

## Summary

The Bay Area Delta Conservation Plan (BDCP) Draft EIR/EIS<sup>1</sup> is an exhaustive document, but its emphasis is on quantity instead of quality. The plan is rich with details about how Northern California's water supplies might be moved south across the Delta, but it is poor in predictive science supporting how the plan would work in practice, and it provides precious little evidence of how much the plan's implementation would actually cost the state's citizens.

The term "predictive" is of fundamental importance here, because predictiveness, reproducibility and verifiability are fundamental principles of scientific investigation. The Draft EIR/EIS fails all of these tests of science, and its computational modeling efforts lie well outside the mainstream of accepted practice for numerical simulation of natural and engineered systems. The computational models that lie at the heart of many of the predictions in the Draft EIR/EIS are based on over-simplified idealizations of natural systems such as aquifers, and all-too-often these models rely on methodologies that have long been superseded by more accurate physical models for predicting the response of geological systems like the Delta and the Central Valley.

The people of California deserve at a minimum an open and scientifically-accurate accounting of the environmental risks and financial costs of this water transfer apparatus, and the current Draft EIR/EIS provides neither. The plan's authors should return to the drawing board and start again, this time with their efforts founded on the best-available science and engineering principles.

## Professional Credentials

My professional experience has long been concentrated in the development and deployment of large-scale computational models for engineered and natural systems. I have worked in this professional field for well over thirty years, and have published refereed journal publications on subsurface mechanics and computational simulation of geological processes, as well as texts and related educational works on computational modeling in solid and fluid mechanics. I have served as a regular faculty member on the Civil Engineering faculties of two major U.S. research universities (the University of California, Davis, and the University of Oklahoma), as well as in leading-edge technical and administrative capacities at federal national laboratories. With my academic colleagues and graduate students, I have published journal articles and technical reports on aquifer mechanics, earthquake engineering, computational geomechanics, soil-structure interaction, high-performance computing, and the limits of computational modeling for systems in the presence of inherent uncertainties. I have earned M.S. and Ph.D. in Civil Engineering and a B.S. in Mathematics, all from the University of California, Davis. I have lived in Northern California for more than one-half of my adult life, and have long provided *pro bono* technical assistance on science and engineering topics of import to the quality of life for residents of California. My current work involves simulation of complex man-made and natural systems using some of the largest computers on the planet, and so I am well-equipped to describe the state-of-the-art in predictive modeling for large-scale engineering efforts in the Delta.

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<sup>1</sup> Throughout this document, the Bay Area Delta Conservation Plan Draft EIR/EIS will be referred to as "the Draft EIR/EIS", in the interest of brevity.

## Representative Technical Details of This Critique

The size of the Draft EIR/EIS numbers in the tens of thousands of pages, so it is impractical to provide a comprehensive critique of that document in only a handful of pages. Therefore, I will list here only a few key concerns where the plan's authors fall short of the mark demanded by the scope of the project and by its potential for environmental and financial harm if the plan proves inaccurate in its predictions. As always, I am happy to provide more detail on my concerns if such detail is needed. The taxpayers of the state of California helped support my doctoral education via generous financial aid when I was a graduate student in the University of California, and I have long stood ready, willing, and able to return technical dividends to those taxpayers by providing my expertise on topics of importance to the citizens of this great state.

### Uncertainty in Engineered and Natural Systems

First, some discussion is warranted on the difference between a natural and an engineered system, as the Draft EIR/EIS includes both, so such understanding is of fundamental importance here. An engineered system is designed entirely by humans, so each component of that system is reasonably well-understood *a priori*, and the uncertainties that are inherent in any system (natural or man-made) are limited to defined uncertainties such as materials chosen, geometric specifications, and conditions of construction and use. So an engineered system such as an automobile (or a tunnel through the Delta) is uncertain in many aspects, but that uncertainty can in theory be constrained by quality-control efforts or similar means of reproducibility. Constraining these uncertainties comes at a price, of course: that is a large part of what we mean when we refer to *quality* in an engineered system such as in cars or consumer electronics.

A natural system has a much higher threshold for uncertainty, as we often do not even know of all the components of the system, much less their precise characterization (e.g., in a water-bearing aquifer, the materials that entrain the water are by definition unavailable for characterization, and the mere act of digging some of them up for laboratory inspection generally changes their physical behaviors so that the tests we perform in the laboratory may not be entirely relevant to the response of the actual subsurface system). So when studying a natural system, a scientist or engineer must exercise due diligence in the examination and characterization of the system's response to stresses of operational use, and must consistently provide means to determine the presence and effect of these inherent uncertainties. To do otherwise is to risk visitation by Murphy's Law, i.e., "anything that can happen, will happen."

Thus one of the first metrics for evaluating the quality of any environmental plan is to examine the plan's use of terms such as "uncertainty", as well its technical relatives such as "validation" (testing of models via physical processes such as laboratory experiments), "verification" (testing of models via comparison with other generally-accepted models), and "calibration" (tuning a model using a given set of physical data that will be used as initial conditions for subsequent verification, validation, and uncertainty characterization). These basic operations are fundamental characteristics of any computational model, and are used in everyday life for everything from weather prediction (where uncertainty dominates and limits the best efforts at forecasting) to the simple requirement that important components of infrastructure such as highway bridges be modeled using multiple independent analyses to provide verification of design quality before construction can begin.

### Lack of Uncertainty Characterization in the BDCP Draft EIR/EIS

Unfortunately, there is no substantial discussion of model uncertainty in the Draft EIR/EIS. There are plenty of discussions of uncertainty of biological data, of uncertainty due to climate change, and of the difficulty of handling uncertain measures of water supply and quality, but beyond a rudimentary sensitivity analysis of how the results of computational models used in the Draft EIR/EIS respond to changes in key parameters, the topic of model uncertainty is barely addressed (or at least, not addressed where it is easy to find in the tens of thousands of pages in the Draft EIR/EIS). A model for a natural system needs a formal effort to quantify uncertainty, so that the various benefits and costs can be put into perspective. Such an effort is apparently lacking in the Draft EIR/EIS, and the following paragraphs present some representative examples of the problems with the approaches outlined in the Draft EIR/EIS:

- In Chapter 7 (groundwater), it is stated that the CVHM (Central Valley Hydrologic Model) that lies at the heart of many of the most important predictions found in the Draft EIR/EIS was calibrated using trial-and-error methods. First, trial-and-error techniques are technically indefensible in this setting, as they are not even reproducible (i.e. calibration performed by one person will not necessarily yield the same result if performed by another technician), hence they fail fundamental tests of science, that of reproducibility and verifiability. Formal methods exist for calibrating complex computational models, but there is no readily-apparent indication in the Draft EIR/EIS that any of these standard calibration measures were utilized.
- Second, calibration of a model is a necessary condition for its practical use, but it is certainly not a sufficient one: comprehensive sensitivity analyses for all relevant parameters and uncertainty quantification for both the computational model and its associated data should be developed before a model can be determined as sufficiently robust for practical use in society-critical venues such as the plans presented in the Draft EIR/EIS. Calibration of a model merely implies that the model has been tuned to a particular data set: it does not necessarily imply that the model is ready for broad use in society-critical settings, as that is the role of uncertainty quantification, validation, and verification. There are technically-sound methods available to demonstrate that a calibrated model can be trusted within a properly-calibrated range of expected use, but I could find no discussion of any of these methods in the EIR/EIS. This omission moves the modeling sections of the Draft EIR/EIS to a place well outside the state-of-practice mainstream for computational modeling in critical-infrastructure applications.
- This lack of uncertainty information is especially apparent in the seismic sections of the report, where the recommendation is made that uncertainty in analysis and design parameters should be minimized. Unfortunately, no feasible (i.e., cost-effective) strategies for realizing that goal are readily found in the plan, even though the cost of protecting such a large set of water-conveyance structures against all credible earthquake risks may prove to be astronomical. The plan promises that seismic risks will be addressed during the design and construction phases of the project, but also explicitly admits that no substantial efforts toward accurate identification of seismic risks yet exist within the plan's scope. Thus the costs of mitigating these risks is unknown from the outset, and any estimate of project cost must thus be considered to be a substantial underestimate of actual project lifespan costs.
- One of the worst cases of poor risk assessment in seismic sections of the report is the discussion of possible liquefaction effects. After a good introductory discussion of the natural phenomenon of liquefaction, the Draft EIR/EIS provides little in the way of realistic mitigation

plans to handle the very-real risk that liquefaction could destroy the project once it is built (or even damage components of the system during construction). Mitigation schemes that might prove virtually impossible to implement in practice (e.g., removing liquefiable soil deposits and replacing them with more stable materials) for a project of this scale are mentioned, but accurate estimates of costs required to mitigate this particular seismic hazard are not readily apparent to the technically-informed reader of the Draft EIR/EIS.

- Chapter 5 (water supply, potentially the most important aspect of the project) uses the term “uncertainty” twice in the chapter body (166 pages). The first use is fundamental, and demonstrates the all-important nature of the term: “Variability and uncertainty are the dominant characteristics of California’s water resources.” But unfortunately, no subsequent attempt is made in this chapter (and precious little in its appendices) to quantify these uncertainties and variabilities. Such a quantification of margins of uncertainty (QMU) is a difficult task, but it is not an intractable one, and this effort is well within the mainstream of computational modeling for everything from weather prediction to automotive design. So this quantification of uncertainty effort should be treated as an essential requirement for a project of this scale, and its omission is yet-one-more indication of the technical weakness of the Draft EIR/EIS.
- Validation results are primarily confined to tidal effects and to scenarios associated with climate change, which are important risk-management venues, but are hardly the primary focus of the plan. Validation is essential for modeling of subsurface structures, as the inelastic, stress-dependent, and hysteretic nature of soils often compromise the utility of traditional model verification methods. Yet there are apparently no validation measures applied to the components of the models used for subsurface effects (e.g., Chapters 7 and 9), and the term “validation” in general is used in the Draft EIR/EIS as an adjunct to calibration, instead of being treated as an essential component of establishing trust in a model.

### Subsidence as the Achilles’ Heel of the Project

One particularly troubling sign of potential problems is found throughout Chapter 7 and its appendices, where it is asserted that the CVHM can be used for modeling subsidence. Like its poromechanical cousin liquefaction, subsidence is an Achilles’ Heel for this project, because this physical phenomenon has the potential to destroy the project’s utility during construction and operation. This kind of single-point-physics existential risk to the project requires the best science and engineering analysis feasible with current technology, yet the Draft EIR/EIS provides only a minimal treatment of this vulnerability. To make matters worse, the fundamental scientific assumptions that form the foundation of the Draft EIR/EIS’s assertions are not presented within the plan document, so an independent technical expert attempting to evaluate the accuracy of those assertions must consult the open literature and other available sources to perform a technically-defensible evaluation of the Draft EIR/EIS.

The open literature on groundwater modeling has demonstrated that the one-dimensional methods used to estimate three-dimensional subsidence effects in CVHM (based on Helm’s method from 1975<sup>2</sup>) may provide acceptable results for overall land subsidence in a broad area, but yield inadequate and generally poor predictive results for local-scale hazards such those

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<sup>2</sup> Helm, D.C., “One-dimensional simulation of aquifer system compaction near Pixley, Calif. 1. Constant parameters”; *Water Resources Research*, 11, 465-478, 1975

required for analysis of subsidence effects on engineered structures<sup>3</sup>. In particular, the methods used to predict subsidence effects in the CVHM appear to be practically incapable of predicting local differential settlement, and that is exactly the physical response that can compromise or destroy the operation of the tunnels and channels that permit the water transfers that form the heart of the Draft EIR/EIS. So the use of the subsidence idealizations found in CVHM is simply an inadequate means to assess subsidence risk for the project, much less to mitigate it.

The fundamental problem here is that the basic assumptions for modeling groundwater flow in software tools such as CVHM all-too-often preclude accurate simulation of subsidence by assuming from the start that subsidence does not occur in an aquifer. The purpose of this mechanical over-idealization is to permit an especially simple mathematical formulation for porous-media flow that was arguably appropriate decades ago, when computers were expensive and slow, but that is technically unwarranted today, when computers are fast and relatively inexpensive. The extra work required to perform an accurate analysis using the relevant science commonly deployed in higher-fidelity aquifer simulations (e.g., aquifer simulations used in the fossil fuel extraction industries) is readily manageable when deployed on modern computational platforms, and most (if not all) of the model data obtained from well borings and similar data-gathering efforts could be re-used in these higher-fidelity model. So there is simply no excuse for the BDCP Draft EIR/EIS modeling efforts failing to utilize the appropriate scientific body of knowledge to assess subsidence risk.

Worse still, the authors of the Draft EIR/EIS don't even mention these well-known improvements to their model, or how these techniques could provide much more accurate estimates of the likelihood that the entire system would even work in the presence of subsidence. The scientific field that underlies the prediction of subsidence is termed "poromechanics", yet this all-important term never appears in the many thousands of pages of the Draft EIR/EIS. This neglect of the well-established governing science is inexcusable, given the existential risk to the construction and operation of the water-conveyance systems that form the heart of the plan's long-term operation.

It is important to note that these higher-fidelity poromechanics principles are not exactly new or little-known to practitioners in Civil Engineering. The relevant theory was developed by the famous geotechnical engineer Karl von Terzaghi<sup>4</sup> in the 1930's (Terzaghi is widely known as "the father of soil mechanics") and further honed by Maurice Anthony Biot<sup>5</sup> in the the 1940's. For but one example, poromechanics simulation capabilities for clay, sand, and silt soil deposits that utilized Terzaghi's and Biot's scientific principles (and that were thus capable of higher-fidelity predictions of subsidence) were developed and deployed in the public domain through the efforts of faculty and students at the University of California, Davis, three decades ago<sup>6</sup>, so there is simply no excuse for not including these best-practices scientific models in current aquifer simulation tools such as CVHM. A project that will cost at least several tens of billions of

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<sup>3</sup> Galloway, D.L., and M. Sneed, "Analysis and simulation of regional subsidence accompanying groundwater abstraction and compaction of susceptible aquifer systems in the USA"; *Bulletin of the Geological Society of Mexico, Volume 65, Number 1, 123-136, 2013*

<sup>4</sup> [http://en.wikipedia.org/wiki/Karl\\_von\\_Terzaghi](http://en.wikipedia.org/wiki/Karl_von_Terzaghi)

<sup>5</sup> [http://en.wikipedia.org/wiki/Maurice\\_Biot](http://en.wikipedia.org/wiki/Maurice_Biot)

<sup>6</sup> Mish, K.D., and Herrmann, L.R., "User's manual for SAC-3 : a three-dimensional nonlinear, time dependent soil analysis code using the bounding surface plasticity model"; *Naval Civil Engineering Laboratory Technical Report CR 8409, Port Hueneme, CA, 1983*

dollars should be based on the best science available, and not on over-simplified idealizations that were long ago superseded by more accurate scientific principles.

There does appear to be an emerging recognition in the hydrological modeling community that these higher-fidelity methods are warranted for use when natural systems (e.g., aquifers) are utilized to support engineered systems (e.g., water-conveyance infrastructure), but this recognition is not made explicit in the Draft EIR/EIS, and citizens should not have to pore through open-source documents trying to determine whether or not the Draft EIR/EIS's predictions of groundwater effects utilize the most accurate science available.

The technical risks associated with this ambitious project, and the immense budget required for its construction and operation, clearly mandate that the best-available scientific principles be deployed and documented in all project artifacts, including the Draft EIR/EIS. It is technically indefensible that these principles (including all fundamental physical assumptions) are not readily available in the tens of thousands of pages of the Draft EIR/EIS, and the omission of the particulars of the science used to estimate these environmental effects precludes both accurate prediction of the environmental effects of this project, as well as independent technical verification of the claims made in the plan. Since independent verification is a fundamental hallmark of scientific investigation, the current version of the BDCP Draft EIR/EIS fails even this most basic test of science.

### Problems with CalSim II

If insufficiently-accurate modeling of subsidence is the Achilles' Heel of the Draft EIR/EIS, then a similar anatomical analogy might be proposed for the plan's broad use of the California Department of Water Resources' CalSim II computer model. CalSim II is used to evaluate the environmental effects of the various alternatives presented in the Draft EIR/EIS, and hence this software lies at the heart of the EIR/EIS. Unfortunately, CalSim II has a substantial set of its own technical weaknesses, so the Draft EIR/EIS suffers from heart problems as well as possessing an Achilles' Heel. The next several paragraphs outline some of the most substantial weaknesses of CalSim II, but many more can be found in the various peer review documents that have been generated and disseminated as part of the CalSim II development process<sup>7,8,9</sup>. In the interest of simplicity, only a few key concerns about the suitability of the current version of CalSim will be presented here, but these should be sufficient to indicate that CalSim II does not yet warrant sufficient trust to justify its use for analysis of the alternatives that lie at the heart the water-transfer plan.

Some of the most important problems with CalSim II include the following concerns, most of which have been cited here previously as serious limitations of the Draft EIR/EIS:

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<sup>7</sup> Close, A., Haneman, W.M., Labadie, J.W., Loucks, D.P., Lund, J.R., McKinney, D.C. and Stedinger, J.R., "A Strategic Review of CALSIM II and its Use for Water Planning, Management, and Operations in Central California", California Bay Delta Authority Science Program Association of Bay Governments, December 2003.

<sup>8</sup> Arora, S. and Peterson L., "Peer Review Response: A Report by DWR/Reclamation in Reply to the Peer Review of the CalSim-II Model Sponsored by the CALFED Science Program In December 2003", California Department of Water Resources and U.S. Bureau of Reclamation, August, 2004

<sup>9</sup> Ford, D., Grober, L., Lund, J.R., and D. McKinney, "Review Panel Report: San Joaquin River Valley CalSim II Model Review", CALFED Science Program – California Water and Environment Modeling Forum, January 2006

- insufficiently-accurate assumptions underlying estimates of aquifer and groundwater response, including poor (or perhaps even nonexistent) characterizations of the risk of subsidence,
- inattention to concerns of provenance of the input data used to generate results used for analysis of alternatives, and
- lack of a sound technical basis for characterizing uncertainty in the model and in the input data.

This critique has already pointed out the need for higher-fidelity estimates of subsidence effects, because these effects have the potential to compromise the function of the proposed conveyance infrastructure. The peer-review documents cited above include only one single use of the word “subsidence”, and that use occurs in association with a proposal to incorporate another DWR model (IGSM2) into CalSimII<sup>10</sup>. Unfortunately, this model is not mentioned in the Draft EIR/EIS, so it is not clear whether its subsidence capabilities are employed in the Draft EIR/EIS’s analysis of alternatives. And this question is rendered moot by the fact that attempts to learn (e.g., by reviewing various DWR open-source publications) whether IGSM2 even utilizes an accurate method for modeling subsidence prove unsuccessful. So it is not clear whether *any* of the analyses of alternatives presented in the Draft EIR/EIS include accurate modeling of the relevant physical effects that could characterize success or failure of the conveyance structures proposed in the EIR/EIS.

The concerns of data provenance are more subtle, but they are equally important, and they lead to one of the continuing critiques of CalSim II made by the peer reviewers. The initial peer review effort identified a software quality problem<sup>11</sup> with archiving of code and input datasets in CalSim II, a problem that is currently being remedied by the CalSim II developers, but which should never have occurred in the first place. That problem is one of establishing the all-important mapping between input data and the CalSim II results that are generated by those datasets. This mapping is termed *data provenance*.

Provenance is a subtle concept, but it is fundamentally important, as anyone who has ever enjoyed watching an episode of the PBS television series “Antiques Roadshow” knows. A valuable antique, such as a painting by Monet, must be distinguished from a cheap imitation prepared by a forger by the process of examining the trail of custody of the antique. If a trusted mapping from the current owner of the antique back to the artist can be established, then the claim of value and authenticity is validated. If not, then the antique may prove to be worthless.

Provenance is equally important in computational modeling, as input datasets contain the fundamental assumptions that generate computed results, which are then used to effect policy decisions, e.g., water transfers based on the computational simulation. If the chain of custody between the policy decision and the input data that generated the results that influenced that policy cannot be established, then the results (and the policy) cannot be trusted. So as in the world of antiques, provenance is a fundamentally-important requirement for computer analysis.

Provenance is established in computer models by providing an appropriate form of configuration management for both the software source code, and for all the datasets used, both as input and as output. Normal software-quality-assurance practices would require that the mapping between input datasets and generated results be tested regularly (often daily), so that changes to the

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<sup>10</sup> Arora and Peterson, *op. cit.*, page F-2

<sup>11</sup> Close, *et al.*, *op. cit.*, page 8 and 58

software do not cause deviations in the results. Such deviations could easily call into question the legitimacy of policy decisions made on the basis of these computations.

The original 2003 review panel pointed out that CalSim II did not include such configuration management capabilities, and the CalSim II developer community agreed to remedy this substantial deviation from standard software quality practices<sup>12</sup>. CalSim II now includes some configuration management capabilities for input datasets, but it is not clear from the Draft EIR/EIS or from the various review documents how effectively these new data management capabilities are utilized. This problem alone causes serious concerns about whether the analyses of the various Draft EIR/EIS alternatives can be trusted. And this question of trust touches on another problem with CalSim II identified during the peer review process<sup>13</sup>, namely that CalSim II analyses may not be repeatable, i.e., the results may be strongly dependent on the experience and personal preferences of the particular analysts carrying out the modeling, so that the computed results may not be objective. This opens the door to concerns that model results may be biased, either accidentally or intentionally. Thus there are serious limitations in how much the results of CalSim II can be trusted.

The best way to remedy these problems is to provide open access to the computer model and to the input datasets used in the Draft EIR/EIS, so that a more diverse community of interested parties can evaluate the model and its data towards the goal of more accurate results. Another means to help remedy the problem of lack of trust in computed results is to utilize formal techniques to characterize uncertainty, so that the practical effect of potential analyst bias can be assessed to determine whether or not inter-analyst differences lead to substantial discrepancies in results. But as already mentioned in this critique, uncertainty characterization is lacking in the CalSim II effort, and while the various peer review documents consistently identify the need for better characterization of model uncertainty, it is not clear whether this improved uncertainty characterization has been implemented yet, which is yet-another factor that diminishes trust in CalSim II's key role in the evaluation of alternatives in the Draft EIR/EIS.

The peer review documents also identify the potential for a completely-inaccurate assumption embedded in the groundwater modeling components of CalSim II<sup>14</sup>, and the CalSim II response to this criticism<sup>15</sup> is insufficient in technical detail to determine whether this inaccuracy is present or not. The criticism is based on an inherent assumption of simple porous-flow models, such as those used in CalSim II, namely that these models assume an infinite supply of usable groundwater available at the outer boundaries of the geographic domain modeled.

A groundwater aquifer has physical limits, e.g., the alluvial deposits that store the water eventually reach bedrock, and hence the aquifer's capacity is limited by geologic constraints. But including these hard constraints into a porous-flow model is not trivial: in particular, the resulting modeling problem becomes nonlinear, and requires more complex solution techniques that require more computer resources. It is not clear from the Draft EIR/EIS's discussion of the modeling assumptions inherent in CalSim II, or from the various peer review documents, exactly how the CalSim II model incorporates these all-important constraints, and this type of potential

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<sup>12</sup> Arora and Peterson, *op. cit.*, page 12

<sup>13</sup> Close, *et al.*, *op. cit.*, page 24, and Arora and Peterson, *op. cit.*, page 17

<sup>14</sup> Close, *et al.*, *op. cit.*, page 8

<sup>15</sup> Arora and Peterson, *op. cit.*, page 7 and A-1 through A-3



limitation of the CalSim II model needs to be included in the Draft EIR/EIS groundwater modeling discussions, with due technical detail for how it is (or could be) overcome in practice.

It is therefore apparent that too much uncertainty is present in the current Draft EIR/EIS document regarding the scope, technical basis, and practical utility of the CalSim II model to support due trust in this model for a project as large as that proposed in the BDCP Draft EIR/EIS. The current modeling assumptions and the software-engineering practices utilized to develop the CalSim II model should be vetted before a broader variety of independent technical experts before the citizens of California can fully trust these results.

The current model is clearly “not ready for prime time”, and future review teams should be enlarged to include independent experts in uncertainty quantification, software engineering, poromechanics, and operations research. Until the CalSim II model and its associated input data is reviewed by a wider community of independent experts, this computer tool simply does not warrant the trust placed in it via the Draft EIR/EIS.

In short, the existing review processes cited are a good start, but they are still only that: a start.

### **Towards a Scientifically-Defensible Bay Delta Conversation Plan**

I began my technical critique of the BDCP Draft EIR/EIS by stating the obvious:

*The Bay Delta Conservation Plan (BDCP) Draft EIR/EIS is an exhaustive document, but its emphasis is on quantity instead of quality.*

The means to remedy the myriad technical shortcomings of the plan is simple in theory and completely feasible in practice: all that is required is to improve the plan’s quality so as to match its exhaustive quantity. In spite of its technical shortcomings, the plan includes many excellent references for assessment and mitigation of the natural and man-made risks inherent in its analysis, design, construction, and operation. All that is required to generate a technically-accurate version of the Draft EIR/EIS is for its authors to utilize those best-practices references (e.g., relevant codes for seismic design) to improve the estimates of costs and risk currently found in the plan, towards the goal of a technically-unimpeachable set of risk and cost estimates for the construction and operation of this ambitious project.

Unfortunately, carrying out this more-accurate cost and risk assessment exercise will be an ambitious task, but it is a necessary one given that some of the risks short-changed by the current Draft EIR/EIS have the potential to render the proposed project scope unusable (e.g., differential settlement effects caused by liquefaction or subsidence) or prohibitively expensive. These risks alone warrant an accurate risk-management strategy, which the Draft EIR/EIS currently lacks.

But the citizens of the state of California deserve an accurate accounting of the technical and financial risks of this project *before* the project is initiated. The authors of this Draft EIR/EIS should return to the drawing board to develop accurate estimates of what this project will actually cost, and what natural risks and technical impediments must be overcome in construction and operation. The real costs, financial and environmental, of this project must be assessed before work is begun, not after, and the current Draft EIR/EIS simply does not make this assessment possible.