# The origin and evolution of the california state plan of flood control levee system

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## ABSTRACT

In the State of California, a complex system of levees, weirs, bypasses, dams, reservoirs, and other features constructed over the last 150 years help to protect urban and rural areas against flooding, including the State's capital city, Sacramento. This collection of structures, lands, programs, and modes of operation and maintenance have been brought together in a State-federal flood protection system referred to as the State Plan of Flood Control (SPFC). The extensive flood control system includes approximately 1,600 miles of levee, many of which were constructed incrementally by local, state, or federal agencies. Additionally, the SPFC relies on many non-SPFC dams and other features to attenuate flows and aid in operations. The geographic area protected by the SPFC encompasses two major river systems, the Sacramento and San Joaquin rivers and tributaries with more than 43,000 square miles of combined drainage area. The region has experienced many devastating floods, which were often a motivator for significant advancements in statewide flood risk management. This paper discusses the origin and evolution of this innovative system, recent efforts to inventory and assess the conditions of the system, and ongoing efforts to upgrade the flood project works in an ever-changing environmental and regulatory world.

## 1. INTRODUCTION

There are significant flooding risks in California's Central Valley, due to both the probability of flooding and resulting consequences. The region is in the United States' most populous state, and includes several major urbanized communities, such as Sacramento and Stockton, and billions of dollars in infrastructure. To manage flood risk in the Central Valley, a complex system of levees, weirs, bypasses, and other features were constructed over the last 150 years by local, State, and federal agencies. This collection of structures in combination with lands, programs, and modes of operation and maintenance have been brought together in a State-federal flood protection system referred to as the State Plan of Flood Control (SPFC). The SPFC relies on many other non-SPFC features, such as non-State or federal reservoirs to regulate flows and reduce loading on the system, and private levees in the Central Valley or non-project (local) levees in the Sacramento-San Joaquin Delta (Delta).

The purpose of the SPFC is the management of floodwaters to lessen their adverse economic and social impacts, not to absolutely prevent floods from occurring (DWR, 2009). Numerous devastating floods have had significant effects on life and property in the Central Valley, including some in recent history, indicating that failures within the system are unavoidable. The most recent significant floods occurred in 1986 and 1997, which caused significant loss of life and over $1 billion in collective damages (USACE, 1999). The cause of levee failures has been due to flows that exceed the system capacity during extraordinary events, but also due to unpredicted levee behavior resulting from imperfect knowledge of conditions and variability in construction and materials. The SPFC has evolved over its lifetime as a result of numerous technical, political, and policy decisions based on a progression of engineering concepts, best practices, and governmental priorities (DWR, 2009). The result is a massive and variable system of structures and operations that were in many cases initially developed to protect agricultural land, but are now the primary defense against substantial flooding in highly urbanized areas.

This paper discusses the origin and evolution of this innovative flood management system, providing an overview of key decisions and factors contributing to its development. Recent efforts to assess the condition of the SPFC and transition to system-wide integrated flood management approaches will also be described.

## 2. SETTING AND FLOOD HISTORY IN CALIFORNIA'S CENTRAL VALLEY

### 2.1 Geographic and Hydrologic Setting

The Central Valley of California is a gently sloping valley averaging approximately 50 miles across that drains into Sacramento-San Joaquin Delta (Delta). The Central Valley encompasses two major river basins, Sacramento River basin and the San Joaquin River basin (Figure 1). Both river basins are composed of a dense network of several rivers and their tributaries. The Sacramento River basin encompasses the northern portion of the Central Valley, covering 26,300 square miles, and is drained by the Sacramento River. The San Joaquin River basin encompasses the southern portion of the Central Valley covering 16,700 square miles and is drained by the San Joaquin River. Together, the Sacramento and San Joaquin rivers convey more than 40 percent of the surface water in California, joining at their lowest elevations at the Delta (DWR, 2009). Prior the construction of levees and other flood control structures, the lower-lying lands along both the Sacramento River and the San Joaquin River basins were floodplains that were regularly inundated for long periods during large, seasonal flood events.

The valley is bounded on three sides by mountain ranges, the Coast Mountains on the west, the Cascade Mountains on the north, and the Sierra Nevada Mountains on the east. Rivers and tributaries in the Central Valley begin in these surrounding mountain ranges, with most rivers draining from the Sierra Nevada Mountains. The Sierra Nevada range extends 400 miles in the north-south direction along the western border of California, and is approximately 70 miles across, increasing in elevation from roughly 1,000 feet in the Central Valley to a maximum elevation of 14,505 feet (Mount Whitney). Average annual precipitation in the Sacramento and San Joaquin river basins can be as much as 95 inches in the higher elevations of the Sierra Nevada and Cascade mountains. Much of the State's precipitation is released in the Sierras in the form of rain or snow, which in turn drains into the Central Valley through the distribution of rivers and streams.

California's wet season is from about mid-October to mid-April. The highest runoff in the valley is often caused by warm Pacific Storms that pick-up moisture over thousands of miles of ocean and can cause

torrential rains when intercepted by the mountains surrounding the Central Valley (DWR, 2012). Melting snow in these bordering mountain ranges also contributes to river and stream levels. Warmer storms in the winter months can lead to earlier snow melts in the mountains, adding discharge to the storm waters in the river systems. Under pre-levee conditions, the river system generally had sufficient capacity to carry winter and spring flows, but the channels could overflow onto the surrounding land if the channel capacity was exceeded. During these overflow conditions, the discharge velocity dramatically decreases, which allows suspended sediments to deposit on the surrounding land. Over many years, this cycle of periodic overflow of the river banks resulted in high ground deposits and natural levees of coarser-grained sand adjacent to the rivers and finer-grained deposits of sediment in the floodplains setback from the rivers. The higher elevation land attracted settlers and even led to construction of some of the first levees by these settlers, while early agricultural development occurred in the fertile soils of the floodplain (DWR, 2009).

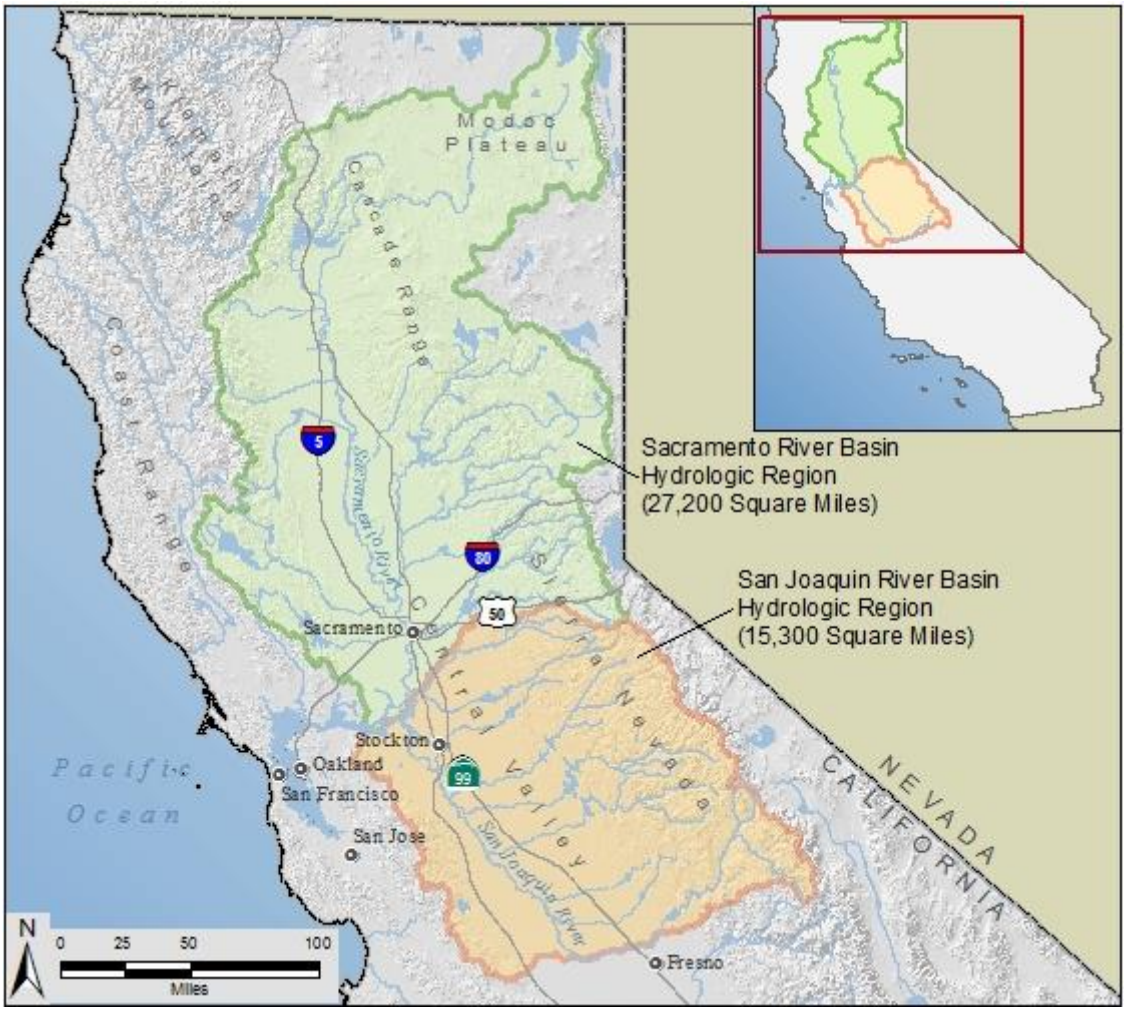


**Figure 1. Sacramento and San Joaquin River Basins**

## 2.2 Flood History and Development

With few exceptions, the largest and most damaging floods in California have occurred in the Central Valley (DWR, 2010). Devastating floods have been documented in the Sacramento and San Joaquin river basins since the mid-1800s. Prior to this time little information is available about flooding in the area. According to histories of Native Americans and early pioneers, great floods occurred on numerous occasions, including an event in the early nineteenth century, which was responsible for thousands of deaths. This early period pre-dates the California Gold Rush, which began in 1849 and was the beginning of a series of dramatic changes in California (Figure 2) and led to more systematic recording of river stage and/or flow. Over time, floodplains that were primarily agricultural land when levees where first built in the Central Valley grew into cities, industrial areas, and suburbs. Cities grew close to river

and streams banks as channels were used for commerce. More than one million people now live and work in these floodplains (DWR, 2012).

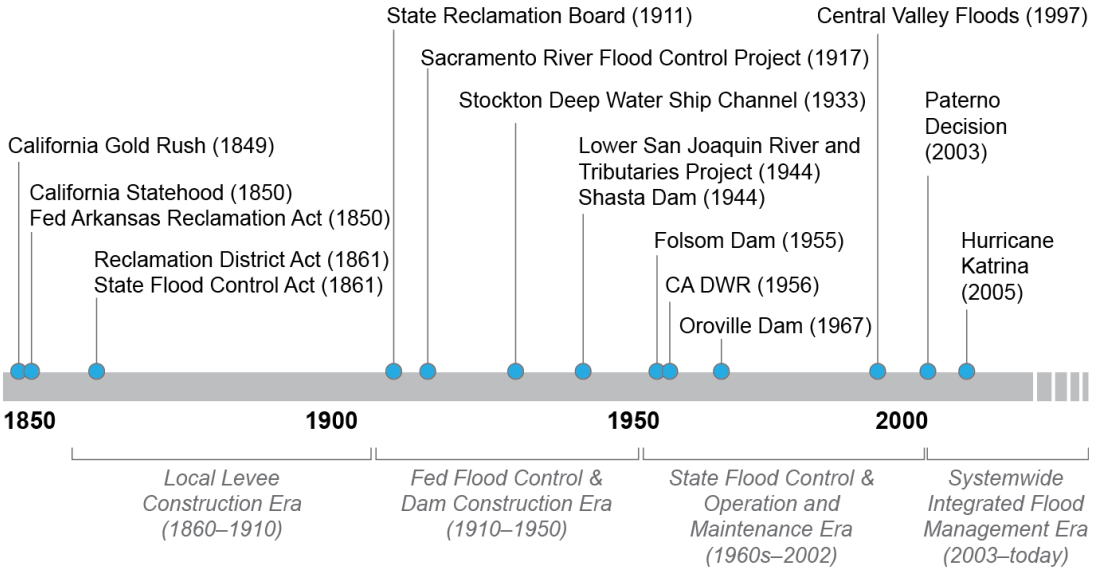


**Figure 2. Overview of Central Valley Development and Flood Control**

### 2.2.1 Local Levee Construction Era

The discovery of gold in the Sierra Nevada Mountains spurred the development of practices and industries that significantly impacted flooding in the Central Valley. One of the most impactful practices introduced during the Gold Rush period was the use of hydraulic mining for recovery of gold and minerals. Hydraulic mining uses high pressure water to blast away hillsides to release sediments, which were screened to recover the valuable components. Hydraulic mining increased erosion and sediment runoff and sent large amounts of sediment downstream to be deposited in the streams and rivers (Figure 3). Also, beginning in the 1850s, logging in the mountains surrounding the Central Valley intensified to provide raw materials for industry and urban development. In some areas, logging increased surface erosion and contributed to increased sedimentation in the streams and rivers, but to a lesser extent than hydraulic mining (DWR, 2009). The sediment raised channel beds above their natural levels and in many cases above surrounding lands, which decreased channel capacity and increased the vulnerability of surrounding lands to flooding (DWR, 2012).

**Figure 3. Hydraulic Mining for Gold and Minerals in the Late-1800s**

In response to the growing population, some of the most productive farmland in California was developed in the Central Valley and foothills. In 1850, the U.S. Congress passed the Arkansas Act, which gave to the states all public land considered to be swamp or overflow areas, and required states

to use the proceeds from sale of the land to drain and reclaim the land for agricultural uses. In 1861, the first reclamation districts (RDs) were formed as a result of the Reclamation District Act. The RDs and levee districts (LDs) were responsible for maintenance and repair of levees and other flood control facilities within their boundaries. These early pieces of legislation helped propel agricultural growth in the Central Valley's fertile floodplains and led to construction of many of the region's early levees in an effort to maximize agricultural development (DWR, 2009).

At the same time, navigation along the Sacramento and San Joaquin rivers was being impacted by the hydraulic mining debris deposited in the river system. Shipping was critical for transporting goods to support the blooming population in California during this period. As early as 1856, newspapers were describing increased sediment loads in the Sacramento River, which began hampering navigation in certain areas of the Central Valley, particularly in the northern portion where hydraulic mining was more prevalent. In the period of hydraulic mining between 1850 and 1900, agricultural expansion in the Central Valley continued along with increasing use of more powerful hydraulic mining equipment. Flooding during these early periods prompted competitive piecemeal levee building, where agricultural landowners raised and strengthened their levees to prevent flooding by ensuring another property would flood first. To promote scouring of the hydraulic mining deposits from the river channel, some early levees were built very close to the river channel. This period of piecemeal levee construction and/or enlargement and confinement of the river channel in some areas created some of the legacy conditions that still challenge the system today.

Toward the end of the 1800s, agriculture continued to expand in the Central Valley and navigation challenges continued to build because of hydraulic mining debris. Frequent flooding had taken a toll on the Central Valley, and public sentiment turned against hydraulic mining. The Caminetti Act was passed in 1893 to create the California Debris Commission (CDC) to regulate hydraulic mining operations and encourage the use of debris dams. Additionally, Congress was lobbied to appropriate matching funds for debris dam projects. The dwindling use of hydraulic mining and rise of debris dams to capture sediment led to improved navigation along the Sacramento River and the eventual demise of hydraulic mining by about 1900 (DWR, 2009).

### 2.2.2 Federal Flood Control and Dam Construction Era

Despite the navigation improvements resulting from the reduction of hydraulic mining in the Sierra Nevada Mountains, flooding continued to occur in the Central Valley after 1900. Flood control concerns were prevalent, and it was apparent that a coordinated plan was needed. Both the federal and State governments were interested in improving the piecemeal levee system that had developed in the Central Valley. The period from the early to mid-1900s represents a period of significant federal flood control and dam construction. By this time, agriculture and irrigation had grown immensely in the Central Valley. The warmer, drier climate and advancements in irrigation allowed crops to mature much earlier than other parts of the country, which allowed farmers to sell products for premium prices (FWUA, 2008). The federal government was most interested in flood control solutions that did not adversely impact navigation. Restricted channel widths were viewed as an effective option for scouring hydraulic mining debris from the channel and reducing maintenance. The narrow channel widths were effective at moving the mining debris through the system, but now promote erosion along the levees throughout the system and do not support environmental habitats as favorably as setback levees.

In 1917, the federal government authorized the Sacramento River Flood Control Project consisting of a system of levees and bypasses through the Sacramento River basin. The original intent of the project was to assure conveyance of floodwaters to support navigation and agriculture, and keep the rivers and bypasses clear of hydraulic mining debris and sediment. Dams were not included in the project because of multiple previous debris dam failures on the Yuba and Bear rivers (DWR, 2009). Eventually, the CDC abandoned its debris dams and barriers after several more failures along the Yuba River before 1917. Subsequently, several years of large-scale dredging projects were performed to remove sediment and improve navigation. Commercial transportation on the Sacramento River reached its peak in 1925 as a result of Sacramento River Flood Control Project levee construction projects and channel dredging.

Population growth and the expanding amount of land in agricultural production continued in the Central Valley through the early-1900s. Within the period from about 1900 to 1950, the United States was involved in World War I, the Great Depression followed by the "New Deal", and World War II. During wartime, it was considered patriotic duty to put the greatest amount of land into food production, and the "New Deal" legislation helped improve the national economy and set the stage for multiple large project

authorizations in the Central Valley. Also, since no major system-wide flooding in the Central Valley occurred between 1909 and 1955, the government and public focus was more on water supply related issues to support agriculture and urban development. Planning for the multipurpose Central Valley Project (CVP) began in 1920, which had elements to address both water supply and flood control. Construction and operation of the CVP was assigned to the U.S. Department of the Interior, Bureau of Reclamation. Shasta Dam (on the Sacramento River) and Friant Dam (on the San Joaquin River) were two major facilities constructed as part of the CVP that included flood storage capacity and were put into full operation in 1949. Shasta Dam is the largest reservoir in California, with a total capacity of 4,552,000 acre-feet.

The Flood Control Act of 1944 provided federal authorization for the Lower San Joaquin River and Tributaries Project. Although this project included flood storage in new reservoirs and flood control levees, water supply elements were more significant. The original intent of the Lower San Joaquin River and Tributaries Project was to regulate flood storage in Friant Reservoir, consolidate flows into the San Joaquin River, which would naturally overflow the riverbank in several low-lying areas along the valley floor. Several major reservoirs were constructed as part of the project, including New Melones Reservoir (on the Stanislaus River) and Jacksonville Reservoir (on the Tuolumne River), which was later replaced by New Don Pedro Reservoir.

### 2.2.3 State Flood Control and Operations and Maintenance Era

By the late-1940s, California's continued rapid development and population growth had increased demands for water and power to levels that exceeded the CVP's capacity (DWR, 2009). Central Valley agricultural water demands were surpassing any previous year on record, and estimated future water needs far exceeded the system supply. State planning for the multipurpose State Water Project (SWP), which was originally authorized by the Central Valley Act of 1933 but had stalled due to the economic depression, was reinvigorated in 1947. At the same time, large federal project planning and construction continued with the CVP, Sacramento River Flood Control Project, and San Joaquin River and Tributaries Project. Construction of the Sacramento River Flood Control Project was substantially completed by 1961, but several significant design modifications delayed completion of the San Joaquin River and Tributaries Project to 1968, with some related elements by 1972 (DWR, 2009).

Beginning with the construction of the Sacramento River Flood Control Project in 1918, the State and federal government shared responsibility for building, repairing, and maintain the levees, weirs, and bypasses, while the flood control system in the San Joaquin Valley continued to be constructed and operated in a piecemeal fashion. In 1953, a Memorandum of Understanding (MOU) was signed by the federal government (U.S. Army Corps of Engineers) and the State of California to designate responsibilities for construction, operations, and maintenance of the Central Valley flood protection system, which became the State Plan of Flood Control. The responsibilities differed between what was called the "Old Project" and the "Major and Minor Tributaries Project." The "Old Project" includes facilities authorized in federal Flood Control Acts of 1917, 1928, and 1941, which includes the Sacramento River Flood Control Project. The "Major and Minor Tributaries Project" was defined as facilities authorized under the Flood Control Acts of 1944 and 1950, which includes the San Joaquin River and Tributaries Project. Under this MOU, the federal government would construct levees and specified features to complete the Old Project, and be responsible for operations and maintenance related to navigation. The State accepted the obligation to operate and maintain the facilities of the Old Project, and would work with local interests to operate and maintain the Major and Minor Tributaries Projects (USACE and Board, 1953). Supplements to the MOU were signed in 1957 and 1958, adding features and items to the agreement resulting from system repairs and upgrades that had occurred since 1951.

The flood of 1955 was the largest on record in the Central Valley, resulting from a warm storm in December that melted accumulated snowfall up to an elevation of 10,000 feet (DWR, 1997). Significant damage occurred throughout the Central Valley flood protection system from this flood, and prompted several pieces of legislation authorizing additional flood control projects. The existing levee system suffered widespread damage, including levee failures, seepage damage (piping), structural damage to weirs and levees, and erosion of riverbank and levee slopes. In 1956, several existing state divisions and agencies were combined to form the Department of Water Resources (DWR), with the purpose of first developing a plan for the SWP, and then building and operating the new system to provide both flood protection and water supply benefits. The Burns-Porter Act of 1960 provided State authorization for construction of portions of the SWP, including Oroville Dam (on the Feather River). In total, the SWP includes 21 primary reservoirs providing a total storage of approximately 5,800,000 acre-feet.

The resulting SPFC is a shared State-federal flood protection system that incorporates a complex integrated system of levees, weirs, bypasses, dams, reservoirs, and other features to help address the flood conditions in the Central Valley (Figure 4). Table 1 provides an overview of the SPFC features as of 2010. The SPFC also benefits from the non-SPFC reservoirs of the SWP, and others, which provide substantial regulation of flows within the SPFC system.


**Figure 4. Geographic Overview of the State Plan of Flood Control**
Note: Figure reproduced from Figure G-1 of State Plan of Flood Control Descriptive Document (DWR, 2010)

**Table 1. Overview of State Plan of Flood Control Features (as of 2010)**

| **Project Works** |
|---|
| • Approximately 1,600 miles of levee<br>• Two flood relief structures and one natural overflow area spilling floodwaters from the Sacramento River into the Butte Basin<br>• Four fixed weirs (Moulton, Colusa, Tisdale, Fremont) and one operable weir (Sacramento) spilling floodwaters from the Sacramento River into the Butte Basin, Sutter Bypass, and Yolo Bypass<br>• Four dams<br>• Five control structures directing flow in bypass channels along the San Joaquin River<br>• Seven major pumping plants<br>• Channels<br>• Bypasses and sediment basins<br>• Environmental mitigation areas<br>• Associated facilities, such as bank protection, stream gages, and drainage facilities |
| **Lands** |
| • Fee title, easements, and land use agreements<br>• Approximately 18,000 parcels |
| **Operations and Maintenance** |
| • Two standard operations and maintenance manuals<br>• 118 unit-specific operations and maintenance manuals<br>• Maintenance by State and local maintaining agencies |
| **Conditions** |
| • Assurances of Cooperation (as specified in Memorandums of Agreement, the California Water Code, and agreements)<br>• Flood Control Regulations, Section 208.10, 33 Code of Federal Regulations<br>• Requirements of standard and unit-specific operations and maintenance manuals<br>• Design profiles (e.g., 1955 and 1957) |
| **Programs and Plans** |
| • Historical documents and processes<br>• As-constructed drawings<br>• Oversight and management<br>• Ongoing programs and plans |

Note: Table adapted from Table 1-1 of 2012 Central Valley Flood Protection Plan (DWR, 2012)

## 3. INTEGRATED SYSTEM WIDE FLOOD MANAGEMENT

Floods in 1986 and 1997 were the most damaging floods experienced in the Central Valley. Like the 1955 flood, warm winter storms unleashed torrents of warm rain which filled rivers and melted high elevation snow. The 1986 flood resulted in the disastrous levee break that inundated the Linda and Olivehurst areas adjacent to the Feather and Yuba rivers, and caused 13 deaths, 50,000 people to evacuate and over $400 million in property damage. As described in DWR's 1997 *Flood Emergency Action Team* Report, the January 1997 flood resulted in the most extensive flood disaster in California's history, again resulting in numerous deaths and billions of dollars in damages (DWR, 1997a). The capacity of numerous channels with the levee system was significantly exceeded, and multiple major levee breaches caused widespread flooding in portions of the Sacramento and San Joaquin River Basins. The levee failure that led to flooding of the Linda and Olivehurst areas in 1986 eventually resulted in the November 2003 California Supreme Court decision on the case of *Paterno v. State of California*. This landmark decision found the State of California largely liable for damages, because when a public entity operates a flood control system built by others, it accepts liability as if it had planned and built the system itself. The *Paterno* ruling held the State responsible for hundreds of millions of dollars in damages caused by the 1986 levee failure, which resulted from defects in the levee foundation that existed when the levee was constructed by local agricultural interests in the 1930's (DWR, 2005).

After the 1997 flood, the Governor of California formed the Flood Emergency Action Team (FEAT), which held citizen advisory meetings throughout Sacramento River Basin to hear from those that were most affected by the January floods. These meetings provided a forum for local officials, landowners, and business owners to let the government in Sacramento know what worked and what needed improvement in the State and federal flood response efforts. The FEAT responded to many questions, primarily regarding disaster response processes, and listened to recommendations for future flood response actions and needed flood control system improvements.

In January 2005, DWR issued a white paper entitled *Flood Warnings: Responding to California's Flood Crisis* that presented an overview of the current conditions of flood management in California's Central Valley and outlined a recommended plan to reduce flood risks through an integrated approach for better planning, new investments, improved management of existing infrastructure, and closer collaboration between water agencies and users (DWR, 2005). The white paper described the flood control related challenges that California faced as a combination of recent factors that included: a growing Central Valley population pushing new housing developments and job centers into areas that are vulnerable to flooding, aging floodplain protection system infrastructure weakened by deferred maintenance, reduction in State and local funding for flood prevention and management programs, and court decisions that resulted in greater State flood damage liability.

Later in 2005, Hurricane Katrina hit the Gulf Coast of the United States and the storm surge and subsequent levee failures cause major flooding of the area, resulting in severe damage and loss of life. Though significant damaging floods in the Central Valley have only occurred in concentrated areas in the Central Valley since 1997, Hurricane Katrina raised public consciousness about areas of high flood risk throughout the country. The Sacramento and San Joaquin river basins are recognized as having urban areas with some of the highest flood risk in the United States (DWR, 2009). In particular, federal emergency planners ranked the City of Sacramento second in flood risk vulnerability to New Orleans after Hurricane Katrina (O'Neill, 2006).

The SPFC, while integrating several flood control features, evolved through an incremental learning and construction process. The facilities were constructed with materials at hand over many decades, to evolving design standards and construction techniques (DWR, 2012). The result is facilities originally constructed to reclaim and reduce flooding on agricultural lands may provide inadequate protection for these urban and urbanizing areas, even if improvements are made to meet minimum federal standards. Further, while levees and other facilities may decrease the frequency of flooding, they do not offer complete protection from flooding (DWR, 2008). As described in 2007 report prepared for DWR by an independent panel entitled *A California Challenge – Flooding in the Central Valley*, it was recommended that federal, State, and local governments consider the following to address the threat of flooding (DWR, 2007):

- Realistic assessment of the risk faced by those in the floodplain
- A comprehensive approach to water management and related land-use
- Anticipation of and protection against future conditions
- Protection, enhancement, and restoration of the badly damaged natural and beneficial functions of the floodplain and watershed
- Clear definition of the responsibilities at federal, State, and local government levels
- Continuous monitoring, assessment, and reporting on flood infrastructure conditions
- Attention to residual risk
- Continuous re-evaluation of the operation of water management structures
- Consideration of agility and redundancy in flood damage reduction planning
- Continuous enhancement of emergency evacuation and response planning and preparation
- Enhancing what the public knows and understands about the flood risks it faces
- Economic incentives for Multi-Objective Management of deep floodplains in the Central Valley

As demonstrated by the recent and major flood events in the Central Valley and in New Orleans, an evolving recognition for an integrated system wide flood management approach developed from the late-1900s through the 2000's (Figure 5).

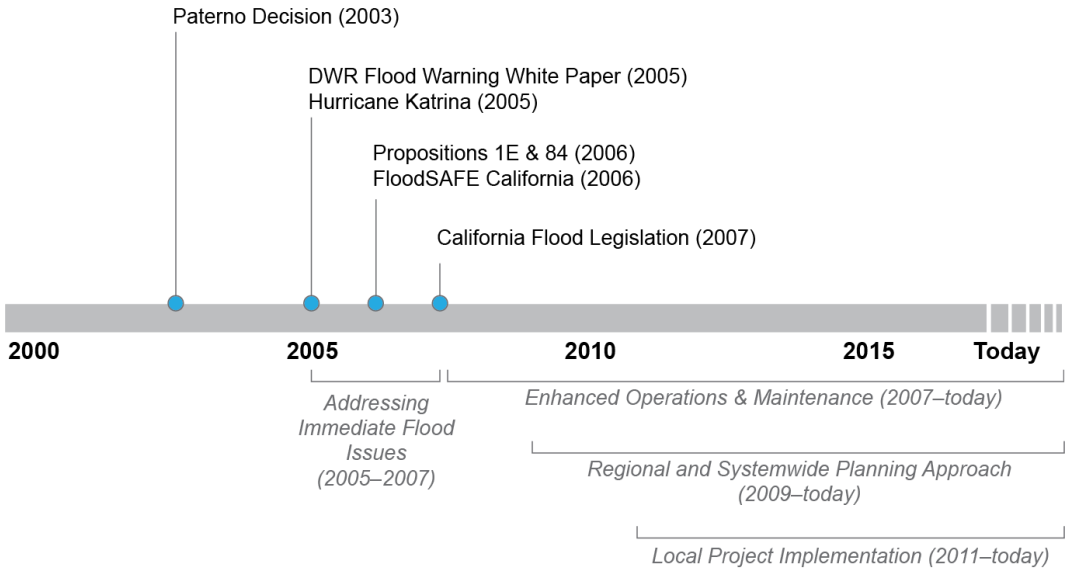


**Figure 5. System Wide Integrated Flood Management Era**

In November 2006, with the increased public awareness on flood risk management in California, California voters approved two bond measures, Proposition 1E (Disaster Preparedness and Flood Prevention Bond Act of 2006) and Proposition 84 (Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act of 2006), with a combined bond funding capability of $4.9 billion specifically for flood risk reduction measures (DWR, 2012). Also in 2006, DWR consolidated and coordinated its various flood risk management programs under the FloodSAFE California (FloodSAFE) program, a multifaceted initiative to improve public safety through integrated flood management in California through a system wide approach, while reducing flood risk at a local and region level (DWR, 2010). The program incorporates emergency preparedness, flood operations, flood risk reduction and ecosystem restoration projects, flood project maintenance, and comprehensive, system wide assessment and planning to deliver improved flood protection as quickly and efficiently as possible (DWR, 2012).

In addition, in response to the recommendations of the 2005 DWR white paper and the approval of bond funds, the 2007 California Legislature, prepared several bills through a cooperative effort involving the State, members of the Legislature, local governments and planning agencies, landowners and developers. Subsequently, in October 2007, the California Legislature passed and the Governor signed a package of interrelated bills (flood legislation) aimed at addressing the problems of flood protection and liability and helping direct the use of the approved bond funds. This 2007 Flood Legislation was intended to address a number flood management challenges, and the underlying causes of those problems, including flood control system deficiencies, the availability of flood risk information, and links between land use planning and flood management. The legislation outlined specific actions and requirements and responsible parties. New requirements relate to local planning, State planning, risk characterization and notification, and status reporting activities (DWR, 2008). Additionally, the legislation set a higher flood protection threshold for urban areas by requiring that they ultimately be provided with at least 200-year (0.5% annual chance) flood protection as a condition for further development (DWR, 2012).

Through FloodSAFE, the 2007 Flood Legislation, and the approved bond funding numerous planning and evaluation and improvement efforts have been implemented or are ongoing. From 2006 to 2015, DWR completed an unprecedented effort to assess approximately 470 miles of State-federal project and appurtenant non-project levees protecting the Central Valley's urban areas (greater than 10,000 residents), as well as, approximately 1,600 miles of rural State-federal project levees and appurtenant non-project levees. The evaluations included conducting several thousand subsurface investigations, laboratory testing, and analysis to evaluate the performance and safety of existing levees, and development of prefeasibility-level designs and cost estimates for potential levee repairs (DWR, 2010).

In 2009, efforts for system wide and regional planning began in response to requirements of the 2007 Flood Legislation. As part of the legislation, the California DWR and the Central Valley Flood Protection

Board (formerly the Reclamation Board) were required to prepare and adopt a Central Valley Flood Protection Plan (CVFPP) by 2012, with updates every 5 years. The CVFPP is intended to establish a system wide approach to improving flood management in the areas currently receiving some amount of flood protection from the existing facilities of the SPFC (DWR, 2008). The State conducted planning and investigations for the 2012 CVFPP from 2009 through 2011. The 2012 CVFPP considered three different preliminary approaches: (1) achieve SPFC design capacity, (2) protect high risk communities, and (3) enhance flood system capacity. Each approach includes several elements and the first two approaches differed significantly regarding improving SPFC facilities, while the third approach included all of the elements of the first two along with many others. The third approach, enhancing the flood system capacity approach was the identified preferred approach by the 2012 CVFPP and includes elements such as new bypass construction, existing bypass expansion, forecast-coordinated operations/forecast-based operations, and 200-year level of protection for urban communities (DWR, 2012). Following adoption of the 2012 CVFPP, the DWR funded six regionally-led Regional Flood Management Plans that describe local and regional flood management priorities, challenges, and potential funding mechanisms along with site-specific improvement needs.

In parallel to the regional and large-scale planning efforts, many local agencies have also taken advantage of available information developed by DWR to begin formulating structural and non-structural solutions to reduce flooding risk within the SPFC. These local efforts are funded in part through the Proposition 1E and Proposition 84 bond measures, in addition to locally-raised cost share. These improvements embrace the multi-benefit perspective, seek to expand and reintroduce lands to the floodplain, enhance public emergency response and preparedness, but also include direct measures to reduce the risk of levee failure by addressing deficiencies associated with erosion, seepage, stability, and/or overtopping.

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