California Water Plan Volume 1

Flood Management Excerpts

NOTE: The following text related to flood management was excerpted from the Administrative Draft versions of the individual chapters that comprise Volume 1 of the California Water Plan Update 2009. This document is intended to facilitate an understanding of how flood management is addressed in Volume 1 of Update 2009. To more fully appreciate the context of the individual sections, the reader is encouraged to access the complete versions of the individual chapters, which may be found in their entirety at:
http://www.waterplan.water.ca.gov/materials/index.cfm?subject=oct3108

Chapter 1: Introduction

Chapter 1 Introduction outlines the process for preparing *California Water Plan Update 2009* and its new features. It also explains the organization of all five volumes of Update 2009 and its *Highlights* brochure.

Integrated Flood Management

Update 2005 recognized that a new approach to flood management was needed to better protect California from the devastating consequences and economic impacts caused by floods and that flood management cannot occur in isolation.

Consistent with the trend toward more integrated forms of water resource management, Update 2009 introduces a new concept of integrated flood management, a comprehensive approach to flood management that considers land and water resources at a watershed scale within the context of integrated regional water management, which aims to maximize the benefits of floodplains and minimize the loss of life and damage to property from flooding. Integrated flood management does not rely on a single approach to flood management, but instead utilizes various techniques, including traditional (or structural) flood protection projects, non-structural measures (such as land use practices), reliance on natural watershed functions, and the flood management benefits that can result from other forms of water resource management to create an integrated flood management system.

Integrated flood management is discussed in Chapter 2 and related management strategies are in Volume 2.

Chapter 2: Imperative to Act

Chapter 2 *Imperative to Act* lays out the urgent course California must take to ensure that we have enough safe and clean water through year 2050 for California's cities and towns, farms and businesses, and plants and animals when and where they need it. It describes the features of this important roadmap—themes of this Water Plan and elements of its strategic plan. It also includes key policy recommendations for State government and California for the removal of impediments and harnessing of opportunities that will help us achieve the Water Plan's vision, mission, and goals. Details of meeting these goals—through objectives and their related actions—are explained in Chapter 7 *The Implementation Plan.*

Fundamental Lessons…

- Integrated regional water management including integrated flood management is the basis of planning for California's water future with actions that provide multiple benefits. In planning for this integrated management, reducing uncertainties and assessing risks to the system are essential for developing a plan with which we can sustain our water use and resources.

- Solutions to California's water and flood management issues are best planned and carried out on a regional basis. Hydrological, demographic, geopolitical, socioeconomic, and other differences among California's regions demand that the mix of water management strategies be suited to meet each region's needs for the long term.
- California can prepare for future droughts and climate change, and improve water supply reliability and water quality, by taking advantage of the long-term water storage capacity of groundwater basins when managed in closer coordination with surface storage and other water supply sources when available. These supplies include but not limited to recycled municipal water, surface runoff and floodflows, urban runoff and storm water, imported water, water transfers, and desalination of brackish and sea water.

Paramount Challenges

Climate Change

California is already seeing the effects of climate change on hydrology (snowpack, river flows), storm intensity, temperature, winds, and sea levels. Planning for and adapting to these changes, particularly their impacts on public safety and long-term water supply reliability, will be one of the most significant challenges facing water and flood managers this century.

California water and flood management systems have provided the foundation for the state's economic vitality for more than 100 years, providing water supply, sanitation, electricity, recreation, and flood protection. However, the climate patterns that these systems were based upon are different now—and may continue to change at an accelerated pace. These changes collectively result in significant uncertainty and peril to water supplies and quality, ecosystems, and flood protection.

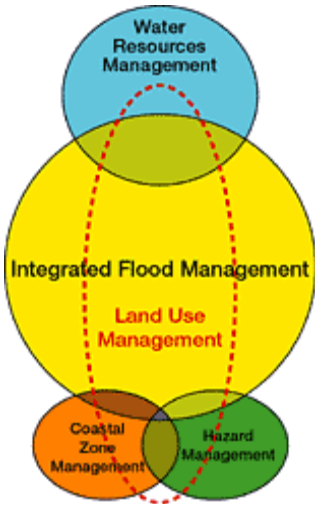
Future climate change impacts to hydrology and water resources management may be significant. The trends of the last century—especially the increases in hydrological variability—will likely intensify in this century, and abrupt changes in climate could also strike. We can expect to experience more frequent and larger floods and deeper droughts.

Future Uncertainty

California's water and flood managers and planners must deal with a broad range of uncertainty. Uncertainty is inherent in the existing system and in all changes that may occur in the future. One simple example of this is that water managers can be certain that the flows in California's rivers will be different next year compared with this year, but the uncertainty lies in not knowing the magnitude or timing of those changes. The threat of a chemical spill that may disrupt water diversion presents uncertainty. Future protections for endangered species may require modifications in water operation procedures that are unknown today. There are many uncertainties about how the system functions today. For example, scientists are trying to understand the reasons for the pelagic fish decline in the Delta, the condition of levee foundations, and the extent of groundwater recharge and overdraft to name a few.

Change may occur gradually over the long-term or short-term, including sudden changes. Gradual changes can include things like variation in population by region, shifts in the types and amount of crops grown in an area, or changes in precipitation patterns or sea level rise. Sudden changes can include episodic events such as earthquakes, floods, droughts, equipment failures, chemical spills, or intentional acts of destruction. The nature of these changes, the uncertainties about their occurrence, and their potential impacts on water and flood management systems can have big influences on how to respond to the changes.

Key Initiatives and Commitments



Integrated Flood Management and Emergency Response

Many Californians currently face unacceptable risk of harm and damage from floods. The personal safety and economic stability of large segments of our population rely on flood management systems that do not meet modern engineering standards. The need to improve public safety through integrated flood management is urgent as more people have chosen to live and work in flood-prone areas and climate changes make large flood flows more likely.

Traditionally, flood management practices largely focused on reducing flooding and susceptibility to flood damage through physical measures intended to store flood waters, increase the conveyance capacity of channels, and separate rivers from adjacent populations. Although this approach may reduce the intensity and frequency of flooding, it limits the natural role of floodplains and relies on a false premise that flood protection can completely eliminate flooding.

In recent years, flood managers have recognized the potential for natural watershed features to reduce the intensity or duration of flooding. Undeveloped floodplains can store and slowly release floodwaters. Wetlands can act as sponges, soaking up floodwaters, filtering runoff, and providing opportunities for infiltration to groundwater. Healthy forests and other open spaces can slow runoff during smaller flood events, reducing peak flows, mudslides, and sediment loads in streams.

(*figure from http://www.apfm.info/ifm.htm)*

A challenge for flood managers is to integrate these natural functions with more traditional flood protection methods, thus reducing floodflow peaks and their subsequent impacts during small and frequent flood events, while simultaneously providing other water resource benefits. To address this integration, the FloodSAFE California initiative and this update of the Water Plan promote the concept of integrated flood management, a comprehensive approach to flood management that considers land and water resources at a watershed scale within the context of integrated water management, which aims to maximize the benefits of floodplains and minimize the loss of life and damage to property from flooding.

Integrated flood management does not rely on a single approach to flood management, but instead utilizes various techniques, including traditional (meaning structural) flood protection projects, non-structural measures (such as land use practices), and reliance on natural watershed functions, to create an integrated flood management system. Depending on the characteristics of individual watersheds, this may include the two flood-specific management strategies introduced in Update 2009 (Volume 2)—floodflow management and flood impact reduction—as well as other resource management strategies which can provide flood management benefits, including: conjunctive management; conveyance; ecosystem restoration; forest management; land use planning and management, surface storage; system reoperation; urban runoff management; and watershed management.

Chapter 3: Companion State Plans

This Water Plan calls for comprehensive and integrated regional management of California's water resources. To advance State government's leadership and role in the water community and to promote the *Water Plan's* framework, recommendations, and strategies, the State needs to better incorporate water issues, initiatives, and information from other State agencies in the Water Plan Update. The Companion Plans chapter and the work of a 20 member State Agency Water Plan Steering Committee, is a central feature of this Water Plan Update. Chapter 3, *Companion State Plans* describes the effort to create a plan that is more than just a plan for DWR, and instead compiles a *State* Water Plan. This plan embraces companion State programs and policies in order to better understand the full possibilities and constraints for water managers.

Draft FloodSAFE Strategic Plan (DWR)

In 2006, DWR launched FloodSAFE California. FloodSAFE is the first statewide initiative designed to help improve integrated flood management with a significant emphasis on the Central Valley and Delta where communities and resources are at high risk of catastrophic damage. DWR leads the FloodSAFE Program with active participation from local, regional, State, Tribal, and federal partners.

State Multi-Hazard Mitigation Plan (Governor's Office of Emergency Services)

The Governor's Office of Emergency Services led the effort to complete the 2007 Enhanced State of California Multi-Hazard Mitigation Plan (SHMP), which includes a flood component. The SHMP is the official statement of the State's hazard identification, vulnerability analysis, and hazard mitigation strategy. The SHMP is the result of a collaborative multi-agency planning process that included DWR.

Chapter 4: California Water Today

Chapter 4 California Water Today describes California's diverse communities and environment and the impediments that challenge us in meeting all our water demands. Meanwhile, we are already seeing the effects of climate change on hydrology (snowpack, river flows), storm intensity, temperature, winds, and sea levels. This chapter discusses how California's policy-makers and water communities are finding ways to break down barriers through integrated planning and management, stewardship and sustainable practices, partnerships, legislation, and funding. Finally, this chapter recounts the many facets of California's water rights, usage, and allocation, including: A State of Diversity, Water Conditions, Challenges, and Responses and Opportunities.

Water Conditions

Flood Management

Traditionally, flood management practices largely focused on reducing flooding and susceptibility to flood damage through the physical measures intended to store flood waters, increase the conveyance capacity of channels, and separate rivers from adjacent populations. In recent years, flood managers have recognized the potential for natural watershed functions and worked to integrate these two methods. Integrated flood management is a comprehensive approach to flood management that considers land and water resources at a watershed scale within the context of integrated regional water management, which aims to maximize the benefits of floodplains and minimize the loss of life and damage to property from flooding. Integrated flood management does not rely on a single approach to flood management, but instead utilizes various techniques, including traditional (or structural) flood protection projects, non-structural

measures (such as land use practices), and reliance on natural watershed functions, to create an integrated flood management system.

For the purposes of federal flood insurance, the Federal Emergency Management Agency (FEMA) has traditionally used the “100 year” flood event, which refers to the level of floodflows expected at least once in a 100-year period. As California’s hydrology changes, what is currently considered a “100-year” flood may strike more often, leaving many communities at greater risk. Moreover, as peak flows and precipitation change over time, climate change calls into question the assumption of “stationarity” that is used in flood-related statistical analyses like the “100-year” flood. Planners need to factor a new level of safety into the design, operation, and regulation of flood control facilities—such as dams, floodways, bypasses, and levees—as well as the design of local sanitary sewers and storm drains. (from *CC White Paper 09-15-08*)

Ongoing Concerns

Floods and Flooding

The need for flood management improvements is more critical now than ever before. Over the years, major storms and flooding have taken many lives, caused significant property losses, and resulted in extensive damage to public infrastructure. However, a combination of recent factors has put public safety and the financial stability of State government at risk. California’s flood protection system, comprised of aging infrastructure with major design deficiencies, has been further weakened by deferred maintenance. Escalating development in floodplains has increased the potential for flood damage to homes, businesses, and communities.

Every region of the state faces flood risks. The Central Valley is a floodplain that historically was inundated at regular intervals. Coastal streams can overflow their banks during winter storms. Southern California is vulnerable to infrequent but devastating flooding. Development on alluvial fans faces unpredictable and changing paths of floodflows. Water supplies and our economy are threatened when Delta islands flood, and every part of California is exposed to the financial liability when levees of the Central Valley flood management system fail.

California’s population growth presents a major challenge to the State’s flood management system. In the Central Valley alone, much of the new development is occurring in areas that are susceptible to flooding. In some cases, land use decisions are based on poor or outdated information regarding the severity of the flood threat. Many flood maps being used by public agencies are decades old and do not reflect the most accurate information regarding potential flooding.

Catastrophic flooding within the Central Valley could mirror or exceed the economic, social, and environmental damages caused by Hurricane Katrina in 2005. More than a half-million people live behind levees in California now, with populations continuing to grow. Further, State government liability in the aftermath of the Paterno decision worsens the financial consequences of flooding.

Due to lack of funding and environmental concerns, both the State and local agencies in all regions of California have found it increasingly difficult to carry out adequate maintenance programs using previous methods. Environmental regulations are requiring development of new approaches for local and State agencies to deal with the backlog of maintenance activities. Time-consuming environmental permitting process can delay prompt maintenance of critical public safety infrastructure.

Climate change may worsen the state's flood risk by producing higher peak flows and a shift toward more intense winter precipitation. Rising snowlines caused by climate change will allow more of the Sierra Nevada watersheds to contribute to peak storm runoff. High-frequency flood events (e.g., 10-year floods) in particular may increase with a changing climate. Along with changes in the amount of the snowpack and accelerated snowmelt, scientists project greater storm intensity, resulting in more direct runoff and flooding, which is exacerbated in urban areas by more impervious land surfaces such as asphalt and concrete. Changes in watershed vegetation and soil moisture conditions will likewise change runoff and recharge patterns. As streamflows and velocities change, erosion patterns will also change, altering channel shapes and depths, possibly increasing sedimentation behind dams, and affecting habitat and water quality. With potential increases in the frequency and intensity of wildland fires due to climate change, there is in turn a potential for more floods following fire, which increase sediment loads and water quality impacts. (from CC White Paper 09-15-08)

Deferred Maintenance and Aging Infrastructure

Levees

DWR's document "Flood Warnings: Responding to California's Flood Crisis," submitted to the Legislature in January 2005 identified major deficiencies and challenges to the flood control system in the California Central Valley. Other levee concerns included:

- A magnitude 6.5 earthquake in the Sacramento Delta region would likely result in a catastrophic levee failure that threatens the drinking water supply for 24 million citizens in California.
- A majority of California's agriculture industry is dependent on water from the Sacramento Delta and a catastrophic levee failure would result in cessation of pumping capacity for as much as 18 months, causing $30 billion to $40 billion in economic damage to the state.
- A catastrophic levee failure would threaten tens of thousands of homes and major transportation corridors.
- A catastrophic levee failure would result in significant environmental impacts including the permanent loss of critical habitat for endangered species around the Sacramento Delta.

Following these revelations and other findings Governor Schwarzenegger in 2006 declared a State of Emergency for California's Levee System. The urgency became more pronounced as the world watched the Katrina disaster hit New Orleans.

The US Army Corps of Engineers in cooperation with the California Department of Water Resources has identified 24 critical erosion sites on project levees in the Sacramento and San Joaquin River Flood Control systems that need repaired before a catastrophic levee failure occurs.

Catastrophic Events and Emergency Response

The Sacramento-San Joaquin River Delta faces extraordinary risks in both the near term and the long term. Earthquakes, river floods, "sunny-day" levee failures, and continuing subsidence and sea level rise all pose substantial risks to people, property, and infrastructure. Yet emergency response is divided among many different entities—at least 14 fire districts and 14 sheriff and police departments. During high water, many islands direct their own flood fights, although some uniformity is provided by DWR. US Army Corps of Engineers have oversight authority only for those levees that meet its standards. Traveling Delta roads for repair levees can be difficult, especially during high water when response crews must cross bridges or use auto ferries. Island living presents challenges for individual family emergency plans when children attend schools on islands separate from their homes.

Effective emergency preparedness and other actions are needed to reduce risks to people, property, and state interests in the Delta. (Delta Vision Strategic Plan and S&T report)

AB162 *– Placeholder for a discussion of how general plans must address flood risk*

Levee Repair and Flood Control Bond

AB 140 signed by the Governor in 2006 is a $4 billion levee repair and flood control bond element of the Strategic Growth Plan meant to protect Californians from a Katrina-style disaster in the future. His signature put the bond on the November ballot.

AB 142, signed by the Governor, paved the way for Proposition 84 on the November 2006 ballot appropriating $500 million from the general fund to the DWR for levee evaluation and repair in 2006-2007. The Governor said public safety drove his decision to fund repairs of some critical levee sites for the following flood season and in years to come.

Chapter 5 Managing for an Uncertain Future

Chapter 5, *Managing for an Uncertain Future*, is based on the need for decision-makers and water and resource managers and planners to use the best available data and analytical tools in planning for California's water future in the face of many uncertainties and risks. It provides examples of uncertainties and discusses the need to consider risks in planning for a more sustainable future. The chapter presents an approach for these evaluations and examples of what was learned during preparation of this Water Plan Update to identify the types of investments that may be useful for a more sustainable future.

Planning Approach

Old Planning Approach – The Past is a Model for the Future

Water managers have always recognized the variable water flow in California's streams and rivers during wet and dry periods spanning seasons to multiple years. Having too little water or too much water, droughts or floods, were often the main reasons that Californians built early water projects. Early in California's water development history, personal observations and experience were often the best data available to help size water facilities because recorded data records did not exist.

A system to record water flow conditions over time gradually improved data available to water managers. *However, the main assumption governing water management for much of California's history has been that past records were a good indication of the frequency, duration, and severity of future floods and droughts, and these were used as models of potential future conditions.* In addition, historical records were generally used to establish trends, such as population growth, that were assumed to continue into the future.

This static view of the range of possible future conditions worked fairly well when the demands on the resources were considerably lower than now. Early designers may have thought they understood the range of streamflows that could occur and the likelihood that a reservoir would refill in a given year, but generally did not fully understand the interrelationships among ecosystem issues, water availability issues, water use issues, water quality issues.

In addition, risks posed by earthquakes, extreme floods, and extreme droughts were generally underestimated. Without a fuller acknowledgement of the uncertainties inherent in the system and

the risks that the system actually faced, the system management was relatively simple compared with today's standards. Conditions appeared more certain and less risky than they actually were. While understanding the past is still an important part of managing for the future, it is becoming increasingly apparent that continued management under this old approach will not provide for sustainable water resources into the future.

New Planning Approach – Anticipate Change

Today, as part of integrated regional water management and integrated flood management, California's water and resource managers must recognize that conditions are changing and that they will continue to change. Traditional approaches for predicting the future based solely on projecting trends will no longer work. Today, there is better understanding that strategies for future water management must be dynamic, adaptive, and durable. In addition, the strategies must be comprehensive and integrate physical, biological, and social sciences.

California's water management system is large, complex, and requires a great deal of cooperation and collaboration among decision-makers at all levels of State, federal, regional, and local entities. The California Water Plan Update 2005 stressed the importance of a common analytical approach for these entities to understand and manage the system, especially when management actions may compete for the same resources. The entities must make sound investments that balance risk with reward, given today's uncertainties and those that may occur in the future. Update 2005 also emphasized the benefits of integrated regional water management. Now, Update 2009 adds integrated flood management as part of overall integrated water management…

Risk Assessment Examples

Delta Risk Management Strategy. The Delta Risk Management Strategy (DRMS) is evaluating Delta issues from the perspective of the risks from levee failures and ways to reduce those risks.

The DRMS provides a framework for evaluating major threats to the Delta levee system and the impacts that levee failure can have on the Delta ecosystem and economy, the State's water delivery system and other infrastructure, and those who rely on the exports of fresh water from the Delta. The purpose of DRMS is to:

- Evaluate the risk and consequences to the state (e.g., water export disruption and economic impact) and the Sacramento-San Joaquin Rivers Delta (e.g., levees, infrastructure, and ecosystem) associated with the failure of Delta levees and other assets considering their exposure to all hazards (seismic, flood, subsidence, seepage, sea level rise, etc.) under present as well as foreseeable future conditions. The evaluation assesses the total risk as well as breaking the risk down for individual islands.
- Propose risk criteria for consideration of alternative risk management strategies and for use in management of the Delta and the implementation of risk-informed policies.
- Develop a management strategy, including a prioritized list of actions to reduce and manage the risks of consequences associated with Delta levee failure.

For more information on DRMS, visit the website at http://www.drms.water.ca.gov/.

The DRMS assessment provides preliminary estimates of the probability that multiple islands will flood simultaneously during a 25-year exposure period due to a seismic event as shown in Figure 5-3. The figure shows that there is about a 25 percent chance that 30 islands would fail simultaneously from a seismic event sometime within the next 25 years. DRMS estimated that

failures that flood 30 islands could disrupt Delta water exports for 16 to 23 months due to salt intrusion which could reduce water exports by 6.5 million acre-feet to 9.3 million acre-feet.

California Statewide Levee Database. California has over 13,000 miles of levees that protect residential and agricultural lands. The levee failures in New Orleans during hurricane protect residential and agricultural lands. The levee failures in New Orleans during hurricane Katrina prompted DWR to initiate development of a state-of-the-art levee database for the purpose of better understanding and managing levees. The California Levee Database (CLD) will support an efficient and effective methodology for assessing levee reliability risk assessment factors and structural data impacting individual levee reaches. The CLD is being coordinated with a similar database being developed by USACE.

DWR Economic Analysis for Flood Risk Management. DWR has prepared draft procedures for consistent economic analysis for the large list of flood risk reduction studies and projects that are underway or will be started over the next several years. These include major analyses for the Central Valley Flood Protection Plan, the State Plan of Flood Control, regional flood management planning, and various bond grant programs.

Because of its considerable water management partnerships with the federal government, DWR has a policy that all economic analyses conducted for its internal use on programs and projects be fundamentally consistent with the federal Economics and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G), which was adopted by the U.S. Water Resources Council on March 10, 1983, and is currently being revised for the first time in 25 years. In addition, The USACE requires that “risk analysis” be conducted for all of its flood damage reduction studies. For agencies seeking USACE funding and/or levee certification, it is strongly recommended that “risk analyses” be conducted. USACE guidance on risk analysis can be found in:

- EM 1110-2-1619, Risk-Based Analysis for Flood Damage Reduction Studies, August, 1996 and
- ER 1105-2-101, Risk Analysis for Flood Damage Reduction Studies, January 2006

Chapter 6: Integrated Data and Analysis

Chapter 6 highlights key actions needed to improve water resources information and analysis by State government, particularly the Department of Water Resources (DWR), and by the many other research institutions, and federal, regional, and local water management entities. This chapter includes: 1) Purpose and motivation for improving our technical infrastructure to support water management decisions; 2) Summary of several recent efforts that have suggested specific actions needed to improve our technical capabilities; 3) Description of existing technical limitations and challenges; 4) Critical activities that support a long term vision for improving water resources information and analysis; 5) Description of the analytical approach applied by DWR for Update 2009 to quantify future water management conditions and evaluate alternative water management strategies.

Integrated flood management

Integrated flood management seeks to include both structural and non-structural methods to manage high water events and seeks to enhance the ability of undeveloped floodplains and open spaces to reduce the incidence of flood events and the implementation of land use practices that minimize the risk to lives and property. This multi-faceted approach to flood management relies on the integration of multiple strategies to achieve the broad goal of improving flood management. Analysis of flood management strategies requires water management information

and analytical tools that are useful to daily or hourly time scales. It also requires accurate information on levee construction details, channel capacities, effects of in-channel vegetation and structures, and existing and future land uses.

Adapting to climate change

As a result of global climate change, California's future hydrologic conditions are changing from patterns observed over the past century. There is much scientific uncertainty about how each of the widely varying regions in California will be affected by climate change. Predictions include increased temperatures, reductions to the Sierra snowpack, earlier snowmelt, and a rise in sea level, although the extent and timing of the changes remain uncertain. These changes could have major implications for water supply, flood management, and ecosystem health.

Scientists and engineers require significant improvements in water management information and analytical tools to effectively examine how California's water infrastructure and natural systems can be managed to accommodate or adapt to climate change. A recent article in the San Francisco Estuary & Watershed Science (Dettinger and Culberson 2008) recommends a series of strategic responses to address challenges facing water managers. The following are some of the strategic responses associated with improving the basic science and analysis:

- Additional emphasis on long term monitoring of restoration and resource management activities
- Support multi-disciplinary, integrated science
- Encourage multi-variate climate monitoring and modeling
- Ensure consistency of observational and analytical methods
- Develop and maintain integrated models that include important subsystems

Chapter 7 Implementation Plan

Chapter 7 lays out the implementation plan for California Water Plan Update 2009 by presenting 13 objectives and their 92related actions.

Objective 1 - Promote, improve, and expand integrated regional water management to create and build on existing partnerships that are essential for California water resources planning, sustainable watershed and floodplain management, and increasing regional self-sufficiency.

Related actions:

3. By 2011, all IRWM plans should include the following elements to help their region adapt to a changing climate using the IRWM partnership's best available information:

   - An assessment of the region's vulnerability to the long-term increased risk and uncertainty associated with climate change.
   - An integrated flood management plan (see Objective 6).

Objective 6 - Promote and practice integrated flood management to provide multiple benefits including better emergency preparedness and response, higher flood protection, more sustainable flood and water management systems, and enhanced floodplain ecosystems.

Integrated flood management is an approach to deal with flood risk that recognizes the:

- Interconnection of flood management actions within broader water resources management and land use planning,
- Value of coordinating across geographic and agency boundaries,
- Need to evaluate opportunities and potential impacts from a system perspective,
- Opportunity for multiple uses of floodplains, and
- Importance of environmental stewardship and sustainability and the fundamental role of flood events to the vitality of California ecosystems.

Balancing the risks of living in floodplains against the benefits of flooding is at the heart of Integrated Flood Management. Flooding is a necessary characteristic of many California ecosystems. Yet floodplains are among the most valuable lands we have, providing the richest agricultural soils, desirable home sites, recreational opportunities, ready sources of water, and great ecological potential. Natural systems that evolved with floods are dependent on the periodic disturbance of flood waters to maintain the quality of the ecosystem. Floods provide renewed soils and nutrients, move plant and animals around, rearrange spatial organizations of natural communities, and convey sands, gravels, and sediments. These factors contribute to the great benefit people experience from living on floodplains while simultaneously posing risks to people.

We have addressed this risk by building dams and levees that constrain flood waters and diminish the natural benefits of floods, while providing protection to people from the harmful aspects of flooding. More than a half-million people live behind levees in California now, with populations continuing to grow. And across the nation and the world we have seen levee protection fall short of our needs. At the same time climate change may worsen the state's flood risk by producing higher peak flows, a shift toward more intense winter precipitation, and sea level rise.

The financial liability of repairing our communities following a flood is an additional concern. A collection of recent laws has refocused attention on flooding and the risks it poses. The laws require an analysis of our existing system of protection, plans for improving these systems, means of sharing financial and operational responsibilities, and a mandate to seek broad arrays of benefits from the manner in which we manage our floodplains and water systems. These laws are leading us towards a new perspective of managing, at least in part, for recovery from disturbance and with a greater dependence on the natural cycles of flooding.

System reoperation is an important element of integrating California's water and flood management systems. Current water resources infrastructure is already strained to meet existing, competing objectives for water supply, flood management, environmental protection, water quality, hydropower, and recreation. With a changing climate, the conflicts between competing interests will be even greater as supplies become less reliable. Because the prediction of climate change impacts will never be perfect, flexibility must be a fundamental tactic, especially with respect to water system operations.

Related Actions:

1. In order to facilitate coordinated operations, State and federal agencies collaboratively established a Joint Operations Center (JOC) that has served California's water supply and flood management needs. In order to successfully meet the potential threats posed by climate change, though, the capacity of the JOC should be expanded and enhanced to:

   - Improve tools and observations to better support decision-making for individual events and seasonal and inter-annual operations, including water transfers.

- Improve communications and coordination during emergencies, such as floods and droughts.
- Develop an operational information clearinghouse related to the major water systems in California, which would facilitate coordination with planning and research groups to ensure that climate change impacts related to operations are addressed.

2. Flood management systems must better utilize natural floodplain processes. Flood management should be approached from a watershed perspective. The basic physical properties of water and sediment flow, and water storage in groundwater basins and reservoirs should be evaluated considering the ecology of watersheds. Agricultural, urban, and recreational activities, and regulations should be considered and planned on this basis to identify management needs and opportunities.

3. Communities in floodplains should consider the consequences of being exposed to floods and should develop, adopt, practice, and regularly evaluate formal flood emergency preparedness, response, evacuation, and recovery plans.

   - State government should assist disadvantaged communities located in floodplains to prepare for and recover from flood emergencies.

4. By January 1, 2012, DWR will collaboratively develop a multi-objective Central Valley Flood Protection Plan that includes actions to improve integrated flood management and accounts for the expected impacts of climate change. The plan will provide strategies for greater flood protection and environmental resilience. It will address:

   - Emergency preparedness, response, evacuation, and recovery actions;
   - Expansion of the flood bypass system to reduce pressure on critical urban levees and provide for habitat, open space, recreation, and agricultural land preservation;
   - Structural and non-structural improvements to provide at least a historical 200-year level flood protection for all urban areas;
   - Increased use of set-back levees, flood easements, zoning, and land acquisitions to provide greater public safety, floodplain storage, habitat, and system flexibility;
   - Evaluation of dam modifications to pass potentially larger floods;
   - Flood insurance requirements to address residual risk;
   - Extensive, grassroots public outreach and education; and
   - Integrate flood management with all aspects of water resources management and environmental stewardship.

5. Local governments should implement land use policies that decrease flood risk.

   - Local land use agencies should update their General Plans to address increased flood risks posed by climate change. For planning purposes, DWR recommends using a higher than historical peak reference flow.
   - Local governments should site new development where flood avoidance strategies are assured. Flood management strategies should identify the relevant flood water elevations and describe how the public will avoid damage from this magnitude of flooding. These strategies should also account for the risks from floods of greater magnitude.
   - Local governments should utilize Low Impact Development techniques that store and infiltrate runoff.
   - Local governments should include flood-resistant design requirements in local building codes.