SECTION 13.0 - CLIMATE CHANGE

The Role of Integrated Regional Water Management Planning in Climate Resilience

The state's IRWM Plan Standards require that IRWM Plans address adapting to the effects of climate change and mitigating the effects of climate change by reducing greenhouse gas emissions. Specifically, IRWM Plans must include a discussion of the potential effects of climate change on the Region, including an evaluation of the Region's vulnerabilities to the effects of climate change, and potential adaptation responses to those vulnerabilities, as well as a process that discloses and considers greenhouse gas emissions when choosing between project alternatives.

Climate change is a complex issue; therefore, guidance provided in the IRWM Plan Standards is meant to help Regional Water Management Groups (RWMGs) integrate climate change considerations into their IRWM planning and project review process. California is already seeing the effects of climate change on hydrology (snowpack, river flows, storm intensity, temperature, winds, and sea levels). Planning for and adapting to these changes, particularly their impacts on public safety, ecosystems, infrastructure, and long-term water supply reliability, will be among the most significant water management challenges of this century. By design, IRWM planning efforts are collaborative and include many entities dealing with water management. These aspects make IRWM a good platform for addressing broad-based concerns like climate change where multiple facets of water management are affected. (Source: 2016 IRWM Grant Program Guidelines – Volume 2 IRWM Plan Standards).

New requirements related to climate change in the IRWM Planning Standards contained in the 2016 IRWM Grant Program Guidelines (Volume 2) include:

Vulnerability Assessment and Prioritization:

- ***At a minimum***, the vulnerability evaluation must be equivalent to the vulnerability assessment contained in the Climate Change Handbook for Regional Water Planning, Section 4 and Appendix B
- Include a list of prioritized vulnerabilities which includes a determination regarding the feasibility for the RWMG to address the priority vulnerabilities
- Describe likely climate change impacts on the region as determined from the vulnerability assessment.

Sea Level Rise:

- Consider the effects of sea level rise (SLR) on water supply conditions and identify suitable adaptation measures.
- Areas of the state that receive water imported from the Sacramento-San Joaquin River Delta, the area within the Delta, and areas served by coastal aquifers must also consider the effects of sea level rise (SLR) on water supply conditions and identify suitable adaptation measures

Adaptation Strategies and Adaptive Management Planning and Coordination:

- Address adapting to changes in the amount, intensity, timing, quality, and variability of runoff and recharge.
- Include potential effects of climate change on the region and consider if adaptations to the water management system are necessary.
- Contain policies and procedures that promote adaptive management and, as more effects of climate change manifest, new tools are developed, and new information becomes available, adjust IRWM Plans accordingly.
- Demonstrate information sharing and collaboration with regional land use planning in order to manage multiple water demands throughout the state, adapt water management systems to climate change, and potentially offset climate change impacts to water supply in California.
- An evaluation of RMS and other adaptation strategies and ability of such strategies to eliminate or minimize those vulnerabilities, especially those impacting water infrastructure systems
- Consider and incorporate water management issues and climate change adaptation and mitigation strategies from local plans into the IRWM Plan

Reducing Energy Use and Greenhouse Gas Emissions (GHG):

- Reducing energy consumption, especially the energy embedded in water use and ultimately reducing GHG emissions.
- In evaluating different ways to meet IRWM plan objectives, where practical, consider the strategies adopted by California Air Resources Board (CARB) in its AB 32 Scoping Plan.
- Consider options for carbon sequestration and using renewable energy where such options are integrally tied to supporting IRWM Plan objectives.

Resource Management Strategies (RMS):

- Identify and implement, using vulnerability assessments and tools such as those provided in the Climate Change Handbook, Resource Management Strategies (RMS) and adaptation strategies that address region-specific climate change impacts.
- Demonstrate how the effects of climate change on the region are factored into the RMS.
- An evaluation of RMS and other adaptation strategies and ability of such strategies to eliminate or minimize those vulnerabilities, especially those impacting water infrastructure systems

Consideration of Climate Change in Project Selection:

- Consider the contribution of selected implementation **projects** to adapting to identified system vulnerabilities to climate change effects on the region.
- Consider the contribution of selected implementation **projects** in reducing GHG emissions as compared to project alternatives.
- At a minimum, that process must determine a project's ability to help the IRWM region reduce GHG emissions as new projects are implemented over a 20-year planning horizon and consider energy efficiency and reduction of GHG emissions when choosing between project alternatives

The California Department of Water Resources (DWR) provides guidance to IRWM Regions in identifying and addressing climate change impacts through *The Climate Change Handbook for Regional Water Planning (2011)* and other climate change resources. The state has also created a web-portal with information regarding recent climate models, links, adaptation and mitigation strategies, and many other related topics: http://www.climatechange.ca.gov/.

The *Climate Change Handbook* outlines a four-step process for completing a climate change adaptation analysis: (1) Assess Vulnerability, (2) Measure Impacts, (3) Develop and Evaluate Strategies, and (4) Implement Under Uncertainty:

Assess Vulnerability: Identify the region-specific water resources (including source areas for imported water) that are potentially vulnerable to climate change in a way that is both significant for the stakeholders involved and measurable in some way. This information was used to help the WCVC conduct the vulnerability analysis above.

Measure Impacts: To the extent appropriate, quantify the climate change impacts to a region's most vulnerable water resources. This step can be highly analytical or qualitative, depending on the estimated level of vulnerability and system, operational complexity, and resources available for the analysis. This information was used to identify impacts to the Region.

Evaluate Strategies: Compare and rank existing and potential resource management strategies (RMS) based on their effectiveness in mitigating and adapting to climate change impacts. New potential projects or programs may be identified during this step of the process. Evaluating strategies for climate change adaptive capacity is an important component of the overall evaluation of individual strategies or projects, as well as integrated project portfolios, in any IRWM planning process. This information helped guide the Region in selecting appropriate RMS for local implementation.

Implement Under Uncertainty: Incorporate regional management strategies into a broader planning context that considers the uncertainties associated with climate change. This can be done in many ways; for example, approaches may be used based on adaptive management, robust decision making, and other decision-support methods. Uncertainty influences every step of a planning process involving climate change, including methods for climate change impact measurement, project selection, implementation, and performance monitoring. This will guide future efforts of the Region in addressing climate change.

13.1 Statewide Projected Impacts of Climate Change

Statewide Assessments of Climate Change Impacts and Vulnerability

Climate change is already impacting California. Climate change, driven primarily by the accumulation of greenhouses gases in the atmosphere resulting from the burning of fossil fuels, will have an increasing impact in future decades. These changes are leading to warmer temperatures, altered patterns of precipitation and runoff, and rising sea levels. Climate change compromises our ability to effectively manage water and energy resources and mitigate flooding and drought impacts. Planning for and adapting to these changes, particularly their impacts on public safety, ecosystems, and long-term water supply reliability, will be among the most significant challenges of this century.

According to Dr. Daniel Cayan, a climatologist at the Scripps Institution of Oceanography, "To prepare for and to reduce these problems requires us to make decisions based on projections of conditions that have never been experienced by humans."

Some basic information about climate change (excerpted from "Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water, California Department of Water Resources, October 2009):

- Historic hydrologic patterns can no longer be solely relied upon to forecast the water future.
- Precipitation and runoff patterns are changing, increasing the uncertainty for water supply and quality, flood management, and ecosystem functions.
- Significant and ongoing investments must be made in monitoring, researching, and understanding the connection between a changing climate, water resources and the environment.
- Extreme climatic events will become more frequent, necessitating improvements in flood protection, drought preparedness an emergency response;
- Water and wastewater managers and customers – businesses, institutions, farms, and individuals – can play a key role in water and energy efficiency, the reduction of greenhouse gas emissions, and the stewardship of water and other natural resources.
- Impacts and vulnerability will vary by region, as will the resources available to respond to climate change, necessitating regional solutions to adaptation rather than the proverbial one-size-fits-all approach.
- An array of adaptive water management strategies must be implemented to better address the risk and uncertainty of changing climate patterns.

California produces periodic scientific assessments on the potential impacts of climate change in California and reports potential adaptation responses. First required by Executive Order #S-03-05,

these assessments influence legislation and inform policy makers. To date, there have been four statewide climate change assessments.

The **First Climate Change Assessment** released in 2006, looked at the potential impacts of climate change on key state resources such as the water supply, public health, agriculture, coastal areas, forestry, and electricity production and demand. The assessment influenced the passage of Assembly Bill 32, the California Global Warming Solutions Act of 2006.

The **Second Climate Change Assessment** released in 2009, attempted to provide initial estimates of the economic impacts of climate change. It concluded that adaptation - as a complementary approach to mitigation - could substantially reduce the economic impacts of loss and damage that result from a changing climate. Findings from the Second Assessment were instrumental in preparing California's 2009 statewide adaptation strategy.

The **Third Climate Change Assessment** released in 2012, was shaped by the request for more information on vulnerability and adaptation options discussed in the 2009 California Adaptation Strategy. It made significant progress in projecting climate change impacts, but also in better understanding the interactions of those potential impacts with on the ground exposure, sensitivity, and response capacity of natural and human systems.

The **Fourth Climate Change Assessment** released in 2018, "advances actionable science that serves the growing needs of state and local-level decision-makers from a variety of sectors. This cutting-edge research initiative is comprised of a wide-ranging body of technical reports, including rigorous, comprehensive climate change scenarios at a scale suitable for illuminating regional vulnerabilities and localized adaptation strategies in California; datasets and tools that improve integration of observed and projected knowledge about climate change into decision making; and recommendations and information to directly inform vulnerability assessments and adaptation strategies for California's energy sector, water resources and management, oceans and coasts, forests, wildfires, agriculture, biodiversity and habitat, and public health. In addition, these technical reports have been distilled into summary reports and a brochure, allowing the public and decision-makers to easily access relevant findings from the Fourth Assessment." Also included in the Fourth Assessment are 12 regional reports which contain assessments to support climate action by providing an overview of climate-related risks and adaptation strategies tailored to specific regions and themes.

Highlights from the Los Angeles Region Report of the Fourth Climate Change Assessment:
The Los Angeles (LA) region contains all of Ventura, LA, and Orange Counties, along with adjacent urbanized portions of San Bernardino and Riverside Counties. Topography in the region includes a large swath of coastal plains along the Pacific Ocean; the Santa Monica, San Gabriel, San Bernardino, Santa Ana, and San Jacinto Mountains; along with the western tip of the Mojave Desert in the Antelope Valley of northern LA County. Home to roughly 18 million people and growing, this region contains approximately half the population of California and has a higher population than 45 other states. Countless ecosystems thrive throughout the region's coasts, mountains, and interior landscapes. The region also has immense economic value to California and the nation, including its entertainment and digital media industries, international trade through the Ports of LA and Long Beach, defense contracting, medicine, and a growing high-tech sector. Therefore, it is imperative to

ensure that the human, economic, and natural systems across the LA region continue to thrive under a changing future climate.

Key projected climate changes include:

- Continued future warming over the LA region. Across the region, average maximum temperatures are projected to increase around 4-5 degrees F by the mid-century and 5-8 degrees F by the late century.
- Extreme temperatures are also expected to increase. The hottest day of the year may be up to 10 degrees F warmer for many locations across the LA region by the late century under RCP8.5. The number of extremely hot days is also expected to increase across the region.
- Despite small changes in average precipitation, dry and wet extremes are both expected to increase. By the late 21st century, the wettest day of the year is expected to increase across most of the LA region, with some locations experiencing 25-30% increases under RCP8.5. Increased frequency and severity of atmospheric river events are also projected to occur for this region.
- Sea levels are projected to continue to rise in the future, but there is a large range based on emissions scenario and uncertainty in feedbacks in the climate system. Roughly 1-2 feet of sea level rise is projected by the mid-century, and the most extreme projections lead to 8-10 feet of sea level rise by the end of the century.
- Projections indicate that wildfire may increase over southern California, but there remains uncertainty in quantifying future changes of burned area over the LA region.

13.2 Local Climate Change Stressors and Vulnerabilities

A. Overview of Current Ventura County Climate

Ventura County has a Mediterranean climate, with wet, mild winters and dry, warm summers. The average July high temperature is 79 degrees, and the average January low temperature is 42 degrees. The average annual rainfall is approximately 18 inches though there is high interannual precipitation variability. Most of the precipitation occurs between the months of November through March with very little precipitation during the rest of the year (Figure 13-1).

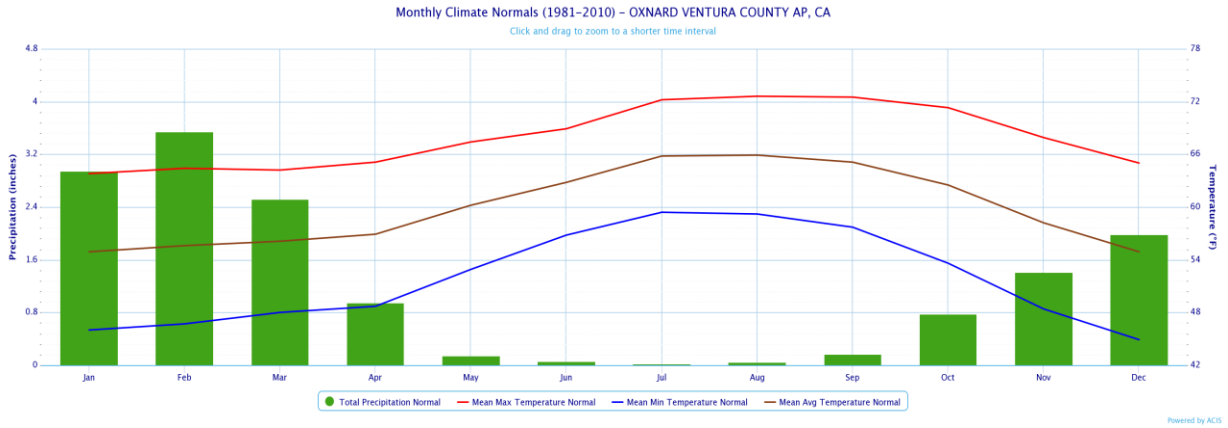


Figure 13-1: Monthly 1981-2010 climate normals for Oxnard-Ventura County Airport. Graph features maximum temperature (red line), average temperature (brown line), minimum temperature (blue line) and precipitation as green bars. Source: Applied Climate Information System (http://scacis.rcc-acis.org/)

Ventura County also has six diverse microclimates as shown below:

- Highlands and mountains of the Western Transverse Mountain Range in the northern portion of the County.
- Coastal Plains primarily located on the Oxnard Plain Coastal Strip.
- Interior valleys such as the Ojai Valley.
- Interior valleys with coastal influence such as the Santa Clara River Valley.
- Interior valleys without coastal influence, such as the Conejo and Simi Valleys.

B. Process for Assessing and Addressing Climate Change Impacts to the WCVC IRWM Region

The WCVC Regional Water Management Group (RWMG) has been considering the impacts of climate change to local water resource management as part of IRWM Plan development since 2006. Local, state and federal agencies working in the Region have been conducting or funding studies, that have, or will, benefit the Region's ability to be climate resilient. Highlights of these efforts are listed below: Highlights of Studies, Programs, and Planning Efforts in the Region Related to Climate Change:

- The USGS Coastal Storm Modeling System (CoSMoS).
- UCLA research on climate change impacts in Southern California.
- The Nature Conservancy's Coastal Resilience Ventura Project mapping inundation areas and considering economic impacts.
- The Central Coast Climate Collaborative (4C) – including 6 Central Coast counties collaborating on development of climate resilience policies and programs.
- Naval Base Ventura County partnership with the Nature Conservancy to minimize the impacts of sea level rise through land acquisition and planning.

- Cities engaged in climate action and energy action planning.
- County of Ventura's updated General Plan including Climate Action Plan and Sea Level Rise Vulnerability Assessment.
- County of Ventura Climate Protection Plan – Climate on the Move and related energy sustainability program.
- County of Ventura's participation in energy efficiency and collaboration with other agencies on community choice energy programs emphasizing renewable energy – to reduce GHG emissions.
- The Coastal Conservancy Climate Ready Grant program and climate adaptation elements of local projects such as the Santa Clara River Parkway and Ormond Beach restoration efforts.
- Southern California Association of Governments (SCAG) climate change programs.
- California Dept. of Fish and Wildlife Climate Science Program - ecosystem protection efforts related to climate change.
- USGS project to downscale climate models and Southern California Bight Modeling project.

The results of these studies inform the RWMG planning process and decision-making regarding regional water management projects and programs. This 2019 IRWM Plan amendment builds on the information and analyses included in the 2014 IRWM Plan.

2014 IRWM Plan:
In 2011, stakeholders in the WCVC Region began to focus on the potential impacts of climate change through discussions in each watershed, and at the regional level, as part of developing the 2014 IRWM Plan Update. In March of 2012, WCVC, in collaboration with the Santa Barbara County and Upper Santa Clara River IRWM Regions and DWR, conducted a local climate change workshop. The workshop was well attended, and it resulted in a compilation of information that was posted on the WCVC website: http://www.ventura.org/wcvc/documents/climate_change.htm

2019 IRWM Plan Amendment:
As stated on page 13-1, the 2016 IRWM Plan Standards outline new guidelines related to how climate change is considered in the IRWM planning and project review process. One purpose of the 2019 IRWM Plan amendment is to address these new standards.

To better understand projected changes to the climate in the region, WCVC partnered with the Ojai Valley Land Conservancy to obtain a grant from the Resources Legacy Fund in 2018 to conduct a climate study. The purpose of the study was to evaluate historic climate patterns and variability, and review climate models in order to project climate changes out to the year 2040. This research was conducted by Dr. Nina Oakley and Dr. Ben Hatchett, with the Western Regional Climate Center located at the Desert Research Institute in Reno, Nevada. The final report from this study, *Projected Changes in Ventura County Climate,* provides information to help "paint a picture" of future climate in the watersheds of Ventura County (Ventura River, Santa Clara River, and Calleguas Creek) to support and inform climate change-related decision-making. Please see Appendix K (link to website) for a copy of the full report.

This study provided much-needed information to help the Region better assess future vulnerabilities to climate change and assess and modify the Region's mitigation and adaptation strategies, which are covered in this and other sections of the Plan. WCVC stakeholders were engaged in the process

through special meetings conducted with Drs Oakley and Hatchett. These meetings included regionwide meetings with all interested stakeholders on October 16, 2018 and April 10, 2019, as well as meetings with small groups of representatives of local water districts, groundwater sustainability agencies, agricultural organizations, and the County Watershed Protection District. The purpose of the meetings with representatives of specific interests was to determine their unique data and information needs regarding climate change and to help them with the process of developing strategies to adapt to those changes. The information presented at those workshops can be found at:
http://www.ventura.org/wcvc/documents/climate_change.htm.

Climate Change Workshop – April 10, 2019

Small Group Meeting – April 11, 2019

The conclusions of this study are found on Page 53 of the June 2019 report *Projected Change in Ventura County Climate (*Appendix K of this IRWM Plan). "Analyses presented herein for the 2021–2040 period demonstrate increases in both maximum and minimum temperatures and heat extremes, more intense precipitation focused during the winter season, and increased evapotranspiration. Increased drought risk, potential for a longer wildfire season with more ignitions as population growth continues, reduced marine stratus (fog), reduction in Sierra Nevada snowpack, and longer duration and more intense atmospheric rivers are also noted as concerns for the region. This report covers the 2021–2040 period; thus, some climate projections commonly discussed in the popular media and associated with mid-to-late century change may not be represented here. There is generally an intensification/augmentation/increase in magnitude of changes across all variables in the mid-to-late century ".

C. Climate Change Stressors and Vulnerabilities in Ventura County (WCVC Region)

This section identifies the potential climate change stressors and vulnerabilities in the WCVC Region, based, in part, on the findings in the document described above - *Projected Change in Ventura County Climate,* and on previous information collected from state resources such as Cal-Adapt (see below), stakeholder input and recent research focused on sea level rise.

As described in the conclusions above and in other sections of the Plan, the primary climate stressors projected by global climate models that are important to this Region are changes in air temperature, changes in precipitation patterns, increased evapotranspiration and drought risk, and sea level rise. An increase in wildfires is a stressor related to increased temperatures, changes in precipitation, and population growth.

In 2012, the California Energy Commission's Public Interest Energy Research Program (PIER) established the Cal-Adapt website (http://cal-adapt.org). The website provides output from 32 CMIP-5 climate models downscaled using the Localized Constructed Analogs (LOCA) method (Pierce et al. 2014). It includes two internationally accepted GHG emissions scenarios, the Representative Concentration Pathway (RCP) 4.5 and RCP 8.5. The RCP 8.5 scenario assumes high growth in population, higher GHG emissions, and little to no global cooperation on reducing GHGs, while the RCP 4.5 scenario assumes social consensus for sustainable development and lower GHG emissions. Given the inability to reach global decisions on climate change mitigation measures, and adopting a precautionary approach, this document, for the most part, analyzes stressors and vulnerabilities based on the RCP 8.5 scenario.

1. Climate Change Stressors in Ventura County

NOTE: Much of the text in this section is provided directly by climatologists Dr. Nina Oakley and Dr. Ben Hatchet from the Desert Research Institute, or excerpted from their study, referenced above.

Stressor: Higher Temperatures

Under RCP 8.5 scenario (high emissions) maximum temperatures in Ventura County are expected to rise. Inland areas see the greatest amount of warming, approximately 3-5 °F in all seasons. More pronounced and widespread increases are observed in summer and fall. Coastal areas see a 2-3 °F change across all seasons in the 2021-2040 period (Fig. 13-2). The increase in maximum temperatures will be accompanied by more frequent extreme heat events (see also Fig. 13-3), with related ecosystem and human health impacts.

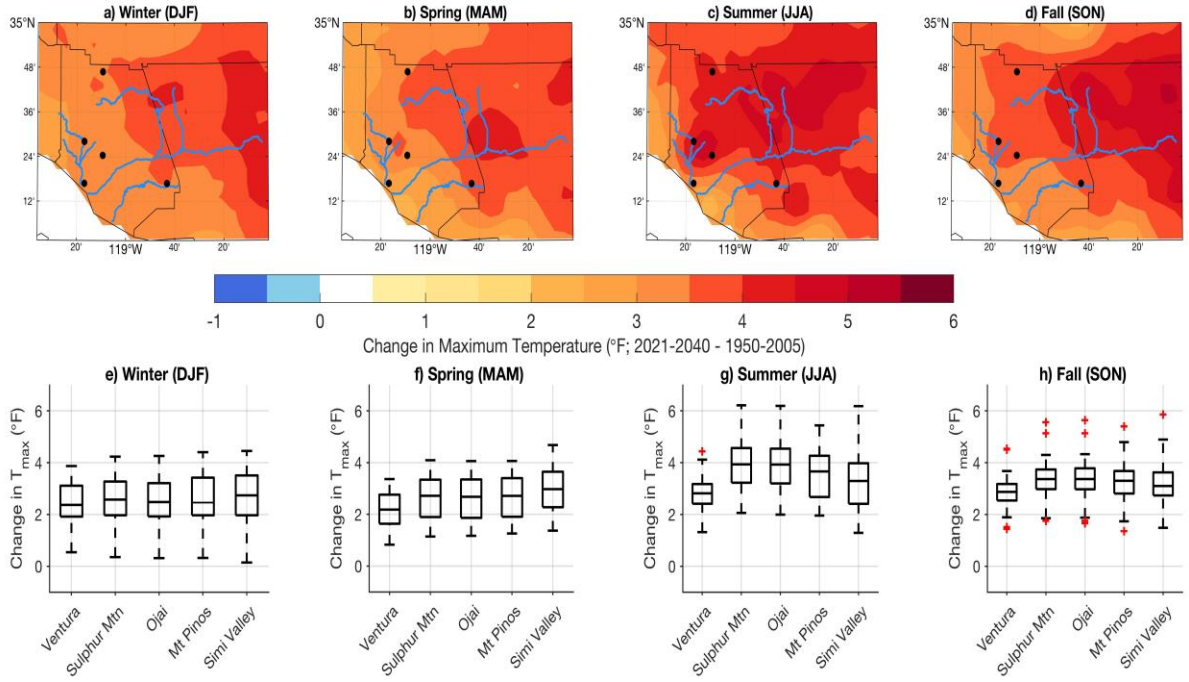


Figure 13-2: Change in maximum temperature by season, 2021-2040 mean minus 1950-2005 mean. Top row of figures show minimum change that >75% of models (>24 of 32) agree on. Bottom row depicts spread of maximum temperature change across 32 climate models for five selected locations within Ventura County (black dots on map). Data Source: LOCA, Pierce et al. 2014.

Minimum temperatures are also projected to increase. The greatest changes in minimum temperature tend to occur in summer and fall, with changes in inland areas on the order of 3-5 °F. The coastal areas see similar changes of approximately 2-3 ° F across all seasons (Fig. 13-3). However, for both maximum and minimum temperatures in the coastal areas, fog may not be well represented in global climate models and this adds uncertainty. Increasing minimum temperatures mean warmer nights, fewer freezing events, and warmer winters, with implications for water resources, agriculture, and ecosystems.

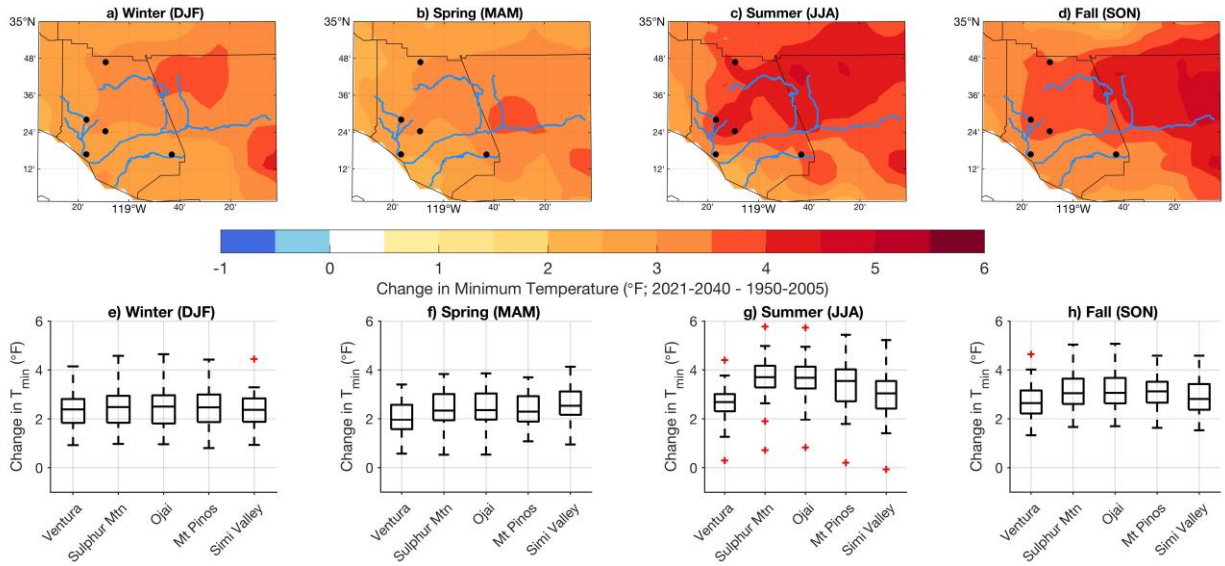


Figure 13-3: Change in minimum temperature by season, 2021-2040 mean minus 1950-2005 mean. Top row of figures show minimum change that >75% of models (>24 of 32) agree on. Bottom row depicts spread of minimum temperature change across 32 climate models for five selected locations within Ventura County (black dots on map). Data Source: LOCA, Pierce et al. 2014.

Stressor: More Frequent Wildfires

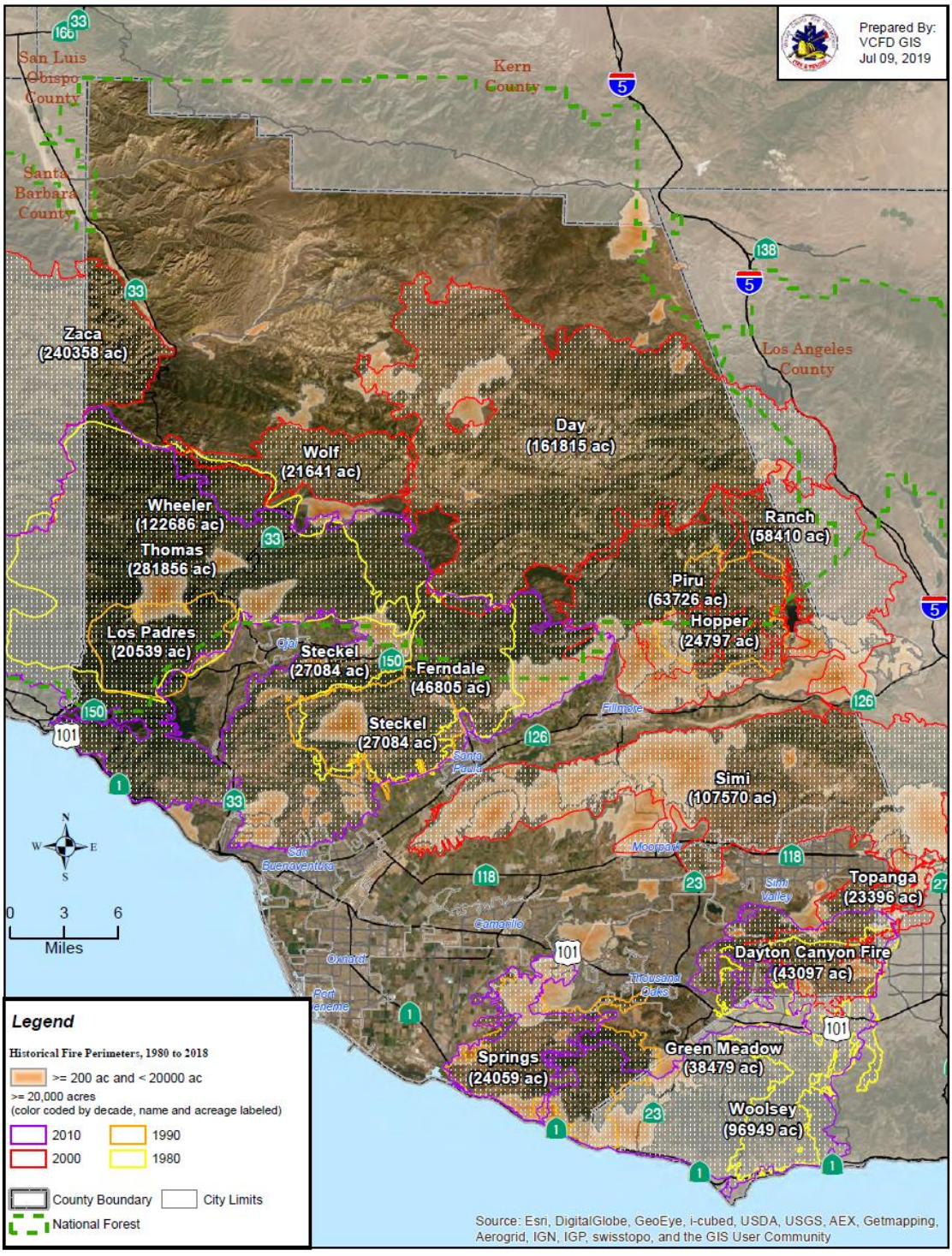
Thomas Fire burns behind United Water Conservation District Pump Station
December 4, 2017

Wildfires are a common occurrence in Ventura County due in part to the meteorological phenomenon known as Santa Ana winds which typically originate during the fall in the hot, dry interior deserts to the north and east of Ventura County. Between 1965 and 2018, there were 13 large wildfires which each affected more than 25,000 acres (Figure 13-4). Four of those thirteen fires burned more than 100,000 acres, three of which occurred in the last 15 years.

Since December 2017, Ventura County has experienced several significant wildfires including the Thomas Fire and the Hill and Woolsey Fire. The Thomas Fire was a massive wildfire that affected Ventura and Santa Barbara Counties, and one of multiple wildfires that ignited in Southern California in early December 2017. It burned a total of 281,893 acres (440 square miles), destroyed at least 1,063 structures, and damaged 280 others before being fully contained on January 12, 2018. The Thomas Fire earned the distinction of being the largest wildfire in modern California history until it was surpassed in size by other larger wildfires in the state that occurred in 2018 – most notably the Camp Fire, the Carr Fire, and the Mendocino Complex Fire.

The Woolsey Fire, which ignited on November 8, 2018, burned 96,949 acres in Los Angeles and Ventura Counties. The fire destroyed 1,643 structures, killed three people, and prompted the evacuation of more than 295,000 people.

Wildfire risk is determined by a combination of factors including precipitation, winds, temperature, population distribution, and landscape and vegetation conditions. Thus, future risks will not be uniform throughout the state. In years with wet winters, annual vegetation growth is plentiful.


Prepared By:
VCFD GIS
Jul 09, 2019
San Luis Obispo County
Kern County
Santa Barbara County
Los Angeles County
Zaca (240358 ac)
Wolf (21641 ac)
Day (161815 ac)
Wheeler (122686 ac)
Thomas (281856 ac)
Ranch (58410 ac)
Piru (63726 ac)
Hopper (24797 ac)
Los Padres (20539 ac)
Steckel (27084 ac)
Ferndale (46805 ac)
Steckel (27084 ac)
Simi (107570 ac)
Topanga (23396 ac)
Dayton Canyon Fire (43097 ac)
Springs (24059 ac)
Green Meadow (38479 ac)
Woolsey (96949 ac)
Ojai
Fillmore
Santa Paula
Moorpark
Simi Valley
Camarillo
Oxnard
Port Hueneme
Thousand Oaks
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E
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0 3 6
Miles
Legend
Historical Fire Perimeters, 1980 to 2018
>= 200 ac and < 20000 ac
>= 20,000 acres
(color coded by decade, name and acreage labeled)
2010
1990
2000
1980
County Boundary
City Limits
National Forest
Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 13-4

Some studies indicate drier spring and fall seasons (Swain et. al. 2018) or an increase in dry days during these seasons (Fig 13-5). Drier spring and fall seasons create a longer period of the year during which Southern California wildlands are susceptible to wildfire.

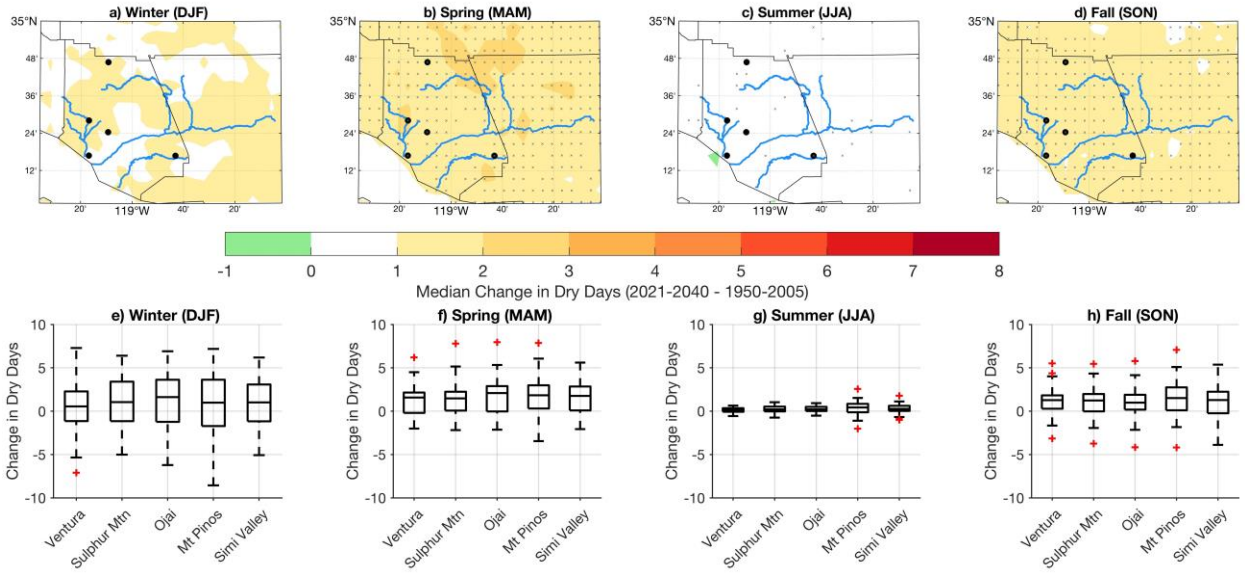


Figure 13-5: Change in median number of dry (zero precipitation) days by season, 2021-2040 median minus 1950-2005 median. Dots represent grid cells where >75% of models agree on the sign of the change depicted in color fill (increasing or decreasing). Data Source: LOCA, Pierce et al. 2014.

With expanding development into the Wildland Urban Interface, threats to human safety and property are even greater. The spread of invasive species that are more fire-prone, coupled with more frequent and prolonged periods of drought, are projected to increase the risk of fires and reduce the capacity of native species to recover. Wildfires also impact air quality, human health, and soil erosion. They are also an added stress on the watersheds. Increased soil erosion following fires can cause sedimentation in reservoirs, impacting water quality and supply and reducing ecosystem services provided in these watersheds. During extreme rainfall events such as the event in Montecito on January 9, 2018 immediately following the Thomas Fire, it can reduce the capacity of flood control infrastructure and increase flooding.

Photo of hills surrounding Lake Casitas, post Thomas Fire,
Courtesy of Casitas Municipal Water District, 2018

The potential for more frequent wildfires, combined with increased precipitation intensities, may lead to more frequent damaging debris flows and/or enhanced runoff and flash flooding in recently burned areas.

Stressor: Longer, More Frequent Droughts

Lake Casitas – Drought Stage - 2018

By virtue of its Mediterranean climate and location along the periphery of the Pacific subtropical high, California experiences warm and dry summers with wet winters. During the wet winter months, which in Southern California typically begin in November and terminate in March, the bulk of precipitation arrives in a few, large storms (Dettinger et al. 2011; Oakley et al. 2018b). Should these storms not arrive due to the presence of a persistent blocking ridge of high pressure in the North Pacific Ocean, precipitation deficits will be large (Cook et al. 2018). These deficits will be superimposed with climatologically high evaporative demands and may be exacerbated by above-normal winter season temperatures. Such dry years occur commonly in California, and multi-year periods of severe drought are not uncommon.

However, evidence from various locations in California and throughout the southwestern United States indicates that extreme droughts lasting decades to several centuries have occurred numerous times since the end of the last ice age (e.g., Stine 1994; Benson et al. 2002; Woodhouse et al. 2010; Dingemans et al. 2014)..These droughts indicate that such extreme periods of aridity can occur under natural conditions (i.e., independent of human-driven changes in greenhouse gas concentrations) implying consideration of extended drought is prudent to sustainable water resource management, especially if projected warming increases drought risk (Cook et al. 2015; Hatchett et al. 2015).

Modeling studies of the Central Sierra Nevada have shown these droughts to be of comparable precipitation deficits to the most recent California Statewide drought that began in winter 2012 and ended in January of 2017 (Hatchett et al. 2015). The severity of the recent drought was exacerbated by anomalously warm temperatures driving a surplus in atmospheric evaporative demand and reducing the fraction of precipitation falling as snow in mountain regions (Williams et al. 2015b; Hatchett et al. 2017). The duration and severity of the recent drought varied statewide, with Ventura County being one of the first regions to go into drought conditions and one of the last to emerge (U.S. Drought Monitor 2019).

California has long experienced drought conditions (Stine 1994; MacDonald 2007, Woodhouse et al. 2010). As a result of changing atmospheric composition and land surface conditions, loss of sea ice and the resultant changes in atmospheric and oceanic circulations, climate models project increased temperatures, more frequent dry days, and greater chances of persistent mid-winter high pressure suppressing storminess for California (Polade et al. 2015, 2017; Cvijanovic et al. 2017). Anthropogenic warming, and the circulation changes it induces, will increase the probability that low precipitation years will coincide with above-average temperature years (Diffenbaugh et al. 2015; Cook et al. 2015). This elevates drought risk via both decreased supply of moisture and an increased atmospheric demand for moisture. Water availability may decline through changes in rainfall-runoff generation processes; as soil moisture declines due to greater evaporation from bare soil and increased plant evapotranspiration, more precipitation will be required to generate the same volume of runoff. GCMs project significantly drier soils in the future over the Southwest (including California), with more than an 80% chance of a multidecadal drought during 2050–2099 under RCP 8.5 ("business as usual" climate change scenario; Cook et al. 2015).

The specific types of drought, their magnitude and duration, and the hydroclimatic patterns that end drought in Ventura County will require additional research that integrates modeling approaches to evaluate water availability changes on both the supply and demand sides as well as examines the dynamical circulation mechanisms. Based upon the analysis provided in this document, clear evidence for increases in drought severity is provided, but evidence for occasional wet years is also demonstrated. Because precipitation remains variable, some years will be less drought prone than others due to more frequent and possibly stronger storms. Yet the ubiquitous projected increases in evaporative demand imply that more water will be lost to the atmosphere and the increases in projected dry days provides additional opportunities for evaporative losses."

More Extreme Flood Events and Changes in Snowpack and Melt

Santa Clara River – High Flows - January 2019

Climate models disagree on the sign and magnitude of annual precipitation changes in Southern California, though the changes in magnitude are modest where present. The median precipitation change across all 32 CMIP 5 models downscaled with the LOCA method reveals little to no change in annual precipitation (Fig 13-6a). The bottom 25th percentile across models note changes towards less precipitation on the order of 2-3 inches in high terrain (Fig 13-6b), while the top 75th percentile suggest an increase of 2-4+ in, with the greater values associated with higher terrain (Fig. 13-6c). Climate models generally agree on an increased number of dry days per year (Fig. 13-5, Polade et al. 2014), with the greatest agreement in the spring and fall seasons (Fig 13-6b, 13-6d). Since overall precipitation changes are projected to be relatively small, it follows that an increased amount of precipitation must fall in the remaining wet days to accommodate the increasing number of dry days.

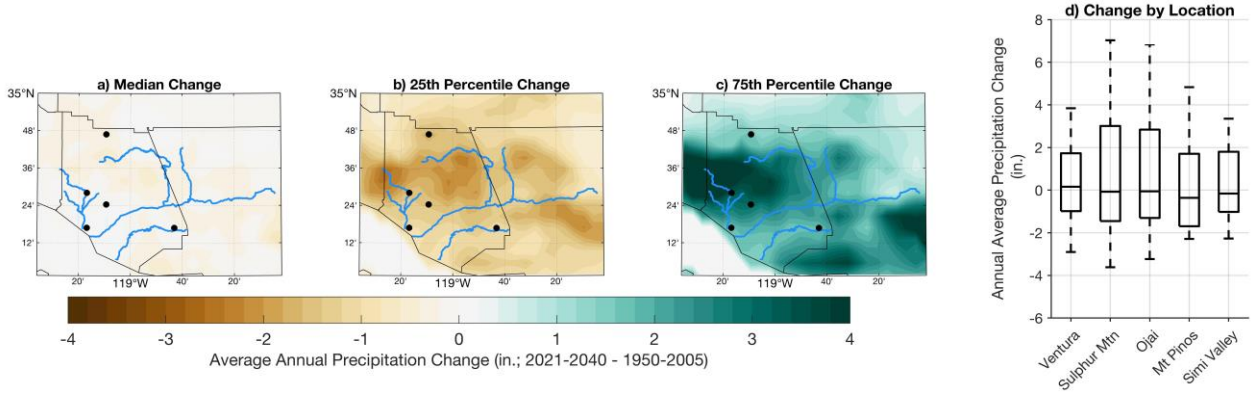


Figure 13-6: Projected changes in annual average precipitation 2021-2040 minus 1950-2005 for: a) Median change from ensemble of 32 models. b) 25th percentile change from ensemble of 32 models. c) 75th percentile change from ensemble of 32 models. Data Source: LOCA, Pierce et al. 2014. d) Annual average precipitation change by location.

A study by UCLA shows a 64% decrease in Sierra Nevada April 1 snow water equivalent (SWE) by the end of the century from the 1981-2000 baseline following the RCP 8.5 scenario (Figure 13-7). Because the County depends at least partially on water from the State Water Project (SWP), the reduction in snowpack may result in reduced availability and increased costs for SWP water.

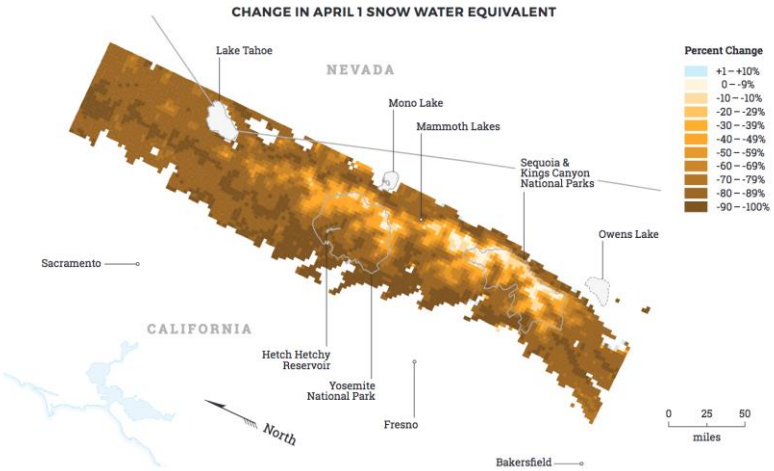


Figure 13-7: Change in April 1 snow water equivalent from baseline period (1981-2000) to future period (2081-2100) based on the RCP 8.5 scenario. Source: Reich et al. 2018.

It is important to note that global models also predict differences in the way precipitation occurs, with more extreme weather events possible. The combination of flood events and sea level rise is particularly critical to coastal communities and ecosystems.

Stressor: Sea Level Rise

Rising sea levels pose a significant threat to coastal areas in California as a result of climate change. According to the 2009 California Climate Adaptation Strategy, sea level has risen by an average of about 7 inches along California's 1,100-mile coastline over the past century, contributing to progressive shoreline retreat and coastal cliff, bluff, and dune erosion. Ventura County has approximately 42 miles of coastline, which supports two naval facilities (Naval Base Ventura), two harbors (Channel Islands and Ventura), residential and other privately developed properties within two cities and the County unincorporated area, critical water and wastewater infrastructure such wastewater treatment plants, water treatment and delivery systems, agricultural operations, recreation areas such as State Parks, local parks and beaches, and transportation infrastructure such as roads and rail lines.

Waves hitting seawall at Faria Beach Colony – Courtesy of Ventura County Planning Department

(California's Cal-Adapt website states that "Global models indicate that California may see up to a 55 inch (1.4 meter) rise in sea level within this century given expected rise in temperatures around the world."[1] This type of sea level rise, combined with a 100-year flood event, would lead to significant inundation in the coastal regions of Ventura County (Figure 13-8).

These data were developed by scientists from the United States Geological Survey (USGS) in the Bay Area and the Pacific Institute (Coast). The darker blue areas are already threatened today, while the lighter shades are areas projected to also be threatened given the expected sea level rise.

[1] This projection is based on a paper prepared by the California Climate Change Center: The Impacts of Sea-Level Rise on the California Coast", CEC-500-2009-024-D. This is consistent with the National Research Council's conclusions, published in "Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present and Future", National Academies Press, 2012.

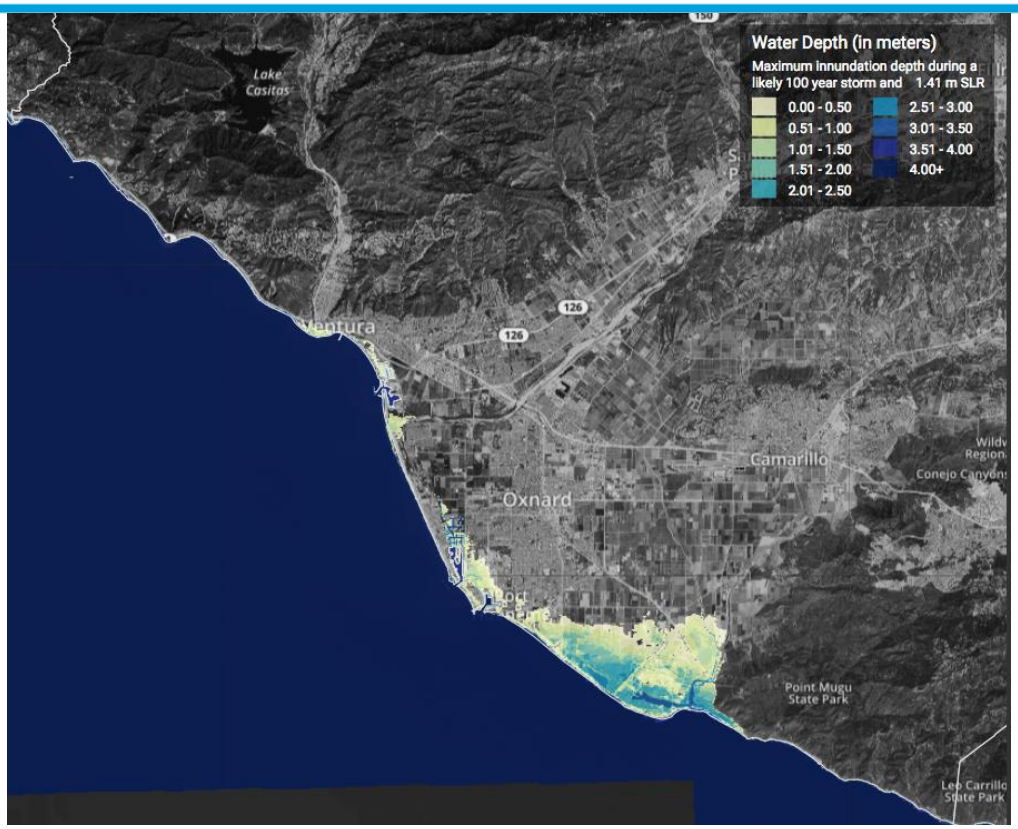


Figure 13-8: Maximum inundation depth (in meters) during a 100-year storm event with 1.41 m of sea level rise. Source: Cal-Adapt (https://cal-adapt.org/tools/slr-calflod-3d/)

The USGS and Scripps Institute estimate that the replacement value of buildings and contents in Ventura County vulnerable to a 100-year coastal flood with a 1.4-meter sea-level rise would be $2.2 billion.

In 2018, the Ventura County Resource Management Agency released a report titled *Ventura County Resilient Coastal Adaptation Project; Sea Level Rise Vulnerability Assessment* which reveals that Ventura County will face considerable challenges adapting to sea level rise. The following excerpt provides an overview of the report: "Analyses focused on the potential impacts of coastal erosion, coastal flooding and future high tides with 8 inches, 16 inches, and nearly 5 feet of sea level rise. Residential properties, critical transportation and infrastructure corridors, as well as high-value coastal recreation top the list of coastal resources that are vulnerable to sea level rise. Agriculture located near the coast, while only preliminarily assessed, is also vulnerable. Beach, foredune and estuarine systems are the most vulnerable sensitive coastal ecosystems and may experience significant changes. The Point Mugu Naval Air Weapons Station is also a vulnerable facility that is located on low-lying coastline within the unincorporated area. While the Navy Base and many coastal communities face similar challenges, the County is fortunate in that there are no critical facilities such

as sewage or water treatment plants, energy plants, airports, or hospitals within the County's jurisdiction that are projected to be impacted through the end of the century.

Ventura County is no stranger to addressing coastal hazards. With over 18 miles of coastal armoring in the unincorporated areas, without any adaptation measures or actions, over $1 billion dollars in oceanfront residential properties are potentially vulnerable to storm erosion and temporary coastal flooding with less than one foot of sea level rise. Small, narrow beaches in the North and South Coasts that support a vibrant $156 million per year coastal recreation economy may be lost within the next few decades. Future adaptation strategies will be needed to reduce hazards and expensive emergency cleanup costs and to conserve vulnerable beaches.

The Report addresses the risks associated with future sea level rise in Ventura County (County), using a science-based vulnerability assessment that evaluates a variety of resources and infrastructure in the unincorporated coastal areas of the county and the risk of future damage associated with coastal hazards (high tides, erosion, and storm flooding) and sea level rise. This Report is being used to support community discussions on existing and future hazards, identify potential adaptation strategies that can reduce the risk of future damage, and guide land use goals, policies, and programs.

For purposes of the Report, the team evaluated a range of available coastal hazard models and sea level rise projections. The hazard modeling selected was largely based on Coastal Resilience modeling partially funded by Ventura County and completed in 2013. These modeling results are also being used by the neighboring jurisdictions of Santa Barbara and Los Angeles Counties, and the Cities of Oxnard and Carpinteria. The Coastal Resilience modeling assumed the following sea level rise projections and time periods. They are consistent with state guidance to use the "best available science" (See Figure 13-9 below).

Figure 13-9. Sea Level Rise Projections used in this Vulnerability Assessment Report*1*

Approximate Year	Maximum Height of Sea Level Rise
2030	8 inches
2060	16 inches
2100	58 inches

1 Year 2010 is the baseline for the Coastal Resilience Modeling used in these projections.

It should be noted that since the Coastal Resilience modeling was completed, more recent scientific projections modeled in preparation for the California 4th Climate Assessment have been integrated into the Rising Seas in California (Griggs et al. 2017), and as part of the State of California Sea-Level

Rise Guidance, 2018 Update. While most of the sea level rise estimates in the 2030 to 2060 timeframes are similar to earlier projections, some of the projections for sea level rise at the end of the century have increased. As such, the findings in the Report should not be considered a worst-case scenario. In fact, recent state guidance suggests considering 10 or more feet of sea level rise by the year 2100 for some types of land uses. For more detailed discussion of the state guidance as it relates to sea level rise and the scenarios considered, please see Section 1.3 of the Report. The amount of sea level rise shown in the projections above will occur in the future and pose considerable planning and operational challenges. Other climate variables such as temperature, precipitation, wildfires, and changes to the earth's polar ice sheets were not evaluated in the Report but will contribute to sea level rise hazards as the climate system changes. These variables may alter the amounts of projected sea level rise that are currently set to planning horizon years of 2030, 2060,

and 2100, and sea level rise may occur sooner or later than those years. The important point is that sea level rise will occur within most of our lifetimes and it will only intensify for future generations."

2. Climate Change Vulnerabilities in Ventura County

As described above**,** primary climate stressors projected by global climate models that are important to this Region are changes in air temperature, changes in precipitation patterns, increased evapotranspiration and drought risk, and sea level rise. An increase in wildfires is a stressor related to increased temperatures, changes in precipitation and population growth. Assessing a region's vulnerability to climate change stressors is the next step toward achieving climate resilience.

The purpose of identifying climate change vulnerabilities is to identify opportunities for making substantive changes to enhance future resilience. This allows planners to determine the degree to which a system is susceptible to the adverse effects of climate change, including climate variability and climate extremes. In 2012 and 2013, WCVC stakeholders developed a detailed matrix to identify vulnerabilities and potential impacts related to the climate change stressors which were described in the 2014 IRWM Plan. At that time, water demand and water supply, water quality, water-related infrastructure, agriculture, ecosystems and public health and safety for human populations were identified as the key vulnerabilities associated with climate change in the IRWM planning area. A tabular version of the following analysis is attached as Table 13-1.

Table 13-1
Water Related Vulnerabilities to Climate Change
Ventura County - 2013

Vulnerabilities and Related Impacts	Key Stressors: Longer, More Frequent Droughts	Higher Air Temps	More Intense Precipitation and More Extreme Flood Events	More Frequent & Intense Wildfires	Sea Level Rise
Water Demand (demands on available supply)					
1. Higher water use, especially for agricultural and landscape irrigation	✓	✓			
2. Increased evaporation and evapotranspiration	✓	✓			
3. Higher water demands for firefighting				✓	
4. Increased water demand from contaminated coastal agricultural wells					✓
Water Supply (available water)					
5. Changing precipitation patterns	✓				
6. Reduction in groundwater recharge	✓	✓			
7. Reduced local and imported water supply reliability	✓	✓	✓		
8. Loss of usable water supply due to reduced water quality due to increased sedimentation and accelerated runoff in burn areas			✓	✓	
9. Damage to reservoir operations, wells, water diversions and conveyance systems due to flooding/sea level rise			✓		
10. Near shore groundwater supplies threatened by salt water intrusions					✓
Water Quality					
11. Increased eutrophication and algal biomass	✓	✓			
12. Reduced dissolved oxygen	✓	✓			
13. Reduced cold water pools for fish (e.g. California steelhead trout)	✓	✓			
14. Inability to meet water quality standards	✓	✓	✓	✓	✓

15. Poor water quality from increased sedimentation (turbidity) and accelerated runoff in burned areas			✓	✓	
16. Increased turbidity, pathogens, trash and other pollutant loads from severe storms			✓		
17. Increased salinity in estuaries and near shore aquifers					✓
18. Reduced groundwater and lake water quality	✓	✓		✓	✓
Water Related Infrastructure					
19. Access to electricity for pumping and distribution threatened by higher summer energy demands and increased power outages	✓	✓			
20. Access to electricity threatened by potential fires, floods and sea level rise			✓	✓	✓
21. Increased sediment in water systems			✓	✓	
22. Insufficient capacity and/or water to address firefighting needs	✓	✓		✓	
23. Levee stress/failure			✓		✓
24. Impacts to wastewater treatment plants and reservoir operations within the watershed			✓		✓
25. Impacts to wastewater treatment plant (Ventura Water Reclamation Plant) outside the watershed (near Santa Clara River mouth) from discharges within the watershed			✓		✓
26. Damage to conveyance systems			✓		
27. Increased sediment in water systems	✓	✓	✓	✓	
Ecosystems and Habitats					
28. Lower in-stream flows and/or more variability in in-stream flows	✓	✓			
29. Increased aquatic and terrestrial ecosystem stress	✓	✓		✓	
30. Increased water temperature and plant/animal mortality	✓	✓			
31. Changes to the range, composition, distribution and migration of plant/animal communities	✓	✓	✓		✓
32. Increased pests, invasive species and diseases	✓	✓		✓	✓
33. Decreased ecosystem services	✓	✓	✓		
34. Short-term habitat loss	✓	✓			
35. Habitat changes from frequent fires due to loss of seedbeds/vegetative restarts				✓	
36. Reduced in-stream water quality	✓	✓	✓	✓	
37. Alteration in stream channels and sediment transport			✓		
38. Increased frequency of disturbance	✓	✓	✓	✓	
39. Increased salinity in estuaries and near shore aquifers		✓			✓
40. Increased coastal erosion			✓		✓
Agriculture					

41. Increased evapotranspiration and soil moisture deficits	✓	✓			
42. Increased water demands and costs	✓	✓			
43. Shifts in crop behavior (flowering/ripening)	✓	✓			
44. Increased pests and diseases	✓	✓			
45. Reduced crop productivity	✓	✓	✓		
46. Cropland taken out of production due to lack of water	✓				
47. Crop losses due to flooding/higher temperatures	✓	✓		✓	
48. Range land losses (reduced soil moisture; fires)		✓		✓	
49. Increased soil erosion			✓		
50. Increased salinity in near shore aquifers used by agriculture					✓
51. Loss of agricultural land near coast					✓
Human Populations					
52. Insufficient local water supplies	✓		✓		
53. Increased water costs (from increased demand)	✓	✓			
54. Displacement of people and services	✓	✓	✓	✓	✓
55. Reduced recreational opportunities	✓	✓	✓	✓	✓
56. Economic losses and potential wide scale economic losses due to lack of water	✓	✓	✓	✓	✓
57. Property damage and losses			✓	✓	✓
58. Mortality and morbidity (from heat, fires and intense flood flows and landslides)		✓	✓	✓	
59. Increased water and sewer costs from reduced water quality and infrastructure damage	✓		✓		✓
60. Increased energy costs		✓	✓		
61. Increased property insurance costs			✓	✓	

These vulnerabilities are briefly described below, and were updated to reflect the work conducted by Drs. Oakley and Hatchett and other recent studies and planning efforts:

Available Water Supply

With increased evapotranspiration and drought susceptibility, water use is likely to increase, especially for agriculture and landscape irrigation. Sea level rise would make coastal agricultural wells more vulnerable to salt water intrusion, increasing the demand for surface or imported water. Less predictable precipitation may result in changes to when and how much local water is available for use and recharge and how water supply is managed.

Reliability of water supply is a function of local and imported water sources being available when needed. A portion of the water supply for eastern Ventura County is imported through Metropolitan Water District. MWD's Integrated Water Resources Plan, 2010 Update describes uncertainties that

create the potential for dramatic shifts in water management. With respect to imported water, the Update states, "Metropolitan's planning relies on nearly 100 years of historical data to forecast future conditions, including the frequency and abundance of rainfall. However, analysis of thousands of years of climate variability, along with models of potential future climate, indicate weather patterns may fall outside the range of the historic data used in Metropolitan's planning models. Changes in climate could significantly affect water supply reliability." (MWD Integrated Water Resources Plan, 2010 Update, Executive Summary).

The State Water Project issued its Final Delivery Reliability Report for 2011 in June 2012. The report states, "…as climate change continues to affect California, past hydrology is no longer a reliable guide to future conditions." (p. 28). Specific aspects related to climate change that may alter reliability are decreased water availability with reduced snowpack, increased SWP water demands, and sea level rise in the Delta.

Water Quality

Longer, more frequent droughts and higher temperatures that result from climate change could impact water quality by increasing eutrophication and algal biomass, reducing dissolved oxygen levels and cold-water pools for fish. These factors may also impact water managers' ability to meet water quality standards, made worse if extreme floods, wildfires, and sea level rise occur simultaneously. Poor water quality may result from increased sedimentation and accelerated runoff from burned areas. Severe storms and floods would generally increase turbidity and deposit waste and other pollutants into local streams and rivers. Sea level rise would increase salinity in estuaries and near shore aquifers, reducing their availability for the current ecosystem and human uses.

Water Related Infrastructure

Impacts on water related infrastructure are direct and indirect. Direct impacts include lack of reliable power supplies when transmission lines and power plants are threatened by fires, floods, and sea level rise. Direct impacts can result from damage to water and/or energy conveyance and treatment systems. Indirect impacts on water related infrastructure include reduced access to reliable electricity for pumping and distribution when high temperatures increase summer energy demands. In addition to lack of reliability, damage and competitive demands for power are likely to result in increased costs for electricity used to treat and deliver water. Another major vulnerability factor is aging water-related infrastructure; some facilities (conveyance lines such as pipe and channels, flood control levees, water and wastewater treatment plants, pumping plants) have outlived their design life. Aging infrastructure is even more vulnerable to the impacts of certain impacts of climate change such as rising sea levels and more extreme flood events. A secondary or indirect impact of climate change on infrastructure is the cost and environmental impacts of funding new water supplies

Ecosystems and Habitats

Ecosystems and habitats are vulnerable to less and/or more variable in-stream water. More droughts, higher temperatures, and wildfires increase aquatic and ecosystem stress by increasing water temperatures and reducing instream water quality. As the climate changes, the range, composition, distribution, and migrations patterns of plant and animal communities are also likely

to change. With increased pests, invasive species and diseases, ecosystem services[2] would likely be reduced. They would likely be reduced further by alteration in stream channels and sediment transport due to altered precipitation patterns producing drought conditions, larger storms, and increased coastal erosion and salinity in estuaries and near shore aquifers. Climate change impacts may also affect how and when, and with which species, restoration projects are conducted.

Agriculture

Agriculture is an important part of the County's economy. As noted above, agriculture is particularly dependent on a reliable supply of acceptable quality water. In the worst-case scenario, cropland may be taken out of production due to lack of water, and agricultural land in coastal areas may become less productive as a result of sea level rise and salt water intrusion. With increased temperatures and more frequent droughts, evapotranspiration will increase, and soil moisture levels will likely decline, increasing water demands and costs. Changes to nighttime temperatures and seasonal water supplies would likely result in shifts in crop behavior and health. Increased pests and diseases that result from heat and drought, along with other factors, would likely impact crop productivity. Figure 13-10 provides an example of this with respect to avocado trees, an important crop in Ventura County. At 88 F, stomatal closure begins to occur in avocado trees, stressing the plants. This is a response to prevent loss of water and embolisms in the plant's xylem. Climate models project an increase in the number of >88 F days in a future climate (Fig. 13-10). Inland low-to-moderate elevation locations are most impacted, such as Ojai, Fillmore, and Simi Valley, and may see on the order of 25-30 more >88 F days. It should be noted, however, that model spread is large, on the order of +/- 10-15 days (Fig. 13-10, right).

[2] Ecosystem services are defined as the important benefits for human beings that arise from healthily functioning ecosystems, including but not limited to production of oxygen, soil genesis, and water detoxification.

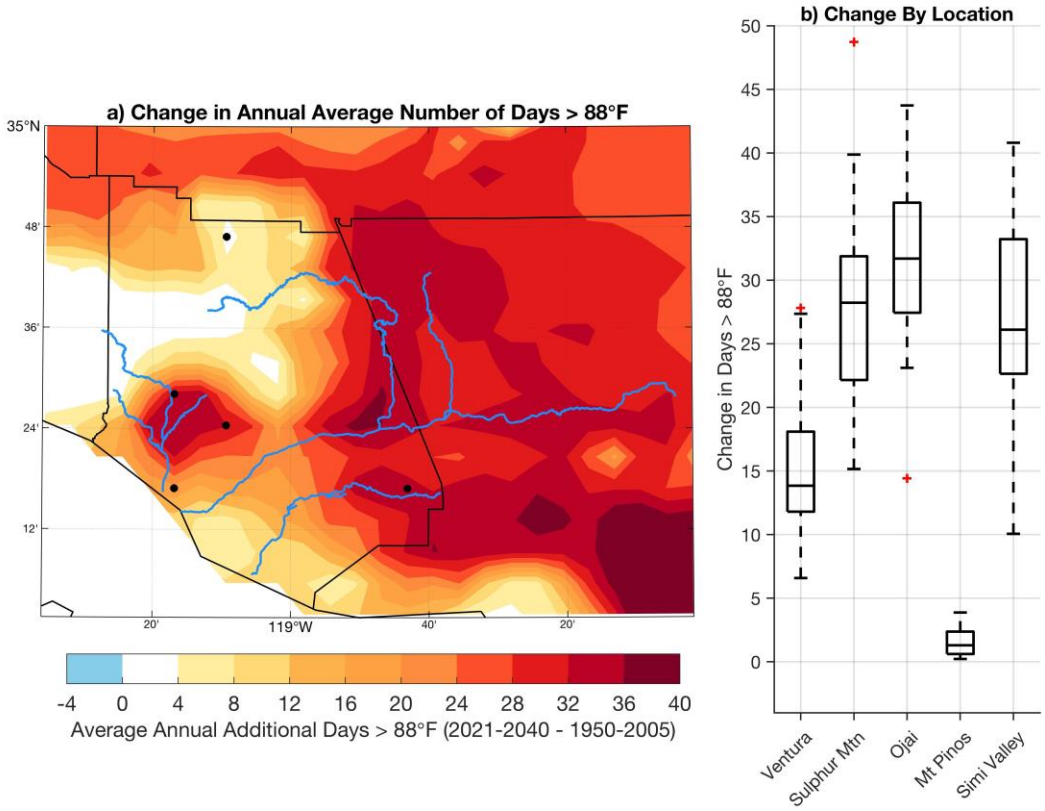


Figure 13-10: Change in annual average number of days >88 F, 2021-2040 minus 1950-2005 mean. Figure shows change that >75% of models (>24 of 32) agree on. Box plot on right displays spread in change of annual average number of days >88 F across 32 climate models for five selected locations within Ventura County (black dots on map). Data Source: Localized Constructed Analogs (LOCA), Pierce et al. 2014.

Human Populations – Public Health and Safety

The IRWM Plan area includes a range of population distribution, including cities, suburbs and less densely populated areas. Climate change impacts on human populations occur both directly and indirectly. Humans may be directly impacted by higher temperatures, exposure to fires and intense floods and landslides brought on by more intense rain events. Public health officials are exploring the impacts of climate change on provision of services to the frail and elderly. From an economic perspective, because climate change may result in reduced availability of water, the impacts range from increased costs to displacement of people and businesses.

Updated Vulnerability Assessment for 2019 IRWM Plan Amendment

An updated vulnerability assessment was conducted for this 2019 IRWM Plan Amendment using the Vulnerability Checklist in the Climate Change Handbook for Regional Water Planning, Section 4, Appendix B. The question and response are listed below along with an overall summary. The full results of the Vulnerability Assessment can be found in Appendix L of this IRWM Plan amendment.

WATER DEMAND

- Are there major industries that require cooling/process water in your planning region? *YES*
- Does water use vary by more than 50% seasonally in parts of your region? *YES*
- Are crops grown in our region climate-sensitive? Would shifts in daily heat patterns, such as how long heat lingers before night-time cooling, be prohibitive for some crops? *YES*
- Do groundwater supplies in your region lack resiliency after drought events? *VARIES*
- Are some instream flow requirements in your region either currently insufficient to support aquatic life or occasionally unmet? *YES*

WATER SUPPLY

- Does a portion of the water supply in your region come from snowmelt? *YES*
- Does part of your region rely on water diverted from the Delta, imported from the Colorado River, or imported from other climate-sensitive systems outside your region? *YES*
- Does part of your region rely on coastal aquifers? Has salt intrusion been a problem in the past? *YES*
- Would your region have difficulty in storing carryover supply surpluses from year to year? NO
- Has your region faced a drought in the past during which it failed to meet local water demands? *NO*
- Does your region have invasive species management issues at your facilities, along conveyance structures, or in habitat areas? *YES*

WATER QUALITY

- Are increased wildfires a threat in your region? If so, does your region include reservoirs with fire-susceptible vegetation nearby which could pose a water quality concern from increased erosion. *YES*
- Does part of your region rely on surface water bodies with current or recurrent water quality issues related to eutrophication, such as low dissolved oxygen or algal blooms? Are there other water quality constituents potentially exacerbated by climate change? *YES*

- Are seasonal low flows decreasing for some water bodies in your region? If so, are the reduced low flows limiting the waterbodies' assimilative capacity? *YES*
- Are there beneficial uses designated for some water bodies in your region that cannot always be met due to water quality issues? *YES*
- Does part of your region currently observe water quality shifts during rain events that impact treatment facility operation? *YES*

SEA LEVEL RISE

- Has coastal erosion already been observed in your region? *YES*
- Are there coastal structures, such as levees or breakwaters, in your region? *YES*
- Is there significant coastal infrastructure, such as residences, recreation, water and wastewater treatment, tourism, and transportation, at less than six feet above mean sea level in your region. *YES*
- Are there climate-sensitive low-lying coastal habitats in your region? *YES*
- Are there areas in your region that currently flood during extreme high tides or storm surges? *YES*
- Is there land subsidence in the coastal areas of our region? *YES*
- Do tidal gauges along the coastal ports of your region show an increase over the past decades? *YES*

FLOODING

- Does critical infrastructure in your region lie within the 200-year floodplain? *YES*
- Does part of your region lie within the Sacramento-San Joaquin Drainage District? *NO*
- Does *aging* critical flood protection infrastructure exist in your region? *YES*
- Have flood control facilities (such as impoundment structures) been insufficient in the past? *YES*
- Are wildfires a concern in parts of your region? *YES*

ECOSYSTEM AND HABITAT VULNERABILITY

- Does your region include inland or coastal aquatic habitats vulnerable to erosion and sedimentation issues? *YES*
- Does your region include estuarine habitats which rely on seasonal freshwater flow patterns? *YES*
- Do climate-sensitive fauna or flora populations live in your region? *YES*
- Do endangered or threatened species exist in your region? Are changes in species distribution already being observed in parts of your region? *YES*
- Does the region rely on aquatic or water dependent habitats for recreation or other economic activities? *YES*
- Are there rivers in your region with quantified environmental flow requirements or known water quality/quantity stressors to aquatic life? *YES*
- Do estuaries, coastal dunes, wetlands, marshes, or exposed beaches exist in your region? If so, are coastal storms possible frequent in your region? *YES*

- Does your region include one or more of the habitats described in the Endangered Species Coalition's Top 10 habitats vulnerable to climate change? *NO*
- Are there areas of fragmented estuarine, aquatic, or wetland wildlife habitat within your region? YES
- Are there movement corridors for species to naturally migrate? YES and NO
- Are there infrastructure projects planned that might preclude species movement? YES

HYDROPOWER

- Is hydropower a major source of electricity in your region? *NO*
- Are energy needs in your region expected to increase in the future? *YES* If so, are there future plans for hydropower generation facilities or conditions for hydropower generation in your region? NO

The full document can be found in Appendix L.

Prioritization of Vulnerabilities

The state's IRWM Plan Standards call for developing a "list of prioritized vulnerabilities based on the vulnerability assessment and the IRWM's decision-making process and including a determination regarding the feasibility for the Regional Water Management Group (WCVC in this case) to address the priority vulnerabilities."

In order to obtain feedback on the priority of these vulnerabilities as seen by stakeholders in the Region, participants at the WCVC Climate Change Workshop in April were asked to identify their biggest concerns. They were asked, "what keeps you up at night?" Posters were set up around the

room, and participants were given one star (for highest area of concern) and four dots (other priority areas of concern) and asked to place their star and dots on the posters next to the impacts that most concerned them. The posters each contained a climate stressor and related impacts. More than 85 people representing a broad cross-section of WCVC members participated in the exercise.

These key climate change stressors and related vulnerabilities for the Region are listed below in blue. These are based on the analysis conducted in the two studies referenced previously in this section - *Projected Change in Ventura County Climate* and *Sea Level Rise Vulnerability Assessment* and incorporates the feedback from stakeholders in the exercise described above.

Each of these stressors and vulnerabilities creates challenges for community stakeholders including growers, residents, business/industry owners, property owners, and the natural environment. Many of the vulnerabilities are inter-related and difficult to prioritize – each area of vulnerability may have a different impact or priority to different groups.

The vulnerabilities under each climate stressor listed below are shown in order according to the number of votes from stakeholders. By far, the two largest concerns are the impacts to agriculture and the duration of future droughts, shown in red.

Maximum Temperatures

Daily highs; increased frequency of extreme maximum temperatures

- Impacts to agriculture (both to crops and farmworker health)
- Impacts to ecosystem health and viability
- Water quality impacts
- Energy demand impacts
- Heat and community health

Minimum Temperatures

Overnight lows; increased frequency of extreme high minimum temperatures

- Impacts to agriculture (both to crops and farmworker health)
- Water quality impacts
- Heat and community health
- Energy demand impacts Ecosystem impacts

Increased Evapotranspiration (ET_0)

- Increased water demand (agricultural and urban)
- Impacts to ecosystem health and viability

- Reservoir evaporation
- Reduction in runoff

Precipitation Changes

Increased number of dry days, more intense storms, higher sub-daily rain rates

- Reduced in-stream flows
- More annual precipitation in fewer days
- Increased flash flood risk (high intensity precipitation)
- Reduced snowpack in the Sierra (impacting imported State Water supplies)

Drought

Increased drought risk

- Duration of droughts
- Frequency of droughts
- Reduced snowpack in the Sierra (impacting imported State Water supplies)
- Magnitude of droughts

Wildfire

Extended season, possible greater frequency of ignitions

- Post-fire runoff: debris flows, flash flooding, water quality impacts
- Threats to life, property and wildlife
- Smoke/air quality impacts

Sea Level Rise

- Coastal Erosion – impacts to infrastructure
- Saltwater intrusion/groundwater impacts

In the graphics below, shown in Figure 13-11, the highest concern for stakeholders, as shown by responses with stars (#1 priority), is drought, followed in order by higher maximum temperatures and changes in precipitation. Figure 13-12 highlights the other priority concerns, as measured by the total number of dots. Highest priority concerns were – in order - greater maximum temperatures, changes in precipitation, changes in evapotranspiration rates, drought, and wildfire.

Figure 13-11

Climate Change Concerns as Ranked by Stars – Highest Level Concern

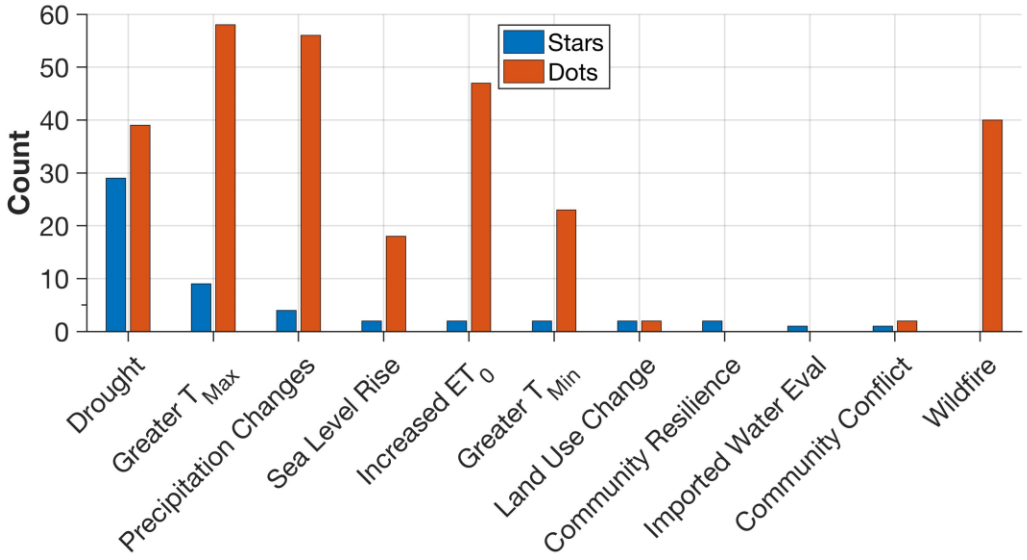
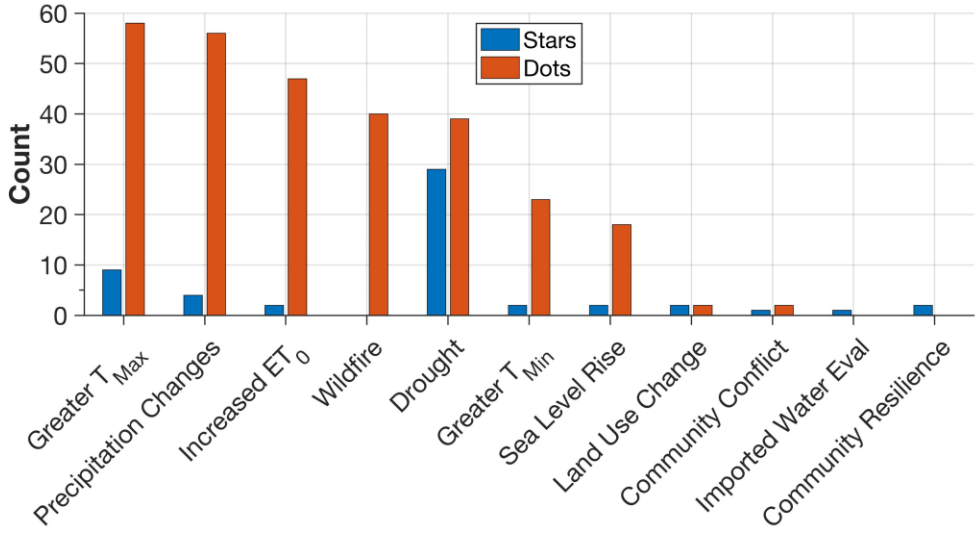


Figure 13-12

Climate Change Concerns as Ranked by Dots – Other Priority Concerns



Summary of High Priority Climate Change Vulnerabilities:
Given the coastal geography, development patterns, importance of agriculture, and natural resource values in the Region, and projected changes in climate, the following vulnerabilities are considered to be of highest priority:

Very High Priority:
Impacts to agriculture – the largest commercial contributor to the local economy - due to drought-driven water shortages, increasing temperatures and evapotranspiration rates, and variation in precipitation (i.e. longer periods without rain).

Impacts to coastal infrastructure and communities including Naval Base Ventura and local groundwater resources due to sea level rise and increased incidences of coastal flooding.

Impacts to in-stream flows and riparian habitats due to more frequent/intense droughts, increasing maximum temperatures and evapotranspiration rates, and changes in precipitation.

High Priority:
Impacts to local urban communities, human populations, and natural resources, due to more intense wildfires, increasing maximum and minimum temperatures, and increased flooding resulting from more intense rainfall events and sea level rise.

Feasibility for WCVC to Address Priority Climate Change Vulnerabilities:
There is no simple answer to address this. WCVC lacks the authority to independently implement many of the solutions and projects to address areas of vulnerability. As previously described, the Region is working to address climate change vulnerabilities through planning and selection of projects and programs that promote resilience to climate change impacts. The feasibility of being resilient to these impacts depends on the rate at which climate changes occur, the cost of implementing necessary projects, policies, and programs, and the ability of state, federal, and local institutions and regulatory entities to align, prioritize, and fund necessary solutions. This will take a higher level of public education and engagement, political will, and considerable financial resources.

13.3 Local Climate Change Adaptation

Adaptation strategies included in the State document *2009 California Climate Adaptation Strategy,* include several strategies already being implemented within the Region:

- Developing the full potential of the IRWM Plan.
- Aggressively increasing water use efficiency.
- Practicing and promoting integrated flood management.
- Enhancing and sustaining ecosystems.
- Expanding (upgrading, restoring) water storage and conjunctive management of surface and groundwater resources.
- Upgrade and increase monitoring, data analysis, and management.
- Plan for and adapt to sea-level rise.

- Support and utilize focused climate change impacts and adaptation research and analysis.

The adaptation capacity of implementing Resource Management Strategies in the Region is addressed at a high level in Section 6 – Resource Management Strategies. Adaptation does not occur at a fixed point in time and is considered an integral part of future planning for projects and programs. In the future, adaptation projects and programs will be adapted and refined as new information becomes available.

WCVC Adaptation Approaches

Stakeholders in the Region recognize the importance of developing strategies and projects which will result in greater local resilience to climate change impacts. Becoming more resilient to climate change impacts is one of the six goals of the WCVC IRWM Plan.
Climate adaptation occurs on many levels:

- Focus on long-range land use planning and development strategies, regulations and water management strategies to minimize risk.
- Development of sustainability policies and programs at the local municipal level – cities, counties, water utilities, energy utilities, environmental management.
- Investment in updated, resilient infrastructure located to accommodate rising sea levels, avoid flood risk and wildfire impacts.
- Education and public awareness programs that fully inform communities about the risks and the actions they can take to mitigate (reduce carbon footprint) and adapt to climate change.
- Establishment of funding mechanisms to implement necessary solutions.
- Prioritization and implementation of projects and programs that directly address climate change impacts.

No regrets adaptations are already being implemented through the projects and programs associated with implementing the IRWM Plan. These include increased water use efficiency, water recycling, integrated flood management, and ecosystem management.

At a recent WCVC Climate Change Workshop participants provided a list of general strategies and projects currently being implemented or considered in the Region:

- Stormwater capture and recharge projects.
- Stormwater wetlands.
- Low impact development.
- Community education and collaboration on resilience (i.e. Project Trim Tab and Climate Now citizen groups).
- Implementation of the Sustainable Groundwater Management Planning Act – through groundwater protection and modeling.
- Analyses and protection of groundwater dependent ecosystems.
- Use of supplemental SWP water – study looking at 99 alternatives to improve resilience.
- Local groundwater desalters and salinity management pipeline.
- Development of potable water reuse projects.

- Natural floodplain management and protection – purchasing easements.
- Agricultural and urban water use efficiency practices and projects.
- Thoughtful long-range planning – addressing climate change in general plans.
- Local funding allocated to match grants to implement projects/programs that increase local resiliency to climate change.
- Intertie and interconnect projects between and among local water purveyors – to assist in emergencies and enhance flexibility and reliability of individual agency portfolio of water supplies.
- Development of additional water reuse projects for irrigation.
- Naval Base Ventura – coastal resilience plans.
- Climate action plans – cities and County.
- More accessible, federated data platforms.
- Public education, messaging – integrating community resilience plans; addressing difficult decision and trade-offs.
- Ocean water desal projects.
- Conversion to drought adapted plants in restoration projects.
- Land acquisition to keep land in open space or hold off development.
- Conserve lands in floodplains.

As the impacts resulting from climate change stressors increase (more severe/longer droughts, more intense rainfall, increasing temperatures, larger more destructive wildfires), entities in the WCVC Region will continue to collaborate on solutions to enhance local resilience. As part of developing this IRWM Plan amendment, WCVC staff, stakeholders and the climatologists from the Western Regional Climate Center in Reno, Nevada reviewed models and studies (such as the 4th Climate Change Assessment and the LOCA models), which guided the assessment of local climate vulnerabilities. Future studies may be needed to develop finer scale projections for climate impacts and updated vulnerability assessments.

Local Project Spotlight: Natural Floodplain Protection Project

One example of a strategy devoted to protecting the Region from the impacts of increased flooding associated with climate change is natural floodplain management. This approach involves employing the concept of "natural infrastructure" (natural processes) to protect property from the impacts of flooding. An example of this is a project being implemented in the Region along the Santa Clara River; The Nature Conservancy's Natural Floodplain Protection Project, funded in part with an IRWM grant from the first round of Proposition 84. Through this project, "grey" infrastructure solutions such as concrete levees are replaced with floodplain easements allowing a creek or river to run its natural course during high flows. Agricultural growers with operations along the river are compensated for placing the floodplain portion of their property in an easement allowing for high flood flows to continue to encroach on their fields. The costs of the easements is far less than the cost to construct and maintain "hard" infrastructure. The floodplain easements prevent expansion of urban flooding while helping ensure that riparian and wetlands on the river will thrive.

13.4 Local Efforts to Reduce Energy Use and Greenhouse Emissions (GHG) for Climate Change Mitigation

Water and energy are inextricably linked. The complex and mutually dependent relationship between water and energy is known as the water-energy nexus. As water constraints increase, energy production becomes more vulnerable, and concerns are raised regarding the effect energy operations have on availability and quality of water. A large amount of water is required to produce energy, and energy is required for water use (heating water) and wastewater treatment and conveyance and distribution.

Balancing these competing needs and increasingly scarce resources will require increased water and energy use efficiency, development of innovative technology, and adoption and implementation of supporting policies programs at the state and local level.

Reducing energy demand associated with water use, treatment, and conveyance can help mitigate climate change by reducing GHG emissions.

The State's IRWM Plan Standards require IRWM Regions to consider ways to reduce energy consumption, disclose and consider greenhouse gas (GHG) emissions when choosing between project alternatives and consider options for carbon sequestration and/or use of renewable energy sources.

The County of Ventura leads a variety of regional water and energy programs. Regional water and energy program teams (staff) in the County of Ventura CEO's office are actively involved with other entities (cities and counties) on the Central Coast to implement sustainability practices, including comprehensive energy efficiency measures. See below for more details regarding these partnerships

designed to improve sustainability and adapt to and mitigate climate change through energy demand reduction and use of renewable energy. Reducing GHG is a major driver in these programs. Water and wastewater utilities in the WCVC Region benefit from these programs through increased use of and access to affordable renewable energy, reduced energy demand, and the cost-effective approach of the collaborative programs among local cities and counties.

Central Coast Climate Collaborative:
WCVC, through the County of Ventura is a member of the Central Coast Climate Collaborative (4C) which includes six counties in the Central Coast of California. Their mission statement describes the organization as follows: "The Central Coast Climate Collaborative is a membership organization fostering a network of local and regional community leaders throughout six Central Coast counties to address climate change mitigation and adaptation. The Collaborative involves representatives from local and regional government, business and agriculture, academia, and diverse community groups to share information and best practices, leverage efforts and resources, and identify critical issues and needs. The Collaborative will engage all communities throughout the region to help ensure a resilient and low-carbon Central Coast prepared for the impacts of climate change." WCVC

and representatives from the other IRWM programs across the six counties participate in the 4C efforts to collaborate on addressing water and energy initiatives related to climate change.

Community Choice Energy (CCE)– Joint Powers Authority:
The Ventura County region, including WCVC, is committed to reducing greenhouse gas (GHG) emissions and energy demand and advancing the use of local renewable energy resources. To realize this commitment, the County of Ventura works with neighboring Santa Barbara, Los Angeles, and San Luis Obispo counties. To implement the regional commitment, the County of Ventura, along with the cities of Camarillo, Moorpark, Ojai, Oxnard, Simi Valley, Thousand Oaks, and Ventura, have joined the Clean Power Alliance of Southern California (CPA) – a Community Choice Energy (CCE) Joint Powers Authority (JPA) that serves Ventura and Los Angeles Counties to procure clean renewable energy for the residents of and businesses in the region. The City of Santa Paula has joined California Choice Energy Authority, which is another CCE serving Southern California. The CCE model puts energy purchasing and pricing options into the hands of local decision-makers and allows the community to determine what type of energy mix serves its needs. In many cases, CCE programs can offer energy with a higher renewable energy content at rates that are competitive with the existing utility's rates. Because a CCE operates as a local non-profit, CCE revenues can also be reinvested in the community in the form of clean energy projects and incentive programs, both of which can spur local economic opportunities. Moreover, the County is the program administrator of the Tri-County Regional Energy Network (3C-REN) with the California Public Utilities Commission. 3C-REN serves the specific needs of Ventura, Santa Barbara, and San Luis Obispo counties and their communities by offering a variety of programs designed for regional integration and delivery of energy efficiency solutions that pilot innovative ideas. For further information about 3C-REN, see below.

The County of Ventura also works locally with the cities, special districts, schools, and community-based organizations (CBOs) within the Ventura County region to establish a local commitment to reduce GHG emissions and energy demand by administering the Ventura County Regional Energy Alliance (VCREA). VCREA is a Joint Powers Authority (JPA) comprised of public agencies working in collaboration to address good energy stewardship and sustainability practices in the region. VCREA coordinates and assists public agencies, including local jurisdictions, schools, and special districts, as well as businesses and residents of Ventura County to best utilize the many resources available to achieve the goal of creating a more sustainable future for the entire region. VCREA's mission is to partner local resources for residential, commercial, and municipal energy efficiency, serving as a one-source resource.

VCREA is the Program Implementer for the Local Government Partnership (LGP) program, which provides centralized access to Southern California Edison's and Southern California Gas Company's wide array of energy efficiency programs which benefits water and wastewater utilities as well as other users. The LGP's focus is to 1) assist its member agencies to address energy efficiency in buildings, 2) offer energy efficiency trainings, 3) support residents through education and outreach, 4) assist local businesses through the Ventura County Green Business Program, and 5) support schools, community colleges, and special districts with their efforts to achieve their sustainability goals.

In addition to implementing energy efficiency projects, VCREA is taking other actions to combat climate change. VCREA collaborates with cities, business, residents, and multi-family property

owners to develop a Ventura County Electric Vehicle Community Readiness Blueprint. The Blueprint will accelerate the deployment of electrified transportation by providing a step-by-step plan for the region. Furthermore, VCREA works with cities, energy analysts, and CBOs to 1) implement an energy efficiency benchmarking and auditing program for businesses and multi-family developments, and 2) provide energy and safety assessment for residents. VCREA and local governments are developing regional and city-specific greenhouse gas inventories and Energy Action Plans. Additionally, the County of Ventura is improving its own environmental performance by developing a Climate Action Plan and implementing the associated commitments and actions to reduce greenhouse gas emissions by 15 percent by the year 2020. Similarly, the City of Simi Valley developed a Climate Action Plan to provide an analysis of GHG emissions and sources attributable to land uses in the City of Simi Valley and to recommend policies and actions that can reduce those associated GHG emissions. Other local actions include investing in solar installations and other renewable energy sources, reducing water usage by changing landscape and irrigation practices, implementing green building and purchasing policies, providing energy efficiency and climate change and adaptation trainings, and encouraging behavioral change throughout the community through outreach and education programs.

Tri-County Regional Energy Network (REN):
The Tri-County (3C) Regional Energy Network (REN) is a collaboration of three counties - Ventura, Santa Barbara, and San Luis Obispo - in the California Central Coast Region, with a diverse service area that is geographically isolated from utility hubs, has pockets of rural and disadvantaged communities, as well as large underserved Spanish-speaking populations. After several years' experience and cooperative administration of energy and sustainability programs, the tri-county local governments formed the 3C-REN, led by the County of Ventura, to better leverage resources in the delivery of effective programs on a regional level. This program includes several elements: a residential direct install energy efficiency program including targeted outreach for hard-to-reach customers, a codes and standards training and enforcement program, and a workforce, education, and training program. The REN was approved by the California Public Utilities Commission (CPUC) as a means to "deliver programs that meet CPUC criteria as indicated by Decision 12-11-015 in the

formation and implementation of programs: filling gaps that the investor-owned utilities ("IOUs") are not serving; developing programs for hard-to-reach markets; and piloting new approaches to programs that have the potential to scale and offer innovative avenues to energy savings." Funding for the REN was authorized by the CPUC and comes from energy utility revenues.

Through these energy and sustainability partnerships, local agencies have been working to establish Ventura County, its communities, and neighboring regions as the leader in developing and implementing durable, sustainable energy initiatives that support sensible growth, a healthy environment and economy, enhanced quality of life, and greater self-reliance for the region. There is a strong link between management of water and energy resources; the County's energy programs are coordinated with the IRWM Program.

County General Plan Update 2040 – Climate Action Plan and Background Report

The County of Ventura is engaged in a multi-year process to prepare a comprehensive update to the General Plan for the unincorporated areas of the County (see Section 12 of this IRWM Plan

amendment for more details about this effort). According to the introduction, "The Ventura County 2040 General Plan is a long-range plan that guides decision-making and establishes rules and standards for development and county improvements. It reflects the County's vision for the future and is intended to provide direction through the year 2040." At the start of the (?) or a (?) multi-year planning process, the County and its consultants prepared a Background Report, which serves as a "snapshot" of existing (2016) conditions and trends in Ventura County. It is divided into 12 chapters that cover a wide range of topics within the county, such as demographic and economic conditions, land use, public facilities, and environmental resources. Unlike the Policy Document, the Background Report is objective and policy-neutral and provides decision-makers, the public, and local agencies with context for making policy decisions. The Background Report also serves as the basis for the "Environmental Setting" section of the Environmental Impact Report (EIR) for the General Plan." Chapter 12 of the Background Report addresses climate change and addresses GHG emissions and climate change effects." (Source, Introduction, Background Report).

The General Plan Update also includes the policy document, which is the vision and blueprint for future planning. The preliminary draft public review document – the 2040 General Plan - addresses climate change across all the elements, and includes a focused discussion about climate change in Appendix B. As noted in the introduction to Appendix B, "the County developed an integrated approach to addressing climate change in the General Plan by incorporating related policies and programs throughout the General Plan elements, such that the General Plan will also serve as the County's Climate Action Plan (CAP). The purpose of this Climate Change Appendix is to provide further details regarding the General Plan's integrated climate action strategy, including a summary of results of key technical analyses used to develop the strategy. Section B.1 of this Appendix includes the components of the County's greenhouse gas (GHG) emissions reduction strategy, (GHG Strategy), while Section B.2 of this Appendix documents the County's vulnerability to climate change and Climate Adaptation strategy." This long-range planning process is being conducted simultaneously with the amendment to the WCVC IRWM Plan.

As part of the IRWM project review and selection process in the Region described in Section 7 – Project Review Process, a high-level analysis of GHG emissions is conducted. The lead agency for a

project undergoing CEQA review must conduct a more detailed assessment of the impacts of GHG emissions associated with the project and make a determination of significance.

A helpful resource for conducting this analysis is the California Air Pollution Control Officers Association (CAPCOA) handbook *Quantifying Greenhouse Gas Mitigation Measures – A Resource for Local Government to Assess Emission Reductions from Greenhouse Gas Mitigation Measures.* Section 4 of that document includes water supply projects such as recycled water, gray water, locally sourced water and water use management projects such as low-flow water fixtures, conservation strategies, water-efficient landscape designs and irrigation systems, reduction of turf in landscapes, and installation of native and drought-resistant landscape plantings. This information will be used by project proponents when project-specific analysis is conducted.

13.5 Plan for Ongoing Data Gathering, Vulnerability Assessment and Adaptive Management

The State's IRWM Plan Standards suggest that IRWM plans "contain policies or procedures that promote adaptive management. As more effects of climate change manifest, new tools are developed, and new information becomes available, RWMGs will need to adjust their IRWM Plans to integrate new knowledge and data into those plans. "

The WCVC Region will incorporate and analyze new data and information related to climate change and continue to assess and modify when necessary the vulnerabilities, inventory of vulnerable infrastructure, and adaptation strategies/projects. This will occur primarily at the watershed level with periodic workshops at the regional level.

Adaptive management will also be conducted through implementation of - and updates - to local general plans, urban water management plans, climate action plans, groundwater sustainability plans, sea level rise plans, habitat management plans and other long and short-range planning efforts directed to climate change adaptation and mitigation.

Cited References:

Pierce, D. W., D. R. Cayan, and B. L. Thrasher, 2014: **Statistical downscaling using Localized Constructed Analogs (LOCA)**. Journal of Hydrometeorology, volume 15, page 2558-2585.

Polade, S. D., Pierce, D. W., Cayan, D. R., Gershunov, A., & Dettinger, M. D. (2014). The key role of dry days in changing regional climate and precipitation regimes. *Scientific reports*, *4*, 4364. https://www.nature.com/articles/srep04364

Reich, KD, N Berg, DB Walton, M Schwartz, F Sun, X Huang, and A Hall, 2018: "Climate Change in the Sierra Nevada: California's Water Future." UCLA Center for Climate Science. https://www.ioes.ucla.edu/wp-content/uploads/UCLA-CCS-Climate-Change-Sierra-Nevada.pdf