Section R: Climate Change

The Integrated Regional Water Management (IRWM) Program Guidelines state: "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, ecosystem, and long-term water supply reliability, will be among the most significant challenges facing water and flood managers this century" (p. 69). 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.

The intent of the Climate Change standard in the IRWM Program Guidelines is to ensure that IRWM Plans describe, consider, and address the effects of climate change on their regions and disclose, consider, and reduce when possible greenhouse gas (GHG) emissions when developing and implementing projects. This chapter describes global climate change and its anticipated impacts for the Greater Monterey County region. The chapter includes an initial vulnerability analysis and risk assessment, and offers preliminary adaptation measures and climate change mitigation and GHG reduction strategies for the region. These strategies will be refined as more climate change data, and more refined analysis tools, become available.

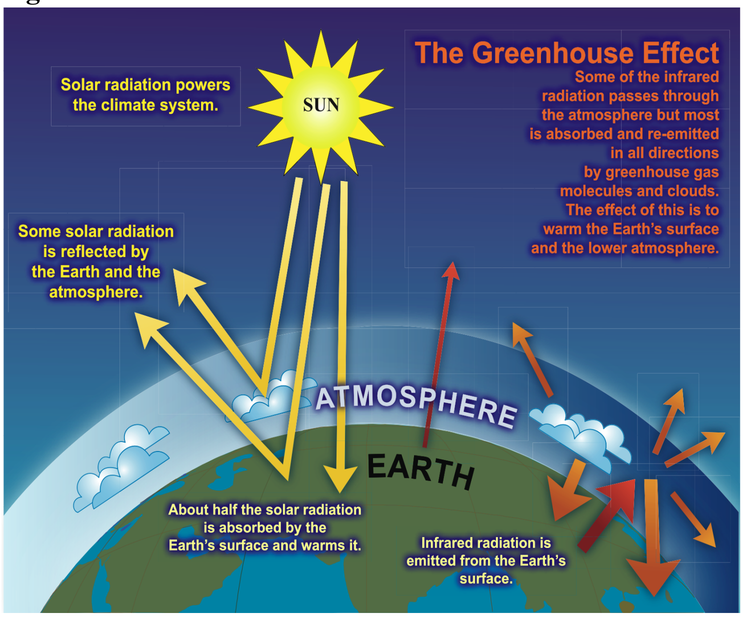
Most of the work for this chapter was conducted by the Central Coast Wetlands Group at Moss Landing Marine Laboratories (CCWG), in collaboration with a Climate Task Force comprised of local scientists, land use managers, water resource managers, and coastal policy experts. Participating entities on the Climate Task Force include: CCWG, Stanford University Center for Ocean Solutions, Monterey Bay National Marine Sanctuary, Santa Cruz County, Association of Monterey Bay Area Governments, Monterey County Planning, California Water Company, Monterey County Water Resources Agency, Stanford University Natural Capital Project, California Department of Water Resources, Santa Cruz County Resource Conservation District, and The Nature Conservancy. The Regional Water Management Group (RWMG) will continue to seek to partner with these entities, as well as with other RWMGs in the Central Coast region, and to participate in other regional climate change efforts in order to collectively and proactively address the issue of climate change on the Central Coast.

R.1 GLOBAL CLIMATE CHANGE: AN OVERVIEW

Climate change refers to any significant change in measures of climate, such as average temperature, precipitation, or wind patterns over a period of time. Climate change may result from natural factors and/or from human activities that change the composition of the atmosphere and alter the surface features of the land. Such changes vary considerably by geographic location. Over time, the earth's climate has undergone periodic ice ages and warming periods, as observed in fossil isotopes, ice core samples, and through other measurement techniques. Recent climate change studies use the historical record to predict future climate variations and the level of fluctuation that might be considered statistically normal given historical trends.

Significant changes in global climate patterns have recently been associated with global warming, an average increase in the temperature of the atmosphere near the Earth's surface. This gradual warming is the result of heat absorption by certain gases in the atmosphere and re-radiation downward of some of that heat, which in turn heats the surface of the Earth. These gases are called "greenhouse gases" because they effectively "trap" heat in the lower atmosphere causing a greenhouse-like effect. Some GHGs occur naturally and are emitted to the atmosphere through natural processes, others are created and emitted solely through human activities, while the production rate of some naturally occurring GHGs can be increased by human activities (California Natural Resources Agency 2018).

Figure R-1: The Greenhouse Effect



Source: IPCC 2007a, p. 115.

The greenhouse effect helps to regulate the temperature of the planet. It is essential to life; without it, our planet would have an average temperature of about 14°F, as opposed to a comfortable 60°F. However, an accumulation of GHGs in the atmosphere is intensifying the greenhouse effect, threatening to raise average temperatures well beyond our "comfort zone." Nearly all climate scientists agree that human activities are to blame for the changing climate. The addition of carbon dioxide, the most prevalent GHG, into the atmosphere as a result of burning oil, natural gas, and coal, in combination with the depletion of our dense forests and wetlands which act as natural carbon dioxide sinks, are leading to an unnaturally high concentration of GHGs that are in turn intensifying the natural greenhouse effect on earth.

The Intergovernmental Panel on Climate Change (IPCC) stated in its 2007 Synthesis Report:

> *Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. (*IPCC 2007a, p. 30)

Each of the last three decades has been increasingly warmer at the Earth's surface than any preceding decade since 1850. The time period 1983 to 2012 was likely the warmest 30-year period of the last 1400 years in the Northern Hemisphere (to the extent that assessment was possible). The temperature increase is widespread over the globe and is greater at higher northern latitudes. Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years. Ocean warming makes up the majority of the increased energy stored in the climate system, and accounts for more than 90% of the excess energy stored between 1971 and 2010. The top 75 meters of the ocean have increased in temperature by approximately 0.1 degree Celsius each decade since 1970, while the average global surface temperature has increased by 0.85 degrees Celsius between 1880 and 2012 (IPCC 2014).

The IPCC has linked this increase in global temperature to a wide array of changes to our natural world, including a widespread decrease in the amount of snow cover and thickness and range of glaciers across the globe. Since 1978, the Arctic ice cap has decreased in size by about 4 percent per year with an average summer decrease of 7.4 percent. A 10 percent decrease in global snow cover and earlier spring thaws of rivers and lakes in the northern hemisphere have also been observed. Over the past 50 years, heat waves and serious rain events have been more common and in the past 30 years, there has been an increase in the number of northern Atlantic tropical storms (IPCC 2007a).

The combination of ice melt and the thermal expansion of seawater (due to warmer water temperatures) has led to global sea level rise (IPCC 2014). Research shows that since 1971, thermal expansion and glacial melt have caused 75% of observed sea level rise (IPCC 2014). From 1870 to 2004, a reconstruction based on tide gauge data finds that during the 20th century, sea-level rise occurred at a rate of 1.7 +- 0.3 mm/year. During this time, sea-level rise also accelerated at a rate of 0.013 +- 0.006 mm/year^2 (Church and White 2006). More recent estimates show that from 1880 to the present, the average global sea level has risen by more than 20 centimeters (Church and White 2011). The IPCC's 2014 Fifth Assessment Report (IPCC 2014) projected sea level rise by the end of the century as a result of thermal expansion to range from 0.23 to 0.98 meters (9 - 48 inches). It predicts with "virtual certainty" that sea level rise will continue beyond 2100, and projects sea level rise beyond 2300 to be between 1 and 3 m (IPCC 2014).

IPCC scientists predict that the serious consequences of climate change will continue to grow and expand. The rate of increase in sea surface temperature is unprecedented, and is accelerating the planet's water cycle, which will result in extreme weather events throughout the globe. Droughts, storms, floods, and wildfires will become more common. These events will expose ecosystem and human system vulnerability, and will likely disrupt and damage food and fresh water supplies (IPCC 2014). The extreme increases in temperature to could result in a summer ice-free arctic by 2050 (IPCC 2014) and cause the oceans to thermally expand, both of which will raise the average level of all oceans. This continuing increase in average global sea level will have various effects, including coastline destruction, the displacement of major population centers, and economic disruption.

R.2 STATE RESPONSE TO CLIMATE CHANGE: LEGISLATION AND POLICY

California State's top scientists consider climate change to be a very serious issue requiring major changes in resource, water supply, and public health management (California Climate Change Center 2012). Below describes some of the more significant pieces of legislation and policy that have been enacted by the State in response to climate change.

California's first statute on climate change was enacted in 1988 when the State Legislature ordered a report on the impacts of climate change and recommendations to avoid, reduce, and address them. In 2002, the State led the country in becoming the first jurisdiction to require standards for GHG emissions from cars. In 2004, Senate Bill 1107 directed the Secretary of Environmental Protection to coordinate all climate change activities in the state. The Secretary chairs the Climate Action Team, which is made up of agency secretaries and department directors from throughout State government. With the passage of California Global Warming Solutions Act of 2006, also known as Assembly Bill (AB) 32, California became the first state to set a binding, economy-wide target for GHGs (California EPA 2010).

Executive Order S-3-05

California is a substantial contributor of global GHGs, emitting over 400 million metric tons of carbon dioxide a year (California Air Resources Board 2007). In June 2005, Governor Schwarzenegger established California's GHG emissions reduction targets in Executive Order S-3-05. The Executive Order established the following goals:

- Greenhouse gas emissions should be reduced to 2000 levels by 2010;
- Greenhouse gas emissions should be reduced to 1990 levels by 2020; and
- Greenhouse gas emissions should be reduced to 80 percent below 1990 levels by 2050.

Global Warming Solutions Act of 2006 (Assembly Bill 32)

The State Legislature enacted AB 32, the California Global Warming Solutions Act of 2006, which Governor Schwarzenegger signed on September 27, 2006 to further the goals of Executive Order S-3-05. AB 32 states:

> *Global warming poses a serious threat to the economic well-being, public health, natural resources, and the environment of California. The potential adverse impacts of global warming include the exacerbation of air quality problems, a reduction in the quality and supply of water to the state from the Sierra snowpack, a rise in sea levels resulting in the displacement of thousands of coastal businesses and residences, damage to marine ecosystems and the natural environment, and an increase in the incidences of infectious diseases, asthma, and other human health-related problems.*

AB 32 represents the first enforceable statewide program to limit GHG emissions from all major industries with penalties for noncompliance. The foremost objective of California Air Resources Board (CARB), tasked with implementing AB 32, is to adopt regulations that require the reporting and verification of statewide GHGs. The initial State goal is to limit GHG emissions to 1990 levels by 2020. In January 2008, a statewide cap for 2020 emissions based on 1990 levels was adopted. In June 2010, CARB prescribed GHG reduction goals to regional governments, including the Association of Monterey Bay Area Governments (AMBAG). These prescriptions are the regional benchmarks from which to track local reductions.

Executive Order S-1-07 (2007)

On January 18, 2007, California further solidified its dedication to reducing GHGs by setting a new Low Carbon Fuel Standard for transportation fuels sold within the state. The target of the Low Carbon Fuel Standard is to reduce the carbon intensity of California passenger vehicle fuels by at least 10 percent by 2020.

Senate Bill 97 (2007)

SB 97, enacted in 2007, amended the California Environmental Quality Act (CEQA 2012) statute to clearly establish that GHG emissions and effects of GHG emissions are subject to CEQA. It also directed the Governor's Office of Planning and Research (OPR) to develop CEQA Guidelines to address GHG emissions for approval by the California Natural Resources Agency. The Natural Resources Agency adopted the amendments in January 2010, which went into effect in March 2010. The amendments do not identify a threshold of significance for GHG emissions, nor do they prescribe assessment methodologies or specific mitigation measures. The amendments encourage lead agencies to consider many factors in performing a CEQA analysis, but preserve the discretion granted by CEQA to lead agencies in making their own determinations based on substantial evidence. The amendments also encourage public agencies to make use of programmatic mitigation plans and programs when they perform individual project analyses.

Executive Order S-13-08 (2008)

Executive Order S-13-08 launched a major initiative for improving the state's adaptation to climate impacts from sea level rise, increased temperatures, shifting precipitation, and extreme weather events. It ordered a California Sea Level Rise Assessment Report to be conducted by the National Academy of Sciences, which was released in June 2012. It also ordered the development of a California Climate Change Adaptation Strategy. The Strategy, published in December 2009, assesses the state's vulnerability to climate change impacts, and outlines possible solutions that can be implemented within and across State agencies to promote resiliency. The Strategy focuses on seven areas: public health, biodiversity and habitat, ocean and coastal resources, water management, agriculture, forestry, and transportation and energy infrastructure.

California Ocean Protection Council Resolution

California Ocean Protection Council (OPC) Resolution, adopted on March 11, 2011, requires the vulnerabilities associated with sea level rise to be considered for all projects or programs receiving funding from the State. The Resolution states: "Given the currently predicted effects of Climate Change on California's water resources, IRWM Plans should address adapting to changes in the amount, intensity, timing, quality and variability of runoff and recharge. 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 will also need to consider the effects of sea level rise on water supply conditions and identify suitable adaptation measures." The OPC resolution and sea level rise guidance can be found at the following link: http://www.opc.ca.gov/council-documents/.

Senate Bill X1-2

This bill codifies California's ambitious goal to increase the quantity of energy generated from renewable sources. The ultimate goal is to have 33% of energy in California generated from renewable sources by 2020, with benchmarks of 20% by 2013, 25% by 2016. This bill enables the California Public Utilities Commission Renewable Energy Resources Program to enforce these goals upon all electricity retailers.

Various Legislative Actions to Promote Electric Vehicles and Zero Emission Vehicles

California passed four different legislative actions between the years of 2013 and 2014 to promote the use of electric and zero emission vehicles. SB 1275 (2014) established a state goal of 1 million zero emission and near zero emission vehicles to be in service by 2020. SB 1204 (2014) created the California Clean Truck, Bus, and Off-Road Vehicle and Equipment Technology Program to develop, pilot and deploy zero- and near zero- emission vehicle technologies. AB 8 (2013) extended extra fees on vehicle and boat registrations and tire sales to fund programs that support promotion of alternative fuels, vehicle technologies, and air emission reduction strategies. AB 1092 (2013) required the Building Standards Commission to adopt mandatory building standards for the installation of future electric vehicle charging infrastructure for parking spaces in multifamily dwellings and nonresidential development.

Senate Bill 350 (2015)

SB 350, enacted in 2015, requires that the amount of renewable electricity generated and sold to retail customers be increased to 50% by December 2030. This requirement is made through the Public Utilities Act and the Public Utilities Commission, which codifies the California Renewables Portfolio Standards (RPS) Program. This act revised the RPS program to incorporate expanded requirements on public and publicly owned electric utilities. This bill also requires the PUC to establish targets to double the energy efficiency savings in electricity and natural gas end uses by 2030.

California Commitment to Paris Climate Accord

California Governor Jerry Brown launched America's Pledge, an initiative to support the goals of the Paris Climate Accord that will report on State efforts to drive down GHG emissions. The initiative is meant to show support for the agreement in the United States. The Paris Climate Accord is a pact that was made by nearly 200 countries in 2015, requiring countries to scale down their carbon emissions along with other measures to slow down the human causes of climate change.

R.3 PREDICTED EFFECTS OF CLIMATE CHANGE IN CALIFORNIA

R.3.1 Statewide Studies

Climate change models predict changes in temperature, precipitation patterns, water availability, and sea levels, and how these altered conditions can have impacts on natural and human systems in California. Sea levels have risen by as much as seven inches along the California coast over the last century, increasing erosion and pressure on the state's infrastructure, water supplies, and natural resources. The state has also seen increased average temperatures, more extreme hot days, fewer cold nights, a lengthening of the growing season, shifts in the water cycle with less winter precipitation falling as snow, and both snowmelt and rainwater running off sooner in the spring (California Natural Resources Agency 2017). According to the California Department of Water Resources (DWR 2013), more changes related to climate change can be expected by the year 2050 and on to the end of the century:

- California's mean temperature may rise 1.5°F to 5.0°F by 2050 and 3.5°F to 11°F by the end of the century.
- Average annual precipitation may show little change, but more intense wet and dry periods can be expected with more floods and more droughts.
- Flood peaks will become higher and natural spring/summer runoff will become lower.
- Global sea level projections suggest possible sea level rise of approximately 14 inches (36 cm) by 2050 and a high value of approximately 55 inches (140 cm) by 2100.[1]

Globally, sea level rise is driven by two primary factors—global ice melt and thermal expansion of seawater—but locally, other factors can alter the rate, extent, and duration of changes in sea level. These processes include "steric variations, wind-driven differences in ocean heights, gravitational and deformational effects, and vertical land motions along the coast" (Committee on Sea Level 2012), and in California are additionally affected by movement along the San Andreas Fault and climate patterns in the Pacific Ocean, including the El Niño Southern Oscillation and the Pacific Decadal Oscillation and Interdecadal Pacific Oscillation. Large El Niño events can temporarily raise the sea level as much as 3 to 12 inches (10-30 cm) for several winter months (Committee on Sea Level 2012).

Mean sea level on the California coast rose approximately 8 inches (17-20 cm) over the past century (1900 – 2005) (Cayan et al. 2008). Since 1993, altimetry data suggests that the global mean sea level rise rate has increased from 2 to 3 mm/year, but during this time, data from altimetry and tide gauges show that the mean sea level along the Pacific coast has been stable due to wind stress (Bromirski et al. 2011).

[1] The State of California uses estimates of global sea level rise produced by Ramstorf 2007 and Cayan et al. 2008 for coastal adaptation planning purposes under Executive Order S-13-08.

The changes in sea levels, temperature, and precipitation that are anticipated to occur with climate change, as described above, will affect California's public health, habitats, ocean and coastal resources, water supplies, agriculture, forestry, and energy use (California EPA 2010), and will result in increased droughts and flooding. Climate change may also have adverse effects on water quality, which would in turn affect the beneficial uses (habitat, water supply, etc.) of surface water bodies and groundwater. Changes in precipitation could result in increased sedimentation, higher concentrations of pollutants, higher dissolved oxygen levels, increased temperatures, and an increase in the amount of runoff constituents reaching surface water bodies.

In addition, climate change is expected to have effects on diverse types of ecosystems, from alpine to deep sea habitat. As temperatures and precipitation change, seasonal shifts in vegetation will occur; this could affect the distribution of associated flora and fauna species. As the range of species shifts, habitat fragmentation could occur, with acute impacts on the distribution of certain sensitive species. The IPCC states that "20 percent to 30 percent of species assessed may be at risk of extinction from climate change impacts within this century if global mean temperatures exceed 2°C to 3°C (3.6°F to 5.4°F) relative to pre-industrial levels" (IPCC 2007a). Shifts in existing biomes could also make ecosystems vulnerable to invasive species encroachment. Wildfires, which are an important control mechanism in many ecosystems, may become more severe and more frequent, making it difficult for native plant species to repeatedly re-germinate. In general terms, climate change is expected to put a number of stressors on ecosystems, with potentially catastrophic effects on biodiversity.

R.3.2 Regional Studies and Efforts

A number of studies have been completed that evaluate hazard vulnerabilities of various portions of the Monterey Bay and Monterey County. The following provides a brief summary of regional studies and efforts.

Philip Williams and Associates (PWA) Coastal Regional Sediment Management Plan for Southern Monterey Bay (2008): This plan, prepared by PWA in 2008, aims to create a comprehensive regional strategy to approach issues of coastal erosion and protection in the Southern Monterey Bay, from Wharf 2 to the Monterey Submarine Canyon. The plan looks at local geomorphology, physical processes of erosion, sediment transport, sediment budget, critical habitat and species, existing vulnerable infrastructure, and various regulatory processes, and then proposes management strategies and analyzes their feasibility and projected effectiveness. These strategies include beach nourishment and restoration, sand reduction and removal, and continued natural erosion, while emphasizing the expansion of policies and governance structures to better manage coastal sediments.

ESA PWA Technical Evaluation of Erosion Mitigation Alternatives (2012): This study, conducted by ESA PWA for the Southern Monterey Bay Coastal Erosion Working Group and the Monterey Bay National Marine Sanctuary, assesses various coastal erosion mitigation strategies through cost-benefit analyses. The analyses compare the coastal erosion mitigation strategies to more traditional coastal armoring in order to develop strategies to minimize erosion hazards in the Southern Monterey Bay Littoral Cell. The set of 22 proposed tools highlights rolling easements, cessation of sand mining, and managed retreat, with specific recommendations over four timeframes for each sub-region.

ESA PWA Monterey Bay Sea Level Rise Vulnerability Study: Technical Methods (2014): This vulnerability study and technical methods report, prepared by ESA PWA for the Monterey Bay Sanctuary Foundation, presents the methods and data used to develop maps of erosion and coastal flooding hazard zones for the Monterey Bay study area, from Año Nuevo to Monterey's Wharf 2. The hazard zones, including dune and cliff erosion, rising tides, and coastal storm flooding, take into account geology, tides, waves, historic erosion, existing armoring, and various sea level rise projections in order to most accurately represent the projected extents of erosion and flooding for 2030, 2060, and 2100. This report describes in depth the GIS layers and metadata for each hazard zone, and the processes used to create those layers.

The Nature Conservancy's Coastal Resiliency Mapping Tool (2015): The Nature Conservancy (TNC) has developed a publicly accessible interactive mapping tool to view projected sea level rise hazards for various geographies across the world, on both local and global scales. Users can explore the extent of flooding and erosion along selected coastlines—specifically in the Americas or on a global scale—for multiple time horizons or amounts of sea level rise, and can overlay ecological, social, or economic layers to view vulnerabilities.

City of Monterey Final Sea Level Rise and Vulnerability Analyses, Existing Conditions and Issues Report (2016): This report, by Revell Coastal, provides analyses of the existing conditions and future vulnerabilities from sea level rise of various sectors, including land use and structures, transportation, wastewater, hazardous materials, emergency services, ecological resources and more in the City of Monterey. The data is reported in detailed maps, charts, and recommendations for each sector. The report also details the physical setting of the City of Monterey, including the geology and geomorphology of the coastline and the coastline ecological habitats and human development, and looks at the current climate science and projections, including temperature, precipitation, wildfires, and sea level rise projections.

TNC Economic Impacts of Climate Adaptation Strategies for Southern Monterey Bay (2016): This report, prepared by TNC, provides detailed economic analyses of various potential adaptation strategies for combating sea level rise and erosion in southern Monterey Bay, from Moss Landing to Del Monte. The report takes into account a range of sea level rise projections, and analyzes the social, environmental, and economic costs and benefits of many adaptation strategies in order to provide coastal planners with an understanding of the value of different strategies within each of the four focus areas. The report found that, contrary to conventional wisdom, in these four areas, hard shoreline armoring had significantly lower net present values than alternative adaptation strategies.

Moss Landing, Capitola, and Santa Cruz County Sea Level Vulnerability reports (2017): The recent Moss Landing Coastal Climate Change Vulnerability Report (CCWG 2017) documented that Moss Landing, Castroville, and nearby farmlands are vulnerable to both river and ocean flooding. Historical examples of this risk include the March 1995 storms which resulted in county-wide flooding to private property resulting in damage to 1,500 homes and 110 businesses. In Castroville 312 residences and 38 businesses were damaged and 1,320 residents were evacuated. The County documented that the flood event in February 1998 resulted in losses of over $38 million, with agriculture-related losses totaling over $7 million and damaging 29,000 acres of crops.

The Capitola and Santa Cruz County reports document similar hazards in Santa Cruz County along the coast with similar or more extensive impacts to residential and agricultural properties. By 2100 sea level rise and fluvial models used in this analysis project that much of the coastal and low-lying areas along rivers may be periodically flooded during winter storms and high river discharges. By 2100 tidal inundation within low lying coastal areas may pose a serious challenge. Each of these reports makes valuable adaptation recommendations.

Federal Emergency Management Agency (FEMA) – Pacific Coastal Flood Mapping (Expected Completion 2018): FEMA is working to update the Pacific Coastal flood maps through the California

Coastal Analysis and Mapping Project for Region IX. This project is incorporating the latest engineering and mapping data for areas impacted by coastal flooding for the California coast in order to provide the most up-to-date coastal flood maps.

Safeguarding California Plan: 2018 Update (2018): This Natural Resources Agency report, which is an update to the 2009 California Climate Adaptation Strategy, provides policy guidance for State decision makers and highlights climate risks in nine sectors impacted by climate change, discusses progress to date, and proposes real-world, realistic recommendations for actions to reduce climate change impacts.

State of California Sea-Level Rise Guidance (2018): This Ocean Protection Council report specifically recommends that "risk assessments and adaptation planning efforts should be conducted at community and regional levels" including "cross-jurisdictional coordination."

Residential Adaptation Policy Guidance (Revised Draft 2018): The California Coastal Commission's Residential Adaptation Policy Guidance provides an in-depth discussion of sea level rise adaptation policies related to residential development.

R.4 PREDICTED EFFECTS OF CLIMATE CHANGE IN THE GREATER MONTEREY COUNTY REGION

This section first evaluates projected changes in climate variables and then considers the impacts of climate change on the local region.

R.4.1 Projected Changes in Climate Variables

Many climate models have been generated to predict changes in ocean and land temperature, rain frequency and intensity, coastal wave exposure, and sea level rise. Modeling using regional climate models has matured over the past decade to enable meaningful climate vulnerability assessment applications (Wang et al. 2004). California has created several web-based interfaces to help local and regional planners "downscale" climate models for local planning purposes. The Cal-Adapt website (http://cal-adapt.org/) provides a geographically based climate model interpretation tool that generates predictive changes to various climate variables using different IPCC GHG emissions projections. Emissions scenario A2 (High Emissions Scenario) coincides with a scenario in which no effort is taken to alter present practices, resulting in increasing rates of emissions. Emissions scenario B1 (Low Emissions Scenario) coincides with emission rates associated with global success at curbing emissions as prescribed within international climate treaties.

The Cal-Adapt tool was used to project changes in various climate variables that may affect water resources within the Greater Monterey County IRWM planning area. Four areas of the region were used to reflect different climate regimes: Coastal Monterey Bay, Coastal Big Sur Mountains, Inland Valley, and Inland Mountains (Figure R-2). Changes in climate variables are presented for the A2 emissions scenario as a worst-case prediction of potential vulnerabilities. Future analysis will be able to increase climate prediction evaluation for a select set of potential impacts based on this initial investigation.

Figure R-2: Four Climate Regimes Modeled in the Greater Monterey County Region

Source: Cal-Adapt (http://cal-adapt.org/)

Temperature Changes

Table R-1 below shows the projected difference in temperature between a baseline time period (1961-1990) and an end of century period (2070-2090) for the four climate regime areas selected for the Greater Monterey County IRWM planning region.

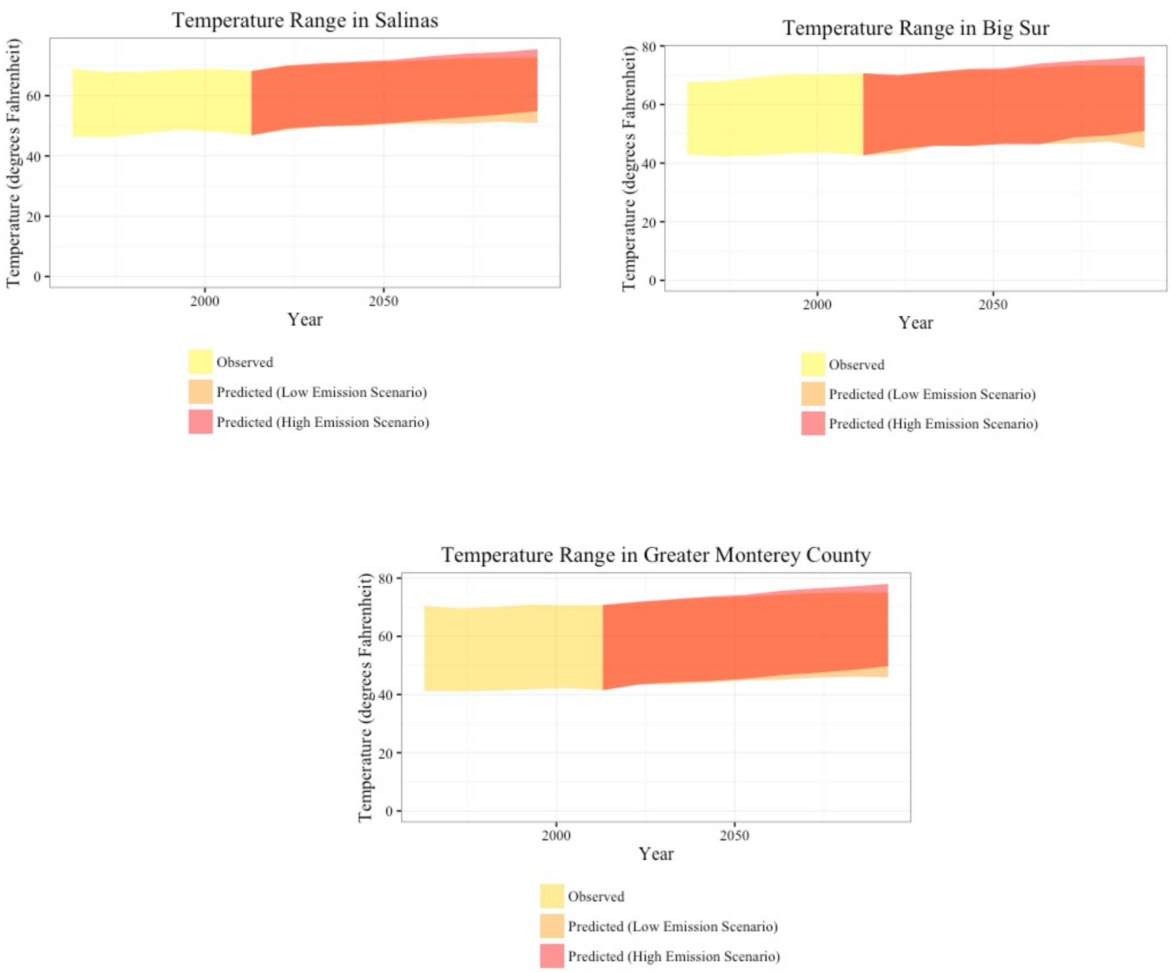
Table R-1: Projected Increases in Average Temperature

Location	Low Emission (°F)	Change in Temp (°F)	High Emission (°F)	Change in Temp (°F)
Salinas	60.3	3.4	62.1	5.2
Moss Landing	60.4	3.2	62.3	5.1
Big Sur	54.4	2.7	56	4.3
Paicines	58.1	3.4	60	5.3

Source: Cal-Adapt web tool (http://cal-adapt.org/)

Projected increases in average temperature are graphed for the Big Sur coast and the Salinas Valley in Figure R-3 below. Projected increases in temperature are similar through 2050 for both the A2 (High Emissions) and B1 (Low Emissions) scenarios. After 2050, temperature increases more rapidly using the high emissions rate scenario.

Figure R-3: Projected Decadal Average Temperature Ranges in Big Sur, Salinas, and Greater Monterey County



Source: Cal-Adapt web tool (http://cal-adapt.org/)

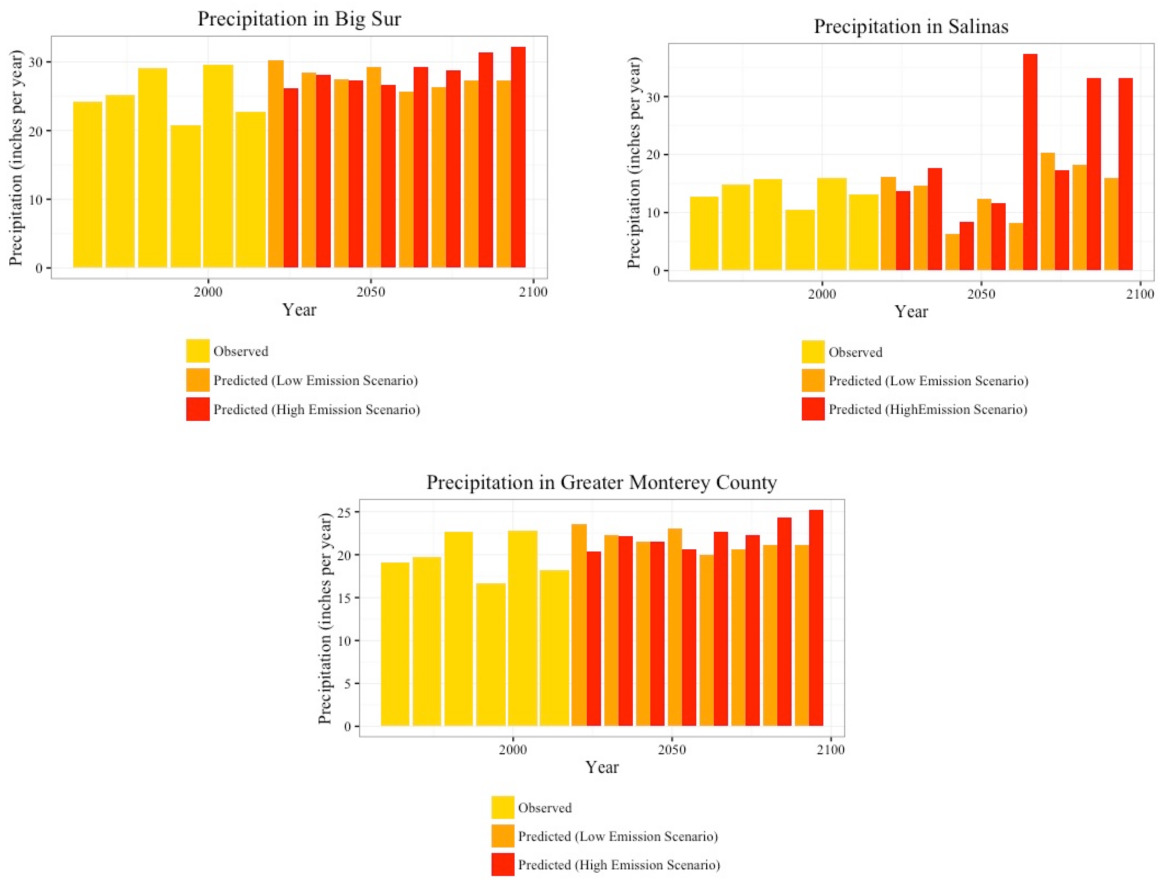
Rainfall Changes

The Cal-Adapt tool predicts that average rainfall will remain relatively constant throughout the Greater Monterey County region with increases in precipitation predicted in a future high emission scenario. Figure R-4 below represents the inter-decadal fluctuations in precipitation (integrating historic decadal fluctuations) and the long-term trends in total precipitation for the areas in question. Note, however, that while most climate change scientists agree that precipitation patterns will change, there is less consensus on the direction of the precipitation change, with some climate models suggesting decreases while others suggesting increases.[2] According to DWR, average annual precipitation throughout the state may show

[2] As an example of variable predictions of precipitation impacts in California: A US Department of the Interior Bureau of Reclamation report (2011) predicts mean-annual precipitation in the Sacramento and San Joaquin basins will stay generally steady during the 21st century and will be quite variable over the next century, with the authors

little change, but more intense wet and dry periods can be expected with more floods and more droughts (DWR 2013). The actual change in precipitation is more difficult to predict on the local level.

Figure R-4: Projected Average Rainfall in Big Sur, Salinas, and Greater Monterey County



Source: Cal-Adapt web tool (http://cal-adapt.org/)

Other climate variables, including evapotranspiration (water loss in plants) and runoff rates from storms, will also increase over time. Average base flow levels in creeks are projected to decline.

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noting that there is significant disagreement among the climate projections regarding change in annual precipitation over the region. The 2009 California Climate Change Adaptation Strategy (California Natural Resources Agency 2009) notes that climate models for the state differ in determining where and how much rain and snowfall patterns will change under different emissions scenarios. However, while the precipitation modeling results vary more than the temperature projections, the authors point out that 11 out of 12 precipitation models run by the Scripps Institution of Oceanography for northern California suggest a small to significant (12-35 percent) overall decrease in precipitation levels by mid-century. Finally, a US Geological Survey report (USGS 2012), using five General Circulation Models (GCM) for two watershed basins in northern California, concludes that precipitation will follow cycles of wetter and drier decadal oscillations during the 21st century.

Sea Level Rise

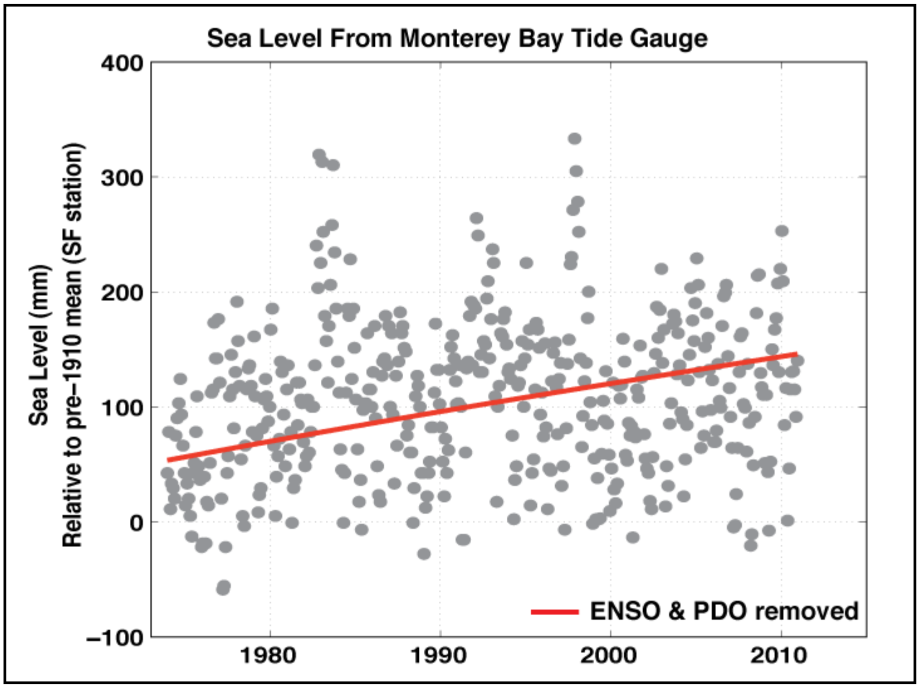
Sea level rise[3] is a complex and dynamic process ultimately controlled by levels of heat-trapping greenhouse gases in the atmosphere. There are numerous processes that can alter the rate, extent, and duration of changes in sea level at the local level. As such, accurately predicting sea level over the coming centuries for specific locations is very challenging.

As noted previously, sea level rose approximately eight inches (17-20 cm) over the past century (1900–2005) along most of the California coast (Cayan et al. 2008). Since 1993, altimetry data suggests that the global mean sea level rise rate has increased from 2 to 3 mm per year, but during this time, data from altimetry and tide gauges show that the mean sea level along the Pacific Coast has been stable due to wind stress. However, when the regional climate patterns that drove local sea level trends shift, the Central Coast will very likely experience a rate of sea level rise that will correspond to, or may even exceed, the mean global rate of sea level rise (Bromirski et al. 2011).

Currently, the State of California is using estimates of global sea level rise produced by Rahmstorf (2007) and Cayan et al. (2008) for coastal adaptation planning purposes under Executive Order S-13-08. These projections suggest possible sea level rise of approximately 14 inches (36 cm) by 2050 and up to approximately 55 inches (140 cm) by 2100. However, recent evidence suggests these values may prove to be underestimates of the possible rise in global sea level.

[3] This section regarding sea level rise has been excerpted from the "Climate Change and Monterey Bay" website (http://www.climatechangemontereybay.org/impacts_main.shtml). Text prepared by Michael Fox, Center for Ocean Solutions. The references in this section are as cited on the "Climate Change and Monterey Bay" website.

Figure R-5: Sea Level in Monterey Bay from 1976 - 2010



Sea level from the Monterey Bay Tide Gauge. Monthly records of sea level from the Monterey Bay tide gauge are shown from 1976 to 2010. Monterey has experienced a consistent rise in sea level on the order of 2 - 3 mm/yr (0.07 - 0.1 in/yr) for the past 35 years. (Developed by Brock Woodson for the Preparing for the Future: Climate Change and the Monterey Bay Shoreline regional workshop; see http://centerforoceansolutions.org/preparingforthefuture. Data obtained from the Permanent Service for Mean Sea Level. Used by permission.)

The anticipated consequences of sea level rise for the Monterey Bay region are serious and far-reaching, and are discussed in Section R.5 below, Potential Impacts of Climate Change in the Greater Monterey County Region.

Changes in Fog

There is evidence to suggest that yearly coastal fog may be declining. A recent study by Todd Dawson from UC Berkeley and James Johnstone from the University of Washington shows that coastal fog in California has declined more than 30 percent over the past 60 years (Sanders 2010; Dayton 2011). With only 60 years of data, it is unclear whether the phenomenon is part of a natural cycle or the result of global climate change.[4] However, a change in coastal fog could have critical implications for the fate of certain ecosystems, in particular coastal redwoods and maritime chaparral, both of which are dependent on fog for their survival. A decline in coastal fog could also lead to increased water use and an increased demand on water supplies in the Greater Monterey County IRWM region.

California coastal fog is caused by the temperature differential between the cool ocean water and the warmer air. The Monterey Bay region is particularly foggy because of oceanic upwelling of the deep, cold

[4] Note that the scientists are working to calibrate tree ring isotope data with actual coastal fog conditions in the past century, and will then be able extrapolate back for 1,000 years or more to estimate climate conditions.

waters of the Monterey submarine canyon. When the cold oceanic water meets the warmer air, the air chills and condenses to form fog. As noted above, one of the effects of global climate change is warmer ocean temperatures. The IPCC stated in a 2007 report, "observations since 1961 show that the average temperature of the global ocean has increased to depths of at least 3000 meters" (IPCC, 2007b). Warmer ocean temperatures could mean less fog for coastal California.

Fog occurs primarily in the summer months, when there is little or no rainfall. Fog provides an important source of water for many coastal plant communities by providing soil drip as a source of irrigation. Redwood trees and 80 percent of their understory plants can absorb fog directly through their leaves. Fog also acts to keep moisture in the ecosystem, preventing evaporation and maintaining cooler temperatures. A significant decline in fog could mean an uncertain future for many of the plant communities in the region, including local endemic plants that depend on fog for their survival (Dayton 2011).

The role that coastal fog plays in preventing evaporation and maintaining cooler temperatures also has important implications for water use and water supply in the Greater Monterey County region. A decline in coastal fog would change the local coastal climate, resulting in warmer temperatures and increased evaporation during the summer months. This in turn may lead to increased agricultural and landscape water use, putting additional demand on water supplies in the region.

R.5 POTENTIAL IMPACTS OF CLIMATE CHANGE IN THE GREATER MONTEREY COUNTY REGION

There have been several efforts conducted by various entities in the Monterey Bay region over the past 10 years to determine potential impacts of climate change for the region. This section describes the outcomes of a one-day workshop conducted in 2011 for regional decision makers that focused specifically on coastal impacts. Following that summary, and based partly on the results of that workshop and other regional studies, is a description of the RWMG's process to determine potential impacts and assess vulnerability and risk for regional infrastructure and natural resources.

R.5.1 Overview of 2011 Regional Climate Change Workshop

On December 6, 2011, the Monterey Bay National Marine Sanctuary (MBNMS) and Center for Ocean Solutions (COS) convened regional decision makers at a one-day workshop titled "Preparing for the Future: Climate Change and the Monterey Bay Shoreline." The event was the first Monterey Bay region-wide gathering on climate change adaptation, intended to facilitate a discussion on how to best prepare coastal communities in the Monterey Bay region to adapt to the impacts of climate change. More than 90 people attended from cities and municipalities in Santa Cruz and Monterey Counties, representing city and county staff, state and federal governments, research institutions and nonprofit organizations.

Presenters at the workshop focused on impacts of concern for the Monterey Bay region, which included increased coastal erosion, coastal inundation, storm and wave damage, and saltwater intrusion. Monterey Bay has variable coastal geology, and as a result, different regions will experience different types and magnitudes of impacts. For example, portions of the sandy beaches and dunes of southern Monterey Bay are currently eroding at some of the highest rates in California, while the low-lying land and large flood plains in the central portion of the Bay make those areas particularly susceptible to inundation (Abeles et al. 2012).

The following provides information presented at the workshop regarding the anticipated impacts of climate change specifically for the Monterey Bay shoreline area. Note that almost all of the text in this section has been excerpted from one of two sources: 1) the "Climate Change and Monterey Bay" website, http://www.climatechangemontereybay.org/; and 2) the workshop Summary Report (Abeles et al. 2012), which is available at: http://centerforoceansolutions.com/preparingforthefuture.

Impacts of Coastal Erosion

Existing levels of coastal erosion in the Monterey Bay region cause significant threats to critical infrastructure, property, and natural habitats.[5] Coastal erosion will increase as global sea levels continue to rise. Higher sea level will allow waves and tides to travel farther inland, exposing beaches, cliffs, and coastal dunes to more persistent erosional forces (Storlazzi and Griggs 2000). Erosion is not a new issue in California, but rising sea levels threaten to increase the severity and frequency of erosion damage to coastal infrastructure and property. Statewide, a 4.6-foot (1.4 m) rise in sea level has the potential to erode approximately 41 square miles (68 km^2) of coastline by the end of the century (Heberger et al. 2009).

The southern portion of Monterey Bay is eroding more rapidly than any other region in the state, with coastal dunes between the Salinas River mouth and Wharf 2 in Monterey eroding at rates between 1.0 and 6.0 feet per year (0.3-1.8 m/yr) (Heberger et al. 2009; Brew et al. 2011; and Hapke et al. 2009). Even without consideration of accelerated sea level rates, eight oceanfront facilities in southern Monterey Bay are at high risk in the next 50 years and will require mitigation measures to prevent their loss (PWA 2008a). One statewide study by the California Energy Commission, *Impacts of Sea Level Rise on the California Coast*, found that in Monterey County a total of approximately 4.4 square miles (7 km^2) of coastline is susceptible to erosion, and the maximum distances coastal dunes and sea cliffs are expected to retreat in this region are approximately 1,300 and 720 feet (400 m and 200 m), respectively (Heberger et al. 2009). Loss of this land threatens to place roughly 820 people in Monterey County at risk of losing their homes. In addition to the loss of the protective service, losing these coastal dunes also means the loss of habitat for coastal species.

Coastal erosion will have long-lasting impacts on the Monterey Bay region's transportation infrastructure, threatening over 50 miles (~83 km) of highway, roads, and rail throughout the region including Highway 1 (Heberger et al. 2009). Important public infrastructure is also at risk of erosion. One example is the Monterey Interceptor pipeline that carries raw sewage from the Monterey Peninsula to the treatment plant located north of the city of Marina. Portions of this critical piece of infrastructure run directly beneath the beach, and if undermined, could result in a significant threat to marine resources and public welfare and safety. Other threatened structures include beachfront hotels, condominiums, private residences, other wastewater pumping appurtenances associated with the Monterey Interceptor pipeline, and Monterey One Water's (formerly Monterey Regional Water Pollution Control Agency) ocean outfall. Given the current rates of erosion, this sewage pipeline faces possible risk of exposure in the next 30 to 50 years (Brew et al. 2011), highlighting the importance of strategic long-term planning efforts.

Impacts of Coastal Inundation

Coastal inundation occurs when normally dry land becomes covered by water. Coastal inundation is one of the most costly and damaging impacts associated with sea level rise.[6] Low-lying coastal areas of the

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[5] This section on coastal erosion has been excerpted from the "Climate Change and Monterey Bay" website: http://www.climatechangemontereybay.org/impacts_erosion.shtml. Text prepared by Michael Fox, COS. All references included in this section are cited on the website.

[6] Much of this section on coastal inundation has been excerpted from the "Climate Change and Monterey Bay" website: http://www.climatechangemontereybay.org/impacts_inundation.shtml. Text prepared by Michael Fox, COS. All references included in this section are cited on the website.

Monterey Bay region will be exposed to a greater risk of major flooding events, and storm surge, high tides, and waves will travel farther inland (Heberger et al. 2009). Elevated sea levels combined with increases in winter storm intensity and wave heights will increase risks associated with coastal inundation (Storlazzi and Wingfield 2005; and Wingfield and Storlazzi 2007).

Given the large impact zone associated with coastal inundation, a significant portion of transportation infrastructure is at risk. Highways, roads, and railways in Monterey County are susceptible to coastal inundation, and flooding may impact several power generation facilities (Heberger et al. 2009). The low-lying coastal location of many agricultural properties in this region increases the likelihood of significant loss of agricultural land due to storm-induced flooding and salinization with increasing sea level and long-term inundation. Loss of agricultural production in the region will have lasting consequences for the largest sector of the regional economy.

In conjunction with coastal inundation, coastal water quality will likely decline as storm-induced flood waters recede, drawing debris, fertilizers, and other contaminants into the bay. This increased runoff has the potential to increase the frequency and severity of harmful algal blooms (HABs) in the area, posing a serious threat to local fisheries and marine mammal populations (Largier et al. 2010).

Coastal inundation also poses a risk to local wetlands. The impact of sea level rise on wetlands is significant for the Greater Monterey County area, since the region contains several important wetland systems. If the rate of sea level rise exceeds the rate of wetland accretion, or if wetlands cannot transgress (migrate up and inland) large tracts of critically important habitat, such as Elkhorn Slough, will become permanently submerged (Heberger 2009; Largier 2010). If these wetland systems become submerged, their ability to provide crucial services such as nursery habitat, wave protection, and nutrient and sediment retention will be greatly diminished. There are several other wetland systems that interact with the main Elkhorn system, including the Moro Cojo and Bennett Sloughs and the Old Salinas River channel. All of these systems' tidal interactions are muted due to culverts and tide gates. Sea level rise will pose significant threats to these systems as well, but those interactions are less well understood.

Monterey County also contains about 30 coastal river and creek mouth lagoon systems that provide a diverse set of environmental services and span the entire of the IRWM planning region. The cumulative impacts of increased rain intensity and flows within coastal watersheds along with increased sea levels and storm wave impacts pose unique threats to these valuable wetland resources. Regional partners have begun to evaluate the potential impacts to these systems, but studies are incomplete and more research is needed.

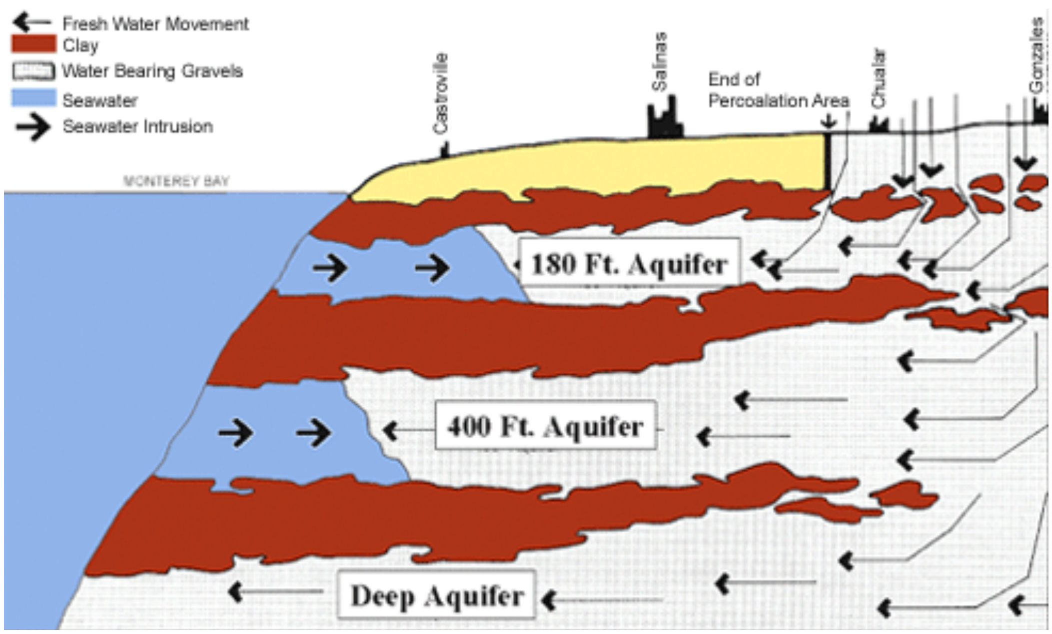
Impacts of Seawater Intrusion

Seawater intrusion is caused by two primary processes: overdrafts of coastal wells that reduces head pressure, and coastal salt water pressure exacerbated by sea level rise. As described in the Region Description of this plan, coastal groundwater basins in the region have been experiencing overdraft for many years. According to the 2015 Urban Water Management Plan for the Salinas District (Cal Water 2016), the annual non-drought overdraft of the Salinas Valley Groundwater Basin is estimated to be approximately 45,300 AF per year. During droughts, the annual overdraft can escalate to between 150,000 to 300,000 AF per year. As a result of this consistent overdraft, groundwater levels in the Salinas Valley Groundwater Basin have dropped below sea level, allowing seawater to intrude from Monterey Bay into aquifers located 180 and 400 feet below ground surface. The East Side and Pressure Subareas of the Salinas Valley Groundwater Basin are most impacted by overdraft. Because of the hydrologic continuity between the ocean and the aquifers of the Pressure Area (Figure R-6), seawater has been intruding into these aquifers at a rate of approximately 28,800 AFY (Cal Water 2010b).

In the mid-1990s, due to seawater intrusion, the Monterey County Water Resources Agency (MCWRA) constructed a water delivery system known as the Castroville Seawater Intrusion Project (CSIP), aimed at providing recycled water produced at the Salinas Valley Reclamation Project (SVRP) tertiary-treatment facility to agricultural growers within the seawater intrusion front area. These growers use the recycled water to supplement groundwater. Since 1998, recycled water deliveries have ranged from approximately 7,500 - 14,000 AFY. As a result of the CSIP, the seawater intrusion front has slowed, but has not been halted. MCWRA also developed the Salinas Valley Water Project as a means to increase the availability of recycled water, thereby further reducing agricultural pumping from intruded Pressure Subarea Aquifers.

In 2017 MCWRA published a special report entitled "Recommendations to Address the Expansion of Seawater Intrusion in the Salinas Valley Groundwater Basin," in which MCWRA staff make six recommendations to address factors that influence the continued advancement of seawater intrusion. Coupled with implementation of groundwater sustainability legislation, the Salinas Valley may look to develop new water supplies for agricultural and urban users in the Salinas Valley Groundwater Basin, which may ultimately be more resilient to climate change impacts than current surface water and groundwater supplies.

Figure R-6: Depicting Aquifers and Seawater Intrusion in the Castroville Area



Map depicting groundwater flow in the lower Salinas Valley. Yellow represents the area where the Salinas Valley Water Project and the Castroville Seawater Intrusion Project have taken steps to resupply groundwater reserves with recycled water. (MCWRA)

While basin overdraft conditions are expected to improve by the year 2030 due to these and other efforts, recent groundwater modeling from the Salinas Valley Integrated Ground and Surface Water Model (SVIGSM) predicted seawater intrusion to continue to worsen, though at a decreased rate. The SVIGSM modeling did not take into account, however, expected sea level rise due to climate change. The problem of seawater intrusion is expected to be exacerbated significantly by sea level rise. Groundwater contaminated by saltwater is not suitable for agricultural use or for drinking water without treatment.

Possible Unforeseen Groundwater Impacts from Coastal Flooding
There are hundreds of groundwater wells in the lower Salinas Valley, managed by different entities for different purposes. Agricultural irrigation wells are often installed by individual farmers and may be decades old. Wells that are not constructed and maintained properly can become a conduit for aquifer contamination if they are routinely flooded, as predicted under conditions of climate change. Such wells can also become a secondary route for vertical saltwater inundation if the wells are not protected during ocean flooding, which is expected to occur periodically with climate change. (See Section R.6.2.b, Vulnerabilities for 2030, 2060, 2100, for more information about the vulnerability of groundwater wells.)

Impacts of Coastal Storms and Waves
Seasonal patterns of storms and wave intensity are the primary driving forces behind coastal erosion along the California coast.[7] While a natural process that shape shorelines and beaches, erosional forces become a hazard when they interact with permanent structures that rely on a stable shoreline. The impacts of storm and wave damage are episodic and have the greatest severity when large storms coincide with high tide events. Despite the gradual day-to-day erosion experienced along the coast, it is the large, episodic erosional events that pose the greatest threat to the Monterey Bay shoreline. Given the recent evidence that suggests storm and wave intensity is likely to increase in this region, these large, episodic erosional events may occur more frequently. Protecting and restoring natural systems to take advantage of their protective services can increase resilience to these coastal impacts. Protecting and restoring these systems will likely provide additional benefits such as improved water quality and increased nursery habitat and recreation areas.

Vulnerability of Natural Coastal Protections
Similar to seawalls, dunes are critical in acting as a buffer between the ocean and the areas behind the dunes. Because dunes are natural, they also preserve existing ecosystems and have the ability to move inland with the beach and the sea level in order to preserve the whole beach-dune system. The dunes directly north of the Salinas River mouth are especially narrow and thus already prone to winter storm erosion and wave overtopping. Breaks in the dunes between Jetty and Potrero roads would reduce the protection this dune system provides to the harbor from winter storms. Possible breaks within the dunes south of the Potrero tide gates would leave much of the Salinas Valley vulnerable to coastal flooding.

R.5.2 Evaluation of Potential Impacts to the Greater Monterey County Region Using State Guidance

The State has provided numerous tools and several comprehensive guidance documents to evaluate the potential impacts of climate change, and the vulnerabilities of human and natural systems in the face of climate change variables. Table R-2 below represents a "broad brush" consideration of potential impacts to water resources associated with changes in climate variables, adapted from Appendix B of *Climate Change Handbook for Regional Water Planning* (US EPA Region 9 and DWR 2011) and deemed applicable to the Greater Monterey County IRWM planning region. The RWMG used this information as the basis for its initial climate vulnerability analysis and risk assessment for the Greater Monterey County region in 2012. Section R.6, following the table below, describes that process.

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[7] This section on coastal storms and waves has been excerpted from the "Climate Change and Monterey Bay" website: http://www.climatechangemontereybay.org/impacts_storms.shtml. Text prepared by Michael Fox, COS.

Table R-2: Potential Impacts to Water Resources in the Greater Monterey County Region

Climate Variable	Potential Vulnerability
Water Supply and Demand	• Agricultural water use is expected to increase to offset higher temperatures and evapotranspiration. • Rangelands are expected to be drier. • Domestic landscaping water needs will be higher. • Sea level rise and higher groundwater extraction will lead to increased rates of saltwater intrusion. • Droughts will be more frequent and severe.
Water Quality	• Lower seasonal surface flows will lead to higher pollutant concentrations. • Changes in storm intensity will increase sediment loading in many systems. • Channel stability will be impacted from higher storm flows causing additional turbidity. • Sea level rise will impact current estuary brackish water interface towards more marine systems.
Flooding	• Regional river levees will provide less protection during higher storm flow events. • Natural creeks and managed conveyance will see higher flow rates leading to increased erosion and flooding. • Coastal levees and control structures will be undersized to manage the combined influences of higher river flows and sea level rise.
Aquatic Ecosystem Vulnerabilities	• Migration patterns and species distribution will change. • Invasive species populations will expand. • Coastal wetland systems are especially vulnerable to the combined influences of climate change • Coastal wetland systems are likely to be inundated with increasing frequency, leading to the dieback of tidal marshes (Philip Williams & Associates 2008b) and the salinization of fresh and brackish marshes. • Changes in hydrograph (driven by rain pattern changes) will cause increased erosion and habitat loss in creeks and rivers. • Some locally unique species and communities such as maritime chaparral, coastal prairie, coastal redwoods and giant kelp are susceptible to changes in certain locally favorable climate variables; for example, redwood forest ecosystems and coastal chaparral species are dependent on fog, and productive kelp forests tend to be associated with areas of significant oceanographic upwelling. As conditions change, these ecosystems and species may face an uncertain future (see Dayton 2011).
Hydropower and Reservoir Storage	• Changes in rainfall patterns may be problematic for timing of release from reservoirs. • More intense rainfall and increased risk of fires in watershed lands can lead to increased sediment loading to reservoirs.

R.6 EVALUATING THE ADAPTABILITY OF WATER MANAGEMENT SYSTEMS IN THE REGION TO CLIMATE CHANGE: CLIMATE VULNERABILITY AND RISK ASSESSMENT

The Integrated Regional Water Management Planning Act, CWC §10541(e)(10), states that IRWM plans must include an evaluation of the adaptability to climate change of water management systems in the region. For the 2012 IRWM Plan, the RWMG conducted an initial climate risk assessment to help water resource managers evaluate the risks to water management systems. As part of the 2017-2018 IRWM

Plan update (for compliance with 2016 IRWM Guidelines), the RWMG performed a more in-depth assessment of vulnerability and risk for regional infrastructure and environmental resources in order to help water resource managers consider potential adaptation measures. The latter effort included interviews with RWMG members to obtain a better understanding of water resource management efforts being planned or implemented by IRWM Plan partners within Greater Monterey County (Appendix N).

The sections below describe the initial risk analysis conducted by the RWMG, followed by a more specific and in-depth analysis (i.e., GIS hazard model evaluation) of sea level rise vulnerability for the lower Salinas Valley area.

R.6.1 Initial Risk Analysis

The RWMG used a combination of tools and two hazard analysis methods to identify priority resources that face the greatest threat from the impacts of climate change. Those impacts were then prioritized based on their likelihood and the potential consequences of those impacts for life, property, public resources, and the natural environment of the Greater Monterey County region.

Key documents used for this climate risk assessment include the State guidance document, *Climate Change Handbook for Regional Water Planning* (US EPA Region 9 and DWR 2011) and the guidebook, *Preparing for Climate Change* (Snover et al. 2007). Both documents outline a process for defining vulnerable infrastructure, land uses, and habitats, for defining the sensitivity of those resources to changes in climate conditions, and evaluating the risk of impacts to those resources. The RWMG also used several tools to identify resources that are sensitive to changes in climate variables. The website for the International Council for Local Environmental Initiatives (ICLEI) – Local Governments for Sustainability provides an online tool to identify important resources (human and natural) that are susceptible to climate change, and the *Climate Change Handbook* provides a useful checklist for identifying potential water resource specific vulnerabilities.

The RWMG conducted a risk analysis for regional assets and areas of concern, as well as several hazard analyses associated with coastal sea level rise. This section describes a narrative risk analysis that was conducted for the region, evaluating the likelihood and relative vulnerability of various risks, using the potential impacts that were initially identified as part of the IRWM climate change evaluation, listed in Table R-3. Following this section, Section R.6.2 describes a hazard-specific analysis (i.e., sea level rise), using projected GIS hazard extents for three future time horizons.

Climate preparedness planning relies on the evaluation and prioritization of risks. Risk is determined based on the probability that a certain impact will occur (*likelihood*) and the significance of that impact (*consequence*) on life, land uses, water resources, the economy, and the environment. The equation is: *Risk = Consequences x Likelihood.* Since no region has sufficient resources to address all potential impacts of climate change simultaneously, this prioritization process is necessary to address impacts that are most likely and that will result in the greatest detriment to life, the economy, and infrastructure (*consequence*).

Likelihood: The probability that a specific impact will occur, defined within the ICLEI workbook as *likelihood*, is estimated based on the increased chance, or periodicity, that a certain event will occur. Table R-3 illustrates how the combined factors of risk and likelihood relate to the determination of priority planning areas. Table R-4 illustrates the "Likelihood Rating" of impacts based on the chance of an infrequent impact occurring more often ("recurrent risk") and the chance that a previously unrealized impact could occur ("single event").

Table R-3: Risk Variables

	Low Likelihood	Medium Likelihood	High Likelihood
High to Extreme Risk	May be priority planning areas	Should be priority planning areas	Should be priority planning areas
Low to Medium Risk	Are unlikely to be priority planning areas	May be priority planning areas	Likely to be priority planning areas

Table R-4: Probability Variables

Likelihood Rating	Recurrent Risks	Single Event
Almost Certain (5)	Could occur several times per year	More likely than not - probability greater than 50%
Likely (4)	May arise about once per year	As likely as not - 50/50 chance
Possible (3)	May arise once in 10 years	Less likely than not but still appreciable - probability less than 50% but still notable
Unlikely (2)	May arise once in 10 years to 25 years	Unlikely but not negligible - probability low but noticeably greater than zero
Rare (1)	Unlikely during the next 25 years	Negligible - probability very small, close to zero

Consequence: The *consequence* of a specific climate change impact occurring was evaluated individually for five different social, economic, and environmental factors, including specifically:

- Public safety
- Local economy and growth
- Community and lifestyle
- Environment and sustainability
- Public administration

The cumulative consequence from the combined impacts to specific social, economic, and environmental factors was then derived. For example, the consequences of failing to address sea level rise will depend on the potential impacts of that future sea level rise on the five factors listed above, combined. The consequence for each factor was estimated from little or no consequence (0) to serious devastation to infrastructure or significant economic or environmental impacts or loss of life (5).

Risk: The amount of *risk* involved from a climate change impact depends on both the likelihood and severity of the consequences that may result from that impact. Using the example of sea level rise, risk can be mitigated by reducing the consequence of the flooding or the possibility that flooding will occur at a given ocean height. Risk was determined for the Greater Monterey County region based on the consequences that are expected to arise from any particular impact occurring within the region. Consequences were evaluated for human wellbeing, economic stability, environmental health, and the ability of municipalities to respond.

Table R-5 depicts the relative risk of each climate change impact scenario, along with a relative level of urgency to act (priority level). The table illustrates results separately for five socio-economic and environmental consequences (including: public safety, local economy and growth, community and lifestyle, environment and sustainability, and public administration), and for the environmental consequence only. This initial priority impact assessment was used by the RWMG to prioritize implementation actions and future studies.

Table R-5: Determining Priority Impacts: Prioritized Impacts Based on the Combined Consequences of Five Social-economic Factors and for Environmental Consequence Alone

Potential Climate Change Impact	Risk Score	Priority Level	Risk Score	Priority Level
Water Supply	**Based on All Five Consequences**		**Environmental Consequence Only**	
Agricultural water use is expected to increase to offset higher temperatures and evapotranspiration	62	High	19	Extreme
Rangelands are expected to be drier	49	Medium	15	High
Domestic landscaping water needs will be higher	51	Medium	15	High
Local rainfall changes are estimated to be reduced by 3-10 inches	61	High	17	Extreme
Sea level rise and higher groundwater extraction will lead to increased rates of saltwater intrusion	66	High	17	Extreme
Droughts will be more frequent and severe	59	High	16	Extreme
Water Quality	**Based on All Five Consequences**		**Environmental Consequence Only**	
Lower seasonal surface flows can lead to higher pollutant concentrations	39	Low	12	High
Changes in storm intensity will increase sediment loading in many systems	48	Medium	13	High
Channel stability will be impacted from higher storm flows causing additional turbidity	39	Low	11	Medium
Flooding	**Based on All Five Consequences**		**Environmental Consequence Only**	
Regional levees will provide less protection during higher storm flow events	69	High	13	High
Natural creeks throughout the region and managed conveyance within the Salinas Valley will see higher flow rates leading to increased erosion and flooding	54	Medium	12	High
Coastal levees and control structures will be undersized to manage the combined influences of higher flow events and sea level rise	89	Extreme	17	Extreme
State recommendations suggest no new critical facilities be built within the 200-year floodplain (DWR 2008, DWR 2009b, CNRA 2009)	23	Low	3	Low
Ecosystem Vulnerabilities	**Based on All Five Consequences**		**Environmental Consequence Only**	
Sea level rise will impact current estuary brackish water interface towards more marine systems	50	Medium	16	Extreme
Migration patterns and species distribution will change	37	Low	13	High
Invasive species populations will expand	38	Low	10	Medium
Coastal wetland systems are especially vulnerable to the combined influences of climate change	45	Medium	16	Extreme

Potential Climate Change Impact	Risk Score	Priority Level	Risk Score	Priority Level
Some locally unique species such as coastal redwoods and giant kelp are susceptible to changes in certain locally favorable climate variables (fog duration, coastal upwelling)	37	Low	13	High
Hydropower and Reservoir Storage	**Based on All Five Consequences**		**Environmental Consequence Only**	
Changes in rainfall patterns may be problematic for timing of releases from reservoirs	47	Medium	9	Low
Higher rainfall and increased risk of fires in watershed lands can lead to increased sediment loading to reservoirs	37	Low	10	Medium

R.6.2 Sea Level Rise GIS Hazard Model Evaluation for Lower Salinas Valley: A Case Study

State guidelines recommend that regional planning groups identify key areas where there is a high risk of climate change vulnerability to water infrastructure. Within the Greater Monterey County IRWM region, the lower Salinas Valley is a priority water management focus area. For the 2017-2018 IRWM Plan update, IRWM partner groups, led by CCWG, performed a sea level rise vulnerability analysis for the Lower Salinas Valley area and completed a comprehensive analysis of water resources and infrastructure that are at risk of impacts associated with sea level rise and climate change-induced storm flooding along the coast.

Water resources and water infrastructure within the Lower Salinas Valley that are at risk of coastal flooding and sea level rise were identified using the base layers and data analysis completed for the Moss Landing Vulnerability Report (CCWG 2017, described in Section R.3.2). Resources at risk of future flooding (by 2030, 2060 or 2100) were identified and tallied, and response actions were evaluated. The Case Study follows steps outlined within State guidelines to identify vulnerable water infrastructure and identify adaptive measures that can be supported and/or implemented by the IRWM Plan.

R.6.2.a Temporal Hazard/Vulnerability GIS Analysis

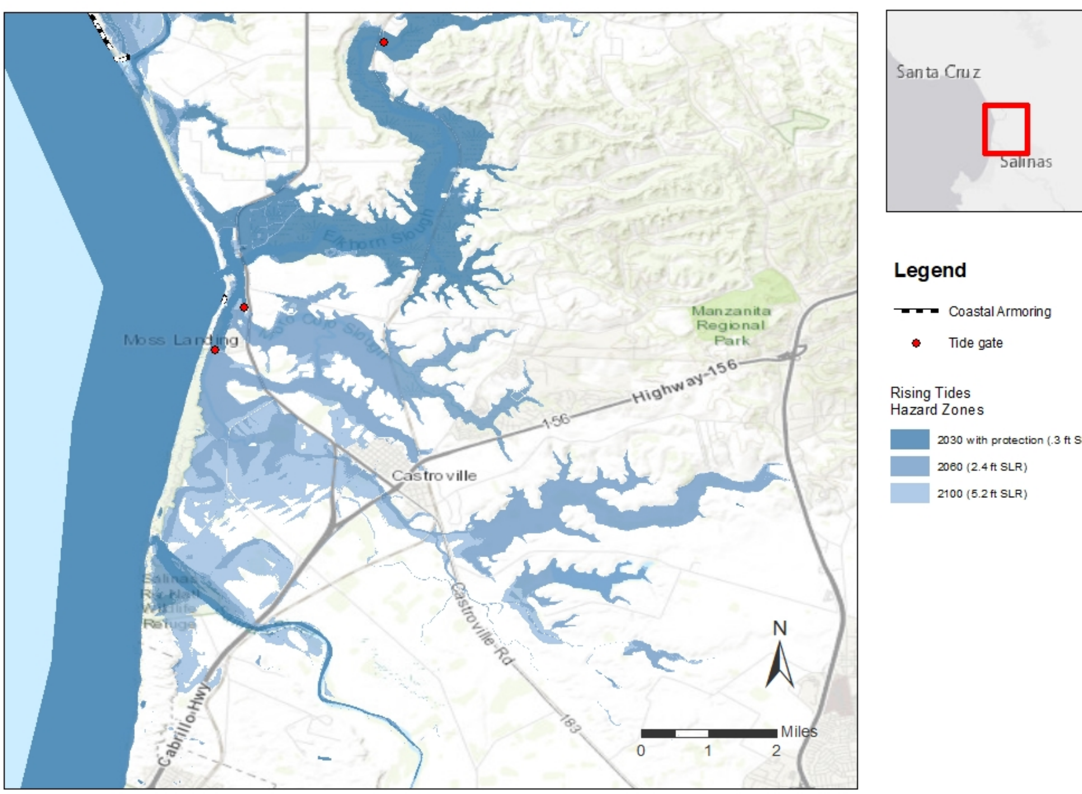
The Lower Salinas Valley hazard evaluation is intended to provide a predictive chronology of future risks to benefit local coastal planning and foster discussions with State regulatory and funding agencies. Estimates of the extent of assets at risk of various climate hazards were made using best available regional data. This approach allows planners to understand the full range of possible impacts that can be reasonably expected based on the best available science, and to build an understanding of the overall risk posed by potential future sea level rise. The hazard maps provide projected hazard zones for each climate scenario for each of the three planning horizons.

Coastal Climate Risk Model Hazard Layers
A coastal hazard modeling and mapping effort by ESA (ESA PWA 2014) led to a set of common hazard map layers that integrate the multiple coastal hazards projected for the Monterey Bay coastline (i.e., hazards of coastal climate change). There is, however, a benefit to evaluating each hazard (or coastal process) separately. CCWG staff posted processed hazard layers to account for reductions in potential hazards provided by current coastal protection infrastructure. This refinement of coastal hazard mapping helped the RWMG better understand the future risks that the Lower Salinas Valley area may face for each

coastal hazard process. The following maps describe and show the modeled hazard zones for each identified coastal climate change hazard type.

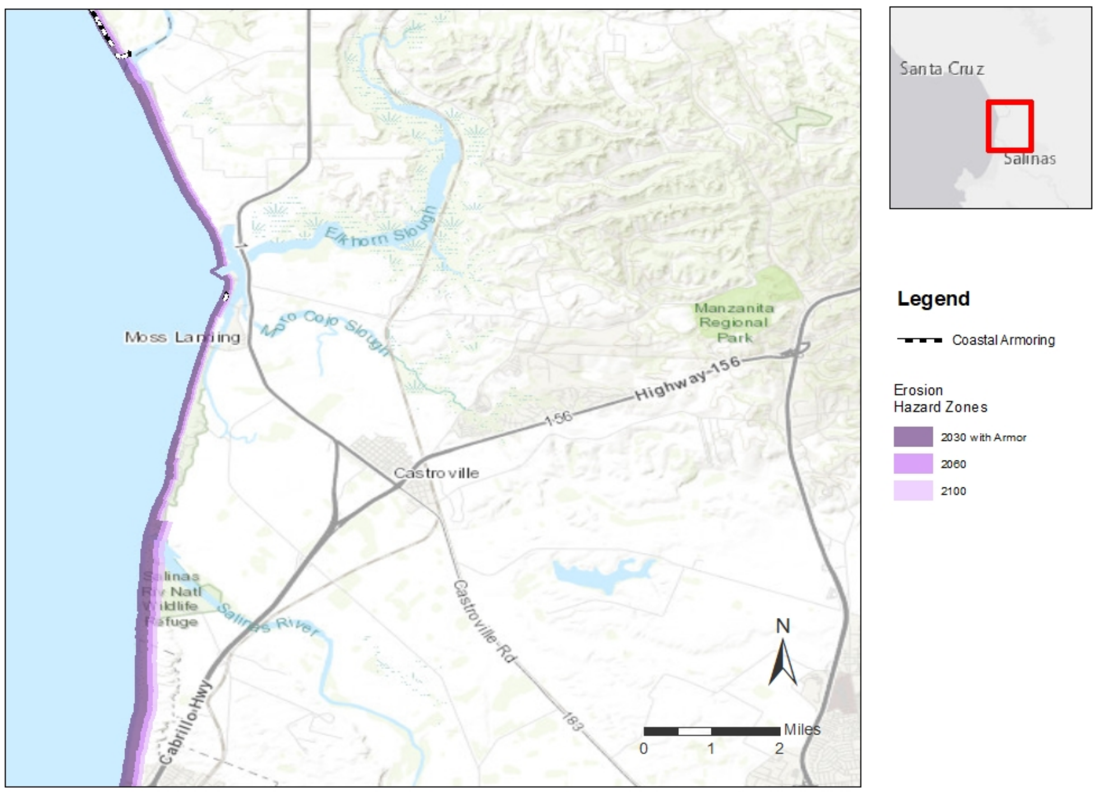
Rising Tides: These hazard zones show the area and depth of inundation caused simply by rising tide and groundwater levels (not considering storms, erosion, or river discharge). The water level mapped in these inundation areas is the Extreme Monthly High Water (EMHW) level, which is the high water level reached approximately once a month. There are two types of inundation areas: (1) areas that are clearly connected over the existing digital elevation through low topography, (2) and other low-lying areas that do not have an apparent connection, as indicated by the digital elevation model, but that are low-lying and flood prone from groundwater levels and any connections (culverts, storm drains and underpasses) that are not captured by the digital elevation model. This difference is captured in the "connection" attribute (either "connected to ocean over topography" or "connectivity uncertain") in each Rising Tides dataset. These zones do not, however, consider coastal erosion or wave overtopping, which may change the extent and depth of regular tidal flooding in the future. Projected risks from rising tides lead to reoccurring flooding hazards during monthly high tide events.

Figure R-7: Projected Rising Tide Hazard Zones for Years 2030, 2060, 2100



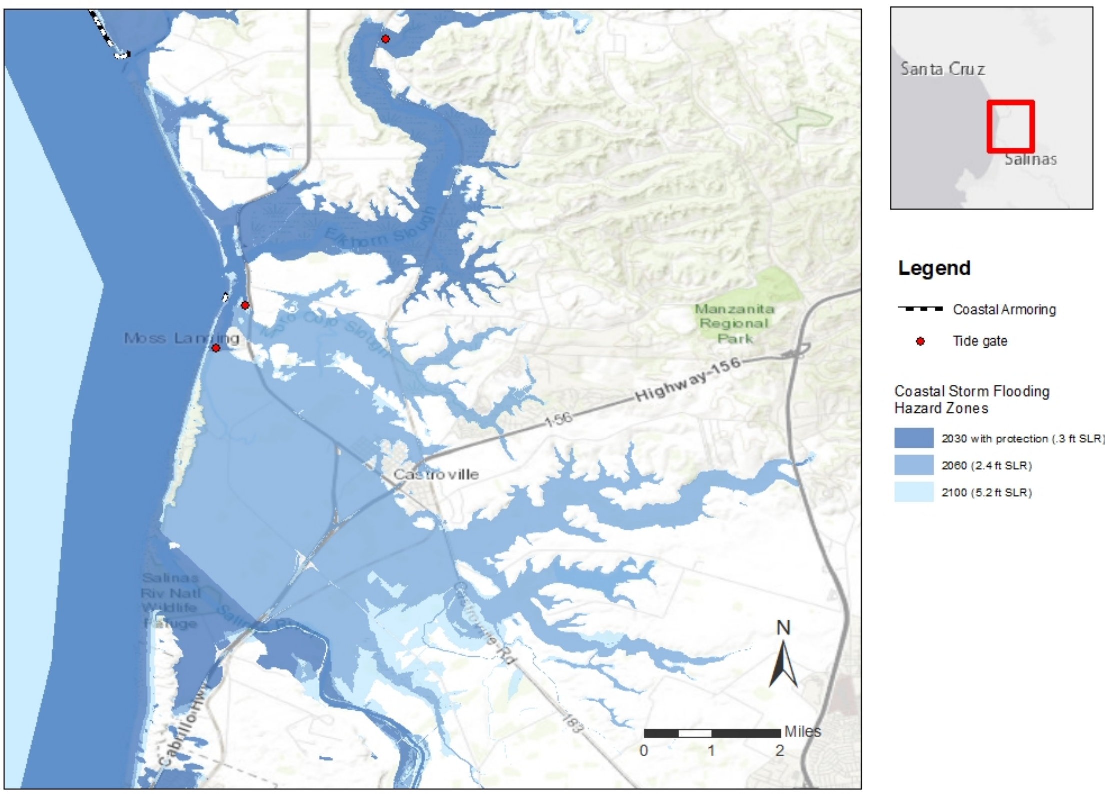
Erosion: These layers represent future dune (sandy beach) erosion hazard zones, incorporating site-specific historic trends in erosion, additional erosion caused by accelerating sea level rise and (in the case of the storm erosion hazard zones) the potential erosion impact of a large storm wave event. The inland extent of the hazard zones represents projections of the future crest of the dunes for a given sea level rise scenario and planning horizon. Erosion can lead to a complete loss of habitat, infrastructure and/or use of properties.

Figure R-8: Projected Erosion Hazard Zones for Years 2030, 2060, 2100



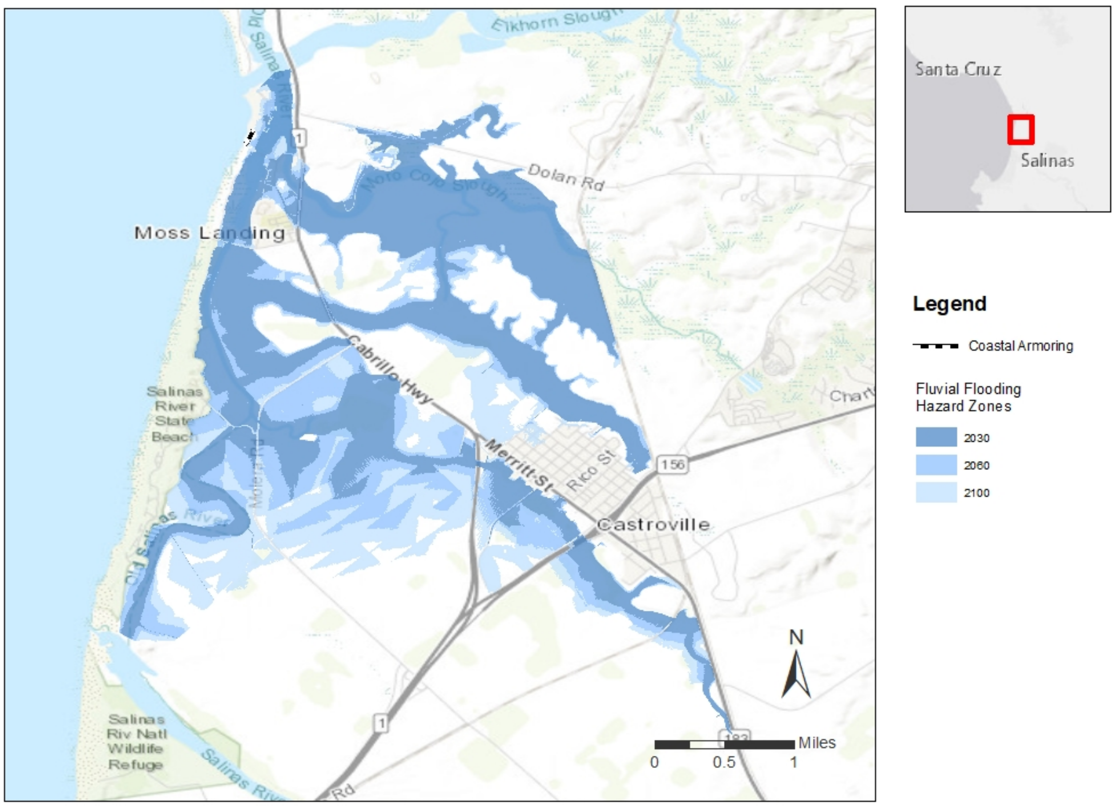
Coastal Storm Flooding: These hazard zones depict the predicted flooding caused by future coastal storms. The processes that drive these hazards include (1) storm surge (a rise in the ocean water level caused by waves and pressure changes during a storm), (2) wave overtopping (waves running up over the beach and flowing into low-lying areas, calculated using the maximum predicted wave conditions), and (3) additional flooding caused when rising sea levels exacerbate storm surge and wave overtopping. These hazard zones also take into account areas that are projected to erode, sometimes leading to additional flooding through new hydraulic connections between the ocean and low-lying areas.

Figure R-9: Projected Coastal Storm Flood Hazard Zones for Years 2030, 2060, 2100



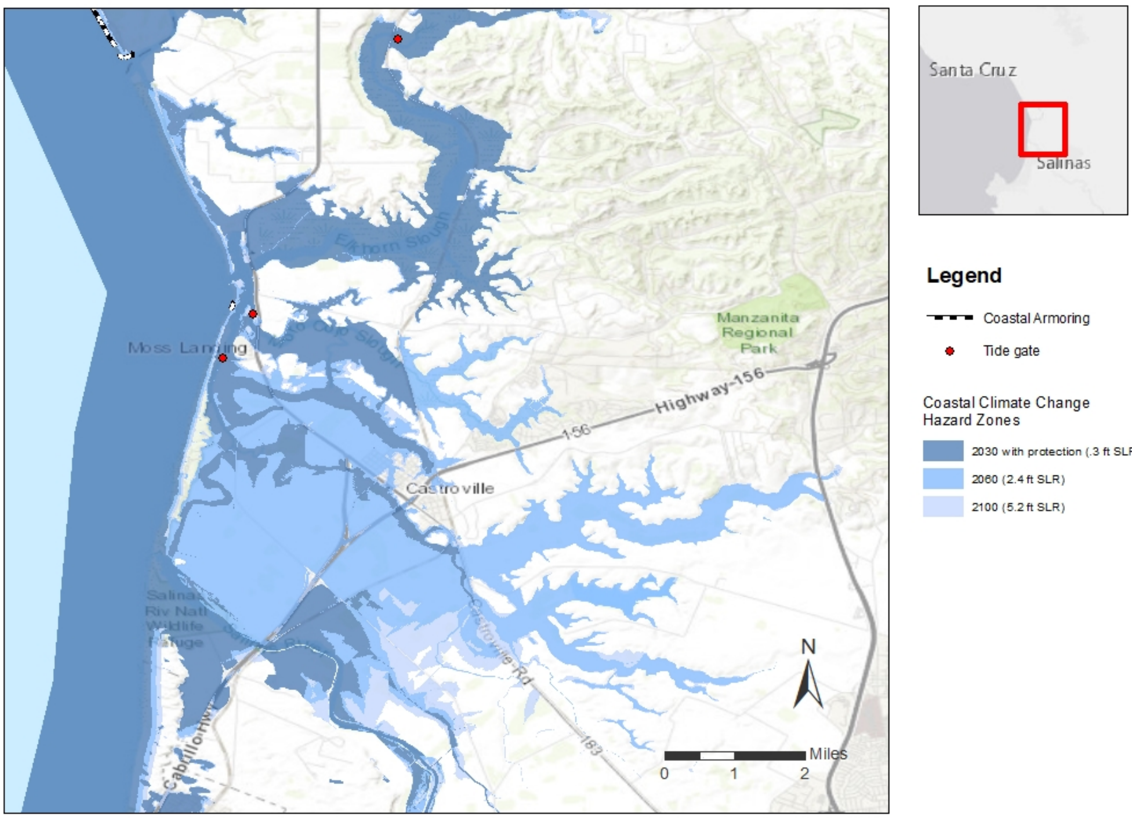
Fluvial Flooding: A river flooding vulnerability analysis was completed to evaluate the cumulative impacts of rising seas and future changes in fluvial discharge within the Gabilan watershed. The ESA modeling team expanded hydrologic models of the Gabilan watershed provided by the County to estimate discharge rates under future climate scenarios (ESA 2016). The fluvial model estimates localized flooding along the Reclamation Ditch/Gabilan Creek when discharge is restricted behind the Potrero tide gates during high tides.

Figure R-10: Projected Fluvial Flood Hazard Zones for years 2030, 2060, 2100



Combined Hazards: CCWG merged the coastal hazard layers (for the specific scenarios as modified to account for structures) to create a new combined hazard layer for each planning horizon (2030, 2060 and 2100). These merged layers represent the combined vulnerability zone for "Coastal Climate Change" for each time horizon. Projections of the combined hazards of Coastal Climate Change are intended to help estimate the cumulative effects on the community and help identify areas where revised building guidelines or other adaptation strategies may be appropriate. Combined hazards, however, do not provide municipal staff with the necessary information to select specific structural adaptation responses. Therefore, this study also evaluates the risks associated with each individual coastal hazard.

Figure R-11: Projected Combined Coastal Climate Change Hazard Zones for 2030, 2060, 2100



Land Use and Infrastructure GIS Base Layers

This case study evaluated water and utility infrastructure and wetland and dune natural resources that may be at risk to sea level rise and associated flooding. GIS layers were obtained from County and State data repositories, or created by CCWG. Assets that fell outside of the coastal flood zone were not included in this report. Assets evaluated for this case study included:

- **Farmland:** The Moss Landing community is surrounded by thousands of acres of productive farmland. Land use maps were used to identify which of these lands are susceptible to flooding.

- **Transportation Infrastructure:**
    - **Highway 1**: Highway 1 runs through Moss Landing with a bridge crossing Elkhorn Slough.

  - **Rail:** The rail line transects the Moss Landing study area passing through Elkhorn and Moro Cojo sloughs. The rail line is operated daily by Southern Pacific for both commercial and passenger service.
  - **Bridges**: There are a number of bridges and roads that overpass the complex network of creek and wetland features within Moss Landing.

- **Water and Utility**
  - **Water Control:** There are two tide gates in place to help reduce tidal range within the Old Salinas and Moro Cojo sloughs. These structures restrict tidal flooding to large areas of the southern Moss Landing study area but also inadvertently restrict river discharge during large winter storms.
  - **Sewer:** There are several wastewater pump stations located in the Moss Landing area. Passive and gravity fed sewer mains were evaluated and reported as impacted where flooding overlay this infrastructure. Pressurized sewer mains were assumed to be resilient to coastal flooding.
  - **Storm Drains:** Storm drains within the urban areas that are located within flood zones were noted as being vulnerable to future flooding.
  - **Wells:** Agriculture, test, and water supply wells exist throughout the lower Salinas Valley. Because these systems are not designed to accommodate surface flooding, saltwater flooding of these wells during periods of coastal storm flooding was determined to risk groundwater contamination and thus noted as vulnerable within the Coastal Storm Flood hazard zones.
  - **Recycled Water Infrastructure:** Recycled water infrastructure within coastal erosion zones was identified.

- **Natural Resources:**
  - **Wetlands:** Elkhorn Slough's tidal salt marsh provides critical habitat for many species. Fresh and brackish water wetlands within the Moro Cojo Slough and Salinas River/Old Salinas River channel provide important habitats for threatened species and flood attenuation during winter storms. Increased flood water depth on marsh plains can threaten plant communities. Saltwater flooding inland of normal mixing areas can threaten fresh and brackish water plant and animal communities.
  - **Dunes:** The beach dunes along Moss Landing State Beach and Salinas River State Beach provide important habitat for many native plants and animals. These dunes are vulnerable to winter wave damage and erosion, leaving low lying lands behind the dunes vulnerable to flooding.

R.6.2.b Vulnerabilities for 2030, 2060 and 2100

Due to climate change, the cumulative amount of infrastructure at risk will increase between 2010 and 2100 as projected ocean water elevation and storm intensity increase. Impacts during early time horizons (2030) will most commonly result from infrequent storm-induced flooding and erosion. Hazards associated with fluvial and tidal flooding will increase during future time horizons (2060 and 2100).

Figure R-12 illustrates what water infrastructure is projected to be vulnerable to coastal climate change hazards for the years 2030, 2060, and 2100. Hazards include dune erosion, frequent to annual wave damage and storm-related flooding, and areas where increases in sea level will lead to monthly inundation during high tides. Infrastructure located behind tide gates are assumed to be protected from projected risks through 2030. Future hazards projected beyond 2030 are assumed to place infrastructure behind tide gates at risk because it is assumed that current tide gate infrastructure will no longer provide flood protection for projected 2060 and 2100 hazards.

Figure R-13 illustrates groundwater well infrastructure projected to be impacted by coastal storm flooding for the years 2030, 2060, and 2100. The amount of water infrastructure, transportation infrastructure, farmland, and natural resource areas at risk from the combined effects of coastal climate change are presented in Table R-6 below for each time horizon.

Figure R-12: Sewer and Storm Water Infrastructure and the Combined Coastal Change Hazards in the Lower Salinas Valley Study Area

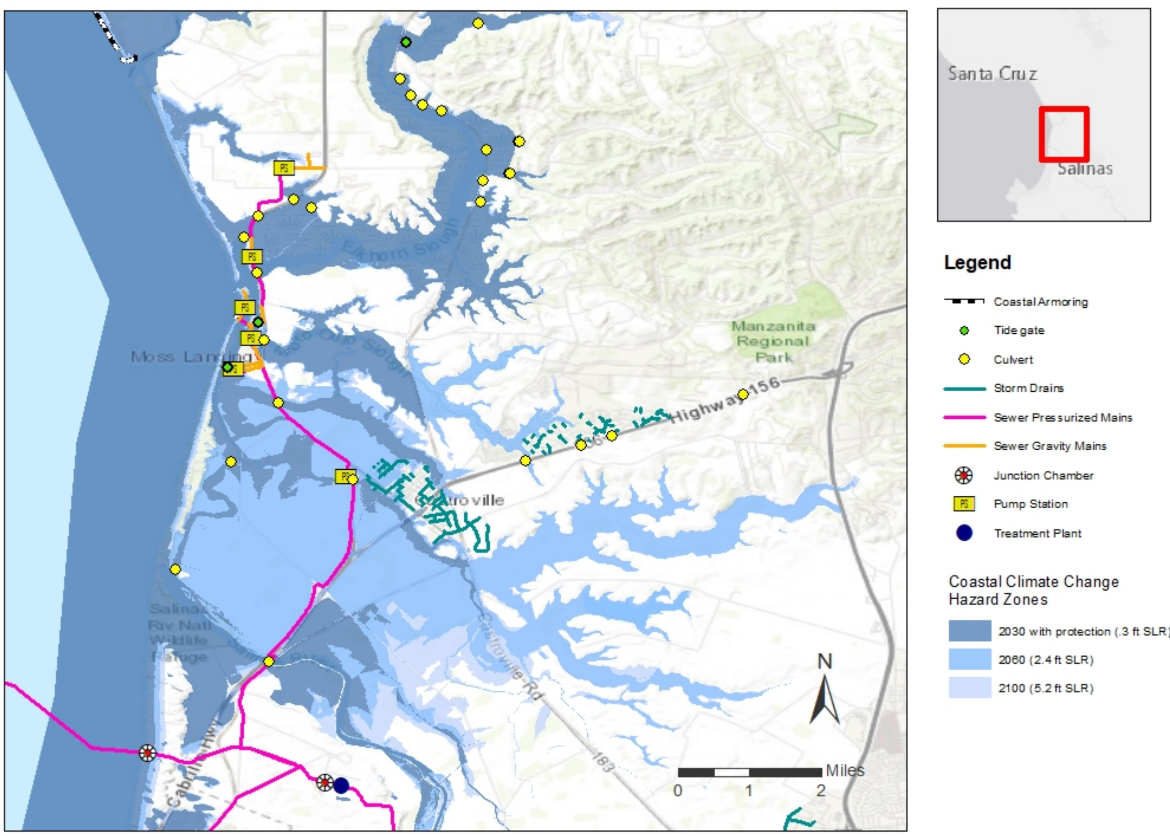


Figure R-13: Wells Projected to be Impacted by Coastal Storm Flooding in the Lower Salinas Valley Study Area

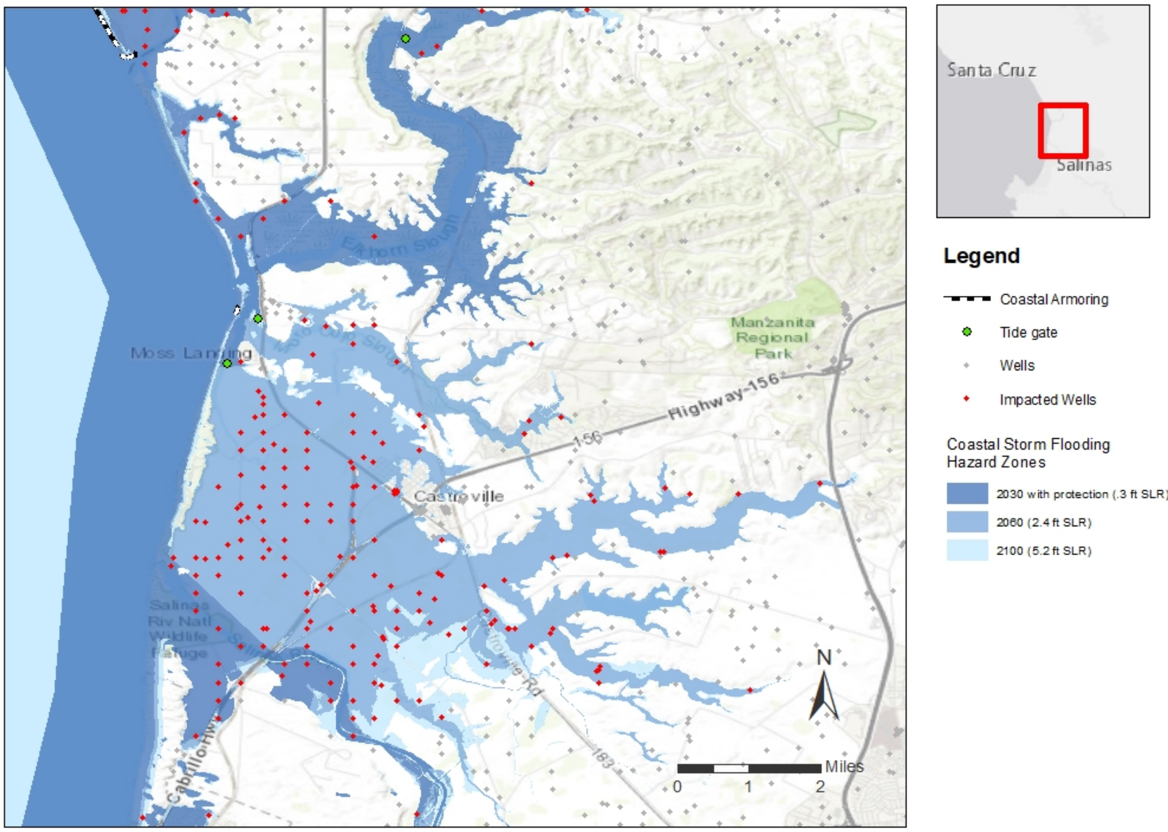


Table R-6: Vulnerability of Assets due to Combined Effects of Coastal Climate Change within the Lower Salinas Valley Study Area

ASSET	UNITS	TOTAL	2030 (with protection)	2030 (no protection)	2060 (no protection)	2100 (no protection)
Land Use						
Farmland	Acres	15,393	1,991	4,731	5,290	5,532
Transportation						
Roads	Feet	687,784	20,279	50,746	73,286	95,284
Rail	Feet	45,730	7,855	11,280	15,901	24,728
Highway 1	Feet	62,949	3,894	14,464	22,780	29,040
Water and Utility Infrastructure						
Storm Drains	Feet	29,201	0	80	100	172
Culverts and Tide Gates	Count	29	19	20	22	24
Wastewater Pumps	Count	6	2	5	5	5

ASSET	UNITS	TOTAL	2030 (with protection)	2030 (no protection)	2060 (no protection)	2100 (no protection)
Sewer Gravity Mains	Feet	12,585	6,329	7,152	8,540	9,593
Recycled Water Infrastructure	Count	2	1	1	1	1
Wells (impacted by storm flooding only)	Count	~1,100	108	259	282	314
Natural Resources						
Dunes	Acres	1,227	636	736	894	969
Critical Habitat	Acres	2,306	1,048	1,126	1,361	1,629
National Wetlands	Acres	5,889	3,382	4,074	4,387	4,495

R.6.2.c Summary of Key Findings

Water Control Structures: By 2060 many of the existing tide gates and culverts will not have the capacity to address the combined impacts of predicted coastal storm flooding and rising tides. It is assumed that the flood protection provided by the Moss Landing Road tide gates for the Moro Cojo watershed will be compromised. The fluvial analysis for the Old Salinas River estimated that the flow restriction posed by these tide gates will increase with higher ocean elevations, reducing flood conveyance, and leading to further flooding of agriculture and urban areas of the lower Salinas Valley. A number of storm drains within the town of Castroville and Moss Landing discharge to drainage areas that are within the coastal storm flood hazard areas, suggesting that future effectiveness of some storm drains to manage flooding within the town will be reduced. This storm drain infrastructure may also act as a conduit for flooding of low-lying areas that are protected behind berms from coastal flooding.

A number of sewer lines and the Moss Landing pump station are located within future hazard zones. For this analysis, CCWG did not determine if the pump station would continue to function when predicted flooding occurs. It is assumed that gravity fed and non-pressurized sewer lines are susceptible to saltwater seepage when flood waters are present.

Groundwater wells throughout the lower Salinas Valley are located within future coastal storm flooding hazard zones. A number of these wells have been found to act as conduits allowing cross contamination between the 180 Foot and 400 Foot aquifers. If these wells are flooded with surface salt water, it is assumed that many of the wells may allow saltwater intrusion to one or multiple aquifers.

Natural Resources: Coastal erosion compromises sand dunes' ability to restrict wave overtopping and flooding within the lower Salinas Valley. By 2060 erosion of the dunes near Potrero Road and near the Salinas River mouth will be at risk of storm wave overtopping, leading to waves flowing into the Old Salinas River channel, bypassing the coastal flood protections provided by the tide gates and river levees. This inland migration of beach along this portion of the coast poses a significant risk to the Salinas Valley if the dunes are not encouraged to migrate inland with the coastline. Such migration will, of course, lead to serious conflicts with adjacent agriculture and the current alignment of the Old Salinas River.

By 2100, the Old Salinas River channel and harbor main channel will be vulnerable to coastal wave processes as the dunes along this stretch of coast experience the effects of "coastal squeeze." Within these areas the dune faces are projected to erode inland while the location of inland development remains static.

Three sections of the coastal sand spit are vulnerable to loss from coastal erosion. The failure of these dunes will likely lead to significant changes in how (or if) the harbor and Sandholdt sand spit development continues to function. Additionally, many of the surrounding freshwater wetland resources may be negatively impacted by the increased tidal range.

R.6.3 Top Priority Climate Risks for the Greater Monterey IRWM Region

By integrating the results of the narrative risk evaluation with the GIS temporal hazard analysis, CCWG was able to use numerous prediction methods to identify priority assets that are at risk of future impact in the broader Greater Monterey County region. The following climate risks were identified as being top priority for the RWMG and other water managers in the Greater Monterey County IRWM region for considering how to adapt the region's water management systems for climate change impacts:

- ***Decreased water supply*** due to changes in precipitation, more frequent and severe droughts, increased surface and groundwater consumption, and increased seawater intrusion (due to sea level rise affecting coastal aquifers). Note, water infrastructure (wastewater and recycled water), which provides a significant secondary water supply to agriculture within the lower Salinas Valley, is vulnerable to sea level rise and storm impacts. Climate hazards may jeopardize this infrastructure, resulting in potential loss to future water supply resiliency.
- ***Increased flooding and erosion of creeks and rivers*** due to more intense storm events (higher river flow rates), and overburdening of conveyance systems, levees, and culverts.
- ***Coastal inundation of urban development and other land uses, and impacts to river and wetland ecosystems*** due to changes in rainfall patterns, storm intensity, storm surges (due to increased storm intensity) and sea level rise.

Water purveyors have spent considerable effort and funding to draft and implement water supply resiliency plans (e.g., California Water Service Conservation Master Plan 2016-2020, Salinas District Urban Water Management Plan 2015). Less attention has been dedicated to risks associated with increased river flows and higher seas. The section below provides an initial evaluation of adaptation options that can be implemented by IRWM partners to increase local water resource resiliency. Where possible, RWMG members and other IRWM partners should work together to develop integrated projects that address two or all three of these priority vulnerabilities.

R.7 ADAPTATION STRATEGY

R.7.1 Adaptation Goals and Objectives

The Greater Monterey County IRWM region's initial adaptation goals and objectives, listed below, were selected from a comprehensive list of potential actions within the DWR guidance document. The goals are intended to direct focus towards the three priority climate risks identified above as well as the water resource goals and objectives defined within this Greater Monterey County IRWM Plan (see Section D, Objectives). The adaptation goals and objectives form the foundation for the RWMG's initial adaptation strategy for the Greater Monterey County region. The goals document specific responses to the priority climate risks that can be accomplished by the various IRWM partner agencies and stakeholders and do not need to be managed or actively coordinated by the RWMG. The Greater Monterey County IRWM planning effort will serve as a forum to hear ideas and results of projects aimed to address these goals by numerous entities.

Adaptation Goals and Objectives

The Greater Monterey County IRWM Plan recognizes the importance of becoming a climate resilient region. Adaptation goals and objectives from DWR's guidance document that support that intention include:

Adaptation Goals:

- Encourage adaptation activities that increase the resiliency of local communities, businesses, and institutions to changes in the climate.
- Minimize the potential for injury of citizens and damage to public and private property from climate change-related impacts.
- Increase the resilience of municipal departments to adapt and respond to climate related emergencies.
- Protect natural lands, agricultural areas, and coastal resources from the future threats of climate change to increase the resilience of communities.
- Do not permit the construction of new critical facilities within the 200-year flood plain (per State recommendations).
- Plan for effective adaptation and resiliency that supports proactive steps towards sustainability rather than response through unplanned emergency actions.

Adaptation Objectives:

- Implement on-going climate change variable monitoring to inform adaptation and response efforts.
- Develop regional sea level rise resiliency strategies to prepare for impacts to water resource infrastructure and lands, that support the multiple benefits described in the IRWM Plan, and that consider short and long-term economic implications.
- Consider potential climate change impacts to water resources in future land use and regional resource planning of the county and other municipalities.
- Support regional collaborations and planning efforts, and provide information to the public regarding potential climate change impacts and status of response planning.
- Encourage the retrofit or relocation of water infrastructure (including waste water and recycled water) that is vulnerable, and evaluate changes to water management strategies that are likely to be less effective due to climate change.
- Prioritize the protection of drinking water resources and sensitive water supplies and aquatic ecosystems that support a sustainable region.

R.7.2 Initial Adaptation Strategy

To develop an initial adaptation strategy for the Greater Monterey County IRWM region, adaptation actions and response scenarios from the California Natural Resources Agency's *2009 California Climate Adaptation Strategy* were selected as applicable to the Greater Monterey County region. High priority responses along with climate mitigation actions are listed in Table R-7, Adaptation and Response Strategies Based on Risk Assessment. The "high priority responses" were prioritized by the RWMG according to the risk assessment described previously and in accordance with the objectives of the Greater Monterey County IRWM Plan. Both the comprehensive risk assessment (which heavily favors human impacts as priorities) and the environmental risk assessment is presented together in Table R-7.

This prioritized list of adaptation actions was considered a first step toward developing a comprehensive adaptation strategy for the Greater Monterey County IRWM planning region to address the impacts of climate change. For the 2017-2018 IRWM Plan update, the RWMG (led by CCWG) took the process a step further by identifying possible strategies to reduce specific climate change vulnerabilities, according to anticipated impacts in three different timeframes. This process is described in Section R.7.3 following Table R-7.

As more tools become available, the RWMG will continue to consider more specific risks to the region due to climate change and will be able to refine its understanding of the tradeoffs and benefits of different adaptations, and to identify additional adaptations relevant to the region.

Table R-7: Adaptation and Response Strategies Based on Risk Assessment

Climate Change Consequences	Including All Consequences		Environment and Sustainability Consequence Only		Adaptation and Response Strategies	Initial Actions
	Risk Score	Priority Level	Risk Score	Priority Level		
Water Demand						
Agricultural water use is expected to increase to offset higher temperatures and evapotranspiration	62	High	19	Extreme	• Promote community resilience to reduce vulnerabilities: food sustainability	• Expand water supplies (purple pipe) and storage • Aquifer management • Expand agriculture water conservation programs
Rangelands are expected to be drier	49	Medium	15	High	• Prepare fire reduction strategies to protect watershed lands using ecologically sustainable strategies. • Implement adaptation strategies to conserve California's biodiversity.	N/A
Domestic landscaping and recycled water irrigation needs will be higher	51	Medium	15	High	• Integrate land use, storm water and climate adaptation planning	• Education • Incentive programs • Demonstration programs • Grey water • Xeriscaping • Expand water supplies (purple pipe) and storage • Aquifer management • Expand domestic conservation programs
Local rainfall is estimated to be reduced by 3-10 inches	61	High	17	Extreme	• Promote community resilience to reduce vulnerabilities: Food sustainability • Implement water conservation and supply management efforts • Manage watersheds, habitat, and vulnerable species	• Education • Incentive programs • Demonstration programs • Grey water • Xeriscaping • Aquifer management • Expand agriculture water conservation programs

Climate Change Consequences	Including All Consequences		Environment and Sustainability Consequence Only		Adaptation and Response Strategies	Initial Actions
	Risk Score	Priority Level	Risk Score	Priority Level		
Sea level rise and higher groundwater extraction will lead to increased rates of saltwater intrusion	66	High	17	Extreme	• Prepare a regional sea level rise adaptation strategy • Promote working landscapes with ecosystem services • Integrate land use and climate adaptation planning	• Education • Incentive programs • Demonstration programs • Grey water • Xeriscaping • Expand water supplies (purple pipe) and storage • Aquifer management • Expand agriculture water conservation programs • Groundwater barriers • More robust monitoring and testing • Easements for retired farmland
Droughts will be more frequent and severe	59	High	16	Extreme	• Implement adaptation strategies to conserve California's biodiversity • Educate, empower, and engage citizens regarding risks and adaptation • Integrate land use, water reuse and climate adaptation planning • Promote community resilience to reduce vulnerabilities	• Human safety response • Education • Incentive programs • Demonstration programs • Grey water • Xeriscaping • Expand water supplies (purple pipe) and storage • Aquifer management • Expand agriculture and urban water conservation programs • Groundwater barriers • More robust monitoring and testing • Easements for retired farmland
Water Quality						
Lower seasonal surface flows can lead to higher pollutant concentrations	39	Low	12	High	• Manage watersheds, habitat, and vulnerable species	• Minimize non-point source pollution • Buffers
Changes in storm intensity will increase sediment loading in many systems	48	Medium	13	High	• Prepare fire reduction strategies to protect watershed lands using ecologically sustainable strategies	• Erosion control on farms and creeks • Buffers

Climate Change Consequences	Including All Consequences		Environment and Sustainability Consequence Only		Adaptation and Response Strategies	Initial Actions
	Risk Score	Priority Level	Risk Score	Priority Level		
Channel stability will be impacted from higher storm flows causing additional turbidity	39	Low	11	Medium	• Provide guidance on protecting critical coastal ecosystems and development	• Erosion control on creeks • Wastewater and stormwater infrastructure vulnerability analysis
Sea level rise will impact current estuary brackish water interface towards more marine systems	50	Medium	16	Extreme	• Implement adaptation strategies to conserve California's biodiversity	• Retain freshwater in watershed • Habitat migration • Buffers • Erosion control • Conservation easements • Xeriscaping
Flooding						
Regional levees will provide less protection during higher storm flow events	69	High	13	High	• Support essential data collection and information sharing • Manage watersheds, habitat, and vulnerable species • Prepare a regional sea level rise adaptation strategy	• Refurbish or expand levees or tide gates (upgrade priority infrastructure) • Map/inventory infrastructure
Natural creeks throughout the region and managed conveyance within the Salinas Valley will see higher flow rates leading to increased erosion and flooding	54	Medium	12	High	• Manage watersheds, habitat, and vulnerable species	• Refurbish or expand levees or tide gates (upgrade priority infrastructure) • Map/inventory infrastructure

Climate Change Consequences	Including All Consequences		Environment and Sustainability Consequence Only		Adaptation and Response Strategies	Initial Actions
	Risk Score	Priority Level	Risk Score	Priority Level		
Coastal levees and control structures will be undersized to manage the combined influences of higher flow events and sea level rise	89	Extreme	17	Extreme	• Support essential data collection and information sharing • Prepare a regional sea level rise adaptation strategy	• Refurbish or expand levees or tide gates (upgrade priority infrastructure) • Map/inventory infrastructure/levee locations and WCS, ownership • Phase II task 5 activity 3 - ecosystem services - be aware of services available • Elevations of levees and sea walls - maybe with PWA-management strategies • USGS elevation data? • Channel dredging • Ecological restoration
State recommendations suggest no new critical facilities be built within the 200-year flood plain (DWR 2008, DWR 2009b, CNRA 2009)	23	Low	3	Low	• Integrate land use and climate adaptation planning	• Work with Monterey County and cities, Coastal Commission (local jurisdiction)
Aquatic Ecosystem Vulnerabilities						
Migration patterns and species distribution will change	37	Low	13	High	• Establish a system of sustainable habitat reserves	• Reduce migration impediments (dams, etc.) • Compile data on species distribution • Primary focus species - amphibians, waterfowl, salmonids, redwoods, tide water gobies • Maintain habitat corridors - contiguous areas • Fish and Game - wildlife adaptation plan - vulnerability for key species for each region • Remove barriers
Invasive species populations will expand	38	Low	10	Medium	• Habitat/ecosystem monitoring and adaptive management	• What are the invasive species and their ranges? Will they expand, be introduced? How are the habitats shifting (awareness)? • Ecological adaptation investigation and strategy • Model range shifts with climate change

Climate Change Consequences	Including All Consequences		Environment and Sustainability Consequence Only		Adaptation and Response Strategies	Initial Actions
	Risk Score	Priority Level	Risk Score	Priority Level		
Coastal wetland systems are especially vulnerable to the combined influences of climate change	45	Medium	16	Extreme	• Establish regional policies to protect critical habitats • Provide guidance on protecting critical coastal ecosystems and development	• Identify critical habitats and ecosystems • Integrate ecosystem management • Regulatory mechanisms dedicated to protecting future locations of these areas • Inventory of wetlands currently • What lands are adjacent? • Rolling easement for ag - retired ag lands • Hazard mitigation
Some locally unique species such as coastal redwoods and giant kelp are susceptible to changes in certain locally favorable climate variables (fog duration, coastal upwelling)	37	Low	13	High	• Manage watersheds, habitat, and vulnerable species	• Identify how they will be impacted - What are the changes? • USGS study outcome - get a better handle on modeling fog changes in climate change
Hydropower and Reservoir Storage						
Changes in rainfall patterns may be problematic for timing of releases from reservoirs	47	Medium	9	Low	• Implement water conservation and supply management efforts	• Modified flood control operations • Opportunities for more water storage • Maintain optimum flow capacity in channels • San Antonio and Nacimiento Reservoirs and rainfall – potential for interlake tunnel
Higher rainfall and increased risk of fires in watershed lands can lead to increased sediment loading to reservoirs	37	Low	10	Medium	• Prepare fire reduction strategies to protect watershed lands using ecologically sustainable strategies	• Fire prevention • Forest management - FireScape Monterey • Rangeland management (much of the area around the reservoirs is grassland) • Erosion control for infrastructure surrounding reservoirs

R.7.3 Adaptive Capacity and Adaptation Response Planning

The Greater Monterey County region's ability to respond to a given climatic impact will enable the region to reduce either the likelihood or consequence of an event. The ability to adapt to sea level rise, for example, can occur in many forms, including coastal armoring and protection, the raising of infrastructure, and inland retreat. Each adaptive measure provides a certain level of additional protection for a certain period of time for a certain cost. Significant resources are required to fully evaluate the adaptive capacity of any social-economic factor to a given climatic variable. Numerous engineering (hard) and adaptive planning (soft) measures would need to be evaluated and cost benefit analyses completed. Additionally, secondary unintended consequences of any adaptive measure to all of the social-economic factors defined within this chapter should also be evaluated and quantified. Because of the complexity of this process, adaptive capacity has not been systematically evaluated by the RWMG.

Nonetheless, understanding which infrastructure is vulnerable to what hazard at what future date can help local agencies and regional partners identify strategies to increase water management resiliency and to develop projects and programs to support those strategies. The sections below describe possible strategies to reduce vulnerabilities, including specific assets that lie within the various future climate hazard zones according to climate scenarios for the years 2018-2030, 2030-2060, and 2060-2100. Table R-8 identifies the asset, the likely hazard, and possible actions to reduce the vulnerability of these assets to these risks.

Table R-8: List of Possible Actions

Asset	Hazard	Recommended Actions	Feasibility	Estimated Cost	Key Partners
Water and Utility Infrastructure					
Storm Drains	Storm and fluvial flooding	Install gates on vulnerable storm drains	Easy	Low	CCSD, MCWRA, Monterey County Public Works
	Rising tides	Estimate effective life using sea level rise predictions	Easy	Low	CCSD, MCWRA, Monterey County Public Works
	Storm and fluvial flooding	Evaluate options to reduce reliance on vulnerable storm drain infrastructure (LID, retention)	Easy	Low	CCWG, City of Salinas, CCSD, MCWRA, Monterey County Public Works
Culverts and Tide Gates	Rising tides	Evaluate necessary upgrade to existing structures	Moderate	Moderate	CCSD, MCWRA, Monterey County Public Works
	Fluvial flooding	Evaluate secondary overflow options	Moderate	Moderate	CCSD, MCWRA, Monterey County Public Works
	Fluvial flooding	Evaluate feasibility of installing additional pumps and control structures	Moderate	Moderate	CCSD, MCWRA, Monterey County Public Works
	Fluvial flooding	Evaluate drainage modifications (retention) in upper watershed that reduce downstream peak flows	Moderate	Moderate	CCWG, City of Salinas, Stormwater planning team, Salinas Valley GSA
Wastewater and Recycled Water	Coastal Storm Flooding and Erosion	Relocate infrastructure out of hazard areas or redesign to accommodate hazards.	Easy	Moderate	Monterey One Water, Salinas Valley GSA, Monterey County Public Works

Groundwater Wells	Coastal storm flooding, rising tides	Evaluate risk of contamination from surface flood waters	Moderate	Moderate	RWQCB, agriculture industry, MCWRA
Moss Landing Lift Station	Coastal storm flooding, rising tides	Evaluate upgrades, resiliency or relocation	Moderate	High	CCSD, MCWRA, Monterey County Public Works
Moss Landing Harbor	Sea level rise and coastal storm flooding	Draft a site specific SLR vulnerability and adaptation plan	Easy	Low	Monterey County Planning, Moss Landing Harbor District
Natural Resources					
Dunes	Coastal storm flooding	Continue restoration and resiliency programs, upgrade trails	Easy	Moderate	Monterey County Planning, State Parks, CCWG
	Coastal storm flooding, rising tides and coastal erosion	Accommodate retreat and investigate development rights exchange program	Moderate	Moderate	BSLT, Center for Ocean Conservation, CCWG, MCRCD, Monterey County Planning
	Coastal storm flooding, rising tides	Beach Nourishment	Moderate	Moderate	Monterey County, State Parks, MBNMS
Beach Habitat	Coastal storm flooding and erosion	Draft a Beach Management Plan that establishes objectives and strategies to retain beach habitat in parallel with other sea level rise adaptation strategies.	Easy	Low	Monterey County, State Parks, CCWG, MBNMS
Wetlands	Sea level rise and coastal storm flooding	Draft Tide Gate Management Plan and Sea Level Rise Adaptation Strategy for Moro Cojo Slough	Moderate	FUNDED	CCWG, MCWRA, CDFW
	Sea level rise and coastal storm flooding	Prioritize Implementation of the Elkhorn Slough Tidal Wetland Project Strategic Plan	Easy	Moderate - High	ESNERR, Elkhorn Slough Foundation, CDFW, Monterey County
	Sea level rise and coastal storm flooding	Update and implement the Salinas River Lagoon Management and Enhancement Plan	Moderate	Moderate	CCWG, MCWRA, CDFW, USFWS, State Parks
	Fluvial flooding, coastal storm flooding, rising tides	Establish easement programs that fairly compensates farmers for lands lost due to adaptive retreat along waterways	Moderate	Moderate	BSLT, Center for Ocean Conservation, CCWG, MCRCD, Monterey County Planning

Acronyms:

BSLT: Big Sur Land Trust
CCSD: Castroville Community Services District
CCWG: Central Coast Wetlands Group
CDFW: California Department of Fish and Wildlife
ESNERR: Elkhorn Slough National Estuarine Research Reserve
GSA: Salinas Valley Groundwater Basin Groundwater Sustainability Agency
MBNMS: Monterey Bay National Marine Sanctuary
MCRCD: Resource Conservation District of Monterey County
MCWRA: Monterey County Water Resources Agency
RWQCB: Central Coast Regional Water Quality Control Board
USFWS: US Fish and Wildlife Service

R.7.3.a Adaptation Response Planning: 2018-2030

Support Dune Restoration Activities: Future wave run-up is projected to undercut dune faces and funnel waves inward along erosion scars, leading to inland flooding of the Old Salinas River valley. Wave overtopping in this area will leave the lower Salinas Valley vulnerable to flooding. Several studies suggest that restoring the complexity of dune species (De Lillis et al. 2004) and the reestablishment of native foredunes will support natural dune building processes and enhance the long-term resiliency of dunes to wave-derived erosion and overtopping. An increase in structural complexity is anticipated to play a key role in maintaining resilience as ocean levels rise and dunes are required to adapt and migrate. Setting restoration goals that ensure the long-term adaptive capacity of these natural dunes through proper management and habitat enhancement should be a priority for the continued protection of the Salinas Valley.

STATE GUIDANCE

The Coastal Act allows for protection of certain existing structures. However, armoring can pose significant impacts to coastal resources.

To minimize impacts, innovative, cutting-edge solutions will be needed, such as the use of living shorelines to protect existing infrastructure, restrictions on redevelopment of properties in hazardous areas, managed retreat, partnerships with land trust organizations to convert at risk areas to open space, or transfer of development rights programs. Strategies will need to be tailored to the specific needs of each community based on the resources at risk, should be evaluated for resulting impacts to coastal resources, and should be developed through a public process, in close consultation with the Coastal Commission and in line with the Coastal Act

Photo by R. Clark

Reduce Risks of Flooding: The periodic flooding predicted within the 2030 hazard maps can be planned for. Actions to provide protection and accommodation can be made that will reduce risks to properties.

Evaluate Tide Gate Upgrades to Improve Flood Release: Through the 2030 planning horizon, the Moss Landing and Potrero tide gates are predicted to continue to serve an important protection from tidal flooding to upstream properties, primarily agriculture and natural habitats. The tide gates, however, have restricted discharge during large rain events, which exacerbates flooding upstream. Upgrades to these gates that allow overflow during large events may help to reduce flooding extent and duration of flooding on upstream farmlands. Using the Salinas River mouth as a secondary discharge pathway during watershed flooding events should be studied.

Establish Managed Retreat Policies to Support Future Adaptation: Managed retreat is designed to facilitate and regulate the gradual move away from areas vulnerable to flooding or erosion. Managed retreat can take many forms, including zoning, setbacks, buffers, restrictions, rolling easements, and land acquisition. These strategies can be used in conjunction with other adaptation measures to facilitate the most fluid and equitable adaptation approach to the varying threats that sea level rise and other climate-related flooding poses. Managed retreat programs can work in tandem with other adaptation strategies to manage flooding, maintain local character, improve natural habitat areas, and secure coastal access.

Improve Flood Attenuation through Creek and Wetland Restoration: Wetlands can act as a critical buffer for waves, tides, and erosion. Additionally, wetlands are able to migrate inland as sea levels rise, if space is provided. Wetlands also provide natural pollution filtration and shoreline stability, sequester carbon, and can store extra water in the case of a flood, along with providing important habitat that can support local fishing and tourism. Numerous wetland restoration efforts are underway within the Elkhorn and Moro Cojo sloughs. The County and local community can support these and other activities within the Gabilan watershed to improve climate resiliency in the lower Salinas Valley.

The Greater Monterey County IRWM Plan outlines strategies to improve the function of local drainages to benefit the goals of numerous stakeholders. Proposed watershed management and drainage enhancement projects included in the plan can help the lower Salinas Valley area become more resilient to predicted increases in flooding during rain events. Numerous low-lying areas along these drainages (notably Carr Lake) can be acquired and redeveloped to provide aquatic habitat, open space, recreation, and flood attenuation, which would greatly reduce the predicted negative effects associated with more intense rainfall and higher sea levels.

R.7.3.b Adaptation Response Planning: 2030-2060

Tide Gate Upgrades: By 2060, the ability of the current tide gates to provide protection from coastal and tidal flooding may be significantly reduced due to the predicted 14-38 inch increase in water elevations within the harbor. Further analysis with help from the Monterey County Water Resources Agency will be necessary to determine the expected reduction in service and the likely increase in water elevation behind the tide gate structures. Replacing tide gates with pump stations may increase the capacity of the system to retain current water levels within the Old Salinas River, but it will likely be cost prohibitive to construct and operate a system large enough to manage predicted increases in winter river discharges of up to 700 cfs. The estimated total costs of installing and operating new pumps on one or both tide gate systems should be evaluated in comparison with the benefit to 1,592 acres of farmland at risk of coastal flooding.

Hard Armor Protection: Structures on Moss Landing Island and within the Monterey Dunes Colony are within projected 2060 coastal erosion hazard zones. Strategies should be developed that identify areas where coastal armoring is feasible and appropriate, and areas where redevelopment and retreat are more appropriate. These decisions should take into account risks from coastal climate change impacts projected forward for the total life of the properties being protected. Future risks to Moss Landing Harbor should also be considered.

Identify Priority Areas for Managed Retreat: Protection of all properties and infrastructure identified at risk during each time horizon is likely infeasible. Therefore, Monterey County will need to establish adaptation strategies that best meet local long-term goals. Public cost considerations, longevity of adopted strategies, and resultant changes to the community should be considered when setting policy. Establishing equitable managed retreat policies early will likely best enable the long-term implementation of these policies to ensure long-term sustainability for the community. Selecting time horizons and climate conditions for which next phase adaptation strategies are triggered will allow the community to anticipate and prepare for future actions.

Providing for the managed retreat of the Salinas River dunes complex onto adjacent farm and residential properties may provide significant long-term protection from coastal storm flooding within the lower Salinas Valley. The RWMG recommends that the County work with State Parks to establish dune adaptation strategies, and to prioritize land acquisition and road realignment to accommodate coastal resiliency.

R.7.3.c Adaptation Response Planning: 2060-2100

Between 2060 and 2100, increased coastal wave damage, greater flooding depths and periodicity, and higher tides will threaten significant portions of properties within Moss Landing and Castroville. Protection of all properties from these risks will be costly and technically challenging. Decisions regarding what the urban and beach front areas will look like in 2100 will need to be made much earlier if adaptation is to be strategic and cost effective. Adopting coastal adaptation and retreat policies once all efforts to protect infrastructure fail would be a costly strategy.

Implement Managed Retreat Strategies*:* There are a number of theoretical managed retreat strategies that have been described within the literature. Examples of coastal communities adopting re-zoning, building restrictions, and other land use policies to drive the removal of buildings and infrastructure from the California coast, however, are few.

The Marin Climate Adaptation effort has completed focus area analysis of coastal communities (e.g., Bolinas) similar to this Monterey County study and has identified infrastructure that will need to be raised or otherwise modified to respond to tides and coastal flooding. Agricultural lands have been identified for transition to wetlands. No residential or commercial private properties have been identified for removal and no procedures have been identified to support municipalities to "convert at risk areas to open space." Such procedures are likely necessary, however, if areas such as Moss Landing and Castroville are to remain viable communities in 2100. The overwhelming hazard predictions for these communities suggest that long-term adaptive planning and managed retreat programs are necessary and should be developed as early as possible (i.e., by 2030) for future implementation (i.e., 2060-2100).

Cost implications from routine impacts from the predicted hazards will lead many property owners to upgrade their properties to be more resilient, or abandon the current uses of those properties. Equitable retreat policies that outline how and when various portions of a community should be relocated will help the community adapt and become more resilient. Cost sharing strategies between private property owners and State and local agencies will need to be defined. Local land trusts will likely play an important role in administering these programs in years to come. Adaptation strategies adopted decades before they are implemented will help property valuation, economic considerations, and land use objectives accommodate these future changes.

Realign Roads and Utility Infrastructure: Between 2060 and 2100, much of the lower Salinas Valley west of Highway 1 is predicted to be flooded during high tides or by winter storms. Highway 1 and other roads will need to be upgraded or realigned if they are to continue to function. Adaptive community planning can help Caltrans and other agencies make better decisions regarding how to upgrade roads and utilities to best serve coastal Monterey County through 2100.

Costs for future realignment of roadways (including Highway 1) and utility infrastructure can be minimized if managed adaptation and retreat policies are established decades before implementation. County agencies and utility districts should integrate future land use changes into current infrastructure repair and replacement decisions to minimize future costs of infrastructure loss and realignment.

R.7.4 No Regret Strategies

In addition to the strategies outlined above, the RWMG encourages the implementation of so-called "no regret" adaptations to general effects of climate change. Such adaptations are those that make sense in light of the current water management context for the region and will also help the region adapt to expected climate change impacts. Examples of "no regret" strategies include increasing water use efficiency, practicing integrated flood management, and enhancing ecosystems and their ability to provide multiple benefits to the region. The RWMG generally encourages the implementation of "no regret" strategies throughout the IRWM Plan and gives higher priority to these strategies in the project ranking process by providing additional points under the "Climate Change" categories.

R.8 CLIMATE CHANGE MITIGATION AND GHG EMISSIONS REDUCTION STRATEGY

The development of a GHG emissions reduction strategy is a required component of an IRWM Plan. All aspects of water resources management have an impact on GHG emissions, including the development and use of water for habitat management and recreation; domestic, municipal, industrial, and agricultural supply; hydroelectric power production; and flood control. Water management results in the consumption of significant amounts of energy in California and the accompanying production of GHG emissions, especially where water must be pumped from long distances, from the ground, or over significant elevations. According to California Energy Commission (2005), 19 percent of the electricity and 30 percent of the non-power plant natural gas of the State's energy consumption (i.e., 12% of all energy used in California) are spent on water-related activities, primarily related to end-uses of water. The close connection between water resource management and energy is an important consideration for helping the State meet its GHG emission reduction goals. IRWM Plans can help mitigate climate change by reducing energy consumption, especially the energy embedded in water use, and ultimately reducing GHG emissions.[8]

This IRWM Plan focuses on several sectors of emissions that are most directly linked to water management and that are most likely to not be addressed within other climate/GHG reduction strategies. Emissions sources to be addressed include:

- Emissions included in the county for the production and distribution of water
- Emissions from privately owned pumps
- Emissions from county staff fleet and private vehicle emission associated with water project construction and maintenance
- Emissions from energy generation that could be mitigated through renewable energy sources

[8] This introductory paragraph has been excerpted from the Proposition 1 IRWM Program Guidelines, pp. 70.

R.8.1 GHG Reduction Strategies

To address the emissions categories identified above, several key strategies and actions described in the *Climate Change Handbook for Regional Water Planning* (US EPA Region 9 and DWR 2011) can be encouraged by the RWMG through the IRWM planning process. These include the following:

Emissions from water supply and delivery

- Select energy sources with low carbon content (green electricity purchases)
- Prioritize pump and infrastructure upgrades based on energy efficiency
- Reduce water use by all sectors of the community through conservation and water efficient irrigation
- Install solar PV at remote pump and infrastructure sites and provide incentives for private investment in solar for similar infrastructure
- Schedule pumping to reduce peak hour (12:00-5:00pm) energy use that has the highest carbon content

Staff fleet and commute

- Encourage carpooling
- Invest in energy efficient/low carbon fleet vehicles
- Encourage efficient driving practices

Emissions from IRWM Plan project construction

- Encourage carpooling within construction contracts
- Encourage use of B20 fuels in construction equipment and other diesel machinery
- Invest in high efficiency pumps and control equipment
- Integrate solar generation in appropriate projects

Renewable energy generation

- Encourage investment in solar and other renewable energy generation options in Greater Monterey County IRWM region facilities
- Work with regional waste district to increase electricity generation from farm-generated food and animal bio-waste
- Increase hydro-electric generation within current water infrastructure

Carbon Sequestration

- Identify new carbon sequestration opportunities including wetland restoration and bio-char soil amendment opportunities.
- Develop funding mechanisms to support sequestration within proposed IRWMP projects or as project mitigation options.

The RWMG encourages the reduction of GHG emissions for IRWM Plan implementation projects through the project review and ranking process. The RWMG can use the IRWM planning process to coordinate with water managers and land use planners throughout the Greater Monterey County region in order to encourage broader implementation of these and other GHG reduction and climate mitigation actions.

R.8.2 Other Climate Change Mitigation/GHG Reduction Activities in the Central Coast Region

The RWMG has been communicating with water managers and land use managers in the broader Central Coast region regarding other climate change mitigation/GHG reduction efforts along the Central Coast.

The RWMG will seek to partner in these and similar efforts as opportunities arise. Regional climate change mitigation/GHG reduction programs include the following.

Climate Action Compact

In October 2007, the County of Santa Cruz, the City of Santa Cruz, and the University of California Santa Cruz partnered to create a Climate Action Compact (CAC). The goal of the CAC is to achieve meaningful and measurable progress towards lowering local GHG emissions through the implementation of cooperative programs. To that end, the CAC partners initiated a process to develop actions necessary to accomplish the goals outlined in the compact. In 2011 CAC members reached out to all municipalities within the Monterey Bay region, including the area covered by the Greater Monterey County IRWM Plan, to join and participate in collaborative GHG reduction efforts. The members pledged to support public, private, and nonprofit partnerships and investments to reach quantifiable reductions in their institutions' GHG emissions (Clark 2011). In taking this leadership role, the CAC partners pledged themselves to the following:[9]

- set and present a GHG reduction goal for their respective organizations;
- identify specific inter-institutional cooperative projects that reduce GHG emissions, stimulate investment in the community, and foster economic development;
- present a comprehensive GHG reduction action plan for their respective organizations; and
- invite others from the public, private, and non-profit sectors in the region to join in the effort.

Association of Monterey Bay Area Governments Programs

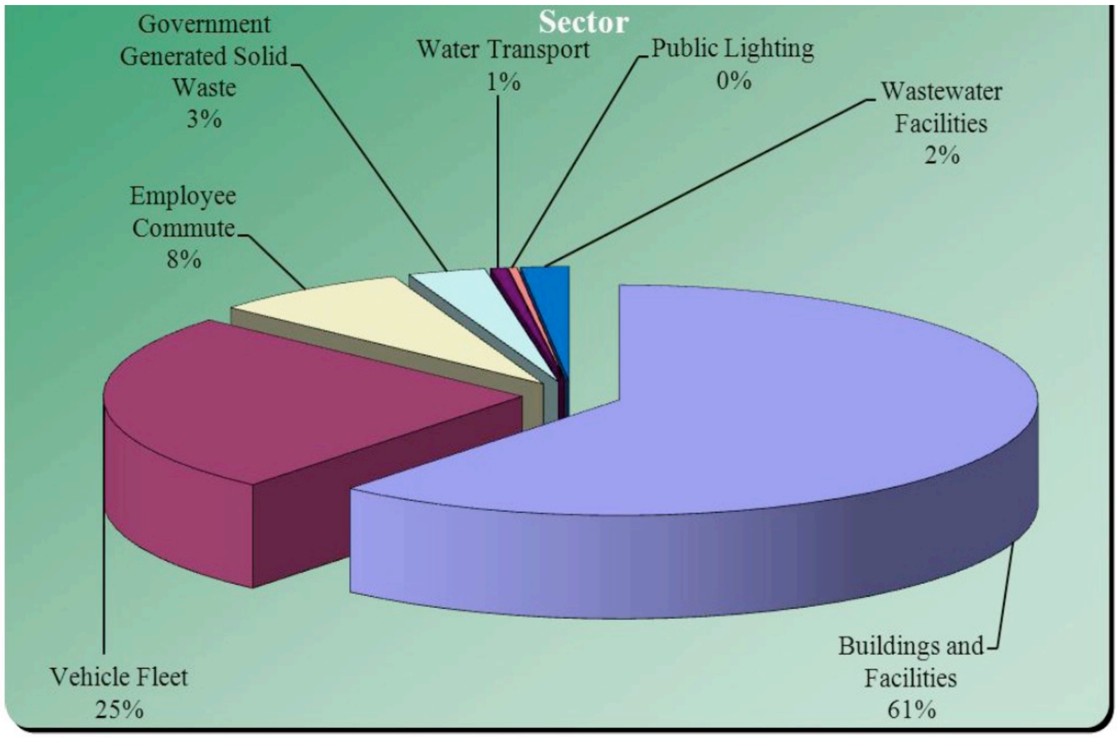
The Association of Monterey Bay Area Governments (AMBAG) has developed regional emission targets in accordance with requirements of SB 375. AMBAG has also initiated a program in collaboration with the Pacific Gas and Electric Company (PG&E) called "Energy Watch." The Energy Watch Program helps local governments in Monterey, San Benito, and Santa Cruz counties to promote energy efficiency and climate action planning. This collaboration has included preparation of GHG emissions inventories.

In early 2011, the AMBAG Energy Watch Program completed a GHG emissions inventory for Monterey County for the year 2005. The inventory for Monterey County was developed using the "Clean Air and Climate Protection" software developed by ICLEI. The inventory examines emissions by community sector and includes direct and indirect emissions. The study also predicts that under a "business-as-usual" scenario, Monterey County GHG emissions are estimated to grow by approximately 9 percent by the year 2020, which represents an average annual rate of increase of about 0.6 percent per year with the total increase between 2005 and 2020.

In 2010, AMBAG completed a set of GHG inventories for all of its 21 municipal members. The cumulative emissions from the unincorporated areas of Monterey County were quantified for various sectors including municipal (county government) residential and commercial/industrial. For 2005, countywide emissions were calculated to be 1,648,410 metric tons. Of that total, municipal emissions comprised 1.3 percent (21,641 tons); and of the municipal emissions total, emissions from municipal supply and distribution of water resources were 0.6 percent (133 tons). Figure R-14 below illustrates emissions from local government operations for Monterey County, by sector. Additional emissions attributable to water management in the Greater Monterey County region that are not included in this calculation include: emissions from small water purveyors, private well and flood management pump infrastructure, and the emissions associated with water agency fleet and staff vehicles used to manage the vast water resource infrastructure of the region.

[9] Source: City of Santa Cruz CAC website: http://www.cityofsantacruz.com/index.aspx?page=1231 (March 2012).

Figure R-14: 2005 GHG Emissions from Monterey County Government Operations



Source: AMBAG 2011, Monterey County Greenhouse Gas Emissions Inventory. Used by permission.

Monterey County General Plan

Monterey County adopted a new General Plan on October 26, 2010. The environmental impact report prepared for the 2010 General Plan contains a discussion of potential GHG emissions impacts. Policies were added to the General Plan as mitigation for these potential GHG impacts related to buildout of the General Plan. The MCAP was prepared pursuant to that mitigation and Policy OS-10.15 of the General Plan to address GHG emissions from County operations.

Monterey County Climate Action Program

Monterey County has prepared a Municipal Climate Action Plan (MCAP) in response to the AB 32 Scoping Plan recommendation. The plan:

- Provides a description of the steps being taken by the County to reduce GHG emissions associated with its municipal operations (i.e., the County's day-to-day activities in providing services to Monterey residents and businesses).
- Describes three potential paths towards the County's goal of reducing GHG emissions to a level that is 15% below the 2005 emissions level before 2020.
- Serves as one component of the County's larger, community-wide Climate Action Plan, which addresses GHG emissions from the community at large.

The Monterey County Energy Efficiency Measure Dashboard on the County's website (http://www.co.monterey.ca.us/government/departments-a-h/administrative-office/intergovernmental-and-legislative-affairs/go-green-monterey-county/energy) provides information on estimated GHG reductions resulting from energy efficiency measures implemented at County facilities. Figure R-15 below illustrates the dashboard as of July 2018.

Figure R-15: Monterey County Energy Efficiency Measure Dashboard