New CVP Water Service Contract Authorized Under Public Law 101-514 (Section 206)

Modeling Technical Memorandum

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August 2007

NEW CVP WATER SERVICE CONTRACT AUTHORIZED UNDER PUBLIC LAW 101-514 (SECTION 206) MODELING TECHNICAL MEMORANDUM

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List of Acronyms

Abbreviation	Definition
ATSP	Automated Temperature Selection Procedure
BA	Biological Assessment
BO	Biological Opinion
CALSIM II	DWR and Reclamation Simulation Model
CBDA	California Bay-Delta Authority
cfs	cubic feet per second
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
D-1644	SWRCB Decision-1644
DA	Drainage Area
Delta	San Joaquin-Sacramento Delta
DWR	California Department of Water Resources
E/I	export-to-inflow
EID	El Dorado Irrigation District
EIR/EIS	Environmental Impact Report/Environmental Impact Statement
ESA	Endangered Species Act (federal)
EWA	Environmental Water Account
FERC	Federal Energy Regulatory Commission
FMS	Flow Management Standard
FUI	Folsom Unimpaired Inflow
GDPUD	Georgetown Divide Public Utilities District
HEC-3	Corp of Engineers Reservoir System Model HEC-3
LongTermGen	Long Term Generation Model
M&I	municipal and industrial
NMFS	National Marine Fisheries Service
Nodes	logical location in CALSIM II model
OCAP	Operations Criteria and Plan
PCWA	Placer County Water Agency
PEIS	Programmatic Environmental Impact Statement
PL	Public Law
ppt	parts per thousand
Proposed Yuba Accord	Proposed Lower Yuba River Accord
QA/QC	Quality Assurance/Quality Control
Reclamation	Bureau of Reclamation
ROD	Record of Decision
SDIP	South Delta Improvements Program
SRWRS	Sacramento River Water Reliability Study
SV	Starting Value
SWP	State Water Project
SWRCB	State Water Resources Control Board
SWRI	Surface Water Resourses, Inc.
TAF	thousand acre-feet
TCD	temperature control device
TU	thermal unit
UARM	Upper American River Model
USFWS	U.S. Fish and Wildlife Service

VAMP	Vernalis Adaptive Management Plan
WQCP	Water Quality Control Plan
WR	Water Right
X2	2 parts per thousand near bottom salinity isohaline

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SECTION 1 INTRODUCTION

El Dorado Irrigation District (EID) and Georgetown Divide Public Utility District (GDPUD) are attempting to obtain a new Central Valley Project (CVP) Water Service Contract under Public Law (PL) 101-514 (Section 206). This Modeling Technical Memorandum documents the computer modeling performed to allow analysis of the alternatives being evaluated as a part of this process.

The modeling scope of work includes:

- Finalize modeling assumptions within project team.
- Implement the defined alternatives in operations, temperature, biological, and hydropower models.
- Perform the required alternative simulations.
- Produce a defined set of outputs comparing reservoir storage, stream flow, water temperatures, salmon mortality and hydropower at various locations throughout the CVP and State Water Project (SWP) system.

There are eight pre-defined alternatives consisting of different combinations of EID and GDPUD diversion allocations to be modeled. **Table 1** summarizes the EID and GDPUD diversion allocations, by water type, modeled in each alternative.

Table 1. Annual EID and GDPUD Diversion Allocation Volumes by Diversion Type for Each Alternative Modeled (TAF)

Alternative	EID CVP MI	EID PL 101-514	EID WR	EID Supp WR	GDPUD @ Auburn PL 101-514	GDPUD @ Auburn Supp WR
Proposed Action (Base Condition)	7.55					
Proposed Action – Scenario A	7.55	7			7.5	
Proposed Action – Scenario B	7.55	15			0	
Proposed Action – Scenario C	7.55	4			11	
Alternative 1 – Reduced Diversion	7.55	3.75			3.75	
Alternative 2 – No Action	7.55		15			
Future – Cumulative	7.55	7.5	15	30	7.5	10
Future C No Action	7.55		15	30		10

TAF = thousand acre-feet
WR = water right

There are eight required comparisons between the eight simulations. **Table 2** lists these comparisons.

Table 2. Simulation Comparisons

Comparison	Base Scenario	Compared Scenario
Proposed Action Evaluation	Proposed Action (Base Condition)	Proposed Action – Scenario A
Proposed Action Evaluation (Max EID)	Proposed Action (Base Condition)	Proposed Action – Scenario B
Proposed Action Evaluation (Max GDPUD)	Proposed Action (Base Condition)	Proposed Action – Scenario C
Reduced Diversion Alternative Evaluation	Proposed Action (Base Condition)	Alternative 1 – Reduced Diversion
No-Action Evaluation	Proposed Action (Base Condition)	Alternative 2 – No Action
Future Cumulative Evaluation	Proposed Action (Base Condition)	Future Cumulative Condition
Proposed Action on Future Cumulative[1]	Future No Action	Future Cumulative Condition
Proposed Action on Future Cumulative[1]	Proposed Action (Base Condition) Vs Future Cumulative Condition Minus Proposed Action (Base Condition) Vs Future No Action	Proposed Action (Base Condition) Vs Future Cumulative Condition Minus Proposed Action (Base Condition) Vs Future No Action

[1] For increment of Proposed Action on the Future Cumulative Condition, there are two possible evaluations. Both will be prepared.

This memorandum provides detailed information regarding the modeling tools, primary modeling assumptions, model inputs, and methodologies that were used to perform the simulations and prepare the outputs under the various alternatives.

The scope does not include any analysis of the modeling output other than quality assurance/quality control (QA/QC) activities to ensure that the alternatives are correctly and adequately represented in the simulations.

SECTION 2 MODELING APPROACH

The scenarios to be modeled all involve changes to diversions at the American River Pump Station and/or Folsom Reservoir. These changes have the potential to create impacts to downstream operations, especially to Folsom Reservoir and American River operations, and to a lesser extent to the entire CVP/SWP system.

2.1 TYPES OF MODELING REQUIRED

Simulation of these potential impacts and production of the specified output requires several specific types of modeling:

- CVP/SWP System Operational Modeling – Simulation of the physical operation of the system, the reservoir storages, and river flows expected under each scenario. Folsom Reservoir is a part of the Bureau of Reclamation's (Reclamation or USBR) CVP. Because the CVP is operated as a single, inter-related system and the CVP and the SWP operate jointly to meet flow and quality requirements in the Sacramento-San Joaquin Delta (Delta), any changes in Folsom Reservoir operations have the potential to impact operations throughout the entire CVP/SWP system.
- Temperature Modeling – Simulation of the temperatures in reservoirs and streams of the system resulting from the physical operation. The temperature modeling on the American River also

includes consideration of the operation of the Folsom Reservoir Cold Water Pool to maximize benefits to downstream aquatic resources.

- Salmon Mortality Modeling – Simulation of the salmon mortality in the system resulting from the physical operation and resulting temperatures.
- Hydropower Modeling – Computation of the hydropower generation and pumping energy usage resulting from the physical operation.

2.2 MODELING PROCESS

The modeling will be done by developing two baseline simulations: (1) the Proposed Action (Base Condition) and, (2) the Future No Action scenario. These two simulations are assumed to represent the Existing and Future Level Conditions, without the project under evaluation included. The alternative simulations are developed by adding the appropriate assumptions for each alternative to the appropriate baseline simulation.

2.2.1 Alternative Simulation Process

Computer simulation models of water systems provide a means for evaluating changes in system characteristics such as reservoir storage, stream flow, and hydropower generation, as well as the effects of these changes on environmental parameters such as water temperature, water quality, and early life stage Chinook salmon survival. The models and post-processing tools used for this modeling effort include the following:

- CALSIM II – Reclamation and the California Department of Water Resources (DWR) simulation model of integrated CVP and SWP system operations. This model provides a monthly simulation of the CVP and SWP water operations including reservoir inflows, releases, and storage, river flow throughout the system, CVP/SWP pumping and Delta operations.
- USBR Reservoir Temperature Model – Reclamation Trinity, Shasta, Whiskeytown, Oroville, and Folsom reservoir water temperature models. This set of models uses the simulated operational data from the CALSIM II model to simulate the reservoir temperature profiles and release temperatures from each of the modeled reservoirs.
- USBR River Temperature Model – Reclamation Trinity, Sacramento, Feather, and American (with Automated Temperature Selection Procedure [ATSP]) river water temperature models. This set of models uses the simulated reservoir release temperatures and operational results from the CALSIM II model to simulate the river water temperatures throughout the CVP/SWP system.
- USBR Salmon Mortality Model – Reclamation Feather, and Sacramento River early life stage Chinook salmon mortality models. This set of models uses the simulated river temperatures and the operational results from the CALSIM II model to simulate the salmon mortality rates resulting from the flow and temperatures for the scenario.
- LongTermGen Model – This model computes the CVP hydropower generation and pumping energy usage resulting from the simulated physical operation.
- General Purpose Output Generation Tool – This tool extracts, processes and formats data from the outputs of all the above modeling to produce the required results.

These models and related post-processing tools are described in detail in Section 3, Models Used.

2.3 MODELING SCENARIO DEVELOPMENT

CALSIM II modeling undertaken for Reclamation's Operations Criteria and Plan (OCAP) Biological Assessment (BA) was used to provide the foundation for CVP/SWP system-wide baseline conditions simulations used to represent the Proposed Action (Base Condition) and the Future No Action scenarios.

The OCAP_2001D10A_TodayEWA_012104, or OCAP 3 simulation, is an existing level simulation with many of the desired baseline assumptions; however, OCAP 3 did not include the higher Trinity minimum flow requirements of the Record of Decision (ROD) of the Trinity River Main Stem Fishery Restoration Environmental Impact Statement/Environmental Impact Report (EIS/EIR). These new requirements were added, and the results reviewed by Reclamation, in a CALSIM II simulation commonly referred to as OCAP 3a. The Proposed Action (Base Condition) is based on the OCAP 3a simulation.

The Future No Action simulation is based on the OCAP_2020D09D_FutureEWA5a simulation.

These two simulations were modified to include updated inputs for lower Yuba River outflow to the Feather River, lower Yuba River diversions at Daguerre Point Dam, Trinity River instream flow requirements downstream of Lewiston Dam (by use of OCAP 3a), and EID diversion at Folsom Lake as required and run to produce the existing and future level baseline simulations. These baseline simulations were then modified as required to implement the specific project changes to produce each the project modeling scenarios.

The final CALSIM II simulations are then used as the basis for the temperature, salmon mortality, and hydropower modeling to complete the simulation of the individual scenarios.

The required outputs for each alternative comparison were created by an automated process that creates a Microsoft Excel file with all desired output tables for each comparison.

Details on this process are given in the following sections.

SECTION 3 MODELS USED

3.1 CALSIM II MODEL

CALSIM II was jointly developed by Reclamation and DWR for planning studies relating to CVP and SWP operations. The primary purpose of CALSIM II is to evaluate the water supply reliability of the CVP and SWP at current or future levels of development (e.g. 2001, 2020), with and without various assumed future facilities, and with different modes of facility operations. Geographically, the model covers the drainage basin of the Delta, and SWP exports to the San Francisco Bay Area, Central Coast, and Southern California.

CALSIM II uses a mass balance approach to simulate the occurrence, regulation, and movement of water from one river reach (computation point or node) to another. Various physical processes (e.g., surface water inflow or accretion, flow from another node, groundwater accretion or depletion, and diversion) are simulated or assumed at each node as necessary. Operational constraints, such as reservoir size, seasonal storage limits, and minimum flow requirements, also are defined for each node. Accordingly, flows are specified as a mean flow for the month, and reservoir storage volumes are specified as end-of-month values. In addition, modeled X2 (2 parts per thousand [ppt] near bottom salinity isohaline) locations are specified as end-of-month locations, Delta outflows are specified as mean outflows for each month, and Delta export-to-inflow (E/I) ratios are specified as mean ratios for each month.

CALSIM II typically simulates system operations for a 73-year period using a monthly time-step. The model assumes that facilities, land use, water supply contracts, and regulatory requirements are constant over this period, representing a fixed level of development (e.g., 2001 or 2020). The historical flow record of October 1921 to September 1994, adjusted for the influence of land use change and upstream flow regulation, is used to represent the possible range of water supply conditions. It is assumed that past hydrologic conditions are a good indicator of future hydrologic conditions.

The model simulates one month of operation at a time, with the simulation passing sequentially from one month to the next, and from one year to the next. Each estimate that the model makes regarding stream flow is the result of defined operational priorities (e.g. delivery priorities to water right holders, and water contractors), physical constraints (e.g., storage limitations, available pumping and channel capacities), and regulatory constraints (flood control, minimum instream flow requirements, Delta outflow requirements). Certain decisions, such as the definition of water year type, are triggered once a year, and affect water delivery allocations and specific stream flow requirements. Other decisions, such as specific Delta outflow requirements, vary from month to month. CALSIM II output contains estimated flows and storage conditions at each node for each month of the simulation period. Simulated flows are mean flows for the month, reservoir storage volumes correspond to end-of month storage.

CALSIM II simulates monthly operations of the following water storage and conveyance facilities:

- Trinity, Lewiston, and Whiskeytown reservoirs (CVP);
- Spring Creek and Clear Creek tunnels (CVP);
- Shasta and Keswick reservoirs (CVP);
- Oroville Reservoir and the Thermalito Complex (SWP);
- Folsom Reservoir and Lake Natoma (CVP);
- New Melones Reservoir (CVP);
- Millerton Lake (CVP);
- C.W. Jones (CVP), Contra Costa (CVP) and Harvey O. Banks (SWP) pumping plants; and
- San Luis Reservoir (shared by CVP and SWP).

To varying degrees, nodes also define CVP/SWP conveyance facilities including the Tehama-Colusa, Corning, Folsom-South, and Delta-Mendota canals and the California Aqueduct. Other non-CVP/SWP reservoirs or rivers tributary to the Delta also are modeled in CALSIM II, including:

- New Don Pedro Reservoir;
- Lake McClure; and
- Eastman and Hensley lakes.

3.1.1 Related Tools

The CALSIM II model requires an enormous amount of input data in order to perform the complicated routing and operations logic included in the model. This data comes from other models and variety of input generation tools. Two of these tools, the Demands Spreadsheet and the Upper American River Model (UARM), were used in this project.

3.1.1.1 Demands Spreadsheet

This is an Excel-based spreadsheet that allows the user to input the demands for different contractors and generates the require time series input to implement these demands. This spreadsheet works by taking the annual total for each contractor demand, applying any adjustments to the total, creating the monthly time series demand data, and combining the contractor demands as required, creating the total monthly demand at CALSIM nodes for use as input to the CALSIM II model.

The spreadsheet computational procedures from this spreadsheet were used to guide the development of the modified CALSIM II input of the EID and GDPUD demands required to implement the alternatives.

3.1.1.2 Upper American River Model

The UARM is a combination of an HEC III model of the reservoir system in the Upper American River Basin and an Excel-based spreadsheet that computes adjustments required to a simulation of the basin to implement the Middle Fork Project coordination with Folsom Reservoir Operations. This model provides CALSIM II input data on Folsom inflows, diversions at the North Fork American River Pump Station, and allowable flood control space in Folsom Reservoir. The UARM is fully described in the report titled:

Upper American River Model, Analysis of Placer County Water Agency's Middle Fork Project (SWRI 2000).

3.2 BUREAU OF RECLAMATION'S WATER TEMPERATURE MODELS

Reclamation has developed water temperature models for the Trinity, Sacramento, Feather, and American rivers. The models have both reservoir and river components to simulate water temperatures in five major reservoirs (Trinity, Whiskeytown, Shasta, Oroville, and Folsom); four downstream regulating reservoirs (Lewiston, Keswick, Thermalito, and Natoma); and four main river systems (Trinity, Sacramento, Feather, and American).

The following sections provide additional detail regarding the reservoir and river components of the water temperature models, respectively. Additional details regarding Reclamation's water temperature models are well documented in the Central Valley Project Improvement Act (CVPIA) *Draft Programmatic EIS Technical Appendix, Volume Nine* (Reclamation 1997). These water temperature models also are documented in the report titled: *U.S. Bureau of Reclamation Monthly Temperature Model Sacramento River Basin* (Reclamation 1990).

3.2.1 Bureau of Reclamation's Reservoir Water Temperature Models

Reclamation's reservoir models simulate monthly water temperature profiles in five major reservoirs: Trinity, Whiskeytown, Shasta, Oroville, and Folsom. The vertical water temperature profile in each reservoir is simulated in one dimension using monthly storage, inflow and outflow water temperatures and flow rates, evaporation, precipitation, solar radiation, and average air temperature. The models also compute the water temperatures of dam releases. Release water temperature control measures in reservoirs, such as the penstock shutters in Folsom Reservoir and the temperature control device (TCD) in Shasta Reservoir, are incorporated into the models.

Reservoir inflows, outflows, and end-of-month storage calculated by CALSIM II and post-processing applications are input into the reservoir water temperature models. Additional input data include meteorological information and monthly water temperature targets that are used by the model to select the level from which reservoir releases are drawn. Water TCDs, such as the outlet control device in Shasta Dam, the temperature curtains in Whiskeytown Dam, and the penstock shutters in Folsom Dam, are incorporated into the simulation. Model output includes reservoir water temperature profiles and water temperatures of the reservoir releases. The reservoir release water temperatures are then used in the downstream river water temperature models, as described in the next section.

3.2.1.1 Automated Temperature Selection Procedure

The ATSP, developed by HDR|SWRI, works with the Folsom Reservoir temperature model to optimize the use of Folsom Reservoir's cold water pool throughout the year for the benefit of downstream aquatic resources. The procedure starts with multiple sets of monthly temperature targets on the American River at Watt Avenue. These targets are designed to provide the optimum biological benefit throughout the year to the downstream aquatic resources for varying levels of cold water availability. The procedure selects a set of targets for each year and runs the Folsom Reservoir temperature model for the period of record. The results are then compared to the targets for each year to see if they were met. If the targets were met, a new set with higher biological benefit is selected; if they are not met, a new set with lower biological benefit is selected. Each year is treated independently, that is, each year has its own set of targets based on the specific characteristics of that year that may be different from any other year. The procedure continues until the selected targets each year represent the highest level of biological benefit that can be met for that year.

3.2.1.2 EID Temperature Control Device

The Folsom Reservoir temperature model does not explicitly model any TCD on the EID diversion; however the model does include a TCD on the main downstream release outlets and at the Folsom Pump Station. The input for the Folsom Reservoir temperature model is generated by a utility the reads flow data from the CALSIM II output and prepares the inputs for the temperature model. To implement an EID TCD, the CALSIM II output is copied and the EID diversion is added to the flow of the Folsom Pump Station then set to 0 to create a "virtual" CALSIM II output that can be read by the utility to generate the Folsom Reservoir Temperature model input. The effect is that the Folsom Temperature model will now route the EID diversion through the Folsom Pump Station TCD as an approximation of a TCD on the EID diversion. The volume of the release to the American River is not changed and the water balance is maintained at Folsom Reservoir.

3.2.2 Bureau of Reclamation's River Water Temperature Models

Reclamation's river water temperature models utilize the calculated temperatures of reservoir releases, much of the same meteorological data used in the reservoir models, and CALSIM II outputs for river flow rates, gains and water diversions. Mean monthly water temperatures are calculated at multiple locations on the Sacramento, Feather, and American rivers.

Reservoir release rates and water temperatures are the boundary conditions for the river water temperature models. The river water temperature models compute water temperatures at 52 locations on the Sacramento River from Keswick Dam to Freeport, and at multiple locations on the Feather and American rivers. The river water temperature models also calculate water temperatures within Lewiston, Keswick, Thermalito, and Natoma reservoirs. The models are used to estimate water temperatures in these reservoirs because they are relatively small bodies of water with short residence times; thereby, on a monthly basis, the reservoirs act as if they have physical characteristics approximating those of riverine environments.

3.3 BUREAU OF RECLAMATION'S EARLY LIFE STAGE CHINOOK SALMON MORTALITY MODELS

Water temperatures calculated for specific reaches of the Sacramento and Feather rivers are used as inputs to Reclamation's Early Life Stage Chinook Salmon Mortality Models (Salmon Mortality Models) to estimate annual mortality rates of Chinook salmon during specific early life stages. For the Sacramento River analyses, the model estimates mortality for each of the four Chinook salmon runs: fall, late fall, winter, and spring. For the Feather River analyses, the model[1] produces estimates of fall-run Chinook salmon mortality. Because hydrologic conditions in the Yuba River are not characterized in Reclamation's current Salmon Mortality Models, it is not possible to estimate changes in early life stage mortality for Chinook salmon in the lower Yuba River.

The Salmon Mortality Models produce a single estimate of early life stage Chinook salmon mortality in each river for each year of the simulation. The overall salmon mortality estimate consolidates estimates of mortality for three separate Chinook salmon early life stages: (1) pre-spawned (in utero) eggs; (2) fertilized eggs; and (3) pre-emergent fry. The mortality estimates are computed using output water

[1] For the purposes of improved technical accuracy and analytical rigor, simulated Chinook salmon early life stage survival estimates specific to the Feather River are derived from a revised version of Reclamation's Salmon Mortality Model (2004), which incorporates new data associated with: (1) temporal spawning and pre-spawning distributions; and (2) mean daily water temperature data in the Feather River. Although the updated Feather River information serving as input into the model deviates slightly from that which was used in Reclamation's OCAP BA, both versions of the model are intended for planning purposes only, and thus should not be used as an indication of actual real-time in-river conditions. Because a certain level of bias is inherently incorporated into these types of planning models, such bias is uniformly distributed across all modeled simulations, including both the Project Alternatives and the bases of comparison, regardless of which version of the model is utilized.

temperatures from Reclamation's water temperature models as inputs to the Salmon Mortality Models. Thermal units (TUs), defined as the difference between river water temperatures and 32°F, are used by the Salmon Mortality Models to track life stage development, and are accounted for on a daily basis. For example, incubating eggs exposed to 42°F water for one day would experience 10 TUs. Fertilized eggs are assumed to hatch after exposure to 750 TUs. Fry are assumed to emerge from the gravel after being exposed to an additional 750 TUs following hatching.

Because the models are limited to calculating mortality during early life stages, they do not evaluate potential impacts to later life stages, such as recently emerged fry, juvenile out-migrants, smolts, or adults. Additionally, the models do not consider other factors that may affect early life stage mortality, such as adult pre-spawn mortality, instream flow fluctuations, redd superimposition, and predation. Because the Salmon Mortality Models operate on a daily time-step, a procedure is required to convert the monthly water temperature output from the water temperature models into daily water temperatures. The Salmon Mortality Models compute daily water temperatures based on the assumption that average monthly water temperature occurs on the 15th of each month, and interpolate daily values from mid-month to mid-month. Output from the Salmon Mortality Models provide estimates of annual (rather than monthly mean) losses of emergent fry from egg potential (i.e., all eggs brought to the river by spawning adults) (Reclamation 2003).

3.3.1 Lower Feather River Early Life Stage Chinook Salmon Mortality Model Revisions

During March 2004, Reclamation's Salmon Mortality Model was revised to include updated information regarding the temporal distribution of Chinook salmon spawning activity in the lower Feather River. The revised Feather River Salmon Mortality Model estimates the water temperature-induced early life stage mortality using updated pre-spawning and spawning temporal distributions, which were derived from estimated daily carcass distributions. Estimated daily carcass distributions were derived from daily observations of Chinook salmon carcasses during the 2002 spawning period. Additional information regarding the use of carcass survey data as a basis for development of pre-spawning and spawning temporal distributions in the Feather River, is described in the Oroville Facilities Relicensing, Federal Energy Regulatory Commission (FERC) Project 2100, Study Plan F-10 - *Task 2C: Evaluation of the timing, magnitude, and frequency of water temperatures and their effects on Chinook salmon egg and alevin survival* (DWR 2004).

While the revised Feather River Salmon Mortality Model utilizes updated pre-spawning and spawning temporal distributions as bases from which to calculate early life stage mortality, the remaining model assumptions, computations, and input variables remain unchanged from Reclamation's Feather River Early Life Stage Chinook Salmon Mortality Model.

3.3.2 Other Salmon Mortality Model Considerations

Three separate reviews of the National Marine Fisheries Service (NMFS) October 2004 Biological Opinion on the Long-Term Central Valley Project and State Water Project OCAP (NMFS 2004) have been conducted to determine whether NMFS (2004) used the best available scientific and commercial information (California Bay-Delta Authority 2005).

McMahon (2006) acknowledged that a lack of information on how water operations related habitat alterations affect Central Valley salmonid populations exists. In this context, McMahon (2006) concluded that, "*…the Biological Opinion (BO) appears to be based on best available information with regards to temperature effects on survival of salmonid embryos and early fry in the upper Sacramento River and major tributaries…*".

Maguire (2006) reported two general concerns related to the salmon mortality model. First, Maguire (2006) stated, "The mean monthly temperature may in fact be of little predictive value for mortality estimation without knowing (using) the variability and duration of variability." Second, Maguire (2006) suggested that the salmon mortality model is of limited usefulness because it does not evaluate potential impacts on emergent fry, smolts, juvenile emigrants, or adults, and the model only considers water temperature as a source of mortality.

With respect to the application of the salmon early life stage mortality model in NMFS (NMFS 2004), three concerns were reported within the California Bay-Delta Authority (CBDA) report (California Bay-Delta Authority 2005). First, CBDA (2005) questioned the use of water temperature predictions that were developed by linear interpolation between monthly means without accounting for variation. Second, water temperature at the time of spawning was taken as an index of pre-spawning water temperature exposure, which reportedly may be an unsatisfactory approach for spring-run Chinook salmon, which may hold in the river throughout the summer. Lastly, and reportedly the expert panel's most serious concern, "*…the data used to develop the relationships between temperature and mortality on eggs, alevins, and especially gametes was not the best available.*"

To address these three concerns, the expert panel recommended that NMFS should: (1) perform a thorough analysis of the data, relationships, and calculations of the salmon mortality model; (2) investigate how variation around monthly mean water temperatures would affect salmon mortality model results; and (3) suggest or make improvements to the model. It is uncertain whether NMFS will accept these recommendations and undertake these efforts to address the concerns raised with technical details of the salmon mortality model. At this time, this process has not been undertaken and salmon mortality model improvements have not been identified and incorporated into the model. Therefore, the existing salmon mortality model is the best available model for comparing the potential water temperature related effects of the Proposed Action and alternatives on Chinook salmon early life stages to those of the basis of comparison.

3.4 LONGTERMGEN MODEL

The LongTermGen Model is a CVP power model developed to estimate the CVP power generation, capacity, and project use based on the operations defined by a CALSIM II simulation. Created using Microsoft's Excel spreadsheet with extensive Visual Basic programming, the LongTermGen Model computes monthly generation, capacity, and project use (pumping power demand) for each CVP power facility for each month of the CALSIM II simulation.

The LongTermGen Model does not compute the energy requirement or loads at the EID pumping plant directly. It does compute the pumping power requirements for the diversion at Node 8, which represents several diversions from Folsom Reservoir, including the EID diversion.

3.5 MODEL LIMITATIONS

Reclamation's OCAP BA outlines the limitations of three of the models that were used in the assessment conducted for the most recent Section 7 consultations on the OCAP, which led to NMFS and USFWS Biological Opinions (BOs) for winter-run and spring-run Chinook salmon, steelhead, and delta smelt. These models (i.e., CALSIM II, water temperature, and salmon mortality) are the same models used to conduct the modeling analysis presented in the Draft EIR/EIS for the Proposed Yuba Accord. The following discussion regarding the model limitations used in the modeling analysis is taken directly from the CVP and SWP OCAP BA.

> *"The main limitation of CALSIM II and the temperature models used in the study is the time-step. Mean monthly flows and temperatures do not define daily variations that could occur in the rivers due to dynamic flow and climatic conditions. However, monthly results are still useful for general comparison of alternatives. The temperature models are also unable to accurately simulate certain aspects of the actual operations strategies used when attempting to meet temperature objectives, especially on the upper Sacramento River. To account for the short-term variability and the operational flexibility of the system to respond to changing conditions, cooler*

water than that indicated by the model is released in order to avoid exceeding the required downstream temperature target. There is also uncertainty regarding performance characteristics of the Shasta TCD [temperature control device]. Due to the hydraulic characteristics of the TCD, including leakage, overflow, and performance of the side intakes, the model releases are cooler than can be achieved in real-time operations; therefore, a more conservative approach is taken in real-time operations that is not fully represented by the models.

The salmon model is limited to temperature effects on early life stages of Chinook salmon. It does not evaluate potential direct or indirect temperature impacts on later life stages, such as emergent fry, smolts, juvenile out-migrants, or adults. Also, it does not consider other factors that may affect salmon mortality, such as in-stream flows, gravel sedimentation, diversion structures, predation, ocean harvest, etc. Since the salmon mortality model operates on a daily time-step, a procedure is required to utilize the monthly temperature model output. The salmon model computes daily temperatures based on linear interpolation between the monthly temperatures, which are assumed to occur on the 15th day of the month.

CALSIM II cannot completely capture the policy-oriented operation and coordination the 800,000 of dedicated CVPIA 3406 (B)(2) water and the CALFED EWA. Because the model is set up to run each step of the 3406(B)(2) on an annual basis and because the WQCP and ESA actions are set on a priority basis that can trigger actions using 3406(b)(2) water or EWA assets, the model will exceed the dedicated amount of 3406(b)(2) water that is available. Moreover, the 3406(b)(2) and EWA operations in CALSIM II are just one set of plausible actions aggregated to a monthly representation and modulated by year type. However, they do not fully account for the potential weighing of assets versus cost or the dynamic influence of biological factors on the timing of actions. The monthly time-step of CALSIM II also requires day-weighted monthly averaging to simulate minimum instream flow levels, VAMP actions, export reductions, and X2-based operations that occur within a month. This averaging can either under- or over-estimate the amount of water needed for these actions.

Since CALSIM II uses fixed rules and guidelines results from extended drought periods might not reflect how the SWP and CVP would operate through these times. The allocation process in the modeling is weighted heavily on storage conditions and inflow to the reservoirs that are fed into the curves mentioned previously in the Hydrologic Modeling Methods section beginning on page 8-1 and does not project inflow from contributing streams when making an allocation. This curve based approach does cause some variation in results between studies that would be closer with a more robust approach to the allocation process" (Reclamation 2004).

Model assumptions and results are generally believed to be more reliable for comparative purposes than for absolute predictions of conditions. All of the assumptions are the same for both the with-project and without-project model runs, except assumptions associated with the action itself, and the focus of the analysis is the differences in the results. For example, model outputs for the Proposed Project/Proposed Action can be compared to that of the No Project and No Action simulations. Results from a single simulation may not necessarily correspond to actual system operations for a specific month or year, but are representative of general water supply conditions. Model results are best interpreted using various statistical measures such as long-term and year-type average, and probability of exceedance.

SECTION 4 MODEL SIMULATION DEVELOPMENT

4.1 FOUNDATION SIMULATIONS

In 2004, several CALSIM II simulations were performed to support Reclamation's Long-Term OCAP BA. These simulations represent a consensus on the physical features and regulatory environment that the SWP/CVP system would operate under at that time. Two of these simulations, OCAP_2001D10A_TodayEWA_012104, modified to include the Trinity minimum flow requirements of the ROD of the Trinity River Main Stem Fishery Restoration EIS/EIR (OCAP 3) and OCAP_2020D09D_FutureEWA5a (OCAP 5a), were selected for use as the basis for development of the alternative simulations performed in this study. Detailed information on the assumptions included in these simulations is included in the OCAP BA.

4.2 BASELINE SIMULATIONS

A number of assumptions in the foundation simulations not directly related to the project need modification or updating based on changes since the OCAP foundation simulations were performed. **Table 3** summarizes these assumptions.

Table 3. Major Differences in Assumptions Between Foundation and Baseline Simulations

Assumption	OCAP3	Existing Level Baseline	OCAP5[a]	Future Level Baseline
Level of Demand	Existing	Existing	Future	Future
Trinity ROD	No	Yes	Yes	Yes
Yuba River Operation	Hec-3	D-1644 Interim	HEC-3	Yuba Accord
Water Forum Agreement Cuts (Pl 101 Water)	No	No	Yes	No
Lower American River Flow Management Study	No	No	No	Yes
Banks Pumping Capacity	6,680 cfs	6,680 cfs	6,680 cfs	6,680 cfs
Supplemental Water Rights Project	No	No	No	Yes
EID Temperature Control Device [1]	No	No	No	Yes
Non EID American River Demands	Same	SRWRS	Same	SRWRS
UARM		SRWRS		SRWRS

[a] This is implemented in the temperature modeling. It has no impact on the CALSIM II modeling.

The Existing and Future level baseline simulations will be compared to the foundation simulations to ensure that the assumptions were properly implemented as part of the QA/QC process. The standard set of outputs for all other alternative comparisons will not be prepared for these comparisons. No evaluation will be made of the potential impacts of the changes from the OCAP simulations will be made. The temperature, salmon mortality, and power models will not be run on these simulations.

4.2.1 Existing Level Baseline simulation

Several updates were made to the OCAP 3 simulation for use as the Existing Level baseline simulation in this project.

- Trinity ROD – OCAP 3 did not include the higher Trinity minimum flow requirements of the ROD on the Trinity River Main Stem Fishery Restoration EIS/EIR. These new requirements have been added, and the results reviewed by Reclamation in a CALSIM II simulation, commonly referred to as OCAP3a. The OCAP 3a simulation was adopted as the starting point for this simulation.
- River Operation – The Yuba River is modeled in CALSIM II as an inflow to and diversion from the Daguerre Point Dam at Node 211. In the OCAP 3a simulation these values were based on an existing

HEC-3 model of the Upper Yuba River basin and did not include State Water Resources Control Board Decision 1644 (D-1644) flow requirements on the Yuba River. The inflow and diversion at Daguerre Point Dam were updated with values based on D-1644 Interim standards on the River and existing level demands on the diversion developed in support of the Proposed Yuba Accord EIR/EIS.

- American River Demands – The demands on the American River have changed since the OCAP simulations were performed. The modeling performed for the Sacramento River Water Reliability Study (SRWRS) developed new American River demand sets that includes these most recent demand assumptions. The demands from the SRWRS Study 1, the SRWRS Existing Condition Baseline, were selected for use in this simulation. **Figure 1** compares the American River demands between the OCAP 3a foundation study and SRWRS Study 1.

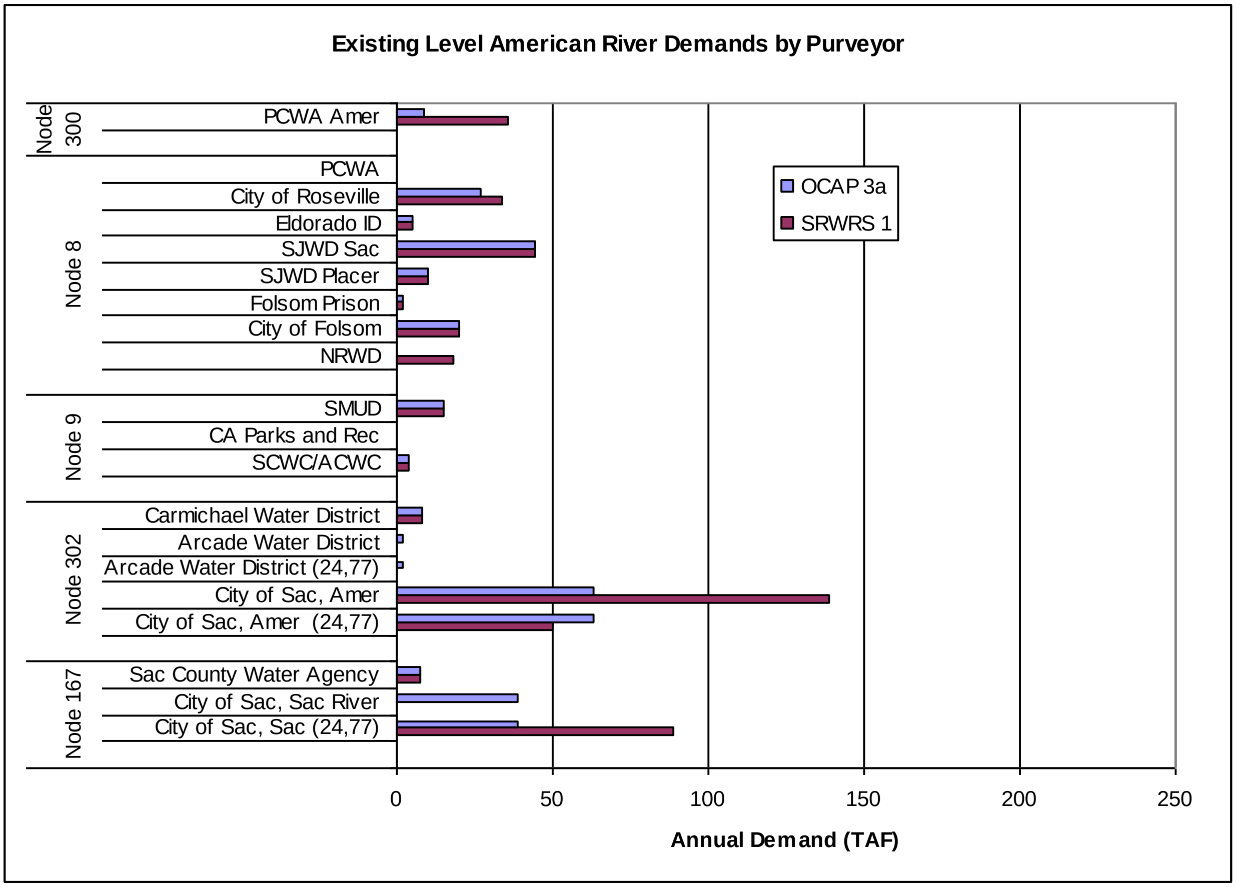

Figure 1. Comparison of OCAP 3a and SRWRS 1 American River Demands

The largest difference between the two simulations is in the way the City of Sacramento demands are modeled. In CALSIM II, the City's demands are imposed at two locations, Node 302 on the American River and Node 167 on the Sacramento River. CALSIM II also imposes the "Hodge" criteria on the City demand. This criteria states that when the flow in the American River becomes low enough, the City of Sacramento will shift some of its diversion from the American River to the Sacramento River. In the SRWRS 1 demands the City of Sacramento demand is initially shifted to the American River, internally CALSIM will shift the demand back to the Sacramento River when the "Hodge" criteria becomes effective. The extremely dry years 1924 and 1977 do not include this shift.

- UARM Simulations – Folsom Reservoir's inflow and flood control reservation are dependant of the operations of reservoirs in the Upper American River. These reservoirs operate for both within-basin requirements, to meet downstream American River demands from the Middle Fork Project and to provide "make up" water for Roseville. The SRWRS modeling included a simulation of the Upper American River model to get the appropriate American River inflows to Folsom Reservoir. The results of these UARM simulations, taken from the SRWRS CALSIM input files, were used in this modeling effort.

4.2.2 Future Level Baseline Simulation

Four updates were made to the OCAP 5a simulation for use as the Future Condition Baseline simulation in this project.

- Yuba River Operation – The Yuba inflow to and diversion from Daguerre Point Dam in the OCAP 5a simulation were based on a HEC-III model of the Upper Yuba River Basin. The inflow and diversion at Daguerre Point Dam were updated with values based on D-1644 standards on the river and Future Level demands on the diversion developed in support of the Proposed Yuba Accord EIR/EIS.
- Water Forum Agreement Cuts – OCAP 5a included some PL 101 water diversions for EID and GDPUD that were assumed subject to cuts based on the Water Forum Agreement. Neither EID nor GDPUD is a signatory to the Water Forum Agreement at this time. For this project, the assumption was made that they would not become signatories and the diversions would not be subject to the cuts. Any CVP water would still be subject to the CVP North of Delta system cuts computed by CALSIM II. This assumptions means that we could be simulating slightly higher diversions in the driest years (FUI <=400 TAF) which could slightly overestimate impacts in those years.
- Lower American River Flow Management Standard – The Lower American River Flow Management Standard (FMS) was not included in the OCAP 5a simulation. This standard is intended to benefit fall-run Chinook salmon, steelhead and other fish species in the lower American River. The new recommended minimum flow requirements in the lower American River below Nimbus Dam vary throughout the year in response to the hydrology of the Sacramento and American River basins and based on the various indices. The October 1 through December 31 minimum flow requirements range between 800 and 2,000 cubic feet per second (cfs), the January 1 through Labor Day minimum flow requirements range between 800 and 1,750 cfs and the post-Labor Day through September 30 minimum flow requirements range between 800 and 1,500 cfs. Nimbus Dam releases may drop below 800 cfs to avoid depletion of water storage in Folsom Reservoir when extreme dry or critical hydrologic conditions are forecasted.
- Banks Pumping Capacity – When the OCAP modeling was performed the South Delta Improvement Program (SDIP) was well underway but not finalized. One of the major components of the SDIP was to increase the allowable Banks Pumping Plant pumping limit to 8,500 cfs instead of the 6,680 cfs limit at that time. Since this would have a major impact on the CVP/SWP Delta operations the OCAP modeling included the 8,500 cfs capacity in the future level OCAP 5 simulation to allow evaluation of the potential impacts of the project. However, since the project was not finalized and implemented at the time a second simulation, with Banks Pumping Plant limited to 6,680 cfs was also performed (OCAP 5a).

  Currently the SDIP project has not been implemented and is now under a legal challenge that could prevent it from ever being implemented. For this analysis the assumption was made that the SDIP will not be in place in the future and Banks pumping capacity is limited to 6,680 cfs.
- Supplemental Water Rights Project – The Supplemental Water Rights Project is assumed to be in place for all future level simulations. This diversion was not included in the OCAP 5a simulation. Table 2 summarizes the new diversions under this project.
- American River Demands – As in the Existing Condition, the American River Demands were taken from the SRWRS modeling. The demands from the SRWRS Study 6, the SRWRS No Action alternative, were selected for use in this simulation. **Figure 2** compares the American River demands between the OCAP 5a foundation study and the SRWRS Study 6.

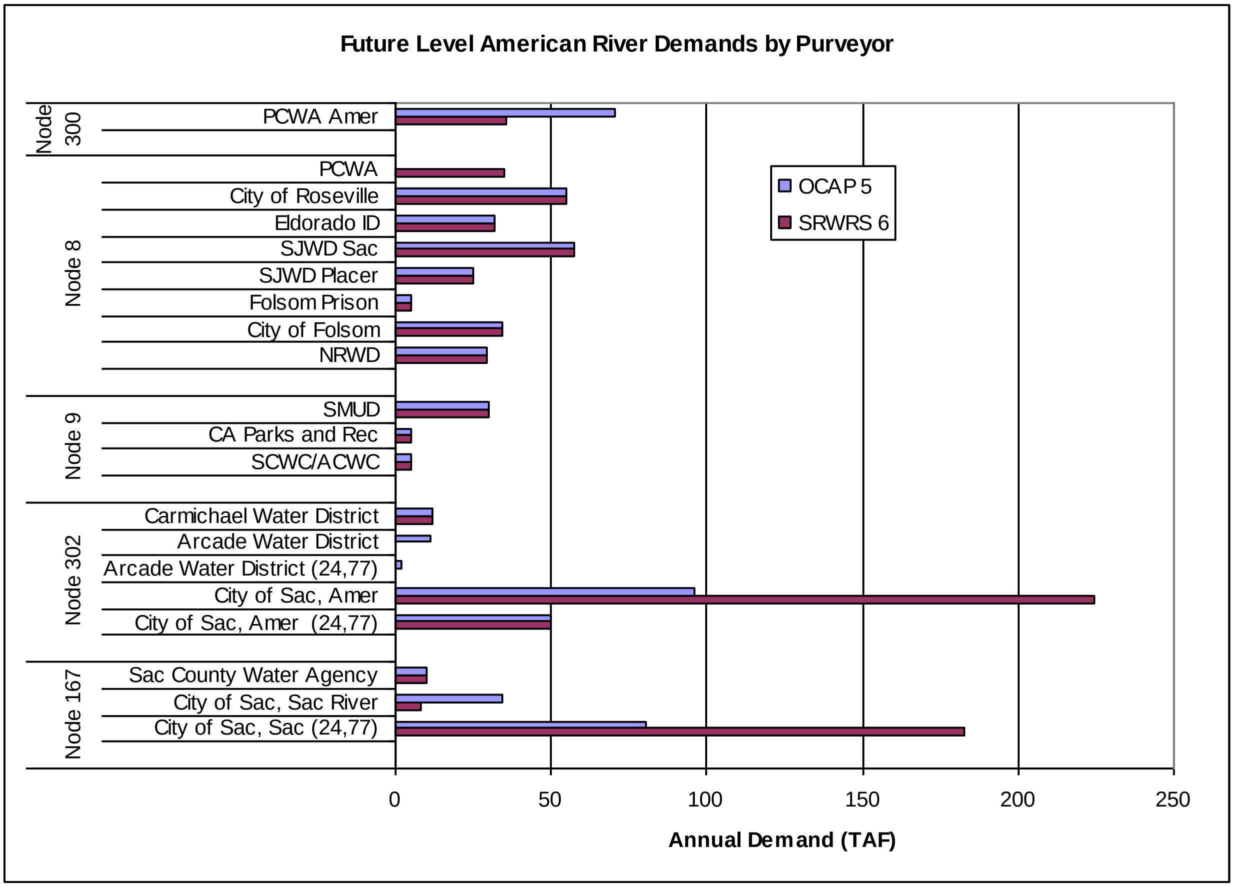

Figure 2. Comparison of OCAP 5 and SRWRS 6 American River Demands

The same shift of the City of Sacramento demands from the Sacramento River to the American River is present as in the existing condition simulation. The Placer County Water Agency (PCWA) diversion has also been split from all at Node 300, the American River Pump Station upstream of Folsom Reservoir, to about half there and half from Folsom Reservoir.

- UARM Simulations – Similar to the Non-EID American River Demands, these have been updated in the Common Assumptions process. The result of the updates is very small and probably has little or no effect on the impacts of the alternatives, but is included for consistency within the American River Basin.
- EID Temperature Control Device – EID plans to construct a TCD on the Folsom Reservoir Intake to allow them to make withdrawals from the reservoir at different elevations to preserve the Cold Water Pool in Folsom Reservoir. CALSIM II only models water operations, not temperature, so this assumption does not impact the CALSIM II simulations. The TCD will be implemented in the temperature modeling for all future level simulations.

4.2.3 Modeling Scenario Development

4.2.3.1 Alternative Implementation and Simulation

The project scenarios to be modeled are defined in Table 1. These alternatives are different combinations of new or additional diversions to EID and/or GDPUD up to an annual total of 15 TAF. For each project alternative scenario the appropriate level baseline simulation will be selected and the EID and GDPUD diversion changes implemented to produce a CALSIM II simulation that represents the alternative.

CALSIM II divides the system into a number of Drainage Areas (DA) that represent different hydrologic basins. The Lower American River basin is represented by DA 70. Each DA is assumed to have a consumptive use demand based on the land use within the basin. This is computed outside the CALSIM II model using the Consumptive Use model. During the CALSIM II simulation, the total diversion at all nodes within the basin is computed and compared to this consumptive use demand each month. If the total diversion is greater than the demand for the DA, then the diversion at each node in the DA is reduced proportionally so that the total diversion equals the total demand for the DA.

This project is assumed to be for an additional diversion to meet a new consumptive demand that was not included in the consumptive use analysis (pers. comm., M. Preszler, 2007). This implies that the alternative diversion should also be added to DA 70 consumptive use to maintain the water balance for the DA. The new annual diversions were converted to monthly CALSIM II diversion and consumptive use demand inputs using the procedures from the Demand Spreadsheet.

The Demand Spreadsheet assigns the annual diversion to the monthly CALSIM II diversion and demands using a different process for each, resulting in a different monthly distribution of each variable. During the monthly simulation this can lead to differences in the water balance process, and impacts to the diversions that are then distributed to all the Nodes in DA 70 by CALSIM II. Because of the difference in the monthly distributions there may be times where the monthly water balance shows a demand less than the monthly diversion and the monthly diversion is reduced even though the annual water balance is maintained. Also since any diversion shortages are spread over all Nodes in the DA other nodes, where the input diversion did not change, may also show a reduction.

Reclamation is aware of this issue, but has no plans to change it in the near future and will use the existing model in the new OCAP simulations that are now in progress (pers. comm., R. Fields 2007). This operation was not changed for the modeling simulations for this project.

4.2.4 EID Diversion Simulation

The EID diversion is modeled at Node 8, Folsom Reservoir, in CALSIM II. The CALSIM II diversion at this node represents a number of diversions from Folsom Reservoir including the EID diversion. The CALSIM II input for this diversion, both for the diversion and for the contribution to the total DA consumptive demand, was computed using methods from the Demand Spreadsheet, and stored in the CALSIM II Starting Value (SV) input database. CALSIM II also requires input of the annual total CVP and Water Rights portion of the total EID annual demand.

Internally CALSIM II then applies any CVP North of Delta allocation shortages to the CVP portion of the EID demand and adds these final demands to the other contractor demands at CALSIM II Node 8 for use in the CALSIM operational simulation. CALSIM only outputs the final, total diversion at Node 8, it does not produce separate output for the EID portion.

4.2.5 GDPUD Diversion Simulation

The GDPUD diversion is modeled in the UARM and in the CALSIM model. In the UARM, the GDPUD demand is split between an upstream diversion point below Stumpy Meadows Reservoir, and a diversion at the North Fork American River Pump Station. This diversion also includes a diversion to PCWA. The final UARM diversion at the North Fork American River Pump Station is included in the CALSIM model in the inflow to and diversion from Node 300, Auburn Reservoir Site.

The GDPUD diversion will be implemented in the CALSIM II at Node 300 by adding the appropriate GDPUD diversion for each alternative. The GDPUD diversion at this location is not directly served by the upstream reservoirs in the GDPUD; however, there is a minimum flow criteria below the diversion location that must be maintained. If the diversion increases enough to cause violation of the minimum flow requirement, the UARM model will be re-run to get the new CALSIM II inputs for use in the simulation.

SECTION 5 MODEL OUTPUTS

5.1 MODELING COMPARISONS

There are 8 modeling comparisons to be performed as presented in Table 2.

5.2 MODELING OUTPUTS

Results from the CALSIM II, temperature, Salmon Mortality and LongTermGen Model will be put together in tables for following outputs:

Folsom Reservoir

- End-of-Month Storage
- Mean Monthly Water Surface Elevation
- Mean Monthly Water Surface Area
- Number of Months Water Surface Elevation below 412 Feet (May through September)

Lower American River

- Mean Monthly Flows below Nimbus
- Mean Monthly Flows at Watt
- Mean Monthly Flows at H Street
- Mean Monthly Flows at Mouth
- Number of Months Flows Below 1,750 cfs (May through September)
- Backwater Recharge at H Street
    - # Years in Optimal Range (2,700-4,000 cfs)
    - # Years in Min/Optimal Range (1,300-4,000 cfs)
    - % Years within Min/Optional Range
- Backwater Recharge Below Nimbus
    - # Years in Optimal Range (2,700-4,000 cfs)
    - # Years in Min/Optimal Range (1,300-4,000 cfs)
    - % Years within Min/Optimal Range

Upper American River

- Mean Monthly Flows Above Auburn Dam
- Mean Monthly Flows Below Auburn Dam

Shasta Reservoir

- End-of-Month Storage
- Mean Monthly Water Surface Elevation
- Mean Monthly Water Surface Area

Trinity Reservoir

- End-of-Month Storage
- Mean Monthly Water Surface Elevation

Sacramento River

- Mean Monthly Flow Releases from Keswick

Mean Monthly Flow at Freeport

Delta

Mean Monthly Delta Outflow
Mean Monthly X2 Position
Export/Import Ratio

Water Supply

Differences in Allocation to SWP Contractors
Differences in Allocation to CVP M&I Contractors (North of Delta, non American River)
Differences in Allocation to CVP Ag Contractors (North of Delta)
Differences in Allocation to CVP M&I Contractors (South of Delta)
Differences in Allocation to CVP Ag Contractors (South of Delta)
Differences in CALSIM II Annual Diversion at Node 300 (Pump Station)
Differences in CALSIM II Annual Diversion at Node 8 (Folsom Res)
Differences in CALSIM II Annual Diversion at Node 167 (Sacramento River)
Differences in CALSIM II Annual Diversion at Node 302 (American River)

Hydropower*

Differences in Annual CVP Generation at Tracy (12 months)
Differences in CVP Capacity at Tracy (12 months)
Mean Monthly Energy Requirements for Pumping at EID and Folsom Pumping Plants

Sacramento River

Mean Monthly Water Temperatures at Keswick
Mean Monthly Water Temperatures at Bend Bridge
Mean Monthly Water Temperature at Freeport

Avenge Annual Early-Life Stage Survival
Fall-Run
Late-fail Run
Winter-Run
Spring-Run

American River

Mean Monthly Water Temperatures at Nimbus
Mean Monthly Water Temperatures at Watt
Mean Monthly Water Temperatures at H Street
Mean Monthly Water Temperatures at the Mouth
Average Annual Early-Life Stage Survival

Fall-Run
Late-fall Run – Not Computed
Winter-Run – Not Computed
Spring-Run – Not Computed

An example output table is provided in **Table 4**. All the numbers in the table are examples only; they are not actual comparison numbers.

Table 4. Output Table Example – Folsom Reservoir End-of-Month Storage for Simulation 1 vs. Simulation 2

Folsom Reservoir Storage – October Water Year	Folsom Reservoir Storage – October Water Year Type	Folsom Reservoir Storage – October Proposed Action Storage (AF) October	Folsom Reservoir Storage – October Proposed Action – Scenario A Storage (AF) October	Folsom Reservoir Storage – October Absolute Difference	Folsom Reservoir Storage – October Relative Difference (%)
1922	AN	488158.5	486761.8	-1396.7	-0.3
1923	BN	630335.6	611931.4	-18404.1	-2.9
1924	C	600000.0	628492.3	28492.3	4.7
1925	D	227452.5	206845.8	-20606.7	-9.1
1926	D	561738.1	549721.9	-12016.2	-2.1
1927	W	281436.8	276598.2	-4838.6	-1.7
1928	AN	710678.8	699071.6	-11607.1	-1.6
1929	C	421478.1	407178.9	-14299.2	-3.4
1930	D	330751.7	326032.6	-4719.1	-1.4
1931	C	391476.0	378804.2	-12671.8	-3.2
1932	D	206577.8	169983.0	-36594.8	-17.7
1933	C	514603.2	497584.4	-17018.8	-3.3
1934	C	305745.7	294152.3	-11593.3	-3.8
1935	BN	163827.1	146406.2	-17420.9	-10.6
1936	BN	578137.9	535528.7	-42609.3	-7.4
1937	BN	585822.3	548534.9	-37287.4	-6.4
1938	W	500630.2	500964.9	334.7	0.1
1939	D	716054.5	706923.8	-9130.8	-1.3
1940	AN	369873.3	330939.3	-38934.1	-10.5
1941	W	633884.2	590614.4	-43269.8	-6.8
1942	W	649506.6	631784.1	-17722.6	-2.7
1943	W	744867.1	725567.2	-19299.9	-2.6
1944	D	643305.7	632891.9	-10413.8	-1.6
1945	BN	476488.8	471424.8	-5064.1	-1.1
1946	BN	621505.3	613394.9	-8110.4	-1.3
1947	D	553046.0	561294.9	8248.9	1.5
1948	BN	390312.9	385706.4	-4606.4	-1.2
1949	D	6717180	659580.4	-12137.6	-1.8
1950	BN	502333.2	424873.6	-77459.5	-15.4
1951	AN	602259.1	600000.0	-2259.1	-0.4

Folsom Reservoir Storage – October Water Year	Folsom Reservoir Storage – October Water Year Type	Folsom Reservoir Storage – October Proposed Action Storage (AF) October	Folsom Reservoir Storage – October Proposed Action – Scenario A Storage (AF) October	Folsom Reservoir Storage – October Absolute Difference	Folsom Reservoir Storage – October Relative Difference (%)
1952	W	631582.0	609510.1	-22071.9	-3.5
1953	W	752500.0	743009.6	-9490.4	-1.3
1954	AN	665791.2	668844.6	3053.4	0.5
1955	D	440583.7	407799.8	-32783.8	-7.4
1956	W	449726.4	434937.5	-14788.9	-3.3
1957	AN	752500.0	752500.0	0.0	0.0
1958	W	513421.2	506244.3	-7176.8	-1.4
1959	BN	752500.0	752500.0	0.0	0.0
1960	D	335896.6	317564.4	-18332.2	-5.5
1961	D	368123.8	359425.9	-8697.9	-.24
1962	BN	273344.6	200152.6	-73192.0	-26.8
1963	W	752500.0	752500.0	0.0	0.0
1964	D	625237.7	601307.1	-23930.6	-3.8
1965	W	300000.0	300000.0	0.0	0.0
1966	BN	671806.4	686057.9	14251.5	2.1
1967	W	328470.9	308613.3	-19857.7	-6.0
1968	BN	752500.0	752500.0	0.0	0.0
1969	W	369808.0	374166.8	-22641.3	-5.7
1970	W	628120.1	608537.7	-19582.4	-3.1
1971	W	452997.5	413404.7	-39592.8	-8.7
1972	BN	713032.8	700621.6	-12411.2	-1.7
1973	AN	442984.6	444675.3	1690.7	0.4
1974	W	576118.4	559012.4	-17105.9	-3.0
1975	W	752500.0	752500.0	0.0	0.0
1976	C	752500.0	752500.0	0.0	0.0
1977	C	337632.2	312064.7	-255675	-7.6
1978	AN	90000.0	90000.0	0.0	0.0
1979	BN	518130.4	508446.7	-9683.7	-1.9
1980	AN	569696.8	556235.5	-13461.3	-2.4
1981	D	752500.0	752500.0	0.00	0.0

Folsom Reservoir Storage – October Water Year	Folsom Reservoir Storage – October Water Year Type	Folsom Reservoir Storage – October Proposed Action Storage (AF) October	Folsom Reservoir Storage – October Proposed Action – Scenario A Storage (AF) October	Folsom Reservoir Storage – October Absolute Difference	Folsom Reservoir Storage – October Relative Difference (%)
1982	W	378386.9	361418.2	-16968.7	-4.5
1983	W	745125.0	745125.0	0.0	0.0
1984	W	727625.0	727625.0	0.0	0.0
1985	D	694836.3	673446.6	-21389.6	-3.1
1986	W	300248.0	308878.3	8630.3	2.9
1987	D	657862.4	642316.3	-15546.1	-2.4
1988	C	379807.9	356581.1	-23226.8	-6.1
1989	D	285350.9	256211.1	-29139.8	-10.2
1990	C	433511.5	406193.3	-27318.3	-6.3
1991	C	322300.7	297780.1	-24520.7	-7.6
1992	C	377552.3	328321.8	-49230.6	-13.0
1993	AN	203386.3	179641.2	-23745.1	-11.7
	Mean:	-902.0	-902.0	-14836.7	-3.7
	Median:	516366.8	507345.5	-12541.5	-2.4
	Min:	90000.0	90000.0	-77459.5	-26.8
	Max:	752500.0	752500.0	28492.3	4.7

SECTION 6 REFERENCES

6.1 PRINTED REFERENCES

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6.2 Personal Communications

M. Preszler, P.E., California Water Consulting, Inc. Telephone conversation regarding handling of diversions in CALSIM II, with Bill Smith, Senior Engineer, HDR|SWRI, on June 26, 2007.

R. Fields, Hydraulic Engineer, Reclamation. Telephone conversation regarding CALSIM II, with Bill Smith, Senior Engineer, HDR|SWRI, June 2007.