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The State Water Project Delivery Reliability Report 2009

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Foreword

The 2009 State Water Project (SWP) Delivery Reliability Report is a bi-annual report on the current and future for SWP water supply conditions, if no significant improvements are made to convey water past the Delta or to store the more-variable run-off that is expected with climate change.

The report shows a continuing erosion of the ability of the SWP to deliver water. For current conditions, the dominant factor for these reductions is the restrictive operational requirements contained in the federal biological opinions. For future conditions, it is these requirements and the forecasted effects of climate change.

Deliveries estimated for the 2009 Report are reduced by the operational restrictions of the biological opinions issued by the U.S. Fish and Wildlife Service in December 2008 and the National Marine Fisheries Service in June 2009 governing the SWP and Central Valley Project operations. The 2007 Report incorporates the interim, and less restrictive, operation rules established by federal Judge Wanger in 2007. The 2005 Report is based upon much less restrictive operational rules contained in the biological opinions issued in 2005.

To illustrate the effect, the median value estimated for the primary component of SWP annual deliveries (Table A) for current conditions in the 2005 Report is 3,170 thousand acre-feet (taf). In the 2007 Report it is 2,980 taf, and in the 2009 Report, it is 2,680 taf. This is an overall reduction of almost 500 taf.

The studies used in this series of reports to estimate future deliveries now also include the potential effects of climate change. The studies for the 2005 report did not include any of these potential effects. For the 2007 report, the changes in run-off patterns and amounts were incorporated into the analyses. For the 2009 studies, the changes in run-off patterns and amounts are included along with a potential rise in sea level. Sea level rise has the potential to require more water to be released to repel salinity from entering the Delta in order to meet the water quality objectives established for the Delta.

The effect of the operational restrictions in addition to the incorporation of potential climate changes impacts amounts to an estimated reduction of 970 taf when the median value for annual SWP deliveries for future conditions in the 2005 report (3,570 taf) is compared to the updated value in the 2009 Report (2,600 taf).

The 2009 Report compares the updated values to those contained in the 2007 Report and provides greater detail on the analytical method used to calculate the estimates. The results of the studies are designed to assist water planners and managers in updating their water management and infrastructure development plans. These results emphasize the need for local agencies to develop a resilient and robust water supply, and a distribution and management system to maximize the efficient use of our variable supply. They also illustrate urgent need to improve the method of conveying water past the Delta in a more sustainable manner that meets the dual goals of increasing water supply reliability and improving the conditions for endangered and threatened fish species.

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Introduction

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The SWP is primarily a water storage and delivery system intended to help close the gap in California between when and where precipitation primarily falls and when and where most water demands occur. Water from the SWP is a critical component of water supply for the 29 state water contractors, who may also receive water from other sources. While each of the water supply contracts defines the maximum amount of water to be delivered annually, the amount of water actually delivered may be less due to such factors as variable precipitation and runoff, physical and institutional limits on storage and conveyance, and contractors' variable water demands. For communities receiving SWP water, the reliability of SWP water deliveries is a key factor for local planners and government officials estimating their own water supply reliability.

The *2009 SWP Delivery Reliability Report* updates the information contained in the 2007 Report by estimating the amounts of water deliveries for current (2009) conditions and conditions twenty years in the future. These estimates incorporate restrictions on SWP and Central Valley Project (CVP) operations in accordance with the biological opinions of the U.S. Fish and Wildlife Service (USFWS) and National Marine Fishery Service (NMFS) issued on Dec. 15, 2008 and June 4, 2009, respectively. The estimates for future conditions also incorporate potential changes in hydrology due to climate change projections recommended by the Climate Action Team and sea level rise.

This report briefly describes the SWP and the Sacramento-San Joaquin Delta (Delta), the hub of water deliveries in California. It discusses the general topic of water delivery reliability and how Department of Water Resources (DWR) calculates delivery reliability for the SWP. It then summarizes key planning activities that may affect future SWP delivery reliability. Three areas of significant uncertainty for SWP delivery reliability are discussed. They are climate change and sea level rise, the vulnerability of Delta levees to failure, and operation restrictions imposed by the USFWS and NMFS in response to decreasing populations of endangered fish species. Next, the general approach taken to simulate SWP operations using CALSIM II is discussed.

The report presents the results of CALSIM II studies and compares them to previous estimates. Finally, the report provides guidance on how to apply the delivery estimates to water management plans. Presented in appendices are detailed CALSIM II simulation assumptions and results and recent SWP deliveries.

This report does not include analyses of how specific water agencies should integrate SWP water supply into their water supply equation. This topic requires extensive information about local facilities, local water resources, and local water use, which is beyond the scope of this report. Moreover, such an analysis would require decisions about water supply and use that traditionally have been made locally. DWR believes that local officials should continue to fill this role.

Background

Purpose

This report is intended to help local agencies, cities, and counties that use SWP water to develop adequate and affordable water supplies for their communities now and in the future. A water management plan, such as the Urban Water Management Plans required by Water Code Sections 10610-10656, is usually prepared by these entities to help them responsibly manage and develop their water supplies. The information in this report can be used by local agencies in preparing or amending their water management plans and identifying the new facilities or programs that may be necessary to meet future water demands. Local agencies and governments will also find in this report useful information for conducting analyses mandated by laws requiring water retailers to demonstrate whether their water supplies are sufficient for certain proposed subdivisions and development projects subject to the California Environmental Quality Act.

November 2009 legislative changes (Senate Bill X7.7, Steinberg) has amended and repealed some sections of the Water Code and may affect the reporting requirements under the Urban Water Management Planning Act and other government codes. DWR has a program to assist urban water suppliers in meeting the requirements of the Act. Program staff assists urban water suppliers with preparing comprehensive and useful water management plans, implementing water conservation programs, and understanding the requirements of the Act. The next cycle of Plans (2010) is due July 1, 2011. It is expected that the 2010 UWMP Guidebook will be available in late 2010. Information on Urban Water Management Plans (UWMP) is posted at http://www.water.ca.gov/urbanwatermanagement/. Any changes in the UWMP Act between now and 2011 will also be posted at this site.

Reporting Requirements

As a result of a court-approved settlement agreement executed by the Planning and Conservation League, DWR, state water contractors and other entities in the wake of the 3rd Circuit Court of Appeals ruling in the "Monterey Amendments" case in 2000, DWR has a legal duty to prepare SWP delivery reliability reports every two years. In that agreement, DWR committed to the following:

> Commencing in 2003, and every two years thereafter, the Department of Water Resources (DWR) shall prepare and deliver to all State Water Project (SWP) contractors, all city and county planning departments, and all regional and metropolitan planning departments within the project service area a report which accurately sets forth, under a range of hydrologic conditions, the then existing overall delivery capability of the project facilities and the allocation of that capacity to each contractor. The range of hydrologic conditions shall include the historic extended dry cycle and long-term average. The biennial report shall also disclose, for each of the ten years immediately preceding the report, the total amount of project water delivered and the amount of project water delivered to each contractor. The information presented in each report shall be presented in a manner readily understandable by the public. (Settlement Agreement Attachment B).

Previous Reports

The 2009 SWP Delivery Reliability Report is the fourth report of this type. The previous reports in 2003, 2005, and 2007 defined and calculated delivery reliability in the same manner as this report, with output from DWR's CALSIM II model. This report differs from those earlier reports because it includes revised estimates of reductions to SWP delivery reliability due to future climate changes and sea level rise and also due to restricted operations to comply with USFWS and NMFS biological opinions. This report also discusses the risk of conveyance disruption due to Delta levee failure.

Context

The State Water Project

The SWP is a water storage and delivery system of reservoirs, aqueducts, power plants, and pumping plants that extends for more than 600 miles. Its main purpose is to divert and store surplus water during wet periods and distribute it to areas in Northern California, the San Francisco Bay area, the San Joaquin Valley, the Central Coast, and Southern California. It is also used for recreation and to control floods, generate power, protect fish and wildlife, and manage water quality in the Sacramento-San Joaquin Delta.

The keystone of the SWP is Lake Oroville, which conserves water from the Feather River watershed. It is the SWP's largest storage facility with a capacity of about 3.5 million acre-feet. Releases from Lake Oroville flow down the Feather River into the Sacramento River, which drains the northern portion of California's Central Valley. The Sacramento River flows into the Sacramento-San Joaquin Delta, comprised of 738,000 acres of land interlaced with channels that receive runoff from about 40% of the state's land area. The SWP and the federal Central Valley Project (CVP) rely on Delta channels as a conduit to move water from the Sacramento River inflow to the points of diversion in the south Delta. Thus, the Delta is actually part of the SWP conveyance system, making the Delta a key component in SWP deliveries. The significance of the Delta to SWP deliveries is described in more detail below.

From the northern Delta, Barker Slough Pumping Plant diverts water for delivery to Napa and Solano counties through the North Bay Aqueduct. Near Byron in the southern Delta, the SWP diverts water into Clifton Court Forebay for delivery south of the Delta. Banks pumping plant lifts water from Clifton Court Forebay into the California Aqueduct, which channels the water to Bethany Reservoir. The water delivered to Bethany Reservoir from Banks Pumping Plant is either delivered into the South Bay Aqueduct for use in the San Francisco Bay Area or continues down the California Aqueduct to O'Neil Forebay, Gianelli Pumping-Generating Plant, and San Luis Reservoir.

San Luis Reservoir is jointly operated by DWR and the Bureau of Reclamation and has a storage capacity of more than 2 million acre-feet (maf). DWR's share of gross storage in the reservoir is about 1.062 maf. Generally, water is pumped into San Luis Reservoir during late fall through early spring, and is temporarily stored for release back to the California Aqueduct to meet summertime peaking demands for SWP and CVP contractors.

SWP water not stored in San Luis Reservoir and water eventually released from San Luis continues to flow south through the San Luis Canal, a portion of the California Aqueduct jointly owned by DWR and the Bureau of Reclamation. As water flows through the San Joaquin Valley, deliveries of CVP water are made through numerous turnouts to farmlands in the service areas of the CVP. Near Kettleman City, the Coastal Branch Aqueduct splits from the California Aqueduct for water delivery to agricultural areas to the west and municipal and industrial water users in San Luis Obispo and Santa Barbara counties.

The remaining water conveyed by the California Aqueduct travels farther in the San Joaquin Valley to agriculture users such as Kern County Water Agency before reaching Edmonston Pumping Plant, which raises the water high enough to travel across the Tehachapi Mountains into Antelope Valley. In Antelope Valley, the Aqueduct divides into the East and West Branches. The East Branch carries water into Silverwood Lake and Lake Perris. Water in the West Branch flows to Quail Lake, Pyramid Lake, and

Castaic Lake.

Twenty-nine state water contractors have signed long-term water supply contracts with DWR for 4.173 million acre-feet (maf) per year. Signed in the 1960s, all contracts are in effect to at least 2035 and are essentially uniform. Each contract contains a schedule of the maximum amount of water the contractor can receive annually. This schedule is contained in SWP Table A. The annual amount was designed to increase each year, with most contractors reaching their maximum amount in 1990. In most cases, SWP water is an important component of local water supplies. Five contractors use SWP water primarily for agricultural purposes and the remaining 24 contractors use SWP water primarily for municipal purposes. All available water is allocated annually in proportion to each contractor's annual SWP Table A amount. Appendix C contains additional information about SWP Table A.

The Sacramento-San Joaquin Delta

The Sacramento-San Joaquin Delta is a network of natural and artificial channels and reclaimed islands at the confluence of the Sacramento and San Joaquin rivers. The Delta forms the eastern portion of the San Francisco estuary, receiving runoff from more than 40% of the state's land area. It is a low-lying region where over the years sediment from the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras rivers mingled with organic matter deposited by marsh plants. Covering 738,000 acres interlaced with hundreds of miles of waterways, much of the land is below sea level and relies on more than 1,100 miles of rather fragile levees for protection against flooding.

Because the SWP and the CVP use Delta channels to convey water to the southern Delta for diversion, the Delta is the focal point for water distribution throughout the state. In fact, the Delta is one of the few estuaries in the world that is used as a major source of drinking water supply: about one-quarter of California's drinking water comes from the Delta; and two-thirds of Californians get some portion of their drinking water from the Delta. The Delta also provides a unique estuarine habitat for many resident and migratory fish and birds, some of which are listed as threatened or endangered. Most of the native fish either migrate through the Delta or move into it for spawning. Resident native fish are mainly present in areas strongly influenced by inflow from the Sacramento River.

The CVP pumps at Jones Pumping Plant have a capacity of 4,600 cubic feet per second (cfs) and divert water directly from Old River. The CVP has contracts to divert 3.3 maf annually from the Delta for primarily agricultural use south of the Delta. The SWP pumps at Banks Pumping Plant have a combined pumping capacity of 10,300 cfs; however, diversions into the buffering Clifton Court Forebay are restricted to 13,870 acre-feet (af) daily and 13,250 af per day over a three-day average. A rate of 13,250 af per day equates to an average pumping of 6,680 cfs.

CVP and SWP reservoir releases and Delta exports follow the Coordinated Operating Agreement (COA), which sets guidelines for the sharing of supply and responsibility for meeting water quality standards in the Delta. Most of the water exported by the SWP depends on water rights derived from Lake Oroville storage; however, the SWP can also divert water considered in excess in the Delta. These excess conditions in the Delta usually result when there is sufficient inflow to meet all beneficial needs and the SWP is not required to make supporting releases from Lake Oroville. Diversions during excess Delta conditions are still governed by various determinations and rules.

In addition to the state and federal projects' diversions, irrigation water for use in the Delta is taken from channels and sloughs through approximately 1,800 diversions which can total more than 5,000 cfs in July and August.

Delta water quality is primarily governed by the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento-San Joaquin Delta (1995 Bay-Delta Plan). This plan established beneficial uses, associated water quality objectives, and an implementation program. The State Water Resources Control Board (SWRCB) in Water Rights Decision 1641 assigned primary responsibility for meeting many of the Delta water quality objectives to the SWP and CVP. Key factors in determining water quality in the western Delta are the quality of important Delta inflows and the intrusion of ocean-derived salts associated with daily tides. The extent of this intrusion is primarily determined by the magnitude of Delta inflows, export pumping rates, and operation of the Delta Cross Channel. Delta inflows are normally regulated by upstream reservoir operations.

The water flowing in Delta channels is constrained by an extensive levee system that protects Delta islands from flooding. This protection is critical because land subsidence in the Delta, primarily due to the consuming oxidation of aerated peat soils, has placed most of the land in the Delta below sea level. In fact, the elevation of Delta islands can be more than 20 feet below sea level. The resulting difference between the elevations of Delta lands and the water surface in adjacent channels makes Delta levees vulnerable to failure. Land subsidence in the Delta is expected to continue, which will increase the vulnerability of levees to failure and subsequent island flooding.

Water Delivery Reliability

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As mentioned in the Introduction, estimates of SWP delivery reliability are intended to help local SWP water users assess their water supply reliability, a key measure of a system's ability to match water supplies with demand. Just how water delivery reliability is assessed is critical to whether it is a meaningful guide for such an analysis. This chapter presents DWR's method for calculating SWP delivery reliability, the factors affecting SWP delivery reliability, and the limitations to estimating future water delivery reliability.

Calculating SWP Delivery Reliability

For this report, "water delivery reliability" is defined as the annual amount of water that can be expected to be delivered with a certain frequency. SWP delivery reliability is calculated using computer simulations based on 82 years of historical data. The annual amounts of SWP water deliveries are ranked from smallest to largest and a probability is calculated for each amount. These results are often displayed as a graph, commonly referred to as an exceedence plot. They can also be presented in a table.

Factors Affecting Water Delivery Reliability

The amount of the SWP water supply delivered to the state water contractors in a given year depends on the demand for the supply, amount of rainfall, snowpack, runoff, water in storage, pumping capacity from the Delta, and legal constraints on SWP operation. Expressed in more general terms, water delivery reliability depends on three general factors: the availability of water at the source, the ability to convey water from the source to the desired point of delivery, and the magnitude of demand for the water.

Availability of Source Water

The availability of water at the source depends on the amount of rain and snow and water use in the source areas. For the SWP, the size of the April 1 snowpack in the Feather River watershed and the storage in Lake Oroville are key components of the annual estimation of the SWP's delivery capabilities from April through September.

Factors of Uncertainty

The inherent yearly variable location, timing, amount, and form of precipitation in California introduce some uncertainty to the availability of future SWP source water and hence future SWP deliveries.

Simulating an 82-year sequence based on historical weather patterns restricts the analytical approach to no more extreme droughts or severe storms than have historically occurred. However, the 82-year sequence of weather patterns does produce a wide range of hydrologic events with which to evaluate the ability of the SWP to deliver water.

Climate change is another factor in source-water uncertainty. Current literature suggests that global warming is likely to significantly affect the hydrologic cycle, changing California's precipitation pattern and amount from that shown by the historical record. In fact, there is evidence that some changes have already occurred, such as Sierra snowmelt starting earlier, more runoff shifting from the spring to the winter, and an increase in winter flooding frequency. These changes would place more stress on the reliability of existing flood management and water supply systems, such as the SWP.

Treating Availability of Source Water Issues in CalSim II Studies

The State Water Project operation analyses in this report are based on operation simulations under an extended record of historical precipitation and adjusted historical runoff. The 82-year record of 1922-2003 runoff patterns in the studies simulating 2009 and 2029 scenarios have been adjusted as needed to reflect the current and future levels of development in the source areas by analyzing land use patterns and projecting future land and water use. These series of data are then used to forecast the amount of water available to the SWP under current and future (2029) conditions.

Climate change is expected to modify rainfall and runoff, which in turn will effect SWP operations. In the 2009 DWR Report, *Using Future Climate Projections to Support Water Resources Decision Making in California*, possible climate change effects to SWP and CVP operations were assessed using 12 future climate projections at mid-century and end-of-century (Chung et al., 2009). The range of results for the 12 projections is detailed throughout that report. Uncertainties in the results increase as the projections move further into the future. These studies assumed that no changes were made to the existing SWP and CVP infrastructure in the future. Future system operations used SWRCB D1641 regulations SWRCB 1995. Operations guidelines that are subject to change, such as restrictions on Delta exports contained in Endangered Species Act biological opinions, were not included in these studies due to the high uncertainty of how such restrictions may be applied 50 or 100 years from now.

In the 2009 climate change assessment, a three-step streamflow adjustment method was used to estimate inflows to major SWP and CVP reservoirs. An 82-year sequence of reservoir inflows that reflects a wide range of hydrologic variability was determined for each of the 12 future climate projections for both the mid-century and end-of-century analysis periods. Because some water allocation and water quality regulations are based on water year type designations (for example, wet or dry years), these designations were modified as necessary to reflect the future climate projections. Agricultural crop and urban outdoor water demands were adjusted to reflect changes in precipitation. Although there is a wide range of uncertainty in sea level rise projections, for simplicity's sake, sea level rise estimates of 1 foot for the mid-century and 2 feet for the end of the century were chosen for these impact studies. The reliability of the SWP and CVP water supply systems is expected to be reduced for the range of future climate projections studied.

In addition to the mid-century and end-of-the-century analysis described above, for this report DWR has estimated potential deliveries for 2029 using one future climate projection which is representative of median effects on the SWP and CVP system based on results from all 12 projections. The 2029 delivery estimates are based on the assumption that the two projects will be operated to meet the requirements of the recently issued Biological Opinions from the USFWS and the NMFS.[1] Estimates do not assume any changes in the way water is conveyed across the Delta. These assumptions are not a prediction of the future but an assessment of the future if these factors do not change. In addition, these estimates must be viewed with caution given the uncertainty of the effects of climate change in the future and the simplifying assumptions required for the analyses.

Ability to Convey Source Water to the Desired Point of Delivery

The ability to convey source water to the desired point of delivery refers to the availability of facilities to capture and convey water and any institutional limitations placed upon the facilities. Uncertainty in SWP deliveries may be, in part, due to uncertainty in the ability to convey water. For the SWP, this uncertainty centers on the Delta.

Factors of Uncertainty

In general, SWP operations are closely regulated by Delta water quality standards established by the State Water Resources Control Board (SWRCB) in Water Rights Decision 1641. In addition SWP and CVP operations are further constrained by requirements in the USFWS and NMFS Biological Opinions (BOs). The requirements in both BOs are based on physical and biological phenomena that do not lend themselves to simulations using a monthly time step. Much scientific and modeling judgment has been employed to represent the implementation of the BOs. The modeled representation of the requirements is the best possible, given the current scientific understanding of environmental factors enumerated in the BOs and the limited historical data for some of these factors. Turbidity, water temperature, and the presence of fish are examples of environmental factors that must be approximated in the model.

Another potential uncertainty for SWP water conveyance through the Delta is the risk of interruptions in SWP diversions from the Delta due to levee failures. SWP source water enters the Delta through the Sacramento River and is conveyed to Banks Pumping Plant via Delta channels lined with fragile levees. If a levee fails, depending on the location and the size of the adjacent island, the flow of water from nearby channels onto the affected island can draw saline water from Suisun and San Pablo bays into the central Delta. In such an incident, SWP pumping at Banks Pumping Plant may have to be curtailed or stopped for a period to prevent drawing saline water into the south Delta. Additional releases from Lake Oroville may also be necessary to flush the Delta of the saline water. As discussed in Chapter 4, the likelihood of levee failures in the future is expected to increase.

Treating SWP Conveyance Issues in CalSim II Simulations

The 2009 base study in this report assumes current facilities and institutional limitations, which include Water Rights Decision 1641, export curtailments for the Vernalis Adaptive Management Plan (VAMP), as well as the operational restrictions contained in the USFWS and NMFS biological opinions. Chapter 6 has a more detailed description of these assumptions. For comparison, the 2029 studies in this report assume the same institutional limitations as the 2009 simulations regarding requirements for Delta water quality flows and fish protection will be in place in 20 years; no facility improvements, expansions, or additions will be made to the SWP; and conveying water through the Sacramento-San Joaquin Delta will not be significantly

[1] U.S. Fish and Wildlife Service Delta Smelt Biological Opinion December 15, 2008. NMFS Biological and Conference Opinion on the Long-Term Operations of the Central Valley Project and State Water Project June 4, 2009.

interrupted by levee failures. These assumptions are not a prediction of the future but an assessment of the future if these conditions do not change. As discussed in Chapter 3, there are several efforts focused on improving the Delta ecosystem and water supply reliability in the near and long term. The 2029 studies also incorporate assumptions about climate change and sea level rise.

Also not included in this report are CALSIM II studies that reflect risk of levee failures. The effect on SWP deliveries due to a single or multiple levee failure is highly dependent on where the levees fail and the Delta conditions at the time. As *Report, Phase 1: Risk Analysis, Delta Risk Management Strategy (DRMS)*(DWR 2009*)* indicates, the effect on SWP deliveries can range from relatively minor to catastrophic with extensive levee failures, depending on whether an earthquake occurs under dry or wet Delta conditions. However, the same report points out that if multiple Delta islands are left flooded with openings to adjacent channels, after a large-scale levee failure, the volume of water that would move in and out of the Delta over a tidal cycle could actually increase, resulting in higher salinities in the west Delta. If Delta water quality standards remain unchanged, releases from Lake Oroville would then most likely need to increase above current levels to enable the same level of SWP pumping. The DRMS report also indicates that multiple levee failures and Delta island flooding due to flood flows may not significantly affect SWP deliveries due to the fresh water Delta-wide conditions that would exist at the time of flood flows. Chapter 4 addresses in more detail Delta levee vulnerability to failure.

Demand for System Water

Water demand in the delivery service area is affected by such factors as the magnitude and types of water demands, the extent of water conservation measures, local weather patterns, and water costs. Supply from a water system may be sufficiently reliable at a low level of demand but become less reliable as the demand increases. In other cases, the reliability of a water supply system to meet a higher demand may be maintained at its past level because new facilities have been added or the operation of the system has been changed. In general, the higher and the more time-concentrated the water demands, the more need for storage and conveyance capacity to achieve the same delivery reliability. For example, if the demand occurs only three months in the summer, a water system with a sufficient annual supply but insufficient water storage may not be able to reliably meet the demand. If, however, the same total amount of demand is distributed over the year, the same system could more easily meet the demand because the need for water storage is reduced.

Demand levels for the SWP water users in this report are derived from historical data and information from the SWP contractors. Annual demand on the SWP is nearing the maximum contract amount (referred to as the "Maximum SWP Table A amount"). Each SWP contract contains a Table A, which states the maximum annual delivery amount from the SWP over the period of the contract. These annual amounts usually increase over time. Most contractors' SWP Table A amounts reached a maximum in 1990. The total of all contractors' maximum SWP Table A amounts is 4.173 maf per year. SWP Table A is used to define each contractor's portion of the available water supply that DWR will allocate and deliver to that contractor. The SWP Table A amounts in any particular contract are not guarantees of annual delivery amounts but are used to allocate individual contractors' portion of the total delivery amount available. Estimates of each contractor's amount of water delivered are determined by the factors described in this report. See Appendix C for additional explanation and listing of the maximum SWP Table A amounts.

Of the 29 SWP contractors, Yuba City, Butte County, and the Plumas County Flood Control and Water Conservation District are north of the Delta. Their total maximum SWP Table A amounts is 0.040 maf per year. The total maximum SWP Table A amounts for the remaining 26 contractors, who all receive their supply from the Delta, is 4.133 maf per year. This report focuses on SWP deliveries from the Delta because the amount of water pumped from the Delta by the SWP is the most significant component of the total amount of SWP deliveries. The results presented in this report in terms of estimated delivered water supplies as a percent of SWP Table A deliveries apply to contractors north of the Delta in the same manner as those contractors receiving supply from the Delta.

SWP contractors may also receive water under Article 21 of their contract. It is available only if it does not interfere with SWP operations or Table A allocations, excess water is available in the Delta, and it will not be stored in the SWP system. Because an SWP contractor must have an immediate use for Article 21 supply or a place to store it outside of the SWP, not all SWP contractors can take advantage of this additional supply. For those SWP contractors who are able to store their wet weather supplies, Article 21 supply can be stored by being put directly into a reservoir or by offsetting other water that would have been withdrawn from storage, such as local groundwater. In the absence of storage, Article 21 water is not likely to contribute significantly to local water supply reliability. Incorporating supplies received under Article 21 into the assessment of water supply reliability is a local decision based on specific local circumstances, facts, and level of water supply reliability required. This report presents information on Article 21 water separately so local agencies can determine whether it is appropriate to incorporate this supply into their analyses.

Factors of Uncertainty

Estimating future demand for SWP water requires assumptions be made about population growth, water conservation, recycling efforts, other sources of supply available to the SWP contractors, and climate change. The estimates also depend on the cost to the SWP contractor for each of the components of their integrated water management plan. These factors are considered by the SWP contractors in the estimates of their current and future demands.

Treating Water Demand Issues in CalSim II Simulations

SWP Table A and Article 21 demands in the 2009 study have increased from those in the 2007 study from the 2007 SWP Delivery Reliability Report. SWP Table A and Article 21 demands in the 2029 study have also increased from those in the 2027 study from the 2007 SWP Delivery Reliability Report. Specific values used in the CalSim II studies are contained in Appendix A.

Limitations to Estimating Future Water Delivery Reliability

Studies Must Rely on Assumptions

Actual, historical water deliveries cannot always be used with a significant degree of certainty to predict future water deliveries. As discussed earlier, there are continual, significant changes over time in the determinants of water delivery for a specific water supply system. These changes include water storage and delivery facilities, water use in the source areas, water demand in the receiving areas, and the regulatory constraints on the operation of facilities for the delivery of water. Given the highly significant changes that have occurred for the SWP over the past 40 years, past deliveries are not a good predictor of SWP current deliveries, much less of future deliveries.

For example, the demand 30 years ago for water from the SWP was lower than it is now or expected to be in the future. Lower demand for SWP water resulted in less water transported through the SWP during normal and wet times than could have been—or would have been if the demand for water had been higher. Less water was delivered then because less water was needed; the amount of source water and conveyance capabilities weren't limiting factors for deliveries. Conversely, the recently issued biological opinions' restrictions on SWP exports from the Delta are estimated to reduce annual deliveries from what has been delivered in the recent past. Analyses estimating future SWP deliveries must include assumptions about future (2029) conditions. Some assumptions are very important to the analyses and are key to understanding the resulting estimates of annual water deliveries. A discussion of the important assumptions for the studies in this report follows.

Studies Assume Repeating Historical Weather Patterns

One of the most significant assumptions for water planning in general is how wet, dry and variable the weather will be. Until recently, assuming the future weather pattern would be similar to the past was sufficient for many planning purposes. Given the evolving information on the potential effects of global climate change in the future, this approach is no longer adequate. Incorporating climate change into future projections is difficult because of the many ways the patterns of rain, snow and temperature could shift. A way to measure some of the uncertainty is to analyze many potential climate change scenarios in order to capture the range of water supply effects.

This report contains estimates of future SWP deliveries under one selected median-impacts climate change projection. The historical record of precipitation information for the Central Valley for the period 1922 through 2003 is modified to reflect the future climate projection. The amount and timing of rainfall and runoff is adjusted but the sequence of dry years or wet years is the same for all scenarios. Evaluating how water management systems will respond under severely dry periods is limited to assuming the worst droughts in the period of historical record. The worst multiyear drought on record is 1928 through 1934, although the brief drought from 1976 through 1977 was more acutely dry.

Other Important Assumptions

To identify the assumptions with the most effect on the estimates of SWP deliveries, DWR conducted a sensitivity analysis for assumptions in CalSim II model studies. In a sensitivity analysis, an assumption such as the amount of water used in the watershed above Lake Oroville is varied over several studies and the results for SWP deliveries are compared. This is done to assess how each assumption affects study results. The *2005 SWP Delivery Reliability Report* presents and discusses the results of DWR's study. The parameters having the largest net effect on SWP Delta deliveries are SWP Table A demands and Banks Pumping Plant limits. The most elastic parameters (i.e., parameters causing the most percent change in SWP deliveries per percent change in value) are SWP Table A demands and Lake Oroville inflow. The estimates for the future inflow to Lake Oroville depend on what is assumed for climate change. Legal limitations are one of the factors defining the rules for operating Banks Pumping Plant. Therefore, the assumptions for climate change and the restrictions of the FWS' and NMFS' BOs directly affecting Banks Pumping Plant operations will significantly affect SWP delivery estimates.

Status of Planning Activities That May Affect SWP Delivery Reliability

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As discussed earlier, the Sacramento-San Joaquin Delta is an essential part of the conveyance system for the SWP. SWP pumping at Banks Pumping Plant is regulated to protect the many uses of the Delta. However, today's uses in the Delta are not sustainable over the long term under current management practices and regulatory requirements. A comprehensive plan to meet the Delta's and California's water challenges was approved by Governor Schwarzenegger in November 2009. That plan and the key planning efforts involving the Delta are discussed below.

2009 Comprehensive Water Package

In November 2009, four legislative bills and the supporting bond bill, creating a comprehensive water package designed to meet California's water challenges, were approved by Governor Schwarzenegger. The legislation establishes the governmental framework to achieve the co-equal goals of providing a more reliable water supply to California and restoring and enhancing the Delta ecosystem. The package includes requirements to improve the management of our water resources by monitoring groundwater basins, developing agricultural water management plans, reducing statewide per capita water consumption 20 percent by 2020, and reporting water diversions and uses in the Delta. It also appropriates $250 million for grants and expenditures for projects to reduce dependence on the Delta.

The Safe, Clean, and Reliable Drinking Water Supply Act of 2010 will come before the California voters in November 2010. If enacted, it would provide funding for California's aging water infrastructure and for projects and programs to improve the ecosystem and water supply reliability for California. The bond bill includes $2.25 billion for actions improving Delta sustainability. These investments will help to reduce seismic risk to Delta water supplies, protect drinking water quality, and reduce conflict between water management and environmental protection.

Delta Vision

In September 28, 2006, Gov. Schwarzenegger signed an executive order to establish an independent Blue Ribbon Task Force to develop a durable vision for sustainable management of the Sacramento-San Joaquin Bay Delta. The Delta Vision process concluded at the end of 2008 with a suite of strategic recommendations for long-term, sustainable management of the Sacramento-San Joaquin Delta. Their recommendations were based upon seven broad goals. These goals helped to guide the development of the 2009 Comprehensive Water Package and are:

- Legally acknowledge the equal goals of restoring the Delta ecosystem and creating a more reliable water supply for California.
- Recognize and enhance the unique cultural, recreational, and agricultural values of the California Delta.
- Restore the Delta ecosystem as the heart of a healthy estuary.
- Promote statewide water conservation, efficiency, and sustainable use.
- Build facilities to improve the existing water conveyance system and expand statewide storage, and operate both to achieve the equal goals.
- Reduce risks to people, property, and state interests in the Delta by effective emergency preparedness, appropriate land used, and strategic levee investments.
- Establish a new governance structure with the authority, responsibility, accountability, science support, and secure funding to achieve these goals.

Delta Risk Management Strategy

The Delta Risk Management Strategy (DRMS) was initiated as a component of the 2000 CALFED Record of Decision. In 2005, the Legislature passed and the governor signed AB 1200, which requires DWR to evaluate the potential effects on water supply derived from the Delta based on 50-, 100-, and 200-year projections for possible effects on the Delta due to subsidence, earthquakes, floods, climate change, and combinations of these. The assessment of risks and the associated consequences to the State are contained in the DRMS Phase 1 Report, completed in February 2009.

In Phase 2 of DRMS, DWR and the Department of Fish and Game (DFG) must determine the principal options for reducing the risks to, among other things, prevent the disruption of water supplies derived from the Delta, improve the water quality of drinking water supplies from the Delta, and maintain Delta water quality for Delta users. DFG is to evaluate and comparatively rate each option for its ability to restore salmon and other fisheries that use the Delta. The study is to be completed by Summer, 2010.

The DRMS is a major source of scientific and technical information on the Delta and Suisun Marsh levees for other major studies and initiatives.

CALFED Ecosystem Restoration Program Conservation Strategy

The Ecosystem Restoration Program (ERP) Conservation Strategy has been developed by the Department of Fish and Game (DFG) in collaboration with the National Marine Fisheries Service (NMFS) and US Fish and Wildlife Service (USFWS), the three implementing agencies for the program. It provides the foundation for regional implementation of the ERP guided by a science based adaptive management approach designed to improve aquatic and terrestrial habitats and improve ecological functions in the

Bay-Delta to support sustainable populations of fish and wildlife species. It represents a "single blueprint" for conservation and recovery of species and will integrate the NMFS recovery plan for Central Valley salmonids and the USFWS Delta Native Fishes Recovery Plan, once these plans are completed. While the ERP Conservation Strategy currently focuses on the Delta and Suisun Marsh it will be expanded to include the tributaries to the Delta.

The ERP Conservation Strategy represents the perspectives of the three fish and wildlife agencies on what is needed at a programmatic level to achieve biological conservation and management goals in the Delta. It serves to guide more detailed planning efforts such as the Bay Delta Conservation Plan (BDCP). The BDCP is currently evaluating specific detailed actions which would implement at least in part those described more generally in the ERP Conservation Strategy. In particular, BDCP will be addressing the issues of conveyance and flows as a component of ecosystem restoration.

Bay-Delta Conservation Plan

The Bay Delta Conservation Plan (BDCP) is being developed to promote the recovery of endangered, threatened and sensitive fish and wildlife species and their habitats in the Sacramento-San Joaquin Delta in a way that will also protect and restore water supplies.

The BDCP is:

- Identifying conservation strategies to improve the overall ecological health of the Delta.
- Identifying ecologically friendly ways to move fresh water through and/or around the Delta.
- Addressing toxic pollutants, invasive species, and impairments to water quality.
- Establishing a framework and funding to implement the Plan over time.

The BDCP is being developed in compliance with the Federal Endangered Species Act and the California Natural Communities Conservation Planning Act. When completed, the BDCP would provide the basis for the issuance of endangered species permits for the operation of the state and federal water projects. The plan would be implemented over the next 50 years. The heart of the BDCP is a long-term conservation strategy that sets guidelines for the actions needed for a healthy Delta.

State and federal agencies are developing a joint Environmental Impact Report/Statement (EIR/EIS) under the Delta Habitat Conservation and Conveyance Program. The EIR/EIS will determine the potential environmental impacts of the proposed BDCP. The draft EIR/EIS is expected to be ready for public review and comment by mid-2012 and the BDCP Habitat Conservation Plan is scheduled to be delivered early in 2011.

Delta Habitat Conservation and Conveyance Program

The DHCCP is a partnership between DWR and the U.S. Bureau of Reclamation to evaluate the ecosystem restoration and water conveyance alternative identified by the BDCP along with other conveyance alternatives. The evaluation culminates in the completion of a joint EIR/EIS. The State and federal lead agencies for the EIR/EIS are DWR, the USBR, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service. Development of the EIR/EIS is being done in cooperation with the California Department of Fish and Game, the U.S. Environmental Protection Agency, and the U.S. Army Corps of Engineers. The draft DHCCP EIR/EIS is scheduled to be completed mid-2012.

2-Gates Fish Protection Demonstration Project

The 2-Gates Fish Protection Demonstration Project (2-Gates Project) is proposed to be installed for 5 years to test its ability to control flows and thereby protect delta smelt and other sensitive aquatic species through reduced entrainment at the SWP and CVP Delta pumping facilities. The 2-Gates Project would install and operate removable gate structures in two key locations in the central Delta; in Old River between Bacon Island and Holland Tract, and in Connection Slough between Mandeville Island and Bacon Island. The structures would be opened and closed in conjunction and coordination with operation criteria established by state and federal water quality and environmental regulators. An extensive water quality and fish monitoring program is proposed, using existing and new monitoring actions, to support the validation of the project.

The structures would be temporary and removed after a five-year evaluation period. These facilities include sheet pile dikes extending from each channel bank to the gates, a pile-supported boat ramp to reduce effects to recreational boating and limited dredging and ground disturbance to minimize other biological effects. Barge-mounted gates will be fabricated off-site, floated to the site, and installed by ballasting each gate in place adjacent to the sheet pile dikes.

The project lead is the U.S. Bureau of Reclamation (USBR). Public review of the draft environmental assessment (EA) and a finding of no significant impacts (FONSI) closed on November 30, 2009. A final EA and FONSI may follow.

Areas of Significant Uncertainty for SWP Delivery Reliability

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There are three significant factors contributing to uncertainty in the delivery reliability of the SWP: possible effects from climate change and sea level rise, the vulnerability of Delta levees to failure, and greater operation restrictions imposed by the USFWS and NMFS in response to decreasing populations of endangered fish species. Each of these uncertainties is discussed below.

Climate Change and Sea Level Rise

Climate change is identified in the draft 2009 update of the *California Water Plan (Bulletin 160-09)* as one of the key considerations in planning for the state's water management. California's reservoirs and water delivery systems were developed based on historical hydrology and, under climate change, the past may no longer be a good guide for the future. In fact, changes have already been observed in California's climate over the past 100 years (DWR, 2009). Air temperatures have risen about 1 degree Fahrenheit with the greatest changes occurring at night and at higher elevations. Early spring snowpack in the Sierra Nevada, a key natural reservoir for California's water supply, has decreased about 10% resulting in a loss of about 1.5 million acre-feet of water storage. Sea levels along the California coast have risen by about 7 inches.

The climate is expected to continue changing in the future (DWR, 2009). Mean temperatures are predicted to increase by 1.5 degrees to 5.0 degrees Fahrenheit by mid-century and 3.5 degrees to 11 degrees by the end of the century. These rising air temperatures are expected to continue to reduce snowpack, especially in low elevation watersheds where more precipitation may fall as rain rather than snow (Chung et al., 2009). Reduced snow pack is expected to lead to higher winter runoff and lower spring runoff. This could increase flooding during the winter and reduce river flows in the spring and summer, which may require water managers to evaluate the tradeoffs between flood protection and water supply. Future sea level rise estimates range from 4 to 16 inches by mid-century and 7 to 55 inches by the end of the century (DWR, 2009). Higher sea levels could threaten the existing levee system in the Sacramento-San Joaquin Delta. Salinity intrusion into the Delta could also require increased releases of freshwater from upstream reservoirs to maintain compliance with water quality standards.

For the SWP, these climate changes have the potential to simultaneously affect the availability of source water, the ability to convey water, and users' demands for water. This may exacerbate the existing mismatch in California between where and when precipitation occurs and where and when people use water.

Previous Assessment of Climate Change Impacts on SWP Delivery Reliability

To better understand how the future reliability of the SWP and CVP may be affected by climate change, DWR examined possible effects for 12 future climate scenarios in a report titled *Using Future Climate Projections to Support Water Resources Decision Making in California* (Chung et al., 2009). The 12 scenarios represent projections from six Global Climate Models for a higher and a lower future greenhouse gas emissions scenario. The studies also took into account Delta salinity intrusion due to sea level rise and resulting changes in reservoir operations to maintain Delta water quality. Shifts in both water supply and water demands were considered. Several factors related to water supply reliability were examined: annual Delta exports, reservoir carryover storage, Sacramento Valley groundwater pumping, and additional water supplies needed to reduce the frequency and extent of system vulnerability to operational interruption. For the range of future climate projections studied, the reliability of the SWP and CVP water supply systems is expected to be reduced. Although the analysis examined both mid-century and end-of-the-century effects, only mid-century effects are discussed in this report.

One indicator of the amount of water that the SWP can supply south of the Delta is annual Delta exports, which is the total amount of water transferred (exported) south of the Sacramento-San Joaquin Delta through the SWP's Banks Pumping Plant and the CVP's Jones Pumping Plant over the course of one year. At mid-century, median Delta exports are reduced by 7% for the lower greenhouse gas emissions scenario and by 10% for the higher emissions scenario. It is important to note that the full range of mid-century changes in Delta exports for the 12 future climate scenarios spans an increase of 2% to a decrease of 19%. These decreases in annual Delta exports would reduce water deliveries south of the Delta.

An important factor in California's water supply reliability is the amount of water stored in reservoirs from one year to the next. This stored water is like a water supply savings account that allows water managers flexibility during tough times. This water supply savings account is called reservoir carryover storage, and it is the amount of water remaining in a reservoir at the end of September that is available (carries over) for use the next water year. At mid-century, median reservoir carryover storage is reduced by 15% for the lower greenhouse gas emissions scenario and by 19% for the higher emissions scenario. These reductions in reservoir carryover storage would reduce the systems' flexibility during water shortages.

In the Sacramento Valley, reduced surface water supplies are assumed to be augmented by increased groundwater pumping. For agricultural and urban areas where there is access to both surface water and groundwater, surface water diversions are assumed to be used first up to the maximum amount allowed by current contracts. Any unmet demand is then supplied by groundwater pumping. For areas where there is no surface water access, all demands are met by groundwater pumping. At mid-century the median Sacramento Valley groundwater pumping increases by 5% for the lower greenhouse gas emissions scenario and by 9% for the higher emissions scenario.

Under climate change and in some years, water levels in the main supply reservoirs (Shasta, Oroville, Folsom, and Trinity) could fall below the lowest release outlets making the system vulnerable to operational interruption. By mid-century, it is expected that a water shortage worse than the one during the 1977 drought could occur in 1 out of every 6-8 years. In those years, it is estimated that an additional

575-850 thousand acre-feet of water would be needed to meet current regulatory requirements and to maintain minimum system operations. This water could be obtained through additional water supplies, reductions in water demands, or a combination of the two. For current conditions, the report concludes the system is not considered vulnerable to this type of operational interruption.

Selection of Climate Change Scenario for Updated Reliability Assessment

For the purposes of this report, the 2029 delivery estimates are based upon a single median future climate projection. To identify this projection, a separate analysis was conducted of the 12 mid-century climate projections contained in *Using Future Climate Projections to Support Water Resources Decision Making in California* (Chung et al., 2009), and their resulting water supply effects to determine which one most closely represented the "central" or "median" projection. The metrics used for comparison consisted of projected climate and hydrology variables, and their effects on CVP/SWP system exports; namely, temperature, precipitation, total inflow to major reservoirs, shifts in timing of run-off, and Delta exports. Using these metrics, the future climate projection from the MPIECHAM5 global climate model run for the higher greenhouse gas emissions scenario was selected to be representative of median SWP-CVP effects, and thus is used for the analyses presented in this report.

Vulnerability of Delta Levees to Failure

Delta levees provide constant protection from flooding because most lands in the Delta are below sea level. Most Delta levees, however, do not meet modern engineering standards and are highly susceptible to failure. Levees are subject to failure at times of high flood flows, but also at any time of the year due to seepage or the piping of water through the levee, slippage or sloughing of levee material, or sudden failure due to an earthquake. According to the URS Corp./Jack R. Benjamin & Associates report, *Report, Phase 1: Risk Analysis, Delta Risk Management Strategy (DRMS)*, December 2008, the risk of levee failure in the Delta is significant, as shown by the fact that most islands in the Delta have flooded at least once over the past 100 years, with many flooding at least twice. Since 1900, there have been 158 levee failures.

A breach of one or more levees and island flooding may affect Delta water quality and water operations. Depending on the hydrology and the size and locations of the breaches and flooded islands, a significant amount of saline water may be drawn into the interior Delta from Suisun and San Pablo bays. At the time of island flooding, exports may be drastically reduced or ceased to evaluate the salinity distribution in the Delta and to avoid drawing higher saline water toward the pumps. The introduced salinity then could become dispersed and degrade Delta water quality for a prolonged period because of complex relationships between Delta inflows, tidal mixing, and the time taken to repair the breaches.

A large earthquake in the Delta causing significant levee failures and island flooding could lead to multiyear disruptions in water supply, significant water quality degradation, as well as permanent flooding of several islands. Such permanent multi-island flooding would probably lead to increased salt water intrusion into the Delta during seasonal low inflows. Maintaining Delta water quality when several islands are flooded and breaches are open would require additional Delta inflow because the volume of water coming into the Delta on the flood tide would increase, requiring more fresh water from the rivers to prevent the saline water from extending into the Delta. When SWP and CVP pumping are restarted, Delta inflow would need to increase again beyond the pumping amount in order to prevent water quality degradation in the Delta. This chain of events would significantly affect water supply reliability by limiting pumping and requiring additional reservoir releases to generate the needed higher Delta inflows. A worst case scenario for water supply effects would be a moderate or large earthquake causing extensive levee failure in the late summer or fall of a dry year.

The levee break on Middle River and subsequent flooding of Upper Jones Tract in 2004 is a small-scale example of this phenomenon. Following the break, Delta pumping was curtailed for several days to prevent seawater intrusion. Water shipments down the California Aqueduct were continued through unscheduled releases from San Luis Reservoir. Also, Shasta and Oroville reservoir releases were increased to provide for salinity control in the Delta.

A growing concern about the long-term viability of the Delta's levee system led to the initiation of the Delta Risk Management Strategy (DRMS).

Delta Risk Management Strategy

The Delta Risk Management Strategy is being developed in two phases. Phase 1 is the analysis of the risk of levee failures and the associated potential economic, environmental, and public health and safety effects. The final Phase 1 Report was completed in February 2009. Phase 2, expected to be completed by Summer 2010, is to develop and evaluate strategies to reduce risks from levee failures. The risk analysis includes the likely occurrence of earthquakes of varying magnitudes in the region, future rates of subsidence given continued farming practices, the likely magnitude and frequency of storms, and the potential effects associated with global climate change (sea level rise, climate change, temperature change). Estimated risks to the Delta were made for 50-, 100-, and 200-year projections since risk can be expected to increase with time.

The DRMS Phase 1 Report looks at several hazards to levees: seismic events that cause levee failures, flood flows that can overtop levees or cause levee failure by increased pressure and seepage, undetected problems during non-flood flow periods, and erosion due to high wind waves. The level of risk of failure of Delta levees was determined by considering: the frequency of different magnitudes of hazards that can challenge the integrity of Delta levees, how vulnerable different levee reaches are to hazards, how hazards and levee vulnerabilities combine to produce levee failure, and the economic and ecosystem effects due to levee failure. The analysis assumes that existing regulatory and management practices will continue.

Potential Interruption/Disruption of SWP Deliveries Due to Earthquakes

A strong earthquake affecting the Delta could cause simultaneous levee failures on several islands, with these islands flooding simultaneously. Preliminary analysis indicates that some water may not be treatable by municipal agencies for many months due to high organic carbon concentrations. This would extend the period that Delta water supply would be unavailable for urban users.

Key findings of the Phase 1 report on possible effects on SWP deliveries due to earthquakes are:

- There is about a 40% chance of 27 or more islands simultaneously failing during a major earthquake in the next 25 years.
- A moderate to large earthquake capable of causing multiple levee failures could happen in the next 25 years. Under such an earthquake, extensive levee failure would most likely occur in the west and central Delta. Levee repairs could take more than 2.5 years and exports from the Delta could be disrupted for about a year with a loss of up to 8 million acre feet of water.
- By 2050, the risk of island flooding from seismic events is expected to increase by 35% over 2005 conditions, if a seismic event has not occurred.

Potential Interruption/Disruption of SWP Deliveries Due to Floods

During an average year, about 85% of the total Delta inflow comes from the Sacramento River and 10% comes from the San Joaquin River. The remaining Delta inflow primarily comes from three eastside tributaries. Inflow from the Sacramento and San Joaquin rivers depends on reservoir releases, precipitation, and snowmelt. Over the long-term, many different combinations of high flood flows in the Sacramento and San Joaquin rivers are possible because of the large geographical extent of the two rivers' watersheds and the variability in storm paths. The Phase 1 analysis considers the magnitude and frequency of flooding in different parts of the Delta from different sources to evaluate the probability of these high flows. This approach allows the inclusion in the risk analysis of floods that, while possible, are larger than any in the historic record. If the analysis solely relied upon the historical data, the analysts believe the risk would be underestimated.

Potential disruption of Delta exports due to floods and levee failures would depend on the number of flooded islands, the timing and size of the flood flows, and the water quality in the Delta and Suisun Bay at the time of the flood. However, during such high flows, there would normally be little or no effect on the water quality of the exports due to levee failures and DRMS assumes no significant effect on Delta exports.

Key findings of the Phase 1 report on possible effects to SWP deliveries by the year 2050 due to flood flows are:

- Delta flood hazard is expected to increase due to sea level rise and more frequent high flows.
- The frequency of island flooding from floods is expected to increase over 2005 conditions.
- The frequency of floods is expected to increase by 35% and levees are expected to become more vulnerable to flooding due to increased seepage and stability problems associated with more subsidence and sea level rise.

The combined effects of increased levee vulnerability and flood flows indicate an expected 80% increase in island flooding from flood flows.

Potential Interruption/Disruption of SWP Deliveries Due to "Sunny Day" Event

A "sunny day" levee failure is a failure that occurs during non-flood times and is not caused by an earthquake. Possible causes of levee failure include wave action, animal activity, and seepage. The DRMS reports that, on average, there will be about 10 sunny-day breaches with 100 years of exposure in the Delta. These types of levee failures are not expected to involve the simultaneous multi-levee events as could happen with high flood flows or a large earthquake.

Combined Potential Interruption/Disruption of SWP Deliveries

DRMS evaluated combined risk of levee failure due to earthquakes, floods, and "sunny day events" as well as how risks may change in the future. Key findings by DRMS are:

- Levee hazards are expected to grow in the future due to such factors as sea level rise and more frequent flood flows that will put more pressure on the levees.
- The overall likelihood of a major Delta event causing extensive levee failure is increasing as is the magnitude of the consequences from a given event.
- There is a possible range of sea level rise of from 0.7 to 4.6 feet over the next 100 years, depending on the assumed future greenhouse gas emissions and the forecast model used. Current estimates by the Intergovernmental Panel on Climate Change indicate that sea level will rise from 0.6 to 1.9 feet over the next 100 years. The CALFED Independent Science Board

(ISB) has recommended that planning that incorporates sea level rise should use the full range of variability of 20-55 inches.

Delta Flood Emergency Preparedness and Response Plan

As part of its efforts to reduce effects to the SWP should a levee failure occur, DWR has initiated the development of the DWR Delta Flood Emergency Preparedness and Response Plan (DWR Delta Flood EPRP). DWR has emergency response procedures for a Delta levee failure in place but the DWR Delta Flood EPRP will enhance the state's ability to prepare for, respond to, and recover from a catastrophic Delta levee failure. This new scalable plan will provide DWR with updated techniques and procedures should a catastrophic Delta levee failure occur. This plan will be DWR's roadmap for coordinating the protection of life and property with our local, state, and federal partners in a levee disaster while protecting the state's water system.

DWR has completed the first of two phases of engineering design work intended to enhance the state's ability to respond to large-scale levee failures or floods in the Delta. In the first phase, DWR conducted a discovery process to analyze previously developed plans and procedures and to identify current DWR capabilities for response to emergencies and disasters in the Delta. In the second phase, DWR will further engage its response partners in local, state, and federal government, and in the private sector to develop a more detailed DWR Delta Flood Emergency Preparedness and Response Plan. This response plan will be consistent with and in compliance with California's Standardized Emergency Management System (SEMS) and with the National Incident Management System (NIMS)[2]. The main goal of this plan is to reduce the recovery time from a catastrophic levee failure of Delta water users. This will be achieved through the development of new response tools, enhanced response methods, and clarifying response roles in the Delta.

National Marine Fisheries Service and Fish and Wildlife Service Biological Opinions

Over the past 5 years and in response to declining fish populations, the rules defined by the federal biological opinions issued under the Endangered Species Act for the operation of the SWP and CVP in the Delta have become more and more restrictive. In December 2008, the USFWS issued a new biological opinion for delta smelt. In June 2009, the NMFS issued a new biological opinion covering winter-run and spring-run Chinook salmon, steelhead, green sturgeon, and killer whales. The biological opinions imposed additional operational requirements that restrict the amount of water supply that can be exported from the Delta. Below are some highlights of each biological opinion.

USFWS Biological Opinion

The USFWS Biological Opinion (BO) includes additional requirements in all but two months of the year. From December to June, an adaptively managed flow restriction is in place for the average Old River and Middle River (OMR) flow. The flow restriction can begin as early as December 1 based on USFWS'

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[2] SEMS is an emergency management system required by California Government Code Section 8607(a) for managing incidents involving multiple jurisdictions and agencies. NIMS is a nationwide, federal emergency management approach, for managing incidents with all levels of government, private-sector, and nongovernmental organizations working together. For more SEMS/NIMS information, please visit: www.oes.ca.gov.

determination. However, the restriction is more likely to start after December 20 and is based on turbidity and salvage triggers. The restriction has three phases that are intended to protect delta smelt at various life stages. The actual OMR flow target is dependent on delta smelt survey information. The USFWS determines the required target flow. Managing to OMR flow is accomplished primarily by reducing the CVP and SWP exports. Because determining an OMR restriction is based on fish location and decisions by USFWS staff, predicting an OMR restriction and corresponding export pumping with any great certainty poses a challenge.

The USFWS BO also imposes an additional salinity requirement in the Delta for September and October in wet and above-normal water years. In these years, fresher water must be maintained at locations further west than during the other types of water years. In November during years when this requirement is in place, inflow into the SWP and CVP reservoirs will be passed downstream to augment the outflow until the prior-month's required location for the fresher water is reached.

NMFS Biological Opinion

The requirements contained in the NMFS' BO also added an OMR requirement. However, we expect that the USFWS OMR requirements will satisfy or be sufficiently protective of the listed species under the NMFS biological opinion.

The NMFS' BO also expands the duration of a Spring-time operation which combines a significant reduction in Delta exports with a pulse flow on the San Joaquin River from one month to two months. The requirement would likely result in total exports being limited to 1,500 cubic feet per second except in extremely wet cases during April and May.

Under the BO, the Delta Cross Channel gates are closed more frequently from October through December 14, and completely closed between December 15 and January 31. Previously, as defined by Water Right Decision 1641, the Delta Cross Channel was closed up to 45 days between November 1 and January 31. This operation can require additional export reductions in order to meet the water quality objectives contained in the water right permits for the SWP and CVP.

There are a number of additional actions under the BO that require temperature, flow and storage requirements on the CVP system. These additional actions or requirements could have an effect on real-time SWP operations.

General Approach for Assessing SWP Delivery Reliability

5

CalSim II, a computer model jointly developed by DWR and U.S. Bureau of Reclamation, simulates much of the water resource infrastructure in the Central Valley and Delta region of California. CalSim II models all areas that contribute flow to the Delta. The geographical coverage includes the Sacramento River Valley, the San Joaquin River Valley, the Sacramento-San Joaquin Delta, the Upper Trinity River, and the CVP and SWP service areas. CalSim II simulates operation of the CVP-SWP system using a monthly time step. The model assumes that facilities, land use, water supply contracts, and regulatory requirements are constant over this period.

General Solution Techniques and Incorporating Operational Constraints

CalSim II routes water through a CVP-SWP system network representation. The network includes more than 300 nodes and more than 900 arcs, representing 24 surface reservoirs and the interconnected flow system. CalSim II uses logic for determining deliveries to north-of-Delta and south-of-Delta CVP and SWP contractors. The delivery logic uses runoff forecast information that incorporates uncertainty and standardized rules that relate forecasted supplies to estimate the water available for delivery and reservoir carryover storage. The assumed delivery levels are updated monthly within the model for the periods January 1 through May 1 for the SWP and March 1 through May 1 for the CVP to correspond to the updated runoff forecasts. The south-of-Delta SWP and CVP deliveries are based on water supply parameters and operational constraints.

Hydrology

A range of hydrologic conditions based on the historical flow record is used to represent the possible range of water supply conditions. The hydrology used by CalSim II was developed jointly by DWR and U.S. Bureau of Reclamation by adjusting the historical flow record to account for the influence of land-use changes and upstream flow regulation. Sacramento Valley and tributary basin hydrologies are developed by adjusting the historical sequence of monthly stream flows to represent a sequence of flows at a current or future level of development. Adjustments to historical water supplies are determined by imposing the current or future level land use on historical meteorological and hydrologic conditions. San Joaquin River basin hydrology is developed in a different manner and uses fixed annual demands and a regression analysis to develop flow accretions and depletions. The resulting hydrology represents the water supply available from Central Valley streams to the CVP and SWP at a current or future level of development. Groundwater is modeled as a series of interconnected basins. Groundwater pumping, recharge from irrigation, stream-aquifer interaction and interbasin flow are calculated dynamically by the model.

The hydrology for the 2029 level of development that was used in the studies in this report has been modified to incorporate effects of climate change for a selected median- impact future climate projection. The effects of climate change on inflows to major SWP and CVP reservoirs was estimated using the method from the 2009 Report *Using Future Climate Projections to Support Water Resources Decision Making in California* (Chung et al., 2009). This method adjusts the base hydrologic sequence to reflect projected changes in the timing and volume of inflow. For each month of the year, streamflows based on the future climate projection were compared to historical streamflows to estimate how much higher or lower future streamflows may be than historical flows. The monthly values for the reservoir inflows were then adjusted to represent the monthly trends for the future climate projection. Further adjustments are made to the hydrology to represent projected changes in annual runoff volume.

Demands

North of Delta

For both the 2009 and 2029 scenarios agricultural and outdoor urban land use based demands are calculated from an assumed cropping pattern and a soil-moisture budget. For the 2009 level study the land use based demands have been estimated using fixed 2009 land use and historical hydrology. For the 2029 level study the land use based demands have been estimated using fixed 2029 land use but the hydrology in the Sacramento Valley has been modified to incorporate effects of climate change under a selected representative climate change projection. This modification procedure is similar to what was used to modify inflows to major SWP and CVP reservoirs as discussed in the 2009 Report (Chung et al., 2009). Both land use based demands and estimated contract amounts serve as upper bounds on deliveries.

South of Delta

South of Delta demands, unlike North of Delta demands, are contract based. SWP Table A and Article 21 demands for the 2009 scenario are preprocessed independent of CalSim II and vary annually according to hydrologic conditions. SWP Table A demands for the 2029 scenario are assumed to be at maximum entitlement annually. Article 21 demands in the 2029 scenario, however, vary annually according to hydrologic conditions.

Meeting Delta Water Quality Standards

CalSim II uses DWR's Artificial Neural Network (ANN) model to simulate the flow-salinity relationships for the Delta. The ANN model correlates salinity at key locations in the Delta with Delta inflows, Delta exports, and Delta Cross Channel operations. The model estimates salinity at four locations for modeling Delta water quality standards. These locations are Old River at Rock Slough, San Joaquin River at Jersey Point, Sacramento River at Emmaton, and Sacramento River at Collinsville.

CalSim II Priorities in Water Deliveries

CalSim II allocates water according to the four priorities shown below. Highest priority is given to prior-right water users, minimum in-stream flow requirements and water quality requirements. While CVP and SWP contractor deliveries take precedence over next year's reservoir storage, a balance between the two is struck in the allocation decision to ensure that enough water is left in storage at the end of the year in case of impending drought.

1. Prior-right water users, minimum in-stream flow requirements, and water quality requirements.
2. SWP Table A contractors and CVP contractors.
3. Reservoir storage for the next year (carryover).
4. SWP Article 21 deliveries.

SWP Table A and Article 21 Deliveries

The CalSim II simulations in this report estimate SWP delivery amounts for SWP Table A and Article 21. As mentioned in Chapter 2, SWP Table A is the contractual method for allocating available supply and the total of all maximum SWP Table A amounts for deliveries from the Delta is 4.133 million acre-feet (maf) per year. Article 21 refers to a provision in the contract for delivering water that is available in addition to SWP Table A amounts. Article 21 of SWP contracts allows contractors to receive additional water deliveries only under specific conditions. These conditions are:

1. The water is available only when it does not interfere with SWP Table A allocations and SWP operations.
2. The water is available only when excess water is available in the Delta.
3. The water is available only when conveyance capacity is not being used for SWP purposes or scheduled SWP deliveries.
4. The water cannot be stored in the SWP system. In other words, the contractors must be able to use the Article 21 water directly or be able to store it in their own system.

CalSim II Performance

Some of the comments to the *Draft 2003 SWP Delivery Reliability Report* expressed concern about the accuracy of CalSim II and the credibility of conclusions about SWP delivery reliability that are based on CalSim II simulations. To respond to these concerns, DWR conducted several CalSim II studies. In one study, results from a CalSim II simulation using historical input from 1975 to 1998 were compared to historical operations. This study is documented in the report *CalSim-II Simulation of Historical SWP/CVP Operations, Technical Memorandum Report, November 2003* and was provided in Appendix E of the *2005 SWP Delivery Reliability Report*. In a second study, a sensitivity analysis was performed to quantify the effects of various inputs on CalSim II results. Two performance measures were used, a Sensitivity Index and Elasticity Index, to quantify the sensitivity of 12 model output responses to 12 different model input parameters. This sensitivity study was also provided in Appendix E of the *2005 SWP Delivery Reliability Report*.

In a follow-up study, DWR staff conducted a more detailed analysis of the sensitivity results, focusing on the delivery reliability of the SWP system. The results of this analysis are documented in an internal memorandum report dated April 30, 2007. The purpose of this analysis was to assist SWP contractors and other interested parties in evaluating the effect of model input parameters on SWP deliveries (SWP Delta deliveries, SWP north-of-Delta deliveries, and SWP deliveries under Article 21) with respect to a selected subset of input parameters.

Recent Improvements to CalSim II Simulations

The CalSim II model is modified in response to new in water system operational requirements, updated information, or improvements in computational methods. Changes to the model are discussed in Appendix A. Enhancements to CalSim II of note are:

- **Greater resolution in the representation of the Delta channel configuration and of the distribution of Net Delta Island Consumptive Use (Net DICU).** The representation of the Delta Channels was reconfigured to mimic the flow dynamics in the interior Delta, specifically to capture the flow effects in the Old and Middle Rivers. Channel configurations and flow regressions were taken from the paper *A Model to Estimate Combined Old & Middle River Flows – Paul Hutton, Ph.D., P.E., Metropolitan Water District of Southern California, April 2008*.
- **Article 56 Extended Carryover deliveries.** Article 56 Extended Carryover deliveries is a category of water delivery available to SWP Table A contractors that was not represented in the previous model used in the 2007 delivery reliability report. Modeling this category of water delivery gives a more realistic representation of real world export patterns throughout the delivery contract year.
- **Three-pattern deliveries.** The practice of the SWP delivering water based on three delivery patterns submitted by the SWP contractors for 30%, 50%, and 100% allocations is now modeled. Modeling the three delivery patterns based on the level of allocation gives a more realistic representation of real world export patterns throughout the delivery contract year.
- **Improved modeling of flow-salinity relationships in the Delta.** The previous Artificial Neural Network (ANN) used to estimate flow-salinity relationships has been replaced with a newer more accurate version. The new ANN and its accompanying implementation to the CalSim II model produces salinities that match more closely the Delta Simulation Model 2 (DSM2) salinities.
- **X2 positions and flow requirements estimated using an Artificial Neural Network.** The X2 positions and flow requirements were previously estimated using the Kimmerer-Monismith Equation. The new ANN used to estimate X2 position more closely matches the DSM2 model X2 position.
- **Sea Level Rise.** The phenomenon of sea level rise and its effect on Delta salinities is now modeled. Artificial Neural Networks were developed to estimate flow-salinity relationships in the Delta with an assumed increment of sea level rise for a mid-century condition.
- **SWP South of the Delta (SOD) Allocations.** The SWP SOD Allocation logic has been modified so that adjustments to the Water Supply Index-Delivery Index based allocations are made to account for the export restrictions imposed by the new Biological Opinions. The Biological Opinions dictate that San Joaquin River flows are now the determining factor for export capacity from the Delta. This new logic forecasts export capacity based on San Joaquin River wetness and then develops allocations from them.

Assessment of Present and Future SWP Delivery Reliability

6

These updated estimates of the current and future delivery reliability of the SWP reflect the changes in project operation due to the requirements contained in the USFWS' biological opinion issued in December 2008 and the NMFS' biological opinion issued in June 2009. These opinions are discussed in more detail in Chapter 4. The estimates for the future delivery amounts also incorporate assumptions regarding rainfall, runoff, and water supply demand based upon changed climatic conditions.

The updated estimates are presented alongside results from the 2007 SWP Delivery Reliability Report to help identify and explain impacts to delivery reliability due to the biological opinions' requirements and future climate change with sea level rise. At the end of the chapter, a comparison of the estimated SWP deliveries under Current (2009) Conditions to those under Future (2029) Conditions is presented. This chapter contains tables summarizing the updated estimated delivery amounts of the studies for the entire study period (1922-2003), dry years, and wet years and presents information on the estimated probability of annual SWP Table A delivery amounts currently and 20 years in the future. The annual values for SWP deliveries estimated by all the CalSim II simulations are listed in tables in Appendix B. These tables also show the annual Table A demands assumed for each study.

The results indicate potentially significant differences between the updated studies and studies done for the 2007 report under both current and future conditions for estimated deliveries during some periods. In general, updated estimates of both current and future SWP Table A deliveries are less than the deliveries presented in the 2007 report, during near-normal to wet years. The updated studies generally show slightly lower SWP Table A deliveries under Future (2029) Conditions when compared to Current (2009) Conditions. There are, however, some larger decreases in deliveries in the future during multiple dry-year periods. This is primarily due to the effects of the assumed climate change scenario that includes sea level rise. In comparison, the 2007 report showed frequent increases in future deliveries.

Assessment of SWP Delivery Reliability under Current (2009) Conditions

Current Conditions refer to those conditions in effect in 2009. They are described below. Corresponding results from the 2007 SWP Delivery Reliability Report are presented throughout this section for comparison. Appendix A presents a detailed discussion of the study assumptions for this report.

Availability of Source Water

The 2005 level of development (level of water use in the source areas) is assumed to be representative of 2009. The hydrologic sequence of simulated years is based upon historical precipitation and runoff patterns and is from water years 1922 through 2003.

Demand for Delta Water

The SWP contractors' Table A demands for deliveries from the Delta assumed for 2009 are shown in Table 6.1. A range in Table A demands is shown because the demand is assumed to vary each year with the weather. The assumed demands for 2009 are higher than the ones used in the corresponding study (2007 Study) in the 2007 report. Differences between the values in updated studies and the 2007 Study are due to increased Table A water demand for municipal uses.

Table 6. 1 SWP Table A demands from the Delta under Current Conditions

Study of Current Conditions	Average Demand		Maximum Demand		Minimum Demand	
	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]
2007 SWP Delivery Reliability Report, Study 2007	3308	80%	3864	94%	2323	56%
Updated Studies (2009)	3711	90%	4115	100%	3007	73%

1/ 4,133 taf /year

The potential demands for SWP Article 21 water are assumed for study purposes to be very high and are more than double the amounts assumed in the 2007 SWP Delivery Reliability Report as shown in Table 6.2. The Article 21 demands are increased in the 2009 updated studies to match the amounts assumed in the studies conducted for the biological opinions. Assuming very large Article 21 demands in the studies for the biological opinions was done to capture the upper bound of the potential impact of Article 21 exports upon the Delta ecosystem. This assumption reflects a condition in which SWP contractors are able to use essentially any available Article 21 water when conveyance capacity for Article 21 water exists in the SWP delivery system.

Table 6. 2 Article 21 demands from the Delta under Current Conditions

Study of Current Conditions	Maximum Article 21 demand (taf /month)[1]	
	December - March	April - November
2007 SWP Reliability Report, Study 2007	184	84
Updated Studies (2009)	414	214

1/ The CalSim II simulations deliver up to these demands in any month in which appropriate conditions exist. However, the actual capability of SWP water contractors to take this amount of Article 21 is not the sum of these maximum monthly values.

Ability to Convey Source Water to the Desired Point of Delivery

The CalSim II simulation assumes that current Delta water quality regulations (contained in the State Water Resources Control Board's Decision 1641) are in place for the Current (2009) Condition study. The simulation also incorporates the requirements of the FWS' and NMFS' biological opinions. Additional information on the characterization of the biological opinions in the model is found in Appendix A. The amount of exports allowed while achieving the Old River and Middle River flow targets are assumed to be shared equally between the CVP and the SWP. Combined CVP and SWP exports also are assumed constrained according to the NMFS BO Action 4.2.1 during April 1 to May 31. The specific rules for this restriction are included in Appendix A.

The simulation of current conditions in the 2007 report assumes the same D-1641 requirements for Delta water quality, but instead assumes an April 15 to May 15 export restriction and Old River and Middle River flow targets from the interim operating rules ordered by the federal court.

Annual Estimates of SWP Deliveries

The CalSim II estimates for the SWP Table A and Article 21 annual deliveries for the Current (2009) Condition are presented in Appendix B. These values are analyzed in the following sections.

SWP Table A Deliveries under Different Hydrologic Scenarios

Table 6.3 contains the average, maximum, and minimum estimates of Table A deliveries from the Delta under Current Conditions from the 2007 SWP Delivery Reliability Report and under 2009 assumptions that include the biological opinions' requirements. The estimated probabilities for a given amount of annual SWP delivery under Current (2009) Conditions are presented in Figure 6.1.

Table 6. 3 SWP Table A delivery from the Delta under Current Conditions

Study of Current Conditions	Average Delivery		Maximum Delivery		Minimum Delivery	
	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]
2007 SWP Delivery Reliability Report, Study 2007[2]	2595	63%	3711	90%	243	6%
Updated Studies (2009)	2483	60%	3338	81%	301	7%

1/ 4,133 taf /year

2/ Values reflect averaging annual deliveries from the two scenarios of Old and Middle River flow targets

Table 6.3 shows that under updated Current (2009) Conditions, average SWP annual delivery amounts may decrease 3% of maximum SWP Table A when compared to the earlier estimate, from 63% to 60%. This decrease is about 110 taf and is primarily due to the required actions in the biological opinions reducing the amount of Delta water available for export by the SWP in comparison to the effect of the Old River and Middle River flow targets in the 2007 study. The maximum delivery of 90% for the 2007 study is reduced by 370 taf to 81% for the updated study. The estimate of minimum SWP Table A delivery actually increases slightly.

Table 6.4 includes estimates of SWP Table A deliveries for Current (2009) Conditions under an assumed repetition of historical drought periods. The years are identified as dry by the Eight River Index, a good indicator of the relative amount of water supply available to the SWP. The Eight River Index is the sum of the unimpaired runoff from the four rivers in the Sacramento Basin used to define water conditions in the basin plus the four rivers in the San Joaquin Basin, which correspondingly define water conditions in that basin. The eight rivers are the Sacramento, Feather, Yuba, American, Stanislaus, Tuolumne, Merced, and San Joaquin. Table 6.4 also includes the average deliveries for comparison purposes.

Table 6. 4 Average and dry period SWP Table A deliveries from the Delta under Current Conditions

Study of Current Conditions	SWP Table A delivery from the Delta (in percent of maximum SWP Table A[1])					
	Long-term Average	Single dry year 1977	2-year drought 1976-1977	4-year drought 1931-1934	6-year drought 1987-1992	6-year drought 1929-1934
2007 SWP Delivery Reliability Report, Study 2007[2]	63%	6%	34%	35%	35%	34%
Updated Studies (2009)	60%	7%	36%	34%	35%	34%

1/ 4,133 taf /year

2/ Values reflect averaging annual deliveries from the two scenarios of Old and Middle River flow targets

Table 6.4 shows that estimates of updated SWP deliveries under Current (2009) Conditions during dry periods are about the same as earlier estimates. The four-year drought of 1931-1934 is estimated to provide 34% of maximum SWP Table A; a reduction of 41 taf/year when compared to the 2007 estimate. The two-year drought of 1976-1977 is an exception with SWP deliveries estimated to increase 2% of maximum SWP Table A, from 34% to 36%. This increase in delivery in 1976-1977 is due to the use of Article 56 carryover storage in the 2009 studies for this report. In the Current (2009) Condition study, 470 taf of water allocated in 1975 is carried over and used in January through March of 1976. Article 56 carryover storage was not modeled for 2007 report studies.

Table 6.5 summarizes SWP Table A deliveries under an assumed repetition of historical wet periods under Current (2009) Conditions. As with drought years, the Eight River Index is used to identify wet years. Table 6.5 shows that estimates of SWP deliveries under updated Current (2009) Conditions may either increase or decrease from earlier estimates during wet years. Decreases in SWP deliveries for these wet periods generally range from 0 to 5% of maximum SWP Table A (0 to 206 taf/year). These decreases are due to the requirements of the biological opinions. The increases in delivery in 1983 and 1982-1983 are due to an assumed increase in demand compared to the 2007 report.

Table 6. 5 Average and wet years SWP Table A delivery from the Delta under Current Conditions

Study of Current Conditions	SWP Table A delivery from the Delta (in percent of maximum SWP Table A[1])					
	Long-term Average	Single wet year 1983	2-year wet 1982-1983	4-year wet 1980-1983	6-year wet 1978-1983	10-year wet 1978-1987
2007 SWP Delivery Reliability Report, Study 2007[2]	63%	60%	66%	68%	73%	71%
Updated Studies (2009)	60%	68%	71%	68%	68%	67%

1/ 4,133 taf/year

2/ Values reflect averaging annual deliveries from the two scenarios of Old and Middle River flow targets

Article 21 Deliveries under Different Hydrologic Scenarios

State Water Project water delivery is a combination of both Table A deliveries and the use of Article 21 by some contractors to store water locally at times when extra water and capacity is available beyond that needed by normal SWP operations. Table 6.6 contains the average, maximum, and minimum SWP Article 21 deliveries over the 1922-2003 period for the earlier study and the updated simulation. Comparing the estimates of SWP Article 21 deliveries, the updated estimates show higher delivery amounts for the maximum delivery over the simulation period. The estimated maximum Article 21 delivery is increased by 260 taf. This increase is due to the higher Article 21 demands assumed for the 2009 studies. The minimum Article 21 delivery for the updated study is 2 taf/yr compared to 0 taf/yr for the 2007 report. This higher minimum delivery is due to a revised assumption in the updated studies that allows the diversion of Article 21 water to the North Bay Aqueduct whenever such water is available in the Delta. In the 2007 report, Article 21 deliveries to North Bay Aqueduct were assumed to be dependent on the availability of Banks pumping capacity to serve all Article 21 demands. The estimated average Article 21 deliveries are the same under the updated Current (2009) Conditions compared to the 2007 report.

Table 6. 6 Annual SWP Article 21 delivery from the Delta under Current Conditions

Study of Current Conditions	Average delivery (taf)	Maximum delivery (taf)	Minimum delivery (taf)
2007 SWP Delivery Reliability Report, Study 2007[1]	85	590	0
Updated Studies (2009)	85	850	2

1/ Values reflect averaging annual deliveries from the two scenarios of Old and Middle River flow targets

Because Article 21 exports happen sporadically, it is best to evaluate the effects by looking at specific years. Table 6.7 shows the updated and earlier estimates of Article 21 deliveries by year during dry periods. Under the updated Current (2009) Conditions, Article 21 deliveries are estimated to be significantly increased during the years 1932 and 1933. These increases are primarily the result of the assumed higher Article 21 demand. Table 6.7 illustrates that opportunities for delivering Article 21 water exist even during drought periods,

Table 6.8 shows the updated and earlier estimates of Article 21 deliveries by year during the 1978-1987 wet period. Under Current (2009) Conditions, updated estimated Article 21 delivery can increase up to 450 taf in an individual year, compared to earlier estimates. Once again, the increases in Article 21 are due to the high level of assumed demand. In two years, 1978 and 1982, the estimated Article 21deliveries decrease when compared to earlier estimates.

Table 6. 7 Average and dry year SWP Article 21 delivery under Current Conditions (taf per year)

Year	2007 SWP Delivery Reliability Report, Study 2007[1]	Updated Studies (2009)
1929	0	10
1930	0	10
1931	0	8
1932	0	160
1933	40	390
1934	0	8
1976	5	9
1977	0	2
1987	0	9
1988	0	10
1989	0	10
1990	0	10
1991	0	12
1992	0	10
Long-term average	85	85

1/ Values reflect averaging annual deliveries from the two scenarios of Old and Middle River flow targets

Table 6. 8 Average and wet year SWP Article 21 delivery under Current Conditions (taf per year)

Year	2007 SWP Delivery Reliability Report, Study 2007[1]	Updated Studies (2009)
1978	100	2
1979	0	120
1980	190	190
1981	0	8
1982	490	460
1983	400	850
1984	460	510
1985	0	2
1986	30	140
1987	0	9
1978-87 average	170	230
Long-term average	85	85

1/ Values reflect averaging annual deliveries from the two scenarios of Old and Middle River flow targets

SWP Table A Delivery Probability

The probability that a given level of SWP Table A amount will be delivered from the Delta is shown for Current (2009) Conditions in Figure 6.1. Results from the 2007 SWP Delivery Reliability Report and updated estimates for 2009 are shown. Probability values for Current (2009) Conditions are presented in Appendix B. To use Figure 6.1, one would first locate the value for the specific percent exceedence along the horizontal axis (x-axis) of the graph, move vertically upward to the curve, then horizontally to the vertical axis (y-axis) and read the annual delivery. For example, for a 50% exceedence, the corresponding annual SWP Delta deliveries would be about 2,980 taf (72% of maximum Table A) from previous estimates and 2,675 taf (65% of maximum Table A) for the updated estimates. The numerical data for this figure is included in Appendix B and should be referenced for specific values corresponding to specific exceedences.

Figure 6.1 shows that under Current (2007) Conditions, for probabilities of exceedence less than 55%, updated annual Table A deliveries can be 300 to 400 taf less than the earlier estimates. Annual Table A deliveries associated with exceedences greater than 70% are generally more than the 2007 study by about 200 taf. Table 6.9 contains the values for SWP Delta deliveries corresponding to 25%, 50%, and 75% exceedence. The information in Table 6.9 can be stated as follows:

For any given year,

- There is a 25% chance that SWP deliveries will be at or above 2,920 taf.
- There is an equal chance (50%) that SWP deliveries will be above or below 2,675 taf.
- There is 75% chance that SWP deliveries will be above 2,397 taf. Another way to state this is that there is a 25% chance that deliveries will be below this value.

Figure 6. 1 SWP Table A delivery probability under Current Conditions

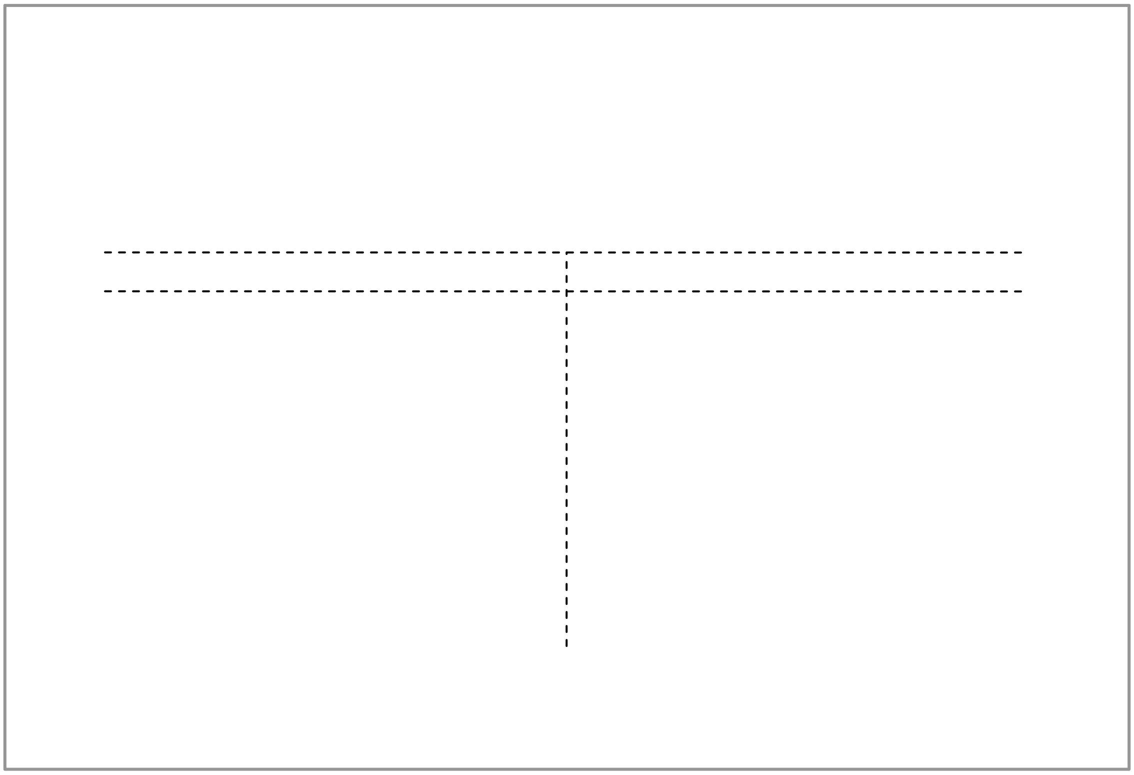

Table 6. 9 Highlighted SWP Table A delivery percent exceedence values under Current Conditions

Exceedence	Annual SWP Table A Delivery (taf)		Change in delivery compared to 2007 report (taf)
	2007 SWP Delivery Reliability Report, Study 2007[1]	Updated Studies (2009)	
25%	3218	2920	-298
50%	2976	2675	-301
75%	2168	2397	+229

1/ Values reflect averaging annual deliveries from the two scenarios of Old and Middle River flow targets

Assessment of SWP Delivery Reliability under Future (2029) conditions

Future Conditions refer to conditions that are assumed in effect in the year 2029. These conditions as described below include effects of climate change and the same requirements of the biological opinions assumed under Current Conditions. Results from the CalSim II simulations for the 2007 SWP Delivery Reliability Report under 2027 future scenario (Study 2027) are presented throughout this section for comparison purposes. A detailed list of the study assumptions for this report is presented in Appendix A.

Availability of Source Water

DWR's 2009 report, *Using Future Climate Projections to Support Water Resources Decision Making in California* (Chung et al., 2009) evaluates possible future effects on California water supply through CalSim II simulations with hydrologic sequences which reflect different scenarios of climate change. The 82-year hydrologic sequence used to develop the delivery estimations for the 2029 study discussed below is based upon the methods used in *Using Future Climate Projections*. The method for developing the hydrologic sequence for 2029 is described in Appendix B.

It was pointed out earlier in Chapter 4 of this report that the studies in *Using Future Climate Projections* of potential climate changes by mid-century indicate a potential for operational interruptions due to one or more reservoirs reaching minimum levels of storage. The study for 2029 conditions indicates a slight increase in system vulnerability when compared with the 2009 study but it does not approach the levels forecasted in *Using Future Climate Projections*. For the 2029 study, it is assumed that actions such as a program to acquire water to meet Delta water quality objectives would be implemented to maintain system operation.

Demand for Delta Water

The SWP contractors' SWP Table A demands for deliveries from the Delta assumed for 2029 and for Study 2027 are shown in Table 6.10. The maximum annual SWP Table A demand of 4,133 taf is assumed in all 82 years of the simulation. There is no variation in demand due to different annual hydrologic conditions. The assumed demands for 2029 are the same as the demands presently developed for the Bay-Delta Conservation Plan.

Table 6. 10 SWP Table A demands from the Delta under Future Conditions

Study of Future Conditions	Average Demand		Maximum Demand		Minimum Demand	
	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]
2007 SWP Delivery Reliability Report, Study 2027	4111	99%	4133	100%	3935	95%
Updated Studies (2029)	4133	100%	4133	100%	4133	100%

1/ 4,133 taf /year.

The assumed Article 21 demands, shown in Table 6.11, are higher than the demands assumed for study 2027 and are at the same level as the Article 21 demands assumed for the 2009 study. This assumption reflects a condition in which SWP contractors are able to use essentially any available Article 21 water when conveyance capacity for Article 21 water exists in the SWP delivery system.

Table 6. 11 Article 21 demands from the Delta under Future Conditions

Study of Future Conditions	Maximum Article 21 demand (taf/month)[1]	
	December - March	April - November
2007 SWP Delivery Reliability Report, Study 2027	184	84
Updated Studies (2029)	414	214

1/ The CalSim II simulations deliver up to these demands in any month in which appropriate conditions exist. However, the actual capability of SWP water contractors to take this amount of Article 21 is not the sum of these maximum monthly values.

Ability to Convey Source Water to the Desired Point of Delivery

One of the most significant assumptions regarding SWP conveyance is that the rules and facilities related to Delta conveyance will remain at the status quo. That is, no new facilities are assumed to be in place to convey water through or around the Delta. As noted in Chapter 3, there are several processes under way to identify modifications to the existing method of conveying water through the Delta to reduce the conflict between fishery concerns and water supply reliability. However, these programs are not at a stage where such changes can be used in this report. The CalSim II simulations for 2029 scenarios assume the current Delta water quality regulations (contained in the State Water Resources Control Board's Decision 1641) are in place as well as the requirements of the USFWS and NMFS biological opinions. The exports resulting from meeting Old River and Middle River flow targets related to delta smelt are again assumed shared equally between the CVP and the SWP.

The simulations of Future Conditions in the 2007 report (study 2027) also assumed D-1641 Delta water quality requirements but it assumed that flow restrictions for Old River and Middle River ordered by the federal court in December 2007 were in place.

To simulate the assumed 2029 conditions, two CalSim II simulations are needed: a scenario with climate change and a scenario assuming no climate change. SWP deliveries derived from these two simulations were modified as explained below before being used to describe Future (2029) Conditions.

Presentation of CalSim II Results

For the purpose of describing SWP deliveries under Future Conditions in this chapter, the annual deliveries with climate change simulated by CalSim II have been adjusted to better estimate deliveries reflecting 2029 conditions. The climate change scenario for Future Conditions assumes projections of climate and hydrology for the year 2050. Currently, 2029 climate change projections are not available. In order to estimate SWP deliveries 20 years in the future with potential changes in climate, annual SWP deliveries were interpolated between deliveries from the CalSim II simulation with the climate change scenario and deliveries from the CalSim II simulation which assumes no climate change. Both CalSim II simulations for future conditions assume a 2029 SWP demand level.

The following tables and graph contain the interpolated values from these two simulations. The annual SWP Table A and Article 21 deliveries for the two simulations upon which the information in this section is based are presented in Appendix B.

SWP Table A Deliveries under the Future Hydrologic Scenario

Table 6.12 contains the average, maximum, and minimum estimates of SWP Table A deliveries from the Delta under Future Conditions of study 2027 from the 2007 SWP Delivery Reliability Report and under the updated 2029 assumptions. The estimated probabilities for a given amount of annual SWP delivery under Future (2029) Conditions and those for the 2027 conditions are presented in Figure 6.4.

Table 6.12 shows that under the updated Future (2029) Conditions, average SWP delivery amounts may decrease from 6 to 9% of maximum SWP Table A (240 taf /yr to 360 taf/yr) when compared to the earlier estimates. This decrease in deliveries is primarily due to the effect of the biological opinions' requirements in reducing the amount of Delta water available for export by the SWP in comparison to the effect of the Old River and Middle River flow targets assumed for the 2027 study. Differences in the assumed hydrologic changes associated with climate change could also affect deliveries. The estimate of minimum annual SWP Table A delivery for the updated study is shown to increase from 4 to 5% of maximum SWP Table A amounts (165 taf/yr to 200 taf/yr). Minimum annual deliveries are associated with the conditions simulated for year 1977, the driest year on record.

Table 6.13 includes estimates of SWP Table A deliveries for a single-year and multiyear droughts. It also includes the average of the SWP Table A deliveries for comparison purposes. Estimates of updated SWP deliveries under Future (2029) Conditions during dry periods are about the same as the 2007 report for four-year and six-year droughts. The six-year drought of 1987-1992 is estimated to provide 32% of maximum SWP Table A, a reduction of 1% to 3% when compared to the 2007 estimate. Updated SWP deliveries in the 1976-1977 drought increase by 11% to 12% of maximum Table A (about 450 taf/yr) compared to the earlier studies. About 180 taf of this increase is due to water allocated in 1975 and delivered in 1976 under the Article 56 carryover program.

Table 6. 12 SWP Table A delivery from the Delta under Future Conditions

Study of Future Conditions	Average Delivery		Maximum Delivery		Minimum Delivery	
	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]
2007 SWP Delivery Reliability Report, Study 2027[2]	2724 – 2850	66 – 69%	4133	100%	255 – 293	6 – 7%
Updated Studies (2029)	2487	60%	3999	97%	458	11%

1/ 4,133 taf /year

2/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Table 6. 13 Average and dry period SWP Table A deliveries from the Delta under Future Conditions

Study of Future conditions	SWP Table A delivery from the Delta (in percent of maximum Table A[1])					
	Long-term Average	Single dry year 1977	2-year drought 1976-1977	4-year drought 1931-1934	6-year drought 1987-1992	6-year drought 1929-1934
2007 SWP Delivery Reliability Report, Study 2027[2]	66 – 69%	6-7%	26 – 27%	32 – 37%	33 – 35%	33 – 36%
Updated Studies (2029)	60%	11%	38%	35%	32%	36%

1/ 4,133 taf /year

2/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Table 6.14 summarizes SWP Table A deliveries under an assumed repetition of historical wet periods under Future Conditions. As with drought years, the Eight River Index is used to identify wet years. SWP deliveries increase in 1983 compared to earlier studies by 3% of maximum SWP Table A due to an assumed increase in demand. Reductions in delivery amounts are significant for the two-, four-, six-, and 10-year wet periods. The highest reduction occurs in the 1978-1987 period and ranges from 8% to 11% of maximum SWP Table A. This is a reduction of 330 taf/yr to 450 taf/yr.

Table 6. 14 Average and wet period SWP Table A deliveries from the Delta under Future Conditions

Study of Future Conditions	SWP Table A delivery from the Delta (in percent of maximum Table A[1])					
	Long-term average	Single wet year 1983	2-year wet 1982-1983	4-year wet 1980-1983	6-year wet 1978-1983	10-year wet 1978-1987
2007 SWP Delivery Reliability Report, Study 2027[2]	66 – 69%	94%	97%	86 – 87%	84 – 87%	80 – 83%
Updated Studies (2029)	60%	97%	93%	82%	79%	72%

1/ 4,133 taf/year

2/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Article 21 Deliveries under Different Hydrologic Scenarios

Table 6.15 contains the average, maximum, and minimum SWP Article 21 delivery estimates over the 1922-2003 period for the updated simulations of Future (2029) Conditions. Comparing the estimates of SWP Article 21 deliveries, the updated estimates show more delivery amounts on average and for the maximum annual delivery over the simulation period. Estimated average Article 21 delivery under the updated Future (2029) Conditions is 30 taf/yr more than the corresponding estimate in the 2007 SWP

Delivery Reliability Report. Estimated maximum annual Article 21 delivery is increased about 120 taf. These increases are due to the assumed higher Article 21 demands in the 2029 studies. The minimum Article 21 delivery for the updated study is 1 taf/yr compared to 0 taf/yr for the 2007 report. This higher minimum delivery is due to a revised assumption in the updated studies that allows the diversion of Article 21 water to the North Bay Aqueduct whenever such water is available in the Delta. In the 2007 report, Article 21 deliveries to North Bay Aqueduct were assumed to be dependent on the available Harvey O. Banks pumping capacity to serve all Article 21 demands.

Table 6. 15 Annual SWP Article 21 delivery from the Delta under Future Conditions

Study of Future Conditions	Average delivery (taf)	Maximum delivery (taf)	Minimum delivery (taf)
2007 SWP Delivery Reliability Report, Study 2027[1]	30	410 – 420	0
Updated Studies (2029)	60	540	1

1/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Table 6.16 contains the estimates for Article 21 deliveries during historical dry periods. The Article 21 deliveries for the updated 2029 study have a dry period maximum of 370 taf/yr compared to 90 taf/yr for the 2027 studies. Table 6.16 illustrates that opportunities for delivering Article 21 water exist even during drought periods.

Table 6.17 shows updated and earlier estimates of Article 21 deliveries by year during the 1978-1987 wet period. The availability of Article 21 deliveries is also increased for this wet period. The average Article 21 delivery for the 1978-1987 period under Future (2029) Conditions is 140 taf/yr, compared to a range of 90 taf/yr to 100 taf/yr for the 2027 studies.

Table 6. 16 Average and dry year SWP Article 21 delivery under Future Conditions (taf per year)

Year	2007 SWP Delivery Reliability Report, Study 2027[1]	Updated Studies (2029)
1929	0	160
1930	0	10
1931	0	8
1932	0 – 40	370
1933	20 – 90	230
1934	0 – 10	70
1976	0	12
1977	0 – 10	3
1987	0	60
1988	0	60
1989	0	6
1990	0	11
1991	0	13
1992	0	9
Long-term Average	30	60

1/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Table 6. 17 Average and wet year SWP Article 21 delivery under Future Conditions (taf per year)

Year	2007 SWP Delivery Reliability Report, Study 2027[1]	Updated Studies (2029)
1978	40 – 150	70
1979	0	11
1980	90 – 130	30
1981	0	14
1982	0	100
1983	270 – 290	510
1984	410 – 420	540
1985	0	9
1986	0 – 10	50
1987	0	60
1978-87 Average	90 – 100	140
Long-term Average	30	60

1/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

SWP Table A Delivery Probability

The probability that a given level of SWP Table A amount will be delivered from the Delta is shown for Future (2029) Conditions in Figure 6.4. Results of the 2027 studies from the 2007 SWP Delivery Reliability Report and the updated 2029 study are shown. Probabilities for 2027 conditions are shown as a set of dotted lines representing the four climate change scenarios analyzed in the 2007 report.

Figure 6.2 shows that under Future (2029) Conditions, for probabilities of exceedence under 60%, updated annual SWP Table A deliveries can be significantly less than the earlier estimates. For example, a delivery estimate which has a 40% chance of being larger is reduced to about 2,700 taf/yr (65% of maximum Table A) in the updated study from the earlier estimates of about 3,260 taf to 3,450 taf annually (79-83% of maximum Table A). The information upon which Figure 6.2 is based for the updated future condition is contained in Tables B.4 and B.5 in Appendix B.

Figure 6. 2 SWP Delta Table A delivery probability under Future Conditions

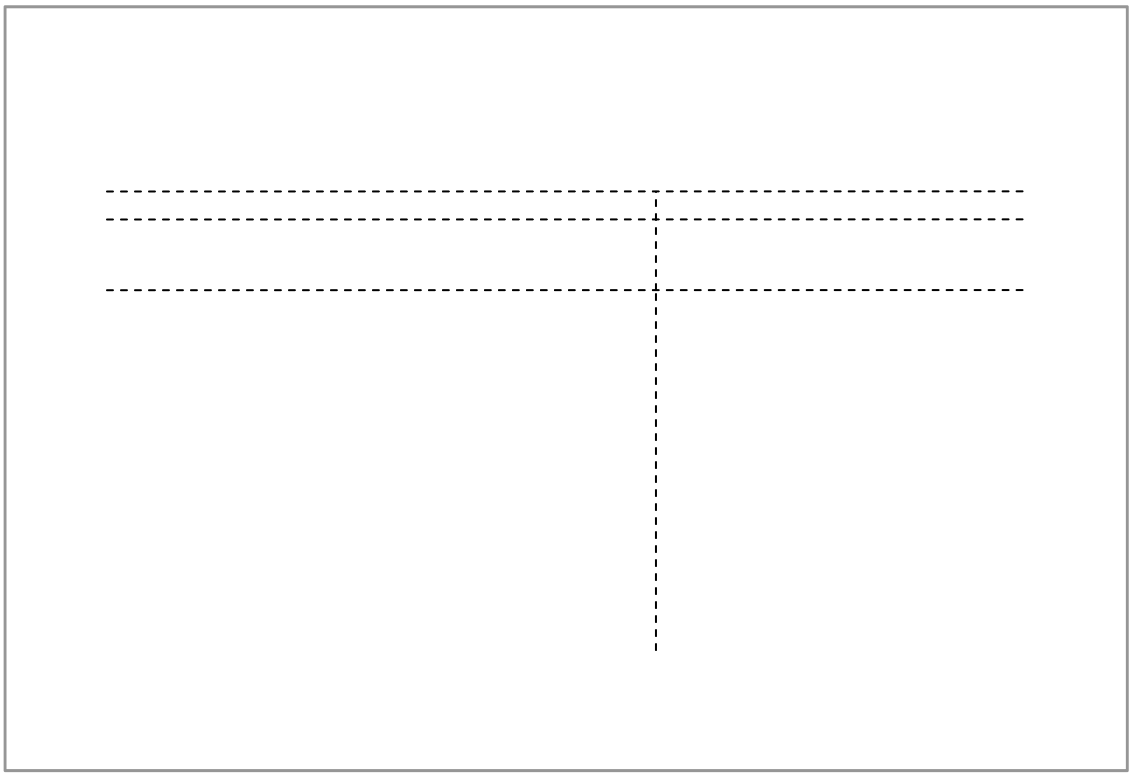

Table 6.18 presents the SWP Table A annual deliveries associated with 25%, 50%, and 75% exceedence illustrated in Figure 6.2 and contained in Table B.5. The information in this table can be stated as follows:

For any given year,

- There is 1 chance in 4 (25% chance) that SWP deliveries will be at or above 2,915 taf.
- There is an equal chance (50% chance) that SWP deliveries will be above or below 2,596 taf.
- There is 75% chance that SWP deliveries will be above 2,137 taf. Another way to state this is that there is a 25% chance that deliveries will be below this range.

Table 6. 18 Highlighted SWP Table A delivery percent exceedence values under Future Conditions

Exceedence	Annual SWP Table A Delivery (taf)		Change in delivery in updated studies compared to 2007 report (taf)
	2007 SWP Delivery Reliability Report, Study 2027[1]	Updated Studies (2029)[2]	
25%	3687 – 3815	2915	-772 to -900
50%	2967 – 3205	2596	-371 to -609
75%	1860 – 2077	2137	+60 to +277

1/ Range in value reflects four modified scenarios of climate change.

2/ Annual SWP Table A deliveries were interpolated between year 2050 with climate change and no climate change scenarios.

Comparing Current and Future SWP Delivery Reliability

The results presented earlier in this chapter compare updated delivery projections for both the current and future scenarios with those contained in the 2007 Delivery Reliability Report. The comparisons show that deliveries are estimated to be less than projected in the 2007 report due to implementing the requirements of the recent biological opinions and, for the future projection, a change in the assumed climate change scenario. This section presents the same CalSim II simulation-based results as a comparison of current reliability, projected for 2009, to the future reliability, projected for 2029. Comparisons to the results of the 2007 SWP Delivery Reliability Report are also included

SWP Table A Deliveries under Different Hydrologic Scenarios

Tables 6.19, 6.20, and 6.21 summarize the estimated Table A deliveries from the Delta under current and future conditions from the 2007 SWP Delivery Reliability Report and as derived from the updated CalSim II simulations for this report. A significant observation involves the change over the twenty-year period of the average amount of projected Table A deliveries. In the 2007 report, average future SWP deliveries are projected to increase 3 to 6 percent of maximum Table A whereas, under the updated estimate, the average delivery does not change. The updated average annual delivery is estimated to remain at 60% of maximum Table A in the future.

In both the 2007 report and this updated report, the changes between current and future deliveries fluctuate within 4 percentage points during dry periods greater than 2 years (Table 6.20), and increase during wet periods (Table 6.21). The increases during the wet periods for both sets of studies become less as the wet periods lengthen. For the 2007 report, these increases range from 34% of maximum Table A for a single year to 9% for the 10-year period. For the updated study, the increases range from 29% for the single year to 5% for the 10-year period. The amounts of the increases for the updated estimates are consistently less than those for the 2007 report. This is primarily due to the SWP demands assumed for the updated study for current conditions and the climate change scenario assumed for the updated future condition that now includes sea level rise. The assumed demands are very similar between the current and future updated studies whereas the assumed demand for the 2027 study is significantly higher than the assumed demand in the 2007 study.

The projections for the single-year and 2-year drought periods are very sensitive to the assumed conditions immediately preceding the drought and the operational rules for the SWP. Two key factors are the reservoir storages assumed at the beginning of the period and the amount of water allocated under Table A for the previous year being carried over into the subsequent year. Under a 2-year drought condition (1976-1977), the 2007 report estimates the future SWP Table A deliveries as being lower than the projected current deliveries by as much as 8% of maximum SWP Table A (Table 6.20). The updated estimates indicate that future SWP Table A deliveries under the 2-year drought period could be slightly higher than under Current (2009) Conditions (Table 6.20). The updated future SWP Table A deliveries for a single dry year are estimated to be higher than the 2009 study by 4% of maximum SWP Table A.

Table 6. 19 SWP Table A delivery from Delta under Current and Future Conditions

	Average Delivery		Maximum Delivery		Minimum Delivery	
	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]	taf /year	% of maximum SWP Table A[1]
2007 SWP Delivery Reliability Report						
Current (2007)	2595	63%	3711	90%	243	6%
Future (2027)[2]	2724 – 2850	66 – 69%	4133	100%	255 – 293	6 – 7%
Updated Studies						
Current (2009)	2483	60%	3338	81%	301	7%
Future (2029)	2487	60%	3999	97%	458	11%

1/ 4,133 taf /year

2/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Table 6. 20 Average and dry period SWP Table A deliveries from the Delta under Current and Future Conditions

	SWP Table A delivery from the Delta (in percent of maximum Table A[1])					
	Long-term Average	Single dry year 1977	2-year drought 1976-1977	4-year drought 1931-1934	6-year drought 1987-1992	6-year drought 1929-1934
2007 SWP Delivery Reliability Report						
Current (2007)	63%	6%	34%	35%	35%	34%
Future (2027)[2]	66 – 69%	6-7%	26 – 27%	32 – 37%	33 – 35%	33 – 36%
Updated Studies						
Current (2009)	60%	7%	36%	34%	35%	34%
Future (2029)	60%	11%	38%	35%	32%	36%

1/ 4,133 taf /year

2/ Range in values reflects four modified scenarios of climate change: annual Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Table 6. 21 Average and wet period SWP Table A deliveries from the Delta under Current and Future Conditions

	SWP Table A delivery from the Delta (in percent of maximum Table A[1])					
	Long-term Average	Single wet year 1983	2-year wet 1982-1983	4-year wet 1980-1983	6-year wet 1978-1983	10-year wet 1978-1987
2007 SWP Delivery Reliability Report						
Current (2007)	63%	60%	66%	68%	73%	71%
Future (2027)[2]	66 – 69%	94%	97%	86 – 87%	84 – 87%	80 – 83%
Updated Studies						
Current (2009)	60%	68%	71%	68%	68%	67%
Future (2029)	60%	97%	93%	82%	79%	72%

1/ 4,133 taf /year

2/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Article 21 Deliveries under Different Hydrologic Scenarios

Tables 6.22, 6.23, and 6.24 contain summaries and highlights of estimated SWP Article 21 deliveries from the Delta under current and Future Conditions from the 2007 SWP Delivery Reliability Report and as derived from updated CalSim II simulations for this report. The studies for the 2007 report and this updated report conclude lower amounts of deliveries will be made in the future under Article 21. Updated estimates of future SWP Article 21 deliveries may increase over updated current values for specific years; however, the long-term average future Article 21 delivery is reduced to about two-thirds of the estimate for the current (2009) scenario. Because the updated studies include the assumption that the SWP water contractors have a much greater ability receive water under Article 21, the updated studies show greater annual variation in the amount of Article 21 deliveries when compared to the 2007 report.

Table 6. 22 Annual SWP Article 21 delivery from the Delta under Current and Future Conditions

	Average delivery (taf)	Maximum delivery (taf)	Minimum delivery (taf)
2007 SWP Delivery Reliability Report			
Current (2007)	85	590	0
Future (2027) [1]	30	410 – 420	0
Updated Studies			
Current (2009)	85	850	2
Future (2029)	60	540	1

1/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Table 6. 23 Average and dry year SWP Article 21 delivery under Current and Future Conditions (taf per year)

Year	2007 SWP Delivery Reliability Report		Updated Studies	
	Current (2007)	Future (2027) [1]	Current (2009)	Future (2029)
1929	0	0	10	160
1930	0	0	10	10
1931	0	0	8	8
1932	0	0 – 40	160	370
1933	40	20 – 90	390	230
1934	0	0 – 10	8	70
1976	5	0	9	12
1977	0	0 – 10	2	3
1987	0	0	9	60
1988	0	0	10	60
1989	0	0	10	6
1990	0	0	10	11
1991	0	0	12	13
1992	0	0	10	9
Long-term Average	85	30	85	60

1/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Table 6. 24 Average and wet year SWP Article 21 delivery under Current and Future Conditions (taf per year)

Year	2007 SWP Delivery Reliability Report		Updated Studies	
	Current (2007)	Future (2027) [1]	Current (2009)	Future (2029)
1978	100	40 – 150	2	70
1979	0	0	120	11
1980	190	90 – 130	190	30
1981	0	0	8	14
1982	490	0	460	100
1983	400	270 – 290	850	510
1984	460	410 – 420	510	540
1985	0	0	2	9
1986	30	0 – 10	140	50
1987	0	0	9	60
1978-87 Average	170	90 – 100	230	140
Long-term Average	85	30	85	60

1/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

SWP Table A Delivery Probability

The current and future probability that a given level of SWP Table A amount will be delivered from the Delta is shown in Figure 6.3 from the 2007 SWP Delivery Reliability Report and in Figure 6.4 for updated studies for this report. In the 2007 report, future SWP Table A deliveries exceeded current deliveries at exceedence levels less than 60%. Under the updated simulations for this report, future SWP Table A deliveries exceed current estimated deliveries at exceedence levels less than 15%. Above this exceedence, future deliveries are generally smaller than current deliveries; with the most significant reduction being exceedence levels of 70% and 80%. The SWP demands are very similar for the current and future scenarios in the updated studies. Therefore, the differences in SWP Table A delivery amounts for the updated studies are primarily due to the climate change scenario that is assumed.

Figure 6. 3 Current and future SWP Table A delivery probability from the 2007 SWP Delivery Reliability Report

Figure 6. 4 Updated current and future SWP Table A delivery probability

Table 6.25 presents SWP Table A delivery values which correspond to 25%, 50%, and 75% exceedence for current and future conditions. Previously in the 2007 report, future annual SWP deliveries were estimated to be larger than the estimated current deliveries by approximately 500 taf to 600 taf for 25% exceedence and 0 taf to 200 taf for 50% exceedence. At 75% exceedence, future study 2027 deliveries were estimated to be less than current 2007 study deliveries by about 100 taf to 300 taf. For the updated studies, future SWP Table A deliveries associated with the 25%, 50%, and 75% exceedence levels are about the same or lower than for the deliveries at the current level (2009). The most significant reduction in updated future deliveries occurs at the 75% exceedence level where future deliveries are about 260 taf less than under Current (2009) Conditions. As previously mentioned, this difference is primarily due to the climate change scenario included under Future (2029) Conditions.

Table 6. 25 Highlighted SWP Table A delivery percent exceedence values under Current and Future Conditions

Exceedence	Annual SWP Table A Delivery (taf)			
	2007 SWP Delivery Reliability Report		Updated Studies	
	Current (2007)	Future (2027) [1]	Current (2009)	Future (2029)
25%	3218	3687 – 3815	2920	2915
50%	2976	2967 – 3205	2675	2596
75%	2168	1860 – 2077	2397	2137

1/ Range in values reflects four modified scenarios of climate change: annual SWP Table A deliveries were first interpolated between full 2050 level and no climate change scenarios, then averaged over the two scenarios of Old and Middle River flow targets.

Interpreting and Applying the Results for Local Planning

7

Chapter 6 presents estimates for current-level deliveries and for deliveries 20 years in the future. Chapter 6 and Appendix B explain how these estimates are developed. This chapter provides guidance on how to apply the delivery estimates to water management plans.

All results in this report are presented as percentages of the maximum Table A amount for SWP deliveries from the Delta of 4,133 taf/yr. In previous delivery reliability reports, all the percentage values of maximum Table A presented in the report were directly applicable to individual contractors. In this report however, the CalSim II simulations model the practice of certain contractors to carry over water supply from the year in which it was allocated and have it delivered in the following year, as allowed by Article 56 of their contract. See Appendix D for a discussion of Article 56 carryover storage.

The long-term average percentage values of Table A deliveries in this report continue to be directly applicable to all water contractors but values for individual years or averages over shorter periods of time, such as a dry-year period or a wet-year period, should be applied with caution as they may be affected by the amount of water assumed to be held over from one year and delivered in the next under Article 56. For values other than the long-term averages, we recommend individual contractors contact the Department of Water Resources' Bay-Delta Office at (916) 653-1099 to obtain the values specific to their water agency or download the information directly from the SWP Delivery Reliability website at http://baydeltaoffice.water.ca.gov/swpreliability/index.cfm. The Bay-Delta Office should also be contacted with other questions regarding the use of the information contained in this report.

The following example illustrates how to incorporate the long-term average values into a local water management plan. It is developed for a hypothetical SWP contractor with a maximum Table A amount of 100,000 acre-feet per year.

Example

This example uses data directly from Table 6.20 for updated current and future estimates of SWP Table A deliveries for the long-term average. Table 7.1 shows the long-term current and future averages of Delta Table A deliveries interpolated for 5-year periods. Since the long-term average Table A value is 60% of maximum Table A for both the current and future estimates, the interpolated value for each 5-year period is also 60%. Although the values shown in Tables 7.1 and 7.2 are for the period 2009 – 2029, they are the best estimates available for use in developing water management plans for the period 2010-2030.

Table 7. 1 SWP average Table A delivery from the Delta in five-year intervals for studies 2009 and 2029

Year	2009	2014	2019	2024	2029
Average Percent of Maximum Table A 1922-2003	60%	60%	60%	60%	60%

How to Calculate Supplies

In order to estimate delivery amounts for each 5-year increment from 2009 to 2029, multiply the contractor's maximum Table A amount for a particular year by the corresponding delivery percentages for that year from Table 7.1. The maximum Table A amounts of each contractor are listed in Appendix C. Table A amounts can be amended and a contractor's Table A amount over the next 20 years may be less than its maximum over some or all of this period. In this case, the contractor should use the amended Table A amounts for the corresponding years during this period.

Table 7.2 shows the SWP Table A deliveries projected to be available to a hypothetical contractor with a maximum Table A amount of 100,000 acre-feet during average hydrologic conditions. Although the estimates for the SWP delivery amount is constant over the 20-year period, estimates for the long-term average delivery for the other sources of supply could change over the twenty-year period and, therefore, produce different estimates for the total water supply available to an individual contractor for each 5-year period.

Data for other year types can also be presented this way. As mentioned previously, State Water Project contractors should contact the Bay Delta Office for their specific percentages to be used in estimating deliveries for a specific year or for wet or dry-year periods.

Table 7. 2 Average annual SWP deliveries assuming a maximum Table A amount of 100,000 acre-feet (acre-feet)

Water Supply Source	2009	2014	2019	2024	2029
State Water Project (Table A)	60,000	60,000	60,000	60,000	60,000
State Water Project (Article 21)[1]					
Groundwater					
Local Surface Water					
Transfers					
Exchanges					
Reclaimed Water					
Other (identify)					
Total					

1/ Annual Article 21 amounts vary significantly from year to year. Without the ability to store Article 21 supply, it is not likely to contribute to local supply. See discussion of Article 21 supply in Chapter 5.

Appendix A. CalSim II Modeling Assumptions

The SWP operation simulations in this report use the CalSim II model developed for the 2009 DWR-USBR Benchmark Study that was then modified specifically for these studies. The 2009 DWR-USBR Benchmark Study model was developed from the 2008 OCAP model and the 2008 Common Assumptions model. Additional information on these models is available at http://baydeltaoffice.water.ca.gov/swpreliability/index.cfm. The main difference between the 2009 Benchmark Study and the 2008 OCAP and the 2008 Common Assumptions models is the representation of the 2008 U.S. Fish and Wildlife Service Biological Opinion for Proposed Coordinated Operation of the Central Valley Project (CVP) and the State Water Project (SWP) and the 2009 National Marine Fisheries Service Biological Opinion on the Long Term Operations of the CVP and the SWP.

The 2008 OCAP model version was also modified to include the following changes listed below.

1. Replacement of the previous Artificial Neural Network (ANN) with a more accurate version. Implementation of the new ANN in the CalSim II model produces salinities that more closely match those of Delta Simulation Model 2 (DSM2).
2. More detailed representation of Delta channel configuration. This was done to capture the flow effects in Old and Middle Rivers.
3. Modeling of Article 56 extended carryover deliveries that are available to SWP Table A contractors.
4. Use of three delivery patterns (based on 30%, 50% and 100% allocations) which provides a more accurate representation of SWP deliveries.
5. Estimation of X2 position and flow requirements using an ANN. X2 positions are now more similar to those calculated in DSM2.
6. The phenomenon of sea level rise and its effect on Delta salinities is now modeled. Artificial Neural Networks were developed to estimate flow-salinity relationships in the Delta with an assumed increment of sea level rise for a mid-century condition.
7. Modified SWP South of the Delta (SOD) allocation logic to account for export restrictions that are established by the new Biological Opinions.

All studies assume current SWP Delta diversion limits (often referred to as "Banks Pumping Plant capacity"), existing conveyance capacity of the upper Delta-Mendota Canal/California Aqueduct system, and current SWP/CVP operations agreements. The following table, A.1, is a complete list of the study assumptions. Tables A.2 and A.3 provide the assumptions for American River demands.

Table A. 1 2009 Delivery Reliability Report CalSim II modeling assumptions

	2009 Studies	2029 Studies
Period of Simulation	82 years (1922-2003)	Same
HYDROLOGY		
Level of Development (Land Use)	2005 Level, DWR Bulletin 160-98 [1]	2020 Level, DWR Bulletin 160-98 [2]
Demands		
Sacramento River Region (excluding American River)		
CVP	Land Use based, limited by Full Contract	Land Use based, full build-out of contract amounts
SWP (FRSA)	Land Use based, limited by Full Contract	Same
Non-Project	Land Use based	Same
Davis-Woodland	None	Proposal 2B from EIR/S
Antioch	Pre-1914 water right	Same
CVP Refuges	Recent Historical Level 2 water needs	Firm Level 2 water needs
American River Basin		
Water rights	2005 Level [3]	2020 Level [4]
CVP	2005 Level; including Freeport Regional Water Project (FRWP)	2020 Level, full contracts including FRWP and Sacramento River Water Reliability Project
San Joaquin River Basin		
Friant Unit	Limited by contract amounts, based on current allocation policy	Same
Lower Basin	Land-use based, based on district level operations and constraints.	Same
Stanislaus River Basin [5]	Land-use based, based on New Melones Interim Operations Plan and NMFS BO (Jun 2009) Actions III.1.2 and III.1.3 [11]	Same
South of Delta		
CVP	Full Contract	Same
CCWD	140 TAF/YR [6]	195 TAF/YR [6]
SWP (with North Bay Aqueduct)	3.0-4.1 MAF/YR	4.1 MAF/YR
SWP Article 21 Demand	MWDSC up to 200 TAF/month, Dec-Mar, KCWA demand up to 180 TAF/month and others up to 34 TAF/month	Same

	2009 Studies	2029 Studies
FACILITIES		
Red Bluff Diversion Dam	Diversion dam with gates out except Jun 15 – Aug31 based on NMFS BO (Jun 2009) Action I.3.2; assume interim facilities in place	Diversion dam with gates out all year, NMFS BO (Jun 2009) Action I.3.1; assume permanent facilities in place
Freeport Regional Water Project	Included [7]	Included [7]
Banks Pumping Capacity	Physical capacity is 10,300 cfs but 6,680 cfs permitted capacity in all months up to 8,500 cfs during Dec 15th – Mar 15th depending on Vernalis flow conditions [8]; additional capacity of 500 cfs (up to 7,180 cfs) allowed for Jul – Sep for reducing impact of NMFS BO (Jun 2009) Action IV.2.1[11] on SWP	Same
Jones (Tracy) Pumping Capacity	Permit capacity is 4,600 cfs but exports limited to 4200 cfs plus diversions upstream of DMC constriction	Exports up to 4,600 cfs permit capacity in all months (allowed for by the Delta-Mendota Canal/California Aqueduct Intertie)
REGULATORY STANDARDS		
Trinity River		
Minimum Flow below Lewiston Dam	Trinity EIS Preferred Alternative (369-815 TAF/YR)	Same
Trinity Reservoir End-of-September Minimum Storage	Trinity EIS Preferred Alternative (600 TAF as able)	Same
Clear Creek		
Minimum Flow below Whiskeytown Dam	Downstream water rights, 1963 USBR Proposal to FWS and NPS, predetermined CVPIA 3406(b)(2) flows and NMFS BO (June 2009) Action I.1.1 [11]	Same
Upper Sacramento River		
Shasta Lake End-of-September Minimum Storage	NMFS 2004 Winter-run Biological Opinion (1900 TAF), predetermined CVPIA 3406(b)(2) flows, and NMFS BO (Jun 2009) Action I.2.1 [11]	Same
Minimum Flow below Keswick Dam	Flows for SWRCB WR 90-5 and 1993 Winter-run Biological Opinion temperature control, predetermined CVPIA 3406(b)(2) flows, and NMFS BO (Jun 2009) Action I.2.2 [11]	Same
Feather River		
Minimum Flow below Thermalito Diversion Dam	2006 Settlement Agreement (700 / 800 CFS)	Same
Minimum Flow below Thermalito Afterbay outlet	1983 DWR, DFG Agreement (750 – 1700 CFS)	Same
Yuba River		

	2009 Studies	2029 Studies
Minimum flow below Daguerre Point Dam	D-1644 Operations (Lower Yuba River Accord) [9]	Same
American River		
Minimum Flow below Nimbus Dam	American River Flow Management [10] as required by NMFS BO (Jun 2009) Action II.1 [11]	American River Flow Management [10] required by anticipated SWRCB order
Minimum Flow at H Street Bridge	SWRCB D-893	Same
Lower Sacramento River		
Minimum Flow near Rio Vista	SWRCB D-1641	Same
Mokelumne River		
Minimum Flow below Camanche Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (100 – 325 CFS)	Same
Minimum Flow below Woodbridge Diversion Dam	FERC 2916-029, 1996 (Joint Settlement Agreement) (25 – 300 CFS)	Same
Stanislaus River		
Minimum Flow below Goodwin Dam	1987 USBR, DFG agreement, and flows required for NMFS BO (Jun 2009) Actions III.1.2 and III.1.3 [11]	Same
Minimum Dissolved Oxygen	SWRCB D-1422	Same
Merced River		
Minimum Flow below Crocker-Huffman Diversion Dam	Davis-Grunsky (180 – 220 CFS, Nov – Mar), and Cowell Agreement	Same
Minimum Flow at Shaffer Bridge	FERC 2179 (25 – 100 CFS)	Same
Tuolumne River		
Minimum Flow at Lagrange Bridge	FERC 2299-024, 1995 (Settlement Agreement) (94 – 301 TAF/YR)	Same
San Joaquin River		
Maximum Salinity near Vernalis	SWRCB D-1641	Same
Minimum Flow near Vernalis	SWRCB D-1641, NMFS BO (Jun 2009) Action IV.2.1 [11]	Same
Sacramento River-San Joaquin River Delta		
Delta Outflow Index (Flow and Salinity)	SWRCB D-1641, FWS BO (Dec 2008) Action 4 [11]	Same
Delta Cross Channel Gate Operation	SWRCB D-1641, NMFS BO (Jun 2009) IV.1.2 [11]	Same
Delta Exports	SWRCB D-1641, NMFS BO (Jun 2009) Action IV.2.1 [11]	Same
Combined Flow in Old and Middle River (OMR)	FWS BO (Dec 2008) Actions 1 through 3 and NMFS BO (Jun 2009) Action IV.2.3 [11]	Same

	2009 Studies	2029 Studies
OPERATIONS CRITERIA		
Subsystem		
Upper Sacramento River		
Flow Objective for Navigation (Wilkins Slough)	NMFS BO (Jun 2009) Action I.4 [11]; 3,250 – 5,000 CFS based on CVP water supply condition	Same
American River		
Folsom Dam Flood Control	Variable 400/670 (without outlet modifications)	Same
Feather River		
Flow at Mouth	Maintain the DFG/DWR flow target above Verona or 2800 cfs for Apr– Sep dependent on Oroville inflow and FRSA allocation	Same
Stanislaus River		
Flow below Goodwin Dam	NMFS BO (Jun 2009) Actions III.1.2 and III.1.3 [11]	Same
System-wide		
CVP Water Allocation		
CVP Settlement and Exchange	100% (75% in Shasta Critical years)	Same
CVP Refuges	100% (75% in Shasta Critical years)	Same
CVP Agriculture	100% - 0% based on supply; additionally limited due to D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions [11]	Same
CVP Municipal & Industrial	100% - 50% based on supply; additionally limited due to D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions [11]	Same
SWP Water Allocation		
North of Delta (FRSA)	Contract specific	Same
South of Delta	Based on supply, Monterey Agreement; allocations limited due to D-1641, FWS BO (Dec2008) and NMFS BO (Jun 2009) export restrictions [11]	Same
CVP/SWP Coordinated Operations		
Sharing of Responsibility for In-Basin-Use	1986 Coordinated Operations Agreement	Same
Sharing of Surplus Flows	1986 Coordinated Operations Agreement	Same
Sharing of Restricted Export Capacity	Equal sharing of export capacity under SWRCB D-1641, FWS BO (Dec 2008) and NMFS BO (Jun 2009) export restrictions [11]	Same

	2009 Studies	2029 Studies
Transfers		
Lower Yuba River Accord [12]	Yuba River acquisitions for reducing impact of NMFS BO export restrictions [11] on SWP	Same
Dry Year Program	None	Same
Phase 8	None	Same
MWDSC/CVP Settlement Contractors	None	Same
CVP/SWP Integration		
Dedicated Conveyance at Banks	None	Same
NOD Accounting Adjustments	None	Same

1. The Sacramento Valley hydrology used in the Existing Conditions CALSIM II model reflects nominal 2005 land-use assumptions. The nominal 2005 land-use was determined by interpolation between the 1995 and projected 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects 2005 land-use assumptions developed by USBR. Existing-level projected land-use assumptions are being coordinated with the California Water Plan Update for future models.
2. The Sacramento Valley hydrology used in the Future Conditions CALSIM II model reflects 2020 land-use assumptions associated with Bulletin 160-98. The San Joaquin Valley hydrology reflects draft 2030 land-use assumptions developed by USBR. Development of future-level projected land-use assumptions are being coordinated with the California Water Plan Update for future models.
3. Presented in attached table of 2009 Study American River Demand Assumptions.
4. Presented in attached table of 2029 Study American River Demand Assumptions.
5. The CALSIM II model representation for the Stanislaus River does not necessarily represent USBR's current or future operational policies. A suitable plan for supporting flows has not been developed for NMFS BO (Jun 2009) Action 3.1.3.
6. The actual amount diverted is operated in conjunction with supplies from the Los Vaqueros project. The existing Los Vaqueros storage capacity is 100 taf. Associated water rights for Delta excess flows are included.
7. Mokelumne River flows are modified to reflect modified operations associated with EBMUD supplies from the Freeport Regional Water Project.
8. Current ACOE permit for Harvey O. Banks PP allows for an average diversion rate of 6,680 cfs in all months. Diversion rate can increase up to 1/3 of the rate of San Joaquin River flow at Vernalis during Dec 15th – Mar 15th up to a maximum diversion of 8,500 cfs, if Vernalis flow exceeds 1,000 cfs.
9. D-1644 and the Lower Yuba River Accord are assumed to be implemented for Existing and Future Conditions. The Yuba River is not dynamically modeled in CALSIM II. Yuba River hydrology and availability of water acquisitions under the Lower Yuba River Accord are based on modeling performed and provided by the Lower Yuba River Accord EIS/EIR study team.

10. Under Existing Conditions, the flow components of the proposed American River Flow Management are as required by the NMFS BO (June 4, 2009). Under Future Conditions the American River Flow Management is treated as a SWRCB permit term.
11. In cooperation with USBR, National Marine Fisheries Service, Fish and Wildlife Service, and Ca Department of Fish and Game, the Ca Department of Water Resources has developed assumptions for implementation of the FWS BO (December 15, 2008) and NMFS BO (June 4, 2009) in CALSIM II. The FWS BO and NMFS BO assumptions are included as separate appendices.
12. Acquisitions of Component 1 water under the Lower Yuba River Accord, and use of 500 cfs dedicated capacity at Banks PP during Jul – Sep, are assumed to be used to reduce as much of the effect of the April – May Delta export actions on SWP contractors as possible.

Table A. 2 2009 Study American River Demand Assumptions

CVP CONTRACTOR	Geographic Location	CVP Water Service Contracts (TAF/yr)		Settlement/ Exchange Contractor (TAF/yr)	Water Rights/ Non-CVP (TAF/yr)	Diversion Limits (TAF/Yr) If FUI (Mar-Nov Folsom Unimpaired Inflow - TAF/Yr)			Notes
		AG	M&I			> 1600	> 950	< 400	
Placer County Water Agency	Auburn Dam Site		0.0		35.5	35.5	35.5	35.5	
Sacramento Suburban Water District					17.0	17.0	0.0	0.0	
City of Folsom (includes P.L. 101-514)			7.0		27.0	34.0	34.0	34.0	1
Folsom Prison					2.0	2.0	2.0	2.0	
San Juan Water District (Placer County)					17.0	17.0	17.0	17.0	
San Juan Water District (Sac County) (includes P.L. 101-514)	Folsom Reservoir		24.2		33.0	44.2	44.2	44.2	1
El Dorado Irrigation District			7.55		0.0	7.55	7.55	7.55	1
City of Roseville			32.0		5.0	37.0	37.0	37.0	1
Placer County Water Agency			0.0			0.0	0.0	0.0	
El Dorado County (P.L. 101-514)			15.0			4.0	4.0	4.0	1
Total		0.0	85.8	0.0	101.0	162.8	145.8	145.8	
So. Cal WC/ Arden Cordova WC					5.0	5.0	5.0	5.0	
California Parks and Recreation	Folsom South Canal		5.0			1.0	1.0	1.0	1
SMUD (export)			30.0		15.0	20.0	20.0	20.0	1
Canal Losses					1.0	1.0	1.0	1.0	
Total		0.0	35.0	0.0	21.0	27.0	27.0	27.0	
City of Sacramento					58.0	58.0	58.0	50.0	
Arcade Water District	Lower American River				0.0	0.0	0.0	0.0	
Carmichael Water District					12.0	12.0	12.0	12.0	
Total		0.0	0.0	0.0	70.0	70.0	70.0	62.0	
City of Sacramento					62.3	62.3	62.3	70.3	
Sacramento County Water Agency			10.0			10.0	10.0	10.0	
(SMUD transfer)			20.0			20.0	20.0	20.0	
Sacramento County Water Agency (P.L. 101-514)	Lower Sacramento River		15.0			15.0	15.0	15.0	
Sacramento County Water Agency - assumed Appropriated Water					31.3				2
EBMUD (export)			133.0						3
Total		0.0	178.0	0.0	93.6	107.3	107.3	115.3	
Total (American R)		0.0	298.75	0.00	321.10				

1. When the CVP Contract quantity exceeds the quantity of the Diversion Limit minus the Water Right (if any), the diversion modeled is the quantity allocated to the CVP Contract (based on the CVP contract quantity shown times the CVP M&I allocation percentage) plus the Water Right (if any), but with the sum limited to the quantity of the Diversion Limit.
2. SCWA targets 68 taf of surface water supplies annually. The portion unmet by CVP contract water is assumed to come from two sources:
   (1) Delta "excess" water- averages 16.5 taf annually, but varies according to availability. SCWA is assumed to divert excess flow when it is available, and when there is available pumping capacity.
   (2) “Other” water- derived from transfers and/or other appropriated water, averaging 14.8 taf annually but varying according remaining unmet demand.
3. EBMUD CVP diversions are governed by the Amendatory Contract, stipulating:
   (1) 133 taf maximum diversion in any given year.
   (2) 165 taf maximum diversion amount over any 3 year period.
   (3) Diversions allowed only when EBMUD total storage drops below 500 taf.
   (4) 155 cfs maximum diversion rate.

Table A. 3 2029 Study American River Demand Assumptions

CVP CONTRACTOR	Geographic Location	CVP Water Service Contracts (TAF/yr)		Settlement/ Exchange Contractor (TAF/yr)	Water Rights/ Non-CVP (TAF/yr)	Diversion Limits (TAF/Yr) If FUI (Mar-Nov Folsom Unimpaired Inflow - TAF/Yr)			Notes
		AG	M&I			> 1600	> 950	< 400	
Placer County Water Agency	Auburn Dam Site		0.0		35.5	35.5	35.5	35.5	
Sacramento Suburban Water District	Folsom Reservoir				0.0	0.0	0.0	0.0	
City of Folsom (includes P.L. 101-514)			7.0		27.0	34.0	34.0	34.0	1
Folsom Prison					5.0	5.0	5.0	5.0	
San Juan Water District (Placer County)					24.0	24.0	24.0	24.0	
San Juan Water District (Sac County) (includes P.L. 101-514)			24.2		33.0	57.2	57.2	57.2	1
El Dorado Irrigation District			7.55		17.0	24.55	24.55	24.55	1
City of Roseville			32.0		0.0	32.0	32.0	32.0	1
Placer County Water Agency			35.0			35.0	35.0	35.0	
El Dorado County (P.L. 101-514)			15.0			15.0	15.0	15.0	1
Total		0.0	120.8	0.0	106.0	226.8	226.8	226.8	
So. Cal WC/ Arden Cordova WC	Folsom South Canal				5.0	5.0	5.0	5.0	
California Parks and Recreation			5.0			5.0	5.0	5.0	1
SMUD (export)			30.0		15.0	45.0	45.0	45.0	1
Canal Losses					1.0	1.0	1.0	1.0	
Total		0.0	35.0	0.0	21.0	56.0	56.0	56.0	
City of Sacramento	Lower American River				96.3	96.3	96.3	50.0	
Arcade Water District					0.0	0.0	0.0	0.0	
Carmichael Water District					12.0	12.0	12.0	12.0	
Total		0.0	0.0	0.0	108.3	108.3	108.3	62.0	
City of Sacramento	Lower Sacramento River				51.9	51.9	51.9	98.2	
Sacramento County Water Agency (SMUD transfer)			10.0			10.0	10.0	10.0	
			20.0			20.0	20.0	20.0	
Sacramento County Water Agency (P.L. 101-514)			15.0			15.0	15.0	15.0	
Sacramento County Water Agency - assumed Appropriated Water					31.2				2
EBMUD (export)			133.0						3
Total		0.0	178.0	0.0	83.1	96.9	96.9	143.2	
Total		0.0	333.75	0.0	353.9				

1. When the CVP Contract quantity exceeds the quantity of the Diversion Limit minus the Water Right (if any), the diversion modeled is the quantity allocated to the CVP Contract (based on the CVP contract quantity shown times the CVP M&I allocation percentage) plus the Water Right (if any), but with the sum limited to the quantity of the Diversion Limit.
2. SCWA targets 68 taf of surface water supplies annually. The portion unmet by CVP contract water is assumed to come from two sources:
   (1) Delta "excess" water- averages 16.5 taf annually, but varies according to availability. SCWA is assumed to divert excess flow when it is available, and when there is available pumping capacity.
   (2) "Other" water- derived from transfers and/or other appropriated water, averaging 14.8 taf annually but varying according remaining unmet demand.
3. EBMUD CVP diversions are governed by the Amendatory Contract, stipulating:
   (1) 133 taf maximum diversion in any given year.
   (2) 165 taf maximum diversion amount over any 3 year period.
   (3) Diversions allowed only when EBMUD total storage drops below 500 taf.
   (4) 155 cfs maximum diversion rate.

Appendix A-1. Incorporation of U.S. Fish and Wildlife Service Biological Opinions into CALSIM II

The Reasonable and Prudent Action (RPA) in the U.S. Fish and Wildlife Service Biological Opinions (FWS BO) consists of required actions based on physical and biological phenomena that do not lend themselves readily to simulations using a monthly time step. Much scientific and modeling judgment has been employed to represent the implementation of the RPA actions. The interagency staff has developed modifications to the CALSIM II model to represent the RPA actions as best as possible, given the scientific understanding of environmental factors enumerated in the BO (e.g., turbidity, water temperature, and the presence of fish) and the limited historical data for some of these factors. It is further noted that there are on-going discussions on the interpretation of some of RPA actions which have potential to change modeling assumptions, and the resulting project operations.

Given the relatively generalized representation of the RPA actions assumed for CALSIM II modeling, much caution is required when interpreting outputs from the model.

RPA Component 1

Action 1: Limit Exports so OMR flows >= -2,000 cfs (14-day avg.) w/ 5-day running avg. + 25%

Period:		Action would cover 14 day period
Trigger:		Dec 1-20 (low entrainment risk period)
	AND	FWS discretion based on turbidity, flows, Fall Midwater Trawl (FMWT), and salvage
		After Dec 20 (high entrainment risk period)
	AND	Turbidity: 3-day avg. >= 12 NTU @ Prisoner's Pt., Holland Cut & Victoria Canal (all three)
	OR	Salvage: daily salvage index value >= 0.5 (daily delta smelt salvage > 1/2 prior yr. FMWT index value)

Off-ramp:		Temperature: 3 Station daily mean water temperature (Mossdale, Antioch & Rio Vista) >= 12 degree C
	OR	Biological: Onset of spawning (presence of spent females in Spring Kodiak Trawl (SKT) or at Banks or Jones Pumping Plants (PPs))

Proposed CALSIM implementation:

Using a turbidity trigger based on a flow surrogate of Sac River Index > 20,000 cfs, Set OMR target at -2,000 cfs:

- If turbidity trigger first occurs in December, assume action starts Dec 21 (background OMR target of -8,000 cfs Dec 1-20)
- If turbidity trigger first occurs in January, assume action starts Jan 1
- If turbidity trigger first occurs in February, assume action starts Feb 1
- If turbidity trigger first occurs in March, assume action starts Mar 1

Assume action, once triggered, continues for a duration of 14 days

Uses surrogate temperature trigger for off-ramping when converting to weighted month

Implement more constraining 5-day running avg in CALSIM II by use of Hutton's (1/2/09 app 5) approach to relate 5-day to 14-day avgs

RPA Component 1

Action 2: Limit Exports so OMR flows >= -1,250 to -5,000 cfs (as determined weekly by the Smelt Working Group (SWG))

Trigger:		Immediately after Action 1
	OR	If Action 1 not implemented, SWG will determine start date
Suspension:		Flow: 3 day avg. Sacramento R. flow at Rio Vista >= 90,000 cfs
	AND	Flow: 3 day avg. San Joaquin R. flow at Vernalis >= 10,000 cfs
Off-ramp:		Temperature: 3 Station daily mean water temperature (Mossdale, Antioch & Rio Vista) >= 12 degree C
	OR	Biological: Onset of spawning (presence of spent females in SKT or at Banks or Jones PPs)

Proposed CALSIM implementation:

Action is always triggered by the end of RPA Action 1

Assume OMR criteria by condition of X2 as shown in table below (using prev mon X2)

Using surrogate conditions for suspension (> 50% frequency of 3-day events described above, Use Hutton's 12/16/08 app 4 method for determining frequency of high flows)

Assumed -5000 OMR flow criteria in 9 years the RPA Action 1 is not triggered

Uses surrogate temperature trigger for off-ramping when converting to weighted month

Implement more constraining 5-day running avg in CALSIM II by use of Hutton's 1/2/09 app 5 approach to relate 5-day to 14-day avgs

	OMR Criteria (cfs)		
40-30-30 Year Type	X2 East of Roe	X2 West of Roe	If No Action 1
W 1	-3500	-5000	-99999
AN 2	-3500	-5000	-99999
BN 3	-3500	-5000	-99999
D 4	-3500	-5000	-99999
C 5	-3500	-5000	-99999

RPA Component 1

Action 3: **Limit Exports so OMR flows >= -1,250 to -5,000 cfs (14-day avg.) w/ 5-day running avg. + 25%**

Trigger: Temperature: 3 Station daily mean water temperature (Mossdale, Antioch & Rio Vista) >= 12 degree C
OR Biological: Onset of spawning (presence of spent females in SKT or at Banks or Jones PPs)

Off-ramp: End of period: 30-Jun
OR Temperature: daily avg. temperature of 25 degree C for 3 consecutive days @ Clifton Court Forebay

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Proposed CALSIM implementation:

Uses surrogate temperature trigger for initiating, but no later than Apr-1, specific dates used to convert to weighted month

Assume OMR criteria by water year type as shown in table (using previous month X2, using April X2 for June)

Assume more constraining OMR or VAMP for the period of Apr 15-May 15

Uses surrogate temperature trigger for off-ramping when converting to weighted month

Implement more constraining 5-day running avg in CALSIM II by use of Hutton's (1/2/09 app 5) approach to relate 5-day to 14-day avgs

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		OMR Criteria (cfs)		
40-30-30 Year Type		X2 East of Chipps	X2 in between	X2 West of Roe
W	1	-1250	-3500	-5000
AN	2	-1250	-3500	-5000
BN	3	-1250	-3500	-5000
D	4	-1250	-3500	-5000
C	5	-1250	-3500	-5000

RPA Component 3

Action 4: **Manage X2 Position in the Fall through increasing Delta outflow when the preceding year was wetter than normal**

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Period: Average Monthly position

Trigger: September, October, or November

AND Preceding water year type for Sacramento 40-30-30 is Wet or Above Normal

Off-ramp: In November, limit monthly releases for meeting X2 position management to the volume of monthly natural inflow into the reservoirs

Proposed CALSIM implementation:

Fall Months following Wet or Above Normal Years	Action Implementation
September	Meet monthly average X2 requirement (74 km in Wet years, 81 km in Above Normal years)
October	Meet monthly average X2 requirement (74 km in Wet years, 81 km in Above Normal years)
November	Make reservoir releases up to natural inflow as needed to continue to meet monthly average X2 requirement (74 km in Wet years, 81 km in Above Normal years)

Appendix A-2. Incorporation of National Marine Fisheries Service Biological Opinion into CALSIM II

The Reasonable and Prudent Action (RPA) in the National Marine Fisheries Service Biological Opinion (NMFS BO) consists of required actions based on physical and biological phenomena that do not lend themselves readily to simulations using a monthly time step. Much scientific and modeling judgment has been employed to represent the implementation of the RPA actions. The interagency staff has developed modifications to CALSIM II model to represent the RPA actions as best as possible at this time, given the scientific understanding of environmental factors enumerated in the BO (e.g., turbidity, water temperature, and the presence of fish) and the limited historical data for some of these factors. It is further noted that there are on-going discussions on the interpretation of some of RPA actions which have potential to change modeling assumptions, and the resulting project operations.

Given the relatively generalized representation of the RPA actions assumed for CALSIM II modeling, much caution is required when interpreting outputs from the model.

Action Suite 1.1 Clear Creek

Action 1.1.1 Spring Attraction Flows

Action: USBR must annually conduct at least two pulse flows in Clear Creek in May and June of at least 600 cfs for at least three days for each pulse, to attract adult spring-run holding in the Sacramento River main stem.

Action 1.1.1 Assumptions for CALSIM II Modeling Purposes

Action: Model is modified to meet 600 cfs for 3 days twice in May. In the CALSIM II analysis, flows sufficient to increase flow up to 600 cfs for a total of 6 days are added to the flows that would have otherwise occurred in Clear Creek.

Action 1.1.5. Thermal Stress Reduction

Action: USBR must manage Whiskeytown releases to meet a daily water temperature of: 1) 60°F at the Igo gage from June 1 through September 15; and 2) 56°F at the Igo gage from September 15 to October 31.

Action 1.1.5 Assumptions for CALSIM II Modeling Purposes

Action: It is assumed that temperature operations can perform reasonably well with flows included in model.

Action Suite 1.2 Shasta Operations

Action 1.2.1 Performance Measures

Action: To ensure a sufficient cold water pool to provide suitable temperatures, long-term performance measures for temperature compliance points and EOS carryover storage at Shasta Reservoir must be attained. Performance measures for EOS carryover storage at Shasta Reservoir are as follows:

- 87% of years: Minimum EOS storage of 2.2 maf.
- 82% of years: Minimum EOS storage of 2.2 maf and end-of-April storage of 3.8 maf in following year (to maintain potential to meet Balls Ferry compliance point).
- 40% of years: Minimum EOS storage 3.2 maf (to maintain potential to meet Jelly's Ferry compliance point in following year).

Performance measures (measured as a 10-year running average) for temperature compliance points during summer season are:

- Meet Clear Creek Compliance point 95% of time.
- Meet Balls Ferry Compliance point 85% of time.
- Meet Jelly's Ferry Compliance point 40% of time.
- Meet Bend Bridge Compliance point 15% of time.

Action 1.2.1 Assumptions for CALSIM II Modeling Purposes

Action: Performance measures will be met using an iterative approach where full models will be run, model results will be post-processed to assess performance, and then model will be re-run with adjustments to operations until performance measures are met.

Operations adjustments may include changes in rules for delivery allocation, Delta export operations, storage balancing between the CVP north-of Delta reservoirs, and/or triggering of other FWS and NMFS BO actions. Currently there are no reiterations of runs being performed to ensure that performance measures are being met.

Action 1.2.2 November through February Keswick Release Schedule (Fall Actions)

Action: Depending on EOS carryover storage and hydrology, USBR must develop and implement a Keswick release schedule, and reduce deliveries and exports as needed to achieve performance measures.

Action 1.2.2 Assumptions for CALSIM II Modeling Purposes

Action: Keswick flows based on operation of 3406(b)(2) releases in OCAP Study 7.1 (for Existing) and

Study 8 (for Future) are used in CALSIM II. These flows will be reviewed for appropriateness under this action. A post-process based evaluation similar to what has been explained in Action 1.2.1 will be conducted. Currently there are no reiterations of runs being performed to ensure that performance measures are being met.

Action 1.2.3 February Forecast; March – May 14 Keswick Release Schedule (Spring Actions)

Action: 1) USBR must make its February 15 forecast of deliverable water based on an estimate of precipitation and runoff within the Sacramento River basin at least as conservative as the 90% probability of exceedance. Subsequent updates of water delivery commitments must be based on monthly forecasts at least as conservative as the 90% probability of exceedance.
2) USBR must make releases to maintain a temperature compliance point not in excess of 56 degrees between Balls Ferry and Bend Bridge from April 15 through May 15.

Action 1.2.3 Assumptions for CALSIM II Modeling Purposes

Action: It is assumed that temperature operations can perform reasonably well with flows included in model.

Action 1.2.4 May 15 through October Keswick Release Schedule (Summer Action)

Action: USBR must manage operations to achieve daily average water temperatures in the Sacramento River between Keswick Dam and Bend Bridge as follows:

1) Not in excess of 56°F at compliance locations between Balls Ferry and Bend Bridge from May 15 through September 30 for protection of winter-run, and not in excess of 56°F at the same compliance locations between Balls Ferry and Bend Bridge from October 1 through October 31 for protection of mainstem spring run, whenever possible.

2) USBR must operate to a final Temperature Management Plan starting May 15 and ending October 31.

Action 1.2.4 Assumptions for CALSIM II Modeling Purposes

Action: It is assumed that temperature operations can perform reasonably well with flows included in model. If time permits, a temperature modeling and post-process based approach will be followed to verify temperatures are met at the compliance points. In the long-term approach, for a complete interpretation of the action, development of temperature model runs are needed to develop flow schedules if needed for implementation into CALSIM II.

Action Suite 1.3 Red Bluff Diversion Dam (RBDD) Operations

Action 1.3.1 Operations after May 14, 2012: Operate RBDD with Gates Out

Action: No later than May 15, 2012, USBR must operate RBDD with gates out all year to allow unimpeded passage for listed anadromous fish.

Action 1.3.1 Assumptions for CALSIM II Modeling Purposes

Action: Adequate permanent facilities for diversion are assumed; therefore no constraint on diversion schedules is included in the future condition modeling.

Action 1.3.2 Interim Operations

Action: Until May 14, 2012, USBR must operate RBDD according to the following schedule:

•September 1 - June 14: Gates open. No emergency closures of gates are allowed.

•June 15 - August 31: Gates may be closed at USBR's discretion, if necessary to deliver water to TCCA.

Action 1.3.2 Assumptions for CALSIM II Modeling Purposes

Action: Adequate interim/temporary facilities for diversion are assumed; therefore no constraint on diversion schedules is included in the Existing condition modeling.

Action 1.4 Wilkins Slough Operations

Action: The SRTTG must make recommendations for Wilkins Slough minimum flows for anadromous fish in critically dry years, in lieu of the current 5,000 cfs navigation criterion to NMFS by December 1, 2009. In critically dry years, the SRTTG will make a recommendation.

Action 1.4 Assumptions for CALSIM II Modeling Purposes

Action: Current rules for relaxation of NCP in CALSIM II (based on OCAP BA models) will be used. In CALSIM II, NCP flows are relaxed depending on allocations for agricultural contractors. Table A.4 is used to determine the relaxation.

Table A. 4 NCP Flow Schedule with Relaxation

CVP AG Allocation (%)	NCP Flow (cfs)
<10	3250
10-25	3500
25-40	4000
40-65	4500
>65	5000

Action 2.1 Lower American River Flow Management

Action: Implement the flow schedule specified in the Water Forum's Flow Management Standard (FMS), which is summarized in Appendix 2-D of the NMFS BO.

Action 2.1 Assumptions for CALSIM II Modeling Purposes

Action: The AFRMP Minimum Release Requirements (MRR) range from 800 to 2,000 cfs based on a sequence of seasonal indices and adjustments as in 2008 OCAP BA. The minimum Nimbus Dam release requirement is determined by applying the appropriate water availability index (Index Flow). Three water availability indices (i.e., Four Reservoir Index (FRI), Sacramento River Index (SRI), and the Impaired Folsom Inflow Index (IFII)) are applied during different times of the year, which provides adaptive flexibility in response to changing hydrological and operational conditions.

During some months, Prescriptive Adjustments may be applied to the Index Flow, resulting in the MRR. If there is no Prescriptive Adjustment, the MRR is equal to the Index Flow.

Discretionary Adjustments for water conservation or fish protection may be applied during the period extending from June through October. If Discretionary Adjustments are applied, then the resultant flows are referred to as the Adjusted Minimum Release Requirement (Adjusted MRR).

The MRR and Adjusted MRR may be suspended in the event of extremely dry conditions, represented by "conference years" or "off-ramp criteria". Conference years are defined when the projected March through November unimpaired inflow into Folsom Reservoir is less than 400,000 acre-feet. Off-ramp criteria are triggered if forecasted Folsom Reservoir storage at any time during the next twelve months is less than 200,000 acre-feet.

Action 2.2 Lower American River Temperature Management

Action: USBR must develop a temperature management plan that contains: (1) forecasts of hydrology and storage; (2) a modeling run or runs, using these forecasts, demonstrating that the temperature compliance point can be attained (see Coldwater Management Pool Model approach in Appendix 2-D); (3) a plan of operation based on this modeling run that demonstrates that all other non-discretionary requirements are met; and (4) allocations for discretionary deliveries that conform to the plan of operation.

Action 2.2 Assumptions for CALSIM II Modeling Purposes

Action: It is assumed that temperature operations can perform reasonably well with flows included in model. The flows in the model reflect the ARFMP implemented under Action 2.1

Action Suite 3.1 Stanislaus River / Eastside Division Actions

Action 3.1.2 Provide Cold Water Releases to Maintain Suitable Steelhead Temperatures

Action: USBR must manage the cold water supply within New Melones Reservoir and make cold water releases from New Melones Reservoir to provide suitable temperatures for CV steelhead rearing, spawning, egg incubation smoltification, and adult migration in the Stanislaus River downstream of Goodwin Dam.

Action 3.1.2 Assumptions for CALSIM II Modeling Purposes

Action: It is assumed that temperature operations can perform reasonably well with flow operations resulting from the minimum flow requirements described in action 3.1.3.

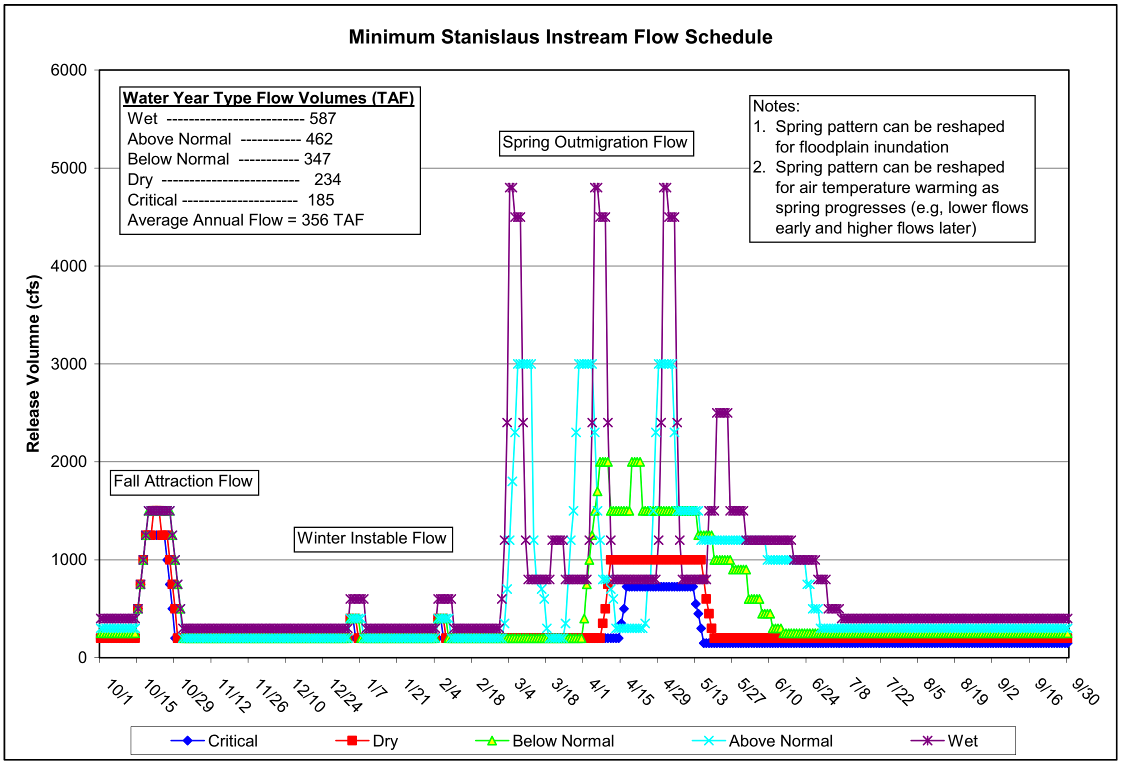
Action 3.1.3 Operate the East Side Division Dams to Meet the Minimum Flows, as Measured at Goodwin Dam

Action: USBR must operate releases from the East Side Division reservoirs to achieve a minimum flow schedule as prescribed in NMFS BO Appendix 2-E and generally described in figure 11-1. When operating at higher flows than specified, USBR must implement ramping rates for flow changes that will avoid stranding and other adverse effects on CV steelhead.

Action 3.1.3 Assumptions for CALSIM II Modeling Purposes

Action: Minimum flows based on Appendix 2-E flows (presented in Figure A.1) are assumed consistent to what was modeled by NMFS (5/14/09 and 5/15/09 CALSIM II models provided by NMFS; relevant logic merged into baselines models). The NMFS model assumes an allocation scheme for New Melones releases similar to what is included in the Interim Operations Plan.

Figure A. 1 Minimum Stanislaus instream flow schedule as prescribed in Appendix 2-E of the NMFS BO (06/04/09)



Annual allocation in New Melones is modeled to ensure availability of required instream flows (Table A.5) based on a water supply forecast that is comprised of end-of-February New Melones storage (in taf) plus forecasted inflow to New Melones from March 1 to September 30 (in taf). The "forecasted inflow" is calculated using perfect foresight in the model. Allocated volume of water is released according to water year type following the monthly flow schedule illustrated in Figure A.1.

Table A. 5 New Melones Allocations to Meet Minimum Instream Flow Requirements

New Melones index (TAF)	Annual allocation required for instream flows (TAF)
<1000	0-98.9
1,000 - 1,399	98.9
1,400 - 1,724	185.3
1,725 – 2,177	234.1
2,178 - 2,386	346.7
2,387 – 2,761	461.7
2,762 – 6,000	586.9

Action Suite 4.1 Delta Cross Channel (DCC) Gate Operation, and Engineering Studies of Methods to Reduce Loss of Salmonids in Georgiana Slough and Interior Delta

Action 4.1.2 DCC Gate Operation

Action: During the period between November 1 and June 15, DCC gate operations will be modified from the proposed action to reduce loss of emigrating salmonids and green sturgeon. From December 1 to January 31, the gates will remain closed, except as operations are allowed using the implementation procedures/modified Salmon Decision Tree.

Timing: November 1 through June 15.

Triggers: Action triggers and description of action as defined in NMFS BO are presented in Table A.6.

Table A. 6 NMFS BO DCC Gate Operation Triggers and Actions

Date	Action Triggers	Action Responses
October 1 – November 30	Water quality criteria per D-1641 are met and either the Knights Landing Catch Index (KLCI) or the Sacramento Catch Index (SCI) are greater than 3 fish per day but less than or equal to 5 fish per day.	Within 24 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days.
	Water quality criteria per D-1641 are met and either the KLCI or SCI is greater than 5 fish per day	Within 24 hours, close the DCC gates and keep closed until the catch index is less than 3 fish per day at both the Knights Landing and Sacramento monitoring sites.
	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria.	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5.
December 1 – December 14	Water quality criteria are met per D-1641.	DCC gates are closed. If Chinook salmon migration experiments are conducted during this time period (e.g., Delta Action 8 or similar studies), the DCC gates may be opened according to the experimental design, with NMFS' prior approval of the study.
	Water quality criteria are not met but both the KLCI and SCI are less than 3 fish per day.	DCC gates may be opened until the water quality criteria are met. Once water quality criteria are met, the DCC gates will be closed within 24 hours of compliance.
	Water quality criteria are not met but either of the KLCI or SCI is greater than 3 fish per day.	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5
December 15 – January 31	December 15-January 31	DCC Gates Closed.
	NMFS-approved experiments are being conducted.	Agency sponsoring the experiment may request gate opening for up to five days; NMFS will determine whether opening is consistent with ESA obligations.
	One-time event between December 15 to January 5, when necessary to maintain Delta water quality in response to the astronomical high tide, coupled with low inflow conditions.	Upon concurrence of NMFS, DCC Gates may be opened one hour after sunrise to one hour before sunset, for up to 3 days, then return to full closure. Reclamation and DWR will also reduce Delta exports down to a health and safety level during the period of this action.
February 1 – May 15	D-1641 mandatory gate closure.	Gates closed, per WQCP criteria
May 16 – June 15	D-1641 gate operations criteria	DCC gates may be closed for up to 14 days during this period, per 2006 WQCP, if NMFS determines it is necessary.

Action 4.1.2 Assumptions for CALSIM II Modeling Purposes

Action: The DCC gate operations for October 1 through January 31 were layered on top of the D-1641 gate operations already included in the CALSIM II model. The general assumptions regarding the NMFS DCC operations are summarized in Table A.7.

Timing: October 1 through January 31.

Table A. 7 DCC Gate Operation Triggers and Actions as Modeled in CalSim II

Date	Modeled Action Triggers	Modeled Action Responses
October 1-December 14	Sacramento River daily flow at Wilkins Slough exceeding 7,500 cfs; flow assumed to flush salmon into the Delta	Each month, the DCC gates are closed for number of days estimated to exceed the threshold value.
	Water quality conditions at Rock Slough subject to D-1641 standards	Each month, the DCC gates are not closed if it results in violation of the D-1641 standard for Rock Slough; if DCC gates are not closed due to water quality conditions, exports during the days in question are restricted to 2,000 cfs.
December 15 – January 31	December 15-January 31	DCC Gates Closed.

Flow Trigger: It is assumed that during October 1 – December 14, the DCC will be closed if Sacramento River daily flow at Wilkins Slough exceeds 7,500 cfs. It is assumed that during December 15 through January 31 that the DCC gates are closed under all flow conditions.

Water Quality: It is assumed that during October 1 – December 14 the DCC gates may remain open if water quality is a concern. Using the CALSIM II-ANN flow-salinity model for Rock Slough, current month's chloride level at Rock Slough is estimated assuming DCC closure per NMFS BO. The estimated chloride level is compared against the Rock Slough chloride standard (monthly average). If estimated chloride level exceeds the standard, the gate closure is modeled per D1641 schedule (for the entire month).

It is assumed that during December 15 through January 31 that the DCC gates are closed under all water quality conditions.

Export Restriction: During October 1 – December 14 period, if the flow trigger condition is such that additional days of DCC gates closed is called for, however water quality conditions are a concern and the DCC gates remain open, then Delta exports are limited to 2,000 cfs for each day in question. A monthly Delta export restriction is calculated based on the trigger and water quality conditions described above.

Action Suite 4.2 Delta Flow Management

Action 4.2.1 San Joaquin River Inflow to Export Ratio

Action: The Phase 1 – Interim Operations in 2010-2011 are assumed. From April 1 through May 31, Interim flow operations: 1) USBR must continue to implement the Goodwin flow schedule for the Stanislaus River prescribed in Action 3.1.3 and Appendix 2-E of the NMFS BO and increases in releases at Goodwin Reservoir, if necessary, in order to meet the flows required at Vernalis (as provided in table 1 of NMFS BO page 642); and 2) Combined CVP and SWP exports must be restricted to 1,500 cfs for Vernalis flows from 0 – 6,000 cfs, 4:1 (Vernalis flow:export ratio) for Vernalis flows 6,000 cfs – 21,750 cfs, and unrestricted for Vernalis flows above 21,750 cfs.

Action 4.2.1 Assumptions for CALSIM II Modeling Purposes

Action: Flows at Vernalis are assumed consistent to what was modeled by NMFS (5/15/09 CALSIM II models provided by NMFS; relevant logic merged into baselines models). In addition, Delta exports are restricted as stated above.

Minimum flow schedule for Vernalis (April 1 – May 31) is modeled in NMFS CALSIM II model as illustrated in Table A.8.

Table A. 8 Minimum Flow Required at Vernalis During April and May

New Melones index (TAF)	Minimum Flow Required at Vernalis (cfs)
<1000	No new requirements
1000 - 1,399	1,500
1,400 - 1,999	3,000
2,000 - 2,499	4,500
>2,500	6,000

In addition to prescribed minimum flow requirement at Vernalis, exports are also restricted as illustrated in Table A.9

Table A. 9 Maximum Combined CVP and SWP Export during April and May

Flows at Vernalis (cfs)	Combined CVP and SWP Export
0 - 6,000	1,500 cfs
6,000 – 21,750	4:1 (Vernalis flow : export ratio)
>21,750	Unrestricted until flood recedes below 21,570 cfs

Action 4.2.3 Old and Middle River Flow Management

Action: From January 1 through June 15, reduce exports, as necessary, to limit negative flows to -2,500 to -5,000 cfs in Old and Middle Rivers, depending on the presence of salmonids. The reverse flow will be managed within this range to reduce flows toward the pumps during periods of increased salmonid presence. Refer to NMFS BO document for the negative flow objective decision tree.

Action 4.2.3 Assumptions for CALSIM II Modeling Purposes

Action: Old and Middle River flows required in this BO are assumed to be covered by OMR flow requirements developed for actions 1 through 3 of the FWS BO actions in Appendix A-2.

Appendix B. Results of Report CalSim II Studies

The model studies selected for this report are intended to estimate current SWP delivery reliability and future SWP delivery reliability in the year 2029. Estimating current SWP delivery reliability assumes that SWP and CVP operations incorporate the reasonable and prudent alternative (RPA) actions defined in two biological opinions on the proposed long-term operations of the Central Valley Project and State Water Project. The biological opinions are the U.S. Fish and Wildlife Service's (USFWS) biological opinion released on December 15, 2008, and the National Marine Fisheries Service's (NMFS) biological opinion and conference opinion released on June 4, 2009. The USFWS' biological opinion has RPA actions to protect threatened Delta smelt. The NMFS biological opinion and conference opinion have RPA actions to protect the following federally listed species:

- Endangered Sacramento River winter-run Chinook salmon.
- Threatened Central Valley spring-run Chinook salmon.
- Threatened Central Valley steelhead.
- Threatened Southern Distinct Population Segment of North American green sturgeon.
- Southern Resident killer whale.

The RPA actions from the two biological opinions are summarized below. Details regarding how the RPA actions are incorporated into CalSim II are found in Appendices A-2 and A-3.

1. Restrict upstream flow in Old River and Middle River.
2. Implement fall X2 requirements.
3. Provide spring attraction flows in Clear Creek.
4. Implement water temperature requirements for Whiskeytown Lake releases.
5. Implement end-of-September carryover storage criteria for Shasta Lake.
6. Implement November through February Keswick Dam release schedule.
7. Base USBR's February 15 forecast for Sacramento River basin runoff on 90% probability of exceedence.
8. Implement water temperature criteria between Balls Ferry and Bend Bridge from April 15

through October 31.

9. Operate Red Bluff Diversion Dam with gates out of the water.
10. Implement Wilkins Slough minimum flow criteria in critically dry years.
11. Implement Nimbus Dam minimum release requirements.
12. Provide cold water releases to maintain suitable water temperatures for steelhead downstream of Goodwin Dam.
13. Implement minimum flow schedule at Goodwin Dam.
14. Modify Delta Cross Channel gate operations.
15. Implement San Joaquin River inflow to export ratio.

Estimating future SWP delivery reliability in 2029 assumes an altered hydrology due to climate change, sea-level rise, no new facilities or improvements to existing facilities, an increased SWP water demand, and existing institutional requirements, including the RPA actions.

As listed in Table B.1, a total of three CalSim II simulations were used in this report: one for estimating current (2009) SWP delivery reliability and two for estimating future (2029) SWP delivery reliability.

Table B. 1 Summary of CalSim II simulations used to update SWP delivery estimates

Time Frame	Climate Change Model	Greenhouse Gas Emissions Scenario
Current	None	None
Future	None	None
Future	MPI-ECHAM5[1]	A2[2]

1/ MPI ECHAM5 refers to the most recent version of ECHAM which is the Global Climate Model developed by the Max Planck Institute (MPI) for Meteorology.

2/ A2 emissions scenario assumes high growth in population, regional based economic growth, and slow technological changes, which results in significantly higher greenhouse gas emissions.

Two CalSim II simulations were needed to estimate future (2029) reliability due to the need to adjust CalSim II results to account for the climate change scenario assuming a 2050 level of emissions. The two CalSim II simulations were used to generate one sequence of future (2029) SWP deliveries which is used to describe future SWP delivery reliability in Chapter 6 of this report. This process consisted of interpolating between sequences to estimate SWP deliveries under climate change affects for 2029 instead of 2050. The A2 greenhouse gas emissions scenario assumes a 2050 level of emissions. Scenarios for 2029 were not available at the time of composing this report. A key assumption in estimating 2029 SWP delivery reliability for this report is that SWP deliveries for a CalSim II simulation which assumes 2029 SWP demands and 2029 climate change, would fall somewhere between CalSim II simulations which assume 2029 SWP demands and no climate change and 2029 SWP demands and climate change corresponding to 2050 emissions. Just where these SWP deliveries would fall is estimated in this report by interpolating between each sequence from a scenario which assumes 2050 emissions and a scenario which assumes no climate change. The interpolation is as follows:

Future (2029) annual SWP delivery = NCC + (20/41) (CC – NCC)

Where
NCC = annual SWP delivery for future, no climate change scenario
CC = annual SWP delivery for future with climate change scenario which assumes 2050 emission levels

The ratio of 20/41 corresponds to the ratio of calendar years: (2029-2009)/(2050-2009).

The key study assumptions are described in detail in Chapter 6 and Appendix A.

Study Results

The annual SWP Table A delivery amounts estimated by the three CalSim II simulations are contained in Tables B.3 through B.7. The tables show the demand level, the amount of delivery from the Delta, and percent of maximum total Table A amounts for the SWP contractors receiving water from the Delta. Of the 29 SWP contractors, 26 receive their deliveries from the Delta. The total maximum Table A amount for all SWP contractors is 4.173 maf/year. Of this amount, 4,133 taf/yr is the maximum Delta Table A amount. Also presented are the results of interpolating SWP delivery sequences which provide the information used in Chapter 6 in assessing future SWP delivery reliability. Current and future SWP deliveries are presented both in time sequence and by ranking to correspond to the data presented in the summary/highlight tables and used to generate the probability curves in Chapter 6.

These values must be interpreted within the context of the assumptions upon which they are calculated. For example, for the year 1958 in the 2029 study the annual delivery is calculated to be 3,503 taf or 85% of maximum Delta Table A (see Table B.4). This result should be stated as follows:

The SWP would deliver approximately 3,503 taf, or 85% of maximum Delta Table A, given

1. Rainfall that was similar to what it was in 1958 but modified to reflect climate change effects.
2. The level of water use in the source area is increased to the level it would be in 2029.
3. SWP facilities and operation requirements are the same as they are today with the RPA actions in effect.
4. SWP contractor demands are at their maximum Delta Table A level.

Actually, the conditional statement associated with the result for any particular year is even more complicated than this because the result is also dependent upon the rainfall that has occurred in previous years. For example, if the previous year (1957) was wet, runoff for 1958 for the same amount of rainfall would be greater than if 1957 were dry. In addition, reservoir storage for the beginning of 1958 varies depending upon the weather conditions in 1957. Thus, each year’s simulation is dependent on the previous year’s simulation and, hence, any year in the entire historical sequence is linked to all previous years.

Table B.2 summarizes the delivery estimates for the SWP for important dry sequences computed in the studies for current (2009) and future (2029) conditions. The percentages of maximum Table A amounts are based on current deliveries and interpolating future annual SWP Table A deliveries as previously discussed.

This information can be helpful in analyzing the delivery reliability of a specific water system that receives a portion of its water supply from the SWP. The series of data contained in Tables B.3 through B.5 are also helpful in analyzing longer periods of time that contain not only dry periods but wetter periods which can replenish water supplies.

Table B.6 presents the annual SWP Article 21 deliveries under Current (2009) Conditions and Table B.7 presents the annual SWP Article 21 deliveries under Future (2029) Conditions.

Probability distribution curves derived from the CalSim II simulations used in this report are presented in Figures B.1 and B.2 to visually show the estimated percentage of years a given annual delivery is equaled or exceeded. In this report, this value represents the probability of receiving at least a given level of delivery in any particular year. As a reference, probability distribution curves for the 2007 and 2027 studies from the 2007 State Water Project Delivery Reliability Report are presented along with the curves from the 2009 and 2029 studies in this report. SWP Table A delivery values for 25%, 50%, and 75% exceedences are shown for all scenarios in Table B.8.

Finally, the SWP Table A delivery amounts under current conditions as calculated in the 2007 SWP Delivery Reliability Report and the 2009 updated report are presented in Table B.9 to show the estimated impact on SWP Table A deliveries due to the RPA actions.

Table B. 2 SWP average and dry year Table A delivery from the Delta (in percent of maximum Table A amounts[1])

Study of Current Conditions	SWP Table A delivery from the Delta (in percent of maximum SWP Table A[1])					
	Long-term Average[2]	Single dry year 1977	2-year drought 1976-1977	4-year drought 1931-1934	6-year drought 1987-1992	6-year drought 1929-1934
Updated Studies (2009)	60%	7%	36%	34%	35%	34%
Updated Studies (2029)	60%	11%	38%	35%	32%	36%

1/ 4,133 taf/year

Table B. 3 SWP Table A Deliveries under Current (2009) Conditions
Derived values for estimating probability curve

Year	Table A demands (taf)	SWP Table A deliveries for 2009 study (taf)	Percent of Maximum Table A[2]	Probability Curve[1] Year	SWP Table A Delivery (taf)	Exceedence Frequency (%)	Percent of Maximum Table A[2]
1922	3,407	2,451	59%	1998	3,338	0%	81%
1923	3,717	2,849	69%	1974	3,267	1%	79%
1924	3,961	841	20%	1938	3,262	2%	79%
1925	3,940	1,845	45%	1996	3,247	4%	79%
1926	3,777	2,080	50%	1997	3,191	5%	77%
1927	3,543	2,680	65%	1943	3,174	6%	77%
1928	3,897	2,836	69%	1942	3,142	7%	76%
1929	3,952	1,210	29%	1999	3,140	9%	76%
1930	3,922	1,571	38%	1958	3,090	10%	75%
1931	3,971	1,255	30%	1970	3,082	11%	75%
1932	3,673	1,543	37%	1984	3,070	12%	74%
1933	3,938	1,569	38%	1982	3,054	14%	74%
1934	3,981	1,239	30%	1975	3,023	15%	73%
1935	3,697	2,412	58%	1986	3,023	16%	73%
1936	3,769	2,749	67%	1939	3,021	17%	73%
1937	3,451	2,995	72%	1953	3,013	19%	73%
1938	3,418	3,262	79%	1979	2,996	20%	72%
1939	3,673	3,021	73%	1956	2,995	21%	72%
1940	3,713	2,524	61%	1937	2,954	22%	71%
1941	3,013	2,608	63%	1952	2,927	23%	71%
1942	3,583	3,140	76%	1995	2,924	25%	71%
1943	3,632	3,174	77%	1980	2,907	26%	70%
1944	3,563	2,396	58%	1968	2,894	27%	70%
1945	3,612	2,612	63%	1985	2,875	28%	70%
1946	3,710	2,875	70%	1946	2,869	30%	69%
1947	3,954	2,780	67%	1965	2,867	31%	69%
1948	3,959	2,427	59%	2000	2,858	32%	69%
1949	3,864	2,444	59%	1923	2,855	33%	69%
1950	3,812	2,222	54%	1947	2,854	35%	69%
1951	3,779	2,671	65%	1928	2,849	36%	69%
1952	3,078	2,924	71%	1983	2,836	37%	69%
1953	3,790	3,013	73%	1969	2,811	38%	68%
1954	3,833	2,535	61%	1936	2,811	40%	68%
1955	3,761	2,095	51%	1993	2,780	41%	67%
1956	3,639	2,954	71%	1967	2,768	42%	67%
1957	3,759	2,475	60%	1966	2,749	43%	67%
1958	3,481	3,090	75%	1959	2,731	44%	66%
1959	4,055	2,544	62%	1971	2,724	46%	66%
1960	4,115	2,211	54%	1927	2,712	47%	66%
1961	4,115	2,461	60%	1951	2,692	48%	65%
1962	3,689	2,494	60%	1976	2,680	49%	65%
1963	3,634	2,569	62%	2003	2,671	51%	65%
1964	3,907	2,858	69%	1945	2,612	52%	63%
1965	3,586	2,731	66%	1941	2,608	53%	63%

1/ Percent of time at or above given value

2/ 4,133 taf/year

Table B. 3 (cont.) SWP Table A Deliveries under Current (2009) Conditions
Derived values for estimating probability curve

Year	Table A demands (taf)	SWP Table A deliveries for 2009 study (taf)	Percent of Maximum Table A[2]	Probability Curve[1] Year	Table A Delivery (taf)	Exceedence Frequency (%)	Percent of Maximum Table A[2]
1966	3,722	2,867	69%	1978	2,606	54%	63%
1967	3,439	2,768	67%	1964	2,576	56%	62%
1968	3,792	2,907	70%	2002	2,569	57%	62%
1969	3,157	2,854	69%	1981	2,544	58%	62%
1970	3,714	3,082	75%	1954	2,535	59%	61%
1971	3,837	2,712	66%	1940	2,532	60%	61%
1972	4,012	2,409	58%	1973	2,524	62%	61%
1973	3,611	2,477	60%	1957	2,494	63%	60%
1974	3,649	3,247	79%	1961	2,477	64%	60%
1975	3,720	3,023	73%	1963	2,475	65%	60%
1976	4,014	2,692	65%	1962	2,461	67%	60%
1977	3,948	301	7%	1922	2,451	68%	59%
1978	3,126	2,606	63%	1949	2,444	69%	59%
1979	3,527	3,023	73%	1972	2,427	70%	59%
1980	3,197	2,869	69%	1935	2,412	72%	58%
1981	3,834	2,532	61%	1944	2,409	73%	58%
1982	3,451	3,054	74%	1989	2,399	74%	58%
1983	3,007	2,811	68%	1994	2,396	75%	58%
1984	3,692	3,070	74%	1948	2,310	77%	56%
1985	3,753	2,894	70%	1950	2,222	78%	54%
1986	3,345	2,996	72%	1960	2,211	79%	54%
1987	3,904	1,957	47%	1926	2,095	80%	51%
1988	4,026	902	22%	1955	2,080	81%	50%
1989	4,097	2,399	58%	1987	1,957	83%	47%
1990	3,961	1,241	30%	1925	1,845	84%	45%
1991	3,957	1,102	27%	1933	1,571	85%	38%
1992	3,880	1,061	26%	1932	1,569	86%	38%
1993	3,559	2,724	66%	1930	1,543	88%	37%
1994	3,739	2,310	56%	2001	1,409	89%	34%
1995	3,451	2,927	71%	1931	1,255	90%	30%
1996	3,692	3,267	79%	1929	1,241	91%	30%
1997	3,559	3,191	77%	1992	1,239	93%	30%
1998	3,451	3,338	81%	1990	1,210	94%	29%
1999	3,692	3,142	76%	1934	1,102	95%	27%
2000	3,720	2,855	69%	1991	1,061	96%	26%
2001	3,961	1,409	34%	1988	902	98%	22%
2002	4,097	2,576	62%	1924	841	99%	20%
2003	3,720	2,811	68%	1977	301	100%	7%
Avg	3,711	2,483	60%	Avg	2,483		60%
Min	3,007	301	7%	Min	301		7%
Max	4,115	3,338	81%	Max	3,338		81%

1/ Percent of time at or above given value

2/ 4,133 taf/year

Table B. 4 SWP Table A deliveries from the Delta under Future (2029) Conditions MPI-ECHAM5 Model with A2 Emissions

Year	SWP Table A Demands (TAF)	No Climate Change		MPI-ECHAM5 model with A2 Emissions		Estimated Delivery Interpolated to 2029[1]	
		SWP Table A Delivery (taf)	Percent of Maximum SWP Table A[2]	SWP Table A Delivery (taf)	Percent of Maximum SWP Table A[2]	SWP Table A Delivery (taf)	Percent of Maximum SWP Table A[2]
1922	4,133	2,633	64%	2,488	60%	2,562	62%
1923	4,133	2,692	65%	2,469	60%	2,583	63%
1924	4,133	1,017	25%	701	17%	863	21%
1925	4,133	1,822	44%	1,606	39%	1,717	42%
1926	4,133	2,384	58%	1,860	45%	2,128	51%
1927	4,133	2,695	65%	2,866	69%	2,779	67%
1928	4,133	2,783	67%	2,736	66%	2,760	67%
1929	4,133	1,243	30%	1,663	40%	1,448	35%
1930	4,133	1,754	42%	1,663	40%	1,710	41%
1931	4,133	1,257	30%	1,174	28%	1,217	29%
1932	4,133	1,605	39%	1,579	38%	1,592	39%
1933	4,133	1,599	39%	1,600	39%	1,599	39%
1934	4,133	1,138	28%	1,500	36%	1,315	32%
1935	4,133	2,711	66%	2,508	61%	2,612	63%
1936	4,133	2,893	70%	2,531	61%	2,716	66%
1937	4,133	3,533	85%	2,905	70%	3,226	78%
1938	4,133	4,088	99%	3,906	94%	3,999	97%
1939	4,133	2,409	58%	1,587	38%	2,008	49%
1940	4,133	2,577	62%	2,525	61%	2,551	62%
1941	4,133	3,162	77%	2,746	66%	2,959	72%
1942	4,133	2,791	68%	2,725	66%	2,759	67%
1943	4,133	3,079	74%	2,770	67%	2,928	71%
1944	4,133	2,559	62%	1,952	47%	2,263	55%
1945	4,133	2,882	70%	2,882	70%	2,882	70%
1946	4,133	2,755	67%	2,458	59%	2,610	63%
1947	4,133	2,631	64%	2,033	49%	2,339	57%
1948	4,133	2,359	57%	2,509	61%	2,432	59%
1949	4,133	2,454	59%	2,208	53%	2,334	56%
1950	4,133	2,312	56%	2,537	61%	2,422	59%
1951	4,133	2,964	72%	2,791	68%	2,880	70%
1952	4,133	3,724	90%	2,982	72%	3,362	81%
1953	4,133	2,408	58%	2,726	66%	2,563	62%
1954	4,133	2,368	57%	2,491	60%	2,428	59%
1955	4,133	2,106	51%	1,421	34%	1,772	43%
1956	4,133	3,347	81%	2,965	72%	3,161	76%
1957	4,133	2,484	60%	2,383	58%	2,435	59%
1958	4,133	3,656	88%	3,343	81%	3,503	85%
1959	4,133	2,089	51%	2,153	52%	2,120	51%
1960	4,133	2,170	53%	1,694	41%	1,938	47%
1961	4,133	2,556	62%	1,668	40%	2,123	51%
1962	4,133	2,525	61%	2,849	69%	2,683	65%
1963	4,133	2,435	59%	2,532	61%	2,483	60%
1964	4,133	2,526	61%	2,618	63%	2,571	62%
1965	4,133	2,707	65%	2,732	66%	2,719	66%

1/ As described in Appendix B

2/ 4,133 taf/year

Table B. 4 (cont.) SWP Table A deliveries from the Delta under Future (2029) Conditions MPI-ECHAM5 Model with A2 Emissions

Year	Table A Demand (TAF)	No Climate Change		MPI-ECHAM5 model with A2 Emissions		Estimated Delivery Interpolated to 2029[1]	
		Table A Delivery (taf)	Percent of Maximum Table A[2]	Table A Delivery (taf)	Percent of Maximum Table A[2]	Table A Delivery (taf)	Percent of Maximum Table A[2]
1966	4,133	2,765	67%	2,502	61%	2,637	64%
1967	4,133	3,731	90%	2,660	64%	3,208	78%
1968	4,133	2,234	54%	2,705	65%	2,464	60%
1969	4,133	3,862	93%	3,919	95%	3,890	94%
1970	4,133	3,130	76%	2,701	65%	2,920	71%
1971	4,133	2,707	65%	2,336	57%	2,526	61%
1972	4,133	2,349	57%	2,433	59%	2,390	58%
1973	4,133	2,691	65%	2,530	61%	2,612	63%
1974	4,133	3,354	81%	2,654	64%	3,012	73%
1975	4,133	2,885	70%	2,811	68%	2,849	69%
1976	4,133	2,560	62%	2,812	68%	2,683	65%
1977	4,133	226	5%	701	17%	458	11%
1978	4,133	2,962	72%	3,039	74%	3,000	73%
1979	4,133	2,976	72%	2,815	68%	2,897	70%
1980	4,133	3,516	85%	3,143	76%	3,334	81%
1981	4,133	2,472	60%	2,701	65%	2,583	63%
1982	4,133	3,861	93%	3,525	85%	3,697	89%
1983	4,133	3,950	96%	4,031	98%	3,990	97%
1984	4,133	3,071	74%	3,065	74%	3,068	74%
1985	4,133	2,884	70%	2,731	66%	2,810	68%
1986	4,133	3,514	85%	2,762	67%	3,147	76%
1987	4,133	1,302	32%	1,139	28%	1,223	30%
1988	4,133	927	22%	1,537	37%	1,224	30%
1989	4,133	2,665	64%	2,028	49%	2,355	57%
1990	4,133	806	19%	986	24%	894	22%
1991	4,133	986	24%	1,344	33%	1,161	28%
1992	4,133	1,192	29%	787	19%	994	24%
1993	4,133	2,806	68%	2,424	59%	2,619	63%
1994	4,133	2,356	57%	2,536	61%	2,444	59%
1995	4,133	3,304	80%	3,124	76%	3,216	78%
1996	4,133	2,890	70%	2,617	63%	2,757	67%
1997	4,133	3,503	85%	2,939	71%	3,228	78%
1998	4,133	3,271	79%	3,549	86%	3,407	82%
1999	4,133	3,046	74%	2,824	68%	2,938	71%
2000	4,133	2,767	67%	2,715	66%	2,742	66%
2001	4,133	1,491	36%	1,199	29%	1,348	33%
2002	4,133	2,827	68%	2,475	60%	2,656	64%
2003	4,133	2,583	63%	2,424	59%	2,506	61%
Avg	4,133	2,565	62%	2,406	58%	2,487	60%
Min	4,133	226	5%	701	17%	458	11%
Max	4,133	4,088	99%	4,031	98%	3,999	97%

1/ As described in Appendix B

2/ 4,133 taf/year

Table B. 5 SWP Table A deliveries from the Delta under Future (2029) Conditions
Derived values for estimating probability curve

Ranking of calculated Table A deliveries for probability curve				Ranking of calculated Table A deliveries for probability curve			
Exceedence Frequency (%)	Year	Table A Delivery (taf)	Percent of Maximum Table A[1]	Exceedence Frequency (%)	Year	Table A Delivery (taf)	Percent of Maximum Table A[1]
0%	1983	3,999	97%	54%	1964	2,563	62%
1%	1938	3,990	97%	56%	1940	2,562	62%
2%	1969	3,890	94%	57%	1953	2,551	62%
4%	1982	3,697	89%	58%	1971	2,526	61%
5%	1998	3,503	85%	59%	1993	2,506	61%
6%	1958	3,407	82%	60%	1963	2,483	60%
7%	1980	3,362	81%	62%	1948	2,464	60%
9%	1952	3,334	81%	63%	1957	2,444	59%
10%	1995	3,228	78%	64%	1954	2,435	59%
11%	1997	3,226	78%	65%	2003	2,432	59%
12%	1937	3,216	78%	67%	1968	2,428	59%
14%	1956	3,208	78%	68%	1972	2,422	59%
15%	1967	3,161	76%	69%	1994	2,390	58%
16%	1986	3,147	76%	70%	1947	2,355	57%
17%	1984	3,068	74%	72%	1950	2,339	57%
19%	1974	3,012	73%	73%	1944	2,334	56%
20%	1941	3,000	73%	74%	1949	2,263	55%
21%	1951	2,959	72%	75%	1961	2,128	51%
22%	1978	2,938	71%	77%	1959	2,123	51%
23%	1970	2,928	71%	78%	1939	2,120	51%
25%	1943	2,920	71%	79%	1926	2,008	49%
26%	1999	2,897	70%	80%	1960	1,938	47%
27%	1945	2,882	70%	81%	1925	1,772	43%
28%	1979	2,880	70%	83%	1955	1,717	42%
30%	1975	2,849	69%	84%	1930	1,710	41%
31%	1985	2,810	68%	85%	1933	1,599	39%
32%	1927	2,779	67%	86%	1932	1,592	39%
33%	1942	2,760	67%	88%	1929	1,448	35%
35%	1928	2,759	67%	89%	2001	1,348	33%
36%	1996	2,757	67%	90%	1934	1,315	32%
37%	1965	2,742	66%	91%	1988	1,224	30%
38%	2000	2,719	66%	93%	1931	1,223	30%
40%	1976	2,716	66%	94%	1987	1,217	29%
41%	2002	2,683	65%	95%	1992	1,161	28%
42%	1962	2,683	65%	96%	1991	994	24%
43%	1935	2,656	64%	98%	1924	894	22%
44%	1946	2,637	64%	99%	1990	863	21%
46%	1973	2,619	63%	100%	1977	458	11%
47%	1936	2,612	63%	Avg		2,487	60%
48%	1981	2,612	63%	Min		458	11%
49%	1923	2,610	63%	Max		3,999	97%
51%	1966	2,583	63%				
52%	1989	2,583	63%				
53%	1922	2,571	62%				

1/ 4,133 taf/year

Table B. 6 SWP Article 21 deliveries under Current (2009) Conditions

Year	Article 21 Demand (taf)	Article 21 Delivery (taf)	Year	Article 21 Demand (taf)	Article 21 Delivery (taf)
1922	3,368	16	1966	3,368	11
1923	3,368	12	1967	3,368	18
1924	3,368	56	1968	2,726	8
1925	3,368	436	1969	1,442	191
1926	3,368	7	1970	3,368	238
1927	3,368	67	1971	3,368	9
1928	3,368	8	1972	3,368	20
1929	3,368	10	1973	3,368	16
1930	3,368	10	1974	3,368	12
1931	3,368	8	1975	3,368	11
1932	3,368	156	1976	3,368	9
1933	3,368	393	1977	2,726	2
1934	3,368	8	1978	1,442	2
1935	3,368	14	1979	2,726	124
1936	3,368	12	1980	1,442	189
1937	3,368	184	1981	3,368	9
1938	3,368	443	1982	2,726	463
1939	3,368	2	1983	1,442	853
1940	2,726	14	1984	3,368	507
1941	1,442	2	1985	2,726	2
1942	3,368	6	1986	1,442	140
1943	3,368	10	1987	3,368	9
1944	3,368	7	1988	3,368	10
1945	3,368	288	1989	3,368	10
1946	3,368	14	1990	3,368	10
1947	3,368	8	1991	3,368	12
1948	3,368	12	1992	3,368	10
1949	3,368	12	1993	3,368	14
1950	3,368	17	1994	2,726	6
1951	2,726	485	1995	1,442	2
1952	1,442	50	1996	3,368	6
1953	3,368	8	1997	2,726	47
1954	3,368	14	1998	1,442	201
1955	3,368	14	1999	3,368	123
1956	3,368	704	2000	3,368	8
1957	3,368	12	2001	3,368	14
1958	3,368	18	2002	3,368	25
1959	3,368	4	2003	3,368	16
1960	3,368	12	Avg	3,086	85
1961	3,368	10	Min	1,442	2
1962	3,368	10	Max	3,368	853
1963	3,368	18			
1964	3,368	10			
1965	3,368	16			

Table B. 7 SWP Article 21 deliveries under Future (2029) Conditions MPI-ECHAM5 with A2 emissions

Year	Article 21 Demand (taf)	Article 21 Deliveries: No Climate Change (taf)	Article 21 Deliveries: MPI-ECHAM5 A2 emissions (taf)	Article 21 Deliveries: Interpolated to 2029[1] (taf)	Year	Article 21 Demand (taf)	Article 21 Deliveries: No Climate Change (taf)	Article 21 Deliveries: MPI-ECHAM5 A2 emissions (taf)	Article 21 Deliveries: Interpolated to 2029[1] (taf)
1922	3,368	16	16	16	1966	3,368	16	15	15
1923	3,368	15	16	15	1967	3,368	12	18	15
1924	3,368	22	72	46	1968	2,726	13	11	13
1925	3,368	449	431	440	1969	1,442	38	34	36
1926	3,368	15	8	11	1970	3,368	102	16	60
1927	3,368	14	14	14	1971	3,368	14	18	16
1928	3,368	12	10	11	1972	3,368	20	18	19
1929	3,368	10	324	163	1973	3,368	16	22	19
1930	3,368	10	10	10	1974	3,368	15	14	15
1931	3,368	8	8	8	1975	3,368	13	18	16
1932	3,368	401	336	369	1976	3,368	12	12	12
1933	3,368	431	21	231	1977	2,726	2	4	3
1934	3,368	10	129	68	1978	1,442	2	135	67
1935	3,368	10	10	10	1979	2,726	12	10	11
1936	3,368	12	17	15	1980	1,442	32	35	34
1937	3,368	98	114	106	1981	3,368	15	12	14
1938	3,368	9	13	11	1982	2,726	187	13	102
1939	3,368	8	8	8	1983	1,442	549	468	509
1940	2,726	14	12	13	1984	3,368	547	530	539
1941	1,442	2	2	2	1985	2,726	8	10	9
1942	3,368	14	18	16	1986	1,442	94	2	49
1943	3,368	12	16	14	1987	3,368	12	107	58
1944	3,368	10	12	11	1988	3,368	10	125	66
1945	3,368	265	240	253	1989	3,368	6	6	6
1946	3,368	18	18	18	1990	3,368	11	12	11
1947	3,368	10	10	10	1991	3,368	12	14	13
1948	3,368	10	8	9	1992	3,368	10	8	9
1949	3,368	10	17	13	1993	3,368	12	19	16
1950	3,368	18	19	19	1994	2,726	10	8	9
1951	2,726	364	24	198	1995	1,442	1	2	2
1952	1,442	1	2	1	1996	3,368	14	16	15
1953	3,368	16	17	17	1997	2,726	79	156	117
1954	3,368	14	12	13	1998	1,442	24	2	13
1955	3,368	13	12	13	1999	3,368	250	14	135
1956	3,368	383	601	490	2000	3,368	14	12	13
1957	3,368	17	19	18	2001	3,368	14	14	14
1958	3,368	9	32	20	2002	3,368	12	43	27
1959	3,368	10	12	11	2003	3,368	16	12	14
1960	3,368	10	12	11	Avg	3,086	62	58	60
1961	3,368	8	9	8	Min	1,442	1	2	1
1962	3,368	8	8	8	Max	3,368	549	601	539
1963	3,368	19	15	17					
1964	3,368	16	12	14					
1965	3,368	15	14	14					

1/ As described in Appendix B

Figure B. 1 SWP Table A delivery probability under Current Conditions

Figure B. 2 SWP Table A delivery probability under Future Conditions

Table B. 8 Highlighted SWP Table A delivery percent exceedence values under Current and Future Conditions

	Exceedence values (taf)		
	25%	50%	75%
2007 SWP Delivery Reliability Report			
Current (2007)	3218	2976	2168
Future (2027)			
GFDL + A2	3703	3017	1883
GFDL + B1	3686	2967	1966
PCM + A2	3782	3084	1860
PCM + B1	3813	3205	2077
Updated studies			
Current (2009)	2920	2675	2397
Future (2029)	2915	2596	2137

1/ Based upon SWP Table A deliveries that have been interpolated between the “no climate change” scenario and the climate change scenarios determined by climate change model (GFDL or PCM) and greenhouse gas emissions scenario (A2 or B1). SWP Table A deliveries for two scenarios of Old and Middle River flow targets were then averaged.

2/ Based upon SWP Table A deliveries that have been interpolated between the “no climate change” scenario and the climate change scenario determined by climate change model MPI-ECHAM5 and greenhouse gas emissions scenario A2.

Table B. 9 Comparing SWP Table A deliveries under Current Conditions from updated studies to deliveries from 2007 Report

Year	SWP Table A Deliveries Study 2007 (2007 Report) (taf)	SWP Table A Deliveries Updated Study 2009 (taf)	SWP Table A Deliveries Change in Deliveries (taf)	Year	SWP Table A Deliveries Study 2007 (2007 Report) (taf)	SWP Table A Deliveries Updated Study 2009 (taf)	SWP Table A Deliveries Change in Deliveries (taf)
1922	3,674	2,451	-1,223	1963	3,406	2,569	-837
1923	3,159	2,849	-310	1964	2,211	2,858	648
1924	400	841	441	1965	2,861	2,731	-130
1925	1,644	1,845	202	1966	3,265	2,867	-399
1926	2,186	2,080	-107	1967	2,990	2,768	-222
1927	3,699	2,680	-1,019	1968	3,297	2,907	-390
1928	2,059	2,836	777	1969	2,626	2,854	228
1929	753	1,210	457	1970	3,257	3,082	-176
1930	2,028	1,571	-457	1971	3,317	2,712	-604
1931	1,105	1,255	150	1972	1,707	2,409	701
1932	1,305	1,543	238	1973	3,085	2,477	-608
1933	1,981	1,569	-412	1974	3,184	3,247	63
1934	1,315	1,239	-75	1975	3,218	3,023	-195
1935	3,334	2,412	-923	1976	2,604	2,692	88
1936	3,124	2,749	-374	1977	243	301	58
1937	3,219	2,995	-223	1978	3,599	2,606	-993
1938	3,394	3,262	-133	1979	3,128	3,023	-106
1939	3,256	3,021	-235	1980	2,710	2,869	159
1940	3,165	2,524	-641	1981	3,128	2,532	-596
1941	2,526	2,608	82	1982	2,940	3,054	114
1942	3,167	3,140	-27	1983	2,497	2,811	314
1943	3,154	3,174	20	1984	3,227	3,070	-157
1944	2,930	2,396	-533	1985	3,198	2,894	-304
1945	3,085	2,612	-472	1986	2,294	2,996	701
1946	3,199	2,875	-324	1987	2,825	1,957	-868
1947	2,314	2,780	466	1988	477	902	426
1948	2,609	2,427	-182	1989	3,130	2,399	-732
1949	1,271	2,444	1,173	1990	360	1,241	882
1950	2,462	2,222	-240	1991	729	1,102	373
1951	3,497	2,671	-827	1992	1,087	1,061	-26
1952	2,585	2,924	339	1993	3,711	2,724	-987
1953	3,323	3,013	-310	1994	2,105	2,310	206
1954	3,201	2,535	-667	1995	2,993	2,927	-66
1955	1,137	2,095	958	1996	3,440	3,267	-172
1956	3,581	2,954	-627	1997	3,101	3,191	90
1957	2,545	2,475	-70	1998	3,008	3,338	330
1958	3,030	3,090	60	1999	3,439	3,142	-297
1959	3,465	2,544	-921	2000	3,451	2,855	-596
1960	1,460	2,211	751	2001	1,164	1,409	245
1961	2,357	2,461	104	2002	2,162	2,576	414
1962	2,962	2,494	-467	2003	2,943	2,811	-133

Appendix C. State Water Project Table A Amounts

The contracts between the DWR and the 29 SWP water contractors define the terms and conditions governing the water delivery and cost repayment for the SWP. Table A is an exhibit to these contracts. Comprehension of Table A is important in understanding the information in this report. To understand the table, it is necessary to understand how the contracts work.

All water-supply related costs of the SWP are paid by the contractors, and Table A serves as a basis for allocating some of the costs among the contractors. In addition, Table A plays a key role in the annual allocation of available supply among contractors. When the SWP was being planned, the amount of water projected to be available for delivery to the contractors was 4,173 thousand acre-feet (taf) per year. This was referred to as the maximum project yield, and it was recognized that in some years the project would be unable to deliver that amount and in other years project supply could exceed that amount. This amount was used as the basis for apportioning available supply to each contractor and as a factor in calculating each contractor's share of the project's costs. This apportionment is accomplished by Table A in each contract. Table A lists by year and acre-feet the portion of the 4,173 taf deliverable to each contractor. Other contract provisions permit changes to an individual contractor's Table A under special circumstances. The total of the maximums in all the contracts now equals 4,173 taf.

A copy of the consolidated Table A from all the contracts follows this explanation. The amounts listed in Table A cannot be viewed as an indication of the SWP water delivery reliability, nor should these amounts be used to support an expectation that a certain amount of water will be delivered to a contractor in any particular time span. Table A is simply a tool for apportioning available supply and cost obligations under the contract. In this report, reference to "Table A amounts" means the amounts listed in Table A. Contractors also receive other classifications of water from the project, as distinguished from Table A (for example, Article 21 water, and turnback pool water). These other contract provisions are discussed in Appendix D.

Table C. 1 Maximum annual SWP Table A amounts (acre-feet)

Contractor	**Maximum SWP Table A**
NORTH BAY AREA	
Napa County FC&WCD	29,025
Solano County WA	47,756
Subtotal	*76,781*
SOUTH BAY AREA	
Alameda County FC&WCD, Zone 7	80,619
Alameda County WD	42,000
Santa Clara Valley WD	100,000
Subtotal	*222,619*
SAN JOAQUIN VALLEY AREA	
Oak Flat WD	5,700
County of Kings	9,305
Dudley Ridge WD	57,343
Empire West Side ID	3,000
Kern County WA	998,730
Tulare Lake Basin WSD	95,922
Subtotal	*1,170,000*
CENTRAL COASTAL AREA	
San Luis Obispo County FC&WCD	25,000
Santa Barbara County FC&WCD	45,486
Subtotal	*70,486*
SOUTHERN CALIFORNIA AREA	
Antelope Valley-East Kern WA	141,400
Castaic Lake WA	95,200
Coachella Valley WD	121,100
Crestline-Lake Arrowhead WA	5,800
Desert WA	50,000
Littlerock Creek ID	2,300
Mojave WA	75,800
Metropolitan WDSC	1,911,500
Palmdale WD	21,300
San Bernardino Valley MWD	102,600
San Gabriel Valley MWD	28,800
San Gorgonio Pass WA	17,300
Ventura County FCD	20,000
Subtotal	*2,593,100*
DELTA DELIVERY SUBTOTAL	*4,132,986*
FEATHER RIVER AREA	
County of Butte	27,500
Plumas County FC&WCD	2,700
City of Yuba City	9,600
Subtotal	*39,800*
GRAND TOTAL	**4,172,786**

Appendix D. Recent State Water Project Deliveries

SWP Contract Water Types

The SWP contracts define several classifications of water available for delivery to contractors under specific circumstances. All classifications are considered "project" water. Many contractors make frequent use of these additional water types to increase or decrease the amount available to them under Table A.

Table A Water

Each contract's Table A is the amount in acre-feet that is used to determine the portion of available supply to be delivered to that contractor. Table A water is water delivered according to this apportionment methodology and is given first priority for delivery.

Article 21 Water

Article 21 of the contracts permits delivery of water excess to delivery of Table A and some other water types to those contractors requesting it. It is available under specific conditions discussed in Chapter 5. Article 21 water is apportioned to those contractors requesting it in the same proportion as their Table A.

Turnback Pool Water

Contractors may choose to offer their allocated Table A water excess to their needs to other contractors through two pools in February and March. Contributing contractors receive a reduction in charges, and taking contractors pay extra.

Carryover Water

Pursuant to the long-term water supply contracts, contractors have the opportunity to carry over a portion of their allocated water approved for delivery in the current year for delivery during the next year. Contractors can carry over water under Article 56C with advanced notice when they submit their initial request for Table A water, or within the last three months of the delivery year, under Article 12E for various reasons, including local wet conditions and exchange and transfer arrangements. The carryover program was designed to encourage the most effective and beneficial use of water and to avoid obligating the contractors to use or lose the water by December 31 of each year. The water supply contracts state the criteria of carrying over Table A water from one year to the next. Normally, carryover water is water that has been exported during the year, has not been delivered to the contractor during that year, and has remained stored in the SWP share of San Luis Reservoir to be delivered during the following year. Storage for carryover water no longer becomes available to the contractors if it interferes with storage of SWP water for project needs.

Updated Historical Deliveries

Table D.1 through D.10 list annual historical deliveries by various water classifications for each contractor for 1999 through 2008. Similar delivery tables for years 1997 through 2006 are included in the *State Water Project Delivery Reliability Report 2007*.

Table D. 1 Historical State Water Project Deliveries: 1999
Sacramento River Index=1, Year Type=Wet

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	286				286
City of Yuba City	1,096				1,096
Napa County FC&WCD	4,550	754			5,304
Solano County WA	37,753				37,753
Alameda County FC&WCD, Zone 7	46,000	2,910			48,910
Alameda County WD	34,871	2,781			37,652
Santa Clara Valley WD	67,465	15,480			82,945
Oak Flat WD	4,871				4,871
County of Kings	4,000				4,000
Dudley Ridge WD	51,870	4,990	6,566		63,426
Empire West Side ID	3,000	176			3,176
Kern County WA	1,077,755	58,241	42,154		1,178,150
Tulare Lake Basin WSD	118,500	49,898	121,337		289,735
San Luis Obispo County FC&WCD	3,743				3,743
Santa Barbara County FC&WCD	20,137				20,137
Antelope Valley-East Kern WA	69,073				69,073
Castaic Lake WA (+Rch 31A, 5 & 7)	32,899				32,899
Coachella Valley WD	23,100		27,380		50,480
Crestline-Lake Arrowhead WA	1,132				1,132
Desert WA	38,100		20,000		58,100
Littlerock Creek ID	342				342
Mojave WA	5,144				5,144
Metropolitan WDSC	829,777	22,840			852,617
Palmdale WD	13,278				13,278
San Bernardino Valley MWD	12,874				12,874
San Gabriel Valley MWD	18,000				18,000
Ventura County FCD	1,850				1,850
Totals	**2,521,466**	**158,070**	**217,437**	**0**	**2,896,973**
Total South of Delta	**2,520,084**	**158,070**	**217,437**	**0**	**2,895,591**

Table D. 2 Historical State Water Project Deliveries: 2000

Sacramento River Index=2, Year Type=Above Normal

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	586				586
City of Yuba City	901				901
Napa County FC&WCD	3,136	297		1,525	4,958
Solano County WA	32,882	1,040		1,417	35,339
Alameda County FC&WCD, Zone 7	53,877	3,740			57,617
Alameda County WD	33,598	2,380			35,978
Santa Clara Valley WD	70,433	18,381		13,174	101,988
Oak Flat WD	4,494			14	4,508
County of Kings	3,600				3,600
Dudley Ridge WD	38,673	7,454	12,193	2,884	61,204
Empire West Side ID	1,271	528			1,799
Kern County WA	825,856	78,908	233,202	13,193	1,151,159
Tulare Lake Basin WSD	98,595	56,818	27,073	15,827	198,313
San Luis Obispo County FC&WCD	3,962				3,962
Santa Barbara County FC&WCD	22,741				22,741
Antelope Valley-East Kern WA	83,577				83,577
Castaic Lake WA (+Rch 31A, 5 & 7)	40,680				40,680
Coachella Valley WD	20,790	17,820	3,713		42,323
Crestline-Lake Arrowhead WA	1,194				1,194
Desert WA	34,290	17,820	6,124		58,234
Mojave WA	9,135				9,135
Metropolitan WDSC	1,273,729	103,124		169,529	1,546,382
Palmdale WD	8,221			839	9,060
San Bernardino Valley MWD	18,399				18,399
San Gabriel Valley MWD	14,000	475			14,475
Ventura County FCD	4,050				4,050
Totals	**2,702,670**	**308,785**	**282,305**	**218,402**	**3,512,162**
Total South of Delta	**2,701,183**	**308,785**	**282,305**	**218,402**	**3,510,675**

Table D. 3 Historical State Water Project Deliveries: 2001
Sacramento River Index=4, Year Type=Dry

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	513				513
City of Yuba City	1,065				1,065
Napa County FC&WCD	4,293	996	82	1,723	7,094
Solano County WA	17,756	2,304		1,021	21,081
Alameda County FC&WCD, Zone 7	22,307		308	5,990	28,605
Alameda County WD	13,695	10	107	4,192	18,004
Santa Clara Valley WD	35,689			12,233	47,922
Oak Flat WD	2,089		22	101	2,212
County of Kings	1,560				1,560
Dudley Ridge WD	18,467	933	347	6,815	26,562
Empire West Side ID		253		1,107	1,360
Kern County WA	363,204	23,233	6,502	92,052	484,991
Tulare Lake Basin WSD	40,830	8,755	769	7,889	58,243
San Luis Obispo County FC&WCD	4,184		99		4,283
Santa Barbara County FC&WCD	14,285	396	296		14,977
Antelope Valley-East Kern WA	45,071		899		45,970
Castaic Lake WA (+Rch 31A, 5 & 7)	30,471	850	618		31,939
Coachella Valley WD	9,009		91		9,100
Crestline-Lake Arrowhead WA	1,057				1,057
Desert WA	14,859		151		15,010
Mojave WA	4,433				4,433
Metropolitan WDSC	686,545	10,415	7,949	200,000	904,909
Palmdale WD	8,170			2,257	10,427
San Bernardino Valley MWD	26,488				26,488
San Gabriel Valley MWD	6,534				6,534
Ventura County FCD	1,850				1,850
Totals	**1,374,424**	**48,145**	**18,240**	**335,380**	**1,776,189**
Total South of Delta	**1,372,846**	**48,145**	**18,240**	**335,380**	**1,774,611**

Table D. 4 Historical State Water Project Deliveries: 2002
Sacramento River Index=4, Year Type=Dry

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	419				419
City of Yuba City	1,181				1,181
Napa County FC&WCD	2,022	827	283	3,743	6,875
Solano County WA	28,223	2,242			30,465
Alameda County FC&WCD, Zone 7	40,707	1,484	556	8,113	50,860
Alameda County WD	24,250	83	862	2,331	27,526
Santa Clara Valley WD	55,896	202	2,053	3,311	61,462
Oak Flat WD	3,841	50	76	134	4,101
County of Kings	2,800		54		2,854
Dudley Ridge WD	38,688	1,861	1,177	1,994	43,720
Empire West Side ID	1,278	26		101	1,405
Kern County WA	670,884	21,951	20,543	15,680	729,058
Tulare Lake Basin WSD	73,785	3,749	2,289	5,385	85,208
San Luis Obispo County FC&WCD	4,355				4,355
Santa Barbara County FC&WCD	24,166	436	324	3,455	28,381
Antelope Valley-East Kern WA	53,907		1,008	3,256	58,171
Castaic Lake WA (+Rch 31A, 5 & 7)	61,880	280		6,657	68,817
Coachella Valley WD	16,170	111	474		16,755
Crestline-Lake Arrowhead WA	2,189				2,189
Desert WA	26,670	189	781		27,640
Mojave WA	4,346				4,346
Metropolitan WDSC	1,273,205	9,624	14,335	97,940	1,395,104
Palmdale WD	8,359		437		8,796
San Bernardino Valley MWD	68,268			3,801	72,069
San Gabriel Valley MWD	18,353			4,698	23,051
Ventura County FCD	4,998				4,998
Totals	**2,510,840**	**43,115**	**45,252**	**160,599**	**2,759,806**
Total South of Delta	**2,509,240**	**43,115**	**45,252**	**160,599**	**2,758,206**

Table D. 5 Historical State Water Project Deliveries: 2003
Sacramento River Index=2, Year Type=Above Normal

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	551				551
City of Yuba City	1,324				1,324
Napa County FC&WCD	6,026	376	180	1,055	7,637
Solano County WA	25,135	2,280		1,918	29,333
Alameda County FC&WCD, Zone 7	30,695		656	13,099	44,450
Alameda County WD	31,086		354	5,150	36,590
Santa Clara Valley WD	90,620	936	841	14,104	106,501
Oak Flat WD	4,059	19	48	140	4,266
County of Kings	3,600	58	34		3,692
Dudley Ridge WD	49,723	1,928	482	1,452	53,585
Empire West Side ID	1,074	175		187	1,436
Kern County WA	841,697	27,891	8,419	22,380	900,387
Tulare Lake Basin WSD	94,376	6,243	938	4,284	105,841
San Luis Obispo County FC&WCD	4,417	36			4,453
Santa Barbara County FC&WCD	24,312	339	43	2,274	26,968
Antelope Valley-East Kern WA	52,730		250	7,049	60,029
Castaic Lake WA (+Rch 31A, 5 & 7)	49,895	991	90	4,760	55,736
Coachella Valley WD	14,045	204	194		14,443
Crestline-Lake Arrowhead WA	1,563				1,563
Desert WA	23,168	330	321		23,819
Mojave WA	10,907			3,528	14,435
Metropolitan WDSC	1,550,356	17,622	16,920	134,845	1,719,743
Palmdale WD	9,701			1,846	11,547
San Bernardino Valley MWD	25,371	200		1,844	27,415
San Gabriel Valley MWD	13,034	200			13,234
San Gorgonio Pass WA	116				116
Ventura County FCD	5,000				5,000
Totals	**2,964,581**	**59,828**	**29,770**	**219,915**	**3,274,094**
Total South of Delta	**2,962,706**	**59,828**	**29,770**	**219,915**	**3,272,219**

Table D. 6 Historical State Water Project Deliveries: 2004
Sacramento River Index=3, Year Type=Below Normal

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	1,440				1,440
City of Yuba City	1,434				1,434
Napa County FC&WCD	5,030	1,450	52	1,602	8,134
Solano County WA	17,991	7,787		47	25,825
Alameda County FC&WCD, Zone 7	39,898			11,466	51,364
Alameda County WD	20,956		214	6,714	27,884
Santa Clara Valley WD	52,867	2,983	508		56,358
Oak Flat WD	4,324		29	276	4,629
County of Kings	5,850	3,157	46		9,053
Dudley Ridge WD	36,377	7,393	291	2,185	46,246
Empire West Side ID	1,310	626		1,626	3,562
Kern County WA	640,190	86,513	5,075	40,120	771,898
Tulare Lake Basin WSD	58,575	15,299	489	5,638	80,001
San Luis Obispo County FC&WCD	4,096	69			4,165
Santa Barbara County FC&WCD	29,566		122		29,688
Antelope Valley-East Kern WA	50,532			9,199	59,731
Castaic Lake WA (+Rch 31A, 5 & 7)	46,358	1,618		35,785	83,761
Coachella Valley WD	8,631		89	6,745	15,465
Crestline-Lake Arrowhead WA	2,006				2,006
Desert WA	9,966		102	11,122	21,190
Mojave WA	11,176				11,176
Metropolitan WDSC	1,195,807	91,601	10,223	215,000	1,512,631
Palmdale WD	10,549			1,613	12,162
San Bernardino Valley MWD	35,522			20,631	56,153
San Gabriel Valley MWD	15,600				15,600
San Gorgonio Pass WA	841				841
Ventura County FCD	5,250				5,250
Totals	**2,312,142**	**218,496**	**17,240**	**369,769**	**2,917,647**
Total South of Delta	**2,309,268**	**218,496**	**17,240**	**369,769**	**2,914,773**

Table D. 7 Historical State Water Project Deliveries: 2005
Sacramento River Index=2, Year Type=Above Normal

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	527				527
City of Yuba City	1,894				1,894
Napa County FC&WCD	5,322	606		1,741	7,669
Solano County WA	24,515	10,421		83	35,019
Alameda County FC&WCD, Zone 7	38,388		275	7,849	46,512
Alameda County WD	36,469	846	943	6,341	44,599
Santa Clara Valley WD	89,476	6,298	342	11,899	108,015
Oak Flat WD	4,067		127		4,194
County of Kings	8,100	11,504	202		19,806
Dudley Ridge WD	51,609	28,197	1,286	821	81,913
Empire West Side ID	1,448	1,799		587	3,834
Kern County WA	893,439	453,078	22,397	9,851	1,378,765
Tulare Lake Basin WSD	86,604	47,267	2,158	3,973	140,002
San Luis Obispo County FC&WCD	4,006	245			4,251
Santa Barbara County FC&WCD	22,981		155		23,136
Antelope Valley-East Kern WA	57,205			2,626	59,831
Castaic Lake WA (+Rch 31A, 5 & 7)	54,303	2,451		2,702	59,456
Coachella Valley WD	26,984		2,716	12,819	42,519
Crestline-Lake Arrowhead WA	807				807
Desert WA	33,168		1,122	14,799	49,089
Mojave WA	10,360			1,201	11,561
Metropolitan WDSC	1,247,183	168,300	6,530	106,032	1,528,045
Palmdale WD	10,174			1,538	11,712
San Bernardino Valley MWD	31,211	56		283	31,550
San Gabriel Valley MWD	10,500				10,500
San Gorgonio Pass WA	655	15	22		692
Ventura County FCD	1,665				1,665
Totals	**2,753,060**	**731,083**	**38,275**	**185,145**	**3,707,563**
Total South of Delta	**2,750,639**	**731,083**	**38,275**	**185,145**	**3,705,142**

Table D. 8 Historical State Water Project Deliveries: 2006
Sacramento River Index=1, Year Type=Wet

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	468				468
City of Yuba City	4,148	1,194			5,342
Napa County FC&WCD	7,312	300		172	7,784
Solano County WA	12,070	18,195		390	30,655
Alameda County FC&WCD, Zone 7	50,785		491	2,252	53,528
Alameda County WD		2,375	39,373	1,331	43,079
Santa Clara Valley WD	47,344	26,769		524	74,637
Oak Flat WD	4,118		107	17	4,242
County of Kings	8,991	366	173		9,530
Dudley Ridge WD	55,343	18,515	1,068		74,926
Empire West Side ID	1,500	1,124		658	3,282
Kern County WA	961,882	256,634	18,610	5,418	1,242,544
Tulare Lake Basin WSD	48,361	59,424	1,787		109,572
San Luis Obispo County FC&WCD	3,382	827			4,209
Santa Barbara County FC&WCD	19,255	4,020			23,275
Antelope Valley-East Kern WA	76,623			3,761	80,384
Castaic Lake WA (+Rch 31A, 5 & 7)	56,758	2,089		3,905	62,752
Coachella Valley WD	121,100				121,100
Crestline-Lake Arrowhead WA	257				257
Desert WA	50,000				50,000
Mojave WA	32,496			1,518	34,014
Metropolitan WDSC	1,103,538	238,478	11,638	136,424	1,490,078
Palmdale WD	10,374	1,653	130	335	12,492
San Bernardino Valley MWD	31,902			3,427	35,329
San Gabriel Valley MWD	13,524				13,524
San Gorgonio Pass WA	4,262				4,262
Ventura County FCD	1,850				1,850
Totals	**2,727,643**	**631,963**	**73,377**	**160,132**	**3,593,115**
Total South of Delta	**2,723,027**	**630,769**	**73,377**	**160,132**	**3,587,305**

Table D. 9 Historical State Water Project Deliveries: 2007
Sacramento River Index=4, Year Type=Dry

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	956				956
City of Yuba City	2,327				2,327
Napa County FC&WCD	6,362	3,597		998	10,957
Solano County WA	14,892	8,217		1,822	24,931
Alameda County FC&WCD, Zone 7	32,972	912	378	2,895	37,157
Alameda County WD	16,541	550	197	2,103	19,391
Santa Clara Valley WD	38,812	4,840	469	8,161	52,282
Oak Flat WD	3,430	41	27	69	3,567
County of Kings	4,924	474	43		5,441
Dudley Ridge WD	28,457	8,953	269	2,000	39,679
Empire West Side ID	397	1,172		515	2,084
Kern County WA	592,423	99,861	4,683	19,645	716,612
Little Rock Creek ID	1,380				1,380
Tulare Lake Basin WSD	57,272	12,902	450	16,459	87,083
San Luis Obispo County FC&WCD	3,752	24			3,776
Santa Barbara County FC&WCD	24,760	1,070		1,390	27,220
Antelope Valley-East Kern WA	74,459			4,364	78,823
Castaic Lake WA (+Rch 31A, 5 & 7)	44,974			4,216	49,190
Coachella Valley WD	72,660		568		73,228
Crestline-Lake Arrowhead WA	1,768				1,768
Desert WA	30,000		234		30,234
Mojave WA	45,372			737	46,109
Metropolitan WDSC	1,146,900	166,517	8,962	28,098	1,350,477
Palmdale WD	12,780	843	100	985	14,708
San Bernardino Valley MWD	57,116				57,116
San Gabriel Valley MWD	10,000				10,000
San Gorgonio Pass WA	4,009				4,009
Ventura County FCD	3,000				3,000
Totals	**2,332,695**	**309,973**	**16,380**	**94,457**	**2,753,505**
Total South of Delta	**2,329,412**	**309,973**	**16,380**	**94,457**	**2,750,222**

Table D. 10 Historical State Water Project Deliveries: 2008
Sacramento River Index=5, Year Type=Critical

	Table A	Article 21	Turnback	Carryover	Total
County of Butte	9,436				9,436
City of Yuba City	1,923				1,923
Plumas County FC & WCD	243				243
Napa County FC&WCD	3,636	1,219	21	7,363	12,239
Solano County WA	10,436	1,510		12,389	24,335
Alameda County FC&WCD, Zone 7	13,633			15,400	29,033
Alameda County WD	4,206		37	8,659	12,902
Santa Clara Valley WD	11,133		88	21,188	32,409
Oak Flat WD	1,929		5		1,934
County of Kings	3,187		8		3,195
Dudley Ridge WD	12,260		51	5,949	18,260
Empire West Side ID				915	915
Kern County WA	271,636		883	6,815	279,334
Little Rock Creek ID	805				805
Tulare Lake Basin WSD	32,302		85	281	32,668
San Luis Obispo County FC&WCD	8,512				8,512
Santa Barbara County FC&WCD	11,311		40	2,532	13,883
Antelope Valley-East Kern WA	31,082		125	10,381	41,588
Castaic Lake WA (+Rch 31A, 5 & 7)	18,710			12,146	30,856
Coachella Valley WD	42,385		107		42,492
Crestline-Lake Arrowhead WA	1,159			689	1,848
Desert WA	17,500		44		17,544
Mojave WA	26,288			108	26,396
Metropolitan WDSC	654,304		1,689		655,993
Palmdale WD	4,226		19		4,245
San Bernardino Valley MWD	30,562			4,444	35,006
San Gabriel Valley MWD	10,080				10,080
San Gorgonio Pass WA	5,419			300	5,719
Ventura County FCD	3,798				3,798
Totals	**1,242,101**	**2,729**	**3,202**	**109,559**	**1,357,591**
Total South of Delta	**1,230,499**	**2,729**	**3,202**	**109,559**	**1,345,989**

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