Appendix 5A
Modeling Technical Appendix

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BDCP EIR/EIS Modeling Technical Appendix

This Appendix provides information about the assumptions, modeling tools and the methods used for Bay Delta Conservation Plan Environmental Impact Report/Environmental Impact Statement (BDCP EIR/EIS) Alternatives analyses including information for the Existing Conditions and No Action Alternative simulations. The Appendix also provides model results for the BDCP EIR/EIS Alternatives analyses, and additional modeling information pertaining to the development of the analytical tools, incorporating climate change and sea level rise effects and a few sensitivity analyses.

The Appendix consists is organized into four main sections that are briefly described below:

- Section A: Modeling Methodology
- Section B: CALSIM II and DSM2 Modeling Simulations and Assumptions
- Section C: CALSIM II and DSM2 Modeling Results
- Section D: Additional Modeling Information

Section A: Modeling Methodology

Several models are used to assess and quantify the effects of BDCP Alternatives on the long-term operations and the environment. This section provides information about the overall analytical framework explaining how the modeling information obtained from different models fit together; and descriptions of the key analytical tools that were part of the analytical framework. It also summarizes the modifications to the key analytical tools used in this process.

Section B: CALSIM II and DSM2 Modeling Simulations and Assumptions

This section provides a detailed description of the assumptions for the CALSIM II (Hydrology and System Operations) and DSM2 (Delta Hydrodynamics, Water Quality, and Delta Particle Tracking) model simulations of the Existing Conditions, No Action Alternative and the BDCP action Alternatives.

Section C: CALSIM II and DSM2 Modeling Results

This section provides CALSIM II and DSM2 model simulation results for the BDCP EIR/EIS Alternatives in comparison to the Existing Conditions and the No Action Alternative. Key parameters are selected for display; and several different formats of presentations are provided for each parameter to enable the reader to understand different kinds of analyses.

Section D: Additional Modeling Information

This section provides additional details related to the development of the analytical tools, and climate change and sea level rise modeling. In addition, it also provides information on various sensitivity analyses performed in support of the overall impact analysis.

Bay-Delta Conservation Plan EIR/EIS Appendix 5A

Section A: Modeling Methodology

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Outline

A.1. Introduction

This section summarizes the modeling methodology used for the Bay Delta Conservation Plan Environmental Impact Report/Environmental Impact Statement (BDCP EIR/EIS) Existing Conditions, No Action Alternative and other Alternatives. It describes the overall analytical framework and contains descriptions of the key analytical tools and approaches used in the quantitative evaluation of the Alternatives.

BDCP includes several main components that will have significant effects on SWP and CVP operations and the hydrologic response of the system. Most of the Alternatives include construction and operation of new north Delta intakes and associated conveyance, modifications to the Fremont Weir, large scale tidal marsh restoration in the Delta and changes in the operation of the existing south Delta export facilities can significantly influence the hydrologic response of the system.

For the purposes of the modeling, the Alternatives are simulated at three phases in time: Near-Term (NT), representing a point in time 5-10 years into the permit (~2015), Early Long-Term (ELT) representing a point in time 15 years into the permit (~2025), and Late Long-Term (LLT) representing the end of the 50-year permit (~2060).

In the Alternatives including the new north Delta intakes and isolated conveyance facility, the facility is assumed not to be functional until the ELT phase. All the Alternatives, except for Existing Conditions and No Action Alternative, include the tidal marsh restoration. The acreages of the tidal marsh restoration incrementally increase with each phase. NT includes 14,000 acres, ELT includes 25,000 acres and LLT includes 65,000 acres of tidal marsh restoration.

In the evaluation of the No Action Alternative and the other Alternatives at the ELT and LLT phases, sea level rise was assumed to be inherent. ELT assumes 15cm and LLT assumes 45cm sea level rise to exist. The analytical framework and the tools described in this are developed to evaluate these complex, inter-dependent, large-scale changes to the system. The full modeling assumptions for all the alternatives are provided in Section B.

For the purpose of BDCP EIR/EIS impacts evaluation, Alternatives' modeling results at LLT phase are considered.

A.2. Overview of the Modeling Approach

To support the impact analysis of the Alternatives, modeling of the physical variables (or "physical modeling") such as flows is required to evaluate changes to conditions affecting resources within the Delta as well as effects to upstream and downstream resources. A framework of integrated analyses including hydrologic, operations, hydrodynamics, water quality, and particle tracking analysis are required to provide baseline and comparative information for water supply, surface water, aquatic resources and water quality assessments. This analytical framework is also useful to assess changes in the function of the alternatives under varying assumptions of future, non-project conditions such as climate change, future demands, and changes in Delta morphology.

The Alternatives include complex changes to internal forcings such as Delta conveyance, SWP/CVP water project operations, floodplains and tidal marsh, and Delta channel structure/gates. Both these internal forcings and external forcings such as climate and sea level changes influence the future conditions of reservoir storage, river flow, Delta flows, exports, water quality, and tidal dynamics. Evaluation of these conditions is the primary focus of the physical modeling analyses. The interaction between many of the elements proposed under the Alternatives necessitated modifications to existing analytical tools or application of new analytical tools to account for these dynamic relationships.

Figure A-1 shows the analytical tools applied in these assessments and the relationship between these tools. Each model included in Figure A-1 provides information to the next "downstream" model in order to provide various results to support the impact analyses. Changes to the historical hydrology related to the future climate are applied in the CALSIM II model and combined with the assumed operations for each Alternative. The CALSIM II model simulates the operation of the major SWP and CVP facilities in the Central Valley and generates estimates of river flows, exports, reservoir storage, deliveries, and other parameters. The Delta boundary flows and exports from CALSIM II are then used to drive the DSM2 Delta hydrodynamic and water quality models for estimating tidally-based flows, stage, velocity, and salt transport within the estuary. Particle tracking modeling uses the velocity fields generated under the hydrodynamics to emulate movement of particles throughout the Delta system. River and temperature models for the primary river systems use the CALSIM II reservoir storage, reservoir releases, river flows, and meteorological conditions to estimate reservoir and river temperatures under each scenario. The results from this suite of physical models are used to inform the understanding of effects of each individual scenario considered in the BDCP.

A.2.1. Analytical Tools

A brief description of the hydrologic, hydrodynamic, water quality, particle transport, reservoir and river temperature modeling tools used in the analytical framework is provided below.

CALSIM II

The California Department of Water Resources (DWR)/U.S. Bureau of Reclamation (Reclamation) CALSIM II planning model was used to simulate the operation of the CVP and SWP over a range of hydrologic conditions. CALSIM II is a generalized reservoir-river basin simulation model that allows for specification and achievement of user-specified allocation targets, or goals (Draper et al. 2002). CALSIM II represents the best available planning model for the SWP and CVP system operations and has been used in previous system-wide evaluations of SWP and CVP operations (USBR, 1994, 2004, 2008).

Inputs to CALSIM II include water diversion requirements (demands), stream accretions and depletions, rim basin inflows, irrigation efficiencies, return flows, non-recoverable losses, and groundwater operations. Sacramento Valley and tributary rim basin hydrologies are developed using a process designed to adjust the historical sequence of monthly stream flows over an 82-year period (1922 to 2003) 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 CVP and SWP at a future level of development.

CALSIM II produces outputs for river flows and diversions, reservoir storage, Delta flows and exports, Delta inflow and outflow, Deliveries to project and non-project users, and controls on project operations. Reclamation's 2008 Operations Criteria and Plan (OCAP) Biological

Assessment (BA) Appendix D provides more information about CALSIM II (USBR, 2008a).CALSIM II output provides the basis for multiple other hydrologic, hydrodynamic, and biological models and analyses. CALSIM II results are used to determine water quality, hydrodynamics, and particle tracking in the DSM2 model. The outputs feed into temperature models including the Upper Sacramento River Water Quality Model (USRWQM), the Reclamation Temperature Model, and other habitat and biological models.

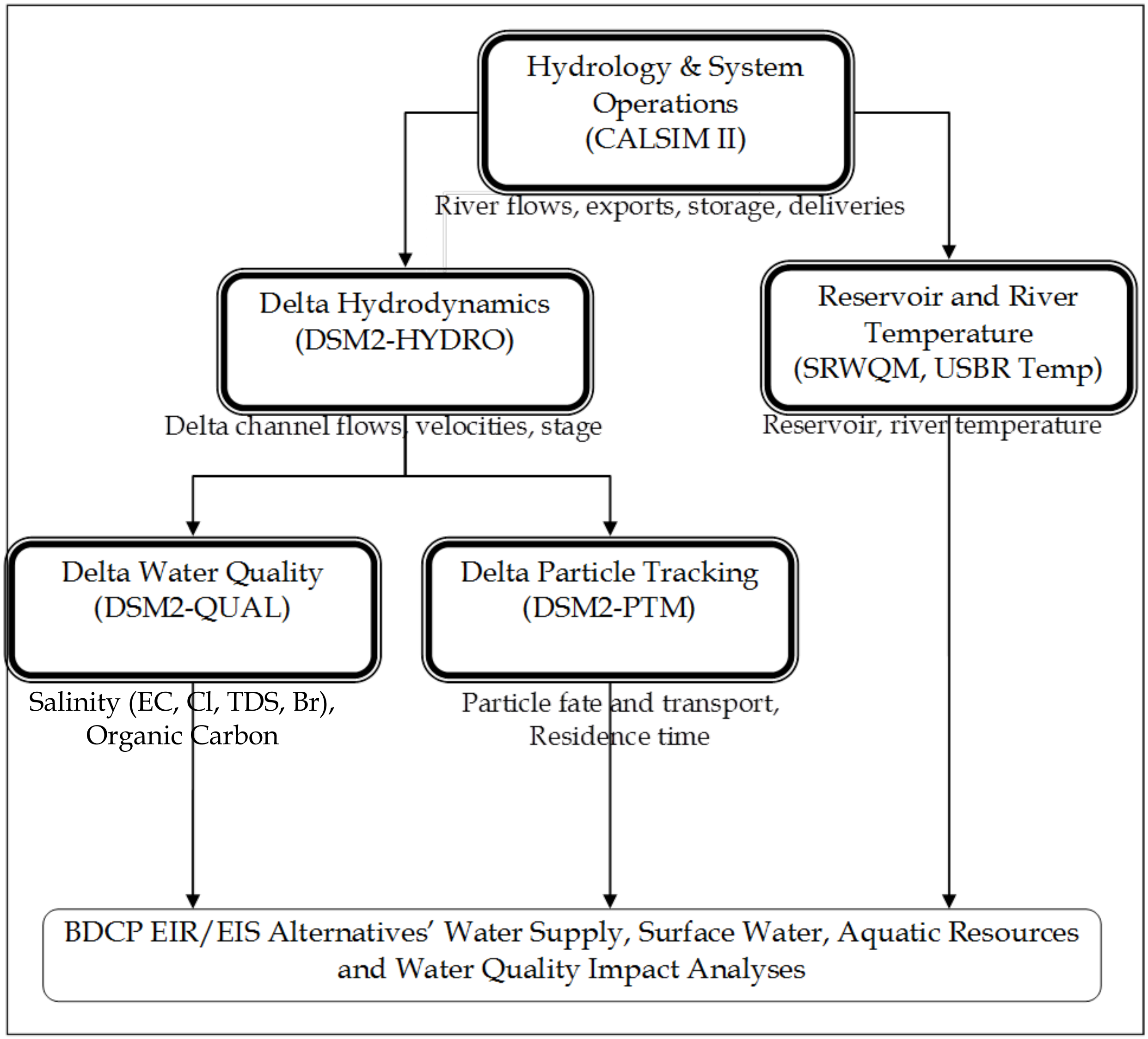


Figure A-1: Analytical Framework used to Evaluate Impacts of the Alternatives

Artificial Neural Network (ANN) for Flow-Salinity Relationships

An Artificial Neural Network (ANN) has been developed (Sandhu et al. 1999, Seneviratne and Wu, 2007) that attempts to faithfully mimic the flow-salinity relationships as modeled in DSM2, but provide a rapid transformation of this information into a form usable by the statewide CALSIM II model. The ANN is implemented in CALSIM II to constrain the operations of the upstream reservoirs and the Delta export pumps in order to satisfy particular salinity requirements. The current ANN predicts salinity at various locations in the Delta using the following parameters as input: Sacramento River inflow, San Joaquin River inflow, Delta Cross Channel gate position, and total exports and diversions. Sacramento River inflow includes Sacramento River flow, Yolo Bypass flow, and combined flow from the Mokelumne, Cosumnes, and Calaveras rivers (East Side Streams) minus North Bay Aqueduct and Vallejo exports. Total exports and diversions include State Water Project (SWP) Banks Pumping Plant, Central Valley Project (CVP) Tracy Pumping Plant, Contra Costa Water District (CCWD) diversions including diversion to Los Vaqueros Reservoir. The ANN model approximates DSM2 model-generated salinity at the following key locations for the purpose of modeling Delta water quality standards: X2, Sacramento River at Emmaton, San Joaquin River at Jersey Point, Sacramento River at Collinsville, and Old River at Rock Slough. In addition, the ANN is capable of providing salinity estimates for Clifton Court Forebay, CCWD Alternate Intake Project (AIP) and Los Vaqueros diversion locations. A more detailed description of the ANNs and their use in the CALSIM II model is provided in Wilbur and Munévar (2001). In addition, the DWR Modeling Support Branch website (http://modeling.water.ca.gov/) provides ANN documentation.

Upper Sacramento River Water Quality Model (USRWQM)

The Upper Sacramento River Water Quality Model (USRWQM) was used to simulate the effects of operations on water temperature in the Sacramento River and Shasta and Keswick reservoirs. The USRWQM was developed using the HEC-5Q model to simulate mean daily (using 6-hour meteorology) reservoir and river temperatures at key locations on the Sacramento River. The timestep of the model is daily and provides water temperature each day for the 82 year hydrologic period used in CALSIM II. The model has been used in the previous CVP and SWP system operational performance evaluation (USBR, 2008c). Monthly flows from CALSIM II for an 82 year period (WY 1922-2003) are used as input into the USRWQM after being temporally downsized to daily average flows. Temporal downscaling is performed on the CALSIM II monthly average tributary flows to convert them to daily average flows for HEC5Q input. Monthly average flows are converted to daily tributary inflows based on 1921 through 1994 daily historical record for the following aggregated inflows:

1. Trinity River above Lewiston;

2. Sacramento River above Keswick; and

3. Incremental inflow between Keswick and Bend Bridge (Seven day trailing average for inflows below Butte City).

Each of the total monthly inflows specified by CALSIM II is scaled proportionally to one of these three historical records. Reservoir inflows were proportioned as defined above. Outflows and diversions are smoothed for a better transition at the end of the month without regard for reservoir volume constraints or downstream minimum flows. As flows are redistributed within the month, the minimum flow constraint at Keswick, Red Bluff and Knights Landing may be violated. In such cases, operation modifications are required for daily flow simulation to satisfy minimum flow requirements. A utility program is included in SRWQM to convert the monthly CALSIM II flows and releases into daily operations. More detailed description SRWQM and the temporal downscaling process is included in an RMA calibration report (RMA 2003). For more information on the USRWQM, see Appendix H of the Reclamation's 2008 OCAP BA (USBR, 2008c).

Reclamation Temperature Model

The Reclamation Temperature Model was used to predict the effects of operations on water temperatures in the Trinity, Feather, American, and Stanislaus river basins and upstream reservoirs. The model is a reservoir and stream temperature model, which simulates monthly reservoir and stream temperatures used for evaluating the effects of CVP/SWP project operations on mean monthly water temperatures in the basin based on hydrologic and climatic input data. It has been applied to past CVP and SWP system operational performance evaluations (USBR, 2008c).

The model uses CALSIM II output to simulate mean monthly vertical temperature profiles and release temperatures for five major reservoirs (Trinity, Whiskeytown, Shasta, Oroville and Folsom), four downstream regulating reservoirs (Lewiston, Keswick, Goodwin and Natoma), and three main river systems (Sacramento, Feather and American), although the model is not be applied to the Sacramento River because the USRWQM was deemed superior as a result of its daily time step. For more information on the Reclamation Temperature Model, see Appendix H of the Reclamation's 2008 OCAP BA (USBR, 2008c).

DSM2

DSM2 is a one-dimensional hydrodynamic and water quality simulation model used to simulate hydrodynamics, water quality, and particle tracking in the Sacramento-San Joaquin Delta (DWR, 2002). DSM2 represents the best available planning model for Delta tidal hydraulic and salinity modeling. It is appropriate for describing the existing conditions in the Delta, as well as performing simulations for the assessment of incremental environmental impacts caused by future facilities and operations.

The DSM2 model has three separate components: HYDRO, QUAL, and PTM. HYDRO simulates velocities and water surface elevations and provides the flow input for QUAL and PTM. DSM2-HYDRO outputs are used to predict changes in flow rates and depths, and their effects on covered species, as a result of the BDCP and climate change.

The QUAL module simulates fate and transport of conservative and non-conservative water quality constituents, including salts, given a flow field simulated by HYDRO. Outputs are used to estimate changes in salinity, and their effects on covered species, as a result of the BDCP and climate change. Reclamation's 2008 OCAP BA Appendix F provides more information about DSM2 (USBR, 2008b).

DSM2-PTM simulates pseudo 3-D transport of neutrally buoyant particles based on the flow field simulated by HYDRO. It simulates the transport and fate of individual particles traveling throughout the Delta. The model uses velocity, flow, and stage output from the HYDRO module to monitor the location of each individual particle using assumed vertical and lateral velocity profiles and specified random movement to simulate mixing. PTM has multiple applications ranging from visualization of flow patterns to simulation of discrete organisms such as fish eggs and larvae. Additional information on DSM2 can be found on the DWR Modeling Support Branch website at http://modeling.water.ca.gov/.

A.2.2. Key Components of the Analytical Framework

Major components of the BDCP physical modeling, including Hydrology and Systems Operations Modeling, Reservoir and River Temperature Modeling, Delta Hydrodynamics and

Water Quality Modeling and Delta Particle Transport and Fate Modeling are described in separate sections. Each section describes in detail the key tools used for modeling, data inter-dependencies and limitations. It also includes description of the process of how the tools are applied in a long-term planning analysis such as evaluating the Alternatives and describe any improvements or modifications performed for application in BDCP modeling.

Section A.3. *Hydrology and Systems Operations Modeling* describes the application of the CALSIM II model to evaluate the effects of hydrology and system operations on river flows, reservoir storage, Delta flows and exports, and water deliveries. Section A.4. *Reservoir and River Temperature Modeling* includes a description of the Sacramento River Water Quality Model for analysis of temperature in the Shasta-Whiskeytown complex and the Sacramento River. Section A.5. *Delta Hydrodynamics and Water Quality* section describes the application of the DSM2 model to implement new elements of the BDCP and resulting effects to tidal stage, velocity, flows, and salinity. Finally, Section A.6. *Delta Particle Transport and Fate Modeling* describes the methodology and application of the DSM2-PTM model for simulating particle transport in the Delta.

A.2.3. Climate Change and Sea Level Rise

The physical modeling approach applied for the BDCP integrates a suite of analytical tools in a unique manner to characterize changes to the system from “atmosphere to ocean”. Figure A-2 illustrates the general flow of information for incorporating climate and sea level change in the physical modeling analyses. Climate and sea level can be considered the most upstream and most downstream boundary forcings on the system analyzed in the physical modeling for the BDCP. However, these forcings are outside of the influence of the BDCP and are considered external forcings. The effects of these forcings are incorporated into the key models used in the analytical framework.

The selection of the future climate and the sea level rise scenarios is described in Section A.7. *Climate and Sea Level Change Scenarios* section along with the process of science review, incorporation of uncertainty, and analytical methods for selecting appropriate scenarios. For all the selected future climate scenarios, regional hydrologic modeling was performed with the Variable Infiltration Capacity (VIC) hydrology model using temperature and precipitation projections of future climate. In addition to a range of hydrologic process information, the VIC model generates natural streamflows under each assumed climate condition. Section A.8. *Regional Hydrologic Modeling* describes the application of the macro-scale VIC hydrology model that translates the effects of future climate conditions on watershed processes ultimately affecting the timing and volume of runoff.

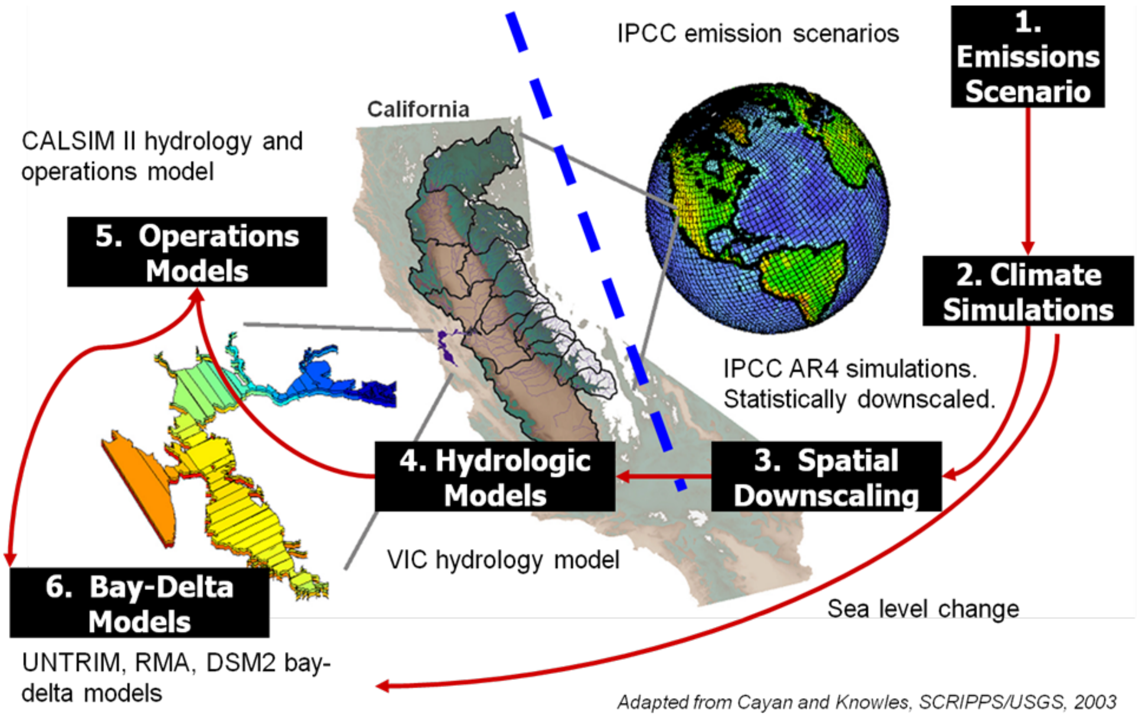


Figure A-2: Characterizing Climate Impacts from Atmosphere to Oceans

A.3. Hydrology and System Operations

The hydrology of the Central Valley and operation of the CVP and SWP systems is a critical element toward any assessment of changed conditions in the Delta. Changes to conveyance, flow patterns, demands, regulations, and/or Delta configuration will influence the operation of the SWP and CVP reservoirs and export facilities. The operations of these facilities, in turn, influence Delta flows, water quality, river flows, and reservoir storage. The interaction between hydrology, operations, and regulations is not always intuitive and detailed analysis of this interaction often results in new understanding of system responses. Modeling tools are required to approximate these complex interactions under future conditions.

The Bay Delta Conservation Plan (BDCP) includes several main components that will have significant effects on SWP and CVP operations and the hydrologic response of the system. The proposed construction and operation of new north Delta intakes and associated conveyance, modifications to the Fremont Weir, large scale tidal marsh restoration in the Delta, and changes in the operation of the existing south Delta export facilities can significantly influence the hydrologic response of the system.

This section describes in detail the methodology used to simulate hydrology and system operations for evaluating the effects of the BDCP. It discusses the primary tool (CALSIM II) used in this process and improvements made to the model to better simulate key components of the BDCP.

A.3.1 CALSIM II

The DWR/USBR CALSIM II planning model was used to simulate the operation of the CVP and SWP over a range of hydrologic conditions. CALSIM II 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 II and represents the best available planning model for the SWP and CVP system operations. CALSIM II includes major reservoirs in the Central Valley of the California including Trinity, Lewiston, Whiskeytown, Shasta, Keswick, Folsom, Oroville, San Luis, New Melones and Millerton located along the Sacramento and San Joaquin Rivers and their tributaries. CALSIM II also includes all the major CVP and SWP facilities including Clear Creek Tunnel, Tehama Colusa Canal, Corning Canal, Jones Pumping Plant, Delta Mendota Canal, Mendota Pool, Banks Pumping Plant, California Aqueduct, South Bay Aqueduct, North Bay Aqueduct, Coastal Aqueduct and East Branch Extension. In addition, it also includes some locally managed facilities such as the Glenn Colusa Canal, Contra Costa Canal and the Los Vaqueros Reservoir. Figure A-3 shows the major reservoirs, streams and facilities included in the CALSIM II model.

The CALSIM II simulation model uses single time-step 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. 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 process of routing water through the channels and storing water in reservoirs is performed by a mixed integer linear programming solver. 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.

Figure A-3: Major Reservoirs, Streams and Facilities (both CVP and SWP) Included in the CALSIM II Model

CALSIM II 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 efficiencies, return flows, non-recoverable losses, and groundwater operations are components that make up the hydrology used in CALSIM II. 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. Figure A-4 shows the valley floor depletion regions, which represent the spatial resolution at which the hydrologic analysis is performed in the model.

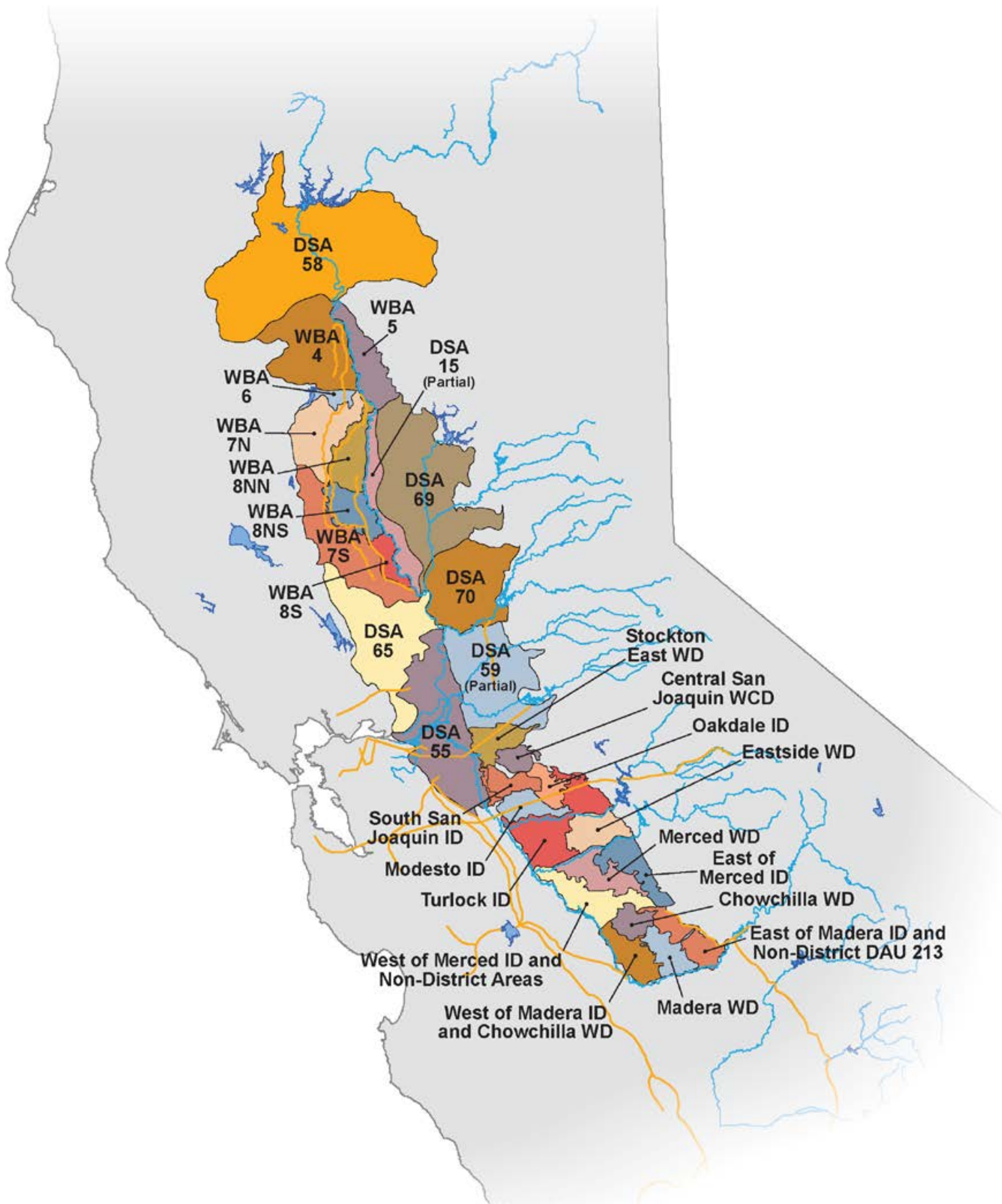


Figure A-4: CALSIM II Depletion Analysis Regions

CALSIM II 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 II model utilizes a monthly time-step to route flows throughout the river-reservoir system of the Central Valley. While monthly time steps are reasonable for long-term planning analyses of water operations, two major components of the BDCP conveyance and conservation strategy include operations that are sensitive to flow variability at scales less than monthly: the operation of the modified Fremont Weir and the diversion/bypass rules associated with the proposed north Delta intakes. Initial comparisons of monthly versus daily operations at these facilities indicated that weir spills were likely underestimated and diversion potential was likely overstated using a monthly time step. For these reasons, a monthly to daily flow disaggregation technique was included in the CALSIM II model for the Fremont Weir, Sacramento Weir, and north Delta intakes. The technique applies historical daily patterns, based on the hydrology of the year, to transform the monthly volumes into daily flows. The procedure is described in more detail further in this document. Reclamation's 2008 OCAP BA Appendix D provides more information about CALSIM II (USBR, 2008a).

A.3.2. Artificial Neural Network for Flow-Salinity Relationship

Determination of flow-salinity relationships in the Sacramento-San Joaquin Delta is critical to both project and ecosystem management. Operation of the SWP/CVP facilities and management of Delta flows is often dependent on Delta flow needs for salinity standards. Salinity in the Delta cannot be simulated accurately by the simple mass balance routing and coarse timestep used in CALSIM II. Likewise, the upstream reservoirs and operational constraints cannot be modeled in the DSM2 model. 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 II operations model. The ANN is implemented in CALSIM II 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 II model is provided in Wilbur and Munévar (2001).

The ANN developed by DWR (Sandhu et al. 1999, Seneviratne and Wu, 2007) attempts to statistically correlate the salinity results from a particular DSM2 model run to the various peripheral flows (Delta inflows, exports and diversions), gate operations and an indicator of tidal energy. The ANN is calibrated or trained on DSM2 results that may represent historical or future conditions using a full circle analysis (Seneviratne and Wu, 2007). For example, a future reconfiguration of the Delta channels to improve conveyance may significantly affect the hydrodynamics of the system. The ANN would be able to represent this new configuration by being retrained on DSM2 model results that included the new configuration.

The current ANN predicts salinity at various locations in the Delta using the following parameters as input: Northern flows, San Joaquin River inflow, Delta Cross Channel gate position, total exports and diversions, Net Delta Consumptive Use, an indicator of the tidal energy and San Joaquin River at Vernalis salinity. Northern flows include Sacramento River flow, Yolo Bypass flow, and combined flow from the Mokelumne, Cosumnes, and Calaveras rivers (East Side Streams) minus North Bay Aqueduct and Vallejo exports. Total exports and diversions include State Water Project (SWP) Banks Pumping Plant, Central Valley Project (CVP) Jones Pumping Plant, and CCWD diversions including diversions to Los Vaqueros Reservoir. A total of 148 days of values of each of these parameters is included in the correlation, representing an estimate of the length of memory of antecedent conditions in the Delta. The ANN model approximates DSM2 model-generated salinity at the following key locations for the purpose of modeling Delta water quality standards: X2, Sacramento River at Emmaton, San Joaquin River at Jersey Point, Sacramento River at Collinsville, and Old River at Rock Slough. In addition, the ANN is capable of providing salinity estimates for Clifton Court Forebay, CCWD Alternate Intake Project (AIP) and Los Vaqueros diversion locations.

The ANN may not fully capture the dynamics of the Delta under conditions other than those for which it was trained. It is possible that the ANN will exhibit errors in flow regimes beyond those for which it was trained. Therefore, a new ANN is needed for any new Delta configuration or under sea level rise conditions which may result in changed flow – salinity relationships in the Delta.

A.3.3. Application of CALSIM II to Evaluate BDCP Alternatives

Typical long-term planning analyses of the Central Valley system and operations of the CVP and SWP have applied the CALSIM II model for analysis of system responses. CALSIM II 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 II, informs the flow-salinity relationships and several flow-related regressions for interior Delta conditions (i.e. X2 and OMR) included in the model. For each set of hydrologic, facility, operations, regulations, and Delta configuration conditions, the CALSIM II 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. These refinements are generally made by experienced modelers in conjunction with project operators. Water transfers are generally considered “additional” releases that may result in additional exports, additional outflow, or both depending on the purpose, timing, and operations associated with the transfer. However, any water transfer would need to comply with the same conditions as considered for project exports.

The CALSIM II model produces outputs of river flows, exports, water deliveries, reservoir storage, water quality, and several derived variables such as X2, Delta salinity, OMR, and QWEST. The CALSIM II model is most appropriately applied for comparing one alternative to another and drawing comparisons between the results. This is the method in which CALSIM II is applied for the BDCP. For each phase of the Alternatives a companion No Action Alternative simulation has been prepared. The No Action simulation includes the existing infrastructure, existing regulatory restrictions including the recent biological opinions, but may include future demands, climate, and sea level rise depending on the time frame. The Alternative is compared to the No Action Alternative to evaluate areas in which the project changes conditions and the seasonality and magnitude of such changes. The change in hydrologic response or system conditions is important information that informs the effects analysis related to water-dependent resources in Sacramento-San Joaquin watersheds.

There are a number of areas in which the CALSIM II model has been improved or is applied differently for the BDCP analyses. This section briefly describes these key changes.

Changes to the CALSIM II Model Network

The main feature of the Alternatives that necessitated changes to the CALSIM II model network was the proposed diversion intakes in the north Delta along the Sacramento River. The intakes and associated conveyance allow for SWP and CVP diversions on the Sacramento River between Freeport and Courtland. Some of the Alternatives include up to 5 intakes in this reach of the river with individual diversion capacity up to 3,000 cfs. Since there are relatively small existing diversions and negligible inflows occurring in this reach of the Sacramento River, the CALSIM II aggregates all proposed diversions into a single diversion arc (Figure A-5) near Hood. This diversion arc (D400) conveys water diverted by the SWP and CVP to their respective pumping plants (either Banks PP or Jones PP) in the south Delta. Since dual conveyance – diverting from either or both north and south facilities -- is being considered, the model comingles the water at the pumping plant. Water for each project is tracked separately.

Additional changes were made to the CALSIM II network in the south Delta to allow for better estimation of the Combined Old and Middle River (OMR) flow.

The Delta island consumptive use (DICU) is applied in CALSIM II at five nodes representing regions in the north, west, central, south, and San Joaquin regions of the Delta. A review of the DICU was performed in 2009 to discern if any adjustments would be necessary to best reflect the flow available at the points of diversion. The DICU was disaggregated further, into a total of seven parts, including to split out the DICU upstream and downstream of the proposed north Delta diversion, and portion of the DICU in the south Delta to improve estimates of the OMR flow.

The full schematic for the CALSIM II model is included in Section D.11.

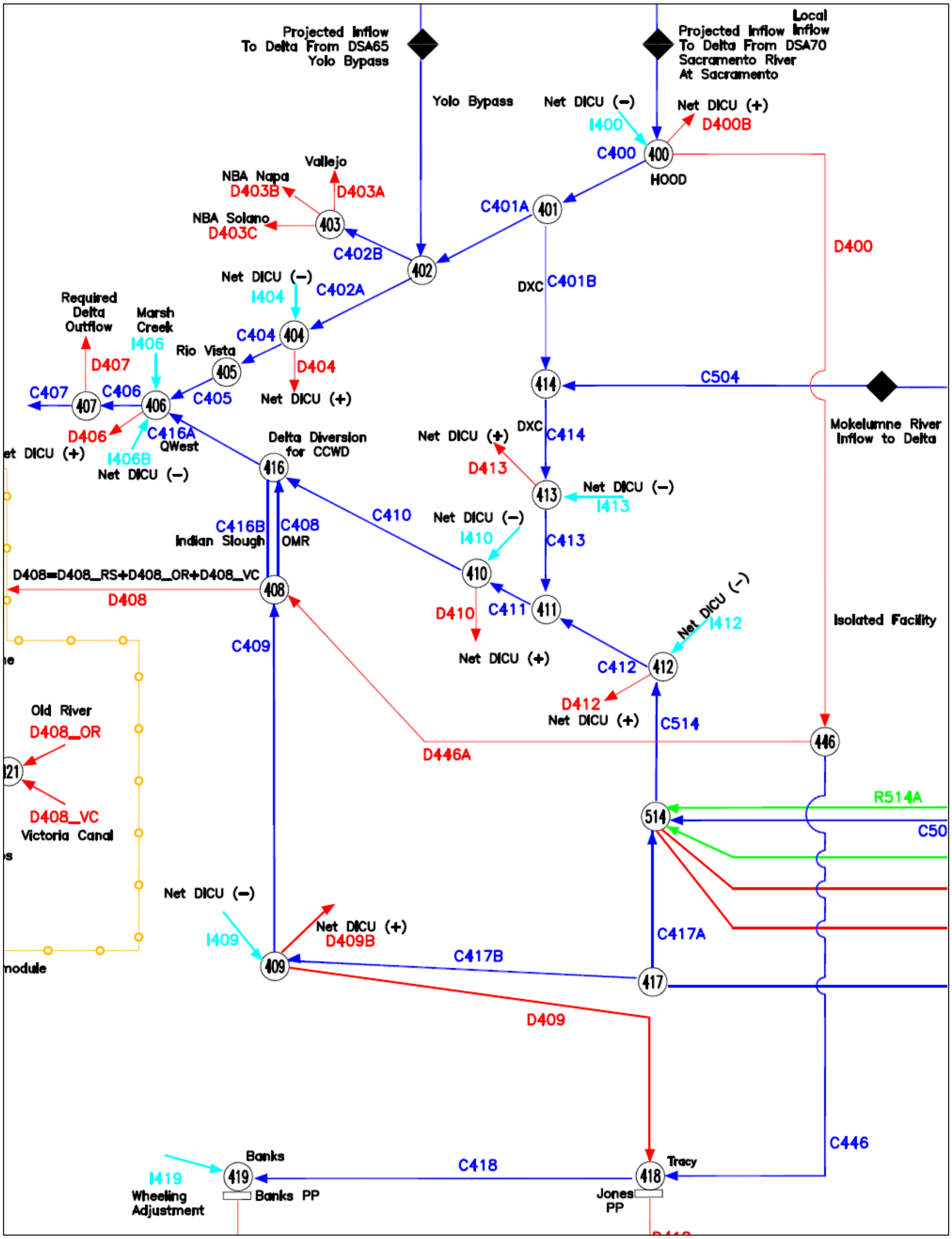


Figure A-5: Updated CALSIM II network for the inclusion of north Delta diversion (D400)

Incorporation of Sacramento River Daily Variability

As described above, the operation of the modified Fremont Weir and the diversion/bypass rules associated with the proposed north Delta intakes are sensitive to the daily variability of flows. Short duration, highly variable storms are likely to cause Fremont Weir spills. However, if flows are averaged for the month, as is done in a monthly model, it is possible to not identify any spill. Similarly, the operating criteria for the north Delta intakes include variable bypass flows and pulse protection criteria. Storms as described above may permit significant diversion but only for a short period of time. Initial comparisons of monthly versus daily operations at these facilities indicated that weir spills were likely underestimated and diversion potential was likely overstated using a monthly time step.

Figure A-6 shows a comparison of observed monthly averaged Sacramento River flow at Freeport and corresponding daily flow as an example. The figure shows that the daily flow exhibits significant variability around the monthly mean in the winter and spring period while remaining fairly constant in summer and fall months. Figure A-7 shows the daily historical patterns by water year type. It shows that daily variability is significant in the winter-spring while the summer flows are holding fairly constant in the most water year types. The winter-spring daily variability is deemed important to species of concern.

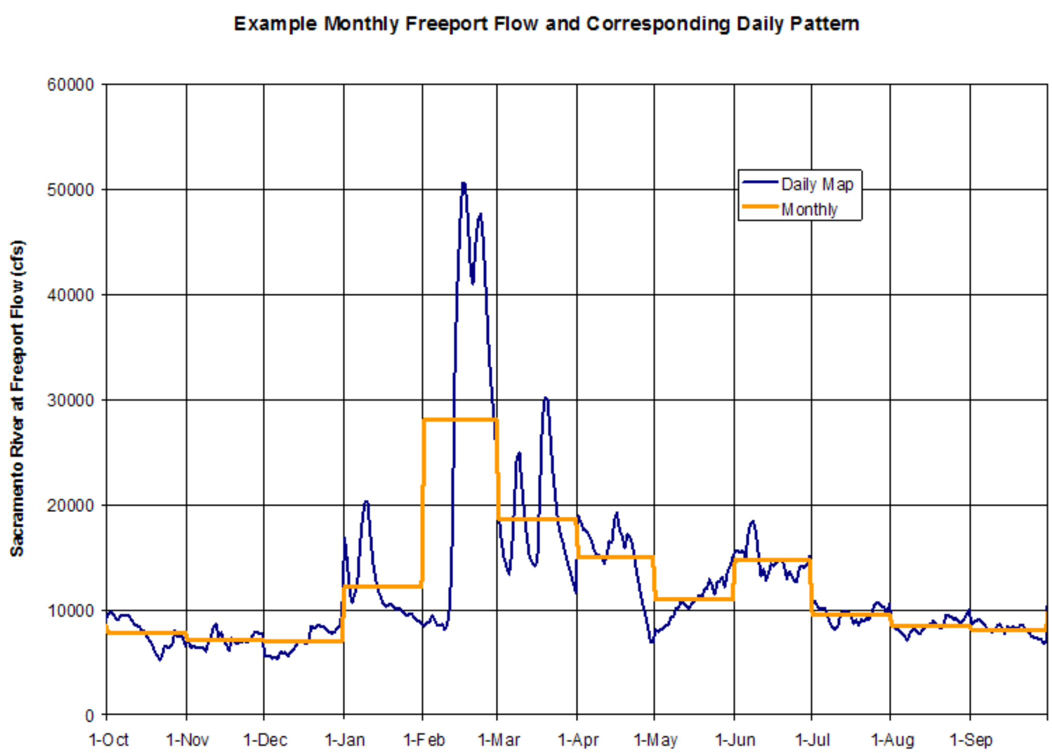


Figure A-6: Example monthly-averaged and daily-averaged flow for Sacramento River at Freeport

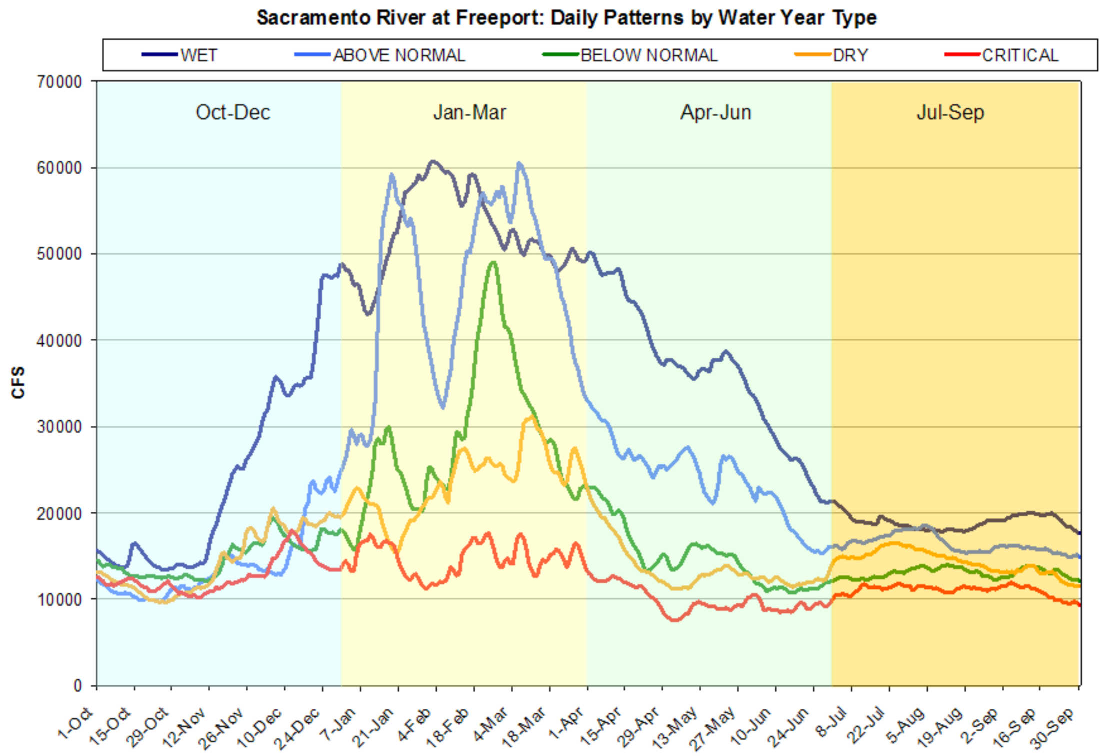


Figure A-7: Mean daily flows by Water Year Type for Sacramento River at Freeport

In an effort to better represent the sub-monthly flow variability, particularly in early winter, a monthly-to-daily flow mapping technique is applied directly in CALSIM II for the Fremont Weir, Sacramento Weir, and the north Delta intakes. The technique applies historical daily patterns, based on the hydrology of the year, to transform the monthly volumes into daily flows. Daily flow patterns are obtained from the observed DAYFLOW period of 1956-2008. In all cases, the monthly volumes are preserved between the daily and monthly flows. It is important to note that this daily mapping approach does not in any way represent the flows resulting from operational responses on a daily time step. It is simply a technique to incorporate representative daily variability into the flows resulting from CALSIM II's monthly operational decisions. It helps in refining the monthly CALSIM II operations by providing a better estimate of the Fremont and Sacramento weir spills which are sensitive to the daily flow patterns and allows in providing the upper bound of the available north Delta diversion in the Alternatives.

Observed Daily Patterns

CALSIM II hydrology is derived from historical monthly gauged flows for 1922-2003. This is the source data for monthly flow variability. DAYFLOW provides a database of daily historical Delta inflows from WY 1956 to present. This database is aligned with the current Delta infrastructure setting. Despite including the historical operational responses to various regulatory regimes existed over this period, in most winter and spring periods the reservoir operations and releases are governed by the inflows to the reservoirs.

Daily patterns from DAYFLOW used directly for mapping CALSIM II flows for water years 1956 to 2003. For water years 1922 to 1955 with missing daily flows, daily patterns are selected from water years 1956 to 2003 based on similar total annual unimpaired Delta inflow. The daily pattern for the water year with missing daily flows is assumed to be the same as the daily pattern of the identified water year. Correlation among the various hydrologic basins is preserved by selecting same pattern year for all rivers flowing into the Delta, for a given year in the 1922-1955 period. Table A-1 lists the selected pattern years for the water years 1922 to 1955 along with the total unimpaired annual Delta inflow.

Thus, for each month in the 82-year CALSIM II simulation period, the monthly flow is mapped onto a daily pattern for computation of spills over the Fremont Weir and Sacramento Weir and for computing water available for diversions through the north Delta intakes. A preprocessed timeseries of daily volume fractions, based on Sacramento River at Freeport observed flows, is input into CALSIM II. The monthly volume as determined dynamically from CALSIM II then is multiplied by the fractions to arrive at a daily flow sequence. The calculation of daily spills and daily diversions are thus obtained. In the subsequent cycle (but still the same month), adjustments are made to the daily river flow upstream of the Sacramento Weir and the north Delta intakes to account for differences between the monthly flows assumed in the first cycle and the daily flows calculated in subsequent cycles. For example, if no spill over Fremont was simulated using a monthly flow, but when applying a daily pattern spill does occur, then the River flow at the Sacramento Weir is reduced by this amount. In this fashion, daily balance and monthly balance is preserved while adding more realism to the operation of these facilities.

TABLE A-1
Identified “Pattern” Water Year for the Water Years 1922 to 1955 with Missing Daily Historical Flows

Water Year	Total Annual Unimpaired Delta Inflow (TAF)	Selected “Pattern” Water Year	Total Annual Unimpaired Delta Inflow (TAF)
1922	32,975	1975	31,884
1923	23,799	2002	23,760
1924	8,174	1977	6,801
1925	26,893	1962	25,211
1926	18,534	1959	17,967
1927	38,636	1984	38,188
1928	26,363	1962	25,211
1929	12,899	1994	12,456
1930	20,326	1972	19,863
1931	8,734	1977	6,801
1932	24,179	2002	23,760
1933	14,126	1988	14,019
1934	12,895	1994	12,456
1935	28,486	2003	28,228
1936	30,698	2003	28,228
1937	25,448	1962	25,211
1938	56,949	1998	56,482
1939	12,743	1994	12,456
1940	37,185	1963	36,724
1941	46,746	1986	46,602
1942	42,301	1980	41,246
1943	36,870	1963	36,724
1944	17,158	1981	17,131
1945	26,757	1962	25,211
1946	28,823	2003	28,228
1947	16,206	2001	15,460
1948	23,741	1979	22,973

TABLE A-1
Identified "Pattern" Water Year for the Water Years 1922 to 1955 with Missing Daily Historical Flows

Water Year	Total Annual Unimpaired Delta Inflow (TAF)	Selected "Pattern" Water Year	Total Annual Unimpaired Delta Inflow (TAF)
1949	19,176	1960	19,143
1950	23,272	1979	22,973
1951	39,110	1984	38,188
1952	49,270	1986	46,602
1953	30,155	2003	28,228
1954	26,563	1962	25,211
1955	17,235	1981	17,131

Fremont Weir Operations

All the Alternatives, except for Existing Conditions and No Action Alternative, include the measure for modifying the current Fremont Weir by notching it to allow for more frequent inundation in the Yolo Bypass. Details of the Fremont Weir and Yolo Bypass Hydraulics are described in Section D.4. The HEC-RAS modeling included in that section provides modified rating curves of the Fremont Weir for use in CALSIM II. CALSIM II simply includes two sets of rating curves, one with the "notch" and one without the notch. Input tables allow specification of when the notch is assumed to be operated. The amount of spill over the Fremont Weir or the notch is computed using the daily patterned Sacramento River flow at Verona and the rating curves included in the model.

North Delta Diversion Operations

Several of the Alternatives include new intakes (1 to 5 intakes depending on the Alternative) on Sacramento River upstream of Sutter Slough, in the north Delta. Each intake is proposed to have 3,000 cfs maximum pumping capacity. It is also proposed that the intakes will be screened using positive barrier fish screens to eliminate entrainment at the pumps. Water diverted at the five intakes is conveyed to a new forebay in the south Delta via a new isolated conveyance facility capable of conveying up to a maximum flow of 15,000 cfs (the conveyance capacity depends on the Alternative). Detailed assumptions for each Alternative are provided in Section B.

The BDCP proposes bypass (in-river) rules, which govern the amount of water required to remain in the river before any diversion can occur. Bypass rules are designed with the intent to avoid increased upstream tidal transport from downstream channels, to maintain flow supporting the migration of the salmonid and transport of pelagic species to regions of suitable habitat, to preserve shape of the natural hydrograph which may act as cue to important biological functions, to lower potential for increased tidal reversals that may occur because of the reduced net flow in the river and to provide flows to minimize predation effects downstream. The bypass rules include three important components:

- a constant low level pumping of up to 300 cfs at each intake depending on the flow in the Sacramento River,
- an initial pulse protection, and
- a post-pulse operations that permit a percentage of river flow above a certain threshold to be diverted (and transitioning from Level I to Level II to Level III).

It should be noted that these components, as further defined in Tables B-10 through B-17, are represented in CALSIM II to the extent possible. Modeling assumptions may differ from actual operations because of real-time monitoring of fish entry into the Plan Area and other variables. Tables B-10 through B-17 clearly state conditions where biological triggers or off-ramps that cannot be simulated in CALSIM II are assumed.

The bypass rules are simulated in CALSIM II using daily mapped Sacramento River flows as described above to determine the maximum potential diversion that can occur in the north Delta for each day. The simulation identifies which of the three criteria is governing, based on antecedent daily flows and season. An example of the north Delta flows and diversion is illustrated in Figure A-8. As can be seen in this figure, bypass rules begin at Level I in October until the Sacramento River pulse flow develops. During the pulse flow, the constant low level pumping (Level 0) is permitted, but is limited to a certain percentage of river flow. After longer periods of high bypass flows, the bypass flow requirements moves to Level II and eventually Level III which permit greater potential diversion. CALSIM II uses the monthly average of this daily potential diversion as one of the constraints in determining the final monthly north Delta diversion.

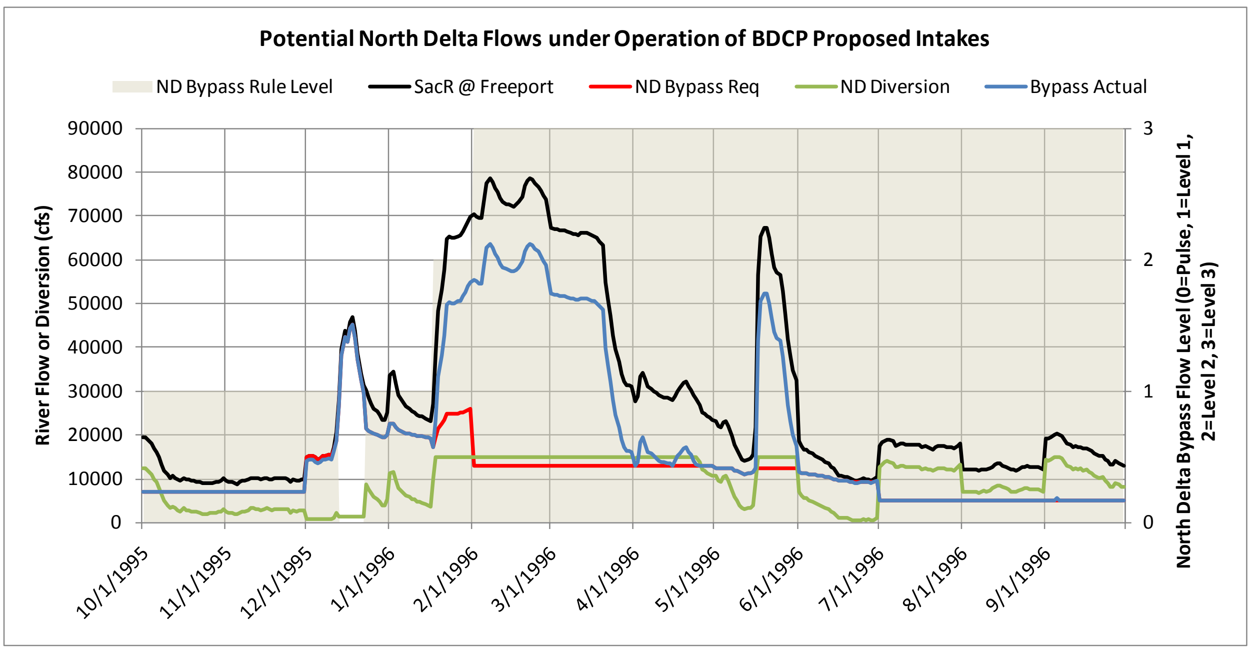


Figure A-8: Example year daily patterns and operation of the north Delta intakes. Note: the grey shading indicates the active bypass rule (0=pulse/low level pumping, 1=level I, 2=level II, and 3=level III).

ANN Retraining

ANNs are used for simulating flow-salinity relationships in CALSIM II. They are trained on DSM2 outputs and therefore, emulate DSM2 results. ANN requires retraining whenever the flow – salinity relationship in the Delta changes. As mentioned earlier, BDCP analysis assumes different tidal marsh restoration acreages at NT, ELT and LLT phases and 15cm and 45cm sea level rise at ELT and LLT, respectively. Each combination of restoration and sea level condition results in a different flow – salinity relationship in the Delta and therefore require a new ANN.

New ANNs have been developed by DWR for each new proposed combination of tidal marsh and sea level. ANN retraining process is described in Section A.5.3.

Incorporation of Climate Change

Climate and sea level change are incorporated into the CALSIM II model in two ways. As described in Section A.8., changes in runoff and streamflow are simulated through VIC modeling under representative climate scenarios. These simulated changes in runoff are applied to the CALSIM II inflows as a fractional change from the observed inflow patterns (simulated future runoff divided by historical runoff). These fraction changes are first applied for every month of the 82-year period consistent with the VIC simulated patterns. A second order correction is then applied to ensure that the annual shifts in runoff at each location are consistent with that generated from the VIC modeling. A spreadsheet tool has been prepared to process this information and generate adjusted inflow time series records for CALSIM II. Once the changes in flows have been resolved, water year types and other hydrologic indices that govern water operations or compliance are adjusted to be consistent with the new hydrologic regime.

Sea level rise and restored tidal marsh effects on the flow-salinity response is incorporated in the new ANNs. CALSIM II model simulations require the modeler to select which hydrology should be paired with which sea level/tidal marsh ANN.

The following input parameters are adjusted in CALSIM II to incorporate the effects of climate change:

- Inflow time series records for all major and minor streams in the Central Valley
- Sacramento and San Joaquin Valley water year types
- Runoff forecasts used reservoir operations and allocation decisions
- Delta water temperature as used in triggering biological opinion smelt criteria
- Modified ANNs to reflect the flow-salinity response under sea level change scenarios

The CALSIM II simulations do not consider future climate change adaptation which may manage the SWP and CVP system in a different manner than today to reduce climate impacts. For example, future changes in reservoir flood control reservation to better accommodate a seasonally changing hydrograph may be considered under future programs, but are not considered under the BDCP. Thus, the CALSIM II BDCP results represent the risks to operations, water users, and the environment in the absence of dynamic adaptation for climate change.

A.3.4. Output Parameters

The Hydrology and System Operations models produce the following key parameters on a monthly time-step:

River flows and diversions

Reservoir storage

Delta flows and exports

Delta inflow and outflow

Deliveries to project and non-project users

Controls on project operations

Some operations have been informed by the daily variability included in the CALSIM II model for the BDCP, and where appropriate, these results are presented. However, it should be noted that CALSIM II remains a monthly model. The daily variability in the CALSIM II model to better represent certain operational aspects, but the monthly results are utilized for water balance. For example, diversions from the north-Delta facilities are informed by the daily variability of Sacramento River flow, whereas diversions from south-Delta intakes are modeled on a monthly time step because daily modeling for Delta would require several assumptions on daily operations that cannot be modeled, and therefore, was not attempted. All diversions are reported on a monthly basis.

Appropriate use of model results is important. Despite detailed model inputs and assumptions, the CALSIM II results may differ from real-time operations under stressed water supply conditions. Such model results occur due to the inability of the model to make real-time policy decisions under extreme circumstances, as the actual (human) operators must do. Therefore, these results 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. For example, reductions to senior water rights holders due to dead-pool conditions in the model can be observed in model results under certain circumstances. These reductions, 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. Chapter 5, *Water Supply* provides appropriate interpretation and analysis of such model results.

As noted earlier, Reclamation's 2008 OCAP BA Appendix W (USBR 2008e) included a comprehensive sensitivity 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 for the largest changes in several operational outputs. Understanding the findings from this appendix may help bracket the range of uncertainty in the CALSIM II results.

A.3.5. Linkages to Other Physical Models

The Hydrology and System Operations models generally require input assumptions relating to hydrology, demands, regulations, and flow-salinity responses. DWR and USBR have prepared hydrologic inputs and demand assumptions for various levels of development (future land use and development assumptions) based on historical hydroclimatic conditions. Regulations and associated operations are translated into operational requirements. The flow-salinity ANN, representing appropriate Delta configuration, is embedded into the system operations model. The river flows and Delta exports from the CALSIM II model are used as input to the Delta Hydrodynamics and Water Quality models and reservoir storage and releases are used as input to the River and Reservoir Temperature models.

A.4. Reservoir and River Temperature

The CVP and SWP are required to operate the reservoirs and releases such that specific temperature compliance objectives are met downstream in the rivers, to protect habitat for the anadramous fish. Models are necessary to study the impacts of operational changes on the river and reservoir temperatures. Several models are available to study the impacts to the water temperatures on various river systems in the Central Valley. These models in general are capable of simulating mean monthly and mean daily downstream temperatures for long-term operational scenarios taking into consideration the selective withdrawal capabilities at the reservoirs. 2008 OCAP BA Technical Appendix H (USBR, 2008c) provides a good summary of the temperature modeling tools used in this section.

This section briefly describes the tools used to model the reservoir and river temperatures as part of the BDCP physical modeling.

A.4.1. SRWQM

Sacramento River Water Quality Model (SRWQM) was developed by Reclamation to simulate temperature in the upstream CVP reservoirs and the upper Sacramento River. It was developed using integrated HEC-5 and HEC-5Q models. The HEC-5 component of SRWQM simulates daily flow operations in the upper Sacramento River. The HEC-5Q component of SRWQM simulates mean daily reservoir and river temperatures at Shasta, Trinity, Lewiston, Whiskeytown, Keswick and Black Butte Reservoirs and the Trinity River, Clear Creek, the upper Sacramento River from Shasta to Knights Landing, and Stony Creek based on the flow and meteorological parameters on a 6-hour time step. Figure A-9 shows the model schematic for HEC-5 component of the SRWQM. HEC-5Q is a cross-section based model and has a higher spatial resolution in comparison to the HEC-5 component of SRWQM. The HEC-5Q was customized to simulate the operations of the temperature control device at Shasta Dam.

SRWQM was successfully calibrated based on the observed temperatures in the reservoirs and the upper Sacramento River. More detailed description SRWQM and the calibration performance is included in the calibration report (RMA, 2003).

A.4.2. Reclamation Temperature Model

Reclamation Temperature Model includes reservoir and stream temperature models, which simulate monthly reservoir and stream temperatures used for evaluating the effects of CVP/SWP project operations on mean monthly water temperatures in the basin. The model simulates temperatures in seven major reservoirs (Trinity, Whiskeytown, Shasta, Oroville, Folsom, New Melones and Tulloch), four downstream regulating reservoirs (Lewiston, Keswick, Goodwin and Natoma), and five main river systems (Trinity, Sacramento, Feather, American and Stanislaus). The river component of the Reclamation Temperature model calculates temperature changes in the regulating reservoirs, below the main reservoirs. With regulating reservoir release temperature as the initial river temperature, the river model computes temperatures at several locations along the rivers. The calculation points for river temperatures generally coincide with tributary inflow locations. 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.

A.4.3. Application of Temperature Models to Evaluate BDCP Alternatives

The temperature modeling for planning analysis is driven by the long term operations modeled using CALSIM II. The objective is to find temperature variability in the reservoirs and streams, given CVP/SWP operations, and compare between existing and assumed future scenarios. This section briefly describes the general temperature modeling approach used in a planning analysis and any changes to the approach as part of the BDCP.

SRWQM

SRWQM is designed for long-term planning simulation of temperature at key locations on the Sacramento River at a mean daily time step that captures diurnal fluctuations and is sensitive to fishery management objectives. The geographical scope of the model ranges from Shasta Dam and Trinity Dam to Knights Landing. Monthly flows, simulated by the CALSIM II model for an 82 year period (WY 1922-2003), are used as input to the SRWQM. Temporal downscaling is performed on the CALSIM II monthly average tributary flows to convert them to daily average flows for SRWQM input. Monthly average flows are converted to daily tributary inflows based on 1921 through 1994 daily historical record for the following aggregated inflows:

- Trinity River above Lewiston.
- Sacramento River above Keswick.
- Incremental inflow between Keswick and Bend Bridge (Seven day trailing average for inflows below Butte City).

Each of the total monthly inflows specified by CALSIM II is scaled proportional to one of these three historical records. Outflows and diversions are smoothed for a better transition at the end of the month without regard for reservoir volume constraints or downstream minimum flows. As flows are redistributed within the month, the minimum flow constraint at Keswick, Red Bluff and Knights Landing may be violated. In such cases, operation modifications are required for daily flow simulation to satisfy minimum flow requirements. A utility program is included in SRWQM to convert the monthly CALSIM II flows and releases into daily operations. More detailed description of SRWQM and the temporal downscaling process is included in calibration report (RMA, 2003). The boundary conditions required for simulating SRWQM planning run are listed in Table A-2.

Reclamation Temperature Models

The Reclamation temperature model suite is a monthly time-step model. It was applied to estimate temperatures in the Trinity, Feather, American, and Stanislaus River systems. Monthly flows, simulated by the CALSIM II model for an 82 year period (WY 1922-2003), are used as input to the model. Because of the CALSIM II model's complex structure, where applicable, flow arcs were combined at the appropriate temperature nodes to insure compatibility with the temperature model (see Table A-3). Monthly mean historical air temperatures for the 82-year period and other long-term average climatic data for Trinity, Shasta, Whiskeytown, Redding, Red Bluff, Colusa, Marysville, Folsom, Sacramento, New Melones, and Stockton were obtained from National Weather Service records and used to represent climatic conditions for the four river systems.

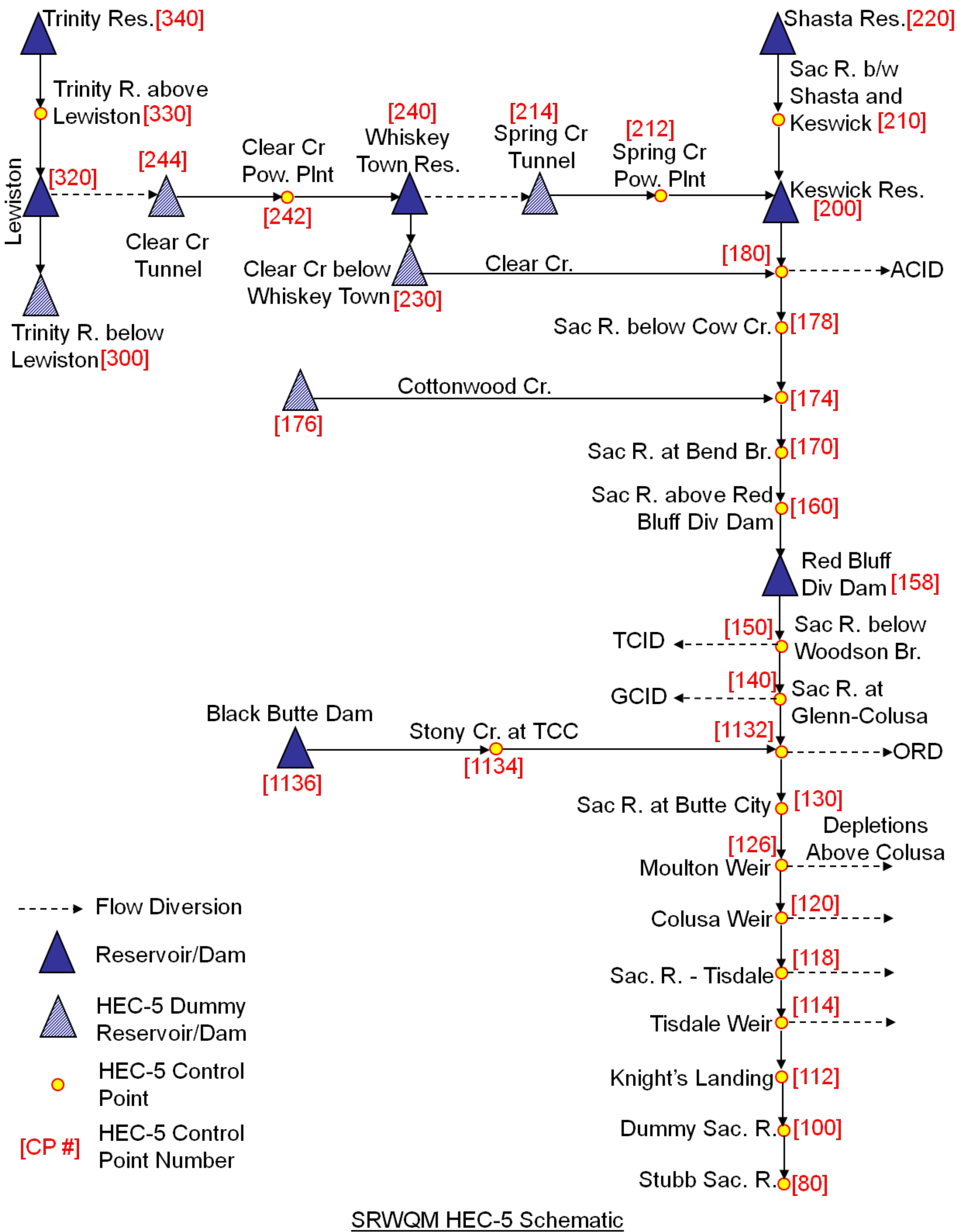


Figure A-9: SRWQM HEC-5 Model Schematic

A.4.4. Incorporating Climate Change Inputs

When simulating alternatives with climate change, some of the inputs to the temperature models are required to be modified. This section states the assumptions and approaches used for modifying meteorological and inflow temperatures in the temperature models.

SRWQM

SRWQM requires meteorological inputs specified in the form of equilibrium temperatures, exchange rates, shortwave radiation and wind speed. The exchange rates and equilibrium temperatures are computed from hourly observed data at Gerber gauging station. Considering the uncertainties associated with climate change impacts, it was assumed that the equilibrium temperature inputs derived from observed data would be modified by the change in daily average air temperature in the climate change scenarios.

The inflow temperatures in SRWQM are specified as seasonal curve fit values with diurnal variations superimposed as a function of heat exchange parameters. The seasonal temperature values are derived based on the observed flows and temperatures for each inflow. SRWQM superimposes diurnal variations on the seasonal values specified using the heat exchange parameter inputs. The diurnal variations are superimposed by adjusting the equilibrium temperature to reflect the inflow location environment and scaling it based on the heat exchange rate scaling factor and the weighting factor for emphasis on the seasonal values specified (RMA, 1998). In this fashion, any changes in the equilibrium temperature are translated to the inflow temperatures in the SRWQM. Therefore, for the climate change scenarios, the equilibrium temperatures were adjusted for the projected change in temperature, and these influence the inflow temperature, but independent inflow temperature inputs were not changed.

Reclamation Temperature Models

The Reclamation temperature models require mean monthly meteorological inputs of air and equilibrium temperature, and heat exchange rates. The heat exchange rates and equilibrium temperatures are computed from the mean monthly air temperature data and long-term estimates of solar radiation, relative humidity, wind speed, cloud cover, solar reflectivity and river shading. Considering the uncertainties associated with climate change impacts, it was assumed that the equilibrium temperature and heat exchange rate inputs would be modified by the change in mean monthly air temperature in the climate change scenarios.

Reservoir inflow temperatures were derived from the available record of observed data and averaged by month. The mean monthly inflow temperatures are then repeated for each study year. The inflow temperatures were further modified based on the computed change in mean annual air temperature, by climate-change scenario.

A.4.5. Output Parameters

SRWQM results in daily averaged temperature results. The Reclamation Temperature Models provide monthly averaged results. In general, the following outputs are generated from the temperature models:

Reservoir temperature thermocline used to compute cold water pool volume in the reservoirs

River temperature at locations along the streams

TABLE A-2
Inputs Required for SRWQM Planning Analysis

Input Type	Location	Description of the Input
Initial Storage	Trinity Lake	End-of-day storage to initialize reservoir storage condition at the start of the SRWQM run
	Whiskeytown Lake	
	Shasta Lake	
	Black Butte Reservoir	
Reservoir Inflows	Trinity Lake	Daily net inflow to reservoirs computed based on the reservoir inflow and the evaporation
	Lewiston Reservoir	
	Whiskeytown Lake	
	Shasta Lake	
	Black Butte Reservoir	
Tributary Inflows	Cottonwood Creek	Local unregulated tributary inflows
	Thomes Creek	
	Colusa Drain	
Distributed flows	Bend Bridge	Net inflows, accretions and depletions along the Sacramento River distributed along the River
	Lower River	
Outflow	Trinity Lake	Daily reservoir release specification
	Whiskeytown Lake	
	Shasta Lake	
	Black Butte Reservoir	
Diversions	Clear Creek Tunnel from Lewiston Reservoir	Inter-basin transfer reservoir releases
	Spring Creek Tunnel from Whiskeytown Lake	
	Anderson Cottonwood Irrigation District Canal	Lumped diversions along various reach of the River specified at point locations
	Tehama Colusa Canal	
	Glenn Colusa Canal	
	Miscellaneous Diversions above	

TABLE A-2
Inputs Required for SRWQM Planning Analysis

Input Type	Location	Description of the Input
	Ord	
	West Banks Diversions	
	Diversions near Colusa Weir	
	Lower River Diversions	
Meteorological Inputs including Equilibrium Temperature, Exchange Rate, Shortwave Radiation and Wind Speed	Entire Spatial Domain	Meteorological inputs on 6-hour time step derived primarily from Gerber gauging station. Calibration report provides more details (RMA, 2003). This dataset remains unchanged as long as the climate conditions are the same across the alternatives.
Inflow Temperatures	Reservoir and tributary inflows included in the model	Seasonal temperatures based on historical flows and temperatures. These inputs remain unchanged for all alternatives
Target Temperatures	Shasta Lake Tail Water	Seasonal temperature targets specified based on the end-of-May Shasta storage conditions

TABLE A-3
Reclamation Temperature Model Nodes

River or Creek System	Location
Trinity River	Lewiston Dam
	Douglas City
	North Fork
Feather River	Oroville Dam
	Fish Barrier Dam
	Upstream of Thermalito Afterbay
	Thermalito Afterbay Release
	Downstream of Thermalito Afterbay
	Gridley
	Honcut Creek
	Yuba River
	Bear River
	Nicolaus

TABLE A-3
Reclamation Temperature Model Nodes

River or Creek System	Location
	Nelson Slough
	Confluence
American River	Folsom Dam
	Nimbus Dam
	Sunrise Bridge
	Cordova Park
	Arden Rapids
	Watt Avenue Bridge
	American River Filtration Plant
	H Street
	16th Street
	Confluence
Stanislaus River	New Melones Dam
	Tulloch Dam
	Goodwin Dam
	Knights Ferry
	Orange Blossom
	Oakdale
	Riverbank
	McHenry Bridge
	Ripon
	Confluence

A.4.6. Use of Model Results

Since the temperature models are driven by the operations simulated in CALSIM II on a monthly time step, typically the temperature results are presented on a monthly time step from both SRWQM and the Reclamation Temperature Models. Monthly flows and temperatures are unlikely to address the daily variability in the river temperatures, but reflect changes in the mean. The daily variability, around a changed mean, could be added to the monthly temperature results by scaling the historical daily temperature patterns to reflect the monthly means. However, this approach of incorporating daily variability does not account for the uncertainty associated with the daily flow conditions which are not included in the boundary flows used by the temperature models. Thus, while the models generate daily results they need to be interpreted with the understanding that the monthly changes are the most appropriate use of the modeling results.

A.4.7. Modeling Limitations

The Reclamation temperature models operate on a monthly 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. It is important to note that even though SRWQM runs on a daily time step, it adheres to the CALSIM II in terms of the reservoir releases and other operations. Neither SRWQM nor the Reclamation temperature models alter operations to meet a temperature requirement downstream in the River. There is no feedback to CALSIM II to alter the operations, either. Using the daily results from SRWQM to check the compliance includes some uncertainty. Both SRWQM and the Reclamation temperature models perform selective temperature withdrawal based on the tail water temperature target and this may or may not meet the temperature requirement downstream in the River.

A.4.8. Linkages to Other Physical Models

The Reservoir and River Temperature models require inputs for representative meteorological conditions, reservoir storage, reservoir release rates, tributary flows, and channel morphology. The output from the Reservoir and River Temperature models are sometimes used to evaluate performance of satisfying temperature requirements and refine the simulated project operation in CALSIM II. The temperature outputs are commonly used in the biological assessments of salmonid mortality.

A.5. Delta Hydrodynamics and Water Quality

Hydrodynamics and water quality modeling is essential to understand the impact of proposed modifications to the morphology of the Delta and the operations of the CVP and SWP. Changes to the configuration of the Delta, restoration of tidal marsh, and project operations will influence the hydrodynamics and water quality conditions in the Delta. The analysis and understanding of the hydrodynamics and water quality changes as a result of these complex changes are critical in understanding the impacts to habitat, species and water users that depend on the Delta.

Large scale tidal marsh restoration and a north Delta diversion are two main components of the BDCP that can significantly alter the hydrodynamics in the Delta, along with the external forcing, sea level rise.

This document describes in detail the methodology used for simulating Delta hydrodynamics and water quality for evaluating the alternatives. It briefly describes the primary tool (DSM2) used in this process and any improvements. Additional detail is included in Section D and appropriate references are provided in here. The portions of the modeling that were performed elsewhere are only described briefly in this document with appropriate references included.

A.5.1. Overview of Hydrodynamics and Water Quality Modeling Approach

Some of the Alternatives assume changes to the existing Delta morphology through the restoration of large acreages of tidal marshes in the Delta. Also, changes in sea level are assumed in the analysis of the future scenarios. These changes result in modified hydrodynamics and salinity transport in the Sacramento – San Joaquin Delta.

There are several tools available to simulate hydrodynamics and water quality in the Delta. Some tools simulate detailed processes, however are computationally intensive and have long runtimes. Other tools approximate certain processes and have short runtimes, while only compromising slightly on the accuracy of the results. For a planning analysis it is ideal to understand the resulting changes over several years such that it covers a range of hydrologic conditions. So, a tool which can simulate the changed hydrodynamics and water quality in the Delta accurately and that has short runtimes is desired. Delta Simulation Model (DSM2), a one-dimensional hydrodynamics and water quality model serves this purpose.

DSM2 has a limited ability to simulate two-dimensional features such as tidal marshes and three-dimensional processes such as gravitational circulation which is known to increase with sea level rise in the estuaries. Therefore, it is imperative that DSM2 be recalibrated or corroborated based on a dataset that accurately represents the conditions in the Delta under restoration and sea level rise. Since the proposed conditions are hypothetical, the best available approach to estimate the Delta hydrodynamics would be to simulate higher dimensional models which can resolve the two- and three-dimensional processes well. These models would generate the data sets needed to corroborate or recalibrate DSM2 under the proposed conditions so that it can simulate the hydrodynamics and salinity transport with reasonable accuracy.

Figure A-10 shows a schematic of how the hydrodynamics and water quality modeling is formulated for BDCP. UnTRIM Bay-Delta Model (MacWilliams et al., 2009), a three-dimensional hydrodynamics and water quality model was used to simulate the sea level rise effects on hydrodynamics and salinity transport under the historical operations in the Delta.

UnTrim modeling is described in Section D.7. RMA Bay-Delta Model (RMA, 2005), a two-dimensional hydrodynamics and water quality model was used to simulate tidal marsh restoration effects with and without sea level rise on hydrodynamics and salinity transport under the historic operations. RMA modeling is described in Section D.6. The results from the UnTRIM model were used to corroborate RMA and DSM2 models so that they simulate the effect of sea level rise accurately. The results from the RMA model were used to corroborate DSM2 so that it can simulate the effect of tidal marsh restoration with and without sea level rise accurately. The corroboration process and the results are presented in Section D.8.

The corroborated DSM2 was used to simulate hydrodynamics and water quality in the Delta by integrating the tidal marsh restoration and sea level rise effects over a 16-year period (WY 1976 – 1991), using the hydrological inputs and exports determined by CALSIM II under the projected operations. It was also used to retrain ANNs that can emulate modified flow-salinity relationship.

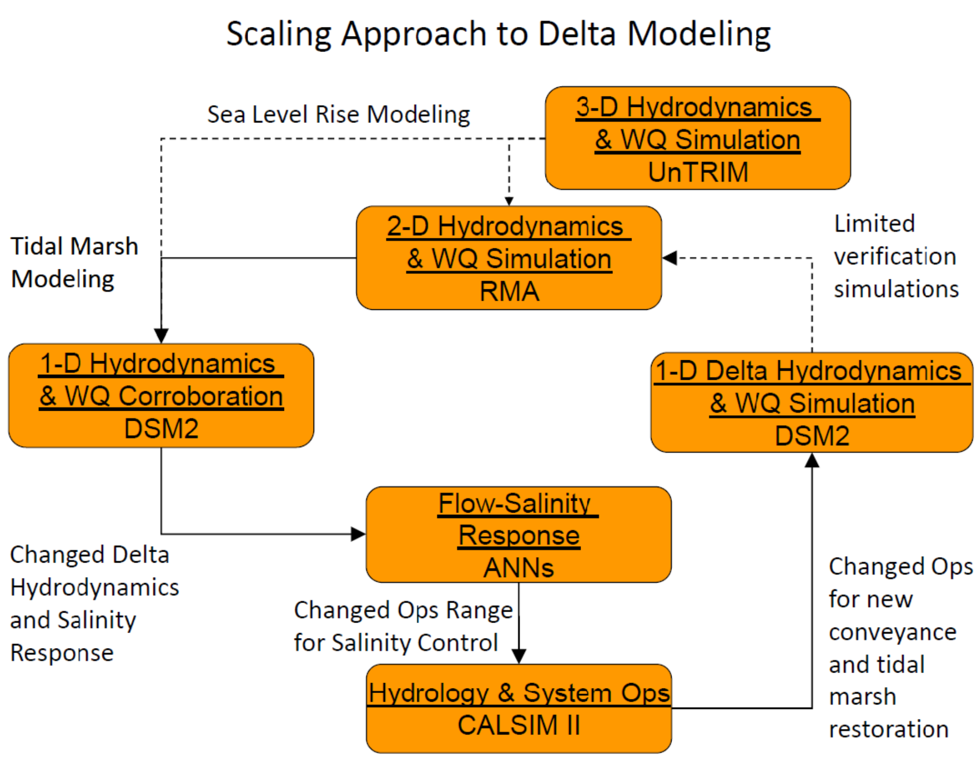


Figure A-10: Hydrodynamics and Water Quality Modeling Approach used in the BDCP

A.5.2. Delta Simulation Model (DSM2)

DSM2 is a one-dimensional hydrodynamics, water quality and particle tracking simulation model used to simulate hydrodynamics, water quality, and particle tracking in the Sacramento-San Joaquin Delta (Anderson and Mierzwa, 2002). DSM2 represents the best available planning model for Delta tidal hydraulics and salinity modeling. It is appropriate for describing the existing conditions in the Delta, as well as performing simulations for the assessment of incremental environmental impacts caused by future facilities and operations. The DSM2 model has three separate components: HYDRO, QUAL, and PTM. HYDRO simulates one-dimensional hydrodynamics including flows, velocities, depth, and water surface elevations. HYDRO provides the flow input for QUAL and PTM. QUAL simulates one-dimensional fate and transport of conservative and non-conservative water quality constituents given a flow field simulated by HYDRO. PTM simulates pseudo 3-D transport of neutrally buoyant particles based on the flow field simulated by HYDRO.

DSM2 v8.0.4 was used in modeling of the BDCP Existing Conditions, No Action Alternative and the other Alternatives. The v8 of the DSM2 includes several enhancements compared to the v6 such as improved data management, increased speed and robustness, ability to simulate gates with multiple structures and the ability to specify Operating Rules in the HYDRO module. The Operating Rules form a powerful tool which triggers changes in gate operations or source/sink flow boundaries while model is running, based on the current value of a state variable (flow, stage or velocity), pre-specified timeseries or the simulation timestep.

DSM2 hydrodynamics and salinity (EC) were initially calibrated in 1997(DWR, 1997). In 2000, a group of agencies, water users, and stakeholders recalibrated and validated DSM2 in an open process resulting in a model that could replicate the observed data more closely than the 1997 version (DSM2PWT, 2001). In 2009, CH2M HILL performed a calibration and validation of DSM2 by including the flooded Liberty Island in the DSM2 grid, which allowed for an improved simulation of tidal hydraulics and EC transport in DSM2 (CH2M HILL, 2009). Technical report documenting this calibration effort is included in Section D.5. The model used for evaluating the BDCP scenarios was based on this latest calibration.

Simulation of Dissolved Organic Carbon (DOC) transport in DSM2 was successfully validated in 2001 by DWR (Pandey, 2001). The temperature and Dissolved Oxygen calibration was initially performed in 2003 by DWR (Rajbhandari, 2003). Recent effort by RMA in 2009 allowed for improved calibration of temperature, DO and the nutrients transport in DSM2.

DSM2-HYDRO

The HYDRO module is a one-dimensional, implicit, unsteady, open channel flow model that DWR developed from FOURPT, a four-point finite difference model originally developed by the USGS in Reston, Virginia. DWR adapted the model to the Delta by revising the input-output system, including open water elements, and incorporating water project facilities, such as gates, barriers, and the Clifton Court Forebay. HYDRO simulates water surface elevations, velocities and flows in the Delta channels (Nader-Tehrani, 1998). HYDRO provides the flow input necessary for QUAL and PTM modules.

The HYDRO module solves the continuity and momentum equations fully implicitly. These partial differential equations are solved using a finite difference scheme requiring four points of computation. The equations are integrated in time and space, which leads to a solution of stage and flow at the computational points. HYDRO enforces an “equal stage” boundary condition for all the channels connected to a junction. The model can handle both irregular cross-sections derived from the bathymetric surveys and trapezoidal cross-sections. Even though, the model formulation includes a baroclinic term, the density is held constant, generally, in the HYDRO simulations.

HYDRO allows the simulation of hydraulic gates in the channels. A gate may have a number of associated hydraulic structures such as radial gates, flash boards, boat ramps etc., each of which may be operated independently to control flow. Gates can be placed either at the upstream or downstream end of a channel. Once the location of a gate is defined, the boundary condition for the gated channel is modified from "equal stage" to "known flow," with the calculated flow. The gates can be opened or closed in one or both directions by specifying a coefficient of zero or one.

Reservoirs are used to represent open bodies of water that store flow. Reservoirs are treated as vertical walled tanks in DSM2, with a known surface area and bottom elevation and are considered instantly well-mixed. The flow interaction between the open water area and one or more of the connecting channels is determined using the general orifice formula. The flow in and out of the reservoir is controlled using the flow coefficient in the orifice equation, which can be different in each direction. DSM2 does not allow the cross-sectional area of the inlet to vary with the water level.

DSM2v8 includes a new feature called "operating rules" using which the gate operations or the flow boundaries can be modified dynamically when the model is running based on the current value of a state variable (flow, stage or velocity). The change can also be triggered based on a timeseries that's not currently simulated in the model (e.g. daily averaged EC) or based on the current timestep of the simulation (e.g. a change can occur at the end of the day or end of the season). The operating rules include many functions which allow derivation of the quantities to be used as trigger, from the model data or outside timeseries data. Operating rules allow a change or an action to occur when the trigger value changes from false to true.

DSM2-QUAL

The QUAL module is a one-dimensional water quality transport model that DWR adapted from the Branched Lagrangian Transport Model originally developed by the USGS in Reston, Virginia. DWR added many enhancements to the QUAL module, such as open water areas and gates. A Lagrangian feature in the formulation eliminates the numerical dispersion that is inherently in other segmented formulations, although the tidal dispersion coefficients must still be specified. QUAL simulates fate and transport of conservative and non-conservative water quality constituents given a flow field simulated by HYDRO. It can calculate mass transport processes for conservative and non-conservative constituents including salts, water temperature, nutrients, dissolved oxygen, and trihalomethane formation potential.

The main processes contributing to the fate and transport of the constituents include flow dependent advection and tidal dispersion in the longitudinal direction. Mass balance equations are solved for all quality constituents in each parcel of water using the tidal flows and volumes calculated by the HYDRO module. Additional information and the equations used are specified in the 19th annual progress report by DWR (Rajbhandari, 1998).

The QUAL module is also used to simulate source water finger printing which allows determining the relative contributions of water sources to the volume at any specified location. It is also used to simulate constituent finger printing which determines the relative contributions of conservative constituent sources to the concentration at any specified location. For fingerprinting studies, six main sources are typically tracked: Sacramento River, San Joaquin River, Martinez, eastside streams (Mokelumne, Cosumnes and Calaveras combined), agricultural drains (all combined), and Yolo Bypass. For source water fingerprinting a tracer with constant concentration is assumed for each source tracked, while keeping the concentrations at other inflows as zero. For constituent (e.g., EC) fingerprinting analysis, the concentrations of the desired constituent is specified at each tracked source, while keeping the concentrations at other inflows as zero (Anderson, 2003).

DSM2 Input Requirements

DSM2 requires input assumptions relating to physical description of the system (e.g. Delta channel, marsh, and island configuration), description of flow control structures such as gates, initial estimates for stage, flow and EC throughout the Delta, and time-varying input for all boundary river flows and exports, tidal boundary conditions, gate operations, and constituent concentrations at each inflow. Figure A-11 illustrates the hydrodynamic and water quality boundary conditions required in DSM2. For long-term planning simulations, output from the CALSIM II model generally provides the necessary input for the river flows and exports.

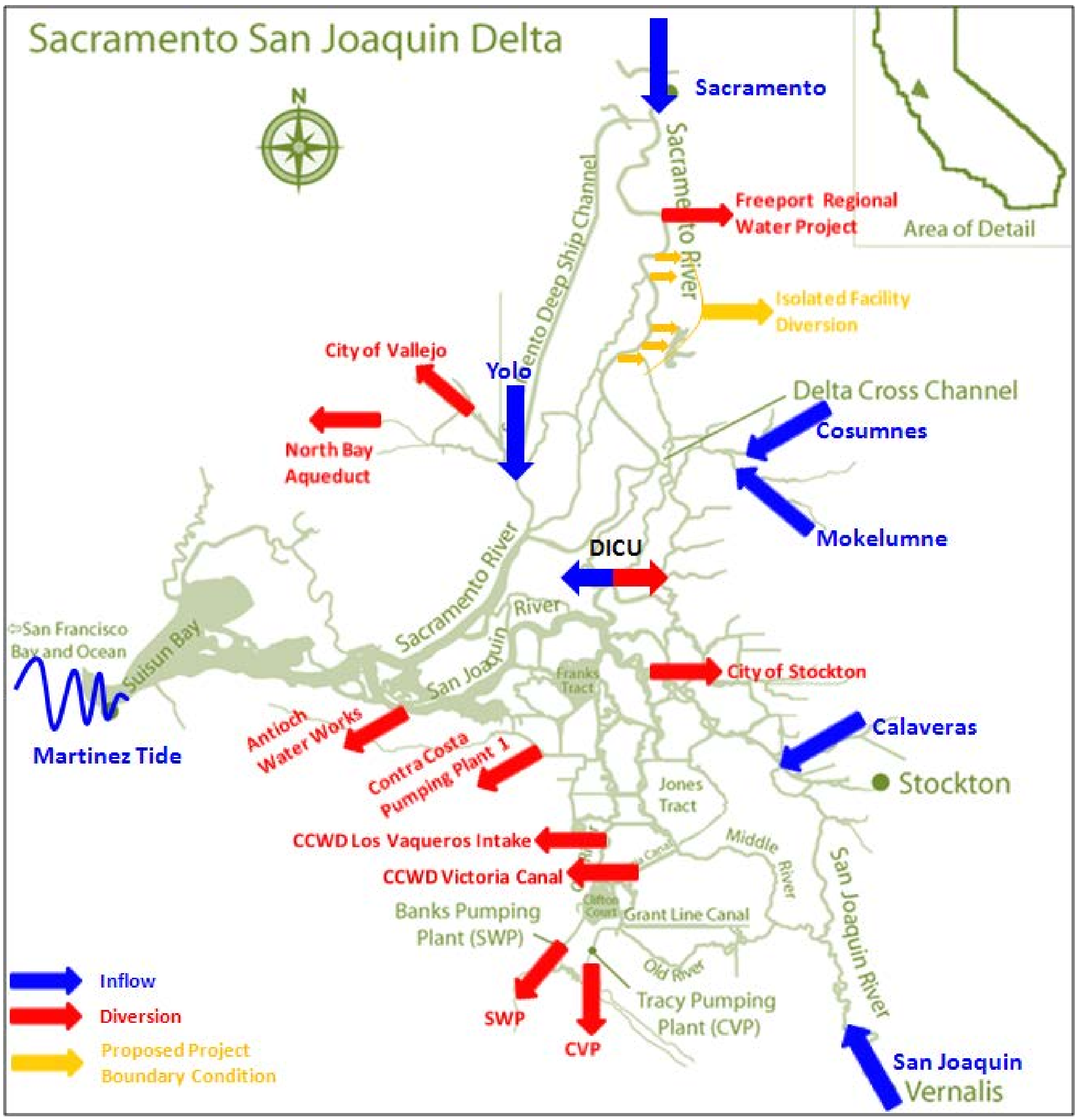


Figure A-11: Hydrodynamic and Water Quality Boundary Conditions in DSM2

For long-term planning simulations, output from the CALSIM II model generally provides the necessary input for the river flows and exports. Assumptions relating to Delta configuration and gate operations are directly input into the hydrodynamic models. Adjusted astronomical tide (Ateljevich, 2001a) normalized for sea level rise (Ateljevich and Yu, 2007) is forced at Martinez boundary. Constituent concentrations are specified at the inflow boundaries, which are either estimated from historical information or CALSIM II results. EC boundary condition at Vernalis location is derived from the CALSIM II results. Martinez EC boundary condition is derived based on the simulated net Delta outflow from CALSIM II and using a modified G-model (Atljevich, 2001b).

The major hydrodynamic boundary conditions are listed in Table A-4 and the locations at which constituent concentrations are specified for the water quality model are listed in Table A-5.

TABLE A-4
DSM2 HYDRO Boundary Conditions

Boundary Condition	Location/Control Structure	Typical Temporal Resolution
Tide	Martinez	15min
Delta Inflows	Sacramento River at Freeport	1day
	San Joaquin River at Vernalis	1day
	Eastside Streams (Mokelumne and Cosumnes Rivers)	1day
	Calaveras River	1day
	Yolo Bypass	1day
Delta Exports/Diversions	Banks Pumping Plant (SWP)	1day
	Jones Pumping Plant (CVP)	1day
	Contra Costa Water District Diversions at Rock Slough, Old River at Highway 4 and Victoria Canal	1day
	North Bay Aqueduct	1day
	City of Vallejo	1day
	Antioch Water Works	1day
	Freeport Regional Water Project	1day
	City of Stockton	1day
	Isolated Facility Diversion	1day
Delta Island Consumptive Use	Diversion	1mon
	Seepage	1mon

TABLE A-4
DSM2 HYDRO Boundary Conditions

Boundary Condition	Location/Control Structure	Typical Temporal Resolution
	Drainage	1mon
Gate Operations	Delta Cross Channel	Irregular Timeseries
	South Delta Temporary Barriers	dynamically operated on 15min
	Montezuma Salinity Control Gate	dynamically operated on 15min

TABLE A-5
DSM2 QUAL Boundary Conditions Typically used in a Salinity Simulation

Boundary Condition	Location/Control Structure	Typical Temporal Resolution
Ocean Salinity	Martinez	15min
Delta Inflows	Sacramento River at Freeport	Constant
	San Joaquin River at Vernalis	1mon
	Eastside Streams (Mokelumne and Cosumnes Rivers)	Constant
	Calaveras River	Constant
	Yolo Bypass	Constant
Delta Island Consumptive Use	Drainage	1mon (repeated each year)

Notes: For other water quality constituents, concentrations are required at the same locations

A.5.3. Application of DSM2 to Evaluate BDCP Alternatives

Several long-term planning analyses used DSM2 to evaluate Delta hydrodynamics and water quality, in the past. In those studies, DSM2 was run for a 16-year[1] period from WY1976 to WY1991, on a 15-min timestep. Typically the inputs needed for DSM2 – inflows, exports, and Delta Cross Channel (DCC) gate operations were provided by the 82-year CALSIM II simulations. The tidal boundary condition at Martinez was provided by an adjusted astronomical tide (Ateljevich and Yu, 2007). Monthly Delta channel depletions (i.e., diversions,

[1] Model simulation period for DSM2 is further described in *Section D-12. DSM2 16 Year Planning Simulation versus 82Year Planning Simulation*. This section includes a technical memorandum prepared by DWR comparing and contrasting the DSM2 planning simulations performed over the 16 year period versus the 82 year period.

seepage and drainage) were estimated using DWR's Delta Island Consumptive Use (DICU) model (Mahadevan, 1995).

CALSIM II provides monthly inflows and exports in the Delta. Traditionally, the Sacramento and San Joaquin River inflows are disaggregated to a daily time step for use in DSM2 either by applying rational histosplines, or by assuming that the monthly average flow as constant over the whole month. The splines allow a smooth transition between the months. The smoothing reduces sharp transitions at the start of the month, but still results in constant flows for most of the month. Other inflows, exports and diversions were assumed to be constant over the month.

Delta Cross Channel gate operation input in DSM2 is based on CALSIM II output. For each month, DSM2 assumes the DCC gates are open for the "number of the days open" simulated in CALSIM II, from the start of the month.

The operation of the south Delta Temporary Barriers, if included in the model is determined dynamically in using the operating rules feature in DSM2. These operations generally depend on the season, San Joaquin River flow at Vernalis and tidal condition in the south Delta. Similarly, the Montezuma Slough Salinity Control Gate operations are determined using an operating rule that sets the operations based on the season, Martinez salinity and tidal condition in the Montezuma Slough.

For salinity, EC at Martinez is estimated using the G-model on a 15-min timestep, based on the Delta outflow simulated in CALSIM II and the pure astronomical tide at Martinez (Ateljevich, 2001a). The monthly averaged EC for the San Joaquin River at Vernalis estimated in CALSIM II for the 82-year period is used in DSM2. For other river flows, which have low salinity, constant values are assumed. Monthly average values of the EC associated with Delta agricultural drainage and return flows was estimated for three regions in the Delta based on observed data identifying the seasonal trend. These values are repeated for each year of the simulation.

For BDCP, several enhancements were incorporated in the planning analysis approach traditionally used for DSM2. Some of the changes were to address the assumptions for BDCP while the others are improvements which make the DSM2 planning simulations more realistic.

The changes that are based on the BDCP assumptions include modifications to DSM2 to capture the effect of sea level rise, tidal marsh restoration with and without sea level rise, and north Delta diversion intakes. The DSM2 models incorporating above changes were used in developing new ANNs for CALSIM II.

The other enhancement is with regard to the flow boundary conditions used in DSM2. As described above, traditional approach does not represent the variability that would exist in the Delta inflows within a month. Since CALSIM II, from which the boundary flows are derived is a monthly time step model, a new approach was developed to incorporate daily variability in the DSM2 boundary flows using the monthly results from CALSIM II.

The following sections describe in detail various enhancements and changes made to the DSM2 hydrodynamics, salinity and nutrient modeling methods as part of the BDCP analyses.

Changes to the DSM2 Grid

DSM2 model grid from the 2009 recalibration (CH2M HILL, 2009) was further modified in the north Delta to locate the DSM2 nodes at the proposed north Delta diversion intake locations as agreed on January 29th BDCP Steering Committee meeting. Two new nodes and two new channels are added to the grid and several existing nodes were relocated and channel lengths were modified in the reach upstream of Delta Cross Channel. Figure A-12 shows the grid used in the baseline models for BDCP. The DSM2 grid includes several other changes related to the north Delta diversion intakes and the tidal marsh restoration. DSM2 grids representing various BDCP Alternatives are included in Section D.11.

Incorporation of Daily Hydrologic Inputs to DSM2

DSM2 is simulated on a 15-minute time step to address the changing tidal dynamics of the Delta system. However, the boundary flows are typically provided from monthly CALSIM II results. In all previous planning-level evaluations, the DSM2 boundary flow inputs were applied on a daily time step but used constant flows equivalent to the monthly average CALSIM II flows except at month transitions.

As shown in Figures A-6 and A-7, Sacramento River flow at Freeport exhibits significant daily variability around the monthly mean in the winter and spring period in the most water year types. The winter-spring daily variability is deemed important to species of concern. In an effort to better represent the sub-monthly flow variability, particularly in early winter, a monthly-to-daily flow mapping technique is applied to the boundary flow inputs to DSM2. The daily mapping approach used in CALSIM II and DSM2 are consistent. The incorporation of daily mapping in CALSIM II is described in the Section A.3.3. A detailed description of the implementation of the daily variability in DSM2 boundary conditions is provided in Section D.9.

It is important to note that this daily mapping approach does not in any way represent the flows that would result from any operational responses on a daily time step. It is simply a technique to incorporate representative daily variability into the flows resulting from CALSIM II's monthly operational decisions.

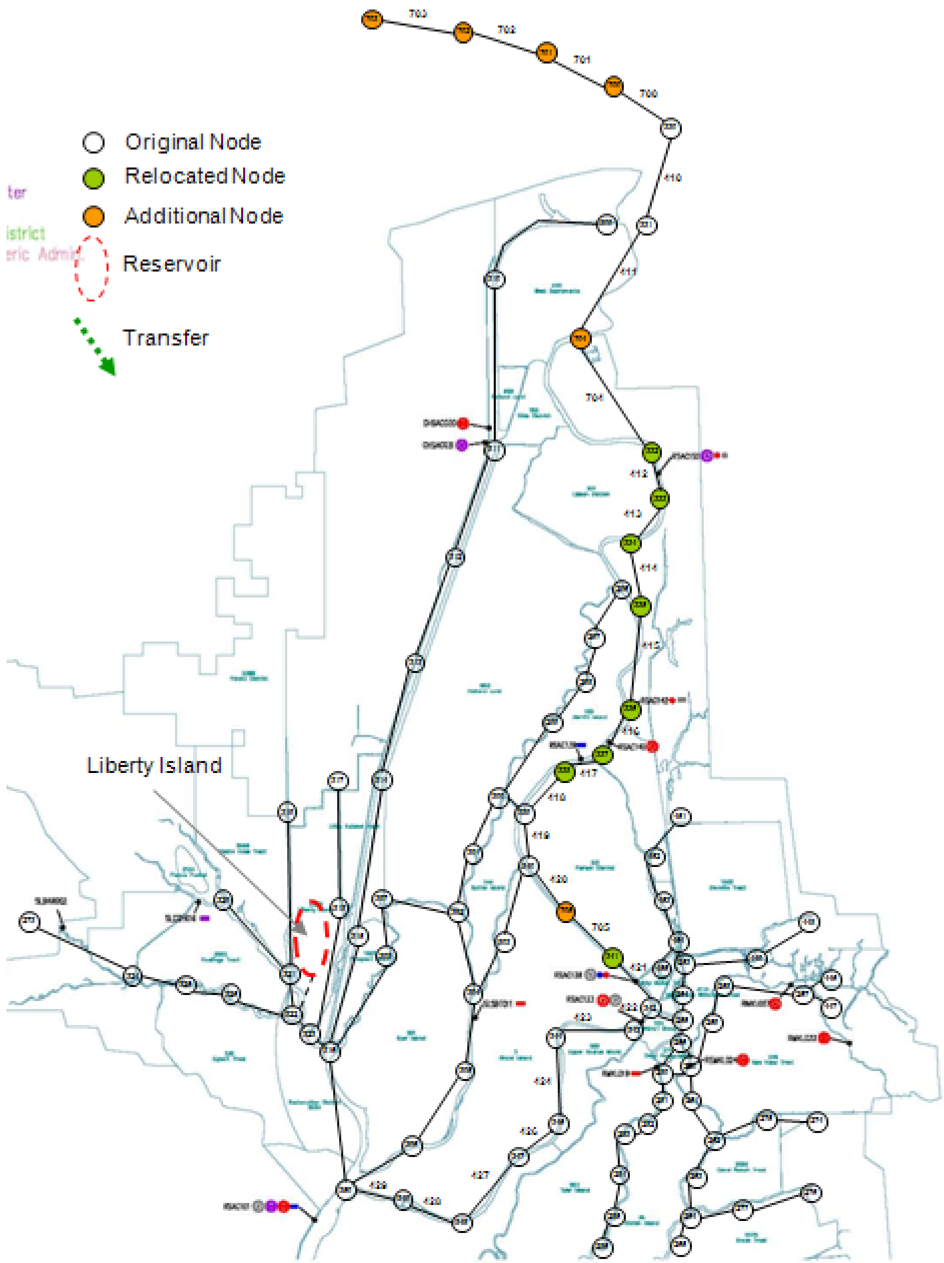


Figure A-12: North Delta DSM2 grid used in the BDCP Modeling (NOTE: Intake locations slightly modified in Chapter 3: Description of Alternatives)

Incorporating Tidal Marsh Restoration and Sea Level Rise Effects in DSM2 Planning Simulations

The effects of sea level rise were determined from the UNTRIM Bay-Delta model and the effects of tidal marsh restoration were determined from the RMA Bay-Delta model. DSM2 model results were corroborated for the effects of sea level rise and tidal marsh restoration using the UnTRIM and RMA model results. Detailed descriptions of the UnTRIM modeling of the sea level rise scenarios, RMA modeling of the tidal marsh restoration, and DSM2 corroboration are included in the Sections D.7, D.6 and D.8, respectively.

Using the corroboration described above described, seven (7) separate DSM2 grid configurations and model setups were prepared for use in the planning simulations for the Alternatives. Each configuration corresponds to one combination of sea level rise and restoration scenario.

Using the results from the RMA current conditions and tidal marsh models, three sets of regression relationships were developed to estimate the stage and EC at Martinez location for the 14,000ac (NT), 25,000ac (ELT) and 65,000ac (LLT) restoration scenarios based on the baseline stage and EC at Martinez. Similarly, using the results from the UnTRIM models, two sets of correlations were developed to compute the resulting stage and EC at Martinez location for the 15cm (ELT) and 45cm (LLT) sea level rise scenarios.

Based on the RMA integrated tidal marsh and sea level rise scenarios, two sets of correlations were developed for estimating Martinez stage and EC resulting for the 25,000ac restoration under 15cm sea level rise (ELT) and for the 65,000ac restoration under 45cm sea level rise (LLT) scenarios.

Table A-6 shows the Martinez stage and EC correlations for these seven (7) scenarios described above. It also shows the lag in minutes between the baseline stage or EC and the resulting stage or EC under the scenario with sea level rise and/or restoration. The regressed baseline stage or EC timeseries needs to be shifted by the lag time noted in the Table A-6.

Accurate effects of the tidal marsh restoration and sea level rise are incorporated in DSM2 simulations for the Alternatives in two ways. First, by incorporating consistent grid configuration and model setup identified in corroboration process into the DSM2 model for the selected Alternative, based on the tidal marsh restoration acreage and sea level rise assumptions selected for the Alternative. Second, by modifying the downstream stage and EC boundary conditions at Martinez in the DSM2 model inputs using the regression relationships identified in the corroboration process for the selected restoration and sea level rise assumptions.

As noted earlier, adjusted astronomical tide at Martinez is used as the downstream stage boundary in the DSM2 planning simulation representing current Delta configuration without any sea level rise or tidal marsh restoration. This stage timeseries is modified using one of the stage correlation equations identified in Table A-6 for use in a planning simulation with either restoration or sea level rise or both.

The EC boundary condition in a DSM2 planning simulation is estimated using the G-model based on the monthly net Delta outflow simulated in CALSIM II and the pure astronomical tide (Ateljevich, 2001b). Even though the rim flows and exports are patterned on a daily step in DSM2, the operational decisions are still on a monthly timestep. This means that the net Delta outflow may or may not meets the standards on a daily timestep. Therefore, to estimate the EC boundary condition at Martinez, monthly net Delta outflow simulated in CALSIM II is used. For a planning simulation with either restoration or sea level rise or both, EC timeseries from the G-model is regressed using one of the EC correlations listed in Table A-6 to account for the anticipated changes at Martinez.

TABLE A-6
Correlations to Transform Baseline Martinez Stage and EC for use in DSM2 BDCP Planning Runs with Tidal Marsh Restoration, Sea Level Rise or both Restoration and Sea Level Rise

Scenario	Martinez Stage (ft NGVD 29)		Martinez EC (µS/cm)	
	Correlation	Lag (min)	Correlation	Lag (min)
NT (14,000ac)	Y = 0.966 * X + 0.04	-3	Y = 1.001 * X + 191.5	8
ELT (25,000ac)	Y = 0.964 * X + 0.04	-4	Y = 0.999 * X + 114.7	10
LLT (65,000ac)	Y = 0.943 * X + 0.06	-3	Y = 0.996 * X + 68.2	13
15cm SLR	Y = 1.0033*X + .47	-1	Y = 0.9954* X + 556.3	0
45cm SLR	Y = 1.0113*X + 1.4	-2	Y = 0.98* X + 1778.9	-2
ELT (25,000ac &15cm SLR)	Y = 0.968 * X + 0.5	-5	Y = 0.999 * X + 357.78	9
LLT (65,000ac & 45cm SLR)	Y = 0.958 * X + 1.49	-9	Y = 1.002 * X + 1046.3	11

Notes: X = Baseline Martinez stage or EC and Y = Scenario Martinez stage or EC

ANN Retraining

ANNs are used for flow-salinity relationships in CALSIM II. They are trained on DSM2 outputs and therefore, emulate DSM2 results. ANN requires retraining whenever the flow – salinity relationship in the Delta changes. BDCP analysis assumes different restoration acreages at NT, ELT and LLT phases. In addition it includes 15cm and 45cm sea level rise at ELT and LLT, respectively. Each combination of restoration and sea level condition results in a different flow – salinity relationship in the Delta and therefore require a new ANN. Table A-7 lists the ANNs developed and used as part of the BDCP analysis.

DWR Bay-Delta Modeling staff has retrained the ANNs for each scenario. ANN retraining process involved following steps:

- Corroboration of the DSM2 model for each scenario as described above
- Range of example long-term CALSIM II scenarios to provide range of boundary conditions for DSM2 models
- Using the grid configuration and the correlations from the corroboration process several 16-year planning runs are simulated based on the boundary conditions from the identified CALSIM II scenarios to create a training dataset for each new ANN
- ANNs are trained using the Delta flows and DCC operations from CALSIM II, EC results from DSM2and the Martinez tide

- The training dataset is divided into two parts. One is used for training the ANN and the other to validate
- Once the ANN is ready a full circle analysis is performed to assess the performance of the ANN

Detailed description of the ANN training procedure and the full circle analysis is provided in DWR's 2007 annual report (Seneviratne and Wu, 2007).

TABLE A-7
List of ANNs Developed and Used in the BDCP Modeling

ANN	Description	Reference DSM2 Model
BST_noSLR_111709	Represents current Delta configuration with no sea level rise	2009 DSM2 Recalibration
BDCP_ROA0ac_SLR15cm_16Mar2010	Represents current Delta configuration with 15cm sea level rise	DSM2 model corroborated with UnTRIM results for 15cm sea level rise case
BDCP_ROA0ac_SLR45cm_18Mar2010	Represents current Delta configuration with 45cm sea level rise	DSM2 model corroborated with UnTRIM results for 45cm sea level rise case
BDCP_ROA14Kac_SLR0cm_22Dec2009	Represents 14000ac tidal marsh restoration assumed, with no sea level rise	DSM2 model corroborated with RMA results for 14,000ac restoration proposed for NT phase
BDCP_ROA25Kac_SLR0cm_29Dec2009	Represents 25000ac tidal marsh restoration assumed, with no sea level rise	DSM2 model corroborated with RMA results for 25,000ac restoration proposed for ELT phase
BDCP_ROA65Kac_SLR0cm_30Mar2010	Represents 65000ac tidal marsh restoration assumed, with no sea level rise	DSM2 model corroborated with RMA results for 65,000ac restoration proposed for LLT phase
BDCP_ROA25Kac_SLR15cm_14Apr2010	Represents 25000ac tidal marsh restoration assumed, with 15cm sea level rise	DSM2 model corroborated with RMA results for 25,000ac restoration proposed for ELT phase under 15cm sea level rise
BDCP_ROA65Kac_SLR45cm_30Mar2010	Represents 65000ac tidal marsh restoration assumed, with 45cm sea level rise	DSM2 model corroborated with RMA results for 65,000ac restoration proposed for LLT phase under 45cm sea level rise

North Delta Diversion Operations

As described in Section A.3.3, several Alternatives include new intakes on Sacramento River upstream of Sutter Slough, in the north Delta. The diversions at the intakes are governed by the bypass rules. The bypass rules are simulated in CALSIM II using daily mapped Sacramento River flow, which provides the maximum potential diversion that can occur in the north Delta for each day. CALSIM II uses the monthly average of this daily potential diversion as one of the constraints in determining the final monthly north Delta diversion. For use in DSM2, the monthly diversion output for the north Delta intakes is mapped onto the daily pattern of the potential diversion estimated in CALSIM II.

In DSM2 diversion at each intake is determined on a 15 min timestep, subject to sweeping velocity criteria so that the fish migrating past the fish screens do not impinge on them. For BDCP, Delta Smelt criterion of 0.4fps, required by DFG (DFG, 2009) is used in determining whether or not water can be diverted at an intake. The intake operations are also subjected to ramping rates that are required to shut off or start the pumps. The current design allows ramping up or down the pumps between 0 and 3,000cfs in less than an hour. These criteria cannot be simulated in CALSIM II. They are dynamically simulated using the operating rules feature in DSM2.

The north Delta diversion operating rule in the DSM2 allows diverting up to the amount specified by CALSIM II each day while subjecting each intake to the sweeping velocity and the ramping criteria. The intakes are operated as long as the daily diversion volume specified by CALSIM II is not met. Once the specified volume is diverted for the day, the pumps are shut off until next day.

The volume corresponding to first 100cfs per intake (for five intakes 500 cfs) of the daily north Delta diversion specified by CALSIM II is diverted equally at all the intakes included for the Alternative. The remaining volume for the day will be diverted such that operation of the upstream intakes is prioritized over the downstream intakes. Intake diversions are ramped over an hour to allow smooth transitions when they are turned on and off.

In the current modeling of the Alternatives, the diversion flow at an intake for each time step is estimated assuming that the remaining diversion volume in a day would have to be diverted in one time step at the upstream-most intake first and immediate downstream one next and so on until the daily specified total is diverted. However, the estimated amount of diversion at each intake is only diverted when the velocity measured just downstream of the DSM2 diversion node is greater than or equal to 0.4fps. If in any time step this criteria is violated then the diversion occurs in a future time step when the velocity is above 0.4fps or may occur at a different intake. The sweeping velocity criterion is measured at 1000ft downstream from the diversion node in DSM2 to minimize potential instabilities in the model. Even though DSM2 produces a cross-sectional averaged velocity, it is not corrected for the velocity profile across the cross-section as the actual screen location is still uncertain.

New channels, transfers and a reservoir are added to the DSM2 grid to simulate up to five (5) north Delta diversion intakes as shown in the Figure A-13. Five channels, 601 – 605, divert water off the Sacramento River and transfer to channel 607 and 608, from where the total diverted water is transferred to a new reservoir (IF_FOREBAY). Figure A-14 shows an example timeseries of sweeping velocities and the diversions at each intake. The plot shows how the intakes are ramped up and down when the velocity falls below 0.4 ft/s.

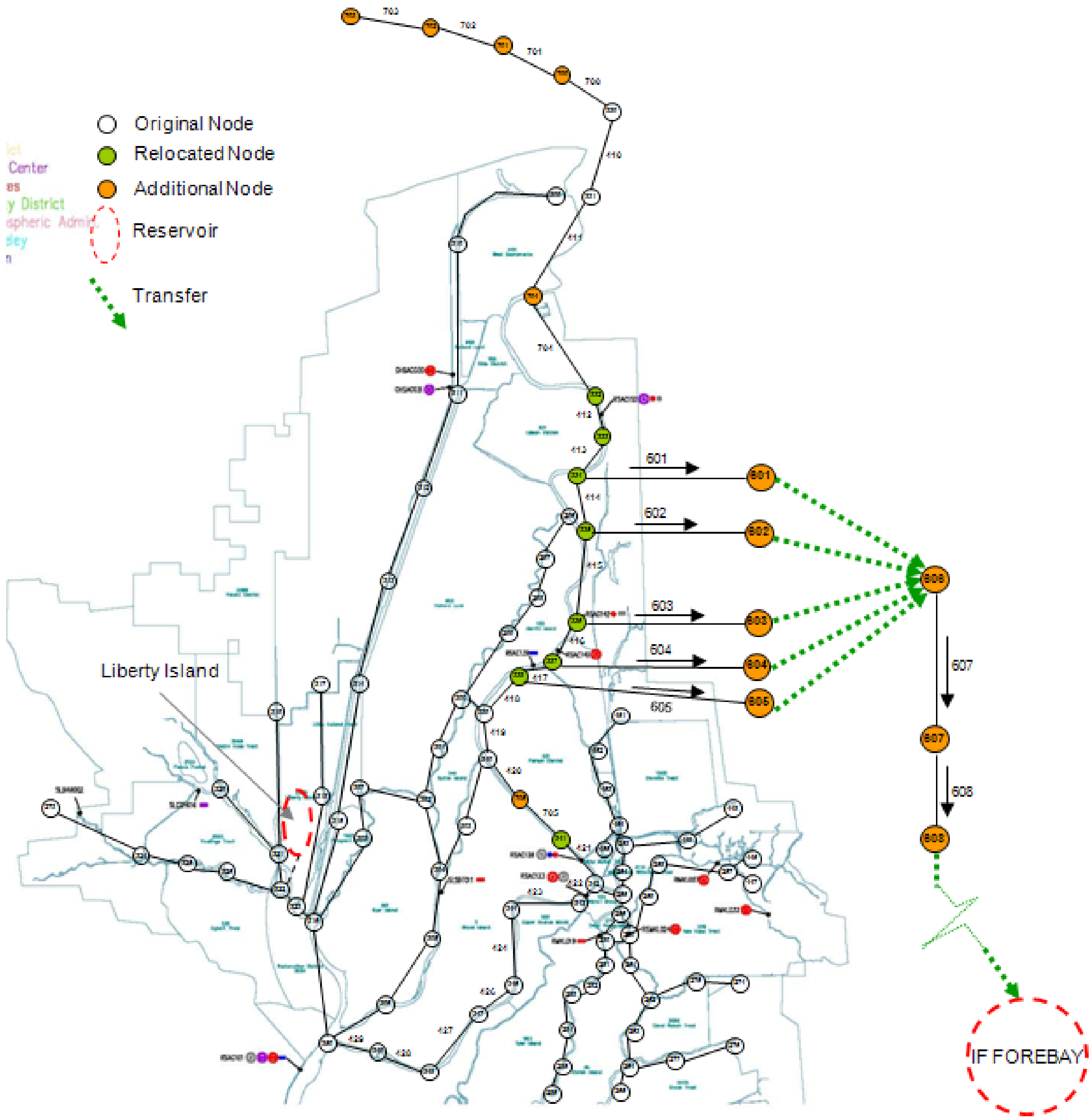


Figure A-13: North Delta DSM2 Grid Modifications for Simulating North Delta Diversions

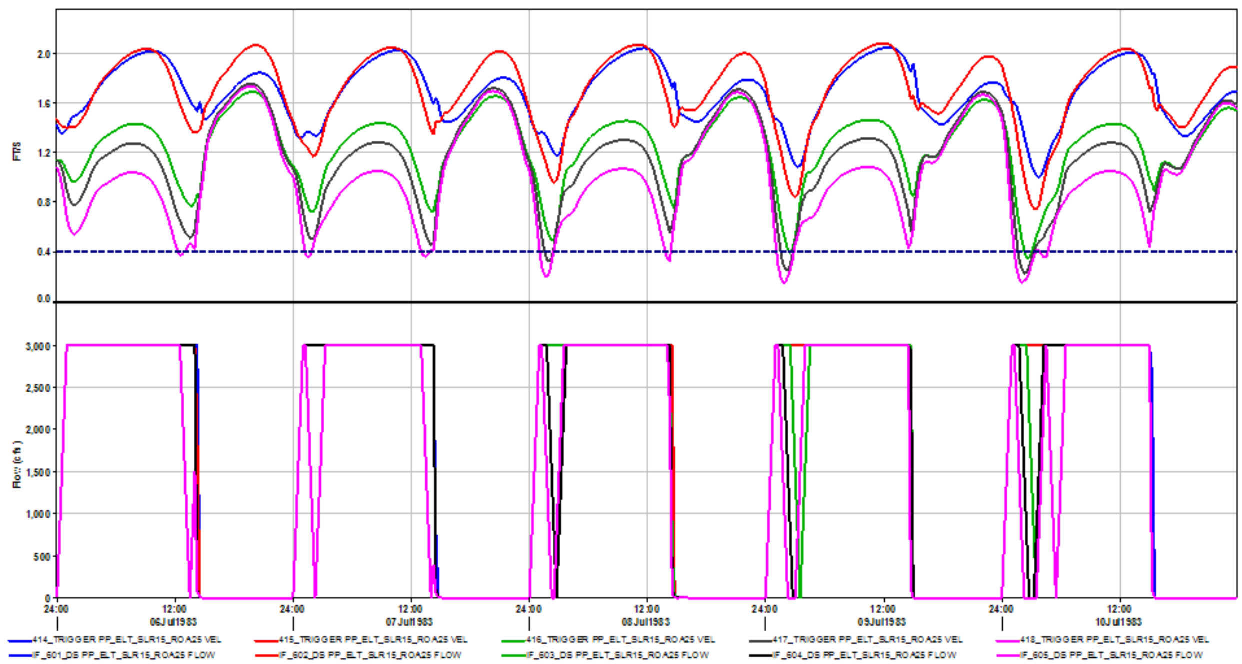


Figure A-14: An Example of Sweeping Velocity and the Diversion at the Five Intakes Simulated in DSM2

A.5.4. Output Parameters

DSM2 HYDRO provides the following outputs on a 15-minute time step:

Tidal flow

Tidal stage

Tidal velocity

Following variables can be derived from the above outputs:

Net flows

Mean sea level, mean higher high water, mean lower low water and tidal range

Water depth

Tidal reversals

Flow splits, etc.

DSM2 QUAL provides the following outputs on a 15-minute time step:

Salinity (EC)

DOC

Source water and constituent fingerprinting

Following variables can be derived from the above QUAL outputs:

Bromide, chloride, and total dissolved solids

Selenium and mercury

In a planning analysis, the flow boundary conditions that drive DSM2 are obtained from the monthly CALSIM II model. The agricultural diversions, return flows and corresponding salinities used in DSM2 are on a monthly time step. The implementation of Delta Cross Channel gate operations in DSM2 assumes that the gates are open from the beginning of a month, irrespective of the water quality needs in the south Delta.

The input assumptions stated above should be considered when DSM2 EC results are used to evaluate performance of a baseline or an alternative against the standards. Even though CALSIM II releases sufficient flow to meet the standards on a monthly average basis, the resulting EC from DSM2 may be over the standard for part of a month and under the standard for part of the month, depending on the spring/neap tide and other factors (e.g. simplification of operations). It is recommended that the results are presented on a monthly basis. Frequency of compliance with a criterion should be computed based on monthly average results. Averaging on a sub-monthly (14-day or more) scale may be appropriate as long as the limitations with respect to the compliance of the baseline model are described in detail and the alternative results are presented as an incremental change from the baseline model. A detailed discussion is required in this case.

In general, it is appropriate to present DSM2 QUAL results including EC, DOC, volumetric fingerprinting and constituent fingerprinting on a monthly time step. When comparing results from two scenarios, computing differences based on these mean monthly statistics would be appropriate.

A.5.5. Modeling Limitations

DSM2 is a 1D 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 a reservoir surface area is constant in DSM2, it impacts the stage in the reservoir and thereby impacting 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 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. Water quality results inside the water bodies representing the tidal marsh areas were not validated specifically and because of the bottom elevation assumptions, preferably do not use it for analysis.

A.6. Delta Particle Tracking Modeling

Particle tracking models (PTM) are excellent tools to visualize and summarize the impacts of modified hydrodynamics in the Delta. These tools can simulate the movement of passive particles or particles with behavior representing either larval or adult fish through the Delta. The PTM tools can provide important information relating hydrodynamic results to the analysis needs of biologists that are essential in assessing the impacts to the habitat in the Delta.

A.6.1. DSM2-PTM

DSM2-PTM simulates pseudo 3-D transport of neutrally buoyant particles based on the flow field simulated by HYDRO. The PTM module simulates the transport and fate of individual particles traveling throughout the Delta. The model uses geometry files, velocity, flow, and stage output from the HYDRO module to monitor the location of each individual particle using assumed vertical and lateral velocity profiles and specified random movement to simulate mixing. The location of a particle in a channel is determined as the distance from the downstream end of the channel segment (x), the distance from the centerline of the channel (y), and the distance above the channel bottom (z).PTM has multiple applications ranging from visualization of flow patterns to simulation of discrete organisms such as fish eggs and larvae.

The longitudinal distance traveled by a particle is determined from a combination of the lateral and vertical velocity profiles in each channel. The transverse velocity profile simulates the effects of channel shear that occurs along the sides of a channel. The result is varying velocities across the width of the channel. The average cross-sectional velocity is multiplied by a factor based on the particle's transverse location in the channel. The model uses a fourth order polynomial to represent the velocity profile. The vertical velocity profile shows that particles located near the bottom of the channel move more slowly than particles located near the surface. The model uses the Von Karman logarithmic profile to create the velocity profile. Particles also move because of random mixing. The mixing rates (i.e., distances) are a function of the water depth and the velocity in the channel. High velocities and deeper water result in greater mixing.

At a junction the path of a particle is determined randomly based on the proportion of flow. The proportion of flow determines the probability of movement into each reach. A random number based on this determined probability then determines where the particle will go. A particle that moves into an open water area, such as a reservoir, no longer retains its position information. A DSM2 open water area is considered a fully mixed reactor. The path out of the open water area is a decision based on the volume in the open water area, the time step, and the flow out of the area. At the beginning of a time step the volume of the open water area the volume of water leaving at each opening of the open water area is determined. From that the probability of the particle leaving the open water area is calculated. Particles entering exports or agricultural diversions are considered "lost" from the system. Their final destination is recorded. Once particles pass the Martinez boundary, they have no opportunity to return to the Delta. (Smith, 1998, Wilbur, 2001, Miller, 2002)

A.6.2. DSM2-PTM Metrics

The particle transport and fate metrics resulting from DSM2 PTM are outlined below.

1. Fate Mapping – an indicator of entrainment. It is the percent of particles that go past various exit points in the system at the end of a given number of days after insertion.
2. Delta-wide Residence Time – an indicator of transport of larval fish and plankton. It is the time taken for 75% of the particles inserted to leave the system via all the exit points.

A.6.3. PTM Period Selection

PTM simulation periods for the residence time and fate computations were selected based on the simulated Delta inflows and the exports from the No Action Alternative CALSIM II results. A two-pronged approach was used to identify the particle insertion periods such that the selected periods cover the entire range of hydrology and also represent full range of export operations that occurred in the 82-year simulation period. Representative periods with various combinations of total inflow and exports were identified over the whole range of simulated values.

Briefly, the process included sorting all the months in the 82-year period into 25 hydrology bins based on the percent ranks of monthly Sacramento and San Joaquin inflows as shown in Figure A-15. The 984 months were then sorted based on the monthly total Delta inflow and the monthly exports as shown in Figure A-16. Several months falling on the 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6 EI ratio isopleths were manually identified such that they cover all the hydrology bins. Figures A-17 and A-18 show the selected periods plotted on the hydrology binning plot and the EI ratio plot, respectively. Both the plots show that the selected periods cover the full range of hydrology and export operations. Figure A-19 shows number of selected periods in each month. The selected periods were reviewed to ensure representation of all the seasons. The selection was biased to include more periods in the Dec – Jun period. The variability captured in the selected periods, in terms of the hydrology and the operations, is mostly sustained for both the early long-term and late long-term conditions.

A.6.4. PTM Simulations

PTM simulations are performed to derive the metrics described above. PTM model can track flux at twenty locations in one simulation. The particles are inserted at the 39 locations shown in Figure A-20. These locations are listed in Table A-8. The locations were identified based on the 20mm Delta Smelt Survey Stations. They also include special interest stations such as Mokelumne River and Cache Complex.

A total of 39 PTM simulations are performed in a batch mode for each insertion period. For each insertion period, 4000 particles are inserted at the identified locations over a 24.75-hour period, starting on the 1st of the selected month. The fate of the inserted particles is tracked continuously over a 120-day simulation period. The particle flux is tracked at the key exit locations – exports, Delta agricultural intakes, past Chipps Island, to Suisun Marsh and past Martinez and at several internal tracking locations as shown in Figure A-20. Generally, the fate of particles at the end of 30 days, 60 days, 90 days and 120 days after insertion is computed for the fate mapping analysis. For the Delta-wide residence time analysis, the number of days taken for 25%, 50%, 75% of the total inserted particles to be removed via all the exit points in the Delta are computed.

Table A-8: List of Particle Insertion Locations for Residence Time and Fate Computations

Location	DSM2 Node
San Joaquin River at Vernalis	1
San Joaquin River at Mossdale	7
San Joaquin River D/S of Rough and Ready Island	21
San Joaquin River at Buckley Cove	25
San Joaquin River near Medford Island	34
San Joaquin River at Potato Slough	39
San Joaquin River at Twitchell Island	41
Old River near Victoria Canal	75
Old River at Railroad Cut	86
Old River near Quimby Island	99
Middle River at Victoria Canal	113
Middle River u/s of Mildred Island	145
Grant Line Canal	174
Frank's Tract East	232
Threemile Slough	240
Little Potato Slough	249
Mokelumne River d/s of Cosumnes confluence	258
South Fork Mokelumne	261
Mokelumne River d/s of Georgiana confluence	272
North Fork Mokelumne	281
Georgiana Slough	291
Miner Slough	307
Sacramento Deep Water Ship Channel	314
Cache Slough at Shag Slough	321
Cache Slough at Liberty Island	323
Lindsey slough at Barker Slough	324
Sacramento River at Sacramento	330
Sacramento River at Sutter Slough	339
Sacramento River at Ryde	344
Sacramento River near Cache Slough confluence	350
Sacramento River at Rio Vista	351
Sacramento River d/s of Decker Island	353
Sacramento River at Sherman Lake	354
Sacramento River at Port Chicago	359
Montezuma Slough at Head	418
Montezuma Slough at Suisun Slough	428
San Joaquin River d/s of Dutch Slough	461
Sacramento River at Pittsburg	465
San Joaquin River near Jersey Point	469

A.6.5. Output Parameters

The particle tracking models can be used to assist in understanding passive fate and transport, or through consideration of behavior or residence time. In, general the following outputs are generated:

Fate of particles and cut lines or regions

Time of travel breakthrough curves

Residence time

Spatial plots of fate and residence time can be prepared as shown in the Figure A-21 and A-22. Scatter plots of entrainment with a hydrologic variable as shown in Figure A-23 can be helpful in assessing the correlation between hydraulics and entrainment, as well as the spatial extent over which such correlations hold.

A.6.6. Limitations

PTM results are most often used to understand the potential movement of eggs and larval fish with flow changes. Similarly, the PTM is also used to study the changes in the residence time (residence time being a surrogate of the water quality conditions in the Delta) in the Delta associated with flow changes. However, the PTM only approximates movement of neutrally-buoyant particles based on the hydraulics of flow. They do not include elements of fish behavior such as active swimming or tidal surfing which may be important for certain species and life stages. The version of the PTM model used in this analysis does not have a capability to simulate fish behavior. The PTM model requires input of channel velocity fields from HYDRO model, which leads to the translation of the limitations inherent to HDYRO to the PTM model. The partitioning of the particles at a junction is simplistic and is based on the flow split into different branches at a junction. Information related to higher order hydraulics such as acceleration around the bend and secondary are not simulated in the PTM, despite its use of an approximate 3D velocity field. Use of the PTM results to analyze certain species and life stages with significant active behavior responses should be used with caution. The PTM model used for this analysis is incapable of simulating fish screens and blocking the particles from entering small sump pumps in the Delta channels. While some uncertainty exists in the PTM results, the model is a reasonable tool to compare the movement and fate of particles across various scenarios, if results are interpreted within the context of these limitations.

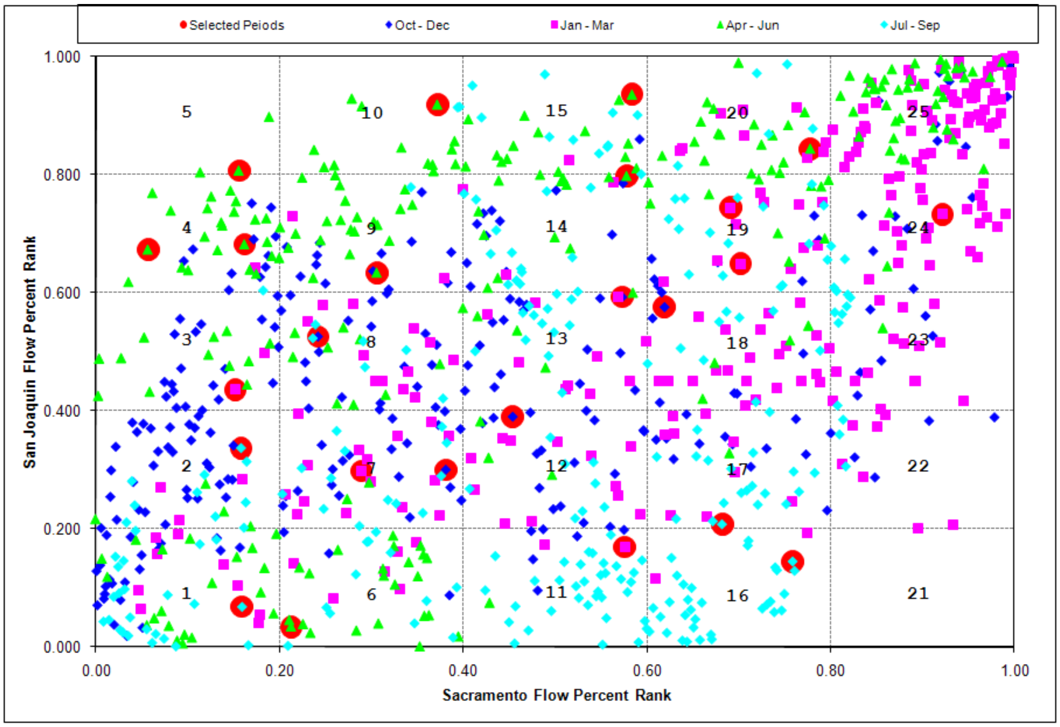


Figure A-15: Sorting of the 984 months (82-years) into 25 hydrology bins based on the percent rank of Sacramento River inflow and San Joaquin River inflow

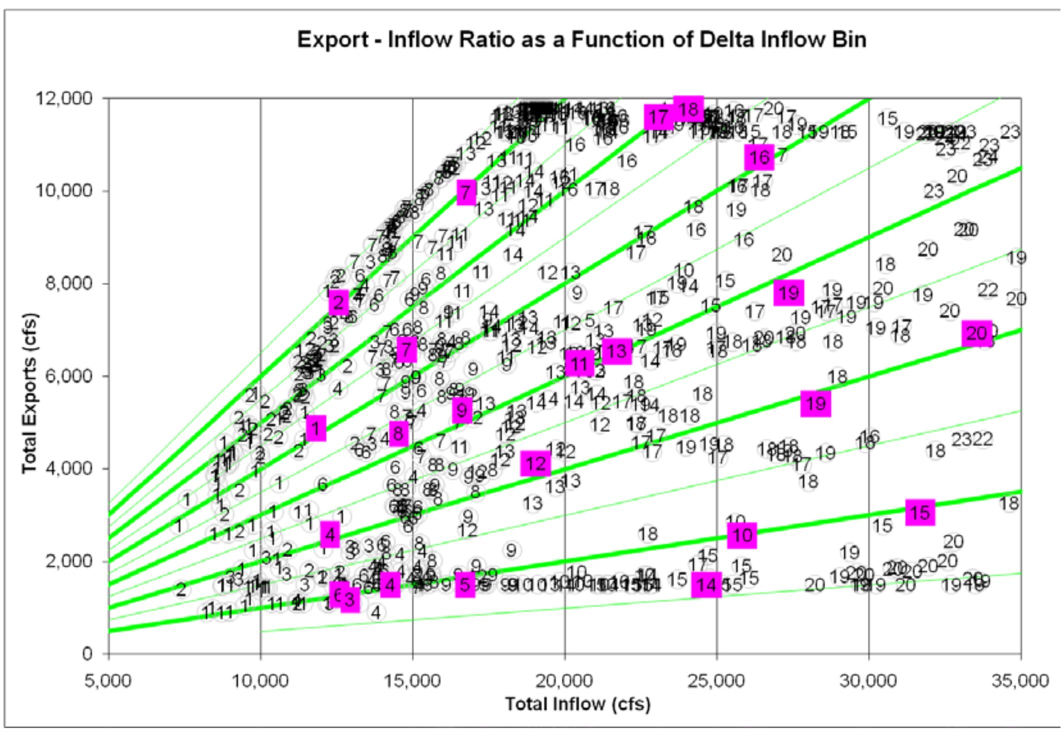


Figure A-16: Identification of months falling on the 0.1, 0.2, 0.3, 0.4, 0.5 and 0.6 EI ratio isopleths while covering the full range of hydrology bins (Numeric labels indicate hydrology bin)

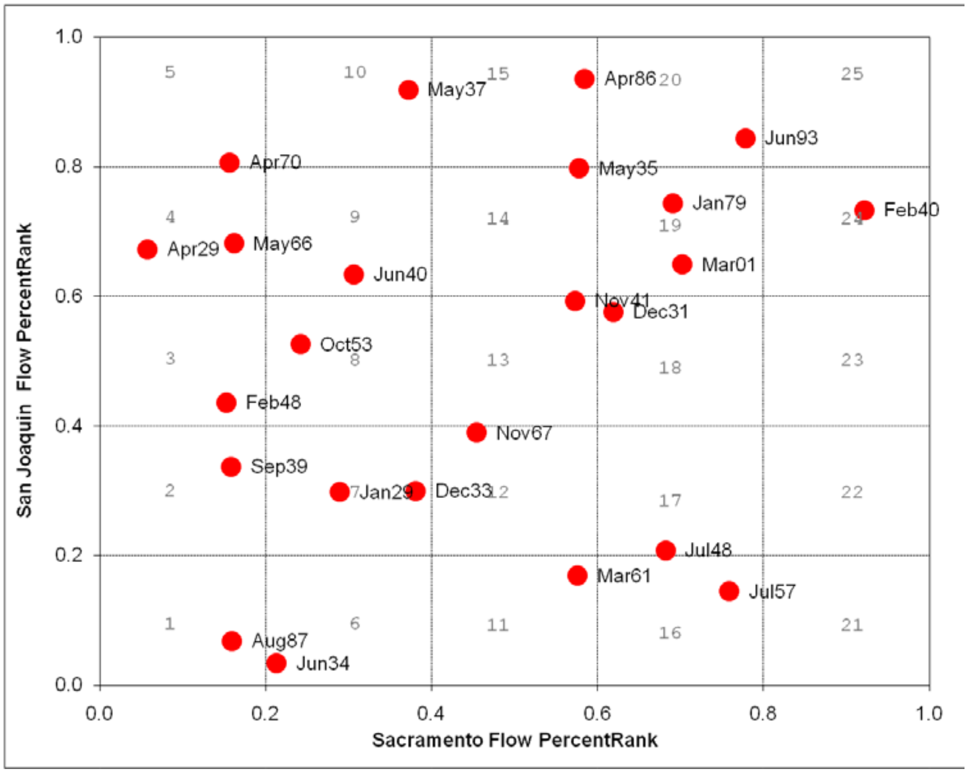


Figure A-17: Selected PTM insertion periods plotted on the Sacramento River and San Joaquin River inflow hydrology bins with month and year identified for each insertion period

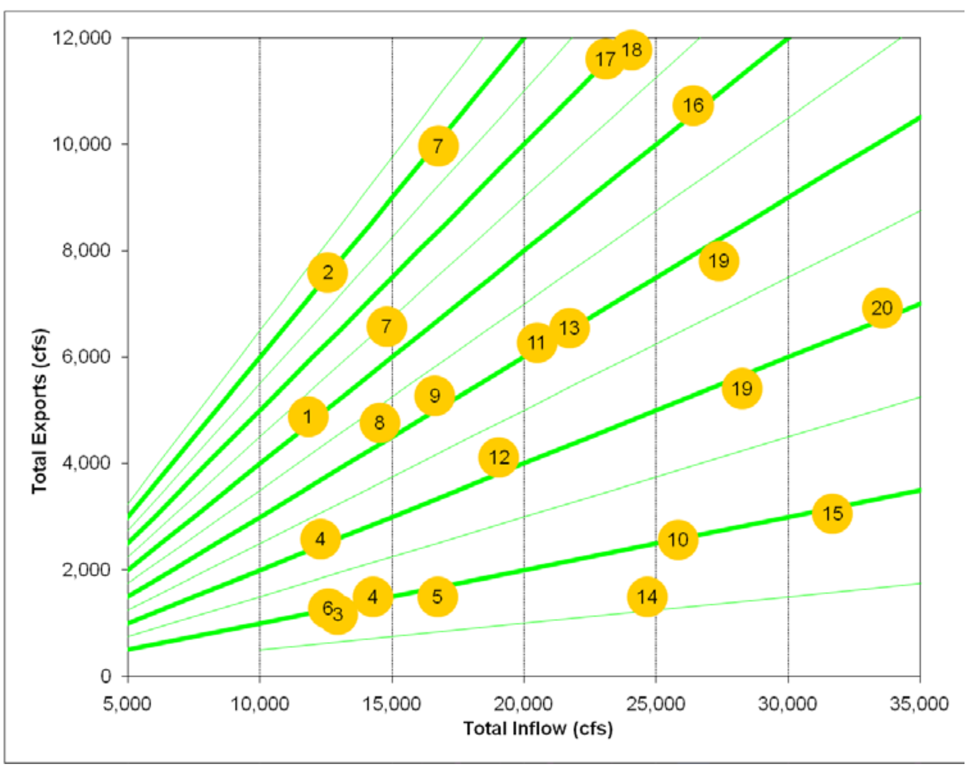


Figure A-18: Selected PTM insertion periods plotted on the EI ratio plot with the hydrology bin for each period identified

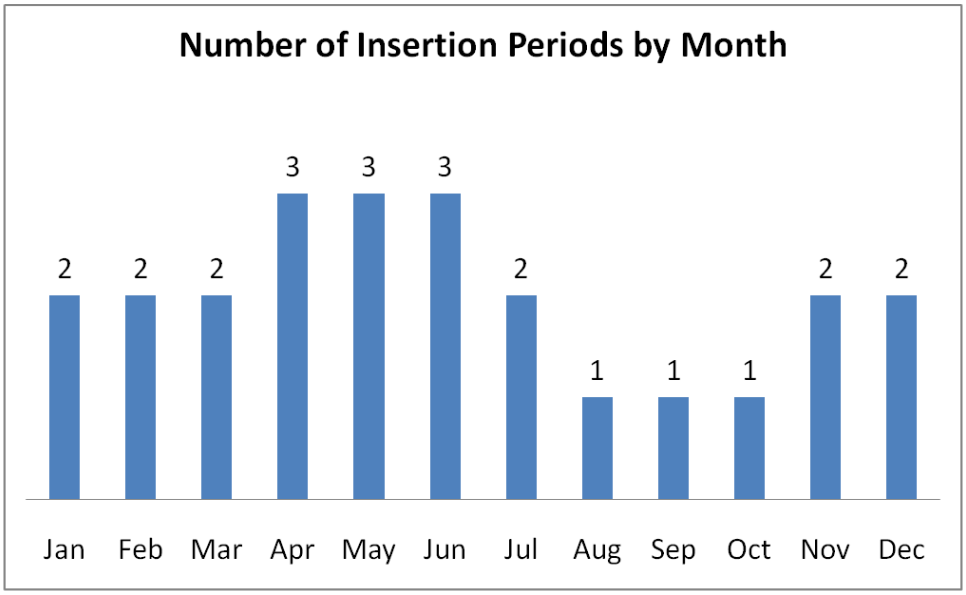
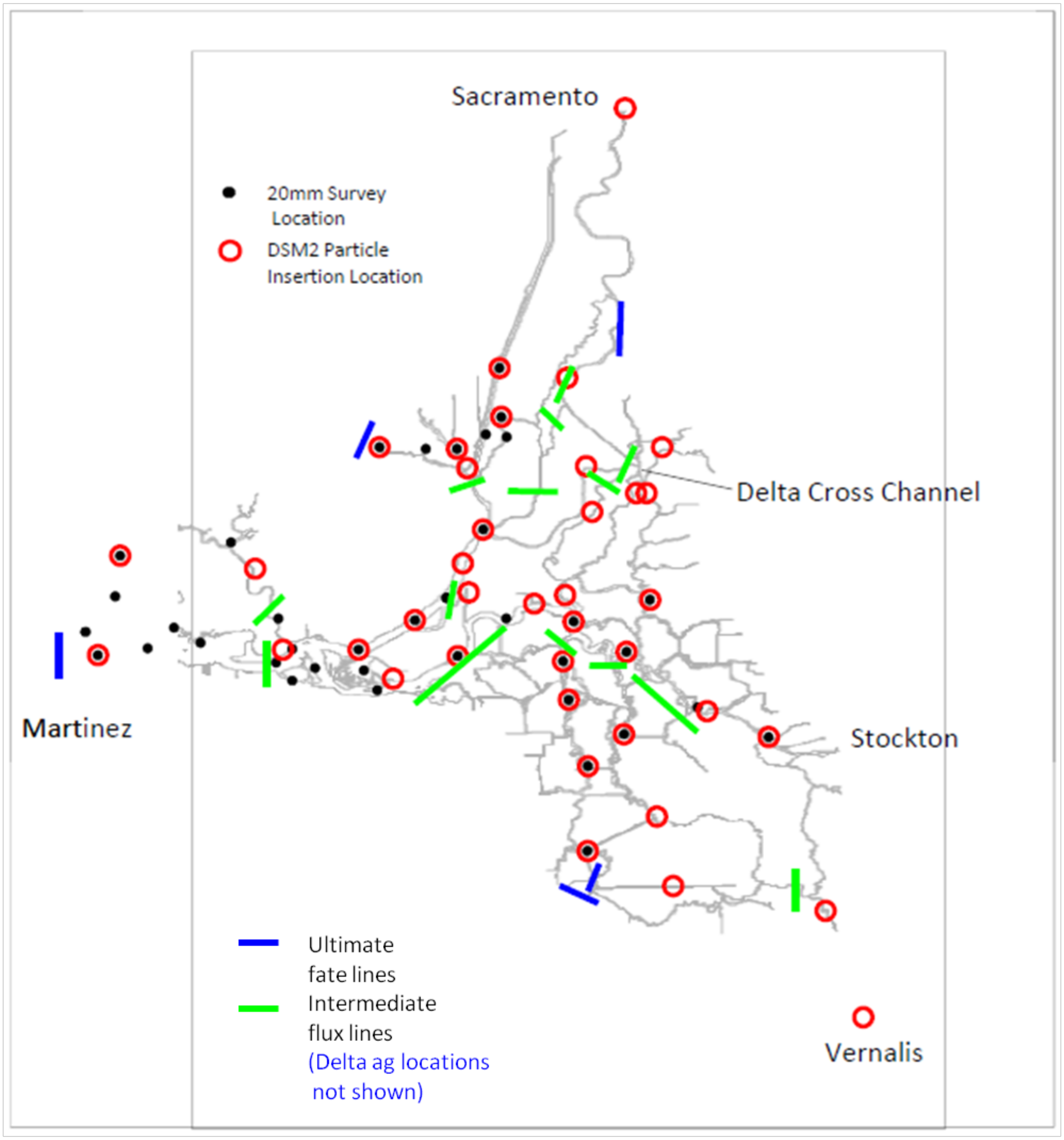


Figure A-19: Number of selected PTM insertion periods in each Month

1



2 Figure A-20: Particle insertion and tracking locations for residence time and fate computations

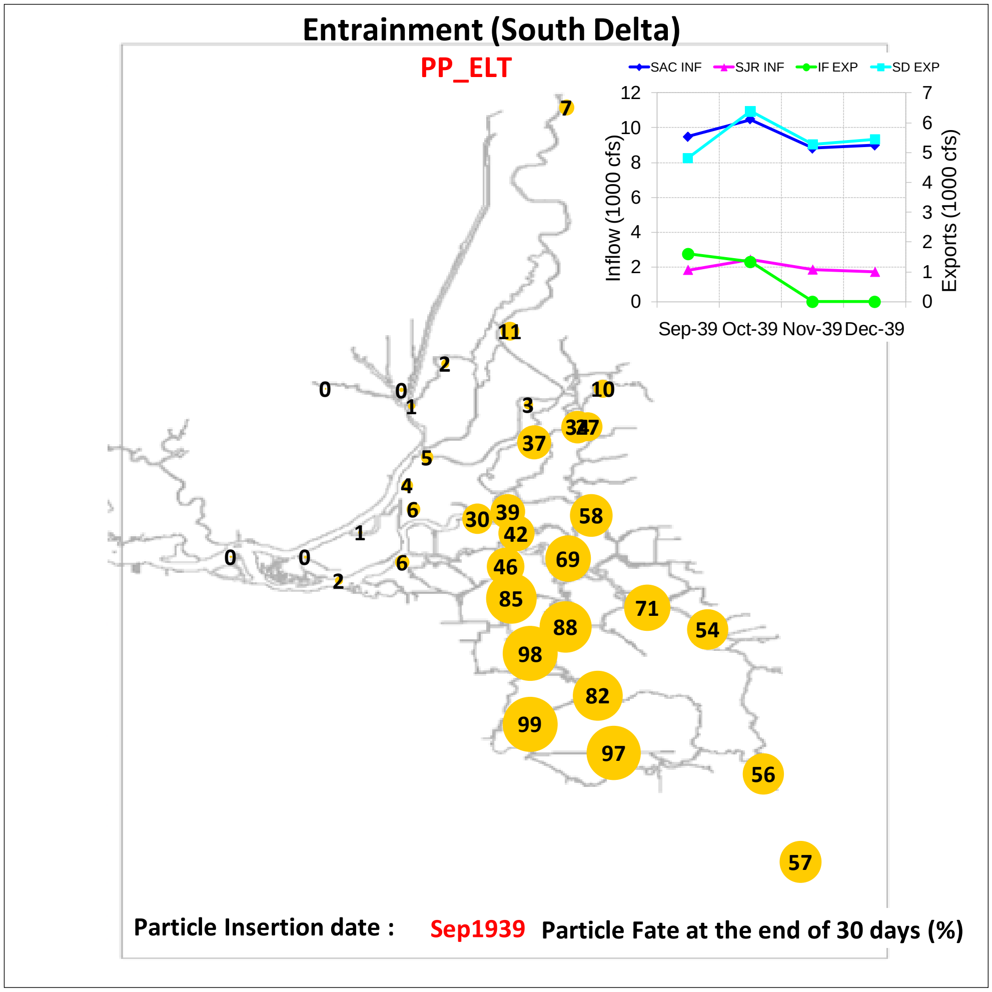


Figure A-21: An example spatial plot showing the percent entrainment for particles released at various locations in the Delta at the end of 30 days after insertion

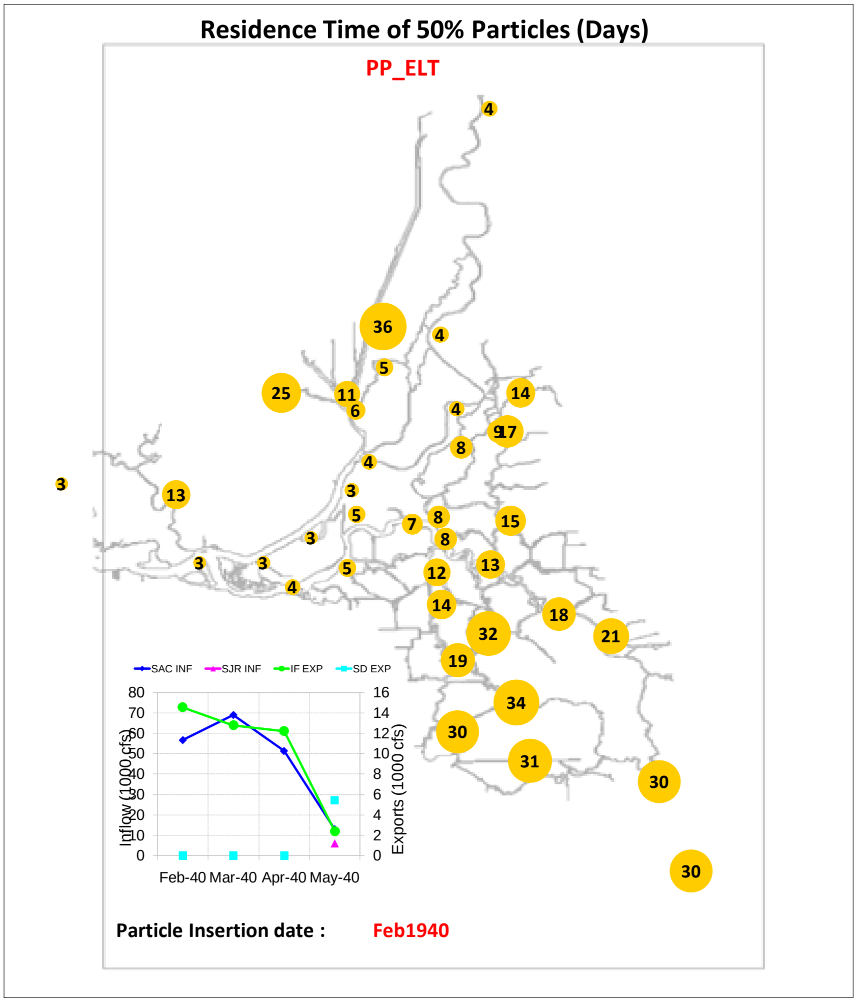


Figure A-22: An example spatial plot showing the residence time for 50 percent particles to exit the Delta

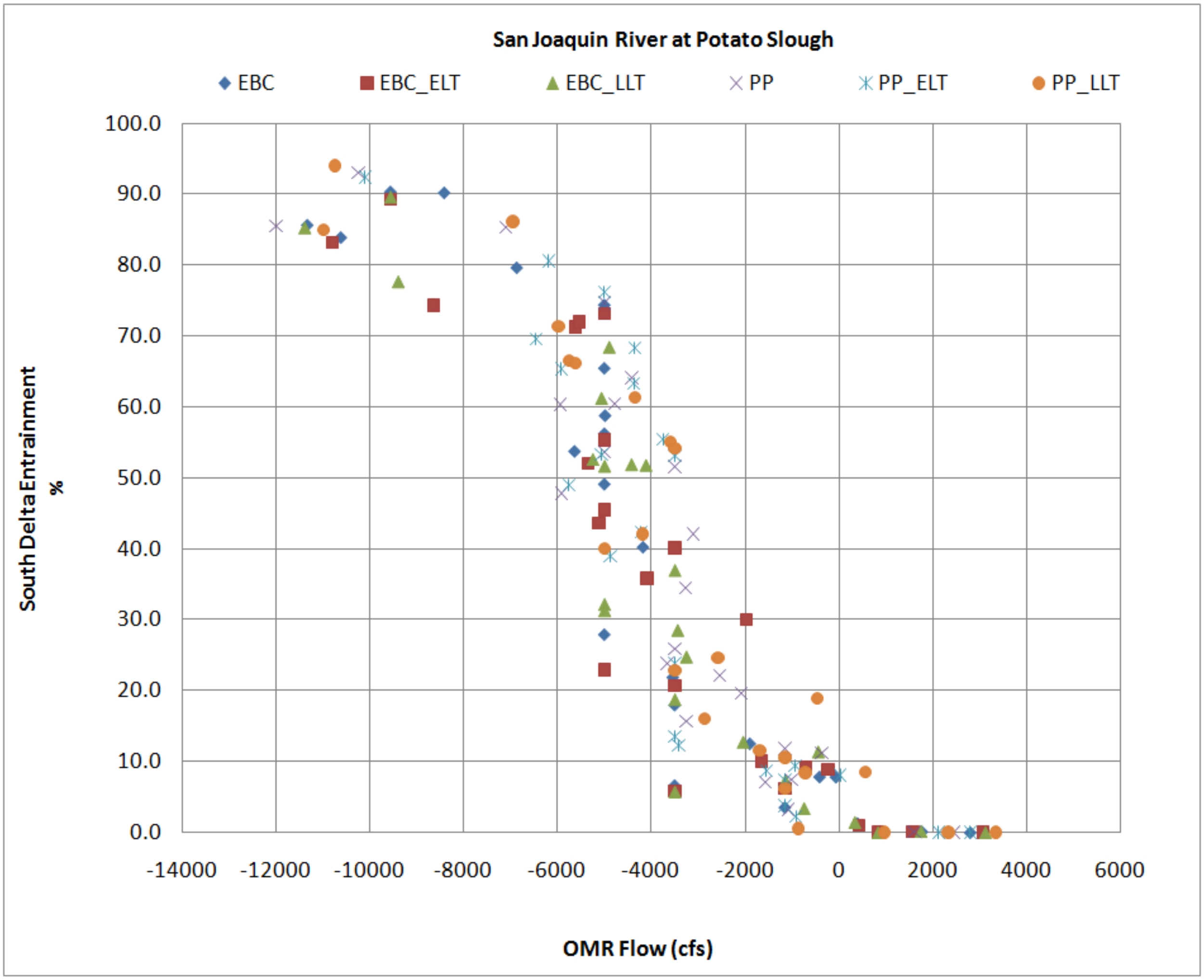


Figure A-23: An example scatter plot showing the percent entrainment of particles at south Delta pumps inserted at San Joaquin River at Potato Slough location and OMR flow, 60 days after the particles were inserted

A.7. Climate Change and Sea Level Rise Scenarios

A.7.1. Selection of BDCP Climate Scenarios

A technical subgroup was formed with representatives from DWR, Reclamation, USFWS, and NMFS to review the technical merits of several approaches for incorporating climate change into BDCP analytical processes. The outcome of this coordinated effort is described in Section D.2. The issues of multi-decadal variability in the sampling of any one GCM projection and the superiority of multi-model projections over any one single projection were emphasized by the group members. These and other comments received from the group members led to the recommendation of the following criteria to guide the selection of climate scenarios:

- Select a range of scenarios to reflect the uncertainty with GCM projections and emission scenarios;
- Select scenarios that reduce the "noise" inherent with any particular GCM projection due to multi-decadal variability that often does not preserve relative rank for different locations and time periods;
- Select an approach that incorporates both the mean climate change trend and changes in variability; and
- Select time periods that are consistent with the major phases used in BDCP planning.
- The selected approach for development of climate scenarios for the BDCP incorporates three fundamental elements. First, it relies on sampling of the ensemble of GCM projections rather than one single realization or a handful of individual realizations. Second, it includes scenarios that both represent the range of projections as well as the central tendency of the projections. Third, it applies a method that incorporates both changes to the mean climate as well as to the variability in climate. These elements are described further in the sections below.

A.7.2. Downscaled Climate Projections

A total of 112 future climate projections used in the IPCC AR4, subsequently bias-corrected and statistically downscaled (BCSD), were obtained from Lawrence Livermore National Laboratory (LLNL) under the World Climate Research Program's (WCRP) Coupled Model Intercomparison Project Phase 3 (CMIP3). This archive of contains climate projections generated from 16 different GCMs developed by national climate centers (Table A-9) and for SRES emission scenarios A2, A1b, and B1. Many of the GCMs were simulated multiple times for the same emission scenario due to differences in starting climate system state, thus the number of available projections is greater than simply the product of GCMs and emission scenarios. These projections have been bias corrected and spatially downscaled to 1/8th degree (~12km) resolution over the contiguous United States through methods described in detail in Wood et al. 2002, Wood et al. 2004, and Maurer 2007.

TABLE A-9
General Circulation Models used in the World Climate Research Program's (WCRP) Coupled Model Intercomparison Project Phase 3 (CMIP3) Database

Modeling Group, Country	WCRP CMIP3 I.D.
Bjerknes Centre for Climate Research	BCCR-BCM2.0
Canadian Centre for Climate Modeling & Analysis	CGCM3.1 (T47)
Meteo-France / Centre National de Recherches Meteorologiques, France	CNRM-CM3
CSIRO Atmospheric Research, Australia	CSIRO-Mk3.0
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory, USA	GFDL-CM2.0
US Dept. of Commerce / NOAA / Geophysical Fluid Dynamics Laboratory, USA	GFDL-CM2.1
NASA / Goddard Institute for Space Studies, USA	GISS-ER
Institute for Numerical Mathematics, Russia	INM-CM3.0
Institut Pierre Simon Laplace, France	IPSL-CM4
Center for Climate System Research (The University of Tokyo), National Institute for Environmental Studies, and Frontier Research Center for Global Change (JAMSTEC), Japan	MIROC3.2 (medres)
Meteorological Institute of the University of Bonn, Meteorological Research Institute of KMA	ECHO-G
Max Planck Institute for Meteorology, Germany	ECHAM5/ MPI-OM
Meteorological Research Institute, Japan	MRI-CGCM2.3.2
National Center for Atmospheric Research, USA	CCSM3
National Center for Atmospheric Research, USA	PCM
Hadley Centre for Climate Prediction and Research / Met Office, UK	UKMO-HadCM3

A.7.3. Climate Periods

Climate change is commonly measured over a 30-year period. Changes in temperature and precipitation for any particular scenario are compared to a historical period. The historical period of 1971-2000 is selected as the reference climate since it is the currently established climate normal used by NOAA and represents the most recent time period. Corresponding to the long-term timelines of the BDCP analysis, in which climate change is likely to be relevant, future climate periods are identified as approximately 2025 (2011-2040) [early long-term] and 2060 (2046-2075) [late long-term]. The difference in mean annual temperature and precipitation among the two future periods and historic period were identified as the climate change metric.

A.7.4. Multi-Model Ensemble and Sub-Ensembles

The recommended approach makes use of all 112 downscaled climate projections of future climate change described in the previous section. The group of multi-model, multi-emission scenario projections is termed the ensemble. Individual model-emission scenario projections are termed “members” of the ensemble. It is often useful to characterize climate change projections in terms of the simulated change in annual temperature and precipitation compared to an historical reference period. At any selected 30-yr future climatological period, each projection represents one point of change amongst the others. This is graphically depicted in Figure A-24 for a region in Feather River watershed.

Since the ensemble is made up of many projections, it is useful to identify the median (50th percentile) change of both annual temperature and annual precipitation (dashed blue lines). In doing so, the state of climate change at this point in time can be broken into quadrants representing (1) drier, less warming, (2) drier, more warming, (3) wetter, more warming, and (4) wetter, less warming than the ensemble median. These quadrants are labeled Q1-Q4 in Figure A-24. In addition, a fifth region (Q5) can be described that samples from inner-quartiles (25th to 75th percentile) of the ensemble and represents a central region of climate change. In each of the five regions the sub-ensemble of climate change projections, made up of those contained within the region bounds, is identified. The Q5 scenario is derived from the central tending climate projections and thus favors the consensus of the ensemble.

Through extensive coordination with the State and Federal teams involved in the BDCP, the bounding scenarios Q1-Q4 were refined in April 2010 to reduce the attenuation of climate projection variability that comes about through the use of larger ensembles. A sensitivity analysis was prepared for the bounding scenarios (Q1-Q4) using sub-ensembles made up of different numbers of downscaled climate projections. The sensitivity analysis was prepared using a “nearest neighbor” (k-NN) approach. In this approach, a certain joint projection probability is selected based on the annual temperature change-precipitation change (i.e. 90th percentile of temperature and 90th percentile of precipitation change). From this statistical point, the “k” nearest neighbors (after normalizing temperature and precipitation changes) of projections are selected and climate change statistics are derived. Consistent with the approach applied in OCAP, the 90th and 10th percentile of annual temperature and precipitation change were selected as the bounding points. The sensitivity analysis considered using the 1-NN (single projection), 5-NN (5 projections), and 10-NN (10 projections) sub-ensemble of projections. These were compared to the original quadrant scenarios which commonly are made up of 25-35 projections and are based on the direction of change from 50th percentile statistic.

The very small ensemble sample sizes exhibited month by month changes that were sometimes dramatically different than that produced by adding a few more projections to the ensemble. The 1-NN approach was found to be inferior to all other methods for this reason. The original quadrant method produced a consensus direction of change of the projections, and thus produced seasonal trends that were more realistic, but exhibited a slightly smaller range due to the inclusion of several central tending projections. The 5-NN and 10-NN methods exhibited slightly wider range of variability than the quadrant method which was desirable from the "bounding" approach. In most cases the 5-NN and 10-NN projections were similar, although they differed at some locations in representation of season trend. The 10-NN approach (Figure A-24) was found to be preferable in that it best represented the seasonal trends of larger ensembles, retained much of the "range" of the smaller ensembles, and was guaranteed to include projections from at least two GCM-emission scenario combinations (in the CMIP3 projection archive, up to 5 projections – multiple simulations – could come from one GCM-emission scenario combination). The State and Federal representatives agreed to utilize the following climate scenario selection process for BDCP:

(1) the use of the original quadrant approach for Q5 (projections within the 25th to 75th percentile bounding box) as it provides the best estimate of the consensus of climate projections and
(2) the use of the 10-NN method to developing the Q1-Q4 bounding scenarios.

An automated process has been developed that generates the monthly and annual statistics for every grid cell within the Central Valley domain and identifies the members of the sub-ensemble for consideration in each of the five scenarios.

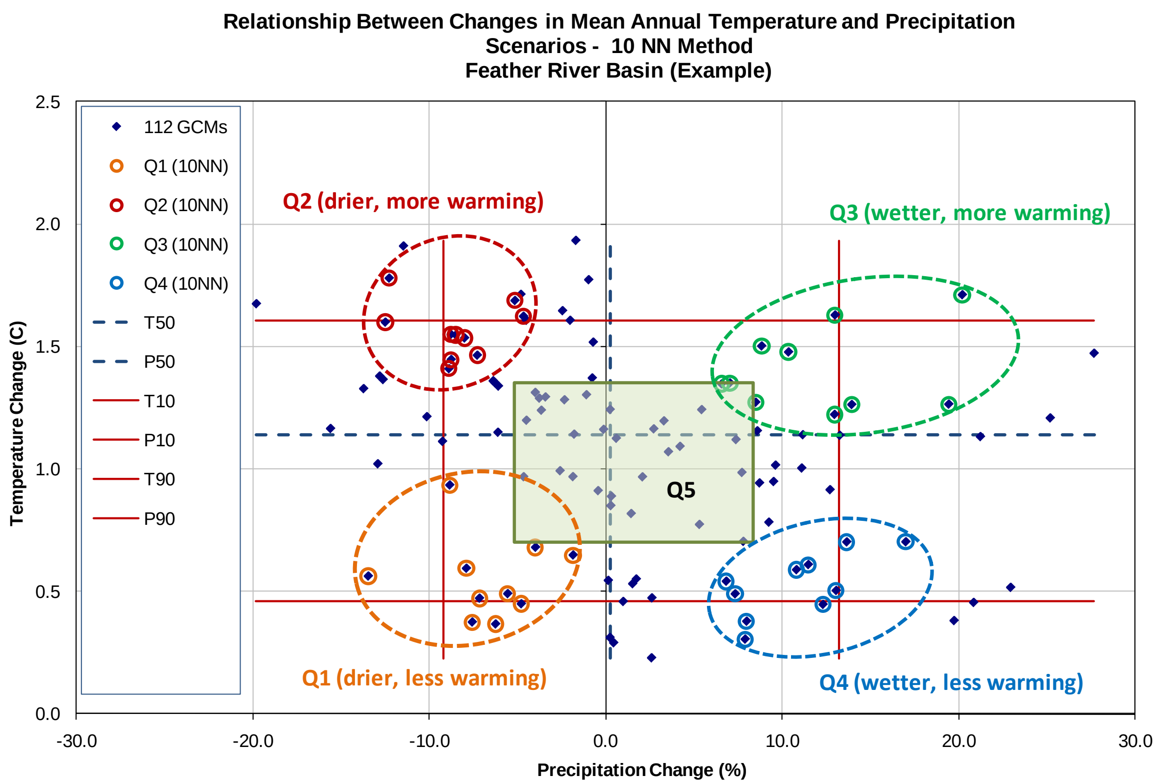


Figure A-24. Example downscaled climate projections and sub-ensembles used for deriving climate scenarios (Q1-Q5), Feather River Basin at 2025. The Q5 scenario is bounded by the 25th and 75th percentile joint temperature-precipitation change. Scenarios Q1-Q4 are selected to reflect the results of the 10 projections nearest each of 10^{th} and 90^{th} joint temperature-precipitation change bounds. Note: the temperature and precipitation changes are normalized before determining the nearest neighbors.

A.7.5. Incorporating Changes in Mean Climate and Climate Variability

Climate is usually defined as the "average" condition of weather over a period of time. More rigorously, climate can be defined as the "statistical description" in terms of mean and variability of the relevant quantities over a period of time ranging from months to millions of years (IPCC TAR). The standard averaging period defined by the World Meteorological Organization (WMO) is 30 years. The parameters that are most often associated with the description of climate state are temperature, precipitation, and wind speed. Thus, climate change refers to a shift in the statistical properties of climate variables over extended periods of time.

One difficulty that arises in implementing climate change into long-term water resources planning is that the natural variability is often greater than the magnitude of change expected over several decades. In many water resource management areas, it is the extreme events (droughts and floods) that drive the decision-making and long-range planning efforts. Thus, there is a need to combine the climate change signal with the range of natural variability observed in the historical record.

In many current climate change analyses, only the mean state of climate change is analyzed through the use of the "delta" method. In this method, temperature and/or precipitation are adjusted by the mean shift from one future 30-year period to a historical 30-year period. However, climate change is unlikely to manifest itself in a uniform change in values. In fact, the climate projections indicate that the changes are nonlinear and shifts in the probability distributions are likely, not just the mean values. In other analyses, a transient 30-year depiction of climate is used and compared against a similar 30-year historical period. Hydrologic analyses are performed and summarized as the "mean" change between the future and base periods. This latter approach is roughly what has been applied in the OCAP and CAT processes. The difficulty with this approach is that the natural observed variability may be large and not fully present in the 30-year period, resulting in truncated variability. Also, because the sequence of variability is different under each period it is difficult to make comparisons between the resulting hydrologic variables beyond the mean response.

In order to incorporate both the climate change signal and the natural variability in the longer-term observed record, the recommended approach is to create an expanded time series which allows use of the long-term observed records. The approach is similar to that applied by the Climate Impacts Group for development of hydrologic scenarios for water planning in the Pacific Northwest (Wood et al 2002, Salathe et al 2007, Hamlet et al 2009), applied in the Lower Colorado River, Texas studies (CH2M HILL 2008), and recent Reclamation planning (USBR, 2010). The approach uses a technique called "quantile mapping" which maps the statistical properties of climate variables from one data subset with the time series of events from a different subset. In this fashion, the approach allows the use of a shorter period to define the climate state, yet maintains the variability of the longer historic record. The quantile mapping approach involves the following steps:

1. Extract a 30-year slice of downscaled climate projections based on the ensemble subset for the quadrant of interest and centered on the year of investigation (i.e. 2025 or 2060)
2. For each calendar month (i.e. January) of the future period, determine the statistical properties (cumulative distribution function, CDF) of temperature and precipitation at each grid cell
3. For each calendar month of the historical period (1971-2000 in our case), determine the statistical properties (CDFs) of temperature and precipitation at each grid cell
4. Develop quantile maps between the historic observed CDFs and the future downscaled climate CDFs, such that the entire probability distribution (including means, variance, skew, etc) at the monthly scale is transformed to reflect the climate scenario
5. Using the quantile maps, redevelop a monthly time series of temperature and precipitation over the observed period (1915 -2003) that incorporates the climate shift of the future period
6. Convert monthly time series to a daily time series by scaling monthly values to daily sequence found in the observed record

The result of the quantile mapping approach is a daily time series of temperature and precipitation that has the range of variability observed in the historic record, but also contains the shift in climate properties (both mean and expanded variability) found in the downscaled climate projection. Figure A-25 provides an example of this process a grid cell in the Feather River watershed. As shown in this figure, the precipitation change quantities are not expected to shift uniformly across all percentiles. For example, in this wetting climate scenario, the median (50^{th} percentile) January precipitation is projected to exhibit almost no change from baseline conditions. However, for large precipitation events (i.e. the 90^{th} percentile) January precipitation is projected to increase by almost 2 mm/day (more than 2 inches/month). That is, the climate shift is larger at higher precipitation events and lower at low precipitation events. While this may be different for each climate scenario, future period, spatial location, and month, the need to map the full range of statistic climate shift is important to characterize the projected effects of climate change.

The resulting changes in the climate variables under the selected scenarios are presented in Section D.3.1.

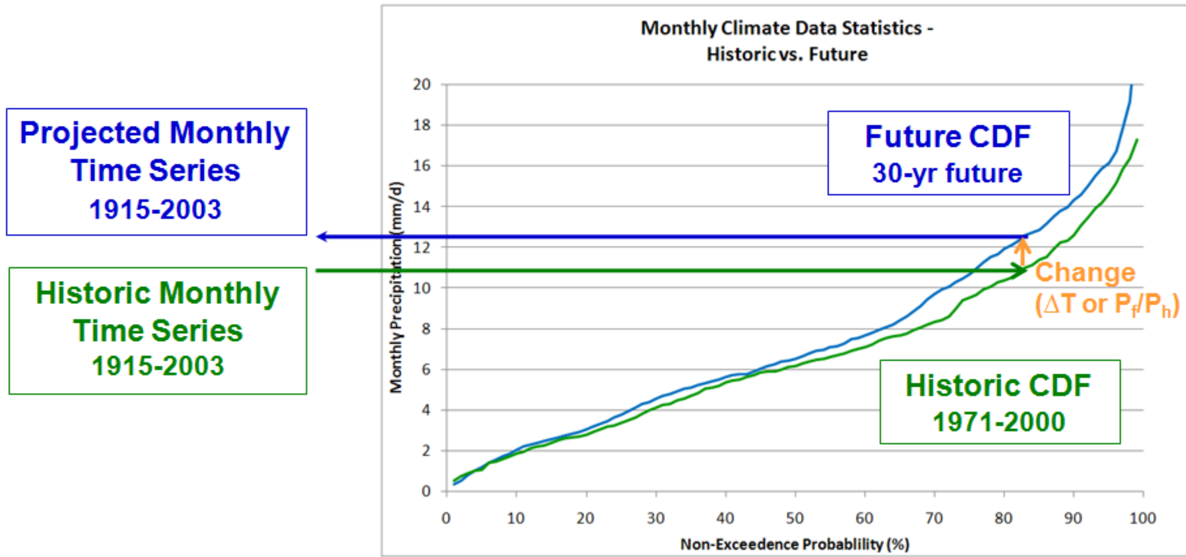


FIGURE A-25:
Historical Monthly Precipitation Statistics for a Grid Cell in Feather River Basin (January - EXAMPLE ONLY)

A.7.6. Sea Level Rise Scenarios

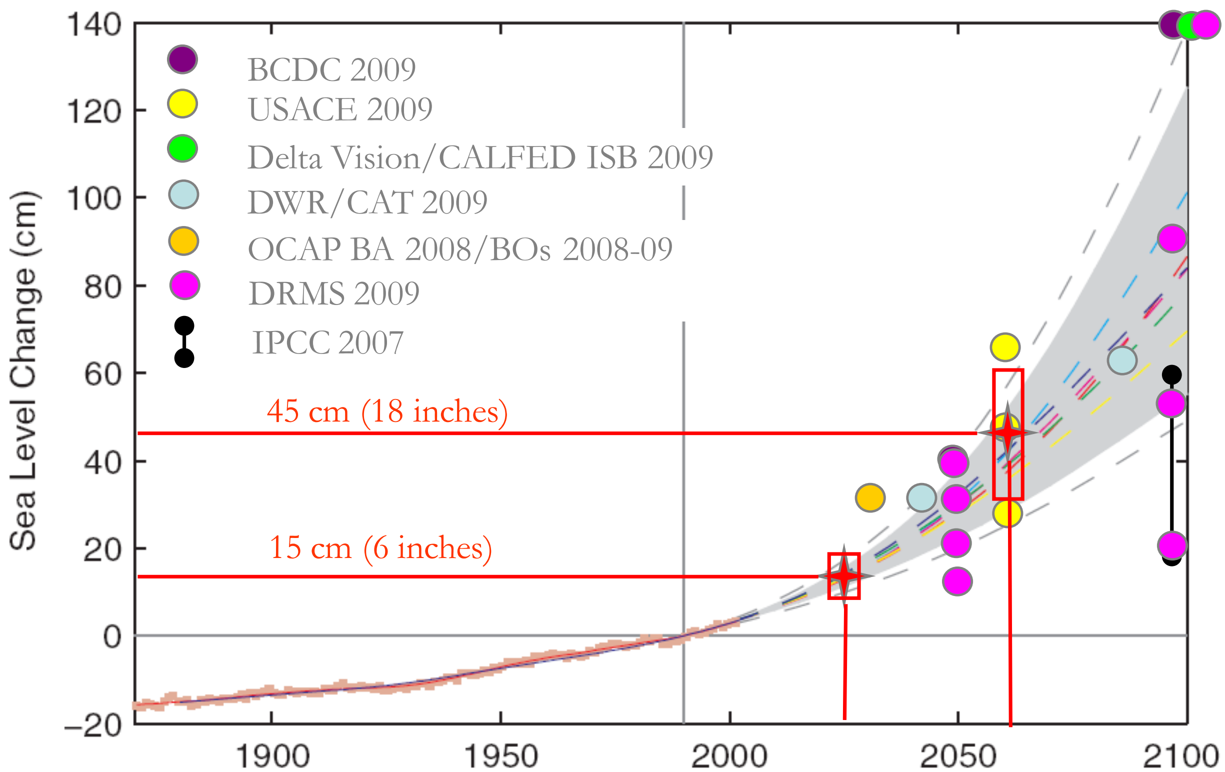
In early 2007, the IPCC released their latest assessment of the scientific assessment for projections of future climate. Included in the IPCC AR4 were revised estimates of global mean sea level rise. The IPCC estimates are based on physical models that attempt to account for thermal expansion of oceans and storage changes associated with melt of land-based ice and snowfields (Healy 2007). Since their release, the IPCC AR4 sea level rise estimates have been widely criticized for their failure to include dynamic instability in the ice sheets of Greenland and Antarctica, and for their under-prediction of recent observed increases in sea level.

Due to the limitations with the current state of physical models for assessing future sea level rise, several scientific groups, including the CALFED Independent Science Board (ISB) (Healy 2007), recommend the use of empirical models for short to medium term planning purposes. Both the CALFED ISB and CAT 2009 assessments have utilized the empirical approach developed by Ramsdorf (2007) that projects future sea level rise rates based on the degree of global warming. This method better reproduces historical sea levels and generally produces larger estimates of sea level rise than those indicated by the IPCC (2007). When evaluating all projections of global air temperature, Ramsdorf projects a mid-range sea level rise of 70 – 100 cm (28 – 40 inches) by the end of the century, and when factoring the full range of uncertainty the projected rise is 50 - 140 cm (20 – 55 inches). The CAT scenarios utilized an identical empirical approach, but limited the sea level rise estimates to the degree of warming range from 12 GCM projections selected for that study.

Using the work conducted by Ramsdorf, the projected sea level rise at the early long-term timeline for the BDCP analysis (2025) is approximately 12 - 18 cm (5 - 7 inches). At the late long-term timeline (2060), the projected sea level rise is approximately 30 – 60 cm (12 – 24 inches).

In 2011, the United States Army Corps of Engineers (USACE) issued guidance on incorporating sea level change in civil works programs (USACE 2011). The guidance document reviews the existing literature and suggests use of a range of sea level change projections, including the “high probability” of accelerating global sea level rise. The ranges of future sea level rise were based on the empirical procedure recommended by the National Research Council (NRC, 1987) and updated for recent conditions. The three scenarios included in the USACE guidance suggest end of century sea level rise in the range of 50 to 150 centimeters (20 to 59 inches), consistent with the range of projections by Rahmstorf (2007) and Vermeer and Rahmstorf (2009). The USACE Bulletin expires in September 2013.

These sea level rise estimates are also consistent with those outlined in the USACE guidance circular for incorporating sea-level changes in civil works programs (USACE 2009). Due to the considerable uncertainty in these projections and the state of sea level rise science, it is proposed to use the mid-range of the estimates for each BDCP timeline: 15 cm (6 inches) by 2025 and 45 cm (18 inches) by 2060. In addition, sensitivity scenarios will be prepared to consider sea level rise of up to 60 cm by 2060.



A.7.7. Changes in Tidal Amplitude

As discussed previously, mean sea level has been increasing across the globe and is exhibited on all U.S. coasts and almost all long-term stations. Tidal amplitude appears to be increasing, particulary in the eastern Pacific but the trend is not consistent for all stations on the West Coast. Tidal amplitude can be significantly affected by physical changes in coasts, harbors, bays, and estuaries. At long-term open-ocean stations along the California coast (La Jolla, Los

Angeles, San Francisco, and Crescent City), which are less influenced by the physical changes, Flick et al. (2003) found a statistically significant increase in tidal amplitude (MHHW - MLLW), except at Crescent City which showed a slight decreasing trend. At San Francisco, the trend in tidal amplitude was found to be around 3-5% increase per century. Jay (2009) recently completed research into changes in tidal constituents, using long-term stations. Results indicated that on average tidal amplitude along the West Coast increased by about 2.2% per century. San Francisco indicated higher increases, while some stations (Alaska/Canada) were relatively constant. Jay hypothesized that global sea level rise may be influencing the location of the amphidrominc points (locations in the ocean where there are no tides) and thus affecting tidal range. However, Jay notes that it remains unclear whether rapid evolution of tidal amplitudes can be described as a symptom of global climate change.

Inland stations such Alameda and Port Chicago showed larger increases in tidal amplitudes than open ocean stations (9% and 26%, respectively). These inland stations have both short records and may be influenced by physical changes in the Bay. The importance of long-term tide records and open-ocean stations is stressed by both Flick et al and Jay for identifying trends in tidal amplitude due to the 18.6-year periodicity and influence of physical changes. Flick et al discounts the use of these inland stations for trends in tidal amplitude. In addition, Flick et al found that other nearby stations exhibited a decreased tidal amplitude trend (Point Reyes at -12% per century and Monterey at -14% per century).

Due to the considerable uncertainty associated with the tidal amplitude increase and the evolving science relating these changes to climate change and mean sea level rise, it is recommended to include a sensitivity analysis of increased tidal amplitude. The recommendation is to evaluate the effect of an amplitude increase of 5% per century, relying on the published observed trends of Flick et al and Jay and assuming that they would continue in the future. We do not propose using the inland stations trends, adhering to guidance from Flick et al. Thus, it is proposed to include one sensitivity simulation with the UNTRIM model, which incorporates an open-ocean tidal boundary, with increased tidal amplitude of 5% per century to contribute to understanding of the relative effect of amplitude increase in comparison to mean sea level increase.

A.7.8. Analytical Process for Incorporating Climate Change

The analytical process for incorporation of climate change effects in BDCP planning includes the use of several sequenced analytical tools (Figure A-2). The GCM downscaled climate projections (DCP), developed through the process described above, are used to create modified temperature and precipitation inputs for the Variable Infiltration Capacity (VIC) hydrology model. The VIC model simulates hydrologic processes on the $1/8^{th}$ degree scale to produce watershed runoff (and other hydrologic variables) for the major rivers and streams in the Central Valley. The changes in reservoir inflows and downstream accretions/depletions are translated into modified input time series for the CALSIM II model. The CALSIM II simulates the response of the river-reservoir-conveyance system to the climate change derived hydrologic patterns. The CALSIM II model, in turn, provides monthly flows for all major inflow sources to the Delta, as well as the Delta exports, for input to the DSM2 hydrodynamic model. DSM2 also incorporates the assumptions of sea level rise for an integrated assessment of climate change effects on the estuary.

At each long-term BDCP analysis timeline (Early Long-Term: 2025 and Late Long-Term: 2060), five regional climate change projections are considered for the 30-year climatological period centered on the analysis year (i.e. 2011-2040 to represent 2025 timeline). DSM2 model simulations have been developed for each habitat condition and sea level rise scenario that is coincident with the BDCP timeline. New Artificial Neural Networks (ANNs) have been developed based on the flow-salinity response simulated by the DSM2 model. These sea level rise-habitat ANNs are subsequently included in CALSIM II models. The CALSIM II model has been simulated with each of the five climate change hydrologic conditions in addition to the historical hydrologic conditions for the No Project/No Action Alternative and Alternative 1A, to understand the sensitivity of projected operations to the range of climate change scenarios. For other Alternatives CALSIM II simulations have been developed only for the mid-range climate change scenario (Q5).

A.8. Regional Hydrologic Modeling

Regional hydrologic modeling is necessary to understand the watershed-scale impacts of historical and projected climate patterns on the processes of rainfall, snowpack development and snowmelt, soil moisture depletion, evapotranspiration, and ultimately changes in streamflow patterns. Future projected climate change, downscaled from global climate models (GCMs), suggests substantial warming throughout California and changes in precipitation. The effect of these changes in critical to future water management. In most prior analyses of the water resources of the Central Valley, the assumptions of hydroclimatic "stationarity", the concept that variability extends about relatively unchanging mean, have been made. Under the stationarity assumption, the observed streamflow record provides a reasonable estimate of the hydroclimatic variability. However, recent observations and future projections indicate that the climate will not be stationary, thus magnifying the need to understand the direct linkages between climate and watershed processes. Hydrologic models, especially those with strong, directly linkages to climate, enable these processes to be effectively characterized and provide estimates of changes in magnitude and timing of basin runoff with changes in climate conditions.

A.8.1. Variable Infiltration Capacity (VIC) Model

The VIC model (Liang et al. 1994; Liang et al. 1996; Nijssen et al. 1997) is a spatially distributed hydrologic model that solves the water balance at each model grid cell. The VIC model incorporates spatially distributed parameters describing topography, soils, land use, and vegetation classes. VIC is considered a macro-scale hydrologic model in that it is designed for larger basins with fairly coarse grids. In this manner, it accepts input meteorological data directly from global or national gridded databases or from GCM projections. To compensate for the coarseness of the discretization, VIC is unique in its incorporation of subgrid variability to describe variations in the land parameters as well as precipitation distribution. Parameterization within VIC is performed primarily through adjustments to parameters describing the rates of infiltration and baseflow as a function of soil properties, as well as the soil layers depths. When simulating in water balance mode, as done for this California application, VIC is driven by daily inputs of precipitation, maximum and minimum temperature, and windspeed. The model internally calculates additional meteorological forcings such short-wave and long-wave radiation, relative humidity, vapor pressure and vapor pressure deficits. Rainfall, snow, infiltration, evapotranspiration, runoff, soil moisture, and baseflow are computed over each grid cell on a daily basis for the entire period of simulation. An offline routing tool then processes the individual cell runoff and baseflow terms and routes the flow to develop streamflow at various locations in the watershed. Figure A-26 shows the hydrologic processes included in the VIC model.

The VIC model has been applied to many major basins in the United States, including large-scale applications to California's Central Valley (Maurer et. al 2002; Brekke et al 2007; Cayan et al. 2009), Colorado River Basin (Christensen and Lettenmaier, 2009), Columbia River Basin (Hamlet et al 2010), and for several basins in Texas (Maurer et al 2003; CH2M HILL 2008). The VIC model application for California was obtained from Dan Cayan and Tapash Das at Scripps Institute of Oceanography (SIO) and is identical to that used in the recent Climate Action Team (2009) studies. The VIC model was simulated by CH2M HILL and comparisons were performed with SIO to ensure appropriate transfer of data sets. No refinements to the existing calibration was performed for the BDCP application.

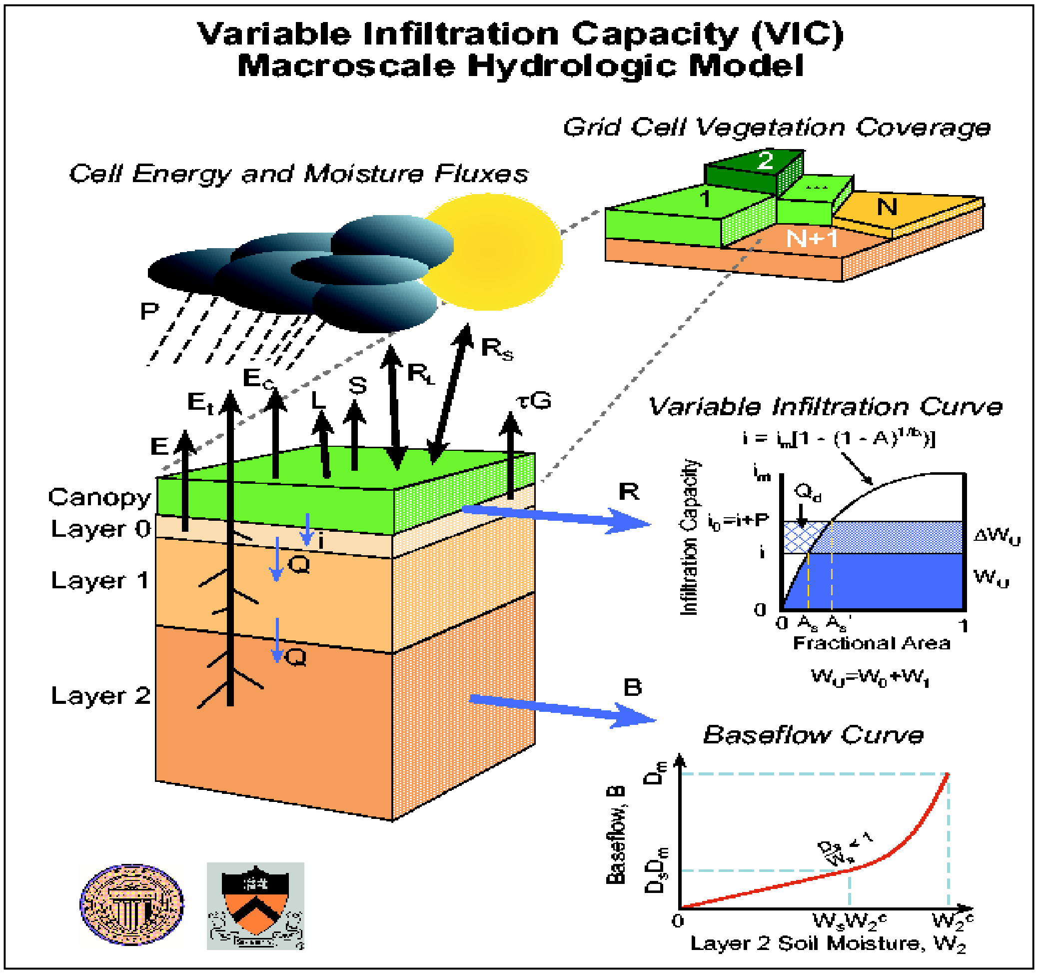


Figure A-26. Hydrologic Processes Included in the VIC Model (Source: University of Washington 2010)

A.8.2. Application of VIC Model for BDCP Evaluations

The regional hydrologic modeling is applied to support an assessment of changes in runoff associated with future projected changes in climate. These results are intended for use in comparative assessments and serve the primary purpose of adjusting inflow records in the CALSIM II long term operations model to reflect anticipated changes in climate. This section describes the regional hydrologic modeling methods used in the planning analysis for BDCP. The general flow of information is shown graphically in Figure A-2.

The GCM downscaled climate projections (DCP) are used to adjust historical California climate for the effects of climate change for each of the climate scenarios described in Section A.7. The resulting adjusted climate patterns, primarily temperature and precipitation fields are used as inputs to the VIC hydrology model. The VIC model is simulated for the each of the five climate scenarios at each BDCP long-term timeline. The VIC model simulations produce outputs of hydrologic parameters for each grid cell and daily and monthly streamflows at key locations in the Sacramento River and San Joaquin River watersheds. The changes in "natural" flow at these locations between the observed and climate scenarios are then applied to adjust historical inflows to the CALSIM II model.

Model Domain

The VIC application for California was originally developed by University of Washington (Wood et al, 2000), but has been subsequently refined by Ed Maurer and others (Maurer et al 2002). The model grid consists of approximately 3000 grid cells at a 1/8th degree latitude by longitude spatial resolution. The VIC model domain is shown in Figure A-27 and covers all major drainages in California.

Observed Meteorology

The VIC application for the BDCP is run in water balance mode with inputs consisting of daily precipitation, minimum temperature, maximum temperature, and windspeed. The model internally calculates additional meteorological forcings such short-wave and long-wave radiation, relative humidity, vapor pressure and vapor pressure deficits. Daily gridded observed meteorology was obtained from the University of Washington (Hamlet and Lettenmaier 2005) for the period of 1915-2003. This data set adjusts for station inhomeniety (station length, movement, temporal trends) and is comparable to a similar observed data set developed by Maurer et al (2002) for the 1950-99 overlapping period. The longer sequence of this observed meteorology data set allow for improved simulation techniques and integration with CALSIM II model with commensurate time coverage. In addition, this observed data set is currently being applied by Cayan et al (2010) for the recent study on Southwest drought and Hamlet et al (2010) in their study of climate change in the Pacific Northwest. To better understand the sensitivity of the VIC modeling to different observed meteorology, comparative simulations using both the Hamlet data set and the Maurer data set were performed. The resulting simulated streamflows were comparable between the two data sets with relatively minor differences in individual months and years.

Daily Meteorology for Future Climate Scenarios

Scenarios of future climate were developed through methods as described in Section A.7. These ensemble informed scenarios consist of daily time series and monthly distribution statistics of temperature and precipitation for each grid cell for the entire state of California. Historical daily time series of temperature and precipitation are converted to representative future daily series through the process of quantile mapping which applies the change in monthly statistics derived from the climate projection information onto the input time series. The result of this process (described in detail in Section A.7.) is a modified daily time series that spans the same time period as the observed meteorology (1915-2003). Daily precipitation and temperature are adjusted based on the derived monthly changes and scaled according to the daily patterns in the observed meteorology. Wind speed was not adjusted in these analyses as downscaling of this parameter was not available, nor well-translated from global climate models to local scales.

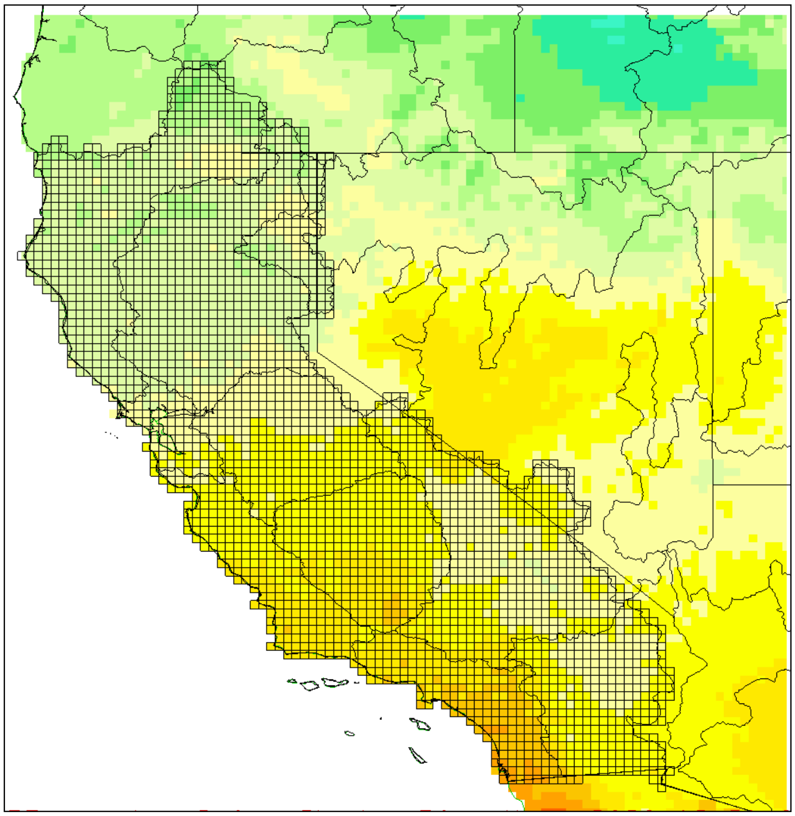


Figure A-27: VIC model domain and grid as applied for the BDCP application.

Grid Cell Characterization and Water Balance

As described previously, the VIC model was simulated in water balance mode. In this mode, a complete land surface water balance is computed for each grid cell on a daily basis for the entire model domain. Unique to the VIC model is its characterization of sub-grid variability. Sub-grid elevation bands enable more detailed characterization of snow-related processes. Five elevation bands are included for each grid cell. In addition, VIC also includes a sub-daily (1 hour) computation to resolve transients in the snow model. The soil column is represented by three soil zones extending from land surface in order to capture the vertical distribution of soil moisture. The VIC model represents multiple vegetation types as uses NASA's Land Data Assimilation System (LDAS) databases as the primary input data set.

For each grid cell, the VIC model computes the water balance over each grid cell on a daily basis for the entire period of simulation. For the simulations performed for the BDCP, water balance variables such as precipitation, evapotranspiration, runoff, baseflow, soil moisture, and snow water equivalent are included as output. In order to facilitate understanding of these watershed process results, nine locations throughout the in the watershed were selected for more detailed review. These locations are representative points within each of the following hydrologic basins: Upper Sacramento River, Feather River, Yuba River, American River, Stanislaus River, Tuolumne River, Merced River, and Upper San Joaquin River. The flow in these main rivers are included in the Eight River Index which is the broadest measure of total flow contributing to the Delta. A ninth location was selected to represent conditions within the Delta itself.

Routing of Streamflows

The runoff simulated from each grid cell is routed to various river flow locations using VIC's offline routing tool. The routing tool processes individual cell runoff and baseflow terms and routes the flow based on flow direction and flow accumulation inputs derived from digital elevation models (Figure A-28). For the simulations performed for the BDCP, streamflow was routed to 21 locations that generally align with long-term gauging stations throughout the watershed. For the VIC application for the BDCP, several additional streamflow routing locations were added to ensure that all major watersheds contributing to Delta inflow were considered. The primary additions were the smaller drainages in the upper Sacramento Valley consisting of Cottonwood Creek and Bear River and the Eastside streams consisting of Cosumnes, Mokelumne, and Calaveras Rivers. Table A-10 lists these 21 locations. The flow at these locations also allows for assessment of changes in various hydrologic indices used in water management in the Sacramento-San Joaquin Delta. Flows are output in both daily and monthly time steps. Only the monthly flows were used in subsequent analyses. It is important to note that VIC routed flows are considered "naturalized" in that they do not include effects of diversions, imports, storage, or other human management of the water resource.

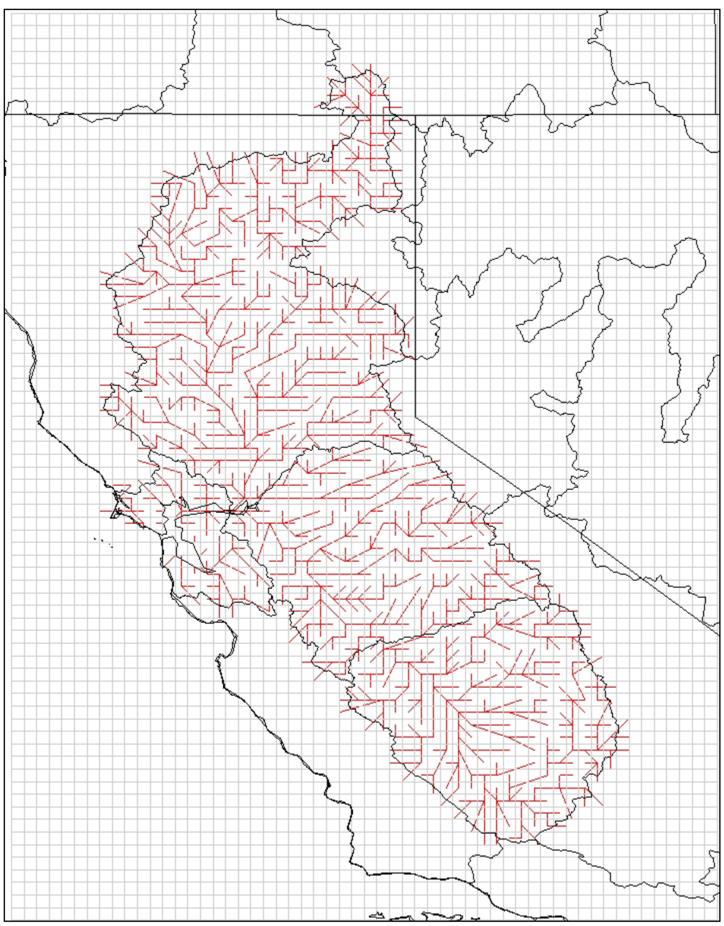


Figure A-28: VIC model routing network as applied for the BDCP application.

Table A-10: Listing of flow routing locations included in the VIC modeling.

Abbr	Name	Lat	Lon	VIC Lat	VIC Lon
SMITH	Smith River at Jed Smith SP	41.7917	-124.075	41.8125	-124.063
SACDL	Sacramento River at Delta	40.9397	-122.416	40.9375	-122.438
TRINI	Trinity River at Trinity Reservoir	40.801	-122.762	40.8125	-122.813
SHAST	Sacramento River at Shasta Dam	40.717	-122.417	40.6875	-122.438
SAC_B	Sacramento River at Bend Bridge	40.289	-122.186	40.3125	-122.188
OROVI	Feather River at Oroville	39.522	-121.547	39.5625	-121.438
SMART	Yuba River at Smartville	39.235	-121.273	39.1875	-121.313
NF_AM	North Fork American River at North Fork Dam	39.1883	-120.758	39.1875	-120.813
FOL_I	American River at Folsom Dam	38.683	-121.183	38.6875	-121.188
CONSU	Cosumnes River at Michigan Bar	38.5	-121.044	38.3125	-121.313
PRD_C	Mokelumne River at Pardee	38.313	-120.719	38.3125	-120.813
N_HOG	Calaveras River at New Hogan	38.155	-120.814	38.1875	-120.813
N_MEL	Stanislaus River at New Melones Dam	37.852	-120.637	37.9375	-120.563
MERPH	Merced River at Pohono Bridge	37.7167	-119.665	37.9375	-119.563
DPR_I	Tuolumne River at New Don Pedro	37.666	-120.441	37.6875	-120.438
LK_MC	Merced River at Lake McClure	37.522	-120.3	37.5625	-120.313
MILLE	San Joaquin River at Millerton Lake	36.984	-119.723	36.9375	-119.688
KINGS	Kings River - Pine Flat Dam	36.831	-119.335	37.1875	-119.438
COTTONWOOD	Cottonwood Creek near Cottonwood	40.387	-122.239		
CLEARCREEK	Clear Creek near Igo	40.513	-122.524		
BEARCREEK	Bear River near Wheatland	39.000	-121.407		

A.8.3. Output Parameters

As discussed previously the following key output parameters are produced on a daily and monthly time-step:

Temperature, precipitation, runoff, baseflow, evapotranspiration, soil moisture, and snow water equivalent on grid-cell and watershed basis

Routed streamflow at major flow locations to the Sacramento Valley and San Joaquin Valley

The results from VIC modeling for the selected climate scenarios are presented in Section D.3.2.

A.8.4. Critical Locations for Analysis

The watershed hydrologic process information can be characterized for each of the approximately 3,000 grid cells, but the nine locations described above provide a reasonable spatial coverage of the changes anticipated in Central Valley. The routed streamflows at all 21 locations identified in Table A-10 are necessary to adjust the inflow timeseries and hydrologic indices in the CALSIM II model. Analysis of flows for watersheds much smaller than what is included here should be treated with caution given the current spatial discretization of the VIC model domain. The streamflows included in this analysis and used to adjust hydrology in the CALSIM II model account for over 95% of the total natural inflow to the Delta.

A.8.5. Modeling Limitations

The regional hydrologic modeling described using the VIC model is primarily intended to generate changes in inflow magnitude and timing for use in subsequent CALSIM II modeling. While the model contains several sub-grid mechanisms, the coarse grid scale should be noted when considering results and analysis of local scale phenomenon. The VIC model is currently best applied for the regional scale hydrologic analyses. The model is only as good as its inputs. There are several limitations to long-term gridded meteorology related to spatial-temporal interpolation and bias correction that should be considered. In addition, the inputs to the model do not include any transient trends in the vegetation or water management that may affect streamflows; they should only be analyzed from a "naturalized" flow change standpoint. Finally, the VIC model includes three soil zones to capture the vertical movement of soil moisture, but does not explicitly include groundwater. The exclusion of deeper groundwater is not likely a limiting factor in the upper watersheds of the Sacramento and San Joaquin River watersheds that contribute approximately 80-90 percent of the runoff to the Delta, however, in the valley floor groundwater management and surface water regulation is considerable. Water management models such as CALSIM II should be utilized to characterize the heavily "managed" portions of the system.

A.8.6. Linkages to Other Physical Models

The VIC hydrology model requires input related to historic and future meteorological conditions. Long-term historical gridded datasets have been obtained to characterize past climate. Future estimates of meteorological forcings are derived from downscaled climate projections incorporating the effects of global warming. The changes in routed streamflows between historic and future VIC simulations are used to adjust inflows and hydrologic indices for use in the CALSIM II model.

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Bay-Delta Conservation Plan EIR/EIS Appendix 5A

Section B: CALSIM II and DSM2 Modeling Simulations and Assumptions

Section B: CALSIM II and DSM2 Modeling Simulations and Assumptions

Outline

B.1. Introduction

As described in section A of this appendix, modeling was prepared for evaluation of the Alternatives considered in the Bay Delta Conservation Plan Environmental Impact Report/Environmental Impact Statement (BDCP EIR/EIS). This section describes the assumptions for the CALSIM II and DSM2 modeling of the Existing Conditions, No Action Alternative and other Alternatives.

The following model simulations were prepared as the basis of evaluating the impacts of the other alternatives:

1. Existing Conditions
2. No Action Alternative at Late Long-Term (LLT)

The following model simulations of alternatives were prepared:

1. Alternative 1A, 1B, 1C – Dual Conveyance with Intakes 1 through 5
2. Alternative 2A, 2B, 2C – Dual Conveyance with Intakes 1, 2, 3, 6 and 7
3. Alternative 3 – Dual Conveyance with Intakes 1 and 2
4. Alternative 4 – Dual Conveyance with Intakes 2, 3 and 5
5. Alternative 5 – Dual Conveyance with Intake 1
6. Alternative 6A, 6B, 6C – Isolated Conveyance with Intakes 1 through 5
7. Alternative 7 – Enhanced Aquatic Conservation Alternative (Dual Conveyance with Intakes 2, 3 and 5)
8. Alternative 8 – SWRCB Criteria for Flow and Cold Water Pool Storage (Dual Conveyance with Intakes 2, 3 and 5)
9. Alternative 9 – Separate Corridors

Existing Conditions and No Action Alternative modeling assumptions were developed through a coordinated process with the Federal and State Lead Agencies to reflect the best CALSIM II and DSM2 model representation of the Reasonable and Prudent Actions (RPAs) in the 2008 Fish and Wildlife Service (FWS) and 2009 National Marine Fisheries Service (NMFS) Biological Opinions (BO).

Alternative 1A, 1B and 1C modeling assumptions were developed under the guidance of the BDCP Steering Committee in February 2010. Assumptions for Alternatives 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7 and 9 were developed by the BDCP EIR/EIS Lead Agencies based on the assumptions for the Alternative 1. Alternative 8 assumptions were developed by the State Water Resources Control Board (SWRCB) in collaboration with DWR.

B.2. Assumptions for Existing Conditions and No Action Alternative Model Simulations

This section presents the assumptions used in developing the CALSIM II and DSM2 model simulations of the Existing Conditions and No Action Alternative at Late Long-term (also referred to as "No Action Alternative") for use in the BDCP EIR/EIS evaluation.

These assumptions were selected by the Department of Water Resources (DWR) management team for the BDCP EIR/EIS in coordination with the Bureau of Reclamation (Reclamation), Fish and Wildlife Service (USFWS) and National Oceanic and Atmospheric Administration National Marine Fisheries Service (NMFS).

The assumptions were selected to satisfy CEQA and NEPA requirements. The basis for these assumptions is described in the appendix, "EIR-EIS Appendix 3D – Defining Existing Conditions, No Action Alt., No Project Alt., and Cumulative Impact Conditions". Assumptions that applied to the CALSIM II and DSM2 modeling are included in the following section.

The Existing Conditions and No Action Alternative assumptions include implementation of water operations components of the Reasonable and Prudent Alternatives (RPA) specified in the 2008 Fish and Wildlife Service (FWS) and 2009 National Marine Fisheries Service (NMFS) Biological Opinions (BO). The specific assumptions and implementation in the CALSIM II and DSM2 models were developed by a multiagency team comprised of fisheries and modeling experts from the DWR, Department of Fish and Game (DFG), Reclamation, USFWS, and NMFS.

The detailed assumptions used in developing CALSIM II and DSM2 simulations of Existing Conditions and No Action Alternative are included in Section B.5, in Tables B-8 and B-9, respectively. Additional information is provided in the table footnotes of each table. Table entries and footnotes make reference to supporting appendix sections and other documents.

B.2.1. Existing Conditions

The Existing Conditions model simulation was developed assuming Year 2009 level of development and regulatory conditions. The Existing Conditions assumptions include existing facilities and ongoing programs that existed as of February 13, 2009 (publication date of the Notice of Preparation and Notice of Intent) that could affect or could be affected by implementation of the Alternatives. One exception to this was that, NMFS Salmon BO released in June 2009, was included in the development of the Existing Conditions simulation. The rational for this decision is included in the appendix, "EIR-EIS Appendix 3D – Defining Existing Conditions, No Action Alternative, No Project Alternative, and Cumulative Impact Conditions".

CALSIM II Assumptions for Existing Conditions

Hydrology

Inflows/Supplies

CALSIM II model includes the historical hydrology with modifications for the operations upstream of the rim reservoirs, for the Existing Conditions run. Reservoir inflows, stream gains, diversion requirements, irrigation efficiencies, return flows and groundwater operation are all components of the hydrology for CALSIM II.

Level of Development

CALSIM II uses a hydrology which is the result of an analysis of agricultural and urban land use and population estimates. The assumptions used for Sacramento Valley land use result from aggregation of historical survey and projected data developed for the California Water Plan Update (Bulletin 160-98). The San Joaquin Valley hydrology reflects land use assumptions developed by Reclamation to support the CALSIM II San Joaquin River Model development. Generally, land use projections are based on Year 2005 estimates (hydrology serial number 2005A01A). Where appropriate, Year 2009 projections of demands associated with water rights and SWP and CVP water service contracts have been included. Specifically 2009 projections are used to describe the American River region demands for water rights and CVP contract supplies and California Aqueduct and the Delta Mendota Canal SWP/CVP contractor demands.

Demands, Water Rights, CVP/SWP Contracts

CALSIM II demand inputs are preprocessed monthly time series for a specified level of development (e.g. 2009) and according to hydrologic conditions. Demands are classified as CVP project, SWP project, local project or non-project. CVP and SWP demands are separated into different classes based on the contract type. A description of various demands and classifications included in CALSIM II is provided in the 2008 OCAP Biological Assessment Appendix D (USBR, 2008a).

Table B-1 below includes the summary of the CVP and SWP project demands in thousand acre-feet (TAF) included under Existing Conditions. More detail regarding the American River demands assumed under the Existing Conditions simulation are provided in Section B.7. For SWP contractors, demands vary by year from 3.0 to 4.1 million acre-feet (MAF) depending on district level hydrologic and operational conditions assumed. The SWP variable demands for Kern County Water Agency (KCWA) and other agricultural contractors and Metropolitan Water District of Southern California (MWDSC) are described in more detail in Section B.8.

The full detailed listing of SWP and CVP contract amounts and other water rights assumptions for the Existing Conditions simulation are included in the delivery specification tables in Section B.9.

Table B-1: Summary of SWP and CVP Demands (TAF/Year) under Existing Conditions

Project **Contractor Type**	**North-of-the-Delta** **(TAF)**	**South-of-the-Delta** **(TAF)**
CVP Contractors		
Settlement/Exchange	2194	840
Water Service Contracts		
Agriculture	378	1937
M&I	304	164
Refuges	157	305

Project Contractor Type	North-of-the-Delta (TAF)	South-of-the-Delta (TAF)
SWP Contractors		
Feather River Service Area	796	0
Table A	108	4056
Agriculture	0	1048
M&I	108	3008

Facilities

CALSIM II includes representation of all the existing CVP and SWP storage and conveyance facilities. Assumptions regarding selected key facilities are included in the callout tables in the Section B.5.

CALSIM II also represents the flood control weirs such as the Fremont Weir located along the Sacramento River at the upstream end of the Yolo Bypass. Rating curves for the existing weir are used to model the spills over the Fremont Weir. The modeling approach used in CALSIM II model to estimate the Fremont Weir spills using the daily patterned Sacramento River flow at Verona, is provided in Section A.3.3.

A brief description of the key export facilities that are located in the Delta and included under the Existing Conditions run is provided below.

The Delta serves as a natural system of channels to transport river flows and reservoir storage to the CVP and SWP facilities in the south Delta, which export water to the projects' contractors through two pumping plants: SWP's Harvey O. Banks Pumping Plant and CVP's C.W. Jones Pumping Plant. Banks and Jones Pumping Plants supply water to agricultural and urban users throughout parts of the San Joaquin Valley, South Lahonton, Southern California, Central Coast, and South San Francisco Bay Area regions.

The Contra Costa Canal and the North Bay Aqueduct supply water to users in the northeastern San Francisco Bay and Napa Valley areas.

SWP Banks Pumping Plant Capacity

SWP Banks pumping plant has an installed capacity of about 10,668 cfs (two units of 375 cfs, five units of 1,130 cfs, and four units of 1,067 cfs). The SWP water rights for diversions specify a maximum of 10,350 cfs, but the U. S. Army Corps' of Engineers (ACOE) permit for SWP Banks Pumping Plant allows a maximum pumping of 6680 cfs. With additional diversions depending on Vernalis flows the total diversion can go up to 8,500 cfs during December 15th – March 15th. Additional capacity of 500 cfs (pumping limit up to 7,180 cfs) is allowed to reduce impact of NMFS BO Action 4.2.1 on SWP.

CVP C.W. Bill Jones Pumping Plant (Tracy PP) Capacity

The Jones Pumping Plant consists of six pumps including one rated at 800 cfs, two at 850 cfs, and three at 950 cfs. Maximum pumping capacity is about 4,600 cfs, however in the Existing Conditions pumping is limited to 4,200 cfs plus diversions upstream of the DMC constriction.

CCWD Intakes

The Contra Costa Canal originates at Rock Slough, about four miles southeast of Oakley, and terminates after 47.7 miles at Martinez Reservoir. Historically, diversions at the unscreened Rock Slough facility (Contra Costa Canal Pumping Plant No. 1) have ranged from about 50 to 250 cfs. The canal and associated facilities are part of the CVP, but are operated and maintained by the Contra Costa Water District (CCWD). CCWD also operates a diversion on Old River. CCWD can divert water to the Los Vaqueros Reservoir to store good quality water when available and supply to its customers.

Regulatory Standards

Major regulatory standards that govern the operations of the CVP and SWP facilities are briefly described below. Specific assumptions related to key regulatory standards are also outlined below.

D-1641 Operations

The SWRCB Water Quality Control Plan (WQCP) and other applicable water rights decisions, as well as other agreements are important factors in determining the operations of both the Central Valley Project (CVP) and the State Water Project (SWP).

The December 1994 Accord committed the CVP and SWP to a set of Delta habitat protective objectives that were incorporated into the 1995 WQCP and later, were implemented by D-1641. Significant elements in the D-1641 standards include X2 standards, export/inflow (E/I) ratios, Delta water quality standards, real-time Delta Cross Channel operation, and San Joaquin flow standards.

Coordinated Operations Agreement (COA)

The CVP and SWP use a common water supply in the Central Valley of California. The DWR and Reclamation have built water conservation and water delivery facilities in the Central Valley in order to deliver water supplies to project contractors. The water rights of the projects are conditioned by the SWRCB to protect the beneficial uses of water within each respective project and jointly for the protection of beneficial uses in the Sacramento Valley and the Sacramento-San Joaquin Delta Estuary. The agencies coordinate and operate the CVP and SWP to meet the joint water right requirements in the Delta.

The Coordinated Operations Agreement (COA), signed in 1986, defines the project facilities and their water supplies, sets forth procedures for coordination of operations, identifies formulas for sharing joint responsibilities for meeting Delta standards, as the standards existed in SWRCB Decision 1485 (D-1485), and other legal uses of water, identifies how unstored flow will be shared, sets up a framework for exchange of water and services between the Projects, and provides for periodic review of the agreement.

CVPIA (b)(2) Assumptions

The previous 2008 Operations Criteria and Plan (OCAP) Biological Assessment (BA) modeling included a dynamic representation of Central Valley Project Improvement Act (CVPIA) 3406(b)(2) water allocation, management and related actions (B2). The selection of discretionary actions for use of B2 water in each year was based on a May 2003 Department of the Interior policy decision. The use of B2 water is assumed to continue in conjunction with the USFWS and NMFS BO RPA actions. The CALSIM II implementation used for modeling for the BDCP EIR/EIS does not explicitly account for the use of (b)(2) water, but rather assumes pre-determined USFWS BO upstream fish objectives for Clear Creek and

Sacramento River below Keswick Dam in addition to USFWS and NMFS BO RPA actions for the American River, Stanislaus River, and Delta export restrictions.

Continued CALFED Agreements

The Environmental Water Account (EWA) was established in 2000 by the CALFED Record of Decision (ROD). The EWA was initially identified as a 4-year cooperative effort intended to operate from 2001 through 2004 but was extended through 2007 by agreement between the EWA agencies. It is uncertain, however, whether the EWA will be in place in the future and what actions and assets it may include. Because of this uncertainty, the EWA has not been included in the current CALSIM II implementation.

One element of the EWA available assets is the Lower Yuba River Accord (LYRA) Component 1 water. In the absence of the EWA and implementation in CALSIM II, the LYRA Component 1 water is assumed to be transferred to South of Delta (SOD) State Water Project (SWP) contractors to help mitigate the impact of the NMFS BO on SWP exports during April and May. An additional 500 cfs of capacity is permitted at Banks Pumping Plant from July through September to export this transferred water.

USFWS Delta Smelt BO Actions

The USFWS Delta Smelt BO was released on December 15, 2008, in response to Reclamation's request for formal consultation with the USFWS on the coordinated operations of the Central Valley Project (CVP) and State Water Project (SWP) in California. To develop CALSIM II modeling assumptions for the RPA documented in this BO, the Department led a series of meetings that involved members of fisheries and project agencies. This group has prepared the assumptions and CALSIM II implementations to represent the RPA in Existing Conditions CALSIM II simulation. The following actions of the USFWS BO RPA have been included in the Existing Conditions CALSIM II simulations:

- Action 1: Adult Delta smelt migration and entrainment (RPA Component 1, Action 1 – First Flush)
- Action 2: Adult Delta smelt migration and entrainment (RPA Component 1, Action 2)
- Action 3: Entrainment protection of larval and juvenile Delta smelt (RPA Component 2)
- Action 5: Temporary spring head of Old River barrier and the Temporary Barrier Project (RPA Component 2)

A detailed description of the assumptions that have been used to model each action is included in the technical memorandum "Representation of U.S. Fish and Wildlife Service Biological Opinion Reasonable and Prudent Alternative Actions for CALSIM II Planning Studies", prepared by an interagency working group under the direction of the lead agencies. This technical memorandum is included in the Section B.10.

Action 4 – Estuarine habitat during Fall (RPA Component 3) is not included in the Existing Conditions simulation based on the assumptions outlined for the CEQA baseline by the lead agencies.

NMFS BO Salmon Actions

The NMFS Salmon BO on long-term actions of the CVP and SWP was released on June 4, 2009. To develop CALSIM II modeling assumptions for the RPA documented in this BO, the Department led a series of meetings that involved members of fisheries and project agencies. This group has prepared the assumptions and CALSIM II implementations to represent the RPA in Existing Conditions CALSIM II simulations for future planning studies. The following NMFS BO RPA have been included in the Existing Conditions CALSIM II simulations:

- Action I.1.1: Clear Creek spring attraction flows
- Action I.4: Wilkins Slough operations
- Action II.1: Lower American River flow management
- Action III.1.4: Stanislaus River flows below Goodwin Dam
- Action IV.1.2: Delta Cross Channel gate operations
- Action IV.2.1: San Joaquin River flow requirements at Vernalis and Delta export restrictions
- Action IV.2.3: Old and Middle River flow management

For Action I.2.1, which calls for a percentage of years that meet certain specified end-of-September and end-of-April storage and temperature criteria resulting from the operation of Lake Shasta, no specific CALSIM II modeling code is implemented to simulate the performance measures identified.

A detailed description of the assumptions that have been used to model each action is included in the technical memorandum "Representation of National Marine Fisheries Service Biological Opinion Reasonable and Prudent Alternative Actions for CALSIM II Planning Studies", prepared by an interagency working group under the direction of the lead agencies. This technical memorandum is included in the Section B.11.

Water Transfers

Lower Yuba River Accord (LYRA)

Acquisitions of Component 1 water under the Lower Yuba River Accord, and use of 500 cfs dedicated capacity at Banks PP during July – September, are assumed to be used to reduce as much of the impact of the Apr – May Delta export actions on SWP contractors as possible.

Phase 8 transfers

Phase 8 transfers are not included in the Existing Conditions simulation.

Short-term or Temporary Water Transfers

Short term or temporary transfers such as Sacramento Valley acquisitions conveyed through Banks PP are not included in the Existing Conditions simulation.

Specific Regulatory Assumptions

Minimum flow near Rio Vista

The minimum flow required on the Sacramento River at Rio Vista under the WQCP, SWRCB D-1641 is included. During September through December months, the flow requirement ranges from 3,000 cfs to 4,500 cfs, depending on the month and D-1641 40-30-30 index water year type.

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:
All flow based Delta outflow requirements per SWRCB D-1641 are included in the Existing Conditions simulation. Similarly, for the February through June period X2 standard is included in the Existing Conditions simulation.

USFWS BO (December, 2008) Action 4:
This action is not included in the Existing Conditions simulation.

Combined Old and Middle River Flows

USFWS BO restricts south Delta pumping to preserve certain OMR flows in three of its Actions: Action 1 to protect pre-spawning adult Delta smelt from entrainment during the first flush, Action 2 to protect pre-spawning adults from entrainment and from adverse hydrodynamic conditions, and Action 3 to protect larval Delta smelt from entrainment. CALSIM II simulates these actions to a limited extent.

Brief description of USFWS BO Actions 1-3 implementations in CALSIM is as follows: Action 1 is onset based on a turbidity trigger that takes place during or after December. This action requires limit on exports so that the average daily OMR flow is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than 2,500 cfs (within 25 percent of the monthly criteria). Action 1 ends after 14 days of duration or when Action 3 is triggered based on a temperature criterion. Action 2 starts immediately after Action 1 and requires range of net daily OMR flows to be no more negative than -1,250 to -5,000 cfs (with a 5-day running average within 25 percent of the monthly criteria). The Action continues until Action 3 is triggered. Action 3 also requires net daily OMR flow to be no more negative than -1,250 to -5,000 cfs based on a 14 day running average (with a simultaneous 5-day running average within 25 percent). Although the range is similar to Action 2, the Action implementation is different. Action 3 continues until June 30 or when water temperature reaches a certain threshold. A more detailed description of the implementation of these actions is provided in Section B.10.

NMFS BO Action 4.2.3 requires OMR flow management to protect emigrating juvenile winter-run, yearling spring-run, and Central Valley steelhead within the lower Sacramento and San Joaquin rivers from entrainment into south Delta channels and at the export facilities in the south Delta. This action requires reducing exports from January 1 through June 15 to limit negative OMR flows to -2,500 to -5,000 cfs. CALSIM II assumes OMR flows required in NMFS BO are covered by OMR flow requirements developed for actions 1 through 3 of the USFWS BO as described in Section B.11.

South Delta Export-San Joaquin River Inflow Ratio

NMFS BO Action 4.2.1 requires exports to be capped at a certain fraction of San Joaquin River flow at Vernalis during April and May while maintaining a health and safety pumping of 1,500 cfs.

Exports at the South Delta Intakes

Exports at Jones and Banks Pumping Plant are restricted to their permitted capacities per SWRCB D-1641 requirements. In addition, the south Delta exports are subjected Vernalis flow based export limits during April and May as required Action 4.2.1. Additional 500 cfs pumping is allowed to reduce impact of NMFS BO Action 4.2.1 on SWP during July through September period.

Under D-1641 the combined export of the CVP Tracy Pumping Plant and SWP Banks Pumping Plant is limited to a percentage of Delta inflow. The percentages range from 35% to 45% during February depending on the January eight river index and 35%during March through June months. For rest of the months 65% of the Delta inflow is allowed to be exported.

Delta Water Quality

Existing Conditions simulation includes SWRCB D-1641 salinity requirements. However, not all salinity requirements are included as CALSIM II is not capable of predicting salinities in the Delta. Instead, empirically based equations and models are used to relate interior salinity conditions with the flow conditions. DWR's Artificial Neural Network (ANN) trained for salinity is used to predict and interpret salinity conditions at Emmaton, Jersey Point, Rock Slough and Collinsville stations. Emmaton and Jersey Point standards are for protecting water quality conditions for agricultural use in the western Delta and they are in effect from April 1st to August 15th. The EC requirement at Emmaton varies from 0.45 mmhos/cm to 2.78 mmhos/cm, depending on the water year type. The EC requirement at Jersey Point varies from 0.45 mmhos/cm to 2.20 mmhos/cm, depending on the water year type. Rock Slough standard is for protecting water quality conditions for M&I use for water through the Contra Costa Canal. It is a year round standard that requires a certain number of days in a year with chloride concentration less than 150 mg/L. The number of days requirement is dependent upon the water year type. Collinsville standard is applied during October through May months to protect the water quality conditions for the migrating fish species, and it varies between 12.5 mmhos/cm in May and 19.0 mmhos/cm in October.

Operations Criteria

Delta Cross Channel Gate Operations

SWRCB D-1641 DCC standards provide for closure of the DCC gates for fisheries protection at certain times of the year. From November through January, the DCC may be closed for up to 45 days for fishery protection purposes. From February 1 through May 20, the gates are closed for fishery protection purposes. The gates may also be closed for 14 days for fishery protection purposes during the May 21 through June 15 time period. Reclamation determines the timing and duration of the closures after discussion with USFWS, DFG, and NMFS.

NMFS BO Action 4.1.2 requires gates to be operated as described in the BO based on presence of salmonids and water quality from October 1 through December 14; and gates to be closed from December 15 to January 31, except short-term operations to maintain water quality. CALSIM II includes NMFS BO DCC gate operations in addition to the D-1641 gate operations. When the daily flows in the Sacramento River at Wilkins Slough exceeds 7,500 cfs (flow assumed to flush salmon into the Delta), DCC is closed for a certain number of days in a month as described in Section B-11. During October 1 – December 14 period, if the flow trigger condition is such that additional days of DCC gates closed is called for, however water quality conditions are a concern and the DCC gates remain open, then Delta exports are limited to 2,000 cfs for each day in question.

Allocation Decisions

CALSIM II includes allocation logic for determining deliveries to north-of-Delta and south-of-Delta CVP and SWP contractors. The delivery logic uses runoff forecast information, which incorporates uncertainty in the hydrology and standardized rule curves (i.e. Water Supply Index versus Demand Index Curve). The rule curves relate forecasted water supplies to deliverable "demand," and then use deliverable "demand" to assign subsequent delivery levels to estimate the water available for delivery and carryover storage. Updates of delivery levels occur monthly from January 1 through May 1 for the SWP and March 1 through May 1 for the CVP as runoff forecasts become more certain. The south-of-Delta SWP delivery is determined based on water supply parameters and operational constraints. The CVP system wide delivery and south-of-Delta delivery are determined similarly upon water supply parameters and operational constraints with specific consideration for export constraints.

San Luis Operations

CALSIM II sets targets for San Luis storage each month that are dependent on the current South-of-Delta allocation and upstream reservoir storage. When upstream reservoir storage is high, allocations and San Luis fill targets are increased. During a prolonged drought when upstream storage is low, allocations and fill targets are correspondingly low. For the Existing Conditions simulation, the San Luis rule curve is managed to minimize situations in which shortages may occur due to lack of storage or exports.

DSM2 Assumptions for Existing Conditions

River Flows

For the Existing Conditions DSM2 simulation, the river flows at the DSM2 boundaries are based on the monthly flow time series from CALSIM II.

Tidal Boundary

For the Existing Conditions DSM2 simulation, the tidal boundary condition at Martinez is provided by an adjusted astronomical tide normalized for sea level rise (Ateljevich and Yu, 2007).

Water Quality

Martinez EC

For the Existing Conditions DSM2 simulation, the Martinez EC boundary condition is estimated using the G-model based on the net Delta outflow simulated in CALSIM II and the pure astronomical tide (Ateljevich, 2001).

Vernalis EC

For the Existing Conditions DSM2 simulation, Vernalis EC boundary condition is based on the monthly San Joaquin EC time series estimated in CALSIM II.

Morphological Changes

No additional morphological changes were assumed as part of the Existing Conditions simulation. DSM2 model and grid developed as part of the 2009 recalibration effort (CH2M HILL, 2009) was used as part of the Existing Conditions modeling.

Facilities

Delta Cross Channel

Delta Cross Channel gate operations are modeled in DSM2. The number of days in a month the DCC gates are open is based on the monthly time series from CALSIM II.

South Delta Temporary Barriers

South Delta Temporary Barriers are included in the Existing Conditions simulation. The three agricultural temporary barriers located on Old River, Middle River and Grant Line Canal are included in the model. The fish barrier located at the Head of Old River is also included in the model.

Clifton Court Forebay Gates

Clifton Court Forebay Gates are operated based on the Priority 3 operation, where the gate operations are synchronized with the incoming tide to minimize the impacts to low water levels in nearby channels. Priority 3 operation is described in the 2008 OCAP Biological Assessment (BA) Appendix F section 5.2 (USBR, 2008b).

Operations Criteria

South Delta Temporary Barriers

South Delta Temporary Barriers are operated based on San Joaquin flow conditions. Head of Old River Barrier is assumed to be only installed from September 16th to November 30th and is not installed in the spring months, based on the USFWS Delta Smelt BO Action 5. The agricultural barriers on Old and Middle Rivers are assumed to be installed starting from May 16th and the one on Grant Line Canal from June 1st. All three agricultural barriers are allowed to operate until November 30th. The tidal gates on Old and Middle River agricultural barriers are assumed to be tied open from May 16th to May 31st.

Montezuma Salinity Control Gate

The radial gates in the Montezuma Slough Salinity Control Gate Structure are assumed to be tidally operating from October through February each year, to minimize propagation of high salinity conditions into the interior Delta.

B.2.2. No Action Alternative Late Long-Term

No Action Alternative Late Long-Term (aka No Action Alternative) was developed assuming projected Year 2060 conditions. Year 2060 was selected to support the full 50 year planning horizon assumed for the Alternatives evaluation. The No Action Alternative assumptions include existing facilities and ongoing programs that existed as of February 13, 2009 (publication date of the Notice of Preparation and Notice of Intent) that could affect or could be affected by implementation of the Alternatives, same as the Existing Conditions simulation. The No Action Alternative assumptions also includes facilities and programs that received approvals and permits by 2009 because those programs were consistent with existing management direction as of the Notice of Preparation. The No Action Alternative assumptions and the models do not include any restoration actions or additional conveyance over the Existing Conditions.

The No Action Alternative Late Long-Term includes projected climate change and sea level rise assumptions corresponding to the Year 2060. Change in climate result in the changes in the reservoir and tributary inflows included in CALSIM II. The sea level rise changes result in modified flow-salinity relationships in the Delta. The climate change and sea level rise assumptions at Late Long-Term are described in detail in Section B.4. CALSIM II simulation for the No Action Alternative Late Long-Term, does not consider any adaptation measures for future climate change, which may result in managing the SWP and CVP system in a different manner than today to reduce climate impacts. For example, future changes in reservoir flood control reservation to better accommodate a seasonally changing hydrograph may be considered under future programs, but are not considered under the BDCP. A more detailed discussion on the climate change modeling is included in the Section A and Sections D.2 and D.3.

CALSIM II Assumptions for No Action Alternative Late Long-Term

Hydrology

Inflows/Supplies

Similar to the Existing Conditions simulation, however with projected 2020 modifications and with modifications related to the changed climate at Late Long-Term for the operations upstream of the rim reservoirs.

Level of Development

Similar to the Existing Conditions, the assumptions used for Sacramento Valley land use result from aggregation of historical survey and projected data developed for the California Water Plan Update (Bulletin 160-98). Generally, land use projections are based on Year 2020 estimates (hydrology serial number 2020D09E), however the San Joaquin Valley hydrology reflects draft 2030 land use assumptions developed by Reclamation. Where appropriate Year 2020 projections of demands associated with water rights and SWP and CVP water service contracts have been included. Specifically projections of full build out are used to describe the American River region demands for water rights and CVP contract supplies and California Aqueduct and the Delta Mendota Canal SWP/CVP contractor demands are set to full contract amounts.

Demands, Water Rights, CVP/SWP Contracts

Table B-2 below includes the summary of the CVP and SWP project demands in thousand acre-feet (TAF) included under No Action Alternative Late Long-Term. The CVP M&I

demands, North-of-the-Delta, increased under No Action Alternative late Long-Term. The increase is mainly on the American River. More detail regarding the American River demands assumed under the No Action Alternative are provided in Section B.7. For SWP contractors, full Table A demands are assumed every year. There are small changes in the total non-project demands, as well. The demand assumptions are not modified for changes in climate conditions.

The full detailed listing of SWP and CVP contract amounts and other water rights assumptions for the No Action Alternative are included in the delivery specification tables in Section B.9.

Table B-2: Summary of SWP and CVP Demands (TAF/Year) under No Action Alternative

Project **Contractor Type**	**North-of-the-Delta** **(TAF)**	**South-of-the-Delta** **(TAF)**
CVP Contractors		
Settlement/Exchange	2194	840
Water Service Contracts		
Agriculture	378	1937
M&I	557	164
Refuges	189	281
SWP Contractors		
Feather River Service Area	796	0
Table A	114	4056
Agriculture	0	1032
M&I	114	3024
Urban demands noted above are for full build out conditions		

Facilities

Facilities assumptions under No Action Alternative are consistent with the Existing Conditions simulation unless noted explicitly, below.

Freeport Regional Water Project, located along the Sacramento River near Freeport, is assumed to be operational under the No Action Alternative. Similarly, 30 mgd capacity, City of Stockton Delta Water Supply Project is assumed to be operational under the No Action Alternative.

SWP Banks Pumping Plant Capacity

Consistent with Existing Conditions simulation

CVP Jones Pumping Plant Capacity

Consistent with Existing Conditions simulation, except, in the No Action Alternative, DMC-California Aqueduct Intertie that allows 400 cfs additional DMC capacity is assumed to be in place; therefore pumping capacity is 4,600 cfs in all months.

CCWD Intakes

In addition to the Rock Slough and Old River diversions for CCWD that are included in the Existing Conditions, Alternative Intake Project (AIP) is included in the No Action Alternative. The Alternative Intake Project is a new drinking water intake at Victoria Canal, about 2.5 miles east of Contra Costa Water District's (CCWD) existing intake on the Old River.

Regulatory Standards

The regulatory standards that govern the operations of the CVP and SWP facilities under the No Action Alternative Late Long-Term are consistent with the Existing Conditions simulation. Briefly, the assumptions noted in the Existing Conditions simulation for D-1641 Operations, COA, CVPIA (b)(2), USFWS Delta Smelt BO Actions, NMFS BO Salmon Actions and Water Transfers are continued in the No Action Alternative simulation. Even though, the assumptions for the key regulatory standards remain consistent between the No Action Alternative and the Existing Conditions simulations, and the standards are included in both cases, the resulting flows may be different. Additional assumptions related to the regulatory standards that are unique to the No Action Alternative are listed below.

USFWS Delta Smelt BO Actions

In addition to the RPA actions included in the Existing Conditions simulation, the following action is included in the No Action Alternative.

- Action 4: Estuarine habitat during Fall (RPA Component 3)

A detailed description of the assumptions that have been used to model each action is included in the technical memorandum "Representation of U.S. Fish and Wildlife Service Biological Opinion Reasonable and Prudent Alternative Actions for CALSIM II Planning Studies", prepared by an interagency working group under the direction of the lead agencies. This technical memorandum is included in the Section B.10.

Specific Regulatory Assumptions

Minimum flow near Rio Vista

The Rio Vista minimum flow assumptions are consistent with the Existing Conditions Simulation. However, the resulting flows can be different as a result of the differences in the other assumptions.

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:

All flow based Delta outflow requirements per SWRCB D-1641 are included in the No Action Alternative simulation. Similarly, for the February through June period X2 standard is included in the No Action Alternative simulation.

USFWS BO (December, 2008) Action 4:

USFWS BO Action 4 requires additional Delta outflow to manage X2 in the fall months following the wet and above normal years to maintain average X2 for September and October no greater (more eastward) than 74 kilometers in the fall following wet years and 81 kilometers in the fall following above normal years. In November, the inflow to CVP/SWP reservoirs in the Sacramento Basin should be added to reservoir releases to provide an added increment of Delta inflow and to augment Delta outflow up to the fall X2 target. This action is included in the No Action Alternative.

The sea level rise change assumed at the Late Long-Term, results in a modified flow – salinity relationship in the Delta. A new ANN, which is capable of emulating DSM2 results at Late Long-Term is used to simulate the flow-salinity relationship in CALSIM II simulation for the No Action Alternative Late Long-Term, as described in the Section A.3.3.

Combined Old and Middle River Flows

The OMR flow requirements are consistent with the Existing Conditions Simulation. However, the resulting flows can be different as a result of the differences in the other assumptions.

South Delta Export-San Joaquin River Inflow Ratio

This assumption is consistent with the Existing Conditions Simulation. However, the resulting flows can be different as a result of the differences in the other assumptions.

Exports at the South Delta Intakes

This assumption is consistent with the Existing Conditions Simulation. However, the resulting flows can be different as a result of the differences in the other assumptions.

Delta Water Quality

This assumption is consistent with the Existing Conditions Simulation. However, the resulting flows can be different as a result of the differences in the other assumptions.

The sea level rise change assumed at the Late Long-Term, results in a modified flow – salinity relationship in the Delta. A new ANN, which is capable of emulating DSM2 results at Late Long-Term is used to simulate the flow-salinity relationship in CALSIM II simulation for the No Action Alternative Late Long-Term, as described in the Section A.3.3.

Operations Criteria

Delta Cross Channel Gate Operations

This assumption is consistent with the Existing Conditions Simulation. However, the resulting flows can be different as a result of the differences in the other assumptions.

Allocation Decisions

The rules and assumptions used for allocation decisions under No Action Alternative simulation are consistent with Existing Conditions simulation.

San Luis Operations

The rules and assumptions used for San Luis operations under No Action Alternative simulation are consistent with Existing Conditions simulation.

DSM2 Assumptions for No Action Alternative Late Long-Term

DSM2 modeling assumptions for the No Action Alternative Simulation are consistent with the Existing Conditions Simulation. For the DSM2 assumptions that depend upon the CALSIM II outputs, the DSM2 inputs are obtained from the appropriate CALSIM II simulation.

River Flows

For the No Action Alternative DSM2 simulation, the river flows at the DSM2 boundaries are based on the monthly flow time series from CALSIM II.

Tidal Boundary

For No Action Alternative Late Long-Term, the tidal boundary condition at Martinez is based on an adjusted astronomical tide normalized for sea level rise (Ateljevich and Yu, 2007) and is modified to account for the sea level rise using the correlations derived based on three-dimensional UnTRIM modeling of the Bay-Delta with sea level rise at Late Long-Term.

Water Quality

Martinez EC

For No Action Alternative Late Long-Term, the Martinez EC boundary condition in a DSM2 planning simulation estimated using the G-model based on the net Delta outflow simulated in CALSIM II and the pure astronomical tide (Ateljevich, 2001), is modified to account for the salinity changes related to the sea level rise using the correlations derived based on the three-dimensional UnTRIM modeling of the Bay-Delta with sea level rise at Late Long-Term.

Vernalis EC

For the No Action Alternative DSM2 simulation, Vernalis EC boundary condition is based on the monthly San Joaquin EC time series estimated in CALSIM II.

Morphological Changes

Consistent with the Existing Conditions Simulation

Facilities

Delta Cross Channel

The number of days in a month the DCC gates are open is based on the monthly time series from CALSIM II.

South Delta Temporary Barriers

Consistent with the Existing Conditions Simulation

Clifton Court Forebay Gates

Consistent with the Existing Conditions Simulation

Operations Criteria

South Delta Temporary Barriers

Consistent with the Existing Conditions Simulation

Montezuma Salinity Control Gate

Consistent with the Existing Conditions Simulation

B.3. Assumptions for Alternatives Model Simulations

This section describes the CALSIM II and DSM2 modeling assumptions for the Alternatives 1A, 1B, 1C, 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9. The assumptions that are different from the No Action Alternative are described below. Even though some Alternative assumptions remain consistent with the No Action Alternative, they are described for completeness.

Several key assumptions are common to all of the alternatives. For example all the alternatives, except for the Existing Conditions and the No Action Alternative, include the conservation measures related to the modifications to the Fremont Weir and the large scale tidal marsh restoration in the Delta. Except for the Alternative 9, all the other alternatives include the proposed construction and operation of the new north Delta intakes and associated conveyance, although the assumed location of the intakes, the number of the intakes and the type of conveyance may vary.

The Alternative 1A, 1B and 1C assumptions reflect the long-term BDCP water operations and analytical range agreed to by the BDCP Steering Committee on January 29, 2010 and handed out at February 11, 2010 BDCP Steering Committee Meeting. Assumptions for Alternatives 2A, 2B, 2C, 3, 4, 5, 6A, 6B, 6C, 7, 8 and 9 are provided by the lead agencies.

The long-term water operations assumptions for all the Alternatives are tabulated in the Section B.6. The assumptions for the Alternatives as provided by the lead agencies are listed in Tables B-10 to B-17. Table B-18 summarizes the key CALSIM II and DSM2 modeling assumptions for the Alternatives along with the Existing Conditions and No Action Alternative.

B.3.1. Alternative 1A, 1B, and 1C – Dual Conveyance with Intakes 1, 2, 3, 4, and 5

Alternative 1A, 1B, and 1C assumptions are summarized in the Section B.6, in Table B-10. Alternative 1 is a dual conveyance alternative and includes the five proposed intakes in the north Delta with a total of 15,000 cfs capacity (3,000 cfs at each intake). The tidal marsh restoration acreages and footprints assumed in the Alternative 1 are described in Section B.4. Alternative 1 includes the operational criteria specified under Scenario A in the Chapter 3 of BDCP EIR/EIS.

Alternative 1A, 1B and 1C all share the same long term operations assumptions, described below. However, 1A, 1B and 1C, each have a different conveyance configuration. 1A assumes a pipeline/tunnel conveyance option. 1B assumes an option that includes open channel and siphons and located east of the Sacramento River. 1C assumes an option that includes, open channel and tunnel located west of the Sacramento River. A detailed description of the different conveyance configurations is included in the Chapter 3 of BDCP EIR/EIS. For modeling, the differences in conveyance configuration are assumed to not change the long-term operations.

CALSIM II and DSM2 modeling is the same for the Alternative 1A, 1B and 1C. The changes in the type of conveyance and the alignment are assumed to cause no changes in the overall modeling results.

Alternative 1 CALSIM II and DSM2 assumptions that are different from the No Action Alternative are described below.

CALSIM II Assumptions for Alternative 1:

Facilities

Fremont Weir

Fremont Weir is a flood control structure located along the Sacramento River at the head of the Yolo Bypass. To enhance the potential benefits of the Yolo Bypass for various fish species, the Fremont Weir is assumed to be notched in the Alternative 1 to provide increased seasonal floodplain inundation. It is assumed that an opening in the existing weir and operable gates are constructed at elevation 17.5 feet along with a smaller opening and operable gates at elevation 11.5 feet. Derivation of the rating curve for the elevation 17.5 feet opening used in the CALSIM II model is described in Section D.4 of this appendix. The modeling approach used in CALSIM II model to estimate the Fremont Weir spills using the daily patterned Sacramento River flow at Verona, is provided in Section A.3.3

Isolated Conveyance Facility and the North Delta Diversion Intakes

An Isolated Conveyance Facility is included in the Alternative 1 which diverts water from the Sacramento River in the north Delta near Hood and conveys to the existing export facilities in the south Delta. The maximum conveyance capacity is assumed to be 15,000 cfs. Five separate intakes (intakes 1, 2, 3, 4 and 5) each capable of diverting 3,000 cfs are proposed along the Sacramento River near Hood, all located upstream of the Sutter Slough.

Banks Pumping Plant Capacity

Physical capacity of the Banks Pumping Plant is 10,300 cfs. Under Alternative 1, it was assumed that the diversions may occur up to the full physical capacity of the Banks Pumping Plant from the south Delta, subject to other regulatory and operational constraints.

Jones Pumping Plant Capacity

The diversion capacity of the Jones Pumping Plant is up to 4,600 cfs. Under Alternative 1, this assumption remained consistent with the No Action Alternative.

Regulatory Standards

North Delta Diversion Bypass Flows

Bypass flows in the Sacramento River are specified downstream of the north Delta diversion intakes, which govern the flow required to remain in the river before any diversion can occur. Bypass rules are designed with the intent to avoid increased upstream tidal transport from downstream channels, to support salmonid and pelagic species transport to regions of suitable habitat, to preserve shape of the natural hydrograph which may act as cue to important biological functions, to lower potential for increased tidal reversals that may occur because of the reduced net flow in the River and to provide flows to minimize predation effects downstream. The rules include constant low level pumping each intake during December to June period, initial pulse protection in November to January period and post-pulse operations that transition through three levels of protection (Level I to Level II and subsequently to Level III).

Between December and June, constant low level pumping allows diversions of up to 6% of the river flow for flows greater than 5,000 cfs upstream of the north Delta diversion. The low level pumping is less than 300 cfs at any one intake, with a combined limit of 1,500 cfs for the five intakes in Alternative 1. The low level pumping is constrained such that the river flow never falls below 5,000 cfs.

During an initial pulse protection period low level pumping is maintained until the pulse period is ended. For modeling purposes, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over[1] a five day period and (2) Wilkins Slough flow greater than 12,000 cfs. Low level pumping continues until (1) Wilkins Slough returns to pre-pulse flows (flow on first day of 5-day increase), (2) Wilkins Slough flows decrease for five consecutive days, or (3) Bypass flows are greater than 20,000 cfs for 10 consecutive days. If the initial pulse begins before December 1st, a second pulse period will be assumed and afforded the same protective operation.

After the pulse period has ended, the bypass flows noted in the Table B-3 are maintained. After the initial pulse(s), Level I post-pulse bypass rule is applied until 15 days of bypass flows above 20,000 cfs. Then Level II post-pulse bypass rule is applied until 30 days of bypass flows above 20,000 cfs. Then Level III post-pulse bypass rule is applied. The bypass rules were applied on the mean daily river flows in the CALSIM II model.

A detailed description of the modeling of the north Delta diversion operations for Alternative 1 in the CALSIM II model is provided in the Section A.3.3 of this appendix, along with the approach used to estimate the potential north Delta diversion based on the daily patterned Sacramento River flow at Freeport.

Minimum flow near Rio Vista

For September through December months the minimum flow required on the Sacramento River at Rio Vista under the Water Quality Control Plan, SWRCB D-1641 is maintained. In addition, for January through August a minimum flow of 3,000 cfs is maintained in all years, under Alternative 1.

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:

All flow based Delta outflow requirements included in SWRCB D-1641 are consistent with the No Action Alternative. Similarly, for the February through June period X2 standard is included and is consistent with the No Action Alternative.

USFWS BO (December, 2008) Action 4:

USFWS BO Action 4 requires additional Delta outflow to manage X2 in the fall months following the wet and above normal years under the No Action Alternative. This action is not included in the Alternative 1.

Combined Old and Middle River Flows

The combined Old and Middle River (OMR) flow criteria are based on concepts addressed in the 2008 USFWS and 2009 NMFS BOs related to adaptive restrictions for temperature, turbidity, salinity, and presence of Delta smelt. The OMR flow criteria in the Alternative 1 are consistent with the No Action Alternative.

South Delta Export-San Joaquin River Inflow Ratio

NMFS BO (June 2009) Action 4.2.1 requires the south Delta exports are governed by this ratio in the months of April and May under the No Action Alternative. This action is not included in the Alternative 1.

[1] The modeling assumptions state "45% increase over a 5-day period" as one of the pulse triggers. However, the intent of the rule is that a 45% increase occurring over any period of time shorter than 5 days can trigger the pulse.

Exports at the South Delta Intakes

The south Delta exports in Alternative 1 are operated per SWRCB D-1641. The combined export of the CVP Tracy Pumping Plant and SWP Banks Pumping Plant is limited to a percentage of the total Delta inflow, based on the export-inflow ratio specified under D1641. In the Alternative 1, however, this requirement is applied to the south Delta exports only. The north Delta diversion is not included in the Delta inflow or the Delta exports computation used to determine this requirement.

Delta Water Quality

Alternative 1 includes SWRCB D-1641 salinity requirements consistent with the No Action Alternative. However, the salinity compliance location on the Sacramento River at Emmaton is assumed to be moved upstream to Threemile Slough under the Alternative 1.

Operations Criteria

Fremont Weir Operations

To provide seasonal floodplain inundation in the Yolo Bypass, the 17.5 feet and the 11.5 feet elevation gates are opened between December 1st and March 31st. This may extend to May 15th, depending on the hydrologic conditions and the measures to minimize land use and ecological conflicts in the bypass. As a simplification for modeling, the gates are assumed opened until April 30th in all years. The gates are operated to limit maximum spill to 6,000 cfs until the Sacramento River stage reaches the existing Fremont Weir crest elevation. When the river stage is at or above the existing Fremont Weir crest elevation, the notch gates are assumed to be closed. While desired inundation period is on the order of 30 to 45 days, gates are not managed to limit to this range, instead the duration of the event is governed by the Sacramento River flow conditions. To provide greater opportunity for the fish in the bypass to migrate upstream into the Sacramento River, the 11.5 feet elevation gate is assumed to be open for an extended period between September 15th and June 30th. As a simplification for modeling, the period of operation for this gate is assumed to be September 1st to June 30th. The spills through the 11.5 ft elevation gate are limited to 100 cfs. The Alternative 1 assumptions from the BDCP Steering Committee include a requirement of 25,000 cfs at Freeport, before opening the Fremont Weir notch. However, this criterion is not included in the model explicitly, as the Freeport flows are typically high during the December through April months, and to maintain synchrony between the spills and the natural changes in hydrology.

Delta Cross Channel Gate Operations

The modeling of the Delta Cross Channel Gate operations under the Alternative 1 is consistent with the No Action Alternative.

Operations for Delta Water Quality and Residence Time

Alternative 1 assumptions state that the south Delta pumping is preferred up to 3,000 cfs before diverting from the north Delta during July through September period, to provide limited flushing flows required for improving the circulation and general water quality in the south Delta channels. This assumption is not included explicitly in the model.

Allocation Decisions

The rules and assumptions used for determining the allocations in the Alternative 1 CALSIM II simulation are similar to the No Action Alternative simulation. Alternative 1 CALSIM II includes allocation logic based on the standardized rule curves (i.e. Water Supply Index versus Demand Index Curve). However, new rule curves are developed for the Alternative 1 simulation.

San Luis Operations

Under Alternative 1, CALSIM II San Luis rule curve is modified in expectation that new conveyance can capture winter and spring excess flows and fill earlier in the year.

DSM2 Assumptions for Alternative 1:

Tidal Boundary

For the No Action Alternative, the tidal boundary condition at Martinez is provided by an adjusted astronomical tide normalized for sea level rise (Ateljevich and Yu, 2007). For Alternative 1, the adjusted astronomical tide specified in the No Action Alternative is modified to account for the habitat restoration and sea level rise using the correlations derived based on two-dimensional RMA modeling of the Delta with restoration and sea level rise, as described in Section A.5.3.

Water Quality

Martinez EC

For the No Action Alternative, the Martinez EC boundary condition in a DSM2 planning simulation is estimated using the G-model based on the net Delta outflow simulated in CALSIM II and the pure astronomical tide (Ateljevich, 2001). For Alternative 1, EC time series resulting from the G-model is modified to account for the salinity changes related to the habitat restoration and sea level rise using the correlations derived based on the two-dimensional RMA modeling of the Delta with restoration and sea level rise, as described in Section A.5.3.

Morphological Changes

DSM2 grid and other inputs such as the channel roughness coefficients and the dispersion coefficients are modified to reflect the changes related to the tidal marsh restoration and the sea level rise assumptions associated with the Alternative 1. The description of the changes to the DSM2 grid is provided under Section A.

Facilities

South Delta Temporary Barriers

South Delta Temporary Barriers are not included in the Alternative 1.

Isolated Facility and North Delta Diversion Intakes

The locations of the north Delta diversion intakes for Alternative 1 are shown in the Figure B-1. Intakes 1, 2, 3, 4 and 5 are modeled in DSM2 for Alternative 1, with 3,000 cfs diversion capacity at each intake. Diversions at the five proposed intakes are simulated in DSM2. A detailed description of the modeling of the north Delta diversion intakes in DSM2 for Alternative 1 is included in Section A.5.3.

Operations Criteria

South Delta Temporary Barriers

South Delta Temporary Barriers are not included in the Alternative 1.

Montezuma Salinity Control Gate

The radial gates in the Montezuma Slough Salinity Control Gate Structure are assumed to be open year-round in the Alternative 1.

North Delta Diversion Intakes

The diversion operation at the north Delta intakes are dynamically simulated in DSM2 such that the amount specified by CALSIM II each day is diverted while subjecting each intake to the sweeping velocity and the ramping criteria. A maximum of 3,000 cfs is withdrawn at each intake while meeting a velocity requirement of 0.4 fps downstream of each intake. The intakes are operated as long as the daily diversion volume specified by CALSIM II is not diverted. Once the specified volume is diverted for the day, the pumps are shut off until next day. The volume corresponding to first 500 cfs of the daily north Delta diversion specified by CALSIM II is diverted equally at all the five intakes. The remaining volume for the day will be diverted such that operation of the upstream intake is prioritized over the downstream one. Intake diversions are ramped over an hour to allow smooth transitions when they are turned on and off.

A detailed description of the modeling of the north Delta diversion operations for Alternative 1 is included in Section A.5.3.

Figure B-1: North Delta Diversion Intake Locations Assumed for BDCP EIR/S Alternatives 1, 2, 3, 4, 5, 6 and 7 for Modeling in DSM2 (NOTE: Intake locations are slightly modified in Chapter 3: Description of Alternatives) *(Figure B-1 was prepared using ESRI's ArcGIS Explorer Desktop Free Software)*

Table B-3: Post-Pulse Bypass Flow Rules for the North Delta Diversion

Level I

Dec - Apr

If Sacramento River flow is over	But no over	The bypass is
0 cfs	15,000 cfs	100% of the amount over 0 cfs
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs

May

If Sacramento River flow is over	But no over	The bypass is
0 cfs	15,000 cfs	100% of the amount over 0 cfs
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs

Level II

Dec - Apr

If Sacramento River flow is over	But no over	The bypass is
0 cfs	11,000 cfs	100% of the amount over 0 cfs
11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs
15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs
20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs

May

If Sacramento River flow is over	But no over	The bypass is
0 cfs	11,000 cfs	100% of the amount over 0 cfs
11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs
15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs
20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs

Level III

Dec - Apr

If Sacramento River flow is over	But no over	The bypass is
0 cfs	9,000 cfs	100% of the amount over 0 cfs
9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs

May

If Sacramento River flow is over	But no over	The bypass is
0 cfs	9,000 cfs	100% of the amount over 0 cfs
9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs

Table B-3: Post-Pulse Bypass Flow Rules for the North Delta Diversion

Level I

Jun

If Sacramento River flow is over	But no over	The bypass is
0 cfs	15,000 cfs	100% of the amount over 0 cfs
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs

Jul - Sep: 5,000 cfs

Oct - Nov: 7,000 cfs

Level II

Jun

If Sacramento River flow is over	But no over	The bypass is
0 cfs	11,000 cfs	100% of the amount over 0 cfs
11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs
15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs

Jul - Sep: 5,000 cfs

Oct - Nov: 7,000 cfs

Level III

Jun

If Sacramento River flow is over	But no over	The bypass is
0 cfs	9,000 cfs	100% of the amount over 0 cfs
9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs

Jul - Sep: 5,000 cfs

Oct - Nov: 7,000 cfs

B.3.2. Alternative 2A, 2B, and 2C –Dual Conveyance with Intakes 1, 2, 3, 6 and 7

Alternative 2A, 2B, and 2C assumptions are provided by the lead agencies and are summarized in the Section B.6, in Table B-12. Alternative 2 is similar to Alternative 1 in many aspects. However, there are a few key differences in the assumptions. Alternative 2 is a dual conveyance alternative with five proposed intakes in the north Delta with 15,000 cfs total pumping capacity (3,000 cfs at each intake). Alternative 2 includes the operational criteria specified under Scenario B in the Chapter 3 of BDCP EIR/EIS. The tidal marsh restoration acreages and footprints assumed in Alternative 2 are consistent with Alternatives 1.

Alternative 2A, 2B and 2C all share the same long term operations assumptions, described below. However, 2A, 2B and 2C, each have a different conveyance configuration. 2A assumes a pipeline/tunnel conveyance option. 2B assumes an option that includes open channel and siphons and located east of the Sacramento River. 2C assumes an option that includes, open channel and tunnel located west of the Sacramento River. A detailed description of the different conveyance configurations is included in the Chapter 3 of BDCP EIR/EIS. For modeling, the differences in conveyance configuration are assumed to not change the long-term operations.

CALSIM II and DSM2 modeling is the same for the Alternative 2A, 2B and 2C. The changes in the type of conveyance and the alignment are assumed to cause no changes in the overall modeling results.

Alternative 2 CALSIM II and DSM2 assumptions that are different from the No Action Alternative are described below.

CALSIM II Assumptions for Alternative 2:

Facilities

Fremont Weir

Consistent with Alternative 1

Isolated Conveyance Facility and the North Delta Diversion Intakes

An Isolated Conveyance Facility is included in the Alternative 2 which diverts water from the Sacramento River in the north Delta near Hood and conveys to the existing export facilities in the south Delta. The maximum conveyance capacity is assumed to be 15,000 cfs. Five separate intakes (intakes 1, 2, 3, 6 and 7) each capable of diverting 3,000 cfs are assumed along the Sacramento River near Hood. Intakes 1, 2 and 3 are located upstream of the Sutter Slough and intakes 6 and 7 are located downstream of the Steamboat Slough as shown in the Figure B-1. In CALSIM II, north Delta diversion is modeled as a single diversion located along the Sacramento River at Hood. Modification of the intake locations as shown in Chapter 3: Description of Alternatives would not result in changes in CALSIM II results.

Banks Pumping Plant Capacity

Consistent with Alternative 1

Jones Pumping Plant Capacity

Consistent with Alternative 1

Regulatory Standards

North Delta Diversion Bypass Flows

North Delta bypass flows are consistent with Alternative 1.

Minimum flow near Rio Vista

Consistent with Alternative 1

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:

All flow based Delta outflow requirements included in SWRCB D-1641 are consistent with the No Action Alternative. Similarly, for the February through June period X2 standard is included consistent with the No Action Alternative.

USFWS BO (December, 2008) Action 4:

USFWS BO Action 4 requires additional Delta outflow to manage X2 in the fall months following the wet and above normal years. This action is included in the Alternative 2. The assumptions for this action under the Alternative 2 are consistent with the No Action Alternative.

Combined Old and Middle River Flows

Alternative 2 requires the OMR flows to be more positive of the No Action Alternative OMR criteria and the criteria specified below in Table B-4. In April, May and June months the required OMR values are dependent upon the San Joaquin River inflow as noted in the Table B-5. In October and November, the required OMR is dependent on the SWRCB D1641 pulse flow on the San Joaquin River. Prior to the D1641 pulse flow, there are no OMR restrictions. During the pulse flows, the south Delta exports are not allowed. During the two week post-pulse period, OMR is restricted to -5,000 cfs. For modeling purposes, the pulse is assumed to occur during the last two weeks of October (16^{th} – 31^{st}). The first two weeks of October (1^{st} – 15^{th}) are assumed to be pre-pulse period. The first two weeks in November (1^{st} – 15^{th}) are assumed to be post-pulse period. -5,000 cfs was used as the background OMR requirement for the two weeks pre-pulse period, to compute monthly OMR requirement for October. In December, a background OMR requirement of -8,000 cfs is assumed to compute the monthly OMR requirement, except when the north Delta initial pulse, measured at Wilkins Slough, is triggered, OMR flow requirement of -5,000 cfs is assumed. The -5,000 cfs OMR requirement is continued until when Delta smelt triggers (2008 USFWS RPA Action 1) occur. For the remaining days in December, after the Delta Smelt Action 1 is triggered, OMR requirement of -2,000 cfs is assumed.

Table B-6 shows the Head of Old River Barrier (HORB) open percentages for each month. The percent values noted in the Table B-6, indicate the appropriate opening for the new operable gates, to allow the specified fraction of "the flow that would have entered the Old River if the barrier were fully open".

In computing the OMR flow in the CALSIM II model, the percent opening noted in Table B-6 is assumed as the percent of time in a month the HORB is open. For October, since HORB is required to be open 50% for 2 weeks (pre-pulse) and closed for 2 weeks (pulse), the net percent open for the whole month was assumed to be 25%. Similarly, for November, since HORB is required to be open 50% for 2 weeks (post-pulse) and 100% open for 2 weeks, the net percent open for the whole month was assumed to be 75%. Similarly, the net percent open for the whole month of June was assumed to be 75% based on the values noted in the Table B-6. Further, it was assumed that the salmon fry start immigrating on January 1st, for simplification, and therefore, the net percent open for the whole month of January is assumed to be 50%.

South Delta Export-San Joaquin River Inflow Ratio

Consistent with Alternative 1

Exports at the South Delta Intakes

Consistent with Alternative 1

Delta Water Quality

Consistent with Alternative 1

Operations Criteria

Fremont Weir Operations

Consistent with Alternative 1

Delta Cross Channel Gate Operations

Consistent with Alternative 1

Operations for Delta Water Quality and Residence Time

Consistent with Alternative 1

Allocation Decisions

Rules and assumptions are consistent with Alternative 1, however, new water supply index versus demand index curves are developed for Alternative 2.

San Luis Operations

Rules and assumptions are consistent with Alternative 1.

DSM2 Assumptions for Alternative 2:

Tidal Boundary

Consistent with Alternative 1

Water Quality

Martinez EC

Consistent with Alternative 1

Morphological Changes

Consistent with Alternative 1

Facilities

South Delta Temporary Barriers

The temporary agricultural barriers and the HORB are included under Alternative 2 consistent with the No Action Alternative.

Isolated Facility and North Delta Diversion Intakes

The locations of the north Delta diversion intakes for Alternative 2 are shown in the Figure B-1. Intakes 1, 2, 3, 6 and 7 are modeled in DSM2 for Alternative 2, with 3,000 cfs diversion capacity at each intake. The modeling of the north Delta diversion intakes in DSM2 for Alternative 2 is consistent with Alternative 1. Modification of intake locations as shown in “Chapter 3:

Description of Alternatives" would result in changes in DSM2 results for Sacramento River flows between a location downstream of Intake 3 and Rio Vista. No substantial changes would occur in DSM2 results downstream of Rio Vista.

Operations Criteria

South Delta Temporary Barriers

The operations of the agricultural barriers are consistent with the No Action Alternative. The HORB operations are modified under Alternative 2 such that appropriate gate opening is simulated to allow the fraction of "the flow that would have entered the Old River if the barrier were fully open", as noted in Table B-6. For October, the HORB is closed for the last two weeks, during the pulse flows.

Montezuma Salinity Control Gate

Consistent with Alternative 1

North Delta Diversion Intakes

The assumptions for Alternative 2 are consistent with Alternative 1 except that the two of the five intakes are located downstream of Steamboat Slough. The volume corresponding to first 500 cfs of the daily north Delta diversion specified by CALSIM II is diverted equally at all the five intakes.

Table B-4. Old and Middle River Flow Criteria

	Combined Old and Middle River Flows to be No Less than Values Below[a] (cfs)				
Month	Wet Water Year	Above Normal Water Year	Below Normal Water Year	Dry Water Year	Critical Dry Water Year
January	0	-3,500	-4,000	-5,000	-5,000
February	0	-3,500	-4,000	-4,000	-4,000
March	0	0	-3,500	-3,500	-3,000
April	see Table B-5	see Table B-5	see Table B-5	see Table B-5	see Table B-5
May	see Table B-5	see Table B-5	see Table B-5	see Table B-5	see Table B-5
June	see Table B-5	see Table B-5	see Table B-5	see Table B-5	see Table B-5
July	N/A	N/A	N/A	N/A	N/A
August	N/A	N/A	N/A	N/A	N/A
September	N/A	N/A	N/A	N/A	N/A
October[b]	Based on State Water Board D-1641 pulse trigger.	Based on State Water Board D-1641 pulse trigger.	Based on State Water Board D-1641 pulse trigger.	Based on State Water Board D-1641 pulse trigger.	Based on State Water Board D-1641 pulse trigger.
November[b]	Based on State Water Board D-1641 pulse trigger.	Based on State Water Board D-1641 pulse trigger.	Based on State Water Board D-1641 pulse trigger.	Based on State Water Board D-1641 pulse trigger.	Based on State Water Board D-1641 pulse trigger.
December[c]	-5,000	-5,000	-5,000	-5,000	-5,000

[a] Values are monthly average for use in modeling. Values are reflective of the "most likely" water operation under the 2008 USFWS Biological Opinion. It is assumed under this Alternative that the OMR values would be compared to the OMR values included in the No Action Alternative to select the more positive OMR value for operations.

[b] OMR is triggered based upon State Water Board D-1641 pulse trigger.

Before State Water Board D-1641 pulse trigger: Head of Old River Barrier open and no OMR restrictions.

During State Water Board D-1641 pulse trigger: Head of Old River Barrier closed and no south Delta exports.

Following State Water Board D-1641 pulse trigger: Head of Old River Barrier open 50% for two weeks, and OMR operated up to -5,000 cfs through November.

[c] OMR restrictions of -5,000 cfs for Sacramento River winter-run Chinook salmon when North Delta initial pulse is triggered, or OMR restrictions of -2,000 cfs when delta smelt triggers occur.

Table B-5. San Joaquin Inflow Relationship to Old and Middle River Flow Criteria

April and May		June	
If San Joaquin River flow at Vernalis is (cfs):	Minimum Average OMR flows (interpolated linearly between values) (cfs)	If San Joaquin flow at Vernalis is the following (cfs):	Average OMR flows would be at least the following (cfs):
≤ 5,000	-2,000	≤ 3,500	-3,500
6,000	+1000	3,501 to 10,000	0
10,000	+2000		
15,000	+3000	10,001 to 15,000	+1000
≥30,000	+6000	>15,000	+2000

Table B-6. Head of Old River Operable Barrier Operations Criteria if San Joaquin River Flows at Vernalis are Equal To or Less Than 10,000 cfs

Month	Head of Old River Barrier Open Percentage
Oct	50%
Nov [a]	100%
Dec	100%
Jan [b]	50%
Feb	50%
Mar	50%
April	50%
May	50%
Jun 1-15	50%
Jun 16-30	100%
Jul	100%
Aug	100%
Sep	100%

[a] Head of Old River Barrier operation is triggered baseed upon State Water Board D-1641 pulse trigger.

Before State Water Board D-1641 pulse trigger: Head of Old River Barrier open and no OMR restrictions.

During State Water Board D-1641 pulse trigger: Head of Old River Barrier closed and no south Delta exports.

Following State Water Board D-1641 pulse trigger: Head of Old River Barrier open 50% for two weeks, and OMR operated up to -5,000 cfs through November.

[b] The Head of Old River Barrier becomes operational at 50% when salmon fry are immigrating (based on real time monitoring).

B.3.3. Alternative 3 – Dual Conveyance with Intakes 1 and 2

Alternative 3 assumptions are provided by the lead agencies and are summarized in the Section B.6, in Table B-10. The assumptions for Alternative 3 are consistent with Alternative 1 in all aspects except for the number of intakes and total diversion capacity in the north Delta. Alternative 3 is a dual conveyance alternative and includes first two of the five proposed intakes in the north Delta with total 6,000 cfs capacity (3,000 cfs at each intake). Alternative 3 includes the operational criteria specified under Scenario A in the Chapter 3 of BDCP EIR/EIS. The tidal marsh restoration acreages and footprints assumed in Alternative 3 are also consistent with the Alternative 1.

Alternative 3 CALSIM II and DSM2 assumptions that are different from the No Action Alternative are described below.

CALSIM II Assumptions for Alternative 3:

Facilities

Fremont Weir

Consistent with Alternative 1

Isolated Conveyance Facility and the North Delta Diversion Intakes

An Isolated Conveyance Facility is included in the Alternative 3 which diverts water from the Sacramento River in the north Delta near Hood and conveys to the existing export facilities in the south Delta. The maximum conveyance capacity is assumed to be 6,000 cfs. Two separate intakes (intakes 1 and 2) each capable of diverting 3,000 cfs are proposed along the Sacramento River near Hood, all located upstream of the Sutter Slough. In CALSIM II, north Delta diversion is modeled as a single diversion located along the Sacramento River at Hood.

Banks Pumping Plant Capacity

Consistent with Alternative 1

Jones Pumping Plant Capacity

Consistent with Alternative 1

Regulatory Standards

North Delta Diversion Bypass Flows

North Delta bypass flows are consistent with Alternative 1, except, under Alternative 3, the bypass flows govern 2 intakes instead of 5. The constant low level pumping is limited to 600 cfs in the Alternative 3.

Minimum flow near Rio Vista

Consistent with Alternative 1

Delta Outflow Index (Flow and Salinity)

Consistent with Alternative 1

Combined Old and Middle River Flows

Consistent with Alternative 1

South Delta Export-San Joaquin River Inflow Ratio

Consistent with Alternative 1

Exports at the South Delta Intakes

Consistent with Alternative 1

Delta Water Quality

Consistent with Alternative 1

Operations Criteria

Fremont Weir Operations

Consistent with Alternative 1

Delta Cross Channel Gate Operations

Consistent with Alternative 1

Operations for Delta Water Quality and Residence Time

Consistent with Alternative 1

Allocation Decisions

Rules and assumptions are consistent with Alternative 1. Alternative 1 water supply index versus demand index curves are used for Alternative 3, considering the similarities between the two Alternatives.

San Luis Operations

Rules and assumptions are consistent with Alternative 1.

DSM2 Assumptions for Alternative 3:

Tidal Boundary

Consistent with Alternative 1

Water Quality

Martinez EC

Consistent with Alternative 1

Morphological Changes

Consistent with Alternative 1

Facilities

South Delta Temporary Barriers

Consistent with Alternative 1

Isolated Facility and North Delta Diversion Intakes

The locations of the north Delta diversion intakes for Alternative 3 are shown in the Figure B-1. Intakes 1 and 2 are modeled in DSM2 for Alternative 3, with 3,000 cfs diversion capacity at each intake. The modeling of the north Delta diversion intakes in DSM2 for Alternative 3 is consistent with Alternative 1.

Operations Criteria

South Delta Temporary Barriers

Consistent with Alternative 1

Montezuma Salinity Control Gate

Consistent with Alternative 1

North Delta Diversion Intakes

The diversion operation of the north Delta intakes in Alternative 3 is consistent with Alternative 1, except that it includes two intakes instead of five. The volume corresponding to first 200 cfs of the daily north Delta diversion specified by CALSIM II is diverted equally at both the intakes.

B.3.4. Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4 – Dual Conveyance with Intakes 2, 3, and 5

Alternative 4 assumptions are provided by the lead agencies and are summarized in the Section B.6, in Table B-13. Alternative 4 water conveyance operations would follow the similar operational criteria as Alternative 2A with the exception of evaluating a range of possible operations for the spring and fall Delta outflow requirements that are considered to be equally likely. This range of operations is encompassed by four separate scenarios as described in detail in Section 3.6.4.2 in Chapter 3, *Description of Alternatives.* These four scenarios vary depending on assumptions for Delta outflow requirements in spring and fall.

- Alternative 4 Operational Scenario H1 (Alternative 4 H1) does not include enhanced spring outflow requirements or Fall X2 requirements,
- Alternative 4 Operational Scenario H2 (Alternative 4 H2) includes enhanced spring outflow requirements but not Fall X2 requirements,
- Alternative 4 Operational Scenario H3 (Alternative 4 H3) does not include enhanced spring outflow requirements but includes Fall X2 requirements (similar to Alternative 2A), and
- Alternative 4 Operational Scenario H4 (Alternative 4 H4) includes both enhanced spring outflow requirements and Fall X2 requirements.

Alternative 4 is a dual conveyance alternative with three proposed intakes in the north Delta with 9,000 cfs total pumping capacity (3,000 cfs at each intake). Alternative 4 includes the operational criteria specified under Scenario H in the Chapter 3 of BDCP EIR/EIS. The tidal marsh restoration acreages and footprints assumed in Alternative 4 are consistent with Alternatives 1.

Alternative 4 CALSIM II and DSM2 assumptions that are different from the No Action Alternative are described below. Unless stated explicitly, the operational assumptions for the four Alternative 4 scenarios are consistent.

CALSIM II Assumptions for Alternative 4:

Facilities

Fremont Weir

Consistent with Alternative 1

Isolated Conveyance Facility and the North Delta Diversion Intakes

An Isolated Conveyance Facility is included in the Alternative 4 which diverts water from the Sacramento River in the north Delta near Hood and conveys to the existing export facilities in the south Delta. The maximum conveyance capacity is assumed to be 9,000 cfs. Three separate intakes (intakes 2, 3 and 5) each capable of diverting 3,000 cfs are assumed along the Sacramento River near Hood, all located upstream of Sutter Slough. In CALSIM II, north Delta diversion is modeled as a single diversion located along the Sacramento River at Hood.

Banks Pumping Plant Capacity

Consistent with Alternative 1

Jones Pumping Plant Capacity

Consistent with Alternative 1

Regulatory Standards

North Delta Diversion Bypass Flows

Consistent with Alternative 1

Minimum flow near Rio Vista

Consistent with Alternative 1

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:

Alternative 4 includes all flow based Delta outflow requirements per SWRCB D-1641 and are consistent with the No Action Alternative. Similarly, for the February through June period X2 standard is included consistent with the No Action Alternative.

USFWS BO (December, 2008) Action 4:

USFWS BO Action 4 requires additional Delta outflow to manage X2 in the fall months (September through November) following the wet and above normal years. This action is included in the Alternative 4 scenarios H3 and H4. The assumptions for this action under the Alternative 4 scenarios H3 and H4 scenarios are consistent with the No Action Alternative.

Enhanced Spring Outflow Requirement:

Alternative 4 scenarios H2 and H4 include an additional outflow requirement as an average over the March through May months. This enhanced spring outflow requirement is based on the probability of exceedance of Mar-May Delta outflow proposed by the lead agencies. The operational implementation to achieve this spring outflow objective includes assigning the proposed outflows at various exceedance levels to the Mar-May Eight River Index (8RI) values corresponding to the same exceedance levels. This allows operation of the CVP-SWP to attain the proposed outflows at the proposed frequency.

Each year in March, the enhanced spring Delta outflow target for the Mar-May period is determined based on the 90% forecast value of the Mar-May 8RI and its exceedance probability, from the table below, linearly interpolating for values in-between.

Percent Exceedance of Proposed Outflow assumed as the Percent Exceedance of Forecasted Mar-May 8RI:	10%	20%	30%	40%	50%	60%	70%	80%	90%
Proposed Mar-May Delta Outflow Target (cfs):	44,500	44,500	35,000	32,000	23,000	17,200	13,300	11,400	9,200

For modeling purposes, an estimate of forecasted Mar-May 8RI is computed using a correlation between the Jan-Feb 8RI and Mar-May 8RI as a surrogate to the 90% forecast of the Mar-May 8RI at ELT and LLT. The projected 8RI under the climate change is used to develop this correlation at both ELT and LLT. The correlation is used to predict the Mar-May 8RI using the projected Jan-Feb 8RI. Using this forecasted Mar-May 8RI, the required average outflow over Mar-May period is estimated.

This average Mar-May outflow target is further parsed to targets for individual months as follows:

- For March, the average Mar-May outflow target is used.
- To ensure the April outflow target is in line with the forecasted hydrology, the additional outflow needed to meet the Mar-May average target taking into account the resulted Delta outflow in March, is estimated and multiplied by
    - the ratio of 90% forecast of April Feather River unimpaired flow to the forecasted Apr-May unimpaired flow, in the wet years (years with the 8RI values that have less than 50% exceedance probability), or
    - the ratio of forecast of April 8RI to the forecasted Apr-May 8RI, in the dry years (years with the 8RI values that have greater than 50% exceedance probability)
- For May, the outflow target is the additional outflow needed to meet the Mar-May average target, taking into account the resulted Delta outflow in March and April.

This outflow requirement is first achieved by curtailing Delta exports at Banks and Jones Pumping Plants by an amount needed to meet the outflow target, such that the minimum exports are at least 1,500 cfs. In drier years, the outflow target is only achieved through the export curtailments.

In wetter years, if the outflow target is not achieved by export curtailments, then the additional flow needed to meet the outflow target is released in April and May months from the Oroville reservoir as long as its projected end-of-May storage is at or above 2 MAF. Oroville end-of-May storage is forecasted at the beginning of April and May using the 90% forecast of the Feather River unimpaired flow as inflow to the reservoir and estimated releases to meet the Feather River demands and minimum in-stream flow needs. Additional releases from Oroville for meeting the enhanced spring outflow requirement are allowed in April and May only when end-of-May Oroville storage is projected to be at or above 2 MAF at the beginning of April and May, respectively.

Stored water releases to meet the enhanced spring outflow requirement occurs only from Oroville, minimizing storage impacts to other reservoirs like Shasta and Folsom. Thus, the additional spring outflow is not considered as an "in-basin use" for CVP-SWP Coordinated Operations. The releases from Oroville reservoir are capped to power house capacity of 17,000 cfs.

Combined Old and Middle River Flows

The OMR requirements under Alternative 4 are consistent with Alternative 2A, 2B, 2C.

South Delta Export-San Joaquin River Inflow Ratio

Consistent with Alternative 1

Exports at the South Delta Intakes

The south Delta exports in Alternative 4 are operated per SWRCB D-1641. The combined export of the CVP Tracy Pumping Plant and SWP Banks Pumping Plant is limited to a percentage of the total Delta inflow, based on the export-inflow ratio specified under D1641. In the Alternative 4 scenarios H1 and H3, however, this requirement is applied to the south Delta exports only, and the north Delta diversion is not included in the Delta inflow or the Delta exports computation used to determine this requirement. Conversely, in the Alternative 4 scenarios H2 and H4, this requirement is applied to the total Delta exports by including the north Delta diversion in the Delta inflow and the Delta exports computation used to determine this requirement.

Delta Water Quality

Consistent with Alternative 1

Operations Criteria

Fremont Weir Operations

Consistent with Alternative 1

Delta Cross Channel Gate Operations

Consistent with Alternative 1

Operations for Delta Water Quality and Residence Time

Consistent with Alternative 1

Allocation Decisions

Rules and assumptions are consistent with Alternative 1, except for SWP allocation decisions under Alternative 4 scenarios H2 and H4, which are consistent with No Action Alternative. However, new water supply index versus demand index curves are developed for Alternative 4 scenarios H1, H2, H3 and H4.

San Luis Operations

Rules and assumptions are similar to Alternative 1, except managed to protect upstream storage under Alternative 4 scenarios H2 and H4.

DSM2 Assumptions for Alternative 4:

Tidal Boundary

Consistent with Alternative 1

Water Quality

Martinez EC

Consistent with Alternative 1

Morphological Changes

Consistent with Alternative 1

Facilities

South Delta Temporary Barriers

The temporary agricultural barriers and the HORB are included under Alternative 4 consistent with the No Action Alternative.

Isolated Facility and North Delta Diversion Intakes

The locations of the north Delta diversion intakes for Alternative 4 are shown in the Figure B-1. Intakes 2, 3 and 5 are modeled in DSM2 for Alternative 4, with 3,000 cfs diversion capacity at each intake. The modeling of the north Delta diversion intakes in DSM2 for Alternative 4 is consistent with Alternative 1.

Operations Criteria

South Delta Temporary Barriers

The operations of the agricultural barriers are consistent with the No Action Alternative. The HORB operations are modified under Alternative 4 such that appropriate gate opening is simulated to allow the fraction of "the flow that would have entered the Old River if the barrier were fully open", as noted in Table B-6. For October, the HORB is closed for the last two weeks, during the pulse flows.

Montezuma Salinity Control Gate

Consistent with Alternative 1

North Delta Diversion Intakes

The assumptions for Alternative 4 are consistent with Alternatives 1 except that the only three intakes are assumed. The volume corresponding to first 300 cfs of the daily north Delta diversion specified by CALSIM II is diverted equally at all the three intakes.

B.3.5. Alternative 5 – Dual Conveyance with Intake 1

Alternative 5 assumptions are provided by the lead agencies and are summarized in the Section B.6, in Table B-14. The assumptions for Alternative 5 are similar to the Alternative 1 in all aspects except for the number of intakes, total diversion capacity in the north Delta, and the additional constraints in the south Delta. Alternative 5 is a dual conveyance alternative and includes the intake 1 shown in the Figure B-1, with 3,000 cfs diversion capacity. Alternative 5 includes the operational criteria specified under Scenario C in the Chapter 3 of BDCP EIR/EIS. The tidal marsh restoration acreages and footprints assumed in modeling of Alternative 5 are also consistent with the Alternative 1. Note that the tidal marsh restoration acreage specified in the Alternative 5 assumptions by the lead agencies is 25,000 acres. However, the modeling assumed the hypothetical 65,000 acres footprint used in the Alternative 1. For the analyses of water operations and water quality, the results are based upon 65,000 ac restoration assumptions and the impacts would be more conservative than use of 25,000 ac. For effects on fisheries and terrestrial biological resources, 25,000 ac of restoration was assumed as described Chapters 11 and 12.

Alternative 5 CALSIM II and DSM2 assumptions that are different from the No Action Alternative are described below.

CALSIM II Assumptions for Alternative 5:

Facilities

Fremont Weir

Consistent with Alternative 1

Isolated Conveyance Facility and the North Delta Diversion Intakes

An Isolated Conveyance Facility is included in the Alternative 5 which diverts water from the Sacramento River in the north Delta near Hood and conveys to the existing export facilities in the south Delta. The maximum conveyance capacity is assumed to be 3,000 cfs. One intake (intakes 1) capable of diverting 3,000 cfs is proposed along the Sacramento River near Hood. In CALSIM II, north Delta diversion is modeled as a single diversion located along the Sacramento River at Hood.

Banks Pumping Plant Capacity

Physical capacity of the Banks Pumping Plant is 10,300 cfs. However, the diversions from the south Delta channels are restricted to the permitted capacity, consistent with the No Action Alternative. This assumption is different from Alternative 1, as the 3,000 cfs diversion capacity available in the north Delta may not provide enough flexibility to meet the south of Delta export needs and, it may exacerbate the violations of the permit capacity.

Jones Pumping Plant Capacity

Consistent with Alternative 1

Regulatory Standards

North Delta Diversion Bypass Flows

North Delta bypass flows are consistent with Alternative 1, except, under Alternative 5, the bypass flows govern 1 intake instead of 5. The constant low level pumping is limited to 300 cfs in the Alternative 5.

Minimum flow near Rio Vista

Consistent with Alternative 1

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:

All flow based Delta outflow requirements included in SWRCB D-1641 are consistent with the No Action Alternative. Similarly, for the February through June period X2 standard is included consistent with the No Action Alternative.

USFWS BO (December, 2008) Action 4:

USFWS BO Action 4 requires additional Delta outflow to manage X2 in the fall months following the wet and above normal years. This action is included in the Alternative 5. The assumptions for this action under the Alternative 5 are consistent with the No Action Alternative.

Combined Old and Middle River Flows

Consistent with Alternative 1

South Delta Export-San Joaquin River Inflow Ratio

NMFS BO (June 2009) Action 4.2.1 requires the south Delta exports are governed by this ratio in the months of April and May under the No Action Alternative. Under Alternative 5 this criteria is implemented.

Exports at the South Delta Intakes

Consistent with Alternative 1

Delta Water Quality

Consistent with Alternative 1

Operations Criteria

Fremont Weir Operations

Consistent with Alternative 1

Delta Cross Channel Gate Operations

Consistent with Alternative 1

Operations for Delta Water Quality and Residence Time

Consistent with Alternative 1

Allocation Decisions

Rules and assumptions are similar to the No Action Alternative. However, new water supply index versus demand index curves are developed for Alternative 5. The San Luis rule curve is managed to minimize situations in which shortages may occur due to lack of storage or exports.

San Luis Operations

Rules and assumptions are similar to the No Action Alternative.

DSM2 Assumptions for Alternative 5:

Tidal Boundary

Consistent with Alternative 1

Water Quality

Martinez EC

Consistent with Alternative 1

Morphological Changes

Consistent with Alternative 1

Facilities

South Delta Temporary Barriers

The temporary agricultural barriers and the HORB are included under Alternative 5 consistent with the No Action Alternative.

Isolated Facility and North Delta Diversion Intakes

The location of the north Delta diversion intake for Alternative 5 is shown in the Figure B-1. Intake 1 is modeled in DSM2 for Alternative 5, with 3,000 cfs diversion capacity. The modeling of the north Delta diversion intake in DSM2 for Alternative 5 is consistent with Alternative 1.

Operations Criteria

South Delta Temporary Barriers

The operations of the agricultural barriers and the HORB are consistent with the No Action Alternative.

Montezuma Salinity Control Gate

Consistent with Alternative 1

North Delta Diversion Intakes

The diversion operation of the north Delta intakes in Alternative 5 is consistent with Alternative 1, except that it includes one intake instead of five.

B.3.6. Alternative 6A, 6B and 6C – Isolated Conveyance with Intakes 1, 2, 3, 4 and 5

Alternative 6A, 6B and 6C assumptions are provided by the lead agencies and are summarized in the Section B.6, in Table B-11. Alternative 6 is an isolated conveyance alternative and includes the five intakes included in Alternative 1 for a total of 15,000 cfs total pumping capacity (3,000 cfs at each intake). Alternative 6 is consistent with Alternatives 1 in all aspects except for the lack of the exports in the south Delta and the inclusion of USFWS BO (December, 2008) Action 4. Alternative 6 includes the operational criteria specified under Scenario D in the Chapter 3 of BDCP EIR/EIS. The tidal marsh restoration acreages and footprints assumed in Alternative 6 are also consistent with Alternatives 1.

Alternative 6A, 6B and 6C all share the same long term operations assumptions, described below. However, 6A, 6B and 6C, each have a different conveyance configuration. 6A assumes a pipeline/tunnel conveyance option. 6B assumes an option that includes open channel and siphons and located east of the Sacramento River. 6C assumes an option that includes, open channel and tunnel located west of the Sacramento River. A detailed description of the different conveyance configurations is included in the Chapter 3 of BDCP EIR/EIS. For modeling, the differences in conveyance configuration are assumed to not change the long-term operations.

CALSIM II and DSM2 modeling is the same for the Alternative 6A, 6B and 6C. The changes in the type of conveyance and the alignment are assumed to cause no changes in the overall modeling results.

Alternative 6 CALSIM II and DSM2 assumptions that are different from the No Action Alternative are only described below.

CALSIM II Assumptions for Alternative 6:

Facilities

Fremont Weir

Consistent with Alternative 1

Isolated Conveyance Facility and the North Delta Diversion Intakes

An Isolated Conveyance Facility is included in the Alternative 6 which diverts water from the Sacramento River in the north Delta near Hood and conveys to the existing export facilities in the south Delta. The maximum conveyance capacity is assumed to be 15,000 cfs.

Five separate intakes (intakes 1, 2, 3, 4 and 5) each capable of diverting 3,000 cfs are assumed along the Sacramento River near Hood, all located upstream of Sutter Slough. In CALSIM II, north Delta diversion is modeled as a single diversion located along the Sacramento River at Hood.

Banks Pumping Plant Capacity

Physical capacity of the Banks Pumping Plant is 10,300 cfs, consistent with Alternative 1. However, it is assumed that no diversions can occur from the south Delta channels, considering this is an isolated conveyance alternative.

Jones Pumping Plant Capacity

The capacity of the Jones Pumping Plant is consistent with Alternative 1. However, it is assumed that no diversions can occur from the south Delta channels.

Regulatory Standards

North Delta Diversion Bypass Flows

Consistent with Alternative 1

Minimum flow near Rio Vista

Consistent with Alternative 1

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:

All flow based Delta outflow requirements included in SWRCB D-1641 are consistent with the No Action Alternative. Similarly, for the February through June period X2 standard is included consistent with the No Action Alternative.

USFWS BO (December, 2008) Action 4:

USFWS BO Action 4 requires additional Delta outflow to manage X2 in the fall months following the wet and above normal years. This action is included in the Alternative 6. The assumptions for this action under the Alternative 6 are consistent with the No Action Alternative.

Combined Old and Middle River Flows

Consistent with Alternative 1

South Delta Export-San Joaquin River Inflow Ratio

Consistent with Alternative 1

Exports at the South Delta Intakes

The south Delta exports are restricted to zero in Alternative 6. Therefore, the health and safety minimum pumping criteria is not included.

Delta Water Quality

Consistent with Alternative 1

Operations Criteria

Fremont Weir Operations

Consistent with Alternative 1

Delta Cross Channel Gate Operations

Consistent with Alternative 1

Operations for Delta Water Quality and Residence Time

The south Delta exports are restricted to zero in Alternative 6.

Allocation Decisions

Allocation rules and assumptions are significantly different in Alternative 6. Even though, new water supply index versus demand index curves are developed for Alternative 3, since the supply available for south-of-Delta exports is limited to the Sacramento River inflow, the allocation decisions are based on a standardized rule curve defined between Sacramento River four river index and the export index. Due to uncertainty in forecasting river conditions and the effect of the north Delta diversion bypass rules, and since the north Delta diversion is the only intake available for exports, the deliveries may fall short of allocated quantities.

San Luis Operations

Similar to Alternative 1, CALSIM II San Luis rule curve is modified under Alternative 6, in expectation that new conveyance can capture winter and spring excess flows and fill earlier in the year.

DSM2 Assumptions for Alternative 6:

Tidal Boundary

Consistent with Alternative 1

Water Quality

Martinez EC

Consistent with Alternative 1

Morphological Changes

Consistent with Alternative 1

Facilities

South Delta Temporary Barriers

Consistent with Alternative 1

Isolated Facility and North Delta Diversion Intakes

The locations of the north Delta diversion intakes for Alternative 6 are shown in the Figure B-1. Intakes 1 through 5 are modeled in DSM2 for Alternative 6, with 3,000 cfs diversion capacity at each intake. The modeling of the north Delta diversion intakes in DSM2 for Alternative 6 is consistent with Alternative 1.

Operations Criteria

South Delta Temporary Barriers

Consistent with Alternative 1

Montezuma Salinity Control Gate

Consistent with Alternative 1

North Delta Diversion Intakes

The operation of the north Delta intakes in Alternative 6 is consistent with Alternative 1.

B.3.7. Alternative 7 – Enhanced Aquatic Conservation – Dual Conveyance with Intakes 2, 3 and 5

Alternative 7 assumptions are provided by the lead agencies and are summarized in the Section B.6, in Table B-15. Alternative 7 is similar to Alternative 1 in several aspects. However, there are a few key differences in the assumptions. Alternative 7 is a dual conveyance alternative and includes three proposed intakes in the north Delta with 9,000 cfs total pumping capacity (3,000 cfs at each intake). Alternative 7 includes the operational criteria specified under Scenario E in the Chapter 3 of BDCP EIR/EIS. The tidal marsh restoration acreages and footprints assumed in Alternative 7 are consistent with Alternative 1.

Alternative 7 CALSIM II and DSM2 assumptions that are different from the No Action Alternative are described below.

CALSIM II Assumptions for Alternative 7:

Facilities

Fremont Weir

Under Alternative 7, it is assumed that a notch opening in the existing Fremont Weir and operable gates are constructed at elevation 17.5 feet, consistent with Alternative 1. The smaller opening at 11.5 feet elevation that is assumed in the Alternatives 1 is not part of the Alternative 7.

Isolated Conveyance Facility and the North Delta Diversion Intakes

An Isolated Conveyance Facility is included in the Alternative 7 which diverts water from the Sacramento River in the north Delta near Hood and conveys to the existing export facilities in the south Delta. The maximum conveyance capacity is assumed to be 9,000 cfs. Three separate intakes (intakes 2, 3 and 5) each capable of diverting 3,000 cfs are proposed along the Sacramento River near Hood, all located upstream of the Sutter Slough. In CALSIM II, north Delta diversion is modeled as a single diversion located along the Sacramento River at Hood.

Banks Pumping Plant Capacity

Consistent with Alternative 1

Jones Pumping Plant Capacity

Consistent with Alternative 1

Regulatory Standards

North Delta Diversion Bypass Flows

The assumptions for Alternative 7 are consistent with Alternatives 1except that between December and June, constant low level pumping allows diversions of up to 5% of the river flow for flows greater than 5,000 cfs at the north Delta diversion. In addition, under Alternative 7, the bypass rules govern three intakes instead of the five intakes in Alternative 1. The low level pumping continues to be less than 300 cfs at any one intake, with a combined limit of 900 cfs for the three intakes in the Alternative 7.

Further, in the Alternative 7, after the initial pulse(s), Level I post-pulse bypass rule is applied until 20 days of bypass flows above 20,000 cfs. Then Level II post-pulse bypass rule is applied until 45 days of bypass flows above 20,000 cfs. Then Level III post-pulse bypass rule is applied. The bypass rules were applied on the mean daily river flows in the CALSIM II model.

A detailed description of the modeling of the north Delta diversion operations for Alternative 1, which forms the basis of the north Delta diversion operations in Alternative 7 CALSIM II Modeling, is provided in the Section A.3.3 of this appendix.

Minimum flow near Rio Vista

For September through December months the minimum flow required on the Sacramento River at Rio Vista under the Water Quality Control Plan, SWRCB D-1641 is maintained. For January through August a minimum flow of 5,000 cfs is maintained in all years.

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:

All flow based Delta outflow requirements included in SWRCB D-1641 are consistent with the No Action Alternative. Similarly, for the February through June period X2 standard is included consistent with the No Action Alternative.

USFWS BO (December, 2008) Action 4:

USFWS BO Action 4 requires additional Delta outflow to manage X2 in the fall months following the wet and above normal years. This action is included in the Alternative 7. The assumptions for this action under the Alternative 7 are consistent with the No Action Alternative.

Combined Flow in Old and Middle River (OMR)

Alternative 7 assumes that the south Delta exports cannot cause OMR to fall below +1,000 cfs during December through March period. Similarly, the south Delta exports cannot cause OMR to fall below +3,000 cfs in June. Further, the south Delta exports are not allowed during April, May, October and November months. No OMR restrictions in July, August and September months.

South Delta Export-San Joaquin River Inflow Ratio

NMFS BO (June 2009) Action 4.2.1 requires the south Delta exports are governed by this ratio in the months of April and May under the No Action Alternative. Under Alternative 7 this criteria is modified, requiring the south Delta exports be capped at 50% of San Joaquin River flow at Vernalis during December through March and in June months.

Exports at the South Delta Intakes

The south Delta exports in Alternative 7 are operated per SWRCB D-1641. The combined export of the CVP Tracy Pumping Plant and SWP Banks Pumping Plant is limited to a percentage of the total Delta inflow, based on the export-inflow ratio specified under D1641. In the Alternative 7, however, this requirement is limited to the south Delta exports only. The north Delta diversion is not included in the Delta inflow or the Delta exports computation.

Finally, the south Delta exports are not allowed during April, May, October and November months per the requirements set for the OMR under Alternative 7.

Delta Water Quality

Consistent with Alternative 1

Operations Criteria

Fremont Weir Operations

Under Alternative 7, to provide seasonal floodplain inundation in the Yolo Bypass, the 17.5 feet elevation gates are opened between December 1st and April 15th. This may extend to May 15th, depending on the hydrologic conditions. The gates are operated to limit maximum spill to 8,000 cfs until the Sacramento River stage reaches the existing Fremont Weir elevation. When the river stage is at or above the existing Fremont Weir crest elevation, the notch gates are assumed to be closed. While desired inundation period is on the order of 30 to 45 days, gates are not managed to limit to this range, instead the duration of the event is governed by the Sacramento River flow conditions. The opening at 11.5 feet elevation is not included in Alternative 7.

Delta Cross Channel Gate Operations

Consistent with Alternative 1

Operations for Delta Water Quality and Residence Time

Consistent with Alternative 1

Allocation Decisions

Rules and assumptions are consistent with Alternative 1. However, the water supply index versus demand index curves developed for Alternative 6 are used for Alternative 7, as the reliability of the export conditions are similar in these two Alternatives.

San Luis Operations

Rules and assumptions are consistent with Alternative 1.

DSM2 Assumptions for Alternative 7:

Tidal Boundary

Consistent with Alternative 1

Water Quality

Martinez EC

Consistent with Alternative 1

Morphological Changes

Consistent with Alternative 1

Facilities

South Delta Temporary Barriers

Consistent with Alternative 1

Isolated Facility and North Delta Diversion Intakes

The locations of the north Delta diversion intakes for Alternative 7 are shown in the Figure B-1. Intakes 2, 3 and 5 modeled in DSM2, with 3,000 cfs maximum diversion capacity at each intake. The modeling of the north Delta diversion intakes in DSM2 for Alternative 7 is consistent with Alternative 1.

Operations Criteria

South Delta Temporary Barriers

Consistent with Alternative 1

Montezuma Salinity Control Gate

Consistent with Alternative 1

North Delta Diversion Intakes

The diversion operation of the north Delta intakes in Alternative 7 is consistent with Alternative 1, except that it includes three intakes. The volume corresponding to first 300 cfs of the daily north Delta diversion specified by CALSIM II is diverted equally at all the five intakes.

B.3.8. Alternative 8

Alternative 8 assumptions are developed by the SWRCB in collaboration with DWR. The assumptions are summarized in the Section B.6, in Table B-16. Alternative 8 is developed based on the Alternative 7. Similar to Alternative 7, Alternative 8 is a dual conveyance alternative and includes three proposed intakes in the north Delta with 9,000 cfs total pumping capacity (3,000 cfs at each intake). Alternative 8 includes the operational criteria specified under Scenario F in the Chapter 3 of BDCP EIR/EIS. The tidal marsh restoration acreages and footprints assumed in Alternative 8 are consistent with Alternative 1.

Alternative 8 CALSIM II and DSM2 assumptions that are different from the No Action Alternative are described below.

CALSIM II Assumptions for Alternative 8:

Facilities

Fremont Weir

Under Alternative 8, it is assumed that a notch opening in the existing Fremont Weir and operable gates are constructed at elevation 17.5 feet, consistent with Alternative 1. The smaller opening at 11.5 feet elevation that is assumed in the Alternatives 1 is not part of the Alternative 8.

Isolated Conveyance Facility and the North Delta Diversion Intakes

An Isolated Conveyance Facility is included in the Alternative 8 which diverts water from the Sacramento River in the north Delta near Hood and conveys to the existing export facilities in the south Delta. The maximum conveyance capacity is assumed to be 9,000 cfs. Three separate intakes (intakes 2, 3 and 5) each capable of diverting 3,000 cfs are proposed along the Sacramento River near Hood, all located upstream of the Sutter Slough. In CALSIM II, north Delta diversion is modeled as a single diversion located along the Sacramento River at Hood.

Banks Pumping Plant Capacity

Consistent with Alternative 1

Jones Pumping Plant Capacity

Consistent with Alternative 1

Regulatory Standards

North Delta Diversion Bypass Flows

The assumptions for Alternative 8 are consistent with Alternatives 1except that between December and June, constant low level pumping allows diversions of up to 5% of the river flow for flows greater than 5,000 cfs at the north Delta diversion. In addition, under Alternative 8, the bypass rules govern three intakes instead of the five intakes in Alternative 1. The low level pumping continues to be less than 300 cfs at any one intake, with a combined limit of 900 cfs for the three intakes in the Alternative 8.

Further, in the Alternative 8, after the initial pulse(s), Level I post-pulse bypass rule is applied until 20 days of bypass flows above 20,000 cfs. Then Level II post-pulse bypass rule is applied until 45 days of bypass flows above 20,000 cfs. Then Level III post-pulse bypass rule is applied. The bypass rules were applied on the mean daily river flows in the CALSIM II model.

A detailed description of the modeling of the north Delta diversion operations for Alternative 1, which forms the basis of the north Delta diversion operations in Alternative 8 CALSIM II Modeling, is provided in the Section A.3.3 of this appendix.

Minimum flow near Rio Vista

For September through December months the minimum flow required on the Sacramento River at Rio Vista under the Water Quality Control Plan, SWRCB D-1641 is maintained. For January through August a minimum flow of 5,000 cfs is maintained in all years.

Minimum Flow near Freeport

For January through June months a minimum flow of 55% of the Unimpaired Flow in the Sacramento River at Freeport (with an upper limit of 40,000 cfs) is maintained. To balance SWP and CVP contributions to the Freeport requirement, a minimum requirement is applied simultaneously at the mouth of the Feather River that is a proportional amount of the 55% Unimpaired Flow at Freeport.

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:

All flow based Delta outflow requirements included in SWRCB D-1641 are consistent with the No Action Alternative. Similarly, for the February through June period X2 standard is included consistent with the No Action Alternative.

USFWS BO (December, 2008) Action 4:

USFWS BO Action 4 requires additional Delta outflow to manage X2 in the fall months following the wet and above normal years. This action is included in the Alternative 8. The assumptions for this action under the Alternative 8 are consistent with the No Action Alternative.

For January through June months Delta Outflow equal to greater of 55% of the Unimpaired Flow in the Sacramento River at Freeport (with an upper limit of 40,000 cfs) or the SWRCB D-1641 Delta Outflow requirements as stated above, is maintained.

Cold Water Pool Storage

Trinity, Shasta, Oroville and Folsom storages were modified to enable more cold water pool storage by increasing Storage Level 3 to 75% of the maximum storage. Within Storage Level 3, exports are gradually reduced until Storage Level 2 is reached in the reservoir. Project Storage below 75% of maximum storage is limited to releases for environmental uses and/or superior water rights.

Combined Flow in Old and Middle River (OMR)

Alternative 8 assumes that the south Delta exports cannot cause OMR to fall below +1,000 cfs during December through March period. Similarly, the south Delta exports cannot cause OMR to fall below +3,000 cfs in June. Further, the south Delta exports are not allowed during April, May, October and November months. No OMR restrictions in July, August and September months.

South Delta Export-San Joaquin River Inflow Ratio

NMFS BO (June 2009) Action 4.2.1 requires the south Delta exports are governed by this ratio in the months of April and May under the No Action Alternative. Under Alternative 8 this criteria is modified, requiring the south Delta exports be capped at 50% of San Joaquin River flow at Vernalis during December through March and in June months.

Exports at the South Delta Intakes

The south Delta exports in Alternative 8 are operated per SWRCB D-1641. The combined export of the CVP Tracy Pumping Plant and SWP Banks Pumping Plant is limited to a percentage of the total Delta inflow, based on the export-inflow ratio specified under D1641. In the Alternative 8, however, this requirement is limited to the south Delta exports only. The north Delta diversion is not included in the Delta inflow or the Delta exports computation.

Finally, the south Delta exports are not allowed during April, May, October and November months per the requirements set for the OMR under Alternative 8.

Delta Water Quality

Consistent with Alternative 1

Operations Criteria

Fremont Weir Operations

Under Alternative 8, to provide seasonal floodplain inundation in the Yolo Bypass, the 17.5 feet elevation gates are opened between December 1st and April 15th. This may extend to May 15th, depending on the hydrologic conditions. As a simplification, in the model the gates are opened until April 30th in all the years. The gates are operated to limit maximum spill to 8,000 cfs until the Sacramento River stage reaches the existing Fremont Weir elevation. When the river stage is at or above the existing Fremont Weir crest elevation, the notch gates are assumed to be closed. While desired inundation period is on the order of 30 to 45 days, gates are not managed to limit to this range, instead the duration of the event is governed by the Sacramento River flow conditions. The opening at 11.5 feet elevation is not included in Alternative 8.

Delta Cross Channel Gate Operations

Consistent with Alternative 1

Operations for Delta Water Quality and Residence Time

Consistent with Alternative 1

Allocation Decisions

Rules and assumptions are consistent with Alternative 1. However, the water supply index versus demand index curves developed for Alternative 6 are used for Alternative 8, as the reliability of the export conditions are similar in these two Alternatives.

San Luis Operations

Rules and assumptions are consistent with Alternative 1.

DSM2 Assumptions for Alternative 8:

Tidal Boundary

Consistent with Alternative 1

Water Quality

Martinez EC

Consistent with Alternative 1

Morphological Changes

Consistent with Alternative 1

Facilities

South Delta Temporary Barriers

Consistent with Alternative 1

Isolated Facility and North Delta Diversion Intakes

The locations of the north Delta diversion intakes for Alternative 8 are shown in the Figure B-1. Intakes 2, 3 and 5 modeled in DSM2, with 3,000 cfs maximum diversion capacity at each intake. The modeling of the north Delta diversion intakes in DSM2 for Alternative 8 is consistent with Alternative 1.

Operations Criteria

South Delta Temporary Barriers

Consistent with Alternative 1

Montezuma Salinity Control Gate

Consistent with Alternative 1

North Delta Diversion Intakes

The diversion operation of the north Delta intakes in Alternative 8 is consistent with Alternative 1, except that it includes three intakes. The volume corresponding to first 300 cfs of the daily north Delta diversion specified by CALSIM II is diverted equally at all the five intakes.

B.3.9. Alternative 9 – Separate Corridors

Alternative 9 assumptions are provided by the lead agencies and are summarized in the Section B.6, in Table B-17. Alternative 9 is the through-Delta conveyance alternative included in the BDCP EIR/EIS. In this Alternative, water continues to flow by gravity from the Sacramento River into two existing channels, Delta Cross Channel and Georgiana Slough. This scenario does not include north Delta Diversion Bypass Flow Criteria and Operations for Delta Water Quality and Residence Time. Alternative 9 includes the operational criteria specified under Scenario G in the Chapter 3 of BDCP EIR/EIS.

Alternative 9 introduces a number of operable gates designed to separate Middle River from Old River. The existing Clifton Forebay intake is removed and instead, the Forebay is assumed to be connected directly to Victoria Canal via a siphon structure. In order to accommodate the higher flows in Middle River, major dredging is proposed in portions of Middle River and Victoria Canal. In addition two fish screens with a capacity 7,500 cfs are proposed for Delta Cross Channel and Georgiana Slough in order to reduce the movement of fish from Sacramento River into Central Delta. Additional criteria are provided for operations of operable barriers on the Mokelumne River system. For more specific information on this alternative, see the DSM2 assumptions listed below.

Alternative 9 CALSIM II and DSM2 assumptions that are different from the No Action Alternative are described below.

CALSIM II Assumptions for Alternative 9:

Facilities

Fremont Weir
Consistent with Alternative 1

Separate Corridor
A Separate Corridor is included in Alternative 9 which conveys water from the Sacramento River in central Delta through Middle River to the existing export facilities in the south Delta when the San Joaquin River flow at Vernalis is less than 10,000 cfs.

Georgiana Slough Gate
A gate structure with a fish screen is included in Alternative 9 on Georgiana Slough near Sacramento River. This gate structure limits flow in Georgiana Slough to a maximum of 7,500 cfs.

Banks Pumping Plant Capacity
Physical capacity of the Banks Pumping Plant is 10,300 cfs. However, the diversions from the south Delta channels are restricted to the permitted capacity, consistent with the No Action Alternative. When San Joaquin River flow at Vernalis is less than 10,000 cfs, the diversions into the Banks Pumping Plant occur from the Victoria Canal, in the Alternative 9. When San Joaquin River flow at Vernalis is greater than 10,000 cfs, the diversions into the Banks Pumping Plant occur from the West Canal consistent with the No Action Alternative.

Jones Pumping Plant Capacity
Pumping capacity assumptions for Jones Pumping Plant are consistent with the No Action Alternative. When San Joaquin River flow at Vernalis is less than 10,000 cfs, the diversions into the Jones Pumping Plant occur from the Victoria Canal via Clifton Court Forebay, in the Alternative 9. When San Joaquin River flow at Vernalis is greater than 10,000 cfs, the diversions into the Jones Pumping Plant occur from the Old River channel consistent with the No Action Alternative.

Regulatory Standards

Minimum flow near Rio Vista

Consistent with Alternative 1

Delta Outflow Index (Flow and Salinity)

SWRCB D-1641:

All flow based Delta outflow requirements included in SWRCB D-1641 are consistent with the No Action Alternative. Similarly, for the February through June period X2 standard is included consistent with the No Action Alternative.

USFWS BO (December, 2008) Action 4:

USFWS BO Action 4 requires additional Delta outflow to manage X2 in the fall months following the wet and above normal years. This action is included in the Alternative 9. The assumptions for this action under the Alternative 9 are consistent with the No Action Alternative.

Combined Flow in Old and Middle River (OMR)

OMR requirements are consistent with No Action Alternative when San Joaquin River flow at Vernalis is greater than 10,000 cfs, under Alternative 9. It assumes that the south Delta exports cannot cause OMR to fall below the levels specified in USFWS BO (Dec 2008) Actions 1 through 3 and NMFS BO (Jun 2009) Action IV.2.3 when San Joaquin River flow at Vernalis is greater than 10,000 cfs.

Additionally, Alternative 9 assumes the south Delta exports cannot cause Middle River flow to fall below the levels specified in USFWS BO (Dec 2008) Actions 1 through 3 and NMFS BO (Jun 2009) Action IV.2.3 when San Joaquin River flow at Vernalis is less than 10,000 cfs.

South Delta Export-San Joaquin River Inflow Ratio

NMFS BO (June 2009) Action 4.2.1 requires the south Delta exports are governed by this ratio in the months of April and May under the No Action Alternative. Under Alternative 9 this criteria is included when San Joaquin River flow at Vernalis is greater than 10,000 cfs.

Exports at the South Delta Intakes

The south Delta exports in Alternative 9 are operated per SWRCB D-1641 when San Joaquin River flow is less than 10,000 cfs, as in the No Action Alternative.

Allocation Decisions

Rules and assumptions are similar to the No Action Alternative. However, new water supply index versus demand index curves are developed for Alternative 9.

San Luis Operations

Rules and assumptions are similar to the No Action Alternative.

Delta Water Quality

Alternative 9 includes SWRCB D-1641 salinity requirements consistent with the Alternative 1 for all compliance locations except for Rock Slough. The Rock Slough salinity location is not specifically targeted for compliance. Instead, compliance with the Clifton Court Forebay salinity standard of 250 mg/L is simulated, in all years.

Operations Criteria

Fremont Weir Operations

Consistent with Alternative 1

Delta Cross Channel Gate Operations

Under Alternative 9, DCC gates are closed when Sacramento River flows at Delta Cross Channel are less than 11,000 cfs or greater than 25,000 cfs. When Sacramento River flows at Delta Cross Channel are between 11,000 cfs and 25,000 cfs, Delta Cross Channel gates are operated to divert approximately 25% of Sacramento River flow at Delta Cross Channel.

DSM2 Assumptions for Alternative 9:

Tidal Boundary

Consistent with Alternative 1

Water Quality

Martinez EC

Consistent with Alternative 1

Morphological Changes

Consistent with Alternative 1 with some exceptions as noted below.

Middle River and Victoria Canal are dredged based on the DHCCP (Delta Habitat Conservation and Conveyance Program) design drawings for Alternative 9. To separate Old River, Clifton Court Forebay is directly connected to Victoria Canal, while the existing intake to the Forebay is removed. The Meadows Slough, in the Central Delta, is assumed to be connected to Sacramento River. Channel cross-sections on Snodgrass, Stone Lakes, Lost Slough, Mokelumne River and Meadows Slough around McCormick Williamson Tract are also modified to reflect the proposed channel dredging (based on LIDAR data provided by DHCCP).

Facilities

South Delta Temporary Barriers

South Delta Temporary Barriers are not included under Alternative 9.

Additional Delta Facilities

Alternative 9 has additional facilities which are quite different from other Alternatives. The objective of Alternative 9 is to separate Old River from Middle River by blocking channel connections using operable gates. Old River is assumed to be completely disconnected from Victoria Canal and Clifton Court Forebay. Five gates are installed and assumed to be closed when San Joaquin River (SJR) flow at Vernalis is less than 10,000 cfs in order to separate Old River from Middle River. The gates are located on Woodward Canal, Santa Fe Cut, Connection Slough, Mouth of Old River at San Joaquin River near Franks Tract and Fisherman Cut. Two additional gates, one on Middle River gate near the current site of the temporary barrier and the other on San Joaquin River gate just downstream from the head of Old River, are installed in south Delta. For each one, a low head pump with 250 cfs capacity is installed (only when SJR flow is below 10,000 cfs) to improve water quality in south Delta.

The Meadows Slough is assumed to be connected to Sacramento River. A gate is installed on the Meadows Slough to block flow from August through November or when Sacramento River flow is greater than 25,000 cfs. Two additional gates are installed in the channels adjacent to McCormick Williamson Tract. Both gates are open from August through November. One is on Mokelumne River to reroute flow to Sacramento River when Sacramento River flow is below 25,000 cfs (only during December through July). Second gate is on Snodgrass Slough and is closed when Sacramento River flow is below 25,000 cfs (only during December through July) to keep the fish on the path towards Sacramento River.

Two fish screens with a capacity of 7500 cfs are proposed, one on Delta Cross-Channel, and the other on Georgina Slough, near Sacramento River. It is however, assumed that the fish screens do not affect the hydrodynamics and water quality in the Delta, and as such, they are only included in the DSM2 modeling. An operable gate is proposed on Georgiana Slough just downstream of the fish screens to limit the flow to 7,500 cfs in order not to exceed the capacity of fish screens (only for Sacramento River flow above 45,000 cfs).

Furthermore, an operable gate is installed in Three Mile Slough, and operated consistent with the objectives of the Franks Tract Program.

Isolated Facility and North Delta Diversion Intakes

Not included

Operations Criteria

South Delta Temporary Barriers

South Delta Temporary Barriers are not included under Alternative 9.

South Delta Exports

Alternative 9 assumes modified south Delta exports. Both SWP and CVP are assumed to be pumping from Clifton Court Forebay when SJR flow is below 10,000 cfs. When SJR flow is above 10,000 cfs, it is assumed that CVP exports are assigned to the existing intakes.

Montezuma Salinity Control Gate

Consistent with Alternative 1

North Delta Diversion Intakes

Not included

B.4. Time Frames of Evaluation

The No Action Alternative and the other Alternatives are simulated at two points in time, Early Long Term (ELT) and Late Long Term (LLT), in addition to the projected Year 2020 conditions. ELT represents a point in time 15 years into the future (~2025), and LLT representing the end of the 50-year planning horizon (~2060), the assumed end of the permit period for the alternatives.

Changes in climate conditions were assumed at ELT and LLT. The approach used in selecting the climate change scenario is included in Section A.7 and Section D.2. Using this approach the climate scenario was derived based on sampling of the ensemble of GCM projections rather than one single realization or a handful of individual realizations. The Q5 scenario represents the central tendency of the climate projections. The resulting temperature and precipitation changes for the selected climate scenarios are summarized in Section D.3.1. The CALSIM II hydrology input datasets were modified based on the resulting hydrologic changes based on the VIC modeling (Section D.3.2) for the assumed temperature and precipitation changes at the ELT and LLT phases for the selected climate change scenario.

In addition, a 15 cm sea level rise is assumed at the ELT phase and a 45 cm sea level rise at the LLT phase as described in Section A.7.

The climate change and sea level rise assumptions were used for ELT and LLT simulations of the No Action Alternative and all the other alternatives.

In addition, for all the alternatives, except for the No Action Alternative, the ELT point in time includes 25,000 acres of tidal marsh restoration areas. These areas are located in the Cache Slough Complex, the Western Delta, Suisun Marsh, and along the Mokelumne and Consumnes Rivers. Similarly, for the alternatives, the LLT point in time includes 65,000 acres of tidal marsh restoration areas (additional 40,000 acres) located also in these same areas and also in the south Delta and east Delta regions.

Preparation of the CALSIM II and DSM2 models for incorporating restoration changes, sea level rise, and temperature and precipitation changes associated with climate change is described in the methodology section (Section A.3.3 and Section A.5.3). Additional information on this topic is included in Section D.

The GCM downscaled climate projections are used to create modified temperature and precipitation inputs for the Variable Infiltration Capacity (VIC) hydrology model. The VIC model simulates hydrologic processes on the $1/8^{th}$ degree scale to produce watershed runoff (and other hydrologic variables) for the major rivers and streams in the Central Valley. The changes in reservoir inflows and downstream accretions/depletions are translated into modified input time series for the CALSIM II model. The VIC modeling is described in Section A.8 and the results are presented in Section D.3.2.

In an effort to simulate 15cm and 45cm sea level rise effects in the Delta completely, DSM2 was corroborated using the modeling results from the three-dimensional UnTRIM Bay-Delta hydrodynamics and water quality model (McWilliams and Gross, 2010). UnTRIM modeling described in Section D.7. To simulate the effects of tidal marsh restoration areas and sea level rise effects accurately in the Delta, DSM2 was corroborated using the results from RMA models with integrated tidal marsh restoration areas and sea level rise changes (RMA, 2010). RMA Modeling is described in Section D.6. The DSM2 corroboration is included in the Section D.8.

Sea level rise and restored tidal marsh restoration areas effects on the flow-salinity response is incorporated into the modified ANNs. The ANNs were retrained using the corroborated DSM2 models to emulate the flow-salinity relationship under various combinations of the sea level rise and tidal marsh restoration assumed at ELT and LLT phases.

Simulation of the climate, tidal marsh restoration and sea level rise effects in CALSIM II modeling of the Alternatives is accomplished by:

- Incorporating the modified CALSIM II inputs including, inflows, water year types, runoff forecasts, Delta water temperature, for the climate change scenario selected for the Alternative.
- Incorporating the modified ANNs to reflect the flow-salinity response under sea level change and tidal marsh restoration scenarios, for the tidal marsh restoration acreage and sea level rise assumptions selected for the Alternative.

Simulation of the tidal marsh restoration areas and sea level rise effects in DSM2 modeling of the Alternatives is accomplished by:

- Incorporating consistent grid changes identified in corroboration simulation into the DSM2 model for the Alternative, for the tidal marsh restoration acreage and sea level rise assumptions selected for the Alternative.
- Modifying the downstream stage and EC boundary conditions at Martinez in the DSM2 model for the Alternative, using the appropriate regression equation for the tidal marsh restoration acreage and sea level rise assumptions selected for the Alternative. The adjusted astronomical tide specified at Martinez in the No Action Alternative is modified using the correlations shown in Table B-7. The Martinez EC boundary condition resulting from the G-model is modified using the correlations specified in the Table B-7.

Table B-7: Correlations to Transform Baseline Martinez Stage and EC for use in Alternatives DSM2 Simulations at ELT and LLT Phases

Scenario	Martinez Stage (ft NGVD 29)		Martinez EC (µS/cm)	
	Correlation	Lag (min)	Correlation	Lag (min)
ELT (15cm SLR)	Y = 1.0033*X + .47	-1	Y = 0.9954* X + 556.3	0
ELT (25,000ac &15cm SLR)	Y = 0.968 * X + 0.5	-5	Y = 0.999 * X + 357.78	9
LLT (45cm SLR)	Y = 1.0113*X + 1.4	-2	Y = 0.98* X + 1778.9	-2
LLT (65,000ac & 45cm SLR)	Y = 0.958 * X + 1.49	-9	Y = 1.002 * X + 1046.3	11

Notes: X = Baseline Martinez stage or EC and Y = Alternative Martinez stage or EC

B.5. Existing Conditions and No Action Alternative Callout Tables

CALSIM II Assumptions

This subsection provides a summary of the CALSIM II assumptions for the Existing Conditions and No Action Alternative baselines. These assumptions were selected by the Department of Water Resources (DWR) management team for the BDCP EIR/EIS in coordination with the Reclamation, USFWS and NMFS. The assumptions for each scenario are listed in Table B-8. The information included in here is consistent with what was provided to and agreed to by the lead agencies in the "Confirmation of Final Assumptions for Existing and Future No Action Alternative Conditions CALSIM II and DSM2 Models", on March 10, 2010. It also includes any modifications requested by the lead agency staff to improve readability and include additional clarification to the stated assumptions.

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
Planning horizon[a]	Year 2009/Year 2015	Year 2020/Year 2025/Year 2060
Demarcation date[a]	February 2009 (but with operational components of 2008 USFWS and 2009 NMFS BO included)	Same
Period of simulation	82 years (1922-2003)	Same
HYDROLOGY		
Inflows/Supplies	Historical with modifications for operations upstream of rim reservoirs	Historical with modifications for operations upstream of rim reservoirs and with or without changed climate at Early Long Term (Year 2025) or Late Long Term (Year 2060)
Level of development	Projected 2005 level[b]	Projected 2030 level[c]
DEMANDS, WATER RIGHTS, CVP/SWP CONTRACTS		
Sacramento River Region (excluding American River)		
CVP[d]	Land-use based, limited by contract amounts	Land-use based, full build-out of contract amounts
SWP (FRSA)[e]	Land-use based, limited by contract amounts	Same
Non-project	Land use based, limited by water rights and SWRCB Decisions for Existing Facilities	Same
Antioch Water Works	Pre-1914 water right	Same
Federal refuges[f]	Recent historical Level 2 water needs	Firm Level 2 water needs
Sacramento River Region - American River[g]		
Water rights	Year 2005	Year 2025, full water rights
CVP	Year 2005	Year 2025, full contracts, including Freeport Regional Water Project

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
San Joaquin River Region[h]		
Friant Unit	Limited by contract amounts, based on current allocation policy	Same
Lower Basin	Land-use based, based on district level operations and constraints	Same
Stanislaus River[i]	Land-use based, Revised Operations Plan[t] and NMFS BO (Jun 2009) Actions III.1.2 and III.1.3[v]	Same
San Francisco Bay, Central Coast, Tulare Lake and South Coast Regions (CVP/SWP project facilities)		
CVP[d]	Demand based on contract amounts	Same
CCWD[j]	195 TAF/yr CVP contract supply and water rights	Same
SWP[e,k]	Variable demand, of 3.0-4.1 MAF/Yr, up to Table A amounts including all Table A transfers through 2008	Demand based on Table A amounts
Article 56	Based on 2001-08 contractor requests	Same
Article 21	MWD demand up to 200 TAF/month from December to March subject to conveyance capacity, KCWA demand up to 180 TAF/month and other contractor demands up to 34 TAF/month in all months, subject to conveyance capacity	Same
North Bay Aqueduct (NBA)	71 TAF/yr demand under SWP contracts, up to 43.7 cfs of excess flow under Fairfield, Vacaville and Benecia Settlement Agreement	77 TAF/yr demand under SWP contracts, up to 43.7 cfs of excess flow under Fairfield, Vacaville and Benecia Settlement Agreement
Federal refuges[f]	Recent historical Level 2 water needs	Firm Level 2 water needs

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
FACILITIES		
System-wide	Existing facilities	Same
Sacramento River Region		
Shasta Lake	Existing, 4,552 TAF capacity	Same
Red Bluff Diversion Dam	Diversion dam operated gates out, except Jun 15th – Aug 31st based on NMFS BO (Jun 2009) Action I.3.2[v]; assume interim/ temporary facilities in place	Diversion dam operated with gates out all year, NMFS BO (Jun 2009) Action I.3.1[v]; assume permanent facilities in place
Colusa Basin	Existing conveyance and storage facilities	Same
Upper American River[g,l]	PCWA American River Pump Station	Same
Lower Sacramento River	None	Freeport Regional Water Project[n]
San Joaquin River Region		
Millerton Lake (Friant Dam)	Existing, 520 TAF capacity	Same
Lower San Joaquin River	None	City of Stockton Delta Water Supply Project, 30 mgd capacity
Delta Region		
SWP Banks Pumping Plant (South Delta)	Physical capacity is 10,300 cfs but 6,680 cfs permitted capacity in all months up to 8,500 cfs during Dec 15th – Mar 15th depending on Vernalis flow conditions[o]; additional capacity of 500 cfs (up to 7,180 cfs) allowed for Jul – Sep for reducing impact of NMFS BO (Jun 2009) Action IV.2.1 Phase II[v] on SWP[w]	Same
CVP C.W. Bill Jones Pumping Plant (Tracy PP)	Permit capacity is 4,600 cfs but exports limited to 4,200 cfs plus diversions upstream of DMC constriction	Permit capacity is 4,600 cfs in all months (allowed for by the Delta-Mendota Canal–California Aqueduct Intertie)
Upper Delta-Mendota Canal Capacity	Existing	Existing plus 400 cfs Delta-Mendota Canal–California Aqueduct Intertie
CCWD Intakes	Los Vaqueros existing storage capacity, 100 TAF, existing pump locations	Los Vaqueros existing storage capacity, 100 TAF, existing pump locations, Alternative Intake Project

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
		(AIP) included[p]
San Francisco Bay Region		
South Bay Aqueduct (SBA)	Existing capacity	SBA rehabilitation, 430 cfs capacity from junction with California Aqueduct to Alameda County FC&WSD Zone 7 diversion point
South Coast Region		
California Aqueduct East Branch	Existing capacity	Same
REGULATORY STANDARDS		
North Coast Region		
Trinity River		
Minimum flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/yr)	Same
Trinity Reservoir end-of-September minimum storage	Trinity EIS Preferred Alternative (600 TAF as able)	Same
Sacramento River Region		
Clear Creek		
Minimum flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to USFWS and NPS, predetermined CVPIA 3406(b)(2) flows[q], and NMFS BO (Jun 2009) Action I.1.1[v]	Same
Upper Sacramento River		
Shasta Lake end-of-September minimum storage	NMFS 2004 Winter-run Biological Opinion, (1900 TAF in non-critically dry years), and NMFS BO (Jun 2009) Action I.2.1[v]	Same
Minimum flow below Keswick Dam	SWRCB WR 90-5, predetermined CVPIA 3406(b)(2) flows[q], and NMFS BO (Jun 2009) Action I.2.2[v]	Same
Feather River		
Minimum flow below Thermalito Diversion Dam	2006 Settlement Agreement (700 / 800 cfs)	Same
Minimum flow below Thermalito	1983 DWR, DFG Agreement (750-1,700 cfs)	Same

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
Afterbay outlet		
Sacramento River Region (continued)		
Yuba River		
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord)[r]	Same
American River		
Minimum flow below Nimbus Dam	American River Flow Management[s] as required by NMFS BO (Jun 2009) Action II.1[v]	Same
Minimum Flow at H Street Bridge	SWRCB D-893	Same
Lower Sacramento River		
Minimum flow near Rio Vista	SWRCB D-1641	Same
San Joaquin River Region		
Mokelumne River		
Minimum flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100-325 cfs)	Same
Minimum flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25-300 cfs)	Same
Stanislaus River		
Minimum flow below Goodwin Dam	1987 USBR, DFG agreement, and flows required for NMFS BO (Jun 2009) Action III.1.2 and III.1.3[v]	Same
Minimum dissolved oxygen	SWRCB D-1422	Same

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
San Joaquin River Region (continued)		
Merced River		
Minimum flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180-220 cfs, Nov-Mar), and Cowell Agreement	Same
Minimum flow at Shaffer Bridge	FERC 2179 (25-100 cfs)	Same
Tuolumne River		
Minimum flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94-301 TAF/yr)	Same
San Joaquin River		
San Joaquin River below Friant Dam/ Mendota Pool	Water Year 2010 Interim Flows Project [u]	Same
Maximum salinity near Vernalis	SWRCB D-1641	Same
Minimum flow near Vernalis	SWRCB D-1641, and NMFS BO (Jun 2009) Action IV.2.1[v]	Same
Sacramento River – San Joaquin Delta Region		
Delta Outflow Index (Flow and Salinity)	SWRCB D-1641	SWRCB D-1641 and FWS BO (Dec 2008) Action 4
Delta Cross Channel gate operation	SRWCB D-1641 with additional days closed from Oct 1st – Jan 31st based on NMFS BO (Jun 2009) Action IV.1.2[v] (closed during flushing flows from Oct 1st – Dec 14th unless adverse water quality conditions)	Same
South Delta exports (Jones PP and Banks PP)	SWRCB D-1641, Vernalis flow-based export limits Apr 1st – May 31st as required by NMFS BO (Jun, 2009) Action IV.2.1[v] (additional 500 cfs allowed for Jul – Sep for reducing impact on SWP)[w]	Same
Combined Flow in Old and Middle River (OMR)	FWS BO (Dec 2008) Actions 1 through 3 and NMFS BO (Jun 2009) Action IV.2.3[v]	Same

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
OPERATIONS CRITERIA: RIVER-SPECIFIC		
Sacramento River Region		
Upper Sacramento River		
Flow objective for navigation (Wilkins Slough)	NMFS BO (Jun 2009) Action I.4[v]; 3,500 – 5,000 cfs based on CVP water supply condition	Same
American River		
Folsom Dam flood control	Variable 400/670 flood control diagram (without outlet modifications)	Same
Feather River		
Flow at Mouth of Feather River (above Verona)	Maintain DFG/DWR flow target of 2,800 cfs for Apr – Sep dependent on Oroville inflow and FRSA allocation	Same
San Joaquin River Region		
Stanislaus River		
Flow below Goodwin Dam[i]	Revised Operations Plan[t] and NMFS BO (Jun 2009) Action III.1.2 and III.1.3[v]	Same
San Joaquin River		
Salinity at Vernalis	Grasslands Bypass Project (partial implementation)	Grasslands Bypass Project (full implementation)
OPERATIONS CRITERIA: SYSTEMWIDE		
CVP water allocation		
Settlement / Exchange	100% (75% in Shasta critical years)	Same
Refuges	100% (75% in Shasta critical years)	Same
Agriculture Service	100%-0% based on supply, South-of-Delta allocations are additionally limited due to D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009)	Same

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
	export restrictions[v]	
Municipal & Industrial Service	100%-50% based on supply, South-of-Delta allocations are additionally limited due to D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions[v]	Same
SWP water allocation		
North of Delta (FRSA)	Contract specific	Same
South of Delta (including North Bay Aqueduct)	Based on supply; equal prioritization between Ag and M&I based on Monterey Agreement; allocations are additionally limited due to D-1641 and FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions[v]	Same
CVP-SWP coordinated operations		
Sharing of responsibility for in-basin-use	1986 Coordinated Operations Agreement (FRWP EBMUD and 2/3 of the North Bay Aqueduct diversions considered as Delta Export; 1/3 of the North Bay Aqueduct diversion as in-basin-use)	Same
Sharing of surplus flows	1986 Coordinated Operations Agreement	Same
Sharing of total allowable export capacity for project-specific priority pumping	Equal sharing of export capacity under SWRCB D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions[v]	Same
Water transfers	Acquisitions by SWP contractors are wheeled at priority in Banks Pumping Plant over non-SWP users; LYRA included for SWP contractors[w]	Same
Sharing of total allowable export capacity for lesser priority and wheeling-related pumping	Cross Valley Canal wheeling (max of 128 TAF/yr), CALFED ROD defined Joint Point of Diversion (JPOD)	Same
San Luis Reservoir	San Luis Reservoir is allowed to operate to a minimum storage of 100 TAF	Same

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
CVPIA 3406(b)(2)[v,q]		
Policy Decision	Per May 2003 Dept. of Interior Decision:	Same
Allocation	800 TAF, 700 TAF in 40-30-30 dry years, and 600 TAF in 40-30-30 critical years as a function of Ag allocation	Same
Actions	Pre-determined upstream fish flow objectives below Whiskeytown and Keswick Dams, non-discretionary NMFS BO (Jun 2009) actions for the American and Stanislaus Rivers, and NMFS BO (Jun 2009) and FWS BO (Dec 2008) actions leading to export restrictions[v]	Same
CVPIA 3406(b)(2)[v,q] (continued)		
Accounting	Releases for non-discretionary FWS BO (Dec 2008) and NMFS BO (Jun 2009)[v] actions may or may not always be deemed (b)(2) actions; in general, it is anticipated, that accounting of these actions using (b)(2) metrics, the sum would exceed the (b)(2) allocation in many years; therefore no additional actions are considered and no accounting logic is included in the model [q]	Same
WATER MANAGEMENT ACTIONS		
Water Transfer Supplies (long term programs)		
Lower Yuba River Accord[w]	Yuba River acquisitions for reducing impact of NMFS BO export restrictions[v] on SWP	Same
Phase 8	None	None
Water Transfers (short term or temporary programs)		
Sacramento Valley acquisitions conveyed through Banks PP[x]	Post-analysis of available capacity	Post-analysis of available capacity

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

Notes:

[a] These assumptions have been developed under the direction of the Department of Water Resources (Department) and Bureau of Reclamation (Reclamation) management team for the Bay Delta Conservation Plan (BDCP) HCP and EIR/EIS. Only operational components of 2008 USFWS and 2009 NMFS BOs as of demarcation date of Existing Conditions and the No action Alternative assumptions are included. Restoration of at least 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh required by the 2008 USFWS BO and restoration of at least 17,000 to 20,000 acres of floodplain rearing habitat for juvenile winter-run and spring-run Chinook salmon and Central Valley steelhead in the Yolo Bypass and/or suitable areas of the lower Sacramento River required by the NMFS 2009 BO are not included in the No Action Alternative assumptions because environmental documents of projects regarding these actions were not completed as of the publication date of the Notice of Preparation/Notice of Intent (February 13, 2009).

[b] The Sacramento Valley hydrology used in the Existing Conditions CALSIM II model reflects nominal 2005 land-use assumptions. The nominal 2005 land-use was determined by interpolation between the 1995 and projected 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects 2005 land-use assumptions developed by Reclamation. Existing-level projected land-use assumptions are being coordinated with the California Water Plan Update for future models.

[c] The Sacramento Valley hydrology used in the No Action Alternative CALSIM II model reflects 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation. Development of Future-level projected land-use assumptions are being coordinated with the California Water Plan Update for future models.

[d] CVP contract amounts have been updated according to existing and amended contracts as appropriate. Assumptions regarding CVP agricultural and M&I service contracts and Settlement Contract amounts are documented in the Delivery Specifications attachments.

[e] SWP contract amounts have been updated as appropriate based on recent Table A transfers/agreements. Assumptions regarding SWP agricultural and M&I contract amounts are documented in the Delivery Specifications attachments.

[f] Water needs for federal refuges have been reviewed and updated as appropriate. Assumptions regarding firm Level 2 refuge water needs are documented in the Delivery Specifications attachments. Refuge Level 4 (and incremental Level 4) water is not analyzed.

[g] Assumptions regarding American River water rights and CVP contracts are documented in the Delivery Specifications attachments. The Sacramento Area Water Forum agreement, its dry year diversion reductions, Middle Fork Project operations and "mitigation" water is not included.

[h] The new CALSIM II representation of the San Joaquin River has been included in this model package (CALSIM II San Joaquin River Model, Reclamation, 2005). Updates to the San Joaquin River have been included since the preliminary model release in August 2005. The model reflects the difficulties of on-going groundwater overdraft problems. The 2030 level of development representation of the San Joaquin River Basin does not make any attempt to offer solutions to groundwater overdraft problems. In addition a dynamic groundwater simulation is not yet developed for the San Joaquin River Valley. Groundwater extraction/ recharge and stream-groundwater interaction are static assumptions and may not accurately reflect a response to simulated actions. These limitations should be considered in the analysis of results.

[i] The CALSIM II model representation for the Stanislaus River does not necessarily represent Reclamation's current or future operational policies. A suitable plan for supporting flows has not been developed for NMFS BO (Jun 2009) Action 3.1.3.

[j] The actual amount diverted is operated in conjunction with supplies from the Los Vaqueros project. The existing Los Vaqueros storage capacity is 100 TAF. Associated water rights for Delta excess flows are included.

[k] Under Existing Conditions it is assumed that SWP Contractors demand for Table A allocations vary from 3.0 to 4.1 MAF/year. Under the No Action Alternative, it

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

is assumed that SWP Contractors can take delivery of all Table A allocations and Article 21 supplies. Article 56 provisions are assumed and allow for SWP Contractors to manage storage and delivery conditions such that full Table A allocations can be delivered. Article 21 deliveries are limited in wet years under the assumption that demand is decreased in these conditions. Article 21 deliveries for the NBA are dependent on excess conditions only, all other Article 21 deliveries also require that San Luis Reservoir be at capacity and that Banks PP and the California Aqueduct have available capacity to divert from the Delta for direct delivery.

[l] PCWA American River pumping facility upstream of Folsom Lake is included in both the Existing and No Action Alternative No Action Alternative . The diversion is assumed to be 35.5 TAF/Yr.

[m] footnote removed

[n] footnote removed

[o] Current ACOE permit for Banks PP allows for an average diversion rate of 6,680 cfs in all months. Diversion rate can increase up to 1/3 of the rate of San Joaquin River flow at Vernalis during Dec 15th – Mar 15th up to a maximum diversion of 8,500 cfs, if Vernalis flow exceeds 1,000 cfs.

[p] The CCWD Alternate Intake Project (AIP), an intake at Victoria Canal, which operates as an alternate Delta diversion for Los Vaqueros Reservoir. This assumption is consistent with the future no-project condition defined by the Los Vaqueros Enlargement study team.

[q] CVPIA (b)(2) fish actions are not dynamically determined in the CALSIM II model, nor is (b)(2) accounting done in the model. Since the FWS BO and NMFS BO were issued, the Department of the Interior (Interior) has exercised its discretion to use (b)(2) in the delta by accounting some or all of the export reductions required under those biological opinions as (b)(2) actions. It is therefore assumed for modeling purposes that (b)(2) availability for other delta actions will be limited to covering the CVP's VAMP export reductions. Similarly, since the FWS BO and NMFS BO were issued, Interior has exercised its discretion to use (b)(2) upstream by accounting some or all of the release augmentations (relative to the hypothetical (b)(2) base case) below Whiskeytown, Nimbus and Goodwin as (b)(2) actions. It is therefore assumed for modeling purposes that (b)(2) availability for other upstream actions will be limited to covering Sacramento releases, in the fall and winter. For modeling purposes, pre-determined timeseries of minimum instream flow requirements are specified. The timeseries are based on the Aug 2008 BA Study 7.0 and Study 8.0 simulations which did include dynamically determined (b)(2) actions.

[r] D-1644 and the Lower Yuba River Accord is assumed to be implemented for Existing and No Action Alternative No Action Alternative . The Yuba River is not dynamically modeled in CALSIM II. Yuba River hydrology and availability of water acquisitions under the Lower Yuba River Accord are based on modeling performed and provided by the Lower Yuba River Accord EIS/EIR study team.

[s] Under Existing Conditions, the flow components of the proposed American River Flow Management are as required by the NMFS BO (June 4th 2009).

[t] The model operates the Stanislaus River using a 1997 Interim Plan of Operation-like structure, i.e., allocating water for SEWD & CSJWCD, Vernalis water quality dilution and Vernalis D1641 flow requirements based on the New Melones Index. OID & SSJID allocations are based on their 1988 agreement and Ripon DO requirements are represented by a static set of minimum instream flow requirements during Jun thru Sep. Instream flow requirements for fish below Goodwin are based on NMFS BO Action III.1.2. NMFS BO Action IV.2.1's flow component is not assumed to be in effect.

[u] SJR Restoration Water Year 2010 Interim Flows Project are assumed, but are *not input into the models; operation not regularly defined at this time*

[v] In cooperation with Reclamation, National Marine Fisheries Service, Fish and Wildlife Service, and Ca Department of Fish and Game, the Ca Department of Water Resources has developed assumptions for implementation of the FWS BO (Dec 15th 2008) and NMFS BO (June 4th 2009) in CALSIM II.

[w] Acquisitions of Component 1 water under the Lower Yuba River Accord, and use of 500 cfs dedicated capacity at Banks PP during Jul – Sep, are assumed to be used to reduce as much of the impact of the Apr – May Delta export actions on SWP contractors as possible.

TABLE B-8
CALSIM II Inputs
Proposed Assumptions

[x] Only acquisitions of Lower Yuba River Accord Component 1 water are included.

DSM2 Assumptions

This subsection provides a summary of the DSM2 assumptions for the Existing Conditions and No Action Alternative. These assumptions were selected by the Department of Water Resources (DWR) management team for the BDCP EIR/EIS in coordination with the Reclamation, USFWS and NMFS. The assumptions for each scenario are listed in Table B-9. The information included in here is consistent with what was provided to and agreed to by the lead agencies in the "Confirmation of Final Assumptions for Existing and Future No Action Alternative Conditions CALSIM II and DSM2 Models", on March 10, 2010. It also includes any modifications requested by the lead agency staff to improve readability and include additional clarification to the stated assumptions.

TABLE B-9
DSM2 Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
Period of simulation	16 years (1976-1991)[a,b]	Same
REGIONAL SUPPLIES		
Boundary flows	Monthly timeseries from CALSIM II output *(alternatives provide different flows and exports)*[c]	Same
REGIONAL DEMANDS AND CONTRACTS		
Ag flows (DICU)	2005 Level, DWR Bulletin 160-98[d]	2020 Level, DWR Bulletin 160-98[d]
TIDAL BOUNDARY		
Martinez stage	15-minute adjusted astronomical tide[a]	Same
WATER QUALITY		
Vernalis EC	Monthly time series from CALSIM II output[e]	Monthly time series from CALSIM II output[e]
Agricultural Return EC	Municipal Water Quality Investigation Program analysis	Same
Martinez EC	Monthly net Delta Outflow from CALSIM output & G-model[f]	Monthly net Delta Outflow from CALSIM output & G-model[f]

TABLE B-9
DSM2 Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
MORPHOLOGICAL CHANGES		
Mokelumne River	None	None
San Joaquin River	None	None
Middle River	None	None
Dutch Slough Restoration Project	None	None
FACILITIES		
Contra Costa Water District Delta Intakes	Rock Slough Pumping Plant, Old River at Highway 4 Intake	Rock Slough Pumping Plant, Old River at Highway 4 Intake and Alternate Improvement Project Intake on Victoria Canal
South Delta barriers	Temporary Barriers Program	Same
Two Gate Program	None	None
Franks Tract Program	None	None
SPECIFIC PROJECTS		
Water Supply Intake Projects		
Freeport Regional Water Project	None	Monthly output from CALSIM II
Stockton Delta Water Supply Project	None	Monthly output from CALSIM II
Antioch Water Works	Monthly output from CALSIM II	Monthly output from CALSIM II
Sanitary and Agricultural Discharge Projects		
Veale Tract Drainage Relocation	The Veale Tract Water Quality Improvement Project, funded by CALFED, relocates the agricultural drainage outlet was relocated from Rock Slough channel to the southern end of Veale Tract, on Indian Slough[k]	Same

TABLE B-9
DSM2 Inputs
Proposed Assumptions

	Existing Conditions Assumption	No Action Alternative Assumption
OPERATIONS CRITERIA		
Delta Cross Channel	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output
Clifton Court Forebay	Priority 3, gate operations synchronized with incoming tide to minimize impacts to low water levels in nearby channels	Same
South Delta barriers	Temporary Barriers Project operated based on San Joaquin River flow time series from CALSIM II output; HORB is assumed only installed[l] Sep 16 – Nov 30; Agricultural barriers on Old and Middle Rivers are assumed to be installed starting from May 16th and on Grant Line Canal from June 1st; All three barriers are allowed to be operated until November 30th; May 16th to May 31st; the tidal gates are assumed to be tied open for the barriers on Old and Middle Rivers[m].	Same

TABLE B-9
DSM2 Inputs
Proposed Assumptions

Notes:

[a] A new adjusted astronomical tide for use in DSM2 planning studies has been developed by DWR's Bay Delta Office Modeling Support Branch Delta Modeling Section in cooperation with the Common Assumptions workgroup. This tide is based on a more extensive observed dataset and covers the entire 82-year period of record.

[b] The 16-year period of record is the simulation period for which DSM2 has been commonly used for impacts analysis in many previous projects, and includes varied water year types.

[c] Although monthly CALSIM output was used as the DSM2-HYDRO input, the Sacramento and San Joaquin rivers were interpolated to daily values in order to smooth the transition from high to low and low to high flows. DSM2 then uses the daily flow values along with a 15-minute adjusted astronomical tide to simulate effect of the spring and neap tides.

[d] The Delta Island Consumptive Use (DICU) model is used to calculate diversions and return flows for all Delta islands based on the level of development assumed. The nominal 2005 Delta region hydrology land-use was determined by interpolation between the 1995 and projected 2020 land-use assumptions associated with Bulletin 160-98.

[e] CALSIM II calculates monthly EC for the San Joaquin River, which was then converted to daily EC using the monthly EC and flow for the San Joaquin River. Fixed concentrations of 150, 175, and 125 µmhos/cm were assumed for the Sacramento River, Yolo Bypass, and eastside streams, respectively.

[f] Net Delta outflow based on the CALSIM II flows was used with an updated G-model to calculate Martinez EC. Under changed climate conditions Martinez EC is modified to account for the sea level rise at early (15 cm) and late (45 cm) long-term phases (Year 2060).

[g] footnote removed.

[h] footnote removed.

[i] footnote removed.

[j] footnote removed.

[k] Information was obtained based on the information from the draft final "Delta Region Drinking Water Quality Management Plan" dated June 2005 prepared under the CALFED Water Quality Program and a presentation by David Briggs at SWRCB public workshop for periodic review. The presentation "Compliance location at Contra Costa Canal at Pumping Plant #1 – Addressing Local Degradation" notes that the Veale Tract drainage relocation project will be operational in June 2005. The DICU drainage currently simulated at node 204 is moved to node 202 in DSM2.

[l] Based on the FWS Delta Smelt BO Action 5, Head of Old River Barrier (HORB) is assumed to be not installed in April or May; therefore HORB is only installed in the Fall as shown.

[m] Based on the FWS Delta Smelt BO Action 5 and the project description provided in the page 119.

B.6. Long-Term Water Operations Assumptions for BDCP Alternatives

The long-term water operations assumptions for all the Alternatives are tabulated in this Section. Tables B-10 to B-17 show the assumptions provided by the lead agencies for the Alternatives. These assumptions were selected by the Lead Agencies for the BDCP EIR/EIS including DWR, Reclamation, USFWS and NMFS.

Table B-10 - Alternatives 1A, 1B, 1C, and 3
Table B-11 - Alternatives 6A, 6B, and 6C
Table B-12 - Alternatives 2A, 2B, 2C
Table B-13 - Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4
Table B-14 - Alternative 5
Table B-15 - Alternative 7
Table B-16 - Alternative 8
Table B-17 - Alternative 9

Table B-10. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 1A, 1B, 1C, and 3
Based upon "January 2010 BDCP Steering Committee Presentation" for Dual Conveyance (revised February 2010)

<table>
<tr><th colspan="9">North Delta Diversion Bypass Flows</th></tr>
<tr><td colspan="9">1. North Delta Diversion Bypass Flows
Objectives include flows of the functional equivalent thereof to (1) maintain fish screen sweeping velocities, (2) reduce upstream transport from downstream channels, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) reduce predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.</td></tr>
<tr><td colspan="9"><u>Constant Low-Level Pumping (Dec-Jun):</u>
Diversions up to 6% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.</td></tr>
<tr><td colspan="9"><u>Initial Pulse Protection:</u>
Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement.
If the first flush begins before Dec 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.</td></tr>
<tr><td colspan="9"><u>Post-Pulse Operations:</u>
After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.</td></tr>
<tr><td colspan="9">Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows</td></tr>
<tr><th colspan="3">Level I Post-Pulse Operations</th><th colspan="3">Level II Post-Pulse Operations</th><th colspan="3">Level III Post Pulse Operations</th></tr>
<tr><td colspan="3">Based on the objectives stated above, it is recommended to implement the following operating criteria:
• Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.</td><td colspan="3">Based on the objectives stated above, it is recommended to implement the following operating criteria:
• Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.</td><td colspan="3">Based on the objectives stated above, it is recommended to implement the following operating criteria:
• Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.</td></tr>
<tr><th colspan="3">Dec - Apr</th><th colspan="3">Dec - Apr</th><th colspan="3">Dec - Apr</th></tr>
<tr><th>If Sacramento River flow is over...</th><th>But not over...</th><th>The bypass is...</th><th>If Sacramento River flow is over...</th><th>But not over...</th><th>The bypass is...</th><th>If Sacramento River flow is over...</th><th>But not over...</th><th>The bypass is...</th></tr>
</table>

Table B-10. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 1A, 1B, 1C, and 3 Based upon "January 2010 BDCP Steering Committee Presentation" for Dual Conveyance (revised February 2010)

0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May			**May**			**May**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)

Table B-10. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 1A, 1B, 1C, and 3
Based upon "January 2010 BDCP Steering Committee Presentation" for Dual Conveyance (revised February 2010)

15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
Jun			**Jun**			**Jun**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs

Table B-10. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 1A, 1B, 1C, and 3
Based upon "January 2010 BDCP Steering Committee Presentation" for Dual Conveyance (revised February 2010)

20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs		

South Delta Channel Flows

2. South Delta Channel Flows

Minimize take at south Delta pumps by reducing incidence and magnitude of reverse flows during critical periods for pelagic species.

OMR Flows

• FWS smelt and NMFS BO's model of adaptive restrictions (temperature, turbidity, salinity, smelt presence)

Table below provides a rough representation of the current estimate of "most likely" operation under FWS and NMFS BO's for modeling purposes.

Combined Old and Middle River flows no less than values below* (cfs)

Month	W	AN	BN	D	C
Jan	-4000	-4000	-4000	-5000	-5000
Feb	-5000	-4000	-4000	-4000	-4000
Mar	-5000	-4000	-4000	-3500	-3000
Apr	-5000	-4000	-4000	-3500	-2000
May	-5000	-4000	-4000	-3500	-2000
Jun	-5000	-5000	-5000	-5000	-2000
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	N/A	N/A	N/A	N/A	N/A
Nov	N/A	N/A	N/A	N/A	N/A
Dec	-6800	-6800	-6300	-6300	-6100

* Values are monthly average for use in modeling. December 20-31 targets are -5000 cfs (W, AN), -3500 cfs (BN, D), and -3000 cfs (C), and are averaged with an assumed background of -8000 cfs for December 1-19. Values are reflective of the "most likely" operation under the FWS Delta Smelt Biological Opinion. Values for modeling may be updated based on review by fishery agencies.

Table B-10. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 1A, 1B, 1C, and 3
Based upon "January 2010 BDCP Steering Committee Presentation" for Dual Conveyance (revised February 2010)

Fremont Weir/Yolo Bypass
3. Fremont Weir/Yolo Bypass *Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.*
Sacramento Weir - No change in operations; improve upstream fish passage facilities
Lisbon Weir - No change in operations; improve upstream fish passage facilities
Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities; construct opening and operable gates at a smaller opening with fish passage enhancement at elevation 11.5 feet
Fremont Weir Gate Operations -
December 1-March 30 (extend to May 15, depending on hydrologic conditions and measures to minimize land use and ecological conflicts) open the 17.5 foot and 11.5 foot elevation gates when Sacramento River flow at Freeport is greater than 25,000 cfs (provides local and regional flood control benefit and coincides with pulse flows and juvenile salmonid migration cues, provides seasonal floodplain inundation for food production, juvenile rearing, and spawning) to provide Yolo Bypass inundation of 3,000 to 6,000 cfs depending on river stage. Operating the gates to allow Yolo Bypass inundation when Sacramento River flow is greater than 25,000 cfs will reduce impacts to water supply associated with Hood bypass flow constraints. Potential impacts to water supply would be avoided or minimized through an operations plan.
Close the 17.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 20,000 cfs but keep 11.5 foot elevation gates open to provide greater opportunity for fish within the bypass to migrate upstream into the Sacramento River; close 11.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 15,000 cfs
Delta Cross Channel Gate Operations
4. Delta Cross Channel Gate Operations Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.
Oct-Nov: DCC gate closed if fish are present (assume 15 days per month; may be open longer depending on presence of fish) Dec-Jun: DCC gate closed Jul-Sep: DCC gate open
Rio Vista Minimum Instream Flows
5. Rio Vista Minimum Instream Flows Maintain minimum flows for outmigrating salmonids and smelt.
Sep-Dec: Per D-1641 Jan-Aug: Minimum of 3,000 cfs

Table B-10. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 1A, 1B, 1C, and 3
Based upon "January 2010 BDCP Steering Committee Presentation" for Dual Conveyance (revised February 2010)

Delta Inflow & Outflow
6. Delta Inflow & Outflow Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring, (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.
Delta Outflow: Jul-Jan: Per D-1641 Feb-Jun: Per D-1641 - Proportional Reservoir Release concept will continue to be evaluated to the extent that it provides similar response to outflow, inflow, and upstream storage conditions
Operations for Delta Water Quality and Residence Time
7. Operations for Delta Water Quality and Residence Time Considerations include (1) maintain a minimum level of pumping from the south Delta during summer to provide limited flushing for general water quality conditions (reduce residence times), (2) for M&I and AG salinity improvements, and (3) to allow operational flexibility during other periods to operate either north or south diversions based on real-time assessments of benefits to fish and water quality.
Assumptions: Jul-Sep: Prefer south delta pumping up to 3,000 cfs before diverting from north Oct-Jun: Prefer north delta pumping (real-time operational flexibility)
In-Delta Agricultural and Municipal & Industrial Water Quality Requirements
8. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements Existing M&I and AG salinity requirements
Assumptions: Existing D-1641 North and Western Delta AG and MI standards EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.

Table B-11. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 6A, 6B, and 6C Based upon "January 2010 BDCP Steering Committee Presentation" for Isolated Conveyance

North Delta Diversion Bypass Flows

1. North Delta Diversion Bypass Flows

Objectives include flows or the functional equivalent thereof to (1) maintain fish screen sweeping velocities, (2) reduce upstream transport from downstream channels, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) reduce predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.

Constant Low-Level Pumping (Dec-Jun):

Diversions up to 6% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.

Initial Pulse Protection:

Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement.

If the first flush begins before Dec 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.

Post-Pulse Operations:

After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows

Level I Post-Pulse Operations			Level II Post-Pulse Operations			Level III Post Pulse Operations		
Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.			Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.			Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.		
Dec - Apr			**Dec - Apr**			**Dec - Apr**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**

Table B-11. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 6A, 6B, and 6C Based upon "January 2010 BDCP Steering Committee Presentation" for Isolated Conveyance

0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May			**May**			**May**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)

Table B-11. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 6A, 6B, and 6C Based upon "January 2010 BDCP Steering Committee Presentation" for Isolated Conveyance

15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
Jun			**Jun**			**Jun**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs

Table B-11. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 6A, 6B, and 6C
Based upon "January 2010 BDCP Steering Committee Presentation" for Isolated Conveyance

20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs		
South Delta Channel Flows - not included due to no operations of South Delta Intakes								
Fremont Weir/Yolo Bypass								
2. Fremont Weir/Yolo Bypass *Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.*								
Sacramento Weir - No change in operations; improve upstream fish passage facilities								
Lisbon Weir - No change in operations; improve upstream fish passage facilities								
Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities; construct opening and operable gates at a smaller opening with fish passage enhancement at elevation 11.5 feet								
Fremont Weir Gate Operations -								
December 1-March 30 (extend to May 15, depending on hydrologic conditions and measures to minimize land use and ecological conflicts) open the 17.5 foot and 11.5 foot elevation gates when Sacramento River flow at Freeport is greater than 25,000 cfs (provides local and regional flood control benefit and coincides with pulse flows and juvenile salmonid migration cues, provides seasonal floodplain inundation for food production, juvenile rearing, and spawning) to provide Yolo Bypass inundation of 3,000 to 6,000 cfs depending on river stage. Operating the gates to allow Yolo Bypass inundation when Sacramento River flow is greater than 25,000 cfs will reduce impacts to water supply associated with Hood bypass flow constraints. Potential impacts to water supply would be avoided or minimized through an operations plan.								
Close the 17.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 20,000 cfs but keep 11.5 foot elevation gates open to provide greater opportunity for fish within the bypass to migrate upstream into the Sacramento River; close 11.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 15,000 cfs								

Table B-11. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 6A, 6B, and 6C Based upon "January 2010 BDCP Steering Committee Presentation" for Isolated Conveyance

Delta Cross Channel Gate Operations
3. Delta Cross Channel Gate Operations Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.
Oct-Nov: DCC gate closed if fish are present (assume 15 days per month; may be open longer depending on presence of fish) Dec-Jun: DCC gate closed Jul-Sep: DCC gate open
Rio Vista Minimum Instream Flows
4. Rio Vista Minimum Instream Flows Maintain minimum flows for outmigrating salmonids and smelt.
Sep-Dec: Per D-1641 Jan-Aug: Minimum of 3,000 cfs
Delta Inflow & Outflow
5. Delta Inflow & Outflow Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring, (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.
<u>Delta Outflow:</u> Jul-Aug & Dec- Jan: Per D-1641 Sep-Nov: Fall X2 per FWS Smelt BO
Operations for Delta Water Quality and Residence Time - not included due to no operations of South Delta Intakes
In-Delta Agricultural and Municipal & Industrial Water Quality Requirements
6. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements Existing M&I and AG salinity requirements
<u>Assumptions:</u> Existing D-1641 North and Western Delta AG and MI standards EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.

Table B-12. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 2A, 2B, 2C for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2011)

North Delta Diversion Bypass Flows

1. North Delta Diversion Bypass Flows

Objectives include flows or the functional equivalent thereof to (1) provide North Delta bypass criteria with adaptive limits, (2) provide for Fall X2, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) reduce predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.

Constant Low-Level Pumping (Dec-Jun)

Diversions up to 6% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.

Initial Pulse Protection

Low level pumping maintained through the initial pulse period. For the purpose of modeling, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to pre-pulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (Sub-Table A). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement.

If the first flush begins before Dec 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.

Post-Pulse Operations

After initial flush(es), go to Level I post-pulse bypass rule (see Sub-Table A) until 15 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows

Level I Post-Pulse Operations			Level II Post-Pulse Operations			Level III Post Pulse Operations		
Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.			Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.			Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.		
Dec - Apr			**Dec - Apr**			**Dec - Apr**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs

Table B-12. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 2A, 2B, 2C for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2011)

5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May			**May**			**May**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)

Table B-12. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 2A, 2B, 2C for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2011)

15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
Jun			**Jun**			**Jun**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs

Table B-12. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 2A, 2B, 2C for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2011)

20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs		
South Delta Channel Flows								

2. South Delta Channel Flows

Minimize take at south Delta pumps by reducing incidence and magnitude of reverse flows during critical periods for pelagic species.

OMR Flows

All OMR criteria required by the various fish protection triggers (density, calendar, and flow based triggers) described in FWS and NMFS OCAP BOs were incorporated into the modeling of the baseline and the January, 2010 proposed project, as well as these newly proposed operational criteria. Whenever those triggers would result in OMRs higher than those shown below, the higher OMR requirements would be met.

Combined Old and Middle River flows no less than values below[1] (cfs)

Month	W	AN	BN	D	C
Jan	0	-3500	-4000	-5000	-5000
Feb	0	-3500	-4000	-4000	-4000
Mar	0	0	-3500	-3500	-3000
Apr	varies[2]	varies[2]	varies[2]	varies[2]	varies[2]
May	varies[2]	varies[2]	varies[2]	varies[2]	varies[2]
Jun	varies[2]	varies[2]	varies[2]	varies[2]	varies[2]
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	varies[3]	varies[3]	varies[3]	varies[3]	varies[3]
Nov	varies[3]	varies[3]	varies[3]	varies[3]	varies[3]
Dec	-5000[4]	-5000[4]	-5000[4]	-5000[4]	-5000[4]

Table B-12. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 2A, 2B, 2C for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2011)

1. These numbers represent the resulting average values based on the implementation of RPA-based triggers for the "most likely" scenario. OMR values assume the proposed OMR or the Reasonable and Prudent Alternative (RPA) (as modeled in the No Action Alternative), whichever provides higher OMR. Resulting operations are expected to be more positive than depicted in this table.

2. Based on San Joaquin inflow relationship to OMR provided below in Sub-Table B.

3. Before the D-1641pulse = HORB open, no OMR restrictions
During the D-1641pulse = no south Delta exports (two weeks); HORB closed
After the D-1641 pulse = -5,000 cfs OMR (through November); HORB open 50% for 2 weeks

4. OMR restriction of -5,000 cfs for Sacramento River winter-run Chinook salmon when North Delta initial pulse flows are triggered or OMR restriction of -2,000 cfs for delta smelt when triggered.

Head of Old River Operable Barrier (HORB) Operations/Modeling assumptions (% OPEN)

MONTH	HORB[1]	MONTH	HORB[1]
Oct	50%	May	50%
Nov	100%[2]	Jun 1-15	50%
Dec	100%	Jun 16-30	100%
Jan	50%[3]	Jul	100%
Feb	50%	Aug	100%
Mar	50%	Sep	100%
April	50%		

1. Percent of time the HORB is open. Agricultural barriers are in and operated consistent with current practices. HORB would be open 100% whenever flows are greater than 10,000 cfs at Vernalis.
2. For modeling assumption only. Action proposed:
Before the D-1641 pulse = no OMR restrictions (HORB open)
During the D-1641 pulse = no south Delta exports for two weeks (HORB closed)
After the D-1641 pulse = -5,000 cfs OMR through November (HORB open 50% for 2 weeks)
Exact timing of the action will be based on hydrologic conditions
3. The HORB becomes operational at 50% when salmon fry are immigrating (based on real time monitoring). This generally occurs when flood flow releases are being made.

Table B-12. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 2A, 2B, 2C for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2011)

Sub-Table B. San Joaquin Inflow Relationship to OMR

April and May		June	
If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (interpolated linearly between values)	If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following
≤ 5,000 cfs	-2,000 cfs	≤ 3,500 cfs	-3,500 cfs
6,000 cfs	+1,000 cfs	3,501 to 10,000 cfs	0 cfs
10,000 cfs	+2,000 cfs		
15,000 cfs	+3,000 cfs	10,001 to 15,000 cfs	+1,000 cfs
≥30,000 cfs	+6,000 cfs	>15,000 cfs	+2,000 cfs

Fremont Weir/Yolo Bypass

3. Fremont Weir/Yolo Bypass

Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.

Weir Improvements

Sacramento Weir - No change in operations; improve upstream fish passage facilities

Lisbon Weir - No change in operations; improve upstream fish passage facilities

Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities; construct opening and operable gates at a smaller opening with fish passage enhancement at elevation 11.5 feet

Fremont Weir Gate Operations

To provide seasonal floodplain inundation in the Yolo Bypass, the 17.5 foot and the 11.5 foot elevation gates are assumed to be opened between December 1st and March 31st. This may extend to May 15th, depending on the hydrologic conditions and the measures to minimize land use and ecological conflicts in the bypass. As a simplification for modeling, the gates are assumed opened until April 30th in all years. The gates are operated to limit maximum spill to 6,000 cfs until the Sacramento River stage reaches the existing Fremont Weir elevation. While desired inundation period is on the order of 30 to 45 days, gates are not managed to limit to this range, instead the duration of the event is governed by the Sacramento River flow conditions. To provide greater opportunity for the fish in the bypass to migrate upstream into the Sacramento River, the 11.5 foot elevation gate is assumed to be open for an extended period between September 15th and June 30th. As a simplification for modeling, the period of operation for this gate is assumed to be September 1st to June 30th. The spills through the 11.5 ft elevation gate are limited to 100 cfs to support fish passage.

Table B-12. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 2A, 2B, 2C for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2011)

Delta Cross Channel Gate Operations
4. Delta Cross Channel Gate Operations Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.
Assumptions Per SRWCB D-1641 with additional days closed from Oct 1 – Jan 31 based on NMFS BO (Jun 2009) Action IV.1.2v (closed during flushing flows from Oct 1 – Dec 14 unless adverse water quality conditions).
Rio Vista Minimum Instream Flows
5. Rio Vista Minimum Instream Flows Maintain minimum flows for outmigrating salmonids and smelt.
Assumptions Sep-Dec: Per D-1641 Jan-Aug: Minimum of 3,000 cfs
Delta Inflow & Outflow
6. Delta Inflow & Outflow Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring and fall, and (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.
Delta Outflow Feb-Jun: Per D-1641 Sep-Nov: Implement Fall X2 experiment
Operations for Delta Water Quality and Residence Time
7. Operations for Delta Water Quality and Residence Time Considerations include (1) maintain a minimum level of pumping from the south Delta during summer to provide limited flushing for general water quality conditions (reduce residence times), (2) for M&I and AG salinity improvements, and (3) to allow operational flexibility during other periods to operate either north or south diversions based on real-time assessments of benefits to fish and water quality.
Assumptions Jul-Sep: Prefer south delta pumping up to 3,000 cfs before diverting from north Oct-Jun: Prefer north delta pumping (real-time operational flexibility)

Table B-12. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternatives 2A, 2B, 2C for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2011)

In-Delta Agricultural and Municipal & Industrial Water Quality Requirements
8. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements Existing M&I and AG salinity requirements
Assumptions Existing D-1641 North and Western Delta AG and MI standards EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.

Table B-13. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4 for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2012)

Briefly, the Alternative 4 Decision Tree Scenarios are described as below:

- Alternative 4 Operational Scenario H1 (Alternative 4 H1) does not include enhanced spring outflow requirements or Fall X2 requirements
- Alternative 4 Operational Scenario H2 (Alternative 4 H2) includes enhanced spring outflow requirements but not Fall X2 requirements
- Alternative 4 Operational Scenario H3 (Alternative 4 H3) does not include enhanced spring outflow requirements but includes Fall X2 requirements (consistent with Alternatives 2A,2B,2C)
- Alternative 4 Operational Scenario H4 (Alternative 4 H4) includes both enhanced spring outflow requirements and Fall X2 requirements

The operational assumptions noted below are the same for all the Alternative 4 Decision Tree Scenarios unless noted explicitly.

North Delta Diversion Bypass Flows

1. North Delta Diversion Bypass Flows

Objectives include flows or the functional equivalent thereof to (1) provide North Delta bypass criteria with adaptive limits, (2) provide for Fall X2, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) reduce predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.

Constant Low-Level Pumping (Dec-Jun)

Diversions up to 6% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.

Initial Pulse Protection

Low level pumping maintained through the initial pulse period. For the purpose of modeling, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to pre-pulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (Sub-Table A). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement.

If the first flush begins before Dec 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.

Post-Pulse Operations

After initial flush(es), go to Level I post-pulse bypass rule (see Sub-Table A) until 15 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows

Level I Post-Pulse Operations	Level II Post-Pulse Operations	Level III Post Pulse Operations
Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.	Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.	Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.

Table B-13. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4 for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2012)

Dec - Apr			Dec - Apr			Dec - Apr		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May			**May**			**May**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs

Table B-13. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4 for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2012)

5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
Jun			**Jun**			**Jun**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs

Table B-13. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4 for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2012)

17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs		
South Delta Channel Flows								
2. South Delta Channel Flows *Minimize take at south Delta pumps by reducing incidence and magnitude of reverse flows during critical periods for pelagic species.*								

OMR Flows

All OMR criteria required by the various fish protection triggers (density, calendar, and flow based triggers) described in FWS and NMFS OCAP BOs were incorporated into the modeling of the baseline and the January, 2010 proposed project, as well as these newly proposed operational criteria. Whenever those triggers would result in OMRs higher than those shown below, the higher OMR requirements would be met.

Combined Old and Middle River flows no less than values below[1] (cfs)

Month	W	AN	BN	D	C
Jan	0	-3500	-4000	-5000	-5000
Feb	0	-3500	-4000	-4000	-4000
Mar	0	0	-3500	-3500	-3000
Apr	varies[2]	varies[2]	varies[2]	varies[2]	varies[2]
May	varies[2]	varies[2]	varies[2]	varies[2]	varies[2]
Jun	varies[2]	varies[2]	varies[2]	varies[2]	varies[2]
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	varies[3]	varies[3]	varies[3]	varies[3]	varies[3]
Nov	varies[3]	varies[3]	varies[3]	varies[3]	varies[3]
Dec	-5000[4]	-5000[4]	-5000[4]	-5000[4]	-5000[4]

Table B-13. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4 for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2012)

1. These numbers represent the resulting average values based on the implementation of RPA-based triggers for the "most likely" scenario. OMR values assume the proposed OMR or the Reasonable and Prudent Alternative (RPA) (as modeled in the No Action Alternative), whichever provides higher OMR. Resulting operations are expected to be more positive than depicted in this table.

2. Based on San Joaquin inflow relationship to OMR provided below in Sub-Table B.

3. Before the D-1641pulse = HORB open, no OMR restrictions
During the D-1641pulse = no south Delta exports (two weeks); HORB closed
After the D-1641 pulse = -5,000 cfs OMR (through November); HORB open 50% for 2 weeks

4. OMR restriction of -5,000 cfs for Sacramento River winter-run Chinook salmon when North Delta initial pulse flows are triggered or OMR restriction of -2,000 cfs for delta smelt when triggered.

Head of Old River Operable Barrier (HORB) Operations/Modeling assumptions (% OPEN)

MONTH	HORB[1]	MONTH	HORB[1]
Oct	50%	May	50%
Nov	100%[2]	Jun 1-15	50%
Dec	100%	Jun 16-30	100%
Jan	50%[3]	Jul	100%
Feb	50%	Aug	100%
Mar	50%	Sep	100%
April	50%		

4. Percent of time the HORB is open. Agricultural barriers are in and operated consistent with current practices. HORB would be open 100% whenever flows are greater than 10,000 cfs at Vernalis.
5. For modeling assumption only. Action proposed:
Before the D-1641 pulse = no OMR restrictions (HORB open)

During the D-1641 pulse = no south Delta exports for two weeks (HORB closed)
After the D-1641 pulse = -5,000 cfs OMR through November (HORB open 50% for 2 weeks)

Exact timing of the action will be based on hydrologic conditions

6. The HORB becomes operational at 50% when salmon fry are immigrating (based on real time monitoring). This generally occurs when flood flow releases are being made.

Table B-13. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4 for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2012)

Sub-Table B. San Joaquin Inflow Relationship to OMR			
April and May		**June**	
If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (interpolated linearly between values)	If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following
≤ 5,000 cfs	-2,000 cfs	≤ 3,500 cfs	-3,500 cfs
6,000 cfs	+1,000 cfs	3,501 to 10,000 cfs	0 cfs
10,000 cfs	+2,000 cfs		
15,000 cfs	+3,000 cfs	10,001 to 15,000 cfs	+1,000 cfs
≥30,000 cfs	+6,000 cfs	>15,000 cfs	+2,000 cfs

Fremont Weir/Yolo Bypass

3. Fremont Weir/Yolo Bypass

Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.

Weir Improvements

Sacramento Weir - No change in operations; improve upstream fish passage facilities

Lisbon Weir - No change in operations; improve upstream fish passage facilities

Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities; construct opening and operable gates at a smaller opening with fish passage enhancement at elevation 11.5 feet

Fremont Weir Gate Operations

To provide seasonal floodplain inundation in the Yolo Bypass, the 17.5 foot and the 11.5 foot elevation gates are assumed to be opened between December 1st and March 31st. This may extend to May 15th, depending on the hydrologic conditions and the measures to minimize land use and ecological conflicts in the bypass. As a simplification for modeling, the gates are assumed opened until April 30th in all years. The gates are operated to limit maximum spill to 6,000 cfs until the Sacramento River stage reaches the existing Fremont Weir elevation. While desired inundation period is on the order of 30 to 45 days, gates are not managed to limit to this range, instead the duration of the event is governed by the Sacramento River flow conditions. To provide greater opportunity for the fish in the bypass to migrate upstream into the Sacramento River, the 11.5 foot elevation gate is assumed to be open for an extended period between September 15th and June 30th. As a simplification for modeling, the period of operation for this gate is assumed to be September 1st to June 30th. The spills through the 11.5 ft elevation gate are limited to 100 cfs to support fish passage.

Table B-13. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4 for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2012)

Delta Cross Channel Gate Operations

4. Delta Cross Channel Gate Operations

Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.

Assumptions

Per SRWCB D-1641 with additional days closed from Oct 1 – Jan 31 based on NMFS BO (Jun 2009) Action IV.1.2v (closed during flushing flows from Oct 1 – Dec 14 unless adverse water quality conditions).

Rio Vista Minimum Instream Flows

5. Rio Vista Minimum Instream Flows

Maintain minimum flows for outmigrating salmonids and smelt.

Assumptions

Sep-Dec: Per D-1641

Jan-Aug: Minimum of 3,000 cfs

Delta Inflow & Outflow

6. Delta Inflow & Outflow

Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring and fall, and (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.

Delta Outflow

SWRCB D-1641 requirements, or outflow per requirements noted below, whichever is greater

Months	Scenario H1	Scenario H2	Scenario H3	Scenario H4
Spring (Mar-May):	Per D-1641	Per D-1641 and additional flow for the enhanced spring outflow requirement[1]	Per D-1641	Per D-1641 and additional flow for the enhanced spring outflow requirement[1]
Fall (Sep-Nov):	Per D-1641	Per D-1641	Implement Fall X2 experiment	Implement Fall X2 experiment

Notes:

[1] Enhanced Spring Delta Outflow required during the Mar-May period. This additional Mar-May Delta Outflow requirement is determined based on a 90% forecast of Mar-May Eight River Index (8RI). Each year in March, Spring Delta Outflow target for the Mar-May period is determined based on the forecasted Mar-May 8RI value and its exceedance probability from the Table below, linearly interpolating for values in-between. This additional spring outflow is not considered as an "in-basin use" for CVP-SWP Coordinated Operations. This outflow requirement is met through first by curtailing Delta exports at Banks and Jones Pumping Plants by an amount needed to meet the outflow target, such that the minimum exports are at least 1,500 cfs. In wetter years (< 50% exceedance), if the outflow target is not achieved by export curtailments, then the additional flow needed to meet the outflow target is released from the Oroville reservoir as long as its projected end-of-May storage is at or above 2 MAF.

Table B-13. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 4 Decision Tree Scenarios H1, H2, H3 and H4 for Dual Conveyance (DWR, DFG, Reclamation, USFWS, and NMFS 2012)

Percent Exceedance of Forecasted Mar-May 8RI:	10%	20%	30%	40%	50%	60%	70%	80%	90%
Proposed Mar-May Delta Outflow Target (cfs):	44,500	44,500	35,000	32,000	23,000	17,200	13,300	11,400	9,200

Operations for Delta Water Quality and Residence Time

7. Operations for Delta Water Quality and Residence Time

Considerations include (1) maintain a minimum level of pumping from the south Delta during summer to provide limited flushing for general water quality conditions (reduce residence times), (2) for M&I and AG salinity improvements, and (3) to allow operational flexibility during other periods to operate either north or south diversions based on real-time assessments of benefits to fish and water quality.

Assumptions

Jul-Sep: Prefer south delta pumping up to 3,000 cfs before diverting from north

Oct-Jun: Prefer north delta pumping (real-time operational flexibility)

In-Delta Agricultural and Municipal & Industrial Water Quality Requirements

8. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements

Existing M&I and AG salinity requirements

Assumptions

Existing D-1641 North and Western Delta AG and MI standards

EXCEPT move compliance point from Emmaton to Three Mile Slough juncture.

Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.

Table B-14. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 5 (CCWD 2011)

North Delta Diversion Bypass Flows

1. North Delta Diversion Bypass Flows

Objectives include flows of the functional equivalent thereof to (1) maintain fish screen sweeping velocities, (2) reduce upstream transport from downstream channels, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) reduce predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.

Constant Low-Level Pumping (Dec-Jun):

Diversions up to 6% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.

Initial Pulse Protection:

Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement.

If the first flush begins before Dec 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.

Post-Pulse Operations:

After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule.

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows

Level I Post-Pulse Operations			Level II Post-Pulse Operations			Level III Post Pulse Operations		
Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.			Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.			Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) Sacramento River downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.		
Dec - Apr			**Dec - Apr**			**Dec - Apr**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs

Table B-14. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 5 (CCWD 2011)

5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May			**May**			**May**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs

Table B-14. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 5 (CCWD 2011)

17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
Jun			**Jun**			**Jun**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs		

Table B-14. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 5 (CCWD 2011)

South Delta Channel Flows

2. South Delta Channel Flows

Minimize take at south Delta pumps by reducing incidence and magnitude of reverse flows during critical periods for pelagic species.

OMR Flows

• FWS smelt and NMFS BO's model of adaptive restrictions (temperature, turbidity, salinity, smelt presence)

Table below provides a rough representation of the current estimate of "most likely" operation under FWS and NMFS BO's for modeling purposes.

Combined Old and Middle River flows no less than values below* (cfs)

Month	W	AN	BN	D	C
Jan	-4000	-4000	-4000	-5000	-5000
Feb	-5000	-4000	-4000	-4000	-4000
Mar	-5000	-4000	-4000	-3500	-3000
Apr	-5000	-4000	-4000	-3500	-2000
May	-5000	-4000	-4000	-3500	-2000
Jun	-5000	-5000	-5000	-5000	-2000
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	N/A	N/A	N/A	N/A	N/A
Nov	N/A	N/A	N/A	N/A	N/A
Dec	-6800	-6800	-6300	-6300	-6100

* Values are monthly average for use in modeling. December 20-31 targets are -5000 cfs (W, AN), -3500 cfs (BN, D), and -3000 cfs (C), and are averaged with an assumed background of -8000 cfs for December 1-19. Values are reflective of the "most likely" operation under the FWS Delta Smelt Biological Opinion. Values for modeling may be updated based on review by fishery agencies.

South Delta Export - San Joaquin Inflow Ratio:

- Vernalis flow-based export limits Apr 1st – May 31st as required by NMFS BO (Jun, 2009) as assumed in No Action Alternative

Table B-14. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 5 (CCWD 2011)

Fremont Weir/Yolo Bypass
3. Fremont Weir/Yolo Bypass *Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.*
Sacramento Weir - No change in operations; improve upstream fish passage facilities
Lisbon Weir - No change in operations; improve upstream fish passage facilities
Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities; construct opening and operable gates at a smaller opening with fish passage enhancement at elevation 11.5 feet
Fremont Weir Gate Operations -
December 1-March 30 (extend to May 15, depending on hydrologic conditions and measures to minimize land use and ecological conflicts) open the 17.5 foot and 11.5 foot elevation gates when Sacramento River flow at Freeport is greater than 25,000 cfs (provides local and regional flood control benefit and coincides with pulse flows and juvenile salmonid migration cues, provides seasonal floodplain inundation for food production, juvenile rearing, and spawning) to provide Yolo Bypass inundation of 3,000 to 6,000 cfs depending on river stage. Operating the gates to allow Yolo Bypass inundation when Sacramento River flow is greater than 25,000 cfs will reduce impacts to water supply associated with Hood bypass flow constraints. Potential impacts to water supply would be avoided or minimized through an operations plan.
Close the 17.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 20,000 cfs but keep 11.5 foot elevation gates open to provide greater opportunity for fish within the bypass to migrate upstream into the Sacramento River; close 11.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 15,000 cfs
Delta Cross Channel Gate Operations
4. Delta Cross Channel Gate Operations Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.
Oct-Nov: DCC gate closed if fish are present (assume 15 days per month; may be open longer depending on presence of fish) Dec-Jun: DCC gate closed Jul-Sep: DCC gate open
Rio Vista Minimum Instream Flows
5. Rio Vista Minimum Instream Flows Maintain minimum flows for outmigrating salmonids and smelt.
Sep-Dec: Per D-1641 Jan-Aug: Minimum of 3,000 cfs

Table B-14. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 5 (CCWD 2011)

Delta Inflow & Outflow
6. Delta Inflow & Outflow Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring, (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.
<u>Delta Outflow:</u> Feb-Jun and Dec-Jan: Per D-1641 Sep-Nov: Implement Fall X2 per FWS BO
Operations for Delta Water Quality and Residence Time
7. Operations for Delta Water Quality and Residence Time Considerations include (1) maintain a minimum level of pumping from the south Delta during summer to provide limited flushing for general water quality conditions (reduce residence times), (2) for M&I and AG salinity improvements, and (3) to allow operational flexibility during other periods to operate either north or south diversions based on real-time assessments of benefits to fish and water quality.
<u>Assumptions:</u> Jul-Sep: Prefer south delta pumping up to 3,000 cfs before diverting from north Oct-Jun: Prefer north delta pumping (real-time operational flexibility)
In-Delta Agricultural and Municipal & Industrial Water Quality Requirements
8. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements Existing M&I and AG salinity requirements
<u>Assumptions:</u> Existing D-1641 North and Western Delta AG and MI standards EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.

Table B-15. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 7 for Dual Conveyance

North Delta Diversion Bypass Flows

1. North Delta Diversion Bypass Flows

Objectives include flows to (1) maintain fish screen sweeping velocities, (2) minimize upstream transport from downstream channels, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) minimize predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.

Constant Low-Level Pumping (Dec-Jun):

Diversions up to 5% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.

Initial Pulse Protection:

Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A for Level 1). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement.

If the first flush begins before Dec 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.

Post-Pulse Operations:

After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A for Level1) until 20 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule (Subtable A for Level II) until 45 (total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule (Subtable A for Level III).

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows

Level I Post-Pulse Operations			**Level II Post-Pulse Operations**			**Level III Post Pulse Operations**		
Based on the objectives stated above, it is recommended to implement the following operating criteria: • Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough. **Percentages will vary linearly over a 10-day period when transitioning between months.								
Dec - Apr			**Dec - Apr**			**Dec - Apr**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)

Table B-15. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 7 for Dual Conveyance

15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May			**May**			**May**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs

Table B-15. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 7 for Dual Conveyance

20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
Jun			**Jun**			**Jun**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs		
South Delta Channel Flows								
2. South Delta Channel Flows *Minimize mortality, including take at south Delta pumps, by reducing incidence and magnitude of reverse flows during critical periods for pelagic and anadromous species.*								

Table B-15. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 7 for Dual Conveyance

OMR Flows • South Delta exports cannot cause OMR to fall below +1,000 cfs during Dec-Mar. • South Delta exports cannot cause OMR to fall below +3,000 cfs during Jun. • South Delta pumping is not allowed during April, May, Oct, and Nov
South Delta Export - San Joaquin Inflow Ratio: - 50% Dec - Mar & Jun
Fremont Weir/Yolo Bypass
3. Fremont Weir/Yolo Bypass *Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.*
• Spills into Yolo Bypass enabled at water surface elevation 17.5 ft NAVD88 (~15,000 cfs Sac R at Fremont flow) by notch and new gates, as compared to current weir elevation of 33.5 ft (~56,000 cfs Fremont flow). • Flows: 3,000-8,000 cfs* depending on hydrology • Duration: 30-45 days • Period: Gates operable December - April 15 (occasionally April 16 – May 15 depending on hydrologic conditions). * Flows less than 3,000 cfs may require physical modifications to the Yolo Bypass and toe drain to achieve levels of desired floodplain habitat.
Delta Cross Channel Gate Operations
4. Delta Cross Channel Gate Operations Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.
Oct-Nov: DCC gate closed if fish are present (assume 15 days per month; may be open longer depending on presence of fish) Dec-Jun: DCC gate closed Jul-Sep: DCC gate open
Rio Vista Minimum Instream Flows
5. Rio Vista Minimum Instream Flows Maintain minimum flows for outmigrating salmonids and smelt.
Sep-Dec: Per D-1641 Jan-Aug: Minimum of 5,000 cfs

Table B-15. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 7 for Dual Conveyance

Delta Inflow & Outflow
6. Delta Inflow & Outflow Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring, (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.
<u>Delta Outflow:</u> Feb-Aug &Dec - Jan: Per D-1641 Sep-Nov: Fall X2 per FWS Smelt BO
Operations for Delta Water Quality and Residence Time
7. Operations for Delta Water Quality and Residence Time Considerations include (1) maintain a minimum level of pumping from the south Delta during summer to provide limited flushing for general water quality conditions (reduce residence times), (2) for M&I and AG salinity improvements, and (3) to allow operational flexibility during other periods to operate either north or south diversions based on real-time assessments of benefits to fish and water quality.
<u>Assumptions:</u> Jul-Sep: Prefer south delta pumping up to 3,000 cfs before diverting from north Oct-Jun: Prefer north delta pumping (real-time operational flexibility)
In-Delta Agricultural and Municipal & Industrial Water Quality Requirements
8. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements Existing M&I and AG salinity requirements
<u>Assumptions:</u> Existing D-1641 North and Western Delta AG and MI standards EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.

Table B-16. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 8 for Dual Conveyance

North Delta Diversion Bypass Flows

1. North Delta Diversion Bypass Flows

Objectives include flows to (1) maintain fish screen sweeping velocities, (2) minimize upstream transport from downstream channels, (3) support salmonid and pelagic fish transport to regions of suitable habitat, (4) minimize predation effects downstream, and (5) maintain or improve rearing habitat in the north Delta.

Constant Low-Level Pumping (Dec-Jun):

Diversions up to 5% of river flow for flows greater than 5,000 cfs. No more than 300 cfs at any one intake.

Initial Pulse Protection:

Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) flows decrease for 5 consecutive days, or (3) flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A for Level 1). These parameters are for modeling purposes. Actual operations will be based on real-time monitoring of fish movement.

If the first flush begins before Dec 1, May bypass criteria must be initiated following first flush and the second pulse period will have the same protective operation.

Post-Pulse Operations:

After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A for Level1) until 20 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule (Subtable A for Level II) until 45 (total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule (Subtable A for Level III).

Sub-Table A. Post-Pulse Operations for North Delta Diversion Bypass Flows

Based on the objectives stated above, it is recommended to implement the following operating criteria:

- Bypass flows sufficient to prevent upstream tidal transport at two points of control: (1) Sacramento River upstream of Sutter Slough and (2) downstream of Georgiana Slough. These points are used to prevent upstream transport toward the proposed intakes and to prevent upstream transport into Georgiana Slough.

**Percentages will vary linearly over a 10-day period when transitioning between months.

Level I Post-Pulse Operations			Level II Post-Pulse Operations			Level III Post Pulse Operations		
Dec - Apr			Dec - Apr			Dec - Apr		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)

Table B-16. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 8 for Dual Conveyance

15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs
May			**May**			**May**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs

Table B-16. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 8 for Dual Conveyance

20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs
Jun			**Jun**			**Jun**		
If Sacramento River flow is over...	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**	**If Sacramento River flow is over...**	**But not over...**	**The bypass is...**
0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs	0 cfs	5,000 cfs	100% of the amount over 0 cfs
5,000 cfs	15,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	11,000 cfs	Flows remaining after constant low level pumping (main table)	5,000 cfs	9,000 cfs	Flows remaining after constant low level pumping (main table)
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs
Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs			Jul-Sep: 5,000 cfs Oct-Nov: 7,000 cfs		
South Delta Channel Flows								
2. South Delta Channel Flows								

Table B-16. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 8 for Dual Conveyance

Minimize mortality, including take at south Delta pumps, by reducing incidence and magnitude of reverse flows during critical periods for pelagic and anadromous species.
<u>OMR Flows</u> • South Delta exports cannot cause OMR to fall below +1,000 cfs during Dec-Mar. • South Delta exports cannot cause OMR to fall below +3,000 cfs during Jun. • South Delta pumping is not allowed during April, May, Oct, and Nov
<u>South Delta Export - San Joaquin Inflow Ratio:</u> - 50% Dec - Mar & Jun
Fremont Weir/Yolo Bypass
3. Fremont Weir/Yolo Bypass *Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.*
• Spills into Yolo Bypass enabled at water surface elevation 17.5 ft NAVD88 (~15,000 cfs Sac R at Fremont flow) by notch and new gates, as compared to current weir elevation of 33.5 ft (~56,000 cfs Fremont flow). • Flows: 3,000-8,000 cfs* depending on hydrology • Duration: 30-45 days • Period: Gates operable December - April 15 (occasionally April 16 – May 15 depending on hydrologic conditions). * Flows less than 3,000 cfs may require physical modifications to the Yolo Bypass and toe drain to achieve levels of desired floodplain habitat.
Delta Cross Channel Gate Operations
4. Delta Cross Channel Gate Operations Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.
Oct-Nov: DCC gate closed if fish are present (assume 15 days per month; may be open longer depending on presence of fish) Dec-Jun: DCC gate closed Jul-Sep: DCC gate open
Rio Vista Minimum Instream Flows
5. Rio Vista Minimum Instream Flows Maintain minimum flows for outmigrating salmonids and smelt.

Table B-16. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 8 for Dual Conveyance

Sep-Dec: Per D-1641 Jan-Aug: Minimum of 5,000 cfs
Delta Inflow & Outflow
6. Delta Inflow & Outflow Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring, (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.
<u>Delta Outflow:</u> Feb-Aug &Dec - Jan: Per D-1641 Sep-Nov: Fall X2 per FWS Smelt BO SWRCB Flow Criteria of 55% of Unimpaired Flow at Freeport (capped at 40,000 cfs) Jan-Jun
Freeport Minimum Instream Flows
7. Freeport Minimum Instream Flows SWRCB Minimum Requirement of 55% of Unimpaired Flow at Freeport Jan-Jun Minimum flow requirement capped at 40,000 cfs To balance SWP and CVP contributions to the Freeport requirement, a minimum requirement is applied simultaneously at the mouth of the Feather River that is a proportional amount of the 55% Unimpaired Flow at Freeport.
Cold Water Pool Storage
8. Cold Water Pool Storage Trinity, Shasta, Oroville and Folsom storage were modified to enable more cold water pool storage: by increasing Storage Level 3 to 75% of the maximum storage, within Storage Level 3, exports are gradually reduced until Storage Level 2 is reached in the reservoir. Project Storage below 75% of maximum storage would be limited to releases for environmental uses and/or superior water rights.
Operations for Delta Water Quality and Residence Time
9. Operations for Delta Water Quality and Residence Time Considerations include (1) maintain a minimum level of pumping from the south Delta during summer to provide limited flushing for general water quality conditions (reduce residence times), (2) for M&I and AG salinity improvements, and (3) to allow operational flexibility during other periods to operate either north or south diversions based on

Table B-16. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 8 for Dual Conveyance

real-time assessments of benefits to fish and water quality.
Assumptions: Jul-Sep: Prefer south delta pumping up to 3,000 cfs before diverting from north Oct-Jun: Prefer north delta pumping (real-time operational flexibility)
In-Delta Agricultural and Municipal & Industrial Water Quality Requirements
10. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements Existing M&I and AG salinity requirements
Assumptions: Existing D-1641 North and Western Delta AG and MI standards EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.

Table B-17. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 9 Separated Corridors

Delta Cross Channel Criteria

1. Delta Cross Channel Criteria

Objectives to provide separated corridors for South Delta fish passage and water conveyance from Sacramento River to South Delta intakes

Delta Cross Channel Criteria:

Sacramento River Flows less than 11,000 cfs or over 25,000 cfs: Gates Closed

Sacramento River Flows 11,000 cfs to 25,000 cfs: Divert up to 25 percent of Sacramento River flow

South Delta Channel Flows

2. South Delta Channel Flows

Minimize take at south Delta pumps by reducing incidence and magnitude of reverse flows during critical periods for pelagic species.

Apply only to Middle River Flows except during flood events when South Delta gates are open

OMR Flows

• FWS smelt and NMFS BO's model of adaptive restrictions (temperature, turbidity, salinity, smelt presence) [when San Joaquin River flow at Vernalis is greater than 10,000 cfs]. When San Joaquin River flow at Vernalis is less than 10,000 cfs, these OMR restrictions are assumed to control the Middle River flow.

Table below provides a rough representation of the current estimate of "most likely" operation under FWS and NMFS BO's for modeling purposes.

Combined Old and Middle River flows no less than values below* (cfs)

Month	W	AN	BN	D	C
Jan	-4000	-4000	-4000	-5000	-5000
Feb	-5000	-4000	-4000	-4000	-4000
Mar	-5000	-4000	-4000	-3500	-3000
Apr	-5000	-4000	-4000	-3500	-2000
May	-5000	-4000	-4000	-3500	-2000
Jun	-5000	-5000	-5000	-5000	-2000
Jul	N/A	N/A	N/A	N/A	N/A
Aug	N/A	N/A	N/A	N/A	N/A
Sep	N/A	N/A	N/A	N/A	N/A
Oct	N/A	N/A	N/A	N/A	N/A
Nov	N/A	N/A	N/A	N/A	N/A
Dec	-6800	-6800	-6300	-6300	-6100

* Values are monthly average for use in modeling. December 20-31 targets are -5000 cfs (W, AN), -3500 cfs (BN, D), and -3000 cfs (C), and are averaged with an assumed background of -8000 cfs for December 1-19. Values are reflective of the "most likely" operation under the FWS Delta Smelt Biological Opinion. Values for modeling may be updated based on review by fishery agencies.

Table B-17. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 9 Separated Corridors

South Delta Export - San Joaquin Inflow Ratio: - Vernalis flow-based export limits Apr 1st – May 31st as required by NMFS BO (Jun, 2009) as assumed in No Action Alternative (when San Joaquin River flow at Vernalis is greater than 10,000 cfs)
Fremont Weir/Yolo Bypass
3. Fremont Weir/Yolo Bypass *Considerations include (1) increasing spawning and rearing habitat for splittail and rearing habitat for salmonids for >30 days, (2) providing alternate migration corridor to the mainstem Sacramento River, and (3) increasing effectiveness of habitat and food transport in Cache Slough.*
Sacramento Weir - No change in operations; improve upstream fish passage facilities
Lisbon Weir - No change in operations; improve upstream fish passage facilities
Fremont Weir – Improve fish passage at existing weir elevation; construct opening and operable gates at elevation 17.5 feet with fish passage facilities; construct opening and operable gates at a smaller opening with fish passage enhancement at elevation 11.5 feet
Fremont Weir Gate Operations -
December 1-March 30 (extend to May 15, depending on hydrologic conditions and measures to minimize land use and ecological conflicts) open the 17.5 foot and 11.5 foot elevation gates when Sacramento River flow at Freeport is greater than 25,000 cfs (provides local and regional flood control benefit and coincides with pulse flows and juvenile salmonid migration cues, provides seasonal floodplain inundation for food production, juvenile rearing, and spawning) to provide Yolo Bypass inundation of 3,000 to 6,000 cfs depending on river stage. Operating the gates to allow Yolo Bypass inundation when Sacramento River flow is greater than 25,000 cfs will reduce impacts to water supply associated with Hood bypass flow constraints. Potential impacts to water supply would be avoided or minimized through an operations plan.
Close the 17.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 20,000 cfs but keep 11.5 foot elevation gates open to provide greater opportunity for fish within the bypass to migrate upstream into the Sacramento River; close 11.5 foot elevation gates when Sacramento River flow at Freeport recedes to less than 15,000 cfs
Delta Cross Channel and Georgiana Slough Gate Operations
4. Delta Cross Channel Gate Operations Considerations include (1) reduce transport of outmigrating Sacramento River fish into central Delta, (2) maintain flows downstream on Sacramento River, (3) and providing sufficient Sacramento River flow into interior Delta when water quality for M&I and AG may be of concern.
Delta Cross Channel: Sacramento River Flows less than 11,000 cfs or over 25,000 cfs: Closed Sacramento River Flows 11,000 cfs to 25,000 cfs: Divert up to 25 percent of Sacramento River flow Georgiana Slough: Operated to limit flow to less than 7,500 cfs all year to prevent impingement of fish on screens. This will usually allow Georgiana Slough to be open until Sacramento River flow exceeds 45,000 cfs.

Table B-17. Long-Term BDCP Water Operations Proposal for BDCP EIR/EIS Alternative 9 Separated Corridors

Rio Vista Minimum Instream Flows
5. Rio Vista Minimum Instream Flows Maintain minimum flows for outmigrating salmonids and smelt.
Sep-Dec: Per D-1641 Jan-Aug: Minimum of 3,000 cfs
Delta Inflow & Outflow
6. Delta Inflow & Outflow Considerations include (1) Provide sufficient outflow to maintain desirable salinity regime downstream of Collinsville during the spring, (2) explore range of approaches toward providing additional variability to Delta inflow and outflow.
<u>Delta Outflow:</u> Jul-Aug & Dec-Jan: Per D1641 Sep-Nov: Implement Fall X2 per FWS Smelt BO
Mokelumne River Barriers
7. Mokelumne River Barriers Jan-July: Gates Closed (possibly with fish ladder) Aug-Dec: Gates Open.
In-Delta Agricultural and Municipal & Industrial Water Quality Requirements
8. In-Delta Agricultural and Municipal & Industrial Water Quality Requirements Existing M&I and AG salinity requirements
<u>Assumptions:</u> Existing D-1641 North and Western Delta AG and MI standards EXCEPT move compliance point from Emmaton to Three Mile Slough juncture. Maintain all water quality requirements contained in the NDWA/ DWR Contract and other DWR contractual obligations.

Table B-18: CALSIM II and DSM2 Modeling Assumptions for BDCP EIR/EIS Existing Conditions, No Action Alternative and Alternatives

CALSIM II Assumptions:

PARAMETER CATEGORY / STUDY	*EXISTING CONDITIONS*	*NO ACTION ALTERNATIVE*	*Alternative 1A, 1B, 1C*	*Alternative 2A, 2B, 2C*	*Alternative 3*	*Alternative 4*				*Alternative 5*	*Alternative 6A, 6B, 6C*	*Alternative 7*	*Alternative 8*	*Alternative 9*	*COMMENTS*
						H1 (Low Outflow Scenario)	*H2 (includes Enhanced Spring Outflow; excludes Fall X2)*	*H3 (excludes Enhanced Spring Outflow; includes Fall X2)*	*H4 (High Outflow Scenario)*						
GENERAL															
Planning horizon[a]	Year 2009/Year 2015	Year 2020/Year 2025/Year 2060	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Common Assumptions (CA) assumed 2004 and 2030; 2008 OCAP BA assumed 2005 and 2030
Demarcation date[a]	February 2009 (but with June 2009 NMFS BO included)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	CA assumed June 2004; 2008 OCAP BA assumed 2005
Period of simulation	82 years (1922-2003)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
HYDROLOGY															
Inflows/Supplies	Historical with modifications for operations upstream of rim reservoirs	Historical with modifications for operations upstream of rim reservoirs and with or without changed climate at Early Long Term (Year 2025) or Late Long Term (Year 2060)	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Level of development	Projected 2005 level[b]	Projected 2030 level[c]	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
DEMANDS, WATER RIGHTS, CVP/SWP CONTRACTS															
Sacramento River Region (excluding American River)															
CVP[d]	Land-use based, limited by contract amounts	Land-use based, full build-out of contract amounts	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; 2008 OCAP BA included updates to CA assumptions
SWP (FRSA)[e]	Land-use based, limited by contract amounts	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; 2008 OCAP BA included updates to CA assumptions
Non-project	Land-use based, limited by water rights and SWRCB decisions for existing facilities	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Antioch	Pre-1914 water right	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Not included in 2008 BA of CA assumptions
Federal refuges[f]	Recent historical Level 2 water needs	Firm Level 2 water needs	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Sacramento River Region - American River[g]															
Water rights	Year 2005	Year 2025, full water rights	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; CA assumed Sacramento Area Water Forum
CVP	Year 2005	Year 2025, full contracts, including Freeport Regional Water Project	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; CA assumed Sacramento Area Water Forum; CA did not include Sacramento River Water Reliability Project
San Joaquin River Region[h]															
Friant Unit	Limited by contract amounts, based on current allocation policy	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Lower Basin	Land-use based, based on district level operations and constraints	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Stockton Delta Water Supply project included from 2008 OCAP BA model
Stanislaus River[i]	Land-use based, Revised Operations Plan[t] and NFMS BO (Jun 2009) Actions III.1.2 and III.1.3[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 BA assumed draft Transitional Plan for Future; CA assumed Interim Operations Plan
San Francisco Bay, Central Coast, Tulare Lake and South Coast Regions (CVP/SWP project facilities)															
CVP[d]	Demand based on contracts amounts	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
CCWD[j]	195 TAF/yr CVP contract supply and water rights	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
SWP[e,k]	Variable demand, of 3.0-4.1 MAF/Yr, up to Table A amounts including all Table A transfers through 2008	Demand based on full Table A amounts	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA assumed 3.1 – 4.2 MAF/Yr variable demand for Existing; CA assumed Table A transfers only up through 2004.
Article 56	Based on 2001-08 contractor requests	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; CA assumed pattern based on 2002-06 contractor requests
Article 21	MWD demand up to 200 TAF/month from December to March subject to conveyance capacity, KCWA demand up to 180 TAF/month and other contractor demands up to 34 TAF/month in all months, subject to conveyance capacity	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA limited MWD Article 21 to 100 TAF/mon; CA assumed 50 TAF/YR for KCWA in Existing, 2,555 cfs max demand rate for KCWA in Future and unlimited for MWD in Future
North Bay Aqueduct (NBA)	71 TAF/yr demand under SWP contracts, up to 43.7 cfs of excess flow under Fairfield, Vacaville and Benecia Settlement Agreement	77 TAF/yr demand under SWP contracts, up to 43.7 cfs of excess flow under Fairfield, Vacaville and Benecia Settlement Agreement	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; CA assumed 48 TAF/Yr demand under SWP contracts and no Settlement Agreement
Federal refuges[f]	Recent historical Level 2 water needs	Firm Level 2 water needs	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
FACILITIES															
System-wide															
System-wide	Existing facilities	Same as Existing Conditions	Existing facilities and Isolated Facility	Existing facilities and Isolated Facility	Existing facilities and Isolated Facility	Existing facilities and Isolated Facility				Existing facilities and Isolated Facility	Isolated Facility	Existing facilities and Isolated Facility	Existing facilities and Isolated Facility	Existing Facilities and Separate Corridor	
Isolated Facility	None	Same as Existing Conditions	North Delta Diversion: maximum capacity of 15,000 cfs, diversion point near Hood	North Delta Diversion: maximum capacity of 15,000 cfs, diversion point near Hood	North Delta Diversion: maximum capacity of 6,000 cfs, diversion point near Hood	North Delta Diversion: maximum capacity of 9,000 cfs, diversion point near Hood				North Delta Diversion: maximum capacity of 3,000 cfs, diversion point near Hood	North Delta Diversion: maximum capacity of 15,000 cfs, diversion point near Hood	North Delta Diversion: maximum capacity of 9,000 cfs, diversion point near Hood	North Delta Diversion: maximum capacity of 9,000 cfs, diversion point near Hood	Same as No Action Alternative	
Sacramento River Region															
Shasta Lake	Existing, 4,552 TAF capacity	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Red Bluff Diversion Dam	Diversion dam operated gates out, except Jun 15th – Aug 31st based on NMFS BO (Jun 2009) Action I.3.2[v]; assume interim/ temporary facilities in place	Diversion dam operated with gates out all year, NMFS BO (Jun 2009) Action I.3.1[v]; assume permanent facilities in place	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA used May 15th – Sep 31st for Existing; modified to reflect NMFS BO (Jun 2009); CA assumed May 15th – Sep 15th for Future
Colusa Basin	Existing conveyance and storage facilities	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Upper American River[g,l]	PCWA American River Pump Station	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA document assumes permanent pump station in both conditions
Lower Sacramento River	None	Freeport Regional Water Project[n]	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA did not include SRWRP or FRWP in existing; CA did not include Sacramento River Water Reliability Project

PARAMETER CATEGORY / STUDY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	Alternative 1A, 1B, 1C	Alternative 2A, 2B, 2C	Alternative 3	Alternative 4 H1 (Low Outflow Scenario)	Alternative 4 H2 (includes Enhanced Spring Outflow; excludes Fall X2)	Alternative 4 H3 (excludes Enhanced Spring Outflow; includes Fall X2)	Alternative 4 H4 (High Outflow Scenario)	Alternative 5	Alternative 6A, 6B, 6C	Alternative 7	Alternative 8	Alternative 9	COMMENTS
Freemont Weir / Yolo bypass	Exisiting weir	Same as Existing Conditions	**Seasonal Floodplain Inundation** • Period of inundation o December 1 – March 31 (modeled as Dec 1 to Apr 30). o Operational gates at both 17.5 ft and 11.5 ft will be OPEN during this period. • Triggers for inundation o Spills over the Fremont Weir will be triggered based on the river flow. • Duration o Duration of event will be governed by the hydrologic conditions in the Sacramento River, restoring the natural synchrony of inundation timing and frequency with river flows. o While “desired” inundation is on the order of 30-45 days, no management of the gates will be implemented to limit to this range. • Target flows o Gates will be operated to limit maximum spill to 6,000 cfs until river stage reaches existing weir height **Fish Passage** • Period of concern o September 15 – June 30 based on NOAA, DFG, and USFWS anadromous fish surveys in Yolo Bypass o Low elevation gates (11.5 ft) will be OPEN during this period. • Target flows o Limit flows to 100 cfs as required for fish passage and flow continuity	**Seasonal Floodplain Inundation** • Period of inundation o December 1 – March 31 (modeled as Dec 1 to Apr 30). o Operational gates at both 17.5 ft and 11.5 ft will be OPEN during this period. • Triggers for inundation o Spills over the Fremont Weir will be triggered based on the river flow. • Duration o Duration of event will be governed by the hydrologic conditions in the Sacramento River, restoring the natural synchrony of inundation timing and frequency with river flows. o While “desired” inundation is on the order of 30-45 days, no management of the gates will be implemented to limit to this range. • Target flows o Gates will be operated to limit maximum spill to 6,000 cfs until river stage reaches existing weir height **Fish Passage** • Period of concern o September 15 – June 30 based on NOAA, DFG, and USFWS anadromous fish surveys in Yolo Bypass (modeled as Sep 1 to Jun 30). o Low elevation gates (11.5 ft) will be OPEN during this period. • Target flows o Limit flows to 100 cfs as required for fish passage and flow continuity	**Seasonal Floodplain Inundation** • Period of inundation o December 1 – March 31 (modeled as Dec 1 to Apr 30). o Operational gates at both 17.5 ft and 11.5 ft will be OPEN during this period. • Triggers for inundation o Spills over the Fremont Weir will be triggered based on the river flow. • Duration o Duration of event will be governed by the hydrologic conditions in the Sacramento River, restoring the natural synchrony of inundation timing and frequency with river flows. o While “desired” inundation is on the order of 30-45 days, no management of the gates will be implemented to limit to this range. • Target flows o Gates will be operated to limit maximum spill to 6,000 cfs until river stage reaches existing weir height **Fish Passage** • Period of concern o September 15 – June 30 based on NOAA, DFG, and USFWS anadromous fish surveys in Yolo Bypass (modeled as Sep 1 to Jun 30). o Low elevation gates (11.5 ft) will be OPEN during this period. • Target flows o Limit flows to 100 cfs as required for fish passage and flow continuity	**Seasonal Floodplain Inundation** • Period of inundation o December 1 – March 31 (modeled as Dec 1 to Apr 30). o Operational gates at both 17.5 ft and 11.5 ft will be OPEN during this period. • Triggers for inundation o Spills over the Fremont Weir will be triggered based on the river flow. • Duration o Duration of event will be governed by the hydrologic conditions in the Sacramento River, restoring the natural synchrony of inundation timing and frequency with river flows. o While “desired” inundation is on the order of 30-45 days, no management of the gates will be implemented to limit to this range. • Target flows o Gates will be operated to limit maximum spill to 6,000 cfs until river stage reaches existing weir height **Fish Passage** • Period of concern o September 15 – June 30 based on NOAA, DFG, and USFWS anadromous fish surveys in Yolo Bypass (modeled as Sep 1 to Jun 30). o Low elevation gates (11.5 ft) will be OPEN during this period. • Target flows o Limit flows to 100 cfs as required for fish passage and flow continuity				**Seasonal Floodplain Inundation** • Period of inundation o December 1 – March 31 (modeled as Dec 1 to Apr 30). o Operational gates at both 17.5 ft and 11.5 ft will be OPEN during this period. • Triggers for inundation o Spills over the Fremont Weir will be triggered based on the river flow. • Duration o Duration of event will be governed by the hydrologic conditions in the Sacramento River, restoring the natural synchrony of inundation timing and frequency with river flows. o While “desired” inundation is on the order of 30-45 days, no management of the gates will be implemented to limit to this range. • Target flows o Gates will be operated to limit maximum spill to 6,000 cfs until river stage reaches existing weir height **Fish Passage** • Period of concern o September 15 – June 30 based on NOAA, DFG, and USFWS anadromous fish surveys in Yolo Bypass (modeled as Sep 1 to Jun 30). o Low elevation gates (11.5 ft) will be OPEN during this period. • Target flows o Limit flows to 100 cfs as required for fish passage and flow continuity	**Seasonal Floodplain Inundation** • Period of inundation o December 1 – March 31 (modeled as Dec 1 to Apr 30). o Operational gates at both 17.5 ft and 11.5 ft will be OPEN during this period. • Triggers for inundation o Spills over the Fremont Weir will be triggered based on the river flow. • Duration o Duration of event will be governed by the hydrologic conditions in the Sacramento River, restoring the natural synchrony of inundation timing and frequency with river flows. o While “desired” inundation is on the order of 30-45 days, no management of the gates will be implemented to limit to this range. • Target flows o Gates will be operated to limit maximum spill to 6,000 cfs until river stage reaches existing weir height **Fish Passage** • Period of concern o September 15 – June 30 based on NOAA, DFG, and USFWS anadromous fish surveys in Yolo Bypass (modeled as Sep 1 to Jun 30). o Low elevation gates (11.5 ft) will be OPEN during this period. • Target flows o Limit flows to 100 cfs as required for fish passage and flow continuity	**Seasonal Floodplain Inundation** • Period of inundation o December 1 – April 15. o Operational gates at 17.5 ft only and it will be OPEN during this period. • Triggers for inundation o Spills over the Fremont Weir will be triggered based on the river flow. • Duration o Duration of event will be governed by the hydrologic conditions in the Sacramento River, restoring the natural synchrony of inundation timing and frequency with river flows. o While “desired” inundation is on the order of 30-45 days, no management of the gates will be implemented to limit to this range. • Target flows o Gates will be operated to limit maximum spill to 8,000 cfs until river stage reaches existing weir height	**Seasonal Floodplain Inundation** • Period of inundation o December 1 – April 15. o Operational gates at 17.5 ft only and it will be OPEN during this period. • Triggers for inundation o Spills over the Fremont Weir will be triggered based on the river flow. • Duration o Duration of event will be governed by the hydrologic conditions in the Sacramento River, restoring the natural synchrony of inundation timing and frequency with river flows. o While “desired” inundation is on the order of 30-45 days, no management of the gates will be implemented to limit to this range. • Target flows o Gates will be operated to limit maximum spill to 8,000 cfs until river stage reaches existing weir height	**Seasonal Floodplain Inundation** • Period of inundation o December 1 – March 31 (modeled as Dec 1 to Apr 30). o Operational gates at both 17.5 ft and 11.5 ft will be OPEN during this period. • Triggers for inundation o Spills over the Fremont Weir will be triggered based on the river flow. • Duration o Duration of event will be governed by the hydrologic conditions in the Sacramento River, restoring the natural synchrony of inundation timing and frequency with river flows. o While “desired” inundation is on the order of 30-45 days, no management of the gates will be implemented to limit to this range. • Target flows o Gates will be operated to limit maximum spill to 6,000 cfs until river stage reaches existing weir height **Fish Passage** • Period of concern o September 15 – June 30 based on NOAA, DFG, and USFWS anadromous fish surveys in Yolo Bypass (modeled as Sep 1 to Jun 30). o Low elevation gates (11.5 ft) will be OPEN during this period. • Target flows o Limit flows to 100 cfs as required for fish passage and flow continuity	
San Joaquin River Region															
Millerton Lake (Friant Dam)	Existing, 520 TAF capacity	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Lower San Joaquin River	None	City of Stockton Delta Water Supply Project, 30 mgd capacity	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; CA did not include City of Stockton Delta Water Supply Project
Delta Region															
SWP Banks Pumping Plant (South Delta)	Physical capacity is 10,300 cfs but 6,680 cfs permitted capacity in all months up to 8,500 cfs during Dec 15th – Mar 15th depending on Vernalis flow conditions[o]; additional capacity of 500 cfs (up to 7,180 cfs) allowed for Jul – Sep for reducing impact of NMFS BO (Jun 2009) Action IV.2.1[v] on SWP[w]	Same as Existing Conditions	10,300 cfs	10,300 cfs	10,300 cfs	10,300 cfs				Same as No Action Alternative	10,300 cfs	10,300 cfs	10,300 cfs	Same as No Action Alternative	Reducing impact of VAMP on SWP formerly known as limited-EWA
CVP C.W. Bill Jones Pumping Plant (Tracy PP)	Permit capacity is 4,600 cfs but exports limited to 4,200 cfs plus diversions upstream of DMC constriction	Permit capacity is 4,600 cfs in all months (allowed for by the Delta-Mendota Canal–California Aqueduct Intertie)	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Upper Delta-Mendota Canal Capacity	Existing	Existing plus 400 cfs Delta-Mendota Canal–California Aqueduct Intertie	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
CCWD Intakes	Los Vaqueros existing storage capacity, 100 TAF, existing pump locations	Los Vaqueros existing storage capacity, 100 TAF, existing pump locations, Alternative Intake Project (AIP) included[p]	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA did not include the AIP in Existing; AIP was considered under a separate consultation
San Francisco Bay Region															
South Bay Aqueduct (SBA)	Existing capacity	SBA rehabilitation, 430 cfs capacity from junction with California Aqueduct to Alameda County FC&WSD Zone 7 diversion point	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; CA did not include SBA rehabilitation in Existing
South Coast Region															
California Aqueduct East Branch	Existing capacity	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA and CA did not include rehabilitation of capacity at California Aqueduct pool 49 (2,875 cfs)

PARAMETER CATEGORY / STUDY	EXISTING CONDITIONS	NO ACTION ALTERNATIVE	Alternative 1A, 1B, 1C	Alternative 2A, 2B, 2C	Alternative 3	Alternative 4				Alternative 5	Alternative 6A, 6B, 6C	Alternative 7	Alternative 8	Alternative 9	COMMENTS
						H1 (Low Outflow Scenario)	H2 (includes Enhanced Spring Outflow; excludes Fall X2)	H3 (excludes Enhanced Spring Outflow; includes Fall X2)	H4 (High Outflow Scenario)						
REGULATORY STANDARDS															
North Coast Region															
Trinity River															
Minimum flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/yr)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Trinity Reservoir end-of-September minimum storage	Trinity EIS Preferred Alternative (600 TAF as able)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Sacramento River Region															
Clear Creek															
Minimum flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to USFWS and NPS, predetermined CVPIA 3406(b)(2) flows[q], and NMFS BO (Jun 2009) Action I.1.1[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Predetermined flows based on Aug 08 2008 BA Studies; reflects Management Team direction regarding interpretation of NMFS BO (Jun 2009)
Upper Sacramento River															
Shasta Lake end-of-September minimum storage	NMFS 2004 Winter-run Biological Opinion, (1900 TAF in non-critically dry years), and NMFS BO (Jun 2009) Action I.2.1[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Management Team direction regarding interpretation of NMFS BO (Jun 2009)
Minimum flow below Keswick Dam	SWRCB WR 90-5 temperature control, predetermined CVPIA 3406(b)(2) flows[q], and NMFS BO (Jun 2009) Action I.2.2[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Predetermined flows based on Aug 08 2008 OCAP BA Studies; reflects Management Team direction regarding interpretation of NMFS BO (Jun 2009)
Feather River															
Minimum flow below Thermalito Diversion Dam	2006 Settlement Agreement (700 / 800 cfs)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; CA assumed 1983 DWR, DFG Agreement (600 cfs)
Minimum flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750-1,700 cfs)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Requirements under No Action Alternative, and additional flow contribution for the enhanced spring outflow requirement[ab]	Same as No Action Alternative	Requirements under No Action Alternative, and additional flow contribution for the enhanced spring outflow requirement[ab]	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Yuba River															
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord)[r]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Consistent with 2008 OCAP BA; CA assumed D-1644 (long-term, without Lower Yuba River Accord)
American River															
Minimum flow below Nimbus Dam	American River Flow Management[s] as required by NMFS BO (Jun 2009) Action II.1[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Modified to reflect NMFS BO; consistent with 2008 OCAP BA; CA did not include American River Flow Management
Minimum Flow at H Street	SWRCB D-893	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Lower Sacramento River															
Minimum Flow at Freeport	None	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	SWRCB Minimum Requirement of 55% of Unimpaired Flow at Freeport Jan-Jun. Minimum flow requirement capped at 40,000 cfs.	Same as No Action Alternative	
North Delta Diversion Bypass Flow	None	Same as Existing Conditions	Constant Low-Level Pumping: Diversions up to 6% of river flow for flows greater than 5,000 cfs (No diversion if it would cause downstream flow less than 5,000 cfs). No more than 300 cfs at any one intake (combined limit of 1,500 cfs).	Constant Low-Level Pumping: Diversions up to 6% of river flow for flows greater than 5,000 cfs (No diversion if it would cause downstream flow less than 5,000 cfs). No more than 300 cfs at any one intake (combined limit of 1,500 cfs).	Constant Low-Level Pumping: Diversions up to 6% of river flow for flows greater than 5,000 cfs (No diversion if it would cause downstream flow less than 5,000 cfs). No more than 300 cfs at any one intake (combined limit of 600 cfs).	Constant Low-Level Pumping: Diversions up to 6% of river flow for flows greater than 5,000 cfs (No diversion if it would cause downstream flow less than 5,000 cfs). No more than 300 cfs at any one intake (combined limit of 900 cfs).				Constant Low-Level Pumping: Diversions up to 6% of river flow for flows greater than 5,000 cfs (No diversion if it would cause downstream flow less than 5,000 cfs). No more than 300 cfs at the intake.	Constant Low-Level Pumping: Diversions up to 6% of river flow for flows greater than 5,000 cfs (No diversion if it would cause downstream flow less than 5,000 cfs). No more than 300 cfs at any one intake (combined limit of 1,500 cfs).	Constant Low-Level Pumping: Diversions up to 5% of river flow for flows greater than 5,000 cfs (No diversion if it would cause downstream flow less than 5,000 cfs). No more than 300 cfs at any one intake (combined limit of 900 cfs).	Constant Low-Level Pumping: Diversions up to 5% of river flow for flows greater than 5,000 cfs (No diversion if it would cause downstream flow less than 5,000 cfs). No more than 300 cfs at any one intake (combined limit of 900 cfs).	Same as No Action Alternative	
	None	Same as Existing Conditions	Initial Pulse Protection: Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) Wilkins Slough flows decrease for 5 consecutive days, or (3) Bypass flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). If the first flush begins before Dec 1, a second pulse period will have the same protective operation.	Initial Pulse Protection: Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) Wilkins Slough flows decrease for 5 consecutive days, or (3) Bypass flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). If the first flush begins before Dec 1, a second pulse period will have the same protective operation.	Initial Pulse Protection: Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) Wilkins Slough flows decrease for 5 consecutive days, or (3) Bypass flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). If the first flush begins before Dec 1, a second pulse period will have the same protective operation.	Initial Pulse Protection: Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) Wilkins Slough flows decrease for 5 consecutive days, or (3) Bypass flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). If the first flush begins before Dec 1, a second pulse period will have the same protective operation.				Initial Pulse Protection: Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) Wilkins Slough flows decrease for 5 consecutive days, or (3) Bypass flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). If the first flush begins before Dec 1, a second pulse period will have the same protective operation.	Initial Pulse Protection: Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) Wilkins Slough flows decrease for 5 consecutive days, or (3) Bypass flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). If the first flush begins before Dec 1, a second pulse period will have the same protective operation.	Initial Pulse Protection: Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) Wilkins Slough flows decrease for 5 consecutive days, or (3) Bypass flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). If the first flush begins before Dec 1, a second pulse period will have the same protective operation.	Initial Pulse Protection: Low level pumping maintained through the initial pulse period. For the purpose of monitoring, the initiation of the pulse is defined by the following criteria: (1) Wilkins Slough flow changing by more than 45% over a five day period and (2) flow greater than 12,000 cfs. Low-level pumping continues until (1) Wilkins Slough returns to prepulse flows (flow on first day of 5-day increase), (2) Wilkins Slough flows decrease for 5 consecutive days, or (3) Bypass flows are greater than 20,000 cfs for 10 consecutive days. After pulse period has ended, operations will return to the bypass flow table (SubTable A). If the first flush begins before Dec 1, a second pulse period will have the same protective operation.	Same as No Action Alternative	
	None	Same as Existing Conditions	Post-Pulse Operations: After initial pulse(s), apply Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then apply Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then apply Level III post-pulse bypass rule.	Post-Pulse Operations: After initial pulse(s), apply Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then apply Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then apply Level III post-pulse bypass rule.	Post-Pulse Operations: After initial pulse(s), apply Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then apply Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then apply Level III post-pulse bypass rule.	Post-Pulse Operations: After initial pulse(s), apply Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then apply Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then apply Level III post-pulse bypass rule.				Post-Pulse Operations: After initial pulse(s), apply Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then apply Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then apply Level III post-pulse bypass rule.	Post-Pulse Operations: After initial pulse(s), apply Level I post-pulse bypass rule (see SubTable A) until 15 total days of bypass flows above 20,000 cfs. Then apply Level II post-pulse bypass rule until 30 total days of bypass flows above 20,000 cfs. Then apply Level III post-pulse bypass rule.	Post-Pulse Operations: After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A for Level 1) until 20 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule (Subtable A for Level II) until 45 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule (Subtable A for Level III).	Post-Pulse Operations: After initial flush(es), go to Level I post-pulse bypass rule (see SubTable A for Level 1) until 20 total days of bypass flows above 20,000 cfs. Then go to the Level II post-pulse bypass rule (Subtable A for Level II) until 45 total days of bypass flows above 20,000 cfs. Then go to the Level III post-pulse bypass rule (Subtable A for Level III).	Same as No Action Alternative	
Minimum flow near Rio Vista	SWRCB D-1641	Same as Existing Conditions	Sep-Dec: SWRCB D-1641; Jan-Aug: minimum of 3,000 cfs	Sep-Dec: SWRCB D-1641; Jan-Aug: minimum of 3,000 cfs	Sep-Dec: SWRCB D-1641; Jan-Aug: minimum of 3,000 cfs	Sep-Dec: SWRCB D-1641; Jan-Aug: minimum of 3,000 cfs				Sep-Dec: SWRCB D-1641; Jan-Aug: minimum of 3,000 cfs	Sep-Dec: SWRCB D-1641; Jan-Aug: minimum of 3,000 cfs	Sep-Dec: SWRCB D-1641; Jan-Aug: minimum of 5,000 cfs	Sep-Dec: SWRCB D-1641; Jan-Aug: minimum of 5,000 cfs	Sep-Dec: SWRCB D-1641; Jan-Aug: minimum of 5,000 cfs	

PARAMETER CATEGORY / STUDY	*EXISTING CONDITIONS*	*NO ACTION ALTERNATIVE*	*Alternative 1A, 1B, 1C*	*Alternative 2A, 2B, 2C*	*Alternative 3*	*Alternative 4*				*Alternative 5*	*Alternative 6A, 6B, 6C*	*Alternative 7*	*Alternative 8*	*Alternative 9*	*COMMENTS*
						H1 (Low Outflow Scenario)	*H2 (includes Enhanced Spring Outflow; excludes Fall X2)*	*H3 (excludes Enhanced Spring Outflow; includes Fall X2)*	*H4 (High Outflow Scenario)*						
San Joaquin River Region															
Mokelumne River															
Minimum flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100-325 cfs)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Minimum flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25-300 cfs)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Stanislaus River															
Minimum flow below Goodwin Dam	1987 USBR, DFG agreement, and flows required for NMFS BO (Jun 2009) Action III.1.2 and III.1.3[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Reflects Management Team direction regarding interpretation of NMFS BO (Jun 2009); flow schedule to be provided
Minimum dissolved oxygen	SWRCB D-1422	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Merced River															
Minimum flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180-220 cfs, Nov-Mar), and Cowell Agreement	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Minimum flow at Shaffer Bridge	FERC 2179 (25-100 cfs)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Tuolumne River															
Minimum flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94-301 TAF/yr)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
San Joaquin River															
San Joaquin River below Friant Dam/ Mendota Pool	Water Year 2010 Interim Flows Project[u]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA document did not include San Joaquin River Restoration; CA did not include restoration flows
Maximum salinity near Vernalis	SWRCB D-1641	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Minimum flow near Vernalis	SWRCB D-1641, and NMFS BO (Jun 2009) Action IV.2.1[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 BA and CA assumed VAMP flows
Sacramento River–San Joaquin Delta Region															
Delta Outflow Index (Flow, NDOI)	SWRCB D-1641	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	SWRCB D-1641 & SWRCB Flow Criteria of 55% of Umimpaired Flow at Freeport (capped by 40,000 cfs); Trinity, Shasta, Oroville and Folsom storage were modified to enable more cold water pool storage: by increasing Storage Level 3 to 75% of the maximum storage, within Storage Level 3, exports are gradually reduced until Storage Level 2 is reached in the reservoir.	Same as No Action Alternative	2008 BA and CA assumed D-1641 only. For the BDCP PROPOSED PROJECT EARLY LONG-TERM, proportional Reservoir release concept will continure to be evaluated to the extent that it provides similar response to outflow, inflow and upstream storage conditions
Delta Outflow Index (Salinity, X2) - Spring	SWRCB D-1641	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Requirements under No Action Alternative, and additional flow for the enhanced spring outflow requirement[ab]	Same as No Action Alternative	Requirements under No Action Alternative, and additional flow for the enhanced spring outflow requirement[ab]	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 BA and CA assumed D-1641 only
Delta Outflow (Salinity, X2) - Fall	None	FWS BO (Dec 2008) Action 4	None	Same as No Action Alternative	None	None	None	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Delta Cross Channel gate operation	SRWCB D-1641 with additional days closed from Oct 1st – Jan 31st based on NMFS BO (Jun 2009) Action IV.1.2[v] (closed during flushing flows from Oct 1st – Dec 14th unless adverse water quality conditions)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Oct-Nov: DCC gate closed if fish are present (assume 15 days per month; may be open longer; consistent with logic used for the BDCP proposed project) Dec-Jun: DCC gate closed if Sac < 11,000 cfs or Sac >25,000 cfs Jul-Sep: DCC gate open	2008 BA and CA assumed D-1641 only
South Delta exports (Jones PP and Banks PP)	SWRCB D-1641, Vernalis flow-based export limits Apr 1st – May 31st as required by NMFS BO (Jun, 2009) Action IV.2.1[v] (additional 500 cfs allowed for Jul – Sep for reducing impact on SWP)[w]	Same as Existing Conditions	Physical capacity	Physical Capacity	Physical Capacity	Physical Capacity				Same as No Action Alternative	None	Physical Capacity, AND South Delta Export to San Joaquin Inflow ratio: 50% in Dec through Mar and in June.	Physical Capacity, AND South Delta Export to San Joaquin Inflow ratio: 50% in Dec through Mar and in June.	SWRCB D-1641 when SJR flow < 10,000 cfs, Same as No Action Alternative when SJR flow > 10,000 cfs	2008 BA and CA assumed discretionary use of CVPIA 3406(b)(2); 2008 BA also assumed limited Environmental Water Account
Combined Flow in Old and Middle River (OMR)	FWS BO (Dec 2008) Actions 1 through 3 and NMFS BO (Jun 2009) Action IV.2.3[v]	Same as Existing Conditions	Same as No Action Alternative	More positive of the No Action Alternative assumptions and the assumption noted below: • Jan: 0 (W), -3500 (AN), -4000 (BN), -5000 (D, C) • Feb: 0 (W), -3500 (AN), -4000 (BN, D, C) • Mar: 0 (W, AN), -3500 (AN, BN, D, C) • Apr - Jun: Varies based on San Joaquin inflow relationship to OMR povided below in Sub-Table B [y] • Jul - Sep: No Restrictions • Oct - Nov: Varies based SJR pulse flow condition [z] • Dec: -5000 when north Delta initial pulse flows are triggered or -2000 when delta smelt action 1 triggers • HORB opening is restricted [aa]	Same as No Action Alternative	More positive of the No Action Alternative assumptions and the assumption noted below: • Jan: 0 (W), -3500 (AN), -4000 (BN), -5000 (D, C) • Feb: 0 (W), -3500 (AN), -4000 (BN, D, C) • Mar: 0 (W, AN), -3500 (AN, BN, D, C) • Apr - Jun: Varies based on San Joaquin inflow relationship to OMR povided below in Sub-Table B [y] • Jul - Sep: No Restrictions • Oct - Nov: Varies based SJR pulse flow condition [z] • Dec: -5000 when north Delta initial pulse flows are triggered or -2000 when delta smelt action 1 triggers • HORB opening is restricted [aa]				Same as No Action Alternative	No Restrictions	• South Delta exports cannot cause OMR to fall below +1,000 cfs during Dec-Mar. • South Delta exports cannot cause OMR to fall below +3,000 cfs during Jun. • South Delta pumping is not allowed during April, May, Oct, and Nov • No restrictions during Jul-Sep.	• South Delta exports cannot cause OMR to fall below +1,000 cfs during Dec-Mar. • South Delta exports cannot cause OMR to fall below +3,000 cfs during Jun. • South Delta pumping is not allowed during April, May, Oct, and Nov • No restrictions during Jul-Sep.	Same as No Action Alternative	2008 BA and CA did not assume FWS BO (Dec 2008) or other OMR restrictions
Delta Water Quality	SWRCB D-1641	Same as Existing Conditions	Existing SWRCB D-1641, EXCEPT moved compliance point from Emmaton to Three Mile Sl near Sacramento R.	Existing SWRCB D-1641, EXCEPT moved compliance point from Emmaton to Three Mile Sl near Sacramento R.	Existing SWRCB D-1641, EXCEPT moved compliance point from Emmaton to Three Mile Sl near Sacramento R.	Existing SWRCB D-1641, EXCEPT moved compliance point from Emmaton to Three Mile Sl near Sacramento R.				Existing SWRCB D-1641, EXCEPT moved compliance point from Emmaton to Three Mile Sl near Sacramento R.	Existing SWRCB D-1641, EXCEPT moved compliance point from Emmaton to Three Mile Sl near Sacramento R.	Existing SWRCB D-1641, EXCEPT moved compliance point from Emmaton to Three Mile Sl near Sacramento R.	Existing SWRCB D-1641, EXCEPT moved compliance point from Emmaton to Three Mile Sl near Sacramento R.	Existing SWRCB D-1641, EXCEPT Rock Slough compliance point is not specifically targeted	Currently only operate for D1641 standards
OPERATIONS CRITERIA: RIVER-SPECIFIC															
Sacramento River Region															
Upper Sacramento River: Flow objective for navigation (Wilkins Slough)	NMFS BO (Jun 2009) Action I.4[v]; 3,500 – 5,000 cfs based on CVP water supply condition	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
American River: Folsom Dam flood control	Variable 400/670 flood control diagram (without outlet modifications)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Feather River: Flow at Mouth of Feather River (above Verona)	Maintain DFG/DWR flow target of 2,800 cfs for Apr – Sep dependent on Oroville inflow and FRSA allocation	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
San Joaquin River Region															
Stanislaus River: Flow below Goodwin Dam[i]	Revised Operations Plan[t] and NMFS BO (Jun 2009) Action III.1.2 and III.1.3[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 BA assumed draft Transitional New Melones Operations Plan; CA assumed Interim Plan
San Joaquin River: Salinity at Vernalis	Grasslands Bypass Project (partial implementation)	Grasslands Bypass Project (full implementation)	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Existing condition assumptions to be determined Year 2010

PARAMETER CATEGORY / STUDY	*EXISTING CONDITIONS*	*NO ACTION ALTERNATIVE*	*Alternative 1A, 1B, 1C*	*Alternative 2A, 2B, 2C*	*Alternative 3*	*Alternative 4* H1 (Low Outflow Scenario)	*Alternative 4* H2 (includes Enhanced Spring Outflow; excludes Fall X2)	*Alternative 4* H3 (excludes Enhanced Spring Outflow; includes Fall X2)	*Alternative 4* H4 (High Outflow Scenario)	*Alternative 5*	*Alternative 6A, 6B, 6C*	*Alternative 7*	*Alternative 8*	*Alternative 9*	*COMMENTS*
OPERATIONS CRITERIA: SYSTEMWIDE															
North & South Delta Intakes Operation Criteria															
Water quality and residence time	None	Same as Existing Conditions	Jul-Sep: prefer sourth Delta pumping up to 3,000 cfs before diverting from North. Oct-Jun: prefer North Delta pumping (real-time operation flexibility) (No explicit implementation in the model).	Jul-Sep: prefer sourth Delta pumping up to 3,000 cfs before diverting from North. Oct-Jun: prefer North Delta pumping (real-time operation flexibility) (No explicit implementation in the model).	Jul-Sep: prefer sourth Delta pumping up to 3,000 cfs before diverting from North. Oct-Jun: prefer North Delta pumping (real-time operation flexibility) (No explicit implementation in the model).	Jul-Sep: prefer sourth Delta pumping up to 3,000 cfs before diverting from North. Oct-Jun: prefer North Delta pumping (real-time operation flexibility) (No explicit implementation in the model).				Jul-Sep: prefer sourth Delta pumping up to 3,000 cfs before diverting from North. Oct-Jun: prefer North Delta pumping (real-time operation flexibility) (No explicit implementation in the model).	North Delta Pumping only	Jul-Sep: prefer sourth Delta pumping up to 3,000 cfs before diverting from North. Oct-Jun: prefer North Delta pumping (real-time operation flexibility) (No explicit implementation in the model).	Jul-Sep: prefer sourth Delta pumping up to 3,000 cfs before diverting from North. Oct-Jun: prefer North Delta pumping (real-time operation flexibility) (No explicit implementation in the model).	Same as No Action Alternative	Not explicitly included in model; model results with existing weight structure are consistent with intake preferences
CVP water allocation															
Settlement / Exchange	100% (75% in Shasta critical years)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Refuges	100% (75% in Shasta critical years)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Agriculture Service	100%-0% based on supply, South-of-Delta allocations are additionally limited due to D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA and CA did not assume FWS BO (Dec 2008) or NMFS BO (Jun 2009)
Municipal & Industrial Service	100%-50% based on supply, South-of-Delta allocations are additionally limited due to D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA and CA did not assume FWS BO (Dec 2008) or NMFS BO (Jun 2009)
SWP water allocation															
North of Delta (FRSA)	Contract specific	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
South of Delta (including North Bay Aqueduct)	Based on supply; equal prioritization between Ag and M&I based on Monterey Agreement; allocations are additionally limited due to D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA and CA did not assume FWS BO (Dec 2008) or NMFS BO (Jun 2009)
CVP-SWP coordinated operations															
Sharing of responsibility for in-basin-use	1986 Coordinated Operations Agreement (FRWP EBMUD and 2/3 of the North Bay Aqueduct diversions considered as Delta Export; 1/3 of the North Bay Aqueduct diversion considered as in-basin-use)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative[ab]	Same as No Action Alternative	Same as No Action Alternative[ab]	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	CA included exchange of SWP to convey 50 TAF/yr of Level 2 refuge supplies at Banks PP (July – August) and CVP to provide up to max of 37.5 TAF/yr to meet SWP In-Basin-Use (released from Shasta)
Sharing of surplus flows	1986 Coordinated Operations Agreement	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Sharing of total allowable export capacity for project-specific priority pumping	Equal sharing of export capacity under SWRCB D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA and CA did not assume FWS BO (Dec 2008) or NMFS BO (Jun 2009)
Water transfers	Acquisitions by SWP contractors are wheeled at priority in Banks Pumping Plant over non-SWP users; LYRA included for SWP contractors[w]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA assumed transfer of LYRA acquisitions for reducing impact of VAMP on SWP, formerly known as limited-EWA; CA assumed SVWMA and short term temporary transfers
Sharing of export capacity for lesser priority and wheeling-related pumping	Cross Valley Canal wheeling (max of 128 TAF/yr), CALFED ROD defined Joint Point of Diversion (JPOD)	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
San Luis Reservoir	San Luis Reservoir is allowed to operate to a minimum storage of 100 TAF	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
CVPIA 3406(b)(2)[v,q]															
Policy Decision	Per May 2003 Dept. of Interior Decision	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Discretionary 3406(b)(2) operations being replaced by non-discretionary operations for FWS BO (Dec 2008) and NMFS BO (Jun 2009)
Allocation	800 TAF, 700 TAF in 40-30-30 dry years, and 600 TAF in 40-30-30 critical years as a function of Ag allocation	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Actions	Pre-determined upstream fish flow objectives below Whiskeytown and Keswick Dams, non-discretionary NMFS BO (Jun 2009) actions for the American and Stanislaus Rivers, and NMFS BO (Jun 2009) and FWS BO (Dec 2008) actions leading to export restrictions[v]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA and CA did not assume FWS BO (Dec 2008) or NMFS BO (Jun 2009)
Accounting	Releases for non-discretionary FWS BO (Dec 2008) and NMFS BO (Jun 2009)[v] actions may or may not always be deemed (b)(2) actions; in general, it is anticipated, that accounting of these actions using (b)(2) metrics, the sum would exceed the (b)(2) allocation in many years; therefore no additional actions are considered and no accounting logic is included in the model[q]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 OCAP BA and CA did not assume FWS BO (Dec 2008) or NMFS BO (Jun 2009)
WATER MANAGEMENT ACTIONS															
Water Transfer Supplies (long term programs)															
Lower Yuba River Accord[w]	Yuba River acquisitions for reducing impact of NMFS BO export restrictions[v] on SWP	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative				Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	2008 BA assumed Yuba River acquisitions for reducing impact of NMFS BO export restrictions, formerly known as limited-EWA; CA did not include LYRA
Phase 8	None	None	None	None	None	None				None	None	None	None	None	
Water Transfers (short term or temporary programs)															
Sacramento Valley acquisitions conveyed through Banks PP [x]	Post-analysis of available capacity	Post-analysis of available capacity	Post-analysis of available capacity	Post-analysis of available capacity	Post-analysis of available capacity	Post-analysis of available capacity				Post-analysis of available capacity	Post-analysis of available capacity	Post-analysis of available capacity	Post-analysis of available capacity	Post-analysis of available capacity	Consistent with 2008 OCAP BA; CA model outputs available capacity to support such analysis

PARAMETER CATEGORY / STUDY	*EXISTING CONDITIONS*	*NO ACTION ALTERNATIVE*	*Alternative 1A, 1B, 1C*	*Alternative 2A, 2B, 2C*	*Alternative 3*	*Alternative 4*				*Alternative 5*	*Alternative 6A, 6B, 6C*	*Alternative 7*	*Alternative 8*	*Alternative 9*	*COMMENTS*
						H1 (Low Outflow Scenario)	*H2 (includes Enhanced Spring Outflow; excludes Fall X2)*	*H3 (excludes Enhanced Spring Outflow; includes Fall X2)*	*H4 (High Outflow Scenario)*						

CALSIM Notes:

[a] These assumptions have been developed under the direction of the Department of Water Resources (Department) and Bureau of Reclamation (Reclamation) management team for the Bay Delta Conservation Plan (BDCP) HCP and EIR/EIS. Only operational components of 2008 USFWS and 2009 NMFS BOs as of demarcation date of Existing Conditions and the No action Alternative assumptions are included. Restoration of at least 8,000 acres of intertidal and associated subtidal habitat in the Delta and Suisun Marsh required by the 2008 USFWS BO and restoration of at least 17,000 to 20,000 acres of floodplain rearing habitat for juvenile winter-run and spring-run Chinook salmon and Central Valley steelhead in the Yolo Bypass and/or suitable areas of the lower Sacramento River required by the NMFS 2009 BO are not included in the No Action Alternative assumptions because environmental documents of projects regarding these actions were not completed as of the publication date of the Notice of Preparation/Notice of Intent (February 13, 2009)

[b] The Sacramento Valley hydrology used in the Existing Conditions CALSIM II model reflects nominal 2005 land-use assumptions. The nominal 2005 land-use was determined by interpolation between the 1995 and projected 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects 2005 land-use assumptions developed by Reclamation. Existing-level projected land-use assumptions are being coordinated with the California Water Plan Update for future models.

[c] The Sacramento Valley hydrology used in the No Action Alternative CALSIM II model reflects 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by Reclamation. Development of Future-level projected land-use assumptions are being coordinated with the California Water Plan Update for future models.

[d] CVP contract amounts have been updated according to existing and amended contracts as appropriate. Assumptions regarding CVP agricultural and M&I service contracts and Settlement Contract amounts are documented in the Delivery Specifications attachments.

[e] SWP contract amounts have been updated as appropriate based on recent Table A transfers/agreements. Assumptions regarding SWP agricultural and M&I contract amounts are documented in the Delivery Specifications attachments.

[f] Water needs for federal refuges have been reviewed and updated as appropriate. Assumptions regarding firm Level 2 refuge water needs are documented in the Delivery Specifications attachments. Refuge Level 4 (and incremental Level 4) water is not analyzed.

[g] Assumptions regarding American River water rights and CVP contracts are documented in the Delivery Specifications attachments. The Sacramento Area Water Forum agreement, its dry year diversion reductions, Middle Fork Project operations and "mitigation" water is not included.

[h] The new CALSIM II representation of the San Joaquin River has been included in this model package (CALSIM II San Joaquin River Model, Reclamation, 2005). Updates to the San Joaquin River have been included since the preliminary model release in August 2005. The model reflects the difficulties of on-going groundwater overdraft problems. The 2030 level of development representation of the San Joaquin River Basin does not make any attempt to offer solutions to groundwater overdraft problems. In addition a dynamic groundwater simulation is not yet developed for the San Joaquin River Valley. Groundwater extraction/ recharge and stream-groundwater interaction are static assumptions and may not accurately reflect a response to simulated actions. These limitations should be considered in the analysis of results.

[i] The CALSIM II model representation for the Stanislaus River does not necessarily represent Reclamation's current or future operational policies. A suitable plan for supporting flows has not been developed for NMFS BO (Jun 2009) Action 3.1.3.

[j] The actual amount diverted is operated in conjunction with supplies from the Los Vaqueros project. The existing Los Vaqueros storage capacity is 100 TAF. Associated water rights for Delta excess flows are included.

[k] Under Existing Conditions it is assumed that SWP Contractors demand for Table A allocations vary from 3.0 to 4.1 MAF/year. Under the No Action Alternative, it is assumed that SWP Contractors can take delivery of all Table A allocations and Article 21 supplies. Article 56 provisions are assumed and allow for SWP Contractors to manage storage and delivery conditions such that full Table A allocations can be delivered. Article 21 deliveries are limited in wet years under the assumption that demand is decreased in these conditions. Article 21 deliveries for the NBA are dependent on excess conditions only, all other Article 21 deliveries also require that San Luis Reservoir be at capacity and that Banks PP and the California Aqueduct have available capacity to divert from the Delta for direct delivery.

[l] PCWA American River pumping facility upstream of Folsom Lake is included in both the Existing and No Action Alternative No Action Alternative . The diversion is assumed to be 35.5 TAF/Yr.

[m] footnote removed

[n] footnote removed

[o] Current ACOE permit for Banks PP allows for an average diversion rate of 6,680 cfs in all months. Diversion rate can increase up to 1/3 of the rate of San Joaquin River flow at Vernalis during Dec 15th – Mar 15th up to a maximum diversion of 8,500 cfs, if Vernalis flow exceeds 1,000 cfs.

[p] The CCWD Alternate Intake Project (AIP), an intake at Victoria Canal, which operates as an alternate Delta diversion for Los Vaqueros Reservoir. This assumption is consistent with the future no-project condition defined by the Los Vaqueros Enlargement study team.

[q] CVPIA (b)(2) fish actions are not dynamically determined in the CALSIM II model, nor is (b)(2) accounting done in the model. Since the FWS BO and NMFS BO were issued, the Department of the Interior (Interior) has exercised its discretion to use (b)(2) in the delta by accounting some or all of the export reductions required under those biological opinions as (b)(2) actions. It is therefore assumed for modeling purposes that (b)(2) availability for other delta actions will be limited to covering the CVP's VAMP export reductions. Similarly, since the FWS BO and NMFS BO were issued, Interior has exercised its discretion to use (b)(2) upstream by accounting some or all of the release augmentations (relative to the hypothetical (b)(2) base case) below Whiskeytown, Nimbus and Goodwin as (b)(2) actions. It is therefore assumed for modeling purposes that (b)(2) availability for other upstream actions will be limited to covering Sacramento releases, in the fall and winter. For modeling purposes, pre-determined timeseries of minimum instream flow requirements are specified. The timeseries are based on the Aug 2008 BA Study 7.0 and Study 8.0 simulations which did include dynamically determined (b)(2) actions.

[r] D-1644 and the Lower Yuba River Accord is assumed to be implemented for Existing and No Action Alternative No Action Alternative . The Yuba River is not dynamically modeled in CALSIM II. Yuba River hydrology and availability of water acquisitions under the Lower Yuba River Accord are based on modeling performed and provided by the Lower Yuba River Accord EIS/EIR study team.

[s] Under Existing Conditions, the flow components of the proposed American River Flow Management are as required by the NMFS BO (June 4th 2009).

[t] The model operates the Stanislaus River using a 1997 Interim Plan of Operation-like structure, i.e., allocating water for SEWD & CSJWCD, Vernalis water quality dilution and Vernalis D1641 flow requirements based on the New Melones Index. OID & SSJID allocations are based on their 1988 agreement and Ripon DO requirements are represented by a static set of minimum instream flow requirements during Jun thru Sep. Instream flow requirements for fish below Goodwin are based on NMFS BO Action III.1.2. NMFS BO Action IV.2.1's flow component is not assumed to be in effect.

[u] SJR Restoration Water Year 2010 Interim Flows Project are assumed, but are not input into the models; operation not regularly defined at this time

[v] In cooperation with Reclamation, National Marine Fisheries Service, Fish and Wildlife Service, and Ca Department of Fish and Game, the Ca Department of Water Resources has developed assumptions for implementation of the FWS BO (Dec 15th 2008) and NMFS BO (June 4th 2009) in CALSIM II.

[w] Acquisitions of Component 1 water under the Lower Yuba River Accord, and use of 500 cfs dedicated capacity at Banks PP during Jul – Sep, are assumed to be used to reduce as much of the impact of the Apr – May Delta export actions on SWP contractors as possible.

[x] Only acquisitions of Lower Yuba River Accord Component 1 water are included.

[y] Sub-Table B. San Joaquin Inflow Relationship to OMR:

April and May		June	
If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following (interpolated linearly between values)	If San Joaquin flow at Vernalis is the following	Average OMR flows would be at least the following
≤ 5,000 cfs	-2,000 cfs	≤ 3,500 cfs	-3,500 cfs
6,000 cfs	+1000 cfs	3,501 to 10,000 cfs	0 cfs
10,000 cfs	+2000 cfs		
15,000 cfs	+3000 cfs	10,001 to 15,000 cfs	+1000 cfs
≥30,000 cfs	+6000 cfs	>15,000 cfs	+2000 cfs

[z] Before the D-1641pulse = HORB open, no OMR restrictions; During the D-1641pulse = no south Delta exports (two weeks) and HORB closed; After the D-1641 pulse = -5,000 cfs OMR (through November); HORB open 50% for 2 weeks

[aa] Head of Old River Operable Barrier (HORB) Operations/Modeling assumptions (% OPEN)[1] Oct 50%, Nov 100%[2] Dec 100%, Jan 50%[3], Feb - Jun 15th 50%, Jun 16-30 100%, Jul - Sep 100% (1. Percent of time the HORB is open. Agricultural barriers are in and operated consistent with current practices. HORB would be open 100% whenever flows are greater than 10,000 cfs at Vernalis.; 2. For modeling assumption only. Action proposed: Before the D-1641 pulse = no OMR restrictions (HORB open), During the D-1641 pulse = no south Delta exports for two weeks (HORB closed), After the D-1641 pulse = -5,000 cfs OMR through November (HORB open 50% for 2 weeks), Exact timing of the action will be based on hydrologic conditions; 3. The HORB becomes operational at 50% when salmon fry are immigrating (based on real time monitoring). This generally occurs when flood flow releases are being made.)

[ab] Enhanced Spring Delta Outflow required during the Mar-May period. This additional Mar-May Delta Outflow requirement is determined based on 90% forecast of Mar-May Eight River Index (8RI). For modeling purposes the Mar-May 8RI was forecasted based on a correlation between the Jan-Feb 8RI and Mar-May 8RI at ELT and LLT. Each year in March, Spring Delta Outflow target for the Mar-May period is determined based on the forecasted Mar-May 8RI value and its exceedance probability, from the Table below, linearly interpolating for values in-between. This additional spring outflow is not considered as an "in-basin use" for CVP-SWP Coordinated Operations. This outflow requirement is met through first by curtailing Delta exports at Banks and Jones Pumping Plants by an amount needed to meet the outflow target, such that the minimum exports are at least 1,500 cfs. In wetter years (< 50% exceedance), if the outflow target is not achieved by export curtailments, then the additional flow needed to meet the outflow target is released from the Oroville reservoir as long as its projected end-of-May storage is at or above 2 MAF.

Percent Exceedance of Forecasted Mar-May 8RI based on Jan-Feb 8RI values:	10%	20%	30%	40%	50%	60%	70%	80%	90%
Proposed Mar-May Delta Outflow Target (cfs):	44,500	44,500	35,000	32,000	23,000	17,200	13,300	11,400	9,200

Sub Table A: North Delta Diversion Bypass Flows

Level I

Dec - Apr

If Sacramento River flow is over	But no over	The bypass is
0 cfs	15,000 cfs	100% of the amount over 0 cfs
15,000 cfs	17,000 cfs	15,000 cfs plus 80% of the amount over 15,000 cfs
17,000 cfs	20,000 cfs	16,600 cfs plus 60% of the amount over 17,000 cfs
20,000 cfs	no limit	18,400 cfs plus 30% of the amount over 20,000 cfs

May

If Sacramento River flow is over	But no over	The bypass is
0 cfs	15,000 cfs	100% of the amount over 0 cfs
15,000 cfs	17,000 cfs	15,000 cfs plus 70% of the amount over 15,000 cfs
17,000 cfs	20,000 cfs	16,400 cfs plus 50% of the amount over 17,000 cfs
20,000 cfs	no limit	17,900 cfs plus 20% of the amount over 20,000 cfs

Jun

If Sacramento River flow is over	But no over	The bypass is
0 cfs	15,000 cfs	100% of the amount over 0 cfs
15,000 cfs	17,000 cfs	15,000 cfs plus 60% of the amount over 15,000 cfs
17,000 cfs	20,000 cfs	16,200 cfs plus 40% of the amount over 17,000 cfs
20,000 cfs	no limit	17,400 cfs plus 20% of the amount over 20,000 cfs

Level II

Dec - Apr

If Sacramento River flow is over	But no over	The bypass is
0 cfs	11,000 cfs	100% of the amount over 0 cfs
11,000 cfs	15,000 cfs	11,000 cfs plus 60% of the amount over 11,000 cfs
15,000 cfs	20,000 cfs	13,400 cfs plus 50% of the amount over 15,000 cfs
20,000 cfs	no limit	15,900 cfs plus 20% of the amount over 20,000 cfs

May

If Sacramento River flow is over	But no over	The bypass is
0 cfs	11,000 cfs	100% of the amount over 0 cfs
11,000 cfs	15,000 cfs	11,000 cfs plus 50% of the amount over 11,000 cfs
15,000 cfs	20,000 cfs	13,000 cfs plus 35% of the amount over 15,000 cfs
20,000 cfs	no limit	14,750 cfs plus 20% of the amount over 20,000 cfs

Jun

If Sacramento River flow is over	But no over	The bypass is
0 cfs	11,000 cfs	100% of the amount over 0 cfs
11,000 cfs	15,000 cfs	11,000 cfs plus 40% of the amount over 11,000 cfs
15,000 cfs	20,000 cfs	12,600 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	13,600 cfs plus 20% of the amount over 20,000 cfs

Level III

Dec - Apr

If Sacramento River flow is over	But no over	The bypass is
0 cfs	9,000 cfs	100% of the amount over 0 cfs
9,000 cfs	15,000 cfs	9,000 cfs plus 50% of the amount over 9,000 cfs
15,000 cfs	20,000 cfs	12,000 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	13,000 cfs plus 0% of the amount over 20,000 cfs

May

If Sacramento River flow is over	But no over	The bypass is
0 cfs	9,000 cfs	100% of the amount over 0 cfs
9,000 cfs	15,000 cfs	9,000 cfs plus 40% of the amount over 9,000 cfs
15,000 cfs	20,000 cfs	11,400 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	12,400 cfs plus 0% of the amount over 20,000 cfs

Jun

If Sacramento River flow is over	But no over	The bypass is
0 cfs	9,000 cfs	100% of the amount over 0 cfs
9,000 cfs	15,000 cfs	9,000 cfs plus 30% of the amount over 9,000 cfs
15,000 cfs	20,000 cfs	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000 cfs	no limit	11,800 cfs plus 0% of the amount over 20,000 cfs

DSM2 Assumptions:

PARAMETER CATEGORY / STUDY	*EXISTING CONDITIONS*	*NO ACTION ALTERNATIVE*	*Alternative 1A,1B,1C*	*Alternative 2A,2B,2C*	*Alternative 3*	*Alternative 4 (All four decision tree scenarios)*	*Alternative 5*	*Alternative 6A, 6B, 6C*	*Alternative 7*	*Alternative 8*	*Alternative 9*	*COMMENTS*
GENERAL												
Alternate period of simulation *(for use when need or BC data limited)*	16 years (1976-1991)[a,b]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
HYDROLOGY												
Boundary flows	Monthly timeseries from CALSIM II output[c]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
REGIONAL DEMANDS AND CONTRACTS												
Agriculture Flows (DICU)	2005 Level, DWR Bulletin 160-98[d]	2020 Level, DWR Bulletin 160-98[d]	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
TIDAL BOUNDARY												
Martinez stage	15-minute adjusted astronomical tide[a]	15-minute adjusted astronomical tide modified to account for the sea level rise at the early long-term and late long-term phases[a,p]	15-minute adjusted astronomical tide modified to account for the sea level rise and proposed habitat restoration at the early long-term and late long-term phases[a,p]	15-minute adjusted astronomical tide modified to account for the sea level rise and proposed habitat restoration at the early long-term and late long-term phases[a,p]	15-minute adjusted astronomical tide modified to account for the sea level rise and proposed habitat restoration at the early long-term and late long-term phases[a,p]	15-minute adjusted astronomical tide modified to account for the sea level rise and proposed habitat restoration at the early long-term and late long-term phases[a,p]	15-minute adjusted astronomical tide modified to account for the sea level rise and proposed habitat restoration at the early long-term and late long-term phases[a,p]	15-minute adjusted astronomical tide modified to account for the sea level rise and proposed habitat restoration at the early long-term and late long-term phases[a,p]	15-minute adjusted astronomical tide modified to account for the sea level rise and proposed habitat restoration at the early long-term and late long-term phases[a,p]	15-minute adjusted astronomical tide modified to account for the sea level rise and proposed habitat restoration at the early long-term and late long-term phases[a,p]	15-minute adjusted astronomical tide modified to account for the sea level rise and proposed habitat restoration at the early long-term and late long-term phases[a,p]	
WATER QUALITY												
Vernalis EC	Monthly time series from CALSIM II output[e]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Agricultural Return EC	Municipal Water Quality Investigation Program analysis	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Martinez EC	Monthly net Delta Outflow from CALSIM output & G-model[f]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise at the early long-term and late long-term phases[f,r]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise and the proposed habitat restoration at the early long-term and late long-term phases[f,r]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise and the proposed habitat restoration at the early long-term and late long-term phases[f,r]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise and the proposed habitat restoration at the early long-term and late long-term phases[f,r]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise and the proposed habitat restoration at the early long-term and late long-term phases[f,r]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise and the proposed habitat restoration at the early long-term and late long-term phases[f,r]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise and the proposed habitat restoration at the early long-term and late long-term phases[f,r]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise and the proposed habitat restoration at the early long-term and late long-term phases[f,r]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise and the proposed habitat restoration at the early long-term and late long-term phases[f,r]	Monthly net Delta Outflow from CALSIM output & G-model, modified to account for sea level rise and the proposed habitat restoration at the early long-term and late long-term phases[f,r]	
MORPHOLOGICAL CHANGES												
Mokelumne River	None	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action AlternativeSC	
San Joaquin River	None	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
Middle River	None	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Dredging on Middle River and Victoria Canal[SC]	
FACILITIES												
Contra Costa Water District Delta Intakes	Rock Slough Pumping Plant, Old River at Highway 4 Intake and Alternate Improvement Project Intake on Victoria Canal	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
South Delta barriers	Temporary Barriers Project	Same as Existing Conditions	None	Same as No Action Alternative	None	Same as No Action Alternative	Same as No Action Alternative	None	None	None	None[SC]	2008 BA and CA assumed South Delta Improvements Program Permanent Operable Gates (Stage 1); 2008 BA and CA did not consider FWS Delta Smelt BO related operations
Franks Tract Program	None	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Three Mile Slough Operable Gate Installed[SC]	
Isolated Facility	None	Same as Existing Conditions	North Delta Diversion: 5 intakes with a 3,000 cfs maximum capacity (total maximum capacity of 15,000 cfs)[s]	North Delta Diversion: 5 intakes with a 3,000 cfs maximum capacity (total maximum capacity of 15,000 cfs)[w]	North Delta Diversion: 2 intakes with a 3,000 cfs maximum capacity (total maximum capacity of 6,000 cfs)[t]	North Delta Diversion: 3 intakes with a 3,000 cfs maximum capacity (total maximum capacity of 9,000 cfs)[x]	North Delta Diversion: 1 intake with a 3,000 cfs maximum capacity [y]	North Delta Diversion: 5 intakes with a 3,000 cfs maximum capacity (total maximum capacity of 15,000 cfs)[s]	North Delta Diversion: 3 intakes with a 3,000 cfs maximum capacity (total maximum capacity of 9,000 cfs)[u]	North Delta Diversion: 3 intakes with a 3,000 cfs maximum capacity (total maximum capacity of 9,000 cfs)[u]	Same as No Action Alternative	
SPECIFIC PROJECTS												
Water Supply Intake Projects												
Freeport Regional Water Project	None	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	
Stockton Delta Water Supply Project	None	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	
City of Antioch Delta	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	Monthly output from CALSIM II	
Sanitary and Agricultural Discharge Projects												
Veale Tract Drainage Relocation	The Veale Tract Water Quality Improvement Project, funded by CALFED, relocates the agricultural drainage outlet was relocated from Rock Slough channel to the southern end of Veale Tract, on Indian Slough[k]	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	
OPERATIONS CRITERIA												
Delta Cross Channel	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output	Monthly time series of number of days open from CALSIM II output	Oct-Nov: Number of days open from CALSIM II output Dec-Jun: DCC gate open if 11,000 < Sac < 25,000 cfs Jul-Sep: DCC gate open only if Sac<25,000 cfs	
Clifton Court Forebay	Priority 3, gate operations synchronized with incoming tide to minimize impacts to low water levels in nearby channels	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Not installed[SC]	
South Delta barriers	Temporary Barriers Project operated based on San Joaquin River flow time series from CALSIM II output; HORB is assumed only installed[l] Sep 16 – Nov 30; Agricultural barriers on Old and Middle Rivers are assumed to be installed starting from May 16th and the one on Grant Line Canal from June 1st; All the three barriers are allowed to be operated until November 30th; May 16th to May 31st the tidal gates are assumed to be tied open for the barriers on Old and Middle Rivers[m].	Same as Existing Conditions	Not installed	Same as No Action Alternative for South Delta Temporary Agricultural Barriers; Modified operations for Head of Old River Barrier[v]	Not installed	Same as No Action Alternative for South Delta Temporary Agricultural Barriers; Modified operations for Head of Old River Barrier[v]	Same as No Action Alternative	Not installed	Not installed	Not installed	Not installed[SC]	2008 BA and CA assumed South Delta Improvements Program Permanent Operable Gates (Stage 1); 2008 BA and CA did not consider FWS Delta Smelt BO related operations
North Delta Diversion Intakes	None	Same as Existing Conditions	Proposed north Delta diversion intakes are operated with priority from north to south. Maximum of 3,000 cfs is withdrawn at each intake while meeting velocity of 0.4 fps downstream. Daily diversion volume equivalent to CALSIM II output	Proposed north Delta diversion intakes are operated with priority from north to south. Maximum of 3,000 cfs is withdrawn at each intake while meeting velocity of 0.4 fps downstream. Daily diversion volume equivalent to CALSIM II output	Proposed north Delta diversion intakes are operated with priority from north to south. Maximum of 3,000 cfs is withdrawn at each intake while meeting velocity of 0.4 fps downstream. Daily diversion volume equivalent to CALSIM II output	Proposed north Delta diversion intakes are operated with priority from north to south. Maximum of 3,000 cfs is withdrawn at each intake while meeting velocity of 0.4 fps downstream. Daily diversion volume equivalent to CALSIM II output	Proposed north Delta diversion intakes are operated with priority from north to south. Maximum of 3,000 cfs is withdrawn at each intake while meeting velocity of 0.4 fps downstream. Daily diversion volume equivalent to CALSIM II output	Proposed north Delta diversion intakes are operated with priority from north to south. Maximum of 3,000 cfs is withdrawn at each intake while meeting velocity of 0.4 fps downstream. Daily diversion volume equivalent to CALSIM II output	Proposed north Delta diversion intakes are operated with priority from north to south. Maximum of 3,000 cfs is withdrawn at each intake while meeting velocity of 0.4 fps downstream. Daily diversion volume equivalent to CALSIM II output	Proposed north Delta diversion intakes are operated with priority from north to south. Maximum of 3,000 cfs is withdrawn at each intake while meeting velocity of 0.4 fps downstream. Daily diversion volume equivalent to CALSIM II output	Same as No Action Alternative	
Preferential CVP Jones pumping	None	Same as Existing Conditions	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	Same as No Action Alternative	If SJR>10,000 cfs, CVP Pumping from Existing Location If SJR<10,000 cfs, CVP Pumping from Clifton Court Forebay[SC]	
Habitat Restoration												
Habitat Restoration	None	Same as Existing Conditions	25,000 acres at early long-term phase and 65,000 acres at late long-term phase of Tidal Marsh (inclusive of intertidal, subtidal, and sea level rise accommodation area)	25,000 acres at early long-term phase and 65,000 acres at late long-term phase of Tidal Marsh (inclusive of intertidal, subtidal, and sea level rise accommodation area)	25,000 acres at early long-term phase and 65,000 acres at late long-term phase of Tidal Marsh (inclusive of intertidal, subtidal, and sea level rise accommodation area)	25,000 acres at early long-term phase and 65,000 acres at late long-term phase of Tidal Marsh (inclusive of intertidal, subtidal, and sea level rise accommodation area)	25,000 acres at early long-term phase and 65,000 acres at late long-term phase of Tidal Marsh (inclusive of intertidal, subtidal, and sea level rise accommodation area)	25,000 acres at early long-term phase and 65,000 acres at late long-term phase of Tidal Marsh (inclusive of intertidal, subtidal, and sea level rise accommodation area)	25,000 acres at early long-term phase and 65,000 acres at late long-term phase of Tidal Marsh (inclusive of intertidal, subtidal, and sea level rise accommodation area)	25,000 acres at early long-term phase and 65,000 acres at late long-term phase of Tidal Marsh (inclusive of intertidal, subtidal, and sea level rise accommodation area)	25,000 acres at early long-term phase and 65,000 acres at late long-term phase of Tidal Marsh (inclusive of intertidal, subtidal, and sea level rise accommodation area)	Flood plan and Riparian acres not included in the model

PARAMETER CATEGORY / STUDY	*EXISTING CONDITIONS*	*NO ACTION ALTERNATIVE*	*Alternative 1A,1B,1C*	*Alternative 2A,2B,2C*	*Alternative 3*	*Alternative 4 (All four decision tree scenarios)*	*Alternative 5*	*Alternative 6A, 6B, 6C*	*Alternative 7*	*Alternative 8*	*Alternative 9*	*COMMENTS*

DSM2 Notes:

[a] A new adjusted astronomical tide for use in DSM2 planning studies has been developed by DWR's Bay Delta Office Modeling Support Branch Delta Modeling Section in cooperation with the Common Assumptions workgroup. This tide is based on a more extensive observed dataset and covers the entire 82-year period of record.

[b] The 16-year period of record is the simulation period for which DSM2 has been commonly used for impacts analysis in many previous projects, and includes varied water year types.

[c] Although monthly CALSIM output was used as the DSM2-HYDRO input, the Sacramento and San Joaquin rivers were interpolated to daily values in order to smooth the transition from high to low and low to high flows. DSM2 then uses the daily flow values along with a 15-minute adjusted astronomical tide to simulate effect of the spring and neap tides.

[d] The Delta Island Consumptive Use (DICU) model is used to calculate diversions and return flows for all Delta islands based on the level of development assumed. The nominal 2005 Delta region hydrology land-use was determined by interpolation between the 1995 and projected 2020 land-use assumptions associated with Bulletin 160-98.The Common Assumptions work group is adopting 2030 land-use/hydrology inputs and assumptions where possible, and is supporting efforts to develop 2030 land-use/hydrology inputs and assumptions for the entire study area included in CALSIM II and related analyses. At present, the Delta region hydrology used in CALSIM II and DSM2 is limited to 2020 land-use assumptions as per Bulletin 160-98.

[e] CALSIM II calculates monthly EC for the San Joaquin River, which was then converted to daily EC using the monthly EC and flow for the San Joaquin River. Fixed concentrations of 150, 175, and 125 μmhos/cm were assumed for the Sacramento River, Yolo Bypass, and eastside streams, respectively.

[f] Net Delta outflow based on the CALSIM II flows was used with an updated G-model to calculate Martinez EC.

[g] Footnote removed

[h] Footnote removed

[i] Footnote removed

[j] Footnote removed

[k] Information was obtained based on the information from the draft final "Delta Region Drinking Water Quality Management Plan" dated June 2005 prepared under the CALFED Water Quality Program and a presentation by David Briggs at SWRCB public workshop for periodic review. The presentation "Compliance location at Contra Costa Canal at Pumping Plant #1– Addressing Local Degradation" notes that the Veale Tract drainage relocation project will be operational in June 2005. The DICU drainage currently simulated at node 204 is moved to node 202 in DSM2.

[l] Based on the FWS Delta Smelt BO Action 5, Head of Old River Barrier (HORB) is assumed to be not installed in April or May; therefore HORB is only installed in the Fall as shown.

[m] Based on the FWS Delta Smelt BO Action 5 and the project description provided in the page 119.

[n] Near-term proposed Project South Delta export values from CALSIM II are post-processed to re-operate Banks and Jones Pumping Plants during OMR control periods

[o] Martinez baseline stage is modified to account for the proposed habitat restoration in the near-term phase of the proposed project based on RMA2 modeling

[p] Martinez baseline stage is modified to account for the sea level rise at early (15 cm) and late (45 cm) long-term phases under all Alternatives and proposed habitat restoration at the early long-term (25000 ac) and late long-term (65000 ac) phases of the with-project Alternatives based on RMA2 modeling

[q] Martinez EC is modified to account for the proposed habitat restoration in the near-term phase of the proposed project based on RMA2 modeling

[r] Martinez EC is modified to account for the sea level rise at early (15 cm) and late (45 cm) long-term phases under all Alternatives and proposed habitat restoration at the early long-term (25000 ac) and late long-term (65000 ac) phases of the with-project Alternatives based on RMA2 modeling

[s] Five proposed intakes are modeled as transfers from new channels originating DSM2 nodes 334, 335, 336, 337 and 338 to a new DSM2 reservoir called IF_FOREBAY

[t] Two proposed intakes are modeled as transfers from new channels originating DSM2 nodes 334 and 335 to a new DSM2 reservoir called IF FOREBAY

[u] Three proposed intakes are modeled as transfers from new channels originating DSM2 nodes 335, 336 and 338 to a new DSM2 reservoir called IF FOREBAY

[v] Head of Old River Operable Barrier (HORB) Operations/Modeling assumptions (% OPEN)[1:] Oct 50%, Nov 100%[2:] Dec 100%, Jan 50%[3], Feb - Jun 15th 50%, Jun 16-30 100%, Jul - Sep 100% (1. Percent of time the HORB is open. Agricultural barriers are in and operated consistent with current practices. HORB would be open 100% whenever flows are greater than 10,000 cfs at Vernalis.; 2. For modeling assumption only. Action proposed: Before the D-1641 pulse = no OMR restrictions (HORB open), During the D-1641 pulse = no south Delta exports for two weeks (HORB closed), After the D-1641 pulse = -5,000 cfs OMR through November (HORB open 50% for 2 weeks), Exact timing of the action will be based on hydrologic conditions; 3. The HORB becomes operational at 50% when salmon fry are immigrating (based on real time monitoring). This generally occurs when flood flow releases are being made.)

[w] Five proposed intakes are modeled as transfers from new channels originating DSM2 nodes 334, 335, 336, 705 and 341 to a new DSM2 reservoir called IF FOREBAY. Node 705 and 341 are in the Sacramento River reach between Steamboat Slough and Delta Cross Channel

[x] Three proposed intakes are modeled as transfers from new channels originating at DSM2 nodes 334, 335 and 336 to a new DSM2 reservoir called IF FOREBAY

[y] One proposed intake is modeled as transfer from new channel originating at DSM2 node 334 to a new DSM2 reservoir called IF FOREBAY

Separate Corridor (SC) DSM2 Notes:

[1] Old River is separated from Middle River by blocking connections with gates. Old River is completely disconnected from Victoria Canal and Clifton Court Forebay.

[2] Five gates are installed and closed when San Joaquin River (SJR) flow at Vernalis is less than 10,000 cfs to separate Old River from Middle River. The gates are located on Woodward Canal, Santa Fe Cut, Connection Slough, Mouth of Old River at San Joaquin River near Franks Tract and Fisherman Cut.

[3] Two Gates, Middle River gate near the current site of the temporary barrier and San Joaquin River gate below the head of Old River, are installed in South Delta. For each one, a low head pump with 250 cfs capacity and a gate are installed (only when SJR flow is below 10,000 cfs) to improve water quality in South Delta.

[4] Clifton Court Forebay is directly connected to Victoria Canal. Old River connection through gate to the Forebay is removed.

[5] The Meadows Slough is now connected to Sacramento River. A gate is installed on the Meadows Slough to block flow from August through November and when Sacramento flow is greater than 25,000 cfs.

[6] Two more gates are installed in McCormick Williamson Tract. Both gates are open from August through November. One is on Mokelumne River to reroute flow to Sacramento River when Sacramento River flow is below 25,000 cfs (only during December through July). Second gate is on Snodgrass Slough and is closed when Sacramento River flow is below 25,000 cfs (only during December through July) to keep the fish on the path toward Sacramento River.

[7] One gate is operated on Georgiana Slough to limit the flow through it to 7,500 cfs to prevent flooding (for Sacramento River flow above 45,000 cfs).

[8] Channel cross-sections on Snodgrass, Stone Lakes, Lost Slough, Mokelumne River and Meadows Slough around McCormick Williamson Tract are modified based on LIDAR data provoded by DHCCP

[9] Middle River and Victoria Canal are dredged based on DHCCP Design Drawings

[10] Both SWP and CVP are pumping from Clifton Court Forebay when SJR flow is below 10,000 cfs. For SJR flow above 10,000 cfs, CVP is assumed to be pumping from existing intake.

[11] An operable gate in Three Mile Slough is installed which is consistent with Franks Tract Program.

B.7. American River Demands

This section includes the information provided to and agreed to by the lead agencies in the "Bay Delta Conservation Plan EIR/EIS Project - CALSIM II Baselines Models - American River Assumptions", on February 17, 2010.

Introduction

This memorandum describes the assumptions that are being used for the American River in the Existing Conditions and No Action Alternative CALSIM II Baselines models. These assumptions were selected by the DWR management team for the BDCP EIR/EIS in coordination with the Reclamation, USFWS and NMFS. The following sections provide an overview of the assumptions, followed by a summary table of the specific diversion related assumptions for each diverter.

Overview of Assumptions

The following is a summary of the assumptions that will be used to develop the Existing Conditions and No Action Alternative models. For specific diversion related assumptions, see the following section.

Existing Conditions:

- American River Flow Management is included, as required by the NMFS Biological Opinion (Jun 2009) Action II.1
- Water rights and Central Valley Project (CVP) contract demands are assumed at year 2005-2010 levels
- Placer County Water Agency (PCWA) Pump Station is included at full demand
- Freeport Regional Water Project (FRWP) is not included
- Sacramento River Water Reliability Project (SRWRP) is not included
- Sacramento Area Water Forum is not included (dry year “wedge” reductions and mitigation water releases are not included)

No Action Alternative:

- American River Flow Management is included, as required by the NMFS Biological Opinion (Jun 2009) Action II.1
- Water rights and Central Valley Project (CVP) demands are assumed at a full “Build-out” condition with CVP contracts at full contract amounts
- Placer County Water Agency (PCWA) Pump Station is included at full demand
- Freeport Regional Water Project (FRWP) is included at full demand (EBMUD CVP contracts and SCWA CVP contract and new appropriative water rights and water acquisitions as modeled in the FRWP EIS/R)
- Sacramento River Water Reliability Project (SRWRP) is not included
- Sacramento Area Water Forum is not included (dry year “wedge” reductions and mitigation water releases are not included)

Summary of Demands

The Table B-19 below summarizes the water rights, CVP contract amounts, and demand amounts for each diverter in the American River system in the Existing Conditions and No Action Alternative.

Table B-19: American River Diversions Assumed in the Existing Conditions and No Action Alternative

American River Diversion Amounts Assumed in the Existing and Future Conditions Baselines Models							*As of February, 2010*
		Existing Conditions (TAF/Yr)			**No Action Alternative (TAF/Yr)**		
	Diversion Location	**CVP M&I Contracts (max-imum[1])**	**Water Rights (max-imum)**	**Diversion Limit (max-imum capacity)**	**CVP M&I Contracts (max-imum[1])**	**Water Rights (max-imum)**	**Diversion Limit (max-imum capacity)**
American River Diversions							
Placer County Water Agency	Auburn Dam Site		35.5	35.5		35.5	35.5
Total		0	35.5	35.5	0	35.5	35.5
Sacramento Suburban Water District[2]	Folsom Reservoir		17	17		17	17
City of Folsom - includes P.L. 101-514		7	27	34	7	27	34
Folsom Prison			2	2		5	5
San Juan Water District (Placer County)			17	17		24	24
San Juan Water District (Sac County) - includes P.L. 101-514		24.2	33	44.2	24.2	33	57.2
El Dorado Irrigation District		7.55	0	7.55	7.55	17	24.55
City of Roseville		32	5	37	32	5	37
Placer County Water Agency		0		0	35		35
El Dorado County - P.L.101-514		15		4	15		15
Total		85.75	101	162.75	120.75	128	248.75
So. Cal WC/Arden Cordova WC	Folsom South Canal		5	5		5	5
California Parks and Recreation		5		1	5		5
SMUD		30	15	20	30	15	45
Canal Losses			1	1		1	1
Total		35	21	27	35	21	56

City of Sacramento[3]	Lower American River		58	58		82.26	82.26
Carmichael Water District			12	12		12	12
Total		0	70	70	0	94.26	94.26
Total American River Diversions		120.75	227.5	295.25	155.75	278.76	434.51
Sacramento River Diversions							
City of Sacramento	Sacramento River Water Reliability Project		0	0		0	0
Placer County Water Agency (Sac Suburban, Roseville and others)			0	0		0	0
Total		0	0	0	0	0	0
City of Sacramento	Sacramento River Pump Station		62.3	62.3		162.74	162.74
Sacramento County Water Agency		15		15	10		10
Total		15	62.3	77.3	10	162.74	172.74
Sacramento County Water Agency	Freeport Regional Water Project	0		0	20		20
Sacramento County Water Agency - P.L. 101-514		0		0	15		15
Sacramento County Water Agency - water rights and acquisitions			0	0		varies[4], average 31.2	varies[4]
East Bay Municipal Utilities District		0		0	133		varies[5]
Total		0	0	0	168	31.2	35
Total Sacramento River Diversions		0	0	0	168	31.2	35
Total		120.75	227.5	295.25	323.75	309.96	469.51

1/ When the CVP Contract quantity exceeds the quantity of the Diversion Limit minus the Water Right (if any), the diversion modeled is the quantity allocated to the CVP Contract (based on the CVP contract quantity shown times the CVP M&I allocation percentage) plus the Water Right (if any), but with the sum limited to the quantity of the Diversion Limit
2/ Diversion is only allowed if and when Mar-Nov Folsom Unimpaired Inflow (FUI) exceeds 1600 TAF
3/ When the Hodge single dry year criteria is triggered, Mar-Nov FUI falls below 400 TAF, diversion on the American River is limited to 50 TAF and diversion on the Sacramento River is increased to 164.013 TAF (physical capacity of Sacramento River plant)
4/ SCWA targets 68 TAF of surface water supplies annually. The portion unmet by CVP contract water is assumed to come from two sources:
(1) Delta "excess" water- averages 16.5 TAF annually, but varies according to availability. SCWA is assumed to divert excess flow when it is available, and when there is available pumping capacity.
(2) "Other" water- derived from transfers and/or other appropriated water, averaging 14.8 TAF annually but varying according remaining unmet demand.
5/ EBMUD CVP diversions are governed by the Amendatory Contract, stipulating:
(1) 133 TAF maximum diversion in any given year
(2) 165 TAF maximum diversion amount over any 3 year period
(3) Diversions allowed only when EBMUD total storage drops below 500 TAF
(4) 155 cfs maximum diversion rate

B.8. SWP Variable Demands

The State Water Project has 29 long-term contracts for water supply totaling about 4.2 million acre-feet annually, of which about 4.1 million acre-feet are for contracting agencies with service areas south of the Sacramento-San Joaquin Delta. About 70 percent of this amount is the contract entitlement for urban users and the remaining 30 percent for agricultural users. CALSIM II allocations are set per the Monterey Agreement criteria, which imposes any deficiencies equally between agricultural and M&I requests as a percentage. The information noted in this section for the Existing Conditions simulation is consistent with the assumptions from 2008 OCAP BA, as noted in the Appendix D (USBR, 2008a).

SWP contract amounts as simulated in Existing Conditions and No Action Alternative models are summarized in Table B-20.

Table B-20: Summary of SWP Contract Amounts (TAF/Year)

Contract Type	North Of Delta	South of Delta
Existing Conditions		
Feather River Service Area	796	0
Water Right	187	0
Agriculture	0	1048
M&I	108	3008
No Action Alternative		
Feather River Service Area	796	0
Water Right	187	0
Agriculture	0	1032
M&I	114	3024

The SWP Table A amounts and Article 21 demands for each North-of-the-Delta and South-of-Delta contractor is provided in the Section B.9. In addition, the tables show Feather River Service Area water rights and the assumed losses on the California Aqueduct.

SWP south of Delta demands are simulated as full contract amounts in No Action Alternative (SWP AG: 1032 taf, MWDSC M&I: 1911.5 taf, and other M&I: 1226.5 taf) whereas AG and MWDSC demands are variable in Existing Condition. In Existing Condition, SWP agricultural demands in the San Joaquin Valley are capped to the full assigned amount, but are reduced in wetter years using an index developed from annual Kern River inflows to Lake Isabella. Table B-21 shows SWP south of Delta AG demands for years 1921-2003.

Metropolitan Water District of Southern California (MWDSC) demands are variable for Existing Conditions model. Table B-22 shows MWDSC demands for years 1921-2003 assumed in the Existing Conditions CALSIM II simulation.

Table B-21: SWP south of Delta AG demands simulated in Existing Conditions model (TAF/Year) with a minimum of 834 TAF and a maximum of 1048 TAF

Year	SWP SOD AG DEMANDS	Year	SWP SOD AG DEMANDS	Year	SWP SOD AG DEMANDS
1921	1048	1949	1048	1977	1048
1922	1048	1950	1048	1978	834
1923	1048	1951	1048	1979	1048
1924	1048	1952	834	1980	834
1925	1048	1953	1048	1981	1048
1926	1048	1954	1048	1982	1002
1927	1048	1955	1048	1983	834
1928	1048	1956	1048	1984	1048
1929	1048	1957	1048	1985	1048
1930	1048	1958	1002	1986	834
1931	1048	1959	1048	1987	1048
1932	1048	1960	1048	1988	1048
1933	1048	1961	1048	1989	1048
1934	1048	1962	1048	1990	1048
1935	1048	1963	1048	1991	1048
1936	1048	1964	1048	1992	1048
1937	1002	1965	1048	1993	1048
1938	1002	1966	1048	1994	1048
1939	1048	1967	1002	1995	1002
1940	1048	1968	1048	1996	1048
1941	834	1969	834	1997	1048
1942	1048	1970	1048	1998	1002
1943	1002	1971	1048	1999	1048
1944	1048	1972	1048	2000	1048
1945	1048	1973	1048	2001	1048
1946	1048	1974	1048	2002	1048
1947	1048	1975	1048	2003	1048
1948	1048	1976	1048		

Table B-22: SWP MWDSC demands simulated in Existing Conditions model (TAF/Year) with a minimum of 1006 TAF and a maximum of 1900 TAF

Year	MWDSC SWP DEMANDS	Year	MWDSC SWP DEMANDS	Year	MWDSC SWP DEMANDS
1921	1524	1949	1649	1977	1732
1922	1192	1950	1596	1978	1125
1923	1502	1951	1564	1979	1312
1924	1746	1952	1077	1980	1197
1925	1725	1953	1575	1981	1619
1926	1562	1954	1618	1982	1281
1927	1328	1955	1545	1983	1006
1928	1682	1956	1424	1984	1477
1929	1737	1957	1544	1985	1537
1930	1707	1958	1312	1986	1344
1931	1756	1959	1840	1987	1689
1932	1458	1960	1900	1988	1811
1933	1723	1961	1900	1989	1882
1934	1766	1962	1473	1990	1746
1935	1481	1963	1419	1991	1742
1936	1554	1964	1691	1992	1664
1937	1282	1965	1370	1993	1344
1938	1248	1966	1507	1994	1524
1939	1458	1967	1270	1995	1281
1940	1497	1968	1577	1996	1477
1941	1013	1969	1156	1997	1344
1942	1368	1970	1498	1998	1281
1943	1463	1971	1622	1999	1477
1944	1348	1972	1796	2000	1504
1945	1397	1973	1396	2001	1746
1946	1495	1974	1434	2002	1882
1947	1739	1975	1504	2003	1504
1948	1744	1976	1798		

B.9. Delivery Specifications

This section lists the State Water Project (SWP) and Central Valley Project (CVP) contract amounts and other water rights assumptions used in the BDCP EIR/EIS Existing Conditions and No Action Alternative CALSIM II simulations. These specifications are based upon the OCAP BA and have been modified under direction of Reclamation and DWR as described in the preceding sections.

Table B-23. Delta - Baselines - Existing Conditions

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Water Right (TAF/yr)	SWP Table A Amount (TAF)		SWP Article 21 Demand (TAF/mon)	CVP Water Service Contracts (TAF/yr)		Other (TAF/yr)
				Ag	M&I		AG	M&I	
North Delta									
City of Vallejo	City of Vallejo	D403A						16.0	
CCWD[a]	Contra Costa County	D420						140.0	
Napa County FC&WCD	North Bay Aqueduct	D403B			23.20	1.0			
Solano County WA	North Bay Aqueduct	D403C			47.41	1.0			
Fairfield, Vacaville and Benecia Agreement	North Bay Aqueduct	D403D	31.60						
City of Antioch	City of Antioch	D406B	18.0						
Total North Delta			49.6	0.0	70.6	2.0	0.0	156.0	
South Delta									
Delta Water Supply Project	City of Stockton	D514A	0.0						
Total South Delta			0.0	0.0	0.0	0.0	0.0	0.0	
Total			49.6	0.0	70.6	2.0	0.0	156.0	

a The new Los Vaqueros module in CALSIM II is used to determine the range of demands that are met by CVP contracts or other water rights.

Table B-24. SWP North-of-the-Delta - Baselines - Existing Conditions

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	FRSA Amount (TAF)	Water Right (TAF/yr)	Table A Amount (TAF)		Article 21 Demand (TAF/mon)	Other (TAF/yr)
					Ag	M&I		
Feather River								
Palermo	FRSA	D6		17.6				
County of Butte	Feather River	D201				27.5		
Thermalito	FRSA	D202		8.0				
Western Canal	FRSA	D7A	150.0	145.0				
Joint Board	FRSA	D7B	550.0	5.0				
City of Yuba City	Feather River	D204				9.6		
Feather WD	FRSA	D206A	17.0					
Garden, Oswald, Joint Board	FRSA	D206B						
Garden	FRSA	D206BA	12.9	5.1				
Oswald	FRSA	D206BB	2.9					
Joint Board	FRSA	D206BC	50.0					
Plumas, Tudor	FRSA	D206C						
Plumas	FRSA	D206CA	8.0	6.0				
Tudor	FRSA	D206CB	5.1	0.2				
Total Feather River Area			795.8	186.9	0.0	37.1		
Other								
Yuba County Water Agency	Yuba River	D230						Variable 333.6
Camp Far West ID	Yuba River	D285						12.6
Bear River Exports	American R/DSA70	D283						Variable 95.2
Feather River Exports to American River (left bank to DSA70)	American R/DSA70	D223		11.0				

Table B-25. SWP South-of-the-Delta - Baselines - Existing Conditions

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Table A Amount (TAF) Ag	Table A Amount (TAF) M&I	Article 21 Demand (TAF/mon)	Losses (TAF/yr)
Alameda Co. FC&WCD, Zone 7	SBA reaches 1-4	D810		47.60	1.00	
	SBA reaches 5-6	D813		33.02	None	
		Total		80.62	1.00	
Alameda County WD	SBA reaches 7-8	D814		42.00	1.00	
Santa Clara Valley WD	SBA reach 9	D815		100.00	4.00	
Oak Flat WD	CA reach 2A	D802	5.70		None	
County of Kings	CA reach 8C	D847	9.31		None	
Dudley Ridge WD	CA reach 8D	D849	57.34		1.00	
Empire West Side ID	CA reach 8C	D846	3.00		1.00	
Kern County Water Agency	CA reaches 3, 9-13B	D851	582.31	134.60	None	
	CA reaches 14A-C	D859	118.80		180.00	
	CA reaches 15A-16A	D863	66.42		None	
	CA reach 31A	D867	96.60		None	
		Total	864.13	134.60	180.00	
Tulare Lake Basin WSD	CA reaches 8C-8D	D848	95.92		15.00	
San Luis Obispo Co. FC&WCD	CA reaches 33A-35	D869		25.00	None	
Santa Barbara Co. FC&WCD	CA reach 35	D870		45.49	None	
Antelope Valley-East Kern WA	CA reaches 19-20B, 22A-B	D877		141.40	1.00	
Castaic Lake WA	CA reach 31A	D868	12.70		1.00	
	CA reach 30	D896		82.50	None	
		Total	12.70	82.50	1.00	
Coachella Valley WD	CA reach 26A	D883		121.10	2.00	
Crestline-Lake Arrowhead WA	CA reach 24	D25		5.80	None	
Desert WA	CA reach 26A	D884		50.00	5.00	
Littlerock Creek ID	CA reach 21	D879		2.30	None	
Mojave WA	CA reaches 19, 22B-23	D881		75.80	None	

Table B-25. SWP South-of-the-Delta - Baselines - Existing Conditions

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Table A Amount (TAF) Ag	Table A Amount (TAF) M&I	Article 21 Demand (TAF/mon)	Losses (TAF/yr)
Metropolitan WDSC	CA reach 26A	D885		148.67	90.70	
	CA reach 30	D895		756.69	74.80	
	CA reaches 28G-H	D899		102.71	27.60	
	CA reach 28J	D27		903.43	6.90	
		Total		1911.50	200.00	
Palmdale WD	CA reaches 20A-B	D878		21.30	None	
San Bernardino Valley MWD	CA reach 26A	D886		102.60	None	
San Gabriel Valley MWD	CA reach 26A	D887		28.80	None	
San Gorgonio Pass WA	CA reach 26A	D888		17.30	None	
Ventura County FCD	CA reach 29H	D28		3.15	None	
	CA reach 30	D29		16.85	None	
		Total		20.00		
SWP Losses	CA reaches 1-2	D803				7.70
	SBA reaches 1-9	D816				0.60
	CA reach 3	D824				10.80
	CA reach 4	D826				2.60
	CA reach 5	D827				3.90
	CA reach 6	D828				1.20
	CA reach 7	D829				1.60
	CA reaches 8C-13B	D854				11.90
	Wheeler Ridge PP and CA reaches 14A-C	D862				3.60
	Chrisman PP and CA reaches 15A-18A	D864				1.80
	Pearblossom PP and CA reaches 17-21	D880				5.10
	Mojave PP and CA reaches 22A-23	D882				4.00
	REC and CA reaches 24-28J	D889				1.40
	CA reaches 29A-29F	D891				1.90
	Castaic PWP and CA reach 29H	D893				3.10
	REC and CA reach 30	D894				2.40
Total						63.60
Total			1048.10	3008.11	412.00	63.60

Table B-26. CVP North-of-the-Delta - Baselines - Existing Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Representation		CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges[a] (TAF/yr)
		Diversion	Region	AG	M&I			
Anderson Cottonwood ID	Sacramento River Redding Subbasin	D104A	DSA 58			128.0		
Clear Creek CSD		D104B	DSA 58	13.8	1.5			
Bella Vista WD		D104C	DSA 58	22.1	2.4			
Shasta CSD		D104D	DSA 58		1.0			
Sac R. Misc. Users		D104F	DSA 58			3.4		
Redding, City of		D104G	DSA 58			21.0		
City of Shasta Lake		D104H	DSA 58	2.5	0.3			
Mountain Gate CSD		D104I	DSA 58		0.4			
Shasta County Water Agency		D104J	DSA 58	0.5	0.5			
Redding, City of/Buckeye		D104K	DSA 58		6.1			
Total		D104		38.9	12.2	152.4		0.0
Corning WD	Corning Canal	D171	WBA 4	23.0				
Proberta WD		D171	WBA 4	3.5				
Thomes Creek WD		D171	WBA 4	6.4				
Total				32.9	0.0	0.0		0.0
Kirkwood WD	Tehama-Colusa Canal	D172	WBA 4	2.1				
Glide WD		D174	WBA 7N	10.5				
Kanawha WD		D174	WBA 7N	45.0				
Orland-Artois WD		D174	WBA 7N	53.0				
Colusa, County of		D178	WBA 7S	20.0				
Colusa County WD		D178	WBA 7S	62.2				
Davis WD		D178	WBA 7S	4.0				
Dunnigan WD		D178	WBA 7S	19.0				
La Grande WD		D178	WBA 7S	5.0				
Westside WD		D178	WBA 7S	65.0				
Total				285.8	0.0	0.0		0.0
Sac. River Misc. Users	Sacramento River	D113A	WBA 4			1.5		

Table B-26. CVP North-of-the-Delta - Baselines - Existing Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Representation		CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges[a] (TAF/yr)
		Diversion	Region	AG	M&I			
Glenn Colusa ID	Glenn-Colusa Canal	D143A	WBA 8NN			441.5		
		D145A	WBA 8NS			383.5		
Sacramento NWR		D143B	WBA 8NN					41.3
Delevan NWR		D145B	WBA 8NS					19.5
Colusa NWR		D145B	WBA 8NS					24.5
Colusa Drain M.W.C.	Colusa Basin Drain	D180	WBA 8NN			7.7		
		D182A/ D18302	WBA 8NS			62.3		
Total				0.0	0.0	895.0		85.4
Princeton-Cordova-Glenn ID	Sacramento River	D122A	WBA 8NN			67.8		
Provident ID		D122A	WBA 8NN			54.7		
Maxwell ID		D122A	WBA 8NN			1.8		
		D122B	WBA 8NS			16.2		
Sycamore Family Trust		D122B	WBA 8NS			31.8		
Roberts Ditch IC		D122B	WBA 8NS			4.4		
Sac R. Misc. Users		D122A	WBA 8NN			4.9		
		D122B	WBA 8NS			9.5		
Total				0.0	0.0	191.2		0.0
Reclamation District 108	Sacramento River	D122B	WBA 8NS			12.9		
		D129A	WBA 8S			219.1		
River Garden Farms		D129A	WBA 8S			29.8		
Meridian Farms WC		D128	DSA 15			35.0		
Pelger Mutual WC		D128	DSA 15			8.9		
Reclamation District 1004		D128	DSA 15			71.4		
Carter MWC		D128	DSA 15			4.7		
Sutter MWC		D128	DSA 15			226.0		
Tisdale Irrigation & Drainage Co.		D128	DSA 15			9.9		
Sac R. Misc. Users		D128	DSA 15			103.4		
		D129A	WBA 8S			0.9		
Feather River WD export		D128	DSA 15	20.0				
Total				20.0	0.0	722.1		0.0

Table B-26. CVP North-of-the-Delta - Baselines - Existing Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Representation		CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges[a] (TAF/yr)
		Diversion	Region	AG	M&I			
Sutter NWR	Sutter bypass water for Sutter NWR	C136B	DSA 69					14.0
Gray Lodge WMA	Feather River	C216B	DSA 69					41.4
Butte Sink Duck Clubs		C221	DSA 69					15.9
Total				0.0	0.0	0.0		71.3
Sac R. Misc. Users	Sacramento River	D163	DSA 65			56.8		
City of West Sacramento		D165	DSA 65			23.6		
Davis-Woodland Water Supply Project		D165	DSA 65					
Total				0.0	0.0	80.4		0.0
Sac R. Misc. Users	Lower Sacramento River	D162A	DSA 70			4.8		
Natomas Central MWC		D162B	DSA 70			120.2		
Pleasant Grove-Verona MWC		D162C	DSA 70			26.3		
City of Sacramento		D162D	DSA 70		0.0		0.0	
Placer County Water Agency (Sac Suburban, Roseville and others)		D162E	DSA 70		0.0		0.0	
Total					0.0	151.3	0.0	
Total CVP North-of-Delta				377.6	12.2	2193.8	0.0	156.7

[a] *Level 4 Refuge water needs are not included.*

[b] *Refer to Table 8 for more information*

[c] *The new Los Vaqueros module in CALSIM II is used to determine the range of demands that are met by CVP contracts or other water rights.*

Table B-27. CVP and Water Rights for American River - Baselines - Existing Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement/ Exchange Contractor (TAF/yr)	Water Rights/ Non-CVP (TAF/yr)	Diversion Limit (Maximum Capacity) (TAF/Yr)	Footnotes
			AG	M&I[1]				
Placer County Water Agency	Auburn Dam Site	D300		0.0		35.5	35.5	
Sacramento Suburban Water District[2]	Folsom Reservoir	D8A				17.0	17.0	
City of Folsom (includes P.L. 101-514)		D8B		7.0		27.0	34.0	1
Folsom Prison		D8C				2.0	2.0	
San Juan Water District (Placer County)		D8D				17.0	17.0	
San Juan Water District (Sac County) (includes P.L. 101-514)		D8E		24.2		33.0	44.2	1
El Dorado Irrigation District		D8F		7.55		0.0	7.55	1
City of Roseville		D8G		32.0		5.0	37.0	1
Placer County Water Agency		D8H		0.0			0.0	
El Dorado County (P.L. 101-514)		D8I		15.0			4.0	1
Total			0.0	85.8	0.0	101.0	162.8	
So. Cal WC/ Arden Cordova WC	Folsom South Canal	D9AA				5.0	5.0	
California Parks and Recreation		D9AB		5.0			1.0	1
SMUD (export)		D9B		30.0		15.0	20.0	1
Canal Losses		D9A				1.0	1.0	
Total			0.0	35.0	0.0	21.0	27.0	
City of Sacramento[3]	Lower American River	D302A				58.0	58.0	
Carmichael Water District		D302C				12.0	12.0	
Total			0.0	0.0	0.0	70.0	70.0	
City of Sacramento	Lower Sacramento River	D167A				62.3	62.3	
Sacramento County Water Agency (includes SMUD transfer)		D167B		15.0			15.0	
		D168C		0.0			0.0	
Sacramento County Water Agency (P.L. 101-514)		D168C		0.0			0.0	
Sacramento County Water Agency - assumed Appropriated Water		D168C				0.0		2
EBMUD (export)		D168B		0.0				3
Total			0.0	15.0	0.0	62.3	77.3	
Total (American R)			0.0	135.75	0.00	289.80		

Table B-28. CVP South-of-the-Delta - Baselines - Existing Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr) AG	CVP Water Service Contracts (TAF/yr) M&I	Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges[a] (TAF/yr)	Losses (TAF/yr)
Byron-Bethany ID	Upper DMC	D700	20.6					
Tracy, City of		D700		10.0				
		D700		5.0				
		D700		5.0				
Banta Carbona ID		D700	20.0					
Total		D700	40.6	20.0	0.0	0.0	0.0	0.0
Del Puerto WD	Upper DMC	D701	12.1					
avis WD		D701	5.4					
D D		D701	10.8					
Foothill W ospital WD		D701	34.1					
H ern Canon WD		D701	7.7					
K tang WD		D701	14.7					
Mus restimba WD		D701	15.9					
O uinto WD		D701	8.6					
Q ero WD		D701	5.2					
Rom lado WD		D701	9.1					
Sa lower WD		D701	16.6					
Sunf West Stanislaus WD		D701	50.0					
Patterson WD		D701	16.5			6.0		
Total		D701	206.7	0.0	0.0	6.0	0.0	0.0
Upper DMC Loss	Upper DMC	D702						18.5
Panoche WD	Lower DMC Volta	D706	6.6					
San Luis WD		D706	65.0					
Laguna WD		D706	0.8					
Eagle Field WD		D706	4.6					
Mercy Springs WD		D706	2.8					
Oro Loma WD		D706	4.6					
Total		D706	84.4	0.0	0.0	0.0	0.0	0.0
Upper DMC Exchange Contractors	Lower DMC Volta	D707						
entral California ID		D707			140.0			
C								

Table B-28. CVP South-of-the-Delta - Baselines - Existing Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr) AG	CVP Water Service Contracts (TAF/yr) M&I	Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges[a] (TAF/yr)	Losses (TAF/yr)
Grasslands via CCID	Lower DMC Volta	D708					81.8	
Los Banos WMA		D708					11.2	
Kesterson NWR	Lower DMC Volta	D708					19.6	
Freitas - SJBAP		D708					6.9	
Salt Slough - SJBAP		D708					10.3	
China Island - SJBAP		D708					7.2	
Volta WMA		D708					15.9	
Grassland via Volta Wasteway		D708					23.2	
Total		D708	0.0	0.0	140.0	0.0	176.1	0.0
Fresno Slough WD	San Joaquin River at Mendota Pool	D607A	4.0			0.9		
James ID		D607A	35.3			9.7		
Coelho Family Trust		D607A	2.1			1.3		
Tranquillity ID		D607A	13.8			20.2		
Tranquillity PUD		D607A	0.1			0.1		
Reclamation District 1606		D607A	0.2			0.3		
Exchange Contractors		D607B						
Central California ID		D607B			392.4			
Columbia Canal Co.		D607B			59.0			
Firebaugh Canal Co.		D607B			85.0			
San Luis Canal Co.		D607B			23.6			
M.L. Dudley Company		D607B				2.3		
Grasslands WD		D607C					29.0	
Mendota WMA		D607C					37.9	
Losses		D607D						101.5
Total		D607	55.5	0.0	560.0	34.8	66.9	101.5
Exchange Contractors	San Joaquin River at Sack Dam	D608B						
San Luis Canal Co.		D608B			140.0			
Grasslands WD		D608C					2.3	
Los Banos WMA		D608C					12.4	
San Luis NWR		D608C					23.8	
West Bear Creek NWR		D608C					7.5	
East Bear Creek NWR		D608C					0.0	
Total		D608	0.0	0.0	140.0	0.0	46.0	0.0

Table B-28. CVP South-of-the-Delta - Baselines - Existing Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges[a] (TAF/yr)	Losses (TAF/yr)
			AG	M&I				
San Benito County WD (Ag)	San Felipe	D710	35.6					
Santa Clara Valley WD (Ag)		D710	33.1					
Pajaro Valley WD		D710	6.3					
San Benito County WD (M&I)		D711		8.3				
Santa Clara Valley WD (M&I)		D711		119.4				
Total		D710/D711	74.9	127.7	0.0	0.0	0.0	0.0
San Luis WD	CA reach 3	D833	60.1					
CA, State Parks and Rec		D833	2.3					
Affonso/Los Banos Gravel Co.		D833	0.3					
Total		D833	62.6	0.0	0.0	0.0	0.0	0.0
Panoche WD	CVP Dos Amigos PP/ CA reach 4	D835	87.4					
Pacheco WD		D835	10.1					
Total		D835	97.5	0.0	0.0	0.0	0.0	0.0
Westlands WD (Centinella WD)	CA reach 4	D836	2.5					
Westlands WD (Broadview WD)		D836	27.0					
Westlands WD (Mercy Springs WD)		D836	4.2					
Westlands WD (Widern WD)		D836	3.0					
Total		D836	36.7	0.0	0.0	0.0	0.0	0.0
Westlands WD: CA Joint Reach 4	CA reach 4	D837	219.0					
Westlands WD: CA Joint Reach 5	CA reach 5	D839	570.0					
Westlands WD: CA Joint Reach 6	CA reach 6	D841	219.0					
Westlands WD: CA Joint Reach 7	CA reach 7	D843	142.0					
Total			1150.0	0.0	0.0	0.0	0.0	0.0
Avenal, City of	CA reach 7	D844		3.5		3.5		
Coalinga, City of		D844		10.0				
Huron, City of		D844		3.0				
Total		D844	0.0	16.5	0.0	3.5	0.0	0.0

Table B-28. CVP South-of-the-Delta - Baselines - Existing Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr) AG	CVP Water Service Contracts (TAF/yr) M&I	Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges[a] (TAF/yr)	Losses (TAF/yr)
CA Joint Reach 3 - Loss	CVP Dos Amigos PP/CA reach 3	D834						2.5
CA Joint Reach 4 - Loss	CA reach 4	D838						10.1
CA Joint Reach 5 - Loss	CA reach 5	D840						30.1
CA Joint Reach 6 - Loss	CA reach 6	D842						12.5
CA Joint Reach 7 - Loss	CA reach 7	D845						8.5
Total			0.0	0.0	0.0	0.0	0.0	63.7
Cross Valley Canal - CVP	CA reach 14							
Fresno, County of		D855	3.0					
Hills Valley ID-Amendatory		D855	3.3					
Kern-Tulare WD		D855	40.0					
Lower Tule River ID		D855	31.1					
Pixley ID		D855	31.1					
Rag Gulch WD		D855	13.3					
Tri-Valley WD		D855	1.1					
Tulare, County of		D855	5.3					
Kern NWR		D856					14.3	
Pixley NWR		D856					1.3	
Total			128.3	0.0	0.0	0.0	15.6	0.0
Total CVP South-of-Delta			1937.1	164.2	840.0	44.3	304.6	183.7

[a] *Level 4 Refuge water needs are not included*

Table B-29. Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc location - Baselines - Existing Conditions

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Riverview Golf & Country Club	D104F	58	3	240.8	L	255	25	280
Daniell, Harry				240.3	L	13	7	20
Redding Rancheria (Frmrly High-Low Nursery)				240.2	L	70	135	205
Lake Cal. Property Owners Assn			2	221	R	580	200	780
Leviathan, Inc.				221	R	355	345	700
Driscoll Strawberry Associates, Inc.			3	207.5	L	330	490	820
J. B. Unlimited, Inc.				197	L	220	290	510
Micke, Daniel & Nina				196.6	L	81	19	100
Gjermann, Hal				196.55	L	8	4	12
Total	D104F					1,912	1,515	3,427
Meyer, Herbert (Frmrly Diamond Holdings, Inc.)	D113A	58	4	191.5	R	195	230	425
Exchange Bank (The Nature Conservancy)		10		168.85	R	210	570	780
Rubio, Exequiel (Frmrly Elliott&Hadracky)				166.8	R	11	5	16
Penner, Roger & Leona				156.8	R	159	21	180
Freeman, Vola				156.1	R	11	19	30
Mclane, Robert				155.6	R	17	23	40
Alexander, Thomas Et Ux				155.6	R	9	13	22
Total	D113A					612	881	1,493
Green Valley Corp. (Frmrly Cannell, F.)	D122A	15	8NN	106	R	680	210	890
Green Valley Corp. (Frmrly Stegeman Ranch)				106	R	555	325	880
Tuttle, Charles W. - Trust				103.9	R	120	270	390
Cachil Dehe Band Of Wintun Indians(Lee Farms)				103.7	R	80	100	180
Seaver, Charles				99.3	R	200	260	460
Odysseus Farms				93.15	R	1,920	150	2,070
Total	D122A					3,555	1,315	4,870
King, Ben And Laura (Frmrly Dommer, E.)	D122B	15	8NS	89.2	R	12	7	19
King, Laura				89.2	R	13	13	26
Wisler, John W. Jr. (Frmrly Cribari, E.)				88	R	8	27	35
Mehrhof, Susan M.(frmrly.Swinford Tract)				87.7	R	164	16	180
Steidlmayer, Anthony E., Et Al.				83	R	610	700	1,310
Jansen, Peter & Sandy (Frmrly E. J. Ritchey)				70.4	R	150	40	190
Gillaspy, William & Mary (Frmrly Fay Gillaspy)				70.4	R	120	90	210
Beckley, Ralph, And Ophelia				70.4	R	165	135	300
Driver, Gary, Et Al.				69.2	R	8	22	30

Table B-29. Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc location - Baselines - Existing Conditions

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Heidrick, Mildred M.	D122B	65	8NS	30.6	R	86	34	120
Tenhunfeld, F. Wallace, Jack, Et Al.				29.7	R	2,680	960	3,640
Heidrick, Mildred M.				29.2, 30.3	R	370	60	430
Hershey Land Company				28.1	R	2,570	450	3,020
Total	D122B					6,956	2,554	9,510
Pacific Realty Assoc., L.P. (M&T Chico Ranch)	D128	15	9	140.8, 141.5	L	16,980	976	17,956
Spence, Ruth Ann (Spence Farms)				104.8	L	630	100	730
Anderson, Arthur Et Al (Frmrly Westfall, Mary)				102.5	L	445	45	490
Forry, Laurie E.				99.8	L	2,285	0	2,285
Otterson, Mike (Frmrly Wells Joyce M.)				98.9	L	1,515	300	1,815
Nene Ranch, Llc (Frmrly Hollins, Mariette B.)				98.6	L	1,360	200	1,560
Griffin, Jospeh, Et Al.				95.8	L	1,610	1,150	2,760
Baber, Jack Et Al.				95.6	L	3,630	2,630	6,260
Eastside Mwc (Frmrly A&F Boeger Corp.)				95.25	L	2,170	634	2,804
Zelmar Ranch, Inc. (Frmrly Martin, Andrew)				92.5	L	112	52	164
Gomes, Judith (Frmrly. Martin, Andrew)				92.5	L	168	78	246
Butte Creek Farms				89.26	L	20	16	36
Butte Creek Farms				89.24	L	40	55	95
Butte Creek Farms (Frmrly Mayfair Farms)				88.7	L	196	8	204
Butte Creek Farms(Area 1)				88.7	L	300	340	640
Howard, Theordore W. And Linda M.				88.7	L	74	2	76
Locvich, Paul				88.2	L	80	70	150
Ehrke, Allen A. Et Ux				86.8	L	220	160	380
Fedora, Sib Et Al.				82.7	L	190	20	210
Reische, Laverne Et Ux				82.5	L	183	267	450
Reische, Eric				82.5	L	37	53	90
Tarke, Stephen & Debra				81.5	L	1,700	1,000	2,700
Churkin, Michael, Et Al.				79.5	L	75	55	130
Eggleston, Ronald Et Ux				79	L	53	12	65
Hale, Judith Et Al.				79	L	117	13	130
Hale, Judith Et Al.			18	79	L	58	17	75
Pires, Lawrence And Beverly				77.9	L	185	95	280
Davis, Ina M.				76.2	L	71	14	85
Chesney, Adona (R & A, Bypass Trust)				76.15	L	310	390	700
Andreotti, Beverly F., Et Al.				72.1	L	2,060	1,560	3,620
Mclaughlin, Jack				72	L	430	220	650
Lomo Cold Storage (& J. J. Micheli)				67.5	L	6,410	700	7,110
Anderson, R And J, Prop.				67.1	L	149	88	237

Table B-29. Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc location - Baselines - Existing Conditions

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Lonon, Michael Et Al.	D128	15	18	67.1	L	715	440	1,155
Oji Brothers Farm, Inc.				63.9	L	1,340	1,860	3,200
Young, Russell, Et Al.				63.3	L	2	8	10
Sekhon, Arjinderpal & Daljit				62.3	L	350	470	820
Butler, Leslie A., Et Ux				60.5, 61.8	L	180	280	460
Howald Farms Inc.				60.4	L	1,350	1,410	2,760
Kary, Carol				59.8	L	400	600	1,000
Dennis Wilson Farms (Frmrly M&L Farms (Area 1)			19	58.9	L	295	60	355
Lockett, William P. & Jean B.				58.3	L	370	47	417
O'brien, Janice				58.3	L	550	289	839
Wirth, Marilyn L. (Frmrly Davis, Marilyn)				57.75	L	180	340	520
Bardis, C. Et Al 9(Reynen/Broomieside Farms)				55.1	L	8,070	2,000	10,070
Wakida, Tomio				53.9	L	50	275	325
Wakida, Tomio				52.3	L	25	135	160
Nelson, Thomas L., Et Ux				52	L	38	98	136
Rauf, Abdul & Tahmina (Frmrly Forster, J.)				50	L	2,450	710	3,160
Hiatt, Thomas(Hiatt Family Trust)				49, 49.7	L	947	538	1,485
Hiatt, Thomas(Illerich, Phillip)				49	L	372	212	584
Oji, Mitsue Family Partnership				48.7	L	3,430	1,310	4,740
Henle, Thomas N.				46.5	L	935	0	935
Windswept Land&Livestock Co. (P. Burroughs)				44.2, 45.6, 46.45	L	4,040	0	4,040
Schreiner, Joe & Cleo				38.8	L	180	20	200
Munson, James T., Et Ux				37.75	L	70	85	155
Klsy, Llc (Frmrly Mirbach-Harff Antonius)				37.2	L	80	90	170
Driver, John A. & Clare M.				36.45	L	150	80	230
Driver, John A. & Clare M.				36.45	L	6	10	16
Quad-H Ranches, Inc.				36.2	L	190	310	500
Giusti, Richard, Et Al.				36.2	L	850	760	1,610
Drew, Jerry				35.85	L	24	12	36
Jaeger, William, Et Al.						385	485	870
Morehead, Joseph Et Ux						115	140	255
Heidrick, Joe Jr.				33.75	L	360	200	560
Leiser, Dorothy L.				33.75	L	36	24	60
Mcm Properties Inc				33.75	L	860	610	1,470
Richter, Henry D. (Richter Brothers, Et Al.)				33.2	L	1,750	1,030	2,780
Furlan, Emile, Et Ux				32.5, 33.2	L	570	350	920
Byrd, Anna C. And Osborne, Jane				26.8, 30.5	L	1,055	200	1,255
Total	D128					76,633	26,808	103,441

Table B-29. Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc location - Baselines - Existing Conditions

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Edson, Wallace L. & Mary O. *	D129A	65	8S	33.85	R	40	64	104
Driver, William A.(Frmrly Collier, T.)				32.5	R	54	106	160
Driver, Gregory E.(Frmrly Collier, T.)				32.5	R	54	106	160
Giovannetti, B.E. & Mary				31.5	R	470	50	520
Total	D129A					618	326	944
Odysseus Farms Prtnrshp.(Frmrly Leal, Robert)	D162A	70	N/A	19.6	L	220	410	630
Cummings, Wm. (Frmrly Verona Farming Prtnrshp)				18.7	L	180	120	300
Lauppe, Burton And Kathyrn				18.45	L	720	230	950
Natomas Basin Conservancy				18.2	L	221	269	490
E.L.H. Sutter Properties, Inc.				18.2	L	12	28	40
Lauppe, Burton And Kathyrn				18.2	L	153	197	350
Siddiqui, J.&A.T.				10.75	L	110	20	130
Willey, Edwin, Mr. And Mrs.				10.75	L	75	20	95
Siddiqui, Javed&Amna (Et Al.&Fmly.Partnshp.)				10.25	L	860	200	1,060
Sacramento, County Of				9.3	L	520	230	750
Total	D162A					3,071	1,724	4,795
Sacramento River Ranches(Frmrly Deseret Farms)	D163	65	N/A	16.6, 17.0, 22.5	R	4,000	0	4,000
Knaggs Walnut Ranches Co. Lp				16.1	R	630	0	630
Conway Preservation Group				12	R	50,190	672	50,862
Wilson Ranch Partnership				11.1	R	370	0	370
Reclamation Distrs. 900 And 1000 (Frm.Amen,H.)				9.35	R	281	123	404
Riverby Limited Partnership				5.25	R	470	30	500
Total	D163					55,941	825	56,766
Total						149,298	35,948	185,246

[a] *Source: Settlement contractor data provided by USBR*

Table B-30. Delta - Baselines - Future Conditions

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Water Right (TAF/yr)	SWP Table A Amount (TAF)		SWP Article 21 Demand (TAF/mon)	CVP Water Service Contracts (TAF/yr)		Other (TAF/yr)
				Ag	M&I		AG	M&I	
North Delta									
City of Vallejo	City of Vallejo	D403A						16.0	
CCWD[a]	Contra Costa County	D420						195.0	
Napa County FC&WCD	North Bay Aqueduct	D403B			29.02	1.0			
Solano County WA	North Bay Aqueduct	D403C			47.76	1.0			
Fairfield, Vacaville and Benecia Agreement	North Bay Aqueduct	D403D	31.60						
City of Antioch	City of Antioch	D406B	18.0						
Total North Delta			49.6	0.0	76.8	2.0	0.0	211.0	
South Delta									
Delta Water Supply Project	City of Stockton	D514A	32.4						
Total South Delta			32.4	0.0	0.0	0.0	0.0	0.0	
Total			82.0	0.0	76.8	2.0	0.0	211.0	

a The new Los Vaqueros module in CALSIM II is used to determine the range of demands that are met by CVP contracts or other water rights.

Table B-31. SWP North-of-the-Delta - Baselines - Future Conditions

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	FRSA Amount (TAF)	Water Right (TAF/yr)	Table A Amount (TAF)		Article 21 Demand (TAF/mon)	Other (TAF/yr)
					Ag	M&I		
Feather River								
Palermo	FRSA	D6		17.6				
County of Butte	Feather River	D201				27.5		
Thermalito	FRSA	D202		8.0				
Western Canal	FRSA	D7A	150.0	145.0				
Joint Board	FRSA	D7B	550.0	5.0				
City of Yuba City	Feather River	D204				9.6		
Feather WD	FRSA	D206A	17.0					
Garden, Oswald, Joint Board	FRSA	D206B						
	FRSA	D206BA	12.9	5.1				
Garden	FRSA	D206BB	2.9					
Oswald	FRSA	D206BC	50.0					
Joint Board Plumas, Tudor	FRSA	D206C						
	FRSA	D206CA	8.0	6.0				
Plumas	FRSA	D206CB	5.1	0.2				
Tudor								
Total Feather River Area			795.8	186.9	0.0	37.1		
Other								
Yuba County Water Agency	Yuba River	D230						Variable 333.6
Camp Far West ID	Yuba River	D285						12.6
Bear River Exports	American R/DSA70	D283						Variable 95.2
Feather River Exports to American River (left bank to DSA70)	American R/DSA70	D223		11.0				

Table B-32. SWP South-of-the-Delta - Baselines - Future Conditions

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Table A Amount (TAF)		Article 21 Demand (TAF/mon)	Losses (TAF/yr)
			Ag	M&I		
Alameda Co. FC&WCD, Zone 7	SBA reaches 1-4	D810		51.74	1.00	
	SBA reaches 5-6	D813		28.88	None	
		Total		80.62	1.00	
Alameda County WD	SBA reaches 7-8	D814		42.00	1.00	
Santa Clara Valley WD	SBA reach 9	D815		100.00	4.00	
Oak Flat WD	CA reach 2A	D802	5.70		None	
County of Kings	CA reach 8C	D847	9.00		None	
Dudley Ridge WD	CA reach 8D	D849	57.34		1.00	
Empire West Side ID	CA reach 8C	D846	3.00		1.00	
Kern County Water Agency	CA reaches 3, 9-13B	D851	600.61	134.60	None	
	CA reaches 14A-C	D859	111.68		180.00	
	CA reaches 15A-16A	D863	62.77		None	
	CA reach 31A	D867	73.07		None	
		Total	848.13	134.60	180.00	
Tulare Lake Basin WSD	CA reaches 8C-8D	D848	96.23		15.00	
San Luis Obispo Co. FC&WCD	CA reaches 33A-35	D869		25.00	None	
Santa Barbara Co. FC&WCD	CA reach 35	D870		45.49	None	
Antelope Valley-East Kern WA	CA reaches 19-20B, 22A-B	D877		141.40	1.00	
Castaic Lake WA	CA reach 31A	D868	12.70		1.00	
	CA reach 30	D896		82.50	None	
		Total	12.70	82.50	1.00	
Coachella Valley WD	CA reach 26A	D883		133.10	2.00	
Crestline-Lake Arrowhead WA	CA reach 24	D25		5.80	None	
Desert WA	CA reach 26A	D884		54.00	5.00	
Littlerock Creek ID	CA reach 21	D879		2.30	None	
Mojave WA	CA reaches 19, 22B-23	D881		75.80	None	

Table B-32. SWP South-of-the-Delta - Baselines - Future Conditions

SWP CONTRACTOR	Geographic Location	CALSIM II Diversion	Table A Amount (TAF) Ag	Table A Amount (TAF) M&I	Article 21 Demand (TAF/mon)	Losses (TAF/yr)
Metropolitan WDSC	CA reach 26A	D885		778.13	90.70	
	CA reach 30	D895		719.66	74.80	
	CA reaches 28G-H	D899		410.31	27.60	
	CA reach 28J	D27		3.40	6.90	
		Total		1911.50	200.00	
Palmdale WD	CA reaches 20A-B	D878		21.30	None	
San Bernardino Valley MWD	CA reach 26A	D886		102.60	None	
San Gabriel Valley MWD	CA reach 26A	D887		28.80	None	
San Gorgonio Pass WA	CA reach 26A	D888		17.30	None	
Ventura County FCD	CA reach 29H	D28		3.15	None	
	CA reach 30	D29		16.85	None	
		Total		20.00		
SWP Losses	CA reaches 1-2	D803				7.70
	SBA reaches 1-9	D816				0.60
	CA reach 3	D824				10.80
	CA reach 4	D826				2.60
	CA reach 5	D827				3.90
	CA reach 6	D828				1.20
	CA reach 7	D829				1.60
	CA reaches 8C-13B	D854				11.90
	Wheeler Ridge PP and CA reaches 14A-C	D862				3.60
	Chrisman PP and CA reaches 15A-18A	D864				1.80
	Pearblossom PP and CA reaches 17-21	D880				5.10
	Mojave PP and CA reaches 22A-23	D882				4.00
	REC and CA reaches 24-28J	D889				1.40
	CA reaches 29A-29F	D891				1.90
	Castaic PWP and CA reach 29H	D893				3.10
	REC and CA reach 30	D894				2.40
Total						63.60
Total			1032.10	3024.11	412.00	63.60

Table B-33. CVP North-of-the-Delta - Baselines - Future Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Representation		CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges[a] (TAF/yr)
		Diversion	Region	AG	M&I			
Anderson Cottonwood ID	Sacramento River Redding Subbasin	D104A	DSA 58			128.0		
Clear Creek CSD		D104B	DSA 58	13.8	1.5			
Bella Vista WD		D104C	DSA 58	22.1	2.4			
Shasta CSD		D104D	DSA 58		1.0			
Sac R. Misc. Users		D104F	DSA 58			3.4		
Redding, City of		D104G	DSA 58			21.0		
City of Shasta Lake		D104H	DSA 58	2.5	0.3			
Mountain Gate CSD		D104I	DSA 58		0.4			
Shasta County Water Agency		D104J	DSA 58	0.5	0.5			
Redding, City of/Buckeye		D104K	DSA 58		6.1			
Total		D104		38.9	12.2	152.4		0.0
Corning WD	Corning Canal	D171	WBA 4	23.0				
Proberta WD		D171	WBA 4	3.5				
Thomes Creek WD		D171	WBA 4	6.4				
Total				32.9	0.0	0.0		0.0
Kirkwood WD	Tehama-Colusa Canal	D172	WBA 4	2.1				
Glide WD		D174	WBA 7N	10.5				
Kanawha WD		D174	WBA 7N	45.0				
Orland-Artois WD		D174	WBA 7N	53.0				
Colusa, County of		D178	WBA 7S	20.0				
Colusa County WD		D178	WBA 7S	62.2				
Davis WD		D178	WBA 7S	4.0				
Dunnigan WD		D178	WBA 7S	19.0				
La Grande WD		D178	WBA 7S	5.0				
Westside WD		D178	WBA 7S	65.0				
Total				285.8	0.0	0.0		0.0
Sac. River Misc. Users	Sacramento River	D113A	WBA 4			1.5		

Table B-33. CVP North-of-the-Delta - Baselines - Future Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Representation		CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges[a] (TAF/yr)
		Diversion	Region	AG	M&I			
Glenn Colusa ID	Glenn-Colusa Canal	D143A	WBA 8NN			441.5		
		D145A	WBA 8NS			383.5		
Sacramento NWR		D143B	WBA 8NN					53.4
Delevan NWR		D145B	WBA 8NS					24.0
Colusa NWR		D145B	WBA 8NS					28.8
Colusa Drain M.W.C.	Colusa Basin Drain	D180	WBA 8NN			7.7		
		D182A/ D18302	WBA 8NS			62.3		
Total				0.0	0.0	895.0		106.2
Princeton-Cordova-Glenn ID	Sacramento River	D122A	WBA 8NN			67.8		
Provident ID		D122A	WBA 8NN			54.7		
Maxwell ID		D122A	WBA 8NN			1.8		
		D122B	WBA 8NS			16.2		
Sycamore Family Trust		D122B	WBA 8NS			31.8		
Roberts Ditch IC		D122B	WBA 8NS			4.4		
Sac R. Misc. Users		D122A	WBA 8NN			4.9		
		D122B	WBA 8NS			9.5		
Total				0.0	0.0	191.2		0.0
Reclamation District 108	Sacramento River	D122B	WBA 8NS			12.9		
		D129A	WBA 8S			219.1		
River Garden Farms		D129A	WBA 8S			29.8		
Meridian Farms WC		D128	DSA 15			35.0		
Pelger Mutual WC		D128	DSA 15			8.9		
Reclamation District 1004		D128	DSA 15			71.4		
Carter MWC		D128	DSA 15			4.7		
Sutter MWC		D128	DSA 15			226.0		
Tisdale Irrigation & Drainage Co.		D128	DSA 15			9.9		
Sac R. Misc. Users		D128	DSA 15			103.4		
		D129A	WBA 8S			0.9		
Feather River WD export		D128	DSA 15	20.0				
Total				20.0	0.0	722.1		0.0

Table B-33. CVP North-of-the-Delta - Baselines - Future Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Representation		CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights/Non-CVP(TAF/yr)	Level 2 Refuges[a] (TAF/yr)
		Diversion	Region	AG	M&I			
Sutter NWR	Sutter bypass water for Sutter NWR	C136B	DSA 69					25.9
Gray Lodge WMA	Feather River	C216B	DSA 69					41.4
Butte Sink Duck Clubs		C221	DSA 69					15.9
Total				0.0	0.0	0.0		83.2
Sac R. Misc. Users	Sacramento River	D163	DSA 65			56.8		
City of West Sacramento		D165	DSA 65			23.6		
Davis-Woodland Water Supply Project		D165	DSA 65	DSA 65				
Total				0.0	0.0	80.4		0.0
Sac R. Misc. Users	Lower Sacramento River	D162A	DSA 70			4.8		
Natomas Central MWC		D162B	DSA 70			120.2		
Pleasant Grove-Verona MWC		D162C	DSA 70			26.3		
City of Sacramento (PCWA)		D162D	DSA 70		0.0		0.0	
PCWA (Water Rights)		D162E	DSA 70		0.0		0.0	
Total				0.0	0.0	151.3	0.0	
Total CVP North-of-Delta				377.6	12.2	2193.8	0.0	189.4

[a] *Level 4 Refuge water needs are not included.*

[b] *Refer to Table 8 for more information*

Table B-34. CVP and Water Rights for American River - Baselines - Future Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement/ Exchange Contractor (TAF/yr)	Water Rights/ Non-CVP (TAF/yr)	Diversion Limits (TAF/Yr)	Foot-notes
			AG	M&I[1]				
Placer County Water Agency	Auburn Dam Site	D300		0.0		35.5	35.5	
Sacramento Suburban Water District[2]	Folsom Reservoir	D8A				17.0	17.0	
City of Folsom (includes P.L. 101-514)	Folsom Reservoir	D8B		7.0		27.0	34.0	1
Folsom Prison	Folsom Reservoir	D8C				5.0	5.0	
San Juan Water District (Placer County)	Folsom Reservoir	D8D				24.0	24.0	
San Juan Water District (Sac County) (includes P.L. 101-514)	Folsom Reservoir	D8E		24.2		33.0	57.2	1
El Dorado Irrigation District	Folsom Reservoir	D8F		7.55		17.0	24.55	1
City of Roseville	Folsom Reservoir	D8G		32.0		5.0	37.0	1
Placer County Water Agency	Folsom Reservoir	D8H		35.0			35.0	
El Dorado County (P.L. 101-514)	Folsom Reservoir	D8I		15.0			15.0	1
Total	Folsom Reservoir		0.0	120.8	0.0	128.0	248.8	
So. Cal WC/ Arden Cordova WC	Folsom South Canal	D9AA				5.0	5.0	
California Parks and Recreation	Folsom South Canal	D9AB		5.0			5.0	1
SMUD (export)	Folsom South Canal	D9B		30.0		15.0	45.0	1
Canal Losses	Folsom South Canal	D9A				1.0	1.0	
Total	Folsom South Canal		0.0	35.0	0.0	21.0	56.0	
City of Sacramento[3]	Lower American River	D302A				82.26	82.26	
Carmichael Water District	Lower American River	D302C				12.0	12.0	
Total	Lower American River		0.0	0.0	0.0	94.3	94.3	
City of Sacramento	Lower Sacramento River	D167A				162.74	162.74	
Sacramento County Water Agency (including SMUD transfer)	Lower Sacramento River	D167B		10.0			10.0	
	Lower Sacramento River	D168C		20.0			20.0	
Sacramento County Water Agency (P.L. 101-514)	Lower Sacramento River	D168C		15.0			15.0	
Sacramento County Water Agency - assumed Appropriated Water	Lower Sacramento River	D168C				varies[4]	varies[4]	2
EBMUD (export)	Lower Sacramento River	D168B		133.0			varies[5]	3
Total	Lower Sacramento River		0.0	178.0	0.0	varies[4]	varies[4,5]	
Total			0.0	333.75	0.0	varies[4]	varies[4,5]	

Table B-35. CVP South-of-the-Delta - Baselines - Future Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr) AG	CVP Water Service Contracts (TAF/yr) M&I	Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges[a] (TAF/yr)	Losses (TAF/yr)
Byron-Bethany ID	Upper DMC	D700	20.6					
Tracy, City of		D700		10.0				
		D700		5.0				
		D700		5.0				
Banta Carbona ID		D700	20.0					
Total		D700	40.6	20.0	0.0	0.0	0.0	0.0
Del Puerto WD	Upper DMC	D701	12.1					
		D701	5.4					
Davis WD		D701	10.8					
Foothill WD		D701	34.1					
Hospital WD		D701	7.7					
Kern Canon WD		D701	14.7					
Mustang WD		D701	15.9					
Orestimba WD		D701	8.6					
Quinto WD		D701	5.2					
Romero WD		D701	9.1					
Salado WD		D701	16.6					
Sunflower WD West Stanislaus WD		D701	50.0					
Patterson WD		D701	16.5			6.0		
Total		D701	206.7	0.0	0.0	6.0	0.0	0.0
Upper DMC Loss	Upper DMC	D702						18.5
Panoche WD	Lower DMC Volta	D706	6.6					
San Luis WD		D706	65.0					
Laguna WD		D706	0.8					
Eagle Field WD		D706	4.6					
Mercy Springs WD		D706	2.8					
Oro Loma WD		D706	4.6					
Total		D706	84.4	0.0	0.0	0.0	0.0	0.0
Upper DMC Exchange Contractors	Lower DMC Volta	D707						
		D707			140.0			
Central California ID								

Table B-35. CVP South-of-the-Delta - Baselines - Future Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr) AG	CVP Water Service Contracts (TAF/yr) M&I	Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges[a] (TAF/yr)	Losses (TAF/yr)
Grasslands via CCID	Lower DMC Volta	D708					81.8	
Los Banos WMA		D708					11.2	
Kesterson NWR	Lower DMC Volta	D708					10.5	
Freitas - SJBAP		D708					6.3	
Salt Slough - SJBAP		D708					8.6	
China Island - SJBAP		D708					7.0	
Volta WMA		D708					13.0	
Grassland via Volta Wasteway		D708					23.2	
Total		D708	0.0	0.0	140.0	0.0	161.5	0.0
Fresno Slough WD	San Joaquin River at Mendota Pool	D607A	4.0			0.9		
James ID		D607A	35.3			9.7		
Coelho Family Trust		D607A	2.1			1.3		
Tranquillity ID		D607A	13.8			20.2		
Tranquillity PUD		D607A	0.1			0.1		
Reclamation District 1606		D607A	0.2			0.3		
Exchange Contractors		D607B						
		D607B			392.4			
Central California ID		D607B			59.0			
Columbia Canal Co.		D607B			85.0			
Firebaugh Canal Co.		D607B			23.6			
San Luis Canal Co. M.L. Dudley Company		D607B				2.3		
Grasslands WD		D607C					29.0	
Mendota WMA		D607C					27.6	
Losses		D607D						101.5
Total		D607	55.5	0.0	560.0	34.8	56.6	101.5
Exchange Contractors	San Joaquin River at Sack Dam	D608B						
		D608B			140.0			
San Luis Canal Co. Grasslands WD		D608C					2.3	
Los Banos WMA		D608C					12.4	
San Luis NWR		D608C					19.5	
West Bear Creek NWR		D608C					7.5	
East Bear Creek NWR		D608C					8.9	
Total		D608	0.0	0.0	140.0	0.0	50.6	0.0

Table B-35. CVP South-of-the-Delta - Baselines - Future Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges[a] (TAF/yr)	Losses (TAF/yr)
			AG	M&I				
San Benito County WD (Ag)	San Felipe	D710	35.6					
Santa Clara Valley WD (Ag)		D710	33.1					
Pajaro Valley WD		D710	6.3					
San Benito County WD (M&I)		D711		8.3				
Santa Clara Valley WD (M&I)		D711		119.4				
Total		D710/D711	74.9	127.7	0.0	0.0	0.0	0.0
San Luis WD	CA reach 3	D833	60.1					
CA, State Parks and Rec		D833	2.3					
Affonso/Los Banos Gravel Co.		D833	0.3					
Total		D833	62.6	0.0	0.0	0.0	0.0	0.0
Panoche WD	CVP Dos Amigos PP/ CA reach 4	D835	87.4					
Pacheco WD		D835	10.1					
Total		D835	97.5	0.0	0.0	0.0	0.0	0.0
Westlands WD (Centinella)	CA reach 4	D836	2.5					
Westlands WD (Broadview WD)		D836	27.0					
Westlands WD (Mercy Springs WD)		D836	4.2					
Westlands WD (Widern WD)		D836	3.0					
Total		D836	36.7	0.0	0.0	0.0	0.0	0.0
Westlands WD: CA Joint Reach 4	CA reach 4	D837	219.0					
Westlands WD: CA Joint Reach 5	CA reach 5	D839	570.0					
Westlands WD: CA Joint Reach 6	CA reach 6	D841	219.0					
Westlands WD: CA Joint Reach 7	CA reach 7	D843	142.0					
Total			1150.0	0.0	0.0	0.0	0.0	0.0
Avenal, City of	CA reach 7	D844		3.5		3.5		
Coalinga, City of		D844		10.0				
Huron, City of		D844		3.0				
Total		D844	0.0	16.5	0.0	3.5	0.0	0.0

Table B-35. CVP South-of-the-Delta - Baselines - Future Conditions

CVP CONTRACTOR	Geographic Location	CALSIM II Diversion	CVP Water Service Contracts (TAF/yr)		Settlement / Exchange Contractor (TAF/yr)	Water Rights / Non-CVP (TAF/yr)	Level 2 Refuges[a] (TAF/yr)	Losses (TAF/yr)
			AG	M&I				
CA Joint Reach 3 - Loss	CVP Dos Amigos PP/CA reach 3	D834						2.5
CA Joint Reach 4 - Loss	CA reach 4	D838						10.1
CA Joint Reach 5 - Loss	CA reach 5	D840						30.1
CA Joint Reach 6 - Loss	CA reach 6	D842						12.5
CA Joint Reach 7 - Loss	CA reach 7	D845						8.5
Total			0.0	0.0	0.0	0.0	0.0	63.7
Cross Valley Canal - CVP	CA reach 14							
		D855	3.0					
Fresno, County of		D855	3.3					
Hills Valley ID-Amendatory		D855	40.0					
Kern-Tulare WD		D855	31.1					
Lower Tule River ID		D855	31.1					
Pixley ID		D855	13.3					
Rag Gulch WD		D855	1.1					
Tri-Valley WD		D855	5.3					
Tulare, County of Kern NWR		D856					11.0	
Pixley NWR		D856					1.3	
Total			128.3	0.0	0.0	0.0	12.3	0.0
Total CVP South-of-Delta			1937.1	164.2	840.0	44.3	281.0	183.7

[a] *Level 4 Refuge water needs are not included*

Table B-36. - Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc locationa - Baselines - Future Conditions

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Riverview Golf & Country Club	D104F	58	3	240.8	L	255	25	280
Daniell, Harry	D104F	58	3	240.3	L	13	7	20
Redding Rancheria (Frmrly High-Low Nursery)	D104F	58	3	240.2	L	70	135	205
Lake Cal. Property Owners Assn	D104F	58	2	221	R	580	200	780
Leviathan, Inc.	D104F	58	2	221	R	355	345	700
Driscoll Strawberry Associates, Inc.	D104F	58	3	207.5	L	330	490	820
J. B. Unlimited, Inc.	D104F	58	3	197	L	220	290	510
Micke, Daniel & Nina	D104F	58	3	196.6	L	81	19	100
Gjermann, Hal	D104F	58	3	196.55	L	8	4	12
Total	D104F					1,912	1,515	3,427
Meyer, Herbert (Frmrly Diamond Holdings, Inc.)	D113A	58	4	191.5	R	195	230	425
Exchange Bank (The Nature Conservancy)	D113A	10	4	168.85	R	210	570	780
Rubio, Exequiel (Frmrly Elliott&Hadracky)	D113A	10	4	166.8	R	11	5	16
Penner, Roger & Leona	D113A	10	4	156.8	R	159	21	180
Freeman, Vola	D113A	10	4	156.1	R	11	19	30
Mclane, Robert	D113A	10	4	155.6	R	17	23	40
Alexander, Thomas Et Ux	D113A	10	4	155.6	R	9	13	22
Total	D113A					612	881	1,493
Green Valley Corp. (Frmrly Cannell, F.)	D122A	15	8NN	106	R	680	210	890
Green Valley Corp. (Frmrly Stegeman Ranch)	D122A	15	8NN	106	R	555	325	880
Tuttle, Charles W. - Trust	D122A	15	8NN	103.9	R	120	270	390
Cachil Dehe Band Of Wintun Indians(Lee Farms)	D122A	15	8NN	103.7	R	80	100	180
Seaver, Charles	D122A	15	8NN	99.3	R	200	260	460
Odysseus Farms	D122A	15	8NN	93.15	R	1,920	150	2,070
Total	D122A					3,555	1,315	4,870
King, Ben And Laura (Frmrly Dommer, E.)	D122B	15	8NS	89.2	R	12	7	19
King, Laura	D122B	15	8NS	89.2	R	13	13	26
Wisler, John W. Jr. (Frmrly Cribari, E.)	D122B	15	8NS	88	R	8	27	35
Mehrhof, Susan M.(frmrly.Swinford Tract)	D122B	15	8NS	87.7	R	164	16	180
Steidlmayer, Anthony E., Et Al.	D122B	15	8NS	83	R	610	700	1,310
Jansen, Peter & Sandy (Frmrly E. J. Ritchey)	D122B	15	8NS	70.4	R	150	40	190
Gillaspy, William & Mary (Frmrly Fay Gillaspy)	D122B	15	8NS	70.4	R	120	90	210
Beckley, Ralph, And Ophelia	D122B	15	8NS	70.4	R	165	135	300
Driver, Gary, Et Al.	D122B	15	8NS	69.2	R	8	22	30

Table B-36. - Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc locationa - Baselines - Future Conditions

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Heidrick, Mildred M.	D122B	65	8NS	30.6	R	86	34	120
Tenhunfeld, F. Wallace, Jack, Et Al.				29.7	R	2,680	960	3,640
Heidrick, Mildred M.				29.2, 30.3	R	370	60	430
Hershey Land Company				28.1	R	2,570	450	3,020
Total	D122B					6,956	2,554	9,510
Pacific Realty Assoc., L.P. (M&T Chico Ranch)	D128	15	9	140.8, 141.5	L	16,980	976	17,956
Spence, Ruth Ann (Spence Farms)				104.8	L	630	100	730
Anderson, Arthur Et Al (Frmrly Westfall, Mary)				102.5	L	445	45	490
Forry, Laurie E.				99.8	L	2,285	0	2,285
Otterson, Mike (Frmrly Wells Joyce M.)				98.9	L	1,515	300	1,815
Nene Ranch, Llc (Frmrly Hollins, Mariette B.)				98.6	L	1,360	200	1,560
Griffin, Jospeh, Et Al.				95.8	L	1,610	1,150	2,760
Baber, Jack Et Al.				95.6	L	3,630	2,630	6,260
Eastside Mwc (Frmrly A&F Boeger Corp.)				95.25	L	2,170	634	2,804
Zelmar Ranch, Inc. (Frmrly Martin, Andrew)				92.5	L	112	52	164
Gomes, Judith (Frmrly. Martin, Andrew)				92.5	L	168	78	246
Butte Creek Farms				89.26	L	20	16	36
Butte Creek Farms				89.24	L	40	55	95
Butte Creek Farms (Frmrly Mayfair Farms)				88.7	L	196	8	204
Butte Creek Farms(Area 1)				88.7	L	300	340	640
Howard, Theordore W. And Linda M.				88.7	L	74	2	76
Locvich, Paul				88.2	L	80	70	150
Ehrke, Allen A. Et Ux				86.8	L	220	160	380
Fedora, Sib Et Al.				82.7	L	190	20	210
Reische, Laverne Et Ux				82.5	L	183	267	450
Reische, Eric				82.5	L	37	53	90
Tarke, Stephen & Debra				81.5	L	1,700	1,000	2,700
Churkin, Michael, Et Al.				79.5	L	75	55	130
Eggleston, Ronald Et Ux				79	L	53	12	65
Hale, Judith Et Al.				79	L	117	13	130
Hale, Judith Et Al.			18	79	L	58	17	75
Pires, Lawrence And Beverly				77.9	L	185	95	280
Davis, Ina M.				76.2	L	71	14	85
Chesney, Adona (R & A, Bypass Trust)				76.15	L	310	390	700
Andreotti, Beverly F., Et Al.				72.1	L	2,060	1,560	3,620
Mclaughlin, Jack				72	L	430	220	650
Lomo Cold Storage (& J. J. Micheli)				67.5	L	6,410	700	7,110
Anderson, R And J, Prop.				67.1	L	149	88	237

Table B-36. - Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc locationa - Baselines - Future Conditions

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Lonon, Michael Et Al.	D128	15	18	67.1	L	715	440	1,155
Oji Brothers Farm, Inc.				63.9	L	1,340	1,860	3,200
Young, Russell, Et Al.				63.3	L	2	8	10
Sekhon, Arjinderpal & Daljit				62.3	L	350	470	820
Butler, Leslie A., Et Ux				60.5, 61.8	L	180	280	460
Howald Farms Inc.				60.4	L	1,350	1,410	2,760
Kary, Carol				59.8	L	400	600	1,000
Dennis Wilson Farms (Frmrly M&L Farms (Area 1)			19	58.9	L	295	60	355
Lockett, William P. & Jean B.				58.3	L	370	47	417
O'brien, Janice				58.3	L	550	289	839
Wirth, Marilyn L. (Frmrly Davis, Marilyn)				57.75	L	180	340	520
Bardis, C. Et Al 9(Reynen/Broomieside Farms)				55.1	L	8,070	2,000	10,070
Wakida, Tomio				53.9	L	50	275	325
Wakida, Tomio				52.3	L	25	135	160
Nelson, Thomas L., Et Ux				52	L	38	98	136
Rauf, Abdul & Tahmina (Frmrly Forster, J.)				50	L	2,450	710	3,160
Hiatt, Thomas(Hiatt Family Trust)				49, 49.7	L	947	538	1,485
Hiatt, Thomas(Illerich, Phillip)				49	L	372	212	584
Oji, Mitsue Family Partnership				48.7	L	3,430	1,310	4,740
Henle, Thomas N.				46.5	L	935	0	935
Windswept Land&Livestock Co. (P. Burroughs)				44.2, 45.6, 46.45	L	4,040	0	4,040
Schreiner, Joe & Cleo				38.8	L	180	20	200
Munson, James T., Et Ux				37.75	L	70	85	155
Klsy, Llc (Frmrly Mirbach-Harff Antonius)				37.2	L	80	90	170
Driver, John A. & Clare M.				36.45	L	150	80	230
Driver, John A. & Clare M.				36.45	L	6	10	16
Quad-H Ranches, Inc.				36.2	L	190	310	500
Giusti, Richard, Et Al.				36.2	L	850	760	1,610
Drew, Jerry				35.85	L	24	12	36
Jaeger, William, Et Al.						385	485	870
Morehead, Joseph Et Ux						115	140	255
Heidrick, Joe Jr.				33.75	L	360	200	560
Leiser, Dorothy L.				33.75	L	36	24	60
Mcm Properties Inc				33.75	L	860	610	1,470
Richter, Henry D. (Richter Brothers, Et Al.)				33.2	L	1,750	1,030	2,780
Furlan, Emile, Et Ux				32.5, 33.2	L	570	350	920
Byrd, Anna C. And Osborne, Jane				26.8, 30.5	L	1,055	200	1,255
Total	D128					76,633	26,808	103,441

Table B-36. - Sacramento River Miscellaneous Users Breakdown by CALSIM II Arc locationa - Baselines - Future Conditions

CVP CONTRACTOR	CALSIM II Representation			Geographic Location		Settlement Contractor Supply (AF/year)		
	Diversion	DSA	WBA	River Mile	Bank (Left, Right)	Base	Project	Total
Edson, Wallace L. & Mary O. *	D129A	65	8S	33.85	R	40	64	104
Driver, William A.(Frmrly Collier, T.)				32.5	R	54	106	160
Driver, Gregory E.(Frmrly Collier, T.)				32.5	R	54	106	160
Giovannetti, B.E. & Mary				31.5	R	470	50	520
Total	D129A					618	326	944
Odysseus Farms Prtnrshp.(Frmrly Leal, Robert)	D162A	70	N/A	19.6	L	220	410	630
Cummings, Wm. (Frmrly Verona Farming Prtnrshp)				18.7	L	180	120	300
Lauppe, Burton And Kathyrn				18.45	L	720	230	950
Natomas Basin Conservancy				18.2	L	221	269	490
E.L.H. Sutter Properties, Inc.				18.2	L	12	28	40
Lauppe, Burton And Kathyrn				18.2	L	153	197	350
Siddiqui, J.&A.T.				10.75	L	110	20	130
Willey, Edwin, Mr. And Mrs.				10.75	L	75	20	95
Siddiqui, Javed&Amna (Et Al.&Fmly.Partnshp.)				10.25	L	860	200	1,060
Sacramento, County Of				9.3	L	520	230	750
Total	D162A					3,071	1,724	4,795
Sacramento River Ranches(Frmrly Deseret Farms)	D163	65	N/A	16.6, 17.0, 22.5	R	4,000	0	4,000
Knaggs Walnut Ranches Co. Lp				16.1	R	630	0	630
Conway Preservation Group				12	R	50,190	672	50,862
Wilson Ranch Partnership				11.1	R	370	0	370
Reclamation Distrs. 900 And 1000 (Frm.Amen,H.)				9.35	R	281	123	404
Riverby Limited Partnership				5.25	R	470	30	500
Total	D163					55,941	825	56,766
Total						149,298	35,948	185,246

[a] *Source: Settlement contractor data provided by USBR*

B.10. USFWS RPA Implementation

The information included in this section is consistent with what was provided to and agreed by the lead agencies in the, "*Representation of U.S. Fish and Wildlife Service Biological Opinion Reasonable and Prudent Alternative Actions for CALSIM II Planning Studies*", on February 10, 2010 (updated May 18, 2010).

Representation of U.S. Fish and Wildlife Service Biological Opinion Reasonable and Prudent Alternative Actions for CALSIM II Planning Studies

The U.S. Fish and Wildlife Service's (Service) Delta Smelt Biological Opinion (BO) was released on December 15, 2008, in response to the U.S. Bureau of Reclamation's (Reclamation) request for formal consultation with the Service on the coordinated operations of the Central Valley Project (CVP) and State Water Project (SWP) in California.

To develop CALSIM II modeling assumptions for reasonable and prudent alternative actions (RPA) documented in this BO, the California Department of Water Resources (Department) led a series of meetings that involved members of fisheries and project agencies. The purpose for establishing this group was to prepare the assumptions and CALSIM II implementations to represent the RPAs in Existing and Future Condition CALSIM II simulations for future planning studies.

This memorandum summarizes the approach that resulted from these meetings and the modeling assumptions that were laid out by the group. The scope of this memorandum is limited to the December 15, 2008 BO. Unless otherwise indicated, all descriptive information of the RPAs is taken from Appendix B of the BO.

Table B-37 lists the participants that contributed to the meetings and information summarized in this document.

The RPAs in the Service's BO are based on physical and biological phenomena that do not lend themselves to simulations using a monthly time step. Much scientific and modeling judgment has been employed to represent the implementation of the RPAs. The group believes the logic put into CALSIM II represents the RPAs as best as possible at this time, given the scientific understanding of environmental factors enumerated in the BO and the limited historical data for some of these factors.

TABLE B-37
Meeting Participants

Aaron Miller/Department	Derek Hilts/Service
Steve Ford/Department	Steve Detwiler/Service
Randi Field/Reclamation	Matt Nobriga/CDFG
Gene Lee/Reclamation	Jim White/CDFG
Lenny Grimaldo/Reclamation	Craig Anderson/NMFS
Parviz Nader-Tehrani/Department	Robert Leaf/CH2M HILL
Erik Reyes/Department	Derya Sumer/CH2M HILL
Sean Sou/Department	

Notes:

CDFG = California Department of Fish and Game

NMFS = National Marine Fisheries Service

The simulated Old and Middle River (OMR) flow conditions and CVP and SWP Delta export operations, resulting from these assumptions, are believed to be a reasonable representation of conditions expected to prevail under the RPAs over large spans of years (refer to CALSIM II modeling results for more details on simulated operations). Actual OMR flow conditions and Delta export operations will differ from simulated operations for numerous reasons, including having near real-time knowledge and/or estimates of turbidity, temperature, and fish spatial distribution that are unavailable for use in CALSIM II over a long period of record. Because these factors and others are believed to be critical for smelt entrainment risk management, the Service adopted an adaptive process in defining the RPAs. Given the relatively generalized representation of the RPAs, assumed for CALSIM II modeling, much caution is required when interpreting outputs from the model.

Action 1: Adult Delta Smelt Migration and Entrainment (RPA Component 1, Action 1 – First Flush)

Action 1 Summary:

Objective: A fixed duration action to protect pre-spawning adult delta smelt from entrainment during the first flush, and to provide advantageous hydrodynamic conditions early in the migration period.

Action: Limit exports so that the average daily Combined OMR flow is no more negative than -2,000 cubic feet per second (cfs) for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent).

Timing:

Part A: December 1 to December 20 – Based upon an examination of turbidity data from Prisoner's Point, Holland Cut, and Victoria Canal and salvage data from CVP/SWP (see below), and other parameters important to the protection of delta smelt including, but not limited to, preceding conditions of X2, the Fall Midwater Trawl Survey (FMWT), and river flows; the SWG may recommend a start date to the Service. The Service will make the final determination.

Part B: After December 20 – The action will begin if the 3-day average turbidity at Prisoner's Point, Holland Cut, and Victoria Canal exceeds 12 nephelometric turbidity units (NTU). However the SWG can recommend a delayed start or interruption based on other conditions such as Delta inflow that may affect vulnerability to entrainment.

Triggers (Part B):

<u>Turbidity:</u> Three-day average of 12 NTU or greater at all three turbidity stations: Prisoner's Point, Holland Cut, and Victoria Canal.

OR

<u>Salvage:</u> Three days of delta smelt salvage after December 20 at either facility or cumulative daily salvage count that is above a risk threshold based upon the "daily salvage index" approach reflected in a daily salvage index value ≥ 0.5 (daily delta smelt salvage > one-half prior year FMWT index value).

The window for triggering Action 1 concludes when either off-ramp condition described below is met. These off-ramp conditions may occur without Action 1 ever being triggered. If this occurs, then Action 3 is triggered, unless the Service concludes on the basis of the totality of available information that Action 2 should be implemented instead.

Off-ramps:

Temperature: Water temperature reaches 12 degrees Celsius (°C) based on a three station daily mean at the temperature stations: Mossdale, Antioch, and Rio Vista

OR

Biological: Onset of spawning (presence of spent females in the Spring Kodiak Trawl Survey [SKT] or at Banks or Jones).

Action 1 Assumptions for CALSIM II Modeling Purposes:

An approach was selected based on hydrologic and assumed turbidity conditions. Under this general assumption, Part A of the action was never assumed because, on the basis of historical salvage data, it was considered unlikely or rarely to occur. Part B of the action was assumed to occur if triggered by turbidity conditions. This approach was believed to tend to a more conservative interpretation of the frequency, timing, and extent of this action. The assumptions used for modeling are as follows:

Action: Limit exports so that the average daily OMR flow is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 percent of the monthly criteria).

Timing: If turbidity-trigger conditions first occur in December, then the action starts on December 21; if turbidity-trigger conditions first occur in January, then the action starts on January 1; if turbidity-trigger conditions first occur in February, then the action starts on February 1; and if turbidity-trigger conditions first occur in March, then the action starts on March 1. It is assumed that once the action is triggered, it continues for 14 days.

Triggers: Only an assumed turbidity trigger that is based on hydrologic outputs was considered. A surrogate salvage trigger or indicator was not included because there was no way to model it.

Turbidity: If the monthly average unimpaired Sacramento River Index (four-river index: sum of Sacramento, Yuba, Feather, and American Rivers) exceeds 20,000 cfs, then it is assumed that an event, in which the 3-day average turbidity at Hood exceeds 12 NTU, has occurred within the month. It is assumed that an event at Sacramento River is a reasonable indicator of this condition occurring, within the month, at all three turbidity stations: Prisoner's Point, Holland Cut, and Victoria Canal.

A chart showing the relationship between turbidity at Hood (number of days with turbidity is greater than 12 NTU) and Sacramento River Index (sum of monthly flow at four stations on the Sacramento, Feather, Yuba and American Rivers, from 2003 to 2006) is shown on Figure B-2. For months when average Sacramento River Index is between 20,000 cfs and 25,000 cfs a transition is observed in number of days with Hood turbidity greater than 12 NTU. For months when average Sacramento River Index is above 25,000 cfs, Hood turbidity was always greater than 12 NTU for as many as 5 days or more within the month in which the flow occurred. For a conservative approach, 20,000 cfs is used as the threshold value.

Salvage: It is assumed that salvage would occur when first flush occurs.

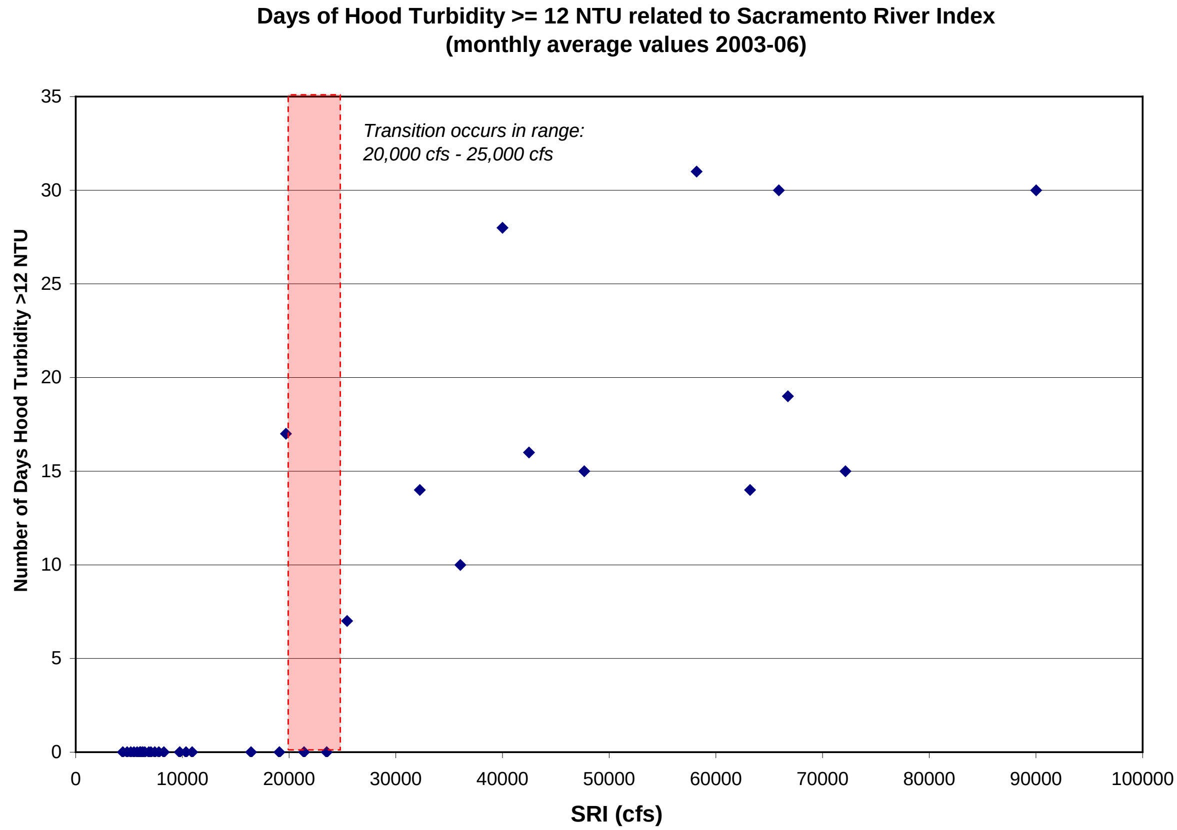


FIGURE B-2
RELATIONSHIP BETWEEN TURBIDITY AT HOOD AND SACRAMENTO RIVER INDEX

Off-ramps: Only temperature-based off-ramping is considered. A surrogate biological off-ramp indicator was not included.

Temperature: Because the water temperature data at the three temperature stations (Antioch, Mossdale, and Rio Vista) are only available for years after 1984, another parameter was sought for use as an alternative indicator. It is observed that monthly average air temperature at Sacramento Executive Airport generally trends with the three-station average water temperature (see Figure B-3). Using this alternative indicator, monthly average air temperature is assumed to occur in the middle of the month, and values are interpolated on a daily basis to obtain daily average water temperature. Using the correlation between air and water temperature, estimated daily water temperatures are estimated from the 82-year monthly average air temperature. Dates when the three-station average temperature reaches 12°C are recorded and used as input in CALSIM. A 1:1 correlation was used for simplicity instead of using the trend line equation illustrated on Figure B-3.

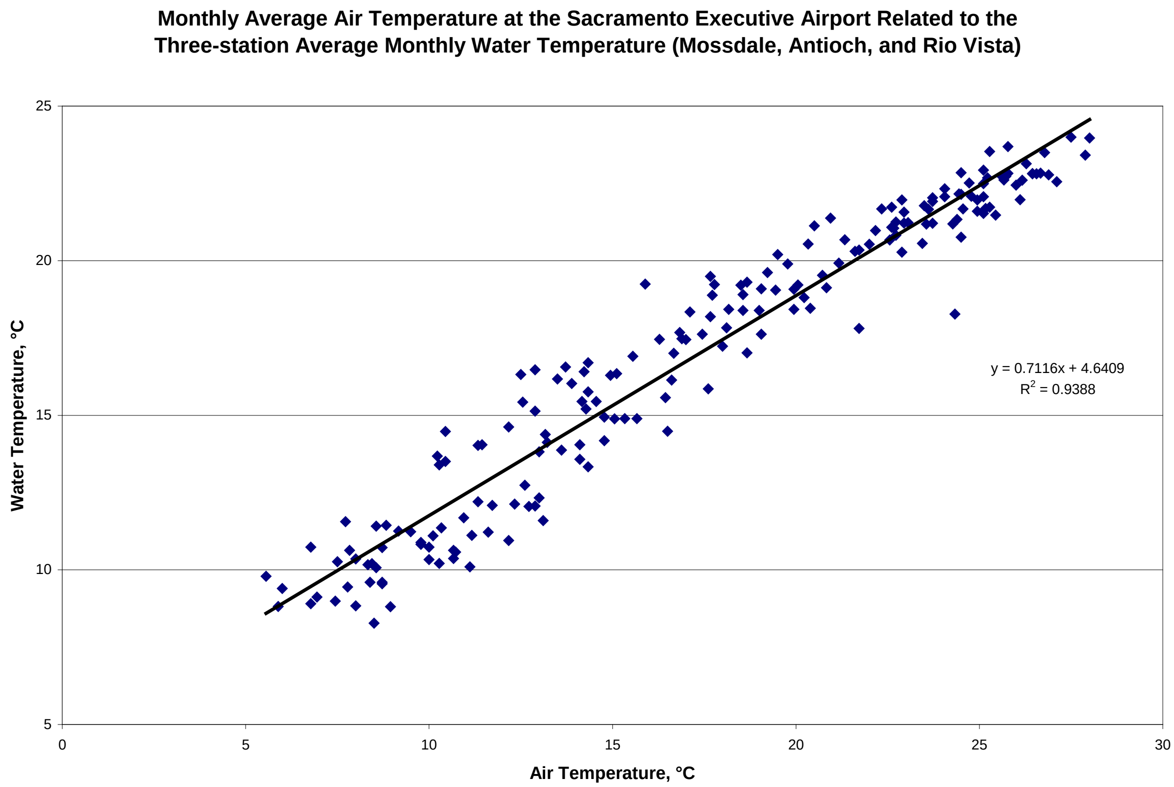


FIGURE B-3
RELATIONSHIP BETWEEN MONTHLY AVERAGE AIR TEMPERATURE AT THE SACRAMENTO EXECUTIVE AIRPORT AND THE THREE-STATION AVERAGE MONTHLY WATER TEMPERATURE

Other Modeling Considerations:

In the month of December in which Action 1 does not begin until December 21, for monthly analysis, a background OMR flow must be assumed for the purpose of calculating a day-weighted average for implementing a partial-month action condition. When necessary, the background OMR flow for December was assumed to be -8,000 cfs.

For the additional condition to meet a 5-day running average no more negative than -2,500 cfs (within 25 percent), Paul Hutton's equation[2] is used. Hutton concluded that with stringent OMR standards (1,250 to 2,500 cfs), the 5-day average would control more frequently than the 14-day average, but it is less likely to control at higher flows. Therefore, the CALSIM II implementation includes both a 14-day (approximately monthly average) and a 5-day average flow criteria based on Hutton's methodology (see Attachment 1).

Rationale: The following is an overall summary of the rationale for the preceding interpretation of RPA Action 1.

[2]Hutton, Paul/Metropolitan Water District of Southern California (MWDSC). Water Supply Impact Analysis of December 2008 Delta Smelt Biological Opinion, Appendix 5. February.

December 1 to December 20 for initiating Action 1 is not considered because seasonal peaks of delta smelt salvage are rare prior to December 20. Adult delta smelt spawning migrations often begin following large precipitation events that happen after mid-December.

Salvage of adult delta smelt often corresponds with increases in turbidity and exports. On the basis of the above discussion and Figure B-2, Sacramento River Index greater than 25,000 cfs is assumed to be an indicator of turbidity trigger being reached at all three turbidity stations: Prisoner's Point, Holland Cut, and Victoria Canal. Most sediment enters the Delta from the Sacramento River during flow pulses; therefore, a flow indicator based on only Sacramento River flow is used.

The 12°C threshold for the off-ramp criterion is a conservative estimate of when delta smelt larvae begin successfully hatching. Once hatched, the larvae move into the water column where they are potentially vulnerable to entrainment.

Results: Using these assumptions, in a typical CALSIM II 82-year simulation (1922 through 2003 hydrologic conditions), Action 1 will occur 29 times in the December 21 to January 3rd period, 14 times in the January 1 to January 14 period, 13 times in the February 1 to February 14 period, and 17 times in the March 1 to March 14 period. In 3 of these 17 occurrences (1934, 1991, and 2001), Action 3 is triggered before Action 1 and therefore Action 1 is bypassed. Action 1 is not triggered in 9 of the 82 years (1924, 1929, 1931, 1955, 1964, 1976, 1977, 1985, and 1994), typically critically dry years. Refer to CALSIM II modeling results for more details on simulated operations of OMR, Delta exports and other parameters of interest.

Action 2: Adult Delta Smelt Migration and Entrainment (RPA Component 1, Action 2)

Action 2 Summary:

Objective: An action implemented using an adaptive process to tailor protection to changing environmental conditions after Action 1. As in Action 1, the intent is to protect pre-spawning adults from entrainment and, to the extent possible, from adverse hydrodynamic conditions.

Action: The range of net daily OMR flows will be no more negative than -1,250 to -5,000 cfs. Depending on extant conditions (and the general guidelines below), specific OMR flows within this range are recommended by the Service's Smelt Working Group (SWG) from the onset of Action 2 through its termination (see Adaptive Process description in the BO). The SWG would provide weekly recommendations based upon review of the sampling data, from real-time salvage data at the CVP and SWP, and utilizing most up-to-date technological expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The Service will make the final determination.

Timing: Beginning immediately after Action 1. Before this date (in time for operators to implement the flow requirement) the SWG will recommend specific requirement OMR flows based on salvage and on physical and biological data on an ongoing basis. If Action 1 is not implemented, the SWG may recommend a start date for the implementation of Action 2 to protect adult delta smelt.

Suspension of Action:

Flow: OMR flow requirements do not apply whenever a 3-day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, the OMR flow requirements of the Action are again in place.

Off-ramps:

Temperature: Water temperature reaches 12°C based on a three-station daily average at the temperature stations: Rio Vista, Antioch, and Mossdale.

OR

Biological: Onset of spawning (presence of a spent female in SKT or at either facility).

Action 2 Assumptions for CALSIM II Modeling Purposes:

An approach was selected based on the occurrence of Action 1 and X2 salinity conditions. This approach selects from between two OMR flow tiers depending on the previous month's X2 position, and is never more constraining than an OMR criterion of -3,500 cfs. The assumptions used for modeling are as follows:

Action: Limit exports so that the average daily OMR flow is no more negative than -3,500 or -5,000 cfs depending on the previous month's ending X2 location (-3,500 cfs if X2 is east of Roe Island, or -5,000 cfs if X2 is west of Roe Island), with a 5-day running average within 25 percent of the monthly criteria (no more negative than -4,375 cfs if X2 is east of Roe Island, or -6,250 cfs if X2 is west of Roe Island).

Timing: Begins immediately after Action 1 and continues until initiation of Action 3.

In a typical CALSIM II 82-year simulation, Action 1 was not triggered in 9 of the 82 years. In these conditions it is assumed that OMR flow should be maintained no more negative than -5,000 cfs.

Suspension of Action: A flow peaking analysis, developed by Paul Hutton[3], is used to determine the likelihood of a 3-day flow average greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and a 3-day flow average greater than or equal to 10,000 cfs in San Joaquin River at Vernalis occurring within the month. It is assumed that when the likelihood of these conditions occurring exceeds 50 percent, Action 2 is suspended for the full month, and OMR flow requirements do not apply. The likelihood of these conditions occurring is evaluated each month, and Action 2 is suspended for one month at a time whenever both of these conditions occur.

[3] Hutton, Paul/MWDSC. 2009. Water Supply Impact Analysis of December 2008 Delta Smelt Biological Opinion, Appendix 4. February.

The equations for likelihood (frequency of occurrence) are as follows:

Frequency of Rio Vista 3-day flow average > 90,000 cfs:

0% when Freeport monthly flow < 50,000 cfs, OR

(0.00289 x Freeport monthly flow – 146)% when 50,000 cfs ≤ Freeport plus Yolo Bypass monthly flow ≤ 85,000 cfs, OR

100% when Freeport monthly flow >85,000 cfs

Frequency of Vernalis 3-day flow average > 10,000 cfs:

0% when Vernalis monthly flow < 6,000 cfs, OR

(0.00901 x Vernalis monthly flow – 49)% when 6,000 cfs ≤ Vernalis monthly flow ≤ 16,000 cfs, OR

100% when Vernalis monthly flow >16,000 cfs

Frequency of Rio Vista 3-day flow average > 90,000 cfs equals 50% when Freeport plus Yolo Bypass monthly flow is 67,820 cfs and the frequency of Vernalis 3-day flow average > 10,000 cfs equals 50% Vernalis monthly flow is 10,988 cfs. Therefore these two flow values are used as thresholds in the model.

Off-ramps: Only temperature-based off-ramping is considered. A surrogate biological off-ramp indicator was not included.

Temperature: Because the water temperature data at the three temperature stations (Antioch, Mossdale, and Rio Vista) are only available for years after 1984, another parameter was sought for use as an alternative indicator. It is observed that monthly average air temperature at Sacramento Executive Airport generally trends with the three-station average water temperature (Figure B-3). Using this alternative indicator, monthly average air temperature is assumed to occur in the middle of the month, and values are interpolated on a daily basis to obtain daily average water temperature. Using the correlation between air and water temperature, daily water temperatures are estimated from the 82-year monthly average air temperature. Dates when the three-station average temperature reaches 12°C are recorded and used as input in CALSIM. A 1:1 correlation was used for simplicity instead of using the trend line equation illustrated on Figure B-3.

Rationale: The following is an overall summary of the rationale for the preceding interpretation of RPA Action 2.

Action 2 requirements are based on X2 location that is dependent on the Delta outflow. If outflows are very high, fewer delta smelt will spawn east of Sherman Lake; therefore, the need for OMR restrictions is lessened.

In the case of Action 1 not being triggered, CDFG suggested OMR > -5,000 cfs, following the actual implementation of the BO in winter 2009, because some adult delta smelt might move into the Central Delta without a turbidity event.

Action 2 is suspended when the likelihood of a 3-day flow average greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and a 3-day flow average greater than or equal to

10,000 cfs in San Joaquin River at Vernalis occurring concurrently within the month exceeds 50 percent, because at extreme high flows the majority of adult delta smelt will be distributed downstream of the Delta, and entrainment concerns will be very low.

The 12°C threshold for the off-ramp criterion is a conservative estimate of when delta smelt larvae begin successfully hatching. Once hatched, the larvae move into the water column where they are potentially vulnerable to entrainment.

Results: Using these assumptions, in a typical CALSIM II 82-year simulation (1922 through 2003 hydrologic conditions), Action 1, and therefore Action 2, does not occur in 11 of the 82 years (1924, 1929, 1931, 1934, 1955, 1964, 1976, 1977, 1985, 1991, 1994, and 2001), typically critically dry years. The criteria for suspension of OMR minimum flow requirements, described above, results in potential suspension of Action 2 (if Action 2 is active) 6 times in January, 11 times in February, 6 times in March (however Action 2 was not active in 3 of these 6 times), and 2 times in April. The result is that Action 2 is in effect 37 times in January (with OMR at -3,500 cfs 29 times, and at -5,000 cfs 8 times), 43 times in February (with OMR at -3,500 cfs 25 times, and at -5,000 cfs 18 times), 31 times in March (with OMR at -3,500 cfs 14 times, and at -5,000 cfs 17 times), and 80 times in April (with OMR at -3,500 cfs 46 times, and at -5,000 cfs 34 times). The frequency each month is a cumulative result of the action being triggered in the current or prior months. Refer to CALSIM II modeling results for more details on simulated operations of OMR, Delta exports and other parameters of interest.

Action 3: Entrainment Protection of Larval and Juvenile Delta Smelt (RPA Component 2)

Action 3 Summary:

Objective: Minimize the number of larval delta smelt entrained at the facilities by managing the hydrodynamics in the Central Delta flow levels pumping rates spanning a time sufficient for protection of larval delta smelt, e.g., by using a VAMP-like action. Because protective OMR flow requirements vary over time (especially between years), the action is adaptive and flexible within appropriate constraints.

Action: Net daily OMR flow will be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR. Depending on extant conditions (and the general guidelines below), specific OMR flows within this range are recommended by the SWG from the onset of Action 3 through its termination (see Adaptive Process in Introduction). The SWG would provide these recommendations based upon weekly review of sampling data, from real-time salvage data at the CVP/SWP, and expertise and knowledge relating population status and predicted distribution to monitored physical variables of flow and turbidity. The Service will make the final determination.

Timing: Initiate the action after reaching the triggers below, which are indicative of spawning activity and the probable presence of larval delta smelt in the South and Central Delta. Based upon daily salvage data, the SWG may recommend an earlier start to Action 3. The Service will make the final determination.

Triggers:

Temperature: When temperature reaches 12°C based on a three-station average at the temperature stations: Mossdale, Antioch, and Rio Vista.

OR

Biological: Onset of spawning (presence of spent females in SKT or at either facility).

Off-ramps:

Temporal: June 30;

OR

Temperature: Water temperature reaches a daily average of 25°C for three consecutive days at Clifton Court Forebay.

Action 3 Assumptions for CALSIM II Modeling Purposes:

An approach was selected based on assumed temperature and X2 salinity conditions. This approach selects from among three OMR flow tiers depending on the previous month's X2 position and ranges from an OMR criteria of -1,250 to -5,000 cfs. Because of to the potential low export conditions that could occur at an OMR criterion of -1,250 cfs, a criterion for minimum exports for health and safety is also assumed. The assumptions used for modeling are as follows:

Action: Limit exports so that the average daily OMR flow is no more negative than -1,250, -3,500, or -5,000 cfs, depending on the previous month's ending X2 location (-1,250 cfs if X2 is east of Chipps Island, -5,000 cfs if X2 is west of Roe Island, or -3,500 cfs if X2 is between Chipps and Roe Island, inclusively), with a 5-day running average within 25 percent of the monthly criteria (no more negative than -1,562 cfs if X2 is east of Chipps Island, -6,250 cfs if X2 is west of Roe Island, or -4,375 cfs if X2 is between Chipps and Roe Island). The more constraining of this OMR requirement or the VAMP requirement will be selected during the VAMP period (April 15 to May 15). Additionally, in the case of the month of June, the OMR criterion from May is maintained through June (it is assumed that June OMR should not be more constraining than May).

Timing: Begins immediately upon temperature trigger conditions and continues until off-ramp conditions are met.

Triggers: Only temperature trigger conditions are considered. A surrogate biological trigger was included.

Temperature: Because the water temperature data at the three temperature stations (Antioch, Mossdale, and Rio Vista) are only available for years after 1984, another parameter was sought to be used as an alternative indicator. It is observed that monthly average air temperature at Sacramento Executive Airport generally trends with the three-station average water temperature (Figure B-3). Using this alternative indicator, monthly average air temperature is assumed to occur in the middle of the month, and values are interpolated on a daily basis to obtain daily average water temperature. Using the correlation between air and water temperature, estimated daily water temperatures are estimated from the 82-

year monthly average air temperature. Dates when the three-station average temperature reaches 12°C are recorded and used as input in CALSIM. A 1:1 correlation was used for simplicity instead of using the trend line equation illustrated on Figure B-3.

Biological: Onset of spawning is assumed to occur no later than *May* 30.

Clarification Note: This text previously read "Onset of spawning is assumed to occur no later than April 30", where the CALSIM II lookup table has May 30 as the date. Based on RPA team discussions in August 2009, it was agreed upon that onset of spawning could not be modeled in CALSIM. This trigger was actually coded as a placeholder in case in future this trigger was to be used; and the date was selected purposefully in a way that it wouldn't affect modeling results. Temperature trigger for Action 3 does occur before end of April. Therefore it does not matter whether the document is corrected to read May 30 or the model lookup table is changed to April 30.

Off-ramps:

Temporal: It is assumed that the ending date of the action would be no later than June 30.

OR

Temperature: Only 17 years of data are available for Clifton Court water temperature. A similar approach as used in the temperature trigger was considered. However, because 3 consecutive days of water temperature greater than or equal to 25°C is required, a correlation between air temperature and water temperature did not work well for this off-ramp criterion. Out of the 17 recorded years, in one year the criterion was triggered in May (May 31), and in 3 years it was triggered in June (June 3, 21, and 27). In all other years it was observed in July or later. With only four data points before July, it was not possible to generate a rule based on statistics. Therefore, temporal off-ramp criterion (June 30) is used for all years.

Health and Safety: In CALSIM II, a minimum monthly Delta export criterion of 300 cfs for SWP and 600 cfs (or 800 cfs depending on Shasta storage) for CVP is assumed. This assumption is suitable for dry-year conditions when allocations are low and storage releases are limited; however, minimum monthly exports need to be made for protection of public health and safety (health and safety deliveries upstream of San Luis Reservoir).

In consideration of the severe export restrictions associated with the OMR criteria established in the RPAs, an additional set of health and safety criterion is assumed. These export restrictions could lead to a situation in which supplies are available and allocated; however, exports are curtailed forcing San Luis to have an accelerated drawdown rate. For dam safety at San Luis Reservoir, 2 feet per day is the maximum acceptable drawdown rate. Drawdown occurs faster in summer months and peaks in June when the agricultural demands increase. To avoid rapid drawdown in San Luis Reservoir, a relaxation of OMR is allowed so that exports can be maintained at 1,500 cfs in all months if needed.

This modeling approach may not fit the real-life circumstances. In summer months, especially in June, the assumed 1,500 cfs for health and safety may not be sufficient to keep San Luis drawdown below a safe 2 ft/day; and under such circumstances the projects would be required to increase pumping in order to maintain dam safety.

Rationale: The following is an overall summary of the rationale for the preceding interpretation of RPA Action 3.

The geographic distribution of larval and juvenile delta smelt is tightly linked to X2 (or Delta outflow). Therefore, the percentage of the population likely to be found east of Sherman Lake is also influenced by the location of X2. The X2-based OMR criteria were intended to model an expected management response to the general increase in delta smelt's risk of entrainment as a function of increasing X2.

The 12°C threshold for the trigger criterion is a conservative estimate of when delta smelt larvae begin successfully hatching. Once hatched, the larvae move into the water column where they are potentially vulnerable to entrainment.

The annual salvage "season" for delta smelt typically ends as South Delta water temperatures warm to lethal levels during summer. This usually occurs in late June or early July. The laboratory-derived upper lethal temperature for delta smelt is 25.4°C.

Results: Action 3 occurs 30 times in February (with OMR at -1,250 cfs 9 times, at -3,500 cfs 11 times, and at -5,000 cfs 10 times), 76 times in March (with OMR at -1,250 cfs 15 times, at -3,500 cfs 27 times, and at -5,000 cfs 34 times), all times (82) in April (with OMR at -1,250 cfs 17 times, at -3,500 cfs 29 times, and at -5,000 cfs 35 times), all times (82) in May (with OMR at -1,250 cfs 19 times, at -3,500 cfs 37 times, and at -5,000 cfs 26 times), and 70 times in June (with OMR at -1,250 cfs 7 times, at -3,500 cfs 37 times, and at -5,000 cfs 26 times). Refer to CALSIM II modeling results for more details on simulated operations of OMR, Delta exports and other parameters of interest. (Note: The above information is based on the August 2009 version of the model and documents the development process, more recent versions of the model may have different results.)

Action 4: Estuarine Habitat During Fall (RPA Component 3)

Action 4 Summary:

Objective: Improve fall habitat for delta smelt by managing of X2 through increasing Delta outflow during fall when the preceding water year was wetter than normal. This will help return ecological conditions of the estuary to that which occurred in the late 1990s when smelt populations were much larger. Flows provided by this action are expected to provide direct and indirect benefits to delta smelt. Both the direct and indirect benefits to delta smelt are considered equally important to minimize adverse effects.

Action: Subject to adaptive management as described below, provide sufficient Delta outflow to maintain average X2 for September and October no greater (more eastward) than 74 kilometers in the fall following wet years and 81 kilometers in the fall following above normal years. The monthly average X2 position is to be maintained at or seaward of these location for each individual month and not averaged over the two month period. In November, the inflow to CVP/SWP reservoirs in the Sacramento Basin will be added to reservoir releases to provide an added increment of Delta inflow and to augment Delta outflow up to the fall X2 target. The action will be evaluated and may be modified or terminated as determined by the Service.

Timing:

September 1 to November 30.

Triggers:

Wet and above normal water-year type classification from the 1995 Water Quality Control Plan that is used to implement D-1641.

Action 4 Assumptions for CALSIM II Modeling Purposes:

Model is modified to increase Delta outflow to meet monthly average X2 requirements for September and October and subsequent November reservoir release actions in Wet and Above Normal years. No off-ramps are considered for reservoir release capacity constraints. Delta exports may or may not be reduced as part of reservoir operations to meet this action. The Action is summarized in Table B-38.

Table B-38. Summary of Action 4 implementation in CALSIM II.

Fall Months following Wet or Above Normal Years	Action Implementation
September	Meet monthly average X2 requirement (74 km in Wet years, 81 km in Above Normal years)
October	Meet monthly average X2 requirement (74 km in Wet years, 81 km in Above Normal years)
November	*Add* reservoir releases up to natural inflow as needed to continue to meet monthly average X2 requirement (74 km in Wet years, 81 km in Above Normal years)

Rationale: Action 4 requirements are based on determining X2 location. Adjustment and retraining of the ANN was also completed to address numerical sensitivity concerns.

Results: There are 38 September and 37 October months that the Action is triggered over the 82-year simulation period.

Action 5: Temporary Spring Head of Old River Barrier and the Temporary Barrier Project (RPA Component 2)

Action 5 Summary:

Objective: To minimize entrainment of larval and juvenile delta smelt at Banks and Jones or from being transported into the South and Central Delta, where they could later become entrained.

Action: Do not install the Spring Head of Old River Barrier (HORB) if delta smelt entrainment is a concern. If installation of the HORB is not allowed, the agricultural barriers would be installed as described in the Project Description. If installation of the HORB is allowed, the Temporary Barrier Project (TBP) flap gates would be tied in the open position until May 15.

Timing: The timing of the action would vary depending on the conditions. The normal installation of the spring temporary HORB and the TBP is in April.

Triggers: For delta smelt, installation of the HORB will only occur when particle tracking modeling results show that entrainment levels of delta smelt will not increase beyond 1 percent at Station 815 as a result of installing the HORB.

Off-ramps: If Action 3 ends or May 15, whichever comes first.

Action 5 Assumptions for CALSIM II and DSM2 Modeling Purposes:

The South Delta Improvement Program (SDIP) Stage 1 is not included in the Existing and Future Condition assumptions being used for CALSIM II and DSM2 baselines. The TBP is assumed instead. The TBP specifies that HORB be installed and operated during April 1 through May 31 and September 16 through November 30. In response to the FWS BO, Action 5, the HORB is assumed to not be installed during April 1 through May 31.

Attachment A

Excerpts from “Water Supply Impact Analysis of December 2008 Delta Smelt Biological Opinion”, by Paul Hutton, Metropolitan Water District of Southern California, February 2009

Entitled

“Appendix 4: Approach to Suspend Actions During High Flows” and “Appendix 5: Approach to Relate 5-Day & 14-Day OMR Flows”

Appendix 4: Approach to Suspend Actions During High Flows

MEMO

Date: December 16, 2008

To: File

From: Paul Hutton

Subject: Modeling Delta Smelt High Flow Action Temporary Suspensions

This memo summarizes an approach that was developed to represent high flow periods when Delta smelt flow actions are temporarily suspended. The actions of interest include the following:

- Wanger Actions – The winter pulse flow action (on or after December 25) is temporarily suspended if the 3-day average flow at Freeport exceeds 80,000 cfs. Similarly, the pre-spawning adult flow action (January and February) is temporarily suspended if the 3-day average flow at Freeport exceeds 80,000 cfs.

- Delta Smelt Biological Opinion Actions – Action 2 is temporarily suspended if the 3-day average flows at Rio Vista and Vernalis exceed 90,000 cfs and 10,000 cfs, respectively.

Methodology

Given that (1) the actions are written in terms of 3-day flow averages and (2) typical water supply impact analyses are conducted assuming monthly average flows, a method is needed to characterize the action in terms of monthly average flows. Historical flows information from DAYFLOW was used to characterize relationships between 3-day flows and monthly flows. The desired product is to determine a frequency of exceeding the 3-day flow target as a function of a monthly flow value. This frequency will be used to proportionally reduce calculated water supply impacts in high flow months.

Results for Wanger Actions

Figure 4-1 plots the frequency that 3-day Freeport flows exceed 80,000 cfs as a function of monthly average Freeport flows (Q_F). The resulting mathematical frequency relationship (in percent units) is as follows:

0% when $Q_F < 50,000$ cfs

$0.0126 * \exp(0.000105*Q_F)$ when $50,000 \text{ cfs} \leq Q_F \leq 85,000$ cfs

100% when $Q_F > 85,000$ cfs

Results for BO Actions

Figure 4-2 plots the frequency that 3-day Rio Vista flows exceed 90,000 cfs as a function of monthly average Freeport flows (Q_F). The resulting mathematical frequency relationship (in percent units) is as follows:

0% when $Q_F < 50,000$ cfs

$-146 + 0.00289*Q_F$ when $50,000 \text{ cfs} \leq Q_F \leq 85,000$ cfs

100% when $Q_F > 85,000$ cfs

Figure 4-3 plots the frequency that 3-day Vernalis flows exceed 10,000 cfs as a function of monthly average Vernalis flows (Q_V). The resulting mathematical frequency relationship (in percent units) is as follows:

0% when $Q_V < 6,000$ cfs

$-49 + 0.00901*Q_V$ when $6,000 \text{ cfs} \leq Q_V \leq 16,000$ cfs

100% when $Q_V > 16,000$ cfs

The BO requires Rio Vista and Vernalis flows to simultaneously exceed the targets to temporarily suspend the flow action. For modeling purposes, it is assumed that these flows are statistically independent. Hence, the suspension frequency is calculated as the product of the individual frequencies. Since Rio Vista and Vernalis flows are modestly correlated, the proposed approach may somewhat understate the true suspension frequency. However, a cursory paired data evaluation suggested that the assumption will provide reasonable results.

Figure 4-1. Frequency of Wanger Freeport Flow Trigger as a Function of Monthly Freeport Flow

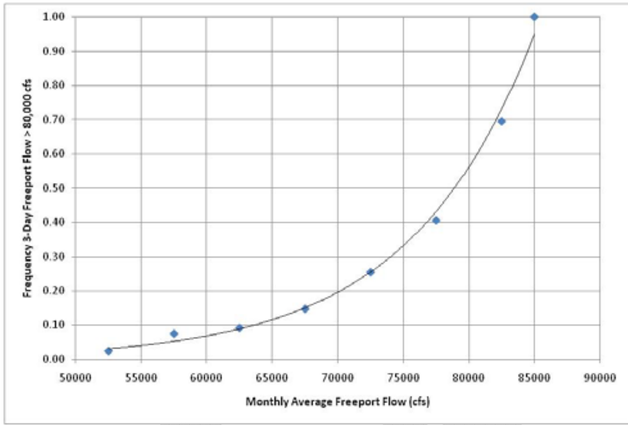


Figure 4-2. Frequency of BO Rio Vista Flow Trigger as a Function of Monthly Freeport Flow

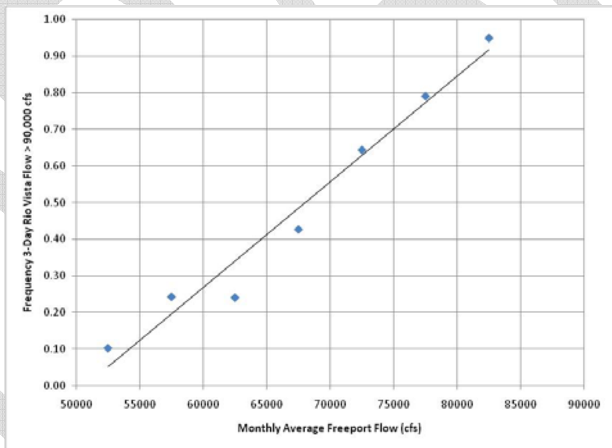
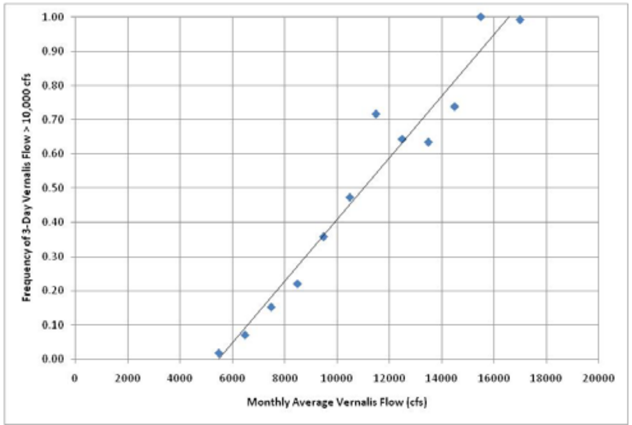


Figure 4-3. Frequency of BO Vernalis Flow Trigger as a Function of Monthly Vernalis Flow



Appendix 5: Approach to Relate 5-Day & 14-Day OMR Flows

MEMO

Date: January 2, 2009

To: File

From: Paul Hutton

Subject: How Frequently Will 5-Day OMR Flows (Rather than 14-Day OMR Flows) Control Project Operations Under New Delta Smelt Biological Opinion?

Background

Several flow actions specified in the December 2008 Delta Smelt biological opinion place limits on reverse flows in Old and Middle Rivers. Limits are given as 14-day averages, but the simultaneous 5-day averages are to be within 25% of the 14-day averages. This memo summarizes an investigation to answer the question "How frequently will 5-day OMR flows, rather than 14-day OMR flows, control project operations under the new Delta smelt biological opinion?"

Water supply impact studies assume the 14-day average flow controls. Such an approach would not be conservative if 5-day flows frequently control project operations. Based upon a recent meeting with SWP and CVP operators, the CVP operators believe that fishery agencies will accept violations of the 5-day flow limit provided that project operators maintain relatively stable pumping operations. Is this belief that 5-day flows will not control operations valid? Will the courts or environmental groups accept such an operation? An investigation into the potential frequency of 5-day flow control seems prudent, given that we don't know the answers to such questions.

Methods

The following methods were employed:

- Review historical Delta flow and operations data for the period between January 1990 and May 2008.
- Identify periods when (1) pumping operations were relatively stable and (2) 5-day OMR flows were more negative than 14-day OMR flows. For periods prior to

October 2006, running average OMR flows were computed from raw 24-hour USGS data. For periods after October 2006, running average OMR flows were computed from tidally filtered USGS data.

- Evaluate differences between 5-day and 14-day OMR flows. Evaluate differences between (1) average period values and (2) peak period values. The rationale for evaluating both differences is as follows. While a 5-day flow violation may be acceptable as a "peak" event, the acceptability of a flow violation over longer periods seems less likely.

Results

Fifty periods were identified when pumping operations were relatively stable and 5-day OMR flows were more negative than 14-day OMR flows. The duration of these periods was typically 7 to 9 days. These periods are summarized in Table 5-1.

Differences Between Average Period Values. For each period, the average 5-day OMR flow is plotted against average 14-day OMR flow in Figure 5-1. This graph shows a linear relationship, suggesting that differences are relatively constant over a wide range of OMR flows. This relationship further suggests that the percent difference between 14-day flows and 5-day flows will generally be greater when the absolute flow value is small. At a 50% confidence interval, 5-day OMR flows are more negative than 14-day OMR flows by nearly 400 cfs (389 cfs). At one standard error, or about 67% confidence, 5-day OMR flows are more negative than 14-day OMR flows by more than 550 cfs (389 cfs + 174 cfs = 563 cfs). At two standard errors, or about 95% confidence, 5-day OMR flows are more negative than 14-day OMR flows by more than 700 cfs (389 cfs + 2*174 cfs = 737 cfs).

By solving the Figure 5-1 regression equation for a condition when the 5-day OMR flow is 25% more negative than the 14-day OMR flow, the following limits are identified when 5-day OMR flows will control:

14-day OMR flow = -1670 cfs at a 50% confidence interval

-2420 cfs at a 67% confidence interval

-3160 cfs at a 95% confidence interval

Differences Between Peak Period Values. For each period, the peak 5-day OMR flow is plotted against peak 14-day OMR flow in Figure 5-2. This graph also shows a linear relationship, suggesting that differences are relatively constant over a wide range of OMR flows. This relationship further suggests that the percent difference between 14-day flows and 5-day flows will generally be greater when the absolute flow value is small. At a 50% confidence interval, 5-day OMR flows are more negative than 14-day OMR flows by nearly 700 cfs (679 cfs). At one standard error, or about 67% confidence, 5-day OMR flows are more negative than 14-day OMR flows by nearly 1000 cfs (679 cfs + 297 cfs = 976 cfs). At two standard errors, or about 95% confidence, 5-day OMR flows are more negative than 14-day OMR flows by nearly 1300 cfs (679 cfs + 2*297 cfs = 1273 cfs).

By solving the Figure 5-1 regression equation for a condition when the 5-day OMR flow is 25% more negative than the 14-day OMR flow, the following limits are identified when 5-day OMR flows will control:

14-day OMR flow = -2980 cfs at a 50% confidence interval

-4280 cfs at a 67% confidence interval

-5580 cfs at a 95% confidence interval

Conclusions

This memo summarizes an investigation to answer the question "How frequently will 5-day OMR flows, rather than 14-day OMR flows, control project operations under the new Delta smelt biological opinion?" An analysis of historical flow and project operations data suggests that 5-day OMR flows will often control operations when the 14-day flow target is in the most stringent range of -1500 cfs to -2500 cfs. When the projects are operating to less stringent OMR flows in the range of -3000 cfs to -5000 cfs, 5-day OMR flows will occasionally be at least 25% more negative than 14-day OMR flows and might control project operations.

If the projects are required to strictly meet the 5-day OMR flow criteria, (1) the current water supply impact assumption of 14-day OMR flow control is not conservative and (2) it would be prudent to incorporate a factor of safety to address the 5-day flow criteria.

Figure 5-1. Average 5d OMR flows as a function of average 14d OMR flows during periods when pumping operations were stable and 5d flows were more negative than 14d flows.

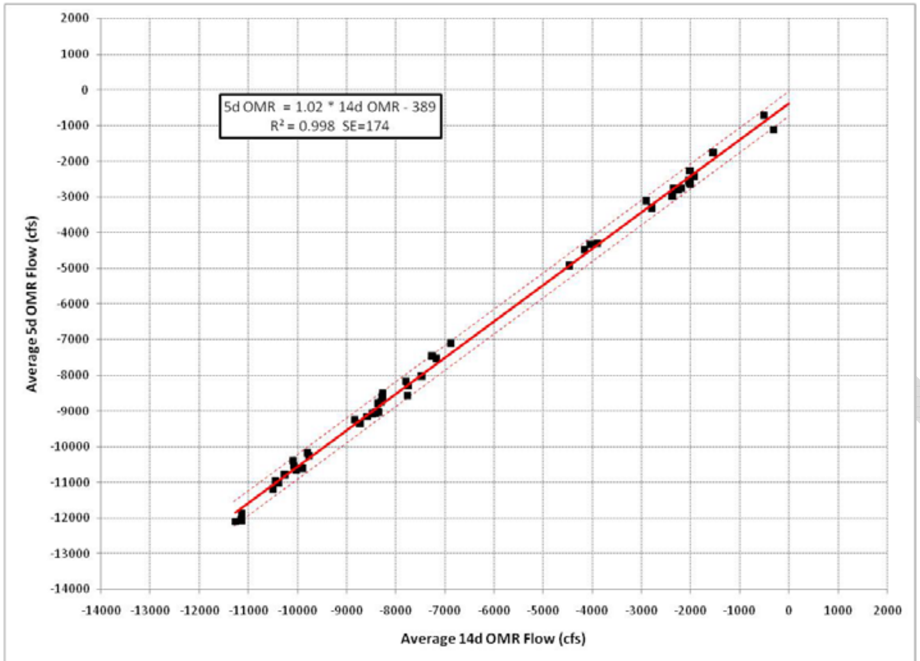


Figure 5-2. Peak 5d OMR flows as a function of peak 14d OMR flows during periods when pumping operations were stable and 5d flows were more negative than 14d flows.

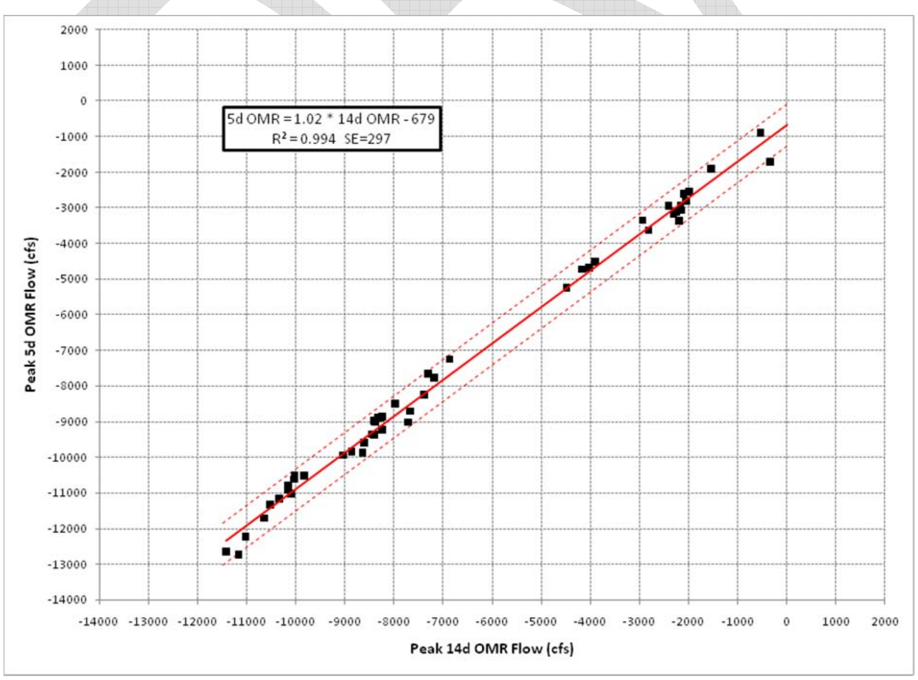


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Table 5-1. Fifty periods were identified when pumping operations were relatively stable and 5-day OMR flows were more negative than 14-day OMR flows.

Period			Daily Export Range (cfs)			14d Export Range (cfs)			Average OMR Difference (cfs)				Peak OMR Difference (cfs)				
Start Date	End Date	Duration (days)	Min	Max	Range	Min	Max	Range	14d	5d	Diff	%Diff	Date	14d	5d	Diff	%Diff
24-Jan-90	1-Feb-90	9	10000	10700	700	10400	10500	100	-8300	-8760	-460	6%	30-Jan-90	-8390	-9010	-620	7%
9-Feb-90	17-Feb-90	9	9900	10600	700	10400	10400	0	-8270	-8590	-320	4%	12-Feb-90	-8280	-8900	-620	7%
24-Feb-90	3-Mar-90	8	10000	10600	600	10400	10500	100	-8270	-8690	-420	5%	27-Feb-90	-8240	-8870	-630	8%
10-Mar-90	19-Mar-90	10	10000	10800	800	10300	10400	100	-8260	-8510	-250	3%	18-Mar-90	-8340	-8890	-550	7%
24-Mar-90	1-Apr-90	9	10300	10600	300	10300	10500	200	-8830	-9250	-420	5%	31-Mar-90	-9040	-9950	-910	10%
1-Apr-91	8-Apr-91	8	9300	10200	900	10200	10300	100	-7470	-8020	-550	7%	4-Apr-91	-7390	-8260	-870	12%
16-Mar-92	24-Mar-92	9	10000	10700	700	10300	10400	100	-8410	-9060	-650	8%	22-Mar-92	-8640	-9880	-1240	14%
20-Aug-93	27-Aug-93	8	10400	10900	500	10600	10700	100	-8730	-9350	-620	7%	24-Aug-93	-8870	-9850	-980	11%
4-Sep-93	10-Sep-93	7	10900	10900	0	10600	10700	100	-8360	-8790	-430	5%	9-Sep-93	-8420	-8990	-570	7%
18-Sep-93	23-Sep-93	6	10300	10900	600	10800	10900	100	-8370	-9030	-660	8%	20-Sep-93	-8450	-9360	-910	11%
1-Oct-93	9-Oct-93	9	10800	11100	300	10600	10900	300	-8340	-9040	-700	8%	3-Oct-93	-8240	-9240	-1000	12%
17-Oct-93	22-Oct-93	6	10800	10900	100	10900	10900	0	-7790	-8170	-380	5%	18-Oct-93	-7980	-8500	-520	7%
22-Nov-95	30-Nov-95	9	4300	4800	500	4400	4400	0	-2780	-3300	-520	19%	25-Nov-95	-2810	-3640	-830	30%
7-Dec-95	13-Dec-95	7	4200	4400	200	4300	4400	100	-2900	-3100	-200	7%	12-Dec-95	-2930	-3360	-430	15%
22-Dec-95	28-Dec-95	7	4200	4400	200	4200	4300	100	-2370	-2980	-610	26%	26-Dec-95	-2250	-3130	-880	39%
12-Aug-99	22-Aug-99	11	8700	11600	2900	10900	11300	400	-9800	-10180	-380	4%	20-Aug-99	-10040	-10630	-590	6%
28-Aug-99	5-Sep-99	9	10900	11600	700	11100	11400	300	-10260	-10790	-530	5%	1-Sep-99	-10350	-11180	-830	8%
13-Sep-99	19-Sep-99	7	11400	11500	100	11500	11500	0	-10090	-10390	-300	3%	17-Sep-99	-10030	-10530	-500	5%
3-May-00	9-May-00	7	1700	2200	500	2100	2300	200	-1930	-2410	-480	25%	8-May-00	-1980	-2560	-580	29%
5-May-01	13-May-01	9	1500	1700	200	1500	1500	0	-2000	-2630	-630	32%	11-May-01	-2190	-3380	-1190	54%
22-May-01	29-May-01	8	800	1600	800	1500	1500	0	-2020	-2590	-570	28%	27-May-01	-2140	-3080	-940	44%
22-Jul-01	29-Jul-01	8	7900	8800	900	8100	8300	200	-8580	-9160	-580	7%	25-Jul-01	-8610	-9610	-1000	12%
20-Aug-01	26-Aug-01	7	7700	8900	1200	8100	8400	300	-8470	-9080	-610	7%	23-Aug-01	-8410	-9370	-960	11%
6-Sep-01	12-Sep-01	7	7200	8300	1100	7500	7600	100	-7760	-8580	-820	11%	8-Sep-01	-7720	-9030	-1310	17%
19-Sep-01	25-Sep-01	7	7200	8200	1000	7700	7800	100	-7750	-8310	-560	7%	22-Sep-01	-7680	-8720	-1040	14%
27-Apr-02	3-May-02	7	1400	1500	100	1500	2000	500	-2190	-2750	-560	26%	30-Apr-02	-2160	-2960	-800	37%
12-May-02	18-May-02	7	1500	1500	0	1500	1500	0	-2030	-2540	-510	25%	16-May-02	-2040	-2810	-770	38%
26-May-02	31-May-02	6	1600	1600	0	1600	1600	0	-2010	-2260	-250	12%	31-May-02	-2100	-2620	-520	25%
1-May-03	7-May-03	7	1400	1500	100	1500	1500	0	-2340	-2760	-420	18%	3-May-03	-2400	-2950	-550	23%
15-May-03	22-May-03	8	1500	2300	800	1400	1700	300	-2250	-2800	-550	24%	20-May-03	-2300	-3190	-890	39%
15-Aug-03	22-Aug-03	8	11300	11600	300	11200	11400	200	-11260	-12100	-840	7%	20-Aug-03	-11430	-12670	-1240	11%
31-Aug-03	6-Sep-03	7	11200	11500	300	11400	11500	100	-11140	-12070	-930	8%	3-Sep-03	-11170	-12750	-1580	14%
13-Sep-03	21-Sep-03	9	10000	11600	1600	11200	11400	200	-11130	-11880	-750	7%	16-Sep-03	-11030	-12240	-1210	11%
25-Jul-05	31-Jul-05	7	11500	11600	100	11500	11500	0	-10020	-10670	-650	6%	28-Jul-05	-10110	-11040	-930	9%
7-Aug-05	15-Aug-05	9	10900	11700	800	11500	11600	100	-10390	-11020	-630	6%	13-Aug-05	-10530	-11350	-820	8%
22-Aug-05	28-Aug-05	7	11600	11700	100	11500	11600	100	-10500	-11190	-690	7%	25-Aug-05	-10650	-11720	-1070	10%
13-Aug-06	18-Aug-06	6	11500	11600	100	11500	11600	100	-10070	-10560	-490	5%	15-Aug-06	-10170	-10930	-760	7%
26-Aug-06	3-Sep-06	9	11300	11600	300	11500	11500	0	-9760	-10260	-500	5%	1-Sep-06	-9840	-10520	-680	7%
10-Sep-06	16-Sep-06	7	11000	11600	600	11500	11600	100	-9900	-10610	-710	7%	14-Sep-06	-10090	-11040	-950	9%
5-Nov-06	13-Nov-06	9	8600	10000	1400	9200	9400	200	-6880	-7100	-220	3%	7-Nov-06	-6870	-7260	-390	6%
15-Nov-06	23-Nov-06	9	9200	10000	800	9200	9500	300	-7260	-7460	-200	3%	20-Nov-06	-7310	-7660	-350	5%
2-Dec-06	6-Dec-06	5	8400	10200	1800	9600	9800	200	-7170	-7530	-360	5%	4-Dec-06	-7180	-7780	-600	8%
27-Jan-07	1-Feb-07	6	6300	6900	600	6500	6800	300	-3890	-4300	-410	11%	28-Jan-07	-3900	-4530	-630	16%
7-Feb-07	13-Feb-07	7	6400	6900	500	6800	6800	0	-4160	-4490	-330	8%	10-Feb-07	-4170	-4730	-560	13%
22-Feb-07	28-Feb-07	7	6600	6900	300	6800	6900	100	-4030	-4330	-300	7%	25-Feb-07	-4020	-4700	-680	17%
3-Apr-07	9-Apr-07	7	5600	7100	1500	6200	6600	400	-4460	-4920	-460	10%	7-Apr-07	-4480	-5250	-770	17%
15-May-07	20-May-07	6	1200	1500	300	1400	1500	100	-1540	-1750	-210	14%	18-May-07	-1540	-1920	-380	25%
14-Aug-07	24-Aug-07	11	11600	11600	0	11500	11600	100	-10450	-10960	-510	5%	17-Aug-07	-10160	-10810	-650	6%
3-May-08	9-May-08	7	1500	1500	0	1500	1600	100	-310	-1110	-800	258%	6-May-08	-330	-1720	-1390	421%
18-May-08	22-May-08	5	1400	1700	300	1500	1500	0	-500	-710	-210	42%	20-May-08	-530	-900	-370	70%

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B.11. NMFS RPA Implementation

The information included in this section is consistent with what was provided to and agreed by the lead agencies in the, "*Representation of U.S. Fish and Wildlife Service Biological Opinion Reasonable and Prudent Alternative Actions for CALSIM II Planning Studies*", on February 10, 2010.

Representation of National Marine Fisheries Service Biological Opinion Reasonable and Prudent Alternative Actions for CALSIM II Planning Studies

The National Marine Fisheries Service's (NMFS) Biological Opinion (BO) on the Long-term Operations of the Central Valley Project and State Water Project was released on June 4, 2009.

To develop CALSIM II modeling assumptions to represent the operations related reasonable and prudent alternative actions (RPA) required by this BO, the California Department of Water Resources (Department) led a series of meetings that involved members of fisheries and project agencies. The purpose for establishing this group was to prepare the assumptions and CALSIM II implementations to represent the RPAs in both Existing- and Future-Condition CALSIM II simulations for future planning studies.

This memorandum summarizes the approach that resulted from these meetings and the modeling assumptions that were laid out by the group. The scope of this memorandum is limited to the June 4, 2009 BO. All descriptive information of the RPAs is taken from the BO.

Table B-39 lists the participants that contributed to the meetings and information summarized in this document.

The RPAs in NMFS's BO are based on physical and biological processes that do not lend themselves to simulations using a monthly time step. Much scientific and modeling judgment has been employed to represent the implementation of the RPAs. The group believes the logic put into CALSIM II represents the RPAs as best as possible at this time, given the scientific understanding of environmental factors enumerated in the BO and the limited historical data for some of these factors.

Given the relatively generalized representation of the RPAs assumed for CALSIM II modeling, much caution is required when interpreting outputs from the model.

TABLE B-39
Meeting Participants

Aaron Miller/Department	Derek Hilts/USFWS
Randi Field/Reclamation	Roger Guinee/ USFWS
Lenny Grimaldo/Reclamation	Matt Nobriga/CDFG
Henry Wong/Reclamation	Bruce Oppenheim/ NMFS
Parviz Nader-Tehrani/ Department	Robert Leaf/CH2M HILL
Erik Reyes/ Department	Derya Sumer/CH2M HILL
Sean Sou/ Department	
Paul A. Marshall/ Department	
Ming-Yen Tu/ Department	
Xiaochun Wang/ Department	

Notes:

CDFG = California Department of Fish and Game

NMFS = National Marine Fisheries Service

USFWS = US Fish and Wildlife Service

Action Suite 1.1 Clear Creek

Suite Objective: The RPA actions described below were developed based on a careful review of past flow studies, current operations, and future climate change scenarios. These actions are necessary to address adverse project effects on flow and water temperature that reduce the viability of spring-run and CV steelhead in Clear Creek.

Action 1.1.1 Spring Attraction Flows

Objective: Encourage spring-run movement to upstream Clear Creek habitat for spawning.

Action: Reclamation shall annually conduct at least two pulse flows in Clear Creek in May and June of at least 600 cfs for at least three days for each pulse, to attract adult spring-run holding in the Sacramento River main stem.

Action 1.1.1 Assumptions for CALSIM II Modeling Purposes

Action: Model is modified to meet 600 cfs for 3 days twice in May. In the CALSIM II analysis, Flows sufficient to increase flow up to 600 cfs for a total of 6 days are added to the flows that would have otherwise occurred in Clear Creek.

Rationale: CALSIM II is a monthly model. The monthly flow in Clear Creek is an underestimate of the the actual flows that would occur subject to daily operational constraints at Whiskeytown Reservoir. The additional flow to meet 600 cfs for a total of 6 days was added to the monthly average flow modeled.

Action 1.1.5. Thermal Stress Reduction

Objective: To reduce thermal stress to over-summering steelhead and spring-run during holding, spawning, and embryo incubation.

Action: Reclamation shall manage Whiskeytown releases to meet a daily water temperature of: 1) 60°F at the Igo gage from June 1 through September 15; and 2) 56°F at the Igo gage from September 15 to October 31.

Action 1.1.5 Assumptions for CALSIM II Modeling Purposes

Action: It is assumed that temperature operations can perform reasonably well with flows included in model.

Rationale: A temperature model of Whiskeytown Reservoir has been developed by Reclamation. Further analysis using this or other temperature model is required to verify the statement that temperature operations can perform reasonably well with flows included in model.

Action Suite 1.2 Shasta Operations

Objectives: To address the avoidable and unavoidable adverse effects of Shasta operations on winter-run and spring-run:

1. Ensure a sufficient cold water pool to provide suitable temperatures for winter-run spawning between Balls Ferry and Bend Bridge in most years, without sacrificing the potential for cold water management in a subsequent year. Additional actions to those

in the 2004 CVP/SWP operations Opinion are needed, due to increased vulnerability of the population to temperature effects attributable to changes in Trinity River ROD operations, projected climate change hydrology, and increased water demands in the Sacramento River system.

2. Ensure suitable spring-run temperature regimes, especially in September and October. Suitable spring-run temperatures will also partially minimize temperature effects to naturally-spawning, non-listed Sacramento River fall-run, an important prey base for endangered Southern Residents.

3. Establish a second population of winter-run in Battle Creek as soon as possible, to partially compensate for unavoidable project-related effects on the one remaining population.

4. Restore passage at Shasta Reservoir with experimental reintroductions of winter-run to the upper Sacramento and/or McCloud rivers, to partially compensate for unavoidable project-related effects on the remaining population.

Action 1.2.1 Performance Measures

Objective: To establish and operate to a set of performance measures for temperature compliance points and End-of-September (EOS) carryover storage, enabling Reclamation and NMFS to assess the effectiveness of this suite of actions over time. Performance measures will help to ensure that the beneficial variability of the system from changes in hydrology will be measured and maintained.

Action: To ensure a sufficient cold water pool to provide suitable temperatures, long-term performance measures for temperature compliance points and EOS carryover storage at Shasta Reservoir shall be attained. Performance measures for EOS carryover storage at Shasta Reservoir are as follows:

- 87 percent of years: Minimum EOS storage of 2.2 MAF
- 82 percent of years: Minimum EOS storage of 2.2 MAF and end-of-April storage of 3.8 MAF in following year (to maintain potential to meet Balls Ferry compliance point)
- 40 percent of years: Minimum EOS storage 3.2 MAF (to maintain potential to meet Jelly's Ferry compliance point in following year)

Performance measures (measured as a 10-year running average) for temperature compliance points during summer season are:

- Meet Clear Creek Compliance point 95 percent of time
- Meet Balls Ferry Compliance point 85 percent of time
- Meet Jelly's Ferry Compliance point 40 percent of time
- Meet Bend Bridge Compliance point 15 percent of time

Action 1.2.1 Assumptions for CALSIM II Modeling Purposes

Action: No specific CALSIM II modeling code is implemented to simulate the Performance measures identified. System performance will be assessed and evaluated through post-processing of various model results.

Rationale: Given that the performance criteria are based on the CALSIM II modeling data used in preparation of the Biological Assessment, the system performance after application of the RPAs should be similar as a percentage of years that the end-of-April storage and temperature compliance requirements are met over the simulation period. Post-processing of modeling results will be compared to various new operating scenarios as needed to evaluate performance criteria and appropriateness of the rules developed.

Action 1.2.2 November through February Keswick Release Schedule (Fall Actions)

Objective: Minimize impacts to listed species and naturally spawning non-listed fall-run from high water temperatures by implementing standard procedures for release of cold water from Shasta Reservoir.

Action: Depending on EOS carryover storage and hydrology, Reclamation shall develop and implement a Keswick release schedule, and reduce deliveries and exports as needed to achieve performance measures.

Action 1.2.2 Assumptions for CALSIM II Modeling Purposes

Action: No specific CALSIM II modeling code is implemented to simulate the Performance measures identified. Keswick flows based on operation of 3406(b)(2) releases in OCAP Study 7.1 (for Existing) and Study 8 (for Future) are used in CALSIM II. These flows will be reviewed for appropriateness under this action. A post-process based evaluation similar to what has been explained in Action 1.2.1 will be conducted.

Rationale: Performance measures are set as percentage of years that the end-of-September and temperature compliance requirements are met over the simulation period. Post-processing of modeling results will be compared to various new operating scenarios as needed to evaluate performance criteria and appropriateness of the rules developed.

Action 1.2.3 February Forecast; March – May 14 Keswick Release Schedule (Spring Actions)

Objective: To conserve water in Shasta Reservoir in the spring in order to provide sufficient water to reduce adverse effects of high water temperature in the summer months for winter-run, without sacrificing carryover storage in the fall.

Action: 1) Reclamation shall make its February forecast of deliverable water based on an estimate of precipitation and runoff within the Sacramento River basin at least as conservative as the 90 percent probability of exceedance. Subsequent updates of water delivery commitments must be based on monthly forecasts at least as conservative as the 90 percent probability of exceedance.

2) Reclamation shall make releases to maintain a temperature compliance point not in excess of 56 degrees between Balls Ferry and Bend Bridge from April 15 through May 15.

Action 1.2.3 Assumptions for CALSIM II Modeling Purposes

Action: No specific CALSIM II modeling code is implemented to simulate the Performance measures identified. It is assumed that temperature operations can perform reasonably well with flows included in model.

Rationale: Temperature models of Shasta Lake and the Sacramento River have been developed by Reclamation. This modeling reflects current facilities for temperature controlled releases. Further analysis using this or another temperature model can further verify that temperature operations can perform reasonably well with flows included in model and temperatures are met reliably at each of the compliance points. In the future, it may be that adjusted flow schedules may need to be developed based on development of temperature model runs in conjunction with CALSIM II modeled operations.

Action 1.2.4 May 15 through October Keswick Release Schedule (Summer Action)

Objective: To manage the cold water storage within Shasta Reservoir and make cold water releases from Shasta Reservoir to provide suitable habitat temperatures for winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon in the Sacramento River between Keswick Dam and Bend Bridge, while retaining sufficient carryover storage to manage for next year's cohorts. To the extent feasible, manage for suitable temperatures for naturally spawning fall-run.

Action: Reclamation shall manage operations to achieve daily average water temperatures in the Sacramento River between Keswick Dam and Bend Bridge as follows:

1) Not in excess of 56°F at compliance locations between Balls Ferry and Bend Bridge from May 15 through September 30 for protection of winter-run, and not in excess of 56°F at the same compliance locations between Balls Ferry and Bend Bridge from October 1 through October 31 for protection of mainstem spring run, whenever possible.

2) Reclamation shall operate to a final Temperature Management Plan starting May 15 and ending October 31.

Action 1.2.4 Assumptions for CALSIM II Modeling Purposes

Action: No specific CALSIM II modeling code is implemented to simulate the Performance measures identified. It is assumed that temperature operations can perform reasonably well with flows included in model. During the detailed effects analysis, temperature modeling and post-processing will be used to verify temperatures are met at the compliance points. In the long-term approach, for a complete interpretation of the action, development of temperature model runs are needed to develop flow schedules if needed for implementation into CALSIM II.

Rationale: Temperature models of Shasta Lake and the Sacramento River have been developed by Reclamation. This modeling reflects current facilities for temperature controlled releases. Further analysis using this or another temperature model is required to verify the statement that temperature operations can perform reasonably well with flows included in model and temperatures are met reliably at each of the compliance points. It may be that alternative flow schedules may need to be developed based on development of temperature model runs in conjunction with CALSIM II modeled operations.

Action Suite 1.3 Red Bluff Diversion Dam (RBDD) Operations

Objectives: Reduce mortality and delay of adult and juvenile migration of winter-run, spring-run, CV steelhead, and Southern DPS of green sturgeon caused by the presence of the diversion dam and the configuration of the operable gates. Reduce adverse modification of the passage element of critical habitat for these species. Provide unimpeded upstream and downstream fish passage in the long term by raising the gates year-round, and minimize adverse effects of continuing dam operations, while pumps are constructed replace the loss of the diversion structure.

Action 1.3.1 Operations after May 14, 2012: Operate RBDD with Gates Out

Action: No later than May 15, 2012, Reclamation shall operate RBDD with gates out all year to allow unimpeded passage for listed anadromous fish.

Action 1.3.1 Assumptions for CALSIM II Modeling Purposes

Action: Adequate permanent facilities for diversion are assumed; therefore no constraint on diversion schedules is included in the Future condition modeling.

Action 1.3.2 Interim Operations

Action: Until May 14, 2012, Reclamation shall operate RBDD according to the following schedule:

•September 1 - June 14: Gates open. No emergency closures of gates are allowed.

•June 15 - August 31: Gates may be closed at Reclamation's discretion, if necessary to deliver water to TCCA.

Action 1.3.2 Assumptions for CALSIM II Modeling Purposes

Action: Adequate interim/temporary facilities for diversion are assumed; therefore no constraint on diversion schedules is included in the Existing Conditions modeling.

Action 1.4 Wilkins Slough Operations

Objective: Enhance the ability to manage temperatures for anadromous fish below Shasta Dam by operating Wilkins Slough in the manner that best conserves the dam's cold water pool for summer releases.

Action: The SRTTG shall make recommendations for Wilkins Slough minimum flows for anadromous fish in critically dry years, in lieu of the current 5,000 cfs navigation criterion to NMFS by December 1, 2009. In critically dry years, the SRTTG will make a recommendation.

Action 1.4 Assumptions for CALSIM II Modeling Purposes

Action: Current rules for relaxation of NCP in CALSIM II (based on BA models) will be used. In CALSIM II, NCP flows are relaxed depending on allocations for agricultural contractors. Table B-40 is used to determine the relaxation.

TABLE B-40

NCP FLOW SCHEDULE WITH RELAXATION

CVP AG Allocation (%)	NCP Flow (cfs)
<10	3250
10-25	3500
25-40	4000
40-65	4500
>65	5000

Rationale: The allocation-flow criteria have been used in the CALSIM II model for many years. The low allocation year relaxations were added to improve operations of Shasta Lake subject to 1.9 MAF carryover target storage. These criteria may be reevaluated subject to the requirements of Action 1.2.1

Action 2.1 Lower American River Flow Management

Objective: To provide minimum flows for all steelhead life stages.

Action: Implement the flow schedule specified in the Water Forum's Flow Management Standard (FMS), which is summarized in Appendix 2-D of the NMFS BO.

Action 2.1 Assumptions for CALSIM II Modeling Purposes

Action: The AFRMP Minimum Release Requirements (MRR) range from 800 to 2,000 cfs based on a sequence of seasonal indices and adjustments. The minimum Nimbus Dam release requirement is determined by applying the appropriate water availability index (Index Flow). Three water availability indices (i.e., Four Reservoir Index (FRI), Sacramento River Index (SRI), and the Impaired Folsom Inflow Index (IFII)) are applied during different times of the year, which provides adaptive flexibility in response to changing hydrological and operational conditions.

During some months, Prescriptive Adjustments may be applied to the Index Flow, resulting in the MRR. If there is no Prescriptive Adjustment, the MRR is equal to the Index Flow.

Discretionary Adjustments for water conservation or fish protection may be applied during the period extending from June through October. If Discretionary Adjustments are applied, then the resultant flows are referred to as the Adjusted Minimum Release Requirement (Adjusted MRR).

The MRR and Adjusted MRR may be suspended in the event of extremely dry conditions, represented by "conference years" or "off-ramp criteria". Conference years are defined when the projected March through November unimpaired inflow into Folsom Reservoir is less than 400,000 acre-feet. Off-ramp criteria are triggered if forecasted Folsom Reservoir storage at any time during the next twelve months is less than 200,000 acre-feet.

Rationale: Minimum instream flow schedule specified in the Water Forum's Flow Management Standard (FMS) is implemented in the model.

Action 2.2 Lower American River Temperature Management

Objective: Maintain suitable temperatures to support over-summer rearing of juvenile steelhead in the lower American River.

Action: Reclamation shall develop a temperature management plan that contains: (1) forecasts of hydrology and storage; (2) a modeling run or runs, using these forecasts, demonstrating that the temperature compliance point can be attained (see Coldwater Management Pool Model approach in Appendix 2-D); (3) a plan of operation based on this modeling run that demonstrates that all other non-discretionary requirements are met; and (4) allocations for discretionary deliveries that conform to the plan of operation.

Action 2.2 Assumptions for CALSIM II Modeling Purposes

Action: The flows in the model reflect the ARFMP implemented under Action 2.1. It is assumed that temperature operations can perform reasonably well with flows included in model.

Rationale: Temperature models of Folsom Lake and the American River were developed in the 1990's. Model development for long range planning purposes may be required. Further analysis using a verified long range planning level temperature model is required to verify the statement that temperature operations can perform reasonably well with flows included in model and temperatures are met reliably

Action Suite 3.1 Stanislaus River / Eastside Division Actions

Overall Objectives: (1) Provide sufficient definition of operational criteria for Eastside Division to ensure viability of the steelhead population on the Stanislaus River, including freshwater migration routes to and from the Delta; and (2) halt or reverse adverse modification of steelhead critical habitat.

Action 3.1.2 Provide Cold Water Releases to Maintain Suitable Steelhead Temperatures

Action: Reclamation shall manage the cold water supply within New Melones Reservoir and make cold water releases from New Melones Reservoir to provide suitable temperatures for CV steelhead rearing, spawning, egg incubation smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam.

Action 3.1.2 Assumptions for CALSIM II Modeling Purposes

Action: No specific CALSIM II modeling code is implemented to simulate the Performance measures identified. It is assumed that temperature operations can perform reasonably well with flow operations resulting from the minimum flow requirements described in action 3.1.3.

Rationale: Temperature models of New Melones Lake and the Stanislaus River have been developed by Reclamation. Further analysis using this or another temperature model can further verify that temperature operations perform reasonably well with flows included in model and temperatures are met reliably. Development of temperature model runs is needed to refine the flow schedules assumed.

Action 3.1.3 Operate the East Side Division Dams to Meet the Minimum Flows, as Measured at Goodwin Dam

Objective: To maintain minimum base flows to optimize CV steelhead habitat for all life history stages and to incorporate habitat maintaining geomorphic flows in a flow pattern that will provide migratory cues to smolts and facilitate out-migrant smolt movement on declining limb of pulse.

Action: Reclamation shall operate releases from the East Side Division reservoirs to achieve a minimum flow schedule as prescribed in NMFS BO Appendix 2-E and generally described in figure 11-1. When operating at higher flows than specified, Reclamation shall implement ramping rates for flow changes that will avoid stranding and other adverse effects on CV steelhead.

Action 3.1.3 Assumptions for CALSIM II Modeling Purposes

Action: Minimum flows based on Appendix 2-E flows (presented in Figure B-4) are assumed consistent to what was modeled by NMFS (5/14/09 and 5/15/09 CALSIM II models provided by NMFS; relevant logic merged into baselines models).

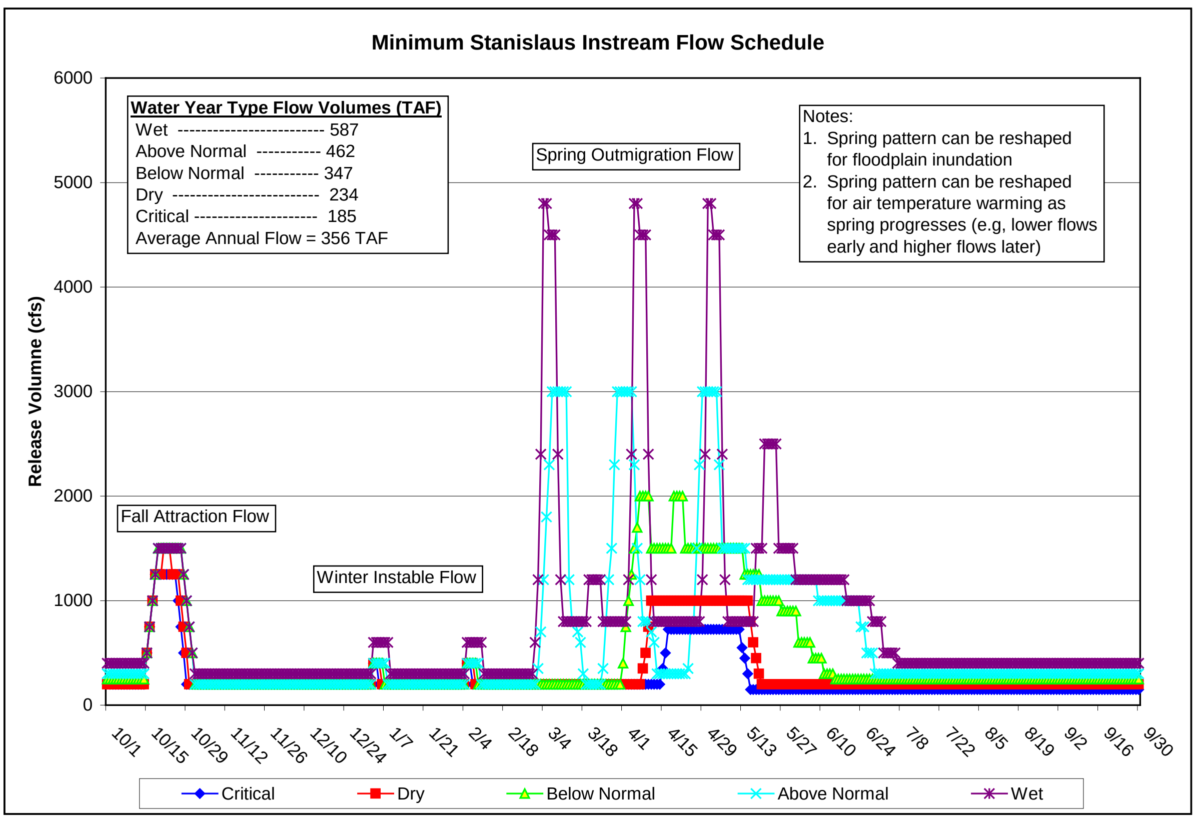

FIGURE B-4. MINIMUM STANISLAUS INSTREAM FLOW SCHEDULE AS PRESCRIBED IN APPENDIX 2-E OF THE NMFS BO (06/04/09)

Annual allocation in New Melones is modeled to ensure availability of required instream flows (Table B-41) based on a water supply forecast that is comprised of end-of-February New Melones storage (in TAF) plus forecasted inflow to New Melones from March 1 to September 30 (in TAF). The "forecasted inflow" is calculated using perfect foresight in the model. Allocated volume of water is released according to water year type following the monthly flow schedule illustrated in Figure B-4.

TABLE B-41

NEW MELONES ALLOCATIONS TO MEET MINIMUM INSTREAM FLOW REQUIREMENTS

New Melones index (TAF)	Annual allocation required for instream flows (TAF)
<1000	0-98.9
1,000 - 1,399	98.9
1,400 - 1,724	185.3
1,725 – 2,177	234.1
2,178 - 2,386	346.7
2,387 – 2,761	461.7
2,762 – 6,000	586.9

Rationale: This approach was reviewed by NOAA fisheries and verified that the year typing and New Melones allocation scheme are consistent with the modeling prepared for the BO.

Action Suite 4.1 Delta Cross Channel (DCC) Gate Operation, and Engineering Studies of Methods to Reduce Loss of Salmonids in Georgiana Slough and Interior Delta

Action 4.1.2 DCC Gate Operation

Objective: Modify DCC gate operation to reduce direct and indirect mortality of emigrating juvenile salmonids and green sturgeon in November, December, and January.

Action: During the period between November 1 and June 15, DCC gate operations will be modified from the proposed action to reduce loss of emigrating salmonids and green sturgeon. From December 1 to January 31, the gates will remain closed, except as operations are allowed using the implementation procedures/modified Salmon Decision Tree.

Timing: November 1 through June 15.

Triggers: Action triggers and description of action as defined in NMFS BO are presented in Table B-42.

TABLE B-42

NMFS BO DCC GATE OPERATION TRIGGERS AND ACTIONS

Date	Action Triggers	Action Responses
October 1 – November 30	Water quality criteria per D-1641 are met and either the Knights Landing Catch Index (KLCI) or the Sacramento Catch Index (SCI) are greater than 3 fish per day but less than or equal to 5 fish per day.	Within 24 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days.
	Water quality criteria per D-1641 are met and either the KLCI or SCI is greater than 5 fish per day	Within 24 hours, close the DCC gates and keep closed until the catch index is less than 3 fish per day at both the Knights Landing and Sacramento monitoring sites.
	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria.	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5.
December 1 – December 14	Water quality criteria are met per D-1641.	DCC gates are closed. If Chinook salmon migration experiments are conducted during this time period (e.g., Delta Action 8 or similar studies), the DCC gates may be opened according to the experimental design, with NMFS' prior approval of the study.
	Water quality criteria are not met but both the KLCI and SCI are less than 3 fish per day.	DCC gates may be opened until the water quality criteria are met. Once water quality criteria are met, the DCC gates will be closed within 24 hours of compliance.
	Water quality criteria are not met but either of the KLCI or SCI is greater than 3 fish per day.	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5
December 15 – January 31	December 15-January 31	DCC Gates Closed.
	NMFS-approved experiments are being conducted.	Agency sponsoring the experiment may request gate opening for up to five days; NMFS will determine whether opening is consistent with ESA obligations.
	One-time event between December 15 to January 5, when necessary to maintain Delta water quality in response to the astronomical high tide, coupled with low inflow conditions.	Upon concurrence of NMFS, DCC Gates may be opened one hour after sunrise to one hour before sunset, for up to 3 days, then return to full closure. Reclamation and DWR will also reduce Delta exports down to a health and safety level during the period of this action.
February 1 – May 15	D-1641 mandatory gate closure.	Gates closed, per WQCP criteria
May 16 – June 15	D-1641 gate operations criteria	DCC gates may be closed for up to 14 days during this period, per 2006 WQCP, if NMFS determines it is necessary.

Action 4.1.2 Assumptions for CALSIM II Modeling Purposes

Action: The DCC gate operations for October 1 through January 31 were layered on top of the D-1641 gate operations already included in the CALSIM II model. The general assumptions regarding the NMFS DCC operations are summarized in Table B-43.

Timing: October 1 through January 31.

TABLE B-43

DCC GATE OPERATION TRIGGERS AND ACTIONS AS MODELED IN CALSIM II

Date	Modeled Action Triggers	Modeled Action Responses
October 1-December 14	Sacramento River daily flow at Wilkins Slough exceeding 7,500 cfs; flow assumed to flush salmon into the Delta	Each month, the DCC gates are closed for number of days estimated to exceed the threshold value.
	Water quality conditions at Rock Slough subject to D-1641 standards	Each month, the DCC gates are not closed if it results in violation of the D-1641 standard for Rock Slough; if DCC gates are not closed due to water quality conditions, exports during the days in question are restricted to 2,000 cfs.
December 15 – January 31	December 15-January 31	DCC Gates Closed.

Flow Trigger: It is assumed that during October 1 – December 14, the DCC will be closed if Sacramento River daily flow at Wilkins Slough exceeds 7,500 cfs. Using historical data (1945 through 2003, USGS gauge 11390500 "Sacramento River below Wilkins Slough near Grimes, CA"), a linear relationship is obtained between average monthly flow at Wilkins Slough and the number of days in month where the flow exceeds 7,500 cfs. This relation is then used to estimate the number of days of DCC closure for the October 1 – December 14 time period (Figure B-5).

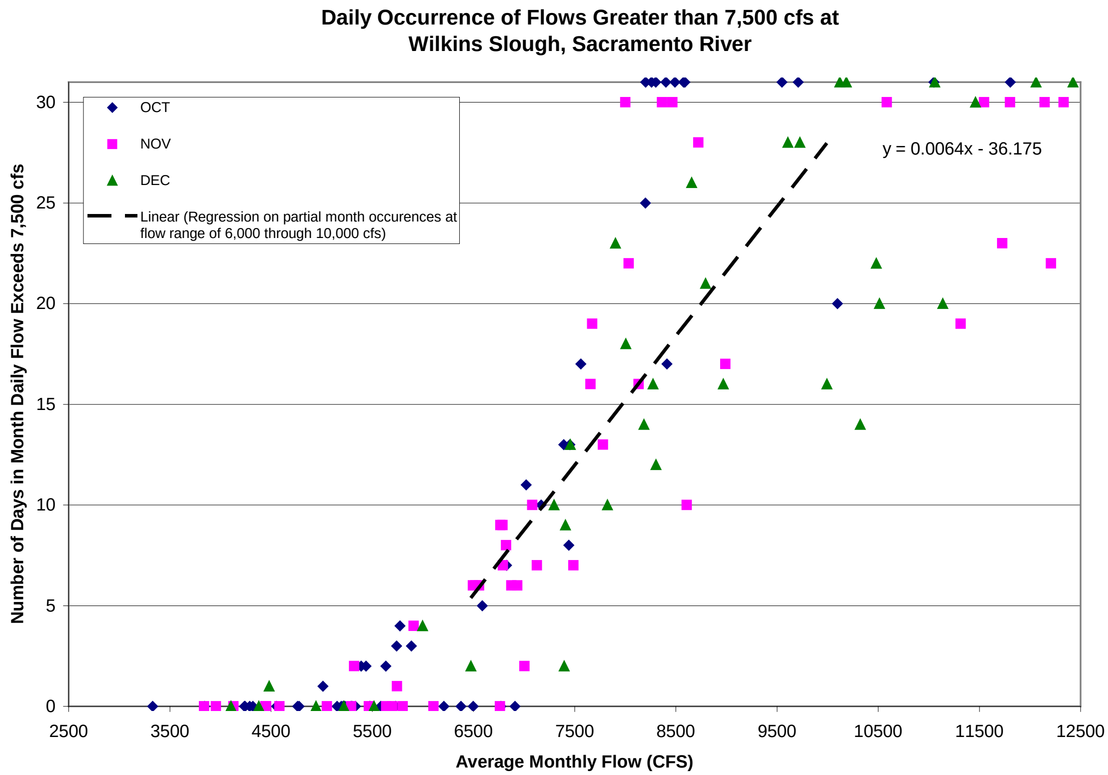

FIGURE B-5. RELATIONSHIP BETWEEN MONTHLY AVERAGES OF SACRAMENTO RIVER FLOWS AND NUMBER OF DAYS THAT DAILY FLOW EXCEEDS 7,500 CFS IN A MONTH AT WILKINS SLOUGH

It is assumed that during December 15 through January 31 that the DCC gates are closed under all flow conditions.

Water Quality: It is assumed that during October 1 – December 14 the DCC gates may remain open if water quality is a concern. Using the CALSIM II-ANN flow-salinity model for Rock Slough, current month's chloride level at Rock Slough is estimated assuming DCC closure per NMFS BO. The estimated chloride level is compared against the Rock Slough chloride standard (monthly average). If estimated chloride level exceeds the standard, the gate closure is modeled per D1641 schedule (for the entire month).

It is assumed that during December 15 through January 31 that the DCC gates are closed under all water quality conditions.

Export Restriction: During October 1 – December 14 period, if the flow trigger condition is such that additional days of DCC gates closed is called for, however water quality conditions are a concern and the DCC gates remain open, then Delta exports are limited to 2,000 cfs for each day in question. A monthly Delta export restriction is calculated based on the trigger and water quality conditions described above.

Rationale: The proposed representation in CALSIM II should adequately represent the limited water quality concerns were Sacramento River flows are low during the extreme high tides of December.

Action Suite 4.2 Delta Flow Management

Action 4.2.1 San Joaquin River Inflow to Export Ratio

Objectives: To reduce the vulnerability of emigrating CV steelhead within the lower San Joaquin River to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta, by increasing the inflow to export ratio. To enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the main stem of the San Joaquin River for emigrating fish, including greater net downstream flows.

Action: For CVP and SWP operations under this action, "The Phase II: Operations beginning is 2012" is assumed. From April 1 through May 31, 1) Reclamation shall continue to implement the Goodwin flow schedule for the Stanislaus River prescribed in Action 3.1.3 and Appendix 2-E of the NMFS BO); and 2) Combined CVP and SWP exports shall be restricted to the ratio depicted in table B-44 below based on the applicable San Joaquin River Index, but will be no less than 1,500 cfs (consistent with the health and safety provision governing this action.)

Action 4.2.1 Assumptions for CALSIM II Modeling Purposes

Action: Flows at Vernalis during April and May will be based on the Stanislaus River flow prescribed in Action 3.1.3 and the flow contributions from the rest of the San Joaquin River basin consistent with the representation of VAMP contained in the BA modeling. In many years this flow may be less than the minimum Vernalis flow identified in the NOAA BO.

Exports are restricted as illustrated in Table B-44.

TABLE B-44

MAXIMUM COMBINED CVP AND SWP EXPORT DURING APRIL AND MAY

San Joaquin River Index	Combined CVP and SWP Export Ratio
Critically dry	1:1
Dry	2:1
Below normal	3:1
Above normal	4:1
Wet	4:1

Rationale: Although the described model representation does not produce the full Vernalis flow objective outlined in the NOAA BO, it does include the elements that are within the control of the CVP and SWP, and that are reasonably certain to occur for the purpose of the EIS/EIR modeling.

In the long-term, a future SWRCB flow standard at Vernalis may potentially incorporate the full flow objective identified in the BO; and the Merced and Tuolumne flows would be based on the outcome of the current SWRCB and FERC processes that are underway.

Action 4.2.3 Old and Middle River Flow Management

Objective: Reduce the vulnerability of emigrating juvenile winter-run, yearling spring-run, and CV steelhead within the lower Sacramento and San Joaquin rivers to entrainment into the channels of the South Delta and at the pumps due to the diversion of water by the export facilities in the South Delta. Enhance the likelihood of salmonids successfully exiting the Delta at Chipps Island by creating more suitable hydraulic conditions in the mainstem of the San Joaquin River for emigrating fish, including greater net downstream flows.

Action: From January 1 through June 15, reduce exports, as necessary, to limit negative flows to -2,500 to -5,000 cfs in Old and Middle Rivers, depending on the presence of salmonids. The reverse flow will be managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. Refer to NMFS BO document for the negative flow objective decision tree.

Action 4.2.3 Assumptions for CALSIM II Modeling Purposes

Action: Old and Middle River flows required in this BO are assumed to be covered by OMR flow requirements developed for actions 1 through 3 of the FWS BO Most Likely scenario (Representation of U.S. Fish and Wildlife Service Biological Opinion Reasonable and Prudent Alternative Actions for CALSIM II Planning Studies – DRAFT, 6/10/09).

Rationale: Based on a review of available data, it appears that implementation of actions 1 through 3 of the FWS RPA, and action 4.2.1 of the NOAA RPA will adequately cover this action within the CALSIM II simulation. If necessary, additional post-processing of results could be conducted to verify this assumption.

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