (There is particular concern in the period 2000 to 2005 when increased Delta pumping during December, January, and February occurred and a tabulation and comparison to prior years would be very informative.) The energy problem is how the additional energy to get to 2020 conditions is to be generated.

Another aspect of the Monterey Amendments that impacts energy demands is the transfer of the Kern Water Bank to the Kern Water Bank Authority (KWBA) combined with the Monterey created delivery categories of Article 21, Carryover, and Turn-back Pool. The combined effect allows the KWBA to request water from these various

accounts to put in the Kern Water Bank for the benefit of the KWBA, which incidentally comprises water entities that are not direct contract recipients of SWP. Thus a demand is placed on the SWP to pump water that would not have necessarily been pumped if KWBA had not been given the Kern Water Bank. The analysis must show how operations of the Kern Water Bank would have been expected to occur if it had remained as an SWP project facility. Also there is the question as to whether non-project participants, such as those comprising the KWBA, should benefit from project contractual provisions regarding the prices they pay for pumping energy. Given that additional energy increments above the previous baseline must come from commercial power, it seems that non-project participants should pay that marginal cost for pumping to fill the Kern water Bank. In other words all other legitimate SWP contractors must pay slightly more for their pumping energy needs because of costs imposed by operations of the KWBA.

In summary, the impact analyses must trace all the different flows that follow from the Monterey Amendments and accurately calculate the pumping energy differences and compare those differences to the previous actual baseline, and not to the year 2020 level of demand.

Land Use and Planning

In California one of the most important elements in land use planning is the availability of a reliable water supply. Because the first Monterey Agreement EIR failed to deal with the well-recognized inability of the SWP to deliver even close to full entitlements the EIR was held to be deficient. The Appellate Court made note that this lack of candid treatment in that EIR placed local planners in a difficult decision as to how much firm water they could count on in approving or rejecting development projects. Because the pre-Monterey contracts had provisions in them to allow DWR to bring entitlements into consonance with real capabilities to deliver and the Monterey Agreement made it a specific objective to eliminate those provisions, the Court stated that a new EIR must be drafted that analyses the consequences of utilizing the eliminated provisions to bring promises of delivery in accord with the project's capability to deliver. The current EIR has attempted to do this, relying on calculations with CALSIM II, but because of the total inadequacy of CALSIM II as presently configured those analyses are flawed. **This brings us to the point in the EIR impact analysis where a fundamental requirement promulgated by the Court of Appeals has not been fulfilled**. The present section of Land Use and Planning is therefore of little use. Nonetheless, there are some observations that can be made that may be useful in correcting the analysis in a future document.

The analysis of impacts on Land Use and Planning avoids the most obvious consequences of the project. Table 7.10-1 attempts to guide the reader to the most important impacts but ignores what must be considered the first order impacts. The table indicates that the only concern with the permanent transfers of water from agriculture to others is with the changes in land uses and agricultural practices of the land from which the water is transferred. However, it should be clear that any transfers to urban uses raises profound issues with changes in developed land use whenever additional water supplies

are make available. A prime example of this is the development now being pursued in the Castaic region solely because the Castaic Lake Water Agency claims to have reliable additional water supplies made available from transfers from Kern County Water Agency, all under the auspices of the Monterey Amendments. How the EIR can be silent on this matter is beyond comprehension.

Furthermore, the amounts of additional, reliable water claimed in the transfers are solely based on DWR's CALSIM II calculations as they are presented in the settlement-mandated provision requiring a reliability report. Because CALSIM II has already been shown to be a grossly inaccurate calculator of reliable water, its use in assessing how much water can be relied upon just continues the problem of "paper water", which the Appellate Court and the Settlement Agreement state must be eliminated from land use planning.

The table also misses the point on the Kern Water Bank transfer. By changing the water bank from a SWP facility to one owned and operated for the benefit of a limited set of water users, the SWP plans for delivery have been necessarily impacted and as a direct consequence the plans regarding the use of whatever water the water bank could have made available for all the SWP contractors are impacted.

Also the Reliability Report fails to account for the presence or absence of local water sources and its guidance to SWP contractors is too simple to be of any practical planning use. For example, many SWP contractors, taking their cue from the Reliability Report, assume a number around 75% reliability, which they apply to their Table A amount in reckoning their reliable supply. In truth, the way that the 75% is calculated depends on the project being able to deliver substantial amounts of Table A to Kern County Water Agency and the Metropolitan Water District because they have large reservoirs and can accept these large amounts in off-demand periods. By contrast, most other SWP contractors do not have such storage means and must take their Table A amounts during seasonal demands and the average amounts that can be relied on under those conditions is much less than 75%. Accordingly, a planner depending on water from one of these other SWP contractors would be misled. It is also an interesting observation that any development which is permitted solely on the basis of a SWP supply can really only depend on approximately 15% of whatever Table A allotment it may have because that is the lowest delivery level in the record. This has proven to be a realistic possibility in Santa Barbara County where transfers of SWP allotments among SWP subcontractors are being made to support developments outside existing water district boundaries. DWR needs to instruct its SWP contractors on how to use the information developed by them respecting each individual contractor's ability to receive SWP water in concert with whatever other water sources it has available.

In summary, the analysis in the EIR of impacts on Land Use and Planning is too superficial and limited to be of any use in prospective project decisions.

APPENDIX A

An Analysis of Reverse Flows at the South Delta Pumps

Recently, additional information on several factors was obtained that could explain the observed Pelagic Organism Decline (POD) in the Delta. It had been posited earlier that unusually high pumping by the SWP in the months of December, January, February, and March could be the cause. The additional information now focuses on the fact that high reverse flows in the Old San Joaquin River brought on by SWP/CVP pumping may explain the loss of the Delta Smelt. The investigations that brought this information to light also were concerned with the same four months (D,J,F,M). This information has been analyzed to relate the Old River flows to export pumping, river flows at Vernalis on the San Joaquin, and the Sacramento at Freeport. To date one quantitative relationship has been developed that explains the reverse flows quite well. The method used was multiple regression analysis and the best relationship so far is given below:

OLDSJ = 243-0.942*EXP+.533*SJVER

Where SJVER = San Joaquin flow at Vernalis, cfs
EXP = export pumping, cfs

Since export pumping is generally much greater than flows at Vernalis, this relationship yields negative flows for Old River in most instances.

The data set covered the years 1981 to 2006. Two data points appear as clear outliers, 1983 and 1997, which were very high run-off years. The standard error for this equation is 430 cfs while the corresponding percentage error of the fit is 18.5%. All coefficients are very significant ("t" values are respectively, 15.11 and 20.23).

What seems clear is that export pumping is a very strong variable; reverse (i.e. negative) Old River flows could be reduced by directly reducing exports. It seems also clear from perusing the input data that San Joaquin flows at Vernalis are not substantial enough to overcome the export reverse draw. This is probably due to the fact that in most years almost all of the San Joaquin is diverted for irrigation.

Another factor not yet analyzed is the magnitude of the exports compared to the volumes of water in the sloughs and Clifton Court forebay. When exports typically average 10,000 cfs for days at a time, the transit time through the sloughs may be quite short. (For example, 10,000 cfs equates to 20,000 acre-feet per day, which could be on the order of the volumetric capacity of Clifton Court forebay.) It seems that the biologists should look at what happens at all the levels of the aquatic food chain when that happens. Perhaps the reduction in smelt numbers and the observation of smaller smelt later in the spring are related to the reduction in biologically available food.

It might also be profitable to take a restricted look at the months of just December and January. Using all four months tends to obscure the fact that quite often river flows in the first two months of the four month period can be quite low, so much so that

exports would be even more devastating. The biologists should be asked to investigate the relationship of POD to just the pumping and flows in the first two months.

The sheer magnitude of the export flows is also interesting. There was a levy failure in one of the Jones tracts during a period when most observers would not have expected any stress on the levies. However, the maps show that the tracts in question are along the channels that lead directly to the pumps. Is it possible that the magnitude of the flows to the pumps was an important factor in the levy failure?

COMMENTS ON DWR'S TECHNICAL MEMORANDUM

"Progress on Incorporating Climate Change into Management of California's Water Resources", July 2006

By Arve R. Sjovold
September 2, 2006

In DWR'S year 2002 report on the "The State Water Project Delivery Reliability Report" it was explicitly acknowledged that climate change would affect the timing and amounts of snowfall and possibly precipitation and that sea level rise was likely. At that time the timing of these impacts was speculative. That report promised that more definitive studies of the impact on climate change would be provided, possibly as soon as the update of the California Water Plan Update 2003. Thus, it was with some anticipation that I looked forward to a comprehensive study of the affects of climate change on the SWP. The subject report fails to provide that comprehensive study. Although DWR did engage in some rather elaborate computerized calculations, the subject of those calculations studiously avoided the impacts, now more widely recognized, but clearly acknowledged in the 2002 Reliability Report. Any keenly interested observer of the debate on climate change would have expected a cogent and objective analysis of the effects of sea level rise and changed Sierra run-off patterns as first order effects.

The report devotes considerable of its quantitative analyses to the calculations of the effects of a very modest sea level rise of 15 inches on the ability of the Delta to deliver water to the pumps without severe violations of salinity thresholds. It does so based on assumptions that upstream reservoir operations are not changed and that sea level rise does not change the hydraulic network in the Delta. Another assumption for this analysis is that the salinity gradient in the western Delta does not change with this sea level rise. No supporting evidence or analysis is given as to why these assumptions are reasonable. In other words, a primary assumption is that the current system of Delta levies remains in tact with a 15 inch sea level rise. I won't argue that that level of sea level rise may indeed leave the levies operationally in tact, but it misses the first order question of what level of sea level rise will compromise the system of levies. There are good maps (produced by DWR, if I am not mistaken) of what the Delta may look like with 1, 2, 4, and 10-foot sea level rises. From these maps it is clear that somewhere between 2 and 4 feet of rise there is little assurance that the Delta can perform as a delivery network of fresh water to the South Delta pumps. Since the subject report acknowledges that 2.9 feet of sea level rise is likely under one of the scenarios studied by the International Panel on Climate Change (IPCC) by the end of the century, clearly the most important question to be addressed by DWR is to calculate at what level the Delta's levies cannot be relied upon. **The subject report does not do this and does not offer a qualitative discussion.**

The other major assumption underlying their quantitative calculations is that reservoir operations (that is, Oroville and Shasta) are not changed by climate change impacts. That this is an untenable assumption is apparent from the report's side study that shows, under 3 different scenarios, that peak discharge from the Feather River may be

substantially altered. In fact, the most severe scenario carefully quantifies that peak discharge for a "15 year event" may be 2 ½ times the current estimate of a 15-year peak discharge. Clearly, any inquiring mind would wonder how reservoir operations might be affected by such a finding. Curiously, the report does not inquire further. But that may be the most intriguing finding of the report. If as a matter of hydrology peak discharges at any return level are 2 ½ times higher, such a finding would call into question the ability of the dams to function as designed. First, 2 1/2 times peak discharge would probably tax the design limits of dam spillways. Second, flood pools in reservoirs would have to be enlarged compromising water conservation objectives. Third, passage of discharges 2 1/2 times as large would undoubtedly cause havoc below the dams. None of this is addressed in the report even though that is where it should logically lead.

In conclusion, the report shows no scientific curiosity concerning the very likely first order impacts of climate change. The detailed quantitative analyses that are performed are totally irrelevant to what are the major questions that are posed by climate change. The report should candidly state that the most reasonable forecasts of what climate change might produce would seriously compromise the project, to the extent that the SWP may be obsolete in its current configuration within the current century. This is certainly a different tone than that conveyed by this report.

Specific Criticisms

1) The report still relies on CALSIM II as a reliable model to study the impacts of climate change. First, as we have so many times stated in the past CALSIM II is a fatally flawed model. It has not been calibrated and is not a true simulation model, as it is commonly referred to. Second, the indices that are use to drive the model in certain of its calculations are without scientific or practical merit. They provide the so-called simulation with perfect information of stream flows in advance of simulated operational decisions and the indices are highly distorted representations of the true stochastic nature of the operational problem, simulating operations in the face of uncertain future stream flows. It is particularly noteworthy that the CALSIM II run labeled "Base" in the report does not resemble the CALSIM II 2021-runs performed for the Reliability Report for ostensibly the very same assumptions. In fact, the variance between these two case studies, the "2021" study in the reliability report and the "Base" in the climate change study, is roughly the same as the differences reported between the "Base" case in the climate change study and the alternative scenarios. (See Table 1 below.) In stark terms, we are using a measuring instrument that is too imprecise to reliably distinguish differences among the scenarios. Scientifically, the model is inappropriate just on that finding and DWR staff should be required to establish why there are such differences between these two reports.

2) Throughout a significant portion of the report detailing previous hydrologic history of the Central Valley, there are many regression analyses results that are portrayed to establish certain trends that may have some significance. The report does not state why they may be relevant. I find it difficult to see any

such relevance except if it is to acknowledge that some climate change may have already occurred. Even then, I fail to see the relevance absent any analysis that shows why it should be. Beyond that observation of relevance, there is the more important issue of deciding when a calculated trend is significant. It appears from the data presented in the report that many of the trends are statistically insignificant at normally accepted thresholds. Why such trends are reported as maybe "real" is puzzling.

3) The preoccupation with the affects of climate change on stream flow temperatures is probably misplaced. Given that current project operations are decimating species in the Delta, the concern seems an attempt to show that the species are doomed anyway and we shouldn't worry about what the projects are doing now. That is a very shortsighted view and seems to be extremely self-serving with respect to current operations. My view would show more emphasis on characterizing future overall stream flow amounts and timing rather than on speculations on stream-flow temperatures as if the basic stream flows are relatively unperturbed.

4) The report does provide a fairly decent summary of the extant scientific theories supporting global warming and the effects on climate. The report depends most strongly on the work reported by the IPCC and the scenarios they cast. However, other more recent work out of the Goddard Space Science Institute (GSSI) strongly suggests that ice sheet breakup of the Greenland and/or Antarctic ice sheets may accelerate sea level rise significantly, an event that is not a major factor in the IPCC scenarios. If the GSSI theory is more correct the integrity of the Delta in the nearer future may be in doubt. Neither the IPCC nor the GSSI can offer precise timelines as to when significant sea level rise may occur. Nonetheless, it is vitally important that DWR include a candid appraisal of the likelihood of sea level impacts on the Delta beyond the mere 15-inch rise assumed in their studies. Calculations can easily show that the generally accepted existing level of climate forcing, .85 watts/m^2, is sufficient to melt sufficient ice to raise sea level by 0.4 feet per year. What is not certain is how future climate forcing will divide between melting ice and warming the biosphere. It is very clear right now that the rate of sea level rise cannot be estimated precisely but the potential for rapid sea level rise is the most important feature of global warming. The report should candidly state so.

5) The report summarizes the past history that has been developed for global warming over the past 650,000 years which shows that within our recorded history the Earth is near a peak warm temperature for this interval. (See; James Hansen, "A Slippery Slope", Climatic Change, 68, 269-279, 2005). If the report had included the corresponding data on the coincidence of greenhouse gas concentrations and sea levels with temperature it would be quite clear that greenhouse gases are the most significant driver of temperature change and consequent sea level rise. The DWR report does

include a table of the existing concentrations of CO_2 and methane, corroborated in the attachment, which are higher than ever measured by the ice cores within the past 650,000 years. This remarkable finding should require the widest possible range of possible changes rather than the restricted ranges chosen by the report. In short, the authors of the report did not delve deeply enough into the current research being performed on climate change and the report cannot claim to have met its objective of "incorporating climate change into the SWP."

6) The analysis to incorporate climate change into CALSIM II involves an intricate attempt to translate IPCC climate change scenarios into specific quantitative changes in major Northern California river run-off as the basis of the computer calculations that form the major effort of the report. It is noted in the analysis that the climate change scenarios are based on global models that incorporate only six grid points to characterize expected rainfall for all of California. The analysis then proceeds to use the information developed for these six grid points to generate estimated changes for 10 of the major rivers. Another model, the Variable Infiltration Capacity (VIC) model, is used to calculate these estimated changes of rainfall into run-off. An important assumption in this exercise is the use of the VIC model to develop perturbation ratios due to climate change that can then be used to modify the characteristic run-off measurements for these rivers. The clear flaw in this methodology is the measured run-off used to characterize the rivers. The analysts chose the year 1976, a readily acknowledged drought year to characterize the average or "normal" run-off. Since 1976 was well below average for any river system in California, this choice necessarily biases the estimated changes low. 1976 run-off was probably less than half the average. Therefore, on translating changed rainfall into estimated run-off for the major rivers feeding the CVP and SWP, the use of 1976 as a basis to scale from as described in the report necessarily underestimates the run-offs under climate change by a significant amount. Accordingly, the entire exercise with the Delta model, DSM, is not even a reasonable estimate. Since this computer exercise seems to comprise the most substantive portion of the report, it calls into question any and all of its findings. DWR should be required to justify the choice of 1976 (although on its face it seems that this can't be done). A standard analysis of this type would have done so as a matter of course.

Table 1
Comparison of "Base" and 2021 CALSIM II Runs

(Million acre-feet per year)

Water Year	Climate Change Report SWP Exports	2002 Reliability Report SWP Exports Fixed Demand	Deviation
76	2.97	2.78	.19
77	1.00	0.83	.17
78	3.61	3.91	.30
79	3.70	3.49	.21
80	4.10	3.46	.64
81	3.33	3.40	.07
82	4.71	4.13	.58
83	3.68	4.13	.45
84	3.42	4.10	.68
85	3.52	3.32	.20
86	4.20	3.01	1.19
87	2.57	2.84	.27
88	1.54	0.99	.55
89	2.72	2.90	.18
90	1.60	1.15	.45
91	1.10	1.00	.10
Average Deviation			**0.39**

APPENDIX B

Development of a Preliminary Algorithm To Guide Pumping from the Delta In the Months of December and January

A look at monthly flows for the runoff record reveals that significant runoff begins in December and increases on through May. The highest runoff measurements generally occur in the spring. However, from time-to-time there are some early winter runoffs that are quite high. When looking at just the dry year portion of the record it is quite clear that the drier years are almost always characterized by runoff in both December and January that are much below average. Thus if the water year is going to produce reasonable runoff it must come from above average spring runoff. But the operators of the projects cannot safely assume that spring will be above average and must then adopt prudent operations when beginning export in the fall and winter. Therefore, an operational procedure must be developed that begins with the assumption that the water year will be dry until conditions show that it is likely to be wet. (We dismiss the notion that the previous water year has any useful information contained in its runoff record as is intimated by the "40-30-30" index.) The question is then, how can we establish with some certainty how much runoff is likely for the year?

To answer this question, we analyzed the relationship between total runoff recorded by the end of the water year to the measurements of monthly runoff as they occur. A perusal of the record shows that trying to rely on December runoff alone does not provide a reliable indicator. Next we examined the potential of the combined runoff of December and January to indicate the character of the impending water year.

We started by defining simple indicator variables. Since we desire to provide indicators that are most useful in the early part of the water year we concentrated on the months of December and January to see how much they could tell us. The indicators that seem to work reasonable well are as follows:

DRYWINTER, which takes on the value of either one or zero. If it is one, then it signifies a combined December-January runoff that is quite dry for that period. We first tried a combined runoff of less than 2.5 million acre-feet (MAF), which is just over half the average for this period. Later we tried a value of less than 2.25 MAF which is just about half.

WETWIN, which takes on the value of either one or zero. If it is one then it signifies a combined December-January runoff of greater than 4.24 MAF, which is the average for this period.

WETSPR, which takes on the value of either one or zero. If it is one then it signifies a combined April-May runoff of greater than 7.4 MAF, which is the average for these two months. Later we tried a threshold value of 6.5 MAF, or slightly less than the average. We felt that more precision in the spring runoff is not necessary since one must wait until spring to measure the runoff. So the role of this indicator variable is to establish explanatory power for the desired relationship for predicted total runoff. Besides operations

can be modified once we have passed beyond the months of December and January and the water year record unfolds.

The best relationship that we could find is given below:

TOTAL= 12.81- 2.99 (DRWWINTER) + 7.22(WETWIN) + 5.17(WETSPR)
Where:
TOTAL = total water year runoff in MAF
DRYWINTER = 1,0 where 1 is sum of Dec-Jan when less than 2.25 MAF
WETWIN = 1,0 where 1 is sum of Dec-Jan when more than 4.24 MAF
WETSPR = 1,0 where 1 is sum of April-May runoff when greater than 6.5 MAF

These variables were then tried in a linear multiple regression relationship to examine their explanatory power. All of the indicator variables were highly significant and the standard deviation of the fit was 3.27 MAF. Nine of the 98 data points in the sample were deleted from the regression calculation as probably too extreme on a probability basis. 7 of those 9 were for extremely high runoff years. Since the problem of export pumping is much less dependent on very high runoff years these deletions are not of prime importance and their inclusion only tends to skew the results. It is also noteworthy that the deletion of these data points appears not to affect the coefficients materially but does improve the precision of the relationship.

Conclusions

With three independent, stratifying variables that take on either of two possible values there are 6 independent outcomes. They are:

DRYWINTER and a dry spring (1,0,0), which produces an estimate of TOTAL of 9.82 MAF.

A winter (December-January runoff) that is greater than 2.25 but less than 4.24 MAF and a dry spring (0,0,0), which produces an estimated total runoff of 12.8 MAF.

DRYWINTER and a WETSPR (1,0,1), which produces an estimated total runoff of 15.0 MAF

A winter that is greater than 2.25 but less than 4.24 MAF and a WETSPR (0,0,1), which produces an estimated total runoff of 18.0 MAF.

WETWIN and a dry spring (0,1,0), which produces an estimated total runoff of 20.5 MAF.

WETWIN and WETSPR (0,1,1), which produces an estimated total runoff of 25.7 MAF.

Of the 98 years of the runoff record, nearly half the points (47) are included in the three categories that have estimated runoff less than the average for the total record.

Twenty four (24) of the 47 points are associated with the estimate of 9.82 MAF. 15 are associated with the estimate of 12.8 MAF and 8 are associated with the estimate of 15.0 MAF. All three of these categories are determined by the combined monthly runoff of December and January and make no assumption that the spring will be wet. Accordingly, one may conclude that all December and January operations should assume that the water year is part of the dry period until spring runoff dictates otherwise. It is particularly important to note that for fully one quarter of the record (24 years), only 9.82 MAF can be relied upon. This should be the starting point for developing operations criteria for export pumping that take due care to preserve the Delta environment.

At present it appears that December and January pumping are little modified by the hydrologic indications to that time. Since project demands are low at this time of the year, these months are used to fill south of the Delta reservoirs. Only the constraints on Delta outflow and salinity may limit the pumping; and the restrictions here are highly skewed because of the influence of the erroneous "water year index" discussed in the body of the text. Questions that should be asked include: Should there be much of any export pumping if December and January runoff is below 2.25 MAF? Can the health of the Delta fisheries and its broader ecology be assured under such low flow conditions? Of those 24 years that comprise this condition three are for years that are extremely dry, averaging just under 6 MAF. What would be prudent operations under those conditions? The same questions must be answered for the other two dry year categories. The biologists should be asked to weigh in on what would be desirable under these drier conditions to assure Delta health.

It is possible that integration of snow-pack measurements might improve the ability to forecast more accurately or at least earlier with the same accuracy. However, reliable snow-pack measurements are usually not available until the end of March. Accordingly, early runoff is the most readily available and reliable indicator that can be useful.

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