CENTRAL VALLEY
FLOOD MANAGEMENT
PLANNING PROGRAM

FloodSAFE
CALIFORNIA

2012 Central Valley Flood Protection Plan

Climate Change Scope Definition Work Group Summary Report

DRAFT December 2009

STATE OF CALIFORNIA
THE NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES

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Acronyms and Abbreviations

°C .... degrees Celsius

°F .... degrees Fahrenheit

AB .... Assembly Bill

CAT .... Climate Action Team

CCSDWG .... Climate Change Scope Definition Work Group

CCTAG .... Climate Change Technical Advisory Group established for California Water Plan Update

cfs .... cubic feet per second

cm .... centimeters

CO_2 .... carbon dioxide

CVFPP .... Central Valley Flood Protection Plan

CVP .... Central Valley Project

Delta .... Sacramento-San Joaquin River Delta

DWR .... California Department of Water Resources

FEMA .... Federal Emergency Management Agency

GHG .... greenhouse gas

in/yr .... inch per year

IPCC .... Intergovernmental Panel on Climate Change

IRMWP .... Integrated Regional Water Management Plans

LOP .... level of protection

M&I .... municipal and industrial

mm/yr .... millimeters per year

NFIP .... National Flood Insurance Program

O&M .... operations and maintenance

PPIC .... Public Policy Institute of California

RCSR .... Regional Conditions Summary Report

SB .... Senate Bill

SCS .... sustainable community strategy

SWP .... State Water Project

USACE .... U.S. Army Corps of Engineers

1.0 Introduction

Recent legislation directs the California Department of Water Resources (DWR) to prepare a Central Valley Flood Protection Plan (CVFPP) and submit it to the Central Valley Flood Protection Board by January 1, 2012. The CVFPP will document and assess current performance of the State-federal flood protection system in the Sacramento-San Joaquin Valley[1] (see Figure 1-1), and make recommendations to improve integrated flood management.[2] The legislation also requires that the CVFPP be updated every 5 years thereafter. The 2012 CVFPP will accomplish the following:

- Promote understanding related to integrated flood management from State, federal, local, regional, tribal and other perspectives (e.g., agriculture, urban, rural, environment, environmental justice, etc.)
- Create a broadly supported vision for improving integrated flood management in Central Valley
- Develop new data and information that can be shared for many purposes

The Climate Change Scope Definition Work Group (CCSDWG) was formed to provide input to DWR about the scope of climate change considerations that will be addressed in the 2012 CVFPP.

This CCSDWG Summary Report presents the outcomes of the group's work sessions, including the five deliverables identified in Section 1.3.

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[1] The planning area defined in Government Code 65007: "Sacramento-San Joaquin Valley means any lands in the bed or along or near the banks of the Sacramento River or San Joaquin River, or any of their tributaries or connected therewith, or upon any land adjacent thereto, or within any of the overflow basins thereof, or upon any land susceptible to overflow therefrom. The Sacramento-San Joaquin Valley does not include lands lying within the Tulare Lake basin, including the Kings River.

[2] Integrated Flood Management is an approach to dealing with flood risk that recognizes the interconnection of flood management actions within broader water resources management and land use planning; the value of coordinating across geographic and agency boundaries; the need to evaluate opportunities and potential impacts from a system perspective; and the importance of environmental stewardship and sustainability (DWR, Draft FloodSAFE Strategic Plan, 2008).

Figure 1-1. CVFPP Planning Area

1.1 Work Group Roles and Responsibilities

The CCSDWG consists of DWR representatives, voluntary members, and supporting staff.

1.1.1 DWR Representatives

1. Gary Hester, Central Valley Flood Management Program Manager
2. Michael Anderson, State Climatologist
3. Roger Lee, Central Valley Flood Protection Office
4. Thomas Filler, Climate Change Technical Advisory Group established under the 2009 California Water Plan Update

1.1.2 Volunteer Members

The work group includes the following members representing a broad range of interests and perspectives:

1. Stephen Crooks, National Blue Ribbon Panel: Wetlands Restoration Greenhouse Gas Mitigation Emission Offset Protocol
2. Michael Dettinger, U.S. Geological Survey
3. David Edwards, California Air Resources Board
4. Elizabeth Patterson, California Department of Water Resources (retired)
5. David Raff, U.S. Department of the Interior, Bureau of Reclamation
6. Kelly Redmond, Western Regional Climate Center (Desert Research Institute)
7. Nat Seavy, PRBO (founded as Point Reyes Bird Observatory) Conservation Science
8. Michael Tansey, U.S. Department of the Interior, Bureau of Reclamation
9. Susan Tatayon, The Nature Conservancy
10. Stu Townsley, U.S. Army Corps of Engineers
11. Robert Webb, National Oceanic and Atmospheric Administration

12. Terry Roscoe, California Department of Fish and Game

The CCSDWG Group also coordinated with the Climate Change Technical Advisory Group (CCTAG) established for the California Water Plan Update. The current CCTAG includes the following members:

1. Barney Austin, Texas Water Development Board
2. Carolyn Hunsaker, U.S. Forest Service
3. Dan Cayan, Scripps Institution of Oceanography
4. Doug Rotman, Lawrence Livermore National Laboratory
5. Ed Maurer, Santa Clara University
6. Guido Franco, California Energy Commission
7. Kathy Jacobs, Arizona Water Institute
8. Kosta Georgakakos, Hydrologic Research Center
9. K.T. Shum, LICALL – Licensing and Allocation, British Columbia
10. Larry A. Rabin, U.S. Forest Service
11. Levi Brekke, U.S. Department of the Interior, Bureau of Reclamation
12. Marion J. Gee, Sierra Nevada Alliance
13. Michael Dettinger, U.S. Geological Survey
14. Michael Hanemann, University of California, Berkeley
15. Michael Tansey, U.S. Department of the Interior, Bureau of Reclamation
16. Norm Miller, Lawrence Livermore National Laboratory
17. Peter Gleick, Pacific Institute
18. Peter Jacobsen, Metropolitan Water District
19. Phil Duffy, Climate Central
20. Richard Palmer, University of Washington

21. Richard Snyder, University of California, Davis

22. Robert Lempert, RAND Corporation

23. Robert Wilkinson, University of California, Santa Barbara

24. Robin Newmark, Lawrence Livermore National Laboratory

25. Spreck Rosekrans, Environmental Defense

26. Stu Townsley, U.S. Army Corp of Engineers

1.1.3 Supporting Staff

The CCSDWG Group was ably supported in its discussions by the following:

1. Yung-Hsin Sun, MWH

2. Alexa La Plante, MWH

3. Mary Selkirk, Center for Collaborative Policy

4. Charlotte Chorneau, Center for Collaborative Policy

5. Debra Bishop, EDAW/AECOM

6. Curtis Alling, EDAW/AECOM

7. David Curtis, Carlton Engineering, Inc.

1.2 Work Group Purpose and Scope

The purpose of the CCSDWG was to provide input on the following questions:

1. What are the key aspects of climate change that would affect integrated flood management and should be covered in the 2012 plan?

2. What are the primary categories of existing problems and expected future challenges related to climate change within the planning area?

3. What are the climate change considerations that should be addressed when working on integrated flood management within the 2012 plan?

4. What are the key climate change studies and adaptation planning with which the CVFPP should coordinate?

5. What are the uncertainties associated with climate change that may affect flood management planning and considerations for other resource areas?

1.3 Work Group Deliverables

The charge of the CCSDWG is to produce the deliverables listed below. The resulting written material will inform all relevant work to develop content for the CVFPP. The first direct application of the products of the CCSDWG will be in the five Regional Conditions Summary Work Groups. These deliverables are presented in Chapters 2–6 in this Summary Report.

1. **List of Key Aspects of Climate Change that May Affect Flood Management:** A list with definitions of the key topic areas of climate change that would affect integrated flood management and should be covered in the 2012 CVFPP to create a successful plan. Prioritize the list into three levels of importance (essential, highly desirable but not essential, outside of the scope of the CVFPP).

2. **List of Existing Problems and Expected Future Challenges Within the CVFPP Project Area Related to Climate Change:** List and describe the primary categories of existing problems and expected future challenges related to climate change within the CVFPP planning area. Additional details about the identified problems and future challenges will be developed and captured in the Regional Conditions Summary Work Groups.

3. **Checklist of Climate Change Considerations for the CVFPP:** Develop a checklist of climate change considerations that should be addressed in integrated flood management within the CVFPP. This checklist may include a list of principles for considering management actions related to levee performance.

4. **List of Related Climate Change Projects and Programs:** Develop a list of other climate change studies and adaptation planning that the CVFPP Plan Development Team should become familiar with and coordinate with regularly.

5. **List of Climate Change References for the CVFPP:** Develop a comprehensive list of available documents to use as reference

material related to climate change problems, opportunities, and standards.

1.4 Purpose of this Report

This CCSDWG Summary Report records the outcomes of the group's efforts and presents the deliverables identified above in Section 1.3. It serves as the vehicle for providing CCSDWG input to development of the Regional Conditions Summary Report (RCSR), which is the first major milestone report in CVFPP development. This input from the CCSDWG will not become a separate section in the RCSR; rather, it will be incorporated in sections, where appropriate, similar to the input from other topic and regional work groups. Climate change considerations will be incorporated in all aspects of the CVFPP planning process.

CCSDWG members will be offered the opportunity to review and comment on the administrative draft RCSR for proper incorporation of their input by the Plan Development Team.

This CCSDWG Summary Report will remain a draft document until the CVFPP is finalized, as will all interim CVFPP documents. Further development of the CVFPP may yield additional improvements to the results documented in this report.

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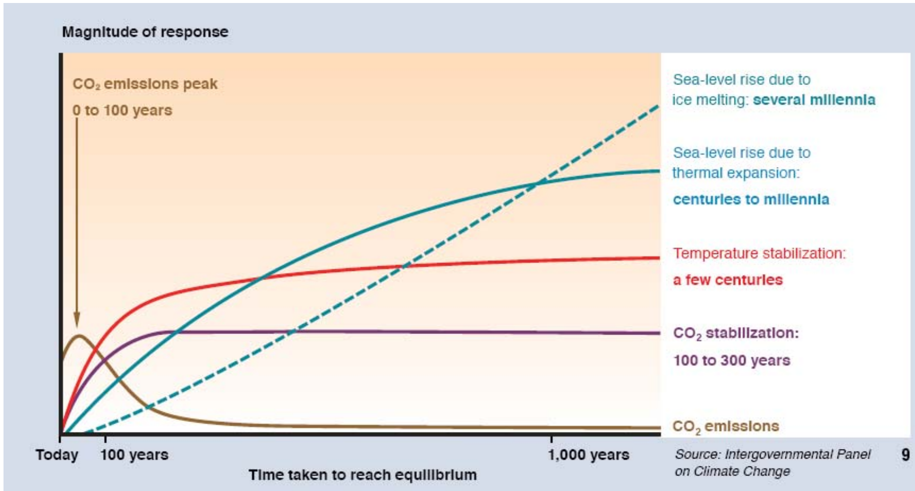
2.0 Key Aspects of Climate Change that May Affect Integrated Flood Management

California's climate is dynamic. Traditionally, flood management agencies have used past experience and historical climate records to make decisions and develop investment strategies. Advances in climate science over the past decade or so have produced multiple future scenarios that allow flood management issues to be considered from a different perspective. Climate change already affects California, and the potential future consequences of climate change are significant (Resources Agency 2008). Therefore, California recognizes that the time to act is now. In response to the need for action, State legislation requires consideration of climate change conditions in plan development. According to Senate Bill (SB) 5 (Statutes of 2007), the CVFPP should include the following:

> *A description of the probable impacts of projected climate change, projected land use patterns, and other potential flood management challenges on the ability of the system to provide adequate levels of flood protection (Water Code § 9614).*

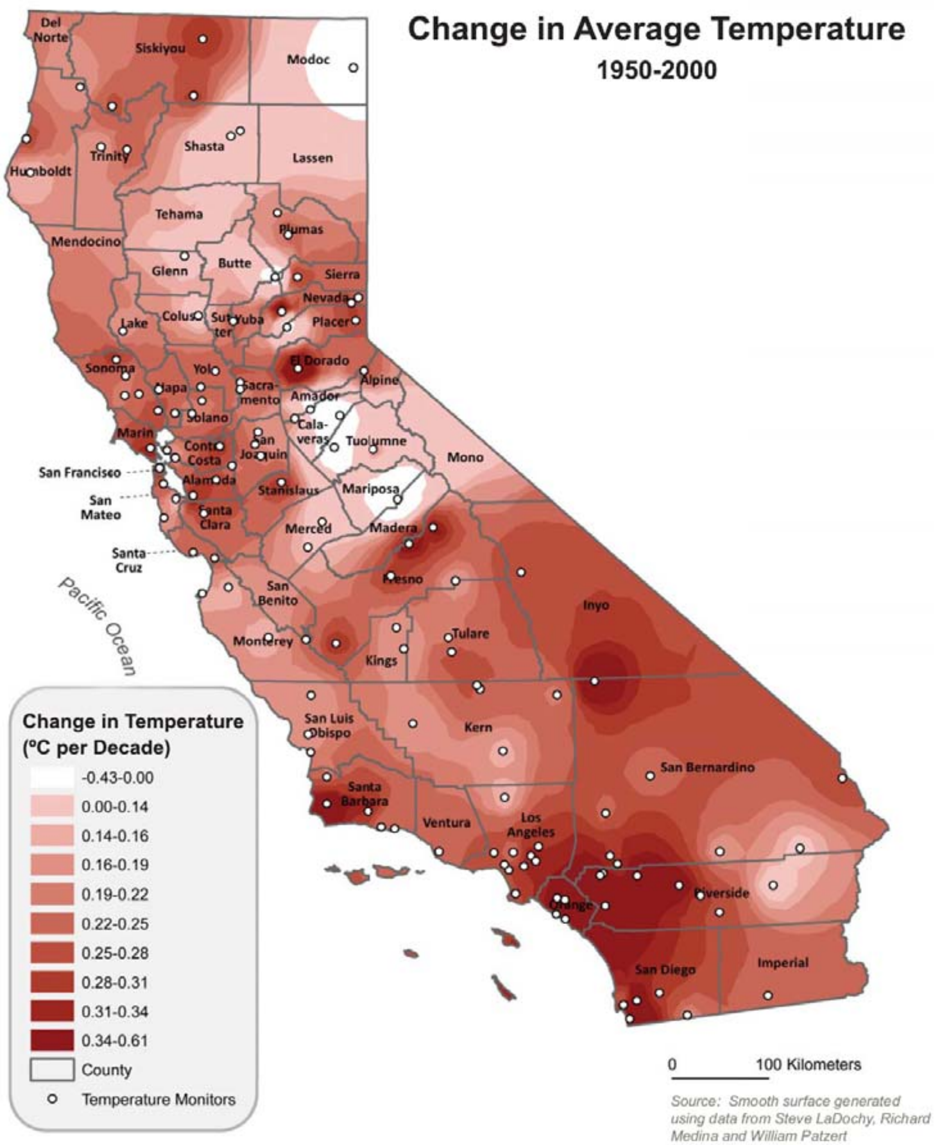
It is uncertain exactly how the world will choose to mitigate future climate conditions; however, the projection by the Intergovernmental Panel on Climate Change (IPCC) (IPCC 2007a) suggests that carbon dioxide (CO_2) concentration in the atmosphere, air temperatures, and sea levels continue to rise long after CO_2 emissions are reduced (see Figure 2-1). For example, Eby et al. (2009) found that following stabilization of CO_2 emissions, natural processes of atmospheric carbon dioxide removal gradually decrease radioactive forcing, but are largely compensated by slower loss of heat and greenhouse gases (GHG) from the ocean, so that atmospheric CO_2 concentration, air temperatures, and sea level rise do not stabilize for at least 1,000 years.



Source: IPCC 2001

Figure 2-1. Carbon Dioxide Concentration, Temperature and Sea Level Projections with Decreasing Carbon Dioxide Emissions

Signs of the rising temperatures are already evident in California. Overall, observed temperature changes in California are not uniform. Figure 2-2 shows average decadal temperature changes throughout California (DPH 2007) in degrees Celsius (°C) since 1950.



Source: DPH 2007

Figure 2-2. Change in Average Temperature (°C) (1950-2000) in the State of California

The IPCC released a *Technical Paper on Climate Change and Water* (IPCC 2008) that describes the effects of atmospheric warming in water resources in systems and sectors, including water availability and demand; flood and drought management; ecosystems and biodiversity; agriculture and food security; land use and forestry; human health; water supply and sanitation; settlements and infrastructure; and the economy. The United States Global Change Research Program (USGCRP) report (2009) on "Global Climate Change Impacts in the United States" also highlights critical water sector impacts and issues at the national and regional scales, while noting that "Floods and droughts are likely to become more common and more intense as regional and seasonal precipitation patterns change, and rainfall becomes more concentrated into heavy events (with longer, hotter dry periods in between)." Some of these changes are already underway in California; most are likely in the future. The following discussion focuses on four key aspects of climate change that the 2012 CVFPP should take into consideration:

- Direct effects to flood management
- Related effects for integrated flood management
- Adaptation and mitigation strategies
- Key uncertainties

2.1 Effects Related to Flood Management

Three major categories of effects related to flood management are change in precipitation and runoff patterns, sea level rise, and economic activities.

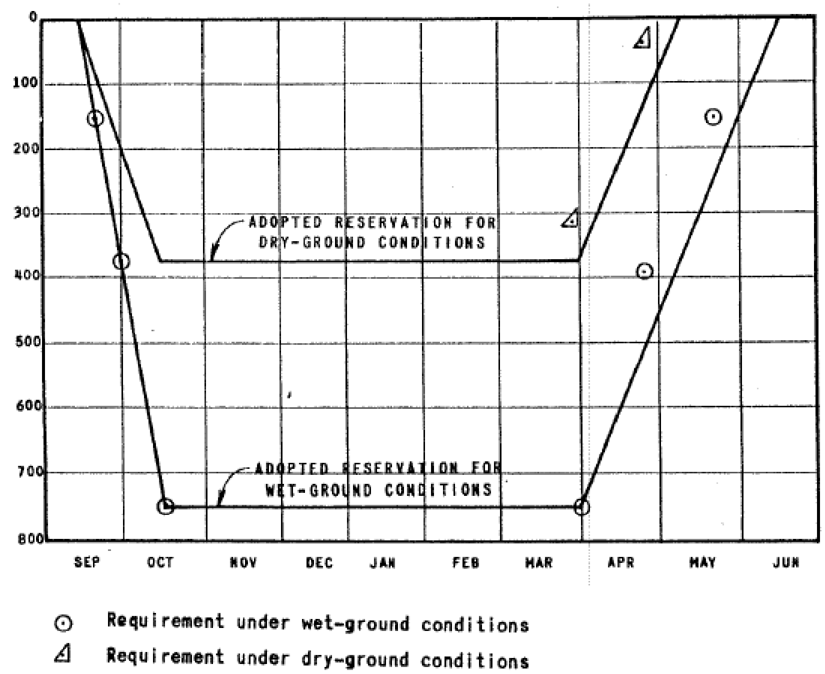
2.1.1 Change in Precipitation and Runoff Patterns

Historically, about 15 million acre-feet of runoff in California (with about 14 million acre-feet estimated in the Central Valley) originated from snowpack that accumulated in winter and melted gradually from April through July (DWR 2008). About two-thirds of the runoff in the Central Valley originates in the Sacramento Valley (DWR 2006). California's water storage and conveyance infrastructure gathers this melting snow in the spring and delivers it for use during the drier summer and fall months.

Increased temperatures may alter precipitation and runoff patterns, such as a rise in snow line elevations, earlier snowmelt occurrence, more precipitation falling as rain instead of snow, and reductions in the volume of overall snowpack. Knowles and Cayan (2002) found that the combination of warmer storms and earlier snowmelt may cause April watershed total snow accumulation to drop by 5 percent of present levels by 2030, 36 percent by 2060, and 52 percent by 2090. Already, a greater proportion of annual runoff has been occurring earlier in a water year (Knowles, Dettinger, and Cayan 2006). The combination of earlier snowmelt and shifts from snowfall to rainfall seem likely to increase flood peak flows and flood volumes (Miller et al. 2003; Fissekis 2008; Dettinger et al., 2009), which is likely to affect associated flood risk. Higher snow lines could increase flood risk because more watershed area contributes to direct runoff. From an operations and maintenance (O&M) viewpoint, these higher snow lines could increase erosion rates that would result in greater sediment loads and turbidity, altering channel shapes and depths, and possibly increasing sedimentation behind dams and affecting habitat and water quality (DWR 2008).

Just as climate change is expected to change the magnitude and frequency of flooding, the same is expected of forest fires because of drier warm-season fuel conditions. For 70 years, the 220,000-acre Matilija fire of 1932 stood as California's largest wildfire. It has been surpassed twice in the past 6 years. Of the 10 largest California wildfires since 1932, 7 have occurred since 2003. Increased frequency and severity of wildfires (Resources Agency 2009) reduces the availability of vegetation that absorbs runoff, which results in further increased runoff, erosion, and sedimentation.

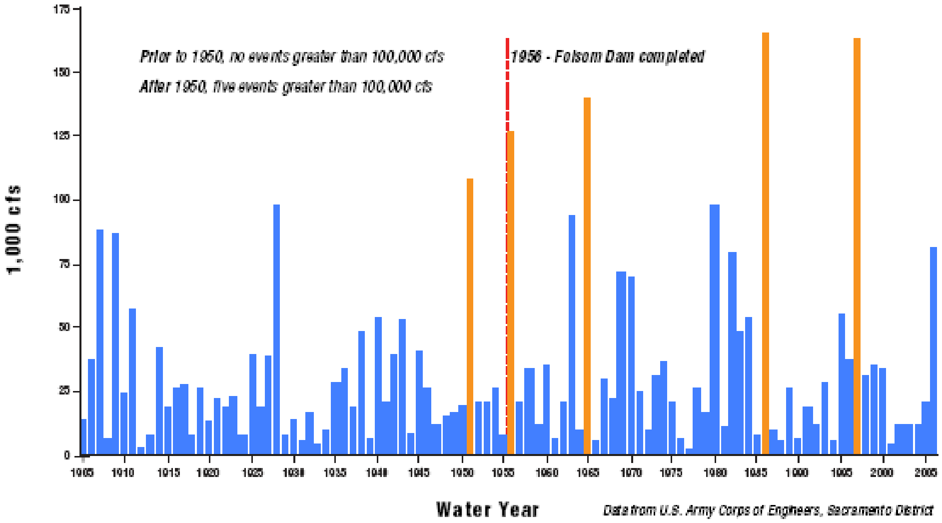
For reservoirs downstream from significant mountain snowpack, the resulting temporal shift in reservoir inflows could pose major challenges for management of flood storage capacity and water supply, particularly if reservoir operations are not modified to accommodate the new conditions (DWR 2006; Medellin et al., 2008; Fissekis 2008). Flood control space requirements are generally specified using reservoir drawdown curves as a function of accumulated snowpack forecasts, measured rainfall, and the seasonality of precipitation. Existing drawdown curves for major flood control reservoirs were mostly based on characterization of local watershed hydrology while a dam was under construction. For example, Oroville Reservoir, the only major reservoir in the State Plan of Flood Control, has a requirement for a seasonal flood control storage range of 375–750 thousand acre-feet based on soil moisture conditions (see Figure 2-3; USACE 1970). Changes in precipitation form (snow vs. rain) associated with temporal shifts in runoff, and potential increases in flood frequencies and magnitudes, are likely to require reevaluation of existing operational rules developed based on then-known historical conditions.



Source: USACE 1970

Figure 2-3. Oroville Reservoir Seasonal Flood Control Space Requirement

Figure 2-4 shows 3-day peak flows of the American River runoff in the past century (DWR 2008). Five events with 3-day peak flows greater than 100,000 cubic feet per second (cfs) have been observed since 1950. These high peak flow volumes have resulted in a recharacterization of the level of flood protection offered by Folsom Dam, which was designed in the 1940s (DWR 2008).



Source: DWR 2008 (with top 5 annual maximum 3-day flow highlighted)

Figure 2-4. American River Runoff, Annual Maximum 3-Day Flow

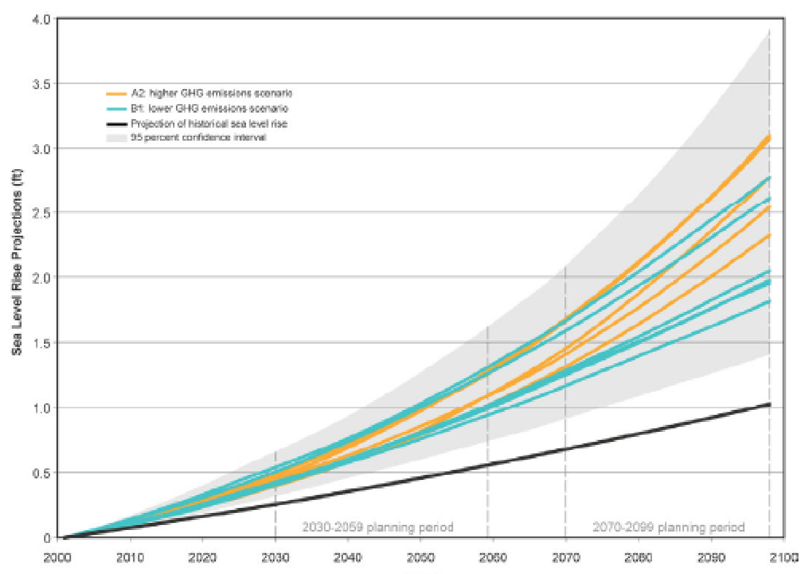
2.1.2 Sea Level Rise

Increasing temperature also results in sea level rise due to the melting of land-based glaciers, snowfields, and ice sheets, along with thermal expansion of the ocean as the surface layer warms (DWR 2008). In the last century, sea level has risen about 20 centimeters (cm) (7 inches) along California's coast (DWR 2008). Recent studies suggest that since 1990, global sea level has been rising at a rate of approximately 3.5 millimeters per year (mm/yr) (0.14 inch per year (in/yr)) (CALFED 2007). Continuation or acceleration of this sea level rise, in combination with changes in precipitation and runoff patterns, would significantly augment flood problems in the Central Valley (Knox 1993; Florsheim and Dettinger 2007).

Sea level rise is likely to produce more frequent and potentially more damaging floods, increasing risks for those already at risk, and increasing the size of the coastal floodplain, placing new areas at risk (CEC 2009a). Increased risk of storm surge and flooding is expected to increase risks for California's coastal residents and infrastructure, including wastewater treatment plants (DWR 2008).

Sea level rise impacts would be most significant for the Sacramento-San Joaquin River Delta (Delta), where a rise in sea level would increase hydrostatic pressure on levees currently protecting low-lying land, much of which is already below sea level. These effects threaten to cause potentially catastrophic levee failures that could inundate communities, damage infrastructure, and interrupt water supplies throughout the State (Hanak and Lund 2008). Roos (2005) found that a 1-foot rise in sea level could increase the frequency of the 100-year peak high tide to a 10-year event. The resulting higher tides, in combination with increases in storm intensity and flood volumes, would significantly aggravate the existing flood problems in upstream areas along the Sacramento and San Joaquin rivers.

Although it is generally accepted that sea levels will continue to rise on a global scale, the exact rate of rise remains unknown. Recent peer-reviewed studies estimate a rise of between 0.6 and 4.6 feet by 2100 along California's coast (DWR 2008). Another projection based on 12 future climate scenarios selected by the California Climate Action Team (CAT) indicates a 1.8- to 3.1-foot rise in sea level (see Figure 2-5; CEC 2009b). A CEC report prepared by The Pacific Institute on sea level rise along the California coast estimated that a 1.4-meter sea level rise will put 480,000 people at risk of a 100-year flood event, given the existing population (CEC 2009a).



Source: CEC 2009b

Figure 2-5. Sea Level Rise Projections Based on Air Temperatures from 12 Future Climate Scenarios

2.1.3 Economic Activities

With 76,000 farms and 26.3 million acres in production, agriculture is an important component to California's economy. Much of California's $36 billion agricultural industry is concentrated in the Central Valley (CDFA 2009). More frequent and larger flood events are likely to damage structures, threaten livestock, contaminate crop lands, cause increased erosion and sedimentation, take crop lands out of production for extended periods as fields dry and recover, threaten levees that protect crop land and, in conjunction with sea level rise, increase farm land vulnerability in coastal areas and the Delta. Notably, despite decades of construction of flood management structures and levees in the Central Valley and its tributaries, levees continue to fail under existing flood conditions (Florsheim and Dettinger 2007; Florsheim and Dettinger 2005).

Currently, there is a trend toward converting annual crops to perennial crops with higher economic value. Because it takes longer for growers to recover perennial crops from flood damage, potential increased flooding resulting from climate change would likely have even greater economic impacts on the agricultural industry.

The Central Valley is also under pressure to urbanize while future floods could be of a greater volume and intensity under climate change. Much is at stake because California has $4 trillion in real estate assets, of which $2.5 trillion are exposed to potential climate change effects (Fredrich and Roland-Holst 2008). Increasing populations in high-risk areas means more flood damage and requires additional flood protection. Increasing costs of providing greater flood protection hinder local economic development by constraining growth and limiting money available for other community needs.

2.2 Related Effects On Other Aspects of Water Resources Management

Climate change is also likely to impact water supply and ecosystem management in ways that bear on flood management.

2.2.1 Water Supply

California's current major water systems are designed and operated to store water for supply in late spring, summer, and fall, and to regulate flood flow in winter and early spring. Water supplies meet statewide demands for municipal and industrial (M&I), agricultural, and environmental water. More than 20 million (of about 37 million) Californians rely on two large water projects: the State Water Project (SWP) and federal Central Valley Project (CVP). The effects of climate change on SWP and CVP operations are expected to include changes in reservoir inflows, delivery reliability, and annual average carryover storage (DWR 2006). In particular, higher snow elevation, early snowmelt, more precipitation as rainfall instead of snow, and reductions in overall snowpack are likely to contribute to reductions in water supply reliability. Accommodating higher flood volumes may require more flood storage in the winter and early spring, making it more difficult to refill reservoirs during the traditional April through July snowmelt runoff period.

In addition to overall changes in water volumes, water supplies will likely be affected by changes in water quality as a result of climate change. For example, higher temperatures are likely to increase the rates of chemical reactions in water generally, increasing biological oxygen demand through algal growth and decay. Broader areas of the watersheds receiving rain rather than snow may increase erosion and thus downstream turbidity and sediment transports. M&I water supply may also be compromised because water treatment processes are affected by water temperature (Hanak and Lund 2008).

Sea level rise is likely to increase seawater intrusion into the Delta, which will further degrade water quality for those who use Delta water by increasing salinity (DWR 2006). More freshwater releases from upstream reservoirs could be required to maintain compliance with existing Delta water quality standards, resulting in further stress to available water supplies in upstream reservoirs.

In an average year, groundwater meets about 30 percent of California’s applied urban and agricultural water demands, and this increases to more than 60 percent during drought years (DWR 2003). This important component of the State’s water supply is likely to be affected by climate change by the reduced ability for groundwater replenishment, increasing demand, and expanding areas of saltwater intrusion in coastal aquifers (CEC 2008).

Aquatic species are likely to be affected by increase in water temperatures throughout the system, including inflows into reservoirs, water stored within reservoirs, and water flowing downstream. The rising water temperature in river stretches serving as aquatic habitats would increase the demand for temperature management, using already limited cold-water reserve in the major reservoirs, creating additional competing needs of limited stored water.

2.2.2 Ecosystem Management

While ecosystems have always naturally changed over time, the ecosystem effects of climate change are likely to be exacerbated by the dramatic loss of natural areas experienced in the half century (CEC 2009c) and by the relatively rapid rate at which climate change, and other stresses, are advancing. The abundance, production, distribution, and quality of ecosystems throughout California are likely to be dramatically affected this century by a combination of climate-change-associated disturbances (e.g., flooding, drought, wildfire, insects, ocean acidification) and other global change drivers (e.g., land use change, pollution, fragmentation of natural systems, overexploitation of resources) (IPCC 2007). Species most vulnerable to climate change are endangered and threatened species, plants and animals living within confined geographic ranges with limited abilities to move rapidly, and species migrating to new areas where they meet increased competition for habitat or food (IPCC 2007).

Climate change effects on ecosystem land management include both the geographic loss of habitat and the loss of habitat connectivity. Sea level rise is expected to cause increased seawater intrusion into California's coastal marshes and estuaries. Increased intrusion will likely disrupt marsh and estuary ecosystems, especially at the higher projections of sea level rise. The loss of natural areas in turn reduces the opportunities to use ecological systems and functions within flood management systems.

Higher water temperatures resulting from climate change are likely to negatively impact aquatic and terrestrial resources. Warmer temperatures can compromise the health and resilience of aquatic and terrestrial species, and thus make it more challenging for them to compete with nonnative species for survival. Of specific concern to Central Valley aquatic habitats, Chinook salmon and steelhead prefer temperatures of less than 64.4–68°F (18–20°C) in mountain streams, although they may tolerate higher temperatures for short periods (Bennett 2005; Moyle 2002). Increased water temperatures could reduce the habitat suitability of California rivers for these species. Impacts on terrestrial ecosystems have also been observed in North America, including changes in the timing and length of growing season, timing of species life cycles, primary production, and species distributions and diversity (CEC 2009c).

Competition for habitat and food will be intensified by climate change. For example, climate change is expected to decrease suitable summer habitat of delta smelt, a federally listed endangered species, because waters in the lower Delta may be too saline and lack food, and freshwater in the upper Delta may be too warm. Climate change could combine with nonclimate stressors, such as land use changes, wildfire, and agriculture, and cause habitat fragmentation at increasing rates, contributing to species extinction (USFWS 2009).

2.3 Adaptation and Mitigation Strategy

The terms “adaptation” and “mitigation” are important and fundamental in addressing climate change. Climate adaptation refers to the actions taken to adjust to climate change, to moderate potential direct impacts, to take advantage of opportunities, or to manage the potential consequences of actions. The IPCC defines mitigation as an anthropogenic intervention to reduce the sources or enhance the sinks of GHGs (IPCC 2007). This section describes California’s adaptation and mitigation strategies related to integrated flood management, as well as the potential benefits of coordinating various strategies for mitigation and adaptation.

2.3.1 Adaptation Strategy

Challenges involved in adapting to a changing climate include the following: (1) climate change is one of many competing priorities for government officials and the public, (2) a lack of guidance can constrain the ability of officials to consider climate change in management and planning decisions, (3) insufficient site-specific information can reduce the capability of officials to manage the effects of climate change on the resources they oversee, and (4) officials are struggling to make decisions based on projected future climate scenarios that may not reflect past conditions (GAO 2009; DWR 2008). In addition, fiscal constraints limit the financial resources local and regional government can apply to climate change adaptation planning and implementation.

Brekke et al. (2009) emphasize the need for planning frameworks to be flexible enough to incorporate uncertainties related to climate change in managing risks. Planning approaches that incorporate climate change probabilities, robust decision making, and adaptive management are all adaptation strategy options that allow decisions to be more flexible. These approaches also consider future advances in scientific understanding as they become available.

An important first step in probabilistic adaption planning is identifying key system vulnerabilities and/or critical risk thresholds. Subsequently, regional downscaled climate projections could be used to assess the likelihood that projected climate conditions cross system vulnerability or environmental thresholds. As climate science, global circulation modeling, and downscaling methods improve, better information can be used to assess whether there has been a change in probability of occurrence of critical climate condition thresholds.

Much of California's water infrastructure was designed based on hydrologic observations, limited almost exclusively to the first half of the twentieth century. For flood management purposes, frequency analyses are often used as performance-based criteria in infrastructure and investment planning. As noted earlier in Figure 2-4, the most recent 60 years of observations paint a picture of more variable hydrology with higher highs and lower lows. Now, California's water infrastructure is unable to meet performance objectives as originally intended in many areas.

Climate change has been observed and is expected to continue. To meet that challenge, adaptation to change must enter the fabric of engineering design and resource management. The five FloodSAFE goals[3] reflect the importance of adaptation and long-term sustainability (DWR 2008b). The following identifies major areas for change in management policy.

Managing Facilities for Multiple Uses

In California, the physical infrastructure used for water supply for human consumption, food production, hydropower generation, and environmental protection is also used for flood management in the winter and early spring. The flood management objective is typically achieved through designated reservoir storage used to reregulate flood flows for downstream protection. The change of runoff patterns under climate change conditions will unavoidably increase the conflict in reservoir operation between flood management and water supply purposes (California Natural Resources Agency 2009).

Projected changes to California hydrology will amplify the tension between flood management and water supply (DWR, 2008a). Currently, reservoir operation policies are a predominantly fixed set of rules based on historical averages that balance the needs of flood management and water supply, as well as hydroelectric generation, recreation, navigation, water quality, and riverine habitat. Some studies have shown that even historical records may underestimate the historical range of flood possibilities because weather conditions of the twentieth century were milder compared to those in a longer-term history (Schimmelmann et al. 2003; Malamud-Roam et al. 2007).

As future hydrology changes, already stressed existing reservoir policies will need to cope with this new pressure. Meaning, flexible policies that anticipate changing requirements and the ability to refine adaptation strategies will be needed.

Land Use

Land use decisions in California are under the jurisdiction of local governments (cities, counties, and city and county). This can lead to fragmentation among numerous cities and counties in the Central Valley, making regional floodplain protection more difficult. A Public Policy Institute of California (PPIC) survey on local climate policy in California found that most local governments have not yet acted on developing local adaptation strategies even though scientific projections point to significant climate change impacts (PPIC 2008b).

[3] The five FloodSAFE goals are (1) Reduce the Chance of Flooding; (2) Reduce the Consequences of Flooding; (3) Sustain Economic Growth; (4) Protect and Enhance Ecosystems; and (5) Promote Sustainability.

Challenges exist in achieving regional land use planning because of the numerous, separate city and county jurisdictions. Regional councils of government and metropolitan planning organizations and Department of Housing and Community Development can play a key role in guiding local land use planning for enhanced flood protection. As part of the Federal Emergency Management Agency's (FEMA) National Flood Insurance Program, FEMA encourages and provides assistance to communities for implementing floodplain management programs (American Planning Association 2005).

Recent State legislation, and strategy and guidance documents reflect an emerging trend to improve regional-scale land use planning. In 2007, the California Legislature passed and the Governor signed several interrelated bills (collectively, 2007 California Flood Legislation) aimed at addressing the problems of flood protection and liability (DWR 2009b). Many new requirements stipulated in the 2007 California Flood Legislation are related to land use planning by local jurisdictions based on flood risk in their community. In particular, many land use planning tools will require regular updates after the CVFPP is adopted by the Central Valley Flood Protection Board.

The *2009 California Adaptation Strategy Discussion Draft* also stresses the importance of integrated land use planning as a climate adaptation strategy (California Natural Resources Agency). Integrated regional land use planning is also recognized increasingly as an important way to mitigate the impacts of climate change, as exemplified by SB 375, passed in 2008. SB 375 focuses on transportation planning, travel demand models, sustainable community strategy (SCS), and environmental review to reduce GHG emissions from cars and light trucks. SB 375 is the nation's first law to control GHG emissions by seeking to improve urban development patterns and transportation systems, and it provides incentives for regional and local governments to develop more carbon-efficient land use/transportation plans. SB 375 recognizes the importance of considering flood risk and requires assessing flood protection adequacy for development. Major Central Valley urban centers such as Sacramento, Stockton, and Modesto are prime examples of locations where local governments must balance the goals of SB 375 with the need to appropriately manage flood risk (e.g., increasing densities in levee-protected urban areas).

Given the long-range view of general plans, cities and counties are encouraged to consider how a changing climate will affect existing communities and long-term development. As part of the State's efforts to encourage regional land use planning, Integrated Regional Water Management Plans (IRWMP) are part of State policy. An IRWMP is a comprehensive planning document that encourages regional, collaborative strategies for managing water resources. Several new requirements for general plan content related to flood hazards are associated with the CVFPP. For example, each city and county within the Sacramento-San Joaquin Valley is required to amend its general plan to include elements of the CVFPP within 24 months of adoption of the CVFPP (Government Code §65302.9). The zoning ordinance is to be made consistent with the amended general plan within 36 months of adoption of the CVFPP or within 12 months after amendment of the general plan (Government Code §65860.1). The adoption and enforcement of floodplain management ordinances, particularly with respect to new development, is an important element in making flood insurance available to communities.

Environmental Justice

Environmental justice in the context of climate change adaptation and mitigation strategy refers to the mitigation of an inequitable distribution of environmental burdens to disadvantaged communities (good food, clean water, etc.). Inevitably, some communities will bear a greater burden from impacts of climate change and associated actions; potentially, the additional layer of burdens could compound existing ones from environmental, societal, and economic activities. Existing disadvantaged communities may be located in areas subject to increasing flood risk from climate change, such as sea level rise influences (PPIC 2008a).

2.3.2 Mitigation Strategy

California is leading the nation with legislation to implement major GHG reductions on an ambitious timeline. In 2006, Governor Arnold Schwarzenegger and the California Legislature enacted Assembly Bill (AB) 32 – The Global Warming Solutions Act, which establishes a statewide target to reduce GHG emissions to 1990 levels by 2020 (CARB 2006). As part of its mitigation strategy, California’s Title 24 building codes for building energy efficiency are the most stringent in the U.S., and are proposed to evolve into zero-energy performance regulations in the coming decades. The State’s Title 20 appliance standards continue to regulate products not preempted by federal law, and in many cases have led to adoption of federal standards (Schiller et al. 2008). SB375, Statutes of 2007, requires emissions inventories and encourages carbon-efficient land use patterns supported by transportation facilities designed to reduce total miles driven, and GHG emissions from cars and light trucks. Low Carbon Fuel Standards, a Million Solar Roofs Initiative, the Renewable (Energy) Portfolio Standard, and automotive emissions standards are other policies pursued by California to mitigate climate change (CARB 2009).

Flood management practices need to consider the GHG emissions originating from construction and O&M activities that will be subject to regulation and mitigation considerations. There are also GHG emission considerations under the related operation of the shared water system for water supply and power generation. Changing flood operation could have effects on those related operation; however, the associated effects are not as straightforward and require additional evaluation.

The flood management system could also provide the potential of carbon (CO_2) sequestration,[4] which is conceptually feasible for incorporating into the system-wide approach to improve flood management, and ecosystem restoration. It could potentially provide additional benefit category that could facilitate sustainable planning, project finance, carbon offset for the aforementioned GHG mitigation needs for regular O&M activities.

2.3.3 Potential Benefits of Coordinated Climate Strategy

As previously mentioned, the FloodSAFE Goals include many adaptation strategies, and the 2007 Flood Legislation establishes additional linkage between the system-wide flood management approach in the CVFPP and local land use planning tools (e.g., general plans, zoning ordinances) for better coordination and planning. While many details are to be developed, the importance of policy and strategy coordination among different levels of governments is recognized.

The climate strategy under flood management consideration is no exception. For example, without the 2007 Flood Legislation, improvement in flood management through actions taken by the State and federal agencies could lead to additional development, for which authorizing actions are reserved to local governments. Similarly, the resulting loss in vegetation, and other carbon sequestration potential due to development, could become an indirect consequence of uncoordinated policy implementation, countering the intent to develop additional sequestration potential as part of flood management improvement, wherever feasible.

Policy and legislation related to a mitigation strategy, such as AB 32 and SB 375, can be coordinated with those of an adaptation strategy, such as the *2009 California Climate Adaptation Strategy* developed by the California Natural Resources Agency and other agencies, and DWR's *Managing an Uncertain Future: Climate Change Adaptation Strategies for California's Water* (2008).

[4] Carbon sequestration the long-term storage of carbon dioxide or other forms of carbon as a mitigation option for climate change.

As the number of climate change policies grows, it is critical that new climate change policies avoid potential conflicts with policies in other areas. Table 2-1, developed by PPIC, is a good example of coordinated strategy. Well-coordinated strategy is demonstrated in the column on the far left of the table, indicating most favorable actions for adaptation and mitigation efforts.

Table 2-1. Example Display of Complementary and Conflicting Actions in Adaptation and Mitigation Efforts

Favorable Actions ◄────────────► Unfavorable Actions

Favorable for Adaptation and Mitigation Efforts	Favorable for Mitigation, but Unfavorable for Adaptation Efforts	Favorable for Adaptation, but Unfavorable for Mitigation Efforts	Unfavorable for Adaptation and Mitigation Efforts
Energy demand management Energy-efficient buildings Water conservation Biodiversity-oriented forestry "Smart growth" Development in cooler regions	Forestry with nonnative species Urban forestry (shade trees) with high water demand Some biofuels production	Meeting peak energy demand with fossil fuels Wastewater recycling and desalination Groundwater banking Increased air conditioner use Use of drainage pumps in low-lying areas	Development in floodplains Traditional "sprawl" development Development in hotter regions

Source: PPIC 2008s

2.4 Key Uncertainties

When planning for climate change impacts, it would be helpful to know how likely they are. However, projections of climate change and its subsequent impact on human society and to the environment are subject to significant uncertainties. Uncertainties range from imperfect understanding of nondeterministic physical and ecological processes, incomplete model representation of the natural system, and the unpredictable future of human development and our responses to climate change prediction (Dessai and Hulme, 2003). While imperfect understanding and model implementation may be progressively remedied by more data, improved model representation, and more comprehensive scenario analyses, uncertainties will remain.

Human uncertainties present a challenge for any decision making process because actions taken by humans will be in response to climate changes and will also affect subsequent projections of climate change consequences. Further uncertainties in regional climate change impacts include human climate-forcing other than GHGs, such as the impact of aerosols on clouds and associated precipitation, the influence of aerosol deposition (e.g., black soot), reactive nitrogen, and the role of changes in land use. Pielke et al. (2009) argue that these effects are not sufficiently acknowledged in IPCC reports, particularly the importance of these effects to climate predictability at the regional scale.

Uncertainties in various aspects of climate change are not "uniform." Current scientific evidence suggests higher certainties associated with temperature changes and sea level rise than with precipitation changes (IPCC 2008; DWR 2009c). While there is an indication of potential increases in future flood frequencies and magnitudes in California due to climate change, making accurate quantitative predictions remains a significant challenge to planners (Brekke et al. 2004).

In the context of integrated flood management, uncertainties prevail in all predictions of changes in temperature, precipitation, runoff patterns, and ecosystem responses. Climate projections become less consistent between models as spatial scales decrease from global to regional and local (IPCC 2008). For current CVFPP development, the period of analysis is from 2015 through 2050 for benefit-cost analysis and other projections. Most of the divergence between projections of climate change scenarios presented by IPCC occurs after 2050, so that some of the anxiety about uncertainties in the planning and policy making process may be ameliorated by limiting planning efforts to the pre-2050 period, even though the effects of many management actions and climate change effects will last much longer, and change as the mitigation and adaptation progresses.

However, where there are threats of serious or irreversible damage, lack of full scientific certainty should not be taken as a reason for postponing precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate its adverse effects (United Nations 2003, Article 3). The governance of such deep uncertainties rests on three pillars: precaution, risk hedging, and crisis prevention and management (IPCC 2007c). Climate change policies and measures should be cost-effective to provide global benefits at the lowest possible cost (United Nations 2003, Article 3). To that end, life-cycle costing[5] and avoided costs should be included in addition to traditional benefit-cost analyses.

Taking preventive action in the absence of full scientific certainty is called the precautionary principle. This principle is especially important because divided public belief systems regarding the occurrence and cause of climate

[5] A Life-Cycle Costing is the total discounted dollar cost of owning, operating, maintaining, and disposing of a project, including a facility, over the project life span (U.S. Department of Commerce 1996)

change could contribute additional uncertainties for implementing any adaptation actions, including those for integrated flood management.

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3.0 Existing Problems, Future Challenges, and Opportunities Within the CVFPP Planning Area Related to Climate Change

The CVFPP planning area is the Sacramento-San Joaquin Valley (see Figure 1-1). One of the major steps in planning is to identify existing problems, future challenges, and opportunities for planning efforts to focus on.

In this context, this section summarizes input from CCSDWG on the following:

- Existing adverse effects related to climate change
- Future challenges that adverse effects are expected to exacerbate or create
- Opportunities that could be leveraged to create additional benefits, including developing measures to mitigate identified problems and address future challenges

The following are categories used to organize the problem, future challenge, and opportunity statements developed in this work group:

- Flood system performance (channel capacity, levee structural integrity, hydraulic features, operation, level of protection)
- System maintenance and repairs
- Habitat quality, quantity, and connectivity (loss and degradation of habitat and species, lack of natural processes)
- Policy and institutional issues (federal/State/local coordination, liability, funding)
- Water supply and quality (conflict of management policy, flood-induced water quality concern)
- Land use

- Emergency response and postflood recovery
- Information and education

The following is a list of statements developed by the CCSDWG on the existing problems and future challenges identified within each category are likely to be exacerbated and/or created because of climate change. Although this is not a definitive list, it includes several examples.

3.1 Flood System Performance (including the level of protection)

1. The current flood management system lacks flexibility to accommodate climate change (e.g., changes in precipitation intensity, duration and frequency, and sea level rise).
2. Levee stability is likely to be more difficult to maintain because of land subsidence, sea level rise, increased bank erosion, and stresses due to increasing flood frequencies and magnitudes.
3. Changes in both hydrology and vegetation are likely to result in increases in stream sediment loads, sediment transport, erosion, and deposition in the flood management system, which may affect the performance of the system.
4. Climate change is likely to increase flood risk.
    a. Changes in hydrology and runoff patterns are likely to increase flood risk in riverine areas.
    b. Sea level rise is likely to increase flood risk in tidally influenced areas.
5. Current flood management standards based on historical hydrology may not adequately reflect future flood risk.

3.2 System Maintenance and Repairs

6. Increased stress on the flood management system under projected climate change conditions (due to changes in precipitation intensity, duration, and frequency, and sea level rise) will likely increase the need for maintenance and repairs, requiring increased funding and other resources for State and local maintenance agencies.

7. O&M deficiencies stemming from fragmented maintenance responsibilities and funding sources are likely to worsen because of increased O&M needs under climate change.

3.3 Habitat Quality, Quantity, and Connectivity

8. Changes in seasonality, quantity and temperature of water, as well as sea level rise, may affect establishment of riparian vegetation, and the quality, quantity, and connectivity of terrestrial and aquatic habitat.

9. The limited availability and connectivity of habitat (due to disruption of natural floodplain processes by existing flood management system facilities) is likely to limit the response of species to changing climatic conditions.

10. Historical reference conditions alone cannot provide a guide for future habitat function and rehabilitation under climate change conditions.

11. Increased stresses on the flood management system and associated public safety concerns are likely to exacerbate conflicts between needed facility maintenance and protection of species and habitat, and the conflict among various water supply purposes, including between human consumption and environmental uses.

3.4 Policy and Institutional Issues

12. The ability to balance water supplies for flood system performance, agriculture industries, municipalities, and ecosystems will likely become more challenging with climate change.

    a. Changes in flood characteristics are likely to require changes in land use policy, new reservoir flood operations, and new storage requirements.

    b. Changes in flood characteristics are likely to exacerbate tensions between flood storage and water supply needs.

13. Fragmentation of mitigation and adaptation strategies among local jurisdictions, with their differing acceptable levels of risk, is likely to result in inconsistent performance of the flood management system, resources management, and land use policies.

14. Conventional flood management planning does not provide adequate flexibility for adapting to climate change.

    a. Current economic analyses for flood management do not adequately consider project life-cycle costs and socioeconomic costs for recovery and emergency response.

    b. Flood management planning requirements may not consider emerging adaptation and mitigation strategies.

    c. Current approaches for deciding investment strategies do not properly consider climate change uncertainties.

3.5 Water Supply, Demand, and Quality

15. Potential conflicts between water supply and flood management that characterize the Central Valley will require significant integration of management approaches and policy updates, and may require facility modifications and/or augmentation.

    a. Warming trends are expected to increase water demands from all sectors, including M&I and agriculture, as well as use of water for habitat protection, reservoir and river temperature management, and other environmental preservation efforts; large uncertainties in the magnitude of these projected increases persist.

    b. Prolonged droughts interrupted by intensified flooding events may result in significantly increased runoff and inundation episodes and, thus, increased water quality impacts from pollutants (naturally occurring and anthropogenic) in the watershed being carried by the runoff.

    c. Warmer conditions are very likely to result in new juxtapositions of more intense flood seasons paired (often in the same year) with much-depleted runoff in warm seasons. Water year 1997 may be a reasonable analog for conditions that warming will make more common; huge, warm-storm flooding in winter followed by some of the driest spring and summer conditions on record. This annual scale of flood risk and elevated warm-season drought conditions will challenge existing facilities and operations procedures.

    d. Sea level rise could lead to changes in water quality for consumptive use and ecological functions in the Delta by increasing salinity levels, among other effects. Such changes may result in new constraints on water and flood management upstream.

3.6 Land Use

16. A continued lack of coordination between State legislation and local policy is likely to result in unintended conflicts between flood management and land use development, hindering the capacity of needed flood-management adaptations to climate change.

17. Climate change is likely to increase the need for updating FEMA Flood Insurance Rate Maps, as well as the cost of flood insurance, potential financial burden of federal government in supporting the National Flood Insurance Program, and projected flood damages resulting from a severe flooding event, and to require more frequent updates.

18. Climate change impacts on flood risks and management are likely to disproportionately affect disadvantaged communities in the State, resulting in potential environmental justice issues.

19. Urban development can worsen interior drainage conditions, thus exacerbating increased flood risks in local communities due to climate change.[6]

3.7 Emergency Response and Postflood Recovery

20. Investment decisions in postflood recovery to restore preflood conditions for socioeconomic or environmental purposes will become more complicated with climate change, impacting the long-term sustainability of the preflood conditions.

21. Climate change is likely to increase the frequency and cost of emergency response and recovery efforts.

[6] There are different opinions among members about whether this item should be included in the context of the CVFPP due to its localized and detailed nature for storm drainage planning.

3.8 Information and Education

22. Communicating climate change uncertainties and related flood risks to the public is difficult.

23. Quantifying climate change uncertainties and flood risks will require increased investment in research, the results of which can improve decision-making.

4.0 Checklist of Climate Change Considerations

4.1 Purpose of the Checklist

Checklist items are for determining success in addressing critical issues that the work group identified as necessary to be considered regarding climate change in the 2012 CVFPP.

4.2 Checklist of Climate Change Considerations for the 2012 CVFPP

Two groups of checklists were identified by the Work Group:

- Considerations that should be included in an overall approach for plan development
- Considerations that should be included for a specific category of plan development

4.2.1 Overall Approach Checklist

The CVFPP should include the following considerations in an overall approach:

1. A summary of climate change literature on flood risk, including climate uncertainty and variability, and on flood conditions, to identify the level of conditions that need to be accommodated.
2. A requirement to use the best available science with each 5-year update because of the rapidly advancing knowledge in climate change science.
3. A clear statement about assumptions for climate change that will be used in the analysis to support CVFPP development (i.e., what to plan for and in what time frame), including sea level rise, extreme precipitation events, timing of snowmelt and runoff, temperature and precipitation scenarios, and range of uncertainty.
4. A clearly defined baseline condition for the existing flood management system in terms of flood protection, operations, and

ecosystem resources; this baseline condition is to be the reference for flood management planning.

5. Based on the established baseline risk (item 4), a description of the components of the existing flood management system and mode of operation vulnerable to climate change impacts, and associated threshold indicators for such vulnerability. The thresholds are to provide clear targets for the scientific community in refining the associated climate change uncertainties for improved investment decisions.

6. A framework and approach to examine the sensitivity of flood management decisions to uncertainties associated with climate change.

4.2.2 Category-Specific Checklist

The 2012 CVFPP should include the following considerations, corresponding to specific categories of problem statements (see Chapter 3):

7. Flood protection criteria that account for climate change to guide integrated flood management. (Flood System Performance)

8. Clear statements on how climate change considerations are incorporated into the definition of the 200-year level of protection standard for urban and urbanizing areas. (Flood System Performance)

9. A strategy for flood management O&M activities that incorporates ways to reduce expected O&M costs resulting from climate change impacts. (System Maintenance and Repairs)

10. Incorporation of management actions for improving ecological functions and, potentially, for accommodating climate change mitigation techniques as part of the CVFPP integrated flood management approach. (Habitat Quality, Quantity, and Connectivity)

11. Guidelines for identifying additional benefits in GHG mitigation requirements that could be considered as part of project cost/benefit ratios. (Habitat Quality, Quantity, and Connectivity)

12. Documentation of a process for incorporating/reconciling U.S. Army Corps of Engineers (USACE), FEMA, and DWR flood management guidelines. (Policy and Institutional Issues)

13. Documentation of which elements in established State and federal adaptation strategies are reflected in the CVFPP. (Policy and Institutional Issues)

14. Guidance to State, federal, and local agencies for incorporating climate change considerations into regional permitting processes (e.g. Habitat Conservation Plans, IRWMPs, and General Plans). (Policy and Institutional Issues)

15. Identification of critical policies, rules and regulations that should be modified to better accommodate climate change in flood management planning. (Policy and Institutional Issues)

16. Guidelines to incorporate climate change considerations into flood management components of the IRWMP effort. (Water Supply and Quality)

17. Guidelines to incorporate practices into flood management actions to reduce the impacts of climate change on by enhancing groundwater recharge. (Water Supply and Quality)

18. Identification of the additional land areas that become part of regulated floodplains under defined climate change scenarios. (Land Use)

19. Identification of potential riparian corridors and tributary floodplains that could be protected in local land use plans to increase instream capacity or transient storage for accommodating increased flood flows under climate change conditions. (Land Use)

20. Documentation of needed changes in local land use planning requirements/authorities to enforce conditions regarding building in flood zones for purposes of item #19. (Land Use)

21. Identification of additional resources needed because of climate change for development of State and local emergency response plans and recovery efforts. (Emergency Response and Post-Flood Recovery)

22. Recommendations on improvements needed in flood management monitoring and forecast systems. (Emergency Response and Post-Flood Recovery)

23. Recommendations for development of an effective public communication strategy to explain how climate change has been addressed in the CVFPP. (Information and Education)

24. Recommendation of physical and social science research areas that will be most critical in improving flood management in response to climate change. (Information and Education)

5.0 Related Climate Change Projects and Programs

Establishing consistency with climate change efforts in integrated flood management involves comprehensive consideration of other climate change projects and programs, and adaptation planning that will likely be or certainly be in place soon. The CVFPP Plan Development Team should become familiar and coordinate regularly these projects and programs to leverage developed products and knowledge, or to properly account for potential changes in agency policy and protocols that could affect CVFPP development. Based on input from Work Group members, Table 5-1 lists the programs and projects related to climate change that should be coordinated.

Table 5-1. Projects and Programs Related to Climate Change that Should Be Coordinated

Name	Responsible Entity	Description	Reason for Project/Program Coordination
Bay Area Ecosystems Climate Change Consortium	For more information: contact Ellie Cohen (ecohen@prbo.org)	The BAECCC identifies and addresses climate change impacts on ecosystems by using science to inform adaptive management for long-term ecological and economic benefits.	BAECCC includes portion of the Delta, and may overlap with flood planning decisions related to sea level rise, etc.
USFWS LCC's – Landscape Conservation Cooperatives	USFWS	A Central Valley-SF Bay subregion that will almost certainly include floodplain management but is only in the earliest stages now.	Clearly overlaps with CVFPP in many ways. Central Valley Joint Venture will likely be involved with this effort.
Sierra Water and Climate Change Campaign	Sierra Nevada Alliance	The Sierra Water and Climate Change Program alerts the public and decision makers to the impacts of climate change in the Sierra and assists the adoption of smart local resource management plans (watershed plans, general plans, hydropower relicensing, integrated regional water management, forestry, etc.) and protect natural resources by reducing emissions and adapting to the changing climate.	Although somewhat outside the planning area, the decisions being made upslope from the CVFPP efforts should be considered and engaging this group would seem to appropriate.
California Department of Fish and Game	Amber Pairis, DFG Climate Advisor	DFG is committed to minimizing to the greatest extent practical the effects of climate change on the State's natural resources through development of adaptation and mitigation measures, policies, and practices that provide clear benefits to fish and wildlife and recognize the uncertainty associated with future climatic states. DFG is working to identify, respond, and prepare for climate change through landscape scale efforts, including the State wildlife action plan, the North American Waterfowl Management Plan, the National Fish Habitat Action Plan, and other efforts that support managing robust populations and healthy fish and wildlife habitats.	Offers synergies with wildlife plans in California.

Name	Responsible Entity	Description	Reason for Project/Program Coordination
Delta Habitat Conservation and Conveyance Program/ Bay-Delta Conservation Plan	DWR and Reclamation partnership	The DHCCP was formed in 2008 as a result of Governor Schwarzenegger's calls for studies to assess potential habitat restoration and water conveyance options in the Delta. As part of the program, the BDCP is under preparation with partnerships among USFWS, NMFS, DFG, DWR, Reclamation, Resources Agency, CVP/SWP water contractors, and various nongovernmental organizations. The BDCP, which will address CVP/SWP water operations and facilities in the legal Delta, will focus primarily on aquatic ecosystems and natural communities.	Provide consistency in DWR's approach to addressing climate change considerations in all aspects of water management. In addition, according to Secretary Mike Chrisman's recent memorandum on the BDCP Process and FloodSAFE California Initiative on October 7, 2009, these two planning processes should be integrated to "adapt water and flood management systems and environmental rehabilitation efforts to respond to cope with the impacts of climate change."
DWR Water Plan Update (Bulletin 160)	DWR	The California Water Plan provides a framework for water managers, legislators, and the public to consider options and make decisions regarding California's water future. The plan, which is updated every 5 years, presents basic data and information on California's water resources, including water supply evaluations and assessments of agricultural, urban, and environmental water uses to quantify the gap between water supplies and uses. The plan also identifies and evaluates existing and proposed statewide demand management and water supply augmentation programs and projects to address the State's water needs.	Provides consistency in DWR's approach to addressing climate change considerations in all aspects of water management. For the water plan update, DWR organized the Climate Change Technical Advisory Group to help guide the incorporation of climate change considerations into long-term water resources planning.
Integrated Regional Water Management Program	DWR	The IRWMP is intended to promote and practice integrated regional water management for sustainable water uses, reliable water supplies, better water quality, environmental stewardship, efficient urban development, protection of agriculture, and a strong economy. Through this program, DWR and SWRCB administer bond funding to local agencies for planning and implementation purposes.	Provides regional collaboration in development of integrated strategies for water resources management, including effective integration of flood management and climate change considerations.

Name	Responsible Entity	Description	Reason for Project/Program Coordination
Climate Action Team	Led by CalEPA, and includes several State agencies.	The CAT, established by Governor Schwarzenegger under an Executive Order (EO) on June 1, 2005, coordinates State-level actions relating to climate change. The CAT is tasked with implementing global warming emission reduction programs, and reporting on the progress being made toward meeting statewide GHG targets that were established in the EO and further refined in the Scoping Plan developed by the ARB under the Global Warming Solutions Act of 2006.	Provide consistency with statewide policy, which the CAT helps to develop.
Energy Commission's Public Interest Energy Research Program	California Energy Commission	The purpose of the program is to support research on developing environmentally sound, safe, reliable and affordable energy services and products.	In conjunction with other State agencies, PIER is addressing climate change by leading the development of a long-term climate change research plan for California, providing an organized initiative for developing California-focused scientific research on climate change.
CALFED Bay-Delta Program	CALFED	CALFED is a collaboration of 25 federal, State, and local agencies that established a program to improve California's water supply and the ecological health of the San Francisco Bay/Sacramento-San Joaquin Delta. Major CALFED programs include the Water Quality, Levee System Integrity, Conveyance, Water Use Efficiency, Storage, Ecosystem Restoration and Watershed Management, and Science programs.	The CALFED Levee System Integrity Program, Ecosystem Restoration, and Watershed Management, and Science programs could provide relevant information on CVFPP development and, in particular, climate change considerations. The coordination could avoid duplicated efforts.
Central Valley Integrated Flood Management Study	USACE	The CVIFMS will define a long-range program for the Sacramento and San Joaquin river basins and the corresponding level of federal participation in project implementation. This program will identify opportunities to reduce flood risk by improving the flood capacity of the system while restoring and protecting floodplain and environmental features, including wetlands and other fish and wildlife habitat.	The CVIFMS is the companion study of the CVFPP to address flood management challenges in the Central Valley through a watershed approach. The current strategy for coordination is to develop as much joint product as possible that could fit the needs of both studies.

Name	Responsible Entity	Description	Reason for Project/Program Coordination

Key:

ARB = Air Resources Board
BAECCC = Bay Area Ecosystems Climate Change Consortium
BDCP = Bay/Delta Conservation Plan
CALEPA = California Environmental Protection Agency
CALFED = CALFED Bay-Delta Program
CAT = Climate Action Team
CVFPP = Central Valley Flood Protection Plan
CVP/SWP = Central Valley Project/State Water Project
CVIFMS = Central Valley Integrated Flood Management Study
Delta = Sacramento-San Joaquin Delta
DFG = California Department of Fish and Game
EO = Executive Order
DHCCP = Delta Habitat Conservation and Conveyance Program
DWR = California Department of Water Resources
IRWMP = Integrated Regional Water Management Plan
LCC = Landscape Conservation Cooperatives
NMFS = National Marine Fisheries Service
PIER = Public Interest Energy Research
Reclamation = U.S. Department of the Interior, Bureau of Reclamation
SF = San Francisco
State = State of California
SWRCB = State Water Resources Control Board
USACE = U.S. Army Corps of Engineers
USFWS = U.S. Fish and Wildlife Service

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6.0 Related Climate Change References

CCSDWG members provided input on a list of environmental stewardship references, which is a subset of a larger list of references used for CVFPP development. The purpose of this list is to provide insight on potential varying views about each reference to the CVFPP Plan Development Team. A key effort in CVFPP development is to capture a variety of perspectives.

Work Group members provided input by categorizing each reference according to the categories shown in Table 6-1, and included narrative comments about why the category was chosen. Members also supplied additional references deemed relevant to climate change in the CVFPP.

Table 6-1. Reference Category Codes

Code	Category
Must	Extremely important, must include
Good	Good general reference
Use	Use – but with caution
Sup	Superseded by later documents/studies
Irr	Irrelevant
No	Not acceptable

While only a limited number of Work Group members provided comments on the reference list, there was disagreement over the quality and utility of several of the listed documents. This input will be considered as the reference list developed by the CCSDWG is integrated with the overall list being compiled for the CVFPP. DWR is developing an online repository of all CVFPP reference documents, which will be available to Work Group members.

The following list includes references that were reviewed and contributed by CCSDWG members; references that were superseded or unanimously considered irrelevant were left out.

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