Appendix 5A6 Model Limitations and Improvements

1 Introduction

Models are commonly used to evaluate changes in the management and operations of water resources systems. These models are computer based and use mathematical expressions, methods, and input data to represent hydrologic, physical, environmental, operational, and institutional aspects of the water resources systems. As complex as water resources systems are, the representation of the water resources system in input data, calculations and model outputs is understood to be simplified and generalized in comparison to what is observed in the historical records and documents that describe the real-world water resources system. Even so, models are useful tools in assessing historical, current, and future projected conditions of the water resources system. These conditions are described by models based on assumptions that are captured in the data and calculations used.

Because the representation of the water resources system in models is understood to be simplified and generalized in comparison to what is observed in the historical records and documents, the use of model results should be subject to a set of agreed upon limitations and subsequent analysis of results is thereby limited. The developers and expert users of the models in question should be consulted regarding these limitations. The following is a presentation of information that the team of modelers involved in the Sites project consider relevant to the limitations of the models and modeled scenarios. This information should be considered in use of the model results and any subsequent analysis derived from these model results.

2 General Limitations of Model Used

2.1 CALSIM II

CALSIM II is a monthly model developed for planning level analyses. The model is run for an 82-year historical hydrologic period, at a projected level of hydrology and demands; and under an assumed framework of regulations. Therefore the 82-year simulation does not provide information about historical conditions, but it does provide information about variability of conditions that would occur at the assumed level of hydrology and demand with the assumed operations, under the same historical hydrologic sequence. Because it is not a physically based model, CALSIM II is not calibrated and cannot be used in a predictive manner. CALSIM II is intended to be used in a comparative manner.

In CALSIM II, operational decisions are made on a monthly basis, based on a set of pre-defined rules that represent the assumed regulations. Modifications by the model user would be required to allow for variation in these rules based on a sequence of hydrologic events such as a prolonged drought, or statistical performance criteria such as meeting a storage target in an assumed percentage of years.

While there are certain components in the model that are downscaled to a daily time step (simulated or approximated hydrology), such as an air-temperature based trigger for a fisheries action, the results of those daily conditions are always averaged to a monthly time step. For example, a certain number of days with and without the action is calculated and the monthly result is calculated using a day-weighted average based on the total number of days in that month. Operational decisions based on those components are again made on a monthly basis. Any reporting or use of sub-monthly results from CALSIM II should include disaggregation methods that are appropriate for the given application, report, or subsequent model.

Appropriate use of model results is important. Despite detailed model inputs and assumptions, the CALSIM II results differ from real-time operations under stressed water supply conditions. Such model results occur due to the inability of the model to make unique real-time policy decisions under extreme circumstances, as the actual (human) operators must do. Therefore, results which indicate severely low storage, or inability to meet flow requirements or senior water rights should only be considered an indicator of stressed water supply conditions under that alternative, and should not necessarily be understood to reflect literally what would occur in the future under that alternative. These conditions, in real-time operations, would be avoided by making policy decisions on other requirements in prior months. In actual future operations, as has always been the case in the past, the project operators would work in real time to satisfy legal and contractual obligations given then current conditions and hydrologic constraints.

Reclamation’s 2008 BA on the coordinated long-term operations Appendix W (Reclamation 2008) included a comprehensive sensitivity and uncertainty analysis of CALSIM II results relative to the uncertainty in the inputs. This appendix provides a good summary of the key inputs that are critical to the largest changes in several operational outputs.

2.2 HEC 5Q

The model is one-dimensional in the vertical and longitudinal directions for reservoirs and rivers, respectively. HEC 5Q assumes fully mixed river cross sections. The effect of tributary inflow on river temperature is computed by mass balance calculation. When used with inputs derived from CALSIM II outputs, changes in results between two scenarios should be considered at a monthly timestep, consistent with the changes in inputs. HEC 5Q computes at a 6-hour timestep to capture the range of daily temperatures. Despite capturing sub-daily changes, a 6-hour timestep may not capture all variations in flow and climate conditions. Spatial resolution of the model may miss inflow from small tributaries or culverts, rapid changes in roughness, or variations in river slope.

HEC5Q was used for Sacramento, Trinity, and American Rivers.

2.3 Reclamation Temperature Model

Reclamation Temperature model is one-dimensional in the vertical direction for reservoirs. The reservoir is divided into isothermal, horizontal layers of uniform thickness. Energy exchange between the reservoir and the atmosphere is assumed to occur at the reservoir surface (Rowell 1990).

The model is one-dimensional in the longitudinal direction and assumes fully mixed river cross sections. The effect of tributary inflow on river temperature is computed by mass balance calculation. The river temperature calculations are based on regulating reservoir release temperatures, river flows, and climatic data. The model uses up to ten computational steps for each monthly timestep to approximate results for each month. Mean monthly flows and temperature do not capture daily variations in flow and climate conditions.

Reclamation's 1990 report (Rowell 1990) includes a comprehensive description of the Reclamation Temperature Model and its limitations.

The Reclamation Temperature Model was used for the Feather River.

2.4 DSM2

DSM2 is a one-dimensional model with inherent limitations in simulating hydrodynamic and transport processes in a complex estuarine environment such as the Sacramento – San Joaquin Delta. DSM2 assumes that velocity in a channel can be adequately represented by a single average velocity over the channel cross-section, meaning that variations both across the width of the channel and through the water column are negligible. DSM2 does not have the ability to model short-circuiting of flow through a reach, where a majority of the flow in a cross-section is confined to a small portion of the cross-section. DSM2 does not conserve momentum at the channel junctions and does not model the secondary currents in a channel. DSM2 also does not explicitly account for dispersion due to flow accelerating through channel bends. It cannot model the vertical salinity stratification in the channels.

It has inherent limitations in simulating the hydrodynamics related to the open water areas. Since an open water surface area (represented with a reservoir in the model) is constant in DSM2, it impacts the stage in the reservoir and thereby impacts the flow exchange with the adjoining channel. Due to the inability to change the cross-sectional area of the reservoir inlets with changing water surface elevation, the final entrance and exit coefficients were fine tuned to match a median flow range. This causes errors in the flow exchange at breaches (levee openings) during the extreme spring and neap tides. Using an arbitrary bottom elevation value for the reservoirs representing the proposed marsh areas to get around the wetting-drying limitation of DSM2 may increase the dilution of salinity in the reservoirs. Accurate representation of RMA's tidal marsh areas, bottom elevations, location of breaches, breach widths, cross-sections, and boundary conditions in DSM2 is critical to the agreement of corroboration results.

For open water bodies DSM2 assumes uniform and instantaneous mixing over entire open water area. Thus, it does not account for the any salinity gradients that may exist within the open water bodies. Significant uncertainty exists in flow and EC input data related to in-Delta agriculture, which leads to uncertainty in the simulated EC values. Caution needs to be exercised when using EC outputs on a sub-monthly scale, and therefore results are only presented at the monthly scale. Water quality results inside the water bodies representing the tidal marsh areas were not validated specifically and because of the bottom elevation assumptions, preferably should not be used for analysis.

3 Improvements to the CALSIM II Model

CALSIM II modeling has been updated with revised daily flow patterns for the Sites Reservoir Project Final Environmental Impact Report/ Environmental Impact Statement (Final EIR/EIS). Accurate representation of daily variability in river flows and weir spills is necessary to adequately evaluate Sites diversion criteria. Through review and calibration to historical data, CALSIM representation of daily flows between Sacramento River at Red Bluff and Sacramento River at Freeport has been improved. More information regarding improvement of the CALSIM II model used as well as the limitations of the daily patterns is included in Appendix 5A7 Daily Pattern Development for the Estimation of Daily Flows and Weir Spills in CALSIM II.

4 References Cited

ICF International. 2016. Final Environmental Impact Report/Environmental Impact Statement for the Bay Delta Conservation Plan/California WaterFix. Appendix 5A, December 2016.

Rowell, J.H., "USBR Monthly Temperature Model-Sacramento River Basin," Bureau of Reclamation, Sacramento, CA, June 1990.

U. S. Bureau of Reclamation, 2008. Biological Assessment on the Continued Long-term Operations of the Central Valley Project and State Water Project, Appendix W Sensitivity and Uncertainty Analysis, August 2008.