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APPENDIX 5A, SECTION B
MODELING TECHNICAL APPENDIX –
HYDROLOGY AND SYSTEMS OPERATIONS
MODELING

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Appendix 5A, Modeling Technical Appendix

Section B

– Hydrology and Systems Operations Modeling

B.1 Introduction

This appendix provides a summary of modeling performed to simulate the hydrology, water resources, and water management of the Central Valley with particular focus on operations of the State Water Project (SWP) and Central Valley Project (CVP) for the Delta Conveyance Project Final Environmental Impact Report (EIR). It includes a description of the California Simulation model (CalSim) used for the analysis. CalSim model results for Existing Conditions are presented in Attachment 3, and model results for Future No Project Alternative are presented in Attachment 5.

B.2 Model Selection

B.2.1 WRIMS

In 2000, the California Department of Water Resources (DWR) Bay-Delta Office created a general-purpose simulation environment for analyzing management options for reservoirs and river systems. The software, known as WRIMS, is entirely data driven and can be applied to most reservoir-river basins. WRIMS represents the physical system (e.g., reservoirs, streams, canals, pumping plants) by a network of nodes and arcs. The model user describes system connectivity and various operational constraints using a modeling language known as Water Resources Simulation Language (WRESL). The language allows the model user to formulate linear constraints, which may be conditional on the state of the system (e.g., previous end-of-month reservoir storage), and set objectives through a set of relative weights. WRIMS subsequently simulates system operation by routing water through the network based on prioritization of operational goals and mass balance accounting. A mixed-integer programming solver determines an optimal set of decisions in each timestep for a set of user-defined priorities (weights) and system constraints. The modeling package is described by Draper et al. (2004).

B.2.2 CalSim 3

DWR and the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) have jointly developed a new version of CalSim, known as CalSim 3. This model is an application of the WRIMS software described above. CalSim 3 replaces its predecessor, CalSim II, for conducting planning studies relating to operations of SWP and CVP. DWR took the lead in developing the Sacramento Valley and Sacramento–San Joaquin Delta (Delta) portion of CalSim 3 (California Department of Water Resources 2017: 1-1). Reclamation developed the San Joaquin portion of the model.

CalSim 3 contains many additions and enhancements over CalSim II. These include the following:

- 1 • Expansion of model domain to dynamically simulate the mountain watersheds of the
2 Sacramento and San Joaquin valleys using a physically based network schematic, which is
3 available in geo-referenced form.
- 4 • Delineation of over 230 mountain and foothill (rim) watersheds and corresponding unimpaired
5 runoff to major reservoirs and to mountain rivers and streams at points of diversion and points
6 of measurement.
- 7 • Finer spatial resolution, whereby water demands are based on individual water districts and
8 water agencies rather than large geographic regions and points of diversion are based on
9 contracts and water rights.
- 10 • Updated agricultural land use, crop water demands, and irrigation efficiencies.
- 11 • Updated urban demands based on 2015 Urban Water Management Plans (UWMP) projections
12 for 2020 and 2040.¹
- 13 • Improved simulation of groundwater flows and storage, including stream-groundwater
14 interaction, by linking CalSim 3 to a distributed, finite element groundwater model and
15 improved distinction between surface water use and groundwater use.
- 16 • Extended period of simulation to include water years (WY) 2004 through 2015.

17 DWR and Reclamation have extensively reviewed CalSim 3 performance through comparison to
18 CalSim II and to recent historical observed data. CalSim 3 is considered the best available tool for
19 performing planning studies and supporting environmental review of proposed projects and
20 programs, including the Delta Conveyance Project.

21 Similar to CalSim II, CalSim 3 uses a monthly timestep for making water allocation and management
22 decisions and routing flows through the model network. Adopting a daily timestep for the 94-year
23 model simulation would pose significant challenges in terms of data collection, development, and
24 handling and model run-time. Additionally, at finer steps the model must account for travel time
25 (e.g., 5-days for water released from Shasta to reach the Delta) and the hydraulics of channel flow.
26 Significant investment would also be needed to develop hydrology pre-processing tools.

27 While monthly timesteps are reasonable for long-term planning analyses of water operations,
28 operations of some facilities are sensitive to flow variability at scales less than a month. This
29 includes modeling of the proposed north Delta diversion bypass rules associated with the proposed
30 north Delta intakes. Initial comparisons of monthly versus daily operations at these intakes
31 indicated that diversion potential may be over-estimated using a monthly timestep. Therefore, a
32 monthly to daily flow disaggregation technique was included in the CalSim 3 model for the Fremont
33 Weir, Sacramento Weir, and north Delta diversions.

¹ At the time of model development, the 2020 Urban Water Management Plans were unavailable.

B.3 CalSim 3 Model Components

B.3.1 Input Data

Timeseries Data

Inputs for the CalSim 3 hydrology consist of monthly timeseries data that describe rim watershed inflows, surface runoff from valley watersheds, flow closure terms (bias corrections), agricultural, urban, and managed wetland water demands, and associated surface return flows and deep percolation of precipitation and irrigation to the underlying groundwater. All hydrology inputs are for October 1921 through September 2015. Timeseries data are stored in the Hydrologic Engineering Center's Data Storage System (HEC-DSS) (U.S. Army Corps of Engineers 1995).

Within a HEC-DSS file, data are stored in records or blocks. Records are identified by pathnames that may be up to 80 characters long, and are separated into six parts using a forward slash, as follows:

/A/B/C/D/E/F/

The A part for all HEC-DSS pathnames is "CalSim." The D part indicates the date. The E part indicates the time interval, typically "1MON" for CalSim 3 applications. The F part for all HEC-DSS pathnames is "L2020A" where 2020 indicates the level of development.² CalSim 3 uses the B and C parts to identify individual timeseries stored in a HEC-DSS file. Table 5A-B.1 lists the naming convention for the major inputs to CalSim 3.

Table 5A-B.1. CalSim 3 Timeseries Input Data

Type	B Part	C Part	Units
Applied Water for Rice	AWr_{WBA}_{Demand Unit}	Applied-Water	TAF
Applied Water for Other Crops	AWo_{WBA}_{Demand Unit}	Applied-Water	TAF
Applied Water for Wetlands	AWw_{WBA}_{Demand Unit}	Applied-Water	TAF
Closure Term	CT_{Name of flow gage}_{SV}	Closure-Term	TAF
Delta Accretion	DRN_{Delta Region}	DRN	TAF
Delta Depletion	IRR_{Delta region}	IRR	TAF
Delta Net Depletion	SEEP_{Delta region}	SEEP	TAF
Deep Percolation	DP_{WBA}_{INT}	Deep-Percolation	TAF
Evaporation Rate	ER_{Reservoir name}	Evaporation-Rate	inches
Inflow	I_{Downstream node}	Inflow	TAF
Surface Runoff	SR_{WBA}	Surface-Runoff	TAF
Tailwater from Irrigation	TW_{WBA}_{Demand Unit}	Tailwater	TAF
Urban Demand	UD_{WBA}_{Demand Unit}	Urban-Demand	TAF
Treated Wastewater	WW_{WBA}_{Demand Unit}	Wastewater	TAF

Key: TAF = thousand acre-feet; WBA = Water Budget Area

² The same F-part was retained for input data for the No Project Alternative (2040) because it facilitated use of post-processing tools developed for CalSim 3.

Paired Data

All relational (paired) data such as reservoir area-elevation-capacity data, year-type-dependent flow standards, and monthly flood control requirements, are stored in simple space-delimited text files, known as “lookup” tables, contained in the CalSim 3 *run/lookup* directory. CalSim 3 includes approximately 360 lookup tables.

B.3.2 CalSimHydro

For the valley floor, CalSim 3 simulates the movement of both surface water (e.g., storage regulation, stream diversions, and return flows) and groundwater (e.g., groundwater recharge, groundwater pumping, subsurface lateral flows, and stream-groundwater interaction). However, not all parts of the hydrologic cycle need to be simulated dynamically in CalSim 3. Some flow components, such as rainfall-runoff, can be preprocessed for a fixed land use and a particular climate scenario.

DWR has developed a hydrology model, known as CalSimHydro, to develop all data inputs to CalSim 3 related to the valley floor. CalSimHydro comprises the following modules.

- A daily rainfall runoff model to route precipitation across the land surface and determine infiltration to the soil profile.
- A monthly crop water use model for non-ponded crops.
- A monthly crop water use model for rice cultivation, including winter flood-up for rice straw decomposition and duck habitat.
- A monthly managed wetland water use model.

B.3.3 WRESL Code

CalSim 3 operational logic is contained in a series of text files organized in a folder structure to assist navigation. The logic is formulated using WRESL. CalSim 3 contains over 1,000 WRESL files.

B.3.4 Groundwater DLL

DWR has developed the Integrated Water Flow Model (IWFM), an open-source software package, that couples a three-dimensional finite element groundwater flow simulation process with one-dimensional land surface, streamflow, lake, unsaturated zone, and small-stream watershed processes (Dogrul and Kadir 2021). DWR has also developed the California Central Valley Groundwater-Surface Water Simulation (C2VSim) model, an application of IWFM to the Central Valley.

CalSim 3 is linked to the groundwater component of the C2VSim model. The groundwater simulation component of IWFM was separated from the rest of the IWFM numerical engine and compiled into a dynamic link library (DLL). The resulting groundwater DLL includes a collection of functions that are invoked from CalSim 3 using the WRESL language. These functions initialize the underlying finite element grid, initiate and control simulation of the groundwater flow system, and pass simulated data between the groundwater module and CalSim 3.

Only the groundwater component of C2VSim (including the small watershed routines) is linked to CalSim 3. The stresses on the groundwater system in C2VSim are different from those in CalSim 3.

C2VSim was developed to simulate evolving historical conditions beginning WY 1922. CalSim 3 has been developed to determine water supply conditions for a particular time horizon, such as 2020 or 2040. CalSim 3 development focused in greater detail on the stream network and diversions, C2VSim development placed greater emphasis on the hydrogeology of the underlying aquifer.³

B.3.5 Artificial Neural Network

The purpose of CalSim 3's representation of the Delta is to simulate the net fresh water or tidally averaged movement of water through the Delta at a monthly timescale, including major diversions at Federal, State, and local facilities, and combined flows in Old and Middle River that are subject to regulatory requirements. It is not the purpose of the model to simulate the flood and ebb tidal cycles that occur at a finer timescale or to directly simulate the movement of salinity throughout the Delta. However, for the purposes of meeting Delta water quality objectives, CalSim 3 needs a relationship between Delta salinity at compliance locations and monthly averaged freshwater flows through the Delta.

Salinity variation in the western Delta (represented by the X2⁴ location in the model) is affected by seawater intrusion. Delta salinity is also influenced by boundary inflows, operation of the Delta Cross Channel gates, salinity of the San Joaquin River at Vernalis, and export pumping. Agricultural drainage and municipal and industrial (M&I) wastewater discharges also can affect local salinity conditions. CalSim 3 uses an Artificial Neural Network (ANN) algorithm⁵ developed by DWR (Sandhu et al. 1999; Jayasundara et al. 2020:04020015) to translate Delta water quality standards into flow equivalents that are to be met through SWP and CVP simulated operations. The ANN is a statistical model that mimics the Delta flow–salinity relationships as simulated in a Delta hydrodynamic and water quality model using a 15-minute timestep, known as DSM2. The ANN provides a rapid transformation of this information into a form usable by CalSim 3 operations. A more detailed description of the use of ANNs in the CalSim model is provided in Wilbur and Munévar (2001).

The ANN statistically correlates the salinity results from a particular DSM2 model run to the various peripheral flows (Delta inflows, exports, and diversions), Delta channel depletions, Delta Cross Channel gate operations, and Suisun Marsh Salinity Control Gates (SMSCG).⁶ 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). A total of 148 days of values for key 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

³ The terms *C2VSim* and *groundwater DLL* are not interchangeable; the latter uses the aquifer parameters from a calibrated C2VSim run but simulates groundwater elevations under different stresses (groundwater pumping, deep percolation, and stream stage).

⁴ X2 is the distance in kilometers from the Golden Gate Bridge to the point where daily average salinity is 2 parts per thousand (ppt) at one meter above the bottom of the Sacramento River channel. The location of X2 is used as a surrogate measure of ecosystem health in the Delta. Under the State Water Resources Control Board Water Right Decision 1641 (D-1641), SWP and CVP operators are responsible for maintaining the X2 location, as specified in the 1995 Water Quality Control Plan.

⁵ An ANN is a non-linear statistical data modeling tool that can be used to model complex relationships between inputs and outputs or to find patterns in data.

⁶ The revised ANN used in CalSim 3 no longer uses the salinity for the San Joaquin at Vernalis as an input.

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, and Contra Costa Water District's (CCWD) Old River and Middle River at Victoria Canal intake locations.

B.3.6 Upper Watershed Modules

A series of upper watershed modules have been developed as part of CalSim 3 to simulate water management facilities located in the Sierra Nevada and to create boundary conditions for the main body of the CalSim 3 model. These upper watershed modules can be run as standalone simulation models and their output stored as input to CalSim 3. Alternatively, the modules can be run concurrently with the main CalSim 3 simulation and boundary flows dynamically passed between the modules and main body at run time. Table 5A-B.2 summarizes the exchange of data between modules and the main body.

1 **Table 5A-B.2. CalSim 3 Upper Watershed Modules**

Outputs	Description	Notes
Upper Feather Module		
C_TTC002	Toadtown Canal above Butte Canal	Boundary Flow
D_MIO023_10_NA	Miocene Canal agricultural delivery	
D_MIO023_12_NU1	Miocene Canal M&I delivery	
D_WTPMNR_13_NU1	Miners Ranch Canal M&I delivery	
D_MNRRH_13_NU2	Miners Ranch Canal M&I delivery	
D_MNRRH_13_NA	Miners Ranch Canal agricultural delivery	
D_OWC000_13_NA	Forbestown Ditch agricultural delivery	
C_KRT000	Kelly Ridge Powerhouse	Boundary Flow
C_FTR074	Feather River above Lake Oroville	Boundary Flow
S_UPPERFEATHER	Total surface storage above Lake Oroville	Used for Oroville inflow forecasts
Upper Yuba-Bear Module		
C_STH007	Newcastle Powerhouse	Boundary Flow
C_MRM001	Mormon Slough	Boundary Flow
D_NFA016_ABT002	American River Pump Station	Boundary Flow
C_CMBIE	Bear River below Combie Reservoir	Boundary Flow
C_CBC000	Combie Canal	Boundary Flow
C_LBC010	Lower Boardman Canal	Boundary Flow
D_BRR050_BEC000	Bear River Canal	Boundary Flow
D_CYN009_LBC001	Lower Boardman Canal inflow	Boundary Flow
D_LBR002_LBC001	Lower Boardman Canal inflow	Boundary Flow
Lower Yuba Module		
C_YUB022	Yuba River at Smartville	Boundary Flow
C_MERLC	Merle Collins Reservoir release	Boundary Flow
Upper American Module		
C_JNKS	Sly Creek below Jenkinson Lake	Boundary Flow
C_CMP014	Camp Creek below Camp Creek Dam	Boundary Flow
C_NFA016	NF American River at Auburn Dam Site	Boundary Flow
C_SFA011	SF American River above confluence	Boundary Flow
D_WTPRS1_ELDID_NU3	M&I delivery to El Dorado Hills	
D_WTPRSA_ELDID_NU3	M&I delivery to El Dorado Hills	
D_FOLSM_WTPEDH_WR	M&I delivery to El Dorado Hills	
S_FRMDW	French Meadows Reservoir storage	Used for Folsom inflow forecast
S_HHOLE	Hell Hole Reservoir storage	Used for Folsom inflow forecast
S_LOONL	Loon Lake Reservoir storage	Used for Folsom inflow forecast
S_UNVLY	Union Valley Reservoir storage	Used for Folsom inflow forecast
S_ICEHS	Ice House Reservoir storage	Used for Folsom inflow forecast

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Table 5A-B.2. CalSim 3 Upper Watershed Modules (continued)

Outputs	Description	Notes
Upper Mokelumne Module		
S_SLTSP	Salt Springs Reservoir storage	Used for Pardee inflow forecast
S_LBEAR	Lower Bear River Reservoir storage	Used for Pardee inflow forecast
C_MOK079	Mokelumne River at Mokelumne Hill	Boundary Flow
E_SLTSP	Salt Springs Reservoir evaporation	Used for Pardee inflow forecast
E_LBEAR	Lower Bear Reservoir evaporation	Used for Pardee inflow forecast
Upper Stanislaus Module		
C_STS072	Stanislaus River above New Melones	Boundary Flow
Upper Tuolumne Module		
C_TU0073	Tuolumne River above New Don Pedro	Boundary Flow

M&I = municipal and industrial; NF = North Fork; SF = South Fork.

Upper Feather Module

The Upper Feather module simulates water management facilities located in the Feather River watershed upstream from Oroville Lake and Dam. The module domain includes the West Branch and the North, Middle, and South Fork of the Feather River covering approximately 3,620 square miles, with an average annual unimpaired runoff of approximately 4,285 thousand acre-feet (TAF) (WY 1922–2015), with a range of 928 TAF to 9,424 TAF. The purpose of the Upper Feather module is to simulate inflows to Oroville Lake and inflows to the Thermalito Diversion Pool⁷ from the Kelly Ridge Powerhouse.

The Upper Feather module includes simulation of the following water development projects (the Federal Energy Regulatory Commission [FERC] Project Number is given in parenthesis, where applicable):

- Elements of the SWP comprising Antelope Reservoir (23 TAF capacity), Lake Davis (84 TAF capacity) and Frenchman Lake (55 TAF capacity). These reservoirs are typically operated independently of Lake Oroville.
- DeSabra-Centerville Project (FERC No. 803), which is owned and operated by Pacific Gas and Electric Company (PG&E). The project is located on the West Branch of the Feather River from where water is exported to Butte Creek for hydropower generation.
- North Fork Hydropower Hydroelectric Project (FERC Nos. 619, 1962, 2105, 2107), which is owned and operated by PG&E. The project, located on the North Fork Feather River, includes Mountain Meadows Reservoir (24 TAF capacity),⁸ Lake Almanor (1,143 TAF capacity), Butt Valley Reservoir (50 TAF capacity), Bucks Lake (24 TAF capacity), and a total of 11 powerhouses.
- South Feather Power Project (FERC No. 2088), which is owned and operated by South Feather Water and Power Agency (SFWPA). The project is primarily operated for hydropower but also delivers both agricultural and municipal water. The major features include Little Grass Valley

⁷ The Thermalito Diversion Pool is created by the Thermalito Diversion Dam, which is located about 4.5 miles below Oroville Dam.

⁸ Mountain Meadows Reservoir and the associated Hamilton Branch Powerhouse is not under FERC jurisdiction.

Reservoir (78 TAF capacity) located on the South Fork Feather River, Sly Creek Reservoir (73 TAF capacity) located on Sly Creek, and four powerhouses. The project imports water from Slate Creek, a tributary of the North Yuba River.

Upper Yuba-Bear Module

The Upper Yuba-Bear module simulates water management facilities located on the Middle and South Yuba Rivers and Deer Creek, which is a tributary to the lower Yuba River. The module also simulates facilities on the Bear River located above Camp Far West Reservoir and Dam.

The purpose of the Upper Yuba-Bear module is to simulate inflows to the Yuba River above Englebright Reservoir, inflows to Camp Far West Reservoir, and flows through PG&E's South Canal that spills into Folsom Lake. The module includes simulation of the following water development projects:

- Drum-Spaulling Project (FERC No. 2310), which is owned and operated by PG&E. The project is principally located on the South Yuba River and Bear River and is operated for both water supply and hydropower generation. The project includes Fordyce Lake (50 TAF capacity) and Lake Spaulling (76 TAF capacity).
- Yuba-Bear Project (FERC No. 2266), which is owned and operated by Nevada Irrigation District. The project is principally located on the Middle Yuba River, Canyon Creek, and Bear River, and is operated for both water supply and hydropower generation. The project includes Jackson Meadows Reservoir (69 TAF capacity), Bowman Lake (69 TAF capacity), and Rollins Reservoir (66 TAF capacity).

Lower Yuba Module

The Lower Yuba module simulates water management facilities located on both the North Yuba River and lower Yuba River. This includes Yuba Water Agency's Yuba River Development Project (FERC No. 2246) and Browns Valley Irrigation District development on Dry Creek. The purpose of the Lower Yuba module is to compute agricultural diversions from Dry Creek and the lower Yuba River and determine the flow for the Yuba River near Marysville (U.S. Geological Survey [USGS] gage 11421500).

The Lower Yuba module includes New Bullards Bar Reservoir (966 TAF capacity), Englebright Reservoir (70 TAF capacity), and Merle Collins Reservoir (57 TAF capacity).

Upper American Module

The Upper American module simulates water management facilities located in the American River watershed upstream from Folsom Lake and Dam. The module domain includes the North, Middle, and South Fork of the American River covering approximately 1,875 square miles with an average annual unimpaired runoff of approximately 2,598 TAF (WY 1922–2015), with a range of 377 TAF to 6,486 TAF, as simulated in CalSim 3. The purpose of the Upper American module is to simulate inflows to Folsom Lake from the North Fork and South Fork American River.

The Upper American module includes simulation of the following water development projects:

- Chili Bar Hydroelectric Project (FERC No. 2155), which was purchased from PG&E by the Sacramento Municipal Utility District (SMUD) in 2021. The project includes a run-of-the-river penstock and powerhouse located on the South Fork American River.
- Drum-Spauling Project (FERC No. 2310), owned and operated by PG&E. Project facilities located in the American River watershed include Lake Valley Reservoir (8 TAF capacity), Kelly Lake Reservoir, Lake Valley Diversion Dam, and Lake Valley Canal. Kelly Lake Reservoir is not represented in the module.
- Stumpy Meadows Project, owned and operated by Georgetown Divide Public Utility District. The project, located on Pilot Creek, consists of Stumpy Meadows Reservoir (20 TAF capacity), Pilot Creek Diversion Dam, and the Georgetown Divide Ditch. The project is operated for agricultural and domestic water supply.
- Middle Fork Project (FERC No. 2079), which is owned and operated by Placer County Water Agency (PCWA). The project, located on the Middle Fork American River and the Rubicon River, consists of two major reservoirs (French Meadows and Hell Hole) with a combined capacity of 343 TAF, and associated diversion dams, tunnels, penstocks, and powerhouses. The project is operated for water supply and hydropower purposes. Additionally, PCWA owns and operates the American River Pump Station on the North Fork American River that provides municipal and agricultural water to Western Placer County.
- Upper American River Project (FERC No. 2101), which is owned and operated by SMUD. The project, located on Silver Creek, Rubicon River, and South Fork American River, includes 11 reservoirs, with a combined capacity of 425 TAF and eight powerhouses.
- El Dorado Hydroelectric Project (FERC No. 184), which is owned and operated by El Dorado Irrigation District (EDID). The project, located on tributaries to the South Fork American River, includes Lake Aloha, Caples Lake, and Silver Lake, the El Dorado Diversion Dam and El Dorado Canal, and El Dorado Powerhouse. Additionally, water is imported from Echo Lake located in the Truckee River watershed.
- Jenkinson Reservoir, formerly part of the Sly Park unit of the CVP, which is owned and operated by EDID. The project is located in the Cosumnes River watershed but influences operation of the El Dorado Hydroelectric Project. Jenkinson Lake (41 TAF capacity) delivers municipal water to the district's service area.

Upper Mokelumne Module

The Upper Mokelumne module simulates water management facilities located in the Mokelumne River watershed above Pardee Reservoir and Dam. The model domain includes the North, Middle, and South Forks of the Mokelumne River, covering approximately 544 square miles with an average annual runoff of approximately 726 TAF (WY 1928–2015), with a range of 129 TAF to 1,848 TAF. The purpose of the module is to simulate flows on the mainstem Mokelumne River near Mokelumne Hill (USGS gage 11319500) and subsequent inflows to Pardee Reservoir.

The Upper Mokelumne module includes simulation of the following water development projects:

- Mokelumne Hydroelectric Project (FERC No. 137), owned and operated by PG&E. The project includes 13 reservoirs and 5 powerplants. The Upper Mokelumne module includes Salt Springs Reservoir (142 TAF capacity), and Lower Bear Reservoir (52 TAF capacity).

- Amador Water System and Central Amador Water Project diversion facilities, owned and operated by Amador Water Agency.
- Calaveras Public Utility District and Calaveras County Water District diversion facilities on the Middle and South Forks.

Lower Mokelumne River Module

The lower Mokelumne module simulates water management facilities located in the Mokelumne River watershed below the Mokelumne Hill gage (USGS 11319500). The module has been integrated with the main body of CalSim 3 because of the need to simulate Mokelumne River seepage losses to groundwater in the river reaches below Camanche Dam. The Lower Mokelumne module simulates the Mokelumne River Project (FERC No. 137), which is owned and operated by East Bay Municipal Utility District (EBMUD). This project includes Pardee Reservoir (198 TAF capacity) and Camanche Reservoir (417 TAF capacity). The module also dynamically simulates diversions by EBMUD as part of the Freeport Regional Water Project.

Upper Stanislaus Module

The Upper Stanislaus module simulates water management facilities located in the Stanislaus River watershed above New Melones Reservoir and Dam. The model domain includes the North, Middle, and South Forks of the Stanislaus River, covering approximately 905 square miles, with an average annual runoff of approximately 1,100 TAF (WY 1922–2015), and with a range of 130 TAF to 2,750 TAF. The module is based on a WRIMS-based model developed for Reclamation (CH2M Hill 2008), which was updated and extended to simulate water years through 2015. The purpose of the Upper Stanislaus module is to simulate inflows to New Melones Reservoir.

The Upper Stanislaus module includes simulation of the following water development projects:

- North Fork Stanislaus River Project (FERC No. 2409), owned by Calaveras County Water District and operated by Northern California Power Agency (NCPA). The project includes New Spicer Meadow Reservoir (189 TAF capacity), which was enlarged to its present capacity in 1988, and three smaller diversion dams. These facilities are operated primarily to generate hydropower at New Spicer Meadows and Collierville Power plants.
- Upper Utica Project (FERC No. 11563), owned and operated by NCPA. The project includes three small reservoirs, which are located on Silver Creek (Lake Alpine) and on the upper part of the North Fork of the Stanislaus River (Union Reservoir and Utica Reservoir) and is operated primarily for regulation of flows for downstream hydropower generation by the North Fork Stanislaus River, Angels, and Utica Projects.
- Utica and Angels Projects (FERC No. 2019 and 2699), owned and operated by the Utica Water and Power Authority. These projects are primarily operated for hydropower, using water diverted from the Collierville Tunnel and from Angels Creek.
- Tri-Dam Project (FERC No. 2005 and 2067), owned by Oakdale Irrigation District and South San Joaquin Irrigation District, consists of three major reservoirs, Beardsley Reservoir (* TAF capacity) and Donnell's Reservoir (64 TAF capacity) on the Middle Fork Stanislaus River and Tulloch Reservoir on the Lower Stanislaus River, all of which were constructed in 1957. Beardsley Reservoir and Donnell's Reservoir are operated primarily for hydropower purposes

on the Middle Fork while Tulloch Lake serves as an afterbay storage for New Melones Power Plant.

- Spring Gap-Stanislaus Project (FERC No. 2130), owned and operated by PG&E. The project consists of Relief Reservoir (15 TAF capacity) on Summit Creek, Pinecrest Lake (18 TAF capacity) on the South Fork Stanislaus River, the Philadelphia diversion from the South Fork Stanislaus River to the Middle Fork Stanislaus River, the Spring Gap Power Plant on the Middle Fork Stanislaus River, and the Stanislaus Tunnel and Power Plant on the Middle Fork Stanislaus River. Project operations are closely coordinated with Tri-Dam's Donnell's, Beardsley, and Sand Bar facilities to meet minimum flow and other regulatory requirements and to generate hydropower benefits for each project.
- Sand Bar Project (FERC No. 2975), operated by the Tri-Dam Power Authority. The project uses Beardsley Afterbay on the Middle Fork Stanislaus River as a point of diversion to a 3.5-mile tunnel leading to the JW Southern Power Plant. The project is operated in close coordination with the Tri-Dam and Spring Gap-Stanislaus Projects to generate hydropower benefits while meeting minimum flow and other regulatory requirements.
- Phoenix Project (FERC No. 1061), owned and operated by PG&E. The project includes Lyons Reservoir (6 TAF capacity) on the South Fork Stanislaus River, which is operated to provide a water supply to Tuolumne Utility District and to derive hydropower benefits through the Phoenix Power Plant.

Upper Tuolumne Module

The Upper Tuolumne module simulates the operation of City and County of San Francisco (CCSF) facilities in the Tuolumne River watershed above Don Pedro Reservoir and Dam. These facilities include Hetch Hetchy Reservoir, Lake Eleanor, and Lake Lloyd and CCSF exports from the watershed through the San Joaquin Pipeline. However, the module is not used directly and analysis for the EIR is based on information provided by CCSF (Steiner pers. comm. 2020).

Upper San Joaquin River

Inflows to Millerton Lake are partly controlled by upstream storage facilities owned by PG&E and Southern California Edison (SCE).

PG&E's Crane Valley Project (FERC No. 1354) includes five small powerhouses connected in series by diversions and canals located along the North Fork and South Fork of Willow Creek, a tributary of the San Joaquin River. Flows are regulated by Crane Valley Reservoir, also known as Bass Lake, (45 TAF capacity). Water from the Crane Valley Project flows into Kerckhoff Reservoir and supplement inflows from the San Joaquin River.

SCE's Big Creek hydroelectric system comprises seven FERC-licensed projects (FERC Nos. 67, 120, 2085, 2086, 2174, 2175) that are owned and operated by the company for power generation. Major reservoirs include Florence Lake (64 TAF capacity), Shaver Lake (136 TAF capacity), Redinger Lake (26 TAF capacity), Mammoth Pool Reservoir (120 TAF capacity), Lake Edison (125 TAF capacity), and Huntington Lake (89 TAF capacity).

No upper watershed module has been developed for the San Joaquin River above Millerton Lake. Similar to CalSim II, simulated inflows to the lake are derived from the Upper San Joaquin River Basin Model (USAN) (Madeheim 2000).

B.3.7 Forecasting

Beginning in February of each year, DWR Division of Flood Management makes forecasts of unimpaired flows at various levels of exceedance (see California Cooperative Snow Survey Bulletin 120) using precipitation, snowpack, flow records, and other watershed information. These forecasts are published in *Bulletin 120: Water Conditions in California* (California Department of Water Resources 2022a) and are used by water agencies to make planning decisions for the water year. The forecasts also are used to determine hydrologic indices and water-year-type flow requirements and delivery obligations. DWR forecast information is updated each month through May. Typically, indices and associated water year types (e.g., Sacramento Valley 40-30-30 index) are then fixed, based on the May forecast, through to the following February.

CalSim 3 includes a dynamic forecasting routine to mimic DWR's forecasting procedures and account for uncertainty in water supply conditions. Forecasting routines and water supply estimates are used in the simulation of SWP and CVP allocations to project contractors and to establish water year types for regulatory standards. CalSim 3 forecast of unimpaired flows are based on multiple log-linear regression models of the form:

$$\hat{Q}_f = aP_p^b P_f^c Q_p^d Q_{t-1}^e$$

where:

Q_f is the forecasted seasonal inflow from the forecasting date to the end of water year in TAF;

P_f is the seasonal precipitation from the forecasting date to the end of water year in inches;

P_p is water year cumulative precipitation from previous October (the beginning of the current water year) to the forecasting date in inches;

Q_p is water year cumulative inflow from previous October (the beginning of the current water year) to the forecasting date in TAF;

Q_{t-1} is the previous month inflow from the forecasting date in TAF.

and a , b , c , d , and e are coefficients.

When the regression equation is used to forecast seasonal inflows with different exceedance levels, P_f is replaced by the precipitation value with the corresponding exceedance from the empirical seasonal (from the forecasting date to the end of water year) precipitation frequency curve over the period of record.

B.4 Modeling Approach

B.4.1 Level of Development

CalSim 3 uses a "level of development" approach to simulate operation of water management facilities and flows in rivers, streams, and channels. In this approach, facilities, land use, contracts, and regulations are held constant over the 94-year period of simulation. Monthly values of unimpaired runoff represent the range of water supply conditions that characterize either existing conditions (year 2020) or future conditions (year 2040) influenced by climate change. Model results

are best interpreted in terms of probabilities or exceedance representing the range of outcomes that could occur for the chosen level of development.

B.4.2 Timestep and Period of Simulation

CalSim 3 simulates monthly water management operations for a 94-year period. The inflow hydrology is based on the historical weather sequence October 1921 through September 2015. Though it uses a monthly timestep, the model includes several adjustments to better represent management operations at a daily timescale. These include (1) daily representation of Sacramento River flows for the purpose of simulating flow over the Fremont and Sacramento weirs, (2) adjustment of instream flow requirements on the Sacramento River at the Navigation Control Point to account for daily flow variation within the month, (3) daily representation of the Sacramento River flow at Wilkins Slough for triggering various Delta regulatory actions, and (4) for the proposed north Delta diversion, daily patterning of flows for the Sacramento River at Hood when applying bypass flow and low-level pumping requirements and simulating diversions.

B.4.3 Spatial Resolution

Water Budget Areas

CalSim 3 divides the Sacramento and San Joaquin valleys into geographic regions termed water budget areas (WBA). WBAs provide a structure to simplify the organization, explanation, and presentation of CalSim 3 data, code, and results. WBAs also define the spatial resolution of meteorological input data for calculating agricultural demands (i.e., precipitation and evapotranspiration [ET]). The CalSim 3 WBAs are depicted in Figures 5A-B.1 and 5A-B.2.

Demand Units

WBAs, described above, are disaggregated into one or more demand units for agricultural, municipal, or wetland water use purposes. A demand unit represents a collection of water users who have the same physical, legal, and contractual access to water, and have similar land uses, water delivery systems, and water use efficiencies.

The size and number of demand units is set partly by the availability of data for model calibration but is also a compromise between a simpler model representation that requires less data input, and a very detailed, physically based, representation that requires greater levels of input and code. The number of demand units has been set to facilitate the use of local planning information and data for CalSim 3, and to facilitate future use of CalSim 3 for regional water resources planning by local agencies.

CalSim 3 has a total of 258 demand units within the model domain. Table 5A-B.3 presents the type and distribution of demand units by hydrologic region. Additional information on demand units is presented under the next section.

1 **Table 5A-B.3. CalSim 3 Demand Units by Hydrologic Region**

Hydrologic Region	Agricultural Demand Units	Urban Demand Units	Wetland Demand Units	Total
Sacramento River	73	64	8	145
San Joaquin River	57	17	9	83
Delta	1	1	0	2
Tulare Lake	3	1	1	5
External Areas ^a	5	18	0	23
Total	139	101	18	258

2 Note:

3 ^a Demand units located outside of the valley floor.

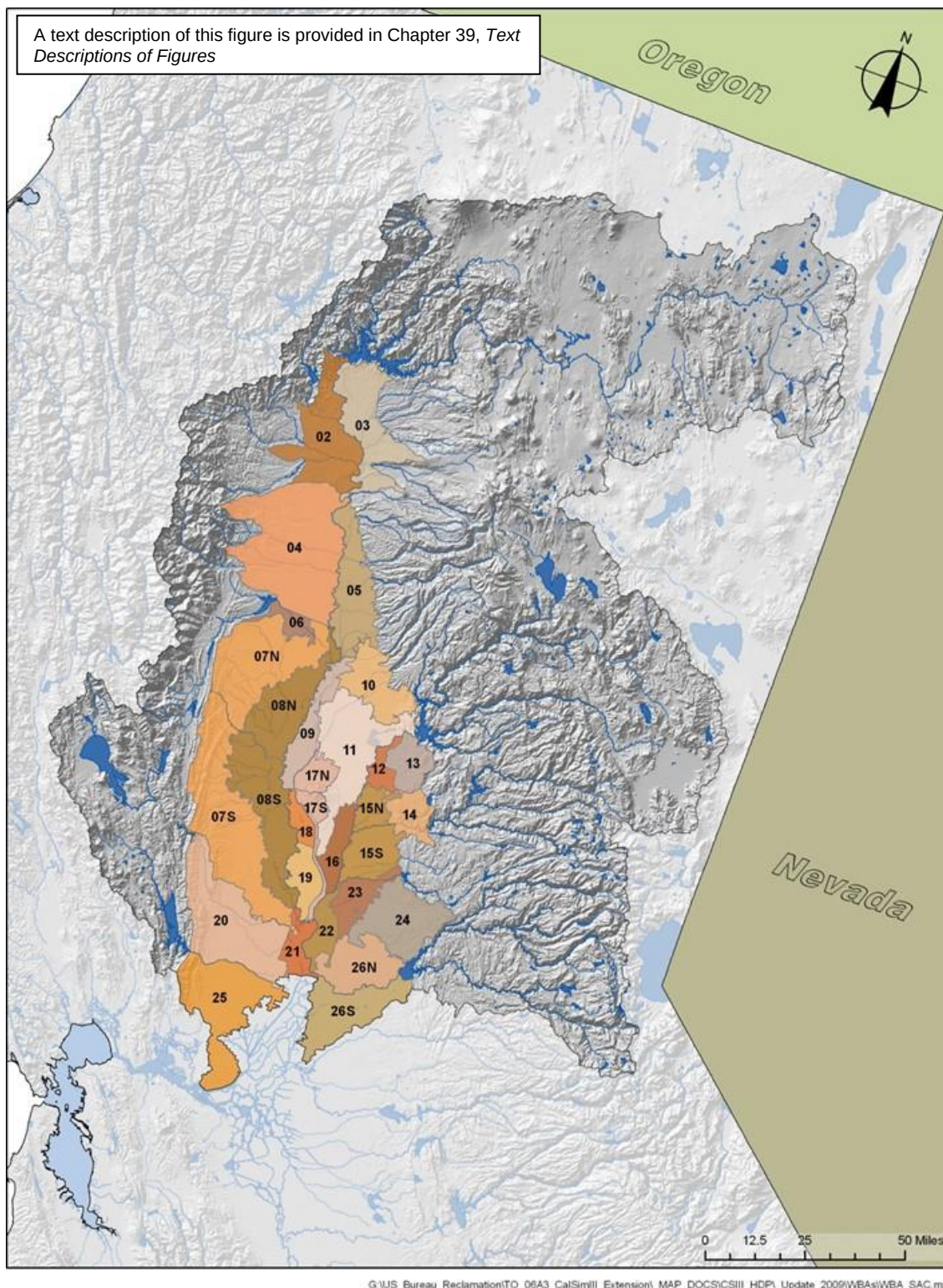


Figure 5A-B.1. Water Budget Areas in Sacramento River Hydrologic Region

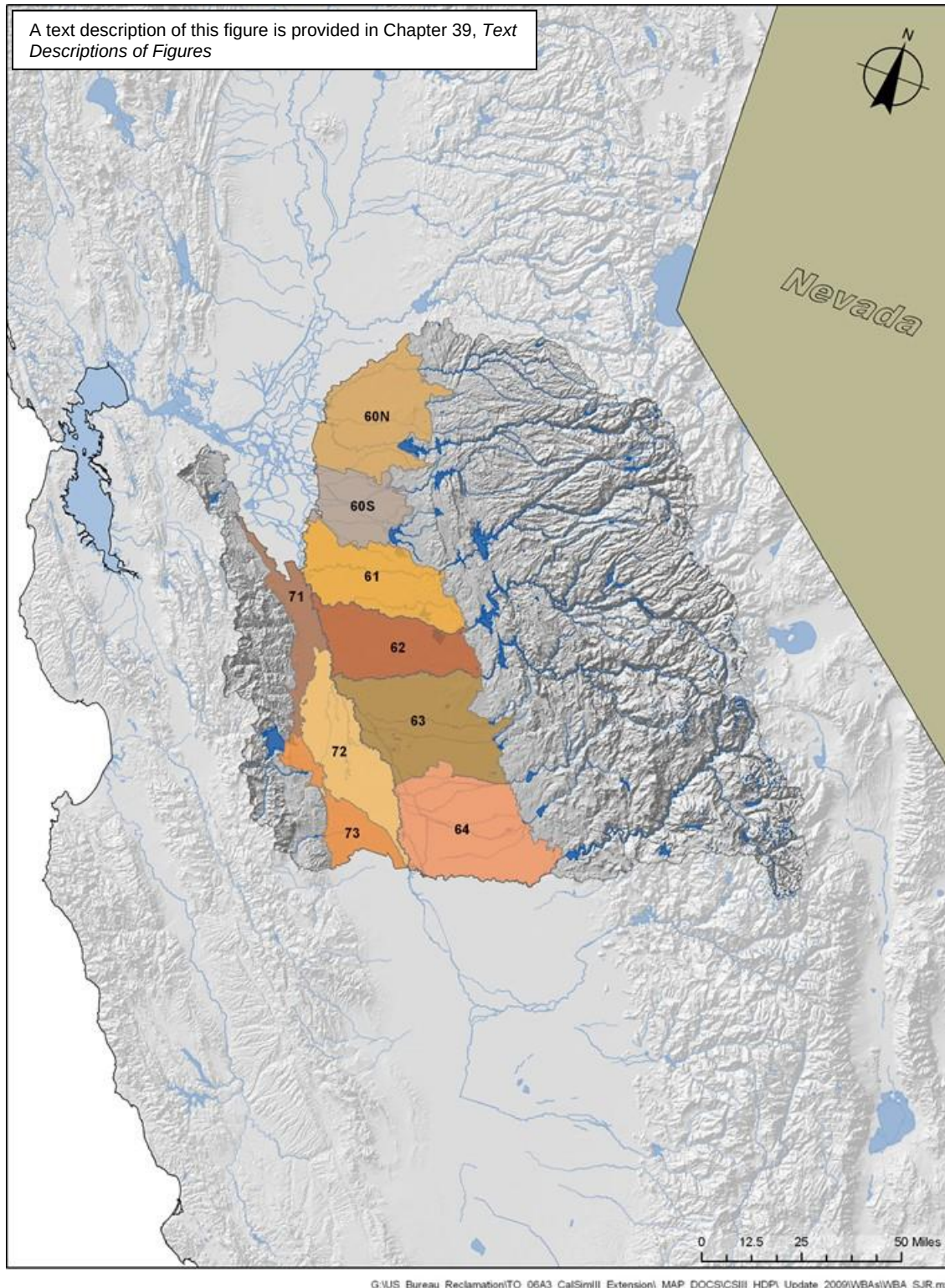


Figure 5A-B.2. Water Budget Areas in San Joaquin River Hydrologic Region

B.5 Existing Conditions

The CalSim 3 existing conditions model represents SWP and CVP operations to comply with the regulatory environment as of 2020. The existing conditions assumptions include facilities and ongoing programs that existed as of January 15, 2020, the publication date of the Notice of Preparation (NOP) for the project. The existing conditions assumptions also include facilities and programs that received approvals and permits by January 15, 2020, because those programs were consistent with existing management direction as of the NOP.⁹

B.5.1 Hydrology

The physical hydrology components of CalSim 3 are based on two assumptions for classifying watersheds. The first assumption is that the foothill and mountainous “rim” watersheds that surround the Central Valley are relatively undeveloped, and changes in land use over time have not significantly affected the natural outflow from these watersheds. Rim watersheds typically are characterized by complex topography, steep slopes, shallow soils, and limited aquifer systems. Precipitation percolating to groundwater quickly returns to streams as baseflow. Groundwater in these upland watersheds is not extensively used as a source of supply.

The second assumption is that the “valley floor” watersheds, which are delineated into WBAs, have been extensively developed for agriculture and contain large urban areas. For these watersheds, the timing and volume of runoff is strongly influenced by human impacts on the environment. Deep percolation from precipitation and irrigation recharges the underlying aquifer, which is hydraulically linked to the stream system. Groundwater is an important source of water both for agricultural and urban uses. Significant changes in groundwater storage occur.

CalSim 3 represents the hydrology of the rim watersheds as preprocessed timeseries of unimpaired flows to the stream system derived from observed streamflow records. In contrast, the hydrology of the valley watersheds is simulated using a rainfall-runoff model, soil moisture accounting in the root zone, and a distributed finite element model of the underlying groundwater aquifer.

Rim Watershed Hydrology

For existing conditions, CalSim 3 rim watershed inflows are the observed or estimated historical unimpaired runoff from over 230 watersheds to key stream locations, e.g., surface water reservoirs and diversions dams. In many cases, historical streamflow records have been extended through linear regression assuming stationarity over the historical period and assuming statistical relationships between (unimpaired) streamflows in adjacent watersheds are constant.

Many of the rim watersheds in the Sierra Nevada have been extensively developed for both hydropower generation and water supply. Natural stream flows in these watersheds are significantly altered by storage regulation and inter-basin water transfers. Consequently, observed

⁹ PCWA owns and operates the Middle Fork Project (FERC No. 2079) located in the Upper American River watershed. As previously described, the project is operated for both water supply and hydropower purposes. The first FERC license for the project was issued in 1963. PCWA began its relicensing process in 2005, which culminated in FERC issuing a new 40-year operating license for the Middle Fork Project on June 11, 2020. Amongst other conditions, the new license contains revised minimum streamflow requirements, pulse flow requirements, and recreational flow requirements. These requirements affect the timing of inflows to Folsom Lake and, therefore, have been included in the CalSim 3 existing conditions model.

streamflow data has been adjusted or unimpaired to account for any changes in upstream storage, reservoir evaporation, and imports and exports.

Inflow to Don Pedro Reservoir

For existing conditions, CCSF facilities in the upper Tuolumne River watershed are not dynamically simulated in CalSim 3. A timeseries of inflows to Don Pedro Reservoir were obtained from CCSF (Steiner pers. comm. 2020) based on an annual CCSF demand of 265 million gallons per day (mgd).

Inflow to Millerton Lake

For existing conditions, PG&E and SCE facilities in the upper San Joaquin River watershed above Millerton Lake are not dynamically simulated in CalSim 3. A timeseries of inflows to Millerton Lake were obtained from CalSim II, which was extended through WY 2015 using historical data.

Valley Floor Hydrology

CalSim 3 data inputs for the valley floor are generated by CalSimHydro, which is described in Section B.1.4, *CalSimHydro* of this document. CalSimHydro land use is based on four sources of information: (1) DWR's county land-use surveys conducted between 1994 and 2006; (2) DWR's annual estimates of irrigated crop area by detailed analysis unit (DAU); (3) CalSim 3 demand unit polygons; and (4) DAU polygons. County land use information are available as GIS layers. DAU land use data are available in tabular form.

The county land use surveys were assembled into a continuous GIS mosaic for the Central Valley and intersected with CalSim 3 demand unit polygons and DAU polygons. The resulting GIS-based crop data were subsequently scaled to be consistent with the average crop data (in tabular form) from 2004 through 2013 for the DAUs.¹⁰

Bias Correction

Four types of water supply are represented in CalSim 3: rim inflows from mountain and foothill watersheds, surface runoff from the valley floor, deep percolation to groundwater from precipitation and irrigation within the valley floor, and subsurface boundary inflows to the Central Valley groundwater aquifer. These water supplies are exogenous to the model, are predetermined, and represented by monthly timeseries input data.

CalSim 3 also includes closure terms that adjust or bias correct surface water supplies (rim inflows and surface runoff) using historical streamflow data as a reference or control. Historical water balances were assembled for reaches of the Sacramento River and its major tributaries. Components of these water balances include CalSim 3 rim inflows, CalSim rainfall-runoff (for historical land use), historical diversion data, estimated return flows, and simulation of historical stream-groundwater interaction. The closure terms are determined from the difference between the calculated and observed flows at the downstream end of a river reach. Table 5A-B.4 summarizes the location and magnitude of the closure terms. In locations and months where irrigation diversions and return

¹⁰ Data were available for 2014 and 2015 but these data were not used as it was considered that the extremely dry conditions and associated land fallowing in these two years are not representative of long-term agricultural cropping patterns.

flows dominate the historical water balance, no closure terms are applied because of uncertainties in the historical data.

Table 5A-B.4. CalSim 3 Closure Terms

Name	Description	Months Applied	Range of Monthly Values		
			Min (TAF)	Max (TAF)	Av. (TAF)
CT_BENDBRIDGE_SV	Sacramento River at Bend Bridge	All	-270	368	9
CT_BUTTECITY_SV	Sacramento River at Butte City	All	-523	1,165	-5
CT_FAIROAKS_SV	American River at Fair Oaks	All	-67	0	-5
CT_FREEPORT_SV	Sacramento River at Freeport	Nov - Mar	-224	309	9
CT_MELON_SV	Stanislaus River at New Melones	All	-40	0	-1
CT_MERCED_SV	Merced River near Stevenson	All	1	52	10
CT_MODESTO_SV	Tuolumne River at Modesto	All	-37	35	8
CT_MUDSLOUGH_SV	Mud Slough near Highway 140	All	-5	6	2
CT_NICOLAUS_SV	Feather River at Nicolaus	Nov - Mar	-659	513	8
CT_OROVILLE_SV	Feather River at Oroville	All	-158	0	-2
CT_PEDRO_SV	Tuolumne River at New Don Pedro	All	-6	0	0
CT_RIPON_SV	Stanislaus River at Ripon	All	-1	36	13
CT_SALTSLOUGH_SV	Salt Slough at Highway 165	All	-9	6	-4
CT_SMARTVILLE_SV	Yuba River near Smartville	All	-81	0	-2
CT_STEVINSON_SV	San Joaquin River near Stevenson	All	-22	-5	-13
CT_VERNALIS_SV	San Joaquin River near Vernalis	All	5	40	19
CT_VERONA_SV	Sacramento River at Verona	Nov - Mar	-1,159	1,891	-5
CT_WHEATLAND_SV	Bear River at Wheatland	All	-59	46	1
CT_WILKINSSL_SV	Sacramento River at Wilkins Slough	Nov - Mar	-300	575	0

Key: TAF = thousand acre-feet

Delta Hydrology

The Delta covers approximately 738,000 acres interlaced with hundreds of miles of waterways. Much of the land is below sea level and relies on more than 1,000 miles of levees for protection against flooding. Land and waterways in the Delta support local communities, agriculture, and recreation, and provide essential habitat for fish and wildlife. The Delta also is the major collection and distribution point for water that serves more than 25 million people. Water conditions in the Delta are carefully managed to meet water quality standards and fish and wildlife habitat needs.

Domain

The official boundary of the Delta, the Legal Delta, was defined in 1959 with the passage of the Delta Protection Act (California Water Code Section 12220). The area of the Legal Delta is 738,000 acres. The Delta, as defined for CalSim II, is known as the "Delta Service Area." The most prominent difference between the Legal Delta and Delta Service Area is that the Legal Delta includes the towns of Pittsburg and Antioch; the Delta Service Area does not. Over the years, various estimates of land area for the Delta Service Area have been reported.

DWR's Bay-Delta Office has traditionally treated the Delta as two separate regions, or Depletion Study Areas (DSA), known as the Delta Lowlands (DSA 54) and Delta Uplands (DSA 55). The Delta Lowlands cover the islands and areas of the Delta below the 5-foot mean sea level contour; a total area of 462,100 acres. The Delta Uplands comprise the rest of the Delta Service Area, including portions of the Yolo Bypass, parts of the City of West Sacramento and City of Stockton, and the entire City of Tracy; a total area of 216,100 acres. DAUs 185 and 186 cover approximately the same area as the Delta Lowlands and Delta Uplands.

CalSim 3 has adopted the boundary of the Delta as defined for the development of Delta Evapotranspiration of Applied Water (DETAW).¹¹ The original 142 subareas for the Delta Island Consumptive Use (DICU) model were digitized from a printed schematic; no digital layers could be found. The resulting total area is 679,699 acres.

Some agricultural and urban water demands within the Delta are partly met by water imported across the Delta boundary. These imports must be considered when simulating Delta water supplies and water demands. For example, the City of Tracy, Banta-Carbona Irrigation District, and West Side Irrigation District are located nearly entirely within the Delta Uplands. The City of Tracy and the three irrigation districts hold contracts with Reclamation for the supply of CVP water from the Delta-Mendota Canal. Similarly, part of the City of West Sacramento is located within the north Delta. The city diverts water from the Sacramento River upstream from the American River confluence. Part of the City of Sacramento, known as the "Pocket Area," as well as parts of the cities of Stockton and Brentwood, also are located within the Delta. For CalSim 3, to avoid double counting the depletion of water supplies, these overlapping areas have been removed from the DCD model, described below.

Delta Channel Depletion

CalSim 3 uses the Delta Channel Depletion (DCD) model to simulate Delta channel depletions and Delta consumptive use. The DCD model replaces the Delta Island Consumptive Use (DICU) model used in CalSim II. The DCD model is a daily timestep model that divides the Delta into 168 subareas and simulates the water entering, leaving, or being stored in each of these subareas (Liang and Suits 2017, 2018). For CalSim 3, Delta accretions and depletions are aggregated into 7 subregions. Average monthly values of Delta net channel depletion are presented in Table 5A-B.5.

Table 5A-B.5. CalSim 3 Average Monthly Delta Net Channel Depletion

Average monthly Net Depletion (thousand acre-feet)												
Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
46	76	23	10	-57	-3	62	110	150	175	143	87	822

Delta Channel Flows

Simulation of Delta channel flows in CalSim 3 is focused on the Sacramento and San Joaquin Rivers, and the combined flow in the Old and Middle River (OMR).

¹¹ DETAW was developed by the University of California at Davis (UC Davis) to estimate consumptive water demands within the Delta (Kadir 2006).

Delta Cross Channel

CalSim 3 calculates the monthly flow through the Delta Cross Channel using the linear equation:

$$Q_{DXC} = (0.1846 * Q_{SAC} + 306.52 \text{ [cfs]}) * F_{fo}$$

where:

Q_{DXC} = flow through the Delta Cross Channel

Q_{SAC} = Sacramento River flow immediately upstream from the gates

F_{fo} = number of days the gates are open in the month divided by number of days in month

Georgiana Slough

CalSim 3 calculates flow through Georgiana Slough using the linear equation:

$$Q_{GS} = 0.1415 * Q_{SAC} + 973.48 \text{ [cfs]}$$

where:

Q_{GS} = flow through Georgiana Slough

Q_{SAC} = Sacramento River flow immediately upstream from the gates

Old and Middle River

CalSim 3 uses the simulated combined flow in the Old River at Bacon Island (USGS 11313405) and Middle River at Bacon Island (USGS 11312676) to comply with various biological opinions and export restrictions. The simulated flow is based on a south Delta flow balance (Hutton 2008), as follows:

Old and Middle River (OMR) flow = San Joaquin River flow at Vernalis

+ Indian Slough at Old River

– San Joaquin River downstream of Head of Old River (HOR)

– Clifton Court Forebay diversions

– Jones Pumping Plant diversions

– Contra Costa WD diversions at Old River and Victoria Canal

– South Delta net channel depletion

OMR flow is negative (i.e., flows from north to south) when south Delta water diversions exceed contributions from the San Joaquin River. Indian Slough hydraulically bypasses the Old River gaging station at Bacon Island and when flowing eastwards the Slough contributes to meeting south Delta diversions without increasing measured OMR flows.

Head of Old River

CalSim 3 calculates flow from the San Joaquin River into the HOR, in the absence of the HOR barrier installation, using the linear equation (Hutton 2008):

$$Q_{HOR} = a * Q_{VER} + c \text{ [cfs]}$$

Where:

Q_{HOR} = Head of Old River flow

Q_{VER} = San Joaquin River flow at Vernalis

a, c = coefficients that are a function of Vernalis flow and whether the Grant Line Canal Barrier is installed

South Delta Pumping and Depletions

Removal of water from the South Delta is from exports at Banks and Jones Pumping Plants, CCWD diversions at Old River and Victoria Canal, and Delta channel depletion in the south Delta. For model simulation, CalSim 3 assumes that south Delta channel depletion is equal to 25% of total Delta channel depletion. This is consistent with real-time operations.

Indian Slough

Flows in Indian Slough are tidally influenced, and net flows may be westwards or eastwards. Data and DSM2 modeling suggest that as OMR downstream flow increases, Indian Slough flow decreases. Thus, under low flow conditions, south Delta diversions have a less than 1-to-1 effect on gaged OMR reverse flows. In CalSim 3, flow through Indian Slough is determined using a linear equation (Hutton 2008):

$$Q_{IS} = (1 - b) * Q_{SOD} \text{ [cfs]}$$

where:

Q_{IS} = Indian Slough flow (positive when flowing east in to Old River)

Q_{SOD} = South Delta pumping and depletions

b = coefficient that is a function of Vernalis flow and whether the Grant Line Canal Barrier is installed

Net Delta Outflow Index

Net Delta outflow refers to the tidally filtered outflow from the Delta into Suisun Bay, so removing the effects of much larger tidal flows from the freshwater outflow. Net Delta Outflow Index (NDOI) is the regulatory representation of net Delta outflow, defined in State Water Board Decision 1641 (D-1641) (December 1999, revised March 2000: 190). The State Water Board, DWR, and Reclamation employ NDOI as a representation of Delta outflow to San Pablo and San Francisco Bays. NDOI is computed from a Delta water balance that includes measured inflows of the major rivers and streams, measured exports by the major water projects and estimates of other water agencies' diversions, channel depletions and precipitation. The D-1641 Delta water balance is as follows:

$$NDOI = \text{Delta Inflow} - \text{Net Delta Consumptive Use} - \text{Delta Exports}$$

Delta Inflow

The D-1641 definition of Delta inflow for purposes of computing NDOI is as follows:

$$\text{Delta Inflow} = \text{SAC} + \text{SRTP} + \text{YOLO} + \text{EAST} + \text{MISC} + \text{SJR}$$

where:

SAC = Sacramento River at Freeport.

SRTP = Sacramento Regional Wastewater Treatment Plant.

YOLO = Yolo Bypass mean daily flow, which is equal to the flows from the Sacramento Weir, Fremont Weir, Cache Creek at Rumsey, and the South Fork of Putah Creek.

EAST = Eastside Streams mean daily flow for the previous day from the Mokelumne River at Woodbridge, Cosumnes River at Michigan Bar, and Calaveras River at Bellota.

MISC = Combined mean daily flow for the previous day of Bear Creek, Dry Creek, Stockton Diverting Canal, French Camp Slough, Marsh Creek, and Morrison Creek.

SJR = San Joaquin River flow at Vernalis.

In practice, the calculation of NDOI has changed since its definition in D-1641 because of gauging stations being discontinued. Delta inflow, as used for determining NDOI, differs from the calculation of Delta inflow used in DayFlow.¹²

CalSim 3 uses the D-1641 definition of Delta inflow to compute NDOI, with some minor exceptions: Bear Creek and Morrison Creek are not simulated in CalSim 3, so these flows are not included in the “MISC” term for modeling purposes.

Net Delta Consumptive Use

For the purposes of calculating NDOI, CalSim 3 uses the DayFlow methodology for calculating net Delta consumptive use. This provides consistency between model simulation and real-time operations. The Dayflow parameter net channel depletion (QCD) is an estimate of the quantity of water removed from Delta channels to meet consumptive use (QGCD). It is calculated as QGCD less Delta precipitation. Dayflow uses a set of 12 monthly repeating values for computing QCD, which result in an annual gross channel depletion is 1.69 million acre-feet (MAF). Dayflow uses the precipitation gage Stockton Fire Station No. 4 to represent Delta-wide precipitation over an area of 682,230 acres.

B.5.2 Water Demands and Water Use

CalSim 3 water demands are preprocessed using CalSimHydro. However, CalSim 3 water use is dynamically simulated in the model. Agricultural water use parameters include conveyance loss factors, factors for field-level miscellaneous evaporative losses, and tailwater reuse factors.

Agricultural Water Demands and Water Use

CalSimHydro calculates applied water demands for 20 crop types using soil moisture accounting on a monthly timestep. Water supplies available to meet crop water demands are a mix of stream and canal diversions, groundwater pumping, and reuse of tailwater. Stream diversions and deliveries from major canal systems are subject to conveyance losses (operational spills, lateral flow, evaporation, and deep percolation). In contrast, groundwater pumping is considered to be at field

¹² Dayflow is a computer program developed in 1978 as an accounting tool for determining historical Delta boundary hydrology. Input data include the principal Delta stream inflows, Delta precipitation, Delta exports, and Delta gross channel depletions. Daily values are used by DWR and Reclamation for compliance purposes.

1 level and not subject to conveyance losses, unless a water district supplements canal deliveries with
2 groundwater pumping into the district canal distribution system. Tailwater (including flow-through
3 from rice fields and drawdown of ponded water) is available for reuse. Water supplies must meet
4 applied water demands and any minor miscellaneous evaporative losses. A fixed fraction of water
5 demands must be met from groundwater pumping, representing farmers who do not have access to
6 surface water.

7 Table 5A-B.6 summarizes agricultural water demands represented in the model. The applied water
8 demands differ from water deliveries because of canal conveyance losses and reuse of tailwater.

9 CalSimHydro water demands for CVP agricultural contractors located on the west side of the San
10 Joaquin Valley and those for Columbia Canal Company located on the east side of the valley were
11 scaled so that the annual demands match the CVP full contract amount. The purpose of the scaling
12 was to better represent CVP contract obligations and operation of the Delta-Mendota Canal and CVP
13 share of San Luis Reservoir. In some cases, land-use based demands were significantly different
14 from CVP full contract amounts. In the real world, water demands may be met through trading of
15 CVP water supplies among these contractors. CalSim 3 does not simulate these trades.

1 **Table 5A-B.6. CalSim 3 Agricultural Water Demands**

Demand Unit	Water District/Agency	Average Annual Applied Water Demand (TAF)	
		Existing Conditions	No Project Alternative (2040)
02_NA	Non-district	11	11
02_SA	Anderson-Cottonwood ID, misc. settlement contractors	37	39
02_PA	Clear Creek CSD	5	5
03_NA	Non-district	16	17
03_SA	Anderson-Cottonwood ID, misc. settlement contractors	5	5
03_PA	Bella Vista WD	8	9
04_NA	Non-district including misc. settlement contractors	206	223
04_PA1	Corning WD, Proberta WD, Thomes Creek WD	35	39
04_PA2	Kirkwood WD	1	1
05_NA	Los Molinos MWC, non-district	233	248
06_NA	Non-district	3	4
06_PA	Orland Unit WUA	62	65
07N_NA	Non-district	183	172
07N_PA	Glide WD, Holthouse WD (65% of total), Kanawha WD, Orland-Artois WD	152	139
07S_NA	Non-district	160	171
07S_PA	4-M WD, Colusa County WD, Cortina WD, Davis WD, Dunnigan WD, Glenn Valley WD, Holthouse WD (35% of total), La Grande WD, Myers-Marsh MWC, Westside WD	303	296
08N_NA	Non-district	102	101
08N_PA	Colusa Drain MWC (8% of total)	25	26
08N_SA1	Maxwell ID (5% of total), Princeton-Codora-Glenn ID, Provident ID, misc. settlement contractors	182	186
08N_SA2	Glenn-Colusa ID (55% of total)	400	406
08S_NA1	Non-district	45	48
08S_NA2	Non-district	35	36
08S_PA	Colusa Drain MWC (70% of total)	154	158
08S_SA1	Maxwell ID (95% of total), Sycamore Family Trust, misc. settlement contractors	106	108
08S_SA2	Glenn-Colusa ID (45% of total)	292	302
08S_SA3	RD 108, River Garden Farms, misc. settlement contractors	283	297
09_NA	Llano Seco Ranch, Dayton MWC, non-district	148	145
09_SA1	Pacific Realty Associates (M&T Chico Ranch)	15	16
09_SA2	RD 1004, Carter MWC, Jack Baber, misc. settlement contractors	171	169
10_NA	Rancho Esquon, Durham MWC, non-district	206	214
11_NA	Sutter Butte MWC, non-district	67	68

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1 **Table 5A-B.6. CalSim 3 Agricultural Water Demands (continued)**

Demand Unit	Water District/Agency	Average Annual Applied Water Demand (TAF)	
		Existing Conditions	No Project Alternative (2040)
11_SA1	Western Canal WD	321	308
11_SA2	Richvale ID	197	188
11_SA3	Biggs-West Gridley WD, Butte WD	248	242
11_SA4	Sutter Extension WD	119	116
12_NA	Non-district	40	40
12_SA	Misc. FRSA diverters	7	7
13_NA	South Feather WPA, Yuba County WD, non-district	16	16
14_NA	Browns Valley ID	46	47
15N_NA1	Non-district	36	38
15N_NA2	Cordua ID, Hallwood ID, Ramirez WD	136	132
15N_SA	Misc. FRSA diverters	3	4
15S_SA	Plumas MWC, misc. FRSA diverters	17	17
15S_NA1	Non-district	37	37
15S_NA2	Brophy WD, Dry Creek MWC, South Yuba WD, Wheatland WD	136	131
16_NA1	Non-district	57	62
16_NA2	Non-district	27	28
16_PA	Feather WD	20	22
16_SA	Garden Highway MWC, Tudor ID, Oswald WD, misc. FRSA	32	33
17N_NA	Non-district	42	44
17S_NA	Non-district,	48	50
17S_SA	Misc. FRSA diverters and minor settlement contractors	15	16
18_NA	Butte Slough IC, Sutter Butte MWC, non-district	51	53
18_SA	Meridian Farms WC, Lomo Cold Storage, Sutter MWC (5%), Tisdale IDC, misc. settlement contractors	86	88
19_SA	Bardis et al., Pelger MWC, Sutter MWC (95% of total), misc. settlement contractors	246	247
20_NA1	Yolo County FC&WCD	349	360
20_NA2	Non-district	14	13
20_PA	University of California, Davis	8	9
21_NA	Non-district	32	33
21_PA	Colusa Drain MWC (22% of total)	37	37
21_SA	Conaway Conservancy Group, misc. settlement contractors	99	97
22_NA	Non-district	26	26
22_SA1	Natomas Central MWC, Pleasant Grove-Verona MWC, misc. settlement contractors	150	142

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1 **Table 5A-B.6. CalSim 3 Agricultural Water Demands (continued)**

Demand Unit	Water District/Agency	Average Annual Applied Water Demand (TAF)	
		Existing Conditions	No Project Alternative (2040)
22_SA2	Misc. FRSA diverters	6	6
23_NA	Camp Far West ID, South Sutter WD, non-district	237	224
24_NA1	Nevada ID	36	35
24_NA2	Placer County WA Zone 5, non-district	56	50
24_NA3	Placer County WA Zone 1	44	44
25_NA	North Delta WA, non-district	177	179
25_PA1	Solano ID (77% of total)	145	148
25_PA2	Maine Prairie WD	70	75
26N_NA	Non-district	12	13
26S_NA	Non-district	3	3
50_PA1	Banta-Carbona ID, West Side ID	29	29
50_PA2	Byron-Bethany ID	N/A ^a	N/A ^a
60N_NA1	Jackson Valley ID	9	7
60N_NA2	Omochumne-Hartnell WD, Clay WD, Galt ID	85	72
60N_NA3	North San Joaquin WCD	125	111
60N_NA4	Woodbridge ID, Woodbridge Users Association	92	95
60N_NA5	Non-district, riparian diverters	185	152
60S_NA1	Non-district east	0	0
60S_NA2	Non-district west	0	0
60S_PA1	Stockton East WD	161	161
60S_PA2	Central San Joaquin WCD	164	166
61_NA1	Non-district east	69	72
61_NA2	Modesto ID	293	271
61_NA3	Non-district, Tuolumne River riparian right bank diverters	8	6
61_NA4	Non-district, Stanislaus River riparian diverters	17	16
61_NA5	Non-district, San Joaquin River riparian diverters between Tuolumne and Stanislaus rivers	17	17
61_NA6	Non-district, San Joaquin River riparian diverters downstream from Stanislaus River confluence	30	26
61_PA1	Oakdale ID north, South San Joaquin ID	80	88
61_PA2	Oakdale ID south	104	111
62_NA1	Non-district east	277	274
62_NA2	Non-district, Merced River riparian right bank diverters	8	8
62_NA3	Turlock ID	597	637
62_NA4	Non-district, Tuolumne River riparian left bank diverters	7	7
62_NA5	Non-district, San Joaquin River riparian diverters between Merced and Tuolumne rivers	34	41

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1 **Table 5A-B.6. CalSim 3 Agricultural Water Demands (continued)**

Demand Unit	Water District/Agency	Average Annual Applied Water Demand (TAF)	
		Existing Conditions	No Project Alternative (2040)
62_NA6	Merced ID (3.5% of total, north of Merced River)	24	25
63_NA1	Non-district east	74	68
63_NA2	Non-district, Merced riparian left bank diverters	13	12
63_NA3	Merced ID (96.5% of total, south of Merced River)	400	383
63_NA4	Non-district West, Plainsburg ID, El Nido ID, La Grande-Athlone WD, Turner Island WD, Stevenson WD, Merced River riparian diverters	475	500
64_NA1	Non-district east	0	0
64_NA2	Non-district west	333	347
64_PA1	Madera ID, Madera WD	351	375
64_PA2	Chowchilla WD	287	290
64_PA3	Gravelly Ford WD, Root Creek WD	60	64
64_XA	Columbia Canal Company	58	59
71_NA1	Non-district San Joaquin River riparian diverters Orestimba Creek to Del Puerto Creek	26	23
71_NA2	El Solyo WD and non-district San Joaquin River riparian diverters Del Puerto Creek to Vernalis	49	45
71_NA3	Non-district	21	20
71_PA1	Hospital WD	35	35
71_PA2	West Stanislaus ID	65	64
71_PA3	Kern Cañon WD	8	8
71_PA4	Patterson ID	47	42
71_PA5	Del Puerto WD, Salado WD, Orestimba WD, Sunflower WD	56	56
71_PA6	Davis WD, Foothill WD, Mustang WD, Quinto WD, Romero WD, Centinella WD	47	47
71_PA7	Oak Flat WD	6	6
71_PA8	Byron-Bethany ID (area that was formerly Plainview ID)	21	21
72_NA1	Non-district San Joaquin River riparian diverters Mud Slough to Orestimba Creek	7	6
72_NA2	Non-district	127	101
72_PA	Laguna WD	1	1
72_XA1	San Luis Canal Company	139	139
72_XA2	Central California ID south	363	363
72_XA3	Central California ID north	129	129
73_NA	Non-district	19	16
73_PA1	San Luis WD north	67	67

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Table 5A-B.6. CalSim 3 Agricultural Water Demands (continued)

Demand Unit	Water District/Agency	Average Annual Applied Water Demand (TAF)	
		Existing Conditions	No Project Alternative (2040)
73_PA2	Eagle Field WD, Mercy Springs WD, Oro Loma WD	8	8
73_PA3	Pacheco WD, Panoche WD, San Luis WD south	171	171
73_XA	Firebaugh Canal WD	63	63
73_PA3	Pacheco WD	171	171
90_PA1	Westlands WD Priority Area I, DD No. 2	1027	1027
90_PA2	Westlands WD Priority Area II, DD No. 1, No. 3	272	272
91_PA	Coelho Family Trust, Fresno Slough WD, James ID, RD 1606, Tranquility ID, Tranquility PUD	86	86

Note:

^a Water demands associated with Byron Bethany ID that lie within the Delta are determined by the Delta Channel Depletion model.

Key: DD = Distribution District, FC&WCD = Flood Control & Water Conservation District, FRSA = Feather River Service Area, IC = Irrigation Company, ID = Irrigation District, IDC = Irrigation and Drainage Company, MWC = Mutual Water Company, N/A = not applicable, RD = Reclamation District, PUD = Public Utility District, WCD = Water Conservation District, WD = Water District

Managed Wetlands Water Demands

A wetlands water use model was developed as part of CalSimHydro to calculate applied water demands, surface water return flows, and deep percolation from water delivered to managed wetlands. The model considers land use, evapotranspiration (ET), precipitation, and different water management operations for seasonal, semi-permanent, and permanent wetlands.

Table 5A-B.7 summarizes the managed wetland water demands represented in the model. The applied water demands differ from water deliveries because of canal conveyance losses and reuse of tailwater.

Most managed wetlands have limited access to groundwater. In the Sacramento Valley, only the Gray Lodge Wildlife Area and Upper Butte Wildlife Area are assumed to pump groundwater. In the San Joaquin Valley, it is assumed that groundwater is used in limited amounts within Merced National Wildlife Refuge and San Luis National Wildlife Refuge.

CalSimHydro water demands for wildlife refuges located on the west side of the San Joaquin Valley were scaled so that the annual demands match the CVP full contract amount. The purpose of the scaling was to better represent CVP contract obligations and operation of the Delta-Mendota Canal and CVP share of San Luis Reservoir.

1 **Table 5A-B.7. CalSim 3 Managed Wetland Water Demands**

Demand Unit	National Wildlife Refuge/Wildlife Area	Average Annual Applied Water Demand (TAF)	
		Existing Conditions	No Project Alternative (2040)
08N_PR1	Sacramento National Wildlife Refuge	41	42
08N_PR2	Delevan National Wildlife Refuge	21	22
08S_PR	Colusa National Wildlife Refuge	15	15
09_PR	Llano Seco Units of Upper Butte Basin Wildlife Area and Sacramento River National Wildlife Refuge	8	8
11_PR	Little Dry Creek and Howard Slough Units of Upper Butte Basin Wildlife Area	43	43
17N_NR	Butte Sink Duck Clubs	42	42
17N_PR	Gray Lodge Wildlife Area	40	40
17S_PR	Sutter National Wildlife Refuge	15	15
63_PR1	Arena Plains and Snow Bird units of Merced National Wildlife Refuge	N/A ^a	N/A ^a
63_PR2	Merced and Lone Tree Units of Merced National Wildlife Refuge	9	8
63_PR3	East Bear Creek Unit of San Luis National Wildlife Refuge	6	2
72_PR1	Volta Wildlife Area	13	13
72_PR2	Kesterson, Freitas, and Blue Goose units of San Luis National Wildlife Refuge	15	15
72_PR3	San Luis and West Bear Creek units of San Luis National Wildlife Refuge	26	26
72_PR4	Los Banos Wildlife Area, Gadwall, Salt Slough, and China Island units of North Grassland Wildlife Area	30	30
72_PR5	Grassland Water District – north	71	71
72_PR6	Grassland Water District – south	54	54
91_PR	Mendota Wildlife Area	28	28

2 Note:

3 ^a Water demands for the Arena Plains and Snow Bird units are not modeled in CalSim 3.

4 Key: TAF = thousand acre-feet

5 **Urban Water Demands**

6 For major water purveyors, urban water demands for existing conditions are based on 2015 Urban
7 Water Management Plans and historical annual production data for years 2016 through 2019
8 contained in DWR's Public Water Supply Statistics Database (PWSS) database.¹³ For small,
9 unincorporated communities, water demands are based on per capita water use rates and
10 population estimates. Annual water demands are disaggregated to monthly demands based on

¹³ DWR collects water use and population data through its PWSS questionnaires, which are mailed annually to public water purveyors. Each public drinking water source has a system identification number and a source number. Data provided in completed PWSS questionnaires include water production, population, metered water deliveries (if metered), and active service connections by customer class.

1 historical monthly production data in the PWSS database. Urban water demands input to CalSim 3
2 consist of a 12-month repeating timeseries with no inter-annual variation.

3 Urban water use is divided into indoor and outdoor components. It is assumed that indoor water
4 use is constant throughout the year and equal to the water production for the month of lowest water
5 use. The model assumes that all indoor water use returns to either the surface water or
6 groundwater system, i.e., there are no evaporative losses. In contrast, the majority of outdoor urban
7 water is used consumptively through irrigation and ET.

8 The majority of urban demand units represented in CalSim 3 depend on a single source of water,
9 either surface water or groundwater. However, for urban demand units that conjunctively use
10 surface water and groundwater, a minimum level of groundwater pumping is specified as a fraction
11 of urban water demand. Once this level of groundwater pumping is met, CalSim 3 diverts surface
12 water, as physically available, to meet demand up to any restrictions imposed by water rights,
13 contracts, and agreements. Finally, any unmet demand is met by additional groundwater pumping.
14 Typically, no system capacity limits (e.g., water treatment capacities) are represented in the model.

15 Table 5A-B.8 summarizes urban water demands represented in the model.

1 **Table 5A-B.8. CalSim 3 Urban Water Demands**

Demand Unit	Water Purveyor	Annual Demand (TAF)	
		Existing Conditions	No Project Alternative (2040)
02_NU	City of Anderson, Cottonwood WD, Rio Alto WD, self-supplied	6.0	5.0
02_PU	Centerville CSD, Clear Creek CSD, Keswick CSA2, Shasta CSD	6.0	6.0
02_SU	City of Redding (part)	9.0	10.0
03_NU	Self-supplied	4.0	0.8
03_PU1	Jones Valley CSA, City of Shasta Lake, Mountain Gate CSD	3.0	4.0
03_PU2	Bella Vista WD	16.0	20.0
03_PU3	City of Redding (part)	5.0	5.0
03_SU	City of Redding (part)	9.0	10.0
04_NU1	City of Red Bluff	5.0	5.0
04_NU2	City of Corning, Gerber-Las Flores CSD, self-supplied	8.0	7.0
05_NU	City of Red Bluff, Los Molinos CSD, self-supplied	5.0	4.0
06_NU	City of Orland, Self-supplied	3.0	3.0
07N_NU	Cal-Water SC – Willows, self-supplied	3.0	3.0
07S_NU	Arbuckle PUD, Cacheville CSD, self-supplied	3.0	2.0
08N_NU	Cal-Water SC – Hamilton, self-supplied	1.0	1.0
08S_NU	City of Colusa, City of Williams, self-supplied	3.0	3.0
09_NU	Self-supplied	0.2	0.1
10_NU1	Cal-Water SC – Chico	29.0	38.0
10_NU2	Durham ID, Self-supplied	1.0	1.0
11_NU1	Thermalito ID – Oroville	2.0	2.0
11_NU2	City of Biggs, City of Gridley, Live Oak WD, self-supplied	7.0	6.0
12_NU1	Cal-Water SC – Oroville	3.0	4.0
12_NU2	Self-supplied	0.1	0.1
13_NU1	South Feather Water and Power Agency – Oroville	5.0	6.0
13_NU2	South Feather Water and Power Agency, self-supplied	0.0	0.0
14_NU	Self-supplied	1.0	1.0
15N_NU	Cal-Water SC – Marysville, self-supplied	5.0	5.0
15S_NU	Olivehurst PUD, City of Wheatland, Linda County WD, self-supplied	9.0	11.0
16_NU	Self-supplied	4.0	0.0
16_PU	City of Yuba City	18.0	32.0
17N_NU	Self-supplied	0.1	0.1
17S_NU	Sutter CSD, self-supplied	0.8	0.8
18_NU	Self-supplied	0.2	0.2
19_NU	Self-supplied	0.3	0.2
20_NU1	City of Davis, University of California at Davis, City of Woodland	30.0	35.0
20_NU2	City of Winters, Esparto CSD, Madison CSD, self-supplied	2.0	2.0

1 **Table 5A-B.8. CalSim 3 Urban Water Demands (continued)**

Demand Unit	Water Purveyor	Annual Demand (TAF)	
		Existing Conditions	No Project Alternative (2040)
20_NU2	City of Winters, Esparto CSD, Madison CSD, self-supplied	2.0	2.0
21_NU	Knights Landing Community Service District, self-supplied	0.3	0.3
21_PU	City of West Sacramento	15.0	25.0
22_NU	Sacramento International Airport, SCWA Zone 50, self-supplied	2.0	2.0
23_NU	Self-supplied	0.9	0.8
24_NU1	Placer County WA – Upper Zone 1	7.0	8.0
24_NU2	Placer County WA – Lower Zone 1	41.0	56.0
24_NU3	Nevada ID – North Auburn	2.0	2.0
24_NU4	Self-supplied	8.0	0.0
25_NU	City of Rio Vista, Cal-Water SC – Dixon, self-supplied	4.0	4.0
25_PU	City of Vacaville	17.0	20.0
26N_NU1	Sacramento Suburban WD – north service area, Cal-Am WC – Antelope, Lincoln Oaks, Rio Linda Elverta CWD	37.0	46.0
26N_NU2	Carmichael WD	10.0	12.0
26N_NU3	City of Sacramento - north	43.0	91.7
26N_NU4	Sacramento Suburban WD – south service area	19.0	19.0
26N_NU5	Golden State WC – Arden, Del Paso Manor WD, Sacramento County WA Zone 41 – Arden Park Vista, Cal-Am WC – Arden	7.0	7.0
26N_PU1	City of Roseville	41.0	62.0
26N_PU2	San Juan WD	16.0	27.4
26N_PU3	Orange Vale WC, Citrus Heights WD, Fair Oaks WD	35.0	54.8
26S_NU1	City of Sacramento - south	79.0	171.9
26S_NU2	Cal-Am WC – Parkway, Suburban, Rosemont	25.0	33.0
26S_NU3	Florin County WD, Fruitridge Vista WC, Tokay Park WC	10.0	7.0
26S_NU4	Aerojet	3.0	3.0
26S_PU1	City of Folsom, Folsom State Prison	24.0	39.0
26S_PU2	Golden State WC – Cordova	17.0	20.0
26S_PU3	California Parks and Recreation	1.0	5.0
26S_PU4	Sacramento County WA Zone 41 – south service area	15.0	27.0
26S_PU5	Elk Grove WD	8.0	8.0
26S_PU6	Sacramento County WA Zone 41 – north and central service area, Cal-Am WC – Sunrise/Security Park	26.0	46.0
50_PU	City of Tracy, Mountain House	30.0	43.0
60N_NU1	City of Galt, City of Lodi, Self-supplied	26.0	32.0
60N_NU2	Rancho Murieta CSD	2.0	2.0
60N_PU	Sacramento Municipal Utility District, Rancho Seco Power Plant	17.0	44.5

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Table 5A-B.8. CalSim 3 Urban Water Demands (continued)

Demand Unit	Water Purveyor	Annual Demand (TAF)	
		Existing Conditions	No Project Alternative (2040)
60S_NU1	City of Stockton, Cal-Water SC – Stockton	63.0	75.0
60S_NU2	Self-supplied	< 1	< 1
61_NU1	City of Modesto	69.0	91.0
61_NU2	City of Lathrop, City of Escalon, City of Manteca	28.0	44.0
61_NU3	City of Ripon, City of Oakdale, City of Riverbank, self-supplied	38.0	21.0
62_NU	City of Turlock, City of Ceres, Delhi CWD, Hilmar County WD, City of Hughson, Keyes, CSD, Denair CSD, self-supplied	65.0	72.0
63_NU	City of Merced, City of Atwater, City of Livingston, Winton CSD, Planada CSD, LeGrand CSD, self-supplied	57.0	61.0
64_NU	City of Madera, City of Chowchilla, Madera Valley WC, California State Prisons, self-supplied	35.0	39.0
71_NU	City of Patterson, self-supplied	10.0	12.0
71_PU1	Musco Olive Products	0.8	0.8
71_PU2	U.S. Department of Veterans Affairs	0.9	0.9
72_NU	Cities of Gustine, City of Firebaugh, City of Los Banos, City of Newman, self-supplied	19.0	27.0
72_PU	City of Dos Palos	1.0	1.0
73_NU	Self-supplied	1.0	1.0
90_PU	City of Avenal, City of Coalinga, City of Huron	16.5	16.5

Key: Cal-Am = California American, CSA = County Service Area, CSD = Community Service District, CWD = Community Water District, ID = Irrigation District, PUD = Public Utility District, RCD = Resource Conservation District, UC = University of California, WA = Water Agency, WC = Water Company, WD = Water District, WSC = Water Service Company

Water Contracts

State Water Project

CalSim 3 considers various types of SWP contracts and associated water deliveries, separating them into North of Delta and South of Delta and distinguishing between Settlement Contracts in the Feather River Service Area (FRSA) and delivery of Table A water, “make-up” water,¹⁴ Article 56 water (carryover water), and Article 21 water to SWP long-term contractors. Section B, Attachment 1, *CalSim 3 State Water Project and Central Valley Project Contract Assumptions* presents details of model contract assumptions.

Central Valley Project

CalSim 3 considers various types of CVP contracts, separating them into north of Delta and south of Delta and distinguishing between settlement contracts, exchange contracts, Schedule II contracts

¹⁴ In CalSim 3, make-up water is delivery of additional Table A water in later months to offset low deliveries of Table A water during the initial months of the contract year in cases when Table allocations increase from January through May.

(for deliveries to senior water right holders from Fresno Slough), agricultural water service contracts, M&I water service contracts, and contracts for delivery of Level 2 refuge water. Section B, Attachment 1, *CalSim 3 State Water Project and Central Valley Project Contract Assumptions* presents details of model contract assumptions.

B.5.3 Stream Diversions and Water Rights

CalSim 3 is not a water rights model and includes only a very limited representation of water rights, although water rights are more fully represented in the upper watershed modules. Limitations on surface water diversions from the major rivers and creeks are described in the following sections.

Sacramento River

Simulated diversions from the Sacramento River upstream from the Delta are divided into CVP diversions and non-CVP diversions.

Diversions to CVP settlement contractors are limited by the product of the full contract amount and annual water allocation, which is governed by the Shasta Index. The resulting annual volume is disaggregated to monthly values based on the pattern of water demand over the CVP contract period. For agricultural diversions, the period of diversion for CVP water is April through October. Additional limits are imposed for diversions in critical and non-critical months. Outside of the contract period, CalSim 3 diversions are limited only by the demand for winter water. Currently, water rights held by settlement contractors for diversion from November through March have not been fully quantified in the model.

Simulated diversions to CVP water service contractors are limited by the product of the full contract amount and annual water allocation. The resulting annual volume is disaggregated to monthly values based on the pattern of water demand over the CVP contract year (March through February).

CalSim 3 representation of individuals or entities that divert from the Sacramento River but do not hold CVP contracts with Reclamation is limited to the City of West Sacramento, City of Sacramento, Davis-Woodland Project, Freeport Regional Water Project, and Llano Seco Ranch.

Feather River

CalSim 3 simulates diversions from the Thermalito Power Canal, Thermalito Afterbay, and the lower Feather River. Simulated diversions to Western Canal Water District, the Joint Board District, Plumas Mutual Water Company, Garden Highway Mutual Water Company, Oswald Water District, and Tudor Mutual Water Company are limited to amounts specified in their settlement agreements with DWR. Contract water is subject to deficiencies of up to 50% in dry years. In model simulation, delivery of winter water for rice straw decomposition and for duck habitat may be curtailed during dry conditions to prevent storage in Lake Oroville dropping below 900 TAF.

Diversions to Yuba City are limited to Table A allocations and water right amounts. SWP Table A water allocated to Butte County are delivered to municipal agencies within the county.

CalSim 3 includes diversion limits for individual water right holders and riparian water users located along the lower Feather River. These limits are based on an analysis of water rights, riparian land use, and historical diversions conducted by DWR.

American River

CalSim 3 simulates diversions for M&I purposes from Folsom Lake, Lake Natomas, and the lower American River. Typically, water is diverted under a mix of water rights and CVP contracts that are explicitly represented in CalSim 3. The model includes preferences for which type of water is diverted in any particular month. City of Sacramento diversions are limited according to the settlement agreement between the City and Reclamation. City of Sacramento diversions are divided between the American River and the Sacramento River intakes based on upper limits of 189 TAF/year at the Fairbairn intake and 81.8 TAF/year at the Sacramento River intake. This split is dynamically adjusted to meet the American River Hodge Criteria.

Lower Yuba River

CalSim 3 simulates Yuba Water Agency deliveries from the lower Yuba River to its member units. Diversions are limited to a maximum annual water right of 162,462 acre-feet and annual contract amount of 388,513 acre-feet. CalSim 3 simulates deficiencies of up to 50% to contract water deliveries. The model does not include dry year deficiencies that are allowed under water right settlement contracts.

Lower Bear River

Simulated diversions from the Bear River below Camp Far West Dam includes deliveries to Camp Far West Irrigation District and South Sutter Water District. Simulated diversions are limited by surface water availability and water demands.

Stony Creek

CalSim 3 simulates diversions from Black Butte Dam and lower Stony Creek as part of Reclamation's Orland Project. These diversions are limited to the simulated annual allocation. In model simulation, no distinction is made between CVP water and Orland Project water, and water previously stored in Black Butte Reservoir may be delivered to the Orland Project.

Cache Creek

CalSim 3 includes two agricultural diversions from Cache Creek: private diversions in Capay Valley and diversion by Yolo County Flood Control and Water Conservation District at the Capay Diversion Dam. Simulated diversions are limited by surface water availability and water demands.

Putah Creek

Simulated diversions from Putah Creek comprise a single diversion at the Putah Diversion Dam to the Putah South Canal. Diversions are constrained to be less than the product of the annual contract amount of 207,350 acre-feet and the annual allocation established by Solano County Water Agency. Solano Project water is subsequently assigned to individual project members based on their individual contract amounts and sale agreements between these members. Annual allocations to member agencies are disaggregated to monthly values based on their pattern of water demand.

Other Minor Creeks

In general, simulated diversions from minor creeks are limited by the available water supply and agricultural water demands.

Mainstem San Joaquin River

CVP Friant Division Diversions from Millerton Lake are limited to Class I and Class II allocations to CVP contractors. River diversions at the Mendota Pool and Sack Dam are limited to CVP contract allocations to the Exchange Contractors, Fresno Slough diverters, and conveyance wheeling of CVP Level 2 refuge water through Central California Irrigation District (CCID) and San Luis Canal Company (SLCC) facilities. Riparian and appropriative diversions from the mainstem below Sack Dam are limited to a maximum flow rate and a period of diversions based on a review of the State Water Board's Electronic Water Rights Information Management System (eWRIMS) database and Statements of Water Use.

Merced River

CalSim 3 simulated diversions from the Merced River include diversions to Merced Irrigation District (MID) at the Merced Falls Dam and the Crocker-Huffman Diversion Dam, individual riparian and appropriative diverters on the left and right banks, and diversions to Stevenson Water District. MID simulated diversions are limited by CalSim 3 annual allocations, which are based on forecasted water supply availability. Riparian diversions in the 19-mile reach from Crocker-Huffman Diversion Dam to Shaffer Bridge are based on Statements of Water Use by the Cowell Agreement diverters. Diversions to Stevenson Water District is based on the district's license and recent reported water use. Other minor diversions from the Merced River are based on a review of the State Water Board's (eWRIMS) database and Statements of Water Use.

Lower Tuolumne River

CalSim 3 simulated diversions from the lower Tuolumne River include diversions to Modesto Irrigation District and Turlock Irrigation District at LaGrange Dam and individual riparian and appropriative diverters on the left and right banks. District simulated diversions are limited by CalSim 3 annual allocations, which are based on forecasted water supply availability. Minor riparian and appropriative diversions are based on a review of the State Water Board's (eWRIMS) database and Statements of Diversion and Water Use.

Lower Stanislaus River

CalSim 3 simulated diversions from the lower Stanislaus River below Tulloch Reservoir include CVP deliveries to Stockton East Water District and Central San Joaquin Water Conservation District that are conveyed through the Upper Farmington Canal and deliveries to senior water right holders at the Goodwin Dam: Oakdale Irrigation District and South San Joaquin Irrigation District. Annual allocations to these districts are based on the New Melones Step Release Plan described by Reclamation (2019). Allocations to the two CVP water service contractors are based on the San Joaquin Valley 60-20-20 water year type.

B.5.4 Water Management Facilities Upstream of Delta

The following sections briefly describe water management facilities simulated in CalSim 3 as part of existing conditions.

Surface Water Reservoirs

In general, CalSim 3 dynamically simulates reservoirs with an active storage greater than 50,000 acre-feet. Reservoir storage is divided into zones, including dead storage or inactive storage and flood control space, where applicable. Storage zones are assigned different weights and are used to allocate water for different purposes.

CalSim 3 dynamically simulates operation of SWP reservoirs, including Lake Oroville, Thermalito Forebay and Afterbay, and the SWP share of San Luis Reservoir. The model also simulates operation of reservoirs on the West and East Branch of the California Aqueduct: Castaic Lake, Pyramid Lake, Silverwood Lake, and Lake Perris. And it simulates Del Valle Reservoir located off the South Bay Aqueduct.

CalSim 3 dynamically simulates operation of CVP reservoirs, including Trinity Lake, Whiskeytown Reservoir, Shasta Lake, Keswick Reservoir, Folsom Lake, Lake Natoma, New Melones Reservoir, CVP share of San Luis Reservoir, and Millerton Lake.

Flood Control Structures

CalSim 3 simulates operations of the Sacramento River Flood Control Project constructed by the U.S. Army Corps of Engineers.

- Between Bend Bridge and Butte City, the model represents M&T and 3Bs flood relief structures that are located upstream from the Ord Ferry gage, and the Goose Lake flood relief structure downstream from this gage.
- Between Butte City and Wilkins Slough, the model represents Moulton, Colusa, and Tisdale weirs that allow flood flows in excess of the downstream channel capacity to escape into the Butte and Sutter basins.
- Between Wilkins Slough and Verona, the model represent the Fremont Weir located at the Sacramento-Feather River confluence that spills excess flow to the Yolo Bypass.
- Between Verona and Freeport, the model represents the Sacramento Weir that spills excess flow to the Yolo Bypass.

Simulated flows over the Fremont Weir and Sacramento Weir are based on a disaggregation of the upstream monthly flow volume into daily flows. Simulation of flows over other weirs is based on the monthly flow.

Stream Gages

The CalSim 3 schematic includes nodes representing major stream gages located downstream of the foothill reservoirs and on the valley floor. Gage locations are used as compliance locations for instream flow requirements, provide locations for model bias corrections (discussed above), were used to develop historical unimpaired inflows, or used in model validation. As described in the

modeling approach CalSim 3 simulated flows do not provide information on historical conditions and simulated flows at stream gages will differ from observed flows.

Additional historical data are available from public agencies for reservoir releases, computed reservoir inflows, weir flows, and stream diversions. The availability of such data is not indicated in the CalSim 3 schematic.

B.5.5 Delta Facilities

Delta Cross Channel

Constructed in 1951 by Reclamation, the Delta Cross Channel is a gated structure that allows passage of Sacramento River water to Snodgrass Slough and, thence, to the Lower Mokelumne River and the San Joaquin River.

CalSim 3 uses an integer variable to close the gates when upstream Sacramento River flows averaged over the month exceed 25,000 cubic feet per second (cfs). For compliance with D-1641, CalSim 3 assumes the Delta Cross Channel to be closed between February 1 and June 4, and closed for 10 days in November, 15 days in December, and 20 days in January.

CalSim 3 simulates additional gate closures for compliance with the 2019 National Marine Fisheries Service (NMFS) Biological Opinion (BiOp). Between October 1 and December 14, the model assumes the gates will be closed if the Sacramento River daily flow at Wilkins Slough exceeds 7,500 cfs. A relationship between the number of days flow exceeds 7,500 cfs and the average monthly flow is based on observed data (USGS gage 11390500, Sacramento River below Wilkins Slough near Grimes). The model implements the target closures unless this action would cause water quality concerns at Rock Slough to be above D-1641 standard.

Using the ANN flow-salinity model for Rock Slough, current month's chloride level at Rock Slough is estimated assuming the target closures. The resulting chloride concentration is compared to the Rock Slough chloride standard (monthly average). If the estimated chloride level exceeds the standard, the gate closure is modeled as for the D-1641 schedule for the entire month. It is assumed that from December 15 through January 31, that the Delta Cross Channel gates are closed under all water quality conditions.

Delta Export Facilities

Banks Pumping Plant

SWP export facilities in the South Delta include the Clifton Court Forebay, the Skinner Fish Facility, and the Harvey O. Banks Pumping Plant (Banks Pumping Plant). Clifton Court Forebay operations are not simulated in CalSim 3. The forebay is simply represented as a conveyance node at the start of the California Aqueduct. The Skinner Fish Facility is not represented in the model. Banks Pumping Plant is represented as a node on the California Aqueduct with an associated capacity of 10,300 cfs. Limits on Delta diversions in to the forebay and constraints limiting flows through the Banks Pumping Plant are discussed in Section B, Attachment 2, *CalSim 3 Regulatory Assumptions and State Water Project/Central Valley Project Operations Criteria*.

Barker Slough Pumping Plant

SWP facilities in the North Delta include the Barker Slough Pumping Plant (BSPP) and the North Bay Aqueduct. The Barker Slough Pumping Plant diverts water from Barker Slough into the North Bay Aqueduct (NBA) for delivery to Napa and Solano counties. The NBA intake is located approximately 10 miles from the mainstem Sacramento River at the end of Barker Slough. Diverted water consists of a mix of SWP water, Vallejo Permit Water, and Fairfield, Vacaville, and Benicia Settlement Water.

The nominal design capacity of the BSPP is 175 cfs with the installation of 10 pumps. Only nine pumps have been installed. However, pump tests performed by DWR before 2010 determined that the current operational capacity of the intake and pipeline was about 140 cfs with the nine existing pumping units in operation. More recent assessments by DWR indicate that effective capacity of the pipeline in 2011 is approximately 130 cfs. Currently, CalSim 3 has no defined pumping capacity for the facility; pumping is driven by a combination of water supply and water demand. Simulated pumping exceeds flow rates of 130 cfs in about 20 months and exceeds 175 cfs in 2 months.

The City of Vallejo holds a water right (Permit 8993) issued in 1948 to divert up to 31.52 cfs year-round from Cache Slough, equivalent to a maximum of 22.78 TAF per year. The place of use includes the cities of Vallejo and Benicia, and parts of Solano County and the American Canyon area in Napa County. Before the NBA construction, the Cache Slough pipeline conveyed water from Cache Slough to Vallejo. The City of Vallejo subsequently paid DWR for the right to use the NBA to convey this Vallejo permit water. Permit water is senior to the SWP water rights and is not subject to Term 91 curtailments. Under existing agreements, DWR has limited the annual conveyance amount of permit water through the NBA to 17.287 TAF/year. CalSim 3 assumes a fixed monthly delivery of this annual volume based on 2008-2015 historical diversions reported to the State Water Board for 2008 through 2015.

A settlement agreement was executed among DWR, Solano County Water Agency, and the Cities of Fairfield, Vacaville, and Benicia to allow those cities to receive a total of 31.62 TAF/year¹⁵ through the NBA. This settlement water is not available when Term 91 is in effect. CalSim 3 simulates the diversion of settlement water using unstored water for export under the Coordinated Operations Agreement (COA) accounting rules as a surrogate for Term 91.

Jones Pumping Plant

CVP export facilities in the South Delta include the Tracy Fish Collection Facility and the Jones Pumping Plant. The Tracy Fish Collection Facility is not represented in the model. Jones Pumping Plant is represented as a node on the Delta-Mendota Canal with an associated capacity of 4,600 cfs. Limits on flows through the Jones Pumping Plant are discussed in Section B, Attachment 2, *CalSim 3 Regulatory Assumptions and State Water Project/Central Valley Project Operations Criteria*.

Delta Diversion Facilities

Contra Costa Water District

CalSim 3 represents the CCWD's municipal intakes located in the south and western Delta. These include intakes at Rock Slough, Old River near Highway 4, Victoria Canal (also known as the Middle

¹⁵ The Settlement Water is available to up to 11.8 TAF/year (93 cfs) for the City of Fairfield, 10.5 TAF/year (50 cfs) for the City of Benicia, and 9.32 TAF/year (46 cfs) for the City of Vacaville.

1 River intake), and Mallard Slough intake. The model also simulates operation of the 160 TAF Los
2 Vaqueros Reservoir that stores higher quality Delta water for blending with the Delta supply during
3 dry periods when sodium and chloride levels typically increase.

4 The Rock Slough Intake Facility pumps water using four pumping plants located along the initial
5 reaches of the Contra Costa Canal. CalSim 3 assumes a maximum intake capacity of 350 cfs. The
6 model prioritizes diversions at the Rock Slough intake for the months December through March and
7 June.

8 The Old River and Victoria Canal intakes are conveyed through the Old River Pipeline to the Transfer
9 Station where flows are either pumped into Los Vaqueros or conveyed by gravity to the Contra
10 Costa Canal. CalSim 3 assumes intake capacities of 250 cfs at each location with a combined capacity
11 of 320 cfs.

12 The Mallard Slough Pump Station, located at the western-most end of the Delta in Suisun Bay near
13 Bay Point, has a capacity of 39 cfs and pumps water directly into Contra Costa Canal. Diversions
14 from Mallard Slough are unreliable due to frequently poor water quality, specifically high chlorides,
15 in the San Joaquin River at this point of diversion. CCWD only diverts at Mallard Slough when
16 chlorides are 65 milligram per liter (mg/L) or less. Water quality conditions have limited
17 diversions from Mallard Slough to approximately 3,500 acre-feet per year, on average (CALFED Bay-
18 Delta Program 2005: 3-8). In CalSim 3, diversions at Mallard Slough are set to zero.

19 CalSim 3 fills Los Vaqueros Reservoir with water from the Delta of up to 65 mg/L chloride
20 concentration¹⁶ under the district's Los Vaqueros water right permit or under its CVP water supply
21 contract. Existing BiOps and permits for the Los Vaqueros Project impose certain restrictions on
22 operations of the Los Vaqueros Project and CCWD's Delta diversions. These include an annual 75-
23 day no-fill period and a concurrent 30-day no-diversion period, and an additional 0 to 14 days of no-
24 fill in February depending on February 1 Los Vaqueros Reservoir storage. CalSim 3 assumes a no- fill
25 period of 14 to 28 days in February, March, and June with a concurrent no-diversion period in March.
26 These restrictions are waived if storage in Los Vaqueros Reservoir is at or below emergency levels
27 of 70 TAF in wet, above normal, or below normal water years, and 44 TAF in dry or critically dry
28 water years. Additionally, simulated diversions from the Old River Intake and Middle River Intake at
29 Victoria Canal do not occur when Old and Middle River (OMR) flow restrictions are controlling CVP
30 and SWP south Delta export operations under the 2019 U.S. Fish and Wildlife Service USFWS and
31 NMFS Operational Criteria and Plan (OCAP) BiOps. The model operates Los Vaqueros Reservoir to
32 meet a delivered water quality of 65 mg/L chloride.

33 **City of Stockton**

34 CalSim 3 represents the City of Stockton's municipal intake located in the eastern Delta north of the
35 city on Empire Tract. The intake was constructed in 2012 as part of the City's Delta Water Supply
36 Project. San Joaquin River water diverted at the intake pump station is treated at the City's Delta
37 Water Treatment Plant, along with supplemental surface water from the Mokelumne River diverted
38 and conveyed by Woodbridge Irrigation District when the City's supplies from the San Joaquin River
39 are curtailed. The water treatment plant has a 30 mgd capacity. Delta diversions are curtailed

¹⁶ Because of evaporation, it is possible for simulated water quality in Los Vaqueros Reservoir to exceed 65 mg/L chloride concentration; under such a circumstance, filling with water above 65 mg/L chloride concentration is allowed as long as it lowers the salinity in the reservoir.

1 annually from February 15 to June 15 under BiOps issued by USFWS and California Department of
2 Fish and Wildlife (CDFW) for the protection of Delta smelt.

3 CalSim 3 limits diversions at the City's Delta intake to 46 cfs (equivalent to 30 mgd). Additionally,
4 the model limits Delta diversions to be less than return flows from the Stockton Wastewater
5 Treatment Plant to represent the City's water right under Section 1485 of the California Water
6 Code.¹⁷ For protection of Delta smelt, the model assumes no diversions are allowed April 15 through
7 May 20 and pumping is curtailed to 50% of capacity March 15 through April 15 and May 21 through
8 June 20.

9 **Delta Barriers**

10 To maintain water levels in several south Delta waterways, historically DWR has implemented the
11 seasonal South Delta Temporary Barrier Project (TBP), which consists of three temporary rock
12 agricultural barriers and a temporary rock barrier at the HOR.

13 CalSim 3 indirectly simulates the installation and removal of the Grant Line Canal Barrier;
14 installation of the barrier affects flows from the San Joaquin River into the HOR. DSM2 simulation
15 includes all three agricultural barriers located on the Old River near Tracy, Middle River, and Grant
16 Line Canal.

17 Installation of the HOR Barrier is not simulated in CalSim 3. In both the federal proposed action for
18 the long-term operation of the CVP and SWP and the State proposed project for SWP operations, the
19 HOR Barrier was explicitly excluded. Both federal and state permitting through the BiOps from
20 NMFS and USFWS, and the incidental take permit (ITP) from CDFW do not require its installation.

21 **Suisun Marsh Salinity Control Gates**

22 The Suisun Marsh Salinity Control Gates (SMSCG) are located on Montezuma Slough about 2 miles
23 downstream from the confluence of the Sacramento and San Joaquin Rivers, near Collinsville. The
24 objective of Suisun Marsh Salinity Control Gate operation is to decrease the salinity of the water in
25 Montezuma Slough. The gates control salinity by restricting the flow of higher salinity water from
26 Grizzly Bay into Montezuma Slough during incoming tides and retaining lower salinity Sacramento
27 River water from the previous ebb tide. Operation of the gates in this fashion lowers salinity in
28 Suisun Marsh channels and results in a net movement of water from east to west through Suisun
29 Marsh. Under the Suisun Marsh Preservation Agreement, DWR and Reclamation are required to
30 meet salinity standards in accordance with D-1641.

31 Operation of SMSCG is modeled indirectly in CalSim 3. The model uses the ANN to determine the
32 Sacramento River inflow-export relationship and corresponding NDOI to comply with Delta salinity
33 standards. Gate operations increase Delta salinity intrusion and outflow to meet water quality
34 standards. CalSim 3 simulates ITP actions to operate SMSCG for up to 60 days in June through
35 October of below normal, above normal years, and wet years.

¹⁷ California Water Code Section 1485 states "Any municipality, government agency, or political subdivision operating waste disposal plants producing disposal water meeting the requirements of the appropriate regional board, and disposing of said water in the San Joaquin River may file an application for a permit to appropriate an equal amount of water, less diminution by seepage, evaporation, transpiration or other natural causes between the point of discharge and the point of recovery, downstream from disposal plant and out of the San Joaquin River or the Sacramento-San Joaquin Delta."

B.5.6 Regulatory Requirements

Existing conditions for this EIR include continuation of current operations of the SWP and CVP by DWR and Reclamation, respectively. This includes meeting the regulatory requirements of the 2019 NMFS and USFWS BiOps for the Long-Term Operation of the Central Valley Project and State Water Project [ROC LTO] and 2020 CDFW ITP for the Long-Term Operations for the SWP. The modeled regulatory and contractual requirements also include continued operations under the Coordinated Operations Agreement; State Water Resources Control Board (State Water Board) Water Right Decision 1641 (D-1641); and the State Water Board Water Quality Control Plan adopted in 2006.

Details on regulatory requirements included in the CalSim 3 model downstream of the Upper Watershed Modules are shown in Attachment 2, *CalSim 3 Regulatory Assumptions and State Water Project/Central Valley Project Operations Criteria*.

B.5.7 SWP and CVP Operational Assumptions and Modeling Guidelines

Operational Assumptions

Existing conditions for this EIR include current operational rules for the SWP and CVP used by DWR and Reclamation, respectively. Assumptions for operational rules include continued delivery of water to SWP and CVP contractors up to the adopted water contract amounts based upon water availability, shortage policies, and operational constraints; operations under the Coordinated Operations Agreement; use of joint points of diversion to allow Reclamation to use SWP diversion capacity capabilities in accordance with D-1641; Cross Valley Canal wheeling through Banks; and implementation of Central Valley Project Improvement Act, including environmental water actions in accordance with Section 3406(b)(2).

Details on CVP/SWP operational rules included in the CalSim 3 model are shown in Section B, Attachment 2, *CalSim 3 Regulatory Assumptions and State Water Project/Central Valley Project Operations Criteria*.

Modeling Operations Guidelines

During development of the model simulations, SWP and CVP operations were reviewed and compared to specific operational guidelines. These guidelines were developed in conjunction with DWR and Reclamation, for ensuring that project operations in model simulations are realistic and generally represent how the system is and would be operated with uniform risk profiles, and result in consistent operations across baseline and alternative models. Project operations in the baseline and alternative models were refined to meet these guidelines. However, because the SWP and CVP in CalSim 3 operate according to fixed operational rules, which do not include the day-to-day decisions and discretionary actions that occur in real operations, it was not possible to meet all of the guidelines in all simulations. In some cases, improving one guideline could actually worsen another guideline. These issues were magnified in scenarios which used climate change hydrology. Hence the goal in refining project operations was to meet the guideline to the greatest extent possible, while preventing severe violations of any one guideline. The guidelines are described below.

CVP Guidelines

North of the Delta

- Shasta, Trinity, and Folsom storage: Ensure that dead pool situations are very infrequent (<5 months in the entire simulation for each reservoir).
- Shasta end-of-September storage: To the greatest extent possible, ensure that the exceedance plot is similar to one generated from a recently released publicly available model (in this case the 2019 CalSim II model from the 2019 *Delivery Capability Report*). Any differences should make sense in terms of differences between the models independent of project operations.
- North-of-Delta (NOD) agricultural service contractor allocation versus Shasta carryover in the following September: A scatter plot of these two variables should show an approximately linear relationship (though usually with a fair amount of spread).
- NOD delivery shortages: preferred to be very low on average (<3 TAF per year), and only happen in a few years when Shasta is at dead pool.

South of the Delta

- South-of-Delta agricultural service contractor allocation versus CVP San Luis low point later in year. Minimize to the greatest extent possible the number of years when the CVP San Luis low point storage is greater than 150 TAF in low allocation years (<50%).
- CVP south-of-Delta delivery shortages: Multiple criteria are listed below.
 - Should only have shortages when CVP San Luis is at dead pool.
 - Average annual shortages should be 5 to 10 TAF.
 - Maximum annual shortage should be 100 to 150 TAF.
 - 80%–85% of years should have zero shortages.
 - Shortages should not occur before August.

SWP Guidelines

Dry Year Deliveries

- Deliveries in the driest years in the simulation (1977 and 2014) should be close to 8% to 10% of Table A (300 to 400 TAF).

North of the Delta

- Oroville storage: Ensure that dead pool situations are very infrequent (<5 months in the entire simulation for each reservoir).
- NOD delivery shortages: preferred to be very low on average (<3 TAF per year), and only happen in a few years when Oroville is at dead pool.

South of the Delta

- Table A allocation versus SWP San Luis low point later in year. Minimize to the greatest extent possible the number of years when the SWP San Luis low point storage is greater than 150 TAF in low allocation years (<50%). These criteria were not always achieved.
- SWP south-of-Delta delivery shortages: Multiple criteria are listed below
 - Should only have shortages when SWP San Luis is at dead pool.
 - Average annual shortages should be approximately 20 TAF.
 - Maximum annual shortage should be less than 60 to 70 TAF.
 - 80%–85% of years should have zero shortages.
 - Shortages should not occur before August.

B.5.8 Water Transfers

Simulation of long-term water transfers is limited to the Lower Yuba River Accord. No short-term or temporary transfers, such as Sacramento Valley acquisitions conveyed through Banks Pumping Plant, are included in the modeling. However, a post-processing water transfer analysis was conducted based on the available capacity to move water through the Banks and Jones Pumping Plants during the July through November transfer window.

Lower Yuba River Accord

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

B.5.9 Wheeling

The Cross Valley Canal is a CVP facility that conveys water from the California Aqueduct near Tupman east to the Kern River. The canal is used to convey irrigation water to seven contractors that are located along the east side of the San Joaquin Valley. The Cross Valley Canal Contractors have an annual CVP water supply totaling 128,300 acre-feet. However, because of water supply and conveyance constraints, typical CVP delivery to the Cross Valley Canal Contractors is substantially less than the contract amount. In CalSim 3, Cross Valley Canal water is wheeled through Banks Pumping Plant and the California Aqueduct when there is available capacity after simulation of SWP operations and is limited to the months of July through December. Cross Valley Canal simulated deliveries are subject to CVP south-of-Delta agricultural allocation.

Under State Water Board D-1641, (December 1999, revised March 2000: 150), Reclamation and DWR are authorized to divert project water at the other agency's facilities. The sharing of available capacity at the SWP and CVP export facilities is referred to as Joint Point of Diversion. CalSim 3 simulates wheeling of CVP water through Banks Pumping Plant. However, wheeling of SWP water through Jones Pumping Plant is not represented. Wheeling of CVP water through Banks can only occur using the south Delta intakes in months when there are no ITP export cuts or restrictions and when the water being wheeled is Delta excess.

B.5.10 Initial Conditions

Groundwater elevations at the start of the period of simulation are based on output from the California Central Valley Groundwater-Surface Water Fine Grid Simulation Model (C2VSimFG).

The model is a valley-wide regional scale groundwater model designed to simulate surface water and groundwater flow through the Central Valley. Developed by DWR (California Department of Water Resources 2020), the model represents the valley floor rivers and streams downstream from the foothill reservoirs and the underlying groundwater aquifer. The model simulates historical conditions for water years (WY) 1974 through 2015 using a monthly timestep and data inputs of historical reservoir releases, historical stream diversions, and historical Delta exports.

C2VSimFG simulated groundwater elevations for September 2015 are initially input to CalSim 3 to initialize the latter's groundwater Dynamic Link Library (DLL). CalSim 3 is subsequently run for 5 years and the resulting CalSim 3 groundwater elevations for September 1927 are used as initial conditions (September 1922) for existing conditions.

B.6 No Project Alternative

The CalSim 3 model for the No Project Alternative represents projected year 2040 conditions in the absence of the Delt Conveyance Project. In general, the No Project Alternative (2040) model includes facilities and programs that are represented in the existing conditions model. However, water supplies and water demands differ from existing conditions in order to represent projected changes in land use and urban growth, climate change, and sea level rise.

The sections below describe differences between the CalSim 3 No Project Alternative (2040) model and the existing conditions model. The CalSim 3 simulations for future conditions do not consider any special adaptation measures that would result in managing SWP and CVP facilities in a manner different to those under existing conditions other than (a) adjustments to reservoir releases to meet regulatory standards, including Delta outflow, under the changed environment and (b) changes to discretionary project allocations based on future water supplies.

B.6.1 Hydrology

Climate Data

The 2040 climate was developed from 20 Coupled Model Intercomparison Project 5 (CMIP5) global climate projections, selected by the DWR Climate Change Technical Advisory Group (CCTAG). Historical observed meteorological daily data were perturbed using the differences observed in the ensemble of the selected global climate projections for a future 30-year period (2026–2055) centered on 2040 relative to a 30-year historical reference period centered on 1995 (1981–2010). The development of climate transformed input data for the No Project Alternative is described in greater detail in Section B, Attachment 4, *Climate Change Development for Delta Conveyance Project*

Rim Watershed Unimpaired Inflows

For future (2040) conditions, historical unimpaired inflows to the rivers and streams of the Central Valley rim watersheds have been adjusted for the projected effects of climate change. The adjustment of these inflows is described in Section B, Attachment 4, *Climate Change Development for Delta Conveyance Project*. Historical and perturbed meteorological data were input into a gridded watershed model (VIC) to simulate surface runoff and other watershed variables (e.g., surface water evaporation, potential evapotranspiration). The differences in surface water hydrology from simulations based on historical and projected meteorology were applied to transform the historical CalSim 3 boundary flows for 2040 conditions.

Valley Floor Hydrology

For future (2040) conditions, inputs to CalSimHydro were modified to reflect 2040 land use, urban growth, and climate scenario. Modified inputs include land use, precipitation, and potential crop ET. Potential reference crop ET output from the VIC model simulation were used to perturb historical crop ET rates.

Land Use

Year 2040 land use data are based on future scenarios developed by DWR for the California Water Plan (CWP), Update 2013 DWR considered three socioeconomic scenarios:

- Current Trends, which assumed that recent trends would continue into the future.
- Slow Growth, which assumed that future development is less resource intensive than under recent conditions.
- Expansive Growth, which assumed that future development is more resource intensive than under recent conditions.

For each scenario, DWR quantified population projected in 10-year increments from 2010 through 2050. After the population projections were developed for each CWP update 2013 scenario, DWR developed assumptions about the relationships between population growth, urban expansion, and agricultural land use.

CalSim 3/CalSimHydro land use for the No Project Alternative (2040) model corresponds to the CWP Update 2013 Current Trends scenario. These data have previously been used in several planning studies, including the Central Valley Project Integrated Resource Plan (Bureau of Reclamation 2014: 3-1), Sacramento and San Joaquin River Basin Study (Bureau of Reclamation 2016: 7-12), and American River Basin Study.

Flow Forecasts

As for existing conditions, statistical forecasting procedures are used to forecast unimpaired flows and water year types under 2040 conditions. Flow forecasts are typically made in February and updated through May. The May forecast is used to determine the final water year type through to the following year. Under future conditions, the flow forecasting for inflows to Trinity Reservoir, Shasta Lake, and the unimpaired flow for the Sacramento River at Bend Bridge were found to perform poorly. Therefore, model code was modified so that the May forecast for these 3 flows is based on perfect foresight of future flows from May through September of the current water year.

Reservoir Evaporation

For future (2040) conditions, historically based reservoir evaporation rates were adjusted for the projected effects of climate change. Open water evaporation output from the VIC model simulations were used to perturb historical rates.

Reservoir Flood Control Space

Climate change is changing the seasonal runoff pattern from high elevation watersheds surrounding the valley floor. Future changes to reservoir flood control requirements to better accommodate a seasonally changing hydrograph may be considered under future programs but are not considered in the EIR. However, flood control space for Shasta Lake is dynamically calculated in CalSim 3 based on antecedent flow conditions. Similarly, flood control space for Black Butte Reservoir, East Park Reservoir, Eastman Lake, Hensley Lake, New Hogan Reservoir, and Stony Gorge Reservoir are dynamically calculated in CalSim 3 based on antecedent precipitation in the upstream watersheds. Therefore, for these reservoirs the model dynamically responds to shifting patterns in precipitation and runoff.

Bias Correction

As for existing conditions, bias correction terms are included in the No Project Alternative (2040) model. These bias corrections were not modified for the effects of climate change because of uncertainty in the underlying nature of the bias.

B.6.2 Sea Level Rise

Sea level rise assumptions for the project are based on the California Ocean Protection Council's (OPC) guidance updated in 2018, the *State of California Sea-Level Rise Guidance* (Guidance). This Guidance includes science-based methodology for state and local governments to analyze and assess the risks associated with sea level rise, and to incorporate sea level rise into their planning, permitting, and investment decisions. The Guidance incorporates probabilistic sea level rise projections, which associate a likelihood of occurrence (or probability) with sea level rise heights and rates and are directly tied to a range of emissions scenarios. The Guidance also includes an extreme scenario called the H++ scenario (resulting from loss of the West Antarctic ice sheet). The probability of this scenario is currently unknown, but its consideration is important, particularly for high stakes, long-term decisions. Under the extreme H++ scenario, rapid ice sheet loss on Antarctica could drive rates of sea level rise in California above 50 mm/year (2 inches/year) by the end of the century, leading to potential sea level rise exceeding 10 feet. This rate of sea level rise would be about 30 to 40 times faster than the sea level rise experienced over the last century. The range of sea level rise projections at San Francisco are summarized in Table 5A-B.9.

Table 5A-B.9. Sea Level Rise Projections at San Francisco

Year 2040		Year 2050		Year 2070		Year 2100	
0.5% Probability	H++	0.5% Probability	H++	0.5% Probability	H++	0.5% Probability	H++
1.3 feet	1.8 feet	1.9 feet	2.7 feet	3.5 feet	5.2 feet	6.9 feet	10.2 feet

Notes:

^a 0.5% probability corresponds to the Medium-High Risk Aversion.

^b H++ corresponds to an extreme scenario resulting from loss of West Antarctic ice sheet.

Following is the summary of assumptions for the EIR:

- Sea level rise projections at San Francisco tide gage were used for the EIR analysis.
- Guidance recommends consideration of extreme H++ scenario for projects with a lifespan beyond 2050 that have a low tolerance for risk or are critical assets. Therefore, H++ sea level rise projections were used for the climate change analysis.
- The Delta Conveyance Project, if approved, is expected to become operational around 2040. Therefore, for the EIR, an integrated operational analysis of the project was conducted for the year 2040 (climate period 2026–2055). The H++ sea level rise projection at 2040 is 1.8 feet. Additionally, a sensitivity analysis was conducted for the EIR for the No Project Alternative and proposed project for a sea level rise of 0.5 feet by 2040, corresponding to a 66% probability of occurrence. An additional sensitivity analysis was undertaken for an assumed sea level rise of 3.5 feet to occur around 2070, corresponding to a 0.5% probability of occurrence under a high emission scenario.
- For the design of project facilities, the H++ sea level rise projection of 10.2 feet at year 2100 was assumed. The effects of sea level rise are further discussed Section F, *Sea Level Rise and Delta Water Quality Modeling*.

B.6.3 Water Demands

Agricultural Water Demands

Managed agricultural water demands were calculated by CalSimHydro using revised climate data input consistent with the climate change scenario for 2040.

Managed Wetlands Water Demands

Managed wetland water demands were calculated by CalSimHydro using revised climate data input consistent with the climate change scenario for 2040.

Urban Water Demands

For major water purveyors, urban water demands for future (2040) conditions are based on the projected 2040 water demand listed in water purveyors' 2015 Urban Water Management Plans. For small unincorporated communities, water demands are based on per capita water use rates and population projections.

Lower American River Watershed

Water demands for agencies that divert water from the North Fork American River, Folsom Lake, Lake Natoma, and lower American River were modified from the projected 2040 water demand procedure described above so as to be equal to full entitlements under existing contracts, water rights, and settlement agreements. This assumption is consistent with assumptions made by Reclamation for the long-term operation of the CVP (Bureau of Reclamation 2019:47). Assumed water supplies for modeling purposes are presented in Table 5A-B.10.

1 **Table 5A-B.10. American River Watershed Assumed 2020 and 2040 Water Supplies**

Water Purveyor	CalSim 3 Demand Unit	Point of Diversion		Existing Condition			No Project Alternative (2040)		
		Description	CalSim 3 Node	CVP Water	Water Rights	Diversion Limit	CVP Water	Water Rights	Diversion Limit
				Max Annual Amount ^a (acre-feet/year)			Max Annual Amount ^a (acre-feet/year)		
Placer County WA	N/A	Auburn Dam Site	NFA016		35,500	35,500		65,500	65,500
Sacramento Suburban WD – North Service Area ^b	26N_NU1	Folsom Lake	FOLSM		0-14,000	0 - 14,000		0 - 29,000	0 - 29,000
City of Folsom	26S_PU1			7,000	27,000 ^d	34,000	7,000	27,000 ^d	34,000
Folsom Prison	26S_PU1				4,000	4,000		4,000	4,000
Aerojet	26S_NU4					3,000			3,000
San Juan WD	26N_PU2			24,200	54,000 ^c	54,200 - 82,200	24,200	54,000 ^c	54,200 - 82,200
El Dorado ID/El Dorado Co. ⁷	ELDID_NU3			15,050	13,060	7,550	15,050	21,560	24,550
City of Roseville	26N_PU1			32,000	24,000 ^b	39,800 - 58,900	32,000	34,000 ^b	39,800-58,900
Placer County WA	N/A			35,000		0	35,000		35,000
California Parks and Rec.	26S_PU3				5,000	5,000		5,000	5,000
Golden State WC	26S_PU2	Folsom South Canal	FSC003		5,000 ^e	5,000		5,000 ^{e[5]}	5,000
SMUD	60N_PU		FSC025	30,000	14,480	44,480	30,000	14,480	44,480
Carmichael WD	26N_NU2	Lower American River	AMR017		32,627 ^f	12,000		32,627 ^f	12,000
City of Sacramento	26N_NU3, 26S_PU1		AMR007		189,000	189,000 ^g		245,000 ³	245,000 ^g
City of Sacramento	26N_NU3, 26S_PU1	Sacramento River Pump Station	SAC062		81,800	81,800		81,800	81,800
Sacramento County WA	26S_PU4			15,000		12,433 ^h	15,000		15,000
Sacramento County WA		Freeport	SAC050	45,000	varies ⁱ	varies	45,000	varies ⁱ	varies
EBMUD	EBMUD			133,000		varies ⁱ	133,000		varies ⁱ

2

Notes:

^a The diversion limit is the minimum of: (a) the sum of the full CVP contract amount and water right entitlement and (b) annual limits based on the Water Forum Agreement, Update 2015.

^b The City of Roseville has signed a contract with PCWA providing for the delivery of 10,000 acre-feet per year of Middle Fork Project, with options for an additional 20,000 acre-feet per year. The City of Roseville also signed a wholesale contract with SJWD for 4,000 acre-feet per year. This water is derived from part of SJWD's contract with PCWA for 25,000 acre-feet of Middle Fork Project water.

^c San Juan Water District (SJWD) holds a pre-1914 water right for a year-round diversion of 60 cfs and Water Right License 6324 for up to 15 cfs to be diverted June 1 to November 1. Pursuant to a water rights settlement agreement with Reclamation, SJWD water right diversions are limited to a maximum of 75 cfs and an annual total of 33,000 acre-feet. SJWD's contract with PCWA is for 25,000 acre-feet per year of Middle Fork Project water.

^d The City of Folsom holds pre-1914 appropriative water rights for 22,000 acre-feet per year. An additional 5,000 acre-feet of water are available under a cotenancy agreement between the City and Golden State Water Company.

^e Golden State Water Company (GSWC) has a pre-1914 appropriative water right to divert up to 10,000 acre-feet per year. In 1994, Golden State WC entered into an Agreement for Reallocation of Water under Co-Tenancy Agreement with the City of Folsom to lease 5,000 acre-feet per year of water rights in perpetuity.

^f Carmichael Water District (CWD) holds three water rights: Water License 1387 for year-round diversion of 15 cfs; Water Right Permit 8731 for a 10 cfs diversion from May 1 to November 1; and Permit 7356 for year-round diversion of up to 25 cfs. In addition, CWD has rights to GET water supplies derived from GET LA and GET LB under a contract with Aerojet. These supplies are not represented in CalSim 3.

^g When the Hodge single dry year criteria are triggered, or the March-through-November Folsom Unimpaired Inflow falls below 400,000 acre-feet, diversion on the American River is limited and diversion on the Sacramento River is increased.

^h Sacramento County Water Agency (SCWA) currently uses Fazio water to supply the South Service Area of Zone 40. Water is treated at the City of Sacramento's water treatment plant, wheeled through the City's distribution system, and delivered through the Franklin Intertie. The current capacity of the Franklin Intertie is 11.1 MGD, equivalent to 12,433 acre-feet per year. The remaining portion of the Fazio water and the SMUD1 and SMUD2 assignments are available for diversion at the Freeport Regional Water Authority intake to be treated at the Vineyard Water Treatment Plant.

ⁱ SCWA holds Water Right Permit 21209 (Application 30454) for year-round diversion of up to 132 cfs with an annual limit of 71,000 acre-feet. The permit is subject to Term 91.

^j EBMUD CVP diversions are limited to 133 TAF/year, 165 TAF over any 3-year period, and 155 cfs maximum diversion rate. EBMUD Board adopted a policy to take CVP water when EBMUD projected total system storage falls below 450 TAF.

Key: CVP = Central Valley Project, EBMUD = East Bay Municipal Utility District; ID = Irrigation District, M&I = municipal and industrial, SMUD = Sacramento Municipal Utilities District, TAF = thousand acre-feet, WA = Water Agency, WC = Water Company, WD = Water District

B.6.4 Water Management and Control Facilities

Modeling assumptions for water management and control facilities for the No Project Alternative (2040) are the same as for existing conditions, except as described in the following paragraphs.

Hetch Hetchy Water and Power Project

CCSF facilities in the upper Tuolumne River watershed are not dynamically simulated in CalSim 3 but are preprocessed based on climate transformed unimpaired inflows and an annual CCSF demand of 265 mgd. Facilities in the upper watershed include Hetch Hetchy Reservoir, Lake Eleanor, and Lake Lloyd and CCSF exports from the watershed through the San Joaquin Pipeline. The preprocessed inflows to Don Pedro Reservoir are broadly indicative of how inflows may be affected by climate change but may not represent how CCSF would operate its facilities under this particular climate scenario.

Upper San Joaquin River Facilities

PG&E and Southern Edison of California facilities in the upper San Joaquin River watershed above Millerton Lake are not dynamically simulated in CalSim 3 but are preprocessed based on climate transformed unimpaired inflows and current storage regulation patterns. The preprocessed inflows to Millerton Lake are broadly indicative of how inflows to the lake may be affected by climate change.

Yolo Bypass Salmonid Habitat Restoration and Fish Passage Project

DWR has obtained final state and federal approvals to construct a 100-foot-wide gateway or notch within the Fremont Weir to allow increased flow from the Sacramento River to enter the Yolo Bypass. The invert of the notch will be 18 feet below the crest of Fremont Weir with a capacity of up to 6,000 cfs, allowing juvenile salmon to move from the Sacramento River onto the floodplain and then back into the Sacramento River at Cache Slough. The project will also construct an intake channel from the Sacramento River, a headworks structure, a transport channel to the existing Tule Pond, and modifications to the existing Tule channel and agricultural crossing.

Simulation of the Fremont Weir Gateway is as modeled for the proposed action in the BA for ROC LTO (Bureau of Reclamation 2019: 11).

Placer County Water Agency Point of Diversion for CVP Water

Placer County Water Agency (PCWA) holds an interim contract with Reclamation for diversion of up to 35,000 acre-feet per year of CVP water at Folsom Lake for use within the agency's service area. However, no diversions have been made to date. Under the No Project Alternative (2040), it is assumed that PCWA shall take delivery of this CVP water. The construction of any new facilities or the modification of existing facilities would have to undergo environmental review.

B.6.5 Regulatory Requirements

All regulatory requirements for the No Project Alternative (2040) are as for existing conditions, except for hydropower projects located in the upper watersheds of the Sierra Nevada that are currently undergoing FERC relicensing of their facilities. For these projects, non-discretionary

instream flow requirements are based on requirements contained in Water Quality Certifications issued by the State Water Board. These hydropower projects and their owners include the following:

- Nevada Irrigation District Bear River Project (FERC No. 2266)
- PG&E DeSabra-Centerville Hydroelectric Project (FERC No. 803)
- PG&E North Fork Feather Bucks Creek (FERC No. 619)
- PG&E Upper North Fork Feather Project (FERC No. 2105)
- SFWPA South Fork Feather Project (FERC No. 2088)
- Yuba Water Agency Yuba River Development Project (FERC No. 2246)

The Water Quality Certification for PG&E's Drum-Spaulding Project (FERC No. 2310) was issued by the State Water Board on February 3, 2021. Flow requirements listed in this document have not been included in the No Project Alternative (2040) model.

B.6.6 Water Transfers

As for the No Project Alternative, simulated water transfers are limited to the Lower Yuba River Accord.

B.6.7 Initial Conditions

Initial conditions (the state of the system at the beginning of the simulation) are as for existing conditions. These include surface water storage and groundwater elevations.

B.7 Proposed Project and Project Alternatives

Model simulations for the Proposed Project and Project Alternatives include simulation of intake facilities on the Sacramento River, water conveyance through tunnels and forebays, and connection to south Delta SWP and CVP export facilities. Model simulations are characterized by the capacity of the North Delta intakes, SWP and CVP access to the new conveyance, and the connection to existing south-of-Delta facilities, as follows

- Alternatives 1/3: Central/Eastern Alignment, 6,000 cfs, Intakes B and C, SWP only (proposed project)
- Alternatives 2a/4a: Central/Eastern Alignment, 7,500 cfs, Intakes A, B, and C, SWP 6,000 cfs, CVP 1,500 cfs
- Alternatives 2b/4b: Central/Eastern Alignment, 3,000 cfs, Intake C, SWP only
- Alternatives 2c/4c: Central Alignment, 4,500 cfs, Intakes B and C, SWP only
- Alternative 5: Bethany Reservoir Alignment, 6,000 cfs, Intakes B and C, SWP only

B.7.1 North Delta Diversion Operational Criteria

Several new operational criteria would govern the diversions at the proposed north Delta intakes to minimize near-field and far-field effects of intake operations. The following criteria aim to minimize effects of the proposed intake operations on fish passage, survival in the intake reach, and through-Delta survival of migrating fish.

- North Delta intake approach and sweeping velocity requirements at the intake fish screens
- North Delta diversion bypass flow requirements
- North Delta pulse protection and low-level pumping

The proposed operational criteria are discussed in detail in Chapter 3, *Description of the Proposed Project and Alternatives*. The following sections describe how these criteria are represented in CalSim 3.

Approach and Sweeping Velocities

Approach velocity is the velocity of water perpendicular to and moving toward the screens, while sweeping velocity is the velocity of water parallel to and moving past the screens. The instantaneous diversions at the proposed intakes would be subject to fishery agency velocity criteria, currently a maximum approach velocity of 0.2 feet per second (fps) (per U.S. Fish and Wildlife Service [USFWS] criteria for delta smelt) and a minimum sweeping velocity of 0.4 feet per second at the proposed fish screens to help minimize near-field effects of the intake operations.

In addition to the bypass flow criteria described below, a linear constraint is applied in CalSim 3 to potential diversion at the north Delta intakes in all months to account for the fish screen sweeping velocity criteria of 0.4 feet fps cross-sectional average velocity just downstream from the southernmost intake based on diversion limitations from DSM2 modeling.

Bypass Flows and Low-Level Pumping

Bypass flow is the 3-day tidally averaged flow remaining in the Sacramento River immediately downstream of the proposed north Delta intakes computed as flow measured at Freeport minus the diversion rate.

In model simulation, bypass flow requirements in the Sacramento River are specified downstream from the north Delta intakes that govern the flow required to remain in the river before any diversion can occur. The bypass rules include low-level pumping at each intake during the Sacramento River pulse flow(s) period. After a pulse has ended, the allowable diversion is governed by post-pulse operations through June that can transition through three levels of protection (Level 1 to Level 2 and subsequently to Level 3) subject to river and fishery conditions. Minimum bypass flow requirements are specified for July through November, as presented in Table 5A-B.11. The bypass flow rules are simulated in CalSim 3 using daily mapped Sacramento River flows to determine the maximum potential diversion that can occur in the north Delta for each day. Subsequently, CalSim 3 uses the monthly average of this daily potential diversion as one of the constraints in determining the final monthly diversion at the north Delta intakes.

Table 5A-B.11. Post-Pulse Bypass Flow Rules and Bypass Flow Rules During July through November for the North Delta Diversion

Level 1 Post-Pulse Operations			Level 2Post-Pulse Operations				Level 3 Post-Pulse Operations		
Sacramento at Freeport (cfs)		Bypass Flow (cfs)	Sacramento at Freeport (cfs)		Bypass Flow (cfs)	Sacramento at Freeport (cfs)		Bypass Flow (cfs)	
Above	Below		Above	Below		Above	Below		
December – April									
0	5,000	100% of the amount over 0 cfs	0	5,000	100% of the amount over 0 cfs	0	5,000	100% of the amount over 0 cfs	
5,000	15,000	Flows remaining after constant low-level pumping	5,000	11,000	Flows remaining after constant low-level pumping	5,000	9,000	Flows remaining after constant low-level pumping	
15,000	17,000	15,000 cfs plus 80% of the amount over 15,000 cfs	11,000	15,000	11,000 cfs plus 60% of the amount over 11,000 cfs	9,000	15,000	9,000 cfs plus 50% of the amount over 9,000 cfs	
17,000	20,000	16,600 cfs plus 60% of the amount over 17,000 cfs	15,000	20,000	13,400 cfs plus 50% of the amount over 15,000 cfs	15,000	20,000	12,000 cfs plus 20% of the amount over 15,000 cfs	
20,000	No limit	18,400 cfs plus 30% of the amount over 20,000 cfs	20,000	No limit	15,900 cfs plus 20% of the amount over 20,000 cfs	20,000	No limit	13,000 cfs plus 0% of the amount over 20,000 cfs	
May									
0	5,000	100% of the amount over 0 cfs	0	5,000	100% of the amount over 0 cfs	0	5,000	100% of the amount over 0 cfs	
5,000	15,000	Flows remaining after constant low-level pumping	5,000	11,000	Flows remaining after constant low-level pumping	5,000	9,000	Flows remaining after constant low-level pumping	
15,000	17,000	15,000 cfs plus 70% of the amount over 15,000 cfs	11,000	15,000	11,000 cfs plus 50% of the amount over 11,000 cfs	9,000	15,000	9,000 cfs plus 40% of the amount over 9,000 cfs	
17,000	20,000	16,400 cfs plus 50% of the amount over 17,000 cfs	15,000	20,000	13,000 cfs plus 35% of the amount over 15,000 cfs	15,000	20,000	11,400 cfs plus 20% of the amount over 15,000 cfs	
20,000	No limit	17,900 cfs plus 20% of the amount over 20,000 cfs	20,000	No limit	14,750 cfs plus 20% of the amount over 20,000 cfs	20,000	No limit	12,400 cfs plus 0% of the amount over 20,000 cfs	

Table 5A-B.11. Post-Pulse Bypass Flow Rules and Bypass Flow Rules During July Through November for the North Delta Diversion (continued)

Level 1 Post-Pulse Operations			Level 2 Post-Pulse Operations			Level 3 Post-Pulse Operations		
Sacramento at Freeport (cfs)		Bypass Flow (cfs)	Sacramento at Freeport (cfs)		Bypass Flow (cfs) Above	Sacramento at Freeport (cfs)		Bypass Flow (cfs)
Above	Below		Above	Below		Above	Below	
June								
0	5,000	100% of the amount over 0 cfs	0	5,000	100% of the amount over 0 cfs	0	5,000	100% of the amount over 0 cfs
5,000	15,000	Flows remaining after constant low-level pumping	5,000	11,000	Flows remaining after constant low-level pumping	5,000	9,000	Flows remaining after constant low-level pumping
15,000	17,000	15,000 cfs plus 60% of the amount over 15,000 cfs	11,000	15,000	11,000 cfs plus 40% of the amount over 11,000 cfs	9,000	15,000	9,000 cfs plus 30% of the amount over 9,000 cfs
17,000	20,000	16,200 cfs plus 40% of the amount over 17,000 cfs	15,000	20,000	12,600 cfs plus 20% of the amount over 15,000 cfs	15,000	20,000	10,800 cfs plus 20% of the amount over 15,000 cfs
20,000	No limit	17,400 cfs plus 20% of the amount over 20,000 cfs	20,000	No limit	13,600 cfs plus 20% of the amount over 20,000 cfs	20,000	No limit	11,800 cfs plus 0% of the amount over 20,000 cfs
July–September								
Sacramento at Freeport (cfs)						Bypass Flow (cfs)		
Above			Below					
0			5,000			100% of the amount over 0 cfs		
5,000			No limit			A minimum of 5,000 cfs		
October–November								
0			7,000 cfs			100% of the amount over 0 cfs		
7,000			No limit			A minimum of 7,000 cfs		

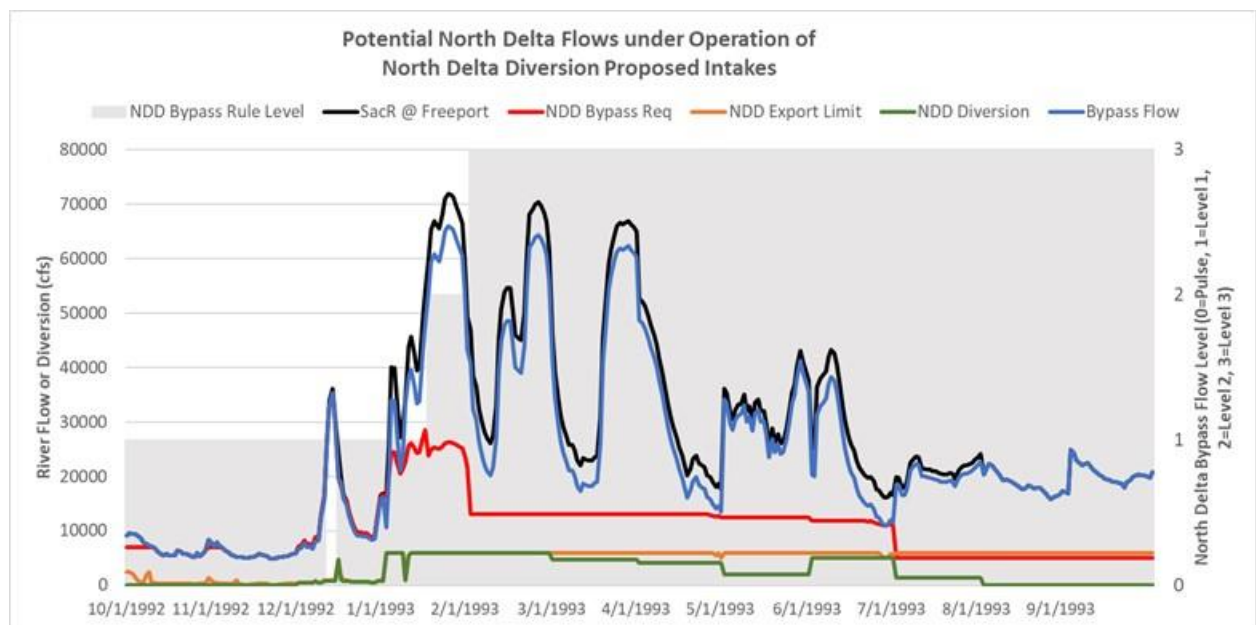
Bypass flow rules are implemented in CalSim 3 as follows: beginning October 1, whenever the initial Sacramento River pulse flow begins, low level pumping allows diversions of up to 6% of Sacramento River flow upstream from the north Delta intakes, but not more than 900 cfs. The low-level pumping is also constrained such that the river flow below the intakes never falls below 5,000 cfs.

During the initial pulse protection period, low level pumping is maintained until the pulse period has ended. For modeling purposes, the initiation of the pulse is defined by the following criteria: (1) increase in flow of the Sacramento River at Wilkins Slough by more than 45% within a 5-day period, and (2) Sacramento River flow at Wilkins Slough flow becomes greater than 12,000 cfs. The pulse protection and the low-level pumping continues until (1) Wilkins Slough returns to pre-pulse flows, (2) Wilkins Slough flows decrease for 5 consecutive days, or (3) bypass flows are greater than 20,000 cfs for 10 consecutive days. If the initial pulse begins and ends before December 1, the October–November criteria will go into effect after the pulse until December 1. On December 1, the

post-pulse rules defined below for December through April, starting with Level 1 apply. If the initial pulse begins and ends before December 1 a second pulse period will be afforded the same protective operation.

After the pulse period has ended, the bypass flows noted in the Table 5.A-B.11 are maintained. After the initial pulse(s), Level 1 post-pulse bypass rules are applied until 15 days of bypass flows above 20,000 cfs have accrued since the pulse ended. Then Level 2 post-pulse bypass rules are applied until 30 days of bypass flows above 20,000 cfs have accrued since the pulse ended. Subsequently, Level 3 post-pulse bypass rules are applied. The bypass rules were applied on the mean daily river flows in the CalSim 3 model. Under the post-pulse operations allowable diversion will be the greater of the low-level pumping or the diversion allowed by the post-pulse bypass flow rules. In actual operations these criteria as well as fishery conditions are expected to guide allowable north Delta intake diversions.

An example of the north Delta flows and diversion is illustrated in Figure 5A-B.3. As presented in this figure, bypass rules begin at Level 1 in October until the Sacramento River pulse occurs (around December 10 in Figure 5A-B.3). During the pulse flow, low-level pumping (Level 0) is permitted, but is limited to 6% of river flow. Following the pulse protection, the bypass flow requirements transitions to Level 1 post-pulse criteria (around December 20 in Figure 5A-B.3). After sustained high flows, the bypass flow requirements transitions to Level 2 (in third week of January in Figure 5A-B.3) and eventually to Level 3 (around February 1 in Figure 5A-B.3), which permit greater potential diversion.



Note: A text description of this figure is provided in Chapter 39, *Description of Figures*.

Note: grey shading indicates active bypass rule (0=pulse/low level pumping, 1=level 1, 2=level 2, and 3=level 3).

Figure 5A-B.3. Example Year Daily Patterns and Operation of the North Delta Intakes

Incorporation of Sacramento River Daily Flow Variability

Operational Considerations

The operation of the proposed north Delta intakes is sensitive to the daily variability of Sacramento River flows, as bypass flow requirements that are described in the previous section also vary on a daily basis. Short duration, highly variable storms may permit significant diversion but only for a short period of time. Similar considerations apply to the operation of the Fremont and Sacramento weirs, where daily short duration storms can cause spills that may not be identified in model calculations based on a monthly average flow rate. Initial comparisons of monthly versus daily operations at these facilities indicated that diversion potential was likely overstated and weir spills were likely underestimated using a monthly timestep.

Figure 5A-B.4 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 5A-B.5 presents the daily historical Sacramento River flow patterns at Freeport averaged by water year type. It shows that daily variability is significant in the winter-spring while the summer flows are relatively constant in most water year types. Individual water years may show even more variability. The winter-spring daily variability is considered important to species of concern.

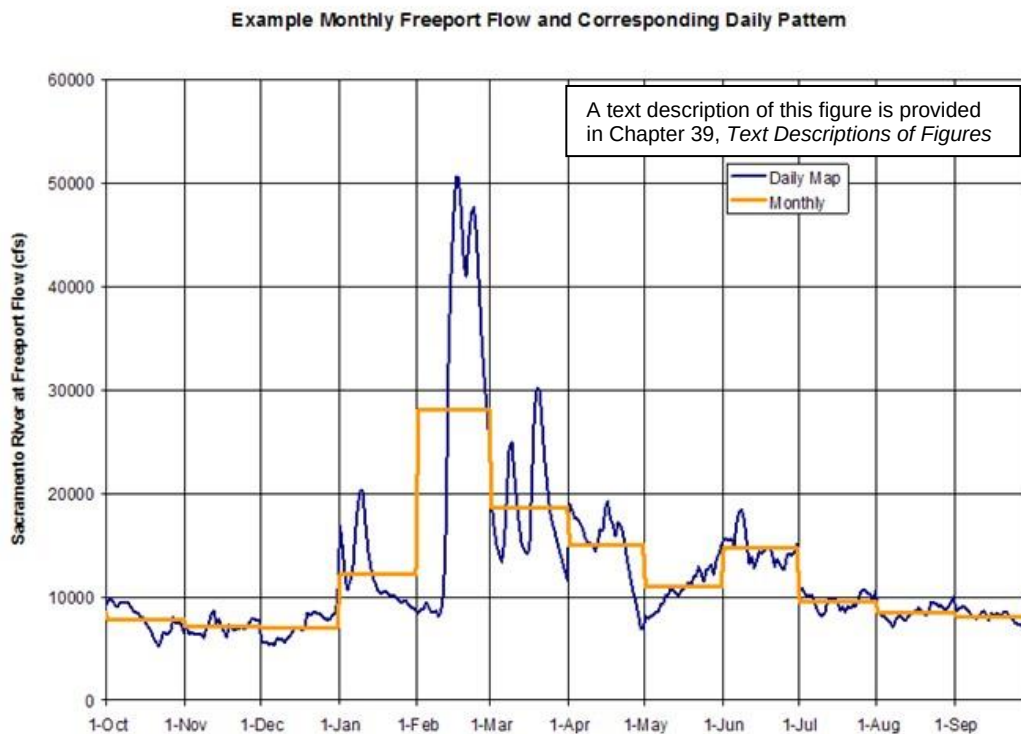


Figure 5A-B.4. Monthly Averaged and Daily Averaged Flow for Sacramento River at Freeport

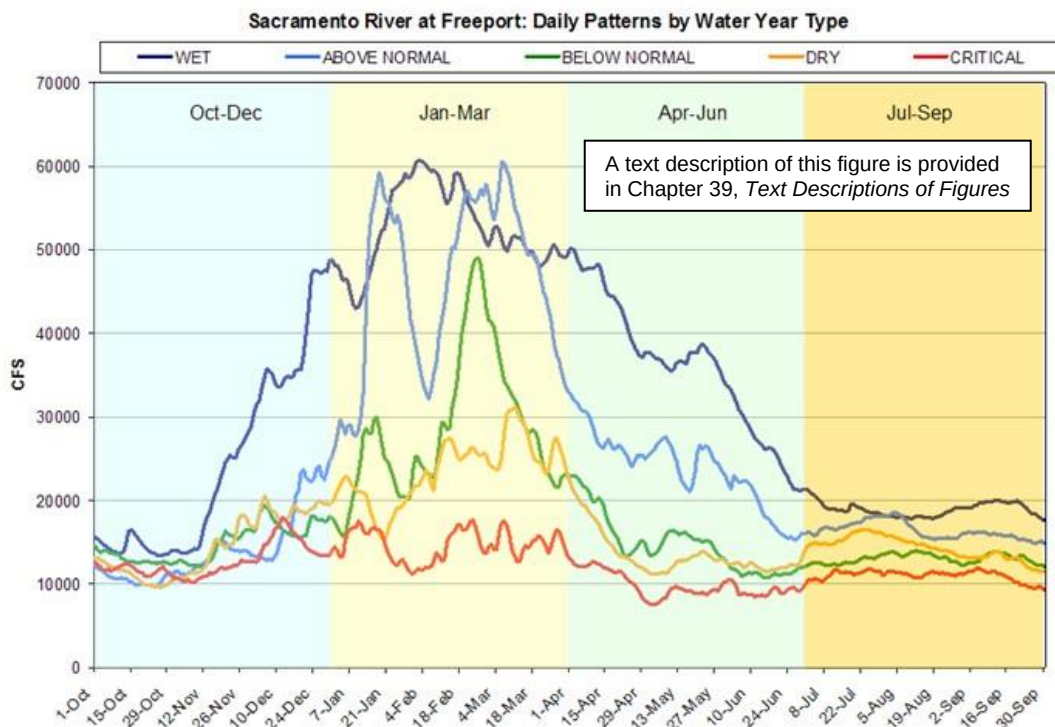


Figure 5A-B.5. Mean Daily Flows by Water Year Type for Sacramento River at Freeport

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 3 for simulated operation of 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. In all cases, the monthly volumes are preserved between the daily and monthly flows. This daily mapping approach does not necessarily represent the flows resulting from future operational responses on a daily timestep. It is simply a technique to incorporate representative daily variability into the flows resulting from CalSim 3's monthly operational decisions. The technique helps refine monthly CalSim 3 operations by providing a better estimate of the Fremont and Sacramento weir spills, which are sensitive to the daily flow patterns, and a better estimate of bypass flow requirements at the north Delta diversion.

Daily Patterning Procedure

CalSim 3 hydrology is derived from historical monthly gaged flows for WY 1922–2015. Daily flow patterns from the Sacramento River gage near Freeport (USGS 11447650) were used to map CalSim 3 monthly flow volumes to daily flows for WY 1949–2015. These data were extracted from DayFlow. Because daily data are not available before 1949¹⁸, for WY 1922–1948, daily patterns were selected

¹⁸ Flow measurements date back to 1879. Historical flows are reported in Bulletin 23, starting 1924. The Sacramento River gage has been sited at various locations in the vicinity of the I-Street Bridge. Between November 1956 and September 1979, the gage was located on the left bank, 1,000 feet upstream from the I-Street Bridge, approximately 0.5 miles downstream from the mouth of the American River. Beginning October 1979, the Sacramento River gage was relocated downstream and renamed Sacramento River at Freeport (USGS 11447650).

1 from the DayFlow dataset for water years 1956 to 2003 based on similar total annual Delta inflow.
2 Despite including the historical operational responses to varying regulatory regimes that existed
3 over these periods, the daily flow patterns should still be valid because in most winter and spring
4 periods reservoir operations and releases are governed by the inflows to the reservoirs. The daily
5 pattern for these pre-1949 water years was assumed to be the same as the daily pattern of the
6 identified DayFlow water year. Correlation among the various hydrologic basins is preserved by
7 using the same water year for all rivers flowing into the Delta, for a given year in the 1922–1948
8 period. Table 5A-B.12 lists the selected DayFlow water years used for WY 1922–1948 along with the
9 total unimpaired annual Delta inflow.

10 Thus, for each month in the 94-year CalSim 3 simulation, the monthly flow volume is mapped onto a
11 daily pattern for computing spills over the Fremont Weir and Sacramento Weir and for computing
12 water available for diversions through the north Delta intakes. A preprocessed timeseries of daily
13 volume fractions (the day's volume as a fraction of the month's volume), based on the datasets
14 described above, was input into CalSim 3. The monthly volume as determined dynamically from
15 CalSim 3 is multiplied by the fractions to determine a daily flow sequence. The calculation of daily
16 spills and daily diversions are thus obtained. In the subsequent cycle (but still the same month),
17 adjustments are made to the daily river flow upstream of the Sacramento Weir and the north Delta
18 intakes to account for differences between the monthly flows assumed in the first cycle and the daily
19 flows calculated in subsequent cycles. For example, if no spill over the Fremont Weir was simulated
20 using a monthly flow, but when applying a daily pattern spill does occur, then the Sacramento River
21 flow above the Sacramento Weir is reduced by this amount. In this fashion, daily balance and
22 monthly balance is preserved while adding more realism to the operation of these facilities.

1 **Table 5A-B.12. Pattern Water Year for Water Years 1922 to 1948**

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

2 Key: TAF = thousand acre-feet

3

Integration with South Delta Facilities

In model simulation of project alternatives, the north Delta intakes operate in conjunction with the existing south Delta export facilities, according to the following operational rules:

- During the winter and spring, at times when the Delta is in excess conditions:
 - South Delta exports are maximized up to that permitted under the 2019 BiOps Biological Opinions and 2020 ITP.
 - North Delta intakes are used to capture additional excess flows when south Delta exports are limited by physical or regulatory constraints and not able to capture these flows.
- Shifting of exports from the south Delta intakes to the proposed north Delta intakes only occurs when there is an operational advantage to doing so in terms of carriage water savings.¹⁹ Carriage water benefits of these operations are split between the SWP and CVP according to COA, with priority placed on exporting this water. Any carriage water savings that cannot be exported are backed up into north of Delta storage.
- From July through September south Delta exports are not allowed to decrease below 3,000 cfs due to shifting, to prevent degradation of south Delta water quality.
- For the SWP only, releases of up to 100 TAF/year can be made from Lake Oroville in wetter years for diversion at the north Delta intakes from July through September.
- The CVP has access to the north Delta intakes in Alternatives 2a/4a but is restricted to using its north Delta intake capacity to months when the SWP is not subject to ITP export cuts and/or restrictions.

The operational rules above result in months when simulated diversions through the proposed north Delta intakes are not maximized even when the bypass flow requirements would allow greater diversions.

Wheeling and Sharing of North Delta Diversion Capacity

Wheeling refers to the use of one agency's facilities to convey another agency's water using available or unused capacity. In all model simulations, wheeling of CVP water through the north Delta intake is not allowed. Conveyance of CVP water through the proposed north Delta intakes is not allowed, except under Alternative 2a/4a.

In Alternatives 2a/4a, sharing of north Delta intake capacity between the SWP and CVP, when the north Delta intakes cannot be used to their full physical capacity because of regulatory restrictions, is simulated as follows:

- When the D-1641 export/import ratio controls total exports, the north Delta intake regulatory capacity is divided according to the appropriate COA sharing formula (60% CVP/40% SWP under Delta excess conditions, 65% CVP/35% SWP under Delta balanced conditions), but with the CVP constrained to its physical limit of 1,500 cfs.

¹⁹ Carriage water refers to the additional Delta outflow required to maintain Delta water quality for an additional unit of export at south Delta facilities and offset the degradation to water quality. Carriage water costs (or savings) occur when compliance with D-1641 water quality objectives is controlling Delta operations.

- When bypass flow criteria are controlling, available north Delta intake capacity is divided according to each project's share of the physical diversion capacity (i.e., 80% SWP/ 20% CVP).
- When one project cannot use or makes the operational choice not to use its share of regulatory capacity under either of the cases above, the other project will be able to use that capacity instead, without exceeding their respective physical limits (6,000 cfs SWP and 1,500 cfs CVP).

B.8 Model Implementation

All CalSim 3 simulations for the EIR are conducted using a single set of files for all operational logic. Simulation of the baselines (existing conditions, No Project Alternative) and project alternatives were implemented as follows:

- Separate HEC-DSS input files of timeseries data were accessed to represent existing (2020) or future (2040) conditions.
- A single HEC-DSS file was accessed to define initial conditions for the first month of simulation (e.g., surface water storage, previous months Delta flows, groundwater elevations).
- A single set of input WRESL files were accessed for simulating existing conditions and No Project Alternative; a level of development "flag", set to a value of zero or one, is used to select either existing or future regulatory, contract, and water use assumptions within these files.
- One of two ANNs was selected to represent Delta flow-salinity relationships under either current (0 centimeter) or future sea level (55 centimeter) assumptions.
- Distinct input tables were selected to define operations of the north Delta intakes for the alternatives. These tables contain settings to turn on the north Delta intake operation, define water sources for the north Delta diversion (i.e., Delta excess outflow, shifting diversions from the South Delta, and upstream storage releases), and adjust the physical capacity of the north Delta intakes for use by the SWP and CVP.
- Distinct input tables were selected to define allocation procedures under each alternative: separate WSI-DI curves were developed for existing conditions and the No Project Alternative for both the SWP and CVP. For the project alternatives, WSI-DI curves were recomputed only for the SWP. CVP WSI-DI curves were kept the same as the baseline to prevent unintended impacts of slight shifts in the curves. Finally, a table containing SWP export capacity was adjusted for the project alternatives.
- For the Bethany alternative (Alternative 5), WRESL code was modified so that north Delta diversions were not constrained by capacity limits at Banks Pumping Plant, which no longer apply because this alternative includes a new pumping plant located near the community of Mountain House to convey water directly to Bethany Reservoir.²⁰
- Under future (2040) conditions, further adjustments were made to the model logic and tables defining CVP allocations and reservoir operating rules to adapt that project operations to the effects of climate change.

²⁰ Bethany Reservoir, located on the California Aqueduct, acts as a forebay for the South Bay Pumping Plant (the start of the South Bay Aqueduct), and an afterbay for Banks Pumping Plant.

B.9 Linkage to Other Models

Delta boundary flows and salinity from CalSim 3 are used as input to DSM2 (described in Section C of the Modeling Technical Appendix, *One-Dimensional Delta Hydrodynamics and Water Quality Modeling*) to compute stage and velocity in Delta channels and Delta water quality (EC)²¹.

The reservoir and river water temperature models described in Section D of the Modeling Technical Appendix, *Water Temperature Modeling*, and the fishery models described in Section E of the Modeling Technical Appendix, *SALMOD and Egg Mortality Models*, require inputs for meteorological conditions, reservoir storage, reservoir releases, tributary inflows, and channel morphology. The output from the reservoir and river water temperature models are used to evaluate compliance performance for water temperature requirements (and potential refinement of simulated project operation in CalSim 3). Water temperature model outputs are used in the biological assessments of salmonid mortality.

B.10 Model Limitations

CalSim 3 is a monthly model developed for planning level analyses. For existing conditions, the model is run using historical observed or reconstructed unimpaired runoff,²² but with 2020 level water demands, facilities, regulations, and operations criteria. Output from the 94-year simulation does not provide information about historical conditions, but does provide information about storage, flow, and water deliveries that could occur under the historical weather sequence. Similarly, the No Project Alternative (2040) model provides information about storage, flow, and water deliveries that would occur under a repeat of the historical weather sequence transformed for (a) climate change and (b) operations of water management facilities to account for sea level rise, changes in land use and population, and associated water demands and water use.

B.10.1 Climate Change Under Existing Conditions

The inflow hydrology for the existing conditions model is based on assumptions of stationarity. However, while there has been no obvious trend in total water year runoff into the Sacramento and San Joaquin Rivers, there have been changes in the timing of that runoff. The fraction of snowmelt runoff between April and July relative to total year-round water runoff has declined over the past century (California Department of Water Resources 2022b). Additionally, as the climate continues to warm it is expected to increase variability in precipitation.

B.10.2 Calibration and Validation

Because CalSim 3 is partly a physically-based model and partly a management model, the model cannot be fully calibrated and cannot be used in a predictive manner.

²¹ Salinity is generally defined as the amount of salt dissolved in a given unit volume of water. It is variously measured in units of electrical conductivity (EC), total dissolved solids (TDS), and practical salinity units (psu), EC is a measure of the ability of water to conduct an electrical current.

²² On the valley floor, rainfall runoff is determined based on historical climate but 2020 land use.

B.10.3 Relaxation of Regulatory Requirements

CalSim 3 makes storage release decisions and routes water through the stream network, based on a set of pre-defined rules that represent existing or future assumed regulations and operations criteria. These pre-defined rules do not include temporary relaxation of non-discretionary regulatory requirements such as occurred in 2014 and 2015 as a result of Temporary Urgency Change Petitions submitted to the State Water Board.

B.10.4 Monthly Timestep

Simulated operational decisions in CalSim 3 are made on a monthly timestep. While there are certain components of the model that are downscaled to a daily timestep, such as north Delta diversion bypass flows, the results of those daily conditions are always averaged to a monthly timestep. For example, a certain number of days with and without the action is calculated and the monthly result is calculated using a day-weighted average based on the total number of days in that month. Operational decisions based on those components are again made on a monthly basis.

Use of CalSim 3 results to provide information at a sub-monthly timescale should include disaggregation methods that are appropriate for the given application, report, or subsequent model and recognize that the CalSim 3 operational decisions are always on a monthly timestep.

B.10.5 Extreme Conditions

Despite detailed model inputs and assumptions, CalSim 3 results differ from real-time operations under stressed water supply conditions caused by drought. The model cannot represent the unique real-time policy decisions that SWP and CVP operators make in consultation with regulatory agencies under extreme circumstances and that deviate from standard operating policies. Model results that indicate severely low reservoir storage, or inability to meet flow requirements or senior water rights, should be considered an indicator of stressed water supply conditions under that alternative and should not necessarily be understood to reflect literally what would occur under that alternative. These simulated conditions (e.g., low storage), in real-time operations would be avoided by making policy decisions on other requirements in prior months. In actual 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 the extreme conditions.

Frequency of extreme conditions is expected to increase in the future under the combined effects of climate change and sea level rise.

B.10.6 Regulatory Uncertainty

Continuing evolution of the regulatory environment makes the long-term planning of SWP and CVP operations challenging. CalSim 3 assumes the full implementation of the operational actions of the State Water Board Decision-1641, the 2019 USFWS and NMFS BiOps for the long-term operation of the CVP and SWP, and 2020 CDFW ITP for long-term operations of the SWP in the Delta. These regulations are likely to evolve under future reconsultations and in the face of climate change.

B.10.7 Delta Salinity Compliance

CalSim 3 simulates Delta flows for a set of regulatory and operational criteria, including salinity standards, using a monthly timestep. CalSim 3 relies on the ANN, described above, for monthly averaged flow versus salinity relationships in the Delta. ANN emulates flow-salinity relationships derived from DSM2 for a given Delta channel configuration and sea level rise condition.

DSM2 application for analyzing existing conditions and project alternatives uses the monthly CalSim 3 Delta inflows and diversions and exports results and simulates Delta hydrodynamics and salinity from the water year 1922 to water year 2015, on a 15-minute timestep. Boundary conditions assumed in DSM2 modeling are based on monthly CalSim 3 outputs. The DSM2 inflows do not represent any sub-monthly operational adjustments that could occur to address any potential issues with salinity control in the Delta.

Monthly CalSim 3 salinity outputs and daily averaged salinity outputs from DSM2 simulations were used to evaluate compliance with D-1641 salinity requirements. CalSim 3 and DSM2 model results presented in this Modeling Technical Appendix may indicate several exceedances of D-1641 salinity standards. These exceedances result from limitations in the modeling process. In actual operations, DWR and Reclamation staff constantly monitor Delta water quality conditions and adjust operations of the SWP and CVP in real time, as necessary, to meet water quality objectives. These decisions are based on real-time conditions and many factors that the best available management models cannot represent or simulate. Under extreme conditions, negotiations, consultations with the State Water Board would occur in order to balance needs of protected resources, beneficial uses, and water rights. Such decisions under extreme conditions cannot be modeled.

Model limitations relating to Delta salinity include using a monthly timestep to model partial month salinity standards and operations under extreme conditions whereby project reservoirs may drop below dead storage.

Partial Month Salinity Standards

In CalSim 3, the reservoirs and facilities of the SWP and CVP are operated to comply with regulatory flow and Delta water quality requirements. Meeting regulatory requirements, including Delta water quality objectives, is one of the highest operational priorities in the model.

Because CalSim 3 is a monthly timestep model and a number of daily D-1641 salinity standards are active during only portions of a month (e.g., April 1–June 20 and June 20–August 15), D-1641 standards are represented as a monthly weighted average in the model. The model attempts to meet these objectives on a monthly average basis, even though the objectives themselves are often transitioning within a month from one value to the other and may start or end in the middle of a month. When the monthly weighted average standards calculated for CalSim 3 are less stringent than the daily D-1641 EC standards, CalSim 3 adjusts SWP and CVP operations to release less flow to meet monthly weighted average EC standards instead of the flow needed to meet higher daily D-1641 EC standards. Therefore, within the months where the salinity standard is transitioning, there may be days where DSM2 inflows are less than the required flow to comply with the salinity standard, and more flow on other days. This results in a few days within such months where the modeled salinity exceeds the compliance standard. Importantly, however, in reality the SWP and CVP operations will be adjusted on day-to-day basis to meet the Delta standards.

Low Reservoir Storage

Under extremely dry conditions, existing obligations and non-discretionary requirements of the SWP, CVP, and other local projects may result in periods when reservoirs levels fall below the top of the inactive zone, or “dead pool” (i.e., reservoir storage is at or below the elevation of the lowest outlet). Under such extreme conditions, simulated flows may fall short of minimum flow criteria, Delta salinities may exceed standards, diversions may fall short of allocated amounts, and operating agreements may not be met in CalSim 3 simulations. Drawdown of reservoirs to dead storage is used in the model to indicate severe water stress and an imbalance between water supply and water demand. Under these conditions, CalSim 3 results do not represent what would occur in the real world in which emergency actions would be implemented.

B.11 Appropriate Use of Model Results

A planning analysis is conducted to understand long-term changes in the water resources of the Central Valley caused by changes in facilities, to facility operations, or the physical system (e.g., climate change, land-use). The models developed and applied in a planning analysis are generalized and simplified representations of an extremely complex water resources system. Even so, the models used are informative and helpful in understanding the performance and potential effects (both positive and negative) of the operation of a proposed project and its interaction with the water resources system under consideration.

Modeling conducted to evaluate existing conditions, proposed project, and project alternatives (including the No Project Alternative) are planning-level analyses.

Some of the models used in the analysis presented in the EIR, such as DSM2, are calibrated and validated to represent physical processes for a given set of observed or historical boundary conditions. In such a case, the accuracy and precision of the model can be quantified. DSM2 simulations undertaken in support of the EIR are based on boundary conditions derived from CalSim 3, a generalized system model. Therefore, for this particular application, DSM2 results only represent generalized long-term trends. The level of confidence, in the results of any well calibrated predictive model is only as good as the level of confidence in the input boundary conditions used. Given the limitations of the planning analysis, a brief description of appropriate use of the model results to compare two scenarios or to compare against threshold values or standards is presented in this section below.

B.11.1 Absolute Versus Relative Analysis

Models used in a planning analysis are not designed to be predictive in nature and, therefore, the results cannot be considered as absolute with a quantifiable confidence interval. Because CalSim 3 relies on generalized rules, a coarse representation of project operations, and no specific operations in response to extreme events, results should not be expected to reflect what operators might do in real time operations on a specific day, month, or year within the simulation period. In reality, the operators would be informed by numerous real-time considerations not represented in CalSim 3, such as salinity monitoring.

CalSim 3 should be used as a comparative tool to assess relative changes between two simulations, e.g., an existing conditions simulation compared to a project alternative simulation. Model results

are only useful in a comparative analysis and can only serve as an indicator of conditions (e.g., water supply reliability) and of trend or tendency (e.g., generalized impacts).

B.11.2 Model Precision in a Relative Analysis

Even with comparative analysis, model uncertainty and its influence on model results presented in the EIR cannot be completely avoided. In addition to showing the potential effects of the project being analyzed, differences between two scenarios can sometimes include the unintended effects of model uncertainty. While no exact quantification of model uncertainty is available, DWR believes that CalSim 3 comparative results are subject to uncertainty that is within 5% and likely much lower. Therefore, the appropriate inference from a difference in modeling results that is less than 5% is likely null, unless there is additional evidence from detailed examination to suggest otherwise. Throughout the use of CalSim 3 and its predecessors, other rule-of-thumb criteria have generally been used for considering the potential significance of an observed difference in modeling results from a comparative analysis. For example, observed changes in monthly flow and/or storage of less than 10 TAF are generally considered null. It should be understood that 5% and 10 TAF are given here as examples, and that the appropriate criteria to be used will vary depending on the exact impact being analyzed.

B.11.3 Appropriate Reporting Timestep

All CalSim 3 model results should be reported on a monthly or annual basis, which is consistent with the model timestep.

B.11.4 Appropriate Reporting Locations

Because of assumptions involved in the preparation of input data and development of model logic, care must be taken to select the most appropriate locations for reporting CalSim 3 results. CalSim 3 is based on a simplified spatial representation of the Central Valley's water resources with lumped representation of inflows and outflows to and from the stream network. Rainfall-runoff and stream-groundwater interaction are aggregated to specific nodes along a river reach. Diversions and return flows are similarly aggregated. Reporting of model results inconsistent with the spatial representation or resolution of the model is inappropriate. In general, reporting of model results should correspond to reservoir releases, compliance locations for regulatory flow requirements, or flows at stream gages, where the model developers have strived for consistency with real-world flows.

B.11.5 Statistical Comparisons are Preferred

Use of absolute differences computed at a point in time between model results from an alternative and a baseline to evaluate potential impacts is an inappropriate use of model results (e.g., calculating differences between the results from a baseline and an alternative for a particular month and year within the period of simulation). Statistics based on the absolute differences at a point in time (e.g., maximum of monthly differences) are an inappropriate use of model results. By computing the absolute differences in this way, an analysis disregards the changes in antecedent conditions between individual scenarios and distorts the evaluation of impacts of a specific action or project.

Reporting seasonal patterns from long-term averages and water year type averages is an appropriate use of model results. Statistics based on long-term and water year type averages are an appropriate use of model results. Computing differences between long-term or water year type averages of model results from two scenarios is appropriate. Care should be taken to use the appropriate water year type for presenting water year type average statistics of model results (e.g., D-1641 Sacramento Valley Water Year Hydrologic Classification River 40-30-30 or San Joaquin Valley Water Year Hydrologic Classification River 60-20-20, and with or without climate modified conditions).

B.11.6 Model Output Metrics

The most appropriate presentation of monthly and annual model results is in the form of probability distributions and comparisons of probability distributions (e.g., cumulative probabilities). If necessary, comparisons of model results against threshold or standard values should be limited to comparisons based on cumulative probability distributions.

Appropriate formats to present model results include the following:

- Long-term and water-year-type summary tables and charts showing monthly and/or annual statistics derived from the model results for the entire period of simulation (94 years).
- Cumulative exceedance probability of monthly and/or annual model results shown only by rank/order or only by probability statistic.
- Comparative statistics based on these two types of presentations are generally acceptable.

B.12 Presentation of Results

CalSim 3 results are included in the Modeling Technical Appendix, Section B, Attachment 3, *CalSim 3 Model Results for Existing Condition and Alternatives at 2020*, and in Attachment 5 *CalSim 3 Model Results for No Project Alternative*.

In Attachment 3, model results for the project alternatives under 2020 conditions Proposed Project and Project Alternatives are compared to existing conditions. Additionally, model results for the No Project Alternative (2040) are compared to existing conditions.

In Attachment 5, model results for the project alternatives under 2040 conditions are compared to the No Project Alternative (2040).

Results for each model simulation are presented in a series of tables and charts for various metrics grouped into categories, as follows:

- Reservoir storage
- Streamflow
- Delta channel flows
- X2 location
- SWP and CVP Delta exports

- SWP and CVP contract deliveries

For each category, monthly tables compare exceedance values, long-term average values, and average values by water year type. Monthly pattern charts compare long-term average values and average values by water year type. Exceedance charts compare results by month.

CalSim 3 dynamically computes water year types based on simulated runoff to date and forecasts of future inflows. Water year types may vary from the initial forecast made in February through to May when the final forecast of water year type is made. Water year types also may vary between existing conditions and future (2040) conditions. For the presentation of results, water year type refers to the Sacramento Valley 40-30-30 hydrologic classification as defined in D-1641 (State Water Resources Control Board 2000: 188) and as computed in CalSim 3 for the month of May under existing conditions.

In general, annual values for flows and deliveries are computed from October 1 through September 30. However, SWP deliveries to its long-term water contractors are presented by SWP contract year (January–December), unless otherwise noted and CVP deliveries to its contractors are presented by CVP contract year (March–February), unless otherwise noted.

As discussed in the previous section, results from a comparative analysis may show minor differences in simulated flows and storage that are not the result of the project alternative but are caused by limitations of representing a very complex water resources system in a mathematical model.

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