Managing Floods in California

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LAO

Cover Photo: The cover photo displays flooding from storms in January 2017, and was provided courtesy of the California Department of Water Resources.

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EXECUTIVE SUMMARY

Recent months have highlighted how quickly statewide concerns can turn from the devastating impacts of too *little* water during a prolonged drought, to the comparably destructive effects of too *much* water and resulting floods. Flood management is a complicated and expensive undertaking in California, given the state's size, its extensive and aging infrastructure, the number of agencies involved, and the magnitude of its flood risk. In light of these complexities, this report provides basic information about floods and flood management in California.

Extensive Flood Risk Across the State. California has experienced destructive flood events throughout its history. While certain flood disasters from the state's earlier years—such as the "Great Flood" of 1862—are famous for their large impacts, California has also experienced more recent flood events. For example, in the early part of 2017 the Governor declared a state of emergency in 52 of the state's 58 counties due to damage from winter storms and floods. All areas of the state are subject to at least some form of flooding—since 1992, every county in California has been declared a federal disaster area at least once for a flooding event. Estimates suggest 7.3 million people (one-in-five Californians), structures valued at $575 billion, and crops valued at $7.5 billion are located in areas that have at least a 1 in 500 probability of flooding in any given year.

Floods Can Also Have Beneficial Impacts. Despite their potential to cause harmful damage, in some cases floods can have positive effects for both humans and the environment. Examples of such benefits include replenishing groundwater basins, creating habitat for fish and wildlife, carrying and depositing sediments that improve agricultural productivity, and improving water quality by flushing out contaminants. For these reasons, flood management strategies often incorporate leaving certain floodplains undeveloped and encouraging flooding in certain areas.

Numerous Governmental Entities Involved in Flood Management Activities. Flood-related responsibilities are shared across a number of agencies at all levels of government, although most activities to protect communities from floods—such as establishing land use policies or maintaining flood infrastructure like levees—are undertaken by local agencies. Local jurisdictions differ in how they organize flood-related activities, and whether local flood management responsibilities are assigned to cities, counties, or special districts (such as flood control or reclamation districts). Federal agencies with significant flood management responsibilities include the U.S. Army Corps of Engineers (USACE) and Federal Emergency Management Agency, and state agencies include the Department of Water Resources and Central Valley Flood Protection Board.

The state has special responsibility for—and liability related to—a system of flood protection infrastructure along the main stem and certain tributaries of the Sacramento and San Joaquin Rivers, known as the State Plan of Flood Control system.

Both Structural and Nonstructural Approaches Used to Manage Floods. Local, federal, and state agencies have developed a variety of physical structures to convey and control water flows and floods. Such structures include levees, weirs, detention basins, dams, seawalls, and bypasses. In addition to physical infrastructure—which mitigates risk by controlling floods—flood managers also employ nonstructural approaches that adapt to and accommodate the potential of floods occurring.

Key nonstructural approaches include (1) adopting land use policies designed to minimize flood damage, (2) enhancing natural floodplain functions so that undeveloped lands can slow and absorb floodwaters before they reach developed areas, and (3) preparing ahead of time for how to effectively respond when a flood does occur.

Billions of Public Dollars Provided Annually for Flood Management Activities. Estimates suggest that statewide expenditures on flood management activities lie somewhere between $2 billion and $3 billion annually. As primary responsibility for managing flood risk rests with local governments, the majority of this funding is generated and spent at the local level from a variety of revenue sources, including property taxes, assessments, and other taxes and fees. The federal government also provides several hundred millions of dollars annually for flood management activities in California, primarily for USACE to undertake large infrastructure projects in partnership with the state and local agencies. Additionally, the state provides several hundred millions of dollars annually for flood management activities, largely through voter-approved general obligation bonds (which are then repaid by the state's General Fund).

Despite these significant expenditures, several studies have estimated that reducing flood risk across the state will cost tens of billions of dollars above current expenditure levels over the next couple of decades.

California Faces Several Key Flood Management Challenges. The state's extensive flood management infrastructure is aged and in need of improvements, and it was not designed to account for evolving statewide goals, scientific knowledge, or conditions. Yet, while additional investments are required to both maintain and upgrade the existing system, generating funding for flood management activities can be challenging—particularly at the local level, where the ability to generate additional tax and assessment revenues is constrained by certain state constitutional provisions. Moreover, both the state and local governments face challenges in determining how to balance flood risk with expanding population and development. As the state population grows, so too does the push to develop into new areas. However, development in flood-prone areas increases the potential for flood damage. Additionally, the overlapping and fragmented nature of flood-related responsibilities among various local, federal, and state governments can complicate flood management efforts and make the process of implementing flood projects exceptionally protracted and difficult. Addressing these challenges will be key to California's efforts to effectively manage its flood risk in the future.

INTRODUCTION

Recent years have shown how variable California's weather and hydrology can be. The four-year stretch of 2012 through 2015 was the driest since statewide record-keeping began in 1896. Just a year later, 2017 is on track to be among the wettest years on record, with precipitation in the northern part of the state registering more than 200 percent of normal at the end of February.

Recent months have also highlighted how quickly statewide concerns can turn from the devastating impacts of too *little* water during a prolonged drought, to the comparably destructive effects of too *much* water and resulting floods. According to the state's Hazard Mitigation Plan, "Floods represent the second most destructive source of hazard, vulnerability and risk, both in terms of recent state history and the probability of future destruction at greater magnitudes than previously recorded." Recent incidents of damaged spillways at Oroville Dam and breached levees in the Sacramento-San Joaquin Delta have highlighted the state's dependence on aged flood management infrastructure. One-in-five Californians live in a flood plain, and state officials estimate that $575 billion in structures are at risk of flood damage. However, when managed appropriately, floods can bring beneficial impacts, including enhanced ecosystems, increased future water supply, and improved water quality.

This report is intended to provide basic information about floods and flood management in California. (Whereas previous generations referred to "flood control" or "flood prevention" activities, experts now prefer the term "flood management" in acknowledgement that floodwaters are recurring and inevitable.) We begin by summarizing the history, causes, and risk of floods across the state. We then describe flood management agencies, infrastructure, and strategies, as well as how governmental agencies typically respond when floods occur. Next, we describe the spending levels and funding sources currently supporting flood management efforts, as well as estimates for how much additional funding may be needed to improve those efforts. We conclude by highlighting some key challenges confronting the state in contemplating how best to manage floods in California.

FLOOD HISTORY, CAUSES, AND RISK

Flood History and Impacts

Long History of Floods Across the State. California has experienced destructive flood events throughout its history, as highlighted in Figure 1 (see next page). While certain flood disasters from the state's earlier years—such as the "Great Flood" of 1862 and floods along the Los Angeles River in the 1930s—are famous for their large impacts, California has also experienced more recent flood events. In early 2017, Governor Brown declared a state of emergency in 52 of the state's 58 counties due to winter storm and flood damage, and 34 of those counties were declared federal disaster areas. (See page 22 for a discussion of federal and state emergency and disaster declarations.) Since February 1954, the state has had 50 federally declared flood disasters, representing nearly two-thirds of all federally declared major disasters in California over that period.

The variety of locations noted in Figure 1 shows how major flood events are not limited to certain areas of the state. Rather, the state's diverse geography means floods occur throughout the

state and from a number of different causes. Over the course of one week in February 2017, flood evacuations occurred across Northern California, from rural San Joaquin County to the urban hub of San Jose, as well as for nearly 200,000 people living downstream from the storm-damaged Oroville Dam. Since 1992, every county in California has been declared a federal disaster area at least once for a flooding event.

Floods Have Caused Extensive Damage. Throughout the state's history, flood events have caused significant damage. Impacts from

Figure 1

Significant Flood-Related Events in California

1825
Los Angeles River Course Change. Flood created by large mountain storms caused the Los Angeles River to jump its banks, establishing the southerly course it follows today.

1862
"The Great Flood." Weeks of heavy precipitation created the largest flood in California's recorded history, lasting several weeks and inundating the entire Central Valley and most of Orange County.

1905
Formation of Salton Sea. Large breaches in irrigation canals inadvertently diverted the Colorado River into a desert basin in the Imperial Valley, reestablishing a long-dry prehistoric lake.

1917
Authorization of Sacramento River Flood Control Project. Through the Flood Control Act of 1917, U.S. Congress provided funding to begin developing a system of flood relief structures and bypasses along the Sacramento River. System eventually expanded to include portions of the San Joaquin River and became the State Plan of Flood Control (SPFC).

1928
Collapse of St. Francis Dam. Catastrophic failure of dam in Los Angeles County caused flood wave that killed around 450 people.

1933
Authorization of Central Valley Project. Legislature authorized sale of revenue bonds to construct system for both water supply and flood control along the Sacramento and San Joaquin Rivers. Project funding and construction ultimately assumed by federal government.

1938
Southern California Floods. Flash flooding and debris flow from heavy rainfall led the Los Angeles, San Gabriel, and Santa Ana Rivers to burst their banks, resulting in more than 100 deaths and massive damage across much of the region.

1941
Los Angeles River Channelization. Destruction from Southern California floods led Congress to enact the Flood Control Act of 1941, which authorized the U.S. Army Corps of Engineers to begin constructing concrete channels and dams to control the Los Angeles River's flows.

1953
Beginning of State Responsibility for SPFC. State signed first of several memorandums of understanding with federal government, committing to operating and maintaining SPFC facilities.

1955
Yuba City Flood. Feather River overtook its banks and levees on Christmas Eve, destroying much of Yuba City, nearly destroying Marysville, killing 38 people, and forcing 30,000 people to flee.

1956
Establishment of California Department of Water Resources. Special legislative session called by Governor Goodwin Knight following Yuba City Flood merged several existing state offices and created new department for statewide water management.

the 1862 flood were the most massive in scale: one-quarter of the state's 800,000 cattle died, ultimately contributing to a large-scale shift in statewide land use from ranching to agriculture. This flood also destroyed one-in-eight homes and one-third of the state's taxable property, with the resulting loss of property tax revenue bankrupting the state such that state employees (including the Governor and Legislature) were not paid wages for a year and a half. In more recent history, between 1954 and 2015, federally declared flood disasters in California claimed 292 lives and resulted in

Significant Flood-Related Events in California *(Continued)*

1960
Enactment of Burns-Porter Act and State Water Project. Voters authorized $1.75 billion bond to construct new water conveyance system that would also play a role in statewide flood management.

1964
North Coast Tsunami. Tsunami caused by earthquake in Alaska destroyed several towns in Northern California.

1964
"Christmas Flood." Severe flooding from heavy precipitation in the northern part of the state, particularly along the coast. State of disaster declared in 34 counties.

1969
Winter Storms and Floods. Serious flooding from thaw of heavy snowfall across numerous mountain ranges across the state. Resulted in disaster declarations in 40 counties, 47 people killed, 161 people injured, and $300 million in economic losses.

1982
Northern California Flooding and Landslides. Massive landslides and debris flows from rainfall throughout Northern California. Santa Cruz received 25 inches of rain in 36 hours.

1997
"New Year's Flood." Major flooding in Central and Northern California from week of heavy rainfall. Resulted in disaster declarations in 48 counties and $1.8 billion in economic losses.

2003
***Paterno* Decision.** Appellate court found that the state is liable for flood damage in 1986 resulting from failure of SPFC levee.

2006
Passage of Propositions 1E and 84. Voters authorized $9.4 billion in general obligation bonds for water-related projects, including $5 billion for flood management.

2007
Enactment of Central Valley Flood Legislation. Passage of legislation including new planning and flood protection requirements for areas of the Central Valley.

2014
Passage of Proposition 1. Voters authorized $7.5 billion in general obligation bonds for water-related projects, including $400 million for flood management.

2017
Winter Storms and Oroville Dam Damage. Exceptionally high rates of precipitation caused localized flooding, mudslides, flood warnings, and road damage around the state. Governor declared state of emergency in 52 counties. Erosion damage to spillways at Oroville Dam led to risk of catastrophic flooding and evacuation of nearly 200,000 residents.

759 injuries. While comprehensive data on total public and private flood-related damage costs are not available, state and federal government expenditures for flood damage have totaled billions of dollars over the past 60 years. Although damage estimates from the recent winter 2017 floods are still being calculated, the California Department of Transportation has estimated nearly $700 million just to repair storm damage to highways.

Floods Can Have Far-Reaching Impacts. Besides causing damage to adjacent communities, floodwaters can also negatively affect areas outside of inundation zones. For example, a flood event that breaches levees in the Sacramento-San Joaquin Delta could have negative consequences not only for Delta farmers and residents, but also communities far downstream. This is because the Delta is a key component in the state's comprehensive water delivery system, and a levee breach could result in increased salt water flowing into the Delta, disrupting deliveries of fresh irrigation water to 3 million acres of farmland and drinking water to 25 million people. Similarly, floods that damage infrastructure important to commerce (such as highways, rail lines, or ports) or industry (such as information technology companies located along the San Francisco Bay) could have statewide, national, or international impacts.

In contrast to such negative impacts, in some cases floods can have beneficial effects for both humans and the environment (such as creating habitat for migrating fish and birds). For these reasons, flood management strategies often incorporate leaving certain floodplains undeveloped and encouraging flooding in certain areas, as discussed later in this report.

Flood Types and Causes

Flood Conditions Vary Across State. Figure 2 summarizes the types of floods that occur in

Figure 2

Types of Flooding in California

Type	Regions/Areas Affected	Description
Slow rise	Statewide, deep floodplains, and low-lying urban areas	Gradual flooding as waterways overflow their banks from heavy precipitation and/or snowmelt.
Stormwater	Statewide, localized urban areas	Localized flooding during or after a storm, generally due to blocked storm drain systems failing to properly convey stormwater runoff.
Flash	Statewide, steep slopes, and near streams or creeks	Quick-forming and fast-moving floods, often from heavy rain falling on saturated or dry soil that has poor absorption ability.
Debris flow	Statewide, downstream of denuded hillsides	Quick-forming and fast-moving floods made up of water, liquefied mud, and debris, from rain falling on hillsides lacking vegetation.
Engineered structure	Statewide, downstream of structures	Flows released due to failure of flood control structures such as dams or levees.
Coastal	Coast and San Francisco Bay Area	Encroaching seas due to storm surges, high winds, and/or exceptionally high tides.
Alluvial fan	Southern and Central California, where canyons fan out from mountains	Shallow and fast-moving floods from rainfall and/or snowmelt displacing sediment along alluvial fans.
Tsunami	Coast	High-speed sea waves caused by earthquakes and/or underwater landslides.

California, as well as the geographic regions in which they typically occur. In general, the figure displays the different types in order of frequency of occurrence. As shown, some types of floods—such as coastal or alluvial fan—only occur in certain regions of the state, whereas other types—such as slow rise or flash—can occur throughout the state. All areas of the state are subject to at least some form of flooding. The variance in flood type, cause, and likelihood of occurrence is driven by factors such as regional weather conditions, hydrologic conditions, and geology, as well as by human development and engineering.

Flood Risk

Flood Risk Defined Based on Estimated Flood Likelihood. Flood managers define flood risk as the likelihood of negative consequences or damages occurring from flood inundation. Frequently, flood risk is described based on the calculated probability that a flood will occur in a given area. For example, a "100-year flood" is estimated to have a 1 in 100 (or 1 percent) probability of occurring in any given year. Calculated flood probabilities are simply predictions and are not meant to imply that a 100-year flood, for example, will occur *only* every 100 years. Flood managers and insurance companies calculate these probabilities by examining flood hazards (such as a building's elevation or proximity to a river), history (such as how often flooding has occurred in the past), and flood management structures (such as the presence and height of levees). While flood management structures help reduce risk, a floodplain can never be fully protected with 100 percent certainty. Flood managers sometimes refer to the remaining risk of damage after implementation of flood management actions—such as constructing levees—as "residual risk."

Widespread Flood Risk to People, Infrastructure, and Crops. Exposure to flood hazards exists across the state, with the potential for greatest damage concentrated in highly developed urban areas. Figure 3 (see next page) shows data compiled by the Department of Water Resources (DWR) and U.S. Army Corps of Engineers (USACE) for the population, value of structures, and crop values located in 500-year floodplains—areas with a 1 in 500 probability of flooding in any given year—across different hydrologic regions of the state. (Hydrologic regions are the geographic areas encompassing the drainage of a river or series of rivers.) In total, 7.3 million people (one-in-five Californians), structures valued at $575 billion, and crops valued at $7.5 billion are located within a 500-year floodplain in California.

The South Coast region (which includes Los Angeles and San Diego) has the largest exposure, with more than 3 million people and structures valued at more than $230 billion located within the 500-year floodplain. The region has 250,000 residents living within the 100-year floodplain. Santa Clara, Orange, and Los Angeles are the three California counties with both the greatest population and the highest structure values located within 500-year floodplains. In contrast, the greatest exposure for crop values exists in the three Central Valley hydrologic regions (Sacramento River, San Joaquin River, and Tulare Lake). Fresno, Tulare, and San Joaquin are the counties with the largest value of agricultural crops located within the 500-year floodplain, together totaling over $2 billion.

Human Development Influences Flood Risk. Human influences can have both positive and negative effects on flood risk and the magnitude of potential damage. Humans have developed extensive flood management structures and practices to control floodwaters and significantly reduce flood occurrences. However, human development has also increased the risk for potential damage from floods, particularly when

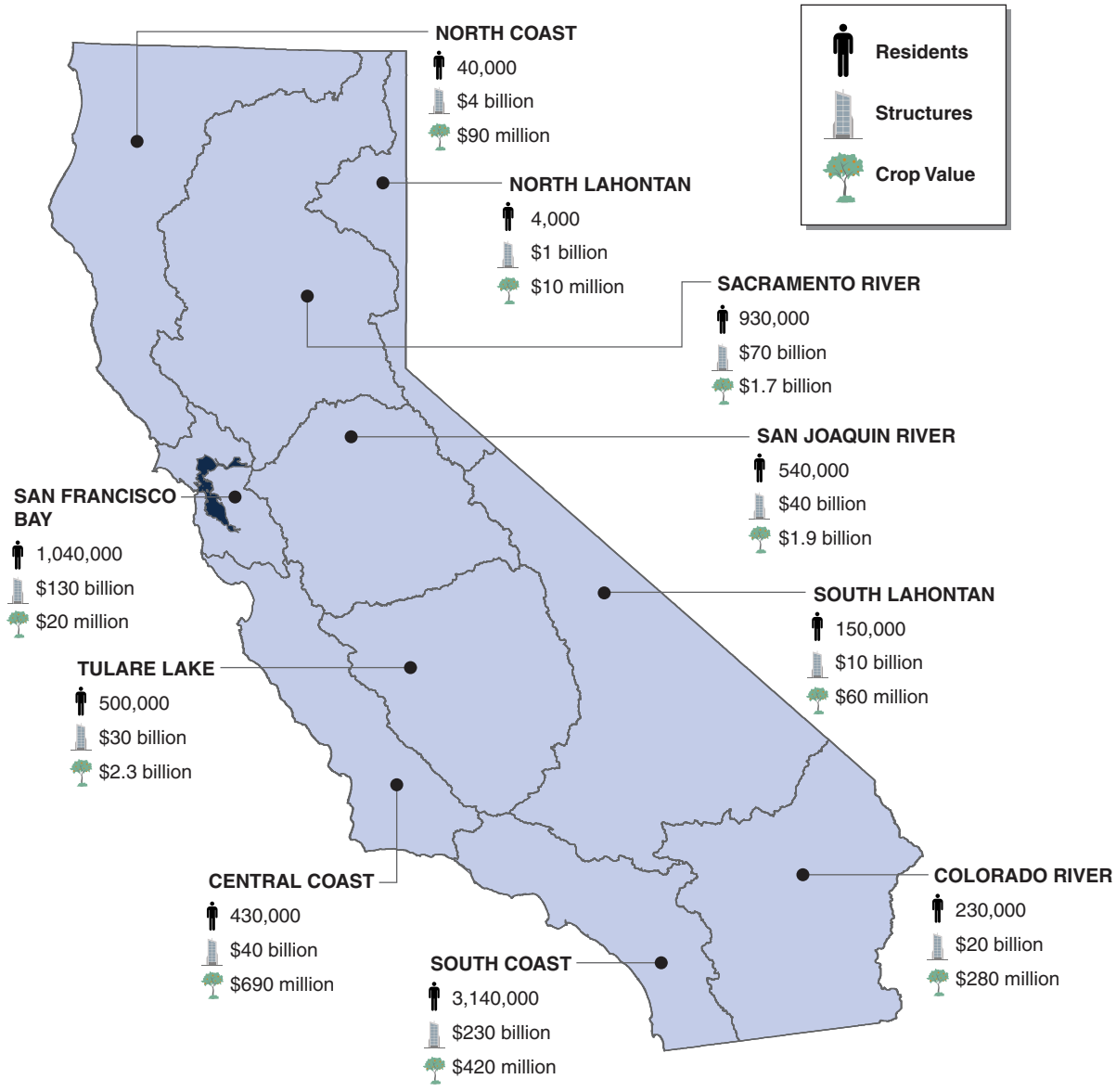
development takes place in areas that are especially prone to flooding. In such cases, flood events that might otherwise have been natural occurrences with little impact instead can have significant effects on developed infrastructure.

California's Central Valley offers an example of how development decisions have increased impacts from floods. This region has experienced many of the largest and most destructive floods in the state's history. This is due in part to the way the course of

Figure 3

Exposure to 500-Year Flood by Region

By Hydrologic Region



Source: *California's Flood Future: Recommendations for Managing the State's Flood Risk* (Department of Water Resources and U.S. Army Corps of Engineers, 2013).

the Sacramento River was engineered beginning in the late 1800s to address the by-products of widespread hydraulic mining during the gold rush era. Levees along the river were constructed into narrow channels to help speed river flows in order to flush mining debris out to sea and preserve the river's navigability. Additionally, areas within the region that had been natural floodplains have been "reclaimed" and developed—originally for agriculture, but over time increasingly for residential and other urban uses. The impacts of these decisions include (1) swift river flows in narrow channels that place stress on and risk overtopping levees, (2) a river that has been forcibly redirected away from its natural course and floodplains, and (3) significant public and private infrastructure existing in close proximity to the river. All of these conditions contribute to flood risk for valley residents. (As described below, the state has taken various steps to help address this risk, including strengthening levees and developing an extensive bypass system.)

There are other examples across the state where building in areas with particular geographical features has increased the potential for flood damage. These include development on hillsides prone to flash floods, within alluvial fans, or along the coast. Rising sea levels are also increasing the risk of flood damage for coastal communities.

FLOOD MANAGEMENT RESPONSIBILITIES

Numerous Government Entities Involved in Flood-Related Activities. Responsibilities for managing flood risk and responding to floods have evolved over time. In the early decades after the state's founding, flood management fell primarily to private entities. Local landowners would build levees—with varying strategies, materials, and effectiveness—to direct and divert rivers, streams, and floodwaters. Major flood disasters in the late 1800s and early 1900s, however, spurred the state and federal governments to play greater roles, including passing flood management policies and building public flood control infrastructure. As shown in Figure 4 (see next page), various flood-related responsibilities are now shared across a number of local, federal, and state agencies.

Local Responsibilities

Local Government Flood Management Arrangements Vary. Statewide, most activities to protect communities from floods are undertaken by local agencies. These activities include establishing and implementing land use policies, constructing and maintaining flood infrastructure such as levees, and emergency preparedness efforts. These activities are carried out by various local entities, depending upon how agency roles and responsibilities have been assigned and defined in a particular jurisdiction. In some cases, a city and/or county may assume primary flood management responsibilities. In other cases, jurisdictions have established government agencies called special districts—such as flood control, levee, or reclamation districts—to provide flood-related services. Other communities have pooled resources to address regional issues by forming joint powers authorities. Some special districts and joint powers authorities have the authority to assess, levy, and collect tax revenues to support their activities.

In some communities, various flood management responsibilities are shared by multiple agencies, whereas in others a single agency handles multiple water and flood management responsibilities. One recent report estimated that flood management responsibilities are spread across over 1,300 local agencies across the state.

Federal Responsibilities

USACE. USACE has built, conducts major repairs on, and holds regulatory authority over certain flood management facilities that were authorized by Congress. The agency, however, typically hands over operations and maintenance to a "nonfederal sponsor" after construction projects are complete. Major flood control projects built in cooperation with USACE in California include the levees of the State Plan of Flood Control (SPFC), the channelization of the Los Angeles River, and many of the large dams in the state (including Shasta and Oroville). As described later, USACE maintains certain flood regulation authority over many of the dams it helped construct.

Under its Public Law (PL) 84-99 program, USACE also provides some emergency preparedness assistance to states and local

Figure 4

Public Agencies With Major Flood Management Responsibilities

Agency	Primary Responsibilities
Local	
Cities, counties, and special districts (such as reclamation or flood control districts)	Conduct various activities based on local arrangements, including: constructing, maintaining, and improving levees and flood management structures; developing land use policies; developing disaster mitigation and emergency response plans; leading emergency response and recovery efforts; and levying assessments on landowners to fund flood management efforts.
Federal	
U.S. Army Corps of Engineers	Undertake and authorize changes to capital flood protection projects when authorized by Congress, generally in partnership with state and local agencies (including SPFC levees). Inspect federally constructed levees for compliance with federal standards. Provide planning and assistance to state and local agencies, including during flood events. Provide funding to repair flood-damaged levees if they meet federal criteria. Establish flood storage and release standards for certain reservoirs.
Federal Emergency Management Agency	Operate National Flood Insurance Program, which includes developing flood hazard maps that define flood risk, establishing floodplain management standards, and offering federally backed insurance policies. Provide coordination, assistance, and funding for federally declared flood disasters.
State	
Department of Water Resources	Conduct flood forecasting, hydrology, and climatology studies. Undertake statewide flood management data collection and planning. Inspect, oversee maintenance of, and in some cases conduct projects on, SPFC levees. Operate and maintain SPFC dams, channels, and other structures. Implement flood-related state grant programs. Help coordinate emergency flood response operations.
Central Valley Flood Protection Board	Ensure that appropriate standards are met for the construction, maintenance, and protection of the SPFC.
Office of Emergency Services	Assist local agencies in responding to floods. Provide coordination, assistance, and funding for state-declared flood emergencies.

SPFC = State Plan of Flood Control.

communities, including planning, training, response exercises, and stockpiling of flood-fight supplies such as sandbags. Additionally, during a flood event USACE will provide advice, staff support, equipment, supplies, and whatever other assistance is requested by state or local flood managers.

Other Federal Agencies Also Involved. The Federal Emergency Management Agency (FEMA) plays an important role in providing disaster assistance during and following a flood event. Some additional federal agencies not highlighted in Figure 4 also play supporting roles in flood management activities. These include the U.S. Environmental Protection Agency, which sets stormwater discharge standards, and the Bureau of Reclamation, which operates some dams as part of the Central Valley Project. Additionally, the U.S. Fish and Wildlife Service and National Marine Fisheries Service monitor and regulate the potential impacts of flood management efforts on fish and wildlife and issue permits for certain flood projects. The U.S. Geological Survey collects and disseminates flood-related data, including real-time streamflow and runoff rates, as well as maps that model potential flood inundation patterns. The Federal Energy Regulatory Commission sets some operational requirements for dams that also produce hydroelectric power.

State Responsibilities

DWR. DWR is the state's lead agency in flood-related activities. The department's responsibilities include the full cycle of flood-related activities, including preparing for future floods, forecasting imminent floods, and responding to actual floods. Besides providing guidance and assistance to local agencies, DWR also maintains certain SPFC levees and facilities.

Central Valley Flood Protection Board (CVFPB). Formerly called the State Reclamation Board, CVFPB was created in 1911 to address flood issues in the Central Valley. The board holds responsibility, on behalf of the state, for overseeing the SPFC. Its activities include collaborating with other agencies to improve the SPFC's flood protection structures, issuing permits for work on the system's levees and structures, enforcing removal of problematic levee encroachments, and serving as the intermediary between USACE and SPFC permit applicants.

Other State Agencies Also Involved. Like FEMA, the state's Office of Emergency Services (OES) provides disaster assistance during and after a flood event. The State Water Resources Control Board and regional water boards set and regulate stormwater discharge requirements. The California Department of Fish and Wildlife monitors and regulates the potential impacts of flood management efforts on fish and wildlife, including issuing permits for certain projects. Additionally, the Delta Stewardship Council evaluates flood projects proposed within the Delta to ensure they are consistent with established state goals for the region, and is developing a Delta Levees Investment Strategy to guide the state in prioritizing levee funding.

FLOOD MANAGEMENT INFRASTRUCTURE

In this section, we discuss the physical structures developed for managing floodwaters in California. We begin by providing an overview of flood-related facilities, then provide additional detail on the SPFC system for which the state has special responsibilities.

Overview of Physical Flood Management System

Many Types of Flood Management Facilities Across State. Local, federal, and state agencies have developed a variety of physical structures to convey and control water flows and floodwaters. Such structures include levees and floodwalls, channels, weirs, and culverts. Additionally, flood managers use detention and retention basins, dams and reservoirs, and bypasses to collect or store water and thereby regulate flood flows. Seawalls and breakwaters are used to armor the shoreline against coastal flooding. Figure 5 defines and illustrates some key flood infrastructure components.

Physical structures—like levees and weirs—are also sometimes paired with nonstructural approaches—like the use of floodplains—for flood management. Additionally, flood management structures—such as dams and reservoirs—frequently are also used for water supply purposes, as discussed below.

Most Flood Infrastructure Locally Owned and Managed. Flood management infrastructure across California includes more than 20,000 miles of levees and channels and more than 1,500 dams and reservoirs. Most of these facilities are owned and managed by local governments. This reflects the history of how most of the facilities were developed, aligns responsibility with beneficiaries (because local communities generally have the most to lose or gain from the efficacy of flood management actions), and is consistent with ownership of most public infrastructure across the state. Large locally owned flood projects around the state include concrete channels and dams on the Los Angeles River (managed by the Los Angeles County Department of Public Works) and the Santa Ana River (managed by the Orange County Public Works Division). Additionally, some levees in the state, particularly in very rural areas and along smaller streams, are privately owned and maintained.

These statewide totals also include 1,600 miles of levees and four dams in the Central Valley that are overseen by the state and considered part of the SPFC system. With the exception of several dams operated by USACE or the Bureau of Reclamation, the federal government generally does not directly operate or maintain many flood control facilities in California.

Water Supply Facilities Also Play Role in Flood Management. In addition to structures built explicitly to manage floods, other water-related facilities across the state are used for flood management. For example, components of the State Water Project and federal Central Valley Project—including dams such as Oroville and Shasta—are operated not only for water supply purposes, but also to store and release water to minimize downriver flood risk during storms and periods of high snowmelt. This is also true of many local dams and reservoirs.

USACE maintains flood control authority over around 20 reservoirs in California that are owned and operated by other governmental agencies but for which construction was partially federally funded. These include some of the largest reservoirs in the state, including Shasta, Oroville, New Melones, and New Don Pedro. Specifically, USACE has computed a specific amount of "flood control space" that must be maintained within these reservoirs to capture runoff and avoid exceeding the maximum capacity of the dam or harming downstream entities. USACE can require dam operators to release water from these reservoirs to ensure this amount of storage capacity is reserved for flood safety—for example, if a storm is forecast and additional runoff is projected to flow into the reservoir.

SPFC

SPFC Provides Flood Protection in Central Valley. The SPFC is a system of flood protection

infrastructure along the main stem and certain tributaries of the Sacramento River and the San Joaquin River, as shown in Figure 6 (see next page). The system includes about 1,600 miles of levees, four dams, five major weirs, seven major drainage pumping plants, and seven bypasses that are used to divert water during periods of high flow. These features have been built over time and by multiple

Figure 5

Illustration of Key Flood Infrastructure Components

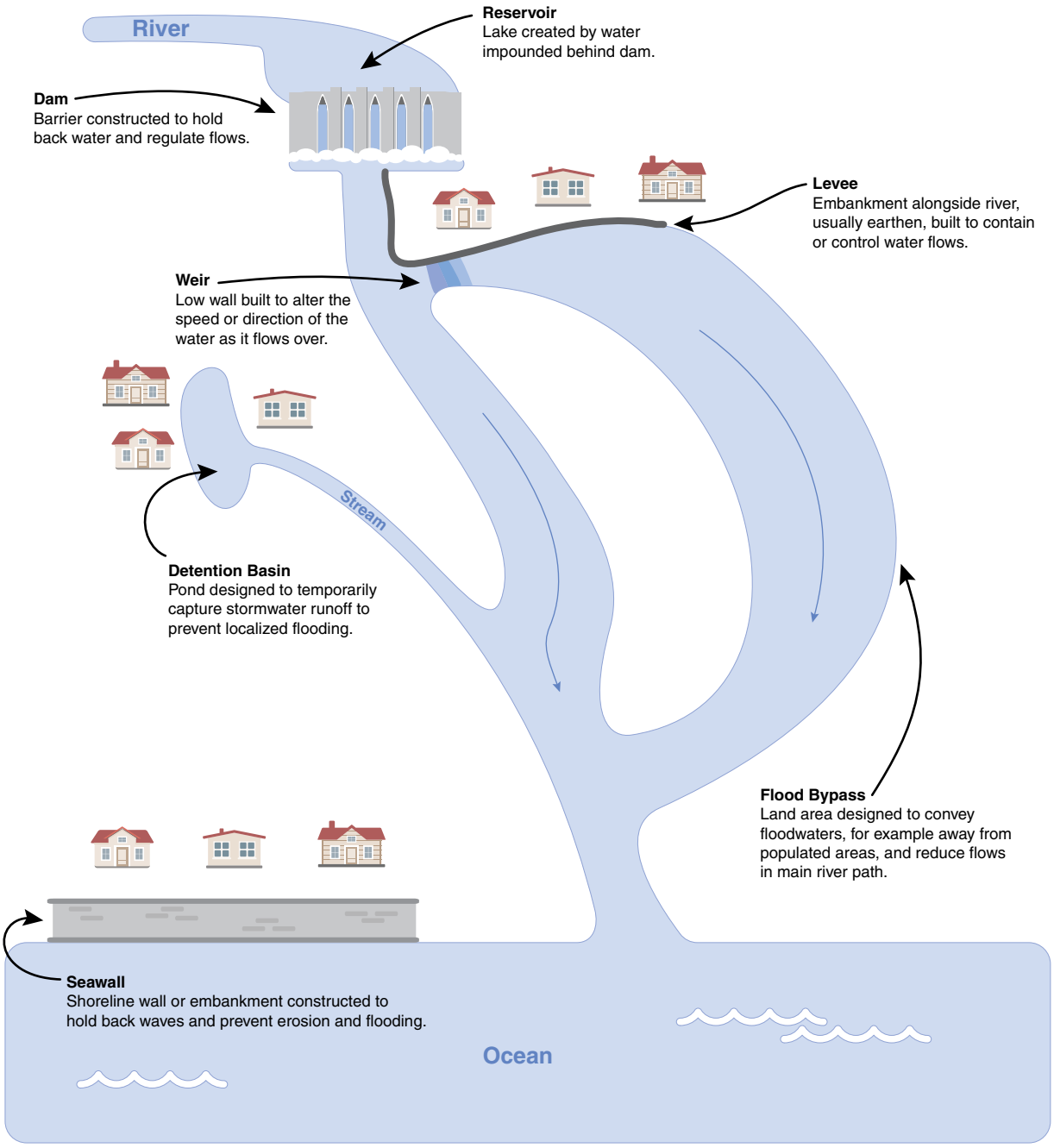


Figure 6

State Plan of Flood Control (SPFC)

Source: California Department of Water Resources.

entities, beginning with private citizens creating levees out of local sands and soils in the mid-1800s. Federally authorized flood control projects to improve the SPFC—undertaken by USACE—began in 1917 in the Sacramento River basin and in 1944 in the San Joaquin River basin.

State Responsible for—but Local Agencies Primarily Maintain—SPFC. Although many SPFC components were locally or federally constructed, in the 1950s the state committed to the federal government that it would oversee the SPFC system and maintain its facilities pursuant to federal standards. (SPFC levees are also commonly referred to as "project levees," in reference to the SPFC being a joint state and federal project.) Only levees and structures along certain tributaries and stretches of river are considered part of the SPFC system and subject to this state-federal agreement. The state has not assumed responsibility for all flood protection facilities in the Central Valley. For example, within the 1,100 miles of levees located in the Sacramento-San Joaquin Delta, only about 380 miles are part of the SPFC—the remaining 720 miles are locally owned and maintained.

CVFPB oversees SPFC facilities on behalf of the state, including issuing permits for modifications and enforcing that levees are maintained up to required standards. For most segments of SPFC levees, the state has developed formal agreements with local governments (primarily local reclamation districts) to handle regular operations and maintenance responsibilities. These responsibilities include conducting daily inspections, ensuring levees stay structurally sound and meet standards, clearing excessive vegetation, and undertaking projects to improve levee effectiveness. DWR maintains approximately 300 miles of SPFC levee segments not covered by such agreements.

Paterno *Court Decision Established State Liability for SPFC.* In 2003, a state appellate court found the state responsible for a SPFC levee failure along the Yuba River, thereby establishing a new standard for the state's flood liability. The 2003 decision in the *Paterno v. California* case found that the state had failed to properly maintain the Linda Levee (located south of Marysville) and therefore was liable for resulting flood damage when it failed in 1986. Although the levee was both originally constructed and maintained at the time by local entities—not the state—and reportedly had *never* met engineering standards, the court found that the state undertook liability when it assumed control of the SPFC in the 1950s. Specifically, courts found that the state "had ample opportunity to examine" and repair the levee. The state eventually paid a $464 million settlement to the nearly 3,000 plaintiffs. The *Paterno* decision's precedent makes it possible that the state could ultimately be held responsible for the structural integrity of all SPFC facilities.

NONSTRUCTURAL FLOOD MANAGEMENT EFFORTS

In contrast to physical infrastructure—which mitigates risk by controlling floodwaters—nonstructural management approaches adapt to and accommodate the potential of floods occurring. In this section, we describe three major nonstructural approaches: land use policies, floodplain restoration, and emergency preparation.

Land Use Policies

Land Use Policies Can Seek to Minimize Potential Damage. A key nonstructural approach to limiting damage from floods is to control the amount and type of development that occurs in flood-prone areas. For example, jurisdictions might

develop land use policies and building codes that discourage construction within floodplains. Other policies might allow development but require that buildings be elevated to a certain height to withstand flooding.

Federal and State Policies Can Influence Local Land Use Decisions. Land use decisions are made primarily by local governments. However, in some cases, they can be influenced by federal and state policies. For example, the federal government identifies areas with a high risk of flooding and requires home and business owners in those areas to have flood insurance in order to be eligible for a federally backed mortgage. Additionally, participation in the federal National Flood Insurance Program (NFIP) is only available in communities that have agreed to adopt and enforce local ordinances that meet or exceed federal floodplain management standards. (Please see the nearby box for more detailed information about NFIP.) Thus, while local jurisdictions are not *required* to meet federal standards for restricting development in flood-prone areas, federal policies strongly encourage them to do so, in order to avoid

National Flood Insurance Program (NFIP)

Program Intended to Reduce Flood Impacts. Congress established the NFIP in 1968 to address a number of policy objectives, including (1) offering affordable insurance premiums to residents in flood-prone areas, (2) reducing federal disaster assistance costs, (3) encouraging better community-based floodplain management, and (4) identifying flood risk across the nation. Under the program, private insurance companies sell and service federally backed flood insurance policies to private property owners. The NFIP is funded through roughly $3.5 billion in annual insurance premium revenues and, when necessary to cover claim payments, loans from the U.S. Treasury. The program currently owes over $20 billion to the Treasury due to substantial hurricane-related claims in 2005 and 2012.

Flood Insurance Required in Certain Circumstances. While federal law does not explicitly require property owners to purchase flood insurance, it does require that federally regulated or insured mortgage lenders mandate flood insurance as a loan condition for buildings located in high-risk flood areas—making it a de facto requirement for certain home and business owners. Additionally, property owners who receive federal disaster assistance after a flood must purchase flood insurance to remain eligible for future disaster relief. The Federal Emergency Management Agency (FEMA), which manages the NFIP, creates maps classifying flood hazard risk as high, moderate, or low based on various characteristics including geography, elevation, and flood history. High-risk areas have at least a one-in-four chance of flooding during a 30-year mortgage.

Mortgage lenders can also require that borrowers purchase flood insurance for non-federally backed loans and/or for properties in low- or moderate-risk areas. Indeed, FEMA notes that over 20 percent of all flood insurance claims come from areas outside of mapped high-risk flood zones. Even when not required by their lenders, some property owners opt to purchase flood insurance, as flood damage is not typically covered by traditional homeowner's insurance.

Eligibility Dependent on Local Flood Management Actions. Federally backed NFIP policies are only available for buildings located in communities that have agreed to adopt and enforce

limiting mortgage financing options for their local property owners.

Similarly, the state has adopted certain policies designed to encourage local jurisdictions to avoid making land use decisions that increase flood risks. For example, several such policies were included in a package of flood-related legislation passed in 2007, as summarized in Figure 7 (see next page). The legislation states that local governments in urban areas of the Central Valley shall plan for an even higher level of protection than the federal floodplain management standards required by the NFIP—200-year protection rather than 100-year protection. They can meet these requirements either by limiting development or by building or improving structural flood infrastructure such as levees. While state policies encourage local actions to limit flood damage, these policies have some notable limitations. Specifically, the policies (1) only apply to the Central Valley, (2) only pertain to new development, and (3) are self-enforced by local governments (with repercussions for lack of compliance somewhat unclear).

local ordinances that meet or exceed FEMA floodplain management standards. FEMA's standards are designed to reduce flood damage, such as requirements that new development does not cause obstructions to the natural flow of floodwaters or increase flood risk for neighboring properties. To encourage even more effective floodplain management, FEMA offers reduced flood insurance premiums through its Community Rating System program for communities that exceed its minimum standards.

California's Participation Somewhat Limited. As of September 2016, Californians held around 296,000 NFIP policies—about 6 percent of the nationwide total. By comparison, Florida residents held 35 percent of national NFIP policies, and Texas represented 12 percent of the nationwide total. (Data regarding the number of properties in high-risk areas in each state are not readily available.) NFIP participation rates in California declined in recent years, likely because the state had been in a drought and had not experienced a major flood for several years so residents had a lower perceived risk. These numbers likely have increased in recent months as a result of winter 2017 floods, though associated data are not yet available. According to researchers at the University of California, Davis (UC Davis), as of October 2016, California's NFIP policies cover $82.6 billion of insured assets and are supported by $213 million in annual premiums payments.

Between October 2015 and September 2016, NFIP policyholders in California submitted 337 insurance claims and received about $4.6 million in claim payments—representing less than 1 percent of both claims and payments nationwide. The UC Davis researchers found that between 1994 and 2014, NFIP damage payouts in California totaled just 14 percent of the amount its residents paid in premiums—an imbalance of over $3 billion, adjusted for inflation. By comparison, North Dakota had the highest rate of NFIP payments as a percentage of the amount paid in premiums—188 percent—over that 20-year period. (These data exclude each state's single largest claim year to avoid skewing the data with a single catastrophic event, otherwise Mississippi would be the greatest net NFIP beneficiary.)

Federal Government Recently Increased Standards for Federally Funded Construction. In January 2015, the federal government announced new flood standards for building federally funded structures such as buildings or roads. The new standards apply when federal funds are used to build or significantly retrofit or repair structures and facilities in and around floodplains. The standards are somewhat flexible, allowing agencies to choose one of three options for how their projects comply:

- Build the structure at an elevation that is above the projected 500-year flood level.
- Build the structure at an elevation that is two feet above the projected level of a 100-year flood for standard projects, and three feet above for critical buildings like hospitals and evacuation centers.
- Build the structure based on data and methods informed by the best-available, actionable climate science.

Figure 7

Major Components of 2007 Central Valley Flood Legislation[a]

- ✓ ***State Planning Requirements.*** Required DWR and CVFPB to prepare, adopt, and implement a CVFPP by 2012, then update that plan every five years. The plan must include (1) a description of existing flood risk and facilities within the SPFC area, (2) an evaluation of the improvements necessary to bring SPFC facilities up to current design standards, and (3) recommendations for improving the SPFC's performance that incorporate multiple benefits (such as to the ecosystem).
- ✓ ***Local Planning Requirements.*** Required Central Valley cities and counties to (1) develop flood emergency response plans and (2) amend general plans to conform to the data, policies, and implementation measures included in the CVFPP, including adopting goals and policies intended to protect lives and property and reduce flood risk.
- ✓ ***Higher Flood Protection Standards.*** Established 200-year flood event (flood with a 1-in-200 chance of occurring in any year) as the minimum level of flood protection to be provided for new development in urban and urbanizing areas.
- ✓ ***Local Zoning and Development Requirements.*** Required Central Valley cities and counties to amend zoning ordinances to conform to the CVFPP and to their amended general plans, including by prohibiting new development in areas not protected up to the 200-year flood standard.
- ✓ ***State Mapping and Notification Requirements.*** Required DWR and CVFPB to (1) map flood risk areas in the Central Valley, (2) prepare levee flood protection zone maps, and (3) annually notify applicable property owners that they live in a flood zone protected by a levee.

[a] Chapters 364 (SB 5, Machado); 365 (SB 17, Florez); 366 (AB 5, Wolk); 367 (AB 70, Jones); 368 (AB 156, Laird), and 369 (AB 162, Wolk) of 2007.
DWR = Department of Water Resources; CVFPB = Central Valley Flood Protection Board; CVFPP = Central Valley Flood Protection Plan; and SPFC = State Plan of Flood Control.

Floodplain Preservation, Expansion, and Restoration

Floodplains Can Help Keep Floodwaters Away From Development. Nonstructural approaches also include preserving and enhancing natural floodplain functions such that undeveloped lands can slow and absorb floodwaters before they reach developed areas. Actions include purchasing easements to preserve lands so they remain available for periodic inundation, or setting back levees and widening channels to allow the river greater access to its original floodplain and accommodate a higher volume of flows. Efforts can also be undertaken to

improve the effectiveness of existing floodplains, such as removing vegetation or sediment that impede floodwater flows. (Please see the nearby box for two examples of recent efforts to restore floodplains in order to reduce potential damage to urban areas.) Another approach to accommodating natural floodwaters is to cultivate wetlands along shorelines to serve as buffers to high tides or surges. Specifically, wetlands can absorb and dissipate seawater surges before they reach and inundate near-shore development.

Bypasses Use Flood Structures to Convey Waters Into Floodplains. Flood bypasses combine structural approaches to control floodwaters with the nonstructural approach of utilizing natural floodplain functions. Specifically, levees and weirs are used to direct waters out of river channels into large floodplains—"bypassing" the normal path of the river—so the water can spread and the flow velocity can dissipate. Bypasses are a particularly important part of the SPFC system, which includes seven "relief" bypasses. During periods of high water flows, more than 80 percent of Sacramento River waters can end up flowing through the Yolo Bypass instead of through the main stem of the river near the City of Sacramento.

Floodplains Provide Additional Benefits. Utilizing floodplains can provide benefits beyond just reducing the risk of flood damage. One example of a positive impact is percolation of water into the ground, helping to replenish groundwater basins for future agricultural and residential uses. Additionally, inundation in natural floodplains can improve habitat conditions for plants and wildlife, such as by providing seasonal flows and creating wetlands needed by migrating fish and birds. For example, recent experiments found that juvenile salmon raised in the flooded Yolo Bypass grew much faster and bigger than those in the main stem of the Sacramento River. Sediments carried and deposited by flood waters can also enrich soils for agricultural purposes. Finally, floodplains can help dilute and flush out pollutants and contaminants and thereby improve water quality when the flows join streams, rivers, and the ocean.

Increasing Shift to Multi-Benefit Flood Management Approach. Flood managers, particularly at the state and local levels, have

Two Examples of Floodplain Restoration Efforts

Floodplain restoration efforts are being implemented across the state. One example of an effort to enhance floodplain capacity is currently underway in West Sacramento. The Southport Levee Setback Project—a collaborative effort between the City of West Sacramento, the local flood control agency, the Department of Water Resources, and the U.S. Army Corps of Engineers—will set back four miles of the existing levee on the Sacramento River. This will expand the river's width, allowing it greater access to its original floodplain, as well as create 152 acres of new riparian habitat.

Another example is the Napa River/Napa Creek Flood Protection Project, which utilized strategies including (1) riverbank terracing (allowing rising floodwaters room to spread into defined areas), (2) converting pastureland to wetlands that are available to hold excess waters, (3) replacing a number of old bridges that had blocked flows, and (4) incorporating a dry bypass channel to provide a shortcut for fast-moving water that historically had overtopped the normal pathway of the river. The bypass, completed in 2015, flooded for the first time in February 2017 and helped prevent the type of widespread flooding in downtown Napa that occurred during storms in 2005.

made efforts in recent years to encourage flood management projects that take advantage of the multiple benefits associated with natural floodplain functions. Recent statewide planning documents—including *California's Flood Future: Recommendations for Managing California's Flood Risk* (2013), *The Water Action Plan* (2014), and the *Central Valley Flood Protection Plan Update* (2017)—emphasize the need for an integrated water management approach. These plans highlight that in addition to protecting public safety, flood management projects also can and should achieve additional benefits such as ecosystem restoration, wildlife habitat development, and groundwater recharge. One component of the *Central Valley Flood Protection Plan Update,* the "Conservation Strategy," identifies specific tools and approaches that should be incorporated into local flood management plans to restore natural areas in ways that benefit fish and wildlife. Specifically, the document describes (1) targeted species to assist (such as Central Valley spring-run Chinook salmon), (2) ecological objectives to pursue (such as increased shaded riverine aquatic cover), (3) environmental stressors to address (such as invasive species or fish passage barriers), (4) potential approaches to implement (such as relocating levees), and (5) strategies for facilitating such approaches (such as streamlining and coordinating project permitting requirements).

The state has also structured certain funding grants to encourage or require multi-benefit flood management projects, including projects funded by Proposition 1, the 2014 water bond. For example, Proposition 1 included $395 million for flood-related projects and explicitly required that "funds shall be allocated to multibenefit projects that achieve public safety and include fish and wildlife habitat enhancement." Recent water bonds—including Proposition 1—have also included a total of $2.3 billion for Integrated Regional Water Management projects. This program provides grants for regionally driven multi-benefit projects that often pair flood-related activities with other water management goals such as water supply.

Emergency Preparation

Another nonstructural approach that can minimize life and property loss from floodwaters is to plan ahead for how to effectively respond when a flood does occur.

Both Federal and State Laws Include Some Flood Emergency Planning Requirements. In order to remain eligible for some federal funding, local jurisdictions are required to plan for flood emergencies and mitigate flood risk. For example, maintaining eligibility for certain federal disaster assistance grants requires local jurisdictions to develop—and submit to FEMA for approval—local hazard mitigation plans. For areas in FEMA-identified flood hazard zones (as described earlier with relation to the NFIP), these plans must include flood mitigation strategies.

The 2007 flood legislation referenced earlier also included some state-level flood planning requirements for Central Valley residents. Specifically, for a local levee-maintaining agency to be eligible for state funds to improve an SPFC levee, the local jurisdiction located behind the levee must develop a flood safety plan. This plan must include (1) flood preparedness measures, including storage of materials that may be used to reinforce or protect a levee; (2) a levee patrol plan for high water events; (3) anticipated flood-fight procedures; (4) an evacuation plan, including for schools and elderly care facilities; and (5) a floodwater removal plan. (The FEMA plan can be used to meet this state planning requirement provided it contains all of the necessary elements.)

Effective Local Preparation Can Help Reduce Flood Impacts. Preparedness activities include training local emergency responders, developing

systems or purchasing equipment for emergency communication, establishing and communicating evacuation procedures, and acquiring flood-fight material stockpiles such as sandbags. Flood managers also prepare for potential responses to particular flood conditions—for example, by developing engineering plans for making emergency relief cuts in levees to relieve pressure from floodwaters. Understanding potential resulting impacts of such actions ahead of time can allow them to be undertaken quickly in emergency situations.

Flood managers also help educate individuals on how they can prepare for floods to minimize risk. For example, individual residents can have emergency supplies prepared and develop family evacuation plans. Farmers can plan for how to quickly get their livestock to higher ground. Individuals, businesses, or farmers can also "floodproof" structures so they are prepared to handle occasional floodwaters. For example, this could include raising the structure's elevation by building impermeable walls and entry points ("dry" floodproofing), or by ensuring anything located on the ground floor can get wet ("wet" floodproofing).

Increasing Warning Time Can Improve Ability to Respond. The state has also undertaken efforts to improve its flood-forecasting ability in order to provide flood managers and local communities with additional warning time to respond to potential floods. These proactive efforts have included improving stream gauges and sensors to get real-time flow information and improving communication procedures to shorten the length of time between when a flood threat is determined and when the public is notified.

FLOOD RESPONSE ACTIVITIES

Flood Response Typically Has Four Stages. The governmental process for responding to an imminent flood typically consists of four stages:

- ***Detection*** by flood managers that a flood could occur, informed by weather forecasts and flow gauges on rivers and streams.
- ***Decision-making*** by local emergency responders regarding what immediate response steps and mitigation actions will be implemented to minimize the potential property damage and loss of life.
- ***Notification*** of the public—through methods such as automated phone and text alerts—about the flood threat and the recommended or required response actions.
- ***Mitigation*** actions by both governmental agencies and local residents. These might include undertaking evacuations, deploying flood-fighting teams, applying sandbags, or removing sensitive equipment to higher ground.

As noted above, increased warning time before a flood occurs can improve response effectiveness, thereby reducing the potential loss of life or damage to property. As such, state and local jurisdictions make efforts to minimize the amount of time spent on the first three steps so that mitigation efforts can be implemented as soon as possible before floodwaters hit.

Emergency Response Typically Collaborative Effort. Emergency response often entails the collaboration of multiple levels of government. Local governments are typically the first entities

to respond to disasters—such as floods—affecting their communities. When faced with flooding, local governments take various actions to protect public safety and mitigate damage to public and private infrastructure. For example, they frequently deploy local government staff—such as law enforcement or firefighting personnel—to provide on-the-ground disaster response. Additionally, if necessary, local governments will activate their local emergency operations center, which serves as a centralized location for staff to coordinate emergency activities, such as tracking and securing disaster response resources and sharing information.

Many flood events are handled entirely at the local level, without the assistance of the state or federal government. However, when floods are large enough to exceed local capacity to respond, local governments typically seek support from the state government through OES. OES provides various types of support to local governments responding to floods, including coordinating the provision of additional resources—such as staff and equipment—from other jurisdictions through the state's system of mutual aid. OES also coordinates the emergency response activities of DWR and all other state agencies to ensure that state resources are provided as needed. Finally, when a flood event is significant, OES coordinates with the federal government to ensure that the state receives federal assistance, such as supplies and personnel. OES maintains Regional Operations Centers as well as State Operations Centers, which it activates, as necessary, to facilitate its disaster coordination efforts.

FLOOD RECOVERY PROGRAMS

State and Federal Programs Provide Certain Post-Flood Assistance. The state and federal governments provide disaster recovery programs through the California Disaster Assistance Act (CDAA) and Stafford Act, respectively. These programs provide financial and other forms of assistance to public agencies and—in some cases—to individuals following a disaster such as a flood. For both programs, a first step in the process is for the local, state, and federal agency representatives, as relevant, to conduct a Preliminary Damage Assessment in order to determine the extent of the damage from the disaster.

State Assistance Provided Through CDAA Based on Request From Local Government. If a local jurisdiction experiences a flood disaster that exceeds its ability to respond, local officials can declare a local emergency and request assistance from the Governor. Depending on the amount of damage, the Governor may declare an official State of Emergency and, through OES, provide funding to the affected local jurisdiction through CDAA. While there is no specific dollar threshold for the amount of damage to qualify for CDAA funding, OES typically provides local governments with assistance when it determines that local financial capacity has been exceeded. A variety of types of local government costs are eligible for reimbursement under CDAA, such as emergency response personnel overtime costs, infrastructure repair and replacement costs, and certain administrative costs. CDAA typically covers no more than 75 percent of eligible costs, with the relevant local agency covering the remaining 25 percent of eligible costs. These ratios apply to both state-declared eligible disaster costs, as well as to the nonfederal share of federally declared disaster costs, as described below. CDAA does not typically pay any funding for individual losses.

Federal Recovery Assistance Based on Request From State. If the Governor determines that the flood disaster exceeds both local and state capacity, he or she can request a federal disaster declaration and disaster assistance from the President. If this request is granted, the federal government typically provides affected state and local governments with disaster assistance when certain per capita dollar thresholds for damage are reached. The federal government may also consider various other factors—such as a state's history of disasters—when determining whether to provide assistance. The federal government provides disaster assistance funding for a somewhat broader range of activities than CDAA, including some limited individual assistance. The federal government typically covers 75 percent of eligible public recovery costs, with the nonfederal share covered by the state (18.75 percent) and local governments (6.25 percent). In addition, the federal Small Business Administration provides disaster recovery loans to individuals and businesses to repair and replace damaged or destroyed property. (We describe state and federal funding programs in greater detail below.)

FLOOD-RELATED SPENDING

In this section, we discuss overall flood management and response expenditures, including the amounts and types of funding supporting these activities from state, federal, and local sources.

Overall Spending

Flood-Related Expenditure Data Difficult to Delineate. Estimating how much funding supports flood management efforts is difficult for several reasons. First, as described earlier, such efforts are undertaken by a multitude of agencies at the local, federal, and state levels. Second, expenditures for large flood management projects—such as reengineering levees or expanding floodplains—can stretch over several years and involve multiple funding partners, sources, and mechanisms. Third, activities that provide flood-related benefits may have other primary or secondary water management goals, such as ecosystem restoration or stormwater management. For example, a local project to capture stormwater in underground basins might reduce flood risk but also decrease the pollution flowing into streams and increase local water supplies. Determining what share of this project to "score" as a flood-related expenditure is difficult.

Estimates for Current Flood Expenditures. Despite these difficulties, some estimates exist for current flood-related expenditures in California. Specifically, *California's Flood Future,* a report produced by DWR and USACE in 2013, estimated average annual statewide expenditures on flood management between 2000 and 2010 to be $2.8 billion. A 2014 report by the Public Policy Institute of California (PPIC), *Paying for Water in California*, had a slightly lower estimate for a more recent time frame: $2.2 billion annually between 2008 and 2011. Figure 8 (see next page) displays the estimates from these two reports. The differences between the estimates probably reflect a combination of the different methodologies and time frames used, as well as some of the data challenges discussed above.

Local Government Spending

As primary responsibility for managing flood risk rests with local governments, the majority of funding for flood management activities is generated and spent at the local level. DWR/USACE estimated that local funding for flood-related activities averaged $2 billion annually between

Figure 8

Two Recent Studies Estimate Statewide Flood-Related Spending by Source

(Average Annual Spending in Millions)

	DWR/USACE 2000-2010	PPIC 2008-2011
Spending		
Local	$2,040	$1,324
Federal	470	254
State	330	574
Totals	**$2,840**	**$2,152**

DWR = Department of Water Resources; USACE = U.S. Army Corps of Engineers; and PPIC = Public Policy Institute of California.

Sources: *California's Flood Future*; *Recommendations for Managing the State's Flood Risk* (DWR/USACE, 2013); and *Paying for Water in California* (PPIC, 2014).

2000 and 2010. PPIC's estimate for 2008 through 2011 was $1.3 billion a year.

Local Agencies Rely on Variety of Funding Sources for Flood Protection. Local governments generate revenues for flood management activities—including planning, construction, operations, and maintenance—from a number of sources. One of the main sources is property taxes, which in some cases is dedicated specifically to a special district with flood management responsibilities based on local tax formulas, and in other cases is allocated within the annual budget of a city or county for flood-related activities. Some local governments also levy special assessments to cover flood management activities. Under the State Constitution, as amended by Proposition 218 (1996), voters can approve assessments with a majority rather than a two-thirds vote if the amount paid by each homeowner is directly related to the benefit his or her property receives. As such, some local flood assessments are structured with different payment tiers for particular neighborhoods based on factors such as historic flood depths.

Other sources of local revenues for flood-related activities include general taxes (such as sales taxes), special taxes (which could be dedicated just for flood or for a range of water management activities), revenues from water sales or service charges (often included in local water bills), fees (such as development impact fees), and proceeds from locally issued bonds.

PPIC conducted an analysis of data from special districts (not including cities or counties) and found that on average between 2008 and 2011, property taxes were the single largest local revenue source for flood-related activities each year (just over one-third of total revenues). Revenues from sales or service charges made up about one-fifth of flood-related revenues, with various other sources comprising the remainder.

Level of Local Special District Expenditures Varies Across the State. PPIC found that per capita flood spending from special districts varied significantly across regions of the state. (Data were not available for cities and counties that have flood management responsibilities.) The researchers estimated that statewide average per capita flood spending from special districts was $31 in 2011, but was as high as $77 in the North Coast region of the state and as low as $0 in the Colorado River hydrologic region. There was also variability across the regions identified as having the greatest magnitude of population and structures at risk (as displayed in Figure 3 on page 8). Residents in the South Coast region paid $26 per capita in 2011 while residents in the Bay Area paid $39. The special districts from the regions where PPIC estimated the greatest capital flood improvement needs exist—the Sacramento and San Joaquin River regions—spent $46 and $24 per capita in 2011, respectively.

Federal Government Spending

States and local communities can access federal funding for certain flood-related activities, but special conditions apply and these funds generally

are more limited than state funding. As shown in Figure 8, annual federal flood management expenditures in California have been estimated at between $254 million and $470 million.

Some Federal Funding for USACE to Conduct Flood Management Projects. Federal funding for USACE to conduct a flood management project is dependent on congressional authorization. Generally, USACE first undertakes an "investigation" of a project to see whether it would merit federal involvement. Then, if Congress approves *and* appropriates funding for the project, USACE will undertake the project with a nonfederal partner (usually a local agency) and the state. Often these projects are large, and the federal government generally funds 65 percent to 75 percent of the project cost, with local partners and the state sharing the remainder. (As noted below, portions of state bond funding have been dedicated to covering some of the local share of these costs not supported by the federal government.) Some of these projects are upgrades to prior USACE efforts, such as the construction of a new spillway for Folsom Dam. USACE is also in the process of strengthening and raising existing levees along the American River. Annual USACE expenditures in California ranged from $310 million to $970 million between 2000 and 2010.

The recent federal Water Infrastructure Improvements for the Nation Act, which authorizes nearly $16 billion in nationwide spending, was enacted in December 2016. The bill provided appropriations for USACE to undertake flood-related projects in California, including $880 million for projects along the American and Sacramento Rivers, $780 million for projects in West Sacramento, and $70 million for a shoreline project along the South San Francisco Bay in Santa Clara County. Additionally, the act authorized USACE to conduct feasibility studies for potential future flood-related projects, including along creeks in Merced and Yolo Counties.

Federal Levee Repair Assistance Contingent Upon Meeting Federal Standards and Criteria. The federal PL 84-99 program funds the rehabilitation and repair of certain levees that are damaged during flood events. The program fully funds the rehabilitation and repair of eligible levees originally constructed as part of a USACE project (including SPFC levees). Certain nonfederally constructed levees can participate in the PL 84-99 program but require a state or local partner to pay 20 percent of rehabilitation costs.

In order to qualify for this federal funding, a levee must meet two key criteria. First, the levee must maintain "active status" in the program by meeting established national levee standards and passing USACE inspections before flood events occur. For example, the levee must not display cracking, ruts, erosion, excessive vegetation, or encroachments (structures or obstructions). (The requirement around encroachments is among the most problematic for many California levees, given structures built over time on top of 100-year old levees.) Second, USACE must calculate that the benefits of repairing the levee exceed the costs. Under USACE's current cost-benefit methodology, meeting this criterion can be hard for some rural communities to achieve. That is, the protection of areas with more sparse population and property located behind the levees might not be calculated to generate sufficient economic benefit to offset the costs of levee rehabilitation. As such, some of the local agencies maintaining rural levees have opted not to pursue active status in the PL 84-99 program.

Currently, only 40 percent of SPFC levee miles (610 miles) maintain active PL 84-99 status and qualify for federal rehabilitation funding. These qualifying levees represent about 85 percent of the total population who live behind SPFC levees.

Given their higher population and greater number of structures, agencies maintaining levees that protect urban areas have more certainty that they would meet USACE's cost-benefit threshold and, therefore, greater incentive to maintain levees up to federal standards. Within the Delta region, which is largely rural, only about one-third of the 412 levee miles that have historically been part of the PL 84-99 program currently maintain active status.

Some Limited Direct Federal Grants Also Available. FEMA offers several hazard mitigation grants to help states and local communities prepare for and lessen the impacts of disasters, including floods. These include the Flood Mitigation Assistance grant program, which annually funds competitive grants for states or local communities to plan or undertake actions that would reduce NFIP claims in the case of a flood. Nationally, $150 million was available for these grants in 2015 and $200 million in 2016. As these are competitive grants, however, California does not receive funding every year. For example, the state applied for $2.8 million to conduct a project in Sonoma County in 2015 and for $11 million for a project along the Carmel River in Monterey County in 2016, but was not awarded funding for either project.

Federal Government Funds Share of State and Local Disaster Assistance Costs in Some Cases. In certain cases, as described earlier, the federal government provides funding assistance through the Stafford Act to states and local governments that experience flood disasters. Over the past decade, California communities have received nearly $300 million in federal assistance grants for federally declared flood disasters. In addition to or in lieu of funding, the federal government may provide direct assistance including food, personnel, or temporary living arrangements like trailers or hotel vouchers. At the time this report was prepared, the Governor had requested federal assistance under the Stafford Act four different times in 2017—three times for funding to bolster state and local response and recovery efforts to damage from storms in January and February 2017—including the damage to the spillway at Oroville Dam—as well as for direct assistance to support evacuations of residents living near Oroville.

Individuals in Federally Declared Disasters May Qualify for Low-Interest Federal Recovery Loans. In certain cases, individuals and businesses that experience flood damage may be able to access federal recovery loans through the U.S. Small Business Administration disaster loan program. Specifically, individuals may qualify for a low-interest loan of up to $200,000 to help cover flood damage to a primary residence and up to $40,000 to repair or replace personal property such as clothing, cars, and appliances. Businesses may apply for a loan of up to $2 million for physical damage or economic injury. Such flood recovery loans, however, typically are available only if the President declares a federal disaster. According to FEMA, federal disaster assistance declarations are issued in fewer than 50 percent of flooding events. Moreover, typically the loans must be repaid along with any existing mortgage, although in some cases the federal government will help refinance mortgage terms.

State Government Spending

Although flood management is largely a local responsibility, the state has a strong interest in avoiding major damage and losses, especially when state-owned infrastructure, such as highways and buildings, is at risk. The state, therefore, provides some funding to local flood agencies for improvements to levees and other flood-related infrastructure, as well as for nonstructural flood projects and activities. These state programs are funded primarily by state general obligation bonds.

As shown in Figure 8, DWR/USACE estimated average annual expenditures for flood management by state agencies to be $330 million between 2000 and 2010, whereas PPIC estimated an average of $574 million annually between 2008 and 2011.

Voters Have Authorized $5.1 Billion in State Bonds for Flood Management Over Past Two Decades. Figure 9 summarizes general obligation bonds authorized by voters for flood-related activities since 2000. Nearly all of this funding was provided to DWR to use mostly for grants to local agencies, but also for some state-level activities. As shown in the figure, the bulk of this funding was approved through two 2006 bonds, Propositions 84 and 1E. These propositions were passed in the wake of Hurricane Katrina, when widespread destruction in Louisiana led to increased concerns about California's flood risk. With the exception of the $395 million from Proposition 1, all of this funding has been appropriated by the Legislature and nearly all of it has already been either expended or committed for specific projects. These bonds will be repaid with interest from the state General Fund over the next couple of decades. In response to recent winter storms and flooding, in late February 2017 the Governor requested that the Legislature make an urgency appropriation of the Proposition 1 funds to undertake additional flood-related projects. That request was still pending at the time of this publication.

Bond Funding Used for Broad Variety of Efforts. As shown in Figure 9, the recent bonds have funded a variety of flood management activities and regions. Efforts have focused on both structural flood projects (such as levee improvements) as well as nonstructural efforts

Figure 9

Recent Bonds Provided $5.1 Billion for Flood Management Activities[a]

(In Millions)

Category	Types of Activities	Proposition 13 (2000)	Proposition 1E (2006)	Proposition 84 (2006)	Proposition 1 (2014)	Totals
Flood control projects: SPFC	Evaluate, repair, reconstruct, and replace levees or structures within SPFC system; develop Central Valley Flood Protection Plan; improve emergency response preparedness at both state and local levels.	—	$3,000	—	—	**$3,000**
Flood control projects: federal	Assist local agencies in paying required nonfederal share of federally authorized flood control projects.	—	500	$180	—	**680**
Flood control projects: Delta	Repair levees, conduct flood risk reduction initiatives, and make habitat improvements—all in the Delta.	—	—	275	$295	**570**
Flood control projects: statewide	Improve levees, conduct feasibility studies, improve emergency response preparedness at both state and local levels, and support multi-benefit projects.	—	—	275	100	**375**
Flood corridors and bypasses	Conduct projects to restore and preserve natural floodplain processes, including acquiring easements.	$140	290	40	—	**470**
Floodplain planning	Map floodplains and assist local land use planning efforts.	—	—	30	—	**30**
Totals		**$140**	**$3,790**	**$800**	**$395**	**$5,125**

[a] Includes only the portion of bond funding dedicated for flood-related activities.
SPFC = State Plan of Flood Control.

(such as floodplain restoration and emergency preparedness). While more than half of the funding has focused on improving the SPFC system—due to the state's responsibility for those facilities—funds have also supported flood improvements for non-SPFC facilities. As shown in the figure, the funds have supported both projects within and outside of the Delta, both federal and nonfederal projects, and activities at both the state and local levels. Some of the specific projects funded have been completed, and others are still underway.

Some General Fund Used for Flood-Related Activities. The state also relies on the General Fund for some flood-related activities. For example, the *2016-17 Budget Act* included more than $50 million from the General Fund for staff at DWR to conduct its routine flood-related activities, including flood forecasting and planning, levee and channel inspections, and maintenance of the SPFC levees it manages. The annual budget provides additional General Fund—about $6 million in 2016-17—to CVFPB to conduct SPFC permitting and oversight. The state also dedicates annual General Fund to pay the debt service costs for the aforementioned bonds that fund flood-related activities. Furthermore, the state provided $100 million in the 2016-17 budget on a one-time basis from the General Fund to conduct deferred maintenance on levees, in particular to address pipes or other encroachments that might be compromising levee integrity. In February 2017, however, the Governor announced plans to repurpose at least half of this funding to address emergency levee repairs resulting from winter storms.

The state also dedicates some General Fund annually to support disaster response and recovery efforts through the CDAA program. As described above, CDAA authorizes the Director of OES to provide financial assistance to support emergency response and to repair and restore damaged public infrastructure. CDAA funds are also used to provide state matching funds for federal disaster assistance programs. In recent years, the CDAA program has had a base budget of $39 million annually from the General Fund. Frequently, the process for local governments to tally eligible disaster-related costs, submit claims, and receive reimbursement funds through CDAA can take years. Between 2004 and 2014, CDAA paid around $300 million to local governments for flood and severe storm-related disasters.

ESTIMATED FLOOD MANAGEMENT FUNDING NEEDS

Given the age and condition of most of the state's dams, levees, and other flood management infrastructure, several studies have estimated that upgrading the existing system will cost many billion dollars above current expenditure levels. Developing such estimates is difficult, in part because no comprehensive statewide assessment defining specific risk—or the projects that would reduce that risk—exists. For example, the state has not defined what projects and level of expenditures would be necessary to prepare all regions for a 100-year or 200-year flood. What is clear is that the gap between existing spending levels and the expenditures that would be needed to significantly reduce the risk of flood damage across the state is substantial.

Below, we summarize the estimates contained in several flood-related reports for additional spending needed beyond current expenditures to address the state's flood risk. In most cases, these estimates were developed by aggregating lists of identified flood management projects created by local flood management agencies. Moreover, the studies do not specify what level of risk reduction

these additional expenditures would yield (such as protection against a 500-year flood). Both the publication dates for the reports and the time frames for their projected costs are somewhat different, which accounts for some of the variance in the estimates.

DWR and USACE—$52 Billion Statewide. The 2013 *California's Flood Future* report estimated costs of $52 billion for 836 flood management improvements and projects across the state that were in the planning or implementation stages. This estimate did not include a time frame for these expenditures. The report also estimated that additional funding of more than $100 billion might be needed to address flood risk that has not yet been comprehensively assessed and for which specific projects are not yet in the planning or implementation stages.

PPIC—$34 Billion Statewide Over 25 Years. The 2014 report, *Paying for Water in California*, combined appraisals from various sources to estimate that it would take $34 billion, or about $1.4 billion annually for 25 years, to implement identified flood risk reduction projects to reduce flood exposure in California. The report also included a cost-benefit analysis which found that "in some regions the avoided costs of private property damage are enough to justify the added expenditures on flood protection, but in others—notably, the Sacramento River, the North Coast, and possibly also the San Joaquin River regions—other benefits will likely be needed to justify these new investments."

American Society of Civil Engineers—$28 Billion Statewide Over Ten Years. In 2012, this group issued its quadrennial *Infrastructure Report Card*, and assigned the state's levees and flood control infrastructure a "D" grade. The authors estimated it would cost an additional $2.8 billion per year for ten years to bring statewide levees and flood control systems up to levels it determined would be safe enough to achieve a passing "B" Grade.

DWR—Around $20 Billion Over 30 Years for SPFC. The *Central Valley Flood Protection Plan 2017 Update*, prepared by DWR for adoption by the CVFPB—and still in public draft form when we published this report—developed a portfolio of prioritized systemwide capital improvements for the SPFC estimated to cost between $13 billion and $17 billion over 30 years. These include multi-benefit efforts that would also promote ecosystem improvements. The plan also calls for additional spending for the SPFC of around $5 billion spread over 30 years for ongoing annual activities such as planning, emergency management, and operations and maintenance.

KEY FLOOD MANAGEMENT CHALLENGES IN CALIFORNIA

As described throughout this report, flood management is a complicated and expensive undertaking in California, given the state's size, its extensive and aging infrastructure, the number of agencies involved, and the magnitude of its flood risk. In this section we highlight some of the key challenges confronting the state as it pursues more effective flood management approaches, which are summarized in Figure 10 (see next page). These are issues the Legislature will face as it seeks to develop additional policies and define budgetary priorities that effectively address California's flood risk.

Existing Infrastructure Is Many Years Old. Much of the state's extensive flood

Figure 10

Key Flood Management Challenges in California

- ✓ **Existing Infrastructure Is Many Years Old**
- ✓ **Infrastructure Not Always Designed to Meet Evolving Goals and Conditions**
- ✓ **Flood Management Needs Are Great, but Funding Is Limited and Inconsistent**
- ✓ **Certain Land Use Decisions Can Increase Flood Risk**
- ✓ **Involvement of Multiple Agencies Complicates Flood Management Efforts**

management infrastructure is aged and in need of improvements. Most of the dams and weirs in the state are at least 60 years old, and many levees—particularly in the Central Valley—were built over 100 years ago and not to modern design standards. Even well-designed flood infrastructure can become less effective over time—for example, as reservoirs fill with sediment behind dams (reducing their capacity) or as earthen levees erode under stress from river flows. As infrastructure ages, it faces a greater risk of malfunction and requires increasing maintenance and repair to remain effectual. Many have raised concerns that statewide maintenance practices—and funding—for flood infrastructure have not kept pace with these demands, contributing to the high estimated infrastructure costs cited in the previous section. For example, the state's *Central Valley Flood Protection Plan 2017 Update* asserts that operations and maintenance activities have been "chronically underfunded" for the SPFC. The recent damage at Oroville Dam highlights both the latent risk inherent in, as well as the state's critical dependence on, its aging infrastructure.

Infrastructure Not Always Designed to Meet Evolving Goals and Conditions. Most of the state's flood management infrastructure was developed in another era, which means much of it is not necessarily consistent with current statewide goals, scientific knowledge, or conditions. For example, narrow or concrete-lined river channels were designed to rapidly direct floodwaters to the ocean. However, this design disrupts the natural floodplain and riverine habitats upon which native fish depend. It also precludes some opportunities to increase water supply because it discharges flood or storm waters before they have the chance to infiltrate into groundwater basins.

Much of the existing system was also developed prior to more recent growth in statewide population and current development patterns, so it was not designed to protect newly developed areas. For example, certain segments of Central Valley levees were originally constructed to protect agricultural lands and could occasionally flood cropland without serious consequences. Those same levees now protect populated communities where similar occasional floods would yield significant damage. Scientific knowledge about earthquake fault lines and seismic risks has also progressed over the past several decades, raising concerns about how well structures such as dams meet current seismic engineering standards. For example, the San Francisco Public Utilities Commission is in the process of completely replacing the Calaveras Dam (straddling the Calaveras fault line in Alameda and Santa Clara Counties) to address serious seismic concerns, at an estimated cost of $810 million.

Moreover, the effects of a changing climate are placing new demands on the state's flood management system. The climate impacts that

scientists predict California will face include rising seas levels, more frequent king tides and storm surges, more frequent periods of drought, more precipitation falling as rain rather than snow, and the mountain snowpack melting more rapidly and earlier in the season. All of these changes have the potential to place increased stress on coastal development, seawalls, dams, levees, and channels that were not necessarily designed to withstand such conditions.

Flood Management Needs Are Great, but Funding Is Limited and Inconsistent. To meet these challenges, additional investments are required to both maintain and upgrade the existing flood management system. As noted earlier, studies have estimated associated costs to be in the tens of billions of dollars. Some of the identified funding needs represent one-time capital projects to upgrade existing infrastructure, while others require ongoing funding for more regular maintenance activities. However, generating funding for flood management activities can be challenging. Some of the key funding challenges include:

- ***Most State Funding Is From Bonds, Creating Difficulties for Meeting Ongoing Needs.*** Bond funds—the primary source the state has traditionally used for flood management activities—are available intermittently and therefore not appropriate for sustaining ongoing operations and maintenance costs. This creates challenges both for local agencies that depend on state grants for many of their activities, as well as for DWR to identify how to maintain its components of the SPFC.

- ***Local Funds Hard to Raise.*** Raising additional local funds for flood-related activities is complicated by certain state constitutional provisions. Proposition 13 (1978) prohibits local governments from raising additional ad valorem property tax revenue (except for voter-approved bond debt). Additionally, to assess a supplemental tax on a property to support flood-related activities, Proposition 218 (1996) can require the community to approve the tax by a two-thirds vote, which can be difficult to attain. Alternatively, a local jurisdiction can levy an assessment for flood-related activities with a lower vote threshold, however, this requires proving that flood projects explicitly benefit each property owner in direct proportion to how much he or she pays. Flood-related projects often provide diffuse benefits, including to downstream residents in other tax districts, making this requirement particularly complicated. Generating sufficient tax and assessment revenue is also challenging in many rural areas where the tax base is relatively small, making it difficult to spread out the cost of large levee projects.

- ***Funding Constraints Can Complicate Multi-Benefit Projects.*** Sometimes funding that *is* available for flood-related projects is restricted for meeting one particular outcome, making funding all the components of multi-benefit projects difficult. For example, both federal funding for USACE projects and local flood assessments typically can only be used to mitigate flood risk. Such funds often cannot be used for complementary efforts that might improve the ecosystem and provide additional habitat for fish and wildlife if they are not directly necessary for flood protection.

- ***Need for Flood-Related Investments Fades From Public Awareness Between Major Floods.*** Public support for flood-related

funding typically wanes and waxes depending on how recently a flood event has occurred. During extended periods without significant flood events, the need for investment and protection fades from public attention even though the risk has not changed. Generating sufficient public support for passing local assessments or statewide bonds can be difficult during these years, even though the best time to maintain and upgrade flood infrastructure is ahead of the next flood occurring. Flood insurance enrollment rates—the primary source of recovery funding for individuals and businesses—also decline during extended flood-free periods, which can exacerbate the impacts of damages when floods do inevitably occur.

Certain Land Use Decisions Can Increase Flood Risk. Both the state and local governments face challenges in determining how to balance flood risk with expanding population and development. As the state population grows, so too does the push to develop into new areas. This development can be both necessary to accommodate additional residents and generate additional tax and fee revenue for certain local jurisdictions. Development in flood-prone areas, however, increases the potential for flood damage. Even with structural protection such as levees in place, the residual risk of flooding remains, particularly in historic floodplains. While the state typically leaves land use decisions up to local governments, in some cases the state bears financial liability if a flood were to occur. For example, the state may be found responsible for damages caused by failures of SPFC levees, need to repair damage to state-owned infrastructure such as highways or buildings, or face pressure to pay a share of local government recovery costs through CDAA. Additionally, the state has an interest in protecting public safety. While the state implemented higher flood protection standards and some land use planning requirements in 2007, they only apply in certain areas of the Central Valley and are enforced at the local (not state) level, so are limited in both scope and effect.

Involvement of Multiple Agencies Complicates Flood Management Efforts. The overlapping and fragmented nature of flood-related responsibilities between various local, federal, and state governments can complicate flood management efforts, particularly for multi-benefit projects. Water-related activities can be assigned to various different local agencies within the same jurisdiction. As such, undertaking a project to capture and retain stormwater flows for future water supply, for example, could involve separate local government agencies that respectively have sewer, flood, groundwater, and drinking water responsibilities. Such coordination needs can make funding, permitting, overseeing, and implementing such a project difficult. Similarly, large flood management projects typically can involve attaining permits and approvals from multiple federal and state agencies, including state and regional water boards, federal and state fish and wildlife agencies, USACE, and CVFPB. There are even instances where these agencies impose permit requirements that contradict each other—for example, when USACE requires removal of vegetation or sediment from a levee or channel, but those conditions are providing habitat for protected fish and wildlife that the fisheries agencies prohibit disturbing.

In part due to the complication of involving multiple agencies, flood management projects can take many years to complete. For example, the recent construction of an auxiliary spillway at Folsom Dam took roughly 30 years to complete, beginning with flood concerns in 1986, to USACE conducting its first project feasibility study in

1991, to the spillway's anticipated completion in 2017. (Additional features of the project, including raising the dam and updating USACE's flood-release requirements, have yet to be completed.) This type of extended implementation timeline helps explain why ten years after voters approved Propositions 84 and 1E, only about 60 percent of the bond funding has yet been spent. While nearly all of the funding has been *committed* for specific projects, the projects are still underway and a significant share remains unspent. (The state typically funds projects on a reimbursement basis after actual costs have been incurred, and therefore generally does not sell bonds and provide funding to grantees until projects are at or near completion.)

CONCLUSION

Damage from storms in the winter of 2017 highlight the state's flood risk and vulnerability. After several years of drought, multiple series of wet storms resulted in instances of overflowing rivers and creeks, crumbling dam spillways, breaching levees, mudslides, and collapsing roads and highways. Moreover, scientists predict that such alternating extremely dry and extremely wet years will occur more frequently as the result of a changing climate, placing additional stress on the state's existing flood infrastructure. However, at the time this report was prepared, the aged statewide flood management system has also performed admirably well, with no catastrophic failures or widespread damages. The billions of dollars that local, federal, and state agencies have invested in flood-related efforts over the past years have borne benefits. Such efforts remain essential and ongoing—particularly given the costs and coordination challenges confronting the state as it seeks to better manage its flood risk.

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This report was prepared by Rachel Ehlers and reviewed by Brian Brown. The Legislative Analyst's Office (LAO) is a nonpartisan office that provides fiscal and policy information and advice to the Legislature.

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