Appendix F
Climate Change

APPENDIX F
Climate Change

F.1 Introduction

This appendix presents the results of simulated changes to surface water resources associated with projected climate change and the El Dorado Water Reliability Project (Proposed Project), which involves the exercise of 40,000 acre-feet (af) of surface water rights on the upper American River. Modeling scenarios were developed as part of a sensitivity analysis to evaluate a range of assumptions about future water demand and how climate change might affect surface water hydrology. These scenarios consider future (2040) climate change conditions and integrate assumptions for both demand and hydrology in the lower American River and the Central Valley Project/State Water Project (CVP/SWP) service areas. This set of simulations is referred to in this appendix as the “Climate Change Conditions.”

Development and analysis of these modeling scenarios is beyond what is required by the California Environmental Quality Act (CEQA), but the results from this additional modeling are presented herein for informational purposes. Thus, the results presented in this appendix are not used as the basis for the CEQA impact analysis. Further, the presentation of results is limited to changes in surface water hydrology parameters only.

F.2 Climate Change Effects in the Study Area

A variety of climate change effects are expected to influence the region, including alterations in temperature, precipitation, hydrology, and sea level rise. This section summarizes key findings from the American River Basin Study (Reclamation 2022).

F.2.1 Projected Temperature and Precipitation Changes

Projections indicate that surface air temperatures in the upper American River watershed are expected to increase steadily, with summer temperatures rising by approximately 7.2 degrees Fahrenheit (°F) by the end of the century. Winter temperatures are projected to increase by 4.9°F. These increases in temperature will have effects on snowpack levels, which traditionally serve as a natural reservoir (Reclamation 2022).

Although annual precipitation trends remain uncertain, seasonal variability is projected to increase. Winter months will likely see more rain and less snow, while spring and fall precipitation may decline. These changes complicate water management strategies, as increased winter runoff may increase flood risks, while earlier and reduced spring runoff will limit water availability during critical summer months (Reclamation 2022).

F.2.2 Effects on Snowpack and Runoff Timing

The primary effect of rising temperatures will be the reduction in snowpack, which traditionally stores water until it is released as runoff during the spring and early summer. By mid-century, peak runoff in the upper American River is expected to shift from May–June to February–March. This shift will strain water management practices, requiring adjustments in reservoir operations to capture winter runoff for use in drier months (Reclamation 2022). The relatively small storage capacity of Folsom Reservoir, which regulates much of the upper American River's flow, will exacerbate these challenges, particularly as increased winter flows raise flood risks (Reclamation 2022).

F.2.3 Water Supply and Demand Imbalances

The American River Basin Study (Reclamation 2022) forecasts that by 2070, the upper American River region is expected to face substantial water supply/demand imbalances as a result of climate change, with projected shortfalls varying across different climate scenarios. These imbalances are driven by increasing water demand from population growth and agricultural development, compounded by diminishing surface water supplies as snowpack declines and runoff shifts earlier in the year.

The upper American River region, which lacks substantial groundwater reserves, is particularly vulnerable to these changes. Under a Central Tendency scenario, the region could experience a deficit of approximately 103,000 acre-feet per year (afy), while in more extreme conditions, such as the Hot-Dry scenario, the imbalance could reach up to 117,000 afy. Even under a Warm-Wet scenario, the upper American River region is projected to face a 76,000 afy shortfall, with only about 50 percent of water demands being met (Reclamation 2022).

These imbalances are also consistent with the estimates developed by the 2019 Water Resources Development and Management Plan for the western foothill region of El Dorado County (West Slope) (EDWA 2020).

F.2.4 Sea Level Rise Considerations

Although the Proposed Project focuses on the upper American River, it is important to consider the broader hydrological systems that connect the region to the Sacramento–San Joaquin Delta (Delta). Rising sea levels are expected to exacerbate challenges associated with salinity intrusion, hydrodynamic changes, and flood management in the Delta. This could influence water management strategies, as increased demand for freshwater flows from upstream sources may be necessary to mitigate the effects of rising sea levels on water quality (Reclamation 2022).

Sea levels along the California coast are projected to rise by as much as 3.11 meters by 2100 under extreme scenarios. This change will push salt water farther inland, affecting the Delta's freshwater supply and potentially increasing the demand for fresh water from the American River. As a result, water management in the American River, including Folsom Reservoir operations, could be affected by the need to balance the freshwater flows required to prevent salinity intrusion with local water needs (Reclamation 2022).

F.3 Approach to Analysis

The hydrological effects of climate change—diminished snowpack, earlier snowmelt, and reduced late-season runoff—are the most relevant effects of climate change in the context of the Proposed Project. These changes will influence water availability, timing, and the operational management of water resources within the upper American River. Moreover, because snowpack acts as a natural reservoir, its reduction will lower water storage capacities and necessitate more complex management of reservoirs in the American River watershed.

Although sea level rise is less directly related to the Upper American River Project (UARP), it could have downstream implications, particularly for the Delta. Rising sea levels are expected to exacerbate salinity intrusion and alter hydrodynamic patterns in the Delta, potentially increasing the demand for fresh water from upstream sources such as the American River and Folsom Reservoir. It will be important to understand the effects of this added demand for surface water along with the Proposed Project.

The analysis of hydrological changes and sea level rise in this assessment follows approaches and methodologies similar to those outlined in the Delta Conveyance Project Draft Environmental Impact Report (EIR). Appendix 5A of the Delta Conveyance Project Draft EIR provides detailed modeling of hydrology and systems operations, offering insights into how climate change could affect water systems throughout the region. This dataset, along with its updated CalSim 3 model, represented the best data available at the time the technical analysis was conducted (Appendix G, *Modeling Technical Appendix*).

This appendix presents two primary modeling scenarios:

- **Climate Change Conditions Baseline:** Simulates future conditions with projected future water demand (future demand in the upper American River, and 2040 demand in the lower American River and CVP/SWP service areas) and hydrology influenced by climate change. This baseline helps evaluate the long-term effects of shifts in precipitation patterns, increased temperatures, and altered water availability, providing context for climate resilience planning.
- **Climate Change Conditions with Project:** Reflects anticipated conditions with the Proposed Project under climate change conditions. This scenario helps to assess how securing additional water rights may support regional water needs in the face of shifting hydrologic conditions driven by climate change.

The Climate Change Conditions Baseline is compared to the existing-conditions baseline to assess changes in water resources conditions attributable to climate change. Subsequently, the Climate Change Conditions with Project scenario is analyzed relative to the Climate Change Conditions Baseline, isolating the incremental effects attributable to the Proposed Project.

The analytical tools used in this appendix are the same as introduced in Section 4.1, *Approach to the Analysis,* and detailed in Appendix G, *Modeling Technical Appendix*. Specifically, two modeling tools were used to evaluate potential changes to surface water resources, primarily with regard to instream flows and to reservoir storage volumes, while a third model, HEC-5Q, was used to assess temperature changes on the lower American River. The American River Integrated Operations Model (ARIOps) was used to assess Proposed Project effects on surface water resources within the Project Area and the CalSim 3 model was used to assess effects on surface water resources in the Study Area. Modeling and assessment of model results followed the same approach as described in Section 4.2, *Summary of Surface Hydrology Results*. This approach is summarized below. More detailed information and complete model simulation results are provided in Appendix G, *Modeling Technical Appendix.*

Potential changes to surface water resources for each set of model scenarios were evaluated by comparing surface water conditions occurring under a baseline model scenario to those occurring under a With-Project model scenario. For example, for the Climate Change Conditions the comparison was between a Climate Change Conditions baseline scenario and a Climate Change Conditions With-Project scenario. All comparisons are quantified as the difference between the With-Project scenario results minus the baseline scenario results. Negative values shown for the With-Project scenario represent a decrease in modeled parameters (e.g., flow, storage) compared to the baseline. Both the magnitude of these differences and the percentage these differences represent relative to the baseline are presented. For each set of comparisons, results are generally presented as long-term annual or long-term monthly averages over the entire simulation period of 1922–2015. Results are also presented as long-term averages by water year type.

The water year types for the ARIOps modeling of the upper American River are based on Sacramento Municipal Utility District's (SMUD's) UARP water year type classification, which are defined in SMUD's UARP Federal Energy Regulatory Commission (FERC) license and are based on historical or simulated water year total unimpaired inflow to Folsom Reservoir. For CalSim 3 and HEC5Q, the water year type is dynamically calculated based on simulated runoff and forecasts of future inflows using the Sacramento Valley 40-30-30 hydrologic classification as defined in State Water Resources Control Board (State Water Board) Water Right Decision 1641 (D-1641) (State Water Board 2000). A summary of relevant model locations and parameters for assessing potential changes to surface water resources are listed in Table 4.2-2, Table 4.2-3, and Table 4.2-4.

F.4 Comparison of the Existing-Conditions Baseline to the Climate Change Conditions Baseline

The climate change hydrology input into the models results in baseline condition model outputs that differ from the existing-conditions baseline (see Chapter 4, *Effects of Proposed Water Diversions*, for a discussion of this scenario). These changes propagate into the Climate Change Conditions With-Project scenario, meaning results from this simulation can, at times, differ substantially from results from the existing-conditions baseline scenario. To characterize the effect solely due to different input hydrology, comparison was made between the existing-conditions baseline and Climate Change conditions baseline model scenarios. Results of this comparison for ARIOps, CalSim 3, and HEC5Q simulations are provided below. For consistency, the presentation and comparison approach mimics results presented in Section 4.2, *Summary of Surface Hydrology Results*. See Appendix G, *Modeling Technical Appendix*, for more complete modeling details and results.

F.4.1 Upper American River Basin Water Operations (ARIOps)

Changes in simulated, long-term average monthly flows, end-of-month reservoir storage, end-of-month reservoir elevations, and average monthly hydropower generation for relevant locations in the upper American River Basin are summarized in **Table F-1**. The table depicts both long-term average magnitudes from simulation scenarios and summary statistics (minimum, maximum, and arithmetic mean) of percent and magnitude changes between the existing-conditions baseline and Climate Change conditions baseline calculated from long-term monthly averaged model output values.[1] Metrics are presented for all water year types and also for just Dry and Critically Dry water year types, when water supplies are often most limited.

Upper American and Cosumnes River Basin Flows

Changes in simulated, long-term average flows for relevant locations on the South Fork American River below Chili Bar Dam and Silver Creek at the mouth are summarized in Table F-1 and **Figure F-1**. Overall, long-term averaged monthly river flows for the Climate Change Conditions baseline scenario show noticeable reductions compared to the existing-conditions baseline, particularly during dry and critical water years. Flow changes vary by location, water year type, and month, making it challenging to generalize across all conditions. However, variability in flow changes is observed, with larger shifts in certain months and water year combinations (see Appendix G, *Modeling Technical Appendix* for detailed analysis).

The largest simulated percentage and magnitude changes in monthly averaged flow under the Climate Change Conditions baseline occurred on the South Fork American River below Chili Bar Dam and Total Inflow to Folsom Reservoir (Table F-1). On average, simulated monthly flows at the South Fork American River below Chili Bar Dam were 6 percent less than those under the existing-conditions baseline, reflecting an overall reduction in water availability due to earlier snowmelt and reduced snowpack in the watershed. The maximum decrease in average monthly flows relative to the existing-conditions baseline was 59.4 percent, with a corresponding magnitude reduction of 2,202 cubic feet per second (cfs). The largest flow reductions occurred from July through December, during which the system experiences greater variability and reduced inflows.

1 Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum magnitude-change values and the minimum and maximum percent-change values do not necessarily correspond to changes occurring in the same month and water year type.

TABLE F-1
SUMMARY OF ARIOPS-SIMULATED MONTHLY LONG-TERM AVERAGE SURFACE HYDROLOGY PARAMETERS UNDER THE EXISTING-CONDITIONS BASELINE AND THE CLIMATE CHANGE CONDITIONS BASELINE

Location and Compared Modeling Scenarios	Long-term Average All Years (Magnitude)[a]	Long-term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-term Average Monthly Changes between Baseline Conditions for All Years (Percent [magnitude])[b]			Comparison of Long-term Average Monthly Changes between Baseline Conditions for Critical/ Dry Water Years (Percent [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Union Valley Reservoir (af)								
Existing-Conditions Baseline	205,954	192,008	-	-	-	-	-	-
Climate Change Conditions Baseline	205,192	185,907	-14.4% (-25484)	18.8% (36369)	-0.3% (-762)	-14.4% (-25484)	11.5% (22075)	-3.3% (-6102)
Ice House Reservoir (af)								
Existing-Conditions Baseline	30,755	30,113	-	-	-	-	-	-
Climate Change Conditions Baseline	31,069	29,199	-13.1% (-4366)	45.4% (11702)	2% (315)	-13.1% (-4366)	13.5% (3599)	-2.6% (-915)
Loon Lake (af)								
Existing-Conditions Baseline	46,433	46,816	-	-	-	-	-	-
Climate Change Conditions Baseline	47,316	46,257	-13.3% (-8380)	109.4% (28077)	4.6% (883)	-13.3% (-8380)	31.9% (13411)	-0.2% (-559)
Jenkinson Lake (af)								
Existing-Conditions Baseline	31,310	26,761	-	-	-	-	-	-
Climate Change Conditions Baseline	29,919	24,844	-12.3% (-3546)	5.7% (1549)	-4.6% (-1391)	-12.3% (-3546)	-0.7% (-170)	-6.9% (-1916)
Stumpy Meadows Reservoir (af)								
Existing-Conditions Baseline	18,239	16,644	-	-	-	-	-	-
Climate Change Conditions Baseline	17,730	15,768	-10% (-1266)	8% (1378)	-3% (-509)	-10% (-1266)	2% (305)	-5.4% (-876)
Caples Lake (af)								
Existing-Conditions Baseline	16,478	15,385	-	-	-	-	-	-
Climate Change Conditions Baseline	16,116	14,609	-20% (-4064)	29.5% (5994)	-1.8% (-363)	-16.2% (-3296)	10% (2033)	-3.8% (-776)
Silver Lake (af)								
Existing-Conditions Baseline	4,118	3,759	-	-	-	-	-	-
Climate Change Conditions Baseline	4,041	3,570	-30.8% (-2664)	38.9% (3357)	-0.9% (-77)	-15.9% (-1374)	21.5% (1860)	-2.2% (-189)

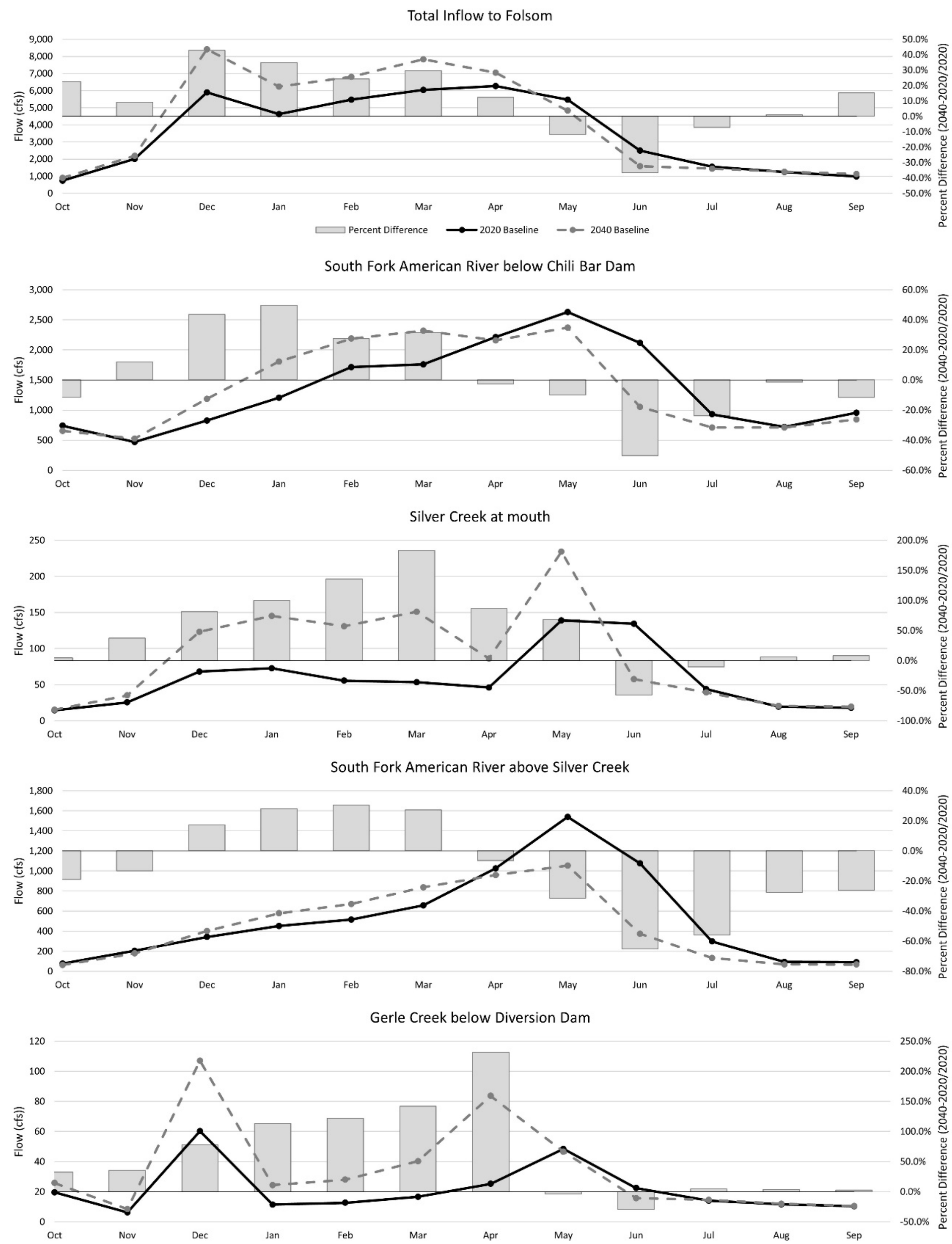
Location and Compared Modeling Scenarios	Long-term Average All Years (Magnitude)[a]	Long-term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-term Average Monthly Changes between Baseline Conditions for All Years (Percent [magnitude])[b]			Comparison of Long-term Average Monthly Changes between Baseline Conditions for Critical/ Dry Water Years (Percent [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Aloha Lake (af)								
Existing-Conditions Baseline	1,202	925	-	-	-	-	-	-
Climate Change Conditions Baseline	1,092	856	-74.6% (-3779)	51.2% (2590)	-2.2% (-110)	-23.4% (-1186)	21.7% (1098)	-1.3% (-68)
Echo Lake (af)								
Existing-Conditions Baseline	474	468	-	-	-	-	-	-
Climate Change Conditions Baseline	633	499	-20% (-399)	75.4% (1508)	8% (159)	-20% (-399)	56.4% (1128)	1.6% (31)
Union Valley Reservoir (ft)								
Existing-Conditions Baseline	4,847	4,841	-	-	-	-	-	-
Climate Change Conditions Baseline	4,846	4,838	-0.2% (-11.9)	0.3% (14.5)	0% (-0.4)	-0.2% (-11.9)	0.2% (9.2)	-0.1% (-2.8)
Jenkinson Lake (ft)								
Existing-Conditions Baseline	3,454	3,446	-	-	-	-	-	-
Climate Change Conditions Baseline	3,451	3,442	-0.2% (-6.6)	0.1% (2.5)	-0.1% (-2.6)	-0.2% (-6.6)	0% (-0.3)	-0.1% (-3.7)
Stumpy Meadows Reservoir (ft)								
Existing-Conditions Baseline	4,253	4,248	-	-	-	-	-	-
Climate Change Conditions Baseline	4,251	4,245	-0.1% (-5)	0.1% (3.9)	0% (-1.7)	-0.1% (-5)	0% (1.3)	-0.1% (-2.9)
Caples Lake (ft)								
Existing-Conditions Baseline	7,947	7,945	-	-	-	-	-	-
Climate Change Conditions Baseline	7,946	7,944	-0.1% (-6.4)	0.1% (9.5)	0% (-0.7)	-0.1% (-5.9)	0% (2)	0% (-1.6)
Silver Lake (ft)								
Existing-Conditions Baseline	7,196	7,195	-	-	-	-	-	-
Climate Change Conditions Baseline	7,196	7,195	-0.1% (-5.9)	0.1% (6.3)	0% (0)	0% (-3)	0.1% (4.6)	0% (-0.4)
Aloha Lake (ft)								
Existing-Conditions Baseline	8,200	8,199	-	-	-	-	-	-
Climate Change Conditions Baseline	8,200	8,199	-0.1% (-9.7)	0.1% (7)	0% (-0.3)	0% (-2.9)	0% (2.8)	0% (-0.2)

Location and Compared Modeling Scenarios	Long-term Average All Years (Magnitude)[a]	Long-term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-term Average Monthly Changes between Baseline Conditions for All Years (Percent [magnitude])[b]			Comparison of Long-term Average Monthly Changes between Baseline Conditions for Critical/ Dry Water Years (Percent [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Echo Lake (ft)								
Existing-Conditions Baseline	7,407	7,407	-	-	-	-	-	-
Climate Change Conditions Baseline	7,407	7,407	0% (-1.2)	0.1% (4.2)	0% (0.5)	0% (-1.2)	0% (3)	0% (0.1)
Total Inflow to Folsom (cfs)								
Existing-Conditions Baseline	3,861	1,634	-	-	-	-	-	-
Climate Change Conditions Baseline	3,340	1,425	-63.1% (-7065)	70.7% (1508)	-8.6% (-522)	-35.9% (-1164)	12.1% (159)	-10.6% (-209)
South Fork American River below Chili Bar Dam (cfs)								
Existing-Conditions Baseline	1,259	615	-	-	-	-	-	-
Climate Change Conditions Baseline	1,145	549	-59.4% (-2202)	47.4% (1083)	-6% (-114)	-29% (-397)	19% (171)	-8.5% (-66)
Silver Creek at Mouth (cfs)								
Existing-Conditions Baseline	56	21	-	-	-	-	-	-
Climate Change Conditions Baseline	65	20	-76.8% (-241)	197.6% (207)	11.6% (9)	-41.1% (-6)	20.6% (4)	-2.6% (0)
Gerle Creek below Diversion Dam (cfs)								
Existing-Conditions Baseline	36	12	-	-	-	-	-	-
Climate Change Conditions Baseline	29	11	-91.2% (-185)	87.9% (14)	-8.1% (-7)	-55.2% (-9)	10.1% (2)	-9.2% (-1)
South Fork American River above Silver Creek (cfs)								
Existing-Conditions Baseline	491	209	-	-	-	-	-	-
Climate Change Conditions Baseline	366	151	-74.2% (-1373)	59.6% (232)	-21.1% (-125)	-62.3% (-392)	16.4% (55)	-22.8% (-58)

NOTES: af = acre-feet; ARIOps = American River Integrated Operations model; cfs = cubic feet per second; ft = feet (surface water elevation)

See Appendix G, *Modeling Technical Appendix*, for complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).
b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage-change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum percent- and magnitude-change values do not necessarily correspond to changes occurring in the same month and water year type. For El Dorado Irrigation District Project 184 reservoirs, percent change calculated as a percentage of developed storage capacity. For these facilities, developed storage capacity is used instead of total storage capacity because the developed storage capacity (i.e., the volume available for water supply) of these reservoirs can be drawn down to zero unlike other reservoirs.



Key: cfs = cubic feet per second
Note: 2020 and 2040 Baselines refer to the existing-conditions baseline and Climate Change Conditions baseline, respectively.

Figure F-1 Comparison of Monthly Average ARIOps-Simulated River Flows under the Existing-Conditions Baseline and the Climate Change Conditions Baseline

At the "Silver Creek at Mouth" location, flow changes were slightly less dramatic. The long-term average monthly flow increased by 11.6 percent under climate change conditions, though variability persisted, with monthly changes ranging from a reduction of 76.8 percent to an increase of 197.6 percent (207 cfs).

These shifts indicate greater unpredictability in flow patterns under climate change, with some months experiencing considerably reduced flows, while others see increased runoff during wetter periods. During dry and critical years, the flow at Silver Creek is expected to decrease slightly, averaging -2.6 percent, with variations between -41.1 percent and +20.6 percent.

Gerle Creek below Diversion Dam is expected to see overall reductions in flow under the Climate Change Conditions baseline, particularly during dry and critical years. The average reduction in flow across all years is 8.1 percent, with more severe reductions of up to 91.2 percent during specific months. The variability in flows, particularly the significant reductions during late summer and fall, highlights the need for adaptive management strategies to mitigate the effects of climate change on water availability in Gerle Creek and its contribution to the broader American River system. These results underscore the challenges of maintaining consistent streamflows under future climate conditions, especially in snowpack-dependent regions like the Sierra Nevada.

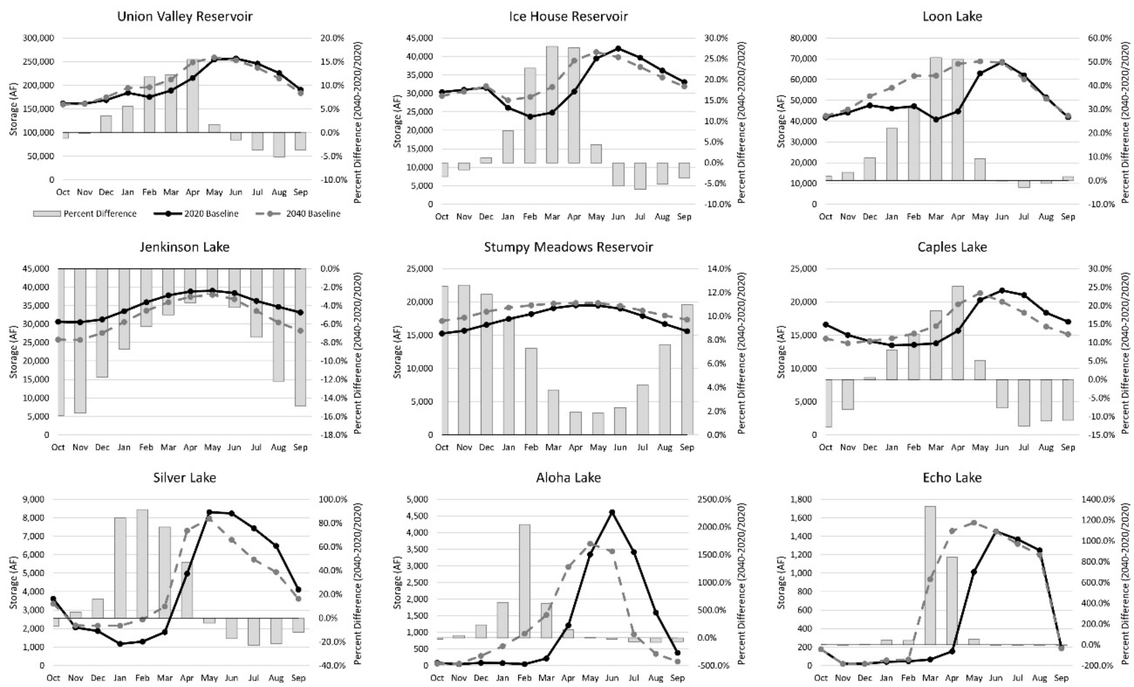
For both the South Fork American River below Chili Bar Dam and Silver Creek at the mouth, ARIOps was able to meet minimum instream flow requirements and recreational flow requirements in the Climate Change Conditions baseline. However, there is increased variability in flows, and the system is more likely to reduce flows to the minimum thresholds during dry periods. These results underscore the challenges that future climate conditions will pose to water management, particularly during the drier months when demands on water resources are highest, and inflows are reduced.

The results suggest that while the system remains capable of meeting regulatory flow requirements, the frequency at which flows approach the minimum thresholds will increase under climate change conditions. This indicates a growing strain on the system's ability to consistently provide higher flow rates during dry months and highlights the need for adaptive management strategies to cope with the increased variability in water availability.

Upper American River, SMUD Reservoirs

The overall trends of changes in Union Valley Reservoir, Ice House Reservoir, and Loon Lake under the Climate Change conditions baseline compared to the existing-conditions baseline reveal a pattern of increased variability in reservoir storage and fluctuating water levels (**Figure F-2**). While the magnitude and direction of changes differ across these locations, the general trend is toward more pronounced changes during certain months, with reduced storage during dry and critical water years, and increased variability during wetter periods.

Under all water year types, Union Valley Reservoir is projected to experience a slight reduction in long-term average storage, with a -0.3 percent decrease (762 af) under climate change conditions compared to existing conditions. However, the data indicates substantial monthly variability, with changes ranging from a reduction of -14.4 percent (-25,484 af) to an increase of 18.8 percent (36,369 af). This variability underscores the increased volatility in reservoir inflows expected under climate change. During dry and critical years, the reduction is more pronounced, with a -3.3 percent decrease (-6,102 af), highlighting the reservoir's sensitivity to reduced inflows during drought periods.



Key: af = acre-foot
Note: 2020 and 2040 Baselines refer to the existing-conditions baseline and Climate Change Conditions baseline, respectively.

Figure F-2 Comparison of Monthly Average ARIOps-Simulated Reservoir Storage under the Existing-Conditions Baseline and the Climate Change Conditions Baseline

For Ice House Reservoir, the Climate Change Conditions baseline shows an overall slight improvement in long-term average storage across all water year types, with a 2 percent increase (315 af). However, the variability remains, with changes ranging from a -13.1 percent decrease (-4,366 af) to a 45.4 percent increase (11,702 af). During dry and critical years, the reservoir shows a more negative trend, with an average decrease of -2.6 percent (-915 af), indicating that during low-water years, Ice House Reservoir will struggle to maintain optimal storage levels.

Loon Lake exhibits a somewhat positive outlook in the Climate Change Conditions baseline, with a 4.6 percent increase (883 af) in long-term average storage under all water years, driven by a maximum increase of 109.4 percent (28,077 af) during certain months. However, during dry and critical years, the overall change is minimal, with a -0.2 percent decrease (-559 af), indicating that while Loon Lake may experience some monthly fluctuations, its overall storage capacity remains relatively stable in critical years.

El Dorado Irrigation District's Project 184 Facilities

The overall trends for Caples Lake, Silver Lake, Aloha Lake, and Echo Lake under the Climate Change Conditions baseline relative to the existing-conditions baseline show variability in water storage, with monthly fluctuations becoming more pronounced compared to the existing-conditions baseline (Figure F-2). These fluctuations highlight the sensitivity of these lakes to changes in precipitation patterns, snowpack levels, and runoff timing due to climate change. While some months may experience increases in water storage, the overall trend leans toward reduced storage during dry and critical water years, which poses challenges for maintaining consistent water availability. Each lake exhibits unique behaviors under these scenarios, reflecting their distinct hydrological settings and characteristics.

For Caples Lake, the overall long-term average storage decreases by 1.8 percent, with the most reductions occurring during dry and critical years, where storage levels fall by 3.8 percent as compared to the lake's developed storage capacity. This suggests that Caples Lake will likely face more difficulties in maintaining adequate water levels during drought conditions, although there are months where storage could increase by up to 29.5 percent due to isolated precipitation events. Despite these potential increases, the lake is still vulnerable to substantial reductions, with monthly decreases as high as 20 percent, particularly during periods of reduced inflows.

Silver Lake experiences even greater variability, with an overall decrease in storage of 0.9 percent under all water year types. During dry and critical years, this reduction deepens to 2.2 percent, although the lake shows month-to-month swings in storage levels, ranging from a 30.8 percent reduction to a 38.9 percent increase. These large fluctuations indicate that Silver Lake is highly sensitive to changing hydrological conditions, making it challenging to predict consistent water availability. The reservoir may face shortages during dry months but could also experience unexpected increases during wetter months.

Aloha Lake follows a similar pattern, with an overall decrease in long-term storage of 2.2 percent and a 1.3 percent reduction during dry and critical years. Aloha Lake is particularly prone to extreme variability, with monthly changes in storage ranging from a 74.6 percent reduction to a 51.2 percent increase. This level of volatility reflects the lake's sensitivity to changes in snowmelt and precipitation patterns, making it highly unpredictable under future climate conditions. While the lake may see occasional increases in storage, it is likely to experience severe reductions during drought periods, posing additional challenges for water management.

Echo Lake, on the other hand, demonstrates a more positive overall trend, with an increase in storage of 8 percent under all water year types and a modest 1.6 percent increase during dry and critical years. While Echo Lake exhibits substantial monthly variability—ranging from a 20 percent reduction to a 75.4 percent increase—it appears more resilient to the effects of climate change compared to the other lakes. The lake's ability to maintain positive storage levels even during dry periods suggests that it could play a crucial role in mitigating some of the water shortages expected in other parts of the upper American River watershed.

Jenkinson Lake and Stumpy Meadows Reservoir

The overall trends for Jenkinson Lake and Stumpy Meadows Reservoir under the Climate Change Conditions baseline reveal a pattern of decreasing water storage, particularly during dry and critical water years. Both reservoirs show reductions in long-term average storage, with increased variability in monthly storage levels, indicating challenges in maintaining consistent water supplies, especially during periods of low precipitation.

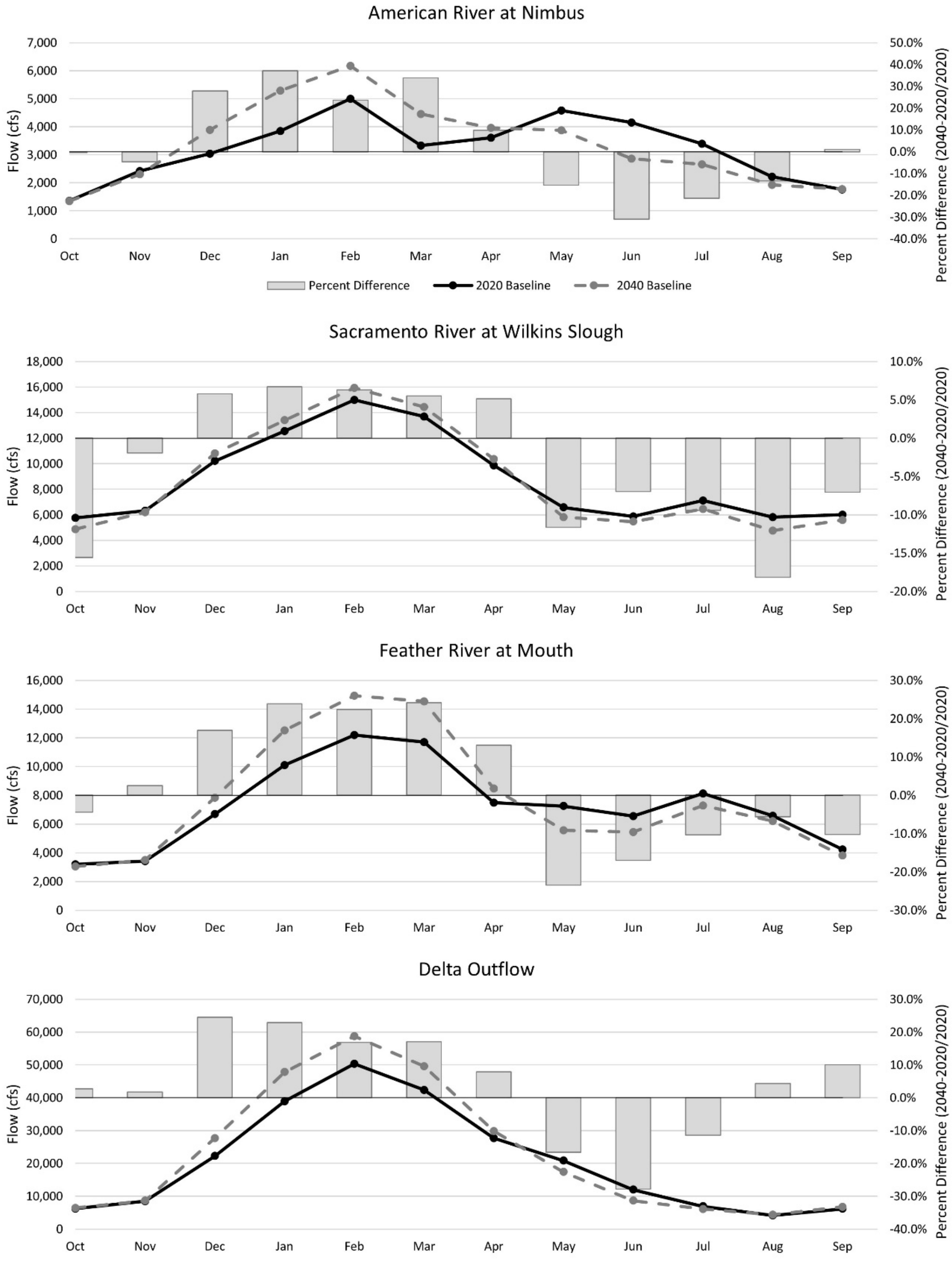
For Jenkinson Lake, the long-term average storage under all water year types is expected to decrease by -4.6 percent (-1,391 af), with monthly changes ranging from a -12.3 percent reduction (-3,546 af) to a 5.7 percent increase (1,549 af). This highlights the reduced ability of Jenkinson Lake to capture and store water consistently under climate change conditions. During dry and critical years, the effects are even more severe, with a -6.9 percent decrease (-1,916 af), indicating that water availability during drought periods will be notably constrained.

Stumpy Meadows Reservoir also shows a slight decrease in water storage under climate change conditions. For all water years, the long-term average storage declines by -3 percent (-509 af), with variability ranging from a -10 percent reduction (-1,266 af) to an 8 percent increase (1,378 af). In dry and critical years, the reservoir sees a -5.4 percent decrease (-876 af), emphasizing its vulnerability to reduced inflows during periods of low precipitation.

F.4.2 Lower American River and CVP/SWP Water Operations and Water Quality (CalSim 3 and HEC-5Q)

The result of shifting flow and reservoir storage patterns is that comparisons of individual long-term monthly average values (i.e., comparison of coincident months in coincident water year types) between the existing-conditions baseline and the Climate Change Conditions baseline often exhibited large, both negative and positive, changes (Table F-1 and **Figure F-3**). On the other hand, average changes from the complete set of results were not as drastic, and were often positive. For instance, except at South Fork American River below Chili Bar and South Fork American River above Silver Creek, monthly flows, on average, increased under the Climate Change Conditions baseline. Similarly, except for at Jenkinson Lake, end-of-month reservoir storage values increased at all other reservoirs under the Climate Change Conditions baseline.

Changes between CalSim 3–simulated surface water parameters for the existing-conditions baseline and Climate Change Conditions baseline for relevant locations in the Study Area are summarized in **Table F-2** and **Figure F-4**. Changes in simulated (HEC-5Q), long-term monthly average water temperatures for the lower American River are summarized in **Table F-3**.



Key: cfs = cubic feet per second
Note: 2020 and 2040 Baselines refer to the existing-conditions baseline and the Climate Change Conditions baseline, respectively.

Figure F-3 Comparison of Monthly Average CalSim 3–Simulated River Flows under the Existing-Conditions Baseline and the Climate Change Conditions Baseline

TABLE F-2
SUMMARY OF CALSIM 3–SIMULATED MONTHLY LONG-TERM AVERAGE SURFACE HYDROLOGY PARAMETERS UNDER THE EXISTING-CONDITIONS BASELINE AND THE CLIMATE CHANGE CONDITIONS BASELINE

Location and Compared Modeling Scenarios	Long-term Average All Years (Magnitude)[a]	Long-term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-term Average Monthly Changes from Baseline Conditions to Project-Only Scenario for All Years (Percent [magnitude])[b]			Comparison of Long-term Average Monthly Changes from Baseline Conditions to Project-Only Scenario for Critical/Dry Water Years (Percent [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Folsom Reservoir (TAF)								
Existing-Conditions Baseline	580	450	-	-	-	-	-	-
Climate Change Conditions Baseline	545	421	-20.2% (-145)	5.6% (24)	-5.7% (-35)	-14.7% (-98)	5.6% (24)	-5.9% (-28)
Shasta Lake (TAF)								
Existing-Conditions Baseline	3,169	2,607	-	-	-	-	-	-
Climate Change Conditions Baseline	2,993	2,394	-22.1% (-491)	3.4% (104)	-6% (-175)	-22.1% (-491)	-0.5% (-12)	-8.6% (-213)
Trinity Lake (TAF)								
Existing-Conditions Baseline	1,547	1,207	-	-	-	-	-	-
Climate Change Conditions Baseline	1,455	1,108	-17.7% (-260)	8% (135)	-6% (-92)	-17.7% (-249)	2.1% (21)	-7.3% (-99)
Lake Oroville (TAF)								
Existing-Conditions Baseline	2,236	1,706	-	-	-	-	-	-
Climate Change Conditions Baseline	2,057	1,548	-21.3% (-523)	5% (117)	-8.7% (-179)	-21.1% (-329)	-0.6% (-12)	-9.9% (-158)
American River at Nimbus (cfs)								
Existing-Conditions Baseline	2,899	1,585	-	-	-	-	-	-
Climate Change Conditions Baseline	2,954	1,573	-	-	-	-	-	-
Sacramento River at Wilkins Slough (cfs)								
Existing-Conditions Baseline	8,253	6,008	-	-	-	-	-	-
Climate Change Conditions Baseline	8,166	6,132	-28.6% (-2288)	22.2% (1973)	-2.1% (-86)	-28.6% (-2097)	22.2% (1973)	1.5% (124)
Feather River Flows at Mouth (cfs)								
Existing-Conditions Baseline	6,474	3,267	-	-	-	-	-	-
Climate Change Conditions Baseline	6,679	3,304	-39.7% (-4910)	47.1% (5874)	1.6% (205)	-28.6% (-2179)	32.6% (1226)	2.5% (37)

Location and Compared Modeling Scenarios	**Long-term Average All Years (Magnitude)[a]**	**Long-term Average Dry/ Critical Years (Magnitude)[a]**	**Comparison of Long-term Average Monthly Changes from Baseline Conditions to Project-Only Scenario for All Years (Percent [magnitude])[b]**			**Comparison of Long-term Average Monthly Changes from Baseline Conditions to Project-Only Scenario for Critical/Dry Water Years (Percent [magnitude])[b]**		
			Minimum Change	**Maximum Change**	**Average Change**	**Minimum Change**	**Maximum Change**	**Average Change**
Delta Outflow (cfs)								
Existing-Conditions Baseline	17,728	7,855	-	-	-	-	-	-
Climate Change Conditions Baseline	19,198	8,660	-45% (-9782)	50.5% (19136)	3.5% (1470)	-9.6% (-591)	30% (5157)	5.4% (805)
Delta Cross Channel (Days gate open)								
Existing-Conditions Baseline	204	171	-	-	-	-	-	-
Climate Change Conditions Baseline	173	146	-64.4% (-169)	13.3% (31)	-13.9% (-31)	-64.4% (-169)	7.2% (11)	-12.9% (-25)
X2 Position (km)								
Existing-Conditions Baseline	6	6	-	-	-	-	-	-
Climate Change Conditions Baseline	4	3	-100% (-37.7)	647.1% (8.7)	1.5% (-2)	-100% (-16.9)	72.2% (4.1)	-16.6% (-3)

NOTES: cfs = cubic feet per second; km = kilometer; TAF = thousand acre-feet

See Appendix G, *Modeling Technical Appendix*, for a complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).
b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage-change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum percent- and magnitude-change values do not necessarily correspond to changes occurring in the same month and water year type.

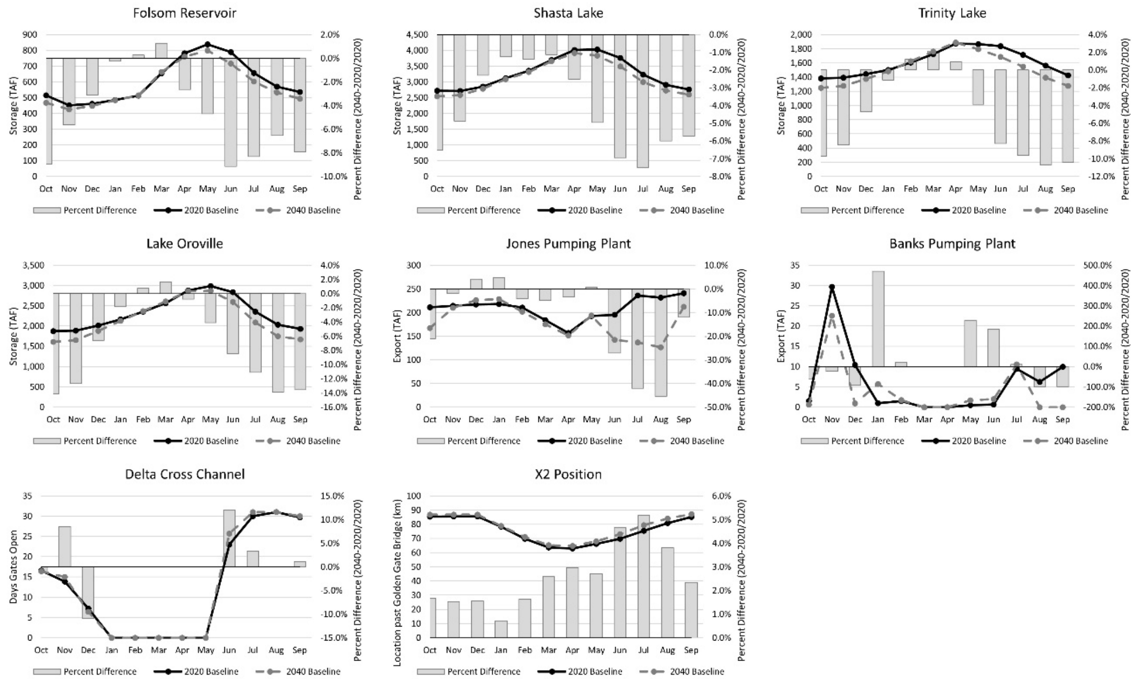
TABLE F-3
SUMMARY OF HEC-5Q SIMULATED MONTHLY LONG-TERM AVERAGE WATER TEMPERATURES UNDER THE EXISTING-CONDITIONS BASELINE AND THE CLIMATE CHANGE CONDITIONS BASELINE

Location and Compared Modeling Scenarios	Long-Term Average All Years (Magnitude)[a]	Long-Term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-Term Average Monthly Changes from Existing-Conditions Baseline to Climate Change Conditions Baseline for All Years (Percent [magnitude])[b]			Comparison of Long-Term Average Monthly Changes from Existing-Conditions Baseline to Climate Change Conditions Baseline for Critical/Dry Water Years (Percent [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
American River below Folsom Dam (°F)								
Existing-Conditions Baseline	56.4	58.0	-	-	-	-	-	-
Climate Change Conditions Baseline	57.6	59.6	-2.1% (-1.1)	6.3% (3.1)	2% (1.1)	0% (0)	6.3% (3.1)	2.8% (1.6)
American River below Nimbus (Hazel Avenue) Dam (°F)								
Existing-Conditions Baseline	57.0	58.6	-		-	-	-	-
Climate Change Conditions Baseline	58.3	60.4	-1.5% (-0.8)	6.5% (3.1)	2.2% (1.3)	1.1% (0.6)	6.5% (3.1)	3.1% (1.8)
American River at Watt Avenue (°F)								
Existing-Conditions Baseline	59.1	61.2	-	-	-	-	-	-
Climate Change Conditions Baseline	60.6	63.2	-0.7% (-0.4)	6.3% (3.8)	2.5% (1.5)	1.7% (1.1)	6.1% (3)	3.4% (2)

NOTES: °F = degrees Fahrenheit

See Appendix G, *Modeling Technical Appendix*, for a complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).
b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage-change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum percent- and magnitude-change values do not necessarily correspond to changes occurring in the same month and water year type.



Key: km = kilometer; TAF = thousand acre-feet
Note: 2020 and 2040 Baselines refer to the existing-conditions baseline and the Climate Change Conditions baseline, respectively.

Figure F-4 Comparison of Monthly Average CalSim 3–Simulated Reservoir Storage and Surface Water Parameters under the Existing-Conditions Baseline and the Climate Change Conditions Baseline

Lower American River Flows and Temperatures, and Folsom Lake Storage

Most changes in storage at Folsom Lake and river flows in the lower American River are modest but noticeable, particularly during dry and critical water years. The largest change in Folsom Lake storage under the Climate Change Conditions baseline is a maximum decrease of 20.2 percent (or -145 thousand acre-feet [TAF]) compared to the existing-conditions baseline. These reductions are concentrated between August and January, reflecting the effect of reduced inflows from the South Fork American River due to earlier snowmelt and lower snowpack levels. However, such large decreases are temporally limited, and on average, the long-term monthly reduction is 5.7 percent (or approximately -35 TAF). During dry and critical years, the average reduction is slightly higher at 5.9 percent (or -28 TAF), with maximum monthly reductions reaching 14.7 percent (or -98 TAF). These changes underscore the vulnerability of Folsom Lake to climate-induced reductions in water availability during critical periods.

For the American River at Nimbus, long-term average monthly flows show a slight increase of +2.9 percent (or 55 cfs) under the Climate Change Conditions baseline compared to the existing-conditions baseline. However, there is variability in flow changes across different months. The maximum decrease in flow reaches 43.7 percent (or -2,749 cfs), while some months see increases of up to 77.9 percent (or +2,817 cfs). These fluctuations are driven by altered precipitation and runoff patterns under climate change, with earlier snowmelt leading to higher flows during certain months and lower flows during others. Despite these fluctuations, the average reduction during dry and critical years is only 1.2 percent (or -12 cfs), indicating that while some months may experience decreases, overall flow reductions are generally small.

The most noticeable reductions in American River flows at Nimbus occur during dry years, particularly in January, February, May, and June, when simulated flow reductions exceed 5 percent for the Climate Change Conditions baseline. Similarly, during wet years, reductions are more prominent in September. The maximum monthly average flow decrease is 9.3 percent, which occurs in specific months, reflecting the increased stress on the river system during drier periods. Like the changes in Folsom Lake storage, these flow reductions are temporally limited, and on average, the long-term monthly simulated flows at the American River at Nimbus decrease by only 1.6 percent compared to the existing-conditions baseline. This suggests that while climate change will cause variability in river flows, the system remains capable of maintaining flow levels within acceptable ranges during most months.

Comparing the existing-conditions baseline to the Climate Change Conditions baseline for water temperatures in the lower American River shows significant warming, particularly during dry and critical water years. Climate-driven factors such as higher air temperatures, reduced snowpack, and altered runoff patterns contribute to this increase. Across all key locations, temperature increases frequently exceed 1°F, highlighting the effect of climate change on river conditions.

The long-term average temperature below Folsom Dam under the Climate Change Conditions baseline increases by 2.0 percent (or 1.1°F) compared to existing conditions, with maximum increases reaching 6.3 percent (or 3.1°F). At Nimbus Dam, temperatures rise by 2.2 percent (or 1.3°F) on average, with a maximum increase of 6.5 percent (or 3.1°F). Farther downstream at Watt Avenue, the average temperature increase is 2.5 percent (or 1.5°F), with a maximum of 6.3 percent (or 3.8°F).

The shift from the existing-conditions baseline to the Climate Change Conditions baseline results in noticeable warming, with temperature increases often exceeding 1°F and reaching up to 3.8°F. These changes could significantly affect cold-water species like salmon and steelhead, emphasizing the need for adaptive water management to mitigate rising temperatures. The findings underscore the broader effect of climate change on river ecosystems and the importance of adjusting water management strategies to address these challenges.

Overall, the changes in Folsom Lake storage and American River flows under the Climate Change Conditions baseline show some variability, particularly during dry and critical water years. Folsom Lake experiences reduced storage primarily between August and January, with maximum decreases of up to 20.2 percent in certain months, though the average reduction is more modest at 5.7 percent. Similarly, the American River at Nimbus sees both reductions and increases in flows depending on the season, with average reductions of only 1.6 percent across all water year types. These results highlight the importance of adaptive management strategies to handle the increased variability in water resources and flow patterns under future climate conditions while ensuring the long-term sustainability of the system.

CVP/SWP–Related Rivers and Storage Facilities

The input of future hydrology under climate change resulted in a volumetric shift in the runoff distribution in selected river locations in the Study Area from May through October to earlier in the season (December to April) as secondary peaks in the hydrograph that historically occur during California's snowmelt recession period were reduced and translated into increased rainfall and associated runoff during California's winter storm period (Figure F-3). The result of these shifting flow patterns is that comparisons of individual long-term monthly average values between the existing-conditions baseline and the Climate Change Conditions baseline often exhibited large, both negative and positive, changes (Table F-2), but that average changes were not as drastic and were often positive. Unlike Project Area reservoirs, Study Area reservoirs (i.e., Folsom, Shasta, Trinity, and Oroville), generally exhibited year-round decreases in simulated storage under the Climate Change Conditions baseline compared to the existing-conditions baseline (Figure F-4).

Changes in simulated (CalSim 3) long-term average monthly surface hydrology parameters between the Climate Change Conditions baseline and the existing-conditions baseline are summarized in Table F-2. The majority of changes for key water storage reservoirs—Folsom Reservoir, Shasta Lake, Trinity Lake, and Lake Oroville—as well as major rivers like the American River, Sacramento River, and Feather River, show reductions in water availability, especially during dry and critical water years. However, some months experience variability, with increases in flows and storage during certain periods under climate change conditions.

For Folsom Reservoir, the long-term average storage under the Climate Change Conditions baseline is reduced by 5.7 percent (-35 TAF) compared to the existing-conditions baseline, with a maximum monthly decrease of 20.2 percent (-145 TAF). These reductions primarily occur between August and January. During dry and critical years, the average reduction in Folsom storage increases slightly to 5.9 percent (-28 TAF), with a peak reduction of 14.7 percent (-98 TAF). These decreases are attributed to changes in runoff timing, reflecting earlier snowmelt and reduced inflows.

At Shasta Lake, the overall reduction in long-term average storage under climate change conditions is 6 percent (-175 TAF), with monthly changes ranging from -22.1 percent (-491 TAF) to +3.4 percent (104 TAF). The effects are more severe during dry and critical years, with an average storage reduction of 8.6 percent (-213 TAF), highlighting the vulnerability of Shasta Lake to reduced inflows under future climate conditions. Trinity Lake exhibits a similar trend, with long-term average storage reduced by 6 percent (-92 TAF) and monthly reductions reaching 17.7 percent (-260 TAF) during critical periods. In dry years, Trinity Lake's average reduction is 7.3 percent (-99 TAF), further illustrating the strain on reservoir systems in a climate-impacted future.

Lake Oroville experiences even more pronounced effects, with long-term average storage reduced by 8.7 percent (-179 TAF) under climate change conditions, and monthly reductions as high as 21.3 percent (-523 TAF). During dry and critical years, the average reduction grows to 9.9 percent (-158 TAF), with maximum monthly reductions of 21.1 percent (-329 TAF), underscoring the challenges of maintaining adequate storage levels at Lake Oroville under drier conditions.

The American River at Nimbus shows slight increases in long-term average flows under climate change conditions, with an overall increase of +2.9 percent (55 cfs). However, monthly variability is high, with reductions as large as 43.7 percent (-2,749 cfs) and increases of up to 77.9 percent (2,817 cfs). In dry years, the flow decreases slightly by 1.2 percent (-12 cfs). Despite these fluctuations, minimum flow requirements for the American River are expected to be consistently met under the Climate Change Conditions baseline.

For the Sacramento River at Wilkins Slough, long-term average flows decrease slightly by 2.1 percent (-86 cfs), with monthly reductions of up to 28.6 percent (-2,288 cfs) and increases of 22.2 percent (1,973 cfs). The Feather River at its mouth shows a similar pattern, with a slight overall increase in flows of 1.6 percent (205 cfs), but substantial monthly variations, including reductions of 39.7 percent (-4,910 cfs) and increases of 47.1 percent (5,874 cfs). During dry and critical years, Feather River flows decrease slightly by 2.5 percent (37 cfs), with reductions reaching 28.6 percent (-2,179 cfs).

Delta Water Quality

Changes in Delta water quality under the Climate Change Conditions baseline compared to the existing-conditions baseline are essential to understanding how salinity management, freshwater outflows, and other water quality parameters will respond to future climate conditions. Key indicators such as the operation of the Delta Cross Channel (DCC) gates, the position of X2 (the location in the Delta where salinity reaches 2 parts per thousand), and Delta outflows are critical to maintaining both water quality and ecological health in the Delta. The CalSim 3 model results summarized in Table F-2 provide insights into how these parameters might shift under climate change.

Under climate change conditions, the number of days the Delta Cross Channel gates are open decreases. On average, the days the gates are open are reduced by 13.9 percent (-31 days) compared to the existing-conditions baseline. In some months, the reduction is as large as 64.4 percent (-169 days), which could limit the ability to manage salinity intrusion in the Delta. The DCC gates are critical for controlling the mixing of fresh and saline water, and fewer open days could increase the risk of salinity intrusion, particularly during critical periods when freshwater inflows are reduced. However, despite these reductions, the system appears to maintain functionality, though the reduced operation time signals a challenge in future salinity management.

The X2 salinity position, which indicates how far saline water intrudes into the Delta, shows high variability under climate change conditions. The average changes are generally minimal, but the maximum shift in X2 position reaches +647.1 percent (8.7 kilometers [km]) farther inland, while some months see reductions of -100 percent (-37.7 km). This variability highlights how changes in freshwater outflows due to changes in climate could lead to more frequent and severe salinity intrusion events, pushing salt water farther upstream into critical regions of the Delta. Meeting regulatory standards for X2 under climate change conditions may require additional freshwater outflows to mitigate these shifts, particularly during dry years.

The Delta outflows, critical for controlling salinity and maintaining water quality, increase by 3.5 percent (1,470 cfs) on average under climate change conditions. However, monthly variability exists, with outflows decreasing by as much as 45 percent (-9,782 cfs) in some months and increasing by 50.5 percent (19,136 cfs) in others. This fluctuation in outflows reflects the changing hydrological patterns under climate change, where increased variability in precipitation and runoff leads to more erratic water releases into the Delta. During dry and critical water years, Delta outflows still increase by 5.4 percent (805 cfs), but certain months experience reductions of up to 9.6 percent (-591 cfs), potentially complicating efforts to maintain salinity control.

Despite the variability in DCC operations and the X2 position, the model results indicate that salinity standards at critical locations in the Delta, such as Rock Slough, Emmaton, Jersey Point, and Collinsville, are generally met under the Climate Change Conditions baseline. These locations are crucial monitoring points for ensuring that salinity levels do not exceed thresholds that would harm agricultural, municipal, or environmental uses of Delta water. The model shows that salinity criteria are met more than 93 percent of the time across all simulation days, suggesting that while the system will face increased challenges, regulatory compliance can still be achieved with appropriate management strategies.

F.5 Comparison of Climate Change Conditions With-Project and Climate Change Conditions Baseline

The following presents results from comparing the Climate Change Conditions With-Project and Climate Change Conditions baseline model results.

F.5.1 Upper American River Basin Water Operations (ARIOps)

Changes in simulated, long-term average monthly flows, end-of-month reservoir storage, and end-of-month reservoir elevations for relevant locations in the upper American River Basin are summarized in **Table F-4**. It depicts both long-term average magnitudes from simulation scenarios and summary statistics (minimum, maximum, and arithmetic mean) of percent and magnitude changes between the Climate Change Conditions With-Project and Climate Change Conditions baseline calculated from long-term monthly averaged model output values.[2] Metrics are presented for all water year types and again for just Dry and Critically Dry water year types, when water supplies are often most limited.

[2] Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum magnitude-change values and the minimum and maximum percent-change values do not necessarily correspond to changes occurring in the same month and water year type.

TABLE F-4
SUMMARY OF ARIOPS-SIMULATED MONTHLY LONG-TERM AVERAGE STREAMFLOW UNDER THE CLIMATE CHANGE CONDITIONS BASELINE AND CLIMATE CHANGE CONDITIONS WITH-PROJECT

Location and Compared Modeling Scenarios	Long-Term Average All Years (Magnitude)[a]	Long-Term Average Dry/Critical Years (Magnitude)[a]	Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for All Years (Percent change [magnitude])[b]			Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for Critical/Dry Water Years (Percent change [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Total Inflow to Folsom (cfs)								
Climate Change Conditions Baseline	3,966	1,799	-	-	-	-	-	-
Climate Change Conditions With-Project	3,915	1,749	-10.3% (-170)	0.1% (15)	-2.2% (-50)	-10.3% (-157)	0% (0)	-3.3% (-50)
South Fork American River below Chili Bar Dam (cfs)								
Climate Change Conditions Baseline	1,381	681	-	-	-	-	-	-
Climate Change Conditions With-Project	1,331	630	-20.9% (-170)	0.4% (13)	-6% (-50)	-20.9% (-157)	-0.1% (0)	-7.4% (-50)
South Fork American River above Silver Creek (cfs)								
Climate Change Conditions Baseline	375	137	-	-	-	-	-	-
Climate Change Conditions With-Project	374	136	-11.3% (-7)	1% (2)	-0.5% (-1)	-11.3% (-7)	1% (2)	-1.1% (-1)
Silver Creek at Mouth (cfs)								
Climate Change Conditions Baseline	89	25	-	-	-	-	-	-
Climate Change Conditions With-Project	88	25	-23.7% (-11)	2.5% (9)	-0.8% (-1)	-13.5% (-4)	0% (0)	-2% (-1)
Gerle Creek below Diversion Dam (cfs)								
Climate Change Conditions Baseline	26	11	-	-	-	-	-	-
Climate Change Conditions With-Project	24	11	-10.5% (-27)	20.5% (3)	0.1% (-2)	-1% (0)	0% (0)	-0.1% (0)

NOTES: ARIOps = American River Integrated Operations model; cfs = cubic feet per second

See Appendix G, *Modeling Technical Appendix*, for a complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).
b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning the minimum and maximum percent- and magnitude-change values do not necessarily correspond to changes occurring in the same month and water year type.

Upper American and Cosumnes River Basin Flows

Overall, long-term averaged monthly river flows for the Climate Change Conditions With-Project scenario were found to have negligible differences compared to the Climate Change Conditions baseline (i.e., simulated changes were within 5 percent). Differences varied by location, water year type, and month, making generalizations difficult. Different combinations of these variables also resulted in variability in the patterns of flow changes, with larger changes in flow sometimes concentrated in certain month and water year combinations (Appendix G, *Modeling Technical Appendix*).

The largest simulated percent and magnitude changes in monthly averaged flow for the Climate Change Conditions With-Project scenario occurred on the South Fork American River below Chili Bar Dam and to Total Inflow to Folsom (Table F-4). On average, Climate Change Conditions With-Project simulated average monthly flows at South Fork American River below Chili Bar Dam were 6 percent less than those under the Climate Change Conditions baseline and Climate Change Conditions With-Project Total Inflow to Folsom was 2.2 percent less than Climate Change Conditions baseline. Across all water year types and months, the maximum decrease in average monthly Climate Change Conditions With-Project simulated flow relative to Climate Change Conditions baseline for the South Fork American River below Chili Bar Dam was 20.9 percent (the maximum magnitude decrease was 170 cfs). Flow decreases at the South Fork American River below Chili Bar Dam model node were greatest from July through December. At the Total Inflow to Folsom model node the maximum decrease in average monthly Climate Change Conditions With-Project simulated flow relative to Climate Change Conditions baseline was 10.3 percent (the maximum magnitude decrease was 170 cfs). Flow decreases at this location were greatest from August through December. During the remaining months, average flows at both locations differed little from Climate Change Conditions baseline flows.

Simulated flow changes between the Climate Change Conditions With-Project scenario and Climate Change Conditions baseline in other relevant tributaries: Silver Creek near the mouth, Gerle Creek and the South Fork of Silver Creek, were generally minimal, with average changes in the long-term average monthly flows being less than 0.8 percent (Table F-4).

For the Climate Change Conditions baseline scenario, ARIOps is always able to meet minimum instream flow requirements and recreational flow requirements for all output locations (e.g., pulse flows, ramping rates/flows, and/or recreation flows set forth by the State Water Board water quality certifications for both the SMUD UARP [FERC Project No. 2101] and the Chili Bar Hydroelectric Project [FERC Project No. 2155]). For the Climate Change Conditions With-Project scenario, ARIOps is able to meet minimum instream flow requirements and recreational flow requirements at all output locations for more than 99.9 percent of the daily outputs. However, the frequency that flows are being reduced to and/or held at required levels increases under the Climate Change Conditions With-Project scenario. Specifically, **Table F-5** summarizes how often Climate Change Conditions With-Project flows at South Fork American River at Chili Bar were near or below numerical thresholds for both daily minimum flows and recreational flows (the latter typically being higher). The analysis indicates the Climate Change Conditions

With-Project scenario would result in a 2.6 percent increase in the number of days that flows at South Fork American River at Chili Bar are at or within 5 percent of the minimum required flow. Regarding recreational flow requirements, the analysis indicates the Climate Change Conditions With-Project scenario would result in a 4.7 percent increase in the number of days that flows at South Fork American River at Chili Bar are at or within 5 percent of the minimum required recreational flow.

TABLE F-5
SOUTH FORK AMERICAN RIVER AT CHILI BAR DAILY FLOW ANALYSIS

	Percent of Days that Simulated Flows Are:					
	Less than the Flow Requirement [a]		At the Flow Requirement [b]		Within 5 Percent of the Flow Requirement	
Modeling Scenario	**Minimum Flow**	**Recreational Flow**	**Minimum Flow**	**Recreational Flow**	**Minimum Flow**	**Recreational Flow**
Climate Change Conditions Baseline	0.0%	0.0%	6.3%	23.1%	6.6%	24.3%
Climate Change Conditions With-Project	0.0%	0.0%	8.5%	27.4%	9.2%	29.0%

NOTES: See Appendix G, *Modeling Technical Appendix*, for a complete description of all modeling scenarios and rationale for effects analysis.

a. Within approximately 1 percent of the flow requirement.

SMUD, and by proxy the Agency through cooperative agreements, are obligated to meet all minimum instream flow and recreational flow requirements and minimum reservoir storage requirements and would make good faith attempts to adjust operations accordingly (e.g., all entities perform operational forecasts for planning purposes, consult with resource agencies, and perform real-time monitoring of instream flows and would take subsequent actions and/or make operational changes in response to such actions). Operationally, this means that if SMUD believes deliveries to meet demands associated with the Proposed Project would result in FERC license violations, the deliveries would be reduced (see Section 4.2, *Summary of Surface Water Hydrology Results* for additional discussion on this topic).

Upper American River, SMUD Reservoirs

Like river flows, simulated changes in long-term average end-of-month reservoir storage volumes in the upper American River and Cosumnes River basins between the Climate Change Conditions With-Project and Climate Change Conditions baseline model scenarios varied by output location, month, and water year type; the results are summarized in **Table F-6**.

TABLE F-6
SUMMARY OF ARIOPS-SIMULATED MONTHLY LONG-TERM AVERAGE RESERVOIR STORAGE UNDER THE CLIMATE CHANGE CONDITIONS BASELINE AND CLIMATE CHANGE WITH-PROJECT

Location and Compared Modeling Scenarios	Long-Term Average All Years (Magnitude)[a]	Long-Term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for All Years (Percent [magnitude])[b]			Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for Critical/Dry Water Years (Percent [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Union Valley Reservoir (af)								
Climate Change Conditions Baseline	213,179	185,907	-	-	-	-	-	-
Climate Change Conditions With-Project	206,730	172,896	-20.1% (-28725)	0% (44)	-3.2% (-6449)	-20.1% (-28725)	-2.2% (-3766)	-7.4% (-13011)
Ice House Reservoir (af)								
Climate Change Conditions Baseline	31,944	29,199	-	-	-	-	-	-
Climate Change Conditions With-Project	31,928	29,198	-0.5% (-128)	0.1% (34)	-0.1% (-16)	0% (-1)	0% (1)	0% (0)
Loon Lake (af)								
Climate Change Conditions Baseline	47,734	46,257	-	-	-	-	-	-
Climate Change Conditions With-Project	47,790	46,257	-0.2% (-71)	2.9% (868)	0.2% (56)	0% (0)	0% (0)	0% (0)

NOTES: af = acre-feet; ARIOps = American River Integrated Operations model

See Appendix G, *Modeling Technical Appendix*, for a complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).
b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum percent and magnitude change values do not necessarily correspond to changes occurring in the same month and water year type.

Under the Climate Change Conditions With-Project scenario, most SMUD UARP reservoirs would generally experience little change in long-term average end-of-month storage volumes or elevations relative to Climate Change Conditions baseline. The largest decreases in storage under the Climate Change Conditions With-Project scenario were simulated to occur at Union Valley Reservoir, which was found to decrease on average by 3.2 percent (Table F-6). During certain month and water year combinations the decreases in long-term average end-of-month storage at Union Valley were in excess of 5 percent. These decreases tended to occur in Critically Dry water year types. These decreases are necessary to convey stored Proposed Project water to the downstream point of diversion.

Results from the Climate Change Conditions baseline scenario were able to meet minimum end-of-month reservoir storage requirements at Union Valley Reservoir, Ice House Reservoir, and Loon Lake more than 94, 76, and 89 percent of the time at each reservoir, respectively. At Union Valley Reservoir, the minimum reservoir storage requirement is not met on 16 of 282 relevant end-of-month simulation days; at Ice House Reservoir, the minimum reservoir storage requirement is not met on 67 of 282 relevant end-of-month simulation days, and at Loon Lake the minimum reservoir storage requirement is not met on 30 of 282 relevant end-of-month simulation days.[3] Under the Climate Change Conditions With-Project scenario, there was no change in the ability to meet storage requirements at Ice House Reservoir and Loon Lake (i.e., Climate Change Conditions With-Project meet storage conditions with the same frequency as the Climate Change Conditions baseline) and minimum storage requirements at Union Valley Reservoir were met more than 85 percent of the time (Union Valley minimum reservoir storage requirement was not met on 41 of 282 relevant end-of-month simulation days).

As discussed in Section 4.2, *Summary of Surface Water Hydrology Results*, while the modeling results predict instances when storage levels would not meet the requirements, this would not occur under actual reservoir operations. SMUD would not violate FERC conditions for the Proposed Project. As occurs now and would continue to occur under the Proposed Project, SMUD consistently monitors and would adjust operations at facilities (e.g., real-time adjustment to releases) to achieve compliance with applicable agreements and regulatory requirements.

El Dorado Irrigation District’s Project 184 Facilities

End-of-month storage in Aloha, Echo, Caples and Silver Lakes under the Climate Change Conditions With-Project scenario were generally either negligible or any average decreases were below one percent of the lake’s developed storage capacity (**Table F-7**). Slightly larger decreases were simulated to occur at Silver Lake. End-of-month storage at Silver Lake was found to decrease on average by 0.9 percent as a result of the Climate Change Conditions With-Project scenario. The average Silver Lake storage decrease of 78 af amounts to approximately 0.9 percent of Silver Lake’s developed storage capacity, with largest decreases of 7.7 percent or 661 af.

[3] Minimum reservoir storage requirements apply only three months of the year (July, August, and September); thus, over the 94-year simulation period there are (94*3) 282 end-of-month simulation days with minimum reservoir storage requirements.

TABLE F-7
SUMMARY OF ARIOPS-SIMULATED MONTHLY LONG-TERM AVERAGE RESERVOIR STORAGE AT EID PROJECT 184 RESERVOIR STORAGE LOCATIONS UNDER THE CLIMATE CHANGE CONDITIONS BASELINE AND CLIMATE CHANGE CONDITIONS WITH-PROJECT

Location and Compared Modeling Scenarios	Developed storage capacity	Long-Term Average All Years (Magnitude)[a]	Long-Term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for All Years (Percent [magnitude])[b]			Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for Critical/Dry Water Years (Percent [magnitude])[b]		
				Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Caples Lake (af)									
Climate Change Conditions Baseline	20,338	16,586	14,609	-	-	-	-	-	-
Climate Change Conditions With-Project	20,338	16,552	14,549	-0.9% (-181)	0.7% (137)	-0.2% (-33)	-0.7% (-143)	0.1% (15)	-0.3% (-59)
Silver Lake (af)									
Climate Change Conditions Baseline	8,640	4,305	3,570	-	-	-	-	-	-
Climate Change Conditions With-Project	8,640	4,227	3,448	-7.7% (-661)	0.7% (64)	-0.9% (-78)	-7.7% (-661)	0.7% (64)	-1.4% (-122)
Aloha Lake (af)									
Climate Change Conditions Baseline	5,063	1,247	856	-	-	-	-	-	-
Climate Change Conditions With-Project	5,063	1,230	836	-3.0% (-150)	1.0% (50)	0.3% (-16)	-3.0% (-150)	0.4% (18)	-0.4% (-20)
Echo Lake (af)									
Climate Change Conditions Baseline	2,000	702	499	-	-	-	-	-	-
Climate Change Conditions With-Project	2,000	700	495	-1.0% (-19)	0% (0)	-0.1% (-2)	-1.0% (-19)	0% (0)	-1.2% (-4)

NOTES: af = acre-feet; ARIOps = American River Integrated Operations model; EID = El Dorado Irrigation District

See Appendix G, *Modeling Technical Appendix*, for a complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).
b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage-change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum percent- and magnitude-change values do not necessarily correspond to changes occurring in the same month and water year type. Percent change calculated as a percentage of developed storage capacity.

The average percent decreases to storage at Aloha Lake and Echo Lake were relatively small, 0.3 percent and 0.1 percent, respectively, and the magnitude of average decreases were also small amounting to only 16 af and 2 af, respectively (Table F-7). As with the SMUD FERC projects (UARP and Chili Bar), all flows and storage elevations at El Dorado Irrigation District (EID) Project 184 facilities are subject to requirements set forth by the State Water Board water quality certifications for the El Dorado Project (FERC Project No. 184). These flow requirements were developed by the State Water Board and others to be protective of upper American River water quality standards and beneficial uses; these requirements are implemented in ARIOps as criteria and are met in all model scenarios for these locations.

Jenkinson Lake and Stumpy Meadows Reservoir

Implementation of the Proposed Project would allow EID and Georgetown Divide Public Utility District more flexibility in their operation of Jenkinson Lake and Stumpy Meadows Reservoir, respectively, and thus presents a unique situation. For instance, comparing the existing-conditions baseline to the Climate Change Conditions baseline, both reservoirs are simulated to experience potentially large reductions in average end-of-month storage under a scenario with climate change and future demands but without the Proposed Project (**Table F-8**). These decreases in storage without the Proposed Project are generally only attributable to water management operations, i.e., decreases are due to increased West Slope water demands and EID and Georgetown Divide Public Utility District facilities being operated to meet the full capacity demand without available supply. However, with implementation of the Proposed Project, these decreases would be less; as such, while a scenario with climate change and future demands with the Proposed Project still results in reductions in average end-of-month storage compared to the Climate Change Conditions baseline, the magnitude of reductions is substantially reduced compared to what would occur without the Proposed Project (Table F-8).

TABLE F-8
SUMMARY OF ARIOPS-SIMULATED MONTHLY LONG-TERM AVERAGE RESERVOIR STORAGE AT JENKINSON LAKE AND STUMPY MEADOWS RESERVOIR UNDER THE CLIMATE CHANGE CONDITIONS BASELINE AND CLIMATE CHANGE CONDITIONS WITH-PROJECT

Location and Compared Modeling Scenarios	Long-Term Average All Years (Magnitude)[a]	Long-Term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-Term Average Monthly Changes from Baseline Conditions to With-Project for All Years (Percent [magnitude])[b]			Comparison of Long-Term Average Monthly Changes from Baseline Conditions to With-Project for Critical/Dry Water Years (Percent [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Jenkinson Lake (af)								
Climate Change Conditions Baseline	31,609	24,844	-	-	-	-	-	-
Climate Change Conditions With-Project	26,248	18,161	-39.8% (-8,278)	-2.5% (-982)	-17.3% (-5361)	-39.8% (-8278)	-15.3% (-3,720)	-27.3% (-6,683)
Stumpy Meadows Reservoir (af)								
Climate Change Conditions Baseline	18,435	15,768	-	-	-	-	-	-
Climate Change d Conditions With-Project	15,946	11,684	-38% (-4,736)	0% (0)	-14% (-2,489)	-38% (-4,736)	-17% (-3,157)	-26.5% (-4,084)

NOTES: af = acre-feet; ARIOps = American River Integrated Operations model

See Appendix G, *Modeling Technical Appendix*, for a complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).
b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum percent and magnitude change values do not necessarily correspond to changes occurring in the same month and water year type.

F.5.2 Lower American River and CVP/SWP Water Operations and Water Quality (CalSim 3 and HEC-5Q)

Lower American River Flows and Temperatures, and Folsom Lake Storage

Changes in simulated (CalSim 3), long-term average monthly surface water parameters between the Climate Change Conditions With-Project scenario under the Climate Change Conditions baseline are summarized in **Table F-9**. Changes in simulated (HEC-5Q), long-term monthly average water temperatures for the Lower American River are summarized in **Table F-10**.

Based on CalSim 3 and HEC5Q modeling results, the majority of the changes for Folsom Lake and the lower American River under the Climate Change Conditions With-Project scenario were relatively negligible compared to Climate Change Conditions baseline. Across all water year types, the maximum decrease in average end-of-month Folsom Lake storage under the With-Project conditions was 7.9 percent (or 25,000 af). However, decreases of this magnitude were temporally limited and, on average, the long-term monthly decrease was 1.7 percent (or approximately 8,000 af).[4] These simulated storage changes are attributable to the simulated decreases in South Fork American River flows into Folsom Lake and primarily occurred between August and January and were greater in drier water year types.

Comparison of Climate Change Conditions With-Project and Climate Change Conditions baseline long-term monthly average flows for the Lower American River at Nimbus for each of the five water year types found that in January, February, May, and June of Dry years and September of Wet years did simulated flow reductions exceed 5 percent for the Project-Only scenario (the maximum simulated long-term monthly average flow decrease was 9.3 percent). Like storage decreases at Folsom Lake, flow decreases of these magnitudes (e.g., greater than 3–4 percent) were temporally limited and, on average, long-term monthly Project-Only simulated flows at the American River at Nimbus decreased by only 1.6 percent compared to Baseline conditions. Despite the slight decreases, simulated flows at this location always met the minimum-flow requirements set forth in State Water Board Decision 893 and were above the minimum-flow targets set forth in the Modified American River Flow Management Standard (Sacramento Water Forum 2015; ARWA 2017) at a near-identical rate across all modeling scenarios. (For example, flows recommended in the standard were met above 98.7 percent of the time in each model scenario.)

HEC-5Q model results for several locations along the Lower American River show no changes in long-term monthly average water temperatures greater than 5 percent (Table F-10). Overall, simulated water temperatures along the Lower American River under the Climate Change Conditions With-Project scenario were always similar to Climate Change Conditions baseline and effectively showed very little change. Maximum simulated increases in long-term average monthly temperature at all Lower American River HEC-5Q model output locations between the Climate Change Conditions With-Project scenario and Climate Change Conditions baseline were always no more than approximately 0.5 percent (i.e., no more than 0.4°F).

4 Decreases of this magnitude represent roughly 0.8 percent of total Folsom storage capacity.

TABLE F-9
SUMMARY OF CALSIM 3–SIMULATED MONTHLY LONG-TERM AVERAGE STREAMFLOWS AND RESERVOIR STORAGE UNDER THE CLIMATE CHANGE CONDITIONS BASELINE AND CLIMATE CHANGE CONDITIONS WITH-PROJECT

Location and Compared Modeling Scenarios	Long-Term Average All Years (Magnitude)[a]	Long-Term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for All Years (Percent change [magnitude change])[b]			Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for Critical/Dry Water Years (Percent change [magnitude change])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
American River at Nimbus (cfs)								
Climate Change Conditions Baseline	3,379	1,585	-	-	-	-	-	-
Climate Change Conditions With-Project	3,323	1,548	-6.1% (-172)	1.2% (18)	-1.6% (-49)	-6.1% (-112)	1.2% (18)	-2.1% (-37)
Sacramento River at Wilkins Slough (cfs)								
Climate Change Conditions Baseline	8,682	6,008	-	-	-	-	-	-
Climate Change Conditions With-Project	8,682	6,023	-1.4% (-61)	1.6% (193)	0.1% (9)	-1.4% (-61)	1.6% (193)	0.1% (14)
Feather River Flows at Mouth (cfs)								
Climate Change Conditions Baseline	7,766	3,267	-	-	-	-	-	-
Climate Change Conditions With-Project	7,765	3,267	-1.8% (-113)	2% (119)	0.1% (1)	-1.5% (-113)	1% (28)	0.1% (-1)
Delta Outflow (cfs)								
Climate Change Conditions Baseline	22,685	7,855	-	-	-	-	-	-
Climate Change Conditions With-Project	22,626	7,851	-1% (-547)	1.7% (379)	-0.2% (-33)	-0.8% (-137)	1.7% (379)	-0.1% (-3)
Folsom Reservoir (TAF)								
Climate Change Conditions Baseline	576	450	-	-	-	-	-	-
Climate Change Conditions With-Project	567	437	-5% (-20)	0.1% (0)	-1.3% (-7)	-5% (-20)	-1.5% (-6)	-2.8% (-12)
Shasta Lake (TAF)								
Climate Change Conditions Baseline	3,125	2,607	-	-	-	-	-	-
Climate Change Conditions With-Project	3,122	2,590	-1.7% (-30)	0% (1)	-0.3% (-8)	-1.7% (-30)	0% (-1)	-0.8% (-17)
Trinity Lake (TAF)								
Climate Change Conditions Baseline	1,527	1,207	-	-	-	-	-	-
Climate Change Conditions With-Project	1,525	1,203	-0.8% (-7)	0% (1)	-0.1% (-2)	-0.8% (-7)	-0.1% (-2)	-0.4% (-4)

Location and Compared Modeling Scenarios	Long-Term Average All Years (Magnitude)[a]	Long-Term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for All Years (Percent change [magnitude change])[b]			Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for Critical/Dry Water Years (Percent change [magnitude change])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Lake Oroville (TAF)								
Climate Change Conditions Baseline	2,172	1,706	-	-	-	-	-	-
Climate Change Conditions With-Project	2,171	1,697	-0.9% (-13)	0% (0)	-0.3% (-6)	-0.9% (-13)	-0.3% (-5)	-0.5% (-8)

NOTES: cfs = cubic feet per second; TAF = thousand acre-feet

See Appendix G, *Modeling Technical Appendix*, for a complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).
b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage-change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum percent- and magnitude-change values do not necessarily correspond to changes occurring in the same month and water year type.

TABLE F-10
SUMMARY OF HEC-5Q SIMULATED MONTHLY LONG-TERM AVERAGE WATER TEMPERATURES UNDER THE CLIMATE CHANGE CONDITIONS BASELINE AND CLIMATE CHANGE CONDITIONS WITH-PROJECT

Location and Compared Modeling Scenarios	Long-Term Average All Years (Magnitude)[a]	Long-Term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for All Years (Percent [magnitude])[b]			Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for Critical/Dry Water Years (Percent [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
American River below Folsom Dam (°F)								
Climate Change Conditions Baseline	57.6	59.6	-	-	-	-	-	-
Climate Change Conditions With-Project	57.6	59.6	-0.9% (-0.5)	0.6% (0.4)	0% (0)	-0.9% (-0.5)	0.6% (0.4)	0% (0)
American River below Nimbus (Hazel Avenue) Dam (°F)								
Climate Change Conditions Baseline	58.3	60.4	-	-	-	-	-	-
Climate Change Conditions With-Project	58.3	60.4	-0.6% (-0.4)	0.5% (0.3)	0% (0)	-0.6% (-0.4)	0.5% (0.3)	0% (0)
American River at Watt Avenue (°F)								
Climate Change Conditions Baseline	60.6	63.2	-	-	-	-	-	-
Climate Change Conditions With-Project	60.7	63.3	-0.3% (-0.2)	0.5% (0.4)	0.1% (0)	-0.3% (-0.2)	0.5% (0.4)	0.1% (0.1)

NOTES: °F = degrees Fahrenheit

See Appendix G, *Modeling Technical Appendix*, for a complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).
b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage-change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum percent- and magnitude-change values do not necessarily correspond to changes occurring in the same month and water year type.

CVP/SWP–Related Rivers and Storage Facilities

Based on CalSim 3 modeling results, average changes in long-term average end-of-month storage at Shasta Lake, Trinity Lake, and Lake Oroville reservoirs under the Climate Change Conditions With-Project scenario were all less than 10 TAF and all changes were below 1 percent of total reservoir storage capacity. Further, no simulated changes in long-term, average end-of-month storage at Shasta Lake, Trinity Lake, and Lake Oroville reservoirs under the Climate Change Conditions With-Project scenario exceeded 5 percent when compared to the Climate Change Conditions baseline (Table F-9). During certain months and water year types, potentially large-magnitude simulated storage decreases (e.g., 10 TAF) occurred at Shasta Lake and Lake Oroville. These decreases occurred primarily during drier water year types. A main driver of these small changes in reservoir storages is re-balancing of CVP north-of-Delta reservoirs and changing requirements under the Coordinated Operations Agreement, to make up for the slight reductions in releases from Folsom due to the Proposed Project (per the CalSim 3 model results). In other words, the reservoirs are releasing more water to meet downstream obligations (e.g., Delta flows, water deliveries), which is why many of the simulated monthly flow changes for the Sacramento and Feather River are slightly positive.

Like the CVP/SWP reservoirs, long-term average monthly flows for the Sacramento and Feather Rivers and Delta outflows were very similar between the Climate Change Conditions With-Project scenario and Climate Change Conditions baseline. For example, on average, average monthly flows for these locations were nearly identical between these modeling scenarios. Further, no simulated changes in long-term, average monthly flows under the Climate Change Conditions With-Project scenario exceeded 5 percent when compared to Climate Change Conditions baseline (Table F-9).

Delta Water Quality

Changes in Delta water quality between the Climate Change Conditions With-Project scenario and the Climate Change Conditions baseline were found to be minimal. The key parameters assessed, including the number of days the DCC gates are open and the X2 salinity position, exhibited only negligible differences between the two scenarios. The results, summarized in **Table F-11**, indicate that the Proposed Project's effect on Delta water quality is limited, with no significant deviations from baseline conditions.

The simulated number of days the DCC gates are open under both the Climate Change Conditions baseline and the With-Project scenario remains virtually unchanged, with only minor variations. On average, there was a maximum decrease of -4.8 percent (or -1 day) in the number of days the gates were open, and a maximum increase of 3 percent (or 0 days). Overall, the change in DCC gate operation due to the project is negligible, with an average variation of 0.1 percent (0 days), indicating that the project does not significantly affect gate operations or salinity management through the DCC.

TABLE F-11
SUMMARY OF CALSIM 3–SIMULATED MONTHLY LONG-TERM AVERAGE WATER QUALITY PARAMETERS UNDER THE CLIMATE CHANGE CONDITIONS BASELINE AND CLIMATE CHANGE CONDITIONS WITH-PROJECT

Location and Compared Modeling Scenarios	Long-Term Average All Years (Magnitude)[a]	Long-Term Average Dry/ Critical Years (Magnitude)[a]	Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for All Years (Percent [magnitude])[b]			Comparison of Long-Term Average Monthly Changes from Climate Change Conditions Baseline to With-Project for Critical/Dry Water Years (Percent [magnitude])[b]		
			Minimum Change	Maximum Change	Average Change	Minimum Change	Maximum Change	Average Change
Delta Cross Channel (Days gates open)								
Climate Change Conditions Baseline	13	13	-	-	-	-	-	-
Climate Change Conditions With-Project	13	13	-4.8% (-1)	3% (0)	-0.1% (0)	0% (0)	0.5% (0)	0% (0)
X2 Position (km)								
Climate Change Conditions Baseline	78	84	-	-	-	-	-	-
Climate Change Conditions With-Project	78	84	-0.1% (-0.1)	0.9% (0.7)	0.1% (0)	0% (0)	0.9% (0.7)	0.1% (0.1)

NOTES: km = kilometers

See Appendix G, *Modeling Technical Appendix*, for complete description of all modeling scenarios and rationale for effects analysis.

a. Calculated as arithmetic mean of long-term average of monthly averages from entire simulation period (1922–2015).

b. Calculated from long-term monthly averages from specified water year types (i.e., all five water year types or just Critically Dry and Dry year types). Percentage-change statistics are shown first followed by magnitude changes in parentheses. Percent-change and magnitude-change statistics are calculated independently, meaning that the minimum and maximum percent- and magnitude-change values do not necessarily correspond to changes occurring in the same month and water year type.

The X2 salinity position, which indicates the location where the salinity level in the Delta reaches 2 parts per thousand (ppt), also showed minimal changes between the With-Project scenario and the Climate Change baseline. The maximum change in X2 position was an increase of 0.9 percent (or 0.7 km), and the average change across all water year types was 0.1 percent (or 0.1 km). These shifts are small enough to be considered insignificant in terms of their effect on salinity control in the Delta. All modeled X2 positions remained within acceptable limits, ensuring compliance with D-1641 objectives, which require the X2 position to remain west of Collinsville during critical months (i.e., less than 81 km).

In addition to the minor changes in the DCC gate operations and X2 position, the modeling results indicate that salinity criteria at key Delta locations—such as Rock Slough, Emmaton, Jersey Point, and Collinsville—were consistently met under both the Climate Change baseline and With-Project scenarios. Salinity objectives, as outlined in D-1641 standards, including the Net Delta Outflow Index and the export-to-inflow ratio, were also maintained across all model scenarios. The results show that salinity criteria were met on more than 93 percent of simulation days, consistent with previous CalSim 3 modeling (DWR 2017, 2021). This highlights the effectiveness of the existing water management systems in meeting regulatory requirements, even under climate change conditions.

The comparison of Delta water quality between the Climate Change Conditions With-Project scenario and the Climate Change Conditions baseline shows that the project has a negligible effect on critical water quality parameters such as the Delta Cross Channel gate operations and the X2 salinity position. Both parameters remain within regulatory limits, and the project does not significantly alter salinity control or water quality management in the Delta. This indicates that the project's contribution to changes in Delta water quality is minimal, ensuring continued compliance with D-1641 objectives and other water quality standards under future climate conditions.

F.6 Summary of Findings

Broadly, changes in simulated surface hydrology parameters follow projected changes to future surface air temperature, precipitation, and runoff patterns and associated expected water system responses. For instance, while there is uncertainty around the magnitude and direction of projected precipitation patterns, most global climate models forecast that regional average fall and spring precipitation in the upper American River basin will decrease, winter and summer precipitation will increase, and a greater proportion of precipitation will occur as rainfall rather than snow (Reclamation 2022). Coupled with increasing surface air temperatures the result is a shift in runoff distribution from May and June to earlier in the season (January to March). These shifts were clearly illustrated in Climate Change Conditions baseline simulated flow patterns, which often exhibited a decrease in May–June flow rates and an increase in November–April flows compared to the existing-conditions baseline (Figure F-1). A similar shift is seen in simulated upper American River basin reservoir storage patterns, whereby peak storage occurs one to two months earlier in the water year under the Climate Change Conditions baseline (i.e., May vs. June) (Figure F-2).

When comparing the Climate Change Conditions With-Project to the Climate Change Conditions baseline, the changes in water storage and river flows are generally modest. At Folsom Reservoir, storage decreases by a maximum of 7.9 percent (or -25,000 af), with an average reduction of 1.7 percent (or -8,000 af). These reductions are mostly concentrated between August and January, particularly during dry years, due to decreased inflows from the South Fork American River. Similarly, American River flows at Nimbus show slight reductions, with an average decrease of 1.6 percent and a maximum monthly reduction of 9.3 percent during certain months. These decreases are limited in duration, indicating that the overall effect of the Proposed Project on river flows is minimal. Water temperatures along the lower American River show little to no change, with a maximum increase of 0.5 percent (or 0.4°F), demonstrating that the Proposed Project has negligible effects on river temperatures.

The transition from the existing-conditions baseline to the Climate Change Conditions baseline reveals more significant effects. Folsom Reservoir experiences an average storage reduction of 5.7 percent (or -35,000 af), with a maximum reduction of 20.2 percent (or -145,000 af), primarily due to earlier snowmelt and reduced snowpack. Shasta, Trinity, and Oroville Lakes also show considerable reductions in storage. Shasta Lake's average storage decreases by 6 percent (or -175,000 af), Trinity Lake by 6 percent (or -92,000 af), and Lake Oroville by 8.7 percent (or -179,000 af), with the most pronounced reductions occurring during dry years. American River flows at Nimbus increase slightly by 2.9 percent (or 55 cfs), but monthly variability is significant, with flow reductions of up to 43.7 percent in some months and increases of 77.9 percent in others. Delta outflows also exhibit variability, with an average increase of 3.5 percent (or 1,470 cfs), although reductions of up to 45 percent occur in some months due to changes in runoff and reservoir operations.

These findings reveal that the Climate Change Conditions baseline introduces noticeable reductions in water storage and increased variability in river flows compared to the existing-conditions baseline. Reservoirs like Folsom, Shasta, Trinity, and Oroville face declines in storage, particularly during dry and critical water years, while river flows become more unpredictable.

In contrast, the Climate Change Conditions With-Project scenario results in only minor additional changes compared to the Climate Change Conditions baseline. Folsom Reservoir and the American River see small reductions in storage and flows, and water temperatures remain stable, indicating that the Proposed Project has minimal incremental effects on the system.

F.7 References

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