Chapter 2 Water Management Issues and Challenges

California faces a number of unprecedented water resources management challenges. The California Water Plan stresses urgency and that it is "imperative to act" as California faces "one of the most significant water crises in its history," which is due to declining ecosystems, greater drought impacts, aging infrastructure, increasing flood risk, and impaired water bodies (DWR, 2009a). Additionally, climate change and population growth are further stressing our water systems and will make all of the effects associated with the challenges above more difficult to manage. Finally, the facilities used to convey water around the state face uncertainties. The Sacramento-San Joaquin Delta (Delta) (See Box 2-1 for a list of acronyms and abbreviations used in this section) is in crisis and as the hub of California's water delivery system, the Delta faces many challenges. There is uncertainty about how the Delta of the future will look and how water will be conveyed through the Delta. The status quo is not working. There are many new programs, policies, and stakeholders that will shape the future of the Delta. Water management planners must incorporate these uncertainties, including potential Delta water management solutions, into both statewide and regional planning efforts.

For more than 50 years, Californians have been able to meet water demands primarily through an extensive network of water storage and conveyance facilities, groundwater development, and more recently, by improving water use efficiency and conservation practices (DWR, 2009a). California's large (state/federal) and small (local/regional) water projects work together to meet the needs for the quantity, quality, timing, and location of water uses. California's climate and hydrology make storage of water essential to survival and to the economy as precipitation is unevenly distributed. Every area of the state experiences many dry months without any precipitation each year, generally starting in the spring and lasting into the fall. The northern and mountainous parts of the state receive far more precipitation than the valleys and southern parts of the state. As a result, surface storage reservoirs play a critical role in helping meet the multiple needs of municipal and industrial (M&I), agricultural, and environmental uses in different geographical regions.

Much has been written about the water issues and challenges in California; this chapter begins with a brief summary of some of those issues and challenges as they relate to the water management system in the Central Valley and the Delta and how these challenges will drive improvements to the water system. Additional details on specific regional challenges, particularly in the areas of the Central Valley—the Sacramento Valley, the San Joaquin Valley, and the Delta—are provided in investigation-specific chapters later in this report. Finally, this chapter provides some general discussion of how increasing surface water storage in the Central Valley water system can help meet the interrelated, and sometimes competing, needs of ecosystem restoration, water supply, water quality, flood management, hydropower generation, and recreation.

Declining Ecosystems

Throughout the Sacramento and San Joaquin river basins and the Delta, there are telling signs of the decline and collapse of the ecosystem, from habitat losses to population declines of threatened and endangered species. Of particular importance for this report are the water-related stresses on these important ecosystems, including the following:

- Sufficient flow patterns to support critical life stages of fish populations in Central Valley streams
- Sufficient flows to support fish passage

- Sufficient water supplies for Central Valley wildlife refuges
- Adequate temperatures to support critical life stages of fish populations
- Quality of water necessary for supporting and enhancing desired fish populations

In each of these areas, quantity, quality, and timing of water flows are important factors for supporting and recovering habitat and species.

As a result of the myriad of changes to the system, including water diversions, pollution, invasive species, rising temperatures and loss of habitat, the Sacramento and San Joaquin river systems and the Delta have experienced a serious decline in many important habitats and species. Historic lows of the delta smelt populations and salmon runs in both the Sacramento and San Joaquin rivers are a focal point of concerns. The following sections provide a summary of the nature of the declines in the Delta and the Sacramento and San Joaquin rivers and an overview of responses, including legal, legislative, regulatory, and water management. Appendix D provides a summary of planning efforts in the Delta that will help address ecosystem declines.

Box 2-1. Chapter 2 Acronym and Abbreviation List

AF	acre-feet
BDCP	Bay-Delta Conservation Plan
BO	Biological Opinion
CALFED	CALFED Bay-Delta Program
CVP	Central Valley Project
Delta	Sacramento-San Joaquin Delta
DHCCP	Delta Habitat Conservation and Conveyance Program
DWR	Department of Water Resources
M&I	municipal and industrial
MAF	million acre-feet
NMFS	National Marine Fisheries Service
Reclamation	United States Bureau of Reclamation
SWP	State Water Project
TAF	thousand acre-feet
USFWS	United States Fish and Wildlife Service

Sacramento-San Joaquin Delta

The Delta is home to 750 species of plants and wildlife and 55 species of fish and is the hub of California's water delivery system providing water to farms and more than two-thirds of the state's population. This important estuary is in crisis; a convergence of various factors has diminished the health of the Delta. Despite many efforts to maintain and recover endangered and threatened fish and wildlife species, and protect critical habitat, species continue to decline. The decline of pelagic fish species, including delta smelt, striped bass, threadfin shad, and longfin smelt (See Figure 2-1), has brought the Delta to the attention of many in California and across the nation.

Over the past several decades, the Delta ecosystem has continued to decline, which was dramatically illustrated by the more recent collapse of the delta smelt population and salmon runs associated with the Sacramento and San Joaquin rivers. These declines triggered a number of environmental and legal actions related to the operation of the Central Valley Project (CVP) and State Water Project (SWP) and reduced the ability to convey water through the Delta. Lawsuits and resultant court decisions include the May 2007 *Natural Resources Defense Council et al. vs. Kempthorne et al.* (regarding delta smelt), and December 2008 *Pacific Coast Federation of Fisherman's Association vs. Gutierrez* (regarding salmonid species). These court decisions led to protective measures that resulted in constrained water conveyance and curtailed CVP/SWP Delta exports. For example, in spring 2007 water exports from the Delta were significantly reduced for CVP facilities and halted at SWP facilities for a period of 10 days to protect delta smelt. The Department of Water Resources (DWR) estimated that over 500 thousand acre-feet (TAF) of scheduled deliveries could not be made during this period.

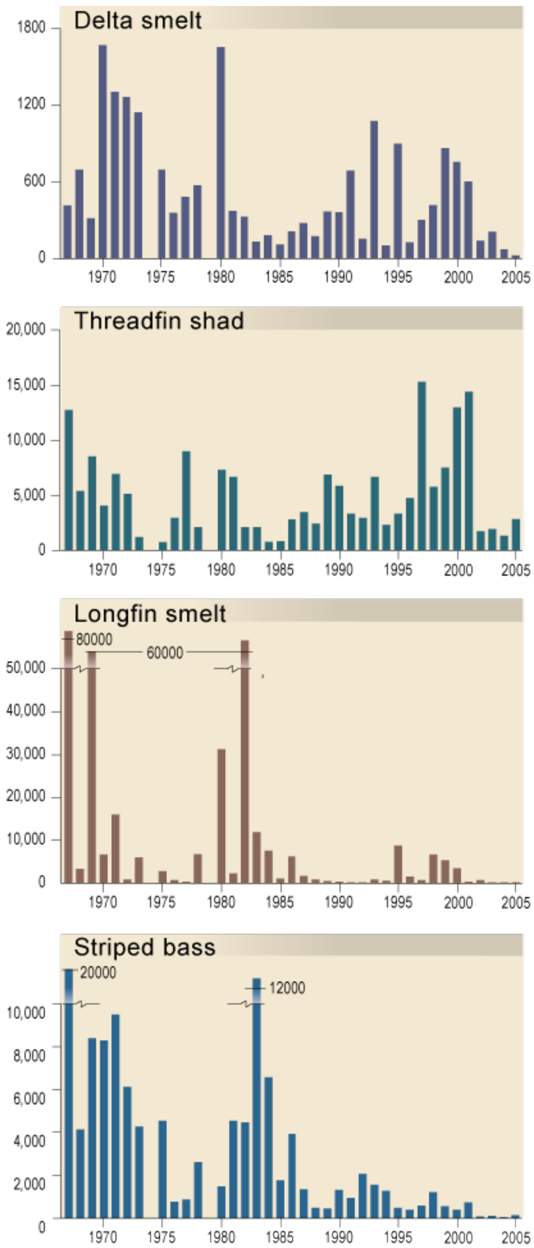

Figure 2-1. Fish Trends Depicting Delta Pelagic Organism Decline, 1967-2005 (Natural Resources Agency, 2007)

In response to these lawsuits and court decisions, the Bureau of Reclamation (Reclamation) and DWR revised their Biological Assessment in May 2008 and the U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) recommended actions to protect delta smelt and anadromous fish in their respective 2008 and 2009 Biological Opinions (BO). These new BOs regulate current operations of the CVP and SWP, and place additional constraints on water management and operations in the Sacramento and San Joaquin river basins and the Delta. NMFS calculates that its BO will reduce by 5% to 7% combined the amount of water federal and state projects will be able to deliver from the Delta. In total, court decisions and new regulations have reduced Delta water deliveries by 30%.

Sacramento / San Joaquin River Systems

The Delta is inextricably linked to its major rivers (Figure 2-2). The Sacramento and San Joaquin rivers each face ecosystem restoration challenges, while also providing inflows to the Delta. The Sacramento and San Joaquin rivers and some of their major tributaries are dammed to capture winter runoff and spring snowmelt from California's snowpack and release water when needed. To successfully restore aquatic, riparian, and floodplain communities the natural patterns of erosion, river meander, sediment deposition and scour depend upon seasonal variations in stream flow.

Tributaries to California's large rivers that were once seasonal have become annual streams due to human contributions from wastewater discharge and irrigation runoff. These changes to inflow have modified the historical Delta from a seasonally brackish estuary to a freshwater system that benefits invasive species. Restoring functional ecosystem characteristics will be essential in restoration efforts. Actions can be taken to improve the ecosystem and water supply of the Sacramento and San Joaquin rivers and provide additional benefits to the Delta.

Sacramento River

The Sacramento River is the state's largest as well as California's most important riverine ecosystem. Restoration challenges are strongly tied to ecosystem processes and functions associated with the river and its nearby land areas. The Sacramento River and its tributaries provide essential riparian habitat for many aquatic and terrestrial species including habitat for anadromous fish spawning, holding, and rearing. The valley floor region adjoining the river provides wintering areas along the Pacific Flyway for many varieties of waterfowl. The region also has several wetland and waterfowl preserves that provide nesting and migration areas for threatened avian species that depend upon a reliable water supply. (DWR, 2009a)

Many Sacramento River restoration opportunities have been identified by previous or on-going planning efforts such as the CALFED Bay-Delta Program (CALFED) Ecosystem Restoration Program Sacramento River Ecological Management Zone Vision and the Sacramento River Conservation Area Forum.

San Joaquin River

Unhealthy ecosystem conditions in the San Joaquin River have resulted from a lack of reliable flows in some sections of the river and poor water quality. Tributaries of the San Joaquin River provide the region with high-quality water that constitutes most of the surface water supply. A recent settlement action that resulted in a long-term restoration effort, the San Joaquin River Restoration Program, proposes to restore flows to the San Joaquin River to sustain naturally reproducing Chinook salmon and other fish populations between Friant Dam and the Merced River.

Drought Impacts and Water Supply Reliability

California's water resources are variable, precipitation—the primary source of the state's water supplies—varies from place to place, season to season, and year to year. In any year, the state's water systems may face the threat of too little water to meet needs during droughts or the threat of too much water during floods. Most of California's snow and rain fall in the mountains in the northern and eastern parts of the state, and most water is used in the central and southern valleys and along the coast. The state's ecosystem, agricultural, and urban water users have variable demands for the quantity, timing, and place of use. The state's water distribution systems, made up of local, state, and federal projects and programs, were designed with this variability of natural precipitation and water use in mind. These projects have worked together to make water available at the right places and times, and to manage floodwaters. In the past, this system has allowed California to meet most of its agricultural and urban water management objectives and flood management objectives.

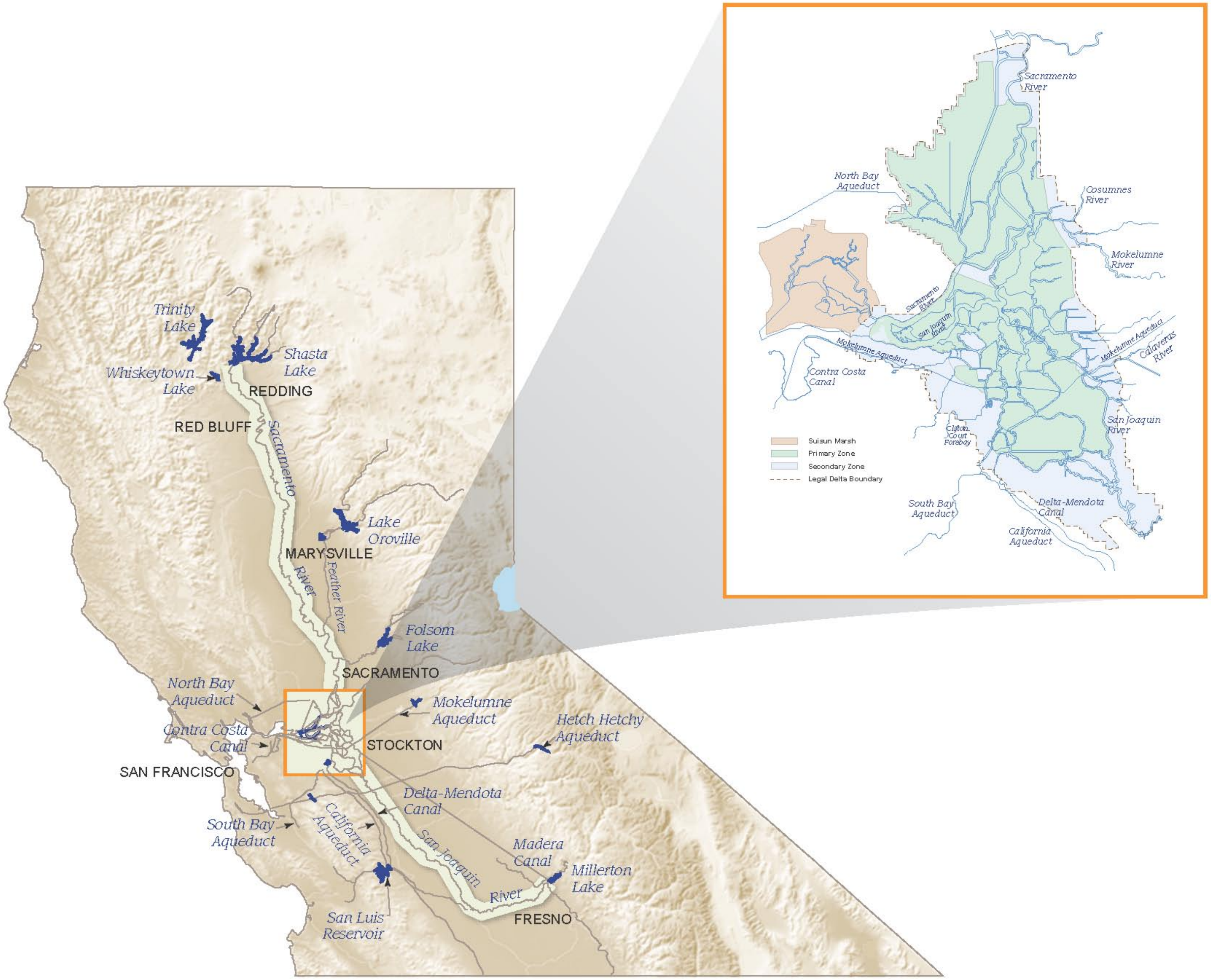

Figure 2-2. The Delta and Sacramento and San Joaquin Rivers

Generally, during a single dry year or two, surface water and groundwater storage can supply most water deliveries, but dry years can result in critically low water reserves. More recently, improved water use efficiency and conservation practices have helped to meet water demands. However, significant water supply and water quality challenges persist. Although some regions have made great strides in water conservation and efficiency, many communities in the state are reaching the limits of their supply with current water systems management practices and regulations. This system is constrained during normal years, but the challenge to make sure that water is in the right place at the right time is at its greatest during dry years. (DWR, 2009a)

Water supply reliability is most affected during drought conditions. The amount of water supplies delivered annually depends on the demand, amount of rainfall, snowpack, runoff, water available in storage, and legal constraints on diversions from the Delta—all of these factors are worsened during drought conditions. The California Water Plan acknowledges that reliability is most challenging during drought conditions, “As competition grows during dry years among water users, water management becomes more complex and, at times, contentious.” The strategic plan of the California Water Plan includes 10 fundamental lessons; including, “California needs additional groundwater and surface water storage capacity. Storage gives water managers tremendous flexibility to meet multiple needs and provide vital reserves in drier years.”

Water Year 2009 represented the third consecutive dry year for the state. Drought conditions changed California’s water management and forced communities to impose mandatory restrictions on water use. During droughts, ecosystems also feel the pressure as less water is available to meet in-stream flow requirements and the temperature of the water increases causing greater impacts to the ecosystem. Droughts affect the state’s economy, slowing development projects and forcing growers to fallow land. The California Department of Food and Agriculture estimated that the water shortage caused a $260 million loss to the state’s agricultural industry in 2009. Droughts, as well as flooding, may be inherent in California’s natural cycles, but their intensity and consequences are worsening. Indeed, in the 25-year period from 1985 to 2010, half of the years have been categorized as dry or critically dry. Warming temperatures and changes in rainfall and runoff patterns may increase the frequency and intensity of droughts. (DWR, 2009a)

Statewide droughts typically occur as a result of multiple dry years. Recent droughts that have seriously affected water supplies include the 1976-1977 drought, which included one of the driest years on record (1977), the 1987-1992 drought, and the current drought. A single dry year is generally manageable because of water in storage. In California, runoff and reservoir storage, which are related, are good indicators of a statewide drought. Runoff for the current drought is 53%, 60%, and 65% of average for water years 2007, 2008, and 2009 respectively. Reservoir storage at the state’s major reservoirs during the same period is 78%, 57%, and 69% of average. (DWR, 2009b) Deliveries to water users and water contractors have been substantially reduced.

Challenges are greatest during dry years and droughts, as we have experienced yet again over the past three years. In drier years, water dedicated to the environment is curtailed, and less water is available for agriculture. Greater reliance on groundwater during dry years results in higher costs for many users and more groundwater overdraft. At the same time, water users who have already increased efficiency may find it more challenging to achieve additional water use reductions during droughts. Longer droughts create numerous problems including extreme fire danger, economic harm to urban and rural communities, loss of crops, and the potential for species collapse and degraded water quality in some regions. (DWR, 2009a)

The Central Valley water system is designed with carry-over water storage in reservoirs to lessen the impacts of drought. Water is stored in wetter years for use in drier years. Similarly, the Central Valley's groundwater basins provide storage and a buffer for the effects of drought. Droughts also affect different areas of the state in different ways. In some years, water shortages in one area are not experienced by other areas. California's water system is designed to create some flexibility to address differing regional impacts through short-term transfers of water to minimize drought impacts.

Impaired Water Bodies

Water quality issues and conflicts in the Central Valley water system present significant challenges for providing adequate and appropriate water supplies for the environment and M&I and agricultural users. The fundamental challenge is the mismatch of water quality needs with the quality of available supplies.

In many areas surface water and groundwater are impaired by natural and human-made contaminants that can threaten human health, degrade the natural environment, increase water treatment costs, and effectively reduce the available water supply. (DWR, 2009a) As water flows from upstream storage reservoirs through the Central Valley to the Delta, it is impaired by increasing pollutants from discharges and runoff and increasing temperatures from warmer weather at lower elevations.

Water storage reservoirs in the Central Valley capture high quality water with low level of pollutants and low temperature and make that water available at appropriate times for the environment, agriculture, or M&I use. The storage reservoirs are operated to manage water quality in the rivers and the Delta to meet multiple needs. For example, existing off-stream water storage reservoirs can store high quality water for use when instream water quality declines in late summer and fall.

Key water quality challenges in the Central Valley include the following issues:

- Improving and maintaining high quality of drinking water supplies for M&I uses
- Achieving appropriate levels of salinity and organics for Central Valley habitats, particularly in the Delta
- Maintaining low temperature flows for critical life stages of fish populations in Central Valley tributaries
- Maintaining appropriate levels of dissolved oxygen to support ecosystem health

Most significantly, these water quality issues are frequently in conflict. For example, M&I users of Delta water supplies seek to maintain low levels of nutrients and organics while ecosystem needs in the same area may require higher levels of nutrients and organics and important habitat, such as tidal marsh, increase dissolved organics in the water supply.

Changes in temperature and precipitation patterns caused by climate change will also affect water quality, and ultimately, ecosystems. Increased water temperatures reduce the dissolved oxygen levels and success of aquatic life that have a low tolerance for variable and warmer in-stream temperature. Higher water temperatures accelerate certain biological and chemical processes, increasing the growth of algae and microorganisms, and affect water treatment processes. Elevated water temperatures will distress many fish species and could require additional cold water reservoir releases to mitigate these higher temperatures.

Changes in the timing of river flows from climate change may affect water quality and beneficial water use. At one extreme, flood peaks may cause more erosion, resulting in higher turbidity and concentrated pulses of pathogens and other pollutants. At the other extreme, lower summer and fall flows may provide less contaminant dilution. These changes will require new approaches to manage point and nonpoint source pollution.

Additionally, saltwater intrusion associated with sea level rise caused by climate change will affect Delta water supplies and aquatic habitat. An increase in the penetration of seawater into the Delta will further degrade drinking and agricultural water quality and alter ecosystem conditions. With the current water management system, more freshwater releases from upstream reservoirs will be required to repel seawater intrusion to maintain salinity levels for M&I and agricultural uses. Alternatively, changes in upstream and in-Delta diversions, exports from the Delta, and conveyance through or around the Delta may be needed. Sea level rise may also affect drinking water supplies for coastal communities due to the intrusion of seawater into overdrafted coastal aquifers.

Climate Change

The inherent variability in location, timing, amount, and form of precipitation has always led to uncertain predictions of water supplies in California. Climate change introduces further uncertainty and risk in the availability of water supplies for California. Global warming is likely to significantly affect the hydrologic cycle, changing California's precipitation pattern and amount from that shown by the historical record. There is evidence suggesting that some changes have already occurred, such as earlier Sierra snowmelt, runoff patterns shifting from the spring to the winter, and an increase in winter flooding levels and frequency, as well as the length and frequency of droughts. These changes will place more stress on the reliability of existing water management and supply systems.

The greatest effect of climate change will be the loss of water storage from the Sierra snowpack (See Figure 2-3) and how the remaining water resources are managed. Snowmelt provides an annual average of 15 million acre-feet (MAF) of water, slowly released between April and July each year. Much of the state's water infrastructure was designed to capture the slow spring runoff and deliver it during the drier summer and fall months. Warmer winters with less snow and more rain may result in more late winter and early spring runoff and less late spring and early summer runoff requiring alteration of how the water system is currently operated.

Water management in California has been based on the assumption that the past is the best predictor of the frequency, duration, and severity of future floods and droughts. Managers of California's historical water landscape believed they understood the variability of storm events and used the historical record to predict the future management decisions based on the storage available. Not only were water managers using past hydrology to make decisions, California's reservoirs and water delivery infrastructure were designed using historical hydrology—based on an assumption that the past is a good guide to the future. With climate change that assumption is no longer valid. (DWR, 2009a)

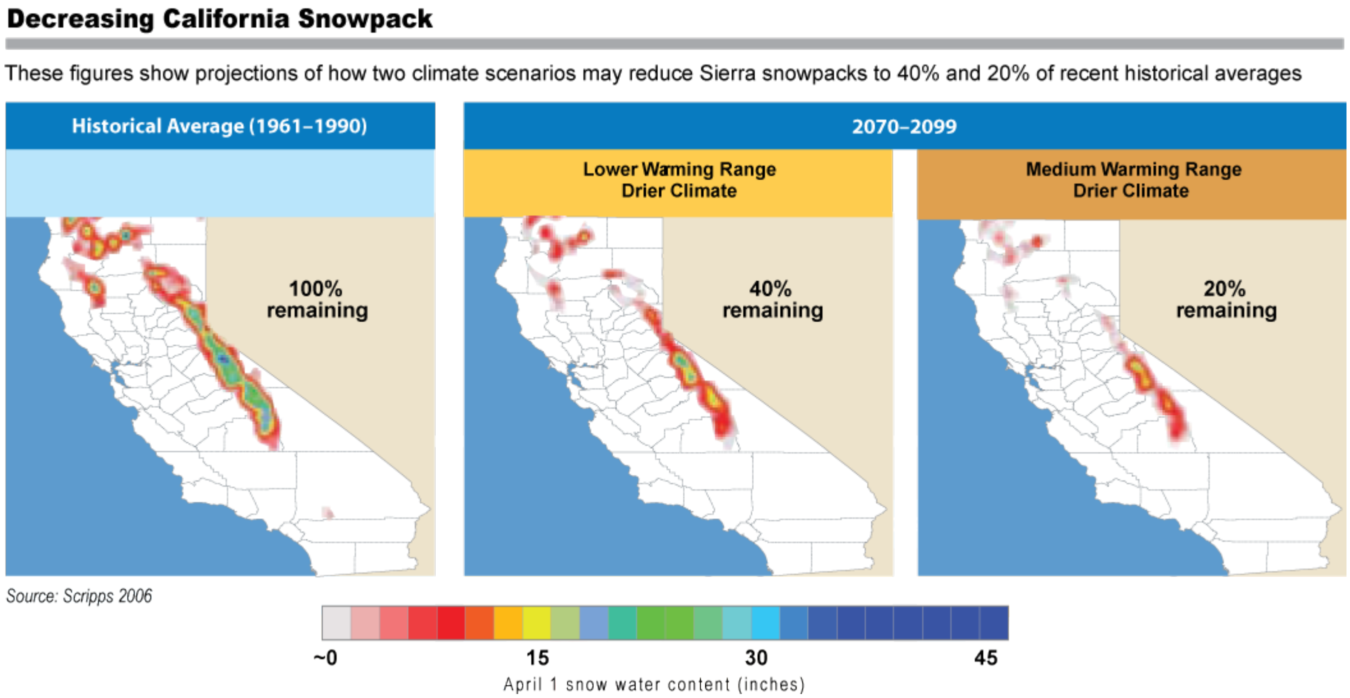

Figure 2-3. Decreasing California Snowpack

The California Climate Change Center issued a report in August 2009 titled "Using Future Climate Projections to Support Water Resources Decision Making in California." Analysis conducted for the report indicated that due to climate change:

1. Reservoir carryover storage is expected to be reduced by 15% to 19% by mid-century and by 33% to 38% by the end of the century.
2. A water shortage worse than the one during the 1977 drought could occur in one out of every six to eight years by mid-century and one out of every three to four years by the end of the century.
3. Annual Delta exports are expected to be reduced by approximately 7% to 10% by 2050 and by 21% to 25% by the end of the century.
4. The SWP and CVP are expected to be more vulnerable to operational interruption.

These changes resulting from climate change will amplify the other water management challenges described in this chapter and alter the timing and availability of water resources in California.

Increasing Flood Risk

California's water distribution system is inextricably integrated with the flood management system; water is conveyed down and through the Sacramento and San Joaquin rivers and the Delta through river channels and sloughs that are confined by levees and many multipurpose water supply reservoirs are operated to provide downstream flood protection. Water storage behind Central Valley reservoirs is a critical component of flood management throughout the Central Valley.

Many of the multipurpose storage facilities contribute to flood management in the Sacramento and San Joaquin river basins. Reservoir operation is essential for management of floodwaters within the Central Valley. Reservoirs can reduce peak discharges by retaining flood waters behind dams and making controlled releases that can be handled by the system. Proper reservoir operation can alleviate flood damages downstream. The United States Army Corps of Engineers establishes seasonal flood reservation storage and rules for the operation of flood storage in reservoirs with flood storage capacity. For example, Shasta Lake on the Sacramento River and Millerton Lake on the San Joaquin River can provide 1.3 MAF and 390 TAF of flood control space, respectively, during the flood season. Oroville Dam, which is the keystone of the SWP, is also identified as part of the State Plan of Flood Control and provides 750 TAF of seasonal flood control space. (DWR, 2010)

Climate change may worsen the state's flood risk by a shift toward more intense winter precipitation and higher peak flood flows. Increasing temperatures and receding snowlines related to climate change will cause the Sierra Nevada watersheds to contribute more precipitation to peak storm runoff and subsequently high-frequency flood events (e.g., 10-year floods) in particular may increase. Scientists project greater storm intensity, resulting in increased direct runoff and flooding. (DWR, 2009a)

Much of the Delta consists of islands that are below sea level and protected by levees. Increasing flood flows and rising sea levels as a result of climate change will increase pressure on fragile levees and will pose a significant threat to water quality. Catastrophic levee failures have great potential to inundate Delta communities and interrupt water supplies throughout the state. Based on work conducted by DWR's Delta Risk Management Strategy, a large earthquake in or near the Delta could likely result in the failure of multiple Delta islands. Levee failures of multiple Delta islands could threaten the drinking water supply of 24 million Californians, California's agriculture industry, tens of thousands of homes, and major transportation corridors, and result in significant environmental impacts, including the permanent loss of critical habitat for endangered species around the Delta.

Following a Delta levee failure, particularly an event that involves multiple breaches and more than one flooded island, decisions must be made to manage Delta inflows and outflows, especially concerning Delta water quality and its effect on water exports, Delta island water, ecosystem functions, and economic disruption. Maintaining Delta water quality when several islands are flooded requires more than the usual inflow of fresh water because of the extra volume of tidal flow under breach conditions. Extensive damage to Delta levees may require re-operation of SWP, CVP, and other surface water reservoirs. Re-operation may include increasing freshwater flows to the Delta (requiring determinations on quantity and schedule for releases) or releasing emergency storage for delivery to water users. Releases during an emergency must be balanced with the need to save water for environmental needs, other water users, future exports, and protection against dry years or a prolonged disruption of Delta exports. Reservoirs upstream of the Delta may be re-operated to provide freshwater flushing flows, whereas reservoirs downstream of the Delta may increase deliveries to water users due to the reduction of exports from the Delta. Some reservoirs maintain storage for emergency water supply. For example, between 44,000 acre-feet (AF) and 70,000 AF of the Los Vaqueros Reservoir are reserved for emergency purposes depending on the water year type.

Population Growth

Per the California Water Plan, "*Conditions today are much different than when most of California's water systems were constructed; and upgrades have not kept pace with changing conditions, especially considering growing population; changing society values, regulations, and operational criteria; and the future challenges accompanying climate change.*" Indeed, the major water systems were designed more than 30 years ago to serve 16 million residents, now the systems serve more than 38 million residents and are struggling to meet the needs of M&I, agriculture, and the environment.

Population growth is a major factor influencing current and future water uses. The state's population continues to grow, estimated by the Department of Finance to increase to about 59.5 million by the year 2050. Population is growing while available water supplies are static, or may even be decreasing. We must adapt and evolve California's water systems more quickly and effectively to keep pace with ever changing conditions now and in the future. (DWR, 2009a)

Uncertainties of Delta Water Management

To address the long-term needs of a sustainable Delta ecosystem and improved water conveyance, the Bay-Delta Conservation Plan (BDCP) and Delta Habitat Conservation and Conveyance Program (DHCCP) are evaluating ecosystem restoration and habitat conservation opportunities associated with different water conveyance options in the Delta. The BDCP and DHCCP are preparing environmental and engineering studies to develop a sustainable resolution to the Delta ecosystem decline and Delta export and conveyance constraints. A Public Draft Environmental Impact Statement/Environmental Impact Report for the BDCP is expected next year. Solutions to Delta ecosystem restoration and improved water conveyance needs may result in changes to the pattern and timing of Delta water diversions, affecting water quality and hydrodynamic conditions in the Delta. As uncertainties regarding these plans and policies are resolved, assumptions will be refined, which may change the basis of comparison for or magnitude of the accomplishments of the initial alternatives plans considered by the surface storage investigations.

Water Management Issues and Challenges and the CALFED Surface Storage Investigations

The Central Valley water management system will need greater flexibility to meet the above challenges in the future. The following is a brief list of some of the ways reservoir storage can contribute to addressing statewide and regional water needs for people and the environment:

- Managing the timing of water availability to better match demand/water use (seasonally and year-to-year to meet drought needs)
- Managing environmental water flows, timing, and temperature in river systems
- Managing the quality of water for different purposes, including temperature
- Promoting conjunctive use of surface water and groundwater
- Providing emergency water supply
- Collecting flood flows to protect resources from damage
- Providing hydropower generation or flexible generation opportunities
- Adapting to loss of snowpack storage
- Enhancing regional self sufficiency
- Supplementing local water supplies, conservation, reuse, and desalination

Some of these storage benefits cannot be addressed with, or would not be addressed as effectively as with, other water management strategies such as conservation, groundwater storage, and recycled water.

The water management challenges described in the sections above greatly influence the CALFED surface storage investigations. Some of the water management challenges may be directly addressed by planning objectives formulated specifically for each of the storage investigations. While other challenges may influence planning decisions and future project operations as the investigations continue and potential projects are implemented. All of the water management challenges affect each of the investigations, but to varying degrees. The investigations require creativity, adaptability, and the ability to look at surface storage in new and unique ways to address these challenges.

The CALFED storage investigations are each studying the potential contributions storage could make to address California water challenges. The following lists state and regional contributions each storage project could provide to address the above challenges:

North-of-the-Delta Offstream Storage Investigation

- Increased water supply reliability for urban and agricultural water users during average and dry years
- Increased flows for threatened fish populations in the Sacramento River and the Delta
- Increased cold water flows for fish populations in the Sacramento River
- Improved Delta water quality
- Increased water supplies for wildlife refuges
- Improved water management and operational flexibility in the face of uncertain and changing conditions
- Flushing flows for the Delta to reduce salinity during Delta levee failures
- Coordinated operations of Sites Reservoir with existing reservoirs to provide flood control benefits
- Flexible generation benefits to integrate renewable generation into the electric grid

Upper San Joaquin River Basin Storage Investigation

- Increased water supply reliability and system operational flexibility for agricultural, urban, and environmental water users in the CVP and SWP service areas
- Improved cold water pool management for enhancing water temperatures in the San Joaquin River below Friant Dam
- Increased San Joaquin River flows in critically dry years
- Reduced flood damages
- Provide emergency water supply to south-of-Delta water users during a Delta supply disruption
- Improved San Joaquin River and Delta water quality
- Improved water quality for urban water users in the San Joaquin Valley and other areas
- Improved water management flexibility in the face of uncertain and changing conditions

Los Vaqueros Expansion Investigation

- Improved operational flexibility to protect fish at export pumps
- Increased water supply reliability for Bay Area water agencies
- Improved water quality for Bay Area water agencies

Shasta Lake Water Resources Investigation

- Increased cold water flows for Sacramento River fisheries
- Improved water supply reliability for agricultural and M&I customers and for environmental purposes
- Increased Sacramento River flood protection
- Improved Sacramento River and Delta water quality

The remaining sections of this report will describe how each surface storage investigation has been conceived to explicitly improve both ecosystems and water supply reliability regionally and throughout the state and how potential surface storage projects could add flexibility and contribute to solutions to improve water management in California.

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