Appendix 5B Water Resources Modeling System

1 Introduction

This appendix provides a description of the CALSIM model that was used in evaluating Sites Reservoir Project (Project) alternatives for this Recirculated Draft Environmental Impact Report/Supplemental Draft Environmental Impact Statement (RDEIR/SDEIS).

2 State Water Project and Central Valley Project Operations Model (CALSIM)

CALSIM is the core model for the impact evaluation of the RDEIR/SDEIS Alternatives. Assumptions used in modeling the alternatives are summarized in Appendix 5A.

2.1 Description

CALSIM is a generalized reservoir-river basin simulation model that allows for specification and achievement of user-specified allocation targets, or goals (Draper et. al., 2004). The current application to the Central Valley system is called CALSIM and represents the best available planning model for simulating the SWP and CVP system operations.

CALSIM covers the valley floor drainage area of the Sacramento and San Joaquin Rivers, the upper Trinity River, and the San Joaquin Valley, Tulare Basin, and southern California areas served by the Federal Central Valley Project (CVP) and the California State Water Project (SWP). The focus of CALSIM II is on the major CVP and SWP facilities, but operations of many other facilities are included to varying degrees.

On a monthly time-step, CALSIM utilizes optimization techniques to route water through a network of storage nodes and flow arcs based on a series of user-specified relative priorities for water allocation and storage. A linear programming (LP)/mixed integer linear programming (MILP) solver determines an optimal set of decisions for each time period given a set of weights and system constraints. Physical capacities and specific regulatory and contractual requirements are input as linear constraints to the system operation using the water resources simulation language (WRESL). The model user describes the physical system (dams, reservoirs, channels, pumping plants, etc.), operational rules (flood-control diagrams, minimum flows, delivery requirements, etc.), and priorities for allocating water to different uses in WRESL statements. For each time step, the solver maximizes the objective function to determine a solution that delivers or stores water according to the specified priorities and satisfies all system constraints.

The sequence of solved linear programming problems represents the simulation of the system over the period of analysis.

CALSIM includes an 82-year modified historical hydrology (water years 1922-2003) developed jointly by DWR and USBR. Water diversion requirements (demands), stream accretions and depletions, rim basin inflows, irrigation efficiency, return flows, non-recoverable losses, and groundwater operation are components that make up the hydrology used in CALSIM. Sacramento Valley and tributary rim basin hydrologies are developed using a process designed to adjust the historical observed sequence of monthly stream flows to represent a sequence of flows at a future level of development. Adjustments to historic water supplies are determined by imposing future level land use on historical meteorological and hydrologic conditions. The resulting hydrology represents the water supply available from Central Valley streams to the system at a future level of development.

An Artificial Neural Network (ANN) has been developed (Sandhu et al. 1999) that attempts to mimic the flow-salinity relationships as simulated in DSM2, but provide a rapid transformation of this information into a form usable by the CALSIM operations model. The ANN is implemented in CALSIM to constrain the operations of the upstream reservoirs and the Delta export pumps in order to satisfy particular salinity requirements. A more detailed description of the use of ANNs in the CALSIM model is provided in Wilbur and Munévar (2001) and more recently in Seneviratne and Wu (2007).

CALSIM uses rule-based algorithms for determining deliveries to north-of-Delta and south-of-Delta CVP and SWP contractors. This delivery logic uses runoff forecast information, which incorporates uncertainty and standardized rule curves. The rule curves relate storage levels and forecasted water supplies to project delivery capability for the upcoming year. The delivery capability is then translated into SWP and CVP contractor allocations which are satisfied through coordinated reservoir-export operations.

The CALSIM model is described in detail in Draper et al (2004) and DWR (2021), and has been subject to two peer reviews in the past 8 years (Close et. al 2003 and Lund et. al 2006). More information on the CALSIM model can be found at https://water.ca.gov/Library/Modeling-and-Analysis/Central-Valley-models-and-tools.

2.2 Objective

The CALSIM model is the fundamental model upon which all the other models used in rely for inputs. The CALSIM model is used to reconcile all of the constraints associated with CVP and SWP operations throughout the state of California. CALSIM model allows for an integrated evaluation of the hydrology, fisheries, water quality, and water supply related operational objectives of the system, and specifically of the Sacramento – San Joaquin River Delta estuary. Plans and policies envisioned for this complex water resources system are simulated in CALSIM. Reconciliation of sometimes conflicting operational rules is the purpose of CALSIM.

Fundamental to the evaluation of the Sites Reservoir Project is the reconciliation of the various constraints included in the No Action Alternative (NAA), described in Appendix 5A.

2.3 Assumptions

The detailed modeling assumptions used for the alternatives modeled for the DEIR/EIS are described in Appendix 5A.

2.4 Overview of the Planning Analysis

Typical long-term planning analyses of the Central Valley system and operations of the CVP and SWP have applied the CALSIM model for analysis of system responses. CALSIM simulates future SWP/CVP project operations based on a 82-year monthly hydrology derived from the observed 1922-2003 period. Future land use and demands are projected for the appropriate future period. The system configuration consisting of facilities, operations, and regulations are input to the model and define the limits or preferences on operation. The configuration of the Delta, while not simulated directly in CALSIM, informs the flow-salinity relationships and several flow-related regressions for interior delta conditions (ie. X2 and OMR) included in the model. For each set of hydrologic, facility, operations, regulations, and delta configuration conditions, the CALSIM model is simulated. Some refinement of the SWP/CVP operations related to delivery allocations and San Luis target storage levels is generally necessary to have the model reflect suitable north-south reservoir balancing under future conditions.

2.5 Analysis of Alternatives

In using CALSIM for alternatives analysis, for each RDEIR/SDEIS Alternative, description of the proposed physical system for Sites Reservoir Project is incorporated into the CALSIM model. For all the Alternatives, operations were formulated in CALSIM to simulate the diversion of Sacramento River flow to fill the proposed Sites Reservoir and meet the primary objectives of the project by integrating the operations of the proposed Sites Reservoir with the operations of the existing CVP and SWP reservoirs.

CALSIM operations used to determine the diversion of the Sacramento River flows to fill the Sites Reservoir were refined based on the daily river flows simulated in the USRDOM. Both the models are simulated iteratively to accurately implement the sub-monthly diversion criteria. This integrated modeling using CALSIM and USRDOM models is described in detail in Appendix 5C. CALSIM operations were also refined to achieve the multiple objectives of the Sites Reservoir Project, based on the feedback from the other models simulating river temperatures, Delta water quality, anadromous fish survival and population, power generation and socioeconomics.

2.6 Limitations

CALSIM is a monthly time-step model. It represents projected conditions under current or future regulatory and operational regimes. The operational decisions in CALSIM (e.g. determining the flow needed to meet a salinity standard in the Delta) are on a monthly time-step which do not consider operational responses to changes that are on a sub-monthly timescale. Results for an individual parameter are either a monthly average or an end-of-month condition. Some specific concerns regarding CALSIM model results include the following:

- CALSIM is intended to be used in a comparative mode. The results from a "With Project" alternative simulation are compared to the results of a "base" simulation, to determine the incremental effects, of a project. The results from a single simulation may not necessarily represent the exact operations for a specific month or year, but should reflect long-term trends. The model should be used with caution to prescribe seasonal or to guide real-time operations, predict flows or water deliveries for any real-time operations.

- Storage results from CALSIM reflect end-of-month conditions and not monthly-average conditions. Therefore, any attributes derived from storage results such as littoral area or water surface elevation in the reservoir reflect end-of-month values.

- CALSIM operates to a monthly approximation of compliance to selected Delta standards. CALSIM monthly average salinity (ANN-based EC and chloride estimates) and X2 location outputs (ANN-based) are insufficient and inappropriate to verify compliance without use of other diagnostic information internal to the CALSIM and the ANN models used (note that ANN outputs are lagged by one month). Following are some more details on CALSIM D1641 compliance limitations:

  - Even though additional standards are identified in SWRCB D-1641, CALSIM only recognizes five stations for compliance with a salinity standard:

    - Sacramento River at Emmaton

    - San Joaquin River at Jersey Point

    - Old River at Rock Slough

    - Sacramento River at Collinsville

    - Sacramento River at Chipps Island

  - Some standards in SWRCB D-1641 require compliance for a specified number of days in a year (e.g. CCWD 150mg/L Chloride Standard). In such cases CALSIM does not have any discretion on which days the standards are met, but rather depends on a predetermined schedule, which cannot be altered dynamically.

  - Some of the standards modeled in CALSIM may not match exactly with the values specified in the SWRCB D-1641. Modeled standards may be more constrained ("ramped") to make operations more responsive to comply with a standard over the season.

  - Under severe operational conditions, CALSIM may fail to comply with D1641 and other standards. This situation occurs rarely and is needed to maintain feasibility of the model solution.

- Determination of X2 compliance in CALSIM is a complex analysis that considers each of "three ways to win" (SWRCB D-1641). CALSIM X2 computations reflect monthly average conditions (note that X2 outputs are lagged by one month).

- San Luis Storage operations in CALSIM are simplified compared to real time operations. The results are uncertain and prone to reflect how CALSIM represents CVP and SWP operations.

This is due to the relatively coarse SWP/CVP allocation decisions (e.g. no updates after May) used in the model and uncertainty in the model's capability to forecast export capabilities.

2.7 Appropriate Use of Modeling Results

The models developed and applied in planning analysis such as the RDEIR/SDEIS impact evaluation, are generalized and simplified representations of a complex water resources system. Even so, the models used are informative and helpful in understanding the performance and potential effects (both positive and negative) of the operation of a project and its interaction with the water resources system under consideration. A brief description of appropriate use of the model results to compare two scenarios or to compare against threshold values or standards is presented below.

Absolute vs. Relative Use of the Model Results

The models used in planning analysis are not predictive models (in how they are applied in this project), and therefore the results cannot be considered as absolute with and within a quantifiable confidence interval. The model results are only useful in a comparative analysis and can only serve as an indicator of condition (e.g. compliance with a standard) and of trend (e.g. generalized impacts).

Appropriate Reporting Time-Step

Due to the assumptions involved in the input data sets and model logic, care must be taken to select the most appropriate time-step for the reporting of model results. Sub-monthly (e.g. weekly or daily) reporting of model results are generally inappropriate for all models and the results should be presented on a monthly basis. Specific to the RDEIR/SDEIS, there are exceptions to this guidance, and selected model results can be reported on a sub-monthly basis with adequate caution.

Appropriate Reporting Locations

Due to the assumptions involved in the input data sets and model logic, care must be taken to select the most appropriate reference locations (and/or boundaries) for the reporting of model results. Each model assumes a simplified spatial representation of the water resource system and sub-systems. Reporting of model results inconsistent with the spatial representation of the model is inappropriate for all models.

Selection of Model Results

Specific to the RDEIR/SDEIS, substantial improvements to existing and new models have been developed to support the project team needs. For features within the Sacramento River and the Colusa Basin (where the proposed Sites Reservoir would be located), a set of new models have been developed. These models have not been used in previous analyses.

Statistical Comparisons are Preferred

Absolute differences computed at a point in time between model results from an alternative and a baseline, or an alternative and a threshold, to evaluate impacts is an inappropriate use of model results. Reporting seasonal patterns from long-term averages and water year type averages (e.g.

D1641 40-30-30 classification) is appropriate. Statistics based on long-term and water year type averages are an appropriate use of model results. Computing differences between long-term or water-year-type averages of model results from two scenarios is appropriate. The most appropriate presentation of monthly and annual model results is in the form of probability distributions and comparisons of probability distributions (e.g. cumulative probabilities). If necessary, comparisons of model results against threshold or standard values should be limited to comparisons based on cumulative probability distributions. Information specific to a model calibration (or lack of) and performance in predictive and comparative evaluations should be considered in making the choice to use these types of comparisons.

Formats for Presentation of Model Results

Acceptable formats considering the preceding recommendations and guidelines were used presenting the modeling results in the RDEIR/SDEIS. Monthly and annual summary data presented in the following formats:

- Long term average summary and year type based summary tables and graphics showing monthly and/or annual statistics derived from the model results
- Cumulative exceedance probability monthly and/or annual model results shown only by rank/order or only by probability statistic

Comparative statistics based on these two types of presentations are generally acceptable. Presentation of specific values associated with exceedance probabilities should be done in the context of a complete presentation of the range of values across all probability levels. If this is not possible, values associated with extremely high or low probabilities should not be presented (it is reasonable to stay within the range of an approximate maximum of 95% to an approximate minimum of 5% exceedence levels if not in the context of the full data range).

3 Results

Results from the State Water Project and Central Valley Project Operations Model (CALSIM) used in the detailed evaluation of the alternatives for the RDEIR/SDEIS are compiled in the attachment below.

- Appendix 5B1, Project Operations
- Appendix 5B2, River Operations
- Appendix 5B3, Delta Operations
- Appendix 5B4, Regional Deliveries
- Appendix 5B5, Water Supply

Reports include monthly tables, monthly pattern charts, and monthly exceedance charts. Monthly tables compare an alternative against the No Action alternative (exceedance values, long-term average, and average by water year type). Monthly pattern charts (long-term average and average by water year type) present all alternatives. Monthly exceedance charts (all months) present all alternatives.

4 References

Close, A., Haneman, W.M., Labadie, J.W., Loucks, D.P. (Chair). 2003. A Strategic Review of CALSIM II and its Use for Water Planning, Management, and Operations in Central California

Department of Water Resources, Modeling Support Branch. Site accessed April 18, 2021. URL = https://water.ca.gov/Library/Modeling-and-Analysis.

Draper, A.J., Munévar, A., Arora, S.K., Reyes, E., Parker, N.L., Chung, F.I., and Peterson, L.E. 2004. CALSIM: Generalized Model for Reservoir System Analysis. American Society of Civil Engineers, Journal of Water Resources Planning and Management, Vol. 130, No. 6.

Lund, J.R. (chair), Ford, D., Grober, L., Harmon, T., and McKinney, Daene.l 2006. Review Panel Report San Joaquin River Valley CalSim II Model Review.

Sandhu, N. and D. Wilson, R. Finch, and F. Chung. (1999). "Modeling Flow-Salinity Relationships in the Sacramento-San Joaquin Delta Using Artificial Neural Networks". Technical Information Record OSP-99-1, Sacramento: California Department of Water Resources.

Seneviratne, S. and Wu, S. (2007). "Chapter 3 – Enhanced Development of Flow-Salinity Relationships in the Delta Using Artificial Neural Networks: Incorporating Tidal Influence". *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.28th Annual Progress Report to the State Water Resources Control Board*. Sacramento, CA.

Wilbur, R. and Munévar, A. (2001). "Chapter 7 – Integration of CALSIM and Artificial Neural Networks Models for Sacramento-San Joaquin Delta Flow-Salinity Relationships". *Methodology for Flow and Salinity Estimates in the Sacramento-San Joaquin Delta and Suisun Marsh.22nd Annual Progress Report to the State Water Resources Control Board*. Sacramento, CA.