California Water Research

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Evaluation of testimony on the reliability of the methods

used to produce CalSim and DSM2 model results

The model results submitted in support of the Petition all rely on a hydrologic / water operations model, CalSim II. This model has never been validated, i.e., approved as reliable, for any use. The validation of the hydrodynamic model, DSM2, has also not been presented for use in the hearing.

Peer Review and Other Relevant Documents

Although the following peer review documents for CalSim II were referenced in testimony by Armin Munevar (Exhibit DWR-71), they were not included in the evidence submitted by the Petitioners.

1. [2003 Peer Review] The December 2003 Strategic Review of CALSIM II, sponsored by the Bay-Delta Authority Science Program, titled, "A Strategic Review of CALSIM II and its Use for Water Planning, Management, and Operations in Central California," Available at http://www.waterboards.ca.gov/waterrights/water_issues/programs/hearings/daviswoodland/daviswoodland_cspa_es9.pdf

2. [2004 Peer Review Response] The August 2004 response by DWR and USBR to the 2003 Strategic Review, titled, "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," Available at http://baydeltaoffice.water.ca.gov/modeling/hydrology/Peer%20Review%20Response%20(August%202004).pdf

These documents were sent to the Board on June 10, 2016, with a request that they be accepted for use in objections. The request, "Evidentiary submission – CALSIM II model peer review reports and 2004 response," was also sent to the WaterFix hearing list. That letter is incorporated by reference.

The following Peer Review is also relevant and was also submitted to the Board with the June 10, 2016 letter:

3. [2006 Peer Review] The January 2006 review of the San Joaquin River module, titled, "Review Panel Report San Joaquin River Valley CalSim II Model Review," obtained from http://science.calwater.ca.gov/pdf/calsim/calsim_II_final_report_011206.pdf

The Board posted the letter and the documents on the Hearing website. Since the Board is in possession of the above documents, and they were prepared and published by a public agency, I request that the documents be accepted for use by reference, per CWC §648.3.

The Board also convened a 2012 scientific panel on "Analytical Tools for Evaluating Water Supply, Hydrodynamic and Hydropower Effects," [Analytical Tools] which made recommendations for use of model results in Board proceedings. The recommendations of that panel were discussed in my "Request for Official Notice," sent on June 20, 2016 with a copy of the report. The Board posted the letter and the report on the Hearing website. Since the Board is in possession of the report, and it was prepared and published by the Board, I hereby request that it be accepted for use by reference, per CWC §648.3.

The testimony of Armin Munevar (Exhibit DWR-71) also referred to the 35th Annual Progress Report to the State Water Resources Control Board. [35th Annual Progress Report] Section 2 of that report defines the process of model calibration and discusses the calibration status of DSM2. That document was also not submitted into evidence by the Petitioners. The hyperlink to the document, on p.7 of Mr. Munevar's testimony, is http://baydeltaoffice.water.ca.gov/modeling/deltamodeling/AR2014/AR-2014-All.pdf. I will email a copy to the Board. Since this document was prepared and published by a public agency, I request that it be accepted for use by reference, per CWC §648.3.

DEFINITIONS

The following are relevant definitions used in ensuring reliability of computer simulations from the Department of Defense, which regularly procures large computer simulations. (Instruction 5000.61 on DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A).[1]) They are based on commonly accepted systems engineering practice. I am sending a copy of Instruction 5000.61 with these comments.

Simulation Conceptual Model. The developer's description of what the model or simulation will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the user's requirements**.**

Verification. The process of determining that a model implementation and its associated data accurately represents the developer's conceptual description and specifications. (p. 15)

[1] Available at http://www.public.navy.mil/cotf/OTD/DoDI_MS_VVA_5000.61.pdf (Downloaded from this site.) There are periodic updates to this instruction, but all contain the same definitions of Verification, Validation, and Accredidation. The 2003 Instruction is used to show that the definitions have been in use for over a decade.

Validation. The process of determining the degree to which a model and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model. (p. 15)

Acceptability Criteria (Accreditation Criteria). A set of standards that a particular model, simulation, or federation must meet to be accredited for a specific purpose. (p. 10)

Accreditation. The official certification that a model, simulation, or federation of models and simulations and its associated data are acceptable for use for a specific purpose. (p. 10)

Calibration. The DOD Instruction does not define model calibration, but the 35th Annual Progress Report to the State Water Resources Control Board had a good definition:

> Calibration, as used with physically-based numerical models, is the process of comparing model output with observed data; changing appropriate parameters in the model; running the model with the new parameter values and comparing again; and repeating until the discrepancy between observed and computed data is considered acceptable and the model "calibrated." (p. 23)

This method of calibration is also appropriate for the components of CalSim II that model hydrologic processes.

Request from Modelling Community in 2009

In 2009, a group of 24 members of the CALFED hydrodynamics modeling community sent a letter to Joe Joe Grindstaff, the Director of the California Bay-Delta Authority, and Clifford Dahm, the Chief Scientist. The letter was titled "Re: Improved Modeling Capabilities Needed for the Bay-Delta Planning Effort." It was included in the report of the 2012 panel on Analytical Tools. The letter stated in part,

> *By agreeing on the most appropriate directions for expanding existing modeling capabilities, our proposed program will permit the development of intermediate products while working toward longer-term objectives. We recommend that the proposed program include the following:*
>
> > *[…]*
> >
> > *Proper mathematical verification of model codes and calculations, field testing of models, and peer-review of model algorithms and documentation*
> >
> > *An external review committee to provide outside scientific advice, oversight, and quality assurance, drawing on expertise from other estuaries*
> >
> > *Model codes and documentation made freely available in the public domain*
> >
> > *Identification of a caretaker of model codes and documentation*
> >
> > *[p. 15]*

Shortly afterward, the Delta Reform Act dissolved the Bay-Delta Authority. As detailed below, these requests may never have been implemented for the CalSim hydrologic model and DSM2 hydrodynamic model. If so, it is unfortunate, because these models have been the foundation for the entire Bay Delta Conservation Plan / WaterFix planning process.

Criteria for Acceptance of Model Results for use in Board Proceedings

The State Water Resources Control Board has not set objective criteria for acceptance of computer model results for use in Board proceedings. In the past, the Board appears to have simply used Government Code § 11513 to determine whether to accept model results for Board proceedings. The criterion in Government Code § 11513 is "the sort of evidence on which responsible persons are accustomed to rely in the conduct of serious affairs." Because of the status of the Department of Water Resources and the US Bureau of Reclamation, this criterion can be circular when applied to their models. That is, models developed by DWR and the Bureau can be regarded as "the sort of evidence on which responsible persons are accustomed to rely in the conduct of serious affairs," regardless of whether the computer models meet any objective engineering standards for reliability.

The Board's 2012 panel on "Analytical Tools for Evaluating Water Supply, Hydrodynamic and Hydropower Effects" referenced the 2009 letter by modelers, and made clear, specific, and objective recommendations for assessment of the reliability of computer models and model results in Board proceedings. I requested that the Board take official notice of those recommendations, because it was clear that an objective standard was needed for the WaterFix hearing.

There appears to have been no complete, technical peer review of the CalSim or DSM2 models, nor has the Board arranged for any independent review of the CalSim and DSM2 modelling and model results proposed for use in the WaterFix hearing. DWR and USBR are instead submitting testimony from two engineers who oversaw the development and application of the BDCP / WaterFix CalSim and DSM2 model versions, Armin Munevar and Parviz Nader-Tehrani. The testimony by these two engineers is proposed to certify the suitability of the model results for the hearing.

On reviewing the testimony by Armin Munevar, I noticed significant omissions and inaccuracies in statements about the peer review status of the CalSim II model, as well as in statements about the agency's ability to calibrate and validate the model. Some of Munevar's statements were in contradiction of recommendations by the CalSim peer review panels. Some statements by both engineers were also in contradiction to the recommendations of the Board's 2012 panel on Analytical Tools. I have attempted to explain some of the discrepancies below.

The Board needs to carefully weigh these discrepancies, and the failure to implement the recommendations requested by the modelers in 2009, when evaluating whether the model results are acceptable for use in the hearing. The refusal by the Petitioners to answer basic questions about the BDCP / WaterFix modelling, or to provide basic information on the existence of model documentation, version control, quality control, testing, and calibration information, and previous external technical reviews,[2] is also relevant and needs to be considered.

The Board is not required to rely on DWR and USBR for computer modelling for Board processes, or for assessment of model results submitted for the WaterFix Change Petition Hearing. Water Code § 1525(c) allows the Board to set the Change Petition fee schedule to include "recoverable costs .. for prescribing terms of permits, …and change orders,… planning, modeling, reviewing documents prepared for the purpose of regulating the diversion and use of water…" Water Code § 85086(d) also mandates that the Board "shall enter into an agreement with the State Water Project contractors and the federal

[2] I incorporate by reference my June 9, 2016, letter, "Request for Extension and Missing Modeling Information."

Central Valley Project contractors, who rely on water exported from the Sacramento River watershed, or a joint powers authority comprised of those contractors, for reimbursement of the costs of the analysis conducted pursuant to this section." This includes § 85086 (c)(2).

Evaluation of Testimony by Armin Munevar on CalSim model reliability

Armin Munevar is the engineer testifying on the hydrologic modelling for the Petitioners. Mr. Munevar's resume states that he was the Integration Lead in the development and application of the physical modelling. Mr. Munevar's submitted testimony in DWR-71 is what supports the proposed uses of the CalSim model in the hearing.

Many statements in Munevar's testimony about the CalSim model are contradicted by statements by the qualified and disinterested experts who served on the 2003 and 2006 peer review panels, and even by statements by the Petitioners, as outlined below. The following compares Munevar's testimony with excerpts from reports by the 2003 and 2006 peer review panels, the 2004 response to the peer review reports by DWR and USBR, and the 2008 FWS Biological Opinion on Delta Smelt.

I. Acceptance of the model

Output from the CalSim model has not been accepted as reliable by experts in the field, in large part because of the failure by the Petitioners to document adequate model testing and calibration. The 2003 Peer Review stated:

> *Better quality control is needed both for the model and its current version and the input data. Procedures for model calibration and verification are also needed. Currently many users are not sure of the accuracy of the results. A sensitivity and uncertainty prediction capability and analysis is needed. (p. 8)*

The 2006 Peer Review of the San Joaquin River component of the model stated:

> *CalSim II work fails to adequately report technical results that would give knowledgeable readers some sense of the quality, accuracy, sensitivity, or uncertainty present in the results. This issue was prominent in the previous CalSim review panel report (Close, et al., 2003). (p. 10)*

Mr. Munevar states in his testimony,

> *It is a well-accepted model and has been used in multiple planning and regulatory processes, including but not limited to, the 2008 Fish and Wildlife Service and 2009 National Marine Fisheries Service Endangered Species Act consultation on coordinated operations of the CVP and SWP ("2008 FWS BiOp" and "2009 NMFS BiOp"), and the related federal litigation. (p. 7)*

This statement is misleading. While the CalSim model was used in the 2008 and 2009 Biological Opinion, the lack of calibration of the model was an issue for the Fish and Wildlife Service biologists, who found that the models of interior Delta flows were too inaccurate for use. The following is from the 2008 2008 Fish and Wildlife Service *Formal Endangered Species*

Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP) (Exhibit SWRCB-87):

> *The biological assessment suggested using CALSIM II study 7.0 as the current baseline, and 6.1 as the historical baseline but the CALSIM monthly simulation model does not capture a precise Delta operation. When Study 6.1 was modeled, changes were expected between Study 6.1 and Studies 7.0 and 7.1 but the results in the August 2008 biological assessment were nearly identical.[p. 204]*

The biologists also stated that the previous CalSim model runs (May 2008) had shown a difference between the historical baseline and the current baseline. The discrepancy between the May 2008 and August 2008 model runs was apparently never adequately explained by Reclamation. The biologists decided to instead use actual historical data to construct a baseline:

> *The inaccuracies in CALSIM lead us to use actual data to develop an empirical baseline. We also developed historical time series data for hydrologic variables used in this effects analysis based on the DAYFLOW database (http://iep.water.ca.gov/dayflow/index.html) and OMR data obtained from USGS. We calculated monthly or multiple month averages or medians based on these daily hydrology data sets. The historical time series are intended to show where changes in water project operations have caused or contributed to changed Delta hydrology and to serve as an empirical baseline of SWP and CVP operations for comparison to proposed futures modeled using CALSIM II.* [p. 206]

The Fish and Wildlife Service biologists' use of actual, empirical Delta flow data for the Biological Opinion was disputed by Petitioners. Petitioners asserted that the model results could not be compared with historical data. Mr. Munevar has reiterated this assertion in his testimony:

> *Because it is a simulation, based on a combination of historical hydrology, the current regulatory environment and projected changes to the hydrology due to climate change, CalSim II cannot be calibrated and therefore, should not be used in a predictive manner. [p.12]*

As documented below, this statement is inconsistent with recommendations by peer reviewers, and with previous statements by the Petitioners in the 2004 Peer Review Response.

II. State of the Art

Mr. Munevar referred in his testimony to an opinion by the 2003 peer review panel that CalSim is "state-of the art." The 2003 Peer Review did confirm that the general modelling approach of using a constraint language and a linear optimization solver was comparable to other models of major water basins. But this was only validation of the Simulation Conceptual Model, which is very different than validation of the model itself. The following statements were quoted in the 2004 Peer Review response, and Mr. Munevar's testimony on p. 8:

> *We believe the use of an optimization engine for simulating the hydrology and for making allocation decisions is an appropriate approach and is in fact the approach many serious efforts of this kind are using.*

And,

> *CalSim II represents a state-of-the art modeling system that is similar in general concept, while differing in specific details, to other data driven river basin modeling systems such as ARSP, MODSIM, OASIS, REALM, RiverWare, and WEAP.*

Mr. Munevar should have been clear that this statement was a validation of the CalSim Simulation Conceptual Model, defined above. The conceptual model of a simulation includes the choice of a general modelling approach, and the overall structure of the model. Validation of the full model requires testing and calibration of the components of the model, not just review of the general approach and overall structure. This testing and calibration of the model components was recommended by the 2003 Peer Review panel.

Mr. Munevar also states,

> *CalSim II has also been peer reviewed as part of the publication of the model. See, Draper, A.J., Munévar, A., Arora, S. K., Reyes, E., Parker, N.L., Chung, F.I., Peterson, L.E. 2004. CALSIM: Generalized Model for Reservoir System Analysis, Journal of Water Resources Planning and Management, 130:6(480) (p. 8)*

A review of the journal article shows that it is a description of the model at the Simulation Conceptual level. The review for publication of a general description of the model and modelling approach is not the same as a technical peer review of the model. Since Mr. Munevar is the Integration Lead for the BDCP / WaterFix physical modeling, his confusion on these points raises significant issues about the reliability of the entire model process.

Mr. Munevar may also have forgotten that the 2003 Peer Review was only at a strategic level. The 2003 Peer Review panel noted that the information provided for review "precluded a thorough technical analysis," and stated that such a technical review should be carried out:

> *The information we received and the shortness of our meetings with modeling staff precluded a thorough technical analysis of CALSIM II. We believe such a technical review should be carried out. Only then will users of CALSIM II have some assurance as to the appropriateness of its assumptions and to the quality (accuracy) of its results. By necessity our review is more strategic. It offers some suggestions for establishing a more complete technical peer review, for managing the CALSIM II applications and for ensuring greater quality control over the model and its input data, and for increasing the quality of the model, the precision of its results, and their documentation. (p. 3)*

The 2003 review panel also recommended:

> *To increase the public's confidence in the many components and features of CALSIM II, we suggest that these components of CALSIM be subjected to careful technical peer review by appropriate experts and stakeholders. (p. 2)*

However, except for the San Joaquin River component of the model, a "careful technical peer review" appears never to have been done, and there have been continuing questions about the reliability of the model, particularly by stakeholders.

The 2006 Peer Review of the San Joaquin River component of the model noted some significant issues, and stated,

> *The panel does not in any way certify or endorse the model presented. On the other hand, we do not disapprove of or discourage its use by knowledgeable users. […]*
>
> *Users must take responsibility for model selection and application, and they must accept the responsibility for decisions that they make with information produced by the model. Relying on an external body to provide a blanket endorsement covering all possible applications is a dangerous practice. It tempts users to avoid accountability for their work. It tempts decisionmakers to place responsibility on general model reviews which are remote from a particular application. Further, it opens the door to intentional and unintentional abuse, negligence or complacency by model users and developers, or their managers who may shift responsibility to tools or some external general review panel for decisions made or actions recommended based on their use of a model. (p. 8, emphasis added.)*

Mr. Munevar's reliance on the 2003 Peer Review for implied endorsement of the use of the CalSim II model for the WaterFix hearing raises significant questions about the reliability of the model.

III. Reservoir, Demand, and Operations modelling

A. Historical Period

Mr. Munevar's testimony states,

> *DWR completed a quasi-validation of the CALSIM II model in 2003. […]*
> *The CalSim II Simulation Study showed that CalSim II could approximate historic trends suggesting that CALSIM II was a reasonable tool for water resource planning. The CalSim II Simulation Study results that are summarized in Exhibit DWR-514, p.3, Table 2 show that simulated SWP Table A and CVP south-of-Delta deliveries during the drought (1987-1992) were within 5 percent of historical values, suggesting a close fit between simulated and actual values. (p. 8)*

However, the 2003 Peer Review panel noted some issues with the "quasi-validation," stating:

> *Because the SWP south of delta demands were set to historical deliveries in many years, comparison with the historical deliveries in the validation report is of limited validity. (p. 68)*

The 2003 Peer Review panel recommended a full calibration and validation of the model:

> *A Calibration/Validation report should be very useful in demonstrating the accuracy of the model. However there are a number of elements in the CALSIM II validation run and the validation report which reduce that confidence including:*
>
> - *State Water Project (SWP) demands south of the Delta were set at historical deliveries in years with no restriction and at the contractor's request level in restricted years. Neither of these pieces of information is available to a production run which calculates demand based on crop areas. Therefore the validation run does not provide reliable information on how well the model can represent these demands.*
>
> *[…]*
>
> - *The DWR (2003) report produces estimates of SWP and Central Valley Project (CVP) deliveries south of the Delta but then adjusts them for changes in storage before presenting comparisons of those results with observed deliveries. This process merely checks that the model is preserving a water balance and does not present a legitimate validation of model deliveries.*
> - *The report provides statistics on long term average deliveries and flows but no statistics on the fit for individual years. Additional analysis of the output would assist stakeholders to assess whether the estimate of water supply reliability and in particular the modeled volumes of water available in the most restricted years are accurate.*
> - *In some instances, such as the examination of water quality in the Delta, the ability to accurately model monthly flows and deliveries will be important. The validation report contains no information that would enable the ability to model monthly flows to be assessed.*
> - *A key model output is the water quality in the Delta. It would assist the validation of the model if a comparison of parameters such as the location of the X2 boundary was provided. (p. 31)*

It should be noted that some of the recommended validation elements are essential to validating the proposed use of the model in the hearing to show "no harm" to other users of water. This includes accurate modelling of monthly flows and water quality in the Delta.

The reviewers also noted:

> *Most successful applications of optimization that attempt to simulate the behavior of a system have calibrated their objective functions (i.e., set the weights that prioritize flows over time and space) so that the model results correspond to what actually happens or would happen under a particular hydrologic and demand scenario. In these cases the*

> *model's decisions correspond to those the operators would make, as often prescribed by rules that have been worked out in a legal/political process. It does not appear that such a calibration of the objective function weights in CALSIM has yet been completed. (p. 4)*

The Petitioners responded that historic validation was not desirable, stating that reservoir operations were subject to change, stating in part:

> *…DWR and Reclamation suggest that a more reasonable approach to defining behavioral parameters is through discussions with system operators to define* current *operational policy or rules. California's water system, especially with regard to the Delta, has undergone many changes in the 1990s (Delta Water Quality Control Plan, CalFed, ESA actions, CVPIA (b)(2), Environmental Water Account) so that calibration to historical practice has limited value. It would appear more reasonable to define operating rules in conversations with operators and subsequently use a recent wet, normal and dry year in a validation exercise. [p. 19, emphasis in original]*

However, since 2004, no limited validation has been reported.

B. Current Period

As indicated in the 2004 Peer Review response, all that is required for testing of the CalSim model is a version that simulates existing biological conditions. These versions were produced for the Preliminary and Administrative Drafts of the Bay Delta Conservation Plan Draft EIR/EIS, as well as for the 2015 Delivery Reliability Report, on which the WaterFix hearing model was based. These models could have been tested with a data set for the years since the Biological Opinion (2009-2015) However, the only publicly available input data set for CalSim is from 1922 to 2003.

Failure to produce a current period data set not only precludes testing of the current operations model, it also makes it extremely difficult for independent experts to assess the validity of any given model version.

Mr. Munevar's testimony states,

> *One noteworthy difference in the current modeling is that CalSim II results show that the September upstream reservoir releases are consistently lower in the drier years compared to the historical values. Although there are detailed model inputs and assumptions, the CalSim II results may differ from real-time operations given that not all of the regulatory requirements (e.g. upstream temperature requirements, reservoir release ramping rates, etc.) or real-time operational adjustments to Shasta operations are modeled in CalSim II. [p.11]*

Without documentation of the "detailed model inputs and assumptions" and the current year validation proposed by DWR and USBR in the 2004 Peer Review response, it is difficult to even evaluate this statement.

C. Future Period

Mr. Munevar admits that the modelling of future reservoir operations during extended droughts is not realistic. His testimony states,

> *When system wide storage levels are at or near dead pool, also described as stressed water supply conditions, the CalSim II model results should only be an indicator of stressed water supply conditions and should not necessarily be understood to reflect actually what would occur in the future under a given scenario. (p. 12)*

The embedded parameters in the simulation include the objective function, the weights on storage zones in the reservoirs, and delivery targets when storage is low. Without detailed documentation of the settings of these parameters, and sensitivity analyses comparing different parameter settings, it cannot be determined whether this failure to accurate model reservoir operations during "stressed water supply conditions" is due to modelling assumptions or to model limitations.

IV. Hydrologic modelling

A. Mass Balance

Mass balance in hydrologic models concern whether water is conserved in the model, i.e., whether errors cause the model to create or lose water. The 2003 Peer Reviewers noted:

> *Large simulation models using optimization and procedural rules both need to have internal checks to ensure to the extent possible that errors in mass balances, for example, do not occur due to errors made when the model is being defined or created. Such internal checking is not apparent to us in our admittedly brief review of CALSIM II. Nor were calibration procedures well defined. (p. 5)*

There are still significant questions about internal error checking and calibration procedures.

V. Relative use

In his submitted testimony, Mr. Munevar states that the CalSim II model can be used in relative mode:

> *CalSim II results are intended to be used in a comparative manner, which allows for assessing the changes in the SWP/CVP system operations and resulting incremental effects between two scenarios. The model should be used with caution where absolute results are needed in instances such as determining effects based on a threshold, prescribing seasonal operations, or predicting flows or water deliveries for any real-time operations… In summary, the CalSim II and DSM2 results should only be used comparatively" (pp. 12-13).*

However, the 2003 Strategic Review panel was "somewhat skeptical" of this proposed use of the model by the Petitioners, and stated that the feature would need to be "documented rather than merely assumed":

> *Modelers sometimes make a distinction between the use of a model for absolute versus comparative analyses. In an absolute analysis one runs the model once to predict an outcome. In a comparative analysis, one runs the model twice, once as a baseline and the other with some specific change, in order to assess change in outcome due to the given change in model input configuration. The suggestion is that, while the model might not generate a highly reliable absolute prediction because of errors in model specification and/or estimation, nevertheless it might produce a reasonably reliable estimate of the relative change in outcome. The panel is somewhat skeptical of this notion because it relies on the assumption that the model errors which render an absolute forecast unreliable are sufficiently independent of, or orthogonal to, the change being modeled that they do not similarly affect the forecast of change in outcome; they mostly cancel out. <u>This feature of the model is something that would need to be documented rather than merely assumed</u>.* [p. 6, emphasis added.]

The 2006 Peer Review panel also recommended documentation of model assumptions and error analyses. Under "Uncertainty in Model Results," the reviewers noted:

> *Currently no general guidance is available to indicate whether differences of 1 taf, 50 taf, 100 taf, or 500 taf are significant enough to rise above the level of error and noise inherent in the model.* [p. 13],

and recommended

> *At a minimum, error analyses should be conducted, combining a sensitivity analysis of critical model results to some of the largest and least well supported model assumptions with an assessment of the likely range of error in these major model parameters and assumptions. [p. 13]*

As discussed below, the submitted documentation of model assumptions, and the error analyses are insufficient to support the proposed use of the model results in the hearing.

VI. Submitted Documentation of Model Assumptions and Error Analyses

The table of model assumptions presented by the Petitioners as Exhibit DWR 15 is at the Simulation Conceptual Model level of detail, i.e., it serves to document the specification of assumed regulatory and operating requirements for the model. It does not document the detailed assumptions used by the model components in simulating the operations to meet these requirements, or the detailed assumptions used in setting of model parameters.

The error analyses presented by the Petitioners also do not meet the recommendations of the 2012 scientific panel on "Analytical Tools for Evaluating Water Supply, Hydrodynamic and Hydropower Effects" for use of model results in Board proceedings. The panel made very specific recommendations with respect to calibrating and testing model representations of the Delta, reproduced below. Some of the underlined flows below are represented by CalSim II.

Some Key Aspects in Calibrating and Testing a Delta Hydrodynamics Model
In the testing and calibration of a Delta hydrodynamic and water quality model, the panel suggests several key aspects to examine. These include:

- Matching point observations of Stage, Flow, Salinity (EC) on tidal and tidally averaged (net) basis
- Matching key interior net-flow splits: Sacramento River to Sutter and Steamboat Sloughs; Sacramento River to Delta Cross Channel and Georgianna Slough; San Joaquin River to Old River at Head; San Joquin River to Old River and Middle River; net flows around Franks Tract; flow between the Sacramento River and San Joaquin through Threemile Slough
- Representing gate/barrier operations: DCC, Suisun Marsh Salinity Control Gate, south Delta barriers, Clifton Court Gates
- Representing Delta Island Consumptive Use
- Representing Delta Exports
- Representing low flow, high flow, and transition periods
- Representing the yearly cycle of salt intrusion and flushing
- Representing spring-neap tidal variation

(p. 5)

Mr. Munevar's testimony includes an attempt to do an error analysis for flow at Freeport, for the Net Delta Outflow Index, and for the Delta exports:

A comparison of Sacramento Valley inflow to the Delta (flow at Freeport) is a good measure of how well Sacramento Valley hydrology is simulated by CalSim II. Exhibit DWR-514, p. 3, Table 2 shows that for this quasi-validation run CalSim II simulated Delta inflows were 0.3 percent greater than historical, a reasonably close fit between simulated and actual values.

Comparison of the Net Delta Outflow Index, a measure of how well the Sacramento-San Joaquin Delta is represented by CalSim II, also show a close fit between simulated and actual. Exhibit DWR-514, p. 3, Table 2 shows simulated values are 3.5 percent less than historical during the 1987-1992 time-period. This exhibit also shows that simulated long-term (1975-1998) average deliveries compare quite well and are within 7 percent of historical values, suggesting a reasonably close fit between simulated and actual values. [p.9]

There are three issues with this error analysis.

1. The analysis is incomplete, in that it does not include analysis of interior Delta flow splits. The analysis also only compares long term averages. It includes no statistics on the fit for individual years. The 2003 Peer Review panel recommendations (cited in part A), indicate that these statistics are required to evaluate the accuracy of the model for the most restricted years. The analysis also provides no information on the ability of the model to match monthly flows under different year types.

2. As noted by the 2003 Peer Review panel, the Historical Operations Study did not use the same demands as those used by the CalSim model it was supposed to validate.

3. The CalSim model has changed since the Historical Operations Study was done in 2003, so the error analysis may not be relevant to the 2015 version of the model. The statement by DWR and USBR in the 2004 peer review response (cited above) indicates that operating rules for the reservoirs may also have changed. Both demands and reservoir operations clearly affect inflow to the Delta, as well as the Net Delta Outflow Index.

To be relevant, the Historical Operations Study would need to be redone using the current version of the model, and the current operating parameters, including actual export demand settings, WSI-DI curves, and reservoir rule curves. This requirement to use the actual operating parameters for validation was previously noted by the 2003 Peer Review panel.

It is also concerning that the Historical Operations Study model code has not been identified by the Petitioners or made available to the hearing. The model code needs to be presented with a complete and accurate set of changes between the 2003 Historical Operations Study model version and the 2015 version used as the basis for the WaterFix hearing models. Without this information, it is impossible to independently evaluate whether the Historical Operations Study has any relevance to the 2015 CalSim model version.

VII. Sensitivity analyses and climate change

Although sensitivity analyses have been done for reservoir inflows, they appear to use very small perturbations. The sensitivity analyses for the San Joaquin River component of the model only tested the model for inflows of +/- 3%. This may be much smaller than perturbations to inflows under climate change. The Petitioner's graph of the 3 year average of the Eight River Index, which includes the San Joaquin Valley, showed that it was the lowest in the historic period in 2015.

Mr. Munevar's testimony also states that

> *All operational scenarios modeled for purposes of this hearing make the same climate change assumptions. Because the assumptions are the same, climate change is not a variable that will be expected to affect the comparison of results.*

Climate change projections are uncertain, particularly for changes in precipitation and runoff. Given the problems that Petitioners have had with meeting D-1641 standards in the recent drought, it seems essential for the Board to also consider proposed operations under the drier climate change scenarios. These sensitivity analyses are being used for the Biological Assessment, which also uses the 2015 CalSim model. It should not be difficult for the Petitioners to produce for the current hearing.

Evaluation of Testimony by Armin Munevar and Parvis Nader-Tehrani on DSM2 model reliability

Mr. Nader-Tehrani directed staff at the Department of Water Resources who were performing the hydrodynamic modeling presented to demonstrate compliance with water quality. It is Mr. Tehrani's testimony (DWR-66) which certifies the DSM2 model results for use in the hearing.

Mr. Tehrani states, "It is my opinion that the model results are accurate" (p. 2.) However, Mr. Tehrani fails to include any discussion of the DSM2 model testing, calibration and validation. Without this discussion, it is impossible to evaluate whether there is adequate basis for Mr. Tehrani's opinion.

Mr. Munevar's testimony refers to the 35th Annual Progress Report required by the State Water Resources Control Board in Decision 1485. The annual report states

> *For the first time in its use, DSM2, the 1D hydrodynamic and water quality simulation model of the Sacramento-San Joaquin Delta, is being calibrated in a quantitative manner with mathematically-based techniques.* [p. 23]

The report describes the proposed calibration method, but does not include any results. It states only,

> *As of this writing, we have confirmed that DSM2 is a suitable candidate for calibration using PEST.* [p. 29]

Mr. Tehrani states,

> *Model results at times show modeling anomalies. A small fraction of these anomalies represent modeled exceedances at some locations.* (p. 2)

Without documented model calibration, and an analysis of the alleged anomalies, it is unclear whether the results are truly anomalies or simply indications that the model is not adequately calibrated.

Mr. Tehrani also does not discuss whether the model meets the conditions specified by the 2012 panel on "Analytical Tools for Evaluating Water Supply, Hydrodynamic and Hydropower Effects." The recommendations for matching point observations of Stage, Flow, Salinity (EC) and representing the yearly cycle of salt intrusion and flushing, and representing spring-neap tidal variation are essential.

Appendix 2 of the report included a letter from 24 members of the modelling community, which detailed specific needs for comparison of DSM2 with 3D model outputs in order for it to be used for modeling sea level rise. The modelers stated,

> *Given the controversial nature of policy-making in the Bay-Delta, these needs must be met with a high level of scientific transparency, proper verification and validation, adequate documentation, and rigorous peer review.* (p. 12)

Information on the calibration of the DSM2 model version used for the WaterFix hearing appears not to have been submitted, nor has there been peer review of the DSM2 model version or model version results. The August 2013 memo to Cathy Crothers (Exhibit DWR-511) does not substitute for calibration, validation, and peer review.

Department of Defense

INSTRUCTION

NUMBER 5000.61

May 13, 2003

USD(AT&L)

SUBJECT: DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)

References: (a) DoD Instruction 5000.61, "DoD Modeling and Simulation (M&S) Verification, Validation, and Accreditation (VV&A)," April 29, 1996 (hereby canceled)
(b) DoD Directive 5000.59, "DoD Modeling and Simulation (M&S) Management," January 4, 1994
(c) DoD 5025.1-M, "Department of Defense Directives System Procedures," March 5, 2003
(d) DoD Directive 5141.2, "Director of Operational Test and Evaluation (DOT&E)," May 25, 2000
(e) through (p), see enclosure 1

1. REISSUANCE AND PURPOSE

This Instruction:

1.1. Reissues reference (a) to implement policy, assign responsibilities, and prescribe procedures under reference (b) for the verification, validation, and accreditation (VV&A) of DoD models and simulations and their associated data.

1.2. Authorizes publication of DoD 5000.61-G, "DoD Verification, Validation, and Accreditation Guide," consistent with DoD 5025.1-M (reference (c)).

2. APPLICABILITY AND SCOPE

This Instruction applies to:

2.1. The Office of the Secretary of Defense (OSD), the Military Departments, the Chairman of the Joint Chiefs of Staff, the Combatant Commands, the Office of the Inspector General of the Department of Defense, the Defense Agencies, the DoD Field Activities, and all other organizational entities in the Department of Defense (hereafter referred to collectively as "the DoD Components").

2.2. All models and simulations developed, used, or managed by the DoD Components after the effective date of this Instruction.

2.3. Models and simulations used in support of Operational Test and Evaluation (OT&E), all of which are subject to guidance from the Director, OT&E, per DoD Directive 5141.2 (reference (d)).

3. DEFINITIONS

Terms used in this Instruction are defined in enclosure 2.

4. POLICY

It is DoD policy that:

4.1. Models and simulations used to support major DoD decision-making organizations and processes (such as the Defense Planning and Resources Board; the Joint Requirements Oversight Council; and the DoD Planning, Programming, and Budgeting System (references (e) through (g)) shall be accredited for that specific purpose by the DoD Component M&S Application Sponsor.

4.2. Each DoD Component shall be the final authority for validating representations of its own forces and capabilities in common-, general-, or Joint-use M&S applications and shall be responsive to the other DoD Components to ensure its forces and capabilities are appropriately represented.

4.3. Models and simulations used to support joint training and joint exercises shall be accredited for that specific purpose by the DoD Component M&S Application Sponsor.

4.4. Accreditation requirements of models and simulations used to support all other applications shall be determined at the DoD Component level.

4.5. The DoD Components shall establish VV&A policies and procedures for models and simulations they develop, use, or manage.

4.6. Each DoD Component shall comply with the responsibilities identified in section 5. and procedures identified in section 6.

5. RESPONSIBILITIES

5.1. The Under Secretary of Defense for Acquisition, Technology, and Logistics shall:

5.1.1. In coordination with the DoD Components, develop policies, plans, procedures, and DoD issuances for the effective implementation and management of VV&A of DoD M&S.

5.1.2. Through the Director, Defense Research and Engineering, as Chair of the DoD Executive Council for Modeling and Simulation (EXCIMS):

5.1.2.1. Encourage improved communication and coordination among and between organizations and agencies conducting DoD VV&A activities.

5.1.2.2. Identify and support investments in VV&A enabling technologies that have high-value return in fulfilling DoD requirements, or that fill gaps in DoD VV&A capabilities.

5.1.2.3. Promote joint and cooperative research, development, acquisition, and application of VV&A technologies and processes among the DoD Components.

5.1.2.4. Establish standards and guidelines to promote DoD VV&A procedural commonality and foster M&S interoperability.

5.1.2.5. Arbitrate differences in representation of forces and capabilities among the DoD Components to ensure standardization in common, general, or Joint-use M&S applications and federations of models and simulations.

5.1.3. Designate the Defense Modeling and Simulation Office as the "DoD VV&A focal point" and the central source of DoD VV&A information.

5.1.4. Comply with responsibilities specified in paragraph 5.3.

5.2. The Assistant Secretary of Defense for Command, Control, Communications, and Intelligence shall:

5.2.1. Through the Director, Defense Intelligence Agency:

5.2.1.1. As the DoD Modeling and Simulation Executive Agent (MSEA) for M&S representations of foreign forces, for other DoD Components' representations of foreign forces, and their systems shall:

5.2.1.1.1. Serve as the final validation authority (reference (b));

5.2.1.1.2. Resolve validation issues; and

5.2.1.1.3. Be responsive to that DoD Component to ensure that foreign forces and capabilities are appropriately represented (reference (b)).

5.2.1.2. As the DoD MSEA for M&S representations of U.S. National and Joint Intelligence processes, for other DoD Components' representations of U.S. National and Joint Intelligence processes shall:

5.2.1.2.1. Serve as the final validation authority (reference (b));

5.2.1.2.2. Resolve validation issues; and

5.2.1.2.3. Be responsive to that DoD Component to ensure that intelligence processes and capabilities are appropriately represented (reference (b)).

5.2.2. Comply with responsibilities specified in paragraph 5.3.

5.3. The Principal Staff Assistants (PSAs) and the Heads of the DoD Components shall:

5.3.1. Plan and provide resources, as needed, to carry out functional VV&A responsibilities according to DoD Component priorities.

5.3.2. Approve DoD VV&A policies and procedures, and DoD Publications.

5.3.3. Ensure non-DoD M&S applications they sponsor comply with established DoD VV&A policies and procedures.

5.3.4. Establish VV&A policies, procedures, and guidelines for M&S applications and their associated data. DoD Component VV&A policies and procedures shall address, as a minimum:

5.3.4.1. Use of existing or new models and simulations, including those that are federates or federations.

5.3.4.2. DoD Component-managed models and simulations used for joint-, general-, or common-use applications.

5.3.4.3. Models and simulations used by the DoD Components that are developed, used, or managed by non-DoD organizations, (i.e., contractors (including federally funded Research and Development Centers), industry, academia, and other Federal or non-Federal government organizations).

5.3.4.4. Designation, authorities, and responsibilities of:

5.3.4.4.1. M&S Proponent(s).

5.3.4.4.2. M&S Application Sponsor(s).

5.3.4.4.3. Verification, Validation, and Accreditation Agent(s).

5.3.4.4.4. DoD Component M&S VV&A focal point(s).

5.3.4.5. VV&A documentation and accessibility requirements, as outlined in enclosure 3.

5.3.4.6. Application-specific data verification and validation activities that are included as an integral part of M&S V&V, accreditation, and documentation activities.

5.3.5. Establish procedures holding the following accountable and responsible for the activities indicated:

5.3.5.1. M&S Proponents:

5.3.5.1.1. Verification and validation of their assigned M&S, as well as the documentation of those activities.

5.3.5.1.2. Coordinating validation activities with the DoD Component who serves as the final authority for the validations of representations within its purview.

5.3.5.1.3. Funding the V&V over the life cycle (e.g., development, upgrades, and maintenance) of their models and simulations.

5.3.5.1.4. For distributed modeling and simulation or federations of models or simulations (hereafter collectively referred to as "federations"):

5.3.5.1.4.1. The M&S Proponent roles and responsibilities pertaining to V&V for the overall federation shall be fulfilled by the DoD Component organization responsible for managing a federation and its associated data.

5.3.5.1.4.2. The responsibility for V&V of a federate and its associated data shall be retained by the M&S Proponent for each federate within a federation.

5.3.5.2. M&S Application Sponsors:

5.3.5.2.1. As the Accreditation Authority, accrediting M&S used for their specific application(s), as well as the documentation of those activities.

5.3.5.2.2. Funding the VV&A activities that support their application-specific accreditation decisions.

5.3.5.2.3. Consulting with the appropriate MSEA during VV&A plan development if the models and simulations will involve representations within the domain of the MSEA.

5.3.5.2.4. Accrediting the federation and its associated data for the specific purpose shall be the responsibility of the DoD Component serving as the M&S Application Sponsor of a federation.

5.3.5.3. Individual Data Producers:

5.3.5.3.1. The quality of their data or data products provided for M&S use.

5.3.5.3.2. Supplying data quality information, including data verification and validation reports for data or data products provided for M&S use.

5.3.6. Designate a "Component VV&A focal point" to interface with the DoD VV&A focal point for their VV&A policies, activities, and documentation.

5.3.7. Document and make accessible to the other DoD Components the results of their VV&A activities, including, but not limited to, information and data on their DoD Component VV&A policies and procedures, V&V results, and accreditation decisions.

5.3.8. When designated as a DoD MSEA:

5.3.8.1. Upon request, provide domain information and expertise in support of VV&A activities.

5.3.8.2. Make certain that data quality information is available and accessible to support the individual DoD Component's VV&A activities.

5.4. The Chairman of the Joint Chiefs of Staff shall:

5.4.1. Establish VV&A policies, procedures, and guidelines to satisfy the needs of joint activities reporting to the Chairman of the Joint Chiefs of Staff.

5.4.2. In coordination with the other DoD Components, establish procedures for the validation and accreditation of joint M&S and federations of models and simulations used for joint applications.

6. PROCEDURES

6.1. Verification and validation (V&V) shall be:

6.1.1. Incorporated into the development and life-cycle management processes of all M&S.

6.1.2. Required for all models and simulations in current use in the Department of Defense.

6.1.3. Commensurate with the relative importance, risk, and life-cycle management phase of the model, simulation, or federation to which they are applied.

6.2. The V&V of a federation shall include a determination that:

6.2.1. Federation elements can physically connect and exchange data.

6.2.2. Federates, when joined together, provide adequate, accurate, and consistent simulated representations that adhere to the principles of fair fight and address the mission objectives.

6.3. Data V&V is an integral part of the M&S VV&A process and shall:

6.3.1. Be addressed, to include programming of V&V resources, at the earliest stages of a new model or simulation development or the upgrade of an existing model or simulation.

6.3.2. Be documented as part of the VV&A documentation requirements, as specified in enclosure 3.

6.4. VV&A information shall be documented and, as a minimum, shall include the information specified in enclosure 3.

7. EFFECTIVE DATE

This Instruction is effective immediately.

E. C. Aldridge, Jr.
Under Secretary of Defense
(Acquisition, Technology and Logistics)

Enclosures - 3

E1. References, continued
E2. Definitions
E3. VV&A Documentation Format and Accessibility Requirements

E1. ENCLOSURE 1

REFERENCES, continued

(e) DoD 5000.2-R, "Mandatory Procedures for Major Defense Acquisition Programs (MDAPS) and Major Automated Information System (MAIS) Acquisition Programs," April 5, 2002
(f) DoD Directive 7045.14, "The Planning, Programming, and Budgeting System (PPBS)," May 22, 1984
(g) Chairman of the Joint Chiefs of Staff Instruction 5123.01, "Charter of the Joint Requirements Oversight Council," March 8, 2001
(h) DoD 5000.59-M, "DoD Modeling and Simulation (M&S) Glossary," January 15, 1998
(i) Title 10, United States Code
(j) DoD Directive 5111.1, "Under Secretary of Defense for Policy (USD(P))," December 8, 1999
(k) DoD Directive 5118.3, "Under Secretary of Defense (Comptroller) (USD(C))/Chief Financial Officer (CFO), Department Of Defense," January 6, 1997
(l) DoD Directive 5124.2, "Under Secretary of Defense for Personnel And Readiness (USD(P&R))," October 31, 1994
(m) DoD Directive 5134.1, "Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L))," April 21, 2000
(n) DoD Directive 5137.1, "Assistant Secretary of Defense for Command, Control, Communications, and Intelligence (ASD(C3I))," February 12, 1992
(o) DoD 8320.1-M, "Data Administration Procedures," March 29, 1994
(p) Chairman of the Joint Chiefs of Staff Instruction (CJCSI) 3500.02C, "Joint Training Master Plan 2002 for the Armed Forces of the United States," August 14, 2000

E2. ENCLOSURE 2

DEFINITIONS

E2.1. GENERAL

Definitions used in this Instruction are divided into two sections: those terms established or continued in this DoD Instruction and terms adopted from other DoD issuances.

E2.2. TERMS ESTABLISHED OR CONTINUED

E2.2.1. Acceptability Criteria (Accreditation Criteria). A set of standards that a particular model, simulation, or federation must meet to be accredited for a specific purpose.

E2.2.2. Accreditation. The official certification that a model, simulation, or federation of models and simulations and its associated data are acceptable for use for a specific purpose (reference (b)).

E2.2.3. Accreditation Agent. The organization designated to conduct an accreditation assessment for an M&S application.

E2.2.4. Accreditation Authority. The organization or individual responsible to approve the use of a model, simulation, or federation of simulations for a particular application. (See Modeling and Simulation (M&S) Application Sponsor, definition E2.2.29.)

E2.2.5. Common-Use M&S. M&S applications, services, or materials provided by a DoD Component to two or more DoD Components (reference (b)).

E2.2.6. Data Verification and Validation (V&V). The process of verifying the internal consistency and correctness of data and validating that it represents real-world entities appropriate for its intended purpose or an expected range of purposes. The process has two perspectives: the producer and the user process.

E2.2.7. Distributed M&S. A set of models and/or simulations operating in a common synthetic environment over a network with two or more nodes.

E2.2.8. DoD Component Verification, Validation, Accreditation (VV&A) Focal Point. An organization, designated by each DoD Component, as its authoritative, single point of contact for information and data on, as a minimum, that DoD Component's VV&A policies and procedures, V&V results, and accreditation documentation. The DoD Component VV&A focal point shall be the designated point of contact to work with the DoD VV&A focal point on VV&A issues.

E2.2.9. DoD Executive Council for M&S (EXCIMS). An organization established by the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD(AT&L)) and responsible for providing advice and assistance on DoD M&S issues. The EXCIMS includes the DoD M&S Executive Council, the DoD M&S Working Group, and the supporting Sub-Working Groups and Task Forces that support them. Membership is determined by the USD(AT&L) (reference (b)).

E2.2.10. DoD Issuance. DoD Directives, Instructions, Publications, and their Changes (reference (c)).

E2.2.11. DoD M&S Executive Agent (MSEA). A DoD Component to whom the USD(AT&L) has assigned responsibility and delegated authority for the development and maintenance of a specific area of M&S application, including relevant standards and databases, used by or common to many models and simulations (reference (b)).

E2.2.12. DoD M&S Investment Plan. A DoD plan, published under the authority of the USD(AT&L) and with the coordination of the DoD Components, that establishes short-term (present to 6 years) and long-term (beyond 6 years) programs and funding for joint and common use M&S to achieve the specified goals and objectives outlined in the DoD M&S Master Plan (reference (b)).

E2.2.13. DoD M&S Master Plan. A DoD plan, published under the authority of the USD(AT&L) and with the coordination of the DoD Components, that establishes short-term (present to 6 years) and long-term (beyond 6 years) DoD goals and objectives for the application of M&S for joint and common use within the Department of Defense. It shall also include an assessment of current M&S capabilities, a status report on M&S efforts under development, and a road map that delineates the management, investment, and technical strategies required to achieve DoD M&S objectives (reference (b)).

E2.2.14. DoD M&S Resource Repository (MSRR)

E2.2.14.1. A geographically distributed and networked series of automated information systems that contain unclassified, classified, or both classified and unclassified data and information on M&S that is accessible by DoD-authorized users.

E2.2.14.2. A single DoD node, source, or site that contains M&S data and/or information that may or may not be part of the DoD MSRR network.

E2.2.15. DoD Publications. A DoD issuance that implements or supplements a DoD Directive and/or Instruction by providing uniform procedures for management or operational systems and disseminating administrative information. DoD Publications include: Catalogs, Directories, Guides, Handbooks, Indexes, Inventories, Lists, Manuals, Modules, Pamphlets, Plans, Regulations, and Standards that implement or supplement DoD Directives or Instructions (reference (c)).

E2.2.16. DoD VV&A Focal Point (VFP). A DoD organization designated as the authoritative, single point of contact for DoD and non-DoD activities on the data and information on DoD VV&A policies, procedures and practices, V&V results, and accreditation documentation.

E2.2.17. Domain. The physical or abstract space in which the entities and processes operate. The domain can be land, sea, air, space, undersea, a combination of any of the above, or an abstract domain, such as an n-dimensional mathematics space, or economic or psychological domains (reference (h)).

E2.2.18. Federate. An individual model or simulation that is part of a federation of models and simulations. Federates may be distributed.

E2.2.19. Federation of Models and Simulations. A system of interacting models and/or simulations, with supporting infrastructure, based on a common understanding of the objects portrayed in the system. (See Federate, definition E2.2.18.)

E2.2.20. Functional Activity. The primary subdivision of a functional area, made up of a collection of processes that can be managed together using policies and procedures not specifically applicable to other functional activities within the functional area.

E2.2.21. Functional Area. A functional area (e.g., personnel) is comprised of one or more functional activities (e.g., recruiting), each of which consists of one or more functional processes (e.g., interviews).

E2.2.22. Functional Process. A well-defined (or definable) set of logically related tasks and decisions within a functional activity that use resources to produce products or services.

E2.2.23. General-use M&S. Specific representations of the physical environment or environmental effects used by, or common to, many models and simulations; e.g., terrain, atmospheric, or hydrographic effects (reference (b)).

E2.2.24. Joint M&S. Abstract representations of joint and Service forces, capabilities, equipment, materiel, and services used in the joint environment by two, or more, Military Services (reference (b)).

E2.2.25. Military Departments. The Department of the Army, the Department of the Navy, and the Department of the Air Force, including their National Guard and Reserve components.

E2.2.26. Military Services. The Army, the Navy, the Air Force, and the Marine Corps.

E2.2.27. Model. A physical, mathematical, or otherwise logical representation of a system, entity, phenomenon, or process (reference (b)).

E2.2.28. Modeling and Simulation (M&S). The use of models and simulations, either statically or over time, to develop data as a basis for making managerial or technical decisions. This includes, but is not limited to, emulators, prototypes, simulators, and stimulators.

E2.2.29. M&S Application Sponsor. The organization that accredits and uses the results or products from a specific application of a model or simulation.

E2.2.30. M&S Interoperability. The ability of a model or simulation to provide services to, and accept services from, other models and simulations, and to use the services so exchanged to enable these M&S to operate effectively together (reference (a)).

E2.2.31. M&S Proponent. The DoD Component organization that has primary responsibility to initiate development and life-cycle management of the reference version of one or more models and/or simulations.

E2.2.32. M&S VV&A Repository. A central library, catalog, registry, database, listing, or World Wide Web Internet site for VV&A data and information that may be part of DoD M&S Resource Repository.

E2.2.33. Office of the Secretary of Defense (OSD). Includes the immediate Offices of the Secretary and Deputy Secretary of Defense, the Under Secretaries of Defense, the Director of Defense Research and Engineering (DDR&E), the Assistant Secretaries of Defense (ASDs), the Director of Operational Test and Evaluation (DOT&E), the General Counsel of the Department of Defense (GC, DoD), the Inspector General of the Department of Defense (IG, DoD), the Assistants to the Secretary of Defense (ATSDs), the OSD Directors, or equivalents, who report directly to the Secretary or the Deputy Secretary of Defense, and such other staff offices as the Secretary of Defense establishes to assist in carrying out assigned responsibilities (reference (i)).

E2.2.34. Office of the Secretary of Defense (OSD) Components. The Undersecretaries of Defense and the Assistant Secretary of Defense (Command, Control, Communications, and Intelligence) and those Principal Staff Assistants and organizations over which they individually exercise authority, direction, control, or staff supervision as outlined in DoD Directives 5141.2, 5111.1, 5118.3, 5124.2, 5134.1, and 5137.1 (references (d) and (k) through (n)).

E2.2.35. Operational Test and Evaluation (OT&E). The field test, under realistic operational conditions, of any item (or key component) of weapons, equipment, or munitions for the purpose of determining the operational effectiveness and operational suitability of the weapons, equipment, or munitions for operational use, including combat, by typical military users, and the evaluation of the results of such test (reference (d)).

E2.2.36. Principal Staff Assistants. The Under Secretaries of Defense; the DDR&E, the ASDs; the Inspector General of the Department of Defense; the GC, DoD; the ATSDs; and the OSD Directors, or equivalents, who report directly to the Secretary or Deputy Secretary of Defense (reference (b)).

E2.2.37. Simulation. A method for implementing a model over time. Also, a technique for testing, analysis, or training in which real-world systems are used, or where real-world and conceptual systems are reproduced by a model (reference (b)).

E2.2.38. Simulation Conceptual Model. The developer's description of what the model or simulation will represent, the assumptions limiting those representations, and other capabilities needed to satisfy the user's requirements.

E2.2.39. Validation. The process of determining the degree to which a model and its associated data are an accurate representation of the real world from the perspective of the intended uses of the model (reference (b)).

E2.2.40. Validation Agent. The person or organization designated to perform validation of a model, simulation, or federation of models and/or simulations and the associated data.

E2.2.41. Verification. The process of determining that a model implementation and its associated data accurately represents the developer's conceptual description and specifications (reference (b)).

E2.2.42. Verification Agent. The person or organization designated to perform verification of a model, simulation, or federation of models and/or simulations and the associated data.

E2.3. TERMS THIS INSTRUCTION ADOPTS

E2.3.1. From DoD 8320.1-M (reference (o)):

E2.3.1.1. Data. A representation of facts, concepts, or instructions in a formalized manner suitable for communication, interpretation, or processing by humans or by automatic means.

E2.3.2. Data Quality. The correctness, timeliness, accuracy, completeness, relevance, and accessibility that make data appropriate for use.

E2.3.2. From Chairman of the Joint Chiefs of Staff Instruction 3500.02C (reference (p)):

E2.3.2.1. Exercise. A military maneuver or simulated wartime operation involving planning, preparation, and execution. It is carried out for the purpose of training and evaluation.

E2.3.2.2. Joint Exercise. A joint military maneuver, simulated wartime operation, or other Chairman of the Joint Chiefs of Staff/Combatant

Commander-designated event involving planning, preparation, execution, and evaluation. A joint exercise involves forces of two or more Military Departments interacting with a Combatant Commander or subordinate joint force commander; involves joint forces and/or joint staffs; and is conducted using joint doctrine or joint tactics, techniques, and procedures.

E2.3.2.3. Joint Training. Military training based on joint doctrine or joint tactics, techniques, and procedures to prepare joint forces and/or joint staffs to respond to strategic and operational requirements deemed necessary by the Combatant Commanders to execute their assigned missions. Joint training involves forces of two or more Military Departments.

E2.3.2.4. Multinational Exercises. Exercises that train and evaluate United States and other national forces or staffs to respond to requirements established by multinational force commanders to accomplish their assigned missions.

E2.3.2.5. Service Training. Military training based on Service policy and doctrine to prepare individuals and interoperable units. Service training includes basic, technical, operational, and interoperability training in response to operational requirements deemed necessary by the Combatant Commands to execute assigned missions.

E3. ENCLOSURE 3

VERIFICATION, VALIDATION, AND ACCREDITATION (VV&A) DOCUMENTATION FORMAT AND ACCESSIBILITY REQUIREMENTS

E3.1. DOCUMENTATION REQUIREMENTS

As a minimum, document verification and validation information supporting accreditation decisions as well as accreditation results as follows:

E3.1.1. For verification:

E3.1.1.1. Identify the verification agent(s) involved in the verification.

E3.1.1.2. Describe the model or simulation version or release and identify the developing organization.

E3.1.1.3. List or reference the M&S requirements.

E3.1.1.4. List and/or describe the verification methodologies and activities.

E3.1.1.5. Summarize the verification results.

E3.1.1.6. Identify any M&S limitations.

E3.1.2. For validation:

E3.1.2.1. Identify the validation agent(s) performing the validation.

E3.1.2.2. Identify the model, simulation, or M&S federation version and/or release and its developing organization.

E3.1.2.3. Describe the Simulation Conceptual Model.

E3.1.2.4. List, describe, and/or identify the validation methodologies and activities used, including the methods for validation of data.

E3.1.2.5. Summarize validation results.

E3.1.2.6. Specify any identified M&S limitations.

E3.1.3. For accreditation: The M&S Application Sponsor shall document accreditation results, to include, at a minimum, the following:

E3.1.3.1. Identify the M&S Application Sponsor.

E3.1.3.2. Identify the accreditation agent organization, if different from the M&S Application Sponsor.

E3.1.3.3. Identify the model, simulation, or federation version and/or release and the developing organization.

E3.1.3.4. Identify the M&S Application Sponsor's intended purpose for the model, simulation, and/or federation to be accredited.

E3.1.3.5. List or describe the requirements to be addressed by the model, simulation, or M&S federation.

E3.1.3.6. Identify, assess, and/or catalog those aspects of the model, simulation, and/or federation that are essential and pertinent to an accreditation decision, as appropriate. For example:

E3.1.3.6.1. Assumptions.

E3.1.3.6.2. Scenarios.

E3.1.3.6.3. Representations of concepts, processes.

E3.1.3.6.4. Environmental representations (e.g., natural and/or human environment: climate, weather, terrain, geographic, political, economic, etc.).

E3.1.3.6.5. Representations of missions, organizations, systems (weapon systems, combat support systems, combat service support systems) and their capabilities.

E3.1.3.6.6. Doctrine, tactics, behaviors, and performance algorithms used by each represented force (blue, red, white).

E3.1.3.6.7. Other information and data, as needed.

E3.1.3.7. Describe the accreditation methodology, including V&V activities, that support accreditation; data verification and validation; risk assessments; and, acceptability criteria.

E3.1.3.8. Assess or evaluate the capabilities and limitations of the particular data, specific model, simulation, or federation as they affect the appropriateness for the intended purposes.

E3.1.3.9. State the M&S Application Sponsor's accreditation decision regarding the acceptability of the model, simulation, or federation for the intended purpose.

E3.2. M&S VV&A DOCUMENTATION ACCESSIBILITY REQUIREMENTS

DoD M&S VV&A information and data should be readily accessible and available to DoD users. To meet this requirement, the DoD Components, to the extent that priorities and resources permit, shall:

E3.2.1. Establish a DoD Component M&S VV&A repository that identifies existing M&S VV&A documentation and ensures the timely addition of current, new, and future VV&A documentation.

E3.2.2. Establish procedures to allow DoD users to identify and access M&S VV&A documentation information and data.

STATEMENT OF SERVICE
CALIFORNIA WATERFIX PETITION HEARING

Department of Water Resources and U.S. Bureau of Reclamation (Petitioners)

I hereby certify that I have this day submitted to the State Water Resources Control Board and caused a true and correct copy of the following document(s):

CWR Evaluation of Testimony on Reliability of the Modeling

DOD MS VVA 5000.61

To be served by Electronic Mail (email) upon the parties listed in the Current Service List for the California Water Fix Petition Hearing, dated July 11, 2016, posted by the State Water Resources Control Board at

http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfis/service_list.shtml

Note: In the event that any emails to any parties on the Current Service List are undeliverable, you must attempt to effectuate service using another method of service, if necessary, and submit another statement of service that describes any changes to the date and method of service for those parties.

I certify that the foregoing is true and correct and that this document was executed on July 12, 2016.

Deirdre Des Jardins

California Water Research

Name: Deirdre Des Jardins
Title: Principal
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