RECLAMATION

Managing Water in the West

West-Wide Climate Risk Assessment

Sacramento and San Joaquin Basins

Climate Impact Assessment

Executive Summary

U.S. Department of the Interior
Bureau of Reclamation

September 2014

Introduction

Section 9503 of the SECURE Water Act, Subtitle F of Title IX of P.L. 111-11 (2009) (SWA), authorizes the Bureau of Reclamation (Reclamation) to evaluate the risks and impacts of climate change in each of the eight major Reclamation river basins identified in the Act, and to work with stakeholders to identify climate adaptation strategies. Reclamation implements Section 9503 of the SWA through the Basin Study Program, part of the Department of Interior's WaterSMART Program, which is working to achieve a sustainable water strategy to meet the Nation's water needs now and for the future. Through West-Wide Climate Risk Assessments (WWCRAs) conducted under that program, Reclamation is conducting reconnaissance-level assessments of risks to water supplies and related resources in eight major Reclamation river basins in the Western United States.

This report presents the results of the Sacramento and San Joaquin Climate Impact Assessment (SSJIA), which addresses impacts in two of these major basins in California. The SSJIA also includes the Tulare Lake Basin in the southern part of the Central Valley of California; part of the Trinity River watershed from which some water is diverted into the Central Valley; and a portion of California's central coast region where Central Valley Project (CVP) and State Water Project (SWP) water supplies are delivered. The water supplies and demands analyzed in the SSJIA include CVP water users, SWP water users, and the other non-project water users in the study area.

Included in the report is an overview of the current climate and hydrology of California's Central Valley (Sacramento, San Joaquin and Tulare Lake Basins), an analysis of observed trends in temperature and precipitation over historical record, and a comparison of these trends to future water operation projections not considering climate change. The report then presents hydrologic projections developed from global climate models to evaluate the ways that projected climatic and hydrologic changes could impact water availability and management and water demands within the Sacramento, San Joaquin and Tulare Lake basins. The SSJIA analyzes potential impacts of climate change under a current trends projection of future urban growth considering the conversion of agricultural to urban land use and assuming the continuation of current crop types in the Central Valley. Finally, the SSJIA assesses risks to the eight major resource categories identified in the SWA by looking at a range of climate futures and attempting to book-end future uncertainties.

The SSJIA complements and builds on several previous climate change impact studies performed by Reclamation. In 2011, Reclamation completed its first climate change and impact assessment report under the SWA (Reclamation 2011). The 2011 SWA report was based on 112 climate change projections developed for the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment report (IPCC 2007) as part of the World Climate Research Program's Coupled Model Intercomparison Project phase 3 (CMIP3). The primary focus of the 2011 SWA report was on 21st century changes in temperature, precipitation and their impact on "unimpaired" flows in the eight major Reclamation river basins, including the Sacramento and San Joaquin rivers. These flows were simulated to represent what would occur without current infrastructure, reservoir and project operations and regulatory requirements. The report also contained qualitative estimates of impacts on other SWA resource categories.

The Central Valley Project Integrated Resource Plan (CVP IRP), completed by Reclamation in 2013, employed the same climate change projections as the 2011 SWA report, with the addition of sea level rise, and expanded the study area to include the entire CVP Service Area. The CVP IRP also used different methods and models to characterize future climate and socioeconomic uncertainties and their impact on water supply, demand, and some related resources. Most significant was the inclusion of current reservoir and conveyance infrastructure, CVP/SWP operational criteria, and regulatory requirements. The SSJIA leverages the methodologies and tools developed for the CVP IRP – expanding the analysis to include all water users in the Sacramento, San Joaquin, and Tulare Lake basins, and completing a more comprehensive assessment of impacts in all the resource categories identified by the SWA.

Reclamation is also currently working with five non-federal cost-share partners on a Sacramento and San Joaquin Basins Study (SSJBS), a collaborative evaluation of potential climate impacts and formulation of adaptation strategies. The SSJBS, conducted under Reclamation's Basin Study Program as a complement to the SSJIA, is scheduled to be completed in 2015 and is not included in this report. Currently, the SSJBS study partners are updating the climate impact assessments using the new IPCC CMIP phase 5 climate projections and the latest California Water Plan Update 2013 socioeconomic projections.

Study Approach

Reclamation employed a scenario based approach in the SSJIA to evaluate the impacts of potential climate change to water and related resources in the 21st century. The two major uncertainties affecting future impacts included climate and socioeconomic conditions. Future socioeconomic assumptions used in the SSJIA were based on population projections to 2050 as developed by the State of California's Department of Finance (DOF) and assumptions about the effects of urban growth on agricultural lands. The DOF projections were extended from 2050 to 2100 using projections developed by the Public Policy Institute of California. Climate uncertainties were addressed by including multiple 21st century projections using Global Climate Model (GCM) simulations to represent a wide range of potential future climate conditions.

A total of 18 socioeconomic-climate scenarios were developed for the SSJIA. A single socioeconomic projection representing a continuation of "Current Trends" in population and land use changes was employed. In this projection, California's Central Valley population was assumed to increase from the 2005 base levels by 8 million in 2050 and 19 million in 2100. The Current Trends scenario also assumed that as population increased in California's Central Valley, the expansion of urban regions would encroach into surrounding agricultural areas and would result in a projected loss of 500,000 irrigated acres by 2050 and 1.7 million acres by 2100.

The Current Trends socioeconomic projection of water demands was combined with 18 projections of potential future climate (temperature, precipitation and carbon dioxide) changes. These transient projections included one which assumed no climate change and 17 GCM-based projections. Of these projections, five future climates were developed using ensembles of multiple climate projections to characterize the central tendency and four bounding potential climates relative to the central tendency. In addition, six GCMs considered to be especially relevant to California hydrology were included and climate projections were developed based on both high and low greenhouse gas (GHG) emissions scenarios to represent a wide range of potential future climate conditions.

The SSJIA also included one projection of sea level rise. This transient projection was the mean estimate developed by the National Research Council (NRC 2012). This sea level rise projection was simulated to estimate the salinity changes of the Sacramento-San Joaquin Delta (Delta). These simulations assumed that Delta levees would remain intact despite rising sea levels in the 21st century.

The modeling of the impacts of potential climate changes on water and the related resources was accomplished by using the suite of decision support tools developed for the CVP IRP study. These models use the 18 socioeconomic-climate projections as inputs to quantify water supplies and demands. Current reservoir and conveyance infrastructure, CVP/SWP operations and regulatory requirements are assumed to remain in place throughout the 21st century. In addition to climate impacts to water supplies and demands, the modeling tools estimate impacts to river and Delta flows, reservoir storage, CVP/SWP exports, groundwater pumping, water quality (river water temperatures and Delta salinity), CVP/SWP hydropower generation and associated GHG emissions. The relative effects of socioeconomic-climate changes on SWA resource categories can also be observed by comparing the model results with various performance metrics which are presented in greater detail in the body of the SSJIA.

Summary of Results

Climate Changes

The central tendency projected changes in annual average temperature in the Central Valley basins relative to the 1970 – 2000 historical period range from approximately 1 °C in the early 21st century to slightly less than 2 °C by mid-century. In the late 21st century, annual average temperatures are projected to increase in excess of 3 °C. A significant west to east geographic trend exists with greater change in temperatures projected in the interior Central Valley and Sierra regions as the distance from the cooling effect of Pacific Ocean increases.

The projected changes in annual average precipitation in the Central Valley basins show a clear north to south trend of decreasing precipitation, similar to historical conditions. This trend is projected to occur throughout the 21st century. In the northern part of the Sacramento Valley, projections indicate a slight increase of a few percent in precipitation around the mid-century period. A slight decrease in precipitation was projected to occur in both the San Joaquin and Tulare Lake basins.

In these basins, the reductions tend to increase throughout the 21st century from a few percent to nearly 10 percent in the southern parts of the Central Valley.

Sea level, relative to levels in 2000 at the Golden Gate Bridge in San Francisco, could rise by 92 centimeters by the end of the century with a potential range from 42 to 166 centimeters.

Water Supplies and Demands

The potential climate change impacts on water supply and demand were assessed for each major hydrologic region in the study area. In each region, the climate scenarios exhibit a shift to more runoff in the winter and less in the spring months. This projected shift occurs because higher temperatures during winter cause more precipitation to occur as rainfall, which increases runoff and reduces snowpack. The projected annual runoff into major Central Valley reservoirs is similar to the historical period with a north to south geographical trend toward slightly reduced runoff reflecting a similar trend in precipitation.

Under current reservoir operational criteria, the seasonal shift in runoff has a negative impact on the ability to store water for later use. With earlier runoff and more precipitation occurring as rainfall, reservoirs may fill earlier and excess runoff may have to be released downstream to ensure adequate capacity for flood control purposes.

Water demands were impacted by both changes in climate and socioeconomics. The projected increases in population resulted in a steady increase in urban water use during the 21st century. Agricultural demands were also impacted by the assumed decrease in irrigated acreage and the changing climate. Unlike urban demands, agricultural demands have considerable inter-annual variability. In low precipitation years, demand is higher while in high precipitation years, agricultural water demands decrease. During the 21st century, the average annual agricultural demands are projected to decrease because of reduced irrigated acreage and to a lesser extent the effects of increasing carbon dioxide on decreasing water use by some crops despite increased temperatures in the latter half of the 21st century.

System Risk and Reliability

The SWA mandates the analysis of impacts that changes in water supply may have on eight specific resource categories. The summary presented in Table 1 provides a generalized assessment of the SWA Resource category impacts. The overall 21st century projected impacts are evaluated by changes in performance metrics with contributing factors described. The evaluation is based on current CVP/SWP operations, infrastructure and regulatory requirements without the implementation of adaptation strategies.

It is important to recognize that there are limitations to the interpretation of the impacts presented in Table 1. First, the resource impacts represent overall 21st century average conditions. However, there exists considerable variability during this period. Second, other limitations exist because of uncertainties in the socioeconomic-climate scenarios, the use of performance-based change metrics, and in the models employed for the impact evaluations. The column titled "Overall 21st Century Projects Impacts" shows an average of the central tendency range of impacts and is a representation of one of several possibilities examined. Please see Chapter 8 of this report for a more in-depth discussion of the projected impacts for each resource category.

Table 1. Summary of Projected Impacts by SWA Resource Category

SWA Resource Category	Change Metrics	Overall 21st Century Projected Impacts	Contributing Factors
Water Deliveries	Unmet Demands, End of September Storage, CVP/SWP Delta Exports	Unmet demands - Projected to increase by 3% End of September Storage – Projected to decrease by 2% CVP/SWP Delta Exports – Projected to decrease by 3%	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; 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 and End of May storage	Delta Salinity – Projected to increase by 33% End of May Storage – Projected to decrease by 2%	Projected sea level rise would contribute to increased salinity in the Delta; climate warming and reduced reservoir storage would contribute to increased river water temperatures
Fish and Wildlife Habitats	Pelagic Species Habitats, Food Web Productivity	Pelagic Species Habitats – Projected to decrease by 12% Food Web Productivity – Projected to decrease by 8%	Increasing Delta salinity would contribute to declining pelagic habitat quality; reduced Delta flows in summer would contribute to declining food web productivity
ESA Species	Adult Salmonid Migration, Cold Water Pool	Adult Salmonid Migration – Projected to decrease by 1% Cold Water Pool – Projected to decrease by 4%	Projected reduced Delta flows in summer would contribute to declining salmonid migration; reduced reservoir storage would contribute to reduced cold water pool
Flow Dependent Ecological Resiliency	Floodplain Processes	Projected to decrease by 1%	Projected reduced reservoir storage and reduced spring runoff due to decreasing snowpack would contribute reduced river flows
Hydropower	Net Power Generation	CVP Net Generation - Projected to decrease by 2% SWP Net Generation – Projected to increase by 8%	Projected decreased in CVP reservoir storage would contribute to less power generation; projected decreased SWP water supply would result in reduced power use for pumping and conveyance
Recreation	Reservoir Surface Area	Projected to decrease by 17%	Projected lower reservoir levels would impact the surface area available for recreation
Flood Control	Reservoir Storage below Flood Control Pool	Projected to increase by 7%	Projected increases in early season runoff would contribute to releases earlier in the flood control period providing more flood storage.