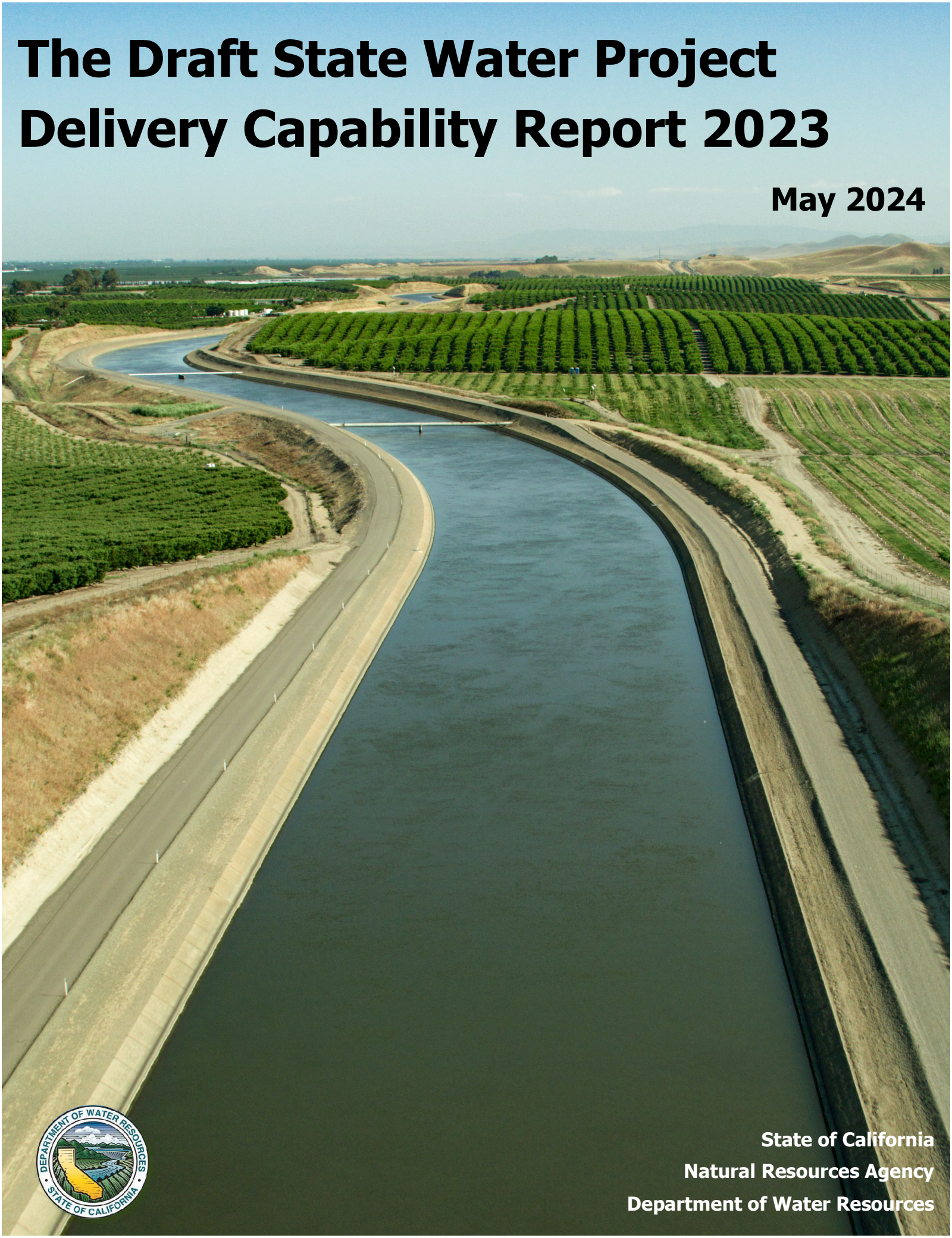
The Draft State Water Project Delivery Capability Report 2023

May 2024



State of California
Natural Resources Agency
Department of Water Resources

State of California
Gavin Newsom, Governor

Natural Resources Agency
Wade Crowfoot, Secretary for Natural Resources

Department of Water Resources
Karla Nemeth, Director
Cindy Messer, Lead Deputy Director
Tom Gibson, Lead Deputy Director

General Counsel Office	Internal Audit Office	Legislative Affairs Office
Ann Carroll	**Mabel Lun**	**Kasey Schimke, Deputy Director**

Public Affairs Office	Tribal Policy Advisor	Office of Workforce Equality
Margaret Mohr, Deputy Director	**Anecita Agustinez**	**Tiffany Vital, Manager**

Deputy Directors

Stephanie Varrelman	Business Operations
John Andrew	Climate Resilience
Laura Hollender	Flood Management and Dam Safety
James Newcomb	Integrated Watershed Management
John Paash	Security and Emergency Management Program
Bianca Sievers	Special Initiatives
John Yarbrough	State Water Project
Paul Gosselin	Statewide Groundwater Management
Delphine Hou	Statewide Water and Energy

Modeling Support Office

This report was prepared under the supervision of

Erik Reyes, Manager

Nazrul Islam, Supervising Engineer, Central Valley Modeling Section

This report was prepared by:

Raymond Hoang, Senior Engineer, WR, Central Valley Modeling Section

Individuals contributing to the development of the report:

Andrew Schwarz, Climate Action Manager, State Water Project

Hongbing Yin, Senior Engineer, WR, Central Valley Modeling Section

Z.Q. Richard Chen, Senior Engineer, WR, Central Valley Modeling Section

Zachary Roy, Engineer, WR, Central Valley Modeling Section

Jonathan Byers, Engineer, WR, Central Valley Modeling Section

Yiwei Cheng, Engineer, WR, Central Valley Modeling Section

Nicole Osorio, Engineer, WR, Central Valley Modeling Section

Christopher Quan, Engineer, WR, Central Valley Modeling Section

Mohammad Hasan, Engineer, WR, Central Valley Modeling Section

James Polsinelli, Engineer, WR, Central Valley Modeling Section

Jianzhong Wang, Engineer, WR, Central Valley Modeling Section

Malinda Wimalaratne, Engineer, WR, Central Valley Modeling Section

Auhona Zaki, Engineering Student Assistant, Central Valley Modeling Section

Aaron Miller, Supervising Engineer, WR, Water Operations Planning Section

Devinder Dhillon, Senior Engineer, WR, Water Operations Planning Section

Romain Maendly, Climate Action Advisor, Integrated Water Management

Wyatt Arnold, Senior Engineer, WR, Alternative Supplies and Operations Section

Alejandro Perez, Engineer, WR, Climate Change Program

Nancy Parker, Applied Hydrologist, U.S. Bureau of Reclamation Technical Service Center

Kunxuan Wang, Modeler, U.S. Bureau of Reclamation Bay-Delta Office

Thomas FitzHugh, Principal Water Resources Scientist, Stantec

Andy Draper, Principal Engineer, Stantec

Jeffrey Weaver, Principal Engineer, HDR Inc.

Daniel Easton, Supervising Engineer, MBK Engineers

Shankar Parvathinathan, Supervising Engineer, MBK Engineers

Director's Foreword

I am pleased to share with you the latest edition of the bi-annual report, the 2023 State Water Project Delivery Capability Report (2023 DCR), which provides a comprehensive analysis of the current and future conditions for the State Water Project (SWP) water supply.

If actions are not taken to address the water delivery challenges faced by the SWP, the 2023 DCR forecasts substantial reductions in SWP delivery capability and reliability. These reductions are driven by the impacts of climate change and constraints within the federal and State permits needed to protect critical species. And these reductions underscore the need for investments in the SWP in order to maintain its historical delivery capability and reliability.

The Delivery Capability Report is used widely both within and outside the State Water Project for water supply planning. The provision of the information in these reports is a key component of the drought planning done by the SWP and is fundamental to the drought planning done by the Public Water Agencies that receive SWP and Central Valley Project (CVP) Water. These reports provide the information needed by these Agencies to develop and manage their own water supply portfolios and are important inputs for Sustainable Groundwater Management Plans, Urban Water Management Plans, Agricultural Water Management Plans, and Integrated Regional Water Management Plans.

Importantly, decreases in the availability of surface water deliveries can lead to supply shortages, an increase in groundwater demand, and reductions in available supplies to support groundwater replenishment. DWR's Sustainable Groundwater Management Office will use the information in the 2023 DCR to update its existing climate change data and guidance that many Groundwater Sustainability Agencies used for their initial Plans. Similarly, DWR's Office of Water Use Efficiency will be advising urban and agricultural water agencies to update their water budget assumptions based on these new assessments.

The 2023 DCR introduces two innovative approaches to characterize current climate change conditions and emphasize the uncertainty in future climate change projections, both of which have undergone independent peer review and are considered significant improvements over previous methodologies.

While the report focuses on current regulations and operations, collaborative efforts between the Department of Water Resources (DWR), the U.S. Bureau of Reclamation (USBR), the Water Board, and resource agencies are ongoing to develop new operating permits for the SWP and Central Valley Project (CVP). These permit conditions, once finalized, will be integrated into the 2025 Delivery Capability Reports.

Simultaneously, the Water Board is developing a new Sacramento-San Joaquin Delta Water Quality Control Plan Update. Board staff has proposed a draft Plan that would meet objectives solely through flow requirements - which would have a substantial impact on the future yield of the State Water Project. In parallel, water users in the Delta Watershed are exploring alternative approaches, such as the Healthy Rivers and Landscapes initiative, that would rely on a combination of water use reductions and habitat improvements. The outcomes of these negotiations and the eventual Plan adopted by the SWRCB will significantly influence the future operations of the SWP.

Despite uncertainties in future regulations and climate conditions, the 2023 DCR unmistakably demonstrates substantial reductions in SWP delivery capability and reliability if no or insufficient action is taken. Immediate action is imperative to address the impact of a warming climate, with the report indicating that these effects are already in motion.

Looking ahead, the SWP is proactively evaluating and developing key adaptation strategies, including Delta Conveyance, Forecast Informed Reservoir Operations, and opportunities for new and expanded storage both above and below ground. A forthcoming SWP Climate Adaptation Analysis in 2024 will provide an evaluation of the expected effectiveness of these strategies.

I encourage all SWP water users to leverage the insights from this report for their own planning and adaptation investigations. Ensuring the water needs of the people of the State are met in the face of a changing climate requires a collaborative and proactive approach.

Karla Nemeth
Director
California Department of Water Resources
May 2024

Contents

List of Figures

List of Tables

List of Acronyms

ANN	Artificial Neural Network
BiOps	Biological Opinions
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CDEC	California Data Exchange Center
CCWD	Contra Costa Water District
CDFW	California Department of Fish and Wildlife
CII	Commercial, Industrial, Institutional
COA	Coordinated Operation Agreement
CVP	Central Valley Project
CY	Calendar/Contract Year
D-1641	State Water Board's Water Right Decision 1641 (D-1641), issued in December 1999 and updated in March 2000
DCD	Delta Channel Depletion
DCP	Delta Conveyance Project
DCR	Delivery Capability Report
DSC	Delta Stewardship Council
DLL	Dynamic Link Library
DO	Dissolved Oxygen
DSM2	Delta Simulation Model 2
E/I	Delta Exports to Inflow ratio
EcoRestore	Governor Brown’s Delta habitat restoration plan
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FCWCD	Flood Control and Water Conservation District
ID	Irrigation District

ITP	Incidental Take Permit for Long-Term Operation of the State Water Project
KCWA	Kern County Water Agency
MAF	Million Acre-Feet
M&I	Municipal and Industrial
MWDSC	Metropolitan Water District of Southern California
NDOI	Net Delta Outflow Index
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NOD	Notice of Determination
NOP	Notice of Preparation
OAL	The State Office of Administrative Law
ROC on LTO	Re-initiation of Consultation on the Long-Term Operations of the Central Valley Project and State Water Project
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
SED	Substitute Environmental Document
SJRRP	San Joaquin River Restoration Program
SMSCG	Suisun Marsh Salinity Control Gate
SVI	Sacramento Valley Index
SWP	State Water Project
SWPAO	State Water Project Analysis Office
SWRCB	State Water Resources Control Board
TAF	Thousand Acre-Feet
USBR	United States Bureau of Reclamation
USFWS	United States Fish and Wildlife Service
UWMP	Urban Water Management Plan
VA	Voluntary Agreements
VIC	Variable Infiltration Capacity Model

WaterFix	Water transfer component of the Bay Delta Conservation Plan
WD	Water District
WGEN	Weather-regime-based Stochastic Weather Generator
WSD	Water Storage District
WSI-DI	Water Supply Index vs. Demand Index Relationship
WQCP	Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta
WY	Water Year
WYT	Water Year Type
X2	Distance in kilometers from Golden Gate, where salinity concentration in the Delta is 2 parts per thousand

Summary

This Delivery Capability Report presents California Department of Water Resources (DWR) analysis of the State Water Project (SWP) system and provides important planning information for users of SWP water. The analysis provides information about how changing climate, regulatory, and operational considerations impact SWP delivery capability.

DWR has authority under state law to construct, operate, and maintain the SWP to manage, store and deliver water for the benefit of the State. This report is intended to provide information about the key factors affecting the operation of the SWP in California, its long-term capability as a source of water for beneficial use, and an estimate of its current delivery capability. This report meets the requirements of Attachment B to the Monterey Plus Settlement Agreement of May 2003.

Water provided by the SWP is a major source of water supplies available to many SWP contractors. SWP contractors consist of 29 public entities that include cities, counties, urban water agencies, and agricultural irrigation districts. SWP contractors' local/regional water users have long-term contracts with the DWR for all, or a portion of their water supply needs. Thus, the delivery capability of water from the SWP system is an important component in the water supply planning of its recipients, and ultimately affects the amount of water available for beneficial use in California.

The availability of these water supplies may be highly variable. A sequence of relatively wet water years[1] may be followed by a varying sequence of dry or critically dry years. Having good and reliable estimates on how much water each contractor will receive each year—whether it be a wet water year, a critical year, or somewhere in between—gives contractors a better sense of the degree to which they may need to implement increased conservation measures, or plan for new facilities or back up sources of water to meet their needs. This is increasingly important given the anticipated effects of climate change on the sources of these water supplies.

The geography of California and the infrastructure of water conveyance from the source areas, located in the Sierra Mountain Range, to areas of demand

[1] Water years start on October 1 and end on September 30 of the next calendar year.

for water, makes the Sacramento-San Joaquin Delta a key feature of the SWP's ability to deliver water to its agricultural and urban contractors in the North Bay, the South Bay, California Central Valley, Central Coast, and Southern California. All but three of the 29 SWP contractors receive water deliveries by diversions from the Delta. These water diversions are pumped by either the Harvey O. Banks or Barker Slough pumping plants.

DWR and the United States Bureau of Reclamation (USBR), the managing entities of the two statewide systems of water conveyance in California, face numerous challenges in the operation of their diversion facilities in the Delta, and are regulated by several state and federal agencies to maintain, and enhance the Delta's long-term sustainability.

Maintaining suitable quality of water flowing in the channels of the Delta for the numerous in-basin beneficial uses, and the protection of endangered and threatened fish species are important factors of concern for the operators of the Delta export diversion facilities. Ongoing regulatory requirements, such as those aimed at protecting the estuary's resident and migratory fish species, are major challenges to a reliable and sustainable water delivery capability of both SWP, and the Central Valley Project (CVP) systems.

Climate change is also increasing the variability, frequency, and magnitude of floods and droughts. The projected sea level rise caused by the increase in average temperature complicates efforts to manage salinity levels in the channels affected by tides. Additionally, higher ocean levels could result in more frequent water quality degradation in the Delta channels requiring additional Delta outflow to maintain water quality objectives. This report provides estimates of both current and future delivery capability to help inform water users and guide their climate change adaptation efforts.

Operationalizing climate change adaptation requires that we continuously evaluate conditions and respond to new trends. However, this DCR does not include any adaptations in the climate change scenarios. This DCR update includes substantially expanded climate change analysis and planning information to evaluate the effect of climate change on delivery capability. This improved planning information includes multiple scenarios of future climate conditions to help examine the resiliency of SWP water supply to changes in climate. This report presents an acknowledgement of climate uncertainties and the need to manage risks to water supply reliability—and a

greater understanding that important climate changes have already occurred and are affecting water supply reliability today. While this DCR evaluates future climate conditions, it does not model future adaptation strategies that DWR is pursuing and plans to have in place by mid-century, analysis of key adaptation strategies with the DCR climate scenarios will be published in mid-2024. The inclusion of this improved planning information is discussed at length in Section 3 and Section 7 of this report.

The analyses in this report factor in all the current regulations governing SWP and CVP operations in the Delta (i.e., D-1641, 2019 BiOps and ITP), existing infrastructure[2] and assumptions about water uses upstream in the Sacramento River and San Joaquin River watersheds. Analyses were conducted that determined the amounts of water that SWP contractors receive and the amounts of water they choose to hold for use in a subsequent year.

SWP Delta exports have decreased since 2005, although the bulk of the change occurred between 2005 and 2009 and in 2019. The former reduction is due to the Delta regulations which constrained exports that culminated in the federal Biological Opinions (BiOps) which went into effect in 2008-2009. These BiOps modified operations of the CVP and SWP diversion pumps. The later reduction is due to two main factors: first, the amended Coordinated Operation Agreement (COA) with accompanying project operation changes which reduced SWP exports and increased CVP exports, and second, a more conservative operation of Lake Oroville by the SWP.

Many of the same assumptions of SWP operations described in the 2021 Report remain the same in this 2023 update, however, there are some

[2] The studies in this report do not consider the diminished capacities of the California Aqueduct due to subsidence, as the assessments from the California Aqueduct Subsidence Program are still ongoing. However, it is anticipated that the Final 2023 DCR will include the impacts of subsidence.

notable changes to the inputs to the simulation. The most notable changes include:

- The extension of the modeling period for an additional six years. The model now simulates a 100-year period from October 1921 to September 2021.
- The baseline projected hydrology incorporates the changes in climate that have already occurred.[3]
- The delivery capability with expected climate change 20 years into the future (2043) was evaluated for three levels of risk to the SWP as compared to only one scenario in prior reports.[4]

As a result of the above improvements and refinements, the differences between the 2021 and 2023 Reports can be attributed to differences in hydrology, temporal expansion, and operational refinements.

The most salient findings in this report are:

- Under existing conditions, the estimated average annual delivery of Tabler A water for this report is 2,238 thousand acre-feet (TAF)/year, 83 less than the 2,321 TAF/year estimated for the 2021 Report (Table 6-2).
- The likelihood of existing condition SWP Article 21 deliveries (supplemental deliveries to Table A water) being greater than 20 TAF/year has increased by 11 percent relative to the likelihood presented in the 2021 Report (Figure 6-6).
- Under the climate change scenarios, which project conditions 20 years into the future under median to extreme hot-dry conditions with no adaptation, the estimated average annual delivery of Table A water shown in the three scenarios is 11 percent to 21 percent lower than under existing conditions. Section 7 highlights the scenario selection

[3] Refer to https://data.cnra.ca.gov/dataset/state-water-project-delivery-capability-report-dcr-2023/resource/ad861b0b-c0aa-4578-8af0-54485e751ca8 for more information.
[4] Refer to Risk-Informed Future Climate Scenario Development for SWP DCR (California Department of Water Resources, 2023) for more information

method and the impact of all three scenarios on the delivery capability of the SWP.

- Under future climate conditions, California's hydrology is likely to become more extreme with periods of high flows that current infrastructure and operations are unable to capture and longer more severe dry periods that challenge operations.
- The analysis of delivery capability under potential future climate change in this report highlights the importance of evaluating system performance under multiple future climate scenarios. However, no adaptation measures were modeled in this report. No single scenario is sufficient to adequately evaluate future system performance and risks to users. The climate studies provided in this report provide a common suite of scenarios that will be used for future adaptation studies.

Section 1. Reasons to Assess SWP Water Delivery Capability

Three major factors underscore the importance of regularly assessing the SWP's water delivery capability: the effects of population growth on California's balance of water supply and demand, State legislation intended to help maintain a reliable water supply, and impact of potential climate change-driven shifts in hydrologic conditions.

Population Growth, Land Use, and Water Supply

California's population has grown rapidly in recent years, with resulting changes in land use. This growth is expected to continue. From 1990 to 2005, California's population increased from about 30 million to about 36 million. Based on this trend, California's population has been projected to be more than 43 million by 2030. The California Water Plan (CWP) indicates that for year 2060 conditions, based on the California Department of Finance's projections of 2010 U.S. Census data, the population is projected to be nearly 51 million — a 70 percent increase compared with the 1990 population.

The amount of water available in California can vary greatly from year to year. Some areas may receive 2 inches of rain a year, while others are deluged with 100 inches or more. As land uses have changed, population centers have emerged in many locations without enough local water supply. Thus, Californians have always been faced with the problem of how best to conserve, control, and move water from areas of abundant water to areas of water need.

The final California Water Plan Update 2023 sets forth objectives, recommendations, and actions for promoting climate change adaptation, supporting California's regions, and strengthening water equity. Action 2.4.1 of the CWP, *Improve SWP Delivery Capability Report*, recommends DWR provide assurance that SWP water users and the public have transparent, risk-informed information about SWP capabilities by making key improvements to the SWP Delivery Capability Report. In support of this action, the 2023 DCR includes use of climate-adjusted hydrology, evaluation of system risk-informed future scenarios, and model updates for recent operational, regulatory, and physical conditions.

For more information on the CWP Update 2023, visit: https://water.ca.gov/Programs/California-Water-Plan/Update-2023.

Legislation on Ensuring a Reliable Water Supply

The laws described below impose specific requirements on both urban and agricultural water suppliers. These laws increase the importance of SWP water delivery capability estimates to local and regional water purveyors.

Urban Water Management Planning Act

The Urban Water Management Planning Act was enacted in 1983 (California Water Code, Sections 10610–10656). As amended, this law requires all public urban water purveyors to adopt Urban Water Management Plans (UWMPs) every five years and submit those plans to DWR. DWR reviews the submitted plans to report to the legislature on the status of these plans and for the purposes of grant eligibility requirements.

UWMPs must include an estimate of water supply and demand for a 20-year planning horizon and three water-year types, normal, single dry year, and a drought lasting five consecutive years. SWP contractors use SWP delivery capability to estimate their long-term water supply needs from other sources available to them. DWR publishes a guidebook to assist water suppliers with preparing their urban water management plans.

Further information is available at: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Urban-Water-Use-Efficiency/Urban-Water-Management-Plans.

Water Conservation Act of 2009: SB X7-7

California became the first state to adopt urban water use efficiency targets with the enactment of the Water Conservation Act of 2009 (SB X7-7, Steinberg 2009). This act mandated the State achieve a 20 percent reduction in urban per capita water use by 2020. It directed urban water suppliers to develop individual targets based on a historical per capita baseline and report interim progress in their 2015 UWMPs and full compliance of their 2020 plans.

In addition, the act requires agricultural water suppliers serving more than 25,000 irrigated acres (excluding recycled water deliveries) to adopt and submit to DWR an Agricultural Water Management Plan (AWMP). These plans must include reports on the implementation status of specific Efficient Water Management Practices (EWMPs), including the measurement and volumetric pricing of water deliveries. Agricultural water suppliers can submit individual

plans or collaborate and submit regional plans if the plans meet the requirements of SB X7-7. Agricultural water suppliers that provide water to between 10,000 and up to 25,000 irrigated acres (excluding recycled water) are not required to prepare or submit AWMPs under SB X7-7 unless State funds are made available to support this.

Water Conservation Legislation of 2018 (AB 1668 and SB 606)

In 2018, new landmark water conservation legislation was signed into law. Together, AB 1668 (Friedman 2018) and SB 606 (Hertzberg 2018), lay out a new long-term water conservation framework for California. This new framework is far-reaching for both the urban and agricultural sectors of California and represents a major shift in focus. Programs and initiatives are organized around four primary goals: (1) use water more wisely, (2) eliminate water waste, (3) strengthen local drought resilience, and (4) improve agricultural water use efficiency and drought planning.

The 2018 legislation defined a process to establish new, standards-based, urban water use objectives (targets) that go beyond the 2020 targets set in the Water Conservation Act of 2009. It also calls for the establishment of performance measures for Commercial, Industrial, Institutional (CII) water use, methods to strengthen local drought resilience including more robust water shortage contingency plans, a new five-year Drought Risk Assessment, and an annual water supply and demand assessment by urban water suppliers. DWR is required to prepare and submit an annual report to the Water Board summarizing the annual assessment results, water shortage conditions, and a regional and statewide analysis of water supply conditions. To improve countywide drought planning, the legislative code requires DWR to conduct a water shortage vulnerability study of rural and small communities and report back to the legislature with recommendations on implementation of drought contingency plans for rural small water systems.

Measures to improve agricultural water use efficiency include strengthened or new agricultural water management planning requirements that include annual water budgets, water management objectives, the quantification of agricultural water use efficiency within an agricultural water supplier's service area, and new drought planning for periods of limited supply.

To fully plan, develop, and implement the new framework, DWR is responsible for numerous studies and investigations over the next three years which include the development of the following:

- Standards.
- Guidelines and methodologies.
- Performance measures.
- Web-based tools and calculators.
- Data and data platforms.
- Reports.
- Recommendations to the State Water Resources Control Board (Water Board) for adoption of new regulations.

A detailed outline of the key authorities, requirements, timeline, roles, and responsibilities of State agencies, water suppliers, and other entities during implementation of actions described in the 2018 water conservation legislation can be found in the summary report "Making Water Conservation a California Way of Life — Primer of 2018 Legislation on Water Conservation and Drought Planning, Senate Bill 606 (Hertzberg), and Assembly Bill 1668 (Friedman)" prepared by DWR and the Water Board.

Additional information on agricultural water use efficiency, water management plans, and supplier compliance can be found in the Agricultural Water Use Efficiency webpage maintained by DWR's Water Use and Efficiency Branch.

Potential Climate Change Driven Shifts in Hydrologic Conditions

DWR continuously reviews and analyzes hydrologic conditions in California and has been monitoring potential shifts in hydrology. The recent hydrologic conditions have been notable for warmer average temperatures, more extreme precipitation (larger storms and drier periods), a change in the form of precipitation to more rain and less snow, and a decreasing Sierra Nevada snowpack which impacts the timing and magnitude of snowmelt runoff volumes. DWR has multiple efforts underway to compare and evaluate recent and long-term hydrologic characteristics. These studies have identified several trends in hydrologic conditions that have shifted the distributions of these conditions outside of the long-term historical distribution.

DWR recognizes the risk posed by climate change to both current and future hydrologic and water supply conditions. The 2023 DCR incorporates analysis of the potential impact of climate change on delivery capability in a more comprehensive manner than previous DCRs. The Hydrologic Conditions Assessment section of this report has a summary of the methods used to conduct this analysis. This report includes substantial peer reviewed enhancements to the methods and information provided in previous reports. DWR will continue to work with state water contractors and the scientific community to further improve and expand the information in future DCRs to provide contractors with decision relevant information for their climate change adaptation planning needs.

Section 2. Regulatory Restrictions on SWP Delta Exports

Multiple objectives converge in the Sacramento-San Joaquin Delta (Delta): to protect a fragile ecosystem, to support Delta recreation and farming, and to provide water for agricultural and urban needs throughout most of California. Various regulatory requirements are placed on the SWP's Delta operations to protect special-status species such as Delta smelt and spring- and winter-run Chinook salmon. As a result, restrictions on SWP operations imposed by State and federal fish and wildlife agencies contribute substantially to the challenge of accurately determining the SWP's water delivery capability in any given year.

Key policies pertaining to Delta operations are undergoing discussions as of the publication of this report. Namely, updates to the Water Quality Control Plan, Voluntary Agreements, and the re-initiation of Consultation for Long-Term Operations. Since none have been finalized, the modeling analysis in this report assumes the same regulatory environment as the 2021 DCR: SWRCB D-1641, 2019 BiOps and its associated ITP (2020). The remainder of this section describes the context and qualitative implications of these regulations on project operations.

Regulations Related to Endangered Species

Biological Opinions on Effects of Coordinated SWP and CVP Operations

Several fish species listed under the federal Endangered Species Act (ESA) as threatened or endangered are found in the Delta. The health and the viability of their populations are impacted by various factors, including SWP and CVP operations, nonnative species, predation, Delta salinity, water quality and contaminants, sediment supply, physical alterations to the Delta, land subsidence, pelagic organism decline, methylmercury and selenium, invasive aquatic vegetation, low dissolved oxygen (DO) levels, and illegal harvest.

Because of the decline of these species, the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) have issued several Biological Opinions (BiOps) since the 1990s on the effects of coordinated SWP/CVP operations on several listed species. Examples are the USFWS BiOp for Delta smelt protection and NMFS BiOp for salmonids, green sturgeon, and Southern Resident killer whales.

These BiOps affect the SWP's water delivery capability in two ways. Most notably, they include terms that restrict SWP exports in the Delta to specific amounts at certain times under certain conditions. The BiOps also include Delta outflow requirements during certain times of the year, consequently reducing the available supply for export or storage.

The first BiOp on the effects of SWP (and CVP) operations was issued in February 1993 (NMFS BiOp) on the effects of project operations on winter-run Chinook salmon, and in March 1995 (USFWS BiOp) on project effects on Delta smelt and splittail. Among other requirements, the BiOps contained requirements for Delta inflow, Delta outflow, and export pumping restrictions to protect listed species. These requirements imposed substantial constraints on Delta water supply operations. Many were incorporated into the 1995 Water Quality Control Plan for the San Francisco Bay/Sacramento–San Joaquin Delta (1995 WQCP), as described in the Water Quality Objectives section, below.

The terms of the USFWS and NMFS BiOps have become increasingly restrictive over the years. In 2004, the USBR sought a new BiOp from USFWS regarding the operation of the CVP and the SWP (referred to collectively as Projects). USFWS issued the opinion in 2005, finding that the proposed coordinated operations of the Projects were not likely to jeopardize the continued existence of the Delta smelt or result in the destruction or adverse modification of its critical habitat. After judicial review, the 2005 BiOp was vacated and USFWS was ordered to prepare a new one. USFWS found that the proposed operations of the Project would result in jeopardy to the Delta smelt and in December 2008 issued a Jeopardy BiOp which included a Reasonable and Prudent Alternative (RPA) with more protective export restrictions and other actions intended to protect the Delta smelt.

Similarly, in 2004 NMFS issued a BiOp on the effects of the coordinated operation of the Projects on salmonids, green sturgeon, and Southern Resident killer whales and found that the proposed operations of the Projects were not likely to jeopardize the continued existence of the listed species or result in the destruction or adverse modification of their critical habitat. After judicial review, the 2004 BiOp was rescinded, and NMFS was ordered to prepare a new one. In June 2009, NMFS issued a Jeopardy BiOp covering effects on winter-run and spring-run Chinook salmon, steelhead, green sturgeon, and killer whales. Like the 2008 smelt BiOp, the salmon BiOp

included an RPA with more protective export restrictions and other actions intended to protect listed species.

The 2008 USFWS BiOp included requirements on operations in all but two months of the year. The BiOp called for "adaptively managed" (adjusted as necessary based on the results of monitoring) flow restrictions in the Delta intended to protect Delta smelt at various life stages. One such requirement is Fall X2, a component to improve fall habitat for Delta smelt through increasing Delta outflow. In September, October and November in wet and above-normal water years, additional outflow—achieved through export reductions and reservoir releases—is required to meet salinity targets. In the event there is an increase in storage during any November this action applies, the increase in reservoir storage is released in December to augment the December outflow requirements in SWRCB D-1641. Because this flow restriction was determined based on fish location and decisions by USFWS staff, predicting the flow restriction and corresponding effects on export pumping with any great certainty posed a challenge.

Among the provisions included in the 2009 NMFS BiOp were reducing exports to limit negative flows on OMR between January and June, as well as restricting total Delta exports in the months of April and May, based on SJR flows for all but extremely wet years.

The 2008 and 2009 BiOps were respectively issued shortly before and after Governor Arnold Schwarzenegger proclaimed a statewide water shortage state of emergency in February 2009, amid the threat of a third consecutive dry year. NMFS calculated that implementing its BiOp would reduce SWP and CVP Delta exports by a combined 5 to 7 percent, but DWR's initial estimates showed an impact on exports closer to 10 percent in average years, combined with the effects of pumping restrictions imposed by the BiOps to protect Delta smelt and other species. The California Department of Fish and Wildlife (CDFW) issued consistency determinations under Section 2080.1 of the California Fish and Game Code for these BiOps. The consistency determinations stated that the USFWS and the NMFS BiOps would be consistent with the California Endangered Species Act (CESA). Thus, CDFW allowed incidental take of species listed under both the federal ESA and CESA to occur during SWP and CVP operations without requiring DWR or the USBR to obtain a separate State-issued permit. In addition to the

consistency determination, CDFW issued a separate ITP for the incidental take of Longfin Smelt, which is not a listed species under ESA.

In August 2016, the USBR and DWR requested a Reinitiation of Consultation for Long-term Operations (RoC on LTO) of the CVP and SWP with NMFS and USFWS because of new information and science on declining listed fish species populations. On October 21, 2019, the USFWS and NMFS released their new BiOps. USBR released a final EIS on the RoC on LTO on December 19, 2019, and approved a Record of Decision that finalized environmental review on February 18, 2020. The USBR began to operate according to the new operations plan in early 2020.

Incidental Take Permit

The 2008 USFWS and 2009 NMFS BiOps were consistent with CESA requirements. As such, further authorizations with respect to species listed under both ESA and CESA were not required. Under section 2081 of the California Fish and Wildlife Code, DWR held an Incidental Take Permit (ITP) from the CDFW related to Longfin Smelt.

With the expiration of the ITP at the end of December 2019 and the decision to pursue a separate State permit to ensure the SWP's compliance with CESA rather than relying on a consistency determination with federal permits, DWR pursued a new ITP.

The ITP covers species listed under CESA subject to incidental take through long-term operation of the SWP, including Delta smelt, Longfin Smelt, winter-run Chinook salmon, and spring-run Chinook salmon. An EIR on the new ITP was issued in November 2019, an ITP application was submitted to CDFW in December 2019, and the new ITP was issued on March 31, 2020. DWR began to operate according to the ITP in April 2020.

The key elements of DWR's long-term operations of the SWP through the ITP include:

- Stronger species protections.
- Water dedicated for Delta outflow.
- Innovative use of facilities for fish management.
- Decision-making authority for CDFW.
- New protections for migrating salmon.
- Operational clarity and flexibility.
- Real-time operations.
- Adaptive management plan.
- Enhanced studies, monitoring, and financial commitments.
- SWP exports similar to existing conditions.

For more information, see the Final EIR for the SWP Long-Term Operations: https://water.ca.gov/News/Public-Notices/2020/March-2020/Final-EIR-for-SWP-Operations.

Re-initiation of Consultation for Long-Term Operations

On September 30, 2021, the USBR again requested RoC on LTO. The reinitiation was requested because of anticipated modifications to the Proposed Action that may cause effects to ESA-listed species or designated critical habitats not analyzed in the 2019 USFWS and NMFS BiOps. Under this 2021 RoC on LTO, which is still in progress, the USBR and DWR anticipate that new BiOps will be developed for the CVP and SWP. DWR will also be an applicant in the consultation, and CDFW will facilitate the process of DWR updating their Incidental Take Permit for SWP operations. On November 1, 2023, DWR submitted a new incidental take permit application. Because the application is still under review, the modeling analysis in this report assumes the 2019 BiOps and 2020 ITP.

For more information on the RoC on LTO, visit: https://www.usbr.gov/mp/bdo/lto/

Water Quality Objectives

1995 Bay-Delta Water Quality Control Plan (D-1641)

Because the Delta is an estuary, salinity is a concern. In the 1995 Bay-Delta Water Quality Control Plan (WQCP), the State Water Board set water quality objectives to protect beneficial uses of water in the Delta and Suisun Bay. The objectives must be met by the SWP and federal CVP as specified in the water right permits issued to DWR and the USBR. These objectives — minimum Delta outflows, limits on SWP and CVP Delta exports, and maximum allowable salinity levels — are enforced through the provisions of the State Water Board's Water Right D-1641, issued in December 1999 and updated in March 2000, which officially instated the 1995 WQCP.

Both DWR and the USBR must monitor the effects of their respective diversions and project operations to ensure compliance with existing water quality objectives.

Among the objectives established in the 1995 WQCP and D-1641 are the "X2" objectives. X2 is defined as the distance in kilometers from the Golden Gate, where salinity concentration in the Delta is 2 parts per thousand. The location of X2 is used as a surrogate measure of Delta ecosystem health.

For the X2 objective to be achieved, the X2 position must remain downstream of Collinsville in the Delta, February through June, and downstream of other specific locations in the Delta on a certain number of days each month from February through June. This means that Delta outflow, which among other factors controls the location of X2, must be at certain specified levels at certain times. This can limit the amount of water the SWP may pump at those times at its Harvey O. Banks Pumping Plant in the Delta.

Because of the relationship between seawater intrusion and interior Delta water quality, meeting the X2 objective can also improve water quality at Delta drinking water intakes; however, meeting the X2 objectives can require a relatively large volume of water for outflow during dry months that follow months with large storms.

The 1995 WQCP and D-1641 also established an export/inflow (E/I) ratio. The E/I ratio is designed to provide protection for the fish and wildlife beneficial uses in the Bay Delta estuary. The E/I ratio limits the fraction of

Delta inflows that are exported. When other restrictions are not controlling, Delta exports are limited to 35 percent of total Delta inflow from March through June and 65 percent of inflow from July through January. The February E/I ratio can vary from 35 percent to 45 percent depending on the January Eight River Index (8RI). The 8RI is the sum of the Sacramento River and San Joaquin River runoff. This index is used from December through May to set flow objectives as implemented in SWRCB D-1641.

In December 2018, the State Water Board updated the WQCP for the San Joaquin River flows and southern Delta salinity. The State Water Board is in the process of updating the WQCP for Sacramento/Delta flows and cold water, Delta outflows, and interior Delta flows. A primary focus of the WQCP update is on additional flows for the beneficial use of fish and wildlife. Based on the environmental documentation that has been produced up to this date by the State Water Board, it is likely that the implementation of these flow requirements will affect SWP contractor deliveries.

The San Joaquin River (SJR) portion of the WQCP update was approved in December 2018 but not implemented. For implementation, there would need to be a Decision (like Decision-1641) that amends the water rights license and permits for the SWP and CVP (the Projects collectively) to require the Projects and others to meet the Bay-Delta Plan before the SWP operates to the approved SJR portion of the update. As a result, this Report assumes the existing Decision-1641 in its modeling.

D-1641 Water Year Types

Delta inflows vary considerably from season to season, and from year to year. For example, in an above-normal year, nearly 85 percent of the total Delta inflow comes from the Sacramento River, more than 10 percent comes from the San Joaquin River, and the rest comes from the three eastside streams (the Mokelumne, Cosumnes, and Calaveras rivers).

All other factors (such as upstream level of development) being equal, much less water will flow into the Delta during a dry or critical water year (that is, during a drought) than during a wet or above-normal water year. Fluctuations in inflows are a substantial overall concern for the Delta, and a specific concern for the SWP; such fluctuations affect Delta water quality and fish habitat, which in turn trigger regulatory requirements that constrain SWP Delta exports.

Delta inflows will also vary by time of year as the amount of precipitation varies by season. About 80 percent of annual precipitation occurs between November and March, and very little rain typically falls from June through September. Upstream reservoirs regulate this variability by reducing flood flows during the rainy season and storing water to be released later in the year to meet regulatory requirements and water demands.

To characterize these varying hydrology conditions, State Water Resources Control Board Decision 1641 defined the Sacramento 40-30-30 Water Year type (https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/decision_1641/). This water year type is discussed here because it is used extensively in defining regulations both in D-1641 and in Biological Opinions. These water year types are defined based on the Sacramento Valley Water Year Index (Index), which is calculated using the sum of unimpaired flow in million acre-feet (MAF) at the following locations:

- Sacramento River Above Bend Bridge.
- Feather River at Oroville (inflow to Lake Oroville).
- Yuba River near Smartville.
- American River below Folsom Lake.

The exact calculation of the Index is 0.4 * Current Apr-Jul Runoff Forecast (in MAF) + 0.3 * Current Oct-Mar Runoff in (MAF) + 0.3 * Previous Water Year's Index (if the Previous Water Year's Index exceeds 10.0, then 10.0 is used). The Index is converted into one of five Water Year types using the thresholds shown in

Table 2-1. The final determination of the Index and Water Year Type is based on 50 percent exceedance forecast of flows as of May 1.

Table 2-1. Sacramento Valley Index Year Type Classification Thresholds in MAF

Year type classification	Threshold criteria (MAF)
Wet	Equal to or greater than 9.2
Above Normal	Greater than 7.8, and less than 9.2
Below Normal	Greater than 6.5, and equal to or less than 7.8
Dry	Greater than 5.4, and equal to or less than 6.5
Critical	Equal to or less than 5.4

Voluntary Agreements

DWR and CDFW are working to establish the Voluntary Agreements (VAs) with participating water users following adoption by SWRCB of the San Joaquin River/southern Delta salinity WQCP update. As stated above under the Water Quality Objectives section, the San Joaquin River/southern Delta salinity portion of the WQCP update was approved in December 2018 but not implemented.

The VAs involve the development of projects that provide flow augmentation, modified storage releases, and non-flow actions such as floodplain inundation to enhance Delta conditions. Both departments are continuing the effort to develop and evaluate proposed voluntary agreements. On March 1, 2019, DWR and DFW submitted documents to the State Water Resources Control Board that reflect progress on the previously submitted framework. The objectives are to improve conditions for fish through targeted river flows and a suite of habitat-enhancing projects including floodplain inundation and physical improvement of spawning and rearing areas.

On March 29, 2022, a "Memorandum of Understanding" (MOU) was released that outlined the terms of an eight-year program for the VAs. The program would provide new flows for the environment above existing regulatory requirements, create new and restored habitat for fish and wildlife, provide funding for environmental improvements and water purchases, and start a collaborative science program for monitoring and adaptive management. However, the VAs have not been officially finalized. Therefore, the modeling analysis in this report assumes the existing Decision-1641.

SWP-CVP Coordinated Operation Agreement

Originally negotiated and signed in 1986, the Coordinated Operation Agreement (COA) establishes the shared responsibility for the SWP and CVP each to meet water quality and regulatory standards. Between 1986 and 2018, the State Water Resources Control Board imposed additional restrictions, including new Delta outflow requirements, which further restricted Delta exports and affect CVP and SWP operations. In response to these changes, a joint review of the 1986 agreement was conducted by both projects. At the conclusion of this review in December 2018, DWR and the USBR agreed to a COA addendum to reflect the current regulatory

environment and operations of the projects. The 2018 agreement addendum is included in the modeling analysis in this report.

Section 3. Hydrologic Conditions Assessment

Historical Hydrologic Conditions

Similar to previous Delivery Capability Reports, the DCR 2023 includes an analysis using historical hydrologic conditions as inputs to the CalSim 3 model. However, the DCR 2023 does not use the historical hydrologic conditions data in its evaluation of existing Project delivery capability, and instead uses the adjusted hydrologic conditions discussed below. The historical hydrologic conditions input data represents a period of record of water years 1922 through 2021 (October 1, 1921, through September 30, 2021). The historical hydrologic conditions data set was developed using historical data (streamflow, land use, and meteorological data) when available, and extrapolation from historical data when the full period of historical data was not available.

Adjusted Historical Hydrologic Conditions

A shortcoming of using the historical hydrologic conditions data set to assess existing Project delivery capability is that the effect of climate change is not consistent throughout the modeled period. Statistical characteristics of historical rim inflow in California's Central Valley show noticeable and statistically significant changes in the past 100 years. Standard deviations of precipitation and rim inflow from most of the rim watersheds in the early periods of the past 100 years are significantly different from the recent 30 years. These differences indicate that the non-stationary historical meteorological and hydrological data may not be completely representative of recent and current conditions. To develop a hydrologic data set for the entire modeled period that represents current hydrology, an adjusted historical hydrologic conditions data set was developed. The intent of the adjusted historical hydrologic conditions data set is to provide a reasonable representation of recent climatic conditions and serve as a basis for creating future climate change scenarios.

The historical hydrologic conditions data set was used as a basis for the adjusted historical hydrologic conditions data set. Precipitation and rim inflows for the last 30 years of the period of record (water years 1992 through 2021) were used as a basis for modification of the first 70 years of the period of record (water years 1922 through 1991). The standard deviation and monthly distribution of historical streamflow for the first 70 years of the period of record were adjusted to match the last 30 years via a

combination of statistical scaling methods. The resulting data set is identical to the historical hydrologic conditions for water years 1992 through 2021, with adjustments to water years 1922 through 1991. The Evaluation and Adjustment of Historical Hydroclimate Data (California Department of Water Resources, 2023) report will include a detailed description of the processes used to develop the adjusted hydrologic conditions data set.

This report will use adjusted historical hydrologic conditions as its baseline, as it is more representative of current conditions. As with previous releases of the DWR, contextual information about the evolution of SWP water delivery capability will be informed by a comparative analysis between the current baseline and the previous baseline. The last baseline for the 2021 DCR used historical hydrology, so the Existing SWP Water Delivery Capability section of this report will compare the results from an *adjusted* hydrology to a historical hydrology. In previous DCR's comparative analyses (historical vs. historical), the outcomes of the comparison reveal the effects primarily from operational and regulatory changes. In this comparison (*adjusted* historical compared with historical) the outcomes reveal the impact of both (1) adopting the adjusted hydrology and (2) operational updates.

Although the Historical Hydrology CalSim 3 model will not be the DCR baseline, it was still developed as part of the overall modeling process. The results of the 2023 Historical Hydrology CalSim 3 study will be presented briefly in this document and in more detail in the Technical Addendum.

Climate Change Scenarios Hydrologic Conditions

The single SWP future conditions scenario provided in past DCRs was developed to represent a median or central tendency of impacts in the SWP watershed area across the ensemble of global climate models. This approach provided a useful starting point for thinking about and planning for future risks. Considering multiple future scenarios allows for more robust planning. Further, applications of the DCR future scenarios may have different risk tolerances or risk aversions depending on the user and purpose. Providing a tractable range of SWP future climate scenarios provides users with additional climate risk information that is more transparent about uncertainty associated with future climate change, allows users to make their own decisions about risk tolerance, and ultimately will lead to better and more informed planning and operational decision-making. The development of those scenarios is described in the Risk-Informed Future

Climate Scenario Development for SWP DCR (California Department of Water Resources, 2023).

The 2023 DCR analyzes Project delivery capability under multiple risk-informed climate scenarios (50 percent, 75 percent, and 95 percent level-of-concern). In developing these scenarios, three key objectives were sought: (1) explicit representation of climate change uncertainties, (2) improved transparency and information for local planners, and (3) maintaining the utility of the DCR and the information it provides. The methods used to develop hydrologic data sets under climate changed conditions are built on the work conducted for previous DCRs and other climate change analyses conducted by DWR and others. The hydrologic data sets for the climate changed conditions were selected to represent specific levels of change to unimpaired flow that stress SWP and CVP operations. This differs from previous approaches that used the ensemble average or central tendency of projected climate conditions. In this new approach, DWR applies a bottom-up stress test and uses a climate-model-informed probability density function to develop "level-of-concern" scenarios at specified climate-informed system performance levels (e.g., a 95 percent level-of-concern scenario depicts a future condition in which 95 percent of model-informed climate outcomes result in better SWP system reliability). The Technical Addendum includes a detailed description of the methods used to develop the climate change conditions hydrologic data sets.

Section 4. Ongoing Environmental, Infrastructure, and Policy Planning Efforts and Projects

The Delta's importance to California's economy and natural heritage cannot be overstated. The Delta supplies a large share of the water used in the state. California would not be the same without that water — hundreds of billions of dollars of economic activity depend upon it. Southern California, with half of the state's population, gets approximately 30 percent of its average water supply from the Delta; Kern County, which produces about $7 billion annually in grapes, almonds, pistachios, milk, citrus, and other agricultural products, depends on the Delta for about a fifth of its irrigation supply. The west side of the San Joaquin Valley also produces billions of dollars worth of food and depends on the Delta for about three-quarters of its irrigation supply; the San Francisco Bay Area, including the innovation hub of Silicon Valley, takes about half of its water supply from the Delta and its tributaries.

At the same time, the hundreds of miles of river channels that crisscross the Delta's farmed islands provide a migratory pathway for Chinook salmon, which support an important West Coast fishing industry. Other native fish species depend upon the complex mix of fresh and saltwater in the Delta estuary. Multiple stressors have impaired the ecological functions of the Delta, and concerns have been growing over the ability to balance the many needs of both people and the ecosystem.

To respond to these concerns, considerable effort by government agencies and the California water community has been spent during the past several decades to study ways that the problems in the Delta can be addressed, and the more recent attention to the effects of climate change has helped the water community to realize the urgency of addressing these problems. The essential part of all these efforts has been to find a comprehensive solution that brings various, sometimes competing, interests together in a coordinated and concerted set of actions. The Delta Plan, Delta Conveyance Project (DCP), and California EcoRestore are three large-scale statewide efforts. Since 2010, the Delta Stewardship Council (DSC) has developed, amended, and begun implementing the Delta Plan. The DCP, on the other hand, is currently under development. Lastly, California EcoRestore celebrated its first five years in 2020 and was on track to exceed initial targets.

Delta Plan

After years of concern about the Delta amid rising water demand and habitat degradation, the DSC was created in legislation to achieve State-mandated coequal goals for the Delta. As specified in Section 85054 of the California Water Code:

"Coequal goals" means the two goals of providing more reliable water supply for California and protecting, restoring, and enhancing the Delta ecosystem. These goals shall be achieved in a manner that protects and enhances the unique cultural, recreational, natural resource, and agricultural values of the Delta as an evolving place.

The DSC is required to review the Delta Plan at least every five years. The first Delta Plan was adopted by the DSC on May 16, 2013. The State Office of Administrative Law (OAL) approved the 14 regulations to implement the Delta Plan, which became effective, with legally enforceable regulations, on September 1, 2013.

To be responsive to changing circumstances and in accordance with commitments made in the 2013 Plan, the DSC amended the Delta Plan twice in 2016. The latest Delta Plan was released April 2018 and amended July 2019. The Delta Plan contains a set of 14 regulatory policies as well as 95 recommendations, which are non-regulatory but identify actions essential to achieving the coequal goals. The next five-year review of the Delta Plan is slated for 2023.

Delta Conveyance Project

Delta conveyance refers to SWP infrastructure in the vast network of waterways comprising the Sacramento-San Joaquin Delta. Modernization of this infrastructure through construction of intakes in the northern Delta and a north-to-south water conveyance tunnel has been planned under previous projects (Bay-Delta Conveyance Plan and California WaterFix). On May 2, 2019, Governor Gavin Newsom officially ended California WaterFix and announced a new approach to modernize Delta Conveyance through a single tunnel alternative. Governor Newsom also released Executive Order N-10-19, which directed State agencies to inventory and assess the new planning for the single tunnel project.

DWR approved the Delta Conveyance Project, a modernization of the infrastructure system that delivers water to millions of Californians. DWR has certified the Environmental Impact Report (EIR) and completed an extensive environmental review of the Delta Conveyance Project on December 21, 2023. DWR selected the "Bethany Reservoir Alignment" for further engineering, design and permitting.

The environmental review included a 142-day public comment period in which DWR received more than 700 letters and 7,000 individual comments. Outreach began in 2020 and has included a multitude of webinars, workshops, briefings, multi-language informational materials, email updates, videos, animations, tabling at local events, and a comprehensive Delta survey. The Final EIR responds to all substantive comments.

For more information about the project, visit water.ca.gov/deltaconveyance. For more information about permitting and to view the final EIR, visit deltaconveyanceproject.com

EcoRestore

Governor Brown announced the creation of the California EcoRestore program in April 2015, committing to restore more than 30,000 acres of Delta habitat by 2020. This comprehensive suite of habitat restoration actions under the California EcoRestore program includes specific targets for floodplain, tidal and sub-tidal, managed wetlands, and fish passage improvements to benefit native fish species and a commitment to adaptive management. As of January 2021, more than 38,000 acres are projected to be restored under the EcoRestore program, with over 6,500 acres already restored.

For more information, visit https://water.ca.gov/Programs/All-Programs/EcoRestore.

California Aqueduct Subsidence Program

Subsidence, or the sinking of land, has been documented throughout California for almost a century, with the primary cause being deep groundwater pumping. The land underlying the California Aqueduct has sustained an alarming and unprecedented increase in subsidence rates in recent years, affecting conveyance capacity of the Aqueduct. For example, in the three years of the drought from 2013 through 2016, areas of the

aqueduct sunk nearly three feet. In addition to reducing flow capacity of the system, subsidence also leads to operational difficulties. The goal of the California Aqueduct Subsidence Program is to address ongoing subsidence while developing solutions and funding sources to preserve the Aqueduct's ability to deliver water. The studies in this report do not consider the diminished capacity of the California Aqueduct due to subsidence, as the assessments from the California Aqueduct Subsidence Program are still being finalized. However, it is anticipated that the Final 2023 DCR will include the impacts of subsidence.

For more information, visit: https://water.ca.gov/Programs/Engineering-And-Construction/Subsidence.

Section 5. State Water Project Historical Deliveries

Sections 5 and 8 present the actual SWP Historical Deliveries from calendar years 2013-2022. Section 5 focuses on the annual minimum, maximum, and average total recorded contractor combined deliveries during this 10-year period. Section 8 includes tables of annual recorded historical deliveries by various water classifications for each SWP Contractor for 2013–2022. Contractor deliveries are presented as four different delivery types: Table A delivery, Article 21 delivery, carryover delivery, or turnback delivery. These delivery types are briefly described below.

Table A Water is an exhibit to the SWP's water supply contracts. The maximum Table A amount is the basis for apportioning water supply and costs to the SWP contractors. Once the total amount of water to be delivered is determined for the year, all available water is allocated in proportion to each contractor's annual maximum SWP Table A amount. Table A water is given priority for delivery over other types of SWP water. Contractors have several options for what to do with the water that is allocated to them: use it, store it for later use, or transfer it to another contractor.

Article 21 Water (so named because it is described in Article 21 of the water contracts) is water that SWP contractors may receive on intermittent, interruptible basis in addition to their Table A water, if they request it. Article 21 water is used by many SWP contractors to help meet demands when allocations are less than 100 percent. The availability and delivery of Article 21 water cannot impact the Table A allocation of the any contractor's water, nor can it negatively impact normal SWP operations.

Carryover Water, also known as Article 56 water, is SWP water that is allocated to an SWP contractor and approved for delivery to that contractor each year, but not used by the end of the year. This water is exported from the Delta by the Banks Pumping Plant, but instead of being delivered to the contractor, it is stored in the SWP's share of San Luis Reservoir, when space is available, for the contractor to use in the following year[5].

[5] In real-time operations, Article 56 water can be carried over for several years if conditions permit. But the modeling assumes single year carryover.

Turnback Pool Water SWP contractors may offer a portion of their Table A water that has been allocated in the current year and exceeds their needs to a "turnback pool," where another contractor may purchase it. Contractors that sell their extra Table A water in a turnback pool receive payments from contractors that buy this water.

Table 5-1 lists the 2023 maximum annual SWP Table A water contract amounts for SWP contractors. Figure 5-1 shows that the historical deliveries from 2013–2022 of SWP Table A water, including the carryover water deliveries, range from a minimum of 278 TAF (2022) to a maximum of 3,094 TAF (2017), with an average 1,416 TAF/year. Total historical SWP deliveries, including Table A, Article 21, turnback pool, and carryover water, range from 279 to 3,404 TAF/year, with an average of 1,484 TAF/year in the same 2013–2022 period (Figure 5-2).

Table 5-1. 2023 Maximum Annual SWP Table A Water Contract Amounts for SWP Contractors

Contractor	Maximum Table A Delivery Amounts (acre-feet)
Feather River Area Contractors	—
Butte County	27,500
Plumas County Flood Control and Water Conservation District	2,700
Yuba City	9,600
Feather River Area Contractors Total	39,800
North Bay Area Contractors	—
Napa County Flood Control and Water Conservation District	29,025
Solano County Water Agency	47,756
North Bay Area Contractors Total	76,781
South Bay Area Contractors	—
Alameda County Flood Control and Water Conservation District, Zone 7	80,619
Alameda County Water District	42,000
Valley Water (also known as Santa Clara Valley Water District)	100,000
South Bay Area Contractors Total	222,619
San Joaquin Valley Area Contractors	—

Contractor	Maximum Table A Delivery Amounts (acre-feet)
Dudley Ridge Water District	41,350
Empire West Side Irrigation District	3,000
Kern County Water Agency	982,730
Kings County	9,305
Oak Flat Water District	5,700
Tulare Lake Basin Water Storage District	87,471
San Joaquin Valley Area Contractors Total	1,129,556
Central Coastal Area Contractors Area Contractors	—
San Luis Obispo County Flood Control and Water Conservation District	25,000
Santa Barbara County Flood Control and Water Conservation District	45,486
Central Coastal Area Contractors Area Contractors Total	70,486
Southern California Area Contractors	—
Antelope Valley-East Kern Water Agency	144,844
Coachella Valley Water District	138,350
Crestline-Lake Arrowhead Water Agency	5,800
Desert Water Agency	55,750
Littlerock Creek Irrigation District	2,300
Metropolitan Water District of Southern California	1,911,500
Mojave Water Agency	89,800
Palmdale Water District	21,300
San Bernardino Valley Municipal Water District	102,600
San Gabriel Valley Municipal Water District	28,800
San Gorgonio Pass Water Agency	17,300
Santa Clarita Valley Water Agency	95,200
Ventura County Watershed Protection District	20,000
Southern California Area Contractors Total	2,633,544
Grand Total	4,172,786

Figure 5-1. Historical Deliveries of SWP Table A and Carryover Water, 2013–2022

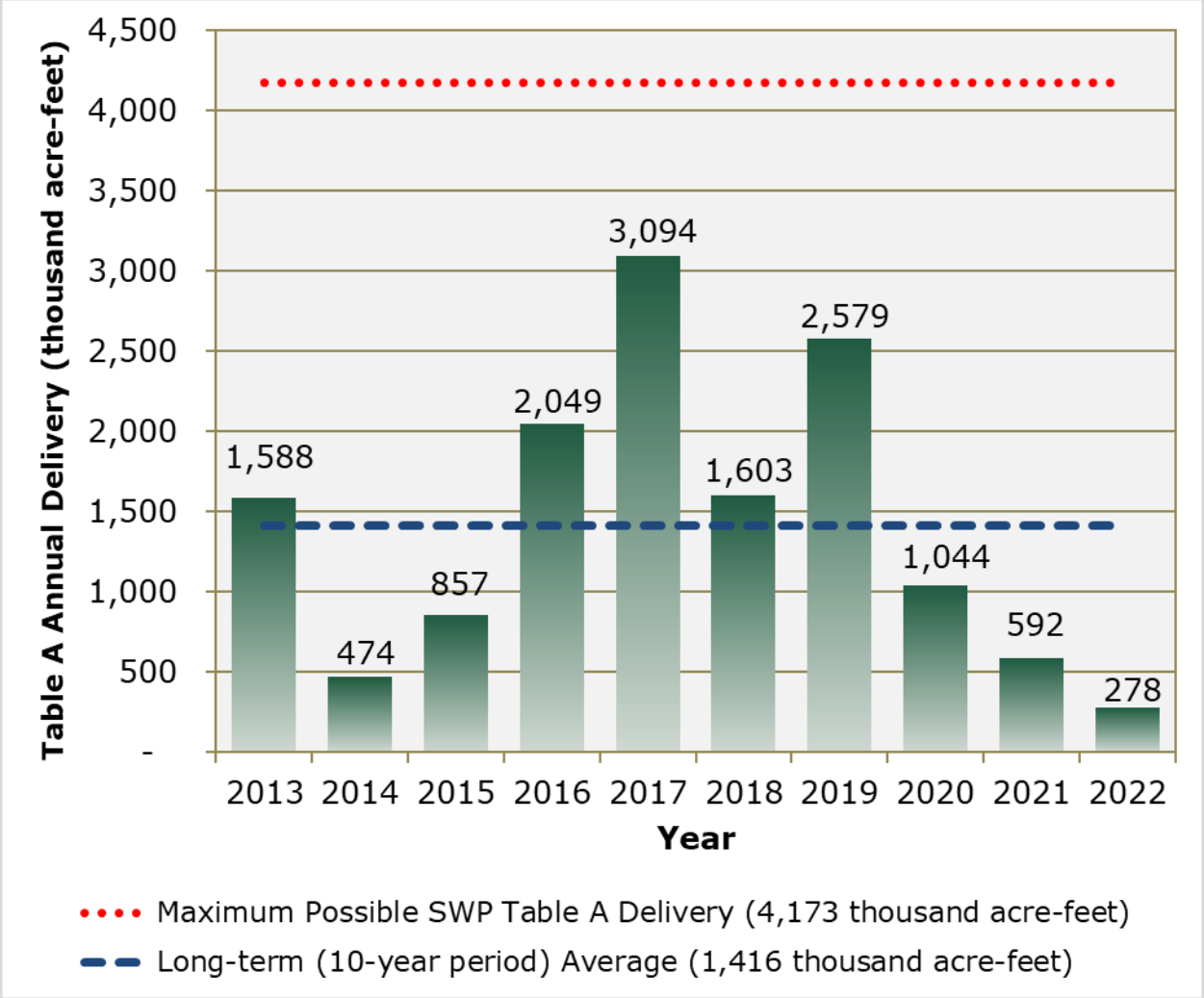
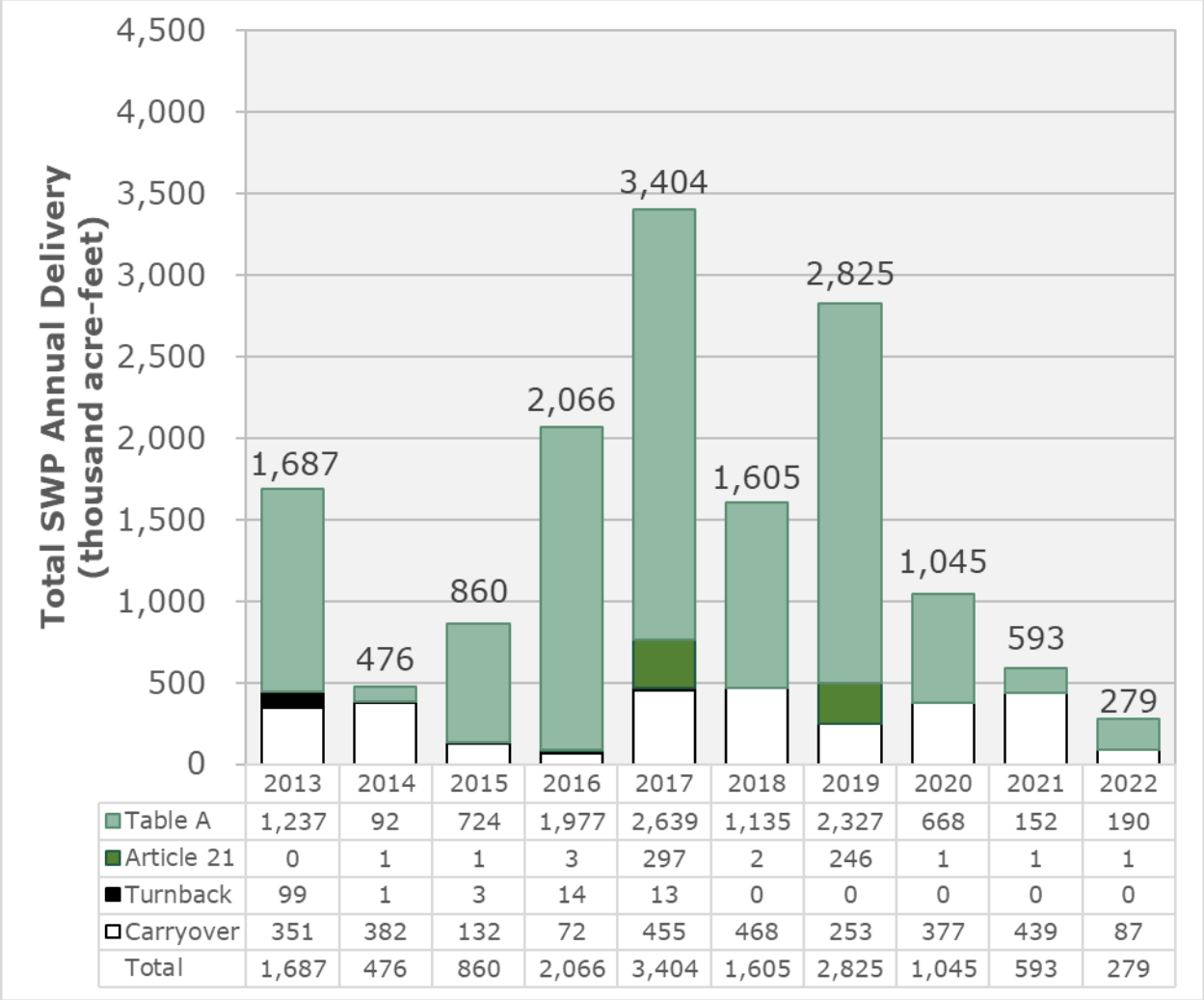


Figure 5-2. Total Historical SWP Deliveries, 2013-2022 (by Delivery Type)



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Table A	1,237	92	724	1,977	2,639	1,135	2,327	668	152	190
Article 21	0	1	1	3	297	2	246	1	1	1
Turnback	99	1	3	14	13	0	0	0	0	0
Carryover	351	382	132	72	455	468	253	377	439	87
Total	1,687	476	860	2,066	3,404	1,605	2,825	1,045	593	279

Section 6. Existing SWP Water Delivery Capability

Modeling Approach

To model existing (Baseline) SWP water delivery capability, CalSim 3 was configured to simulate existing regulations (SWRCB D-1641, 2019 BiOps and its associated ITP (2020)), infrastructure and demands using Adjusted Historical Hydrology.

As described in Section 3, this report uses the Adjusted Historical Hydrology in its Baseline because it is more representative of current conditions. The last baseline for the 2021 report used Historical Hydrology, therefore this report will compare the results from an Adjusted Historical Hydrology to a Historical Hydrology. In previous reports' comparative analysis (Historical vs. Historical), the outcomes of the comparison reveal the impacts mainly due to updated hydrology, and CalSim code refinements. In this report's comparative analysis (Adjusted Historical vs. Historical), the outcomes will reveal the impacts of adjusted hydrology and operational updates. For comparative purposes, the Historical Hydrologic Condition results are presented in Table 6-3 through Table 6-8. For more information on the development process for the Adjusted Historical Hydrology, please refer to the report Evaluation and Adjustment of Historical Hydroclimate Data (California Department of Water Resources, 2023).

Model Period Extension

The simulation period for CalSim 3 for this report is from WY 1922-2021, adding six more years to the period of record used in the 2021 Report.

Hydrologic Sequence

SWP delivery amounts are estimated in this report for existing conditions using computer modeling that incorporates the adjusted historic range of hydrologic conditions (i.e., precipitation and runoff) that occurred from WY 1922 through 2021. This is the period of record used in the CalSim 3 model. As noted in Section 3, the adjusted historic hydrologic conditions were developed by adjusting the standard deviation and monthly distribution of historical streamflow for the first 70 years of the period of record to match the statistics of the last 30 years using a combination of statistical scaling methods. By using this adjusted 100-year historical flow record, the delivery estimates modeled for existing conditions reflect a reasonable range of potential hydrologic conditions from wet years to critically dry years.

Existing Demand for Delta Water

Demand levels for the SWP water users in this report are derived from historical data and information from the SWP contractors themselves. The amount of water that the SWP contractors request each year is related to:

- The magnitude (maximum contracted amount)
- The extent of water conservation measures in place
- Local weather patterns
- Water costs

The existing level of development (i.e., the level of water use in the source areas from which the water supply originates) is based on recent land uses and is assumed to be representative of existing conditions for the purposes of this report.

SWP Table A and Article 56 Water Demands

The current combined maximum Table A amount is 4,173 TAF/year. See Table 5-1 in Section 5, State Water Project Historical Deliveries. Of the combined maximum Table A amount, 4,133 TAF/year is the SWP's maximum Table A water available for delivery from the Delta. The estimated demands by SWP contractors for deliveries of Table A water from the Delta under existing conditions are assumed to be the maximum SWP Table A delivery amount for this report (Table 6-1), which is the same as in the 2021 Report.

Table 6-1. Comparison of Estimated Average, Maximum, and Minimum Demands for SWP Table A Water, Excluding Butte County, Yuba City, and Plumas County FCWCD (Existing Conditions, in TAF/year)

Statistic	2021 Report	2023 Report
Average	4,133	4,133
Maximum	4,133	4,133
Minimum	4,133	4,133

SWP Article 21 Water Demands

Under Article 21 of the SWP's long-term water supply contracts, contractors may receive additional water deliveries only under the following specific conditions:

- Such deliveries do not interfere with SWP Table A allocations and SWP operations.
- Excess water is available in the Delta.
- Capacity is not being used for SWP purposes or scheduled SWP deliveries.
- Contractors can use the SWP Article 21 water directly or can store it in their own system (i.e., the water cannot be stored in the SWP system).

Contractor demand for water is assumed to vary depending on the current month as well as current year hydrologic conditions. Additionally, the capacity to deliver Article 21 water is dependent on available pumping and conveyance capacity within the SWP (e.g. Banks pumping plant, California Aqueduct).

In CalSim3, contractor demands for Article 21 are characterized by an annual total demand specified for each contractor. These annual demands are based on historical data and contractor input. Water is delivered in CalSim3 depending on the availability of water, the capacity to deliver that water, and whether or not a contractors total annual demand has been met or not.

Updates to Article 21 Demand Assumptions

The various assumptions regarding the contractor demands for Article 21 have changed since the 2021 Report. In the 2021 Report, a distinction was made between demands in "Kern wet" and "Kern non-wet" years. This distinction has been removed in this Report.

Previously, Article 21 demands in "Kern wet years" for Kern region contractors (Empire, Tulare, Dudley Ridge, Kern County – Ag, and Santa

Clarita) were assumed to be zero. This assumption was removed for the following reasons:

- Zero Article 21 demand during "Kern wet years" resulted in lower-than-expected Article 21 deliveries. "Kern wet years" coincide with the wettest years in the simulation period.
- Recent historical data shows that Kern region contractors take non-zero deliveries of Article 21 water in "Kern wet years".
- More consultation with Kern region contractors is needed to understand their demands and operations during "Kern wet years".

Estimates of SWP Table A Water Deliveries

Table 6-2 presents the annual average, maximum, and minimum estimates of SWP Table A deliveries from the Delta for existing conditions for the 2021 and 2023 Reports within a SWP contract year (January – December). In this report, SWP Table A deliveries also include Article 56 (carryover) water from last year. Article 56 water delivered in the SWP contract year is some portion of Table A from the previous contract year that the contractors requested to defer for the following year[6].

Average long-term Table A deliveries decreased in this report compared to the 2021 Report by 83 TAF. Note that the simulation periods in both studies are different. This report's simulation period spans WY 1922-2021 while that of the 2021 Report only spans WY 1922-2015.

The average annual SWP Table A delivery in this report during the shorter WY 1922-2015 simulation period is 2,225 TAF/year. When comparing the WY 1922-2015 period between the 2021 and 2023 Reports, the average Table A deliveries decreased by 96 TAF (in contrast to 83 TAF as indicated earlier).

From this point forward (unless otherwise mentioned), the long-term period of record for the 2021 Report spans from WY 1922-2015, and from WY 1922-2021 for this report.

[6] In real-time operations, Article 56 water can be carried over for several years if conditions permit. But the modeling assumes single year carryover.

Table 6-2. Estimated Long-Term Annual Average, Maximum, and Minimum Deliveries of SWP Table A Water, Excluding Butte County, Yuba City, and Plumas County FCWCD (Existing Conditions, in TAF/year)

Statistic	2021 Report (1922-2015)	2023 Report (1922-2021)*
Average	2,321	2,238
Maximum**	4,004	4,060
Minimum***	230	186

* The 2023 Report uses adjusted historical hydrologic conditions as its baseline. See Section 3 for further discussion.
** 2021 Report maximum occurred in 2006. 2023 Report maximum occurred in 1998.
*** 2021 Report minimum occurred in 2014. 2023 Report minimum occurred in 1977.

Figure 6-1 shows the average annual SWP exports and Table A deliveries from the 2005 through 2023 Delivery Capability Reports. Exports and deliveries decreased from 2005 to 2009 due to Delta regulations which constrained exports, culminating in the 2008-2009 BiOps. Average annual exports and deliveries were then relatively stable through 2017, before decreasing again in 2019 and 2021 due to changes described in the respective reports. In this report, annual exports and deliveries decreased due to several factors. These include changes in the hydrology used as the Baseline as discussed in Section 3, and the collective improvements made to the CalSim3 model.

Figure 6-1. Estimated Average Annual Delta Exports and SWP Table A Water Deliveries (Excluding Butte County, Yuba City, and Plumas County FCWCD), for 2005 through 2023 Reports

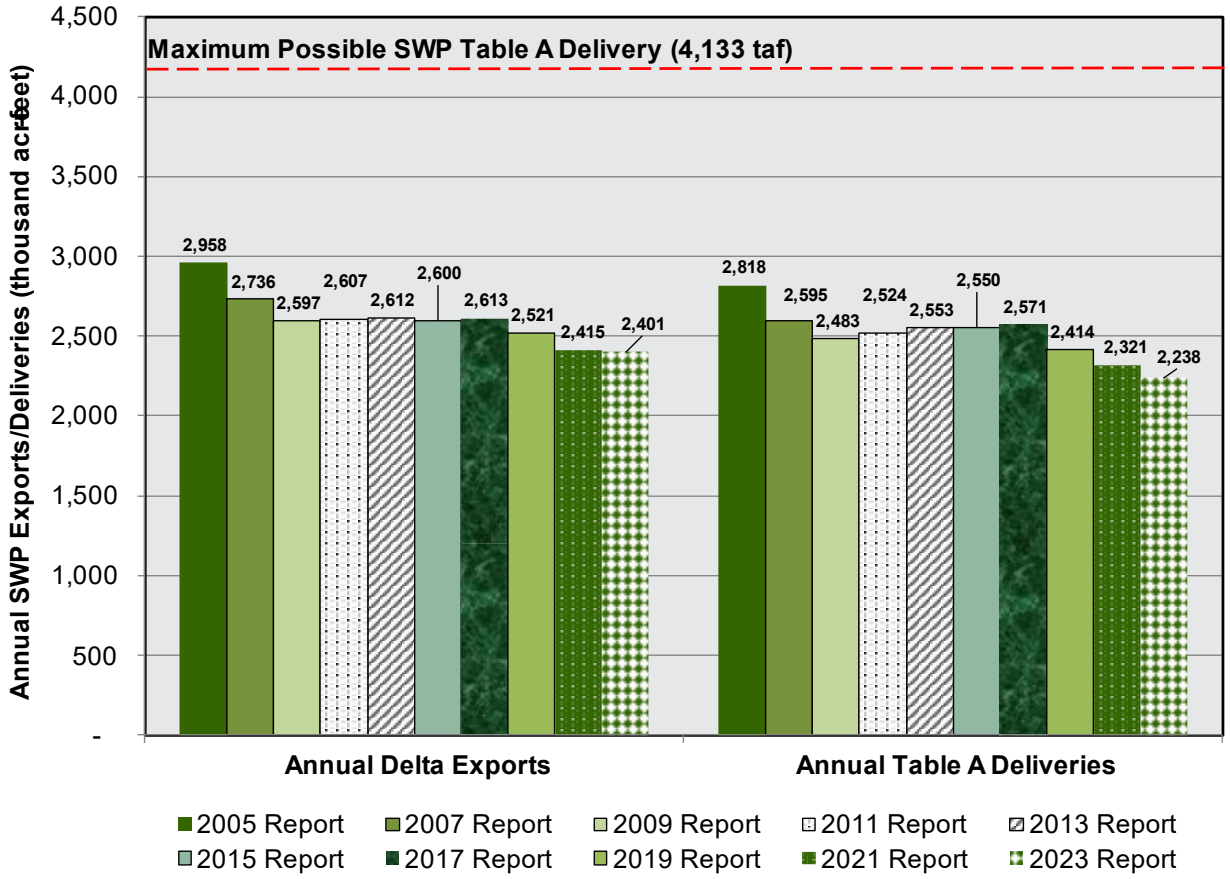
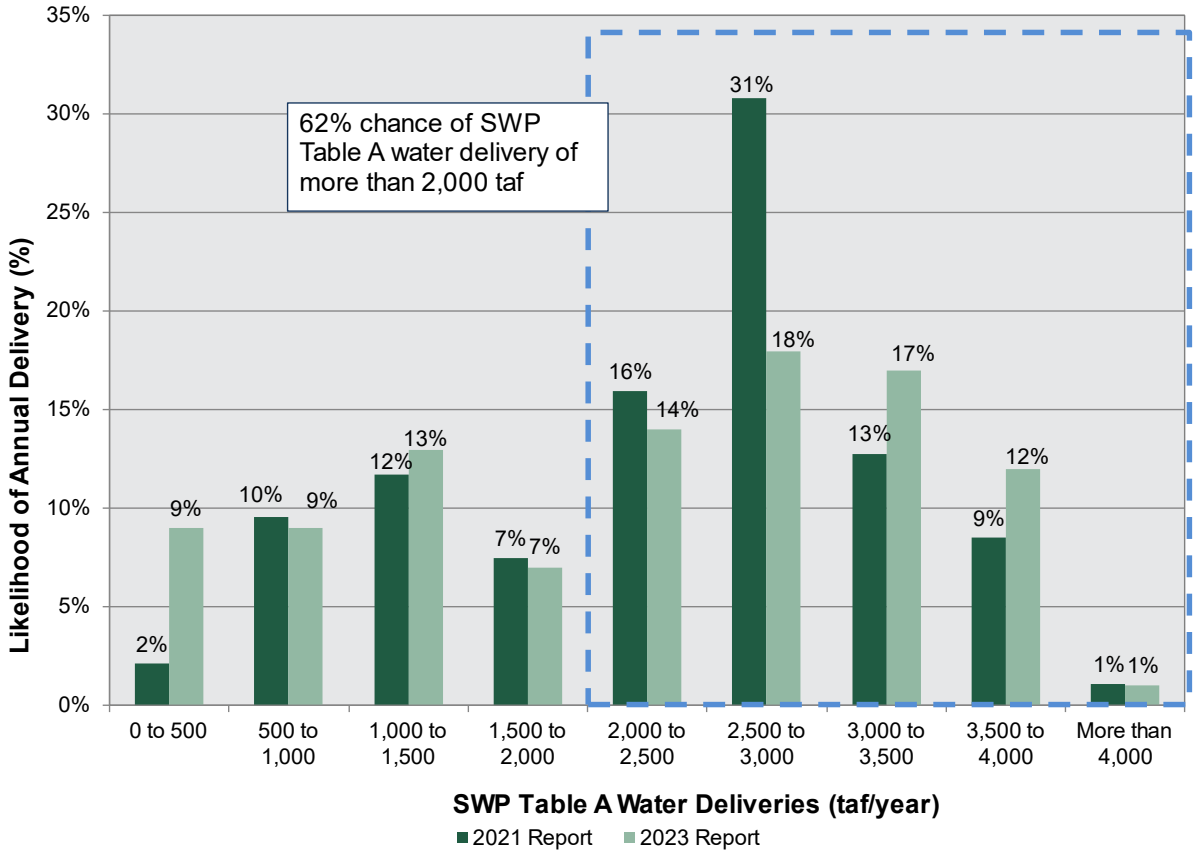


Figure 6-2 presents the estimated likelihood of delivery of a given amount of SWP Table A water under the Baseline scenario, as estimated for both the 2021 and 2023 Reports. This figure shows a 62 percent likelihood (compared to 70 percent in the 2021 Report) that more than 2,000 TAF/year of Table A water will be delivered under the current estimates.

Figure 6-2. Estimated Likelihood of SWP Table A Water Deliveries, by Increments of 500 TAF (Excluding Butte County, Yuba City, and Plumas County FCWCD)



Wet-Year Deliveries of SWP Table A Water

Table 6-3 and Figure 6-3 present estimates of SWP Table A water deliveries under existing conditions during possible wet conditions and compare them with corresponding delivery estimates calculated for the 2021 Report. Wet periods for this report are determined using adjusted historical precipitation and runoff patterns from the 1922-2021 period of record, and existing 2023 conditions (e.g., land use, water infrastructure) are also accounted for in the modeling. For reference, the wettest single year according to the historical Sacramento Valley Index (SVI) during the period of record was 1983. This year had the highest historical index at 15.29 million acre-feet (MAF). Refer to D-1641 Water Year Types section for background on WYTs and SVI.

The results of modeling existing conditions over historical wet years indicate that SWP Table A water deliveries during wet periods can be estimated to

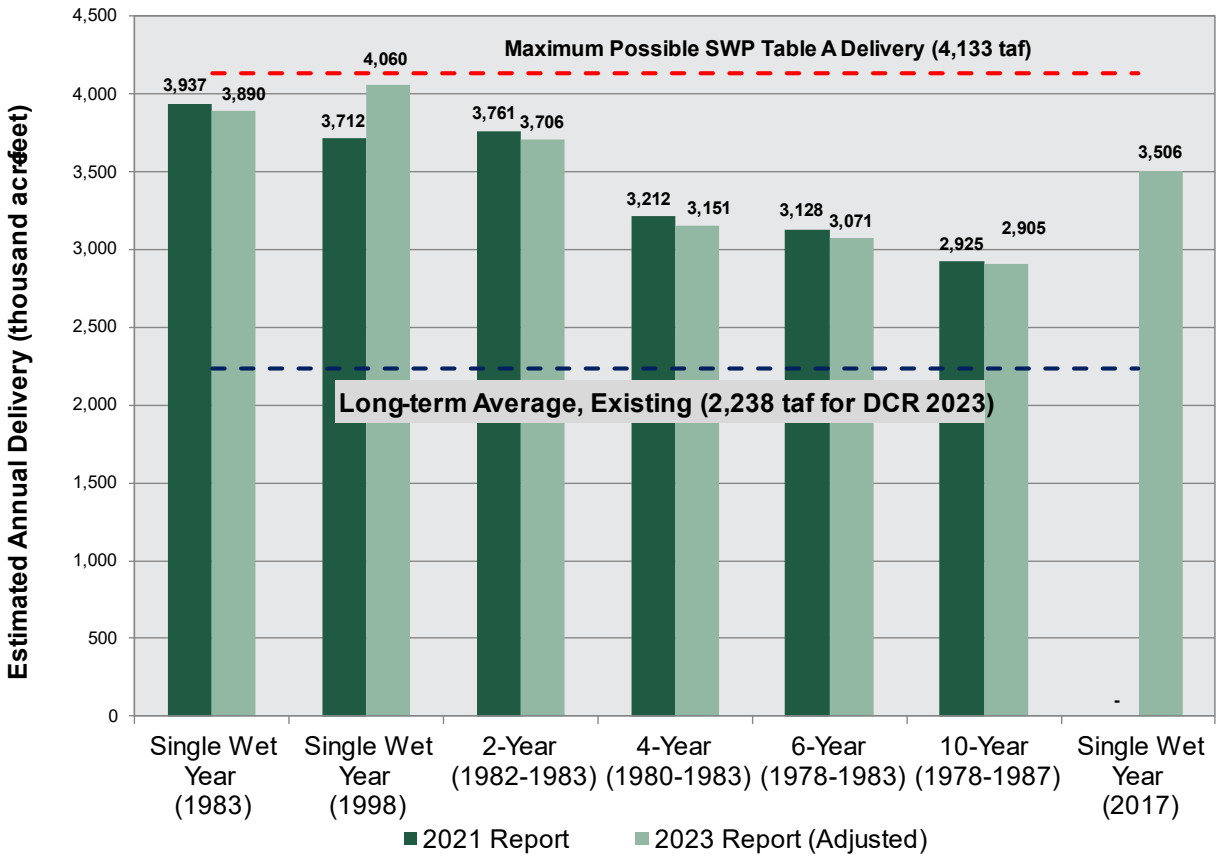
range between yearly averages of 2,905 to 4,060 TAF. Table 6-3 and Figure 6-3 show that the 2023 deliveries of SWP Table A water decreased or in most wet periods in comparison to the 2021 Report, except in 1998. Note that in wet years Table A deliveries may not be 100 percent despite having 100 percent allocation due to Article 56 carryover deliveries.

Table 6-3. Estimated Average and Wet-Period Deliveries of SWP Table A Water (Existing Conditions, in TAF/year) and Percent of Maximum SWP Table A Amount, 4,133 TAF/year.

Period*	Historical		Adjusted
	DCR 2021 (1922 – 2015)	DCR 2023** (1922 – 2021)	DCR 2023 (1922 – 2021)
Long Term Average	2,321 (56%)	2,297 (56%)	2,238 (54%)
Single Year (1983)	3,937 (95%)	3,880 (94%)	3,890 (94%)
Single Year (1998)	3,712 (90%)	4,060 (98%)	4,060 (98%)
2 Year (1982-1983)	3,761 (91%)	3,706 (90%)	3,706 (90%)
4 Year (1980-1983)	3,212 (78%)	3,179 (77%)	3,151 (76%)
6 Year (1978-1983)	3,128 (76%)	3,064 (74%)	3,071 (74%)
10 Year (1978-1987)	2,925 (71%)	2,916 (71%)	2,905 (70%)
Single Year (2017)	-***	3,526 (85%)	3,506 (85%)

* Periods were manually selected to include the wettest, most notable, and most recent years from the simulation.
** Historical Hydrological results are included for comparative purposes.
*** The simulation period for the 2021 report did not include 2017.

Figure 6-3. Estimated Wet-Period SWP Table A Water Deliveries (Excluding Butte County, Yuba City, and Plumas County FCWCD)



Dry-Year Deliveries of SWP Table A Water

Table 6-4 and Figure 6-4 present estimates of SWP Table A water deliveries under existing conditions during possible drought conditions and compare them with corresponding delivery estimates calculated for the 2021 Report. Droughts are analyzed using the adjusted historical drought-period precipitation and runoff patterns from 1922 through 2021, and existing 2023 conditions (e.g., land use, water infrastructure) are also accounted for in the modeling. For reference, the worst multiyear drought on the 1922-2021 record was the 1929-1934 drought, although the brief drought of 1976-1977 was more intensely dry. The driest single year in terms of the historical SVI was 1977, which had the lowest index at 3.11.

The results of modeling existing conditions under historical drought scenarios indicate that SWP Table A water deliveries during dry years can be estimated to range between 186 and 935 TAF. Table 6-4 and Figure 6-4 show that the deliveries of SWP Table A water decreased in most dry periods in comparison to the 2021 Report.

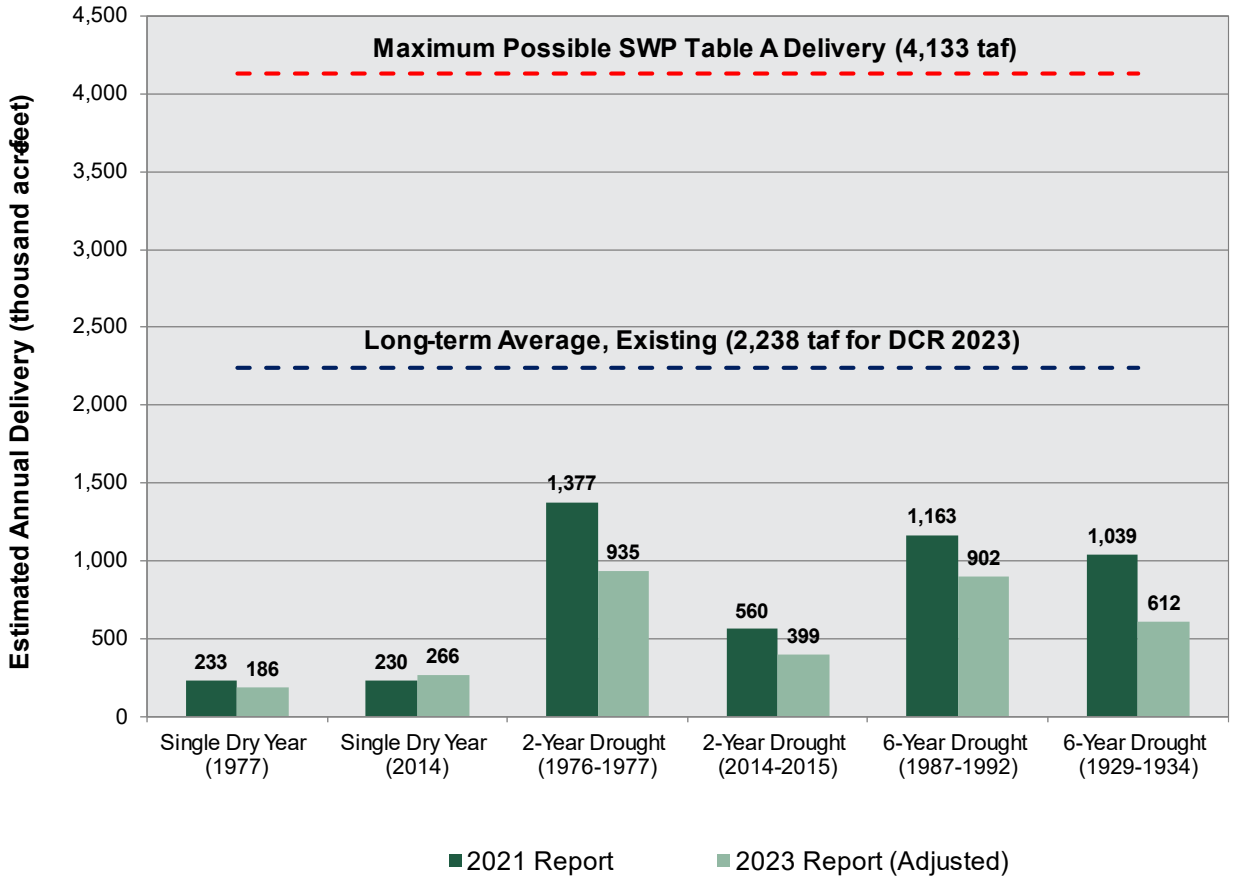
Table 6-4. Estimated Average and Dry-Period Deliveries of SWP Table A Water, Excluding Butte County, Yuba City, and Plumas County FCWCD (Existing Conditions, in TAF/year) and Percent of Maximum SWP Table A Amount, 4,133 TAF/year.

Period*	Historical		Adjusted
	DCR 2021 (1922 – 2015)	DCR 2023** (1922 – 2021)	DCR 2023 (1922 – 2021)
Long Term Average	2,321 (56%)	2,297 (56%)	2,238 (54%)
Single Year (1977)	233 (6%)	263 (6%)	186 (4%)
Single Year (2014)	230 (6%)	319 (8%)	266 (6%)
2 Year (1976-1977)	1,377 (33%)	1,153 (28%)	935 (23%)
2 Year (2014-2015)	708 (17%)	407 (10%)	399 (10%)
6 Year (1987-1992)	1,163 (28%)	905 (22%)	902 (22%)
6 Year (1929-1934)	1,039 (25%)	866 (21%)	612 (15%)

* Periods were manually selected to include the driest, most notable, and most recent years from the simulation.

** Historical Hydrological results are included for comparative purposes.

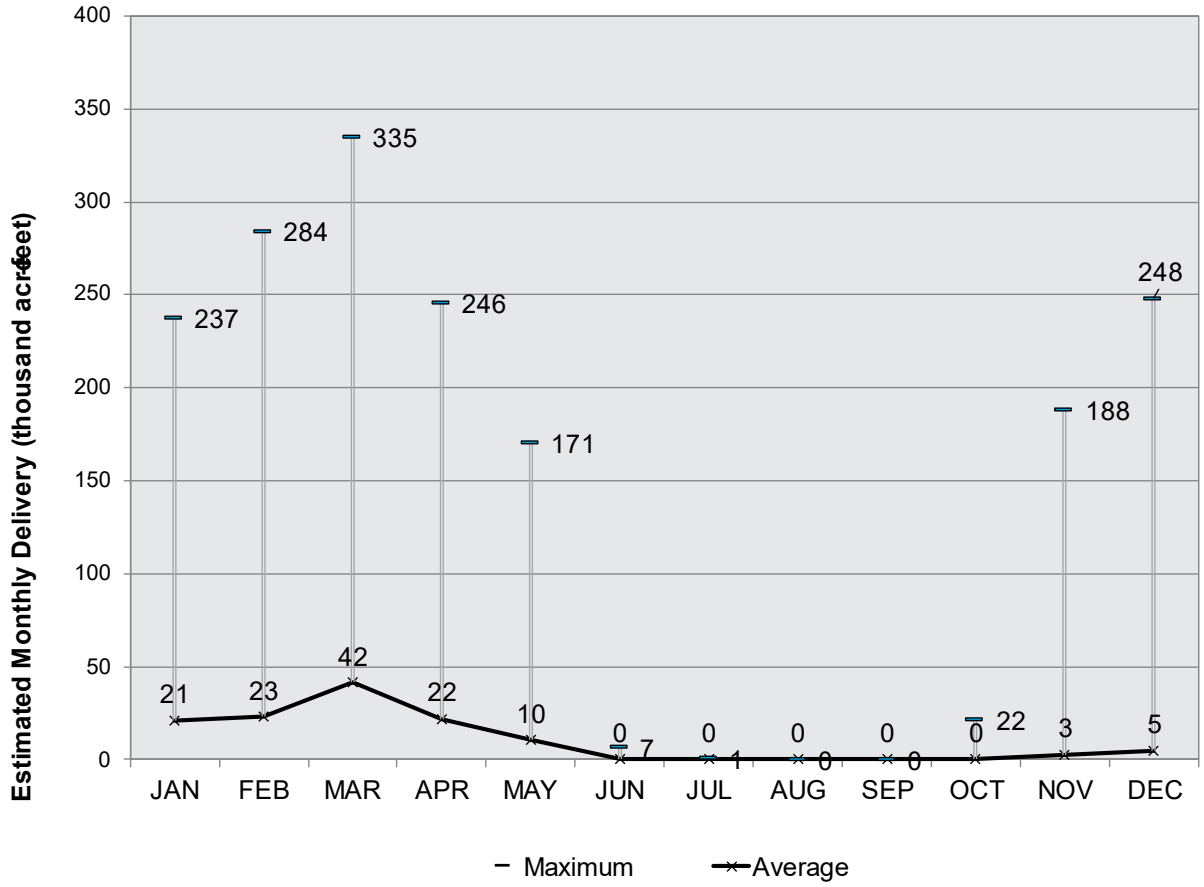
Figure 6-4. Estimated Dry-Period SWP Table A Water Deliveries (Excluding Butte County, Yuba City, and Plumas County FCWCD)



Estimates of SWP Article 21 Water Deliveries

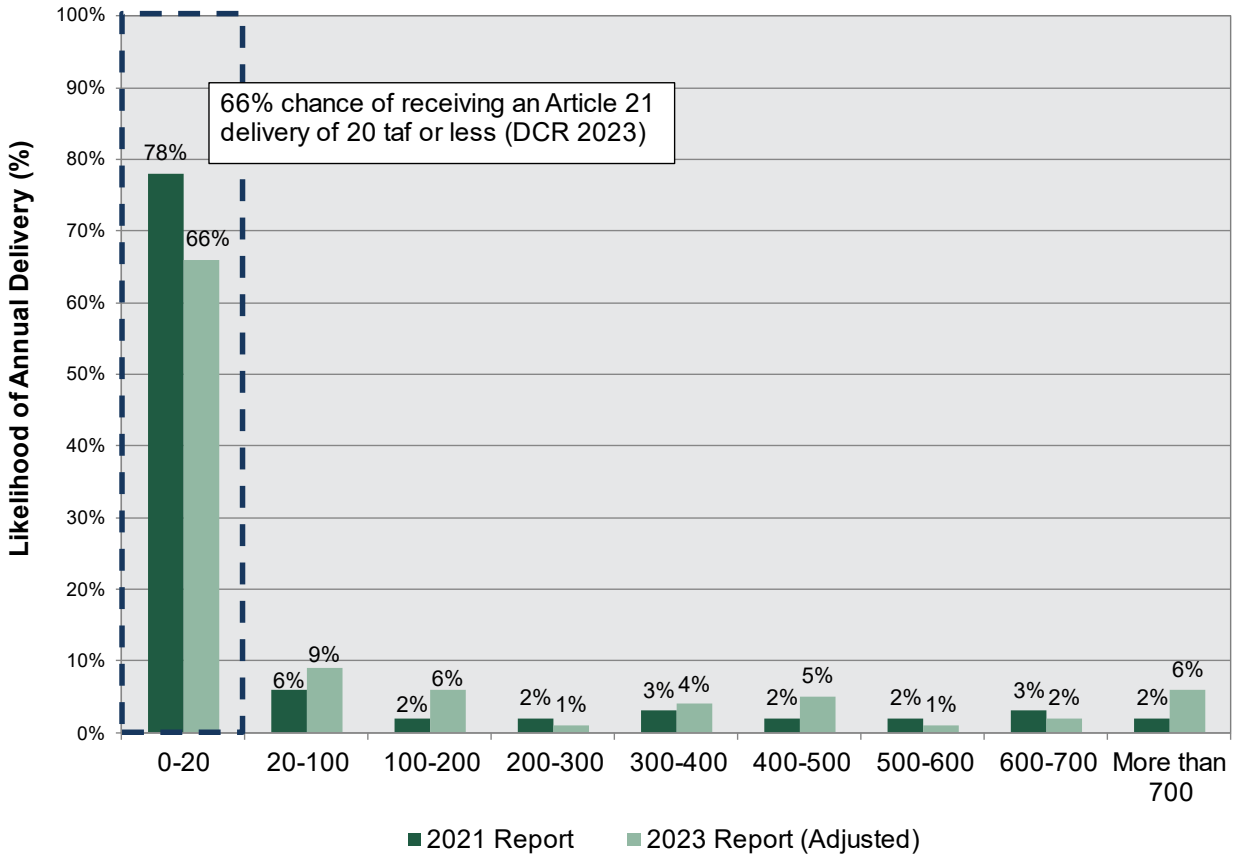
SWP Article 21 water is the third type of SWP delivery considered in the model along with Table A and Article 56. Some SWP contractors store Article 21 water locally when extra water and capacity are available beyond that needed by normal SWP operations. Deliveries of SWP Article 21 water vary not only by year, but also by month. The estimated range of monthly deliveries of SWP Article 21 water is displayed in Figure 6-5 (only the maximum and averages have data labels shown as the minimums are zero). From June through October, essentially no Article 21 water is estimated to be delivered on average. In the winter and spring (November through May), maximum monthly deliveries range from 171 to 335 TAF/month.

Figure 6-5. Estimated Range of Monthly Deliveries of SWP Article 21 Water (Existing Conditions)



The estimated likelihood that a given amount of SWP Article 21 water will be delivered is presented in Figure 6-6. The 66 percent chance of delivering 20 TAF or less is lower than the 77 percent chance in the 2021 Report. The likelihood of receiving greater than 20 TAF/year Article 21 deliveries is 11 percentage points higher (23 percent to 34 percent).

Figure 6-6. Estimated Likelihood of Annual Deliveries of SWP Article 21 Water (Existing Conditions)



Wet-Year Deliveries of SWP Article 21 Water

Table 6-5 shows the estimates of deliveries of SWP Article 21 water during wet periods under existing conditions. Estimated deliveries of SWP Article 21 water in wet periods range between 313 and 1,114 TAF. Wet-period Article 21 deliveries in this report are higher than in the 2021 Report for all periods shown.

Table 6-5. Estimated Average and Wet-Period Deliveries of SWP Article 21 Water (Existing Conditions, in TAF/year)

Period*	Historical		Adjusted
	DCR 2021 (1922 – 2015)	DCR 2023** (1922 – 2021)	DCR 2023 (1922 – 2021)
Long Term Average	89	119	127
Single Year (1983)	593	1,108	1,114
Single Year (1998)	380	415	416
2 Year (1982-1983)	416	731	916
4 Year (1980-1983)	274	510	638
6 Year (1978-1983)	186	343	429
10 Year (1978-1987)	165	259	313
Single Year (2017)	-***	304	317

* Periods were manually selected to include the wettest, most notable, and most recent years from the simulation.
** Historical Hydrological results are included for comparative purposes.
*** The simulation period for the 2021 report did not include 2017.

Dry-Year Deliveries of SWP Article 21 Water

Table 6-6 shows the estimates of deliveries of SWP Article 21 water during dry periods under existing conditions. Estimated deliveries of SWP Article 21 water in dry periods range between 9 and 20 TAF. Although deliveries of SWP Article 21 water are lower during dry years than during wet ones, opportunities exist to deliver SWP Article 21 water during multiyear drought periods. Compared to the 2021 Report, Article 21 deliveries in all dry periods are larger.

Table 6-6. Estimated Average and Dry-Period Deliveries of SWP Article 21 Water (Existing Conditions, in TAF/year)

Period*	Historical		Adjusted
	DCR 2021 (1922 – 2015)	DCR 2023** (1922 – 2021)	DCR 2023 (1922 – 2021)
Long Term Average	89	119	127
Single Year (1977)	3	9	9
Single Year (2014)	5	9	9
2 Year (1976-1977)	3	9	8
2 Year (2014-2015)	4	20	20
6 Year (1987-1992)	5	17	9
6 Year (1929-1934)	6	15	13

* Periods were manually selected to include the driest, most notable, and most recent years from the simulation.

** Historical Hydrological results are included for comparative purposes.

Wet-Year SWP South of Delta Allocation

Table 6-7 shows the estimates of SWP allocations south of the Delta during wet periods under existing conditions. Estimated SWP allocations south of the Delta in wet periods range between 72 and 100 percent. Compared to the 2021 Report, SWP allocations south of the Delta in all wet periods are either the same or within 1 percent of each other.

Table 6-7. Estimated Average Wet-Period SWP South of Delta Allocation (Existing Conditions)

Period*	Historical		Adjusted
	DCR 2021 (1922 – 2015)	DCR 2023** (1922 – 2021)	DCR 2023 (1922 – 2021)
Long Term Average	57%	56%	55%
Single Year (1983)	100%	100%	100%
Single Year (1998)	100%	100%	100%
2 Year (1982-1983)	100%	100%	100%
4 Year (1980-1983)	82%	81%	81%
6 Year (1978-1983)	79%	78%	78%
10 Year (1978-1987)	72%	73%	72%
Single Year (2017)	-***	100%	100%

* Periods were manually selected to include the wettest, most notable, and most recent years from the simulation.
** Historical Hydrological results are included for comparative purposes.
*** The simulation period for the 2021 report did not include 2017.

Dry-Year SWP South of Delta Allocation

Table 6-8 shows the estimates of the percentage of SWP allocations south of the Delta during dry periods under existing conditions. Estimated SWP allocations south of the Delta in dry periods range between 3 and 22 percent. Compared to the 2021 Report, SWP allocations south of the Delta in all dry periods are lower.

Table 6-8. Estimated Average Dry-Period SWP South of Delta Allocation (Existing Conditions)

Period*	Historical		Adjusted
	DCR 2021 (1922 – 2015)	DCR 2023** (1922 – 2021)	DCR 2023 (1922 – 2021)
Long Term Average	57%	56%	55%
Single Year (1977)	3%	4%	3%
Single Year (2014)	5%	7%	5%
2 Year (1976-1977)	30%	20%	15%
2 Year (2014-2015)	18%	10%	9%
6 Year (1987-1992)	26%	22%	22%
6 Year (1929-1934)	24%	20%	15%

* Periods were manually selected to include the driest, most notable, and most recent years from the simulation.

** Historical Hydrological results are included for comparative purposes.

Section 7. SWP Water Delivery Capability Under Future Climate Change Conditions

Interpretation of Delivery Capability Estimates Under Future Climate Change Conditions

Recent Delivery Capability Reports considered a single future climate scenario twenty years into the future. The selected scenario was generally a central tendency or average across several downscaled global model projections. The inclusion of multiple future climate scenarios showing a range of impacts to system performance present an explicit acknowledgement of the uncertainty in estimating potential future delivery capability. While the 50th percentile level of concern scenario described below is generally comparable to central tendency scenarios provided in previous DCRs, the twenty-year forward window continues to proceed. Further, the 75th and 95th percentile level of concern scenarios explore future plausible climate conditions that would result in worse system performance. SWP water users are encouraged to carefully consider the information from all three 2043 potential future climate scenarios and evaluate their vulnerability to a range of climatic changes.

The three-risk informed future climate scenarios provided in the DCR are described in plain language below. These descriptions are intended to further describe the climate and delivery capability conditions that each scenario simulates. For information on the methods used to develop the future climate conditions from these parameters, refer to the Risk-Informed Future Climate Scenario Development for SWP DCR (California Department of Water Resources, 2023). Table 7-1 presents the values for each parameter under each future climate scenario.

Table 7-1. Hydrologic Parameter Changes for each 2043 Climate Change Scenario by Level of Concern

Future System Performance Level of Concern (%)	Change in Temperature (°C)	Change in Average Precipitation (%)	Change in Precipitation Intensification (%)	Sea Level Rise (cm)
50%	1.5	+1.5%	+11%	15
75%	1.7	+0.1%	+12%	30
95%	1.8	-1.8%	+13%	30

Plain Language Description of 50th Percentile Level-of-Concern Scenario

The 50th percentile level-of-concern scenario represents a 2043 middle-of-the-road or central tendency future for the SWP. It includes:

- A temperature increase over current average temperatures of 1.5 degrees Celsius (2.7 degrees Fahrenheit [°F]).
- 1.5 percent wetter average precipitation than current conditions.
- 10.5-percent increase in the 99th percentile daily precipitation event.
- 15 cm of SLR at the Golden Gate Bridge.

Land use is represented by a 2020 level of development, and regulations are represented by current regulations, including the 2019 U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) biological opinions, its associated incidental take permit, and the 2018 addendum to the Coordinated Operations Agreement between the SWP and CVP. Ongoing processes, such as voluntary agreements and the 2021 Reinitiation of Consultation for Long-Term Operations of the CVP and SWP, are not included in the modeling.

Users of this scenario should assume that current climate model simulations indicate that actual 2043 climate conditions would have an approximate equal chance of either being worse than conditions represented in this scenario or as being better than the conditions represented in this scenario — better or worse generally meaning higher or lower SWP water supply deliveries. Put another way, there is an approximate 50-percent chance that planning *only* this scenario would leave an agency under-planned and potentially under prepared for the actual climate conditions to which they would need to operate. Nonetheless, this scenario could also be considered the statistically expected future level of performance of the SWP system. This scenario may be appropriate for use in certain types of planning documents, such as California Environmental Quality Act environmental impact reports which require agencies to consider "reasonably foreseeable indirect physical change in the environment." (Public Resources Code section 21065).

Plain Language Description of 75th Percentile Level-of-Concern Scenario

The 75th percentile level-of-concern scenario represents a 2043 worse than average future for the SWP. It includes:

- A temperature increase above current average temperatures of 1.7 °C (3 °F).
- Average precipitation amount that is very similar to current conditions.
- 12-percent increase in the 99th percentile daily precipitation event.
- 30 cm of SLR at the Golden Gate Bridge.

Land use is represented by a 2020 level of development and regulations are represented by current regulations, including the 2019 USFWS and NMFS biological opinions, its associated incidental take permit and the 2018 addendum to the Coordinated Operations Agreement between the SWP and CVP. Ongoing processes, such as voluntary agreements and the 2021 Reinitiation of Consultation for Long-Term Operations of the CVP and SWP, are not included in the modeling.

Users of this scenario should assume that current climate model simulations indicate that actual 2043 climate conditions would have about a 25-percent chance of being worse than the conditions represented in this scenario. Put another way, there is an approximate 25-percent chance that planning to *only* this scenario would leave an agency under-planned and potentially under prepared for the actual climate conditions to which they need to operate. This scenario may be considered a moderate risk aversion scenario, as it provides significantly more challenging future conditions than the 50th percentile level of concern but does not provide the most extreme planning conditions.

Plain Language Description of 95th Percentile Level-of-Concern Scenario

The 95th percentile level-of-concern scenario represents a 2043 much worse than average future for the SWP. It includes:

- A temperature increase over current average temperatures of 1.8 °C (3.2 °F).
- Average precipitation amount that is 1.8 percent drier than current conditions.
- 12.6-percent increase in the 99th percentile daily precipitation event.
- 30 cm of SLR at the Golden Gate Bridge.

Land use is represented by a 2020 level of development and regulations are represented by current regulations, including the 2019 USFWS and NMFS biological opinions, its associated incidental take permit and the 2018 addendum to the Coordinated Operations Agreement between the SWP and CVP. Ongoing processes, such as voluntary agreements and the 2021 Reinitiation of Consultation for Long-Term Operations of the CVP and SWP, are not included in the modeling.

Users of this scenario should understand that current climate model simulations indicate that actual 2043 climate conditions would have an approximate 5-percent chance of being worse than the conditions represented in this scenario. Put another way, there is only an approximate 5-percent chance that planning for *only* this scenario would leave an agency under-planned and potentially under-prepared for the actual climate conditions to which they need to operate. This scenario may be considered a high-risk aversion scenario, as it provides significantly more challenging future conditions than the 50th and 75th percentile levels-of-concern. This scenario provides the most extreme planning conditions for DCR users provided in this report.

Modeling Approach

As discussed in Section 3, the future climate scenarios analyzed in this DCR report were developed using a risk-informed methodology. "Risk-informed" in this context means future climate scenarios were selected from a large ensemble of potential future conditions, with estimates of the future delivery capability of the SWP for each potential future in the ensemble. Documentation for the methodology used to select and develop future climate scenarios can be found in the Risk-Informed Future Climate Scenario

Development for SWP DCR (California Department of Water Resources, 2023).

Overall Effects of Climate Change

The cumulative effects of climate change on the hydrologic conditions relevant to the Delivery Capability of the SWP can be categorized into three parts:

- Changes to monthly patterns of flows.
- More extreme events.
- Lower reservoir storage levels.

Each of these changes impacts the delivery capability of the SWP in overlapping and related ways, but categorizing the effects can help to understand the complex influences of climate change.

Climate change predicts more precipitation to fall as rain instead of snow. The monthly patterns of flows into reservoirs and into the Delta are expected to be higher in winter months, and lower flows the rest of the year. Increased flows during the winter months are not stored as effectively in reservoirs as inflows that occur later in the water year. This is because storage during the winter months is subject to stricter flood control levels. These levels are set to mediate the risk of reaching critical operational thresholds in each reservoir. Due to these limits, even when there are higher flows in winter months in the future climate scenarios, much of the additional flow cannot be stored.

The ability to export these additional flows is constrained by infrastructure limitations, permitted capacity, and regulatory constraints on existing State Water Project facilities in the Delta. Climate change will lead to increased events in which more water supply through Delta flows is available during times when capturing additional water is already limited, impacting operational flexibility.

In addition to the discussions above regarding changes in the timing and magnitude of reservoir and Delta inflows, rising sea levels influence operations in the Delta. Rising mean sea levels tend to push saltier water into the Delta, which increases the required Delta outflow volumes to meet salinity and X2 requirements. These Delta outflows are supported by

reservoir releases. This increased reliance on reservoir releases, and the limitations on storing increased winter reservoir inflow both tend to cause lower average annual reservoir storage levels.

Recommendations on the Use of the Future Climate Change Scenarios

The choice of which scenario or scenarios to use for planning should be made by the users after careful consideration of several factors. DWR recommends that users of these DCR scenarios evaluate at least two of the scenarios to gauge the sensitivity of their analysis to the choice of scenario. Guidance and other considerations regarding the use of these scenarios is given in Chapter 7 of the "Risk-Informed Future Climate Scenario Development for the State Water Project Delivery Capability Report", (California Department of Water Resources, 2023).

Users should understand that the three potential future climate change scenarios in this report only consider existing regulations, existing infrastructure, and current project operations. Put another way, no adaptation actions, nor future degradation of infrastructure are included. The purpose of these studies is to evaluate the baseline risks and impacts of climate change on the Delivery Capability of the SWP. Additional studies are being conducted to evaluate the impact of different adaptation strategies on SWP delivery capability and will be published in 2024. Climate change adaptation strategies being evaluated in other efforts by DWR and its partners include, but are not limited to:

- Advancement of Forecast-Informed Reservoir Operations (FIRO)
- California Aqueduct subsidence and remediation
- Delta Conveyance Project
- Ground and surface water storage enhancement
- Enhanced SWP asset management

For more information about how DWR is addressing climate change through programs, projects, and activities, view the Climate Action Plan here: https://water.ca.gov/Programs/All-Programs/Climate-Change-Program/Climate-Action-Plan.

Estimates of SWP Table A Water Deliveries Under Climate Change

The three climate change scenarios present an estimate of Table A water deliveries under three various levels of risk. In this report, SWP Table A deliveries also include Article 56 (carryover) water in the year it is delivered. Article 56 water delivered in the SWP contract year is some portion of Table A from the previous contract year that the contractors requested to defer for the following year[7]. From this point forward (unless otherwise mentioned), the long-term period of record for this report is from WY 1922-2021.

The average, minimum, and maximum estimated annual deliveries under each level of risk is presented in Table 7-2. The DCR 2023 baseline scenario is included for reference.

Table 7-2. Estimated Long-Term Annual Average, Maximum, and Minimum Deliveries of SWP Table A Water, Excluding Butte County, Yuba City, and Plumas County FCWCD (2043 Climate Change Conditions with no Adaptation, in TAF/year)

Statistic	DCR 2023 Baseline	2043 50% LOC	2043 75% LOC	2043 95% LOC
Average	2,238	1,990	1,852	1,770
Maximum*	4,060	3,959	3,911	3,910
Minimum**	186	102	22	98

* All maximums occurred in 1998.
** All minimums occurred in 1977.

With respect to Table A water deliveries, the three climate change scenarios are typically more similar to each other than they are to the baseline condition. This similarity, even across the various levels of concern, signals that the SWP will lose delivery capability over the next 20 years if no adaptation measures are made.

Wet-Year Deliveries of SWP Table A Water

The results of modeling future climate conditions over wet years indicate that SWP Table A water during wet periods can be estimated to range between yearly averages of 2,427 to 3,959 TAF under potential future climate conditions. Table 7-3 and Figure 7-1 present estimates of SWP Table

[7] In real-time operations, Article 56 water can be carried over for several years if conditions permit. But the modeling assumes single year carryover.

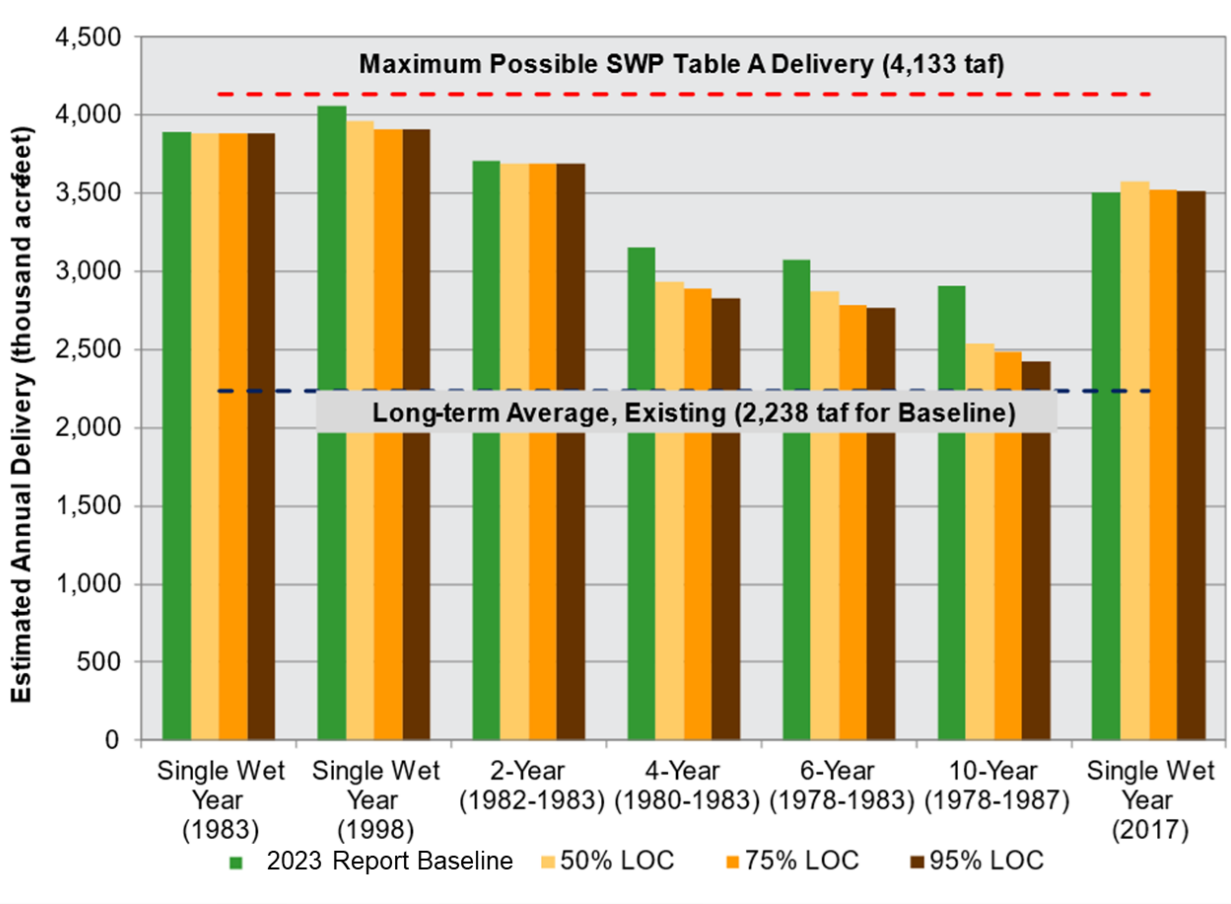
A water deliveries under baseline, and climate change conditions during possible wet conditions. The same wet periods are used as in the existing conditions analysis for comparative purposes.

Table 7-3. Estimated Average and Wet-Period Deliveries of SWP Table A Water (2043 Climate Change Conditions without Adaptation, in TAF/year) and Percent of Maximum SWP Table A Amount, 4,133 TAF/year.

Period*	Baseline**		2043 Future Climate Change Scenarios		
	DCR 2021 (1922 – 2015)	DCR 2023 (1922 – 2021)	50% LOC (1922 – 2021)	75% LOC (1922 – 2021)	95% LOC (1922 – 2021)
Long Term Average	2,321 (56%)	2,238 (54%)	1,990 (48%)	1,852 (45%)	1,770 (43%)
Single Year (1983)	3,937 (95%)	3,890 (94%)	3,880 (94%)	3,880 (94%)	3,880 (94%)
Single Year (2006)	3,712 (90%)	4,060 (98%)	3,959 (96%)	3,911 (95%)	3,910 (95%)
2 Year (1982-1983)	3,761 (91%)	3,706 (90%)	3,691 (89%)	3,691 (89%)	3,691 (89%)
4 Year (1980-1983)	3,212 (78%)	3,151 (76%)	2,936 (71%)	2,892 (70%)	2,830 (68%)
6 Year (1978-1983)	3,128 (76%)	3,071 (74%)	2,873 (70%)	2,780 (67%)	2,770 (67%)
10 Year (1978-1987)	2,925 (71%)	2,905 (70%)	2,539 (61%)	2,487 (60%)	2,427 (59%)
Single Year (2017)	-***	3,506 (85%)	3,573 (86%)	3,520 (85%)	3,509 (85%)

* Periods were manually selected to include the wettest, most notable, and most recent years from the simulation.
** The 2023 Report uses adjusted historical hydrologic conditions as its baseline. See Section 3 for further discussion.
*** The simulation period for the 2021 report did not include 2017.

Figure 7-1. Estimated Wet Period Deliveries of SWP Table A Water (2043 Climate Change Conditions without Adaptation, in TAF/year)



Dry-Year Deliveries of SWP Table A Water

The results of modeling future climate conditions over dry years indicate that SWP Table A water delivers during dry periods can be estimated to range between yearly averages of 22 to 1,990 TAF under potential future climate conditions.

Table 7-4 and Figure 7-2 present estimates of SWP Table A water deliveries under baseline, and climate change conditions during possible dry conditions. The same dry periods are used as in the existing conditions analysis for comparative purposes.

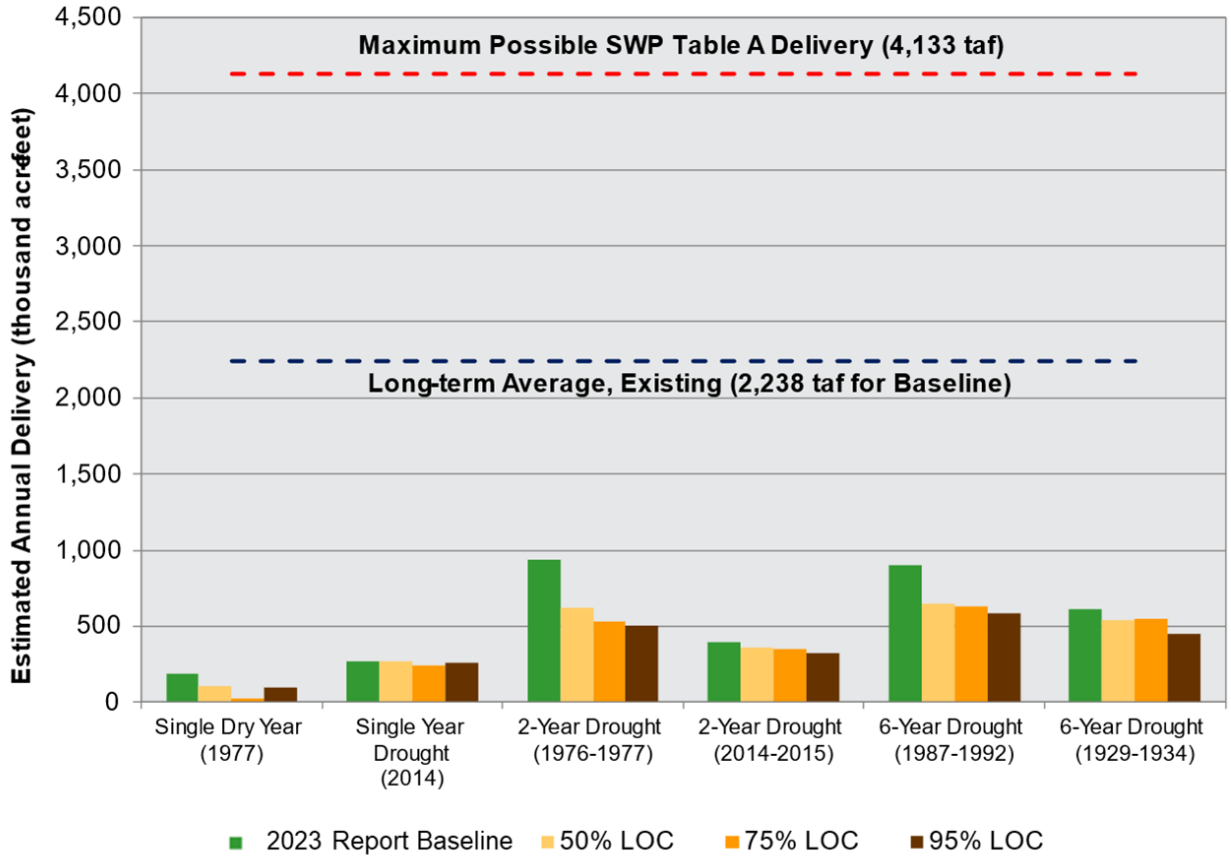
Table 7-4. Estimated Average and Dry-Period Deliveries of SWP Table A Water (2043 Climate Change Conditions without Adaptation, in TAF/year) and Percent of Maximum SWP Table A Amount, 4,133 TAF/year.

Period*	Baseline**		2043 Future Climate Change Scenarios		
	DCR 2021 (1922 – 2015)	DCR 2023 (1922 – 2021)	50% LOC (1922 – 2021)	75% LOC (1922 – 2021)	95% LOC (1922 – 2021)
Long Term Average	2,321 (56%)	2,238 (54%)	1,990 (48%)	1,852 (45%)	1,770 (43%)
Single Year (1977)	233 (6%)	186 (4%)	102 (2%)	22 (1%)	98 (2%)
Single Year (2014)	230 (6%)	266 (6%)	268 (6%)	243 (6%)	259 (6%)
2 Year (1976-1977)	1,377 (33%)	935 (23%)	623 (15%)	532 (13%)	503 (12%)
2 Year (2014-2015)	708 (17%)	399 (10%)	357 (9%)	348 (8%)	322 (8%)
6 Year (1987-1992)	1,163 (28%)	902 (22%)	644 (16%)	629 (15%)	588 (14%)
6 Year (1929-1934)	1,039 (25%)	612 (15%)	543 (13%)	549 (13%)	451 (11%)

* Periods were manually selected to include the driest, most notable, and most recent years from the simulation.

** The 2023 Report uses adjusted historical hydrologic conditions as its baseline. See Section 3 for further discussion.

Figure 7-2. Estimated Dry Period Deliveries of SWP Table A Water (2043 Climate Change Conditions without Adaptation, in TAF/year)



Estimates of SWP Article 21 Water Deliveries Under Climate Change

The availability of Article 21 water deliveries is dependent on the availability of excess water during wet events. As such, the shift in monthly inflow patterns and an increase in the likelihood of large rainfall events increase the availability of Article 21 water in wet periods in future climate change scenarios compared to the baseline. Conversely, there is not a large difference between scenarios in dry years when Article 21 water is not available in either the baseline or the future climate scenarios.

Wet-Year Deliveries of SWP Article 21 Water

In wet periods, the Article 21 deliveries in the climate change scenarios tend to be similar to, or slightly lower than the Baseline conditions deliveries. However, in some years the differences between climate change scenarios and the Baseline can be significant. For example, in 1998 and 2017 the differences are large. In 1998 the climate change scenarios predict lower

Article 21 deliveries, while in 2017 the climate change scenarios predict higher Article 21 deliveries.

Table 7-5. Estimated Average and Wet-Period Deliveries of SWP Article 21 Water (2043 Climate Change Conditions without Adaptation, in TAF/year).

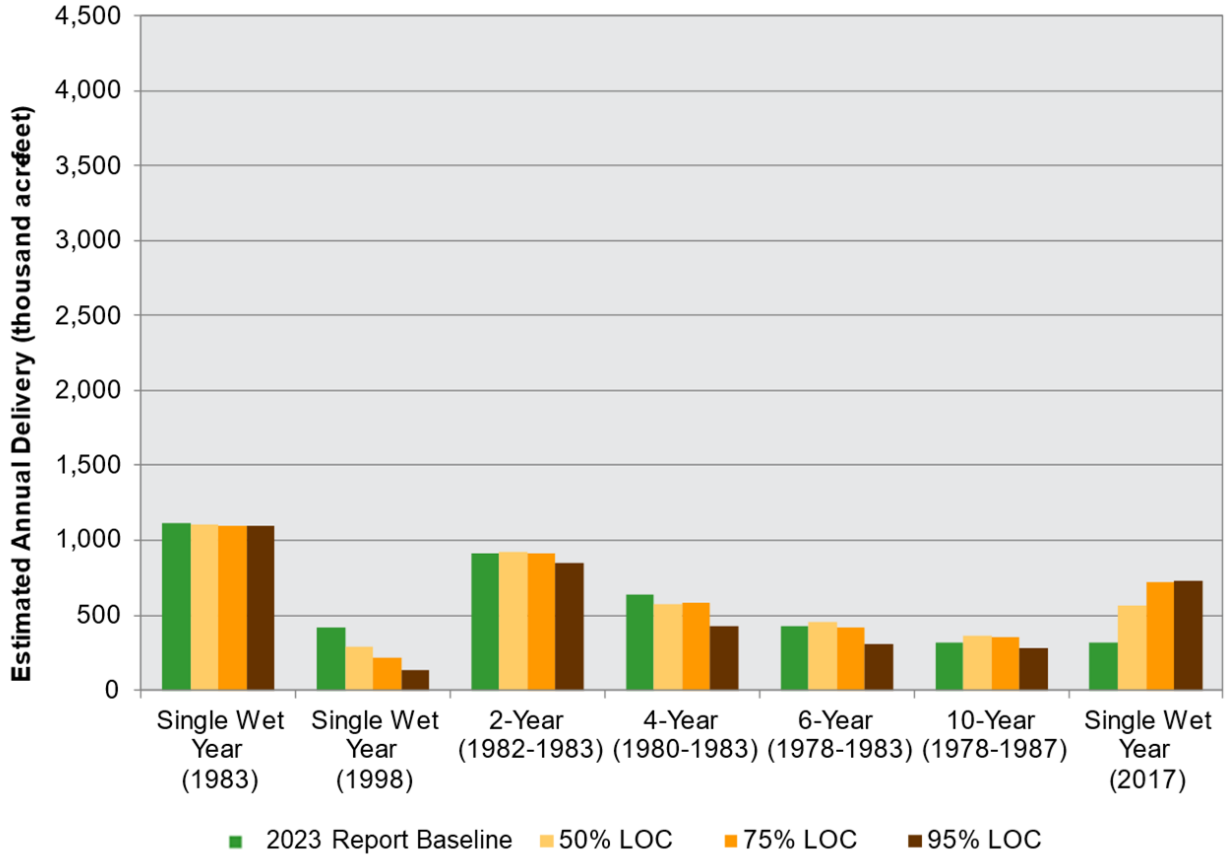
Period*	Baseline**		2043 Future Climate Change Scenarios		
	DCR 2021 (1922 – 2015)	DCR 2023 (1922 – 2021)	50% LOC (1922 – 2021)	75% LOC (1922 – 2021)	95% LOC (1922 – 2021)
Long Term Average	89	127	114	114	91
Single Year (1983)	593	1,114	1,108	1,100	1,100
Single Year (1998)	520	416	293	220	137
2 Year (1982-1983)	416	916	925	909	852
4 Year (1980-1983)	274	638	572	585	430
6 Year (1978-1983)	186	429	452	416	306
10 Year (1978-1987)	165	313	362	350	278
Single Year (2017)	-***	317	567	721	725

* Periods were manually selected to include the wettest, most notable, and most recent years from the simulation.

** The 2023 Report uses adjusted historical hydrologic conditions as its baseline. See Section 3 for further discussion.

*** The simulation period for the 2021 report did not include 2017.1998 and 2017, the

Figure 7-3. Estimated Wet Period Deliveries of SWP Article 21 Water (2043 Climate Change Conditions without Adaptation, in TAF/year).



Dry-Year Deliveries of SWP Article 21 Water

In dry periods, the Article 21 deliveries in the climate change scenarios tends to be similar to the baseline scenario. Since Article 21 water tends to not be available during these periods, and demand is the same across all studies, deliveries of Article 21 water do not tend to differ.

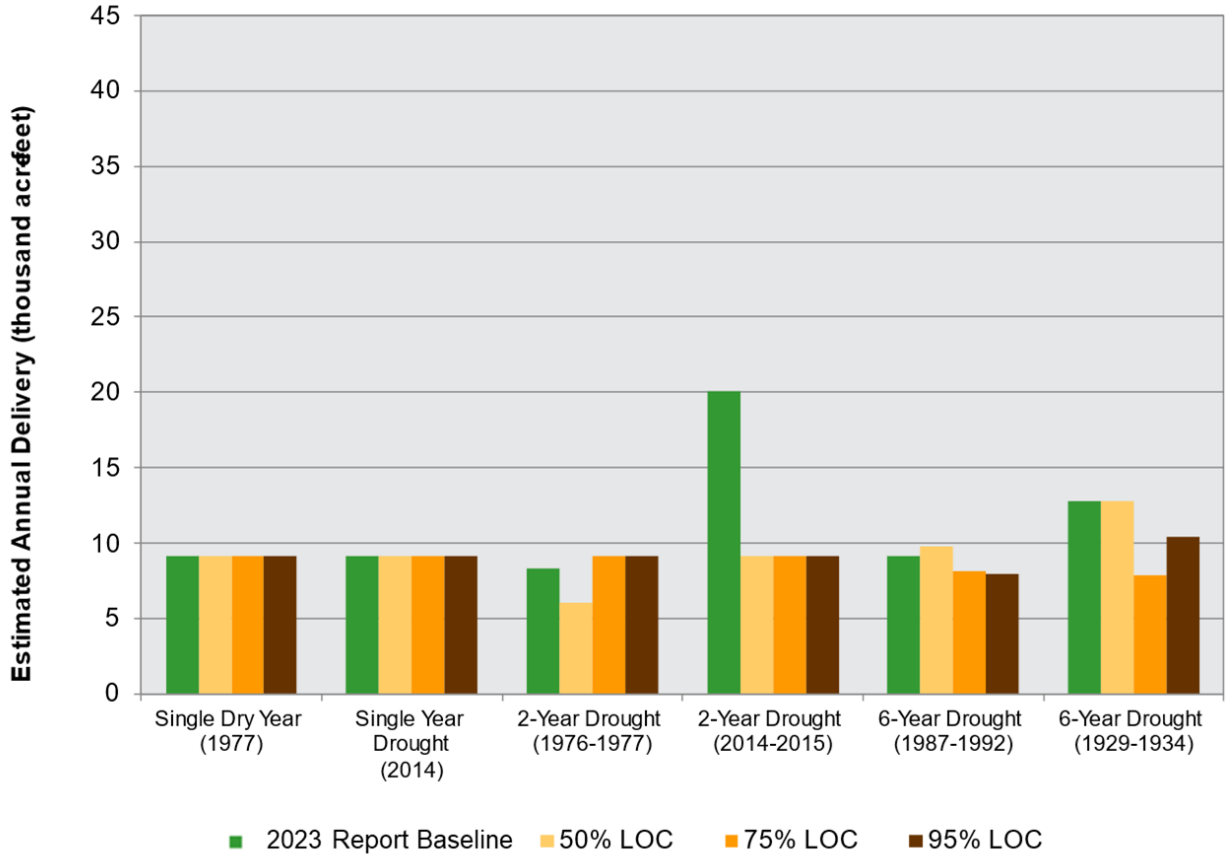
Table 7-6. Estimated Average and Dry-Period Deliveries of SWP Article 21 Water (2043 Climate Change Conditions without Adaptation, in TAF/year).

Period*	Baseline**		2043 Future Climate Change Scenarios		
	DCR 2021 (1922 – 2015)	DCR 2023 (1922 – 2021)	50% LOC (1922 – 2021)	75% LOC (1922 – 2021)	95% LOC (1922 – 2021)
Long Term Average	89	127	114	114	91
Single Year (1977)	3	9	9	9	9
Single Year (2014)	5	9	9	9	9
2 Year (1976-1977)	3	8	6	9	9
2 Year (2014-2015)	4	20	9	9	9
6 Year (1987-1992)	5	9	10	8	8
6 Year (1929-1934)	6	13	13	8	10

* Periods were manually selected to include the driest, most notable, and most recent years from the simulation.

** The 2023 Report uses adjusted historical hydrologic conditions as its baseline. See Section 3 for further discussion.

Figure 7-4. Estimated Dry Period Deliveries of SWP Article 21 Water (2043 Climate Change Conditions without Adaptation, in TAF/year).



* Note that the maximum value of the y-axis on this figure differs from Figure 7-2, and Figure 7-3, and Figure 7-3 by a factor of 100.