PRINCIPIA

December 27, 2004

Mr. Kenneth Parr
U.S. Department of the Interior
Bureau of Reclamation
705 North Plaza Street, Room 320
Carson City, NV 89701-4015

Dear Mr. Parr:

Principia Mathematica, Inc. (Principia) has reviewed and evaluated the Truckee River Operating Agreement (TROA) model used in preparing the draft TROA Environmental Impact Statement/Environmental Impact Report (EIS/EIR). On behalf of the Truckee-Carson Irrigation District, Churchill County and the City of Fallon, Principia hereby submits its comments on the Draft EIS/EIR, specifically concentrating on the TROA model upon which this Draft rests.

1. Introduction:

A review of the mathematical model upon which the Draft TROA EIS/EIR centrally rests was conducted recently by Principia. This review revealed three major facts that call into serious question the fundamental underpinning of this Draft EIS/EIR. These three facts are presented as follows.

(1) The model upon which this Draft EIS/EIR rests so heavily is unreliable in critical respects. In any unbiased scientific review by qualified peers, this model would be rejected for the very uses that are reported in the Draft EIS/EIR.

(2) The model's unreliability is caused by significant, serious and, in some instances, fatal flaws. Such flaws prevent the model from being applied properly to evaluate "what-if" scenarios intended to establish suitable alternatives to or adjustments of planned water allocations.

(3) Employing a fatally flawed model to plan water allocations and to make decisions that would continue well into the future, when other well-tested and reliable stream flow models are readily available for use, introduces scientific unreliability into the TROA process. It leads inevitably to unsupportable management decisions that may be adopted as a regulation and thereby create unintended and seriously flawed consequences.

These facts lead Principia to urge that the model, in its present form, be rejected for use

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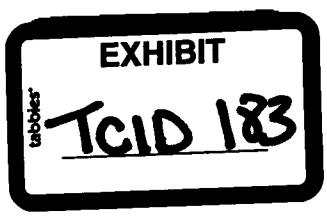


as the foundation for the Draft EIS/EIR. Furthermore, Principia urges that this model be opened to wider and unhindered scrutiny by practitioners who were not involved in this model's development. Only in this way can the affected public be persuaded that the assumptions and procedural rules that are embedded in it are indeed valid and actually implemented as claimed, let alone be demonstrated as unbiased and in the public interest. The flaws identified by Principia even via its preliminary review are summarized below. This summary provides some indication that such assumptions and rules as embedded in the TROA are seriously flawed.

2. **Crippling Flaws in the Model:**

The specific flaws in the model revealed even by Principia's preliminary review conducted in just a few weeks are identified below. This identification should be viewed as illustrative examples of numerous such flaws that exist and not a comprehensive list of such flaws. Requests for additional time needed for a more comprehensive review were denied, we understand.

(1) The computer program embodying the TROA model consists of more than 72,000 lines of convoluted FORTRAN language contained in 173 subroutines. The sparse comments contained among these lines do not illuminate, amongst other facts, the innumerable quantities that are assigned unexplained values. Such values furthermore are inexplicably altered as the program instruction courses through the many subroutines of the program. This is very poor and antiquated programming practice that could not be further away from current accepted scientific methodology. What makes this practice untenable in this instance is that not even a rudimentary documentation seems available for the program. It is therefore virtually impossible for any independent and unbiased reviewer to follow the steps the program does take, evaluate values embedded as facts into it, and test the logic to evaluate whether the program computations are indeed being performed as intended, and as reported.

(2) This flaw is compounded further by the fact that the computer program embodying the TROA model has not been provided with adequate output generating features. Such features would at least allow an independent reviewer to evaluate details of water volumes and flow quantities that the program purports to allocate. For instance, the program claims to track water flow quantities throughout the TROA system, but can produce computed output only for a few selected flows at selected locations. These selections of course were made by the program author and do not reflect the quantities and locations that remain of deep interest to the affected public. In order to evaluate just what the program computes in these matters of interest, an independent reviewer is forced to modify the program code in order to obtain output that is clearly contained in the program but is otherwise unattainable. This tedious and cumbersome task is made unnecessarily difficult by the absence of program documentation.

(3) The accounting of relevant flow quantities is seriously inadequate in the program. In this program, flow quantities associated with different sources are lumped together, but thereafter the program is not equipped to track each flow quantity according to its source. It is not possible to evaluate whether, or not, this poor programming practice was intentionally adopted. However, it denies any independent reviewer the basic tools

needed to understand just why certain results are predicted by this program. This is a serious programming deficiency which makes it impossible to establish just which specific planned action leads to what computed outcome; just the types of basic information essential to manage the TROA system. It is for this very reason that other well-tested and reliable programs such as Riverware® are intentionally equipped to keep rigorous track of flow quantities by their "accounts".

(4) The computer program embodying the TROA model employs antiquated FORTRAN-language programming practices and modeling techniques. The ready availability of modern computer models for river systems makes the continued use of the TROA model suspect. The serious consequences stemming from using an outdated model can neither be easily detected nor readily rectified. Consider an example specific to TROA: each planned action taken on the water system is coded within a program subroutine that is found to have complex, undocumented, and sometimes unexpected interactions with different parts of the program that represent other segments of the flow system. It is thus made impossible for any independent reviewer to evaluate whether, or not these interactions were intentional, and if so why, or merely accidental stemming from the manner in which the program has evolved during the past two decades. In direct contrast, modern modeling programs such as Riverware® are designed to isolate actions specific to certain "objects," enabling a user to keep track of intended actions. Further, such programs employ component flow models with relevant physical realism and accounting procedures that keep rigorous track of flow quantities propagating through the system. In reliable programs, complex management decisions may indeed be specified by prescribing "rules"; however, the programming of these rules leaves no room for unintended and thus hidden side effects. Furthermore, the use of generic "objects" in reliable programs simplifies the tasks of program validation and documentation, and makes them transparent.

(5) Potentially serious differences have been detected between the draft and final versions of the TROA model. The model used in justifying the Draft EIS/EIR is dated June 2003. A review of the model dated as November 3, 2004 indicates that more than 4000 lines of code have been altered involving more than half of the program files, without any documentation being created to establish just why this was done and with what consequences. The unscientific and potentially prejudicial nature of such program alterations suggest that it is futile to expend significant resources in conducting further review of the model used to justify the Draft EIS/EIR since this model has already been substantially changed apparently in preparation for the Final EIS/EIR. It is inconceivable that so many changes to the program would have been done without causing any effect on the predictions made by the model. It would therefore be entirely improper and unprofessional to simply ignore these efforts in commenting on the draft, knowing significant changes are forthcoming in the Final EIS/EIR.

3. Flaws in Demonstrating the Model's Validity:

(1) The TROA model has not been calibrated to known conditions in the flow system. When a mathematical model is considered valid for application to any physical setting, it is essential to demonstrate that the parameters representing physical properties in it are appropriate to this very setting. For surface water models, such parameters include rates of evaporation, seepage from stream segments and other losses, transit times and return

flow delays, among others. The validity and appropriateness of model calibration is typically demonstrated by comparison of quantities predicted by the model against observations as its parameter values are adjusted. In the present instance, it is claimed that some values prescribed as input data to the model, such as the Farad to Derby Dam net change, are based upon some previous (and undocumented) modeling effort. It is further claimed that individual terms such as evaporative losses from reservoirs are based upon observations, that are also unidentified. However, no attempt has apparently been made to check that when all of these estimated quantities are combined in this model, model predictions indeed match physical observations of any recorded stream flow values or similar recorded quantities.

(2) It is a significant flaw that the TROA model is entirely based upon the central premise that available water resources and stream flows will, in future, remain at precisely their historically recorded values. No attempt seems to have been made to estimate, through appropriate stochastic simulations, the future variations in such quantities which will have significant quantitative consequences upon water planning and allocations. No such variations, which accepted scientific methodology would indicate as real possibilities, were apparently tested for purposes of such planning and allocations which this TROA model was apparently designed to quantify. This flaw is exacerbated by the reliance on long term averages to evaluate the effect of various alternatives, instead of a more detailed evaluation of impacts at a time scale that are relevant to water users.

(3) The calculation sequences embedded into the TROA model have not been demonstrated to be valid. When a model program is constructed in support of just one project, it is necessary to demonstrate that the model program operates correctly as intended. This is achieved by running the model with a set of input data for which the output results are known, such as from an analytical solution to even a theoretical stream flow problem. This step is usually referred to as model or program validation. In the present instance, while it is claimed, orally of course and not documented, that a mass balance was performed on some reservoirs to "ensure that input minus output equals change in storage," even such a basic calculation has not been undertaken for the TROA system as a whole. This flaw thus makes it possible for water to be either lost or created in the system simply due to artifacts of mis-programmed complex calculations, because no checks were performed to ensure that the model maintains a valid overall mass balance.

(4) The TROA model has not been verified following its calibration. In generally accepted modeling practice, it is customary to retain some data not used in making calibration adjustments to evaluate just how well the model predictions compare with such data. This step is frequently achieved by calibrating a model using data collected during some selected time period, and then verifying it with data available to represent a different time period. This is a step that tests the robustness of physical representations embedded in the model in their ability to predict values that have been observed for this period, and which have not been consumed during model calibrations. The serious flaw in the TROA model is that no such verification was even attempted.

(5) Sensitivity runs have not been conducted with the TROA model to establish just how its predicted results vary when unknown parameter values are adjusted each within

its reasonable bounds of variability. After all, it is reasonable to hypothesize that future water availability and stream flow conditions will vary if the past millennia of recorded history of natural phenomena are any guide. It is thus important to test the variability of the model predictions to reasonable variations in physical parameter values. Well known and accepted scientific methodology requires that such sensitivity analyses be undertaken in any modeling effort. This step becomes particularly important when predicted impacts of implementing water allocation plans are anticipated to be small, in order to determine if predicted changes are significant. In the present instance, numerous examples exist wherein conducting such sensitivity analysis would be appropriate. For example, when it is assumed that future changes in water use would occur, it is appropriate to test the sensitivity of the model to different amounts of such changes in order to evaluate the sensitivity of the model predictions to that parameter value, all other conditions being held the same. The serious flaw in the TROA model is that no such sensitivity analysis was performed.

(6) Not even a basic User's Manual or Program User's Guide has been prepared for the TROA model. Such a lack of basic documentation is unprecedented and represents a serious flaw. Given the complexity of this model, the absence of a user's manual or guide which explains the syntax, meaning and function of input data sets supplied to the model makes it virtually impossible for any independent reviewer to evaluate the model's uses and thereby verify its validity. Under present circumstances it is difficult to establish just how a valid scientific methodology can be followed to allow a proper peer review of the model can be performed.

4. **Flaws in Model Applications:**

(1) In order for members of the affected public to apply the TROA model for any valid purpose, the computer program embodying it has to be installed in a computer prior to running it. Principia's preliminary test runs have demonstrated that this model is unreasonably sensitive to the computer architecture and FORTRAN-language compiler routinely used to convert the source code to a usable or executable form. In other words, when used on different computers or with different FORTRAN-language compilers, the TROA model predicts quantitatively different results. This is also unprecedented and represents a serious flaw in the TROA model. Such differences indicate either the use of dangerously poor programming practices or the inherently chaotic behavior of the flow system as modeled, or some combinations of both. The differences in results predicted by the model for identical input data sets are particularly significant and troubling since no model sensitivity runs were performed. Discussions held by Principia with authors of this model reveal that the authors themselves had not studied this behavior but were not even surprised by such differences in results. In this TROA flow system as modeled even one extra drop of water can trigger a sequence of program "decisions" which drastically alter how the system is predicted to operate. This serious flaw in applying the model is dramatically demonstrated by the significant changes in model predicted results for some months, even when using identical data sets, simply by running the program on two different computer systems.

(2) Results predicted by the TROA model apparently cannot be checked or verified as valid real-life possibilities. One of the reasons cited by authors of this model for not

having undertaken model calibrations is that the model is known not to predict any flow quantities that can actually be compared to observed values. This is also unprecedented especially for a model intended to reflect water allocation plans that will affect so many and for so long into the future if adopted. For example, the flow system may historically have been operated according to "rules" that differ from their present form. When used to simulate such historical conditions, the TROA model would cause this flow system to operate not according to such historical rules but differently when applied to the same time period. This failure violates the most basic principles of science that are recognized and widely accepted as valid methodology. It is essential to demonstrate that it is not only possible to undertake such comparisons but that important model results indeed compare favorably with actual observations, even just for selected periods. Without the basic ability to subject the TROA model to valid controlled scientific experiments and to compare the resulting model predictions with observed data, the affected public is forced to accept this model as an article of faith based only upon representations by its authors, and without any opportunity to review its basis in science which is the normal practice.

(3) It is a deeply disturbing flaw that the TROA model makes predictions that are driven by the results expected by parties to water allocation plans. This model has been so constructed that it fails to consider changes to gains and losses in the flow system as a result of planned changes in operations. Specifically, the TROA as implemented in the model is aimed at finding unappropriated water, storing that water, and then releasing the water when it is deemed beneficial. What the model as constructed fails to account for is the real possibility that at the time of water releases, water may not reach the lower end of the system as a result of increased losses. Therefore, the increased benefit of such releases may not materialize, may be diminished or even cause additional impact to downstream users who may be "charged" the additional transit losses. Consequently, the model will always predict a benefit from the TROA operations whereas in reality the real benefit would be much smaller and the impact on other water users much greater than predicted. This is also a serious flaw of the TROA model and greatly diminishes its validity as a tool for evaluating real changes in water allocations.

5. Summary Findings:

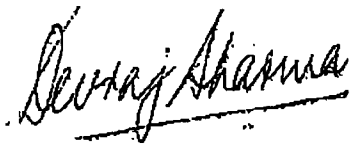
Even this preliminary review of the TROA model illustrates that it is seriously flawed in several significant respects. Some of these flaws prevent a valid model review from being conducted using accepted scientific methodology, given the short time frame allocated for such reviews. Other flaws are more serious and cripple the model from being used in support of the Draft EIS/EIR. Several of the TROA model flaws identified during Principia's review are fatal and prevent it from being used to evaluate the consequences of water allocation plans for the TROA system and its future operations.

It is Principia's scientific view based upon this review, and the experiences of its scientists from modeling reviews conducted during the past two decades, that model flaws which have serious consequences must be revealed and then evaluated through a process of wide and unhindered scrutiny by scientific peers. Thereafter, each flaw must be rectified through rational means and then rigorously tested before a model is finalized and used for predictive purposes. The ultimate goal of a scientific computer model is to create confidence in the user that the model will actually predict an outcome that can be relied upon. It is by documenting such efforts in an open and thorough manner that the

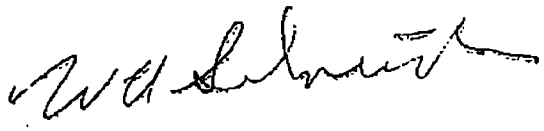
affected public will be persuaded that such confidence is indeed merited. Principia's opinion of the draft TROA model is that it provides little, if any, confidence in the data it is evaluating and no confidence that the output created by this TROA is either reliable or usable for purposes of decision making.

Yours Sincerely

Principia Mathematica, Inc.



Dr. Devraj Sharma



Dr. Willem A. Schreüder