San Luis Low Point Improvement Project Environmental Impact Statement / Environmental Impact Report

Appendix Q: Climate Variability Analysis

Appendix Q
Climate Variability Analysis

This Climate Variability Appendix supplements the San Luis Low Point Improvement Project (SLLPIP) Environmental Impact Statement/Environmental Impact Report (EIS/EIR) and presents the existing and potential future climate conditions within the area of analysis. The appendix also provides an assessment of the proposed alternatives under projected future climate conditions and discusses the environmental impacts of the project alternatives described in Chapter 4, under projected future climate conditions. An evaluation of the greenhouse gas (GHG) emissions from the proposed alternatives and their potential contribution to global climate variability are presented in Section 4.8, Greenhouse Gas Emissions, and Appendix P, Greenhouse Gas Emission Calculations.

Q.1 Affected Environment/Environmental Setting

This section presents the existing climate within Merced and Santa Clara Counties along with projections of the foreseeable affected environment, the area of analysis and regulatory setting.

Q.1.1 Area of Analysis

The climate impact analysis evaluates the existing conditions and impacts across the Sacramento-San Joaquin River watershed given this areas influence on Central Valley Project (CVP) and State Water Project (SWP) operations at San Luis Reservoir. This area of analysis includes Merced and Santa Clara Counties. San Luis Reservoir is in Merced County and the San Joaquin Valley Air Basin. The Santa Teresa Water Treatment Plant is in Santa Clara County. Chapter 2, Project Description, identifies the locations of the various project components.

Q.1.2 Regulatory Setting

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

Q.1.2.1 Federal

Q.1.2.1.1 Secretarial Order No. 3289

In 2009, the Department of Interior (DOI) issued a Secretarial Order on climate variability that expands DOI bureaus' responsibilities in addressing climate variability (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 variability 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 variability. 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.”

Q.1.2.1.2 National Environmental Policy Act Handbook

The United States Department of the Interior, Bureau of Reclamation (Reclamation) *National Environmental Policy Act (NEPA) Handbook* (Reclamation 2012) recommends that climate variability 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” (Reclamation 2012). The *NEPA Handbook* recommends considering different aspects of climate variability (e.g., relevance of climate variability to the proposed action, timeframe for analysis, etc.) to determine the extent to which it should be discussed under NEPA.

Q.1.2.1.3 Department of the Interior Departmental Manual 523

Additionally, DOI Departmental Manual 523 (effective December 20, 2012) states that it is DOI policy to use best available science in decision-making water management planning including integrating adaptation strategies. It also states “that climate change be considered in developing or revising management plans.” Section B further states that “the Department will promote existing processes and when necessary, institute new processes to: 1) Conduct assessments of vulnerability to anticipated or current climate impacts, 2) Develop and implement comprehensive climate change adaptation strategies based on vulnerability and other factors, and 3) Include measurable goals and performance metrics.”

Q.1.2.1.4 Principles and Requirements for Federal Investments in Water Resources

As mentioned in Chapter 2 of the SLLPIP EIS/EIR, to meet the study objectives, the planning process follows the structured six-step planning approach outlined in the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (P&Gs) (U.S. Water Resources Council 1983). 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 variability impacts to be accounted for and addressed.

Q.1.2.1.5 Reclamation Manual Directives and Standards, Water and Related Resources Feasibility Studies

The Reclamation Directive and Standard for Water and Related Resources Feasibility Studies establishes responsibilities, requirements, and procedures for conducting a planning study for the purpose of recommending congressional authorization or funding of a water and related resources implementation plan. The potential impacts of climate variability are to be considered when developing projections of environmental conditions, water supply and demand, and operational conditions at existing facilities as part of the "without-plan future condition" (Reclamation 2015)

Q.1.2.1.6 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."

Q.1.2.1.7 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).

Q.1.2.2 State

Q.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 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.

Q.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 Q.2 and to indicate the likely effect of climate variability on the alternatives.

Q.1.3.1 Historical Climate

Streamflow in the Sacramento River and San Joaquin River basins has historically varied considerably from year to year. Runoff also varies geographically; during any particular year, some portions of the basin may experience relatively greater runoff while other areas experience relatively less runoff (e.g., more abundant runoff in the northern Sacramento Valley versus relatively drier conditions in southern San Joaquin Valley). On a monthly to seasonal basis, runoff is generally greater during the winter to early summer months, with winter runoff generally originating from rainfall-runoff events and spring to early summer runoff generally supported by snowmelt from the Cascade Mountains and Sierra Nevada.

Historical changes in climate have resulted in several important effects on the hydrology of the Sacramento River and San Joaquin River basins. Although annual precipitation may have slightly increased or remained relatively unchanged, corresponding increases in mean annual runoff in the Sacramento and San Joaquin rivers did not occur (Dettinger and Cayan 1995). However, a shift in the seasonal timing of runoff has been observed in the Sacramento River Basin; a decrease of about 10 percent in the fraction of total runoff occurring between April and July has been observed over the course of the 20th century (Roos 1991). Dettinger and Cayan (1995) reported similar results for the combined Sacramento River and San Joaquin River runoff. This decline in spring runoff is contrasted against increases in winter runoff. Peterson et al. (2008) found earlier runoff trends for 18 Sierra Nevada river basins. Analyses such as Cayan et al. (2001) have indicated that increasing spring temperatures, rather than increased winter precipitation, was the primary cause of the observed shift. Studies by these researchers and others showed correlation between the magnitude of decreases in April through July runoff with the altitude of the basin watershed. High altitude basins, like the San Joaquin River Basin, exhibited less decrease in spring runoff than lower elevation watersheds, such as the Sacramento River Basin. However, it is noted that the appearance of runoff trends in the basins is dependent on location within the basin and the period of record assessed.

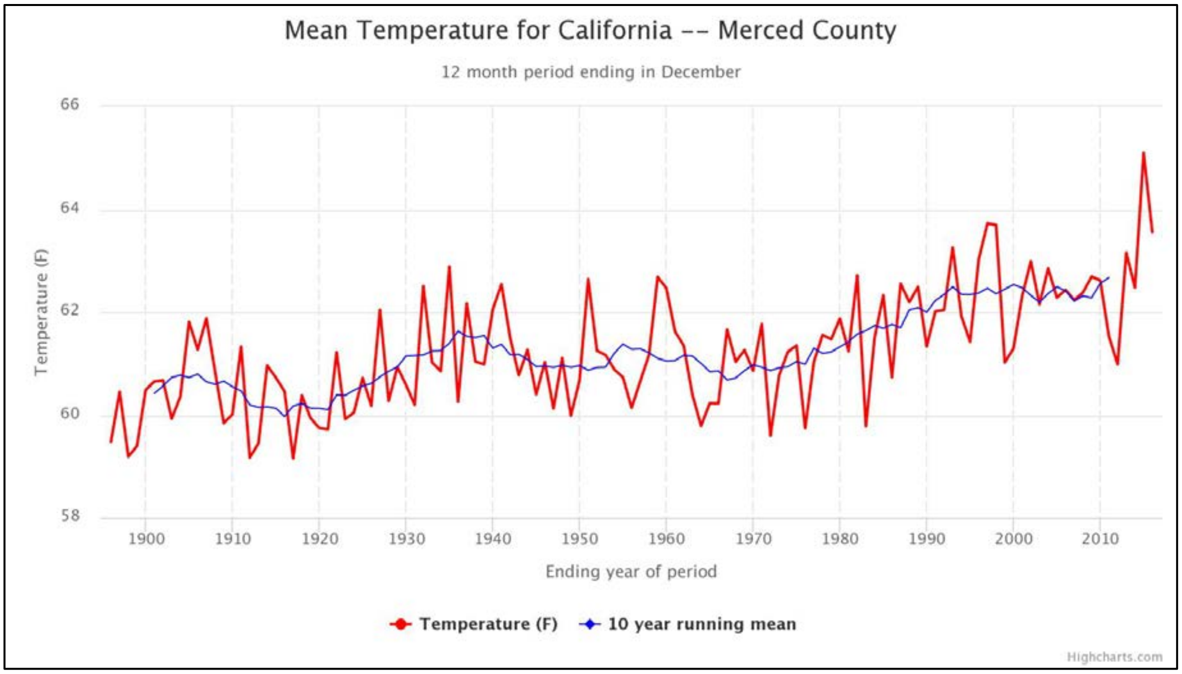
Other historical studies of 20th century spring snowpack, as measured by April 1st Snow Water Equivalent (SWE), showed a decreasing trend in the latter half of the 20th century (Mote 2005). Coincident with these trends, reduced snowpack and snowfall ratios are evidenced by analyses of SWE measurements made from 1948 through 2001 at 173 Western United States stations (Knowles et al. 2007). Additionally, Regonda et al. (2005) reported decreasing spring SWE trends in 50 percent of Western United States locations evaluated.

The historical climate of Merced County like most of the Central Valley is characterized by hot, dry summers and cool, damp winters. As shown in Figure Q-1, average summer daytime temperatures are 95 degrees Fahrenheit (°F) and average winter daytime temperatures are 55°F. Average mean-annual temperature has increased by approximately 2°F during the 20th century in

Merced County. Warming has not occurred steadily throughout the 20th century. Increases in air temperatures occurred primarily during the early part of the 20th century between 1915 and 1935. Subsequently, renewed warming began again in the mid-1970s and appears to be continuing at present, as shown in Figure Q-1. Cayan et al. (2001) reported that Western United States spring temperatures have increased 1.8 to 5.4°F since the 1970s; whereas increased winter temperature trends in the Central Valley were observed to average about 0.9°F per decade (Dettinger and Cayan 1995). In both Merced county, the overall 20th century warming has been about 3 to 4 °F.

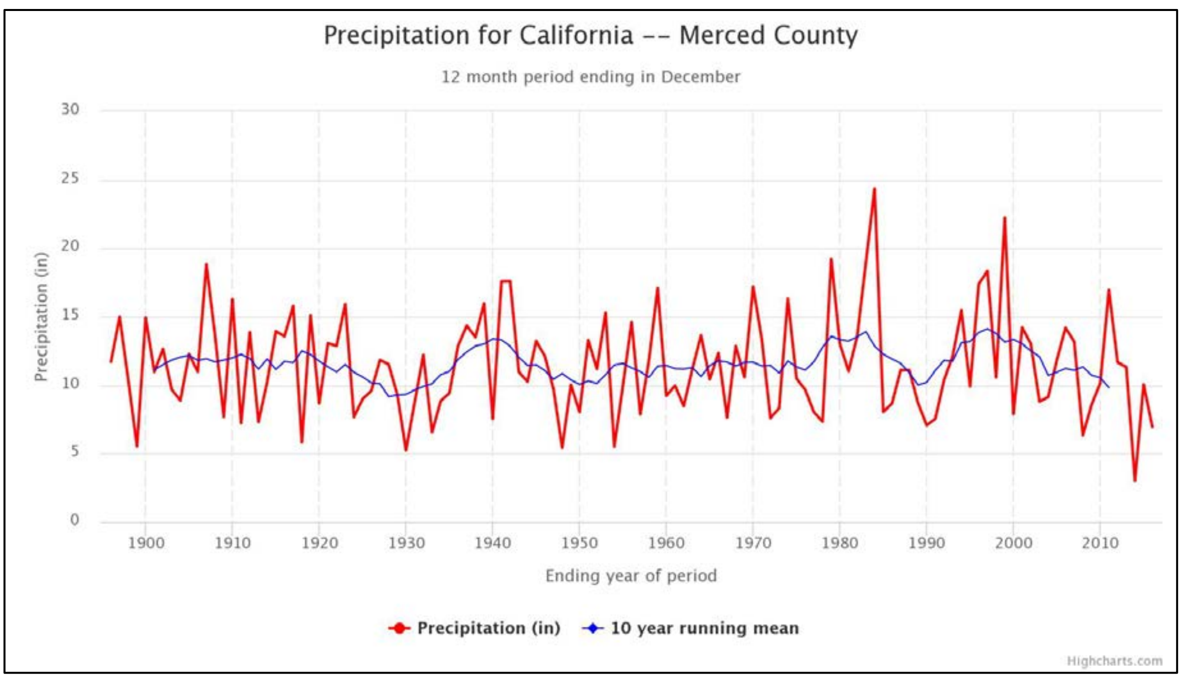
The majority of precipitation in Merced County occurs from mid-autumn to mid-spring. Snowfall is rare in Merced County, temperatures below freezing may occur in the winters but this rarely results in snowfall. Figure Q-2 shows the historic precipitation in Merced County from 1895 to 2015. The variability of annual precipitation appears to have increased in the latter part of the 20th century, as can be seen by comparing the range of differences in high and low values of the solid red line in Figures Q-2. These extremes in wet and dry years have been especially frequent since the 1980s.

Climate in Santa Clara County is heavily influenced by the strength and location of a semi-permanent, subtropical high-pressure cell. During the summer, the Pacific high pressure cell is centered over the northeastern Pacific Ocean resulting in stable meteorological conditions and a steady northwesterly wind flow. Upwelling of cold ocean water from below to the surface because of the northwesterly flow produces a band of cold water off the California coast. The cool and moisture-laden air approaching the coast from the Pacific Ocean is further cooled by the presence of the cold water band resulting in condensation and the presence of fog and stratus clouds along the Northern California coast. In the winter, the Pacific high-pressure cell weakens and shifts southward resulting in wind flow offshore, the absence of upwelling, and the occurrence of storms.



Source: WestMap 2010.

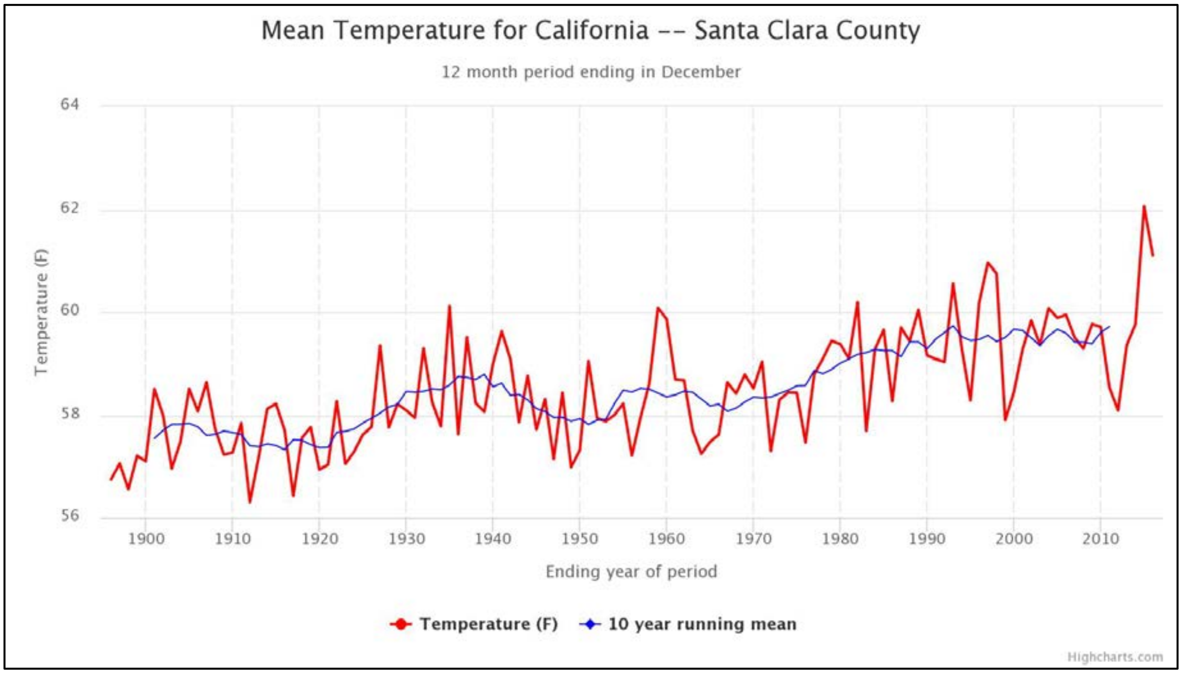
Figure Q-1. Observed Annual (red) and 10-Year Running Mean Annual (blue) Average Temperature in Merced County from 1895 to 2015



Source: WestMap 2010.

Figure Q-2. Observed Annual (red) and 10-Year Running Mean Annual (blue) Average Precipitation in Merced County from 1895 to 2015

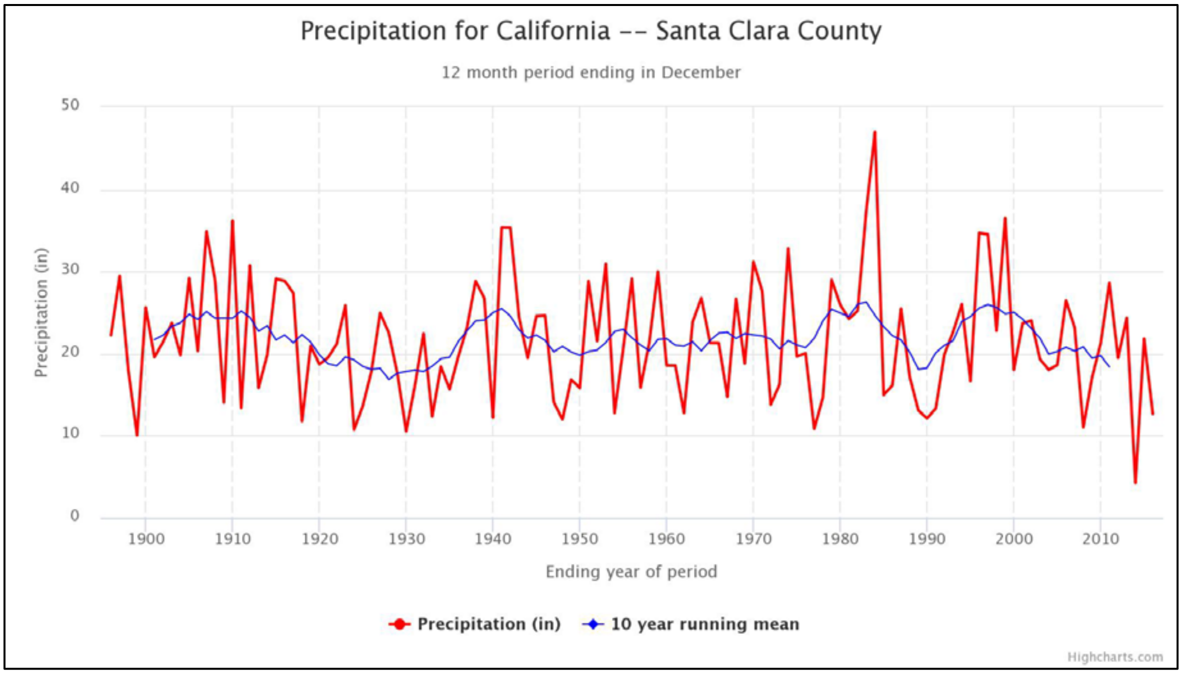
Average mean-annual temperature in Santa Clara County has risen from approximately 58°F in 1900's to 60°F in recent years. As seen in Figure Q-3, warming has not occurred steadily throughout the 20th century. Increases in air temperatures occurred primarily during the early part of the 20th century between 1915 and 1935. Subsequently, renewed warming began again in the mid-1970s and appears to be continuing at present.



Source: WestMap 2010.

Figure Q-3. Observed Annual (red) and 10-Year Running Mean Annual (blue) Average Temperature in Santa Clara County from 1895 to 2015

Precipitation in Santa Clara County is heavily influenced by the strength and location of a semi-permanent, subtropical high-pressure cell. Most of the precipitation in this area primarily occurs in the winter due to the weakening and southward shift of the subtropical high pressure cell centered over the northeastern Pacific Ocean. As shown in Figure Q-4, precipitation in Santa Clara County varies from 10 to 35 inches from 1985-2015.



Source: WestMap 2010.

Figure Q-4. Observed Annual (red) and 10-Year Running Mean Annual (blue) Average Precipitation in Santa Clara County from 1895 to 2015

Q.1.3.2 Projections of Future Climate

Q.1.3.3.1 Data Sources

Six reports were used as the main data sources for projected changes in climate for this evaluation. Each report is based on different Global Climate Models (GCMs) and emission scenarios, as described below. Because each GCM/emission scenario pair has related uncertainty, it is important to consider results from various models to understand the possible outcomes (California Climate Change Center [CCCC] 2009a). For this analysis, the ranges of projected changes published in each report are presented.

- **"Climate Change Scenarios and Sea Level Rise Estimates for the California 2009 Climate Change Scenarios Assessment" (CCCC 2009a) –** This report provides projected climate data for California, including monthly temperature data, monthly precipitation data and snow water equivalent (the amount of water contained in snowpack). In addition to the report, the data is available through a series of interactive, web-based tools provided by the CEC. Four GCMs were used in the report; the National Center for Atmospheric Research (NCAR) Parallel Climate Model (PCM), the National Oceanic and Atmospheric Administration Geophysical Fluids Dynamics Laboratory (GFDL) model (Version 2.1), the NCAR Community Climate System Model (CCSM), and the French Centre National de Recherches Meteorologiques (CNRM) models. Two emission scenarios from the

Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment were used; a low emissions scenario involving substantial reductions in emissions after 2050 (B1) and a medium-high emissions scenario assuming continued increased in emissions (A2). Two downscaling methods were used: 1) constructed analogues and 2) bias correction and spatial downscaling.

- **"Climate Change Impacts on Water Supply and Agricultural Water Management in California's Western San Joaquin Valley, and Potential Adaptation Strategies" (CCCC 2009b) –** This report provides estimated watershed runoff and agricultural and urban water demand projections for the Sacramento River basin and the Delta export region of the San Joaquin Valley. The Water Evaluation and Planning modeling system was used in conjunction with six GCMs: CNRM, GFDL, PCM, CCSM, the Center for Climate System Research, and the Max Planck Institute. Two emissions scenarios, B1 and A2, were evaluated.

- **"Draft National Climate Assessment Report" (NCADAC 2013) –** This report assesses current scientific findings about observed and projected impacts of climate variability in the United States. The report draws from a large body of scientific peer-reviewed research published or in press by July 31, 2012. The draft report is currently open for public comment and is expected to be completed in 2013 and published as "The Third National Climate Assessment."

- **"Global Climate Change Impacts in the United States" (Karl, Melillo, and Peterson 2009) –** This report was prepared by the United States Global Change Research Program, a consortium of 13 federal departments and agencies authorized by Congress in 1989 through the Global Change Research Act of 1990 (Pub. L. 101-606, 104 Stat. 3096, codified as amended at 15 United States Code [USC] 2921), and serves as the basis for "The Second National Climate Assessment." The foundation for this report is a set of 21 Synthesis and Assessment Products, as well as other peer-reviewed scientific assessments, including those of the IPCC, the United States Climate Change Science Program, the United States National Assessment of the Consequences of Climate Variability and Change, the Arctic Climate Impact Assessment, the National Research Council's Transportation Research Board report on the Potential Impacts of Climate Change on United States Transportation, and a variety of regional climate impact assessments.

- **"West-Wide Climate Risk Assessments: Bias-Corrected and Spatially Downscaled Surface Water Projections" (Reclamation 2011) –** This report summarizes climate projections developed by Reclamation consistent with Public Law 111-11, Subtitle F (the SECURE Water Act). The report was based on 112 climate variability projections developed for the IPCC Fourth Assessment report (IPCC 2007) as part of the World Climate Research Program's Coupled Model Intercomparison Project phase 3 (CMIP3). The study encompassed a western United States-wide hydrologic analysis to identify changes in temperature, precipitation and their impact on "unimpaired" flows throughout the Colorado, Columbia, Klamath, Missouri, Rio Grande, Sacramento, San Joaquin, and Truckee river basins.

- **"West-Wide Climate Risk Assessments: Sacramento and San Joaquin Basins Climate Impact Assessment" (Reclamation 2014)-** 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). The 18 climate change projections includes: one no climate change scenario, five ensemble-informed (EI5) scenarios that were developed using downscaled 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.

Q.1.3.3.2 Projected Changes in Climate

The projected changes in climate conditions are expected to result in a wide variety of impacts in the state of California and San Joaquin River area. In general, estimated future climate conditions include changes to:

- Annual temperature
- Extreme heat
- Precipitation
- Sea level and storm surge
- Snowpack and streamflow

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

Annual Temperature. GCM data exhibit warming across California under both a low emission scenario and medium-high emission scenario (CCCC 2009a). While the data contain variability, there is a steady, linear increase over the 21st century (CCCC 2009a). The United States (U.S.) Climate Resilience toolkit reported a similar warming trend in Merced and Santa Clara counties (National Oceanic and Atmospheric Administration [NOAA] 2016). Table Q-1 summarizes the projected changes in temperature in the region. While there is a slight difference in the range of projected changes in temperatures between the two sources, both project a warming trend.

Table Q-1. Projected Changes in Temperature Compared to the Historical Average (1961 to 1990)

Region	Mid-21st Century	End of 21st Century
California[1]	+1.8 to 5.4°F	+3.6 to 9.0°F
Merced County, California[2]	+3.7 to 4.7	+5.1 to 9.1
Santa Clara County, California[2]	+3.6 to 4.2	+5.0 to 8.9

Source: [1] Cayan et al. 2012; [2]NOAA 2016

On a seasonal basis, the models project substantial warming in the spring and greater warming in the summer than in the winter. Summer (July to September) temperature changes range from 2.7 to 10.8 °F and winter (January to March) temperature changes range from 1.8 to 7.2 °F at the end of the 21st century when compared to the historical average (1961 to 1990) (CCCC 2009a). In addition, the models suggest that, during the summer, warming of interior land surfaces will be greater than that observed along the coast (CCCC 2009a).

Extreme Heat. The climate model results consistently show increases in frequency, magnitude, and duration of heat waves when compared to historical averages (1961 to 1990). Historically, extreme temperatures typically occur in July and August. With climate variability, these occurrences are likely to begin in June and continue through September (Cayan et al. 2012). Table Q-2 summarizes the projected number of extreme temperature days i.e. days with temperature above 95°F annually per the U.S. Climate resilience toolkit (NOAA 2016). The modeling results show more warming in interior land surfaces i.e. Merced County in comparison to the coastal areas.

Table Q-2. Projected Changes in Extreme Temperature Days in Merced and Santa Clara Counties, California

Period	Historic/ Observed	Low Emission Model	High Emissions Model
Merced County			
Historic Average (1961 to 1990)	38 days	---	---
Observed Average (2000 to 2005)	51 days	---	---
Mid-21st Century	---	71 days	85 days
End of 21st Century	---	81 days	118 days
Santa Clara County			
Historic Average (1961 to 1990)	1 day	---	---
Observed Average (2000 to 2005)	>1 day	---	---
Mid-21st Century	---	4 days	6 days
End of 21st Century	---	8 days	34 days

Source: NOAA 2016

*Precipitation***.** On average, the climate model projections show little change in total annual precipitation in California (CCCC 2009a). Specifically, the Mediterranean seasonal precipitation pattern is expected to continue, with most precipitation falling between November and March from North Pacific storms and the prevalence of hot, dry summers (CCCC 2009a). In addition, past trends show a large amount of variability from month to month, year to year, and decade to decade. This high degree of variability is expected to continue in the next century (CCCC 2009a).

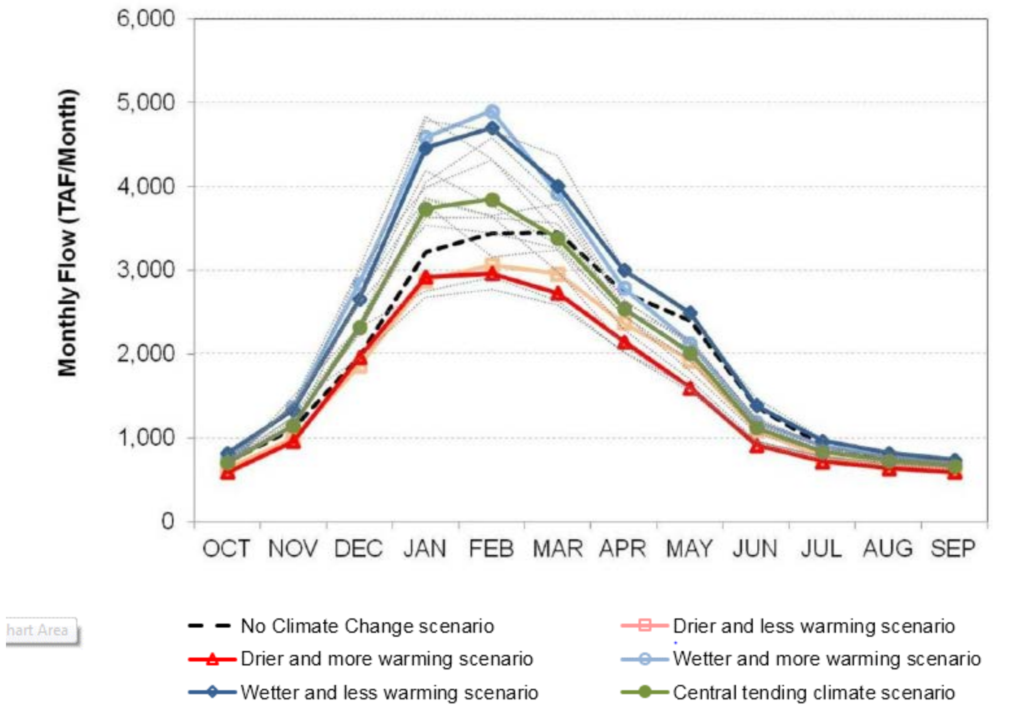
In the western San Joaquin Valley, model simulations suggest that there is a generally decreasing trend in precipitation as the 21st century progresses (CCCC 2009b). In addition, model results indicate that water shortages may be felt more acutely in the western San Joaquin Valley as Delta exports become more constrained (CCCC 2009b).

Sea Level and Storm Surge. Sea level change is also an important factor in assessing the effect of climate on California's water resources, because of its effect on water quality in the Delta. Higher sea levels are associated with increasing salinity in the Delta, which influences the suitability of Delta water supplies for agricultural, urban, and environmental uses.

By 2050, sea level rise is projected to be between 30 and 45 centimeters (cm) (12 to 18 inches), compared to 2000 levels (CCCC 2009a). Global models indicate that California may see up to a 140 cm (55 inch) rise in sea level by the end of the 21st century (CEC 2011). During the 20th century, mean sea level at Golden Gate Bridge in San Francisco Bay has risen by an average of 0.2 cm/year (0.08 in/year) (Anderson et al. 2008). Rates of sea level rise in San Francisco Bay appear to be accelerating based on tidal gauges and remote sensing measurements (Church and White 2006; Beckley et al. 2007).

Snowpack and Streamflow. Snowpack and streamflow amounts are projected to decline because of less late winter precipitation falling as snow and earlier snowmelt (NCADAC 2013). In California, snow water equivalent (the amount of water held in a volume of snow) is projected to decrease by 16 percent by 2035, 34 percent by 2070, and 57 percent by 2099, as compared to measurements between 1971 and 2000 (NCADAC 2013). By the end of the century, late spring streamflow could decline by up to 30 percent (CEC 2011).

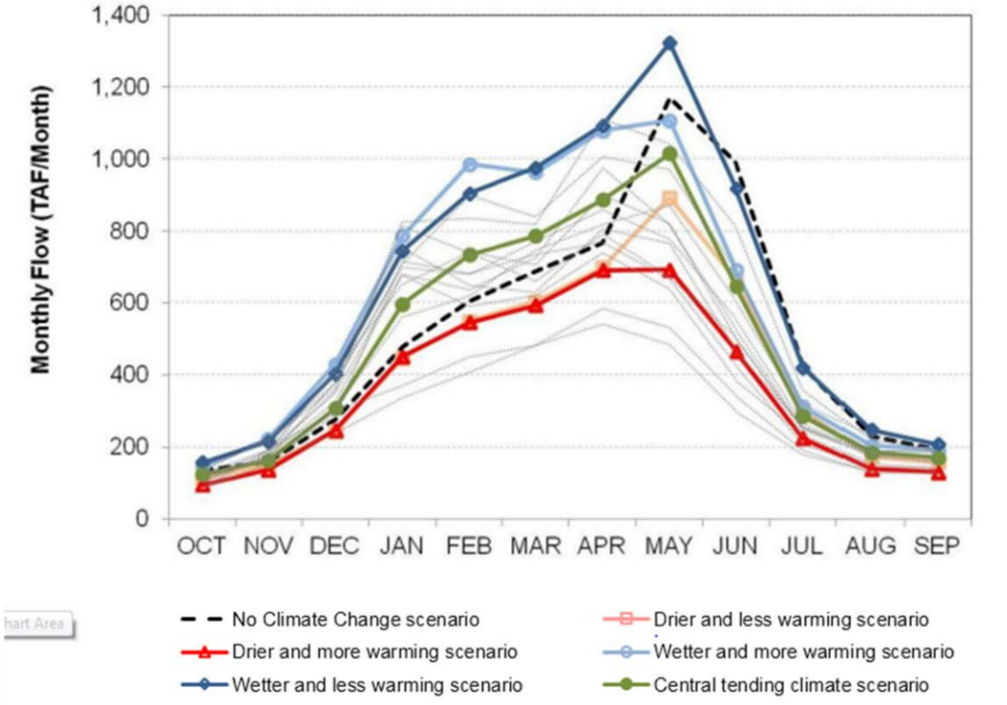
Streamflow amounts are projected to shift to more runoff in the winter and less in the spring months. This projected shift occurs because higher temperatures during winter cause more precipitation to occur as rainfall, which increases runoff and reduces snowpack. Figures Q-5 and Q-6 show the monthly runoff pattern in the Sacramento and San Joaquin River Basins under the five Ensemble-Informed Climate Change Scenarios and twelve CAT scenarios. 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 2014).



Source: Reclamation 2014; Note: TAF/yr = thousand acre-feet per year

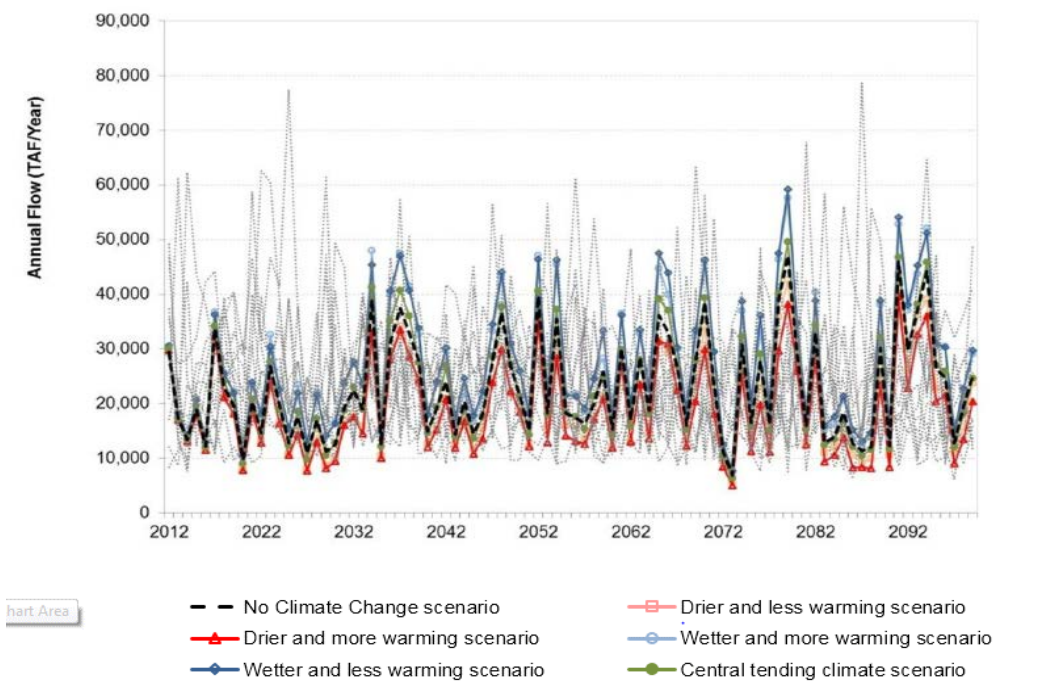
Figure Q-5. Projected Monthly Flows in the Sacramento Basin under five Ensemble-Informed Climate Change Scenarios

Figures Q-7 and Q-8 presents an estimate of the magnitude of wet and dry periods in comparison to historic climate (dashed line) in the future under the climate change scenarios in the Sacramento and San Joaquin basins. Historic observations were used to project inter-annual variability of future wet and dry periods. The extended drought periods from 2025 to 2030 correspond to the historic drought between 1929 and 1934. The magnitude of the projected unimpaired flows differs from historical flow and the climate change scenarios.



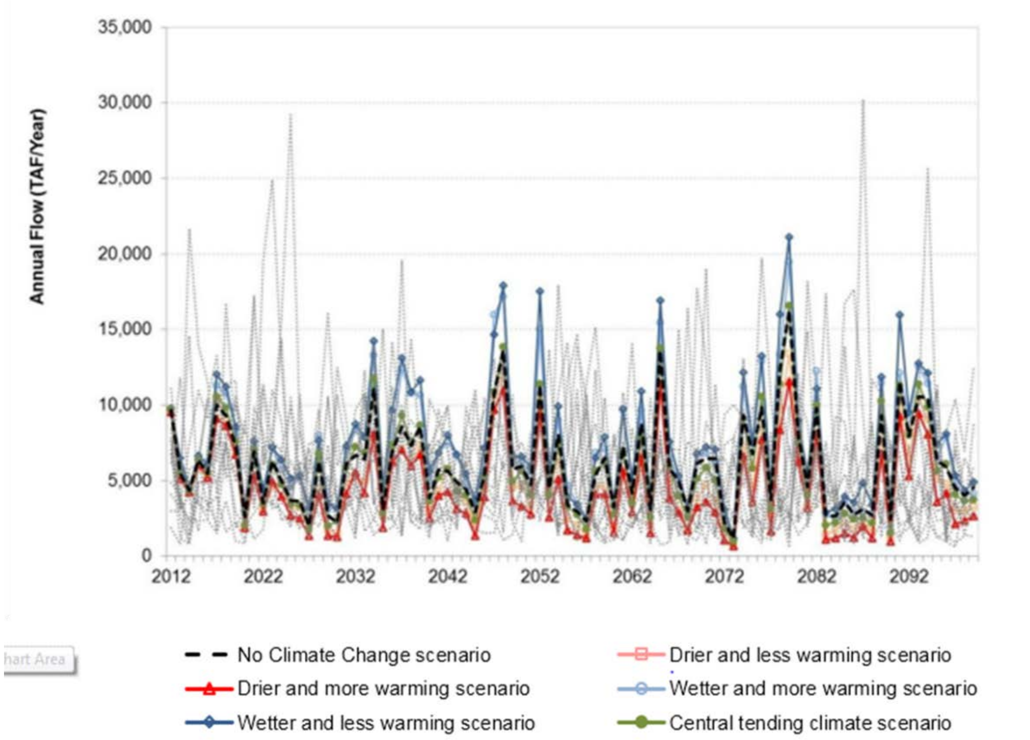
Source: Reclamation 2014; Note: TAF/yr = thousand acre-feet per year

Figure Q-6. Projected Monthly Flows in the San Joaquin Basin under five Ensemble-Informed Climate Change Scenarios



Source: Reclamation 2014; Note: TAF/year = thousand acre-feet per year

Figure Q-7. Unimpaired Flows in the Sacramento River System under five Ensemble-Informed Climate Change Scenarios



Source: Reclamation 2014; Note: TAF/year = thousand acre-feet per year

Figure Q-8. Unimpaired Flows in the San Joaquin River System under five Ensemble-Informed Climate Change Scenarios

Q.1.3.3.3 Associated Impacts

The combined changes in climate result in various impacts for California and the SLLPIP area. Potential impacts include changes to wildfire hazards, water supply and demand, natural resources, infrastructure, agriculture and livestock, and human health. Descriptions of the associated impacts are included below.

Wildfire Hazards. Prolonged periods of higher temperatures combined with associated drought will drive larger and more frequent wildfires in California (NCADAC 2013). The wildfires are projected to start earlier in the summer and last longer into the fall. In California, the risk of wildfire is projected to increase by up to 55 percent, depending on the level of emission reductions that can be achieved globally (CEC 2011). Changes to temperature and precipitation are also projected to change vegetation types and increase the spread of invasive species that are more fire-prone that, when coupled with more frequent and prolonged periods of drought, increase the risk of fires and reduce the capacity of native species to recover (CEC 2011).

Water Quality, Supply and Demand: The projected changes in climate will increase pressure on California's water resources, which are already fully utilized by the demands of a growing economy and population (CEC 2011). Although significant changes in annual precipitation are not projected, increasing temperatures, decreasing snowmelt and changes to spring streamflows will decrease the reliability of water supplies and increase the likelihood of more frequent short-term and long-term droughts and water shortages (NCADAC 2013). Additionally, increasing temperatures will result in increased competition for water among agricultural, municipal, and environmental uses. Larger agricultural demands may lead to increased stress on the management of surface water resources and, potentially, the over exploitation of groundwater aquifers (CCCC 2009b). Agricultural areas could be significantly impacted, with California farmers losing as much as 25 percent of the water supply they need (CEC 2011).

Sea level change is also an important factor in assessing the effect of climate on California's water resources because of its effect on water quality in the Sacramento-San Joaquin Delta. Higher mean sea levels (msl) are associated with increasing salinity in the Delta, which influences the suitability of its water for agricultural, urban, and environmental uses. The global rate of msl change was estimated by IPCC (2007) to be 1.8 +/- 0.5 millimeters (mm)/year (0.07 +/- 0.02 inches per year (in/year)) from 1961–2003 and 3.1 +/- 0.7 mm/year (0.12+/0.03 in/year) during 1993–2003. During the 20th century, msl at Golden Gate Bridge in San Francisco Bay has risen by an average of 2 mm/year (0.08 in/year) (Anderson et al. 2008). These rates of sea level rise appear to be accelerating based on tidal gauges and remote sensing measurements (Church and White 2006; Beckley et al. 2007).

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 US 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 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% of the months, an increase of 29%, and ranges from a minimum of 15% to a maximum of 53%. For the 81 km metric, X2 was above the metric on average in 7% of the months, an increase of 17%, and ranges from a minimum of 1% to a maximum of 16%.

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 variability. 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 SCVWD. Table Q-3 summarizes projected South of Delta CVP deliveries under four climate change scenarios and Table Q-4 summarizes projected SWP Table A deliveries under four climate change scenarios. The project deliveries presented in Table Q-3 and Q-4 summarize key results from the Sacramento and San Joaquin Basins Study CalLite-CV modeling results. These results are summarized in greater detail in the Climate Change Sensitivity Analysis presented in Appendix G of the Feasibility Report.

Table Q-3. 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	2716	2254	-461	2828	113	2602	-113
Above Normal	2360	1589	-771	2593	233	2220	-141
Below Normal	2265	1678	-587	2493	228	2169	-96
Dry	1919	1301	-618	2370	451	1815	-104
Critical	1441	1101	-340	1741	299	1386	-55
All Years	2134	1586	-549	2408	274	2032	-102

Source: Appendix G, Climate Change Sensitivity Analysis, Feasibility Report

[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

Table Q-4. 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	3265	2895	-370	3365	100	3175	-90
Above Normal	2910	2306	-604	3233	322	2770	-141
Below Normal	2635	1912	-723	2894	259	2580	-56
Dry	2329	1607	-722	2753	424	2241	-89
Critical	1652	1268	-384	2036	384	1647	-5
All Years	2557	2006	-551	2857	300	2480	-77

Source: Appendix G, Climate Change Sensitivity Analysis, Feasibility Report

[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

In addition to the changes water quality, supply and demand described above, the entire Delta region is now below sea level, protected by more than a thousand miles of levees and dams, and catastrophic failure of those levees and dams from an extreme high sea level event would greatly affect this resource (Karl, Melillo, and Peterson 2009). Projected changes in the timing and amount of river flow, particularly in winter and spring, is estimated to more than double the risk of Delta flooding events by mid-century, and result in an eight-fold increase before the end of the century (Karl, Melillo, and Peterson 2009). Taking into account the additional risk of a major seismic event and increases in sea level due to climate variability over this century, the California Bay–Delta Authority has concluded that the Delta and Suisun Marsh are not sustainable under current practices (Karl, Melillo, and Peterson 2009).

Natural Resources. Climate variability 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 (NCADAC 2013, Reclamation 2016a, Reclamation 2016b). In particular, species and habitats that are already facing challenges will be the most impacted by climate variability (NCADAC 2013, Reclamation 2016a, Reclamation 2016b). Other impacts to natural resources include:

- Changing water quality of natural surficial water bodies, including higher water temperatures, decreased and fluctuating dissolved oxygen content, increased cycling of detritus, more frequent algal blooms, increased turbidity, increased organic content, color changes, and alkalinity changes (Karl, Melillo, and Peterson 2009).

- Decreased tree growth and habitat change in low- and mid-elevation forests from increased temperature and drought (Karl, Melillo, and Peterson 2009).

- Increased frequency and intensity of insect attacks due to increased temperatures and shorter winters (NCADAC 2013).

- Disruption of the coordination between predator-prey or plant-pollinator life cycles that may lead to declining populations of many native species (Karl, Melillo, and Peterson 2009).

- Changes in the tree canopy that affect rainfall interception, evapotranspiration, and infiltration of precipitation, affecting the quantity of runoff (Karl, Melillo, and Peterson 2009).

- Reduced ability to respond to flooding and increased stress on species populations due to changes in wetland and riparian zone plant communities and hydraulic roughness (Karl, Melillo, and Peterson 2009).

- Shifting distribution of plant and animal species on land, with some species becoming more or less abundant (Karl, Melillo, and Peterson 2009).

- Rare or endangered species may become less abundant or extinct (NCADAC 2013, Reclamation 2016a, Reclamation 2016b).

- Reductions in the number of months with sufficient storage for cold water pool management (Reclamation 2016a and Reclamation 2016b).

- Increased river temperatures under the Central Tendency and Hot-Dry climate future scenarios (Reclamation 2016a and Reclamation 2016b).

- Decreased recreation and tourism opportunities from ecosystems degradation (Karl, Melillo, and Peterson 2009).

Infrastructure. Existing infrastructure were designed based on past, stable climate trends and may not have the capacity to respond to rapid changes in climate that are projected for the future (NCADAC 2013). Impacts to infrastructure include:

- Changes to soil moisture (Karl, Melillo, and Peterson 2009), which may lead to soil subsidence under structures.

- Increased energy demand for cooling, refrigeration and water transport (Karl, Melillo, and Peterson 2009).

- Buckling of pavement or concrete structures (Karl, Melillo, and Peterson 2009).

- Decreased lifecycle of equipment or increased frequency of equipment failure (Karl, Melillo, and Peterson 2009).

- Accelerated erosion when stormwater infrastructure capacity is exceeded (NCADAC 2013).

Agriculture and Livestock. Increased temperatures may lengthen the crop season of some perennial crops, although disruptions from extreme heat, drought, and changes to insects are also expected (NCADAC 2013). With adaptive actions, agriculture in the United States is expected to be resilient in the near-term, but yields of crops are expected to decline mid-century and late-century due to increased extremes in the climate (NCADAC 2013). California produces a large portion of the nation's high-value specialty crops, which are irrigation dependent and vulnerable to extreme changes in temperature and moisture (NCADAC 2013). Increased frequency and duration of heat waves would also put stress on livestock.

Table Q-5 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 2016b)

Human Health. Extreme heat events, increased wildfires, decreased air quality caused by rising temperatures, and diseases transmitted by insects, food and water that are impacted by climate variability are a threat to human health and well-being (NCADAC 2013).

Table Q-5. 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
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: Appendix G, Climate Change Sensitivity Analysis, Feasibility Report
Notes:
[1] Sacramento Valley only.
[2] San Joaquin and Tulare Lake Basins only.

Q.2 Environmental Consequences/Environmental Impacts

This section examines the relationship of climate variability effects to the environmental impacts and mitigation measures presented in Chapter 4. This section discusses impacts of the action alternatives and proposed mitigation measures as anticipated for a range of possible future socioeconomic-climate scenarios.

Q.2.1 Assessment Methods

The climate variability impact assessment characterizes the sensitivity of environmental effects evaluated in this EIS/EIR to uncertainties in potential future socioeconomic and climatic conditions.

This chapter presents the significance determinations made in Chapter 4 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 variability.

Q.3 Effects of Climate Variability on the Impacts Anticipated Under the Action Alternatives

This section examines the relationship of climate variability effects to the environmental impacts and mitigation measures presented in Chapter 4. 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. This discussion relies on information provided previously in this chapter and in greater detail in the Climate Change Sensitivity Analysis completed in the Feasibility Report (Appendix G).

Q.3.1 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 variability: noise and vibration; Indian Trust Assets; GHG emissions; and traffic and transportation. For these resources climate variability is not expected to alter the outcome of the impacts from the action alternatives (e.g., noise and vibration in the study area).

Q.3.2 Water Quality

As discussed in Section 4.1, Water Quality, the action alternatives could result in impacts related to the following:

- Violation of existing water quality standards or waste discharge requirements (Less than significant and significant and unavoidable)

- Substantially degrade existing water quality conditions (Less than significant)
- Result in effects on water quality related beneficial uses (Beneficial)

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 variability 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). Climate variability induced temperature increases and associated eutrophication in the reservoir would be mitigated to some degree by the development of a lower San Felipe Intake that would allow deliveries from San Luis Reservoir from colder deeper levels longer in the year. The Treatment Alternative would increase SCVWD's capacity to treat water quality issues associated with these increased temperatures.

High turbidity could occur with climate variability as storm severity increases and wildfires become more frequent (DWR 2008). Other water quality issues that could result from climate variability 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 may also increase as more extreme rain events occur (DWR 2008).

Significant impacts on surface water quality within the study area could occur with implementation of the pipeline option for Alternative 2, but would not occur if the other action alternatives are implemented. Climate variability may result in additional significant surface water quality impacts 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 surface water quality in the study area.

Q.3.3 Surface Water Supply

As discussed in Section 4.2, Surface Water Supply, the action alternatives could result in impacts related to the following:

- Change deliveries to south-of-Delta CVP contractors and change storage in San Luis Reservoir (Less than significant and beneficial)
- Generate temporary CVP San Felipe Division water supply interruptions during construction (Less than significant)

- Change CVP deliveries to south-of-Delta CVP and SWP contractors via the South Bay Aqueduct and California Aqueduct (Less than significant)

- Change CVP water supply reliability for SCVWD in the long-term (Beneficial)

Under climate variability, CVP and SWP exports would be reduced as summarized in Table Q-3 and Table Q-4; 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. With implementation of the action alternatives, south-of-Delta deliveries would mostly increase (except for SWP deliveries under the San Luis Reservoir Expansion Alternative). With climate variability the magnitude of these benefits are likely to be reduced, but the alternatives would be anticipated to improve water supply conditions in comparison to a climate variability future baseline with no action. Climate variability may result in significant surface water supply impacts 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 surface water supply in the study area.

Table Q-5 summarizes the frequency of San Luis Low Point under the different climate change scenarios. San Luis storage goes below the low-point threshold of 300 thousand acre-feet (TAF) in 35 years out of 88 years simulated under the Hot-Dry scenario, nearly twice the number of years under the No Climate Change scenario. The Warm-Wet scenario results in 14 years of storage below the 300 TAF threshold, and the Central Tendency scenario results in 18 years of San Luis storage below the threshold. San Luis Reservoir storage is more likely to go below the 300 TAF threshold in drier years than in wetter years. Further detail can be found in the Climate Change Sensitivity Analysis completed in the Feasibility Report (Appendix G).

Increases in the frequency or duration of future low-point events as a result of climate variability would not affect the ability of the Lower San Felipe Intake Alternative or Treatment Alternative to continue deliveries to SCVWD uninterrupted by low point conditions. Overall, the frequency of low-point conditions does not change under San Luis Reservoir Expansion Alternative with the exception of the Hot-Dry scenario where there is one less year. The Pacheco Reservoir Expansion Alternative should be able to address more frequent or less frequent low-point conditions with climate variability through changes in operations for the volume and timing of CVP contract supply moved into and out of Pacheco Reservoir.

Table Q-5. Frequency of San Luis Reservoir Low Point Conditions (Storage < 300 TAF)

Sacramento Valley Index	No Climate Change	Hot-Dry		Warm-Wet		Central Tendency	
	Years	Years	Change[1]	Years	Change[1]	Years	Change[1]
Wet	5	7	2	5	0	3	-2
Above Normal	5	7	2	1	-4	7	2
Below Normal	1	4	3	0	-1	2	1
Dry	5	10	5	6	1	7	2
Critical	2	7	5	2	0	2	0
All Years	18	35	17	14	-4	21	3

Source: SLLPIP Feasibility Report, Appendix G, Climate Change Sensitivity Analysis,

[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

Q.3.4 Groundwater Resources

As discussed in Section 4.3, Groundwater Resources, the action alternatives could result in impacts related to the following:

- Cause changes to imported surface water deliveries causing increases in groundwater use (Less than significant, no impact, and beneficial)

- Increased groundwater extraction pumping could affect groundwater levels (Less than significant)

Climate variability 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 variability may result in significant impacts to groundwater resources in the study area. Implementation of the action alternatives would, as was noted above in Section Q.3.3, provide a beneficial effect on surface water deliveries and offset to some degree the impact of climate variability on groundwater conditions. As a result, there would be no changes to the impact conclusions for groundwater resources in the study area.

Q.3.5 Flood Control

As discussed in Section 4.4, Flood Control, the action alternatives could result in impacts related to the following:

- Construction and operation of new facilities could result in the placement of structures in the 100-year flood hazard area which would impede or redirect flood flows (Less than significant)

- Construction and operations 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 (Less than significant, no impact, and beneficial)

- 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 (Less than significant and no impact)

Climate variability 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. None of the action alternatives would generate a significant impact on flood control. Changes to the frequency and severity of flood events with climate variability would not be anticipated to change these significance determinations given the Lower San Felipe Intake Alternative and Treatment Alternatives impact areas well outside of any 100-year flood zone and small increase in impervious surface. As a connected action to the B.F. Sisk Safety of Dams Corrective Action Study, the San Luis Reservoir Expansion Alternative would result in improved flood risk in the area of analysis. The Pacheco Reservoir Expansion Alternative would provide flood control benefits by reducing flows in Pacheco Creek and downstream waterways during flood events.

Q.3.6 Geology and Soils

As discussed in Section 4.5, Geology 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 (Less than significant)

- Construction activities on unstable soils could result in the risk of loss, injury, or death as a result of liquefaction of landslides (Less than significant and no impact)

- Construction activities could take place on expansive soils creating a substantial risk to life or property (No impact and less than significant)

- Construction activities could result in the loss of availability of a known mineral resource of regional or local importance (No impact)

- Maintenance activities during operations could expose people or structures to adverse effects related to the rupture of a known earthquake fault (Less than significant and no impact)

- Operations could result in long-term impacts to geology, soils, or mineral resources (No impact)

- Seismic-related ground failure could impact operation of alternative facilities (Less than significant and no impact)

Climate variability 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 variability, 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 variability. The environmental commitments ensure that significant impacts on geology and soils are avoided and would be resilient to changes in conditions with climate variability. Given this resilience, there would be no anticipated changes to significance determinations with climate variability.

Q.3.7 Air Quality

As discussed in Section 4.7, Air Quality, the action alternatives could result in impacts related to the following:

- Construction activities could cause temporary and short-term construction-related emission of criteria pollutants or precursors that would exceed the significance thresholds (Less than significant and significant and unavoidable)

- Operational activities could cause long-term emissions of criteria pollutants or precursors that would exceed the significance thresholds (Less than significant)

- Construction activities could cause temporary and short-term construction-related emissions of toxic air contaminates that would exceed the significance thresholds (Less than significant).

- Construction activities could cause temporary and short-term construction-related emissions of criteria pollutants or precursors that would exceed the general conformity de minimis thresholds (No adverse impact)

- Construction activities could create objectionable odors affecting a substantial number of people (Less than significant)

Climate variability 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 variability may result in significant air quality impacts in the study area. These impacts from climate variability would not however change how the action alternatives would be implemented or how the action alternatives would impact air quality. As a result, there would be no changes to the impact conclusions for air quality in the study area.

Q.3.8 Visual Resources

As discussed in Section 4.9, Visual Resources, 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) (Less than significant, no impact, and significant and unavoidable)

- Substantially damage scenic resources within a State scenic highway corridor (Less than significant, no impact, and significant and unavoidable)

- Substantially degrade the existing visual character or quality of the site and its surroundings (Less than significant and no impact)

- Create a new source of substantial light or glare, which would adversely affect day or nighttime views in the area (Less than significant and no impact)

- Operational changes at the San Luis Reservoir could affect visual resources (Less than significant and no impact)

Increased temperatures could change the vegetation across the area of analysis, which could result in a substantial visual modification. The types of changes anticipated could include the shift of seasonal grasslands from active green growth to brown dormancy earlier in the year along with the potential for increases in wildfire risk and the associated charring of these grasslands.

These changes in visual quality in the area of analysis would not however be anticipated to impact the magnitude or severity of impacts on visual quality anticipated from construction and operation of the action alternatives. The types of impacts generated by the construction actions and operation of the alternatives would be the same with and without climate variability and would not be expected to change with a shift in vegetation across the larger area of analysis.

Q.3.9 Hazards and Hazardous Materials

As discussed in Section 4.12, 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 (Less than significant)

- Operation of new facilities could, increases the risk of exposure to hazardous materials to the public and workers within the vicinity of the sites from the routine transport, storage, use or disposal of hazardous materials (Less than significant)

- Construction would occur within ¼ mile of existing schools which could increase the potential for exposure to hazardous materials to local school children and staff (No impact)

- The project would be constructed within the vicinity of an active remediation site which could create a hazard to the public or the environment if contaminated soil and/or groundwater is encountered and released to the environment (Less than significant)

- Construction activities could conflict with activities and operations at airports near or within the project area, resulting in safety hazards for pilots or people working and residing in the area (Less than significant and no impact)

- The use of mechanical equipment during construction could increase the risk of wildfire within the vicinity of the project area (Less than significant)

- During construction activities use of local roads, construction activities along SR 152 and traffic control activities could temporarily interfere with an emergency response plan or emergency evacuation plan for the project vicinity (Less than significant)

Most impacts identified for hazards and hazardous materials under the action alternatives are related to project construction. Therefore, climate variability in the longer term would not change the effects evaluations or conclusions. This includes the potential over the long-term for climate variability 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 (OEHHA 2013).

Climate variability 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 variability.

Q.3.10 Aquatic Resources

As discussed in Section 4.13, Aquatic 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 and/or interfere with the movement of any native resident or migratory fish species or with established native resident or migratory corridors, or impede the use of native nursery sites (No impact)

- Construction activities could interfere with the movement of any native resident or migratory fish species or with established native resident or migratory corridors, or impede the use of native nursery sites (No impact)

- Operation could result in impacts to aquatic habitats and special-status fish species in the Delta (Sacramento River Flow, Low Salinity Zone [X2], Delta Outflow, Old and Middle River Flows, and Delta Exports) (No impact and less than significant)

Climate variability 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 to south-of-Delta exports would occur under the action alternatives. The proportional changes in total CVP and SWP exports with implementation of the action alternatives, would be similar in a future with climate variability. 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.

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 variability 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 variability.

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 would potentially suppress fish production in the reservoir.

Climate variability, 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.

Q.3.11 Terrestrial Resources

As discussed in Section 4.14, 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 (Less than significant and no impact)
- Construction activities could kill, harm, or disturb terrestrial wildlife, including special-status species, or their habitats (Less than significant and no impact)
- Construction activities could disturb nesting migratory birds, including raptors (Less than significant)
- Construction activities could destroy or adversely affect special-status plant species (Less than significant and no impact)
- Construction activities could adversely affect wildlife corridors (Less than significant and no impact)

- Construction activities could result in conflicts with local policies or ordinances protecting biological resources (Less than significant and no impact)

- Construction or operation could result in conflicts with Habitat Conservation Plans or Other Local Plans or Policies (No impact)

- Construction activities could reduce foraging habitat for golden eagles and California condors at the San Luis Reservoir (Less than significant and no impact)

- Operations could result in long term impacts to terrestrial resources (No impact and less than significant)

With climate variability, terrestrial habitats could be negatively affected by increased spread of invasive species (USEPA and DWR 2011). Increased temperatures and variations in precipitation (shown in the Climate Change Sensitivity Analysis completed in the Feasibility Report [Appendix G]) 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 variability 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 variability would increase the frequency and intensity of wildfires (USEPA and DWR 2011).

Climate variability may result in significant impacts to terrestrial resources in the study area, but none of these effects would influence implementation of the action alternatives in a way that magnified the effect of those alternatives on terrestrial resources.

Q.3.12 Regional Economics

As discussed in Section 4.15, Regional Economics, the action alternatives could result in impacts related to the following:

- Changes in water supply to SCVWD due to low point interruptions could affect the regional economy (Beneficial)

- Changes in water supply to CVP M&I users in the Bay Area could affect the regional economy (No impact and beneficial)

- Changes in water supply to SWP M&I users in Bay Area and Southern California could affect the regional economy (No impact and beneficial)

- Changes in water supply to agricultural users in the San Joaquin Valley could affect the regional economy (No impact and beneficial)
- Construction expenditures could increase employment, income, and output in the regional economy (Beneficial)
- Operation and maintenance activities could increase employment, income, and output in the regional economy (Beneficial)
- Changes in recreation opportunities could affect economic activity in Merced County related to San Luis Reservoir (Adverse impact)

Climate variability 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. This reduction in south-of-Delta exports is likely to result in increases in the price of water as it becomes more scarce; however, the specific nature and magnitude of these effects is unknown. The action alternatives would all, as was noted above in Section 12.3.3, provide beneficial improvements in water supply conditions even in a future with climate variability. This improvement in water supply would also provide benefits to regional economics when compared to a climate variability future with no action.

Q.3.13 Land Use

As discussed in Section 4.16, Land Use and Agricultural Resources, the action alternatives could result in impacts related to the following:

- Construction activities could affect land use by physically dividing a community or conflicting with an applicable land use plan, policy, or regulation (No impact)
- Construction activities could affect land use by converting Prime Farmland, Unique Farmland, or Farmland of Statewide Importance to nonagricultural use (No impact)
- Operation of the expanded San Luis Reservoir could result in changes to land use that would conflict with the San Luis Reservoir State Recreation Area Resource Management Plan land use designations (Less than significant)
- Operation of Alternative 4 and 5 could result in changes to land use that would conflict with an applicable land use plan, policy, or regulation (No impact and less than significant)
- Operation of Alternative 4 and 5 could result in changes to land use and agricultural resources as a result of any changes to water supply deliveries (No impact and less than significant)

Climate variability 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 carbon dioxide 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, as discussed in the Climate Change Sensitivity Analysis completed in the Feasibility Report (Appendix G).

Climate variability 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. It is unknown to what degree climate variability may affect land uses, but increases in land fallowing from climate variability could add to the temporary increases in land fallowing identified with implementation of the action alternatives.

Climate variability may result in significant impacts to land use in the study area, but these are not directly related to implementation of the action alternatives and would not increase the magnitude of any of the impacts of the action alternatives; consequently, there would be no changes to the impact conclusions for land use in the study area.

Q.3.14 Recreation

As discussed in Section 4.17, 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 (Significant and unavoidable and no impact)
- Project construction could result in temporary closure to recreation facilities, resulting in a substantial loss of recreation opportunities (Significant and unavoidable and no impact)
- Project construction could displace visitors and substantially contribute to overcrowded conditions at other local and regional recreation sites (Significant and unavoidable and no impact)
- Operational changes to water levels in recreational water bodies could affect recreational uses (No impact, less than significant, and beneficial)

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 variability. However, the effects of climate variability on operations at San Luis Reservoir could potentially affect water-based recreation opportunities at the lake. As was noted in Section 12.3.3, reduced south-of-Delta exports with climate variability 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. Conversely, climate variability could result in warmer air temperatures, increasing demand for recreational activities associated with reservoir use.

Climate variability may result in significant impacts to recreation 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 recreation in the study area.

Q.3.15 Environmental Justice

As discussed in Section 4.18, 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 (Potential adverse and disproportionate effect)

Increased temperatures from climate variability 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. While climate variability could result in significant impacts to environmental justice, these impacts are not directly related to implementation of the action alternatives. Consequently, there would be no changes to the impact conclusions for environmental justice in the study area.

Q.3.16 Public Utilities, Services, and Power

As discussed in Section 4.19, 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 including fire and police protection, and schools (Less than significant)
- Construction activities could result in the need for new water, wastewater, or stormwater facilities (Less than significant)
- Construction activities would generate solid waste, the disposal of which could exceed the capacity of landfills designated to accommodate the project’s solid waste disposal needs (Less than significant)

- Construction activities could result in adverse impacts associated with the use and/or depletion of local or regional energy supplies (Less than significant)

- Operations could result in increases in stormwater runoff and the need for new stormwater drainage facilities (Less than significant)

- Changes in the operation of Pacheco Pumping Plant or Gianelli Pumping Plant could result in the need for additional capacity of energy supplies or the depletion of local or regional energy supplies (Less than significant)

- Long-term operations of new facilities could result in the need for additional capacity of energy supplies or the depletion of local or regional energy supplies (Less than significant)

- Construction and operation of the alternatives could result in wasteful, inefficient, or unnecessary consumption of energy (Less than significant)

- Operations could affect the provision of new governmental facilities including fire and police protection or schools (No impact)

The degree of impact from climate variability on energy generation is dependent on many factors and is not known at this time. However, the effects of climate variability are expected to increase energy demand and lower flows during high energy demand times. Climate variability 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 variability. Therefore, climate variability 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 variability.

Q.3.17 Cultural Resources

As discussed in Section 4.20, Cultural Resources, the action alternatives could result in impacts related to the following:

- Project construction could lead to adverse effects to known and unknown historic properties and/or historical resources (Less than significant and significant and unavoidable)

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 variability. Lower San Luis Reservoir levels from climate variability 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 variability 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 variability.

Q.3.18 Population and Housing

As discussed in Section 4.21, Population and Housing, the action alternatives could result in impacts related to the following:

- Temporarily induce population growth in the area of analysis, and potentially require new housing to accommodate this growth (Less than significant)
- Construction could displace people or houses, and potentially require construction of replacement housing (No impact)
- Induce substantial population growth or housing in the area of analysis (No impact)
- Operations could displace a number of people or houses, and potentially require construction of replacement housing (No impact)

Climate variability 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 particularly in coastal areas in Santa Clara County and induce population migration to lower cost communities in the Central Valley. Climate variability is likely to affect population and housing; however, the specific nature and magnitude of these effects is unknown. Climate variability 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.

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