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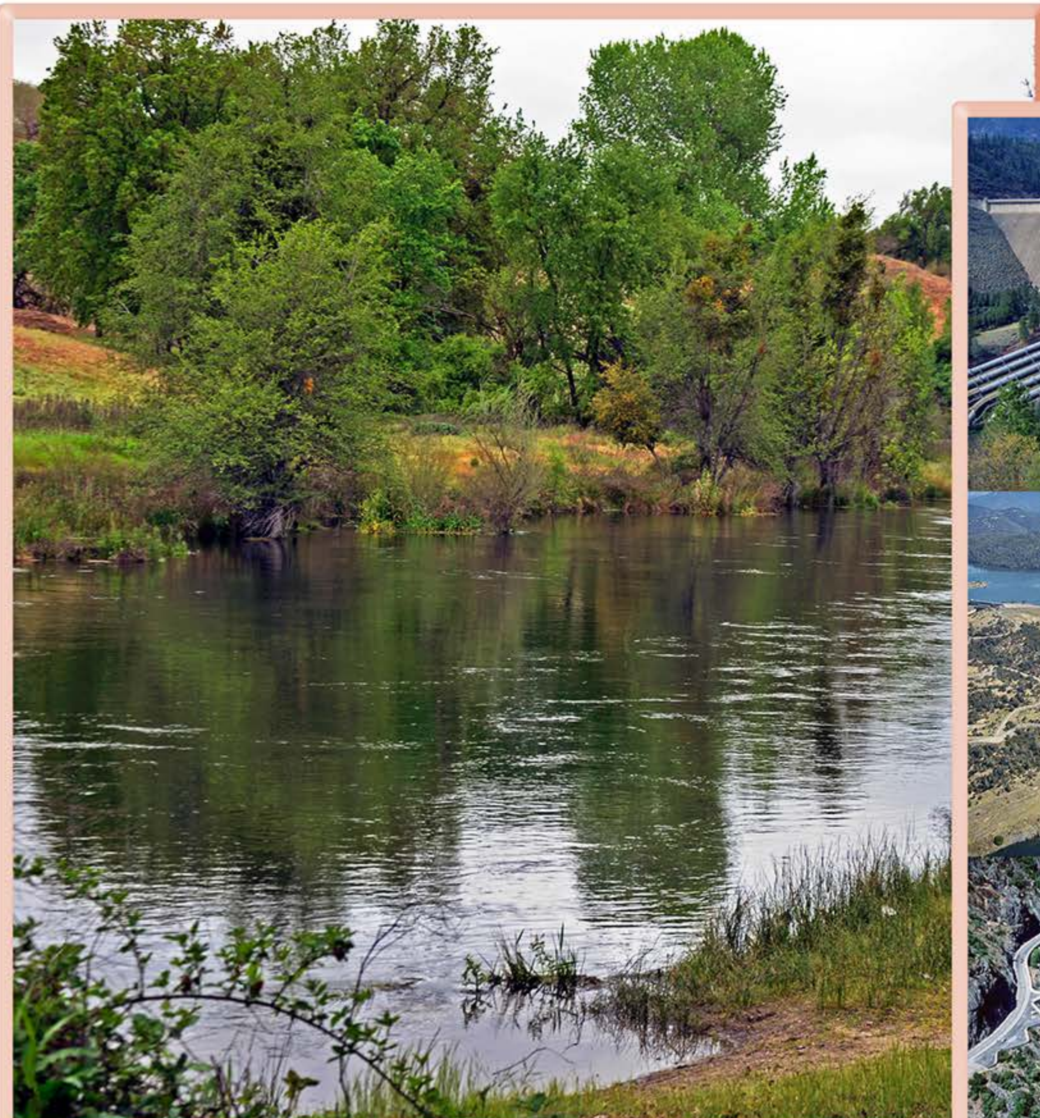
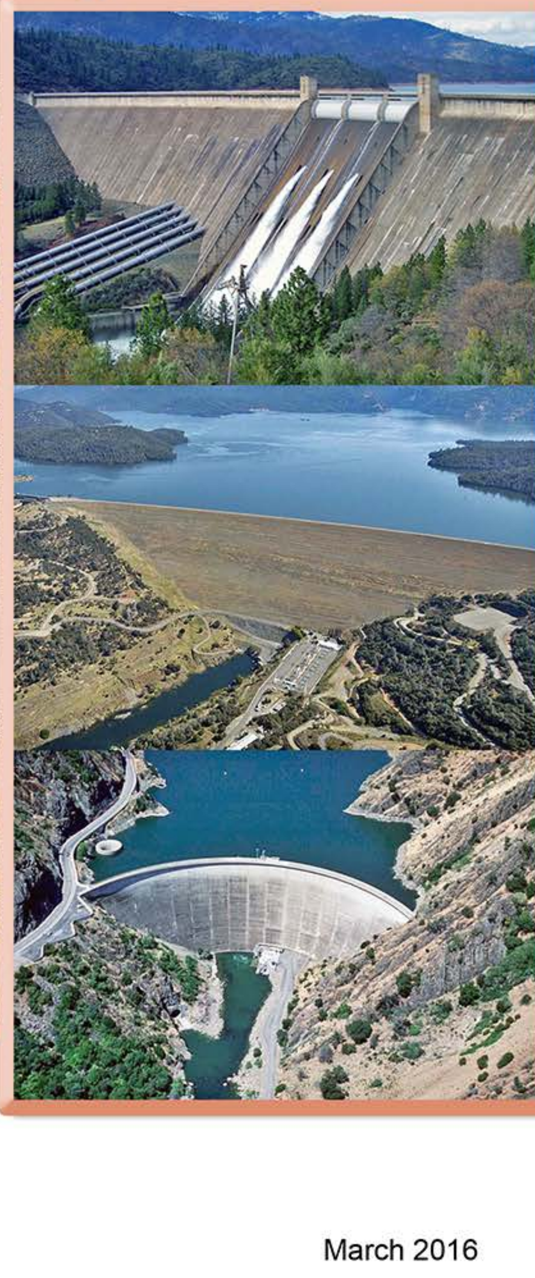
Managing Water in the West

SECURE Water Act Section 9503(c)—Reclamation Climate Change and Water 2016

Chapter 8: Sacramento and San Joaquin River Basins





U.S. Department of the Interior
Bureau of Reclamation

March 2016

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

SECURE Water Act Section 9503(c) Report to Congress

Chapter 8: Sacramento and San Joaquin River Basins

Prepared for

United States Congress

Prepared by

U.S. Department of the Interior
Bureau of Reclamation

U.S. Department of the Interior
Bureau of Reclamation
Policy and Administration
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Acronyms and Abbreviations

°F	degrees Fahrenheit
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
DWR	California Department of Water Resources
GHG	greenhouse gas
MAF	million acre-feet
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	NOAA National Marine Fisheries Service
NRC	National Research Council
Reclamation	Bureau of Reclamation
SWP	State Water Project
TAF	thousand acre-feet
USFWS	U.S. Fish and Wildlife Service
WaterSMART	Sustain and Manage America’s Resources for Tomorrow

About this Chapter

This summary chapter is part of the 2016 SECURE Water Act Report to Congress prepared by the Bureau of Reclamation (Reclamation) in accordance with Section 9503 of the SECURE Water Act. The 2016 SECURE Water Act Report follows and builds on the first SECURE Water Act Report, submitted to Congress in 2011,[1] which characterized the impacts of warmer temperatures, changes to precipitation and snowpack, and changes to the timing and quantity of streamflow runoff across the West.

This chapter provides a basin-specific summary for the Sacramento, San Joaquin and Tulare Lake basins. This chapter is organized as follows:

- **Section 1:** Description of the river basin setting,
- **Section 2**: Overview of the implications for various water and environmental resources,
- **Section 3**: Potential adaptation strategies considered to address basin water supply and demand imbalances, and
- **Section 4**: Coordination activities within the basin to build climate resilience.

Sacramento and San Joaquin River Basins Setting

States: California

Major U.S. Cities: Redding, Sacramento, Stockton, San Jose, Fresno, Bakersfield

River Length: Sacramento 445 miles and San Joaquin 366 miles

River Basin Area: 60,000 square miles

Major River Uses: Municipal (310,000 acre-feet), Agricultural (5.4 million acre-feet), Hydropower (2.1 GW), Recreation, Flood Control, Navigation, and Fish and Wildlife

Notable Reclamation Facilities: Central Valley Project – 20 dams, 11 powerplants, and more than 500 miles of canals

This chapter provides updated information from Reclamation studies completed or initiated in the basin over the past five years. The key studies referenced in this chapter include the Sacramento and San Joaquin Rivers Impact Assessment and Sacramento and San Joaquin River Basins Study. Additional information relevant to the Sacramento and San Joaquin River Basins, including the latest climate and hydrology projections for the basin, is included in Chapter 2: Hydrology and Climate Assessment.

[1] The first SECURE Water Act Report, submitted to Congress in 2011 is available on the Reclamation website: www.usbr.gov/climate/secure/docs/2011secure/2011SECUREreport.pdf.

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1 Basin Setting

The Sacramento and San Joaquin Basins are located in the Central Valley of California. The Central Valley is divided into three hydrographic regions, the Sacramento, San Joaquin, and Tulare Lake Basins. The Sacramento River drains the northern portion of the Central Valley, and the San Joaquin River drains the central and southern portions. Both of these rivers flow into the Delta, which is the largest estuary on the West Coast of the United States. Typically, the Tulare Lake Basin is internally drained. However, in wetter years, flow from the Tulare Lake region reaches the San Joaquin River. This report discusses several other areas as well, because of their importance to Reclamation's water management in California. These areas include a part of the Trinity River watershed, from which water is exported to the Sacramento River, and a portion of the central California coast, where the San Felipe Division of Reclamation's Central Valley Project (CVP) is located. The entire area is shown in Figure 8–1.

The Sacramento River is the largest river in California, with a historical mean annual flow of about 18 million acre-feet (MAF). It drains an area of about 27,000 square miles. The San Joaquin River is the second largest river in California, with a mean annual flow of 6 MAF. The Tulare Lake basin in the southern Central Valley drains about 17,050 square miles and includes the Kings, Kaweah, Tule, and Kern Rivers, which have a combined mean annual runoff of approximately 2 MAF.

The CVP and California's State Water Project (SWP) are the two major water management projects in the Central Valley. Reclamation began construction of the CVP in 1933. Today it consists of 20 dams, 11 hydropower plants, and more than 500 miles of canals that serve many purposes. The CVP provides an average of 3.2 MAF of water per year to senior water rights holders under settlement/stipulation agreements primarily for irrigation purposes, 2.2 MAF for CVP irrigation water contractors, and approximately 310 thousand acre-feet (TAF) for CVP urban water users. The agricultural water deliveries irrigate about 3 million acres of land in the Sacramento, San Joaquin, and Tulare Lake basins. The 1992 Central Valley Project Improvement Act (CVPIA) dedicated about 1.2 MAF of annual supplies for environmental purposes. The State of California built and operates the SWP, which provides up to about 3 MAF/year on average in water supplies from Lake Oroville on the Feather River to municipal and agricultural water users in the Central Valley, as well as in the central and southern coastal areas.

Figure 8–1. Map of the Sacramento and San Joaquin Basins study area.

Rapidly increasing populations, changes in land use, and environmental and other regulatory requirements have put pressures on the CVP that were not envisioned when the project was originally conceived and constructed. In addition, climatic changes that have already occurred in the 20th century are further affecting the ability of the CVP to deliver water and power reliably to its contractors, especially during periods of below-average precipitation. These problems have serious impacts on the people and economy of the Central Valley and California in general.

The Sacramento and San Joaquin Basins Study was performed to address multiple objectives including the assessment of potential impacts from changing climate and socioeconomic conditions on water supplies and demands, as well as effects on water temperature and quality, hydropower and greenhouse gas (GHG) emissions, urban and agricultural economics, and ecological resources in Central Valley basins throughout the 21st century. Employing a scenario-based approach, the partners and Reclamation, along with other stakeholders, worked collaboratively to evaluate risks and uncertainties to Central Valley water and related resources from potential changes in future climate, population, and land use. These vulnerabilities were used as a basis for identifying a variety of potential water management actions responding to these existing and future challenges. Through an objective screening process developed collaboratively with partners, stakeholders, and the public, adaptation strategies were characterized, evaluated, and combined to formulate a variety of robust portfolios addressing identified vulnerabilities posed by future climatic and socioeconomic uncertainties. Through this process, the Basins Study has developed new insights into 21st century vulnerabilities and relevant information useful to future efforts in formulating adaptive responses.

The Basins Study evaluated the effects of projected 21st century climate changes, along with assumptions about potential population increases and land use changes. In total, 18 socioeconomic-climate scenarios, including current socioeconomic conditions combined with historic climate, were employed to characterize future uncertainties. Temperatures and sea levels are projected to increase throughout the century, as described in more detail in subsequent sections. Variation in precipitation, both temporally and spatially, will likely occur, and snowpack will likely decline consistently over time, primarily due to warming. In addition, runoff and river flows will likely continue to exhibit temporal variability and earlier seasonal runoff, with little overall flow changes in the north and slight reductions in the south. In general, impacts to water-related resources include:

- increased river water temperatures and Sacramento-San Joaquin Delta salinity;
- decreased reservoir storage, CVP/SWP water exports and hydropower generation;
- decreased aquatic habitat quality and recreational opportunities; and
- increased opportunities for spring riparian flows and fall flood-control storage.

2 Analysis of Impacts to Water Resources

The analysis of impacts to water and related resources in California's Central Valley were quantified in the Basins Study using CalLite and other performance assessment models. Key findings related to projected changes in temperature, precipitation, snowpack, and runoff are presented below.

- During the 20th century, periods of warming and cooling occurred in the Central Valley, as illustrated in Figure 8–2. Most important is the warming trend that has occurred since the late 1970s. This warming has also been observed in North American and global trends. Overall, basin average annual temperatures have increased by approximately 2 degrees Fahrenheit (°F) since the start of the last century.
- **Temperature** is projected to increase steadily during the century, with changes generally higher farther away from the coast, reflecting a continued ocean cooling influence.

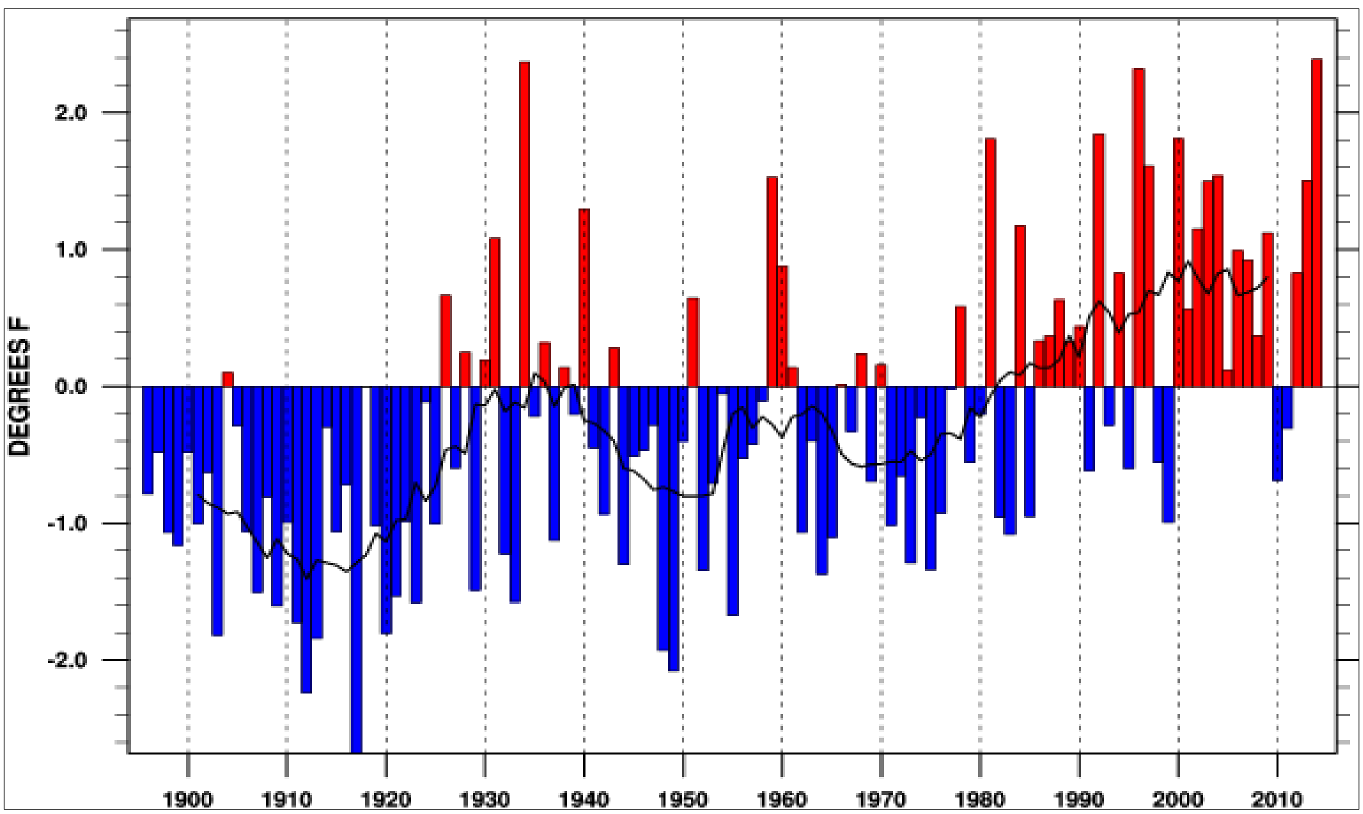

Figure 8–2. California statewide mean annual temperature departures (°F) from 1949–2005 base time period.

Solid line is 10-year moving average of departures. Source: Reclamation 2016 (SSJ Basins Study).

- Projections of future **precipitation** levels are much more uncertain than temperature projections. Trends in annual precipitation also are not as apparent as temperature trends. Regional difference indicate that it is more likely for the upper Sacramento Valley to experience the same or slightly greater precipitation, while the San Joaquin Valley is likely to experience little change. Drier conditions may be experienced in the Tulare Lake Basin.
- Mean annual **streamflow** follows a pattern similar to precipitation and is projected to remain relatively constant to decreasing slightly, especially in the south.
- Each basin is projected to exhibit a **shift in runoff** to more during late fall and winter and less during the spring. This projected shift occurs because higher temperatures during winter cause more precipitation to occur as rainfall, leading to increased runoff, less snowpack water storage, and earlier spring snowmelt runoff with reduced volume. This seasonal shift is greater in basins where the elevations of the historical snowpack areas are lower and therefore are more susceptible to warming-induced changes in precipitation from snow to rain.
- **Sea-level change** is also an important factor in assessing the effect of climate change on California's water resources, specifically on water quality in the Sacramento-San Joaquin Delta. Higher mean sea level (msl) is associated with increasing salinity in the Delta, which influences the suitability of its water for agricultural, urban, and environmental uses. Global and regional sea levels have been increasing steadily over the past century and are expected to continue to increase throughout this century. Over the past several decades, sea level measured at tide gauges along the California coast has risen at rate of about 6.7 to 7.9 inches (17 to 20 centimeters) per century (Cayan, et al., 2009). The National Research Council (NRC) recently completed a comprehensive assessment of sea-level-change projections for the Pacific Coast of North America (NRC, 2012). In the San Francisco Bay and Delta region, mean sea level rise is projected to accelerate during the century, reaching about 1 foot of sea level rise by mid-century and about 3 feet by the end of the century.

The Basins Study also considered a range of water demand projections. Key findings related to projected changes in demand are summarized below.

- Short-term variability and longer-term trends exist in agricultural water demands. The short-term demand variability is highly correlated with the variability in annual precipitation. In years of low precipitation, irrigated crop demands are higher, and in years of high precipitation, these demands decrease. Longer-term agricultural demands were projected to remain relatively constant in the early to mid-21st century and decline in the late-century period, due to multiple factors, including decreases in irrigated lands related to urban area expansion; effects of increasing atmospheric CO_2

concentrations of crop water use efficiency and increasing temperature effects on crop water stress responses.

- In contrast with agricultural demands, the urban demands do not show as large a degree of year-to-year variability because much of the urban demand is for indoor use, which is not sensitive to precipitation variability. Because the urban demands are driven largely by population, they tend to change steadily over time within each of the socioeconomic scenarios with the growth in population and expansion in commercial and industrial activities.
- Reservoir evaporation is an important component of the water budget in the management of water resources in the Central Valley.

Through the WaterSMART program, Reclamation recently completed a study of the potential impacts of climate change on reservoir evaporation (Reclamation, 2015). Results from this study indicate that peak evaporation occurs in August and September, while the minimum evaporation occurs between February and April. The change in annual evaporation and net evaporation from the baseline to the 2080 time period ranges from 7.6 to 14.7 percent (2.5 to 3.5 inches) for Lake Shasta, and 7.7 to 12.3 percent (4.3 to 5.0 inches) for Millerton Lake, respectively. Although other reservoirs were not included in the study, it is likely that these results represent a reasonable range of changes for other Central Valley terminal reservoirs.

The overall 21st century projected impacts were evaluated in the Basins Study assuming that current CVP/SWP operations, infrastructure, and regulatory requirements remain in effect throughout the 21st century without the implementation of any adaptation strategies. The results presented in this section were selected to correspond generally with resource categories identified in Section 9503 of the SECURE Water Act: delivery reliability, water quality, hydropower, flood control, recreational use, and ecological resources. Table 8–1 provides a generalized assessment of the category impacts. The impacts described in the table represent the overall 21st century averaged results for the entire Central Valley and Delta regions. However, considerable temporal and geographic variations exist. These important variations, as well as characteristics of selected performance metrics, are described in more detail in the Sacramento and San Joaquin Basins Study report (Reclamation, 2016 [SSJ Basins Study]).

Table 8–1. Summary of Projected Impacts by SECURE Water Act Resource Category
Source: Reclamation, 2016 (SSJ Basins Study).

SWA Resource Category	Change Metrics	Overall 21st Century Projected Impacts[1]	Contributing Factors
Water Deliveries	Unmet demands	Projected to increase by 2%	Projected earlier seasonal runoff would cause reservoirs to fill earlier, leading to the release of excess runoff and limiting overall storage capability and reducing water supply
	End-of-September reservoir storage	Projected to decrease by 9%	
	CVP/SWP Delta exports	Projected to decrease by 3%	Sea level rise and associated increased salinity would result in more water needed for Delta outflow standards with less water available to deliver to water contractors
Water Quality	Delta salinity	Projected to increase by 20%[2]	Projected sea level rise would contribute to increased salinity in the Delta
	End-of-May storage	Projected to decrease by 9%	Climate warming and reduced reservoir storage would contribute to increased river water temperatures
Fish and Wildlife Habitats	Pelagic species' habitats	Projected to decrease by 33%	Increasing Delta salinity would contribute to declining pelagic habitat quality
	Food web productivity	Projected to decrease by 9%	Reduced Delta flows in summer would contribute to declining food web productivity
ESA Species	Adult salmonid migration	Projected to increase by 7%	Reduced Delta OMR flows in fall would contribute to increasing salmonid migration
	Cold-water pool	Projected to decrease by 19%	Reduced reservoir storage would contribute to reduced cold-water pool
Flow-dependent Ecological Resiliency	Floodplain processes	Projected to decrease by 1%	Reduced reservoir storage and spring runoff due to decreasing snowpack would contribute reduced river flows
Hydropower	Net power generation[3]	Projected to increase by 1%	Projected decreased in CVP reservoir storage would contribute to reduced generation but projected decreased CVP water supply would result in reduced power use for pumping and conveyance
Recreation	Reservoir surface area	Projected to decrease by 17%[4]	Projected lower reservoir levels would impact the surface area available for recreation
Flood Control	Reservoir storage below flood-control pool	Projected to increase by 11%[4]	Increased early season runoff would contribute to releases earlier in the flood control period providing more flood storage.

[1]Unless otherwise noted, all changes represent differences between the projected central tendency climate with projected current trend changes in socioeconomic conditions and the Reference (historical) climate with projected current trend socioeconomics. See Reclamation 2016 for details of socioeconomic-climate scenarios.

[2]Representative change salinity in the western Delta region.

[3]Net generation is the difference between CVP hydropower production and use of CVP hydropower by Delta export pumps and water delivery infrastructure.

[4]Assumes Lake Shasta as representative of Central Valley changes

3 Potential Adaptation Strategies to Address Vulnerabilities

Based on the analysis of impacts, the Basins Study partners and stakeholders developed an array of water management actions targeted at addressing one or more categories of water and related resource risks. A public workshop was conducted to receive input on the types of actions that should be considered. In addition, recognizing the significant previous efforts to develop adaptation strategies, the Basins Study partners reviewed Reclamation's drought-project response list, the California Water Plan Update water management actions, and the California Water Action Plan. Preliminary screening of the large array of potential actions was performed to identify actions that could address impacts to multiple resource categories. The general approach for the development of the adaptation strategies from the Basins Study is summarized below:

- **Solicit input –** In order to examine a broad range of potential actions, the Study team participants, interested stakeholders, and the public were asked to submit actions.
- **Organize actions –** The responses were reviewed and organized into seven broad functional objectives: (1) increase water supply, (2) reduce water demand, (3) improve operational efficiency, (4) improve resource stewardship, (5) improve institutional flexibility, (6) improve data and management, and (7) other.
- **Water management actions** – From these functional groupings, individual water management actions were developed.
- **Characterize actions –** Each action was characterized using a set of both quantitative criteria including potential yield, timing of implementation, annualized cost per acre-foot, energy use, and qualitative criteria such as technical feasibility and implementation risk.
- **Develop portfolios –** No single action is likely to be adequate to meet all of the future demands of the Basin resources. Therefore, combinations of actions (portfolios) were developed to address identified risks to the reliability of Central Valley water management systems. As such, portfolios representing potential strategies to address future supply and demand imbalances were developed from the representative actions and action characterization results. Portfolios were developed by selecting certain action characteristics based on the particular strategy (e.g., remove actions that rated low for implementation risk or technical feasibility.)

Section 3.1 describes the characterized water management actions, the exploratory portfolios, and the performance of these portfolios in addressing the key resource categories mandated in the Secure Water Act Section 9503(c).

3.1 Sacramento and San Joaquin Basins Study Potential Future Actions

The Basins Study considered a wide range of water management actions grouped into six broad categories. Examples of each are listed below:

- **Reduce water demand:** Increase agricultural, municipal and industrial water use efficiency
- **Increase water supply:** Increase regional wastewater reuse, increase ocean desalination, develop local supplies (e.g., rainwater harvesting)
- **Improve operational efficiency:** Conjunctive groundwater management, enhance groundwater recharge, improve salinity and nutrient management, improve river temperature management, increase surface storage
- **Improve resource stewardship:** Improve forest health, particularly in the higher-elevation forested watersheds
- **Improve institutional flexibility:** Improve regulatory flexibility and adaptability to improve water system efficiency
- **Improve data and management:** Improve data management and the use of data to support near-term and long-term decision-making

Within these broad categories, 20 representative actions were evaluated for 11 different criteria related to economic, policy, technical, and environmental characteristics as shown on Figure 8–3. In addition, the actions were also sorted based on the cost, quantity of yield or water provided, and timing (Figure 8–4).

Based on the results of the characterization and development of adaptation actions, various actions were combined into portfolios representing different potential adaptation strategies. The Basins Study developed seven exploratory adaptation portfolios to reflect different strategies for selecting and combining actions to address Central Valley imbalances between water supply and water demand as well as other system vulnerabilities. Each portfolio consists of a unique combination of water management actions included to address potential vulnerabilities existing under future socioeconomic-climate conditions. The following seven portfolios were analyzed to assess the effects of each strategy on resolving vulnerabilities to Basin resources:

- **Least Cost:**[2] Least Cost includes water management actions that either improved system operations at minimal cost per acre-foot of yield or actions that provide additional yield efficiently. These actions include improvements in both urban and agricultural water use efficiency, increased surface and groundwater storage and Delta conveyance.

[2] The Least Cost portfolio represents the least amount of cost per unit of increased supply or reduced demand.

Action Name	Cost	Quantity of Yield	Timing	Technical Feasibility	Permitting	Legal	Policy	Implementation Risk	Long-term Viability Risk	Operational Flexibility	Energy Needs
Agricultural Water Use Efficiency	A	A	B	B	B	B	A	B	C	E	A
M&I Water Use Efficiency	A	A	C	A	A	A	B	B	B	B	A
M&I Water Reuse	B	A	C	B	C	C	B	B	C	D	D
Ocean Desalination	D	B	C	C	C	C	C	B	C	D	D
Precipitation Enhancement	A	C	A	C	B	C	C	B	D	B	C
Rainwater Harvesting	E	D	A	A	A	A	B	A	B	A	A
Conjunctive Management	C	B	C	B	C	C	A	B	C	D	B
Enhance Groundwater Recharge	C	B	C	B	B	B	A	B	B	E	A
Improve Tributary and Delta Environmental Flows	A	E	B	A	C	B	D	B	B	B	C
Improve System Conveyance	E	C	C	B	D	C	C	C	C	D	D
Improve CVP/SWP Operations	A	D	B	A	D	C	C	B	B	B	C
Improve Regional/Local Conveyance	A	D	B	A	B	B	B	A	B	C	C
Increase Sacramento Valley Surface Storage	A	C	C	B	D	C	B	C	B	D	C
Increase San Joaquin Valley Surface Storage	C	D	C	B	D	C	B	C	B	D	C
Increase Export Area Surface Storage	B	C	C	B	D	C	B	C	B	D	C
Increase Upper Watershed Surface Storage	B	D	C	B	D	C	B	C	B	D	B
Improve Forest Health	A	B	C	D	C	C	E	D	D	E	C
Improve Regulatory Flexibility and Adaptability	A	D	B	A	D	D	B	C	B	A	A
Improve River Temperature Management	E	E	B	A	B	C	B	C	D	C	C
Improve Salinity and Nutrient Management	E	E	D	B	C	D	B	D	C	D	B

Figure 8–3. Water management actions and evaluation criteria ratings.

Actions with an A rating (dark green) are most favorable and actions with the E rating (dark red) are least favorable for each of the criteria. Source: Reclamation, 2016 [SSJ Basins Study]).

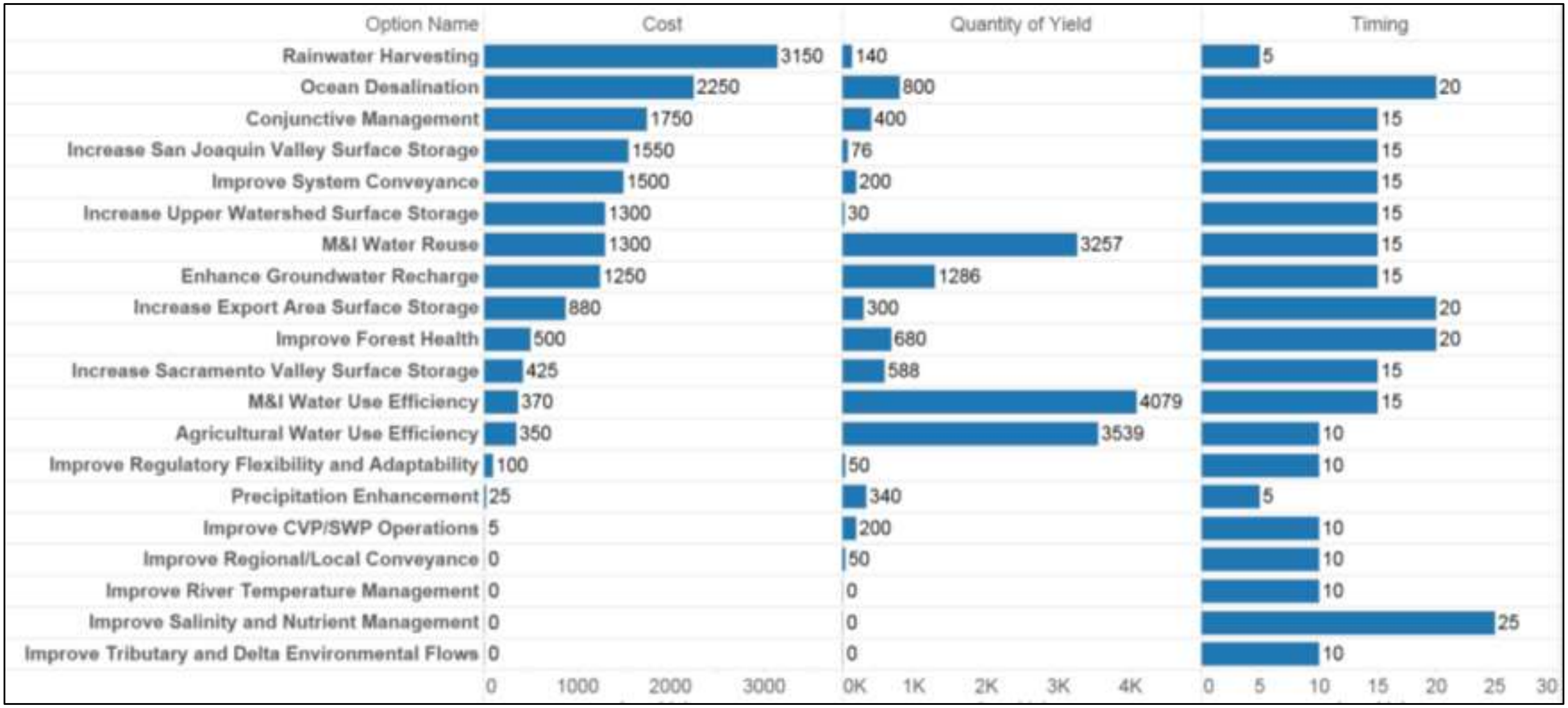

Figure 8–4. Estimated median cost, quantity, and timing for each of the actions.

Costs are in dollars per acre-foot per year ($/AFY) of supply improvement or demand reduction. Quantity of new supply or demand reduction yield is in thousand acre-feet per year (TAFY), and timing for implementation is in years. Source: Reclamation, 2016 [SSJ Basins Study]).

- **Regional Self-Reliance:** Regional Self-Reliance is intended to include regional actions that either reduce demand or increase supply at a regional level without affecting CVP and SWP project operations. These actions include improvements in urban and agricultural water use efficiency, conjunctive use with increased groundwater recharge.
- **Healthy Headwaters and Tributaries:** Healthy Headwaters and Tributaries include adaptation actions that improve environmental and water quality in the Central Valley and upper watershed areas. These actions include additional spring releases that resemble unimpaired runoff and additional Delta outflows in the fall to reduce salinity.
- **Delta Conveyance and Restoration:** Delta Conveyance and Restoration is designed to improve Delta export reliability by developing a new Delta conveyance facility in combination with improved environmental actions in the Delta. These actions include both alternative Delta conveyance combined with water management actions needed for Delta restoration objectives.
- **Expanded Water Storage and Groundwater:** Expanded Water Storage and Groundwater seeks to improve water supply reliability through implementing new surface water storage and groundwater management actions. These actions include increased surface storage in higher elevations of watersheds, expanded reservoir storage in the Sacramento and San Joaquin Basins, and conjunctive use with increased groundwater recharge.
- **Flexible System Operations and Management:** Flexible System Operations and Management includes actions designed to improve system performance without constructing new facilities or expanding the size of existing facilities. These actions include conjunctive use management with increased groundwater recharge.
- **Water Action Plan:** Water Action Plan includes all water management actions that were included in the California Water Action Plan (State of California, 2014). Essentially, this portfolio includes all the water management actions included in the other portfolios.

These seven distinct strategies and dynamic portfolios represent a range of different approaches for resolving future supply and demand imbalances and are not intended to represent all possible groupings. Based on the assessment of the effects of the strategy (see Figure 8–5), key portfolio findings include:

- Central Valley unmet demand was reduced by all portfolios. The Water Action Plan, Least Cost, and Regional Self-Reliance portfolios reduce the unmet demands by more than half but do not fully eliminate the unmet demands in the San Joaquin and Tulare Lake Basins.

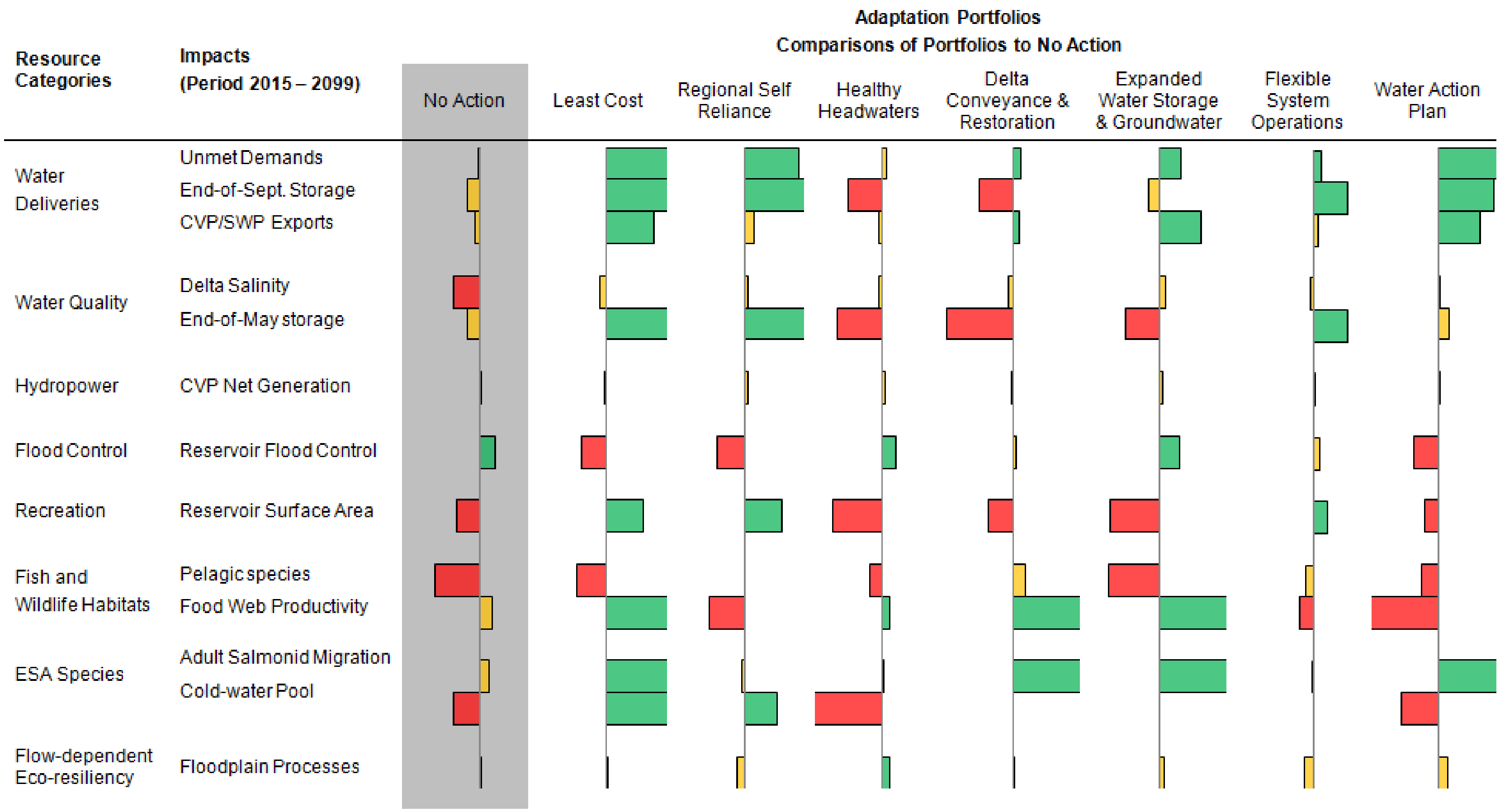

Figure 8–5. Summary comparisons of adaptation portfolios to the No Action Alternative (impacts of climate change without adaptation).

Green = Performance improved more than 10%, Yellow = Performance is within –10% to +10%, Red = Performance declined more than 10%. Source: Reclamation, 2016 [SSJ Basins Study]).

- Delta exports were substantially increased in the Least Cost, Expanded Water Storage, and Water Action Plan portfolios. Healthy Headwaters and Tributaries portfolio results in lower exports as higher spring river flows increased Delta outflow. The Regional Self-Reliance portfolio results in reduced exports by reducing south-of-the-Delta demands.
- Portfolios that include demand reductions through agricultural and M&I water use efficiency actions such as the Least Cost, Regional Self-Reliance, Water Action Plan, and Flexible System Operations increase reservoir storage conditions relative to No Action.
- The Healthy Headwaters and Tributaries, Regional Self-Reliance, and Water Action Plan portfolios show improvements in Delta salinity and habitat conditions, partially attenuating the impacts of future climate and sea level changes.

This Basins Study did not intend to result in the selection of a particular portfolio or any one action from any portfolio. Rather, the objective of the portfolio analysis was to demonstrate the effectiveness of different strategies at resolving future supply and demand imbalances and other system vulnerabilities. Section 3.2 describes completed or ongoing adaptation in the basin.

3.2 Current and Planned Adaptation Actions

The Basins Study explored a wide range of potential adaptation strategies to evaluate opportunities to address future climate and socioeconomic related impacts to water and related resources. As discussed above, current demands for water supplies across these resource categories have already exceeded the capacity of the existing water management system to meet all the potential needs. Consequently, Reclamation, the State of California, and many other stakeholder organizations have been seeking solutions addressing these issues for some time.

The Basins Study added valuable new information to these efforts by considering a longer-term perspective and by including uncertainties in both climate and socioeconomics to provide water managers with a more comprehensive understanding of potential future challenges. The development of the Basins Study adaptation strategies included assessments of many of these activities, programs, and proposals addressing water management concerns throughout the Central Valley and adjacent regions. Some of the current and future planned adaptation strategies similar to those considered in the Basins Study include:

- Reduce Water Demand: Through CalFED Water Conservation Grants and WaterSMART Grants, Reclamation continues to make cost-shared funding available to agricultural and municipal water management agencies in the basin, resulting in improvements in management and water use efficiency.
- Increase Water Supply: Through the CalFED Bay Delta Storage Projects investigations, Reclamation has recently completed planning documents addressing needed improvements in water supply reliability and water

quality (temperature and salinity) by increasing water storage in Sacramento and San Joaquin Basins. These plans are currently being reviewed prior to submission to Congress.

- Improve Operating Efficiency: Through the California Water Fix program (i.e., the Bay Delta Conservation Plan) Reclamation is coordinating with the State of California to develop a comprehensive plan addressing risks to California's current water management system, environment, and economy. Climate change adaptations, including new Delta water conveyance infrastructure, are included to address key vulnerabilities to water supply and the Delta environment from potential changes in climate and rising sea levels. The plan is currently considering public comments.

4 Coordination Activities

The challenges posed to water and related resources by changing climate and socioeconomic conditions throughout the 21st century highlight the need for Federal, state, and local agency partnerships to address the array of complex, interrelated impacts. In the Central Valley, multiagency coordination of water management already supports many important activities. The close coordination between Reclamation and California Department of Water Resources (DWR) in the operation of the CVP and SWP has been ongoing for decades. Management activities also involve other agencies such as U.S. Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife, and the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NOAA Fisheries) in the coordination of reservoir releases for endangered species in rivers and the Delta. Similar coordination between agencies is also occurring in the implementation of the CVPIA and the Trinity and San Joaquin River Restoration Programs.

In addition to the new partnerships formed through the Sacramento and San Joaquin Basins Study and other WaterSMART activities, the Mid-Pacific Region has been collaborating closely with DWR in activities related to the California Water Plan. This coordination has led to the development of both a better understanding of the potential challenges of climate change and improved decision support methods and tools to formulate and evaluate adaptation strategies effectively. Other collaborative adaptation planning activities involving multiple Federal, state, and local partners include the Bay Delta Conservation Plan, CalFED storage project-feasibility investigations, and the California Landscape Conservation Cooperative. By building on this existing collaboration, Reclamation and partners have a strong foundation for addressing future challenges to the management of Central Valley water resources.

4.1 Ongoing Efforts to Enhance System Reliability

A variety of activities to address existing and projected system vulnerabilities to future climate uncertainties in the Central Valley region is currently ongoing or anticipated in the near future. As mentioned above, through CalFED and Reclamation’s WaterSMART program, grants to water districts have been made to increase water use efficiency and water recycling. The projects range from canal lining to water conservation rebates to groundwater recharge. In partnership with the State of California, a WaterSMART Climate Analysis Tools research grant was also made to the University of Arizona to improve the knowledge of basin hydrology through an investigation of ancient tree ring growth and chronology. The results from this paleo-hydrology study were included in the Basins Study (Reclamation, 2016 [SSJ Basins Study]).

Reclamation’s Mid-Pacific Region has also been participating in the California Landscape Conservation Cooperative. In collaboration with the USFWS and other Federal, State, and stakeholder partners, the California Landscape Conservation Cooperative has developed a comprehensive framework identifying knowledge gaps and research priorities and has awarded funds to 15 projects relevant to climate impacts and adaptation planning for species and habitats in the Central Valley and surrounding regions. Since 2011, the funding for these projects has totaled more than $2.6 million.

5 References

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