25. Climate Change and Greenhouse Gas Emissions

25.1 Introduction

This chapter includes (1) a discussion of the environmental setting/affected environment for greenhouse gases (GHGs) and climate change, (2) a GHG emissions impact analysis of the potential environmental effects of GHGs emitted by construction, operation, and maintenance of the Sites Reservoir Project (Project), and (3) a climate change sensitivity analysis of the projected changes in future climate and their expected effects on the Project, as well as the potential for environmental effects on climate associated with the Project.

The GHG emissions impact analysis and climate change sensitivity analysis presented in this chapter provide two related analyses of the Project. The GHG emissions impact analysis is presented first and focuses on the GHG emissions that would result from implementation of the Project alternatives. The impact analysis provides the analysis required by the California Environmental Quality Act (CEQA) (*CEQA Guidelines* §15064.4) to evaluate whether the Project would have an adverse impact by emitting GHGs that could have a potentially significant impact on the environment, or conflict with an applicable plan, policy, or regulation aimed at reducing GHG emissions. The federal, state, and local regulatory setting for GHG emissions and climate change is discussed briefly in this chapter and is presented in greater detail in Appendix 4A Environmental Compliance.

The existing and potential changes in water operations, power generation, and pumping in the Extended and Secondary study areas as a result of construction, operation, and maintenance of the Project were evaluated, and the associated changes in GHG emissions were estimated. GHG emissions are not directly linked to specific impacts at geographic locations. Instead, emissions from individual sources around the globe, including those potential sources of emissions described as part of the Project, result in contributions to global GHG concentrations in the atmosphere, which may result in impacts that manifest themselves at global, regional, and local scales. As a result, this chapter is not separated into analyses of the Extended, Secondary, and Primary study areas. Instead, GHG emissions were analyzed for the Project in terms of shorter-term construction emissions and longer-term operational and maintenance emissions, regardless of source locations. GHG emissions from implementation of the Project were analyzed as a cumulative environmental impact; therefore, GHG emissions from the Project have been placed in the context of the statewide, national, and global GHG emissions, and global atmospheric concentrations of GHGs.

GHG emissions from the Project are not tied directly to potential impacts of climate change. GHG emissions from the Project and potential impacts of climate change on the Project are handled separately.

The climate change sensitivity analysis provides an analysis of how projected future climate change could impact the performance and environmental impacts of the Project, with a focus on water resources and related systems. The climate change sensitivity analysis provides a discussion of the potential effects of climate change on the Existing Conditions/No Project/No Action Condition, and the Project alternatives, including Alternatives A, B, C, C_1, and D.

25.2 Background

Climate is the average of conditions (based on averages of 20 to 30 years) of temperature, seasonality, precipitation, humidity, and types and frequency of extreme events, such as tornadoes or heat waves. For example, the climate of California's Central Valley is a Mediterranean climate, which is hot and dry during the summer, and cool and damp in winter, with the majority of precipitation falling as rain in the winter months. Tornadoes occur rarely. Climate is unique to a particular location and changes on timescales of decades to centuries or millennia.

Global climate change is expressed as changes in the average weather of the earth that are measured by temperature, wind patterns, precipitation, and storms over a long period of time (Intergovernmental Panel on Climate Change [IPCC], 2013). Climate change is a term used to describe large-scale shifts in existing (i.e., historically observed) patterns in Earth's climate system. Although the climate can and has changed in the past in response to natural drivers, recent climate change has been unequivocally linked to increasing concentrations of GHGs in Earth's lower atmosphere, and the rapid timescale on which these gases have accumulated (IPCC, 2013). The major causes of this rapid loading of GHGs into the atmosphere include the burning of fossil fuels since the industrial revolution, agricultural practices, increases in livestock grazing, and deforestation.

The phenomenon known as the greenhouse effect keeps the atmosphere near the Earth's surface warm enough for the successful habitation of humans and other life forms. GHGs present in the Earth's lower atmosphere play a critical role in maintaining the Earth's temperature; GHGs trap some of the long-wave infrared radiation emitted from the Earth's surface that would otherwise escape to space (Figure 25-1). The Kyoto Protocol, which was adopted in December 1997, addresses the following six GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and hydrofluorocarbons (HFCs). *CEQA Guidelines* §15364.5 also identifies these six gases as GHGs.

Higher concentrations of heat-trapping GHGs in the atmosphere result in increasing global surface temperatures, a phenomenon commonly referred to as global warming. Higher global surface temperatures, in turn, result in changes to Earth's climate system, including, but not limited to: the jet stream; El Niño; the Indian monsoon; ocean temperature and acidity; the extent of alpine glaciers, sea ice and polar ice sheets; the extent of deserts; atmospheric water content; and the extent and health of boreal and tropical forests (IPCC, 2007a; IPCC, 2007b).

The IPCC has been established by the World Meteorological Organization and United Nations Environment Programme to assess scientific, technical, and socioeconomic information relevant to the understanding of climate change, its potential impacts, and options for adaptation and mitigation. The IPCC is an organization of more than 800 scientists from around the world. It regularly publishes summary documents that analyze and consolidate all recent peer-reviewed scientific literature, providing a consensus of the state of the science. Thus, IPCC is viewed by governments, policymakers, and scientists as the leading international body on the science of climate change, and its summaries are considered to be the best available science. IPCC documents address change at the global and super-regional scales. IPCC studies and California-specific studies (e.g., California Air Resources Board [ARB], California Energy Commission [CEC], California Department of Water Resources [DWR], California Natural Resources Agency [CNRA], and Bureau of Reclamation [Reclamation]) that are based on IPCC data are referenced throughout this chapter.

Natural Greenhouse Effect

The greenhouse effect is a natural warming process. Carbon Dioxide (CO_2) and certain other gases are always present in the atmosphere. These gases create a warming effect that has some similarity to the warming inside a greenhouse, hence the name "greenhouse effect".

Enhanced Greenhouse Effect

Increasing the amount of greenhouse gases intensifies the greenhouse effect. This side of the globe simulates conditions today, roughly two centuries after the Industrial Revolution began.

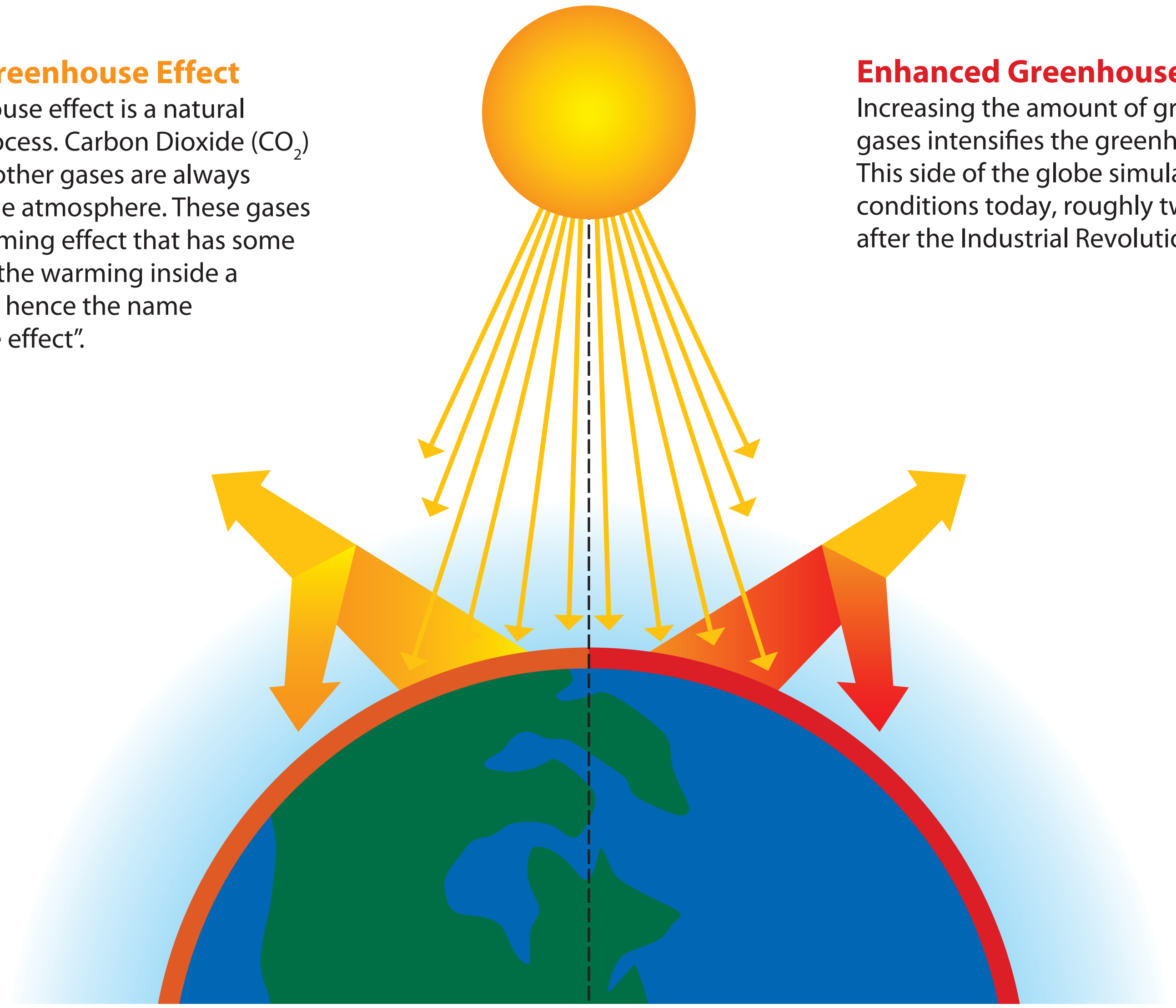

FIGURE 25-1
The Greenhouse Gas Effect
Sites Reservoir Project EIR/EIS

Source: Marion Koshland Science Museum of the National Academy of Sciences

The IPCC estimates that the average global temperature rise between the years 2000 and 2100 could range from 1.1 degrees Celsius (°C), with no increase in GHG emissions above year 2000 levels, to 6.4°C, with substantial increase in GHG emissions (IPCC, 2007a). Large increases in global temperatures could have substantial adverse effects on the natural and human environments on the planet and in California. GHGs are evaluated and regulated at the federal, State, and local levels. In addition, climate change vulnerability assessment and adaptation and resiliency planning are encouraged (although not regulated or required) at the federal, State, and local levels. Provided below is a list of the applicable climate change and GHG laws, policies, guidance, and plans. These are discussed in detail in Appendix 4A Environmental Compliance of this Environmental Impact Report/Environmental Impact Statement (EIR/EIS).

25.2.1 Federal Plans, Policies, and Regulations

- National Environmental Policy Act Guidance on Consideration of the Effects of Climate Change and Greenhouse Gas Emissions (Council on Environmental Quality [CEQ], 2016)
- Greenhouse Gas Reporting Rule (U.S. Environmental Protection Agency [USEPA], 2010)
- Endangerment and Cause or Contribute Findings for Greenhouse Gases Under Section 202(a) of the Clean Air Act (USEPA, 2009)
- Greenhouse Gas Tailoring Rule (USEPA, 2016)
- Federal Standards for Vehicle Fuel Economy (USEPA, 2015)

25.2.2 State Plans, Policies, and Regulations

- *CEQA Guidelines*
- Senate Bill (SB) 97 (Greenhouse Gas Emissions and CEQA) (2007)
- Governor’s Office of Planning and Research Technical Advisory on CEQA and Climate Change (2008)
- Assembly Bill (AB) 1493 (Vehicular Emissions: Greenhouse Gases) (2002)
- Executive Order S-3-05 (2005)
- California Renewables Portfolio Standard Program
- AB 32 (California Global Warming Solutions Act of 2006)
- SB 1368 (Electricity: Emissions of Greenhouse Gases) (2006)
- Executive Order S-01-07 (2007)
- Executive Order S-13-08 (2008)
- SB 375 (Sustainable Communities and Climate Protection) (2008)
- SB 1771 (California Climate Action Registry and Updates to Statewide Inventory) (2008)
- Executive Order B-30-15 (2015)
- SB 605 (Short-lived Climate Pollutants) (2014)

- SB 350 (Clean Energy and Pollution Reduction Act of 2015) (2015)
- SB 1383 (Short-lived Climate Pollutants: CH_4 Emissions, Dairy and Livestock, Organic Waste, Landfills) (2016)
- SB 32 (California Global Warming Solutions Action of 2006: Emissions Limit) and AB 197 (State Air Resources Board: Greenhouse Gases, Regulations) (2016)
- Climate Change Scoping Plan (2008, 2014, 2017)
- California Climate Change Adaptation Strategy (2009, 2014, 2016)
- California Cap and Trade Program
- Climate Action Plan Phase 1: Greenhouse Gas Emissions Reduction Plan (California Department of Water Resources [DWR], 2012a)
- California Air Pollution Control Officers Association (CAPCOA) Guidance Documents on Addressing GHGs under CEQA (2008) and Quantifying GHG Mitigation Measures (2010)

25.2.3 Regional and Local Plans, Policies, and Regulations

- Regional and Local Air District Programs
- County General Plans

Other than the federal and state programs described above, there are no regional or local plans, policies, and regulations applicable to GHG emissions in Glenn and Colusa counties. The air pollution control districts in Glenn and Colusa counties have not established GHG emissions thresholds for CEQA purposes. For evaluation of air quality impacts (see Chapter 24 Air Quality), staff at these districts recommended use of thresholds established by a nearby air quality agency (Tehama County) as surrogates to evaluate potential local and regional impacts in the Primary Study Area (Ledbetter, 2016; Gomez, 2016). For GHG emissions, the Tehama County Air Pollution Control District (TCAPCD) has established a threshold of 900 metric tons per year (mt/yr) (CO_2 or CO_2 equivalents generated annually) for evaluation of land use projects, such as residential or commercial developments[1] (TCAPCD, 2015). The TCAPCD-recommended significance thresholds are further discussed in Section 25.3.2.1.

All of the above federal and state laws, policies, guidance, and plans show California's commitment to reducing GHG emissions and climate change planning and will have important influences on current and future development patterns, behavior, and investments. With respect to the regulation of GHG emissions, California law is already more stringent than federal law, therefore, California entities that meet State level requirements will also comply with federal regulations at this time. California's key GHG regulations are AB 32 and SB 32; AB 32 requires ARB to work to reduce California's statewide GHG emissions to 1990 levels by 2020, and SB 32 establishes a new target for GHG emissions reductions in the state at 40 percent of 1990 levels by 2030. The regulations and GHG emissions reduction programs in place to achieve the goals of AB 32 and SB 32 provide the regulatory framework under which all current and future projects will proceed and the GHG emissions restrictions with which projects will have to

[1] TCAPCD recommends that "the 900 metric ton screening criteria (CO_2 or CO_2 equivalents generated annually) referenced in the CAPCOA whitepaper is being used by the District as a conservative criterion for determining which projects require further analysis and mitigation with regard to Climate Change" (TCAPCD, 2015).

comply. Details on AB 32 and SB 32, and the ARB plans[2] to implement the laws, are provided in Appendix 4 Environmental Compliance and Permit Summary.

25.3 Greenhouse Gas Emissions

25.3.1 Environmental Setting/Affected Environment

25.3.1.1 Global GHG Emissions

Global GHG emissions due to human activities have increased since pre-industrial times, with an estimated increase of 70 percent occurring between 1970 and 2010. Carbon dioxide (CO_2) is the most important anthropogenic GHG. Its annual emissions grew by approximately 80 percent between 1970 and 2010. An estimated 49 billion mt/yr of CO_2 equivalent (CO_2e) were emitted by global anthropogenic sources in 2010 (IPCC, 2014).

Global atmospheric concentrations of CO_2, CH_4, and N_2O have increased markedly as a result of human activities since 1750, and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. Atmospheric concentrations of CO_2 (379 parts per million) and CH_4 (1,774 parts per billion) in 2005 exceed by far the natural range over the last 650,000 years. Global increases in CO_2 concentrations are due primarily to fossil fuel use, with land use change providing another significant, but smaller, contribution (IPCC, 2014).

25.3.1.2 Principal GHG Emissions that Would be Generated by the Proposed Project

The primary GHGs that would be generated by the Project are CO_2, CH_4, N_2O, and SF_6. Each of these gases is discussed below. Note that PFCs and HFCs are not discussed because these gases are primarily generated by industrial processes, which are not anticipated as part of the Project.

Different GHGs have varying climate change impacts. The most commonly accepted metric for the radiative forcing (heat trapping) impact of GHGs is the global warming potential (GWP), which is a ratio intended to quantify the mass of CO_2 that would produce the same impacts over 100 years as 1 unit mass of the GHG. Most current regulatory and voluntary reporting programs in the United States use GWP estimates from the IPCC Fourth Assessment Report (IPCC, 2007a), although some may still use older estimates from the IPCC Second Assessment Report (IPCC, 1996). Updated estimates are provided in the IPCC Fifth Assessment Report (IPCC, 2013).

The California mandatory GHG reporting program uses Second Assessment Report GWPs. As an example, according to the IPCC Second Assessment Report, the GWP of CH_4 is 21. By definition, the GWP of CO_2 is 1. N_2O and the fluorinated gases have much higher GWPs. Emissions of individual and total gases are reported as CO_2e in order to provide a metric for total climate change impact. For example, the emissions of 1 ton of CH_4 and 1 ton of CO_2 would total 22 tons of CO_2e using Second Assessment Report GWPs.

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[2] On January 20, 2017, ARB released "The 2017 Climate Change Scoping Plan Update, the Proposed Strategy for Achieving California's 2030 Greenhouse Gas Target". The proposed framework includes the following elements:

- 50 percent renewable energy
- 50 percent reduction in statewide vehicular petroleum use
- Doubling of energy efficiency in existing buildings
- Carbon sequestration in California's land base
- Aggressive reductions in short-lived climate pollutants, such as black carbon, fluorinated gases, and methane
- Climate adaptation strategy.

GHGs are emitted by both natural processes and human activities. Of the common GHGs, CO_2 and CH_4 are emitted in the greatest quantities from human activities. Emissions of CO_2 are largely byproducts of fossil fuel combustion or oxidation of fixed carbon resulting from land use changes. CH_4 emissions result from offgassing associated with agricultural practices, the decomposition of organic materials within landfills, fugitive emissions from oil and gas production, and other sources. Fluorinated gases such as HFCs, PFCs, and SF_6 are byproducts of certain industrial processes and can also result from fugitive releases of refrigerants and electrical insulators as well as other industrial uses of such gases.

GHGs in the atmosphere regulate the earth's temperature. Without the natural heat trapping effect of GHGs, the earth's surface would be about 34°C cooler. However, it is known that emissions from human activities, particularly the consumption of fossil fuels for electricity production and transportation, have elevated the concentration of GHGs in the atmosphere beyond the level of naturally occurring concentrations. GHGs anticipated to occur as part of the Project include the following:

- **Carbon Dioxide –** The global carbon cycle is made up of large carbon flows and reservoirs. Billions of tons of carbon in the form of CO_2 are absorbed by oceans and living biomass (i.e., sinks) and are emitted to the atmosphere annually through natural processes (i.e., sources). When in equilibrium, carbon fluxes are roughly balanced (USEPA, 2013). CO_2 was the first GHG demonstrated to be increasing in atmospheric concentration, with the first conclusive measurements being made in the last half of the 20th Century. As noted above, CO_2 has a GWP of 1. Concentrations of CO_2 in the atmosphere have risen approximately 35 percent since the Industrial Revolution. According to the IPCC (2007a), the global atmospheric concentration of CO_2 has increased from a pre-industrial value of approximately 280 parts per million by volume (ppmv) to 379 ppmv in 2005. By 2011, concentrations increased to 391 ppmv (IPCC, 2013), and the National Oceanic and Atmospheric Administration Earth System Research Laboratory (NOAA/ESRL) reports a measurement of 404 ppmv at the Mauna Loa, Hawaii station as the 2016 annual average (NOAA/ESRL, 2017).
- **Methane –** CH_4 is an extremely effective absorber of radiation, although its atmospheric concentration is less than CO_2, and its lifetime in the atmosphere is brief (10 to 12 years) compared to some other GHGs. Based on a number of factors, scientific assessments of the climate impact of CH_4 have increased with time. The IPCC Second Assessment Report estimated the GWP of CH_4 as 21 and, as noted above, the IPCC Fourth Assessment Report estimates it at 25. The IPCC Fifth Assessment Report reports a 100-year GWP of CH_4 and fossil CH_4 of 28 and 30, respectively, although few if any reporting organizations have adopted the higher estimates yet. CH_4 concentrations have increased by an estimated 150 percent since pre-industrial times (IPCC, 2013). Anthropogenic sources of CH_4 include natural gas and petroleum systems, agricultural activities, coal mining, wastewater treatment, stationary and mobile combustion, landfills, and certain industrial processes (USEPA, 2013).
- **Nitrous Oxide –** Concentrations of N_2O also began to rise at the beginning of the Industrial Revolution. N_2O is produced by microbial processes in soil and water, including reactions that occur in fertilizers containing nitrogen, as well as a number of industrial processes and other sources. Concentrations of N_2O are estimated to exceed pre-industrial levels by 20 percent (IPCC, 2013). The Second Assessment Report and Fourth Assessment Report estimates of GWP for N_2O are 310 and 298, respectively.
- **Sulfur Hexaflouride –** SF_6, a human-made chemical, is used as an electrical insulating fluid for power distribution and high voltage electrical equipment, in the magnesium industry, in

semiconductor manufacturing, and also as a tracer chemical for the study of oceanic and atmospheric processes (USEPA, 2013). In 2005, atmospheric concentrations of SF_6 were 5.6 parts per billion and steadily increasing in the atmosphere. Second Assessment Report and Fourth Assessment Report estimates of the GWP for SF_6 are 23,900 and 22,800, respectively.

25.3.1.3 GHG Emissions Inventories

A GHG inventory is a quantification of all GHG emissions and sinks within a selected physical and/or economic boundary. GHG inventories can be performed on a large scale (i.e., for global and national entities) or on a small scale (i.e., for a particular building or person). Although many processes are difficult to evaluate, several agencies have developed tools to quantify emissions from certain sources.

From 1750 to 2011, cumulative global CO_2 emissions to the atmosphere from fossil fuel combustion and cement production totaled 365 gigatonnes of carbon (1,340,000 million metric tons [MMT] of CO_2), while deforestation and other land use changes are estimated to have released 180 gigatonnes of carbon (661,000 MMT of CO_2). This results in cumulative anthropogenic emissions of 545 gigatonnes of carbon (2,000,000 MMT of CO_2) over the 261-year period from 1750 to 2011 (IPCC, 2013).

United States GHG emissions in 2015 were estimated to total 6,586 MMT of CO_2e, and in 2014, total GHG emissions were estimated to be 6,736 MMT of CO_2e (USEPA, 2017a). Total GHG emissions rose by 3.4 percent from 1990 to 2015, but total emissions decreased by 2.2 percent from 2014 to 2015 (a reduction of 150.1 MMT of CO_2e). Total GHG emission reductions between 2014 and 2015 were largely to the result of reduced CO_2 emissions from fossil fuel combustion. CH_4 emissions, which have declined from 1990 levels, resulted primarily from enteric fermentation associated with domestic livestock, decomposition of wastes in landfills, and natural gas systems. Agricultural soil management was the major source of N_2O emissions. Overall, net GHG emissions in 2015 were 11.2 percent below 2005 levels (USEPA, 2017a).

California is a substantial contributor of global GHGs, the second largest contributor in the United States and the fourteenth largest contributor in the world in 2007 (ARB, 2011). In 2014, human activities in California released 441.5 MMT of CO_2e, which equaled approximately 6 percent of the United States total. The primary source of GHGs in California is transportation, contributing 42 percent of the state's total GHG emissions. Industrial emissions were the second largest source, contributing 23 percent of the state's GHG emissions (ARB, 2016).

Table 25-1 outlines the most recent global, national, and Statewide annual GHG inventories in MMT of CO_2e to provide context of the magnitude of potential Project-related emissions.

Table 25-1
Global, National, and Statewide Annual GHG Emissions Inventories

Emissions Inventory	CO_2e (MMT)
2010 IPCC Global GHG Emissions Inventory	49,000
2015 USEPA National GHG Emissions Inventory	6,586.2
2014 ARB State GHG Emissions Inventory	441.5

Sources: IPCC, 2014; USEPA, 2017a; ARB, 2011, 2016.

25.3.2 Environmental Impacts/Environmental Consequences

25.3.2.1 Proposed Project Greenhouse Gas Emissions Analysis

Evaluation Criteria and Thresholds of Significance

Significance criteria represent the environmental thresholds that were used to identify whether an impact would be potentially significant. *CEQA Guidelines* §15064.4 indicates the following:

(a) The determination of the significance of greenhouse gas emissions calls for a careful judgment by the Lead Agency consistent with the provisions in §15064. A Lead Agency should make a good faith effort, based to the extent possible on scientific and factual data, to describe, calculate, or estimate the amount of greenhouse gas emissions resulting from a project. A Lead Agency shall have discretion to determine, in the context of a particular project, whether to:

   (1) Use a model or methodology to quantify greenhouse gas emissions resulting from a project, and which model or methodology to use. The Lead Agency has discretion to select the model or methodology it considers most appropriate provided it supports its decision with substantial evidence. The Lead Agency should explain the limitations of the particular model or methodology selected for use; and/or

   (2) Rely on a qualitative analysis or performance-based standards.

(b) A Lead Agency should consider the following factors, among others, when assessing the significance of impacts from greenhouse gas emissions on the environment:

   (1) The extent to which the project may increase or reduce greenhouse gas emissions as compared to the existing environmental setting.

   (2) Whether the project emissions exceed a threshold of significance that the Lead Agency determines applies to the project.

   (3) The extent to which the project complies with regulations or requirements adopted to implement a statewide, regional, or local plan for the reduction or mitigation of greenhouse gas emissions. Such requirements must be adopted by the relevant public agency through a public review process and must reduce or mitigate the project's incremental contribution of greenhouse gas emissions. If there is substantial evidence that the possible effects of a particular project are still cumulatively considerable notwithstanding compliance with the adopted regulations or requirements, an EIR must be prepared for the project.

For the purposes of this analysis, an alternative would result in a potentially significant impact if it would result in the following:

- Generation of Cumulative GHG Emissions

Neither the Authority or Reclamation have established quantitative significance thresholds for GHG emissions; instead the Project is evaluated on a case-by-case basis using up-to-date calculation and analysis methods. By enacting AB 32 (Global Warming Solutions Act of 2006), SB 32 (California Global Warming Solutions Action of 2006: Emissions Limit) and AB 197 (State Air Resources Board: Greenhouse Gases: Regulations), the State Legislature has established statewide GHG emissions reduction targets. Further, the Legislature has determined that GHG emissions, as they relate to global climate change, are a source of adverse environmental impacts in California and should be addressed pursuant to CEQA. AB 32 did not amend CEQA, although the legislation identifies the myriad environmental problems in California caused by global warming (Health and Safety Code, Section 38501(a)). SB 97, in contrast, added explicit requirements that CEQA analysis address the impacts of GHG emissions (PRC Sections 21083.05 and 21097).

Glenn County and Colusa County air pollution control districts have not established GHG emissions thresholds for CEQA purposes. For evaluation of air quality impacts (see Chapter 24), staff at these districts recommended use of thresholds established by a nearby air quality agency (Tehama County) as surrogates to evaluate potential local and regional impacts in the Primary Study Area[3] (Ledbetter, 2016; Gomez, 2016). CAPCD has developed specific air quality guidelines and criteria for compliance with CEQA (TCAPCD, 2015). TCAPCD has established recommended significance thresholds for Project construction and operation. Projects with the potential to have higher emission levels are subject to increasingly more stringent environmental review and mitigation requirements.

For GHG emissions, TCAPCD has established a threshold of 900 mt/yr. However, this threshold is intended to apply to land use projects such as residential or commercial developments. Because the Project is not a residential or commercial development, TCAPCD recommends that "the 900 metric ton screening criteria (CO_2 or CO_2 equivalents generated annually) referenced in the CAPCOA whitepaper is being used by the District as a conservative criteria for determining which projects require further analysis and mitigation with regard to Climate Change" (TCAPCD, 2015). The following discussion provides review and analysis of anticipated potential climate change impacts to and from the Project.

Scientific studies (as best represented by the IPCC's periodic reports) demonstrate that climate change is already occurring due to past GHG emissions. Evidence suggests that global emissions must be reduced below current levels to avoid the most severe climate change impacts. In accordance with scientific consensus regarding the cumulative nature of GHGs, the analysis provides a cumulative evaluation of GHG emissions. Unlike traditional cumulative impact assessments, this analysis is still project-specific in that it evaluates only direct emissions generated by the Project. Because of the global nature of GHG emissions and impacts that result from those emissions, Project emissions are placed into the context of current global atmospheric GHG concentrations and projections of future concentrations. The analysis does not specifically analyze emissions from past, present, and reasonably foreseeable projects in the Extended, Secondary, and Primary study areas.

Impact Assessment Assumptions and Methodology

Combinations of Project facilities were used to create Alternatives A, B, C, C_1, and D. In all resource chapters, the Authority and Reclamation described the potential impacts associated with the construction, operation, and maintenance of each of the Project facilities for each of the five action alternatives. Some Project features/facilities and operations (e.g., reservoir size, overhead power line alignments, provision of water for local uses) differ by alternative and are evaluated in detail within each of the resource areas chapters. As such, the Authority has evaluated all potential impacts with each feature individually and may choose to select or combine individual features as determined necessary.

[3] The Glenn County Air Pollution Control District does not have CEQA guidelines for assessing air quality impacts; it would instead defer to the Tehama County guidelines, if necessary (Ledbetter, 2016). In addition, the Colusa County Air Pollution Control District does not have CEQA guidelines other than its New Source Review rules; thresholds developed by the Tehama County Air Pollution Control District would represent similar values (Gomez, 2016).

Assumptions

The following assumptions were made regarding Project-related construction, operation, and maintenance impacts from GHG emissions:

- Direct Project-related construction, operation, and maintenance activities would occur in the Primary Study Area.
- Direct Project-related operational effects would occur in the Secondary Study Area.
- The only direct Project-related construction activity that would occur in the Secondary Study Area is the installation of an additional pump into an existing bay at the Red Bluff Pumping Plant.
- The only direct Project-related maintenance activity that would occur in the Secondary Study Area is the sediment removal and disposal at the two intake locations (i.e., Glenn-Colusa Irrigation District Main Canal Intake and Red Bluff Pumping Plant).
- No direct Project-related construction or maintenance activities would occur in the Extended Study Area.
- Direct Project-related operational effects that would occur in the Extended Study Area are related to San Luis Reservoir operation; increased reliability of water supply to agricultural, municipal, and industrial water users; and the provision of an alternate Level 4 wildlife refuge water supply. Indirect effects to the operation of certain facilities that are located in the Extended Study Area, and indirect effects to the consequent water deliveries made by those facilities, would occur as a result of implementing the alternatives. Indirect impacts associated with electricity generation and use would extend statewide, or further, depending on the sources of the electrical power used.
- No additional channel stabilization, grade control measures, or dredging in the Sacramento River at or upstream of the Delevan Pipeline Intake/Discharge Facilities would be required.
- Construction activities are anticipated to occur between the hours of 6:00 a.m. and 7:00 p.m. Monday through Friday. Nighttime and weekend construction are not planned, but may occur on an as-needed basis.

Methodology

Existing conditions and the future No Project/No Action alternatives were assumed to be similar in the Primary Study Area given the generally rural nature of the area and limited potential for growth and development in Glenn and Colusa counties within the 2030 study period used for this EIR/EIS, as further described in Chapter 2 Alternatives Analysis. As a result, within the Primary Study Area, it is anticipated that the No Project/No Action Alternative would not entail material changes in conditions as compared to the existing conditions baseline.

With respect to the Extended and Secondary study areas, the effects of the proposed action alternatives would be primarily related to changes to available water supplies in the Extended and Secondary study areas and the Project's cooperative operations with other existing large reservoirs in the Sacramento watershed, and the resultant potential impacts and benefits to biological resources, land use, recreation, socioeconomic conditions, and other resource areas. DWR has projected future water demands through 2030 conditions that assume the majority of Central Valley Project (CVP) and State Water Project (SWP) water contractors would use their total contract amounts, and that most senior water rights users would use most of their water rights. This increased demand in addition to the projects currently under construction and those that have received approvals and permits at the time of preparation of the EIR/EIS would constitute the No Project/No Action Condition. As described in Chapter 2 Alternatives Analysis, the primary difference in these projected water demands would be in the Sacramento Valley. As of the time of preparation of this EIR/EIS, the water demands have expanded to the levels projected to be achieved on or before 2030.

Accordingly, existing conditions and the No Project/No Action alternatives are assumed to be the same for this EIR/EIS and, as such, are referred to as the Existing Conditions/No Project/No Action Condition, which is further discussed in Chapter 2, Alternatives Analysis. With respect to applicable reasonably foreseeable plans, projects, programs, and policies that may be implemented in the future but that have not yet been approved, these are included as part of the analysis of cumulative impacts in Chapter 35 Cumulative Impacts.

The Project was evaluated to determine how construction, operations, and maintenance of Project facilities would generate GHG emissions. GHG emissions associated with the Project could contribute to the cumulatively considerable impact of global climate change by adding GHGs to the atmosphere. The discussion below reviews potential generation of GHG emissions for each of the Project's action alternatives. For the purpose of this analysis, anticipated changes in GHG emissions caused by construction, operation, and maintenance of the Project alternatives were compared to the Existing Conditions/No Project/No Action Condition to identify the potential for impacts.

Construction-related GHG emissions would result primarily from fuel combustion in construction equipment, trucks, and worker vehicles. To support calculations of GHG emissions, lists of the types and numbers of construction equipment and number of days required for construction of each Project facility were developed by Project engineers, and assumptions were developed about hours of operation for each type of equipment (Barnes, 2011). Information on the dates of construction start and finish, and the duration of construction for each project feature, were obtained from the Concept Schedule for Sites Reservoir provided by URS (Barnes, 2011). This schedule was used to estimate emissions for Alternatives A, B, C, and C_1. A different schedule to expedite construction was developed for construction of Alternative D (Herrin, 2017), and that new schedule was used in the emissions estimates for Alternative D.

Appendix 24A Methodology for Air Quality and GHG Emissions Calculations provides the methodology, assumptions, and information used to estimate the GHG emissions associated with construction, operation, and maintenance of the alternatives. In addition, Appendix 24A Methodology for Air Quality and GHG Emissions Calculations includes the detailed emission calculations, emission factors, and summary tables.

Equipment-specific hours of use were multiplied by equipment-specific CO_2 emission factors to calculate total equipment emissions for construction of each Project facility. Total CO_2 emissions for each Project facility were estimated by summing the results of the equipment emissions. For construction, emissions of other GHGs, such as CH_4 and N_2O, were not estimated, due to the lack of equipment-specific emission factors for GHGs other than CO_2. Emissions of CH_4 and N_2O from fuel combustion would be much lower than emissions of CO_2, contributing in the range of 2 to 4 percent of total CO_2 emissions. Therefore, it was assumed that CH_4 and N_2O emissions would not substantially contribute to the construction-related GHG emissions.

To estimate GHG emissions from Project facility operations and maintenance activities, Project facilities were grouped to reflect activities, personnel, and equipment that might be shared to optimize efficiency. Emissions were estimated for maintenance of the following Project facilities:

- Pumping Plants, Intake and Outlet Facilities, Pumping/Generating Plants
- Reservoirs, Recreation Facilities, Dams, Roads, and Bridges
- Electrical Switchyards and Overhead Power Lines
- Tunnels, Pipelines, and Canals

Equipment and personnel requirements for maintenance of facilities were assumed to be the same for all Project alternatives (A, B, C, C_1, and D). Maintenance activities include both routine activities and major inspections. Routine activities would occur on a daily basis throughout the year, whereas major inspections would occur annually. Exhaust emissions from construction-type equipment were calculated using load factors, horsepower, and emission factors from x D in the CalEEMod User's Guide, Appendix D (CAPCOA, 2016). Emission factors for a motor boat and boat-operated dredge were obtained from the OFFROAD2011 model, using the California Harbor Craft Emissions Inventory Database and California Barge and Dredge Emissions Inventory Database, respectively. Vehicle exhaust emissions were estimated using emission factors from ARB's EMFAC2014 model (ARB, 2014) for the Colusa County portion of the Sacramento Valley Air Basin.

Estimating GHG emissions for the electricity used and generated in operation of the alternatives is complex and involves assumptions about the amount and timing of pumping and generating activities, the fuel source used to power pumping operations (fossil sources or renewable sources), and changes in the operation of existing SWP and CVP facilities as operations of the alternatives are integrated into the existing water delivery system and the California electrical distribution and balancing system. As discussed in Chapter 31 Power Production and Energy and summarized below, the Project's action alternatives would consume energy during the pumping phase of operations, Alternatives A, B, C, and D would generate electricity during the release phase of operations, and would be able to provide resource shifting and renewable integration services during pumpback operations. In addition, the seasonal operations of the Project's action alternatives would make them highly conducive to operations during the pumping and generating phases that may result in reductions in GHG emissions.

Emissions from operation of the Project's action alternatives were estimated by post processing the CALSIM II modeling runs used to analyze the impacts of the Project's action alternatives throughout this document. CALSIM II provides estimates of the amount of water that would be pumped and released at each of the facilities during each month of the year for various water year types and hydrologic conditions. The pumping and releasing of water can be converted to electricity use and electricity generation by applying assumptions about efficiency of each pumping or generating plant. Chapter 31 Power Production and Energy describes assumptions of the Project's power and energy operations, including pumpback operations and renewable integration services.

Operation of Proposed Project Alternatives

Although each of the Project alternatives has different features and would operate slightly differently, all alternatives share commonalities among their operations that are important for analysis of GHG emissions.

As discussed in greater detail in Chapter 31 Power Production and Energy, during winter and spring, the Project alternatives would typically function in the pumping phase when excess water flows down the

Sacramento River. This is the time of year when hydroelectric generation and wind generation increase and demand for electricity decreases, thus much of the increased electricity load required to pump water out of the Sacramento River and into the reservoirs could be served by renewable electricity sources. Further, the largest electricity load from the Project alternatives comes from lifting water from the proposed Holthouse Reservoir to the proposed Sites Reservoir. The proposed Holthouse Reservoir has been sized to accommodate a large amount of storage (up to 6 days of fill operations) allowing pumping operations to move water from the proposed Holthouse Reservoir to the proposed Sites Reservoir to occur at night or during other non-peak electricity demand periods or when renewable power is available.

During the summer and fall, Alternatives A, B, C, and D would typically function in the generating phase, as water is released from the reservoirs to meet water supply and water quality objectives. This is the time of year that electricity demand increases to satisfy summer cooling requirements. The release of water from the proposed Sites Reservoir to the proposed Holthouse Reservoir could be timed to meet peak daytime demand for electricity, thereby displacing the need to operate high emissions power plants.

During times of the year when the Project is not functioning in the pumping or generating phase, it could be operated to perform daily pumpback operations. Daily pumpback operations would allow the Project to use power from various high efficiency sources, including renewables, to pump water from the proposed Holthouse Reservoir to the proposed Sites Reservoir typically during the nights and other low demand periods. Then, during higher demand periods, the water could be released back from the proposed Sites Reservoir to the proposed Holthouse Reservoir to generate electricity. Although this operation would actually consume more electricity than is generated, the net result would typically be reduced GHG emissions because electricity used to pump the water would be very low or zero GHG emissions sources, such as ultra-efficient baseload gas fired power plants, nuclear, or renewable, and the generated electricity would displace the least efficient peaking power plants that emit higher levels of GHGs.

In addition to operation of the Project's action alternatives' facilities, the implementation of any of the action alternatives would also result in changes to operations of existing SWP and CVP facilities including:

- Shasta Lake
- San Luis Reservoir
- Folsom Lake
- Trinity Lake
- Lake Oroville
- Banks Pumping Plant
- Jones Pumping Plant

Changes to operations of these facilities as a result of Project operations are described in Chapter 6 Surface Water Resources.

Pumping at Banks and Jones pumping plants would likely increase because of increased water supply reliability created by the Project's alternatives. Thus, additional electricity would be needed to operate the facilities to accommodate integration of the Project facilities and operations. The combined results of all changes in operation of SWP, CVP, and Project facilities are described below for each of the Project's action alternatives.

Topics Eliminated from Further Analytical Consideration

No Project facilities or topics that are included in the significance criteria listed above were eliminated from further consideration in this chapter.

Existing Conditions/No Project/No Action Condition

Existing conditions and the future No Project/No Action alternatives were assumed to be similar in the Primary Study Area given the generally rural nature of the area, and the limited potential for growth and development in Glenn and Colusa counties within the 2030 study period used for this EIR/EIS, as further described in Chapter 2 Alternatives Analysis. As a result, within the Primary Study Area, it is anticipated that the No Project/No Action alternatives would not entail material changes in conditions as compared to the Existing Conditions baseline.

Accordingly, the Existing Conditions/No Project/No Action Alternative is assumed to be the same for this EIR/EIS and, as such, is referred to as the Existing Conditions/No Project/No Action Condition, which is further discussed in Chapter 2 Alternatives Analysis. With respect to applicable reasonably foreseeable plans, projects, programs, and policies that may be implemented in the future but that have not yet been approved, these are included as part of the analysis of cumulative impacts in Chapter 35 Cumulative Impacts.

Impacts Associated with Alternative A

Impact GHG-1: Generation of Cumulative GHG Emissions

Construction, Operation, and Maintenance of the Proposed Project

Project Construction Emissions

Construction-related GHG emissions would result primarily from fuel combustion in construction equipment, trucks, and worker vehicles, and from the production of concrete used for construction. Total estimated GHG emissions resulting from construction of Alternative A are summarized in Table 25-2.

Table 25-2
Estimated Total GHG Emissions from Construction of Alternative A (Metric Tons CO_2e)*

Emissions from Mobile Construction Equipment*	Emissions from Concrete Production	Total Construction-Related Emissions
172,066	66,637	238,704

*Calculated emissions based on Table 24A.A-5 in Appendix 24A Methodology for Air Quality and GHG Emissions Calculations.

The GHG emissions shown in Table 25-2 are the estimated total cumulative CO_2e emissions that would occur over the 9-year construction period of Alternative A. Within the 9-year construction period, annual GHG emissions would fluctuate. Because GHG emissions are well dispersed in the atmosphere and persist for long periods of time (hundreds or thousands of years), estimates of emissions on a yearly basis are less meaningful than the total amount of emissions released during the discrete construction period. After construction is complete, emissions from these sources would cease.

Project Operation and Maintenance Emissions

Once construction is complete, the proposed Alternative A facilities would begin to operate. Unlike construction emissions, operations emissions would occur over a long period of time, i.e., the useful life of the Project, in this case 100 years.

Maintenance of Alternative A facilities would include regular inspections, land management activities, sediment removal from forebays, and servicing of pumping plants. Estimated emissions from maintenance activities are detailed in Appendix 24A Methodology for Air Quality and GHG Emissions Calculations, in Table 24A.D-8. The estimated total for annual operations and maintenance of Project facilities is approximately 5,100 mt/yr of CO_2.

In addition, operation of the proposed Alternative A facilities would involve both the use and generation of electricity, as described in Chapter 31 Power Production and Energy. The amount of GHG emissions from operation of Alternative A would depend on the specific sources of energy used for pumping water into the proposed reservoirs and other operational parameters. Further, electricity needed to pump water into the reservoirs and electricity generated by releasing water from the reservoirs would vary annually and seasonally, depending on hydrologic conditions, renewable system integration, timing of generation and use, and use of pumpback operations.

Operations of Project facilities would generate electricity but would also result in additional electricity consumption from pumping and facility operations. Alternative A would have greater operations-related emissions than the Existing Conditions/No Project/No Action Condition because it would result in net energy consumption and would require additional electricity generation from other sources. To evaluate the potential indirect impacts, GHG emissions were estimated for the predicted systemwide net generation and consumption of electricity by CVP, SWP, and Project facilities associated with Alternative A.

Table 25-3 summarizes the GHG emissions estimated for each of the Project alternatives when compared to emissions estimated for the net long-term generation and consumption of electricity for the Existing Conditions/No Project/No Action Condition. Emissions associated with all Project alternatives are presented in Table 25-3 for the purpose of comparison, and are evaluated in more detail in their respective discussions. Over the long-term, net increased energy consumption associated with Alternative A would result in indirect GHG emissions of approximately 109,000 mt/yr above the Existing Conditions/No Project/No Action Condition.

Table 25-3
Indirect GHG Emissions from Net Long-Term Electricity Use for the Existing Conditions/No Project/No Action Condition, and Alternatives A, B, C, C_1, and D

Condition/Alternative	Electricity Net Use (All Facilities: CVP, SWP, Proposed Facilities) – Long Term (gigawatt hours/year)[a]	Total GHG Emissions (mt/yr CO_2e)[b]	Incremental Increase (Compared to the Existing Conditions/No Project/No Action Condition) in GHG Emissions (mt/yr CO_2e)
Existing Conditions/No Project/No Action Condition	132	39,081.1	Not Applicable
Alternative A	499	147,738.5	108,657.4

Condition/Alternative	Electricity Net Use (All Facilities: CVP, SWP, Proposed Facilities) – Long Term (gigawatt hours/year)[a]	Total GHG Emissions (mt/yr CO_2e)[b]	Incremental Increase (Compared to the Existing Conditions/No Project/No Action Condition) in GHG Emissions (mt/yr CO_2e)
Alternative B	498	147,442.4	108,361.3
Alternative C	543	160,765.5	121,684.4
Alternative C_1	700	207,248.4	168,167.3
Alternative D	477	141,225.0	102,143.8

[a]See Table 31B-2, Power and Pumping Cost Reporting Metrics - Summary of All CVP, SWP and Proposed Sites Facilities, Sites Administrative Draft Environmental Impact Reports and Feasibility Study Alternatives.

[b]Source for Emission Factors: The Climate Registry (2016), General Reporting Protocol, Version 2.1, 2016 Climate Registry Default Emission Factors, Table 14.1, U.S. Emission Factors by eGRID Subregion - updated to eGRID 2015 (2012 data) Version 1.0. eGRID 2015 Subregion Western Electricity Coordinating Council California. Table updated April 2016.

Although operation of the proposed Alternative A facilities would result in a long-term average net use of electricity, the way the facilities would be operated and integrated into the California electricity market would actually result in annual reductions in GHG emissions. As discussed in Chapter 31 Power Production and Energy, water pumping would occur to the extent possible during times when renewable (zero emissions) electricity is available, and releases of water, which generate electricity, would be done to the extent possible when electricity is in high demand. Therefore, electricity generated at the proposed Alternative A facilities – with no emission of GHGs – would offset some of the most inefficient and highest emitting generating resources in the electricity market. These system integration benefits are not reflected in the emissions reported in Table 25-3.

In addition to the analysis provided above, the proposed Alternative A facilities would be configured to allow substantial pumpback operations; i.e., pumping water from the proposed Holthouse Reservoir into the proposed Sites Reservoir during nighttime hours (when excess clean/cheap electricity is available) and then releasing the water back from the proposed Sites Reservoir to the proposed Holthouse during peak demand hours during the day (when the electricity generated can displace high emitting/high cost sources).

Alternative A would also be able to provide critical renewable integration services to the California grid that would facilitate additional renewable energy generation and further reduce GHG emissions. Solar and wind power are intermittent electricity sources; the electricity generated at a solar or wind power station fluctuates unpredictably as clouds obscure the sun or wind speeds decrease. To effectively integrate solar and wind power into an electricity grid, there must be appropriate backup power supplies to ensure that fluctuations in solar or wind generation are smoothed out so that sufficient supply exists in the grid to meet demand. Alternative A could provide this renewable integration service. Both in the pumping and generating phase, Alternative A would have the flexibility to modify its operations to balance generation from intermittent renewable electricity supplies. In the pumping phase, Alternative A would have ample storage at the proposed Holthouse Reservoir and variable speed pumps at the proposed Sites Pumping Plant that could quickly ramp up or down so that pumping from the proposed Holthouse Reservoir to the proposed Sites Reservoir could be slowed or delayed for up to several days to coincide with available renewable electricity. In the generation phase, the proposed Sites Pumping Plant's variable speed turbines could quickly ramp up or ramp down to provide additional generation when renewable electricity decreases or additional pumping load when renewable generation increases.

Assuming use of the TCAPCD threshold of 900 mt/yr as a trigger for "further analysis and mitigation with regard to Climate Change," the potential increase in GHG emissions associated with Alternative A above the Existing Conditions/No Project/No Action Condition has been quantified and evaluated. Construction of Alternative A would generate approximately 239,000 metric tons of CO_2e emissions total, over the 9-year construction period. Once operations begin, Project facility maintenance activities would increase yearly GHG emissions by approximately 5,100 mt/yr of CO_2. As presented in Table 25-3, over the long term, the net increase in energy consumption associated with Alternative A would result in an increase of indirect yearly GHG emissions of approximately 109,000 mt/yr of CO_2e above the Existing Conditions/No Project/No Action Condition. These emission levels have been estimated to represent the maximum potential indirect effects and could potentially be lower because of multiple sources of uncertainty and the assumptions used to estimate electricity generation. These potential electricity-related impacts may add to emissions and potentially significant impacts, depending on how and where the electricity is generated.

The GHG emissions estimate for construction, operation, and maintenance of Alternative A would contribute to a cumulatively considerable effect and would, therefore, be a **potentially significant impact** when compared to the Existing Conditions/No Project/No Action Condition

Open Water Surfaces and Tailraces Emissions

Implementation of Alternative A would include the construction of a surface storage reservoir and would result in the conversion of land that is currently used predominantly for cattle grazing to an open water surface. Research indicates that the surfaces of some reservoirs may be emitting or absorbing GHGs at material rates as a result of diffusion of CO_2 and CH_4 from the water into the atmosphere or from the atmosphere into the water. In addition, as stored water passes through hydroelectric turbines, GHGs that had been dissolved in the water come out of solution and are released to the atmosphere (also known as tailrace emissions). These types of emissions could represent sources or sinks of emissions from Alternative A; however, there are several factors that are not yet fully understood that make it difficult to adequately quantify potential emissions rates from the proposed Alternative A surface storage facilities.

These factors have been identified in both the absorption and emission of GHGs from reservoirs and other aquatic systems. In general, organic inputs, soil type and vegetation inundated, water quality parameters (dissolved oxygen, CO_2, and CH_4, temperature, pH), and duration of inundation have all been found to affect the GHG absorption and emissions characteristics of aquatic systems. In addition to these factors, natural aquatic systems have been shown to be the primary pathway in the global carbon cycle for transmitting carbon sequestered at the watershed level back to the atmosphere, into sediment deposition, or as dissolved carbon to the oceans (Cole et al., 2007). Thus, even if emissions from the surface and tailraces of reservoirs could be accurately quantified, it would not be clear whether the emissions of GHGs measured at the reservoir were different from the emissions that would have occurred within the watershed had the reservoir not been built. Because rivers are significant GHG emissions pathways, it is necessary to compare pre-reservoir watershed emissions with post-reservoir watershed emissions to determine the effect of the reservoir.

Recent studies have provided useful information about the potential scale of emissions from open water systems in temperate areas. Fifty-nine hydropower reservoirs, natural lakes, and rivers in the western and southwestern United States have been sampled to date (Soumis et al., 2004). This sampling shows that some reservoirs in California, Oregon, and Washington are GHG sinks and others have gross emissions equal to or less than natural lakes and rivers of the region (Tremblay et al., 2005). These studies suggest that the proposed Sites Reservoir, Holthouse Reservoir, and other open water facilities associated with Alternative A are unlikely to produce substantial GHG emissions.

Further, ARB has determined that, for the purpose of AB 32 Mandatory GHG Accounting, generation of hydroelectric power shall be excluded from the regulation[4]. The USEPA in its eGrid database (USEPA, 2012) of emissions factors for electricity generating facilities also associates a zero emissions factor to hydroelectric power generation. And finally, excluding biogenic sources of emissions from short-term changes in the form of carbon at stages of the active carbon cycle is a widely accepted practice in GHG accounting as indicated by the lack of protocols, guidance, and tools provided for accounting for these emissions in several important GHG protocols including: The GHG Protocol (www.ghgprotocol.org), The Climate Registry (www.theclimateregistry.org), and The American Carbon Registry (www.americancarbonregistry.org).

Based on these studies of emissions from open water systems, emissions associated with Alternative A's open water surfaces and tailraces would be a **less-than-significant impact** when compared to the Existing Conditions/No Project/No Action Condition. Emissions from the surface or tailraces of proposed Alternative A facilities were not estimated because the quantification would be speculative, considering the lack of protocols, guidance, and tools to do so.

Impacts Associated with Alternative B

Impact GHG-1: Generation of Cumulative GHG Emissions

Construction, Operation, and Maintenance of the Proposed Project

Project Construction Emissions

Construction-related GHG emissions associated with Alternative B would result primarily from fuel combustion in construction equipment, trucks, and worker vehicles, and from the production of concrete used for construction. Total estimated GHG emissions resulting from construction of Alternative B are summarized in Table 25-4.

Table 25-4
Estimated Total GHG Emissions from Construction of Alternative B (Metric Tons CO_2e)*

Emissions from Mobile Construction Equipment*	Emissions from Concrete Production	Total Construction-Related Emissions
212,369	73,269	285,638

*Calculated emissions based on Table 24A.B-5 in Appendix 24A Methodology for Air Quality and GHG Emissions Calculations.

The emissions shown in Table 25-4 are the estimated total cumulative CO_2e emissions that would occur over the 9-year construction period of Alternative B. Similar to Alternative A, annual emissions would fluctuate within the construction period, and after construction is complete, emissions from these sources would cease.

[4] California Code of Regulations, Title 17, Division 3, Chapter 1, Subchapter 10, Article 2, Section 95100.

Project Operation and Maintenance Emissions

Similar to Alternative A, maintenance of Alternative B facilities would include regular inspections, land management activities, sediment removal from forebays, and servicing of pumping plants. Estimated emissions from maintenance activities are detailed in Appendix 24A Methodology for Air Quality and GHG Emissions Calculations, in Table 24A.D-8. Like Alternative A, the estimated total for annual operations and maintenance of Project facilities under Alternative B is approximately 5,100 mt/yr of CO_2.

Construction of Alternative B would generate approximately 286,000 metric tons of CO_2e emissions over the 9-year construction period. Once operations begin, maintenance activities would increase GHG emissions by approximately 5,100 mt/yr of CO_2. As presented in Table 25-3, over the long term, the net increase in energy consumption associated with Alternative B would result in indirect GHG emissions of approximately 108,000 mt/yr of CO_2e above the Existing Conditions/No Project/No Action Condition.

The GHG emissions estimated for construction, operation, and maintenance of Alternative B would contribute to a cumulatively considerable effect and would, therefore, be a **potentially significant impact** when compared to the Existing Conditions/No Project/No Action Condition

Open Water Surfaces and Tailraces Emissions

Refer to the **Impact GHG-1** discussion for Alternative A for open water surfaces and tailraces. That discussion also applies to Alternative B.

Impacts Associated with Alternative C

Impact GHG-1: Generation of Cumulative GHG Emissions

Construction, Operation, and Maintenance of the Proposed Project

Project Construction Emissions

Construction-related GHG emissions would result primarily from fuel combustion in construction equipment, trucks, and worker vehicles, and from the production of concrete used for construction. Total GHG emissions resulting from construction of Alternative C are summarized in Table 25-5.

Table 25-5
Estimated Total GHG Emissions from Construction of Alternative C (Metric Tons CO_2e)*

Emissions from Mobile Construction Equipment*	Emissions from Concrete Production	Total Construction-Related Emissions
212,369	73,269	285,638

*Calculated emissions based on Table 24A.B-5 in Appendix 24A Methodology for Air Quality and GHG Emissions Calculations.

The emissions shown in Table 25-5 are the estimated total cumulative CO_2e emissions that would occur over the 9-year construction period of Alternative C. Similar to Alternative A, annual emissions would fluctuate within the construction period, and after construction is complete, emissions from these sources would cease.

Project Operation and Maintenance Emissions

Similar to Alternative A, maintenance of Alternative C facilities would include regular inspections, land management activities, sediment removal from forebays, and servicing of pumping plants. Estimated emissions from maintenance activities are detailed in Appendix 24A Methodology for Air Quality and GHG Emissions Calculations, in Table 24A.D-8. Like Alternative A, the estimated total for annual operations and maintenance of Project facilities under Alternative C is approximately 5,100 mt/yr of CO_2.

Construction of Alternative C would result in approximately 286,000 metric tons of CO_2e emissions over the 9-year construction period. Once operations begin, maintenance activities would increase GHG emissions by approximately 5,100 mt/yr of CO_2. As presented in Table 25-3, over the long term, the net increase in energy consumption associated with Alternative C would result in indirect GHG emissions of approximately 122,000 mt/yr of CO_2e above the Existing Conditions/No Project/No Action Condition.

The GHG emissions estimated for construction, operation, and maintenance of Alternative C would contribute to a cumulatively considerable effect and would, therefore, be a **potentially significant impact** when compared to the Existing Conditions/No Project/No Action Condition.

Open Water Surfaces and Tailraces

Refer to the **Impact GHG-1** discussion for Alternative A for open water surfaces and tailraces. That discussion also applies to Alternative C.

Impacts Associated with Alternative C_1

Impact GHG-1: Generation of Cumulative GHG Emissions

Construction, Operation, and Maintenance of the Proposed Project

Project Construction Emissions

Estimated construction-related GHG emissions would be the same as those described for Alternative C and are presented in Table 25-5.

Project Operation and Maintenance Emissions

Like Alternative A, maintenance of Alternative C_1 facilities would include regular inspections, land management activities, sediment removal from forebays, and servicing of pumping plants. Estimated emissions from maintenance activities are detailed in Appendix 24A Methodology for Air Quality and GHG Emissions Calculations, in Table 24A.D-8. Like Alternative A, the estimated total for annual operations and maintenance of Project facilities is approximately 5,100 mt/yr of CO_2.

In addition, Alternative C_1 would involve the use of electricity but no generation of electricity by Alternative C_1 facilities, as described in Chapter 31 Power Production and Energy. The amount of GHG emissions from operation of Alternative C_1 would depend on the specific sources of energy used for pumping water into the reservoir and other operational parameters.

Like Alternative B, construction of Alternative C_1 would result in approximately 286,000 metric tons of CO_2e emissions over the 9-year construction period. Once operations begin, maintenance activities would increase GHG emissions by approximately 5,100 mt/yr of CO_2. As presented in Table 25-3, over the long term, the net increase in energy consumption associated with Alternative C_1 would result in indirect GHG emissions of approximately 168,000 mt/yr of CO_2e above the Existing Conditions/No Project/No Action Condition.

The GHG emissions estimated for construction, operation, and maintenance of Alternative C_1 would contribute to a cumulatively considerable effect and would, therefore, be a **potentially significant impact** when compared to the Existing Conditions/No Project/No Action Condition.

Open Water Surfaces and Tailraces

Refer to the **Impact GHG-1** discussion for Alternative A for open water surfaces and tailraces. That discussion also applies to Alternative C_1.

Impacts Associated with Alternative D

Impact GHG-1: Generation of Cumulative GHG Emissions

Construction, Operation, and Maintenance of the Proposed Project

Project Construction Emissions

Construction-related GHG emissions would result primarily from fuel combustion in construction equipment, trucks, and worker vehicles; from the production of concrete used for construction; and from the generation of electricity used during construction. Total GHG emissions resulting from construction of Alternative D are summarized in Table 25-6.

Table 25-6
Estimated Total GHG Emissions from Construction of Alternative D (Metric Tons CO_2e)*

Emissions from Mobile Construction Equipment*	Emissions from Concrete Production	Total Construction-Related Emissions
212,296	73,269	285,565

*Calculated emissions based on Table 24A.B-5 in Appendix 24A Methodology for Air Quality and GHG Emissions Calculations.

The emissions shown in Table 25-6 are the estimated total cumulative CO_2e emissions that would occur over the 9-year construction period of Alternative D. Within the 9-year construction period, annual emissions would fluctuate, with most of the work completed in the first 7 years. After construction is complete, emissions from these sources would cease.

Project Operation and Maintenance Emissions

Like Alternative A, maintenance of Alternative D facilities would include regular inspections, land management activities, sediment removal from forebays, and servicing of pumping plants. Estimated emissions from maintenance activities are detailed in Appendix 24A Methodology for Air Quality and GHG Emissions Calculations, in Table 24A.D-8. The estimated total for annual operations and maintenance of Project facilities is approximately 5,100 metric tons of CO_2 per year.

Construction of Alternative D would result in approximately 286,000 metric tons of CO_2e emissions over the 9-year construction period. Once operations begin, maintenance activities would increase GHG emissions by approximately 5,100 mt/yr of CO_2. As presented in Table 25-3, over the long term, the net increase in energy consumption associated with Alternative D would result in indirect GHG emissions of approximately 102,000 mt/yr of CO_2e above the Existing Conditions/No Project/No Action Condition.

The GHG emissions estimated for construction, operation, and maintenance of Alternative D would contribute to a cumulatively considerable effect and would, therefore, be a **potentially significant impact** when compared to the Existing Conditions/No Project/No Action Condition.

Open Water Surfaces and Tailraces

Refer to the **Impact GHG-1** discussion for Alternative A for open water surfaces and tailraces. That discussion also applies to Alternative D.

Mitigation Measures

Mitigation measures are provided below and summarized in Table 25-7 for the GHG emissions impacts that have been identified as potentially significant.

Assuming use of the TCAPCD threshold of 900 mt/yr as a trigger for "further analysis and mitigation with regard to Climate Change," the potential increase in GHG emissions associated with each of the Project alternatives has been quantified and evaluated. The GHG emissions estimated for construction, operation, and maintenance of the Project under each alternative would contribute to a cumulatively considerable effect and would therefore, be a **potentially significant impact** when compared to the Existing Conditions/No Project/No Action Condition.

Consistent with the requirements of the DWR Greenhouse Gas Emissions Reduction Plan (DWR, 2012), construction activities undertaken for the Project would implement DWR's Construction best management practices (BMPs). If feasible, the same BMPs would be implemented during facility maintenance activities. Further, implementation of Mitigation Measure Air Qual-1b to reduce equipment and vehicle exhaust emissions would also reduce some Project-related GHG emissions.

The following measures are considered BMPs for DWR construction and maintenance activities. Implementation of these practices will reduce GHG emissions from construction projects by minimizing fuel usage by construction equipment, reducing fuel consumption for transportation of construction materials, reducing the amount of landfill material, and reducing emissions from the production of cement.

Pre-Construction and Final Design BMPs

Pre-construction and final design BMPs are designed to ensure that individual projects are evaluated and their unique characteristics taken into consideration when determining whether specific equipment, procedures, or material requirements are feasible and efficacious for reducing GHG emissions from the project. While all projects will be evaluated to determine whether these BMPs are applicable, not all projects will implement all of the following BMPs:

BMP 1. Evaluate project characteristics, including location, project work flow, site conditions, and equipment performance requirements, to determine whether specifications of the use of equipment with repowered engines, electric drive trains, or other high-efficiency technologies are appropriate and feasible for the project or specific elements of the project.

BMP 2. Evaluate the feasibility and efficacy of performing onsite material hauling with trucks equipped with on-road engines.

BMP 3. Ensure that all feasible avenues have been explored for providing an electrical service drop to the construction site for temporary construction power. When generators must be used, use alternative fuels such as propane or solar to power generators to the maximum extent feasible.

BMP 4. Evaluate the feasibility and efficacy of producing concrete onsite and specify that batch plants be set up onsite or as close to the site as possible.

BMP 5. Evaluate the performance requirements for concrete used on the project and specify concrete mix designs that minimize GHG emissions from cement production and curing, while preserving all required performance characteristics.

BMP 6. Limit deliveries of materials and equipment to the site to off-peak traffic congestion hours.

Construction BMPs

Construction BMPs apply to construction and maintenance projects that DWR completes or for which DWR issues contracts. Projects are expected to implement all Construction BMPs unless a variance is granted by the Division of Engineering Chief, Division of Operation and Maintenance Chief, or Division of Flood Management Chief, as applicable, and the variance is approved by the DWR CEQA Climate Change Committee. Variances will be granted when specific project conditions or characteristics make implementation of the BMP infeasible and where omitting the BMP will not be detrimental to the project's consistency with the Greenhouse Gas Reduction Plan. Construction BMPs are the following:

BMP 7. Minimize idling time by requiring that equipment be shut down after 5 minutes when not in use (as required by the State airborne toxics control measure [Title 13, Section 2485 of the California Code of Regulations]). Provide clear signage that posts this requirement for workers at the entrances to the site and provide a plan for the enforcement of this requirement.

BMP 8. Maintain construction equipment in proper working condition and perform preventative maintenance. Required maintenance includes compliance with manufacturer's recommendations, proper upkeep and replacement of filters and mufflers, and maintenance of engine and emissions systems in proper operating condition. Maintenance schedules will be detailed in an Air Quality Control Plan prior to commencement of construction.

BMP 9. Implement tire inflation program on job site to ensure that equipment tires are correctly inflated. Check tire inflation when equipment arrives onsite and every 2 weeks for equipment that remains onsite. Check vehicles used for hauling materials off-site weekly for correct tire inflation. Procedures for the tire inflation program will be documented in an Air Quality Management Plan prior to commencement of construction.

BMP 10. Develop a project-specific ride share program to encourage carpools, shuttle vans, and transit passes, and secure bicycle parking for construction worker commutes.

BMP 11. Reduce electricity use in temporary construction offices by using high-efficiency lighting and requiring that heating and cooling units be Energy Star compliant. Require that all contractors develop and implement procedures for turning off computers, lights, air conditioners, heaters, and other equipment each day at close of business.

BMP 12. For deliveries to project sites where the haul distance exceeds 100 miles and a heavy-duty Class 7 or Class 8 semi-truck or 53-foot or longer box type trailer is used for hauling, a SmartWay[5] certified truck will be used to the maximum extent feasible.

BMP 13. Minimize the amount of cement in concrete by specifying higher levels of cementitious material alternatives, larger aggregate, longer final set times, or lower maximum strength where appropriate.

BMP 14. Develop a project-specific construction debris recycling and diversion program to achieve a documented 50 percent diversion of construction waste.

BMP 15. Evaluate the feasibility of restricting material hauling on public roadways to off-peak traffic congestion hours. During construction scheduling and execution, minimize, to the extent possible, uses of public roadways that would increase traffic congestion.

With regard to the electricity use associated with the Project alternatives, the annual rate of GHG emissions would depend on the specific sources of the electricity used. Further, electricity use and generation would vary annually and seasonally, depending on hydrologic conditions, renewable system integration, timing of generation and use, and use of pumpback operations. Beyond implementation of construction BMPs and Mitigation Measure **Air Qual-1b**, project optimization, and use of renewable electricity sources, there are no feasible mitigation measures that could reduce the potential impact to a less-than-significant level. The impact would, therefore, remain **potentially significant and unavoidable.**

Table 25-7
Summary of Mitigation Measures for Project Impacts from Greenhouse Gas Emissions

Impact	Associated Project Facility	LOS Before Mitigation	Mitigation Measure	LOS After Mitigation
Impact GHG-1: Generation of Cumulative GHG Emissions	Construction, Operation, and Maintenance of Project Facilities	Significant	No Feasible Mitigation	Significant and Unavoidable

Note:
LOS = Level of Significance

25.4 Climate Change

25.4.1 Environmental Setting/Affected Environment

25.4.1.1 Climate

Hot dry summers and mild rainy winters characterize the Mediterranean climate of the Sacramento Valley. During the year, the temperature ranges from 25 degrees Fahrenheit (°F) to 105°F, with average annual rainfall approximately 20 inches and snowfall very rare (California Irrigation Management

[5] The USEPA has developed the SmartWay truck and trailer certification program to set voluntary standards for trucks and trailers that exhibit the highest fuel efficiency and emissions reductions. These tractors and trailers are outfitted at point of sale or retrofitted with equipment that significantly reduces fuel use and emissions including idle reduction technologies, improved aerodynamics, automatic tire inflation systems, advanced lubricants, advanced powertrain technologies, and low rolling resistance tires.

Information System, 2011 and WRCC, 2011). The prevailing winds are moderate in strength, and vary from moist clean breezes from the south to dryland flows from the north. Summer conditions in the northern Sacramento Valley Air Basin are typically characterized by high temperatures and low humidity, with prevailing winds from the south. Winter conditions are characterized by rainstorms interspersed with stagnant and sometimes foggy weather. Winter daytime temperatures average in the low 50s and nighttime temperatures average in the high 30s. During winter, north winds become more frequent, but winds from the south predominate. Rainfall occurs mainly from late October to early May.

Table 25-8 provides climate summaries for selected locations in Glenn and Colusa counties. As shown, the counties are similar in temperature, but differ in levels of precipitation and snowfall.

Table 25-8
Climatic Conditions in Glenn and Colusa Counties

Parameter	Glenn County (Willows)[a]	Colusa County (Colusa)[b]
Average Maximum Temperature (°F)	75.0	75.0
Average Minimum Temperature (°F)	47.5	47.6
Average Total Precipitation (inches)	18.29	16.43
Average Total Snowfall (inches)	0.5	0.1

[a]Period of record for the City of Willows: 7/1/1948 to 12/31/2005.
[b]Period of record for the City of Colusa: 10/1/1948 to 12/31/2005.
Source: Desert Research Institute, Western Regional Climate Center, 2009.

25.4.1.2 Global Climate Trends

Recent Trends

A vast amount of scientific research on climate change, both its causes and effects, at all geographic scales has been conducted during the last 50 years. Scientific measurements have shown that changes in the global climate system are already occurring. These include rising air temperatures; rising ocean temperatures; rising ocean salinity; rising ocean acidity; rising global sea levels; changes in precipitation patterns; and increased intensity and frequency of extreme events such as storms, droughts, and wildfires (IPCC, 2007b; DWR, 2009).

Global average surface temperature has risen at an average rate of 0.15°F per decade since 1901. Worldwide, 2015 was the warmest year on record, and 2006 to 2015 was the warmest decade on record since thermometer-based observations began (USEPA, 2017b). The rate of warming over the last half of that period was almost double that for the period as a whole (IPCC, 2007a). Fourteen of the 15 years from 1997 to 2011 rank among the 15 warmest years in the instrumental record of global average temperature (going back to 1880) (Blunden and Arndt, 2012).

During the same period over which this increased global warming has occurred, many other changes have occurred in other natural systems. Sea levels have risen on average 1.8 millimeters (0.07 inch) per year; precipitation patterns throughout the world have shifted, with some areas becoming wetter and others drier; tropical cyclone activity in the North Atlantic has increased; peak runoff timing of many glacial and snow-fed rivers has shifted earlier; and numerous other changed conditions have been observed. Although it is difficult to prove a definitive cause and effect relationship between global warming and other observed changes to natural systems, there is high confidence in the scientific community that these changes are a direct result of increased global temperatures (IPCC, 2007a).

Much of the western United States has experienced warming during the 20th century (approximately 2°F [1.1°C]) and is projected to experience further warming during the 21st century with central estimates varying from roughly 5°F to 7°F (2.8°C to 3.8°C), depending on location (Reclamation 2016a). Historical trends in annual precipitation are less apparent. Future projections suggest that the northwestern and north-central portions of the United States gradually may become wetter (e.g., Columbia Basin and Missouri River basin) while the southwestern and south-central portions may gradually become drier (e.g., San Joaquin, Truckee, and Rio Grande river basins and the Middle to Lower Colorado River Basin). Areas in between have median projected changes closer to no change, meaning they have roughly equal chances of becoming wetter or drier (e.g., Klamath and Sacramento basins and the Upper Colorado Basin). These summary statements refer to median projected changes in temperature and precipitation, characterized generally across the western United States. Projections show that there is significant variability and uncertainty about these projected conditions both geographically and with time (Reclamation, 2016a).

Warming trends appear to have led to a shift in cool season precipitation toward more rain and less snow, which has caused increased rainfall runoff volume during the cool season accompanied by less snowpack accumulation in some western United States locations (Reclamation, 2016a). Hydrologic analyses-based future climate projections suggest that warming and associated loss of snowpack would persist over much of the western United States. However, there are some geographic contrasts. Snowpack losses are projected to be greatest where the baseline climate is closer to freezing thresholds (e.g., lower lying valley areas and lower altitude mountain ranges). It also appears that, in high altitude and high latitude areas, there is a chance that cool season snowpack actually could increase during the 21st century (e.g., Columbia headwaters in Canada, Colorado headwaters in Wyoming), because precipitation increases are projected and appear to offset the snow-reduction effects of warming in these locations (Reclamation, 2016a).

Average sea level rise over the period from 1880 to 2013 was 0.06 inch per year; however, since 1993, the average sea level has risen at a rate of 0.11 to 0.14 inch per year (USEPA, 2017c). Total average worldwide sea level rise over the 20th century has been approximately 8.5 inches (USEPA, 2017c). Observed trends in sea level rise can be attributed to thermal expansion of the world's oceans and the melting of ice sheets (polar and alpine). Over the period of record from 1901 to 2015, the sea surface temperature rose at an average rate of 0.13°F per decade (USEPA, 2017d). Also during a similar period (1900 to 2007), measurements have shown a decline in the extent of mountain glaciers and global snow cover; increased atmospheric water vapor content; loss in mass of the polar ice sheets; decreased extent of Arctic sea ice; increased precipitation in the eastern portions of North and South America, northern Europe, and northern and central Asia; drying conditions in the Sahel region of the Sahara Desert in Africa, the Mediterranean, and southern Africa; strengthening in mid-latitude westerly winds (since the 1960s); more intense and longer drought conditions in the tropics and sub-tropics (since the 1970s); increased frequency of extreme precipitation events over land areas; higher average night time temperatures; decreased frost days and increased frequency and duration of extreme heat events (since the 1950s); and increased tropical cyclone activity in the North Atlantic (IPCC, 2007a). There may also be additional synergistic impacts of extreme weather events, such as the sea level rise coupled with high tide and extreme storm surges. The above listed changes are, in turn, resulting in changes to the climate of California as the regional climate is moderated by sea surface temperature, westerly wind patterns, and the El Niño Southern Oscillation and Pacific storm patterns.

Projections to 2100

Climate models indicate that global average surface temperature would increase at a rate of approximately 0.4°F (0.2°C) per decade for the period 2000 to 2020, and would increase by at least that amount per decade during the period 2020 to 2080. Based on a number of emissions scenarios, the IPCC conducted 112 climate projections, which all indicated an increase in surface temperatures (IPCC, 2007a). The average surface temperature increase in each of these projections ranged from 3.2 to 7.2°F by 2100 compared to 1980 through 1999 levels. Not including extreme values, the most probable values ranged from a low of 2.0 to a high of 11.5°F over all of the 112 projections. This range was due to the uncertainty in climate science. Approximately half of this warming is the result of past GHG emissions and would occur even if GHG emissions were halted at 2000 levels. Some regions of the globe, particularly high latitudes, would experience much larger changes relative to Existing Conditions. Corresponding global average sea level rise during the period 2000 to 2100 are estimated to be between 7 inches (18 centimeters) and 23 inches (58 centimeters) (IPCC, 2007a). However, scientific data now strongly suggest that these sea level rise projections are likely too low and that actual sea level rise may be significantly greater than initially estimated (Rahmstorf, 2007; National Research Council [NRC], 2012; California Ocean Protection Council [COPC], 2017). COPC (2017) indicated that the "most likely range" of sea level rise above the mean sea level between 1991 and 2009 could be from 12 inches to 41 inches (104 centimeters), depending upon the basis of the climate and sea level rise projections.

The following additional changes to the global climate system are projected: increased ocean acidity due to increased CO_2 uptake by the oceans; reduced global snow cover; increased thaw depth in permafrost regions; decrease in sea ice with potential full disappearance in summer months; increased frequency in heat waves and heavy precipitation events; increased intensity of tropical cyclone events; northward movement of extra-tropical storm tracks; increased precipitation at high latitudes and decreased precipitation in tropical and sub-tropical regions; and increased melting of the ice sheets (IPCC, 2007a).

25.4.1.3 Climate Change Effects on California

Recent Trends

Scientific measurements and observations indicate that California's climate is already changing in a manner consistent with what would be expected from global climate change. Since 1920, California's average temperature has been increasing, although this change, or any climate change impact, is not uniform across California. Nighttime temperatures are rising across California and at a higher rate than daytime temperatures. Further, daytime and nighttime heat wave events throughout California have increased in intensity, particularly the nighttime component (Moser et al., 2009). Since the 1970s the Central Valley has experienced a steady warming trend (Reclamation, 2016a).

Water level measurements from the San Francisco gage (CA Station ID: 9414290) indicate that mean sea level rose by an average of 2 millimeters (0.08 inch) per year from 1897 to 2006, equivalent to a change of 8 inches in the last century (CCCC, 2009; Reclamation, 2016b).

California's water supply system is dependent on snowpack storage in the Sierra Nevada. Temperatures over the Sierra Nevada have increased during the last 100 years, resulting in less snowfall (and more rainfall) and an earlier snowmelt (Moser et al., 2009). From 1930 to 2009, the peak timing of Sierra Nevada runoff analyzed by Kapnick and Hall (2009) exhibited a trend toward earlier in the season of 0.4 day per decade. The average early spring snowpack in the Sierra Nevada has decreased by approximately 10 percent since the early 20th century, a loss of 1.5 million acre-feet of snowpack storage (DWR, 2008).

Data also show evidence for the following additional changes to California climate and conditions during the last 50 years: the warming of Lake Tahoe; decreasing chill hours and increased stresses on California agriculture; shifts and disturbances in managed landscapes; increased frequency of wildfire; changes in Santa Ana winds; increases in photochemical smog production in Southern California; increased frequency and intensity of heat wave events; changes in the El Niño Southern Oscillation and the impact on California temperatures; and changes in extreme precipitation events and daily average precipitation (CEC, 2011).[6]

Plants and animals around the globe are already reacting to changes caused by increasing temperatures. In California, species are also reacting to extreme conditions, including heat waves (and the fires generated by that heat), cold snaps, droughts (and the Delta saltwater intrusion that droughts often cause), floods, and coastal upwelling. Observed changes also include altered timing of animal and plant lifecycles (phenology), disruption of biotic interactions, changes in physiological performance, species range and abundance, increase in invasive species, altered migration patterns of fishes, aquatic-breeding amphibians, birds and mammals, changes in forage base, local extinction of plant and animal populations, and changes in habitat, vegetation structure, and plant and animal communities (CDFG, 2010).

Projections to 2100

Average annual surface temperatures for California are projected to increase by between 2°F and 5°F by 2050 and between 5°F and 7°F by 2100, depending on the GHG emissions scenario assumed. Warming would not be uniform seasonally or across California. In the Central Valley, warming is projected to increase by about 1°C (1.6°F) in the early 21st century and about 2°C (3.2°F) at mid-century, reaching almost °3C (4.8°F) by late in the 21st century (Reclamation, 2016b). Climate models project a greater amount of warming during summer months, during nighttime, and in the interior regions of California. Chill hours in the Central Valley are expected to decrease, but unprecedented extremes of cold weather are still possible (Gershunov, 2011). Changes in temperature and humidity have implications for agriculture in the Central Valley; as the climate warms, crop diversity and production would be affected by unpredictability associated with the changing climate (Jackson, 2011). Extreme events would also stress California's energy system (Auffhammer, 2011).

Best available data indicate that California, as a whole, would experience changes in precipitation; however, there is a larger range of variability than that of temperature. It is likely that some areas in California would experience higher annual rainfall amounts and precipitation in other regions would decrease (Gershunov, 2011). Projected changes in the Central Valley basins show a north-to-south trend of decreasing precipitation, with a slight increase of about 2 percent in the northern part of the Sacramento Valley around the mid-century period, continuing into the late century. Cayan et al. (2009) estimates California, particularly Southern California, would be 15 to 35 percent drier by 2100. Snowpack volumes are expected to diminish by 25 percent by 2050 (DWR, 2008). By 2025, the Sacramento Valley watershed is projected to experience decreases in the April 1st snow water equivalent between 10 percent in higher portions of the watershed to 70 percent in the lower elevations; however, by the end of the century, higher elevations may also experience decreases of up to 70 percent (Reclamation, 2016b).

[6] The State of California under the auspices of the California Energy Commission (CEC) is conducting comprehensive and detailed research into a range of climate change impacts in California as well as research aimed at developing adaptation strategies to deal with impacts already underway and that can no longer be avoided. The majority of this research is available through the California Climate Change Portal. Available at: <http://www.climatechange.ca.gov/>.

Frequency and intensity of large storms and precipitation events may be influenced by changes in atmospheric rivers. An atmospheric river is a narrow band of concentrated moisture in the atmosphere that transports large amounts of water vapor. In California, nearly all major historical flood events have been associated with the presence of atmospheric rivers, which form in fall and winter and transport warm moister air from the tropical Pacific near Hawaii to the Pacific coast of the continental United States. It is estimated that future changes in climate would increase the frequency of years with atmospheric river storms, but the number of storms per year is not likely to be affected. More importantly, occasional “much-larger-than-historical-range storm intensities” are projected to occur under most warming scenarios. Changes in the frequency and magnitude of atmospheric rivers may result in increases in major flood and storm events (Dettinger, 2011).

Sea level rise along the California coast is expected to accelerate during the 21st century. A study completed by the NRC looked at both global (e.g., thermal expansion, land ice melting) and local (e.g., tectonic land movement, localized subsidence) factors affecting sea level relative to land surface. Table 25-9 shows the projection and the range of uncertainty for expected sea level rise along the coast of San Francisco at 2030, 2050, and 2100 (NRC, 2012). The projections represent the mean and the range of standard deviation as computed for the Pacific coast from the model used in the NRC study with a selected GHG emission scenario. The ranges represent the mean values of model outputs in the NRC study using the very low and very high GHG emission scenarios.

Table 25-9
Sea Level Rise Projections and Ranges for San Francisco, California 2030, 2050, and 2100

Location	Units	2030		2050		2100	
		Projection	Range	Projection	Range	Projection	Range
San Francisco	centimeter	14.4 ± 5.0	4.3 to 29.7	28.0 ± 9.2	12.3 to 60.8	91.9 ± 25.5	42.4 to 166.4
	inch	5.7±2	1.7 to 11.7	11±3.6	4.84 to 23.9	36.2±10	16.7 to 65.5

Source: NRC, 2012.

Sea level rise would continue to threaten coastal lands and infrastructure, increase flooding at the mouths of rivers, place additional stress on levees in the Sacramento-San Joaquin Delta (Delta), and would intensify the difficulty of managing the Delta as the heart of the State’s water supply system (DWR, 2008). These changes in temperature, precipitation, and sea level may have substantial effects on other resources areas. Potential effects of climate change anticipated in California (and discussed in this chapter) are listed below (CNRA, 2009):

- Increased average temperatures (air, water, and soil)
- Changes in annual precipitation amounts
- Change from snowfall (and spring snowmelt) to rainfall
- Decreased Sierra snowpack (earlier runoff, reduced maximum storage)
- Increased frequency and intensity of Pacific storms (flood events)
- Increased severity of droughts
- Increased frequency and severity of extreme heat events
- Increased frequency and severity of wildfire events
- Sea level rise (with increased salt water intrusion in the Delta)
- Changes in species distribution and ranges
- Decreased number of species

- Increased number of vector-borne diseases and pests (including impacts to agriculture)
- Altered timing of animal and plant lifecycles (phenology)
- Disruption of biotic interactions
- Changes in physiological performance, including reproductive success and survival of plants and animals
- Increase in invasive species
- Altered migration patterns of fishes, aquatic-breeding amphibians, birds, and mammals
- Changes in food (forage) base
- Changes in habitat, vegetation structure, and plant and animal communities

These changes have significant implications for water quality, water supply, flooding, aquatic ecosystems, energy generation, and recreation throughout the State. Several guidance documents have been drafted or have been published to discuss strategies to protect resources from climate change in California, such as the 2009 California Climate Adaptation Strategy (CNRA, 2009).

25.4.1.4 Climate Change and Sea Level Rise Effects on California's Water Resources

Although measured effects of climate change are occurring, significant uncertainty remains about the specific magnitude and in some cases even the direction of changes expected in the future. Temperature, precipitation, and sea level are all expected to change and would affect California's water resources in measurable ways.

Numerous studies and publications have noted the importance of considering climate change in water resources planning. The California Water Plan update 2009 states, "planning for and adapting to [climate] changes … will be among the most significant challenges facing water and flood managers this century" (DWR, 2009). Both DWR and Reclamation have noted the need to consider climate change effects in water resources planning studies (Reclamation, 2016b). For the purposes of this Draft EIR/EIS and the companion Draft Feasibility Report, the potential effects of climate change on California's water resources, as well as on the Project alternatives, are considered.

25.4.1.5 Water Management and Climate

Water management includes the development and fulfillment of operating schemes on a variety of time scales from days to decades (Reclamation, 2016b). Within water management planning, climate characterization informs estimations of future water supplies, future water demands, and boundaries of system operation. Climate information influences evaluation of resource management strategies through assumptions or characterization of future potential temperature, precipitation, and runoff conditions among other weather information. Water supply estimates are developed by making determinations of what Wet, Dry, and Normal periods may be like in the future and include the potential for hydrologic extremes that can create flood risks and droughts. Water demand estimates are developed across water management system uses, which include both the natural and the socioeconomic systems, including agriculture, municipal and industrial, environmental, and hydroelectric power generation.

25.4.1.6 Water Management, Climate Change Effects, and Associated Challenges

There are climate change effects and challenges that are especially relevant to water resources. These effects and challenges are described below as background to the climate change sensitivity analysis.

Reclamation Literature Synthesis

To support longer-term planning processes, Reclamation has created a region-specific literature synthesis of studies relating to climate change implications for Reclamation operations and activities in the 17 western states (Reclamation, 2013). This report summarizes recent literature on the past and projected effects of climate change on hydrology and water resources, and summarizes implications for key resource areas featured in Reclamation planning processes. The Mid-Pacific Region section of the report describes scientific studies related to climate change for an area that includes most of California, as well as the Klamath River watershed that originates in southern Oregon and the Lahontan watershed that is mainly in Nevada. The Colorado River basin of California is not included within the region. Several observations from the Mid-Pacific Region literature synthesis are listed below by category:

Historical Climate and Hydrology

- Western United States spring temperatures increased 1 to 3°C (1.8 to 5.4°F) between the 1970s and late 1990s. Increasing winter temperature trends observed in central California averaged approximately 0.5°C (0.9°F) per decade from the late 1940s to the early 1990s (Dettinger and Cayan, 1995).
- Increased winter precipitation trends are noted during 1950 to 1999 at many western United States sites, including several in California's Sierra Nevada; but a consistent region-wide trend is not apparent.
- Coincident with these trends, the western United States and Mid-Pacific Region also experienced a general decline in spring snowpack, reduced snowfall to winter precipitation ratios, and earlier snowmelt runoff from the late 1940s to early 2000s.
- On explaining historical trends in regional climate and hydrology, several studies indicate that most observed trends for the snow water equivalent, soil moisture, and runoff in the western United States are the result of increasing temperatures rather than precipitation effects (Barnett et al., 2008).
- In many Mid-Pacific Region headwater basins, even with precipitation being equal, warmer temperatures in these watersheds cause reduced snowpack development during winter, more runoff during the winter season, and earlier spring peak flows associated with an earlier snowmelt.

Projected Future Climate and Hydrology

- Several studies have been conducted to relate potential future climate scenarios to Mid-Pacific Region runoff and water resources management impacts (Reclamation, 2015; Reclamation, 2016b). In general, there is greater agreement reported between model projections of temperature and, thus, higher confidence in future temperature change relative to precipitation change.
- Several studies have examined potential hydrologic impacts associated with projected climate change. Analyses show that runoff could occur as much as 2 months earlier than what currently occurs, and earlier runoff timing of at least 15 days in early-, middle-, and late-season flow is projected for almost all mountainous areas where runoff is snowmelt driven.
- Future impacts on hydrology have been shown to have implications for water resources management. Management of western United States reservoir systems is very likely to become more challenging as net annual runoff decreases and interannual patterns continue to change as the result of climate change.

- Future climate scenarios suggest that temperature increases are projected to continue, resulting in decreased snowpack, differences in the timing and volume of spring runoff, and increases in peak flows (Reclamation, 2016a). Warming is expected to continue causing further impacts on supplies, changing agricultural water demands, and affecting the seasonal demand for hydropower electricity.

Studies of Impacts on Natural Resources

- Biodiversity may be affected by climate change (Janetos et al., 2008), and many studies have been published about the impacts of climate change on individual species and ecosystems. Climate change also has affected forest insect species range and abundance through changes in insect survival rates, increases in life cycle development rates, facilitation of range expansion, and the effect on host plant capacity to resist attack (Ryan et al., 2008). Predicted future impacts are primarily associated with projected increases in air and water temperatures and are expected to result in poleward shifts in the range of many species, adjustment of migratory species arrival and departure, amphibian population declines, and effects on pests and pathogens in ecosystems.
- Studies of the effects of climate change on agriculture and water resources focus on the many issues associated with future agricultural water demands, including climate change impacts on irrigation demands. Limited study findings suggest significant irrigation requirement increases for corn and alfalfa, demand decreases due to crop failures caused by pests and disease exacerbated by climate change, and demand increases if growing seasons become longer or farming practices are adapted by planting more crop cycles per growing season.
- Increased air temperatures could increase aquatic temperatures and affect fisheries habitat. In general, studies of climate change impacts on freshwater ecosystems are more straightforward with streams and rivers, which are typically well mixed and track air temperature closely, as opposed to lakes and reservoirs, where thermal stratification and depth affect habitat (Allan et al., 2005).
- Warmer water temperatures also could exacerbate invasive species issues (e.g., quagga mussel reproduction cycles would respond favorably to warmer water temperatures); moreover, climate change could decrease the effectiveness of chemical or biological agents used to control invasive species (Hellmann et al., 2008). Warmer water temperatures also could facilitate the growth of algae, which could result in eutrophic conditions in lakes, declines in water quality (Barnett et al., 2008), and changes in species composition.
- Another potential effect of climate change impacts on ecosystems and watershed hydrology involves changes in vegetation disturbances due to wildfires and forest dieback. In the western United States, increases in spring-summer temperatures lead to reduced snow melt, soil moisture, and fuel moisture conditions. These reductions, in turn, affect wildland fire activity.

25.4.2 Environmental Impacts/Environmental Consequences

25.4.2.1 Evaluation Criteria

Climate change effects on the action alternatives were analyzed to determine the effectiveness of the alternatives to achieve the project objectives and purpose and need, including the ability to enhance water management flexibility and water supply reliability (see Chapter 1 Introduction). These criteria were based upon guidance issued by CEQ and the Department of the Interior, including guidance in the implementation of projects under National Environmental Policy Act (NEPA) and Principles and Requirements for Federal Investments in Water Resources, as described in the following sections.

Climate Change Effects on the Project – NEPA and CEQ Guidance

The Council on Environmental Quality released the 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* on August 1, 2016 (CEQ, 2016). With respect to the NEPA analysis, the analysis should consider whether climate change would result in beneficial or adverse effects on environmental or human resources under the action alternatives as compared to the No Action Alternative (with climate change assumption) in a different manner than would occur without consideration of climate change.

Overall, the NEPA document must identify substantial beneficial or adverse impacts based upon incremental differences in environmental and human resources conditions under the action alternatives as compared to future No Action Alternative, with an analysis of the incremental differences that would occur with future climate change conditions.

Principles and Requirements for Investments in Federal Water Resources

The 2013 Principles and Requirements for Federal Investments in Water Resources and the 2015 Draft Procedures for Implementing CEQ Principles and Requirements for Investments in Federal Water Resources (Department of the Interior, 2015) discusses that the Principles, Requirements, and Guidelines (PR&Gs) apply to NEPA analyses for Federal investments that affect water quality or quantity, and that the PR&Gs should be integrated into the NEPA analysis. The PR&Gs require the analysis to consider current trends and variability in key environmental and economic indicators, including climate change, under the action alternatives and No Action Alternative.

Unlike the range of alternatives identified under a NEPA analysis, the PR&Gs establish objectives to define action alternatives to maximize public benefits and to maximize sustainable economic development; attempt to avoid the unwise use of floodplains and flood-prone areas and minimize adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used; and protect and restore the functions of natural systems and mitigate any unavoidable damage to natural systems.

Overall, the PR&Gs require the action alternatives to be compared to the No Action Alternative with future trends, including climate change, to identify the incremental differences in conditions, as under the NEPA analyses. In addition, the PR&Gs require the action alternatives to be presented in a manner to allow comparison between alternatives. The results should be used to compare the ability of the action alternatives to respond to changing conditions, including climate change, and the ability to meet the PR&G objectives.

25.4.2.2 Impact Assessment Assumptions and Methodology

As described in Section 25.4.2.1, the NEPA analysis should consider whether climate change would result in beneficial or adverse effects on environmental or human resources under the action alternatives as compared to the Existing Conditions/No Project/No Action Condition (with climate change assumption) in a different manner than would occur without climate change. The NEPA analysis also needs to consider the PR&G criteria that federal investments in water resources consider current trends and variability in key environmental and economic indicators, including climate change, under the action alternatives and the Existing Conditions/No Project/No Action Condition, especially over the long-term life of the project. This EIR/EIS does not identify the extent of the project life; however, for practical purposes, the useful life of a water resources project is generally considered to be through Year 2099, at a minimum.

Determination of the effects of climate change to Alternatives A through D as compared to the existing Conditions/No Project/No Action Condition are based on projected changes in climate change and sea level rise assumptions through year 2060. Results of this analysis are described in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis.

To consider the effects of climate change on the project through 2099, information from the 2016 Sacramento and San Joaquin Rivers Basin Study (2016 Basin Study) (Reclamation, 2016b) was used to qualitatively analyze changes to water supply conditions due to climate change, population growth, changes in land use, and changes in socioeconomic conditions. The 2016 Basin Study used a modeling approach based on the Water Evaluation and Planning Model (WEAP) and CalLite models that included potential changes in land use and water demands throughout California from 2012 through 2099. The CALSIM II model analyses of potential changes due to climate change (see Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis) generally assumed full use of SWP and CVP water supplies and water rights in the Sacramento and San Joaquin rivers watersheds by 2030. The CALSIM II model analyses did not consider other sources of water (e.g., conservation, water recycling, desalination, and water transfers) that would be used to meet other existing or future water demands. Therefore, the results from the WEAP and CalLite models used in the 2016 Basin Study are not directly comparable to the results from the CALSIM II model presented in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis. The WEAP and CalLite models also use an updated methodology to project climate change (See Appendix 25B Effects of Climate Change through 2100) as compared to the version used in the CALSIM II models described in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis.

Methodology

Climate Change and Sea Level Rise Sensitivity Analysis

A detailed and comprehensive analysis of the effects of climate change and sea level rise on the Project alternatives is presented for each of the resource chapters (i.e., Chapters 6 through 31). The climate change and sea level rise sensitivity analyses and results are described in greater detail in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis. The sensitivity analysis attempts to help answer the following questions:

- How would climate change and sea level rise effects (especially modified runoff and hydrology) influence diversion to Project storage?
- How would climate change and sea level rise affect the Project's ability to provide system flexibility (i.e., water in storage)?
- How would climate change and sea level rise affect the ability of the Project to provide primary objective benefits, including water supply reliability, fish survival, Delta water quality, and flexible hydropower generation?
- How would climate change and sea level rise affect the environmental effects of the Project?

The sensitivity analysis provides a context for consideration of uncertainty and anticipated trends due to climate change throughout the planning horizon for the Project. A comparison of the Existing Conditions/No Project/No Action Condition, with and without climate change and sea level rise, is intended to help the reader understand the trend and potential range of effects upon California's major water systems associated with climate change and sea level rise. In addition, the sensitivity analysis is intended to help the reader understand how the trend and range of potential climate change and sea level rise effects would impact the performance of the Project action alternatives.

Limitations of Sensitivity Analysis

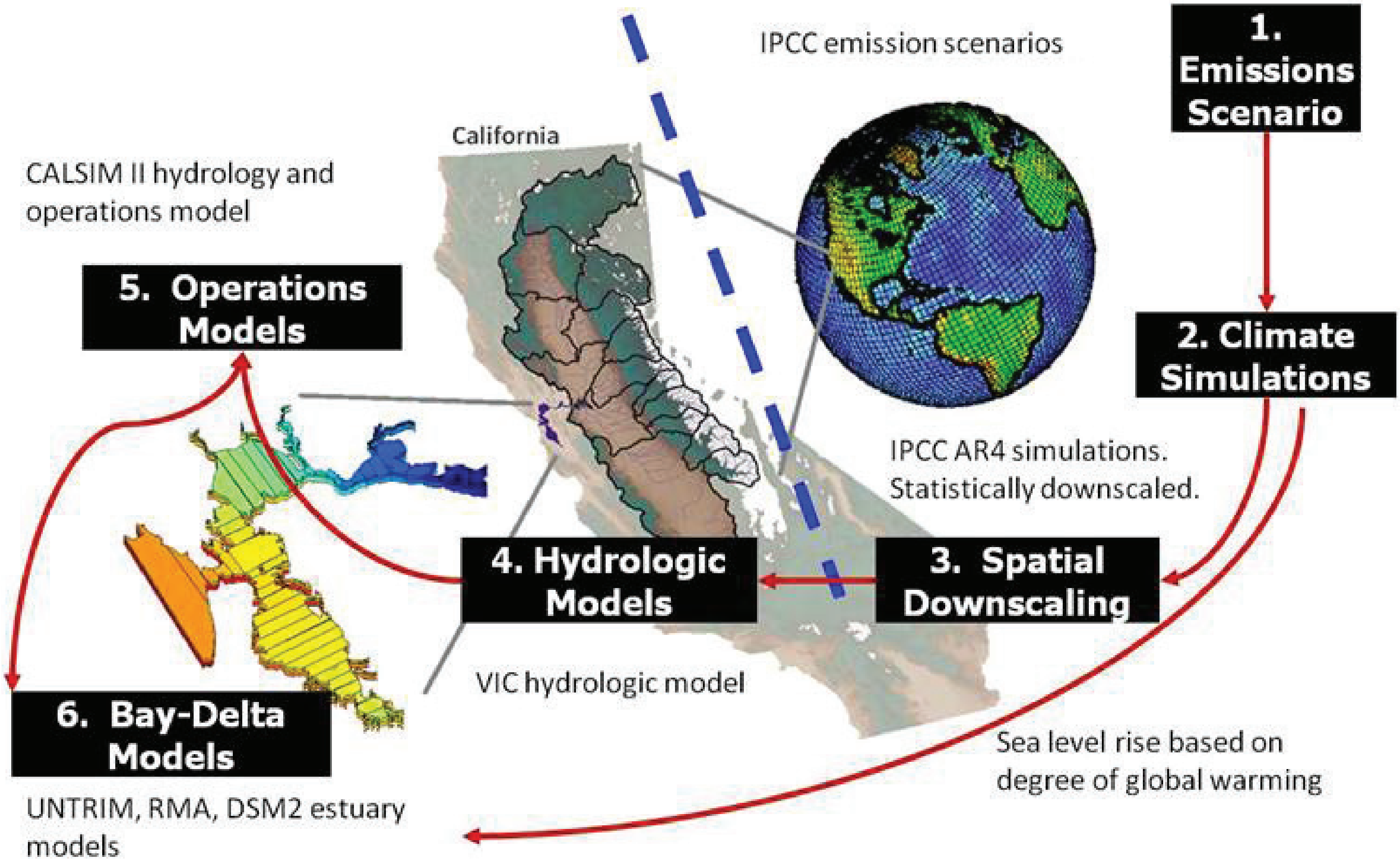
There are limitations associated with the application and use of the Project climate change and sea level rise sensitivity analysis. The limitations are summarized below and described in greater detail in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis.

The sensitivity analysis is limited by uncertainty related to climate change and sea level rise modeling. There is uncertainty in each sequenced step depicted on Figure 25-2. There are also specific uncertainties related to how operations may need to be modified to adapt to climate change, especially to mitigate the frequency of dead storage conditions at reservoirs caused by climate change and sea level rise. In addition, Project operations may need to be modified to adapt to climate change and sea level rise effects to maximize the effectiveness of the additional storage provided by potential Project implementation. These latter two limitations are related to the adjustment of operations that occur over time. Operators have learned how to operate the system of reservoirs and delivery facilities effectively with the historical and current climate. Operators, as well as modelers, understand and learn what works and what does not work for the current climate, system requirements, and commitments. Consequently, operations effectively become "tuned" to the current climate. As climate change effects intensify, modified operations, or refinements, would likely be necessary to meet the multiple objectives of the CVP, SWP, and Central Valley systems. Also, Project operations have been refined for the current climate analysis associated with the detailed evaluation of reasonably foreseeable conditions described in the remainder of the DEIR/EIS. As described below, information available as a result of the detailed and iterative modeling of the current climate was helpful in developing operations that minimize impacts and maximize benefits associated with adding offstream surface storage north of the Delta.

Evaluation Scenarios

The CALSIM II simulations of the Project action alternatives were developed and refined to the conditions of the existing water resources system and current climate. This process was iterative using the full suite of hydrologic, operations, water quality, fisheries, power, and economics models applied to the detailed evaluation of Project action alternatives. A description of the suite of models is provided in Appendix 6B Water Resources for System Modeling. This refinement process was performed for each individual operational element that depends on the proposed Sites Reservoir, and included definition of metrics, assessment of beneficiary performance, modification of assumptions and inputs to improve performance, and prioritization of beneficiary performance.

All quantitative analyses used in this EIR/EIS are based on output from the CALSIM II model. As described in Chapter 6 Surface Water Resources, the CALSIM II model uses a monthly time step and long-term operational assumptions developed for each water year type, including compliance with water quality and flood control criteria, biological opinions, and water demand patterns for users of SWP and CVP water supplies. The analyses assume that these assumptions do not change with climate change and



Adapted from Cayan and Knowles, SCRIPPS/USGS, 2003.

FIGURE 25-2
Graphical Depiction of the Analytical Process for Incorporating Climate Change into the CALSIM II Model for Water Resources Planning Purposes
Sites Reservoir Project EIR/EIS

sea level rise and would continue in a consistent manner in the future. It is recognized that it is probable that water quality and flood control criteria and biological opinions would change in the future in response to climate change, sea level rise, changes in the status of threatened and endangered species, changes in water quality that affects beneficial uses of water, and changes in water demands due to physical and social reasons. However, it would be speculative to predict these changes quantitatively, because most of these changes would require subsequent NEPA and/or CEQA evaluations. For example, changes in population that would occur due to future changes in municipal general plans would require EIRs to consider related land use and water demand changes. Therefore, the analyses in this EIR/EIS includes the same assumptions for non-project items in the Existing Conditions/No Project/No Action Condition as under Alternatives A through D.

As described in Chapters 7 through 15, 21, 22, and 31, the impact analyses presented in this EIR/EIS are based upon changes in water quality (including water temperatures and salinity), fluvial geomorphology and riparian habitat, groundwater, aquatic and terrestrial biological resources, wetlands, recreation, socioeconomics, and power as calculated using models that depend upon CALSIM II input. Changes in CALSIM II model values are directly related to changes in subsequent model results for these other environmental resources. For example, increased Delta outflow values from the CALSIM II model output will result in reduced salinity in Delta water quality in the DSM2 model output. Due to this direct relationship between CALSIM II and the other models, it was determined that no additional modeling would be required following the completion of the CALSIM II model runs because the changes in other environmental resources could be determined qualitatively as compared to conditions without climate change and sea level rise as presented in Chapters 7 through 31.

As described in Chapter 6 Surface Water Resources, because the CALSIM II model uses a monthly time step and long-term assumptions for each water year type, the model results include a noticeable amount of model "noise." Due to this model noise, changes between model results for Alternatives A through D and model results for the Existing Conditions/No Project/No Action Condition of 5 percent or less are considered to be "similar" because these variations cannot be relied upon to indicate changes in environmental conditions.

Limitations Considerations

The results of the sensitivity analysis should be considered as a tool to provide a comparative understanding of the trend of climate change effects and the relative performance of Project alternatives with climate change. Any conclusions derived from the sensitivity analysis results should be considered to be qualitative and as an indicator of potential changes related to climate change and sea level rise. Consequently, the results of this analysis should not be used independently for decision-making purposes, but rather as supplemental to the detailed evaluations in the Draft Feasibility Report and DEIR/EIS.

In the CALSIM II model, dead pool conditions are assumed at 240 thousand acre-feet (TAF) for Trinity Lake, 550 TAF for Shasta Lake, 30 TAF for Lake Oroville, and 90 TAF for Folsom Lake. These are extreme operational limits and are well below the range of reasonable reservoir operations. In real-time reservoir operations, operators and regulators would significantly modify operations to avoid a dead pool condition. As storage in a reservoir approaches dead pool, operators and regulators would initiate an emergency consultation and agree on a modified operational strategy to meet various commitments in a more limited way. This type of modified operation is not included in the CALSIM II operations simulation since the circumstances of an emergency consultation can vary in significant ways. While CALSIM II results are not considered to be predictive generally, the limitations regarding results that indicate dead pool conditions at a reservoir are especially important to understand. Dead pool occurrences in this document should be understood to mean that a reservoir, and more broadly a system of reservoirs, would likely be operating in an emergency condition. The ability to meet one or more system objectives would be impaired and normal operations cannot be sustained.

Climate Change and Sea Level Rise Projections through 2060

For the Project sensitivity analysis, four climate and sea level scenarios were used to compare to "Current" hydrological conditions assumed under the Existing Conditions/No Project/No Action Condition. The Current conditions were based on historical hydrological conditions compiled and analyzed by the DWR to represent conditions in 2005 for the purposes of the CALISM II model operations. The four climate and sea level scenarios used in the sensitivity analysis for this EIR/EIS are described in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis and summarized below:

- The Current conditions assumes hydrologic and sea level rise conditions in 2005 as described in Appendix 6A Modeling of Alternatives with no climate change and sea level rise.
- The Early Long Term (ELT) scenario assuming the median (Q5) of an ensemble of Global Climate Model (GCM) projections at approximately 2025 and a sea level rise of 15 centimeters (6 inches). The ELT Q5 scenario is referred to later in this section as one point in the climate change trend.
- The Late Long Term (LLT) Q5 scenario assuming the median of an ensemble of GCM projections at approximately 2060 and a sea level rise of 45 centimeters (18 inches). The LLT Q5 scenario is also referred to later in this section as one point in the climate change trend.
- The LLT Q2 scenario assuming the "drier, more warming" lower bound (Q2) of an ensemble of GCM projections at approximately 2060 and a sea level rise of 45 centimeters (18 inches). The LLT Q2 scenario is referred to later in this section as the Lower potential range of effect associated with climate change.
- The LLT Q4 scenario assuming the "wetter, less warming" upper bound (Q4) of an ensemble of GCM projections at approximately 2060 and a sea level rise of 45 centimeters (18 inches). The LLT Q4 scenario is referred to later in this section as the Upper potential range of effect associated with climate change.

This analysis included a range of uncertainty in the climate change projections, as described in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis.

The quantitative results of the sensitivity analyses summarized in this chapter and presented in detail in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis were based on a comparison of conditions at 2030 and 2060 using climate change and sea level rise model assumptions developed for the CALSIM II model by DWR and Reclamation for previous projects, including the *Environmental Impact Statement for the Long-Term Coordinated Operation of the Central Valley Project and State Water Project* (Reclamation, 2015).

The analytical process for incorporating climate and sea level scenarios into the CALSIM II simulation model includes the use of several sequenced analytical tools. These tools and the analytical process are discussed in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis. This process includes modified hydrologic inputs (inflow time-series) and modified flow-salinity relationships for Delta salinity compliance modeling.

For the Project sensitivity analysis, ELT and LLT scenario representations (called scenarios) were selected. These scenarios were developed from a larger set of projections and were statistically derived from those projections. The ELT scenario considers climate conditions (temperature and precipitation) for a period of 30 years centered on analysis year 2025 (years 2011 to 2040) and projected sea level conditions at year 2025. Likewise, the LLT scenario considers climate conditions for a period of 30 years centered on analysis year 2060 (years 2046 to 2075) and projected sea level conditions at year 2060.

For evaluating Project alternatives along the trend in climate and sea level conditions over the next 50 years, the ELT and LLT Q5 scenarios were selected. For evaluating Project alternatives throughout the potential range of climate and sea level conditions at 50 years, near the mid-point of the Project planning period, the LLT Q2 (drier, more warming) and Q4 (wetter, less warming) scenarios were selected because these scenarios would likely capture the bounding conditions of climate change and sea level rise relevant to the Project alternatives being considered.

Sea level projections were based on an existing empirical method (Rahmstorf, 2007). This method better reproduces historical sea levels and generally produces larger estimates of sea level rise than those indicated by the IPCC (IPCC, 2007a). When evaluating all projections of global air temperature, this method projects a mid-range sea level rise of 70 to 100 centimeters (28 to 40 inches) by the end of the century, and when factoring the full range of uncertainty, the projected rise is 50 to 140 centimeters (20 to 55 inches). Using this method, the projected sea level rise at year 2025 would be approximately 12 to 18 centimeters (5 to 7 inches), and at year 2060 would be approximately 30 to 60 centimeters (12 to 24 inches). These sea level rise estimates are also consistent with those outlined in the USACE guidance circular for incorporating sea-level changes in civil works programs (USACE, 2009). For the Project sensitivity analysis, a sea level rise of 15 centimeters (6 inches) was assumed for the ELT scenario and a sea level rise of 45 centimeters (18 inches) was assumed for all LLT scenarios.

Climate Change and Sea Level Rise Considerations through 2060

The quantitative climate change sensitivity analyses presented in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis was based upon a set of climate change assumptions developed by year 2010 and sea level rise assumptions developed in 2012. Since 2010, the methodology to project the effects of climate change has evolved. The 2016 Basin Study (Reclamation, 2016b) incorporated climate change projections based on a wider range of global climate model simulations than the methodology presented in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis. The 2016 Basin Study climate projections were based upon a set of GCMs and GHG emission scenarios selected by the DWR Climate Change Technical Advisory Group in 2015.

The 2016 Basin Study utilized 12 climate change projections from the Climate Change Technical Advisory Group projections downscaled for major regions throughout California to develop transient annual climate scenarios for 2012 through 2099. The expected future precipitation and temperature from the climate change projections also were used to develop runoff projections for major watersheds in California. Annual projected changes in land use and other socioeconomic factors that affect water demands also were developed for 2012 through 2099. This information was used as input to the WEAP and CalLite models to develop climate-based runoff projections for major watersheds throughout California.

The 2016 Basin Study analyzed similar but slightly different categories, as follows:

- No-Climate-Change scenario
- Central Tendency – formed from all the projections between the 25th and 75th percentiles of both temperature and precipitation
- Hot-Dry scenario – formed from the 10 individual climate projections closest to the 95th percentile temperature and 5th percentile precipitation changes
- Warm-Dry scenario – formed from the 10 individual climate projections closest to the 5th percentile temperature and 5th percentile precipitation changes
- Hot-Wet scenario – formed from the 10 individual climate projections closest to the 95th percentile temperature and 95th percentile precipitation changes
- Warm-Wet scenario – formed from the 10 individual climate projections closest to the 5th percentile temperature and 95th percentile precipitation changes

As described in Section 2.5.4.1.2, scientific data now strongly suggest that these sea level rise projections are likely too low and that actual sea level rise may be significantly greater than initially estimated (Rahmstorf, 2007; National Research Council [NRC], 2012; COPC, 2017). COPC (2017) indicated that the "most likely range" of sea level rise above the mean sea level between 1991 and 2009 could be from 12 inches (30 centimeters) to 41 inches (104 centimeters), depending on the basis of the climate and sea level rise projections.

As described above, the climate change methodology used for the 2016 Basin Study is not directly comparable to the results using the CALSIM II results because the 2016 Basin Study assumed annual changes in land use and water demands throughout California from 2012 through 2099. The CALSIM II model analyses of potential changes due to climate change (see Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis) generally assumed full use of SWP and CVP water supplies and water rights in the Sacramento and San Joaquin rivers watersheds by 2030. The CALSIM II model analyses did not consider other sources of water (e.g., conservation, water recycling, desalination, and water transfers) that would be used to meet other existing or future water demands. Therefore, the results from the 2016 Basin Study are not directly comparable to the results from the CALSIM II model presented in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis.

25.4.3 Effects of Climate Change and Sea Level Rise on the Project

25.4.3.1 Existing Conditions/No Project/No Action Condition

Climate change and sea level rise are projected to change conditions even without implementation of a Project. As described in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis, it is anticipated that climate change and sea level rise would result in the following trends:

- Increased runoff in late winter/early spring due to more rainfall and less snowfall, and reduced runoff in late spring and summer because of less snow melt flows. The increased runoff in the late winter/early spring generally fill the reservoirs earlier than under historical conditions, and there would be more runoff earlier in the year than there would be with higher snow fall amounts. As water is released from the reservoirs for pre-irrigation water demands and Delta water quality in the spring, there would be less snowpack to refill the reservoirs in the late spring. Therefore, assuming no changes in water demand patterns, there would be lower reservoir storage in the summer, except in wet and some above normal years.

- Reduced river flows and Delta inflow due to decreases in runoff in summer months.
- Increased release of reservoir storage to maintain flow, temperature, and Delta salinity requirements, assuming no changes in federal and State water quality and biological criteria.
- Increased variability and overall decreased SWP and CVP water availability due to decreased reservoir storage conditions and uncertain changes in frequency of annual refilling of existing reservoirs.
- Increased occurrence of dead pool[7] storage at reservoirs and potential operational interruptions.

Increased air temperatures due to climate change also would result in increased water temperatures in reservoirs and rivers. To mitigate the impacts of higher water temperatures on aquatic resources, additional water could be required to be released from the reservoirs, which would further reduce SWP and CVP water availability. In some years when the reservoir storage was extremely low, there would be limited cold water to release to the streams to support aquatic resources, and it is anticipated that significant adverse changes would occur to aquatic resources with or without implementation of Alternatives A through D, as shown in recent projects (Reclamation, 2015; DWR and Reclamation, 2016).

25.4.3.2 Comparison of Alternatives A through D to the Existing Conditions/No Project/No Action Condition

Changes in storage in the SWP and CVP Sacramento Valley reservoirs, flows downstream of those reservoirs, Delta outflow, and X2 positions under Alternatives A through D as compared to the Existing Conditions/No Project/No Action Condition are presented in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis for the Current, ELT Q5, LLT Q5, LLT Q2, and LLT Q4 scenarios. The results of these analyses indicate that under the ELT Q5, LLT Q5, LLT Q2, and LLT Q4 scenarios for climate change and sea level rise through 2060, the storage in Shasta Lake, Lake Oroville, and Folsom Lake at the end of May and end of September and flows in the rivers downstream of these reservoirs would be similar or greater with implementation of Alternatives A through D as compared to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise assumptions. These results are similar to the results presented in Appendix 6B Water Resources System Modeling for these surface water comparisons without climate change and sea level rise. Similarly, changes in X2 position under all of the climate change and sea level rise scenarios considered in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis for Alternatives A through D as compared to the Existing Conditions/No Project/No Action Condition would be similar or more positive. These results are similar to the results presented in Appendix 6B Water Resources System Modeling for these surface water comparisons without climate change and sea level rise.

The results from the 2016 Basin Study indicated that the drier climate scenarios (Warm-Dry and Hot-Dry) resulted in substantially lower stream flows and higher unmet water demands than the No-Climate-Change scenario. The wetter climate change scenarios (Hot-Wet and Warm-Wet) resulted in substantially higher stream flows and lower unmet water demands than the No-Climate-Change scenario. These trends

[7] For the purposes of this analysis, “dead pool” occurs when the operating storage in a reservoir equals zero. For most reservoirs, some water would remain in storage as described previously, but it could not be released for any downstream purpose because the water is at or below the lowest intake level.

are similar to the changes projected using the CALSIM II model to analyze effects of climate change for Alternatives A through D as compared to the Existing Conditions/No Project/No Action Condition.

25.4.4 Climate Change Effects/Impacts from the Proposed Project

The following discussion provides a general understanding of how environmental resources and effects associated with implementation of Alternatives A through D as compared to the Existing Conditions/No Project/No Action Condition may be altered with climate change and sea level rise. Each of the environmental resource categories are described with consideration of the anticipated general climate change effects to the resource at 2060 for conditions with and without implementation of Alternatives A through D. The descriptions of the effects are qualitative and the extent of the changes would depend upon the climate change and sea level rise scenario. However, as indicated in model results presented in Appendix 25A Climate Change and Sea Level Rise Sensitivity Analysis, in most cases the trends in the changes in surface water conditions would be similar in extent for all climate change and sea level rise scenarios considered.

25.4.4.1 Surface Water Resources (Chapter 6)

Climate change and sea level rise would be expected to affect surface water resources due to the anticipated increased air, water, and soil temperatures; altered runoff; increased frequency and severity of floods and droughts; and Delta salinity intrusion. The sensitivity analysis results indicate that most metrics of surface water resources, including reservoir storage, streamflow, and deliveries, would trend negatively as climate change and sea level rise effects increase in the future. However, with implementation of Alternatives A, B, C, and D, SWP and CVP Delta exports generally would be similar under the LLT Q5 and LLT Q2 scenarios as compared to the Existing Conditions/No Project/No Action Condition; however, Delta exports would increase under the LLT Q4 scenario.

With implementation of Alternatives A, B, C, and D, storage in SWP and CVP Sacramento Valley reservoir storage generally would be similar under the LLT Q5 and LLT Q2 scenarios as compared to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions. Total reservoir storage would increase under the LLT Q4 scenario as compared to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions. Therefore, under the LLT Q4 scenario the additional water in storage, both in the proposed Sites Reservoir and in existing SWP and CVP reservoirs, water system operators and managers would be able to more easily adapt to a number of future uncertainties.

25.4.4.2 Surface Water Quality (Chapter 7)

Climate change and sea level rise would be expected to affect surface water quality due to the anticipated increased water temperatures, altered runoff, increased frequency and severity of floods and droughts, and increased Delta salinity. As noted previously, salinity in the western and central Delta is expected to increase due to sea level rise, changes in runoff, and increased reservoir releases to maintain salinity in the Delta even with sea level rise, especially during summer/fall months and drier year type conditions. According to the sensitivity analysis, incremental changes to the X2 position under Alternatives A through D as compared to the Existing Conditions/No Project/No Action Condition with climate change would be similar to the comparative results without climate change (see Appendix 6B Water Resources System Modeling).

25.4.4.3 Fluvial Geomorphology and Riparian Habitat (Chapter 8)

Climate change and sea level rise may change geomorphic characteristics and associated riparian habitat. Changes could occur as a result of the anticipated increased frequency and severity of high flow events and erosion, and changes in runoff timing. Recent studies (Reclamation, 2016b) indicate that there would be limited changes in floodplain processes and flow-dependent processes under Alternatives A through D and the Existing Conditions/No Project/No Action Condition as compared to the Current Condition.

25.4.4.4 Flood Control and Management (Chapter 9)

Climate change and sea level rise would be anticipated to affect flood management. Water storage levels in existing reservoirs with climate change and sea level rise would be expected to trend down. This result is shown in the sensitivity analysis of the Existing Conditions/No Project/No Action Condition. This effect could provide some improvement in flood management capability by providing more space in reservoirs for flood events. However, expected increases in the frequency and severity of high flow events would diminish flood management capability. As noted in Chapter 9 Flood Control and Management, there would be some flood management benefit for the areas immediately downstream of the SWP and CVP dams that are prone to flooding. The adaptive capability related to flood management is less certain. As noted above, water system operators and managers would have more water to manage with Project implementation than without. The expected additional water in storage could potentially provide operators and flood and water managers additional system resources to shift additional flood management protection to existing reservoirs, thus providing some resilience. This type of operation was not included in the Project action alternatives formulations. Although this type of adaptive operation would be possible, this type of flood management operational change is speculative.

25.4.4.5 Groundwater Resources (Chapter 10)

Groundwater resources would likely be affected by climate change and sea level rise. Recent studies (Reclamation, 2016b) indicate that groundwater elevations would decline under drier climate change scenarios (e.g., LLT Q2) and increase under wetter climate change scenarios (e.g., LLT Q4). As described in Section 25.4.4.1, with implementation of Alternatives A, B, C, and D, SWP and CVP Delta exports generally would be similar under the LLT Q5 and LLT Q2 scenarios as compared to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions. Delta exports would increase under the LLT Q4 scenario as compared to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions. Therefore, groundwater use by users of SWP and CVP water would be expected to be similar under Alternatives A, B, C, and D with climate change scenarios LLT Q5 and LLT Q2, and groundwater use would be expected to increase with climate change scenarios under the LLT Q4 scenario as compared to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions. Comparative effects of the Project would likely be similar to impact analysis results without climate change and sea level rise conditions, as presented in Chapter 10 Groundwater Resources.

25.4.4.6 Groundwater Quality (Chapter 11)

Climate change and sea level rise would be expected to affect groundwater quality due to anticipated changes in groundwater elevations, as described in Section 25.4.4.6. If groundwater elevations decline as compared to conditions without climate change and sea level rise, it is anticipated that groundwater quality could decline in areas with poorer groundwater quality at lower elevations. Increased or similar groundwater elevations would be anticipated to not result in changes in groundwater quality, such as would occur under Alternatives A through D as compared to the Existing Conditions/No Project/No Action Condition under all climate change scenarios.

25.4.4.7 Aquatic Biological Resources (Chapter 12)

Climate change and sea level rise would be expected to affect aquatic biological resources due to the anticipated increased air and water temperatures, altered runoff and erosion, and Delta salinity intrusion. Increased air temperatures would be expected to lead to increased water temperatures in streams and reservoirs. Under wetter climate change scenarios, there could be increased Delta outflows, especially if upstream reservoirs are full; this would improve conditions for some aquatic resources in the Delta, depending on the patterns of increased Delta outflows (Reclamation, 2016b).

Alternatives A through D would result in similar conditions as under the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions, except under the LLT Q4 scenario when conditions for aquatic resources could improve depending on management of the additional flows in wetter periods.

25.4.4.8 Botanical Resources (Chapter 13)

Climate change and sea level rise would be expected to affect botanical resources due to the anticipated increased air and water temperatures and altered runoff patterns. With respect to the botanical resources that could be affected by Alternatives A through D it is anticipated that conditions would be similar to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions, except under the LLT Q4 climate change scenario, which would increase stream flows. The increased stream flows could provide localized benefits to botanical resources in the riparian corridor.

25.4.4.9 Terrestrial Biological Resources (Chapter 14)

Climate change and sea level rise would be expected to affect terrestrial biological resources due to the increased air and water temperatures and altered runoff patterns. With respect to the terrestrial biological resources that could be affected by Alternatives A through D it is anticipated that conditions would be similar to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions, except under the LLT Q4 climate change scenario, which would increase stream flows. The increased stream flows could provide localized benefits to terrestrial biological resources in the riparian corridor.

25.4.4.10 Wetlands and Other Waters (Chapter 15)

Climate change and sea level rise would be expected to affect wetlands and other waters of the U.S. Because wetlands and waters of the U.S. are a subset of surface water resources, the effects described for surface water resources would also apply to this resource. Climate change and sea level rise would be expected to affect wetlands and other waters due to the increased air and water temperatures and altered runoff patterns. With respect to wetlands and other water resources that could be affected by Alternatives A through D it is anticipated that conditions would be similar to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions, except under the LLT Q4 climate change scenario, which would increase stream flows. The increased stream flows could provide localized benefits to wetlands and other water resources.

25.4.4.11 Geology, Minerals, Soils, and Paleontology (Chapter 16)

Climate change and sea level rise could affect geology, minerals, soils, and paleontology due to the altered runoff, which could result in erosion. As discussed in Section 25.4.4.3, recent studies (Reclamation, 2016b) indicate that there would be limited changes in floodways due to flow-dependent processes under the Existing Conditions/No Project/No Action Condition as compared to the Current Condition.

25.4.4.12 Faults and Seismicity (Chapter 17)

Faults and seismicity would not be expected to be affected by climate change and sea level rise.

25.4.4.13 Cultural/Tribal Cultural Resources (Chapter 18)

Climate change and sea level rise could affect cultural resources due to altered runoff, which could result in erosion. As discussed in Section 25.4.4.3, recent studies (Reclamation, 2016b) indicate that there would be limited changes in floodways due to flow-dependent processes under the Existing Conditions/No Project/No Action Condition as compared to the Current Condition.

25.4.4.14 Indian Trust Assets (Chapter 19)

The nature of Indian Trust Assets indicates a potential connection to other resource areas including land use, surface water, minerals, and terrestrial and aquatic biological resources. However, as noted in Chapter 19, there are no Indian trust assets within the vicinity of the Project study areas.

25.4.4.15 Land Use (Chapter 20)

Municipal land use in the study area is not expected to change due to climate change because the State requires that all general plans for cities and counties include vulnerability assessments and water strategies that address methods to adapt to climate change. Agricultural land use could change with respect to the total acreage in cultivation or cropping patterns, because of air temperatures and water supply availability. These changes are considered in this EIR/EIS as part of the cumulative impact analysis, because of their uncertainty as compared to the current general plans that are included in the Existing Conditions/No Project/No Action Condition and Alternatives A through D with the same climate change and sea level rise scenario assumptions.

Long-term land use conditions under Alternatives A through D would be expected to be similar to the Existing Conditions/No Project/No Action Condition under the LLT Q5 and LLT Q2 climate change scenarios because the Delta exports would be similar. Under the LLT Q4 climate change scenario, Delta exports would increase, which would decrease the use of groundwater to continue to support the same long-term land use conditions that would occur under the Existing Conditions/No Project/No Action Condition with the same climate change, and sea level rise scenario assumptions would be similar.

25.4.4.16 Recreation Resources (Chapter 21)

Climate change and sea level rise would be expected to affect recreation resources due to less snowpack that supports winter sports, altered runoff patterns that could affect reservoir storage in the summer months, and availability of fish that support sport fishing. Under Alternatives A through D, reservoir storage and stream flows that support recreational activities would be similar under the LLT Q5 and LLT Q2 climate change scenarios as compared to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenario assumptions, and it would increase under the LLT Q4 climate change scenario.

25.4.4.17 Socioeconomics (Chapter 22)

Climate change and sea level rise would be expected to affect socioeconomics due to changes in the cost of adaptation measures that would be implemented by communities, industries, agricultural enterprises, and recreational enterprises. These adaptation measures would require a range of responses including infrastructure expansion and modification to accommodate higher flood flows and sea level rise, and development of additional water supplies, such as desalination and recycled water (Reclamation, 2016b). These measures would increase employment in certain sectors; however, the measures also would increase the cost of living, including the cost of water. Long-term socioeconomic conditions under Alternatives A through D would be expected to be similar to the Existing Conditions/No Project/No Action Condition under the LLT Q5 and LLT Q2 climate change scenarios because the Delta exports would be similar. Under the LLT Q4 climate change scenario, which would increase Delta exports and decrease the use of alternative water supplies, would be similar to the Existing Conditions/No Project/No Action Condition.

25.4.4.18 Environmental Justice (Chapter 23)

Climate change and sea level rise would be expected to affect the general population. Consequently, the direct effects of climate change and sea level rise would be expected to be similar with all populations, including minorities and low-income populations (i.e., environmental justice populations) due to the anticipated increased temperatures, increased severity and frequency of flood and drought events, Delta salinity intrusion, changes in species range, and distribution, and increased fire risk. However, the indirect effect of climate change and sea level rise due to the need for additional infrastructure to address climate change and sea level rise measures would be to increase the cost of living, including the cost of water supplies (see Section 25.4.4.17). These measures would increase employment in certain sectors; however, the measures also would increase the cost of living, including the cost of water. Socioeconomic conditions under Alternatives A through D would be to be similar to the Existing Conditions/No Project/No Action Condition under the LLT Q5 and LLT Q2 climate change scenarios because the Delta exports would be similar. Under the LLT Q4 climate change scenario, which would increase Delta exports and decrease the use of alternative water supplies, socioeconomic conditions would be similar or improve as compared to the Existing Conditions/No Project/No Action Condition.

25.4.4.19 Air Quality (Chapter 24)

Climate change and sea level rise would be expected to affect air quality because of the anticipated increased air temperatures. These conditions would be similar under Alternatives A through D as under the Existing Conditions/No Project/No Action Condition with the similar climate change and sea level rise scenarios.

25.4.4.20 Climate Change and Greenhouse Gas Emissions (Chapter 25)

The effects upon total GHG emissions associated with the Project and pumping specifically would be compensated by the GHG emission improvements related to the renewable integration operation of the Project, as described in the GHG emissions portion of this chapter. These conditions would be similar under Alternatives A through D as under the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenarios.

25.4.4.21 Navigation, Transportation, and Traffic (Chapter 26)

Climate change and sea level rise would be expected to affect navigation, transportation, and traffic due to the anticipated increased frequency and severity of floods unless infrastructure modifications were completed. These conditions would be similar under Alternatives A through D as under the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenarios.

25.4.4.22 Noise (Chapter 27)

Noise is not expected to be affected by climate change and sea level rise.

25.4.4.23 Public Health and Environmental Hazards (Chapter 28)

Climate change and sea level rise would be expected to affect public health and environmental hazards due to the anticipated increased temperatures, increased frequency and severity of floods and droughts, Delta salinity intrusion, spread of pests, and increased fire risk. These conditions would be similar under Alternatives A through D as under the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenarios.

25.4.4.24 Public Services and Utilities (Chapter 29)

Climate change and sea level rise is expected to potentially affect public services and utilities due to changes in availability of surface water and groundwater resources (see Sections 25.4.4.1 and 25.4.4.5). Public service and utilities conditions under Alternatives A through D would be similar to the Existing Conditions/No Project/No Action Condition under the LLT Q5 and LLT Q2 climate change scenarios because the Delta exports would be similar. Under the LLT Q4 climate change scenario, which would increase Delta exports and decrease the use of alternative water supplies, public services and utilities conditions would be similar or improve as compared to the Existing Conditions/No Project/No Action Condition.

25.4.4.25 Visual Resources (Chapter 30)

Climate change and sea level rise would be expected to affect visual resources due to construction of new infrastructure to adapt to climate change and sea level rise and changes in reservoir elevations. Under Alternatives A through D, reservoir storage would be similar under the LLT Q5 and LLT Q2 climate change scenarios as compared to the Existing Conditions/No Project/No Action Condition, and it would increase under the LLT Q4 climate change scenario. Therefore, the visual resources would not be adversely affected under Alternatives A through D as compared to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenarios.

25.4.4.26 Power Production and Energy (Chapter 31)

Climate change and sea level rise would be expected to affect power production and energy due to the anticipated increased temperatures that would increase electricity demand for air conditioning and altered runoff patterns that could affect hydropower generation. Some of these climate change and sea level rise effects would increase or decrease hydropower production; some would increase or decrease energy needs associated with the SWP and CVP systems (Reclamation, 2016b).

The potential for hydropower generation at the SWP and CVP facilities is dependent on reservoir storage. Under Alternatives A through D, reservoir storage would be similar under the LLT Q5 and LLT Q2 climate change scenarios as compared to the Existing Conditions/No Project/No Action Condition, and it would increase under the LLT Q4 climate change scenario. Therefore, the potential for hydropower generation at the SWP and CVP reservoirs related to reservoir storage would not be adversely affected under Alternatives A through D as compared to the Existing Conditions/No Project/No Action Condition with the same climate change and sea level rise scenarios.

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