Chapter 28 Climate Change

28.1 Introduction

This chapter describes the affected environment, methods of analysis, effects of climate change and sea level rise on the Project, and how the Project operations under climate change scenarios affect the environment, with a focus on water resources and related systems.

Climate change is defined as large-scale changes in the state of the climate that can be identified by changes in the mean and variability of its properties over an extended period of time. While climate change can occur naturally, change has accelerated due to human activity that alters the composition of the global atmosphere (Intergovernmental Panel on Climate Change 2018). The study area for the interaction of climate change with the Project consists of the Sacramento Valley region.

There have been several recent changes in Council on Environmental Quality guidance with respect to greenhouse gas (GHG) emissions (Section 28.3, *Methods of Analysis*). This chapter and Chapter 21, *Greenhouse Gas Emissions*, use the Council on Environmental Quality *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* (Council on Environmental Quality 2016) to guide their respective analysis. The 2016 guidance indicates that NEPA analyses should consider (1) the potential effect of the proposed action on climate change by assessing GHG emissions and (2) the effects of climate change on the proposed action and its environmental impacts. This chapter, as described further below, evaluates the effects of climate change on the proposed action and its environmental impacts. Chapter 21 evaluates the Project's potential effect on climate change through evaluation of GHG emissions. The approach described in Chapter 21 is consistent with current scientific evidence that points to the need to achieve carbon neutrality by midcentury to avoid the most severe climate change impacts. Because CEQA impact analysis does not encompass impacts of the environment on a project, this chapter does not analyze impacts of future climate change on the Project for CEQA purposes. However, this chapter's description of future climate change effects is used in the CEQA analysis insofar as Project changes would interact with climate change in future years, particularly with respect to water resources and related systems.

To analyze the effects of climate change on the proposed action, as well as its environmental impacts, Section 28.4, *Surface Water Resources, the Project, and Climate Change*, compares flow and volume indicators of Project performance under a reasonably foreseeable future condition without climate change to two climate scenarios. Assessing changes in flow in the river is an indicator of the effects of diversions of flow to storage on habitat important to aquatic organisms in the river, including several threatened and endangered species. It also allows assessing the changes in opportunities to divert water to storage which are related to the volumes of water available to divert. Assessing changes in volumes of water stored is a measure of effectiveness of the Project's ability to store water for later use to meet environmental and consumptive demands for water. The differences are used to analyze changes in Project performance under future projected climate conditions. The reasonably foreseeable future conditions without climate change reflect a continuation of existing conditions. This was determined to be an appropriate reference because the plans that serve as the basis for the existing-conditions baseline would be reasonably anticipated to continue into the future. As described in Chapter 3, *Environmental Analysis*, the impact analyses in this EIR/EIS use an environmental baseline that incorporates water supply facilities and ongoing plans and programs that existed as of January 23, 2017, the date for the Authority's notice of preparation. The 2020 environmental baseline reflects a range of historical hydrologic conditions (e.g., watershed runoff); current physical conditions (e.g., dams); the water rights orders and decisions and water quality criteria from the State Water Resources Control Board; updated municipal, environmental, and agricultural water uses; updated land uses; and relevant laws, regulations, plans, and policies, including updated regulatory operating conditions for the CVP and SWP. Historical land use and water demands, hydrology, and existing water rights and contracts reflected in the CALSIM II model would not be materially different between the No Action Alternative (NAA) and the environmental baseline. Operational impacts of the Project are evaluated using multiple quantitative and qualitative tools over different timeframes. For example, CALSIM is used to evaluate resources related to hydrology (e.g., water quality and aquatic biological resources); it uses hydrologic conditions from 1922 to 2003 with current infrastructure and regulations to model the existing conditions and the alternatives. The water-year types documented during this period represent a wide range of hydrologic conditions, and this variability is expected to occur during the operation of the Project. The climate change scenarios centered around 2035 (2020–2049) and 2070 (2046–2085) were developed using 20 Coupled Model Intercomparison Project 5 (CMIP5) global climate model projections. With the ensemble informed climate change scenarios, historical temperature and precipitation were adjusted with quantile mapping based on the selected global climate model projections to represent future conditions (see Appendix 28A, *Climate Change*, for a detailed description of the models).

The Authority and Reclamation selected indicators as representations of the Project's objectives and purpose and to quantitatively evaluate effects of the Project on aquatic biological resources, water quality, and water supply under climate change in Section 28.4. Project performance under climate change, and the effects of climate change on the proposed action and its environmental impacts, are analyzed for all resource areas (Section 28.5, *Potential Project-Related Climate Change Effects*). In addition to adverse effects on resource areas, this discussion also describes how the Project could mitigate anticipated climate change impacts based on evaluation of the same indicators of Project performance and describes other benefits from the Project. Finally, this chapter describes key climate impacts on study area resources and discusses how the Project could help mitigate those impacts. Climate change impacts from construction are considered qualitatively in Section 28.5 but are not included in the modeling of climate change impacts because the construction effects are considered short-term and unlikely to be meaningfully affected by climate change. Generation of GHGs from the Project, including construction, is included in Chapter 21, which also includes mitigation measures that reduce the impacts of Alternatives 1, 2, and 3 to less than significant. The focus of this chapter is instead on the relationship between climate change effects and their long-term interactions with Project operations and the resilience of the study area.

Table 28-1 summarizes the NEPA conclusions for Project operational impacts with climate change by alternative. Alternatives 1A and 2 are addressed together because they do not include Reclamation investment and the results are similar. Alternatives 1B and 3 are addressed together because they include Reclamation investment and the results are similar. Reclamation investment increases opportunities for exchanges between Sites Reservoir and Shasta Lake, which enhance management of Shasta cold-water pool and temperature management below Keswick Dam.

Table 28-1. Summary of Project Operation Effects with Climate Change by Alternative

Alternative	NEPA Conclusion	Rationale
Effect CC-1: Project-related climate change effects		
No Action Alternative	NE	Under a modeling scenario in which climate change occurs without the Project, existing reservoir storage, river flow, and system operations would be affected by climate change, but these conditions would occur regardless of construction and operation of the Project.
Alternatives 1A and 2	NE	Under a modeling scenario in which climate change occurs, operation of Alternative 1A or 2 would result in small changes in storage, flow, and operations indicators, compared to a modeling scenario in which climate change occurs and the Project is not constructed or operated. These effects would not be adverse.
Alternatives 1B and 3	NE	Under a modeling scenario in which climate change occurs, operation of Alternative 1B or 3 would result in small changes in flow and operations indicators, compared to a modeling scenario in which climate change occurs and the Project is not constructed or operated. These effects would not be adverse. Small year-round increases in storage during Critically Dry Water Years would occur with operation of Alternative 1B or 3.

Note: Storage, flow, and Sites Reservoir operations are variables analyzed in the climate change scenarios modeled using CALSIM and analyzed in this chapter.
NEPA = National Environmental Policy Act.
NE = NEPA no effect or no adverse effect.

28.2 Affected Environment

28.2.1. Climate

Climate in the Sacramento Valley is Mediterranean, with cool, wet winters and hot, dry summers. The rainy season primarily occurs between November and April, with less precipitation between May and October. The valley region receives less precipitation than coastal regions to the west and mountains to the east due to the topography of the mountains. The valley also experiences more temperature extremes than its surroundings; during winter, the valley is colder than the coast, while in summer it is much hotter (Huber-Lee et al. 2003).

Interannual climate fluctuations occur in the Sacramento Valley due to the El Niño—Southern Oscillation. During El Niño, the rainy season tends to be longer, and strong storms occur during winter. During La Niña, the dry season becomes longer, and fewer storms occur in winter. However, these trends may not hold every year (Huber-Lee et al. 2003). Table 28-2 shows baseline climate conditions for counties where the Project would be located.

Table 28-2. Baseline Climate Conditions in Glenn, Colusa, Tehama, and Yolo Counties (Historical Modeled Baseline from 1961 to 1990)

Climate Variable	Tehama County	Glenn County	Colusa County	Yolo County
Annual Average Minimum Temperature	41.1°F–41.7°F	43.2°F–43.7°F	44.3°F–44.8°F	46.2°F–46.9°F
Annual Average Maximum Temperature	68.3°F–68.8°F	71.3°F–71.8°F	72.6°F–73.1°F	73.8°F–74.3°F
Annual Precipitation	34.9–41.0 inches	23.9–28.6 inches	20.8–24.6 inches	18.7–22.3 inches

Source: Observed historical data derived from Gridded Observed Meteorological Data. Details are described in Livneh et al. 2015. Accessed via: Cal-Adapt.

28.2.2. Global Climate Trends

Climate change has increased global temperatures in recent years and will continue to do so in the future. From 2006–2015, the observed global mean surface temperature was 0.87°C (1.6°F) higher than the historical (1850–1900) baseline. Warming is not equal everywhere—temperatures increase at two or three times the rate in the Arctic, and warming is usually higher over land than over the ocean. The global mean surface temperature continues to rise at about 0.2°C (0.4°F) per decade and may reach 1.5°C (2.7°F) above the historical baseline between 2030 and 2052 at the current rate of increase. If there are no global reductions of GHG emissions, the global mean surface temperature could potentially reach a 2°C (3.6°F) increase by 2050, which would result in much greater impacts on natural and human systems (Intergovernmental Panel on Climate Change 2018).

As global mean surface temperature rises, the frequency of extreme heat events will increase. This may result in higher record-breaking temperatures, longer and more intense heat waves, and fewer cold days and nights that allow for recovery from extreme heat. Impacts from climate change may also include an increase in the intensity and frequency of precipitation extremes, such as heavier rainfall days, tropical cyclones and hurricanes, precipitation-induced flooding, and drought. Climate change may also result in changing seasonal patterns of temperature and precipitation, such as shortened rainy seasons and earlier snowmelt (Intergovernmental Panel on Climate Change 2018).

By 2100, global sea level rise may range from 0.26 to 0.77 meters under 1.5°C global warming (compared to 1985–2005 levels). Sea level rise can be especially impactful for small islands and low-lying coastal areas and deltas. Impacts include saltwater intrusion and flooding damage to leveed infrastructure (Intergovernmental Panel on Climate Change 2018).

Climate change could also result in indirect impacts. These include increases in risks from wildfires, vector-borne diseases, and ecosystem impacts from invasive species and alteration of native plant and animal species. These impacts are likely to have effects on human health, agriculture, energy and water systems, and urban and rural life (Intergovernmental Panel on Climate Change 2018).

28.2.3. Climate Change Effects on California

Climate change is already affecting California. Compared to the start of the twentieth century, peak runoff in the Sacramento River now occurs nearly a month earlier, and glaciers in the Sierra Nevada have lost about 70% of their area. The state has gone through notable recent climate events, including a drought in 2012–2016 followed by an extremely wet winter in 2016–2017 (Bedsworth et al. 2018).

These impacts are likely to continue and worsen in the future under climate change. California expects to see temperature increases of up to 5.8°F (3.2°C) by 2050 and up to 8.8°F (4.9°C) by 2100 under the Representative Concentration Pathway (RCP) 8.5,[1] a GHG concentration trajectory adopted by the Intergovernmental Panel on Climate Change. The state's precipitation patterns consist of dry and wet periods, which are driven by winter storms and atmospheric river events. These atmospheric rivers are projected to increase in strength under climate change, with northern California experiencing more wet extremes while southern California becomes drier. Increases in frequency and intensity of drought are likely to occur across the state as warmer temperatures and decreases in precipitation exacerbate dryness. Warmer temperatures will also reduce the fraction of precipitation falling as snow; since the 1950s, April 1 snow water storage across the western United States has declined 10%, and continued snowpack decline poses significant issues for water supply as spring snowpack can hold as much as 70% of the water for the state's engineered reservoirs (Bedsworth et al. 2018).

The Sacramento Valley is likely to see these changes as well. Warmer temperatures and increases in extreme heat will occur, with July through September increases of 2.7°F (1.5 °C) to 10.8°F (6.0°C). Heat waves are expected to become longer and more spread out geographically, with higher daytime and nighttime temperatures and fewer cooling days, which allow for recovery (Houlton and Lund 2018).

While average precipitation may not change significantly, there will be a change in precipitation patterns and extremes. On the wet extreme, the Sacramento Valley will likely see rainier winter storms, more extreme floods, and greater floodplain vulnerability (Swain et al. 2018). On the dry extreme, the region will see increased dryness in Dry Water Years and more extreme droughts. Precipitation whiplash, which is an abrupt transition from one extreme to another, may also increase by 25% in northern California (Houlton and Lund 2018).

Precipitation timing and its effect on snowpack also have implications for water management in California, particularly the Sacramento Valley. The northern Sierra Nevada, which provides the primary source for water in the region, will see more years with low snowpack and may have almost no annual snowpack by 2100. Precipitation will also fall more often as rain rather than

[1] RCPs portray possible future greenhouse gas and aerosol emissions scenarios to model future climate conditions. RCP 8.5 is referred to the "business as usual" scenario that would result in atmospheric carbon dioxide concentrations exceeding 900 parts per million by 2100 (Bedsworth et al. 2018).

snow due to higher temperatures, which may shift the timing of streamflow in the region from spring to winter, affecting inputs into rivers and reservoirs (Houlton and Lund 2018).

While the Sacramento Valley is not located on the coast, sea level rise is likely to affect the Delta by increasing flood potential and causing saltwater intrusion into the Delta's fresh waters (Houlton and Lund 2018).

The Project is based mostly in the Sacramento Valley, but climate change will also impact key hydrologic regions in the state where Storage Partners of the Sites Reservoir would be located. Table 28-3 shows projected trends for temperature, precipitation, wildfire, sea level rise, drought, and other variables under climate change for these hydrologic regions.

Table 28-3. Climate Change Trends for Hydrologic Regions Participating with Sites Reservoir

Hydrologic Region	Climate Change Trends
Sacramento River	• Increase in average daily maximum temperature by 10°F by 2100 • Increase in number of days above 104°F from 4 to 40 per year in midtown Sacramento • Increased Delta flood potential • Increased runoff and decreased groundwater recharge • Increased wildfire risk
Tulare Lake	• Increase in average annual maximum temperatures by 5°F–9°F by 2100 • Increase in extreme heat days and evapotranspiration and decrease in winter chill-hours • Increase in flooding frequency in low-lying areas • Increase in likelihood of extreme Wet and Dry Water Years • Decrease in snowpack, reducing reliability of surface water and increasing demand for groundwater
San Francisco Bay	• Increase in average annual maximum temperatures by 3.3°F by mid-century • Increase in dry and wet extremes • Increase in winter storm intensity (20-year storm will become 7-year storm or more frequent storm) • Frequent and sometimes large wildfires continue • Increase in sea level rise of 2.5–4.5 feet by 2100 • Beaches will narrow and many may be completely lost over next century
South Lahontan	• Increase in daily maximum temperatures by 5°F–6°F by mid-century • Decrease in southern Sierra snowpack water by 40% • Increase in winter streamflow and decrease in summer flows • Increase in extremes and drought • Decrease in soil moisture by 15%-40% below historic norms • Longer fire season, increase in wildfire frequency, expansion in fire-prone areas
South Coast	• Increase in heat wave frequency, intensity, and duration • Wetter winters, drier springs, and more frequent and severe droughts • Increase in wildfire risk due to drier autumns before Santa Ana wind season • Increase in sea level rise of 1 foot by mid-century and 3+ feet by 2100 • Increased flooding and erosion of beaches and property

Source: Climate projection data comes from California Fourth Climate Change Assessment (State of California 2019) as referenced in Water Resilience Portfolio (California Department of Water Resources 2020a).

28.2.4. Water Management and Climate

In normal water years, about 40% of California's water supply comes from groundwater, while the rest comes mostly from surface water; groundwater usage increases to about half during Dry Water Years. Because northern California receives much more surface water flows than southern California, water conveyance infrastructure delivers water from the Delta to central and southern California and relies heavily on snowpack and runoff for seasonal water storage (Bedsworth et al. 2018). Surface flows from Sacramento River runoff historically reach their peak in spring due to snowmelt. Releasing flows from reservoirs depends on seasonal needs and flooding considerations. Reservoirs historically release large flows in early winter to increase storage for spring, the main runoff season. During spring, reservoirs reduce flows as they capture spring runoff inflows for later release. In summer, reservoirs increase flows higher than they would be naturally to meet downstream irrigation needs (Huber-Lee et al. 2003).

Climate change is likely to alter hydrologic patterns and will require changes in water resources management. More extreme precipitation will result in increased runoff, which in turn is expected to lead to increased flooding (Swain et al. 2018). Furthermore, as precipitation falls more often as rain rather than snow, streamflow timing will shift from spring to winter in Sacramento Valley (Houlton and Lund 2018). Meanwhile, increased drought and potentially greater water demand may also put pressure on increasing water supply. These impacts may result in reduced Delta exports and reservoir carryover storage (i.e., the amount of water in reservoirs before the start of the wet season in October). Carryover in Shasta Lake and Lake Oroville is projected to decline by one-third over the century, reducing needed water supplies for Dry Water Years. The state will also face challenges related to drought resilience, such as flexibility and response time, particularly under longer, more frequent, and more intense droughts (Bedsworth et al. 2018).

The Water Storage Investment Program (WSIP) provides climate projections for four future scenarios for all of California: a 2030 central tendency (CT) scenario, a 2070 CT scenario, a 2070 drier and extreme warming scenario, and a 2070 wetter with moderate warming scenario (California Natural Resources Agency 2018). These climate scenarios were used by California Water Commission to project change to runoff into major reservoirs in the Sacramento River watershed for both 2030 and 2070 time horizons. Climate projections utilized by the California Water Commission showed that, by 2070, winter runoff may increase by an average of 2.1 MAF annually; spring runoff may decrease by an average of 1.6 MAF per year (Contra Costa Water District and Bureau of Reclamation 2017). Thus, historical storage and the general timing of releases of water from reservoirs may change to accommodate the runoff change demonstrated by these climate projections. In other words, altering flow releases from reservoirs and adjusting the timing are likely to be needed to cope with future climate change runoff changes. Some of these changes are manifest in the CALSIM results below and are reflected in the difference in carryover storage in Shasta Lake and Lake Oroville. In its biological assessment for the reinitiated consultation on long-term operation of the CVP, pursuant to Section 7 of the federal Endangered Species Act (2018) in 2018, Reclamation reviewed its operations under two climate change projections: early long-term (ELT) Q5 climate change projections, centered around 2025

(2011–2040) conditions derived from an ensemble of all 112 bias-corrected and statistically downscaled CMIP3 global projections, and a 2035 CT climate projection, centered around 2035 (2020–2049) conditions and derived from an ensemble of 20 CMIP5 localized constructed analog downscaled global climate projections (see Bureau of Reclamation 2019 for more detail). These assessments reflect increases in temperature in major watersheds in the Sacramento and San Joaquin River Basins. These increases are at least 1°C (1.8°F) in each of the major watersheds under the ELT Q5 scenario and at least 1.5°C (2.7°F) in all major watersheds in the Sacramento and San Joaquin River Basins under the 2035 CT scenario (Bureau of Reclamation 2019). The ELT Q5 projections showed a 1.5% increase in precipitation in the Feather River watershed. The 2035 CT projections showed precipitation increases of at least 2% in all major watersheds in the Sacramento and San Joaquin River Basins. Warmer and wetter climates in northern California would lead to increased storage volume and river flows during the wet season, and decreased flow and storage volume in the dry season. While the upper Sacramento Valley may experience equal or greater precipitation, the San Joaquin Valley may experience equal or drier conditions and Tulare Lake region may experience drier conditions. Southern California shows drier projections than northern California (Bureau of Reclamation 2016).

Schwarz et al. (2018) modeled sea level rise impacts on the Delta and found that a future increase in temperature of 2.5°C (4.5°F) could result in sea level rise of 45 centimeters (18 inches) by the end of the century under RCP 8.5, increasing salinity in the Delta. By mid-century, climate change may increase precipitation and the rain-to-snow ratio in rainy months; however, the negative effect of sea level rise would very likely overwhelm the positive impact of increased rainfall on salinity (Wang et al. 2018). This overall increase in salinity would require greater summer outflow to repel sea level rise and maintain currently required Delta salinity standards. These water releases could come at the expense of other system functions, such as carryover storage and cold-water pools.

The state has recently produced regulations and plans related to planning for climate resilience in the water sector, including Sustainable Groundwater Management Act (2014), Executive Order B-30-15: Establishing 2030 CA Emissions Target, Adaptation Initiatives (2015), Senate Bill 246 (2015), Executive Order N-10-19 (2019), California Department of Water Resources California Water Plan Update (2018), and California Natural Resources Agency California Climate Change Adaptation Strategy and Safeguarding California Plan Update (2018). Together, these regulations and plans provide a policy framework for understanding and addressing climate-related risks to water resources. Related to the Project, Proposition 1 Water Bond, the Water Quality, Supply, and Infrastructure Improvement Act of 2014, was designed to appropriate funds for water management projects to create more sustainable water supplies and water surface water storage, including through the WSIP. Reclamation conducted efforts towards the storage objectives of Proposition 1, including investigating and proposing a North of Delta Offstream Storage project to store water in wetter years and release water in drier years for use throughout areas dependent on supplies from the SWP and CVP (Bureau of Reclamation 2016). Additional information regarding statewide water policies for climate adaptation can be found in Appendix 4A, *Regulatory Requirements*.

28.3 Methods of Analysis

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 5, 2016 (Council on Environmental Quality 2016). The 2016 guidance was withdrawn in April 2017 and then new draft guidance was issued in June 2019; however, the 2019 draft guidance was rescinded by Executive Order in January 2021, and the Council on Environmental Quality was directed to review, revise, and update the prior 2016 guidance. As discussed above, the 2016 guidance indicates that NEPA analyses should identify climate change effects on a proposed action and its environmental impacts.

This chapter evaluates interactions between the Project and climate change by comparing model results “with” and “without” climate change. The “without climate change” modeled results are based on historical hydrologic conditions, whereas the “with climate change” modeled results are based on future climate-change driven hydrologic conditions. Incorporating modeling representing “without climate change” allows an understanding of the effects climate change has on Project performance to meet the Project’s objectives and purpose. This analysis is based on comparison of flow and volume indicators of Project performance under no climate change using Chapter 5, *Surface Water Resources*, assessment of Project effects on surface water resources and the same indicators under climate change, using 2035 CT and WSIP 2070 results. While WSIP 2070 climate projections were discussed generally in the RDEIR/SDEIS, an analysis of Project operations under the WSIP 2070 projections was not included. That analysis is presented here, and it does not reveal any new significant impacts or any substantial increase in the severity of significant impacts compared to the analysis in the RDEIR/SDEIS.

The 2035 CT and WSIP 2070 models for hydrology and sea level rise, which form the basis of the analysis for Section 28.4, were selected for use in coordination with the Water Supply and Operations Branch of Reclamation. The 2035 CT model boundary conditions were developed for the reinitiated ESA Section 7 consultation on the long-term operations of the CVP and SWP in 2018 and Final EIR for SWP Long-Term Operations (California Department of Water Resources 2020b). As indicated in Section 28.2.4, *Water Management and Climate*, this model was also utilized for sensitivity analysis in the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project Final Environmental Impact Statement (Bureau of Reclamation 2019). Reclamation also plans to develop its updated baseline models with 2035 CT model hydrology. Use of the 2035 CT model supports assessment of near-term hydrology relevant to the changes made with the Project, in context of current water policy and management.

The WSIP 2070 model was developed as companion information to a technical reference released in 2016 by the California Water Commission. The model was developed to assist applications for funding under the WSIP, which required applicants for public funding to analyze their proposed projects using climate and sea level conditions for California projected at years 2030 and 2070. Use of the WSIP 2070 model supports assessment of longer-term hydrology relevant to the changes made with the Project.

The 2035 CT and WSIP 2070 climate projections differ slightly from the climate projections in the California Fourth Climate Change Assessment summarized in Bedsworth et al. (2018), but they are consistent in their depiction of trends toward increased winter flows associated with more precipitation as rain and decreased spring flows associated with a decrease in precipitation as snow leading to reduced spring flows attributable to reduced snowmelt. Both projections indicate an overall reduction in September carryover storage in the Sacramento basin, but they differ in projections of September carryover storage in specific reservoirs, in particular Lake Oroville. These differences are likely a result of how the CALSIM models used in each of the assessments assign reductions in deliveries to balance Delta outflow requirements (see Appendix 28A). The 2035 CT and WSIP 2070 projections were chosen because they have been used in relevant regulatory processes regarding operation of the CVP and SWP. The 2035 CT was developed to inform the reinitiated ESA Section 7 consultation on long-term operations of the CVP and SWP in 2018, and the SWP incidental take permit application in 2020. The WSIP 2070 projection was developed for compliance with the California Water Commission requirements for applicants for WSIP funding. The Authority considered these projections the most relevant for the purposes of this environmental review. In Section 28.4, the potential for climate change to impact key indicators of the Project is described, with insights on whether certain alternatives perform differently from others in the 2035 CT near-term and WSIP 2070 longer-term climate hydrology. The projection values presented for 2035 CT were calculated by averaging around the 30-year period of 2020–2049 projections from the CALSIM model output, while the values for WSIP 2070 were averaged around the 30-year period of 2056–2085. As described in Chapter 5, “without climate change” is based on CALSIM results for an 82-year modified historical hydrology period (Water Years 1922–2003) developed jointly by DWR and Reclamation to consider hydrologic variability among water years.

Section 28.5 describes the key climate impacts on study area resources under the climate scenarios evaluated, including impacts on water supply, water quality, and aquatic biological resources. This assessment is based on literature review and evaluation of the alternatives under the climate scenario. Section 28.5 also identifies how and whether the Project would help to offset the anticipated impacts of climate change. This is based on evaluation of the same indicators and assessment of whether there are any improvements to indicators associated with aquatic biological resources, water quality, and water supply under the modeled climate change scenario. This section also describes any other benefits from the Project (with climate change) compared to the No Project Alternative (also called No Action Alternative or NAA) under climate change,[2] drawing from both CALSIM modeling and literature.

28.3.1. Indicators

As described in Chapter 1, *Introduction*, the CEQA Project objectives are as follows:

- OBJ-1: Improve water supply reliability and resiliency to meet Storage Partners’ agricultural and municipal long-term average annual water demand in a cost-effective manner for all Storage Partners, including those that are the most cost-sensitive.

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[2] Most of the chapters in this report use the term *No Project Alternative* to refer to the default description of the baseline condition without the Project. However, throughout Chapter 28, the No Project Alternative will be referred to as the *No Action Alternative*. This is to avoid confusion and maintain consistency with the modeling done for Chapter 28 (described in Appendix 28A), which uses the *NAA* acronym to refer to the No Project Alternative.

- OBJ-2: Provide public benefits consistent with Proposition 1 of 2014 and use WSIP funds to improve statewide surface water supply reliability and flexibility to enhance opportunities for habitat and fisheries management for the public benefit through a designated long-term average annual water supply.
- OBJ-3: Provide public benefits consistent with the Water Infrastructure Improvements for the Nation (WIIN) Act by using federal funds, if available, provided by Reclamation to improve CVP operational flexibility in meeting CVP environmental and contractual water supply needs and improving cold-water pool management in Shasta Lake to benefit anadromous fish.
- OBJ-4: Provide surface water to convey biomass from the floodplain to the Delta to enhance the Delta ecosystem for the benefit of pelagic fishes[3] in the north Delta (e.g., Cache Slough).
- OBJ-5: Provide local and regional amenities, such as developing recreational facilities, reducing local flood damage, and maintaining transportation connectivity through roadway modifications.

Reclamation has identified the Project need as providing offstream surface water storage north of the Delta in a manner that is consistent with WIIN Act requirements and Reclamation law. The NEPA purpose of the Project is to provide:

- Increased water supply and improved reliability of water deliveries
- Increased CVP operational flexibility
- Benefits to anadromous fish by improving CVP operations consistent with the laws, regulations, and requirements in effect at the time of operation
- Incremental Level 4 water supply for CVP Improvement Act refuges
- Delta ecosystem enhancement by providing water to convey food resources

The Authority and Reclamation selected indicators as representations of the Project's objectives and purpose and to quantitatively evaluate effects of the Project on aquatic biological resources, water quality, and water supply under climate change in Section 28.4. These effects are discussed qualitatively under Sections 28.5.5, *Aquatic Biological Resources;* 28.5.2, *Surface Water Quality*; and 28.5.1, *Surface Water Resources and Fluvial Geomorphology*, respectively. The indicators for aquatic biological resources are preservation of cold-water pool (storage); meeting fish flows, habitat, and food supply requirements; and meeting salmonid temperature requirements, especially temperature requirements for winter-run spawning. The indicators for water quality are maintaining storage in Sites Reservoir at a high enough level that releases do not need to come from the surface of the reservoir; meeting water temperature requirements; maintenance of minimum flows; and meeting Delta outflow and water quality standards. The indicators for water supply are maintaining dry season yields; providing total water supply benefit; meeting supply demands of CVP and SWP south-of-Delta contractors; and meeting water provision requirements of the Storage Partners. These indicators are associated with

[3] Pelagic fish are species that spend most of their life swimming in the water column, having little contact or dependency with the bottom.

broader water system considerations for habitat and water supply and are focal points for understanding how climate change may affect changes to the surface water system.

Modeling results were assessed for locations listed in Table 28-4 and variables were categorized into three subcategories: storage, flow, and Sites Reservoir Operations. Table 28-4 summarizes these analyzed variables as well as linkage between the variables and benefits.

Table 28-4. Variables Analyzed in Climate Change Model and Benefit Criteria for Climate Change Model Variables

Variable Type	Variable Analyzed	Benefit Criteria Variable
Storage	Shasta Lake storage	Increased storage (TAF) May–October
	Lake Oroville storage	Increased storage (TAF) during summer months (May–October)
	Folsom Lake storage	Increased storage (TAF) May–October
	Total CVP and SWP storage (Shasta Lake, Lake Oroville, Folsom Lake)	Increased storage (TAF) May–October
Flow	Sacramento River flow at Bend Bridge	Increased flow for months important to fish
	Sacramento River flow near Wilkins Slough	Increased flow for months important to fish
	Feather River flow at mouth	Increased flow management flexibility
	American River flow at H Street	Increased flow (cfs) in select months
	Yolo Bypass flow	Number of months with bypass inundation during winter and early spring as indicated by flow over Fremont Weir (the Project would cause a small decrease in winter inundation)
	Delta outflow	Increased outflow (cfs) during all months
Sites Reservoir Operations	Diversions at RBPP	Total diversion for all months
	Diversions at Hamilton City	Total diversion for all months
	Sites Reservoir storage	Increased storage for all months, decreased flood risk in Stone Corral and Funks Creeks
	Sites Reservoir release	Increased deliveries (cfs) in all months
	Total CVP and SWP Delta exports	Increased deliveries (cfs) in all months

Notes: CVP = Central Valley Project; RBPP = Red Bluff Pumping Plant; SWP = State Water Project; cfs = cubic feet per second; TAF = thousand acre-feet.
Reservoir storages must follow U.S. Army Corps of Engineers flood control rules and releases.

28.4 Surface Water Resources, the Project, and Climate Change

A multitude of scientific literature and datasets exist to showcase the potential effects of climate change at local and national scales (Intergovernmental Panel on Climate Change 2018, Bedsworth et al. 2018, Houlton and Lund 2018, California Department of Water Resources 2020a). This section qualitatively and quantitatively addresses key effects of climate change observed on the Project through 2035 CT and WSIP 2070 model results, categorized by alternative: NAA (no structural changes), Alternative 1A, Alternative 1B, Alternative 2, and Alternative 3. Variables are broken into three separate categories: storage/volume, flow, and Sites Reservoir operations. Variables were analyzed to better understand cascading effects that may exist under climate change and the Project. Average results for Wet and Critically Dry Water Years were analyzed to represent likely hydrologic conditions that would be observed under the modeled climate change.

28.4.1. Modeling Results

The results presented in the following section show the variables from Table 28-4 without future climate change and with climate change by 2035 and 2070 compared across Alternatives 1, 2, and 3. The variables from Table 28-4 were identified as the most salient to Sites Reservoir operations based on knowledge of water resources and aquatic biological resources.

Changes are expected from climate change under the NAA or Alternatives 1, 2, and 3. This section is meant to provide an understanding of overall changes under climate change simulations from the CALSIM model and the differences that arise between the NAA and operations of Alternatives 1, 2, and 3. The quantitative analyses include raw value changes (for Sites Reservoir operations and storage variables and percent changes for flow variables).

To understand the full extent of future climate scenarios, the two extremes of Critically Dry and Wet Water Years were analyzed. Many of the results presented are for only the Critically Dry Water Years to focus on worst-case conditions. Only a few variables for Wet Water Years are presented. This was intentional because the greatest ramifications occur in the Project area when drier conditions prevail. Analyses of individual seasons and months are presented below. Seasons are referred to by the conventional meteorological seasons; winter is December through February, spring is March through May, summer is June through August, and fall/autumn is September through November.

The hydrologic modeling results show that there would be small changes in Sites Reservoir operations due to climate change by both 2035 and 2070. Water would still be available for diversion to storage during high flow conditions and water could still be released from storage for water supply and habitat purposes during dry conditions. Climate change is generally expected to reshape the hydrograph by increasing winter runoff and reducing runoff during other times of the year, as is exemplified by simulated flows downstream of Shasta Lake at Bend Bridge, which are presented below. By 2070, compared to 2035, climate change generally results in more extreme changes to Sites Reservoir operations, such as larger decreases in storage and larger increases in flow during winter and spring.

28.4.1.1. Storage

Shasta Lake

Shasta Lake minimums typically occur in November as Reclamation creates flood storage space in the lake. Reclamation then stores water from January to June, with the peak volume stored in April (Table 28-5). Under the 2019 Biological Opinion on CVP operations (National Marine Fisheries Service 2019), end-of-April storage is used to define a four-tiered temperature management strategy for cold-water pool conservation under which temperature management becomes more challenging with each tier. An end-of-April storage volume of less than 2.5 MAF defines Tier 4, which is the most difficult scenario to manage.

The Project would allow Reclamation to deliver water from Sites Reservoir in exchange for conservation of water in Shasta Lake. Table 28-5 compares average monthly storage for the NAAs in Shasta Lake in Critically Dry Years under current conditions and in 2035 and 2070. By 2035, there is a projected loss of 114 TAF in mean monthly storage due to climate change. By 2070, the reduction in mean monthly storge is 588 TAF. This reduction in storage is likely to make conservation of the cold-water pool and temperature control in the upper Sacramento River even more challenging in Critically Dry Years. Although other year types were not analyzed, Below Normal, Above Normal, and Wet Water Years will have higher end-of-November and end-of-April storage levels, and the additional water made available via exchanges with the Project are more likely to facilitate cold-water pool conservation and temperature management.

Table 28-5. Effect of Climate Change on Shasta Lake Storage (TAF) in Critically Dry Water Years

Scenario	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Mean
NAA without future climate change	1,714	1,667	1,806	2,548	2,718	2,914	2,987	2,813	2,486	2,143	1,882	1,831	2,292
NAA with climate change in 2035	1,581	1,571	1,738	2,451	2,619	2,836	2,903	2,684	2,319	1,961	1,767	1,713	
Change by 2035 due to climate change	-133	-96	-68	-97	-99	-78	-84	-129	-167	-182	-115	-118	-114
NAA with climate change in 2070	1,026	1,037	1,317	2,047	2,271	2,496	2,481	2,204	1,793	1,444	1,192	1,148	
Change by 2070 due to climate change	-688	-630	-489	-501	-447	-418	-506	-609	-693	-699	-690	-683	-588

Table 28-6a, Table 28-6b, and Table 28-6c demonstrate the performance of Alternatives 1, 2, and 3 in percent change in storage compared to the NAA within each of the climate scenarios. Under future conditions without climate change, Reclamation could store between 0% and 6% more water than under the NAA (as shown in Table 28-6a).

Table 28-6b presents changes in storage by month for each alternative compared to the NAA under the 2035 climate projection. There is between a 1% and 5% increase in end-of-April storage and between a 1% and 10% increase in end-of-September storage compared to the 2035 NAA.

Table 28-6c presents changes in storage by month compared to the NAA under the 2070 climate projection. There is between a 1% and 6% increase in end-of-April storage and between a 1%

and 15% increase in storage compared to the NAA. Alternative 3 provides the largest increase in storage compared to the NAA. Alternative 3 represents the most participation by Reclamation among the alternative and thus provides the most opportunity for exchanges to assist with conservation of storage in Shasta Lake through the summer months.

Table 28-6. Shasta Lake Storage: Alternatives Compared with NAA (a) without Climate Change in 2035, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	1,714	1,667	1,806	2,548	2,718	2,914	2,987	2,813	2,486	2,143	1,882	1,831
Alt 1A % change	1	1	2	1	1	1	1	2	2	3	3	3
Alt 1B % change	2	2	2	1	1	1	1	3	3	4	4	3
Alt 2 % change	0	1	1	1	1	0	0	2	2	2	3	2
Alt 3 % change	4	4	4	2	2	2	2	4	5	5	6	5

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	1,581	1,571	1,738	2,451	2,619	2,836	2,903	2,684	2,319	1,961	1,767	1,713
Alt 1A % change	0	0	1	0	0	0	1	1	3	3	2	1
Alt 1B % change	3	3	4	2	2	2	2	3	5	6	5	4
Alt 2 % change	2	1	2	2	2	1	2	3	4	5	4	3
Alt 3 % change	11	11	11	6	5	5	5	7	9	11	11	10

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	1,026	1,037	1,317	2,047	2,271	2,496	2,481	2,204	1,793	1,444	1,192	1,148
Alt 1A % change	0	0	0	1	1	1	1	3	5	4	3	1
Alt 1B % change	8	8	7	5	4	3	4	6	9	9	10	8
Alt 2 % change	1	1	1	1	1	1	2	3	5	5	3	2
Alt 3 % change	16	16	13	7	6	5	6	8	11	14	16	15

Note: Alt = alternative; NAA = No Action Alternative; TAF = thousand acre-feet.

Lake Oroville

During Critically Dry Water Years, Lake Oroville storage typically peaks from January through June and is at its lowest in October and November (Table 28-7). The 2035 CT and WSIP 2070 climate scenarios show slight increases in storage compared to scenarios without climate change. These increases in storage are likely a result of how CALSIM assigns reductions in deliveries to balance water Delta outflow requirements (see Appendix 28A). Reductions in deliveries are reflected in increases in storage. SWP operations in 2035 and 2070 reduce deliveries relative to the CVP, and those reduced deliveries are reflected in higher storage in Lake Oroville, even though patterns in precipitation are likely to shift toward more winter rain and less spring snowmelt.

Table 28-7. Effect of Climate Change on Oroville Storage (TAF) in Critically Dry Water Years

Scenario	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Mean
NAA without future climate change	867	855	910	1,440	1,546	1,686	1,702	1,649	1,410	1,124	965	914	1256
NAA in 2035	914	898	1,005	1,473	1,602	1,771	1,777	1,708	1,432	1,162	1,016	976	1311
Change by 2035 due to climate change	47	43	95	33	56	85	75	59	22	38	51	62	56
NAA in 2070	882	923	1,183	1,443	1,634	1,809	1,785	1,656	1,366	1,111	946	919	1305
Change by 2070 due to climate change	15	68	273	3	88	123	83	7	-44	-13	-19	5	49

Note: NAA = No Action Alternative

Table 28-8a, Table 28-8b, and Table 28-8c demonstrate the effects of Alternatives 1, 2, and 3 in the percent change in storage compared to the NAA under each of the respective climate scenarios. Under future conditions without climate change (Table 28-8a), Oroville storage would decline between 0% and 3% in each month except June and July. Storage in June and July would increase between 1% and 2%. This increase in June and July storage is likely related to balancing delivery of water from Sites Reservoir to south-of-Delta Project participants with meeting Delta water quality requirements. Surplus water is backed into Oroville and delivered in the fall months.

In the 2035 climate change scenario (Table 28-8b), there are small increases in storage in the summer months and small decreases in the fall with the Project compared to the NAA. These increases are very likely due to the retention of storage in Lake Oroville as Sites Reservoir water is released to assist with meeting Delta water quality requirements and/or deliveries to participants south of the Delta. The decreases in the fall are very likely the result of releasing water that was backed into Lake Oroville by the fall storage actions.

By 2070 (Table 28-8c), there are increases in storage in almost all months with the Project compared to the NAA, with greater increases in the summer and fall months compared to the winter and spring months.

Table 28-8. Lake Oroville Storage: Alternatives Compared with NAA (a) without Climate Change in 2035, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	867	855	910	1,440	1,546	1,686	1,702	1,649	1,410	1,124	965	914
Alt 1A % change	-3	-3	-3	-1	-1	-1	-1	-1	1	2	1	0
Alt 1B % change	-3	-3	-3	-1	-1	-1	-1	-1	1	2	1	0
Alt 2 % change	-3	-3	-3	-1	-1	-1	-1	-1	1	2	1	-1
Alt 3 % change	-1	-1	-1	-1	-1	-1	-1	-1	1	2	1	-1

(b) With climate change by 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	914	898	1,005	1,473	1,602	1,771	1,777	1,708	1,432	1,162	1,016	976
Alt 1A % change	-1	-1	-1	0	0	0	0	0	1	2	1	1
Alt 1B % change	-1	-1	0	0	0	0	0	0	1	2	1	0
Alt 2 % change	0	0	0	0	0	0	0	0	1	2	1	1
Alt 3 % change	-1	-1	-1	0	0	0	0	0	1	1	0	-1

(c) With climate change by 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	882	923	1,183	1,443	1,634	1,809	1,785	1,656	1,366	1,111	946	919
Alt 1A % change	3	2	2	2	1	1	2	2	3	4	3	3
Alt 1B % change	2	2	2	2	1	1	1	1	3	4	3	3
Alt 2 % change	2	1	1	1	1	1	1	1	2	3	3	3
Alt 3 % change	1	0	0	1	0	1	1	1	2	2	2	2

Note: Alt = alternative; NAA = No Action Alternative; TAF = thousand acre-feet

Folsom Lake

Without the Project, Folsom storage peaks in the spring (March–April) under all climate scenarios and declines through summer to its low point in October (Table 28-9). This trend is evident in all three climate scenarios. There is a progressive reduction in storage associated with the climate scenarios, with a reduction in mean monthly storage of 28 TAF by 2035 and 112 TAF by 2070. This climate-based reduction in storage will very likely make achieving temperature targets for salmonids in the American River difficult. Reclamation targets for steelhead, egg to fry, from December through May are below 54°F and for steelhead juveniles from May 15 through October temperatures are below 68°F at H Street Bridge.

Table 28-9. Effect of Climate Change on Folsom Storage (TAF) in Critically Dry Water Years

Scenario	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Mean
NAA without future climate change	314	338	415	427	426	482	509	524	496	426	362	334	421
NAA in 2035	281	299	400	402	419	512	500	484	431	372	326	297	394
Change by 2035 due to climate change	-33	-39	-15	-25	-7	30	-9	-40	-65	-54	-36	-37	-28
NAA in 2070	226	249	364	309	334	412	379	362	317	277	249	229	309
Change by 2070 due to climate change	-88	-89	-51	-118	-92	-70	-130	-162	-179	-149	-113	-105	-112

Note: NAA = No Action Alternative

Table 28-10a, Table 28-10b, and Table 28-10c demonstrate the effects of Alternatives 1, 2, and 3 in the percent change in storage compared to the NAA under each of the climate scenarios. In the scenario without climate change (Table 28-10a), there are small increases in storage in the summer months and small decreases in the fall compared to the NAA.

In the 2035 climate change scenario there are small deviations from the NAA that vary between -1% and 2% in storage. Alternative 3 increases storage by 2% above the NAA in August and September. However, these increases are not large enough to offset losses in storage due to climate change (see Table 28-10).

In the 2070 climate change scenario there are small decreases in storage compared to the NAA in the fall and winter months and small increases in storage in the spring and summer months. All of the alternatives perform comparably in the 2070 climate change scenario. These small fluctuations in storage are not likely to offset losses in storage due to climate change (Table 28-10).

Table 28-10. Folsom Storage: Alternatives Compared with NAA (a) without Climate Change in 2035, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	314	338	415	427	426	482	509	524	496	426	362	334
Alt 1A % change	-4	-3	-4	-3	-1	-2	-1	-1	0	0	-2	-2
Alt 1B % change	0	1	-1	-1	-1	-1	0	0	0	1	2	2
Alt 2 % change	-1	0	-1	-1	-1	-1	0	0	0	0	1	1
Alt 3 % change	0	-2	-2	-1	1	1	0	1	1	1	-1	-2

(b) With climate change 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	281	299	400	402	419	512	500	484	431	372	326	297
Alt 1A % change	0	1	1	0	0	0	0	0	0	0	0	0
Alt 1B % change	0	0	0	0	0	0	0	0	0	0	0	0
Alt 2 % change	0	1	1	0	-1	-1	0	0	0	0	0	0
Alt 3 % change	1	0	0	0	0	0	0	1	1	1	2	2

(c) With climate change 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	226	249	364	309	334	412	379	362	317	277	249	229
Alt 1A % change	0	0	0	0	0	-1	4	2	3	3	3	3
Alt 1B % change	-2	-2	-1	-2	-2	-2	3	1	2	3	3	3
Alt 2 % change	0	-1	0	-1	-1	-1	3	2	2	3	3	3
Alt 3 % change	-2	-1	-1	-1	-1	-1	3	2	3	4	3	3

Note: Alt = alternative; NAA = No Action Alternative; TAF = thousand acre-feet

28.4.1.2. Flow

Across most rivers in the Sacramento Basin, flow is highest in rainy months from January to May, particularly from January to March. In Wet Water Years, flow during rainy months increases substantially, up to 50 times higher than flow in Critically Dry Water Years. Climate change also tends to increase flow during rainy months for Wet Water Years due to a higher proportion of precipitation falling as rain rather than snow. The reduction in snowpack associated with less precipitation falling as snow and early snowmelt due to higher temperatures will diminish spring and early summer flows compared to existing conditions.

Sacramento River Flow at Bend Bridge in Critically Dry Water Years

Table 28-11a presents Sacramento River flow at Bend Bridge in the without climate change scenario. Flows in April, May, and June are reduced 3% to 6% compared to the NAA and increase from 5% to 7% in August and September. These changes reflect exchanges between Sites Reservoir and Shasta Lake for retention of storage in Shasta Lake for cold-water pool management and other purposes. Reclamation would decrease flow in the spring in exchange for releases from Sites Reservoir and release the water retained in Shasta Lake in late summer and fall for temperature control or flow stability in the river. Each of the alternatives perform slightly differently, but the performance of each alternative is comparable.

By 2035, under the NAA climate change scenario (Table 28-11b), Sacramento River flow at Bend Bridge would fluctuate slightly, with notable increases in December and notable decreases in August. During Critically Dry Water Years, the Project would reduce flow in May and increase flow in the fall.

Comparing 2070 with climate change to 2035 with climate change (Table 28-11c compared to Table 28-11b), Sacramento River flow at Bend Bridge would still fluctuate throughout the year, with notable increases from April through June, which is likely associated with exchanges and conservation of storage in Shasta Lake. Flows increase in July through September, likely reflecting release of stored water in the late summer and fall months. Alternatives 1A, 1B, and 2 are quite similar in the percent increases in flow. Alternative 3 produces lower flows than the other alternatives, particularly in July.

Table 28-11. Sacramento River Flow at Bend Bridge: Alternatives Compared with NAA (a) without Future Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	6,020	6,137	6,291	6,027	6,411	6,189	5,587	8,813	10,137	10,284	8,160	4,860
Alt 1A % change	3	-1	-1	-1	1	0	-5	-2	-4	0	6	7
Alt 1B % change	3	-1	-1	0	2	3	-5	-3	-5	-1	5	7
Alt 2 % change	3	-1	-1	0	2	0	-2	-3	-4	0	6	7
Alt 3 % change	5	-1	1	0	1	4	-2	-6	-5	-2	5	5

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	6,012	5,968	7,301	6,217	6,995	6,657	5,404	9,119	10,248	10,095	7,379	4,943
Alt 1A % change	4	1	-4	0	0	1	-4	-3	-4	0	5	7
Alt 1B % change	4	-1	-4	0	0	2	-5	-5	-5	0	5	7
Alt 2 % change	5	1	-4	0	0	1	-4	-4	-4	0	5	8
Alt 3 % change	2	-3	-2	1	1	2	-5	-5	-6	-1	4	7

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	6,363	6,126	6,953	6,699	6,765	6,987	6,271	9,477	11,067	10,065	7,925	5,201
Alt 1A % change	2	-1	-2	3	0	1	-6	-4	-5	5	6	9
Alt 1B % change	0	-1	-2	1	1	1	-6	-4	-5	4	5	9
Alt 2 % change	2	-1	-2	1	0	1	-6	-4	-4	5	6	9
Alt 3 % change	-1	-1	-2	1	1	1	-5	-5	-4	1	4	8

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Sacramento River Flow at Bend Bridge in Wet Water Years

A comparison of flows in the NAA of Tables 28-11a–c with the flows in the NAA in Tables 28-12a–c shows that winter flows—January, February, and March—may be between four and five times higher in wet years than in the same months during dry years. Flows in the remaining months may be between one and two times higher in wet years than in critically dry years. In Wet Water Years without climate change there is little variation in flows between the NAA and the alternatives, flows vary from -1% to 1% from the NAA. These variations are not likely to result in discernable changes from the NAA (Table 28-12a). The 2035 climate change scenario (Table 28-12b) performs similarly relative to the NAA as the scenario without climate change compares to its NAA (Table 28-12a). In Table 28-12b, there are small deviations in flow varying between -1% and 1% in several months. These deviations are not likely to created effects discernable from those effects attributed to climate change, with the possible exception of May for Alternatives 1B and 3, which have a 4% increase in flow compared to the NAA, and September, in which Alternative 3 has a 2% reduction in flow compared to the NAA.

In the 2070 climate change scenario there are also small deviations from the NAA ranging from -1% to -2%, with the exception of Alternatives 1B and 3, which result in 5% and 4% increases in flow relative to the NAA in May. These are small increases in flow; they may contribute to small increases in habitat for anadromous fish in the upper river compared to the NAA.

Table 28-12. Sacramento River Flow at Bend Bridge: Alternatives Compared with NAA (a) without Future Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Wet Water Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	8,647	9,518	13,102	28,285	31,759	24,312	14,434	12,772	10,789	13,481	11,634	10,954
Alt 1A % change	0	0	0	0	-1	1	0	0	0	0	0	0
Alt 1B % change	0	0	0	0	-1	1	0	1	0	0	0	-1
Alt 2 % change	0	0	0	0	-1	1	0	0	0	0	0	0
Alt 3 % change	0	0	0	1	-1	1	0	1	0	0	0	-1

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	7,566	8,962	14,339	31,512	33,747	25,586	14,357	10,825	10,504	14,342	10,686	9,077
Alt 1A % change	0	0	0	0	-1	1	0	0	0	0	0	0
Alt 1B % change	0	-1	1	0	-1	1	-1	4	0	-1	0	-1
Alt 2 % change	0	0	0	0	-1	1	0	0	0	0	0	0
Alt 3 % change	0	0	1	0	0	1	-1	4	0	-1	-1	-2

(d) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	7,842	7,762	13,062	33,379	37,286	26,597	13,028	10,488	12,381	15,585	11,666	10,165
Alt 1A % change	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1B % change	0	-2	0	1	0	0	0	5	0	-1	-2	-2
Alt 2 % change	0	0	0	0	0	0	0	0	0	0	0	0
Alt 3 % change	-1	-2	0	2	1	0	-1	4	0	-1	-2	-1

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Sacramento River Flow near Wilkins Slough in Critically Dry Water Years

During Critically Dry Water Years without climate change, Sacramento River flow near Wilkins Slough is typically highest from December to March, with lower flows for the rest of the year, as presented in the NAA line of Tables 28-13a, 28-13b, and 28-13c. Alternatives 1, 2, and 3 would result in small reductions in flow varying between 0% and -3%. The reductions in November through April may be related to diversions to Sites Reservoir. The Project would not be diverting June 15 through August 31, and reductions in those months reflect that most of the alternatives do not vary from the NAA. Alternatives 1B and 3 show -1% relative to the NAA in August. The clear signal associated with exchanges between the Project and Shasta Lake that is visible in Tables 28-11a–c is no longer visible at Wilkins Slough. That signal is obscured by the inputs from tributary streams that enter the Sacramento River between Bend Bridge and Wilkins Slough as well as diversions on the Sacramento River, including the Project diversions at Red Bluff and Hamilton City.

Under the 2035 climate change scenario, the seasonal trend in flows is similar to flows under the without climate change (compare NAA lines in Tables 28-13b and 28-13a) with peak flows in December through March and lower flows through spring, summer, and fall. Alternatives 1, 2, and 3 all affect flow similarly, with reductions in flow between 0% and -2%, with the exception of Alternatives 1B and 3, which result in a 4% increase in flow in May.

The 2070 climate scenario is presented in Table 28-13c. The monthly flows under the NAA are similar to flows in the without climate change and 2035 climate change scenarios. Alternatives 1, 2, and 3 all appear to have similar effects in terms of small reductions in flow of between 0% and -3%, and, as in the 2035 scenario, Alternatives 1B and 3 result in a slight increase in May of 6% and 5%, respectively. That equates to an increase of 450 cubic feet per second (cfs) and 375 cfs, respectively. The benefit of these increases is uncertain but likely to be small.

Table 28-13. Sacramento River Flow near Wilkins Slough: Alternatives Compared with NAA (a) without Future Climate Change in 2035, (b) with Climate Change in 2035, and (c) with Climate Change in 2070— Critically Dry Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	7,880	9,114	12,874	21,396	22,104	19,957	16,386	10,690	6,777	7,060	6,134	10,255
Alt 1A % change	-1	-2	-1	-1	-1	-1	-2	-2	0	0	0	0
Alt 1B % change	0	-3	-1	-2	0	-2	-2	0	0	0	-1	-2
Alt 2 % change	-1	-2	-1	-1	-1	-1	-2	-2	0	0	0	0
Alt 3 % change	0	-3	-1	-2	-1	-1	-3	0	0	0	-1	-2

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	6,741	8,575	13,657	22,054	22,382	20,017	15,734	8,119	6,075	7,778	5,148	8,402
Alt 1A % change	0	-1	-2	-2	-1	-1	-2	-1	1	0	0	0
Alt 1B % change	0	-2	-2	-2	-1	-2	-2	4	-1	-1	0	-1
Alt 2 % change	0	-1	-2	-1	-1	-1	-2	-1	1	0	0	0
Alt 3 % change	0	-1	-2	-2	-1	-2	-3	4	-1	-1	-1	-2

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	6,922	7,184	13,776	22,889	23,199	20,456	14,780	7,503	7,993	9,040	6,197	9,573
Alt 1A % change	0	-1	-3	-1	-1	-1	-3	-1	0	0	0	0
Alt 1B % change	0	-2	-3	-1	-1	-1	-3	6	-1	-2	-2	-1
Alt 2 % change	0	-1	-3	-1	-1	-1	-2	-2	0	0	0	0
Alt 3 % change	-1	-2	-3	-1	-1	-2	-4	5	-1	-1	-3	-1

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Sacramento River Flow near Wilkins Slough in Wet Water Years

During Wet Water Years, Sacramento River flow near Wilkins Slough is highest from January to April; throughout all months, the Project results in slight reductions in flow, with the largest reductions in November (Table 28-14a) and comparable reductions in June for Alternative 1B and May and June for Alternative 3.

By 2035 with climate change, during Wet Water Years flow under NAA conditions increases slightly from December to March and decreases across most other months. The Project still reduces flow across most months (Table 28-14b), with the exception of Alternatives 1B and 3, which result in an increase in flow of 4% in the month of May. By 2070 compared to 2035 with climate change, flow under NAA conditions increases from June to September and fluctuates in other months (Table 28-14c compared to Table 28-14b). Alternatives 1, 2, and 3 reduce flow across most months (Table 28-14c), with the exception of Alternatives 1B and 3, which result in an increase in flow of 6% and 5%, respectively.

Table 28-14. Sacramento River Flow near Wilkins Slough: Alternatives Compared with NAA (a) without Future Climate Change in 2035, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Wet Water Years

(a) Without future climate change

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	7,961	9,018	12,477	20,933	21,863	19,607	16,301	10,572	6,786	7,085	6,077	10,096
Alt 1A % change	-2	-4	0	-1	-1	-2	-3	-2	-3	0	-1	0
Alt 1B % change	-2	-4	0	-2	-1	-3	-3	-3	-4	0	-1	0
Alt 2 % change	-2	-4	0	-1	-1	-2	-3	-2	-3	0	-1	0
Alt 3 % change	-2	-4	0	-2	-1	-3	-3	-4	-4	0	-2	0

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	6,741	8,575	13,657	22,054	22,382	20,017	15,734	8,119	6,075	7,778	5,148	8,402
Alt 1A % change	0	-1	-2	-2	-1	-1	-2	-1	1	0	0	0
Alt 1B % change	0	-2	-2	-2	-1	-2	-2	4	-1	-1	0	-1
Alt 2 % change	0	-1	-2	-1	-1	-1	-2	-1	1	0	0	0

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alt 3 % change	0	-1	-2	-2	-1	-2	-3	4	-1	-1	-1	-2

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	6,922	7,184	13,776	22,889	23,199	20,456	14,780	7,503	7,993	9,040	6,197	9,573
Alt 1A % change	0	-1	-3	-1	-1	-1	-3	-1	0	0	0	0
Alt 1B % change	0	-2	-3	-1	-1	-1	-3	6	-1	-2	-2	-1
Alt 2 % change	0	-1	-3	-1	-1	-1	-2	-2	0	0	0	0
Alt 3 % change	-1	-2	-3	-1	-1	-2	-4	5	-1	-1	-3	-1

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Feather River Flow in Critically Dry Water Years

Feather River flow at mouth during Critically Dry Water Years is normally highest from January to July and lowest in October and November (Table 28-15a). Alternatives 1, 2, and 3 would decrease flow from June to July and increase flow from August to November. This is due to exchanges with Sites Reservoir, most likely to improve cold-water supply in the reservoir to reduce river temperatures for fish.

By 2035, under climate change with NAA conditions, flow from January to July increases (Table 28-15b). Alternatives 1, 2, and 3 would still decrease flow from June to July and increase flow from August to November, but the June decreases would be slightly less compared to without climate change.

By 2070, the flows and the changes from Alternatives 1, 2, and 3 are similar to those under 2035 climate change conditions (Table 28-15c).

Table 28-15. Feather River Flow at Mouth: Alternatives Compared with NAA (a) without Future Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	1,418	1,290	1,786	3,145	2,912	2,777	3,018	2,467	3,855	3,396	2,265	1,835
Alt 1A % change	6	7	0	0	0	0	0	0	-12	-3	10	1
Alt 1B % change	3	7	0	0	0	0	0	-1	-12	-3	9	2
Alt 2 % change	4	7	0	0	0	0	0	0	-12	-2	10	1
Alt 3 % change	-3	7	0	0	0	0	0	-1	-10	-1	12	2

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	1,255	1,189	1,717	3,289	3,185	3,046	3,115	2,597	4,217	3,430	2,199	1,807
Alt 1A % change	14	0	0	0	1	0	0	0	-8	-4	8	6

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alt 1B % change	8	0	0	0	1	0	0	0	-8	-3	8	9
Alt 2 % change	9	0	0	0	1	0	0	0	-8	-4	9	7
Alt 3 % change	3	0	0	0	1	1	0	-1	-7	-2	11	6

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	1,420	1,216	1,773	3,271	3,365	3,141	3,173	2,720	4,100	3,186	2,540	1,861
Alt 1A % change	8	11	-2	1	1	0	-2	1	-9	-4	7	0
Alt 1B % change	13	7	-2	2	1	0	-2	1	-9	-3	7	-1
Alt 2 % change	7	6	-2	1	1	0	-2	1	-9	-5	8	0
Alt 3 % change	14	5	-2	1	1	0	-2	3	-7	-2	6	-1

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

American River Flow at H Street Bridge in Critically Dry Water Years

Comparing the NAA lines in Tables 28-16a, 28-16b, and 28-16c shows that flows are higher in January through April and lower in the summer and fall months (with the exception of a spike in flows in August in the without climate change scenario). This comparison also shows the predicted increase in winter flows as a higher proportion of annal precipitation falls as rain (Bedsworth et al. 2018). This is particularly evident when comparing the NAA lines for the without climate change scenario (Table 28-16a) and the 2070 with climate change scenario (Table 28-16c), which show higher flows in December through April and lower flows in May through November than occur under the NAA without climate change scenario (Table 28-16a). The pattern is less evident in comparing the 2035 NAA (Table 28-16b) and without climate change NAA (Table 28-16a), with the exception of March 2035, which shows a decrease from the without climate change scenario, and July and August 2035, which are higher than July and August without climate change.

The Project's effect on flow is also variable among the alternatives and climate change scenarios. Under the without climate change scenario (Table 28-16a), there are increases in flow of between 7% and 13% for all alternatives in October and February compared to the NAA and decreases of between 7% and 17% in May and August for each alternative and in April for Alternatives 2 and 3 compared to the NAA. In the 2035 with climate change scenario, all alternatives appear to create minor differences (less than 5%) from the flows under the NAA. The exception is Alternative 3, which results in an 8% increase in flow in November and a 6% decrease in flow in May and August.

The 2070 with climate change scenario Alternative 1, 2, and 3 effects (Table 28-16c) look more similar to the without climate change scenario (Table 28-16a) than the 2035 with climate change scenario (Table 28-16b). Again, using a threshold of 5% to highlight changes, there are large increases in flow in October ranging from 28% for Alternative 1A to 39% for Alternative 3. There are also increases in May for each alternative and in January for Alternatives 1B (8%) and 3 (9%). There are decreases of between 16% and 17% in April for each of the alternatives and in December for Alternative 1B (8%). These results are puzzling because Reclamation does not intend to conduct exchanges between Folsom Lake and Sites Reservoir, and Reclamation manages flows in the American River for temperatures for fall-run Chinook salmon and Central Valley steelhead spawning and rearing and it would likely avoid large deviations if an adverse effect would result. The variability in these tables likely reflects the results of CALSIM's approach to reservoir balancing to meet Delta water quality standards, among other things.

Table 28-16. American River Flow at H Street: Alternatives Compared with NAA (a) without Future Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	674	596	521	943	1,039	882	1,089	879	835	970	1,130	681
Alt 1A % change	0	9	1	0	10	-2	0	-7	0	4	-14	0
Alt 1B % change	0	10	1	-1	9	1	4	-8	1	1	-13	0
Alt 2 % change	1	11	1	0	10	-5	-10	3	0	1	-13	0
Alt 3 % change	0	13	0	-1	7	-1	-12	2	4	1	-17	0

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	641	611	622	1,201	1,320	741	1,398	948	880	809	772	720
Alt 1A % change	0	-5	-1	0	3	0	-1	1	0	0	0	0
Alt 1B % change	0	0	-1	0	1	1	1	-1	0	1	0	0
Alt 2 % change	0	-5	-1	0	3	0	-3	0	0	0	0	0
Alt 3 % change	4	8	-2	-2	-1	1	-2	-6	0	1	-6	0

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	452	535	722	1,013	1,244	930	1,547	743	809	597	552	585
Alt 1A % change	28	4	-2	2	1	2	-16	16	-5	0	0	0
Alt 1B % change	37	7	-8	8	1	2	-17	11	-5	0	0	0
Alt 2 % change	27	3	-2	2	1	2	-16	16	-4	0	0	0
Alt 3 % change	39	-5	-1	9	0	2	-17	10	-4	0	9	0

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Yolo Bypass Flow in Critically Dry Water Years

There is little flow into Yolo Bypass in Critically Dry Water Years, but it is highest from December to March and reaches a low in October and November under the no climate change scenario (Table 28-17). Alternatives 1, 2, and 3 would slightly decrease flows from December to March, likely as a result of diversions, and increase flows from August to October associated with the fall releases for improving plankton production (i.e., forage for pelagic fishes) in the north Delta. In the without climate change scenario, Alternative 2 has the best performance of the fall pulse into Yolo Bypass for forage production.

The 2035 with climate change scenario (Table 28-17b) shows small differences from the without climate change scenario (Table 28-17a), with the exception that December through February flows in the 2035 NAA are higher than the NAA without climate change. In the 2035 with climate change scenario, the Project effects are greater than in the without climate change scenario—percentage of flow in December through February for all alternatives decreases more than in the without climate change scenario. This is likely related to higher diversions associated with higher flows in the 2035 scenario (compare NAA in Table 28-17b to NAA in Table 28-17a). As in the without climate change scenario, there is an increase August through October associated with the fall releases for plankton production. The alternatives are all similar; however, Alternative 2 has the highest fall release and Alternative 3 the lowest fall release.

The flows for NAA in the 2070 with climate change scenario (Table 28-17c) are similar to the flows for NAA in the 2035 with climate change scenario (Table 28-17b). As in 2035, the alternatives in 2070 result in similar reductions in flow in December through March. Alternatives 1A and 1B seem to perform better than Alternatives 2 and 3 in the release of flow to the bypass in August, September, and October for improving plankton production in the north Delta.

Table 28-17. Yolo Bypass Flow: Alternatives Compared with NAA (a) without Future Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	41	22	385	406	599	351	107	68	64	48	54	78
Alt 1A % change	75	0	0	-2	-4	-4	0	0	0	0	189	70
Alt 1B % change	101	0	-3	-2	-4	-4	0	0	0	0	148	87
Alt 2 % change	75	0	0	-2	-4	-4	0	0	0	0	231	43
Alt 3 % change	75	0	-4	-2	-4	-4	0	0	0	0	60	43

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	41	22	524	424	648	347	107	68	64	48	54	67
Alt 1A % change	5	0	-5	-7	-7	-3	0	0	0	0	0	53
Alt 1B % change	70	0	-4	-7	-7	-3	0	0	0	0	60	55
Alt 2 % change	37	0	-5	-7	-7	-3	0	0	0	0	152	106
Alt 3 % change	70	0	-3	-6	-7	-3	0	0	0	0	10	1

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	41	24	557	498	685	359	107	68	64	48	120	65
Alt 1A % change	65	-8	-4	-9	-6	-3	0	0	0	0	27	95
Alt 1B % change	64	0	-4	-10	-6	-3	0	0	0	0	27	95

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alt 2 % change	36	0	-4	-10	-6	-3	0	0	0	0	54	55
Alt 3 % change	2	0	-2	-10	-6	-3	0	0	0	0	54	96

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Yolo Bypass in Wet Water Years

In Wet Water Years, incidents of Fremont weir overtopping are the primary source of flow in Yolo Bypass in the winter months, as shown by the increase in flows in November through April, with highest flows in January through March and diminishing flow in May through October. In the without climate change scenario (Table 28-18a), there is little distinction among the alternatives. They all result in decreased flows in November through May, likely from diversions to storage at the upstream diversion location. The largest percent decrease in flow is in May, but base flows in May are considerably smaller than in the winter months, so this is actually a relatively small decrease in flow. Each of the alternatives increases flow by comparable amounts in August through October, associated with the fall pulse flow for improving plankton production in the north Delta (volumes are presented instead of percentages). Climate change predictions (Bedsworth et al. 2018) for the Sacramento River Basin indicate wetter winters and dryer springs and summers as the precipitation pattern changes to rain-dominated flows in winter with diminished snowpack and spring runoff. Comparing the NAAs among the three climate scenarios (Tables 28-18a, 28-18b, and 28-18c) shows this trend in peak flows for each of the scenarios, with the highest flows occurring in January, February, and March. Also, there is a trend of increasing flows in January, February, and March among the scenarios, culminating with the highest flows in the 2070 scenario. Within that changing baseline, each of the alternatives has similar effects on flows. There are comparable percent diminishments associated with the diversion season (November through May) and comparable releases in flow to the Yolo Bypass for August, September, and October resulting from the fall release for plankton production in the north Delta.

Table 28-18. Yolo Bypass Flow: Alternatives Compared with NAA (a) without Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Wet Water Years

(a) Without future climate change

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	86	595	5269	28,589	35,823	21,201	6,960	642	169	48	143	80
Alt 1A % change	362	-5	-3	-3	-3	-1	-3	-11	0	0	230	417
Alt 1B % change	325	-8	-4	-3	-3	-1	-3	-11	0	0	230	401
Alt 2 % change	370	-5	-4	-3	-3	0	-3	-11	0	0	230	436
Alt 3 % change	277	-7	-3	-3	-4	-1	-4	-11	0	0	230	386

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	83	551	6,646	36,562	42,483	25,668	7,426	231	111	48	143	80
Alt 1A % change	405	-6	-4	-2	-3	-1	-3	-10	0	0	232	455

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alt 1B % change	406	-8	-3	-2	-3	-1	-3	-10	0	0	232	439
Alt 2 % change	419	-6	-3	-2	-3	0	-3	-10	0	0	232	427
Alt 3 % change	337	-8	-3	-3	-3	-2	-4	-10	0	0	232	401

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	87	318	7,049	47,122	53,407	30,654	7,797	165	121	48	147	79
Alt 1A % change	306	-5	-4	-3	-3	-3	-3	-3	0	0	225	426
Alt 1B % change	321	-5	-5	-2	-3	-3	-3	-2	0	0	225	429
Alt 2 % change	334	-5	-4	-2	-2	-3	-3	-3	0	0	225	427
Alt 3 % change	277	-3	-4	-2	-2	-3	-4	-2	0	0	225	399

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Delta Outflow in Critically Dry Water Years

In Critically Dry Water Years, Delta outflow is normally highest from January through March and lowest in August and September (Table 28-19). Alternatives 1, 2, and 3 would result in slight decreases in outflow from October to March and larger increases in outflow in July to September; this summer increase is due to Sites releases for habitat flows for Yolo Bypass and deliveries to south-of-Delta participants in the Project.

Under the 2035 with climate change scenario (Table 28-19b), the same seasonal trend persists, but flows in December, January, and February are greater than the same months under the without climate change scenario (Table 28-19a). There is little distinction among the alternatives. They all result in small reductions in flow in November through April and small increases in July through October. Alternative 1A has the highest percent increase in outflow, but it differs little from Alternatives 1B and 2. Alternative 3 has the biggest percent decrease in flow in November, but it differs from the other alternatives by only 120 cfs or less.

Under the 2070 with climate change scenario (Table 28-19c) compared to the 2035 with climate change scenario (Table 28-19b), outflow is higher in October, lower in November, and slightly higher in other months. Similar to 2035, in 2070, the alternatives all have comparable but small reductions in outflow. The largest change is in April, when each of the alternatives would reduce outflow by 4% or about 414 cfs. The most notable difference between the 2070 and 2035 scenarios is the change from an increase in outflow to smaller increase in the case of Alternative 1A and to a 1% decrease in Alternatives 1B, 2, and 3.

Table 28-19. Delta Outflow: Alternatives Compared with NAA (a) without Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	4,514	3,749	8,424	10,372	13,481	11,136	9,525	5,686	5,397	4,021	3,536	3,000

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alt 1A % Change	-3	2	-1	-3	0	-3	0	1	0	2	5	6
Alt 1B % change	-3	2	-1	-3	0	-3	0	1	0	3	5	6
Alt 2 % Change	-3	1	-1	-3	0	-3	0	1	0	2	8	7
Alt 3 % change	-3	2	-1	-2	-1	-3	0	1	0	2	3	3

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	3,676	4,056	10,730	11,328	15,093	11,616	9,599	5,861	5,901	4,209	3,525	3,000
Alt 1A % change	10	-4	-3	-2	-2	-1	-1	0	0	2	7	8
Alt 1B % change	8	-3	-3	-2	-1	-1	-1	0	0	3	7	9
Alt 2 % change	9	-3	-3	-2	-1	-1	-1	0	0	2	9	9
Alt 3 % change	6	-6	2	-3	-2	-1	-1	0	0	3	6	5

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	5,737	3,788	11,643	12,673	15,873	12,837	10,358	6,134	6,273	4,291	4,562	3,302
Alt 1A % change	5	-4	-1	3	-3	-1	-4	3	0	4	5	6
Alt 1B % change	-1	-1	-2	0	-3	-1	-4	3	0	4	4	6
Alt 2 % change	-1	0	-1	3	-3	-1	-4	3	0	2	5	5
Alt 3 % change	-1	1	-2	1	-3	-1	-4	3	0	2	3	5

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

28.4.1.3. Sites Reservoir Operations

In this subsection, model results are presented for diversions at RBPP and Hamilton City Pump Station during Wet Water Years when unappropriated water is most likely to be available for diversion to Sites Reservoir and for releases from Sites Reservoir during Critically Dry Water Years when demand for the stored water is likely to be greatest. The NAAs represent future operations or the existing infrastructure; consequently, there are no diversions at the RBPP in December, January, and February and only minor diversions for canal maintenance at the Hamilton City Pump Station in those months. Also, there is no reservoir storage or reservoir releases under the NAAs.

Red Bluff Pumping Plant Diversions in Wet Water Years

Historically, RBPP diversions during Wet Water Years show large contrasts between winter and summer months, with the largest values in June, July, and August and no flow in December, January, and February (Table 28-20a). This pattern reflects the use of these diversions for capture of flows (e.g., settlement contract water) for agricultural use. A comparison of diversions under the NAAs shows a reduction in diversions in April through September that becomes increasingly larger in successive future climate scenarios. The reductions range from 46 TAF in April of the 2035 scenario to 204 TAF in July of the 2070 scenario.

Alternatives 1, 2, and 3 would increase diversions for November through May and result in slight decreases across most other months.

With Alternatives 1, 2, and 3 under climate change, RBPP diversions would increase in December through March compared to Alternatives 1, 2, and 3 without climate change, likely reflecting the shift in peak flows due to more precipitation falling as rain rather than as snow.

Comparing the 2070 with climate change scenario to the 2035 with climate change scenario, RBPP diversions during Wet Water Years would decrease from May to September (Table 28-20c compared to Table 28-20b). With the Project, diversions would increase compared to 2035 from January to April but decrease in August and November.

While Project performance (i.e., TAF diverted) is comparable among each of the alternatives, Alternative 3 tends to provide for the highest total diversions.

Table 28-20. RBPP Diversions: Alternatives Compared with NAA (a) without Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070 —Wet Water Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	153	14	0	0	0	20	193	666	1,105	1,277	1,011	250
Alt 1A change	-15	241	432	863	892	559	303	123	0	-1	-17	7
Alt 1B change	-15	274	418	1,043	867	595	302	123	0	-8	-17	5
Alt 2 change	-15	238	424	854	775	433	303	123	0	-1	-17	7
Alt 3 change	-14	275	377	1,059	1,178	734	349	124	2	-6	-16	5

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	144	14	0	0	0	19	178	606	1,057	1,220	967	249
Alt 1A change	-14	124	663	1,010	945	623	280	62	0	-10	-18	0
Alt 1B change	-14	132	686	1,067	1,101	698	279	64	1	-15	-17	-2
Alt 2 change	-14	123	640	921	905	454	280	62	0	-10	-18	0
Alt 3 change	-14	130	673	1,144	1,201	926	341	64	1	-14	-16	-2

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	137	14	0	0	0	15	132	496	928	1,073	854	191
Alt 1A change	-12	76	760	1,306	1,043	776	314	66	0	15	-27	-7
Alt 1B change	-12	75	781	1,403	1,252	776	344	65	0	-1	-27	-6
Alt 2 change	-12	74	739	1,266	973	755	264	66	0	16	-27	-7
Alt 3 change	-12	57	781	1,407	1,349	942	458	66	2	3	-22	-5

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Hamilton City Diversions in Wet Water Years

Hamilton City diversions are typically highest during summer months and lowest in winter during Wet Water Years (Table 28-21). Alternatives 1, 2, and 3 would result in increased diversions from January through May, with less change for the rest of the year.

By 2035, climate change during Wet Water Years would result in little change to Hamilton City diversions under the NAA (Table 28-21). However, with Alternatives 1, 2, and 3, increases are seen in January and February. With Alternatives 1, 2, and 3 under climate change, diversions would also increase slightly from NAA across most of the year (except for summer when the Sacramento River is fully appropriated to uses senior to the Project), but these increases would be less than what would occur if Alternatives 1, 2, and 3 were implemented without climate change (Table 28-21). The diversions for Alternative 3 increase the most from January to April.

Hamilton City diversions would not change much by 2070 with climate change compared to 2035 (Table 28-21c). However, Alternatives 1, 2, and 3 would result in larger increases from December to April and more substantial decreases in July. Similar to 2035 with climate change, the diversions for Alternative 3 increase the most from January to April.

Table 28-21. Hamilton City Diversions: Alternatives Compared with NAA (a) without Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Wet Water Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	575	696	225	78	64	22	400	2,121	2,247	2,590	2,189	621
Alt 1A change	44	-8	-2	335	406	200	372	111	9	-11	1	34
Alt 1B change	45	12	41	373	440	231	372	104	5	-8	-6	92
Alt 2 change	44	-8	-4	318	305	184	372	109	8	-11	1	34
Alt 3 change	45	12	37	443	600	312	441	101	5	-8	-6	92

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	572	686	226	80	64	22	405	2,107	2,254	2,589	2,161	621
Alt 1A change	14	0	70	407	478	199	357	54	0	-7	-1	-7
Alt 1B change	14	13	70	541	494	254	357	51	0	0	-1	-14
Alt 2 change	14	0	67	407	341	199	357	53	2	-7	0	-5
Alt 3 change	14	13	70	582	667	362	492	50	3	0	-1	-12

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	576	691	218	78	66	20	397	2,095	2,283	2,589	2,194	618
Alt 1A change	11	-1	126	521	562	434	458	45	3	-37	0	-8
Alt 1B change	12	-4	196	617	640	434	485	47	-3	-18	-11	-14

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alt 2 change	12	-1	86	464	531	331	374	45	3	-36	0	-8
Alt 3 change	12	-4	196	657	754	435	519	47	-3	-18	-21	-1

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Sites Reservoir (Total) Storage in Critically Dry Water Years

Without climate change, Sites Reservoir is designed to store between about 130 and 540 TAF of water per year (Table 28-22a). Sites Reservoir storage values differ by month and alternative, with the highest volume of storage expected to occur from January to May under Alternatives 1A and 1B.

By 2035 with climate change (Table 28-22b), Sites Reservoir storage would result in slight fluctuations compared to without climate change (Table 28-22). These are mostly slight increases. Among the alternatives, storage would be highest for Alternative 1A and lowest for Alternative 3. Reclamation investment allows Reclamation to store water in Sites Reservoir, which may be used to facilitate management of the cold-water pool in Shasta Lake for the purpose of improved achievement of temperature goals in the temperature control reach of the Sacramento River below Keswick Dam. This additional water allows Reclamation to deliver water to contractors from Sites Reservoir rather than Shasta Lake, conserving water and the cold-water pool in Shasta Lake for release when it would be useful for temperature control. The deliveries of Reclamation water from Sites Reservoir in Alternative 3 would reduce storage in Sites Reservoir compared to alternatives with less or no investment from Reclamation.

Table 28-22. Sites Reservoir (Total) Storage: Alternatives Compared with NAA (a) without Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A change	213	205	204	515	529	541	508	470	405	336	275	234
Alt 1B change	183	176	175	473	488	499	471	433	366	295	235	198
Alt 2 change	162	154	152	438	453	465	438	403	341	273	215	179
Alt 3 change	139	133	132	385	400	412	384	338	278	208	167	154

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A change	239	235	238	531	549	563	534	500	439	368	306	264
Alt 1B change	201	197	200	496	514	528	500	456	395	323	259	219
Alt 2 change	167	162	164	448	466	481	454	415	355	286	224	188
Alt 3 change	144	141	144	409	427	442	413	366	309	236	185	161

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (TAF)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A change	157	154	165	417	436	449	416	377	311	236	187	167
Alt 1B change	130	125	137	370	391	403	370	330	265	195	157	138
Alt 2 change	121	116	128	339	358	371	339	297	233	178	144	128
Alt 3 change	89	85	96	253	273	286	255	217	168	127	108	94

Note: Alt = alternative; NAA = No Action Alternative; TAF = thousand acre-feet.

Sites Reservoir Releases (Total) in Critically Dry Water Years

The Project would result in exchanges of water between Sites Reservoir and other nearby storage reservoirs (Shasta Lake, Lake Oroville) as well as diversions to and releases from Sites Reservoir (Table 28-23a). Releases would be highest from April to August and smallest from December to February.

By 2035, under climate change during Critically Dry Water Years, the pattern of releases would shift, with higher releases from June to August and smaller releases from November to February (Table 28-23b). Under Alternative 3, releases tend to be lower than for other alternatives (most likely due to decisions that CVP will make regarding its water), and Sites Reservoir water tends to be depleted more quickly, resulting in less water available for Critically Dry Water Years.

By 2070, compared to 2035 under climate change during Critically Dry Water Years, Sites Reservoir releases would be lower from August to October and higher in April and June (Table 28-23c compared to Table 28-23b). Releases are still lower for Alternative 3 compared to other alternatives. Similar to the 2035 analysis, Alternative 3 is lowest likely due to decisions CVP will make regarding its water.

Table 28-23. Sites Reservoir Releases (Total): Alternatives Compared with NAA (a) without Future Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A change	318	129	27	0	1	41	516	550	1,013	1,052	923	647
Alt 1B change	229	117	25	0	1	41	430	566	1,054	1,081	918	573
Alt 2 change	257	133	44	0	0	27	419	521	960	1,042	885	558
Alt 3 change	211	106	26	0	0	27	437	701	942	1,079	619	193

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A change	383	71	21	0	1	41	442	499	935	1,071	947	657

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alt 1B change	278	64	21	0	1	41	438	659	949	1,076	987	621
Alt 2 change	330	74	42	0	0	27	428	564	936	1,057	938	565
Alt 3 change	256	52	22	0	0	26	455	717	893	1,109	790	355

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A change	144	47	2	0	0	28	516	586	1,042	1,150	736	299
Alt 1B change	113	73	2	0	0	28	530	604	1,017	1,081	570	281
Alt 2 change	105	74	2	0	0	28	516	623	1,023	826	506	231
Alt 3 change	65	58	7	0	0	28	496	567	783	609	262	214

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Sites Reservoir Releases to the Sacramento River in Critically Dry Water Years

Without climate change in Critically Dry Water Years, the Project's releases to the Sacramento River would be highest from about April to September and close to or at zero from December to March (Table 28-24a). By 2035, under climate change, these releases would fluctuate slightly, with notable increases in June and August compared to without climate change (Table 28-24b compared to Table 28-24a). Among the alternatives, Alternative 3 would generally result in the smallest releases in both climate change scenarios.

By 2070, compared to 2035 with climate change, releases to the Sacramento River would decrease substantially from August to October and increase slightly from April to May (Table 28-24c compared to Table 28-24b). Alternative 3 would continue to result in the smallest releases.

Table 28-24. Sites Reservoir Release to Sacramento River: Alternatives Compared with NAA (a) without Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A change	228	106	20	0	0	0	337	334	577	539	452	487
Alt 1B change	181	102	20	0	0	0	271	330	577	549	451	445
Alt 2 change	212	109	35	0	0	0	262	332	565	535	357	367
Alt 3 change	167	91	19	0	0	0	256	332	524	530	390	128

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A change	311	54	16	0	0	0	261	295	606	583	500	464

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Alt 1B change	190	47	16	0	0	0	268	431	579	583	501	433
Alt 2 change	263	58	36	0	0	0	267	356	584	583	444	329
Alt 3 change	173	38	16	0	0	0	263	419	522	558	494	273

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	0	0	0	0	0	0	0	0	0	0	0	0
Alt 1A change	89	35	0	0	0	0	370	400	581	583	454	139
Alt 1B change	56	59	0	0	0	0	385	418	568	583	343	137
Alt 2 change	61	60	0	0	0	0	370	442	591	448	258	116
Alt 3 change	36	49	3	0	0	0	341	419	446	397	93	92

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

Total SWP and CVP Exports in Critically Dry Water Years

Total SWP and CVP exports in Critically Dry Water Years are normally high from December to February and at their lowest in April (Table 28-25a). Alternatives 1, 2, and 3 would increase exports (by 15%–30%) from July to October, with smaller increases throughout the rest of the year. This is due to combined effects of diversions to and releases from Sites Reservoir, the limitation on export of Sites Reservoir water in the July through November transfer window, and operational changes for the three reservoirs that would overall increase the water supply to downstream users.

By 2035, there is no consistent trend for what climate change would do to exports under the NAA condition, although overall there would be a small reduction (Table 28-25b). Percent increases in July and August exports from the Project would be slightly higher under climate change, but this is mostly due to changes in the NAA flow.

By 2070, compared to 2035 with climate change, exports would decrease substantially in January, February, and October, with slight fluctuations for other months (Table 28-25c compared to Table 28-25b). Alternatives 1, 2, and 3 would still result in increases in July and August as well as larger increases in October due to changes in NAA flow.

Table 28-25. Total SWP and CVP Exports: Alternatives Compared with NAA (a) without Climate Change, (b) with Climate Change in 2035, and (c) with Climate Change in 2070—Critically Dry Water Years

(a) Without future climate change

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	3,501	4,731	5,720	5,604	6,048	3,742	1,725	2,243	2,138	2,486	3,258	3,740
Alt 1A % change	19	3	2	1	0	1	0	0	0	34	37	19
Alt 1B % change	17	3	2	1	0	7	-1	0	-1	30	36	18
Alt 2 % change	17	3	1	1	0	2	0	0	0	32	33	16
Alt 3 % change	15	2	3	0	0	8	0	0	-3	27	28	9

(b) With climate change in 2035

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	4,134	4,224	4,918	5,609	6,005	3,987	1,668	2,335	2,087	2,033	2,037	3,872
Alt 1A % change	11	6	-1	0	0	-1	4	0	2	41	58	20
Alt 1B % change	7	3	-1	0	-1	-1	4	0	0	41	58	20
Alt 2 % change	9	5	1	0	0	-1	4	0	2	40	55	18
Alt 3 % change	5	4	-7	4	1	0	5	0	-3	38	49	15

(c) With climate change in 2070

–	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
NAA (cfs)	2,267	4,504	4,429	4,742	5,071	3,523	1,793	2,270	2,432	1,816	2,171	3,761
Alt 1A % change	14	6	-4	-9	4	0	3	0	1	60	49	13
Alt 1B % change	21	3	-4	0	4	0	3	0	1	53	43	12
Alt 2 % change	22	2	-4	-9	3	0	3	0	1	45	40	12
Alt 3 % change	20	-1	-1	-4	4	0	3	-1	1	29	25	11

Note: Alt = alternative; cfs = cubic feet per second; NAA = No Action Alternative.

28.5 Potential Project-Related Climate Change Effects

This section qualitatively describes the following Project-related climate change effects based on a literature review and other chapters in the Final EIR/EIS as well as the modeled effects described above:

- How will operations of the Project have an impact on resource areas expected to be affected by climate change?
- How will climate change affect the Project and exacerbate the impacts that the Project would have on these resource areas?
- How could the Project potentially mitigate anticipated impacts due to climate change?

28.5.1. Surface Water Resources and Fluvial Geomorphology

The summary of changes in hydrology described here and in Chapter 5 focuses on Wet and Critically Dry Water Years to concisely capture the type of hydrologic responses that could occur with the Project without climate change. The Project would result in exchanges of water between Sites Reservoir and other nearby storage reservoirs (Shasta Lake, Lake Oroville) due to diversions to and releases from Sites Reservoir. The Project is expected to result in reduced flows in Sacramento River below RBPP for some alternatives due to increases in winter diversions to Sites Reservoir and potential increases in flow during September and October of Critically Dry Water Years due to increased releases from Shasta Lake. Sites Reservoir releases to the Sacramento River would happen most often during dry conditions, while releases to the Yolo Bypass would occur more during Wet Water Years. The alternatives could also increase flow at the downstream end of Sacramento River during July through October of Critically Dry

Water Years. Shasta Lake storage is expected to increase slightly, with more increases in Critically Dry Water Years than Wet Water Years. There could be smaller effects on Lake Oroville. In the Delta, the combined effects of diversions to Sites Reservoir, releases from Sites Reservoir to the Sacramento River and Yolo Bypass, and operational changes for the three reservoirs would result in small reductions in Delta outflow during wetter months and increases in Delta outflow during drier months, particularly during Critically Dry Water Years. Overall, the Project would increase water supply to downstream users, and Delta exports are expected to increase, especially during summers of Critically Dry Water Years without climate change (Table 28-25a).

The Project is not expected to have significant impacts on factors related to fluvial geomorphology (Chapter 7, *Fluvial Geomorphology*) without climate change. These factors include potential changes to drainage patterns that would result in increased erosion and sedimentation; altering of river geomorphic processes and characteristics; and altering of instream woody material, boulders, aquatic habitat, and spawning gravel.

28.5.1.1. Summary of Climate Effect under NAAs

Climate change could affect surface water resources under the NAA scenarios. Increases in precipitation extremes, such as flooding during the wet season and drought during the dry season, are expected to occur more frequently in the future. Expected climate change impacts include slight decreases in storage during Critically Dry Water Years and increases in flow during rainy months during Wet Water Years. Section 28.4.1, *Modeling Results*, describes climate change impacts on surface water resources under the NAA scenarios in more detail.

The indicators for water supply are maintaining dry season yields; providing total water supply benefit; meeting supply demands of CVP and SWP south-of-Delta contractors; and meeting water provision requirements of the Storage Partners. These factors, and the climate change impacts on them, are discussed below.

- **Surface water storage.** The predicted changes in snowfall and timing and intensity of rain events are expected to reduce storage in the reservoirs. This shift in patterns of precipitation, combined with flood control obligations, could result in reduced storage volumes, which would complicate reservoir management and managers' ability to store enough water to meet consumptive uses while providing adequate flow for aquatic resources when they are needed. Increased drought and potentially greater water demand may also put pressure on increasing water supply. These impacts may result in reduced Delta exports and reservoir carryover storage (i.e., the amount of water in reservoirs before the start of the wet season in October). Carryover in Shasta Lake and Lake Oroville is projected to decline by one-third over the century, reducing needed water supplies for Dry Water Years. The state will also face challenges related to drought resilience, such as flexibility and response time, particularly under longer, more frequent, and more intense droughts (Bedsworth et al. 2018).
- **Surface water flows.** Climate change is likely to alter hydrologic patterns. More extreme precipitation would result in increased runoff, which in turn is expected to lead to increased flooding (Swain et al. 2018). Furthermore, as precipitation falls more often as rain rather than snow, streamflow timing will shift from spring to winter in Sacramento

Valley (Houlton and Lund 2018). The warming climate is expected to alter flows in the Sacramento River in several ways. Precipitation patterns are expected to become more extreme; multiyear dry periods are expected to increase in duration, similar to the 2012–2016 dry period; and wet periods are expected to intensify, similar to the 2017 wet year. In addition, the proportion of precipitation that falls as snow is anticipated to diminish, reducing the size of the snowpack and diminishing spring runoff. The consequence of these trends would be a shift in peak inflow into the reservoirs from spring to winter, which may be reflected in flows in the river, depending on reservoir operations. The current storage system is designed to mediate winter flood flows by releasing them in a controlled manner to create room in the reservoirs for the spring snowmelt, which is retained for summer uses, primarily agricultural and municipal uses.

- **Sedimentation, erosion, and fluvial geomorphology.** Climate change could result in increased sediment load due to increased flow and runoff in rainy months during Wet Water Years under the NAA scenarios, especially by 2070 (Table 28-12a to Table 28-12c). A conceptual model of sedimentation in the Delta includes a submodel for river supply, which notes that dams and reservoirs have contributed to decreased sediment supply to the Delta (Schoellhamer et al. 2012:Figure 4). However, a recent analysis examining future climate scenarios predicted significant increases in large flow events and sediment transport over the next century, which may increase turbidity (Stern et al. 2020).

28.5.1.2. Summary of Project Effects under a Changing Climate

Under the 2035 and 2070 climate change scenarios, there will be storm events, which provide divertible sources of water to fill Sites Reservoir. Increased intensity of winter storm events may enhance opportunities to divert water to storage. However, the increased occurrence of multiyear drought periods may mean consecutive years with little diversion and prolonged periods of reservoir operation at low levels. Nevertheless, Alternatives 1, 2, and 3 are viable under the climate change analysis due to the storm events predicted for wetter years.

- **Surface water storage.** As described in Section 28.4, the hydrologic modeling results show that there would be small changes in Sites Reservoir operations due to climate change by both 2035 and 2070. Water would still be available for diversion to storage during high flow conditions, and water could still be released from storage for water supply and habitat purposes during dry conditions. By 2070, compared to 2035, climate change generally results in more extreme changes to Sites Reservoir operations, including larger decreases in storage during winter and spring. The 2035 climate projections suggest that, on average, monthly storage at Shasta Lake during Critically Dry Water Years may decline by about 100 TAF compared to current conditions, and the 2070 projection suggests a decline in monthly storage of nearly 600 TAF (Table 28-6). Exchanges of Shasta water and Project water may help offset the loss of storage from climate change in the near term.
- **Surface water flow.** As described in Section 28.4, climate change is generally expected to reshape the hydrograph by increasing winter runoff and reducing runoff during other times of the year, as exemplified by simulated flows downstream of Shasta Lake at Bend Bridge. By 2070, compared to 2035, climate change generally results in more extreme changes to Sites Reservoir operations, including larger increases in flow during winter

and spring. During Critically Dry Water Years, flows at Bend Bridge are low and fairly stable under the 2035 and 2070 climate change scenarios, with relatively small reductions compared to the scenario without climate change. During Wet Water Years, the shift in peak flows for spring months to winter months is evident (Tables 28-13a to 28-13c). In all Critically Dry Water Years, there are small reductions in flow in the spring months and comparable increases in flow in the fall months. These changes are most likely the result of exchanges that result in decreased releases from Shasta Lake in the spring and increased releases in the fall months for the purpose of temperature management and flow stability. In the wet-year scenarios, each alternative has little effect on flows at Bend Bridge, most likely reflecting minimal exchanges in wet years under each of the climate scenarios.

- **Sedimentation, erosion, and fluvial geomorphology.** The Project is designed to divert unappropriated winter flows, which tend to be heavily laden with sediment. As storms intensify with climate change and flood events increase, transportation of sediment is likely to increase and some of that sediment will be diverted by the Project. Although the diversions will entrain sediments in proportion to their concentration in the water, over time, this will contribute to a reduction in sediment delivered to the Delta. There is concern that the reduction in the Delta sediment budget, attributable to the construction of the rim dams and the myriad of other diversion, has resulted in increased clarity in the Delta, with an adverse effect on the vulnerability of pelagic fishes to predation (Sommer 2020). The Authority will participate in the ongoing investigations of turbidity and its influence on rates of predation and, as appropriate, contribute to its proportional responsibility to mitigate the effect of its diversions on sediment load in the Delta. Although the major factor in the resuspension of fine sediment, which contributes most to turbidity, is wind speed (Bever et al. 2018), under climate change predictions, wind speed in the Delta is expected to decline and may offset efforts to increase turbidity.

The presence of Sites Reservoir is expected to help mitigate or reduce impacts of climate change. Increases in precipitation extremes, such as flooding during the wet season and drought during the dry season, are expected to occur more frequently in the future. Sites Reservoir would retain flood flows from Stone Corral and Funks Creeks, providing a flood benefit in Colusa County, particularly the city of Maxwell, surrounding farmland, and road infrastructure. Those flows plus the diversions from the Sacramento River provide increased water deliveries to Storage Partners during drier conditions. The Project is expected to release the most water during summer months (June to September) under Critically Dry Water Year conditions (Table 28-23a to Table 28-23c). The Project would provide water to downstream users when most needed. The Project under climate change conditions would cause an increase in exports July through November (Table 28-25b and Table 28-25c) with respect to the NAAs of each climate scenario. While the increase in exports provides some resilience to decreases in storage and deliveries, it may not offset them. Habitat flows in Yolo Bypass would result in increased Delta outflows in fall (August to October).

The potential mitigation described above also applies to climate change impacts on fluvial geomorphology.

28.5.2. Surface Water Quality

The Project could have substantial and unavoidable effects associated with methylmercury without climate change. Mitigation Measure WQ-1.1 would reduce those effects; however, there is uncertainty associated with the feasibility of this mitigation measure and therefore effects would remain substantial. The Project is not expected to have substantial adverse effects on water quality for other metals and pesticides with the incorporation of mitigation (Mitigation Measures WQ-2.1 and WQ-2.2). The Project would not have adverse effects on other water quality constituents (e.g., salinity and harmful algal blooms [HABs]).

28.5.2.1. Summary of Climate Effect under NAAs

Climate change could exacerbate existing water quality effects. The indicators for water quality are maintaining storage in Sites Reservoir at a high enough level that releases do not need to come from the surface of the reservoir; meeting water temperature requirements; maintenance of minimum flows; and meeting Delta outflow and water quality standards. These factors, and the climate change impacts on them, are discussed below.

- **Water quality**. With climate change, water storage and flow could be reduced by increased severity of drought and increased evaporation, thus increasing concentrations of pollutants in reservoirs and rivers. Decreases in storage and flow during summer and fall months of Critically Dry Water Years are expected to occur for Shasta Lake storage (Table 28-5), Folsom storage (Table 28-9), and Sacramento River (Table 28-11a and Table 28-11b); however, flow in the Sacramento River could increase slightly during summer and fall under climate change by 2070 (Table 28-14c).

- **Salinity**. In the Delta, sea level rise could result in increased salinity (Bedsworth et al. 2018). Climate change may increase inflow to the Delta during the winter but cause decreases in other parts of the year (Table 28-18 and Table 28-19). The effect on Delta outflow under climate change would depend on changes in exports (Table 28-25a to Table 28-25c).

- **Sedimentation and erosion.** Increases in severe storms associated with climate change could result in more flooding and runoff that wash pollutants into surface waters and results in sedimentation. Under climate change, peak flows in Sacramento River at Bend Bridge may increase compared to peak flows absent climate change (Table 28-12a to Table 28-12c). Increases in wildfires could have similar effects by burning vegetation that stabilizes soil, creating conditions conducive to flash flooding and debris flows, both of which could worsen water quality.

28.5.2.2. Summary of Project Effects under a Changing Climate

Water temperature in Sites Reservoir could increase under climate change due to higher air temperatures and lower flow and storage. Higher water temperature in Sites Reservoir under climate change could also result in increased occurrence of HABs.

- **Water quality**. Sites Reservoir storage levels would not be substantially lower under climate change conditions by 2035 (Table 28-22a and Table 28-22b); therefore, changes in storage would not exacerbate HAB production compared to conditions without climate change. By 2070, climate change could result in lower Sites Reservoir storage levels (Table 28-22). However, for several reasons, impacts from HABs are anticipated to be less than significant with climate change. First, as discussed in Chapter 6, *Surface Water Quality*, effects downstream of Sites Reservoir would be limited by dilution, biodegradation, and, to some degree, photodegradation. Second, release of water from the Project from deeper in the reservoir would be implemented if needed to limit the release of HABs. Third, operation of Sites Reservoir would be managed and monitored on a regular basis to control HABs as specified in Appendix 2D, *Best Management Practices, Management Plans, and Technical Studies*, Section 2D.3.1, *Harmful Algal Blooms*.

- **Salinity**. With climate change, the Project would increase Delta outflow during July through September and cause small changes, with some decreases from October through June (Table 28-19a to Table 28-19c). The Project-related decreases in Delta outflow occur at a time of year when Delta outflow is higher and are therefore less concerning with respect to water quality.

- **Sedimentation and erosion.** Under climate change, peak flows in Sacramento River at Bend Bridge may increase compared to peak flows absent climate change, resulting in higher metal concentrations entering Sites Reservoir (Table 28-12a to Table 28-12c). However, settling of suspended sediments may reduce these concentrations, as expected under the Project without climate change. The Project could act as a barrier to flash flooding or debris flow if a wildfire were to occur upstream of the reservoir.

The Project could mitigate or reduce the climate change effects on water quality. Through storage exchanges and use of CVP Op Flex water, the Project could help maintain storage in Shasta Lake (Table 28-6a to Table 28-6c) or Lake Oroville (Table 28-8a to Table 28-8c), as modeled by CALSIM, over the summer to help preserve cold-water pools. In addition, the Project could augment flow through the Delta in October and contribute to Delta outflow during dry conditions.

28.5.3. Groundwater Resources

The Project is expected to have no adverse effects on groundwater resources without climate change. During operations some seepage would occur resulting in a potential increase in groundwater levels, but this is not anticipated to adversely affect recharge or groundwater quality.

28.5.3.1. Summary of Climate Effect under NAAs

Climate change could have effects on groundwater resources.

- **Groundwater demand.** Drought and high temperatures could increase water demand, causing water users to draw more on groundwater.

- **Groundwater recharge.** During the wet season, intensifying heavy precipitation may increase surface runoff and decrease time for groundwater recharge. If annual precipitation does not also increase, this could result in a reduction of overall annual volumes available for infiltration and recharge.

- **Water quality.** Sea level rise could also result in saltwater intrusion of groundwater resources in the Delta (Houlton and Lund 2018).

28.5.3.2. Summary of Project Effects under a Changing Climate

Climate change is not expected to increase or decrease the effect on groundwater resources from the Project.

The Project would help mitigate the climate change effects on groundwater by regulating flow, allowing more surface water to be available when needed and reducing reliance on groundwater. Flows would generally be released during Dry and Critically Dry Water Years, and flows on Funks and Stone Corral Creeks would be captured by Sites Reservoir in Wet Water Years. This could provide more surface water resources for water users during drought, reduce groundwater withdrawal, and support infiltration for groundwater recharge.

28.5.4. Wildlife and Vegetation Resources

The Project would result in effects on wildlife, vegetation, and wetland resources without climate change. Impacts on vegetation and wetland resources are described in Chapter 9, *Vegetation and Wetland Resources*, and impacts on wildlife and their habitats are described in Chapter 10, *Wildlife Resources*. Affected wildlife species and habitats include aquatic and terrestrial invertebrates, reptiles and amphibians, birds, mammals, and various natural communities. The Project would result in permanent and temporary losses of wildlife habitat, injury or mortality of wildlife from construction and operations, impediments to wildlife movement, and disruption of activities, such as foraging, nesting, breeding, and dispersal without climate change. Once completed, Sites Reservoir would be a permanent barrier to terrestrial wildlife movement. For vegetation and wetland resources, construction of the Project would result in removal of special-status plant species, sensitive natural communities, wetlands, and non-wetland waters, as well as hydrological alteration and increased erosion and sedimentation.

The Project includes mitigation measures that would minimize or avoid some impacts on wildlife, vegetation, and wetland resources (e.g., the Land Management Plan [LMP] and the Recreation Management Plan). Implementing the variety of mitigation measures will reduce the severity of effects. These include conducting special-status wildlife and plant surveys to verify presence and quantify effects, implementing various measures to protect special-status species and sensitive communities during construction, conducting a wildlife connectivity and crossing assessment, restoring temporarily disturbed areas, adjusting the temporal and spatial boundaries of construction as necessary, preserving and restoring wildlife habitat and sensitive communities offsite to compensate for permanent losses, and purchasing mitigation credits from conservation banks. With the implementation of BMPs, the LMP, the Recreation Management Plan, and mitigation measures, the Project would comply with federal, state, and local regulations. With implementation of mitigation measures, the Project would not conflict with local policies and ordinances protecting wildlife. The Project would have substantial adverse effects on riparian, foothill pine, oak savanna, and blue oak woodland after implementation of mitigation due to the time required for replacement of mature trees in these communities without climate change. The Project would also have substantial adverse effects on golden eagle and wildlife movement without climate change.

28.5.4.1. Summary of Climate Effect under NAAs

Climate change impacts in the Sacramento Valley region could exacerbate effects on wildlife, vegetation, and wetland resources.

- **Extreme weather events and wildfire**. Changes in temperature and precipitation patterns and extremes could modify habitats and plant community and wildlife species compositions as some vegetation and wildlife species become unable to survive in the new conditions. Increased wildfire risk may also result in additional acres of vegetation being burned.

- **Water quality.** Increases in extreme precipitation may result in more flooding, exacerbating existing erosion and water quality problems due to pollutants in runoff or increased concentration of contaminants in water.

- **Habitat, sensitive communities, and wildlife movement.** Increases in drought may result in effects on wildlife including lack of drinking water, reduced food supply, increased stress, and increased disease (Cook 2012). These climate impacts may increase the number of wildlife species that need to migrate to other suitable habitats, thus increasing the need to find solutions for wildlife connectivity (Houlton and Lund 2018).

28.5.4.2. Summary of Project Effects under a Changing Climate

Potential climate change impacts on wildlife, vegetation, and wetland resources at and around Sites Reservoir include:

- **Water quality.** As described in Section 28.5.2, *Surface Water Quality*, climate change could exacerbate existing water quality effects in Sites Reservoir as well as other reservoirs. With climate change, water storage and flow could be reduced by increased severity of drought and increased evaporation, thus increasing concentrations of pollutants in Sites Reservoir. Climate change–driven increases in water temperature in Sites Reservoir would be expected to contribute to more frequent or more extensive HABs and cyanotoxins. Increased concentrations of pollutants and more frequent and extensive HABs and cyanotoxins may affect wildlife, vegetation, and wetland resources that utilize Sites Reservoir directly or the surrounding ecosystem or are dependent on species that utilize Sites Reservoir and the surrounding ecosystem.

- **Habitat, sensitive communities, and wildlife movement.** The effects from climate change could compound the permanent and temporary losses of wildlife habitat, injury or mortality of wildlife, impediments to wildlife movement, and disruption of activities, such as foraging, nesting, breeding, and dispersal from the Project. Increased need for migration and wildlife connectivity as a result of climate change could be impeded by Sites Reservoir because it would be a permanent barrier to terrestrial wildlife movement. For vegetation and wetland resources, losses of special-status plant species, sensitive natural communities, wetlands, and non-wetland waters as a result of construction of the Project could compound with climate change impacts on these special-status plant species, sensitive natural communities, wetlands, and non-wetland waters.

The Project may mitigate some of the effects exacerbated by climate change, given anticipated regulation of flows that could help to maintain habitat required by some species, such as western pond turtle. Mitigation measures described in Chapters 9 and 10 would mitigate for some but not all of the impacts on wildlife, vegetation, and wetland resources from the Project with climate change.

28.5.5. Aquatic Biological Resources

The Sacramento River and its tributaries support a variety of endemic and introduced aquatic species of ecological and economic importance to the state of California. Some are listed as threatened or endangered and others contribute to recreation and commercial fisheries (see Chapter 11, *Aquatic Biological Resources*, and Appendix 11A, *Aquatic Species Life Histories*). With the proposed mitigation measures, the Project is expected to have no adverse impacts on aquatic biological resources without climate change.

28.5.5.1. Summary of Climate Effect under NAAs

The indicators of effects on the variables are storage, primarily in Shasta Lake (Table 28-5); flow needs for fish (Feather River: Table 28-15a and Table 28-15b); meeting salmonid temperature requirements; access to floodplain habitat; and pelagic fish food supply in the Delta (Yolo Bypass: Table 28-17a, 28-17b, 28-18a, and 28-18b). These factors, and the climate change impacts on them, are discussed below. The summaries in this subsection are taken largely from the California Fourth Climate Assessment and its supporting documentation (https://climateassessment.ca.gov) as well as the literature referenced in Section 28.2, *Affected Environment*. While changes in flow and its consequent effects on diversions, storage, and releases were modeled, changes in water quality parameters such as temperature, salinity, and turbidity were based on literature cited in this document. Further modeling of those parameters was considered too speculative to be informative.

- **Surface water temperature.** Temperatures for anadromous fish, particularly winter-run Chinook salmon in the upper Sacramento River, are most challenging in the summer and fall when ambient temperatures are high. This is when winter-run Chinook salmon spawn and their eggs incubate in the gravels of the upper Sacramento River. Incubating eggs are the most temperature-sensitive life stage for salmonids. The most effective tool to mitigate high temperatures in the upper Sacramento River is the release of water from the hypolimnion in Shasta Lake (i.e., cold-water pool). Reclamation manages storage in Shasta Lake to maintain the cold-water pool for temperature control in the summer and early fall. The availability of this cold water is particularly important in drier years. The predicted changes in snowfall and timing and intensity of rain events are expected to reduce storage in the reservoirs, with a concomitant reduction in the size of the cold-water pool. These projected changes in Shasta storage under the NAAs for 2035 and 2070 suggest Reclamation will be challenged to meet temperature criteria specified in relevant biological opinions on CVP operations. Fish species in the Delta are also adapted to certain ranges of temperatures. Higher temperatures may result in waters becoming too warm to support life stages of some native species like delta smelt and longfin smelt. Warmer water temperatures tend to favor nonnative and invasive species of fish that can outcompete native species under these conditions (Houlton and Lund 2018). The climate factors likely to affect temperatures in the Delta are atmospheric forcing and inflow (Vroom et al. 2017).

- **Surface water flows.** The warming climate is expected to alter flows in the Sacramento River in several ways. Precipitation patterns are expected to become more extreme; multiyear dry periods are expected to increase in duration, similar to the 2012–2016 dry period; and wet periods are expected to intensify, similar to the 2017 wet year. In addition, the proportion of precipitation that falls as snow is anticipated to diminish, reducing the size of the snowpack and diminishing spring runoff. The consequence of these trends would be a shift in peak inflow into the reservoirs from spring to winter, which may be reflected in flows in the river, depending on reservoir operations. The current storage system is designed to mediate winter flood flows by releasing them in a controlled manner to create room in the reservoirs for the spring snowmelt, which is retained for summer uses, primarily agricultural and municipal uses. This shift in patterns of precipitation, combined with flood control obligations, could result in reduced storage volumes, which would complicate reservoir management and managers' ability to store enough water to meet consumptive uses while providing adequate flow for aquatic resources when they are needed.
- **Water quality and nutrients.** Excessive nutrients and high concentrations of pollutants can be harmful to aquatic life. Increased drought and increased extreme precipitation events can worsen water quality because drought can reduce water levels (thus increasing concentrations of pollutants), and heavy rainfall can cause more surface runoff to wash nutrients and pollutants into surface waters (Houlton and Lund 2018).
- **Salinity.** Fish species in the Delta are adapted to certain ranges of salinity. Sea level rise and increased drought cause salt water to intrude into the Delta (Houlton and Lund 2018). This could limit available habitat for some species of fish that rely on low salinity or freshwater for some or all of their life cycles.
- **Sedimentation and turbidity.** Increased drought and low flows can lead to lower sediments in the water column, increasing light penetration, which facilitates photosynthesis for floating and submerged aquatic vegetation, the majority of which in the Delta is invasive Brazilian waterweed (*Egeria densa*) and water hyacinth (*Eichhornia crassipes*). Invasive warm-water fish species (e.g., largemouth bass [*Micropterus salmonids*]) use aquatic cover to ambush native fish, which are more susceptible to predation in clear water (Zeug et al. 2021). On the other extreme, an overload of sediments can increase the turbidity of water, decreasing the amount of light that can aid in primary productivity to feed fish. High turbidity may also decrease visibility that allows predators to catch prey and allow prey to escape. Increasing extreme precipitation may cause more sedimentation in rivers, increasing turbidity levels (Houlton and Lund 2018). The IEP MAST (2015) conceptual model identifies predation risk as a habitat attribute affecting delta smelt. In general, greater turbidity is thought to lower the risk of predation on delta smelt. Large amounts of sediment enter the Delta from winter and spring storm runoff, with resuspension by tidal and wind action. A conceptual model of sedimentation in the Delta includes a submodel for river supply, which notes that dams and reservoirs have contributed to decreased sediment supply to the Delta (Schoellhamer et al. 2012:Figure 4). However, a recent analysis examining future climate scenarios

predicted significant increases in large flow events and sediment transport over the next century, which may increase turbidity (Stern et al. 2020).

28.5.5.2. Summary of Project Effects under a Changing Climate

Under the 2035 and 2070 climate change scenarios, there will be storm events, which provide divertible sources of water to fill the Sites Reservoir. Increased intensity of winter storm events may enhance opportunities to divert water to storage. However, the increased occurrence of multiyear drought periods may mean consecutive years with little diversion and prolonged periods of reservoir operation at low levels. Nevertheless, Alternatives 1, 2, and 3 are viable under the climate change analysis due to the storm events predicted for wetter years and may still provide a resource to assist with managing for desirable ecosystem functions.

- **Surface water temperature.** The 2035 climate projections suggest that, on average, monthly storage at Shasta Lake during Critically Dry Water Years may decline by about 100 TAF compared to current conditions, and the 2070 projection suggests a decline in monthly storage of nearly 600 TAF (Table 28-6). This will present a challenge for Reclamation to manage temperatures in the upper Sacramento River. Exchanges of Shasta water and Project water may help offset the loss of storage and assist with cold-water pool management in the near term. Only Critically Dry Water Years were analyzed, but there can be temperature challenges in Dry and Below Normal Water Years as well; the use of exchanges will most likely assist in those conditions. The deficit in the 2070 Project, however, is most likely too large for exchanges to be a benefit in cold-water pool management, but the additional storage and exchanges will be available in wetter water year types to assist with temperature management. If not, the exchanges may still be beneficial in managing flow stability in the fall when operations tend to shift from releasing for flood control purposes to storing water or using in generating pulse flows.

- **Surface water flow.** During Critically Dry Water Years, flows at Bend Bridge are low and fairly stable under the 2035 and 2070 climate change scenarios, with relatively small reductions compared to the scenario without climate change. During Wet Water Years, the shift in peak flows for spring months to winter months is evident (Tables 28-13a to 28-13c). In all Critically Dry Water Years, there are small reductions in flow in the spring months and comparable increases in flow in the fall months. These changes are most likely the result of exchanges that result in decreased releases from Shasta Lake in the spring and increased releases in the fall months for the purpose of temperature management and flow stability. In the wet-year scenarios, each alternative has little effect on flows at Bend Bridge, most likely reflecting minimal exchanges in wet years under each of the climate scenarios.

  At Wilkins Slough, the comparison of NAA climate scenarios demonstrates the predicted shift in flow patterns from spring to winter months, with predicted increases in the proportion of annual precipitation that falls as rain. The change is more evident in wet years. In Critically Dry Water Years under each of the climate scenarios, there are small reductions in spring flow and comparable increases in fall flow. This is very likely attributable to operations of Shasta Dam and infrequent diversions to Sites Reservoir because there are very likely few opportunities when the Wilkins Slough flow requirement would be met in Critically Dry Water Years. Under the wet-year scenarios, there are reductions in flow of up to several hundred cubic feet per second, mostly in the winter months, which reflects the availability of water for diversion to Sites Reservoir.

The predicted shifts in flow patterns are not as evident as predicted in the Feather River. This may be due to assumptions in the CALSIM model that control deliveries from the SWP. The shift is evident in the 2070 NAA wet-year scenario, however. In Critically Dry Water Years, the Project in all three climate change scenarios shows a reduction in flow in June and July and a comparable increase in flow in October and November. These changes are most likely due to exchanges between the Project and the SWP for the purpose of optimizing use of Project storage and delivering water to south-of-Delta participants. In wet years, the pattern is more variable, but there are reductions in flow in the late spring/summer months and increases in flow in the fall. The changes in the wet-year scenarios tend to be small. The variability in the wet-year scenarios is most likely a reflection of lower demand in Wet Water Years.

- **Water quality and nutrients**. The Project is expected to have a minimal impact on water quality (see Chapter 6). Releases of Project water into the Yolo Bypass for the purpose of moving primary and secondary production or planktonic species from the bypass into the north Delta water column to enhance forage for pelagic species of fish will be monitored for adverse effects of pollutants and temperature rise. If the measure is determined to have an adverse effect, the program will be modified or eliminated to mitigate the adverse effect.
- **Salinity**. Under climate change predictions, salinity is expected to increase in the Delta as a result of sea level rise (Ackerly et al. 2018). Although the Project would result in small decreases in flows from October to April and result in slight increases from May to September, the effect on salinity is likely to be overwhelmed by the increase in seawater intrusion associated with sea level rise.
- **Sedimentation and turbidity**. The Project is designed to divert unappropriated winter flows, which tend to be heavily laden with sediment. As storms intensify with climate change and flood events increase, transportation of sediment is likely to increase and some of that sediment would be diverted by the Project. Although the diversions would entrain sediments in proportion to their concentration in the water, over time, this would contribute to a reduction in sediment delivered to the Delta. There is concern that the reduction in the Delta sediment budget, attributable to the construction of the rim dams and the myriad of other diversion, has resulted in increased clarity in the Delta, with an adverse effect on the vulnerability of pelagic fishes to predation (Sommer 2020). The Authority will participate in the ongoing investigations of turbidity and its influence on rates of predation and, as appropriate, contribute to its proportional responsibility to mitigate the effect of its diversions on sediment load in the Delta. Although the major factor in the resuspension of fine sediment, which contributes most to turbidity, is wind speed (Bever et al. 2018), under climate change predictions, wind speed in the Delta is expected to decline and may offset efforts to increase turbidity.

28.5.6. Public Health, Environmental Hazards, Environmental Justice, and Socioeconomics

The Project is not expected to have substantial adverse effects on public health and environmental hazards without climate change (Chapter 27, *Public Health and Environmental Hazards*). This includes exposure to hazardous materials, impairment of emergency response plans, substantially exacerbated wildfire risk, and vector-borne diseases. The Project would have some substantial adverse effects on environmental justice without climate change, since the Project could have a disproportionate impact on air quality and visual resources for minority and low-income populations for Alternatives 1 and 3 (Chapter 30, *Environmental Justice and Socioeconomics*). For Alternative 2, these effects would also occur, in addition to disproportionate effects on land use and transportation and traffic for minority and low-income populations. Mitigation Measures AQ-1.1, AQ-1.2, AQ-2.1, and AQ-2.2 would reduce air quality emissions; however, it is anticipated these measures would not reduce emissions below existing thresholds. The Project is not expected to have substantial adverse effects on socioeconomics without climate change (Chapter 30).

28.5.6.1. Summary of Climate Effect under NAAs

Climate change is expected to result in increased environmental hazards, resulting in an impact on public health, and is expected to have disproportionate impacts on minority and low-income populations.

- **Minority and low-income populations**. Climate change may increase the frequency, severity, and geographic extent of wildfires in the future, and extreme precipitation occurring after wildfires may also trigger more landslides. Minority and low-income populations experience disproportionate environmental pollution, which can result from extreme weather events and increased severity of wildfire, affecting their health in the long term as a result, potentially making them more sensitive to climate hazards such as decreased air quality. Minority and low-income populations may also have less adaptive capacity to respond to natural hazards due to socioeconomic and political constraints (Bedsworth et al. 2018). Thus, these populations may lack access to adaptation strategies such as using more air conditioning during heat waves, migrating to other locations in extreme events, or paying health care bills resulting from climate-related injuries (Bedsworth et al. 2018).

- **Public health.** Extreme weather events and wildfire are environmental hazards that pose a risk to public health. Increased heat may also expand the range of mosquitos, potentially increasing the risk of vector-borne diseases (Bedsworth et al. 2018).

28.5.6.2. Summary of Project Effects under a Changing Climate

Climate change is not anticipated to increase or decrease effects on public health, environmental hazards, and socioeconomics from the Project. Climate change is not expected to increase or decrease the effects on visual resources for minority and low-income populations from the Project. For Alternative 2, climate change is not expected to increase or decrease the effects on land use and transportation and traffic for minority and low-income populations from the Project. Climate change is expected to increase the impacts on environmental justice from the Project due to the disproportionate impacts climate change has on minority and low-income populations in general and may thus exacerbate any impacts on these populations from the Project. These effects include:

- **Minority and low-income populations**. Under climate change, some local or state air quality targets may be more difficult for local and state governments to achieve, as climate change will worsen existing air pollution levels (Nolte et al. 2018). The Project would conflict with air quality plans or expose sensitive receptors to criteria pollutants during construction and operations (Chapter 20, *Air Quality*). The Project could have a disproportionate impact on air quality for minority and low-income populations for Alternatives 1, 2, and 3 (Chapter 30). Climate change would also disproportionately affect the health of minority and low-income populations, who experience disproportionate environmental pollution, affecting their health in the long term as a result.

Mitigation measures described in Chapter 20 would mitigate for some but not all of the impacts on environmental justice.

28.5.7. Energy, Air Quality, and Greenhouse Gas Emissions

Without climate change, the Project is not expected to substantially adversely affect energy consumption and energy demand, conflict with renewable energy and energy efficiency plans, or require increased regional capacity (Chapter 17, *Energy*). The Project would consume energy to pump water into the Sites Reservoir and transfer water out. However, it would generate electricity and could provide benefits to the electricity system by generating power through releases of water when demand for electricity is high; the Project is expected to have high releases and thus high power generation during summer months (Table 28-23).

Without climate change, the Project would result in significant and unavoidable impacts on air quality during construction and operation. As described in Chapter 20, Project construction activities would result in the generation of air pollutant emissions throughout the full duration of construction. Construction of the Project would generate emissions of criteria pollutants in exhaust from off-road equipment, helicopters (used only to transport drill rigs to and from remote Project locations), employee vehicles and haul trucks, and concrete and asphalt batch plants. Fugitive dust emissions would occur from paved and unpaved road travel, earthmoving activities (i.e., grading, soil and rock loading/unloading), wind-blown dust from soil stockpiles, onsite crushing and processing of rock, and the use of explosives at the dam features. These emissions would be limited to the construction period and would cease when construction activities are completed. Mitigation Measures AQ-1.1 through AQ-2.2 would reduce the impacts from construction, but impacts would remain significant. Project operations would result in the generation of air pollutant emissions. Operation activities include those associated with maintenance of facilities and use of recreation areas. Impacts would be significant and unavoidable with or without climate change.

Without climate change, the Project is not expected to result in an increase of generation of GHG emissions with Mitigation Measure GHG-1.1 (Chapter 21). The GHG analysis is based upon a net-zero threshold and consistency with California EO B-55-18 (Chapter 21). The net-zero threshold approach is conservative and is in line with current scientific evidence that points to the need to achieve carbon neutrality by midcentury to avoid the most severe climate change impacts. GHG-related impacts would be significant for the Project because construction and operational emissions would generate substantial emissions of GHGs that would constitute a net increase in emissions and thus would not meet the carbon-neutral threshold. The net increase in emissions could also conflict with the state's plans to reduce GHG emissions, resulting in a potentially significant impact with respect to the Project conflicting with plans or policies adopted for the purpose of reducing GHG emissions. Implementation of Mitigation Measure GHG-1.1 would reduce or offset these emissions to net zero through a GHG Reduction Plan. This measure ensures GHG emissions would not result in a significant GHG impact, because there would be no net increase in emissions. Further, with implementation of Mitigation Measure GHG-1.1, conflicts with any plans adopted for the purpose of reducing GHG emissions would not occur because there would be no net increase in emissions.

28.5.7.1. Summary of Climate Effect under NAAs

Climate change could increase impacts related to energy, air quality, and GHG emissions. These effects include:

- **Energy demand, generation, and reliability.** Climate change is expected to have impacts on the energy system. For example, extreme heat could lower power generation efficiency for power plants and transmission lines, flooding could damage energy infrastructure, and increased wildfire risk could result in decreased power reliability as utilities institute public safety power shutoff events (Bedsworth et al. 2018). Extreme heat could result in a need for increased air conditioning use and cooling in facilities associated with the reservoir, which could then result in increased energy demand. Heat and drought associated with climate change could also increase water demand from downstream users, thus increasing the need to increase water releases; however, this could result in incidental benefits due to hydropower generation associated with releases.

- **Air quality.** Climate change may cause air quality impacts. Potential increase in wildfires could increase the concentration of PM_{10} and $PM_{2.5}$ in the air during wildfire events. An increase in drought could potentially increase the spread of Valley Fever spores. Climate change could also increase the concentration of other air pollutants, such as ozone, particulates, and respiratory allergens, which may have impacts on sensitive populations (Houlton and Lund 2018).

- **GHG generation.** Climate change results in generation of GHGs, such as water vapor, carbon dioxide, and methane, creating positive feedback that results in potential additional climate change. Extreme heat could result in a need for increased air conditioning use and cooling in facilities associated with the reservoir, which could then result in increased energy demand and GHG emissions. Increased global temperatures result in additional water vapor due to increased evaporation (U.S. Environmental Protection Agency 2023) and the release of carbon dioxide and methane from melting ice and permafrost (Natali et al. 2021).

28.5.7.2. Summary of Project Effects under a Changing Climate

Climate change is not anticipated to increase or decrease generation of GHGs from the Project with Mitigation Measure GHG-1. Climate change could change the impacts related to energy and air quality from the Project, as described below:

- **Energy demand, generation, and reliability.** Under climate change, the Project is not expected to substantially adversely affect energy consumption or require increased regional capacity (Chapter 17). The Project would also result in increased storage during the summer in each climate scenario for Shasta Lake and Lake Oroville relative to the NAA of the respective climate scenario (Table 28-6 and Table 28-8), benefitting hydropower generation. This provides a general resilience benefit by supporting the grid when energy demand is highest. Project operations that depend on energy are thus vulnerable to climate change threats that affect the electricity system broadly.

- **Air quality.** The Project would not directly contribute to the above-referenced climate-induced air quality impacts. However, under climate change, some local or state air quality targets may be more difficult for local and state governments to achieve, as climate change will worsen existing air pollution levels (Nolte et al. 2018). The Project would conflict with air quality plans or expose sensitive receptors to criteria pollutants during construction and operations (Chapter 20).

Mitigation Measures AQ-1.1, AQ-1.2, AQ-2.1, and AQ-2.2 are proposed for the Project that would reduce emissions; however, it is anticipated these measures would not reduce emissions below existing thresholds.

28.5.8. Geology, Soils, and Minerals

The Project is expected to have substantial adverse impacts on geology and soils without climate change and no impact on minerals without climate change (Chapter 12, *Geology and Soils*; Chapter 13, *Minerals*). The Project would be built according to strict design and engineering standards, and substantial adverse effects from landslides are unlikely to occur (Chapter 7; Chapter 12).

28.5.8.1. Summary of Climate Effect under NAAs

Climate change is not expected to affect seismicity or minerals. Climate change may affect geology and soils, as described below.

- **Extreme weather events and wildfire**. Climate change may indirectly affect soil as a result of drought, flooding, and landslides induced by climate change.

28.5.8.2. Summary of Project Effects under a Changing Climate

Climate change is not expected to increase or decrease the effect on geology, soils, and minerals resources from the Project.

The Project may mitigate some of the climate effects. The Project would provide flooding benefit by capturing runoff and reducing flows during heavy precipitation events, which could reduce erosion and landslide risk.

28.5.9. Land Use, Population, and Housing

The Project is expected to have some impacts on land use, population, and housing without climate change (Chapter 14, *Land Use*; Chapter 25, *Population and Housing*). Alternative 2 would result in physical division of an established community, resulting in a substantial adverse effect with no feasible mitigation (Chapter 14). The Project would not result in unplanned population growth but would displace members of an existing community; this is not expected to be a significant effect, as there is sufficient housing in the larger region for relocation (Chapter 14; Chapter 25).

28.5.9.1. Summary of Climate Effect under NAAs

Climate change could affect land use, population, and housing.

- **Extreme weather events and wildfire**. Increased frequency and severity of extreme heat, wildfire, and flooding events could damage homes and drive migration to other communities less at risk. Expanding designated floodplains and potential increases in insurance related to climate change–induced flooding could result in financial stress, resulting in decisions to relocate (Houlton and Lund 2018).

28.5.9.2. Summary of Project Effects under a Changing Climate

Climate change is not expected to increase or decrease the effect on land use, population, and housing from the Project.

The Project could reduce potential land use–induced effects of climate change. The Project is expected to reduce flooding downstream in the area surrounding the community of Maxwell; this would result in a positive effect under climate change and may lead to a contraction of designated floodplain.

28.5.10. Agriculture and Forestry Resources

The Project would result in conversion of some farmland designations to permanent nonagricultural use, resulting in a substantial adverse effect despite proposed mitigation measures without climate change (Chapter 15, *Agriculture and Forestry Resources*).

28.5.10.1. Summary of Climate Effect under NAAs

Climate change will have effects on agriculture. Climate change may drive the loss of agricultural land because changing heat and precipitation patterns and extremes will likely alter the types of crops that can be grown and change crop productivity (Houlton and Lund 2018). For example, field crops, orchards, grains, grapes, corn, and truck crops are likely to decline 1.9% to 11% in productivity, while cotton, alfalfa, citrus, rice, tomato, and pasture may increase in productivity up to 5%.

28.5.10.2. Summary of Project Effects under a Changing Climate

Climate change is not expected to increase or decrease the effect on agricultural and forestry resources from the Project.

The Project could reduce some of the climate change effects on agricultural productivity. Sites Reservoir would provide a reliable agricultural water supply for use during dry periods, increasing resilience to climate change. The Project would provide releases downstream from Sites Reservoir, with larger releases expected during summer.

28.5.11. Recreation Resources

Popular water-related recreational activities in California fall into two categories: (1) water-dependent activities, such as boating, waterskiing, swimming, and fishing; and (2) water-enhanced activities, such as wildlife viewing, camping, hiking, and hunting. The quality of the water-dependent recreation experience at lakes, reservoirs, and streams depends on water levels, natural conditions, and the level of facility development. The Project is expected to have no substantial adverse effects on existing recreation resources without climate change. Recreational facilities and water-based recreational resources (such as rivers and reservoirs) are not expected to see significant changes under the Project (Chapter 16, *Recreation Resources*).

28.5.11.1. Summary of Climate Effect under NAAs

Climate change effects could result in effects on recreational facilities and water-based recreational resources.

- **Extreme weather events and wildfire**. As described in Section 28.2.3, *Climate Change Effects on California*, the Sacramento Valley is likely to see warmer temperatures, increases in extreme heat, and longer heat waves. Extreme weather is expected to lead to increases in wildfire, smoke, winds, and flooding and decreased vegetation and soil stability. Extreme weather, wildfire, and other associated effects of climate change are expected to limit access and decrease the experience of water-dependent and water-enhanced recreation at existing recreation resources.

- **Water levels**. With climate change and changes to precipitation, storage and the resulting water levels at existing reservoirs could change due to the severity of drought and increased evaporation or due to heavy precipitation and increased severity of flood events, potentially changing long-term recreational potential in these waters.

- **Water quality**. Climate change could exacerbate existing water quality effects. With climate change, water storage and flow could be reduced by increased severity of drought and increased evaporation, thus increasing concentrations of pollutants in reservoirs and rivers. Climate change–driven increases in water temperature would be expected to contribute to more frequent or more extensive HABs and cyanotoxins, which may limit water-dependent recreational opportunities at existing recreation resources.

28.5.11.2. Summary of Project Effects under a Changing Climate

Potential climate change impacts on water-dependent or water-enhanced recreation at Sites Reservoir include:

- **Extreme weather events and wildfire**. As described in Section 28.2.3, the Sacramento Valley is likely to see warmer temperatures, increases in extreme heat, and longer heat waves. The Sacramento Valley will likely see more extreme winter storms and more extreme floods, as well as more extreme droughts. Extreme weather is expected to lead to increases in wildfire, smoke, winds, and flooding and decreased vegetation and soil stability. Extreme weather, wildfire, and other associated effects of climate change are expected to limit access and decrease the experience of water-dependent and water-enhanced recreation at Sites Reservoir.

- **Water levels**. With climate change and changes to precipitation, storage and the resulting water levels at Sites Reservoir could change due to the severity of drought and increased evaporation or due to heavy precipitation and increased severity of flood events, potentially changing long-term recreational potential in these waters. As described in Section 28.4, by 2035 water levels in Sites Reservoir would slightly fluctuate compared to future without climate change. With climate change, by 2070 water levels in Sites Reservoir would decrease compared to future without climate change. These changes in water level as a result of fluctuating and decreasing storage may slightly affect water-dependent activities and water-enhanced activities by decreasing access or changing the recreational experience.
- **Water quality**. As described in Section 28.5.2, climate change could exacerbate existing water quality effects in Sites Reservoir as well as other reservoirs. With climate change, water storage and flow could be reduced by increased severity of drought and increased evaporation, increasing concentrations of pollutants in Sites Reservoir. Climate change–driven increases in water temperature in Sites Reservoir would be expected to contribute to more frequent or more extensive HABs and cyanotoxins, which may limit water-dependent recreational opportunities at Sites Reservoir during the primary recreation season (May 1 through September 20).

However, because other reservoirs such as Lake Oroville and Shasta and Folsom Lakes may also experience similar impacts from climate change, the potential reduction in water-dependent and water-enhanced recreational opportunities at Sites Reservoir would not be expected to increase the use of other similar recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated or require the construction or expansion of recreational facilities.

28.5.12. Navigation, Transportation, and Traffic

Alternatives 1 and 3 would not have substantial adverse effects on navigation, transportation, and traffic without climate change. Alternatives 1 and 3 are not expected to result in increased roadway hazards or affect emergency, school bus, and recreational and commercial navigation without climate change. Without climate change, Alternative 2 would result in a substantial adverse effect that cannot be reduced on school bus routes (Chapter 18, *Navigation, Transportation, and Traffic*).

28.5.12.1. Summary of Climate Effect under NAAs

Climate change effects could result in roadway degradation and traffic disruptions. Increased average and extreme temperatures increase the incidence of rail buckling and pavement warping. Roads, railways, and sidewalks are all vulnerable to flooding and wildfire, which can cause direct damage to infrastructure, block access to areas, and result in increased traffic (Bedsworth et al. 2018).

28.5.12.2. Summary of Project Effects under a Changing Climate

Climate change is not anticipated to increase or decrease effects on navigation, transportation, and traffic from the Project.

28.5.13. Noise and Visual Resources

Implementation of the Project would significantly degrade visual character of the existing Antelope Valley, and there is no feasible mitigation without climate change (Chapter 24, *Visual Resources*). The Project would not have an adverse effect on noise without climate change (Chapter 19, *Noise*).

28.5.13.1. Summary of Climate Effect under NAAs

Climate change is not expected to degrade visual resources. Climate change is also not expected to worsen impacts related to noise.

28.5.13.2. Summary of Project Effects under a Changing Climate

Climate change is not anticipated to increase or decrease significant and unavoidable impacts on visual resources from the Project.

Climate change is not anticipated to increase or decrease effects on noise from the Project.

28.5.14. Cultural Resources, Tribal Cultural Resources, and Indian Trust Assets

Without climate change, the Project would result in significant and unavoidable impacts on cultural resources and tribal cultural resources. As described in Chapter 22, *Cultural Resources*, the Project would result in construction impacts on the potentially significant built resources that are located in the reservoir inundation areas. Mitigation Measures CUL-1.1 through CUL-1.4 would reduce the impacts, but impacts would remain significant on those resources. Operations of the Project would disturb cultural resources due to fluctuating water levels in reservoirs, which can cause erosion and uncover remains in the area (Chapter 22). Impacts would be significant and unavoidable with or without climate change.

As described in Chapter 23, *Tribal Cultural Resources*, the Project would result in disturbance or destruction of tribal cultural resources. The mitigation outlined in Chapter 23 could reduce some, but not all, impacts to a less-than-significant level. Impacts would be significant and unavoidable with or without climate change.

The Project would not have an adverse effect on Indian Trust Assets because there are no Indian Trust Assets within or adjacent to the potential areas of construction disturbance for the Project.

28.5.14.1. Summary of Climate Effect under NAAs

Various climate change hazards, including extreme heat, wildfire, and flooding, could result in damage or increased degradation to cultural and archaeological resources. Climate change is also altering historic temperature, precipitation, flooding, and wildfire patterns, threatening traditional ecological knowledge that developed from knowing the land for centuries (Goode et al. 2018).

28.5.14.2. Summary of Project Effects under a Changing Climate

Climate change is not expected to increase or decrease the significant and unavoidable impacts on cultural resources and tribal cultural resources from the Project.

28.5.15. Public Services and Utilities

The Project would not have a substantial adverse effect on public services and utilities without climate change (Chapter 26, *Public Services and Utilities*).

28.5.15.1. Summary of Climate Effect under NAAs

Climate change could exacerbate the need for reliable water. Increased heat and drought could put more strain on groundwater and surface water resources, preventing these water sources from fully replenishing in the future (Bedsworth et al. 2018). Climate change hazards may also result in a variety of effects on water and wastewater treatment, stormwater drainage, energy, and telecommunications, including direct damage to infrastructure, increase in demand of services, and disrupted operations (Bedsworth et al. 2018).

28.5.15.2. Summary of Project Effects under a Changing Climate

Climate change is not expected to increase or decrease the effects on public services and utilities from the Project.

The Project is anticipated to help decrease flooding and decrease drought risks by controlling and releasing water during times of increased wetness or dryness, thereby mitigating climate stressors on water supply and wastewater treatment.

28.6 References

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