B.F. Sisk Dam Safety of Dam Modification Project Environmental Impact Statement / Environmental Impact Report

Appendix E: Climate Change Analysis

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Appendix E
Climate Change Analysis

This section examines the relationship of climate change effects to the environmental impacts and mitigation measures presented in Chapters 4 through 25. This section discussions impacts after implementation of proposed mitigation measures that are anticipated under the action alternatives for a range of possible future socioeconomic-climate scenarios.

E.1 Affected Environment/Environmental Setting

This section presents the existing climate within the Sacramento and San Joaquin River Basin along with projections of the foreseeable affected environment, the area of analysis and regulatory setting.

E.1.1 Area of Analysis

The climate impact analysis evaluates the existing conditions and impacts across the Sacramento-San Joaquin River watershed given this area’s influence on Central Valley Project (CVP) and State Water Project (SWP) operations at San Luis Reservoir. The study area includes the Sacramento-San Joaquin Delta, San Luis Reservoir and its related water infrastructure, the California Aqueduct, the Delta-Mendota Canal (DMC), and South-of-Delta CVP and SWP contractors’ service areas. Chapter 2, Project Description, identifies the locations of the various project components.

E.1.2 Regulatory Setting

Response to climate change is governed by several Federal and State laws and policies, which are listed below.

E.1.2.1 Federal

E.1.2.1.1 Secretarial Order No. 3289

In 2009, the Department of Interior (DOI) issued a Secretarial Order on climate change that expands DOI bureaus’ responsibilities in addressing climate change (amended on February 22, 2010). The purpose of Secretarial Order No. 3289 is to provide guidance to bureaus and offices within the DOI on how to provide leadership by developing timely responses to emerging climate change issues. This Order replaces Secretarial Order No. 3226, signed on January 19, 2001, entitled “Evaluating Climate Change Impacts in Management Planning.” It reaffirms efforts within DOI that are ongoing with respect to climate change.

Among the requirements of the Order is one that requires each bureau and office of DOI to "consider and analyze potential climate change impacts when undertaking long-range planning exercises, setting priorities for scientific research and investigations, and/or when making major decisions affecting DOI resources."

E.1.2.1.2 National Environmental Policy Act (NEPA) Handbook

The United States (U.S.) Department of the Interior, Bureau of Reclamation (Reclamation) *NEPA Handbook* (Reclamation 2012) recommends that climate change be considered, as applicable, in every NEPA analysis. The *NEPA Handbook* acknowledges that there are two interpretations of climate change in regards to Reclamation actions: 1) Reclamation's action is a potentially significant contributor to climate change and 2) climate change could affect a Reclamation proposed action. The *NEPA Handbook* recommends considering different aspects of climate change (e.g., relevance of climate change to the proposed action, timeframe for analysis, etc.) to determine the extent to which it should be discussed under NEPA.

E.1.2.1.3 Principles and Requirements for Federal Investments in Water Resources

Furthermore, Reclamation is subject to *Principles and Requirements for Federal Investments in Water Resources* (Council on Environmental Quality [CEQ] 2013). This document requires areas of risk and uncertainty to be identified, described, and considered when analyzing potential investments in water resources. It specifically requires climate change impacts to be accounted for and addressed.

E.1.2.1.4 Executive Order 13783

Section 3 of Executive Order (EO) 13783 ("Promoting Energy Independence and Economic Growth") rescinds certain energy and climate-related presidential and regulatory actions. Actions that were revoked include Executive Order 13653, Preparing the United States for the Impacts of Climate Change, and CEQ guidance entitled "Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews."

E.1.2.1.5 Secretarial Order No. 3360

In 2017, the DOI issued a Secretarial Order that continues the implementation of EO 13783 by rescinding documents inconsistent with EO 13783. The order rescinds Departmental Manual Part 523, Chapter 1: Climate Change Policy, and directs each bureau and office to review all existing regulations, orders, guidance documents, policies, instructions, notices, and implementing actions that are inconsistent with EO 13783 and initiate a process to suspend, revise, or rescind any such actions (DOI 2017).

E.1.2.2 State

E.1.2.2.1 California Executive Order S-3-05

On June 1, 2005, former California Governor Arnold Schwarzenegger signed Executive Order S-3-05. The order states that increased temperature due to climate change could reduce the Sierra Nevada snowpack, further exacerbate California's air quality concerns and potentially rise sea level. This executive order established greenhouse gas (GHG) emission reduction targets for California. The Secretary of the California Environmental Protection Agency (CalEPA) is also required to report about climate change impacts on water supply, public health, agriculture, the coastline, and forestry; mitigation and adaptation plans to combat these impacts must also be developed.

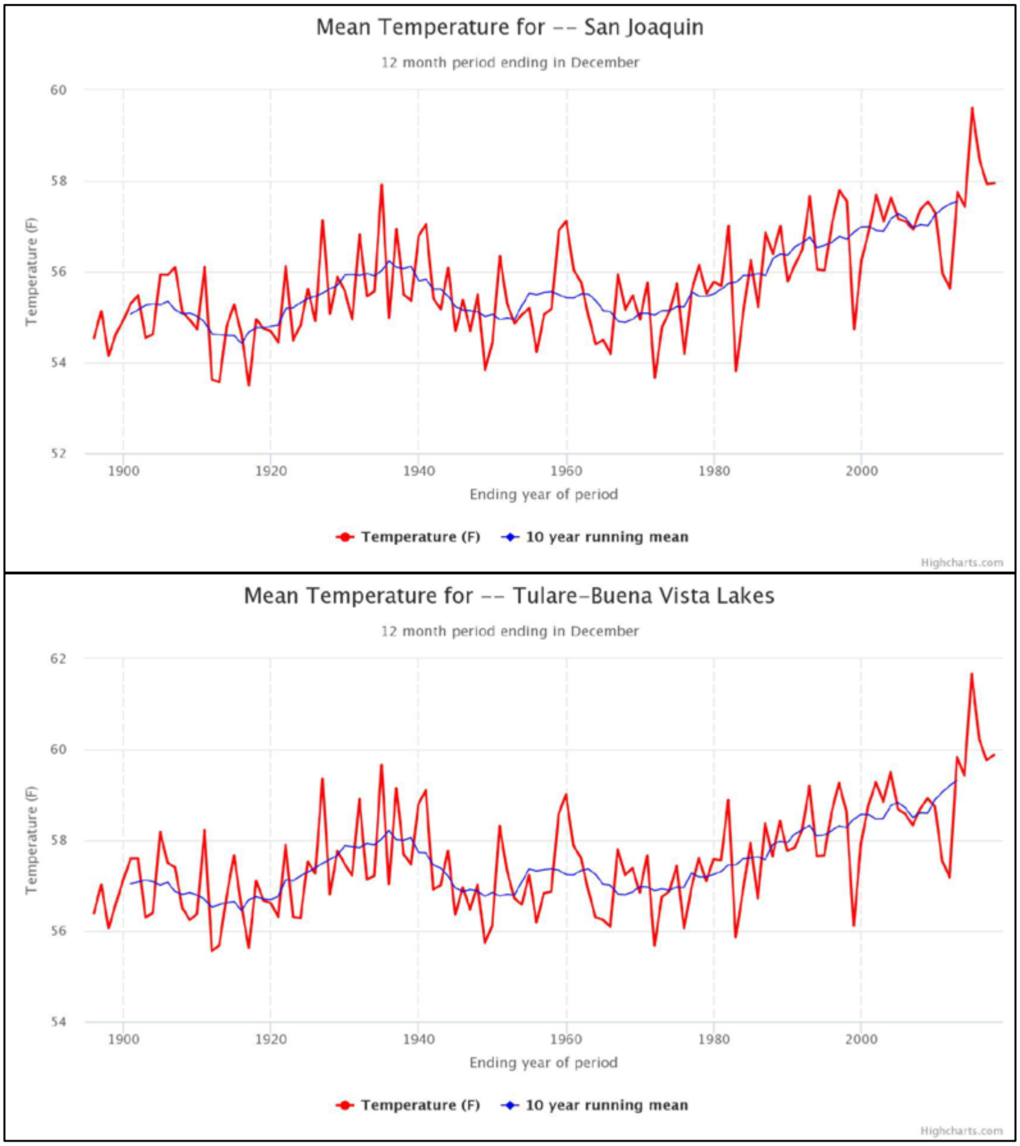
E.1.3 Affected Environment/Existing Conditions

This section presents the current and future climate trends in the area of analysis for use as the basis against which the incremental effects of the alternatives are compared in Section E.2 and to indicate the likely effect of climate change on the alternatives.

E.1.3.1 Historical Climate

E.1.3.1.1 Temperature

The Central Valley is characterized by hot, dry summers and cool, damp winters. Average daytime temperatures are 95 degrees Fahrenheit (°F) in the summer and 55°F in the winter. Over the course of the 20th century, average mean-annual temperature has increased by approximately 2°F, although not steadily. The increases occurred primarily during the early part of the 20th century between 1915 and 1935 and began again in the mid-1970s through the present (WestMap 2010). Figure E-1 shows the mean temperature in the San Joaquin and Tulare-Buena Vista Lakes Hydrological Units from 1895 to 2017.

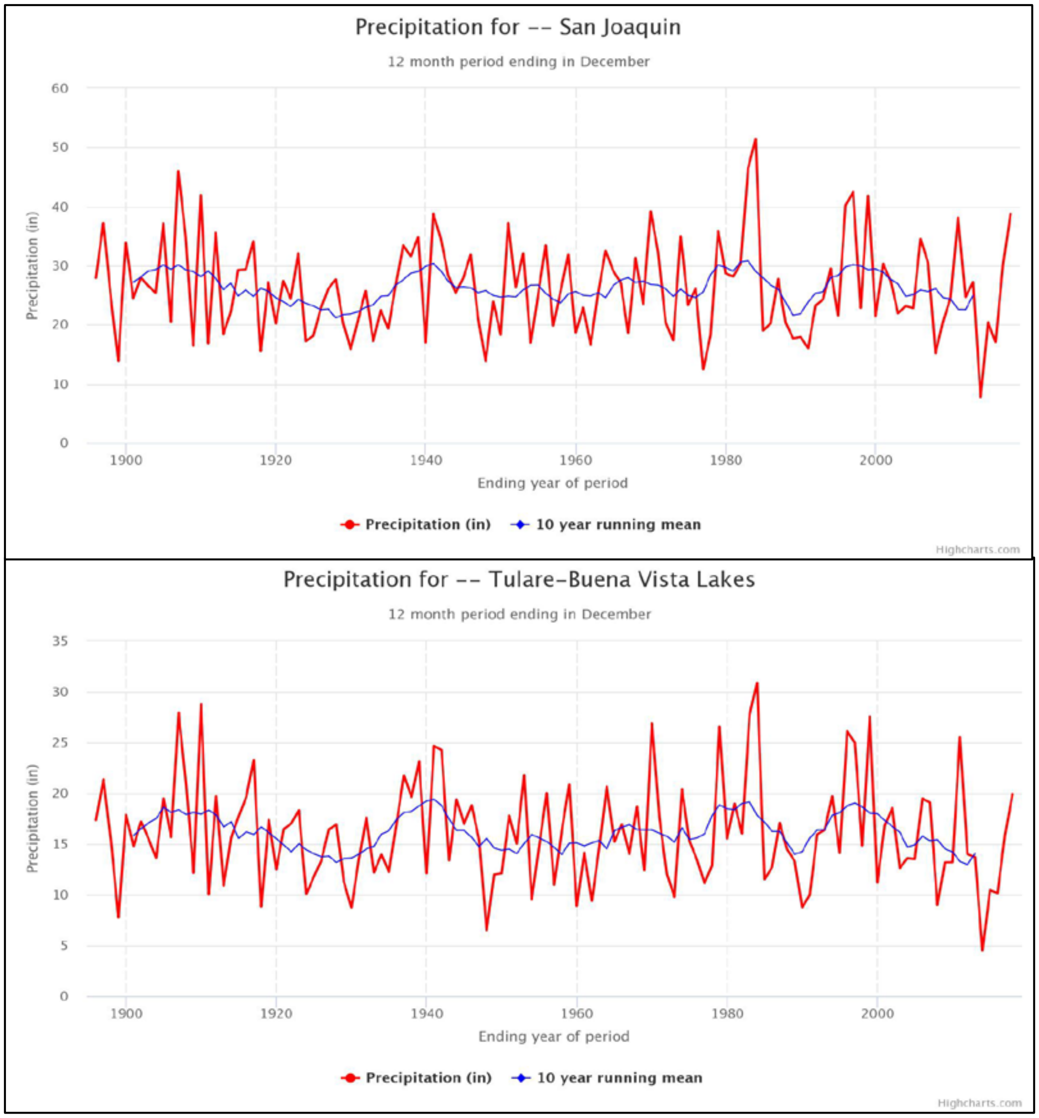


Source: WestMap 2010.
Notes: Red- Observed Annual; Blue- 10-Year Running Mean Annual

Figure E-1. Observed Annual and 10-Year Running Mean Annual Average Temperature in San Joaquin and Tulare-Buena Vista Lakes Hydrological Units from 1895 to 2017

E.1.3.1.2 Precipitation

Precipitation in the Central Valley falls primarily from mid-autumn to mid-spring. While snowfall is rare in the valley, temperatures below freezing may occur in the winter. The variability of annual precipitation has increased in the latter part of the 20^{th} century; These extremes in wet and dry years have been especially frequent since the 1980s (WestMap 2010). Figure E-2 shows the amount of precipitation in San Joaquin and Tulare-Buena Vista Lakes Hydrological Units from 1895 to 2017.



Source: WestMap 2010.
Notes: Red- Observed Annual; Blue- 10-Year Running Mean Annual

Figure E-2. Observed Annual and 10-Year Running Mean Annual Average Precipitation in San Joaquin and Tulare-Buena Vista Lakes Hydrological Units from 1895 to 2017

E.1.3.1.3 Streamflow and Snowpack

Historically, the streamflow in the Sacramento and San Joaquin River basins have varied from year to year. The runoff in the region varies by year and geography; with the northern Sacramento Valley experiencing more runoff than the drier conditions in the southern San Joaquin Valley.

Paleoclimate information is useful in understanding longer time horizons of natural variability (droughts, floods, alternative sequences of wet-dry periods). Paleo-reconstructed streamflow data that contains reconstructions for Sacramento, San Joaquin, and Klamath River streamflows shows significant and prolonged drought periods during the following periods: 975-981, 1292-1301, 1395-1400, 1475-1483, 1578-1582, 1924-1931, 1975-1977, 1987-1992, and 2007-2010 (Reclamation 2016b).

Two important findings can be drawn from this analysis. First, paleo droughts have been identified that demonstrate greater short-term severity than those in the observed streamflow record. Second, multiple droughts extending beyond 8 years have been identified in the paleo record and indicate that droughts of this length are not unique to the 1930s. However, the observed short-term 1975-1977 drought and the long-term 1924-1931 drought are among the most severe in both the paleo and observed records (Reclamation 2016b).

Runoff is also greater during the winter to early summer than the rest of the year. Winter runoff events are the consequence of rainfall while the spring and early summer events are more from snowmelt. Snowpack is measured as Snow Water Equivalent (SWE). Studies have shown a decreasing trend in the latter half of the 20th century, as measured by April 1st (Mote 2005). The research by Knowles et al (2007) supported these findings using SWE measurements from 1948 through 2001 at 173 stations. Another study reported decreasing spring SWE trends as much as 50 percent (Regonda et al. 2005).

Despite a slight increase or unchanged annual precipitation in the area, annual runoff increases did not occur in the Sacramento and San Joaquin rivers (Dettinger and Cayan 1995). However, the seasonal timing of runoff has shifted in the Sacramento River Basin. Between April and July, a 10 percent decrease in total runoff has been observed throughout the course of the 20th century (Roos 1991). This is supported by similar results from Dettinger and Cayan (1995) for the combined Sacramento River and San Joaquin River runoff. This is a contrast to increases in winter runoff, such as the Peterson et al. (2008) study, which found earlier runoff trends for 18 Sierra Nevada river basins.

Cayan et al. (2001) consider that the primary cause of the shift in runoff timing is due primarily from increasing spring temperatures and not increased winter precipitation.

E.1.3.2 Projections of Future Climate

E.1.3.2.1 Data Sources

Several reports were used as the main data sources for projected changes in climate for this evaluation. These reports provide finer-scale predictions of climate that consider the effects the Sierra Nevada have on weather patterns in the San Joaquin Basin and the project area. In some cases, these projections are different from those in California.

- **"Central Valley Project Integrated Resources Plan" (Reclamation 2014a) –** This study investigated the future water resources in the Central Valley, generating hydrology information based no six future climate conditions, five of which reflect climate change conditions. The five future climate conditions included: "(Q1) drier, less warming (relative to median); (Q2) drier, more warming; (Q3) wetter, more warming; and (Q4) wetter, less warming scenarios than captured by the ensemble median (Q5)." This included surface water runoff from San Joaquin River system from 2012 to 2099.

- **West-Wide Climate Risk Assessments: Sacramento and San Joaquin Basins Climate Impact Assessment" (Reclamation 2014b) -** The report complements and builds on the West-Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections (Reclamation 2011) climate change impact study. This report presents the results of the Sacramento and San Joaquin Climate Impact Assessment, which addresses climate change impacts in the Sacramento and San Joaquin Valley of California. A scenario based approach evaluating impacts of uncertainties associated with climate and socioeconomic conditions on water and related resources in the 21st century was evaluated in this report. A single socioeconomic projection representing a continuation of current population and land use trends was combined with 18 projections of future climate change (changes to temperature, precipitation and carbon dioxide [CO_2]). The 18 climate change projections include: one no climate change scenario, five ensemble-informed (EI5) scenarios that were developed using downscaled Global Climate Models (GCM) projections; and 12 California hydrology specific GCM projections identified by the State of California's Climate Action Team (CAT) for use in climate studies performed by the California Department of Water Resources (DWR) for the California Water Plan.

- **Sacramento and San Joaquin Rivers Basin Study: Basin Study Summary Report and Technical Report (Reclamation 2016a and 2016b) -** The Sacramento and San Joaquin Basins Study (Basins Study) was developed to address two primary questions: what is the future reliability of the Central Valley water system in meeting the needs of Basin users during the 21st century; and what are the actions and strategies that can adapt to future risks to these water and related resources? To answer these questions, the study developed an analysis approach to address uncertainties with future socioeconomic and climate conditions and to develop various scenarios with alternative views of how future conditions could change with climate change. The evaluation of these scenarios was completed using a modeling analysis to simulate future socioeconomic and climate conditions. The results of this modeling effort were used to analyze potential changes in future water supply and demand, and then develop and evaluate the potential performance of adaptation portfolios of water management actions designed to address future vulnerabilities.

The Basin Study developed five representative climate futures were developed for use in the Basins Study using results from recent GCM simulations (Intergovernmental Panel on Climate Change [IPCC] 2013) that had been further refined for use in climate studies. From these five climate futures, the Basin Study Summary Report focused on the reporting evaluation results from three of the five scenarios - the Central Tendency, Warm-Wet, and Hot-Dry scenarios. Climate future results from this range of scenarios were then input into the Water Evaluation and Planning model of the Central Valley (WEAP-CV) hydrology model to simulate water supply and demands that were used as inputs to the CalLite-CV model to simulate how the CVP, SWP, and other water management systems operate to meet urban, agriculture, and environmental needs. Results from the CalLite-CV model were used as the basis for a supply and demand imbalance analysis and as inputs into an evaluation of the adaptation portfolios performance. The combination of models assessed the effects of climate change on the following resource categories: delivery reliability, economics, water quality, hydropower and GHG emissions, flood control, recreation, and ecological resources. Various indicator metrics were used to evaluate the effects under each category.

E.1.3.2.2 Projected Changes in Climate

The projected changes in climate conditions are expected to result in a wide variety of impacts in the San Joaquin River Basin and the project area. Estimated future climate conditions include changes to:

- Annual temperature and seasonal temperature
- Extreme heat
- Precipitation
- Snowpack and streamflow

These projected changes are discussed in detail in the following paragraphs.

Annual Temperature. The San Joaquin basin area is expected to experience changes in annual average temperatures. As compared to the Reference-No-Climate-Change climate scenario, temperatures are expected to increase in the San Joaquin and Tulare Lake hydrologic regions by 0.9°C (1.6°F) in the early 21st century, by 1.9°C (3.4°F) by mid-century, and by 2.7°C (4.9°F) by late century (Reclamation 2016b). The further the distance from the cooling effect of the Pacific Ocean, the greater the change in temperature (Reclamation 2014a).

The predicted temperature increases represent the central tendency climate change scenario, but there is a large variability in projected temperatures depending on the modeled scenario. For example, for the Sacramento hydrologic region, projections range from 0.1°C to 1.3°C during the period 2015 to 2039 (Reclamation 2016b).

*Precipitation***.** Trends in annual precipitation trends are not apparent and vary widely based on the modeled climate change scenario and the region. In the San Joaquin hydrologic region, the models vary between predicting a slight decrease in precipitation in early 21st century to a nearly 12 percent increase in precipitation. The Tulare Lake hydrologic region shows a more pronounced variability in precipitation changes depending on the scenario and time frame. However, all regions and climate change scenarios predict an increase in precipitation by the end of the 21st century (Reclamation 2016b). Table E-1 summarizes the uncertainty around the mean projected precipitation changes.

Table E-1. Range of Projected Precipitation Changes between Central Tendency Climate Scenario and 12 CCTAG Mean

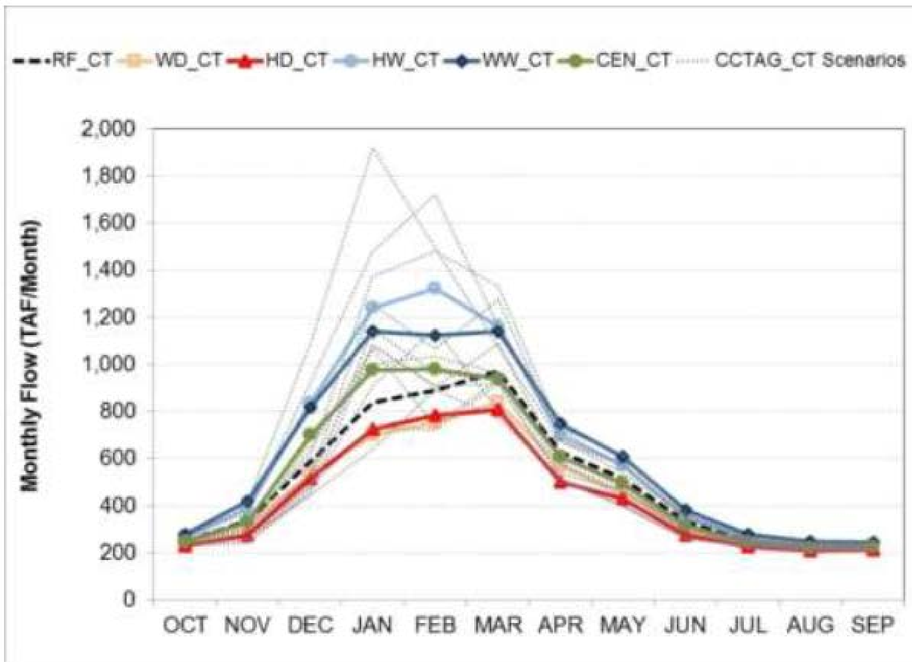
Area	Early 21st Century (2015-2039)	Mid-21st Century (2040-2069)	Late 21st Century (2070-2099)
Sacramento River hydrologic region	+7.9% to +34.5%	+2.1% to +3.7%	+3.9% to +5.2%
San Joaquin River hydrologic region	-0.2% to +11.7%	+0.8% to +1.4%	+4.8% to +2.5%
Tulare Lake hydrologic region	-11.4% to +28.6%	-0.4% to +0.3%	+1.5% to +2.2%

Source: Reclamation 2016b

Snowpack and Streamflow. Predictions in future streamflows vary widely based on the climate change scenario being modeled. In the San Joaquin River region, the Central Tendency climate scenario predicts an average annual streamflow about 0.2 percent lower than the Reference-No-Climate-Change climate scenario. However, the drier climate scenarios predicted a decrease of up to 23 percent, while the wetter climate scenarios predicted substantially higher streamflows of up to 30 percent (Reclamation 2016b). In the Tulare Lake region, the Central Tendency climate scenario predicted a decrease of about 4.3 percent compared to the Reference-No-Climate-Change climate scenarios, while the other scenarios were in the same approximate range as the San Joaquin River (Reclamation 2016b).

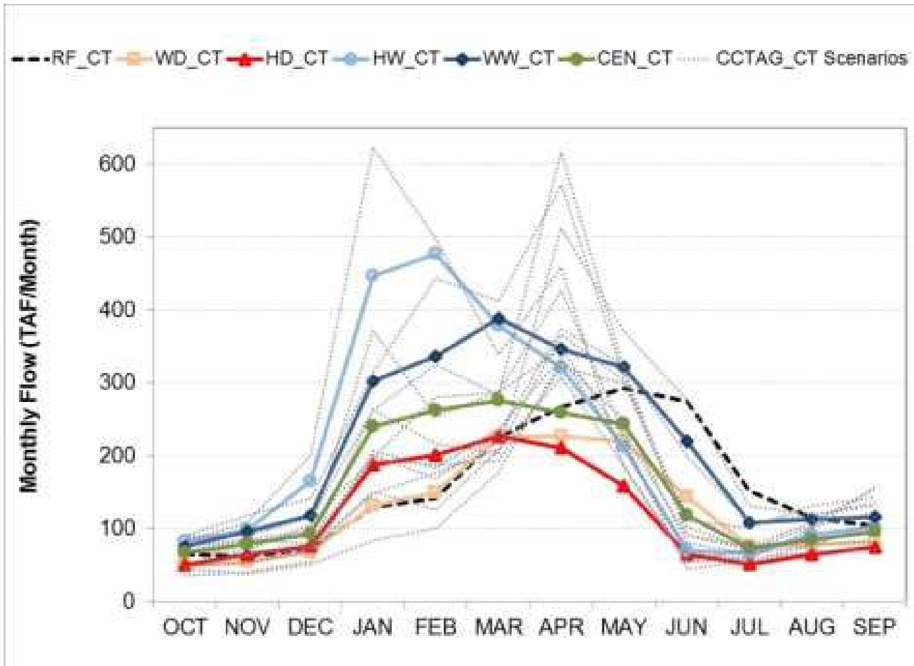
Snowpack is predicted to decline considerably because of warming in the lower elevations. Consequently, spring runoff is predicted to decreased because of the reduced winter snowpack. Peak runoff could occur a month earlier in some water sheds and is predicted to increase during fall and winter months (Reclamation 2016b). The seasonal runoff shift in the Sacramento and San Joaquin basins are primarily due to lower elevations of these basins and their susceptibility to warming-induced changes in precipitation from snow to rain (Reclamation 2014b).

Figures E-3 and E-4 show the monthly inflow pattern in into Lake Shasta on the Sacramento River and Millerton Lake on the San Joaquin River under the five EI5 scenarios and twelve CAT scenarios. The seasonal shifts in runoff into these reservoirs are primarily due to lower elevations of the Sacramento and San Joaquin basins upstream of these reservoirs and their susceptibility to warming-induced changes in precipitation from snow to rain (Reclamation 2016a).



Source: Reclamation 2016a; Note: TAF/yr = thousand acre-feet per year

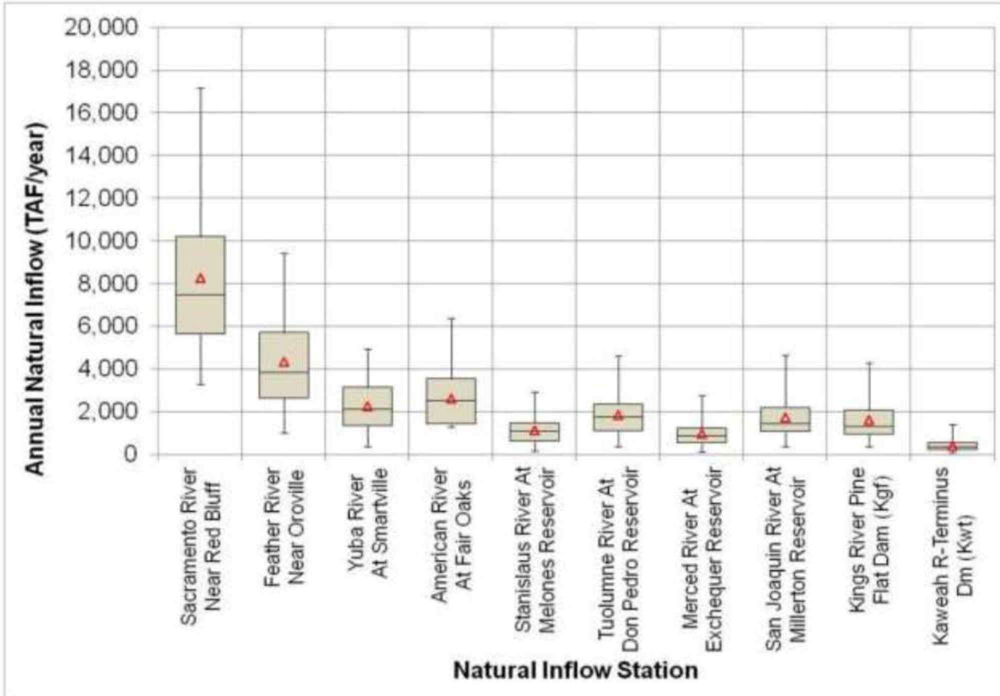
Figure E-3. Projected Average Streamflow in Each Month into Lake Shasta in Each Climate Scenario



Source: Reclamation 2016a; Note: TAF/yr = thousand acre-feet per year

Figure E-4. Projected Average Streamflow in Each Month into Millerton Lake in Each Climate Scenario

The mean historic annual flows from water year 1922 (October 1, 1922 to September 30, 1923) to water year 2010 at each of the major natural flow locations are shown on Figure E-5. Also shown is the variability of annual flows as "boxwhisker" ranges.



Source: Reclamation 2016a
Notes: Black line represents median, box represents the 25th and 75th percentiles; whiskers represent the maximum and minimum, and triangle represents the mean flow. TAF/year = thousand acre-feet per year

Figure E-5. Average Annual Total Natural Flows for Major Locations

E.1.3.2.1 Associated Impacts

The combined changes in climate result in various impacts for California and the project area. Potential impacts include changes to water supply and demand, natural resources, and agriculture. Descriptions of the associated impacts are included below.

Water Quality, Supply and Demand: Within the San Francisco Bay (Bay), fresh water from the Sacramento and San Joaquin rivers mixes with salt water from the Pacific Ocean. This mixing is affected in part by tides, waves, and fresh water inflow and itself affects water quality, sediment transport, and ecology in the Bay and Delta. DWR and Reclamation manage flow release to the Delta to regulate salinity levels to protect municipal and industrial, agricultural, and fish and wildlife uses. Water quality standards for the Delta include salinity levels, which indicate the health of the Bay-Delta ecosystems, levels of seawater intrusion, and fresh water availability. Delta salinity standards are specified in units of electrical conductivity (EC) expressed as micro-Siemens per centimeter (µS/cm) at several Delta compliance locations (Reclamation 2016b).

Under the Reference-No-Climate-Change climate/Current Trends socioeconomic scenarios, the EC at all locations shows only small differences between the averages for the early, middle, and late portions of the 21st century.

However, in the climate change scenarios, the EC results greatly increase as the simulation moves later into the twenty-first century, reflecting the effects of sea level rise on Delta salinity. Among the climate change scenarios, the EC levels are highest among the driest scenarios (e.g., Hot-Dry) and lowest among the wetter scenarios (e.g., Warm-Wet).

X2 is the location of the two parts per thousand (ppt) salinity concentration in the interior Delta (termed “ X2”). Maintaining X2 positions of less than 74 kilometers (km) and 81 km from the Golden Gate Bridge are goals specified in the U.S. Fish and Wildlife Service (USFWS) Biological Opinion (BiOp) for operation of the CVP and SWP, and maintaining them is identified as important for Delta smelt habitat conditions. The Sacramento and San Joaquin Basins Study (Reclamation 2016b) evaluated potential changes to X2 and determined that in all of the climate scenarios, the average X2 position increased as the simulation moved later into the 21st century due to rising sea levels. Specifically, the Basin Study identified an increase in the percentage of all of the February through June months modeled that X2 is greater than the 74 km metric on average in 31 percent of the months, an increase of 29 percent, and ranges from a minimum of 15 percent to a maximum of 53 percent. For the 81-km metric, X2 was above the metric on average in 7 percent of the months, an increase of 17 percent, and ranges from a minimum of 1 percent to a maximum of 16 percent.

SWP and CVP Delta exports is a significant water supply source for south-of-Delta water users. Given the projected changes in rainfall and snowpack, associated runoff patterns, south-of-Delta exports are likely to be impacted by climate change. Reductions in total exports will likely lower average San Luis Reservoir storage levels and increase the occurrence of low point conditions and water supply interruptions to Santa Clara Valley Water District (SCVWD).

Table E-2 summarizes projected South of Delta CVP deliveries under four climate change scenarios and Table E-3 summarizes projected SWP Table A deliveries under four climate change scenarios. The project deliveries presented in Table E-2 and Table E-3 summarize key results from the Sacramento and San Joaquin Basins Study CalLite-CV modeling results.

Table E-2. CVP South of Delta Deliveries

Sacramento Valley Index[1]	No Climate Change	Hot-Dry		Warm-Wet		Central Tendency	
	TAF	TAF	Change (TAF)[2]	TAF	Change (TAF)[2]	TAF	Change (TAF)[2]
Wet	2,716	2,254	-461	2,828	113	2,602	-113
Above Normal	2,360	1,589	-771	2,593	233	2,220	-141
Below Normal	2,265	1,678	-587	2,493	228	2,169	-96
Dry	1,919	1,301	-618	2,370	451	1,815	-104
Critical	1,441	1,101	-340	1,741	299	1,386	-55
All Years	2,134	1,586	-549	2,408	274	2,032	-102

Source: Reclamation 2016c
Notes:
[1] For the purpose of calculating average annual results by year type, the Sacramento Valley Indices for the Central Tendency were used for all climate change scenarios so that the same years and number of years of each year type were averaged for all scenarios. Sacramento Valley Indices for the Central Tendency scenario are similar to those in the No Climate Change scenario and result in a similar distribution of year types as the historical record. The distribution of year types, i.e. the number of wet, above normal, below normal etc. years, in the Hot-Dry and Warm-Wet scenarios can deviate from the historical distributions.
[2] Change calculated as difference from No Climate Change scenario
Key:
TAF = thousand acre feet

Table E-3. SWP Table A Deliveries

Sacramento Valley Index[1]	No Climate Change	Hot-Dry		Warm-Wet		Central Tendency	
	TAF	TAF	Change (TAF)[2]	TAF	Change (TAF)[2]	TAF	Change (TAF)[2]
Wet	3,265	2,895	-370	3,365	100	3,175	-90
Above Normal	2,910	2,306	-604	3,233	322	2,770	-141
Below Normal	2,635	1,912	-723	2,894	259	2,580	-56
Dry	2,329	1,607	-722	2,753	424	2,241	-89
Critical	1,652	1,268	-384	2,036	384	1,647	-5
All Years	2,557	2,006	-551	2,857	300	2,480	-77

Source: Reclamation 2016c
Notes:
[1] For the purpose of calculating average annual results by year type, the Sacramento Valley Indices for the Central Tendency were used for all climate change scenarios so that the same years and number of years of each year type were averaged for all scenarios. Sacramento Valley Indices for the Central Tendency scenario are similar to those in the No Climate Change scenario and result in a similar distribution of year types as the historical record. The distribution of year types, i.e. the number of wet, above normal, below normal etc. years, in the Hot-Dry and Warm-Wet scenarios can deviate from the historical distributions.
[2] Change calculated as difference from No Climate Change scenario
Key:
TAF = thousand acre feet

Natural Resources. Climate change will continue to affect natural ecosystems, including changes to biodiversity, location of species and the capacity of ecosystems to moderate the consequences of climate disturbances such as droughts (Reclamation 2016a and 2016b). In particular, species and habitats that are already facing challenges will be the most impacted by climate change (Reclamation 2016a and 2016b).

Multiple droughts have also been identified in longer time period paleo-climate records. This paleo-climate analysis indicates that severe droughts of longer duration than eight years are not unique to the historical record (Reclamation 2016a).

Other impacts to natural resources include:

- Rare or endangered species may become less abundant or extinct (Reclamation 2016a and 2016b).
- Reductions in the number of months with sufficient storage for cold water pool management (Reclamation 2016a and 2016b).
- Increased river temperatures under the Central Tendency and Hot-Dry climate future scenarios (Reclamation 2016a and 2016b).

Agriculture. Increased temperatures are projected to lengthen the growing season, but warmer temperatures effects individual crops differently. Warmer temperatures result in more rapid crop growth that counteracts the extension of the potential growing season by reducing the growth period. A temperature driven reduction in growth may result in less rather than more crop ET, which mainly affects most annual crops and some perennials. Because a reduction in a crop's growth period generally reduces the crop's yield and its economic value, growers will likely adapt to warming temperatures by planting more heat toleration cultivars that mature more slowly (Reclamation 2016a).

Table E-4 shows projected changes in central valley crop type acreage under the Current Trends Socio-Economic Scenario that was presented in the Sacramento and San Joaquin Basins Study (Reclamation 2016a). Table E-5a and Table E-5b show estimated change in crop yields as percent changes (Reclamation 2016a)

Table E-4. Central Valley Crop Types – Project Acreages

	Crop Acreage (Acres)			
	Period Average			
Crop Type Category	**2012**	**2012-2039**	**2040-2069**	**2070-2099**
Alfalfa	670,002	651,179	537,777	544,460
Almond/Pistachio	777,531	775,071	753,178	757,052
Other Deciduous	565,300	557,187	516,135	462,809
Pasture	259,635	258,678	209,569	142,557
Subtropical	247,333	246,980	224,105	243,875
Vineyards	591,866	587,760	529,984	484,574
Corn	654,120	623,784	509,202	426,455
Cotton	665,770	661,580	596,587	638,042
Cucurbits	91,414	91,303	87,087	90,639

Crop Type Category	Crop Acreage (Acres)			
	Period Average			
	2012	2012-2039	2040-2069	2070-2099
Dry Beans	60,746	59,294	51,574	37,819
Grain	360,558	364,500	304,440	296,034
Onion + Garlic	44,925	44,768	39,709	43,677
Other Field	412,383	378,927	269,827	165,864
Other Truck Cucumber[1] Other TruckLettuce[2]	215,886	207,971	180,453	198,905
Potatoes	25,879	24,834	24,755	24,656
Rice	496,146	546,137	522,968	487,804
Safflower	50,213	48,936	44,838	38,556
Sugar Beets	27,306	21,026	20,016	20,136
Tomatoes	340,921	340,600	331,928	337,863
Total Perennial Crop Acreage	**3,111,667**	**3,076,855**	**2,770,748**	**2,635,326**
Total Annual Crop Acreage	**3,446,266**	**3,413,660**	**2,983,383**	**2,806,449**
Total Central Valley Crop Acreage	**6,557,933**	**6,490,515**	**5,754,131**	**5,441,775**

Source: Reclamation 2016a

Notes:

[1] Sacramento Valley only.

[2] San Joaquin and Tulare Lake Basins only.

Table E-5a. Average Change in Crop Yield under each Climate Scenario (Percent)

Period	Alfalfa	Almonds and Pistachios	Corn	Cotton	Cucurbits	Dry Bean	Fresh Tomatoes	Grain	Onions and Garlic	Other Deciduous
2025										
Q4	7.37	-0.45	-0.47	6.27	11.53	9.93	9.81	12.98	6.03	4.60
Q5	6.68	-2.72	-2.00	6.53	10.45	9.05	8.84	13.63	5.69	2.38
Q2	6.26	-4.73	-3.78	6.20	9.32	7.83	7.21	14.04	5.27	0.73
2055										
Q4	18.48	-2.30	-3.45	13.60	26.53	24.93	25.78	26.66	14.26	12.23
Q5	13.48	-5.63	-6.62	13.37	25.13	23.82	23.66	28.52	13.16	9.42
Q2	17.88	-8.69	-9.40	13.73	24.33	24.67	24.42	29.83	12.70	8.03
2085										
Q4	25.77	-6.13	-9.22	17.21	35.92	35.75	36.52	36.92	18.63	16.28
Q5	27.25	-11.60	-15.62	17.97	37.94	40.64	41.46	41.71	18.15	15.44
Q2	24.64	-19.09	-24.08	15.54	31.44	38.49	38.28	42.24	13.73	9.80

Source: Reclamation 2016b

Table E-5b. Average Change in Crop Yield under each Climate Scenario (Percent)

Period	Other Field	Other Truck	Pasture	Potato	Processing Tomatoes	Rice	Safflower	Sugar Beet	Subtropical	Vine
2025										
Q4	0.98	12.33	5.41	3.23	1.72	6.71	3.88	0.73	-0.32	3.03
Q5	-0.58	13.85	6.17	2.00	-1.68	5.06	4.12	-1.71	-4.67	0.37
Q2	-2.24	15.00	6.20	1.33	-5.63	3.28	4.52	-3.58	-8.20	-1.82
2055										
Q4	-0.35	28.42	11.37	7.89	5.38	16.18	9.39	2.14	0.06	9.12
Q5	-3.06	30.45	11.78	5.58	-1.51	13.81	8.86	-1.97	-5.81	5.92
Q2	-5.42	33.12	12.01	4.55	-5.49	12.28	9.56	-4.54	-9.79	4.44
2085										
Q4	-4.25	39.44	13.75	8.58	4.93	22.27	11.79	0.45	-1.01	12.73
Q5	-9.45	46.17	14.06	6.44	0.61	22.68	12.38	-3.91	-6.15	12.17
Q2	-17.39	48.40	11.68	0.83	-12.09	14.49	10.91	-11.91	-14.87	7.12

Source: Reclamation 2016b

E.2 Environmental Consequences/Environmental Impacts

This section examines the relationship of climate change effects to the environmental impacts and mitigation measures presented in Chapters 4 through 7, 9, 10, 13 through 20, and 22 through 25. This section discusses impacts of the action alternatives and proposed mitigation measures as anticipated for a range of possible future socioeconomic-climate scenarios.

E.2.1 Assessment Methods

The climate change impact assessment characterizes the sensitivity of environmental effects evaluated in this Environmental Impact Statements (EIS)/ Environmental Impact Report (EIR) to uncertainties in potential future socioeconomic and climatic conditions.

This chapter presents the significance determinations made in Chapters 4 through 7, 9, 10, 13 through 20, and 22 through 25, and evaluates how those significance determinations could be changed under future climate change scenarios. This sensitivity analysis does not identify new impacts that were not already analyzed in the other chapters; it instead describes how those impacts might change with future climate change when compared to the future without climate change. For each significance determination presented, the baseline against which the comparison was made is also described.

E.2.2 Resources Eliminated from Further Analysis

The following resources are eliminated from further discussion because the effects of the proposed alternatives are not expected to interact with climate change: noise and vibration; Indian Trust Assets; GHG emissions; and traffic and transportation. For these resources climate change is not expected to alter the outcome of the impacts from the action alternatives (e.g., noise and vibration in the study area).

E.2.3 Water Quality

Potential impacts related to climate change were compared to the CalSim II baseline of 2030. As discussed in Chapter 4, Water Quality, the action alternatives could result in impacts related to the following:

- Substantially degrade existing water quality conditions (Less than significant [Alternative 2] and no impact [Alternative 3])
- Change south-of-Delta CVP and SWP exports and Delta outflow (Less than significant [Alternative 2] and no impact [Alternative 3])
- Violation of existing water quality standards or waste discharge requirements (Significant unavoidable [Alternative 2] and less than significant [Alternative 3])

Surface water quality effects from the action alternatives in the study area related to short-term construction impacts would not be affected by longer-term impacts from climate change given the timing of scheduled construction completion.

Increased surface water temperatures that could occur from higher ambient air temperatures and lower water levels at San Luis Reservoir could result in greater eutrophication (United States Environmental Protection Agency [USEPA] and DWR 2011).

Suspended sediment levels from erosion along the shorelines of San Luis Reservoir are expected to be similar with or without climate change given that this effect is driven primarily by the annual refill and drawdown cycle of the reservoir that will continue unchanged. High turbidity in both natural inflow to the reservoir as well as the imported supply could occur with climate change as storm severity increases and wildfires become more frequent (DWR 2008).

Other water quality issues in the natural inflow to the reservoir and the imported supply that could result from climate change include more frequent spikes in *E. coli* or Cryptosporidium, which typically accompany severe storms (Bates et al. 2008 as cited in USEPA and DWR 2011). Pollutant loads in both these local and imported supplies may also increase as more extreme rain events occur (DWR 2008). These changes driven by climate change in water quality conditions in San Luis Reservoir would then carryover and further contribute to the same corresponding changes anticipated in the water supply delivered to CVP and SWP water users.

Significant impacts on surface water quality within the study area could occur with Alternative 2, as a reduction in reservoir elevation could result in increased algae growth, negatively impacting the quality of water in the reservoir. Significant impacts would not occur if Alternative 3 was implemented. The degree that climate change could alter the outcome of Alternative 2 is unknown because of the variability and uncertainty associated with potential climate change. However, the negative effects of climate change have the potential to increase the significant effects observed for Alternative 2. Climate change may result in additional significant surface water quality impacts in the study area when compared to the 2030 baseline, but there would be no changes to the impact conclusions for surface water quality in the study area.

E.2.4 Surface Water Supply

Potential impacts related to climate change were compared to the CalSim II baseline of 2030. As discussed in Chapter 5, Surface Water Supply, the action alternatives could result in impacts related to the following:

- Change deliveries to south-of-Delta CVP contractors (Significant unavoidable [Alternative 2] and no impact [Alternative 3])
- Change deliveries to south-of-Delta SWP contractors (Significant unavoidable [Alternative 2] and no impact [Alternative 3])
- Construction could result in temporary interruptions in CVP water supply (No impact [Alternative 2] and significant unavoidable [Alternative 3])
- Construction could result in temporary interruptions in SWP water supply (No impact [Alternative 2] and significant unavoidable [Alternative 3])

Under climate change, CVP and SWP exports would be reduced as summarized in Table E-2 and Table E-3; SWP exports could be reduced by up to 13 percent by 2100 and CVP exports could be reduced by up to 8 percent by 2100. Higher predicted temperatures may cause winter precipitation to occur as rainfall rather than snow, thereby causing the monthly runoff pattern to shift. CVP and SWP exports would likely be reduced because less surface water would be available in the spring (Reclamation 2016a).

Climate change may result in significant surface water supply impacts in the study area when compared to the 2030 baseline, but there would be no change to the impact conclusions for surface water supply in the study area under Alternative 2. In a hot-dry climate, the available water supply would be reduced even though the reservoir capacity would be maintained under Alternative 3. Therefore, the impact conclusion could change from less than significant impacts to significant impacts under certain climate scenarios.

E.2.5 Groundwater Resources

Potential impacts related to climate change were compared to the CalSim II baseline of 2030. As discussed in Chapter 6, Groundwater Resources, the action alternatives could result in impacts related to the following:

- Increasing the potential for subsidence (Significant unavoidable [Alternative 2] and no impact [Alternative 3])

Climate change could decrease reservoir levels throughout the CVP and SWP system, which would consequently result in less CVP and SWP exports. Reduced exports could increase groundwater pumping, which would both decrease groundwater levels and could degrade groundwater quality. Climate change may result in significant impacts to groundwater resources in the study area. Implementation of Alternative 2 would also, as was noted above in Section E.2.4, result in a significant impact on surface water deliveries. Other action alternatives would not result in a significant impact on surface water deliveries.

Climate change may result in significant groundwater resource impacts in the study area when compared to the 2030 baseline, but there would be no changes to the impact conclusions for groundwater resources in the study area under Alternative 2. In a hot-dry climate, the available water supply would be reduced even though the reservoir capacity would be maintained under Alternative 3. This could result in additional groundwater pumping, which could cause the impact conclusion to change from less than significant impacts to significant impacts under certain climate scenarios.

E.2.6 Air Quality

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 7, Air Quality, the action alternatives could result in impacts related to the following:

- Construction activities could cause temporary and short-term construction-related emissions of criteria pollutants or precursors that would exceed the significance thresholds (No impact [Alternative 2] and less than significant [Alternative 3])

- Operational activities associated with the alternative could cause long-term operation-related emissions of criteria pollutants or precursors that would exceed the San Joaquin Valley Air Pollution Control District's (SJVAPCD's) significance thresholds (No impact [Alternatives 2 and 3])

- Construction associated with the alternative could cause temporary and short-term construction-related emissions of toxic air contaminants (TACs) that would exceed the SJVAPCD's significance thresholds (No impact [Alternative 2] and less than significant [Alternative 3])

- Construction and operation of the alternative could cause increased emissions of criteria pollutants or precursors that would exceed the general conformity de minimis thresholds (No impact [Alternative 2] and no adverse impact [Alternative 3])

- Construction associated with the alternative could create objectionable odors affecting a substantial number of people (No impact [Alternative 2] and less than significant [Alternative 3])

Climate change could result in increased ground-level ozone concentrations from warmer temperatures. Furthermore, changes in weather patterns could affect how pollutants are dispersed, which could cause localized concentrations of particulate matter to increase. Inhalation of ozone and particulate matter can cause adverse health effects including premature mortality and aggravation of cardiovascular and respiratory disease (USEPA 2015).

Climate change may result in significant air quality impacts in the study area when compared to existing conditions, but it would not affect the criteria (e.g., construction-related emissions) analyzed for the action alternatives; consequently, there would be no changes to the impact conclusions for air quality in the study area.

E.2.7 Flood Control

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 9, Flood Control, the action alternatives could result in impacts related to the following:

- Construction and operations of new facilities could result in the placement of structures in the 100-year flood hazard area which could impede or redirect flood flows (No impact [Alternative 2] and less than significant [Alternative 3])

- Construction could result in the increased exposure of people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam (No impact [Alternative 2] and less than significant [Alternative 3])

- Operation could result in the increased exposure of people or structures to a significant risk of loss, injury or death involving flooding, including flooding because of increases in the potential for the failure of a levee or dam (Beneficial [Alternative 2 and 3])

- Construction and operations could result in the alteration of the existing drainage pattern and/or the creation of runoff water that would exceed the capacity of the existing or planned stormwater drainage system (No impact [Alternative 2] and less than significant [Alternative 3])

Climate change could result in more frequent and severe storms and runoff could occur earlier in the year. This is anticipated to increase the frequency and severity of flood events in the area of analysis when compared to existing conditions. However, it would not affect the criteria (e.g., construction impacts) analyzed for the action alternatives; consequently, there would be no changes to the impact conclusions for flood control in the study area.

E.2.8 Visual

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 10, Visual, the action alternatives could result in impacts related to the following:

- Have a substantial adverse effect on a scenic vista (areas with Scenic Attractiveness Class A or Class B classifications are considered scenic vistas) (No Impact [Alternative 2] and Significant unavoidable [Alternative 3])
- Substantially damage scenic resources within a State scenic highway corridor (No impact [Alternative 2] and less than significant [Alternative 3])
- Substantially degrade the existing visual character or quality of the site and its surroundings (No impact [Alternative 2] and less than significant [Alternative 3])
- Create a new source of substantial light or glare, which would adversely affect day or nighttime views in the area (No impact [Alternative 2] and less than significant [Alternative 3])
- Operational changes at the San Luis Reservoir could affect visual resources (Less than significant [Alternative 2] and no impact [Alternative 3])

Climate change could result in increased storm severity and more frequent flooding, which would increase sediment erosion and transport along with increased potential for landsides from greater flows.

Under climate change, inflow peaks could occur earlier in the water year and, therefore, delta formation at the confluence of lakes and streams would occur earlier in the water year; further, more channelization could occur from downcutting into the delta deposits during the remainder of the year. Certain climate change scenarios could also result in minor increases in inflows to San Luis Reservoir from seasonal creeks that drain to the reservoir.

Impacts from the action alternatives on geology and soils within the area of analysis are not expected to differ greatly with or without climate change when compared to existing conditions. The environmental commitments identified in Chapter 25 ensure that significant impacts on geology and soils are avoided and would be resilient to changes in conditions with climate change. Given this resilience, there would be no anticipated changes to significance determinations with climate change.

E.2.9 Hazards and Hazardous Materials

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 13, Hazards and Hazardous Materials, the action alternatives could result in impacts related to the following:

- During construction activities, the transport, use or disposal of hazardous materials could increase the risk of exposure from hazardous materials to the public and construction workers (No impact [Alternative 2] and less than significant [Alternative 3])
- During construction activities, there is potential to encounter contaminated soil and/or groundwater, which could result in an accidental release of hazardous materials and pose a threat to the public and the environment (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities at San Luis Reservoir could conflict with sea plane maneuvers on San Luis Reservoir and operations at the San Luis Reservoir Sea Plane Base, resulting in safety hazards for pilots and people working and residing in the area (No impact [Alternative 2] and less than significant [Alternative 3])
- During construction activities use of Basalt Road and State Route (SR) 152 for site access could temporarily interfere with an emergency response plan or emergency evacuation plan for the State Responsibility Area (No impact [Alternative 2] and less than significant [Alternative 3])
- The use of mechanical equipment during construction could increase the risk of wildfire within the vicinity of the project area (No impact [Alternative 2] and less than significant [Alternative 3])

Most impacts identified for hazards and hazardous materials under the action alternatives are related to project construction. Therefore, climate change in the longer term would not change the effects evaluations or conclusions. This includes the potential over the long-term for climate change to change the frequency and intensity of wildfire, impacts from the action alternatives associated with wildfires are related to construction only, and mitigation measures would minimize these risks.

The action alternatives would not result in significant impacts from increased habitat that could contribute to the spread of and/or increase existing mosquito populations. Warming temperatures, however, are likely to further increase the abundance and active period of mosquitos and could further increase the potential for negative impacts (Office of Environmental Health Hazard Assessment [OEHHA] 2013).

Climate change has the potential to impact health and hazards in the area of analysis. These impacts would not however be anticipated to influence the shorter-term construction generated impacts of the action alternatives. Longer term effects from operation of the action alternatives would also not change in magnitude with climate change when compared to existing conditions.

E.2.10 Fisheries Resources

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 14, Fisheries Resources, the action alternatives could result in impacts related to the following:

- Construction activities could destroy or adversely affect aquatic habitats for special-status fish species (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could interfere with the movement of any native resident or migratory fish species (No impact [Alternatives 2 and 3])
- Construction activities could conflict with the provisions of an approved local, regional, or State conservation plans (No impact [Alternatives 2 and 3])
- Operations could destroy or adversely affect aquatic habitats for special-status fish species (Less than significant [Alternative 2] and no impact [Alternative 3])
- Operations could interfere with the movement of any native resident or migratory fish species (Less than significant [Alternative 2] and no impact [Alternative 3])
- Operations could conflict with the provisions of an approved local, regional, or State conservation plans (No impact [Alternative 2 and 3])

Climate change could result in the south-of-Delta exports that fill San Luis Reservoir being influenced more by earlier season precipitation than from later season snowmelt across the Sacramento-San Joaquin River watershed. This change could result in as was noted previously, reductions in total Delta exports and reductions in average storage volumes in San Luis Reservoir. The reservoir elevation could refill seasonally on average to lower maximum surface elevations and potential increases in demand on supplies stored in San Luis Reservoir generated by increases in ambient air temperatures across the CVP and SWP south-of-Delta service areas.

Impacts from south-of-Delta exports under Alternative 2 would be significant. The proportional changes in total CVP and SWP exports with implementation of Alternative 2, would be similar in a future with climate change. The total availability of water for Delta exports would be reduced and the increment of additional unused export capacity available for use by the action alternatives would be expected to be similarly reduced. Alternative 3 would have no impact on south-of-Delta exports.

Further, increases in water temperature would occur in San Luis Reservoir overall, particularly later in the year as water levels decrease. Sufficient data are not available to determine if increasing water temperatures resulting from climate change would alter the overall survival for reservoir fish species under the action alternatives. However, because increased water temperatures would have both beneficial and detrimental effects on reservoir fishes depending on the species, it is assumed that the impact conclusions would not be substantially different with or without climate change.

High turbidity and sedimentation have a number of potentially adverse effects on fish, including smothering eggs, injury to gills, impairment of visual feeding, and reducing food web production (Kerr 1995). Increased turbidity under the action alternatives is not likely to occur and would not suppress fish production in the reservoir.

Climate change, as was noted previously, could reduce the overall water supply benefits of the alternatives, but the types and severity of effects from operation of the alternatives on fisheries in the area of analysis would not be expected to change when compared to the No Action Alternative.

E.2.11 Terrestrial Resources

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 15, Terrestrial Resources, the action alternatives could result in impacts related to the following:

- Construction activities could destroy or adversely affect sensitive habitats including wetland and riparian vegetation communities (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could kill, harm, or disturb terrestrial wildlife, including special-status species, or their habitats (No impact [Alternative 2] and less than significant [Alternative 3])

- Construction activities could disturb nesting migratory birds, including raptors (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could destroy or adversely affect special-status plant species (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could adversely affect wildlife corridors (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could result in conflicts with local policies or ordinances protecting biological resources (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could reduce foraging habitat for golden eagles and California condors at the San Luis Reservoir (No impact [Alternative 2] and less than significant [Alternative 3])
- Operations could result in long term impacts to terrestrial resources (Beneficial [Alternative 2] and no impact [Alternative 3])

With climate change, terrestrial habitats could be negatively affected by increased spread of invasive species (USEPA and DWR 2011). Increased temperatures and variations in precipitation (shown in Reclamation Undated) may also displace some native species that may not compete well under changing conditions. Optimal climate conditions for native species may shift to higher elevations; however, these areas may not always be available or suitable for colonization of plant species, depending on land use, physical separation from the existing habitat, and other physical conditions, such as substrate characteristics. Climate change is expected to stress forested areas, making them more susceptible to pests and disease, which would further alter species composition. It is also projected that climate change would increase the frequency and intensity of wildfires (USEPA and DWR 2011).

Regardless of whether an action alternative is implemented, climate change is likely to place additional stress on the terrestrial resources within the study area. Although climate change would have negative effects on species and habitat, as discussed above, these effects are not expected to change the impact conclusions of the alternatives when compared to existing conditions.

E.2.12 Regional Economics

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 16, Regional Economics, the action alternatives could result in impacts related to the following:

- Changes in water supply to CVP municipal and industrial (M&I) water contractors in the Bay Area Region could affect the regional economy (Adverse Impact [Alternative 2] and Adverse Impact Temporary [Alternative 3])
- Changes in water supply to CVP agricultural water users in the San Joaquin Valley could affect the regional economy (Adverse Impact [Alternative 2] and Adverse Impact Temporary [Alternative 3])
- Changes in water supply to SWP M&I water contractors in the Bay Area Region and Southern California Region could affect the regional economy (Adverse Impact [Alternative 2] and Adverse Impact Temporary [Alternative 3])
- Construction and operation and maintenance expenditures could increase employment, income, and output in the regional economy (No impact [Alternative 2] and beneficial [Alternative 3])
- Changes in recreation opportunities could affect economic activity in Merced County related to San Luis Reservoir (Adverse impact [Alternative 2] and no impact [Alternative 3])

Climate change is likely to affect regional economics because the anticipated reduction in south-of-Delta exports amounts would affect the municipal, industrial and agricultural economies dependent on water supplies imported by the CVP and SWP. The Basins Study (Reclamation 2016a) showed more urban economic costs in the Central Tendency climate/Current Trends and Hot-Dry climate/Expanded Growth socioeconomic scenarios due to decreased CVP and SWP water deliveries compared to the Reference-No-Climate-Change scenario. All climate change scenarios anticipate increased agricultural economic benefits because of increases in demands for California agricultural commodities (Reclamation 2016a).

Alternative 2 would, as was noted above in Section E.2.4, result in a significant impact in water supply conditions. Alternative 3 would have no impact on south-of-Delta exports. Regardless of which alternative is selected, climate change may result in significant surface water supply impacts in the study area when compared to the CalSim II baseline of 2030; consequently, there would be no changes to the impact conclusions for regional economics in the study area.

E.2.13 Land Use

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 17, Land Use, the action alternatives could result in impacts related to the following:

- Construction activities associated with the alternative could affect land use around San Luis Reservoir by physically dividing a community (No impact [Alternative 2 and 3])
- Construction of the alternative could affect land use by conflicting with an applicable land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environment effect (No impact [Alternative 2 and 3])
- Operation of the alternative could result in changes to land use by conflicting with an applicable land use plan, policy, or regulation adopted for the purpose of avoiding or mitigating an environment effect (No impact [Alternative 2 and 3])
- Operation of the alternative could result in changes to land use that would conflict with an applicable habitat conservation plan or community conservation plan (No impact [Alternative 2 and 3])

It is unknown to what degree climate change may affect land uses. Current socioeconomic trends show an increase in urban growth and a decrease in agricultural lands, which would also entail changes in water demands (Reclamation 2016b). However, none of the action alternatives would impact land use planning; therefore, there would be no change in the impact significance conclusions for land use when climate change is considered when compared to existing conditions.

E.2.14 Agricultural Resources

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 18, Agricultural Resources, the action alternatives could result in impacts related to the following:

- Construction activities could affect agricultural resources around San Luis Reservoir by converting Important Farmland to nonagricultural use (No impact [Alternatives 2 and 3])
- Construction activities could result in conflicts with existing zoning for agricultural use, or Williamson Act contracts (No impact [Alternatives 2 and 3])

- Operation of the alternative could result in conflicts with existing zoning for agricultural use, or Williamson Act contracts (No impact [Alternatives 2 and 3])

- Operation of the alternative could involve changes in the existing environment (CVP and SWP water supply deliveries) which, due to their location or nature, could result in conversion of Important Farmland to nonagricultural use (Significant unavoidable [Alternative 2] and no impact [Alternative 3])

Climate change could alter agricultural practices because of its influence on several factors related to water demand and crop performance. Increased air temperatures may increase crop evapotranspiration, but when a crop's optimum temperature range is exceeded growth and water demand would decrease. Higher levels of CO_2 can stimulate crop growth but can also reduce transpiration, resulting in lower water demand. Changes in crop growth rates and the timing of crop planting and harvesting due to higher early- and late-season temperatures could result in lower water demand for annuals but higher water demand for perennial crops (Reclamation 2016b). The combined effects of increasing temperature and CO_2 can be beneficial for leafy crops like lettuce and spinach, but could be detrimental to crops like cotton, rice, sorghum, and wheat.

Climate change effects on watershed evapotranspiration and crop water requirements and growth may also result in different crops being farmed in the region, or conversion of more land to other uses. While climate change could change the yield or types of crops being farmed, it would not change the impact conclusions for agricultural resources when compared to existing conditions.

E.2.15 Recreation

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 19, Recreation, the action alternatives could result in impacts related to the following:

- Recreational use on trails would be substantially reduced as a result of project construction (No Impact [Alternative 2] and significant unavoidable [Alternative 3])

- Project construction could result in temporary closure to recreation facilities, resulting in a substantial loss of recreation opportunities (No impact [Alternative 2] and significant unavoidable [Alternative 3])

- Project construction could displace visitors and substantially contribute to overcrowded conditions at other local and regional recreation sites (No impact [Alternative 2] and significant unavoidable [Alternative 3])

- Operational changes to water levels in recreational water bodies could affect recreational uses (Significant unavoidable [Alternative 2] and no impact [Alternative 3])

Most effects on recreational resources from the action alternatives relate to the closure of recreation sites during construction, a shorter term impact considered in the context of the longer term effects of climate change. However, the effects of climate change on operations at San Luis Reservoir could potentially affect water-based recreation opportunities at the lake. As was noted in Section E.2.4, reduced south-of-Delta exports with climate change could result in reservoir levels being lower for longer periods of time, which could affect the availability and quality of recreation activities and experiences throughout the year. Overall, the reservoir surface area in the Sacramento and San Joaquin Basin is expected to decrease by 17 percent (Reclamation 2016b). Conversely, climate change could result in warmer air temperatures, increasing demand for recreational activities associated with reservoir use.

Climate change may result in significant impacts to recreation in the area of analysis, which could magnify the significant effects under Alternative 2 or could cause new significant impacts under Alternative 3 when compared to existing conditions.

E.2.16 Environmental Justice

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 20, Environmental Justice, the action alternatives could result in impacts related to the following:

- Expose a minority and/or low-income population to adverse or disproportionately high effects or hazards from project construction (Adverse and disproportionate effect would not occur [Alternative 2] and Potential adverse effect but not disproportionate [Alternative 3])

Increased temperatures from climate change could negatively affect populations where temperature control is not available in the residences. Furthermore, health issues from pests, increased pollution, and increased temperatures could increase and aggravate health issues in minority and low-income populations. Potential increases in flooding could damage homes or displace residents. Climate change could result in significant impacts to environmental justice when compared to existing conditions. Because the action alternatives could result in adverse effects, there would be no changes to the impact conclusions for environmental justice in the study area.

E.2.17 Public Utilities, Services, and Power

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 22, Public Utilities, Services, and Power, the action alternatives could result in impacts related to the following:

- Construction activities could affect the provision of governmental services or facilities (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could create the need for new stormwater facilities (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could generate solid waste in need of disposal, which could exceed the capacity of landfills (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could use and/or depletion of local or regional energy supplies (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could result in wasteful, inefficient, or unnecessary consumption of energy (No impact [Alternative 2] and less than significant [Alternative 3])
- Long-term operations could result in wasteful, inefficient, or unnecessary consumption of energy (Less than significant [Alternative 2] and no impact [Alternative 3])
- Operations could result in increases in stormwater runoff and the need for new stormwater drainage facilities (Less than significant [Alternative 2 and 3])

The Basins Study (Reclamation 2016b) evaluated the effects on hydropower and GHG emissions from future climate change. The study found only minor differences in the Central Tendency climate/Current Trends socioeconomic scenarios in CVP net generation because changes in CVP operations are small. Depending on the adaptation portfolio, hydropower generation in the SWP could either substantially decrease or moderately increase. Climate change may result in an increase in energy generation in the study area, but these are not directly related to implementation of the action alternatives; consequently, there would be no changes to the impact conclusions for power in the area of analysis.

Most impacts identified for public utilities, services and power under the action alternatives are shorter term construction related effects when considered in the context of the longer-term effects of climate change. Therefore, climate change in the longer term would not change these shorter-term constructions generated impacts. The long-term changes in energy consumption from implementation of the action alternatives were all identified to be less than significant and would not be changed in magnitude with climate change when compared to existing conditions.

E.2.18 Cultural Resources

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 23, Cultural Resources, the action alternatives could result in impacts related to the following:

- Project construction could lead to adverse effects/significant impacts to known or unknown historic properties and/or historical resources (Less than significant [Alternatives 2 and 3])

Most impacts identified for cultural resources under the action alternatives are shorter term construction related effects when considered in the context of the longer term effects of climate change. Lower San Luis Reservoir levels from Alternative 2 and climate change could potentially increase the potential frequency the exposure of cultural resources that are typically submerged. However, because the reservoir is currently operated annually to maximize fill and refill, climate change would not be anticipated to substantially change the potential for this impact. Similarly, the less than significant impacts from operation of the action alternatives would not be changed in magnitude with climate change when compared to existing conditions.

E.2.19 Population and Housing

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 24, Population and Housing, the action alternatives could result in impacts related to the following:

- Construction could temporarily induce population growth in the area of analysis, and potentially require new housing to accommodate this growth (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction could displace people or houses, and potentially require construction of replacement housing (No impact [Alternatives 2 and 3])
- Operation could induce substantial population growth or housing in the area of analysis (No impact [Alternatives 2 and 3])
- Operations could displace a number of people or houses, and potentially require construction of replacement housing (No impact [Alternatives 2 and 3])

Climate change could increase coastal special flood hazard areas (SFHA) by approximately 50 percent along the Pacific Coast due to sea level rise (Federal Emergency Management Agency [FEMA] 2013). This increase in coastal SFHA could affect housing demand or pricing and induce population migration to lower cost communities in the Central Valley. Climate change is likely to affect population and housing; however, the specific nature and magnitude of these effects is unknown. Climate change may result in additional significant impacts to population and housing in the area of analysis, but these are not directly related to implementation of the action alternatives; consequently, there would be no changes to the impact conclusions for population and housing in the area of analysis when compared to existing conditions.

E.2.20 Geology, Seismicity, and Soils

Potential impacts related to climate change were compared to existing conditions. As discussed in Chapter 25, Geology, Seismicity, and Soils the action alternatives could result in impacts related to the following:

- Construction activities could expose people or structures to adverse effects related to the rupture of a known earthquake fault (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities on unstable soils could result in the risk of loss, injury, or death as a result of liquefaction or landslides (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could take place on expansive soils creating a substantial risk to life or property (No impact [Alternative 2] and less than significant [Alternative 3])
- Construction activities could result in the loss of availability of a known mineral resource of regional or local importance (No impact [Alternatives 2 and 3])
- Maintenance activities during operations could expose people or structures to adverse effects related to the rupture of a known earthquake fault (Beneficial [Alternatives 2 and 3])
- Operations could result in long term impacts to geology, soils, or mineral resources (Less than significant [Alternative 2] and no impact [Alternative 3])
- Seismic related ground failure could impact operation of alternative facilities (Beneficial [Alternatives 2 and 3])

Climate change could result in increased storm severity and more frequent flooding, which would increase sediment erosion and transport along with increased potential for landslides from greater flows.

Under climate change, inflow peaks could occur earlier in the water year and, therefore, delta formation at the confluence of lakes and streams would occur earlier in the water year; further, more channelization could occur from downcutting into the delta deposits during the remainder of the year. Certain climate change scenarios could also result in minor increases in inflows to San Luis Reservoir from seasonal creeks that drain to the reservoir.

Impacts from the action alternatives on geology and soils within the area of analysis are not expected to differ greatly with or without climate change. The environmental commitments identified in Chapter 25, Geology, Seismicity, and Soils ensure that significant impacts on geology and soils are avoided and would be resilient to changes in conditions with climate change. Given this resilience, there would be no anticipated changes to significance determinations with climate change when compared to existing conditions.

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