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Abbreviations and Acronyms

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cfs	cubic feet per second
CVFPP	Central Valley Flood Protection Plan
DWR	California Department of Water Resources
FDRE	Flood Diversion and Recharge Enhancement
FIRO	Flood Informed Reservoir Operations
FEMA	Federal Emergency Management Agency
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
SPFC	State Plan of Flood Control
State	State of California
USACE	United States Army Corps of Engineers

Chapter 3 Flood Management

This chapter describes flood management facilities and challenges in the San Joaquin Valley. It begins with a summary of the regional setting and historical development of flood facilities; describes Federal, State, and local agencies involved in flood management; and summarizes existing and projected future flood risk. This is followed by a summary of flood management challenges and priorities identified for planning regions associated with the San Joaquin River through development of the Central Valley Flood Protection Plan (CVFPP). The CVFPP has a strong focus on flood risks, opportunities to improve the flood system performance, and regional planning of flood management in the Sacramento and the San Joaquin River hydrologic regions, but does not address the Tulare Lake Hydrologic Region. This chapter concludes with a description of flood management actions identified through the CVFPP and other efforts that have the potential to also provide water supply and ecosystem benefits in the San Joaquin Valley. Many of the opportunities identified for potential application in the San Joaquin River Hydrologic Region may also be applicable in the Tulare Lake Hydrologic Region.

Setting and Historical Context

The setting of the San Joaquin Valley makes it naturally prone to flooding. As described in Chapter 2, it is bound by the Sierra Nevada Mountains, Tehachapi Mountains, and Coastal Range, and receives significant runoff primarily through rivers and streams originating in the Sierra Nevada Mountains. In the San Joaquin River Hydrologic Region, the San Joaquin River historically lacked sufficient channel capacity to convey high flows as it drains towards the Delta. This resulted in frequent fooding and the formation of vast floodplains with swales, oxbows, and other features that created low-lying areas prone to inundation (USACE 1999). The Tulare Lake Hydrologic Region has been prone to frequent flooding because it is a closed basin where the major rivers and streams flow towards Tulare Lake (which was once the largest natural lake west of the Mississippi River), Buena Vista Lake, and Kern Lake. A portion of flood flows on the Kings River in the Tulare Lake Hydrologic Region are conveyed to the San Joaquin River Hydrologic Region.

Flooding in the San Joaquin Valley is driven by rainfall that typically occurs during winter months and snowmelt that typically occurs in spring and early summer months. The variability of intensity and timing of flooding in the San Joaquin Valley posed a significant challenge to development of farms and communities beginning in the mid-19th century. The first significant flood event post-European settlement was the Great Flood of 1861 and 1862. During this event, nearly the entire San Joaquin Valley floor was inundated which caused significant loss of life and economic hardship (Dowd 2022). During this same time, hydraulic mining also contributed to frequent flooding because it resulted in millions of cubic yards of earth being washed downstream and deposited into channels, further reducing conveyance capacity (USACE 1999). Other significant floods occurred every few years (USGS 1953; USACE 1999). The occurrence of these major flood

events influenced continuous development and reassessments of flood infrastructure and policy in the San Joaquin Valley, as well as in the Sacramento Valley and elsewhere in California.

Initial flood control efforts in San Joaquin Valley in the 19th century included construction of earthen levees to protect low-lying lands. Through a series of local, state and federal investments and policies, a network of weirs, bypasses, and flood control channels were constructed in the 20th century to direct flood flows away from farms and communities (USACE 1999). A summary of events and actions that drove the development of flood control infrastructure and management policies include:

- 1941 – the federal Flood Control Act of 1941 laid the groundwork for flood control projects across the United States, including significant efforts in California. It authorized civil engineering projects such as dams, levees, dikes, and other flood control measures to manage water flow and reduce flood risks.

- 1944 – the federal Flood Control Act of 1944 was the most significant federal authorization for construction of flood facilities in the San Joaquin Valley. It authorized the Lower San Joaquin River and Tributaries Project, which included constructing levees on the San Joaquin River below the Merced River, Stanislaus River, Old River, Paradise Cut, and Camp Slough. It also authorized construction of New Hogan Dam on the Calaveras River, New Melones Dam on the Stanislaus River, and federal costs for flood control toward the construction of Don Pedro Dam on the Tuolumne River. New Melones Dam was later reauthorized for construction under the Flood Control Act of 1962 (USACE 1999). The Flood Control Act of 1944 also authorized construction of Isabella, Success, Terminus, and Pine Flat Dams on rivers in the Tulare Lake Basin.

- 1955 – Following major flooding in 1955, the construction of levees and bypasses on the San Joaquin River upstream of the Merced River was authorized. The Chowchilla and Eastside Bypasses were also constructed during this time period by the State of California.

- 1962-63 – Congress authorized construction of Buchanan Dam on the Chowchilla River and Hidden Dam on the Fresno River, and Federal participation in the cost of New Exchequer Dam on the Merced River.

- 1968 – the National Flood Insurance Act of 1968 established the National Flood Insurance Program (NFIP), which provided federally backed flood insurance to property owners and introduced floodplain management standards. This program significantly influenced flood management practices in California by encouraging local governments to adopt zoning and land use policies that reduce flood risk.

- 1980s and 1990s – major flood events in 1983, 1986, 1995, and 1997 caused extensive damage in both the Sacramento River and San Joaquin River basins. These events raised concerns about the adequacy of the flood management systems and land use practices in flood-prone areas (USBR 2015).

- 2006 and 2007 – in the wake of continued flood risk, California voters approved two key measures: (1) Disaster Preparedness and Flood Prevention Bond Act of 2006, and (2) the Central Valley Flood Protection Act of 2008. These acts formally defined the Sacramento River and San Joaquin River Federal-State flood control projects as the State Plan of Flood Control (SPFC). They also required DWR to develop, and the Central Valley Flood Protection Board (CVFPB) to adopt, a CVFPP, which is a comprehensive strategy updated every five years. Unlike the SPFC, the CVFPP addresses flood risk across the entire watersheds of the Sacramento and San Joaquin valleys and includes land use planning requirements for local jurisdictions (USBR 2015; DWR 2022a; DWR 2022b).

- 2009 – the Delta Reform Act of 2009 was enacted to address water management challenges in the Sacramento–San Joaquin Delta. This legislation includes provisions to reduce flood risks by improving levee systems and integrating ecosystem restoration with flood management strategies.

Today, flow in almost all the major rivers in the San Joaquin Valley is regulated by dams and other flood control facilities. As described in Chapter 2, most dams and reservoirs on rivers in the San Joaquin Valley provide water supply and flood control benefits. Flood management facilities are operated in coordination between multiple local, state, and federal agencies.

In recent years, most investments in flood management have focused on repair and rehabilitation of facilities that were constructed in the 20th century (USACE 1999). The CVFPP, which is updated every five years and most recently in 2022, presents a coordinated strategy to improve flood management throughout the Central Valley (DWR 2022a).

Existing Conditions and Future Flood Risk

The history of flooding in the San Joaquin Valley has driven significant investment in the construction and maintenance of flood control infrastructure and the implementation of flood management policies. Areas of flood risk, referred to as "flood zones", are defined by the Federal Emergency Management Agency (FEMA). FEMA defines several types of flood zones and two primary categories are Special Flood Hazard Areas and Moderate Flood Hazard Areas. Special Flood Hazard Areas are defined by areas inundated by a flood event with a 1-percent chance of occurring in any given year. These areas are often described as 100-year floodplains, however it should be noted that the frequency of occurrence of a flood with a 1-percent chance of occurring can be greater than once in 100 years. Moderate Flood Hazard Areas (often referred to as the 500-year floodplains) are defined by areas inundated by a flood event with a 0.2-percent chance of occurring in any given year (FEMA 2020). Figure 3-1 shows the delineated 0.2-percent and 1-percent flood zones in the San Joaquin Valley, which include approximately 1 million people and $112 billion worth of structures (PPIC 2024).

Recent studies indicate that climate change could intensify flood events in the future (DWR 2024). This could put additional areas at risk of flooding and/or increase the flood risk of areas in the floodplains. This could stress flood control facilities as larger floods occur more frequently, which

further intensifies the need to address existing challenges with aging levees, subsidence induced capacity loss in channels, sedimentation in channels, and limited reservoir flood storage capacity (DWR 2017).

Flood Control Facilities

Managed flood control storage capacity has been designated for reservoirs on most major rivers in both the San Joaquin River Hydrologic Region and the Tulare Lake Hydrologic Region, and numerous leveed channels and bypasses have been developed. These facilities work in tandem to reduce peak flows (e.g., dams/reservoirs), convey high flows as they move downstream (e.g., levees), and/or route water away from the main channel (e.g. bypasses). A summary of authorized dedicated flood control storage capacity for the major reservoirs in the San Joaquin Valley is included in Table 2.1 in Chapter 2. Dedicated flood control storage capacity in reservoirs typically becomes effective in late fall months and remains in effect through winter months to manage rainfall inflows. As runoff transitions from rainfall to snowmelt during spring months, dedicated flood control capacity in reservoirs is reduced and the space is used for water storage.

Hundreds of miles of levees protect farms and communities throughout the San Joaquin Valley. Levees confine flood flows to the channel and have been used in the San Joaquin Valley since the 19th century. The State Plan of Flood Control (SPFC) is the State of California's state-federal flood management system. Federal authorizations of SPFC projects in the San Joaquin Valley began in 1944 and state authorizations began in 1955. Infrastructure under the SPFC is subject to stricter regulations and regular rehabilitation efforts (DWR 2022b). Not all floodways that are defined by levees are a part of the SPFC and thus the levee systems of the San Joaquin Valley work in conjunction with each other.

Flood bypass systems are used to route water away from the main channel, through control structures. Three major flood bypass channels have been constructed to convey flood waters in the San Joaquin Valley:

- The James Bypass diverts flood water from the north fork of the Kings River to Fresno Slough and Mendota Pool on the San Joaquin River. It has a design capacity of 4,750 cfs and is operated by the James Irrigation District.

- The Chowchilla Bypass diverts flood water from the San Joaquin River downstream from Friant Dam to the Fresno River and Eastside Bypass. It has a design capacity of 5,500 cfs and is managed by the Lower San Joaquin River Levee District.

- The Eastside Bypass diverts water from the Chowchilla River, Bear Creek and other tributaries to the San Joaquin River upstream of its confluence with the Merced River. It has a design capacity varying by reach from 17,500 cfs down to 14,400 cfs and it is also managed by the Lower San Joaquin River Levee District.

Flood Control Operations

Reservoir operations are governed by comprehensive documentation to meet authorized water supply and flood risk reduction purposes, and to manage operations during flood events. To ensure

that the flood management operation of each of the flood management projects will be as effective as possible, it is essential that the operating agency be continually advised of possible flood hazards, weather conditions, inflows to the project and upstream reservoirs, and flows in the system downstream from the project (USACE 1999).

The United States Army Corps of Engineers' (USACE) flood management decisions are based on the approved Water Control Plan from the Water Control Manual for each project. The Water Control Plan describes the specific operational rules for managing storage and releases day-to-day in order to fulfil its authorized purpose. The Water Control Manual includes the Water Control Plan and all supporting technical documentation (USACE 2018). The USACE also prepares and applies Water Control Manuals to direct operations of dedicated flood control space in non-USACE reservoirs with federally authorized flood control purposes. Non-USACE reservoirs that are not federally authorized for flood control manage for their authorized purposes and, to the extent possible, contribute to regional flood management objectives.

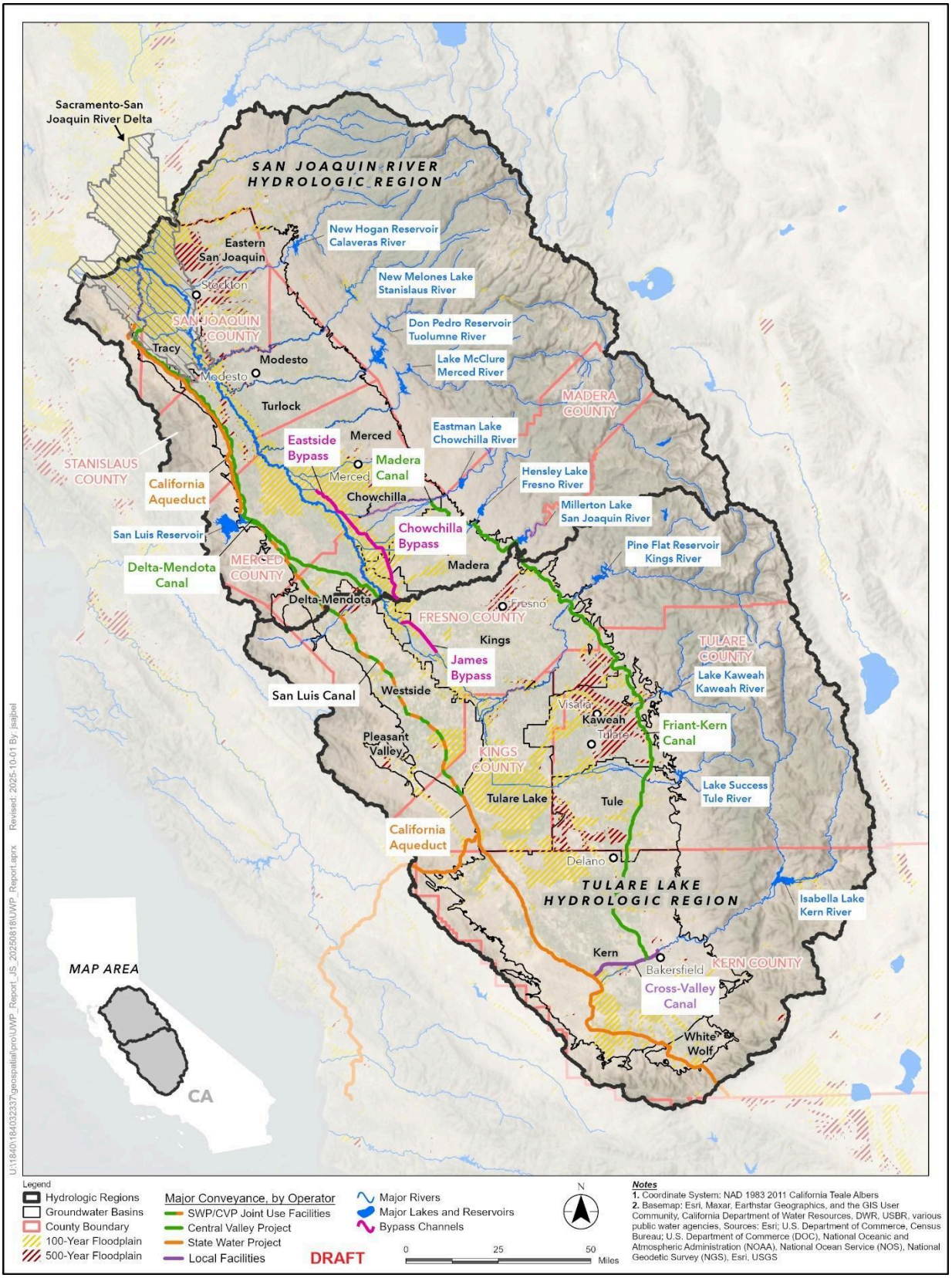

Sacramento-San Joaquin River Delta
SAN JOAQUIN RIVER HYDROLOGIC REGION
Eastern San Joaquin
New Hogan Reservoir
Calaveras River
New Melones Lake
Stanislaus River
Stockton
SAN JOAQUIN COUNTY
Don Pedro Reservoir
Tuolumne River
Tracy
Modesto
Lake McClure
Merced River
Turlock
MADERA COUNTY
Eastman Lake
Chowchilla River
Eastside Bypass
Merced
Madera Canal
STANISLAUS COUNTY
California Aqueduct
Hensley Lake
Fresno River
Chowchilla
Millerton Lake
San Joaquin River
San Luis Reservoir
Chowchilla Bypass
Pine Flat Reservoir
Kings River
Delta-Mendota Canal
MERCED COUNTY
Madera
Delta-Mendota
Fresno
FRESNO COUNTY
TULARE COUNTY
Kings
James Bypass
Lake Kaweah
Kaweah River
San Luis Canal
Westside
Visalia
Kaweah
Tulare
Friant-Kern Canal
Pleasant Valley
KINGS COUNTY
Lake Success
Tule River
Tulare Lake
Tule
California Aqueduct
Delano
TULARE LAKE HYDROLOGIC REGION
Isabella Lake
Kern River
MAP AREA
Kern
Bakersfield
KERN COUNTY
Cross-Valley Canal
White Wolf
CA
Legend
Hydrologic Regions
Groundwater Basins
County Boundary
100-Year Floodplain
500-Year Floodplain
Major Conveyance, by Operator
SWP/CVP Joint Use Facilities
Central Valley Project
State Water Project
Local Facilities
Major Rivers
Major Lakes and Reservoirs
Bypass Channels
DRAFT
N
0
25
50
Miles
Notes
1. Coordinate System: NAD 1983 2011 California Teale Albers
2. Basemap: Esri, Maxar, Earthstar Geographics, and the GIS User Community, California Department of Water Resources, DWR, USBR, various public water agencies, Sources: Esri; U.S. Department of Commerce, Census Bureau; U.S. Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA), National Ocean Service (NOS), National Geodetic Survey (NGS), Esri, USGS

Figure 3-1: Flood Zones and Facilities in the San Joaquin Valley

Flood Management Agencies

Flood management in the San Joaquin Valley involves a collaborative effort among various agencies and organizations to mitigate flood risks and protect communities and farmland. The federal, state, and local agencies primarily responsible for flood management in the San Joaquin Valley are:

- Federal Agencies:
    - The USACE constructs and maintains flood control infrastructure such as levees, dams, and reservoirs. The USACE has emergency authority to fight floods to protect life and property and to rehabilitate federal flood management facilities that are maintained by State and local entities (Reclamation 2015).
    - FEMA provides funding and support for flood risk reduction projects and emergency response during flood events.
- State Agencies:
    - The California Department of Water Resources (DWR) is responsible for statewide flood management planning and coordination. DWR's Division of Flood Management was established in 1977. DWR works to prepare for and manage floods including planning, risk management, emergency response, flood system operation and maintenance, and flood risk reduction (DWR 2022a).
    - The Central Valley Flood Protection Board was established to control flooding along the Sacramento and San Joaquin rivers and their tributaries, in cooperation with the USACE. The Central Valley Flood Protection Board establishes, maintains, and enforces standards for the construction, maintenance, and operation of the flood control system to protect life, property, and habitat in California's Central Valley (DWR 2022a). The Board coordinates State entities, local flood risk control agencies and the federal government to minimize damages from floods in California's Central Valley and is the non-federal sponsor for federal flood control projects in the State Plan of Flood Control. The Board serves as a public forum for flood risk reduction policy in the Central Valley and is responsible for adopting updates to the Central Valley Flood Protection Plan every five years.
- Local Agencies
    - Local agencies, such as county flood control districts and water agencies, are responsible for implementing flood management projects at the local level. These agencies work to maintain and improve flood control infrastructure, conduct floodplain mapping, and develop emergency response plans. As an example, the San Joaquin Area Flood Control Agency provides flood protection for the City of Stockon and surrounding areas.

- The Lower San Joaquin Levee District (LSJLD) was created in 1955 by a special act of the State Legislature to operate, maintain, and repair levees, bypasses, and other facilities built in connection with the Lower San Joaquin River Flood Control Project (Reclamation 2015). The district encompasses approximately 108 river miles, 190 miles of levees, across 468 square miles (300,000 acres) in Fresno, Madera, and Merced counties. LSJLD is responsible for operation, maintenance and emergency management of State flood control facilities within the district boundaries. The LSJLD is not responsible for operation and maintenance of privately owned levees. Operations and maintenance activities include vegetation management activities, sediment management and removal activities, cleaning of screens and trash racks on facilities, opening and closing gates and flap gates in the bypass systems, and flood watch. Important facilities maintained by the district include the Chowchilla Bypass, the Eastside Bypass, and the Mariposa Bypass which connects the Eastside Bypass to the San Joaquin River.

- In addition to the local agencies, community members contribute to flood planning and management by participating in public meetings, providing input on flood management plans, and taking proactive measures to protect their properties from flooding.

Central Valley Flood Protection Plan for the San Joaquin Valley

The CVFPP is jointly developed by DWR and the CVFPB to prepare for and reduce flood impacts using methods that are strategic and achieve wide community support. These plans are updated every five years and identified projects are implemented as funding becomes available. The most recent update was completed in 2022 (DWR 2022a).

In developing the CVFPP and recent updates, DWR focuses on three different planning areas in the San Joaquin Valley: the Upper San Joaquin River Region, the Mid San Joaquin River Region, and the Lower San Joaquin River Region (Figure 3-2). The Central Valley Flood Reduction Act of 2008 requires urban areas in the Central Valley to provide a higher standard of protection than the federal standards (PPIC 2024).

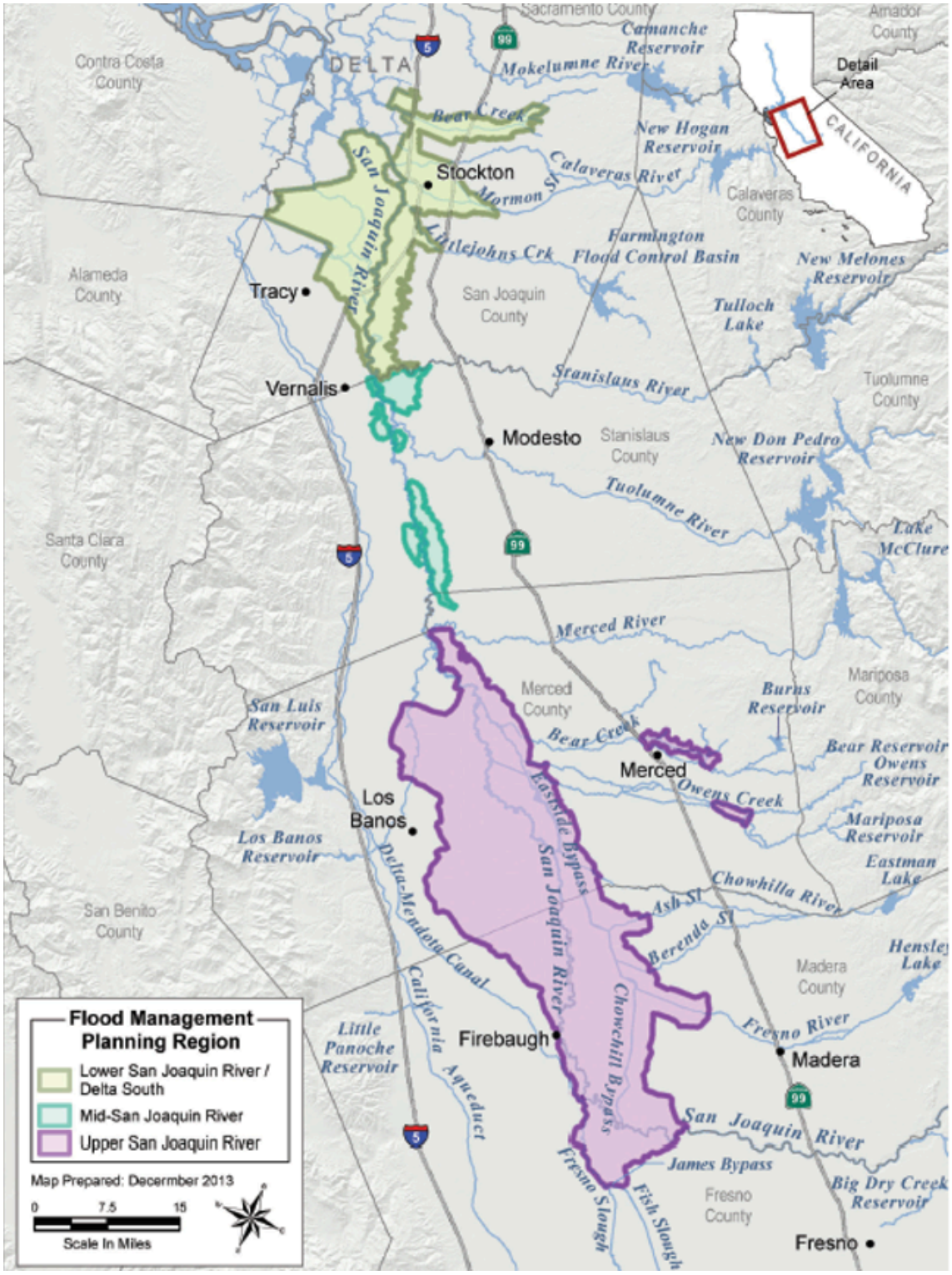
Regional Flood Management Plans

Following the adoption of the 2012 CVFPP, DWR funded three regional flood management plans (RFMPs) in the San Joaquin Valley. The RFMPs identify and describe region-specific priorities and challenges, identify projects and management actions that inform CVFPP updates, and offer valuable insight from the perspective of local and regional flood management groups, landowners, stakeholders, and community groups. RFMPs help support DWR in planning efforts across the Central Valley, align with CVFPP goals, inform CVFPP's investment strategy, and provide an important foundation for regional and local engagement.

The extent of the Upper San Joaquin, Mid San Joaquin, and Lower San Joaquin regions are shown on Figure 3-2. The CVFPP describes several challenges associated in regional flood management

planning, including complex regulatory compliance and permitting requirements for projects and operation and maintenance, limited funding, and the presence of numerous rural and disadvantaged communities within floodplain areas. In consideration of these challenges, the CVFPP identified the following priorities that are common to all regional flood management plans in the San Joaquin Valey:

- Restore flood system to original design capacity or increasing capacity, where feasible, through levee and other infrastructure improvements
- Improve infrastructure that provides flood protection to small communities.
- Implement multi-benefit actions to increase climate resilience and address subsidence
- Apply Forecast Informed Reservoir Operations (FIRO)
- Implement groundwater recharge projects, including Flood Managed Aquifer Recharge (Flood-MAR).
- Implement ecosystem restoration projects.
- Improve operations and maintenance.
- Expedite permitting and construction of flood protection infrastructure improvements
- Improving climate change analyses and planning at an integrated systemwide scale
- Improve emergency response
- Preserve the unique and historical character of agricultural communities.



Source: DWR (2017), Figure 1-1

Figure 3-2: San Joaquin River Basin Flood Management Planning Regions

Upper San Joaquin River Flood Planning Region

The Upper San Joaquin River region covers approximately 660 square miles of floodplain associated with the San Joaquin River, from Gravelly Ford to the confluence of the Merced River. Major tributaries within include the Fresno River; Ash and Berenda sloughs; and Black Rascal, Owens, and Bear creeks. One third of the region is native vegetation and riparian habitat with contiguous wetland complexes.

Land use in the region is predominantly productive agricultural land. Urban areas include the City of Merced, with a population of 83,000 and several smaller communities, including Mendota, Firebaugh, Franklin-Beachwood, and Dos Palos among others. More than 10 communities in the area are classified as disadvantaged communities.

Flood management planning in the Upper San Joaquin River region is coordinated by the San Joaquin River Flood Control Project Agency, a Joint Powers Authority (JPA) formed to represent local interests. It is composed of: Lower San Joaquin Levee District, San Joaquin River Exchange Contractors Water Authority, and Merced County, which provides auditor/controller services.

Challenges and Priorities

Flood infrastructure in the Upper San Joaquin River region suffers from damage and diminishing capacity, lack of funding for maintenance and repairs, and increasing maintenance and repair costs. About 192 miles of SPFC levees and critical flood facilities in the region have been deauthorized and are now ineligible for assistance. In consideration of these challenges, the following priorities for flood management were identified in the CVFPP:

- Restore federal authorization for the San Joaquin River Flood Control Project making the Lower San Joaquin Levee District eligible for PL 84-99 federal disaster and rehabilitation funding.
- Increase or restore flood system conveyance capacity.
- Provide 200-year flood protection for City of Merced.
- Provide 100-year flood protection for small communities of Franklin-Beachwood, Firebaugh, and Dos Palos.
- Modify or remove levees from the SPFC.

Mid San Joaquin River Flood Planning Region

The Mid San Joaquin River region comprises six non-continuous floodplain areas along the San Joaquin River between the Merced and Stanislaus Rivers within Stanislaus and Merced counties . Major tributaries include the Merced and Tuolumne rivers. The region is a network of connected floodplains and waterways managed by SPFC and non-SPFC facilities.

More than 500,000 people reside within the region, which is primarily rural and agricultural; Modesto is the region's largest city. The region does not have a regional flood management agency.

Challenges and Priorities

Levee systems in the Mid San Joaquin River Region are unable to safely convey design flows. Improvements to non-continuous SPFC and non-SPFC facilities require close coordination. Multiple Reclamation Districts lack the ability to comply with state inspection standards due, in part, to insufficient funding to maintain flood system facilities. Some Reclamation Districts have expressed a desire to remove levees from the SPFC. In consideration of these challenges, the following priorities for the Mid San Joaquin River Region were identified in the CVFPP:

- Improve engagement with, and flood protection for, disadvantaged communities
- Develop a pilot project for levee reclassification to remove levees from the SPFC
- Developing a State-federal partnership to acquire land or flowage easements in the San Joaquin River floodplain.
- Identify and implement groundwater recharge opportunities.

Lower San Joaquin River Flood Planning Region

The Lower San Joaquin River region covers approximately 260 square miles of floodplain of the San Joaquin River the Calaveras rivers immediately upstream from the legal Delta. The region extends along the mainstem of the San Joaquin River from the Stanislaus River to Bear Creek and includes the tributaries French Camp Slough and the Calaveras River.

Land use in the region includes rapidly developing urban areas and rural-agricultural areas. The region's urban population is approximately 400,000, accounting for approximately 25% of the land area. The largest urban area is the City of Stockton, and large portion of this region is designated as disadvantaged communities or severely disadvantaged communities.

Flood planning for the region is coordinated by the San Joaquin Area Flood Control Agency (SJAFCA) for the entire region. SJAFCA serves to reduce and manage flood risk and will support other agencies that deliver flood risk management services. Local flood management facilities are managed and maintained by 29 reclamation districts and by the San Joaquin County Flood Control and Water Conservation District.

Challenges and Priorities

Flood management challenges in the Lower San Joaquin River Region include operations and maintenance challenges of current levee systems, capacity to raise local revenue for project construction and maintenance; evolving and increasingly strict standards for levee maintenance, a need for planning resilient projects; and refining the USACE Lower San Joaquin River Project to reduce costs and minimize impacts. In consideration of these broad challenges, the following priorities for the Lower San Joaquin River Region were identified in the CVFPP:

- Provide 200-year flood protection for Mossdale Tract.
- Secure local financing to fund capital improvement projects and support O&M activities.

- Implement the USACE Lower San Joaquin River Project.
- Implement Mormon Slough bank repair and channel restoration projects.
- Initiate and advance recommendations from identified feasibility-level studies.
- Improve flood emergency preparedness and response.

Flood Management Opportunities

A wide range of actions that can reduce flood risk and improve flood management have been identified through the CVFPP and other planning efforts. This section briefly describes flood management actions that have the potential to also provide water supply and/or ecosystem enhancement benefits. Actions include land use management practices in upper watersheds, diversion of flood water from stream channels, modifications to reservoir flood management rules, increased capacity of designated floodways, and development of additional surface water storage capacity. These flood control strategies, and their ability to contribute to water supply and ecosystem enhancement benefits, are described below.

Land Use Modification in Upper Watersheds

Forest management practices in upper watersheds can help enhance water retention, stabilize soils, slow runoff, and minimize debris runoff. Avoiding or minimizing disturbances in forested headwaters of river basins help maintain the capacity of forests to attenuate flood flows during high flow events by slowing the rate of runoff. Forest management practices that prevent or minimize wildfires by reducing fuel loads and improve forest health and create resilient landscapes (USFWS 2025). Minimizing burned areas can reduce fire debris inflow into streams and reservoirs during flood events. Reestablishing meadows within river basins creates natural retention of flood flows. Meadows that are shallow, meandering, and contain impervious features such as logs or rocks naturally slow water, allowing water to infiltrate and slow its movement through the watershed (USFWS 2020). Reducing inflow to reservoirs improves management of inflow and can help reduce the frequency and magnitude of flood releases, thereby improving the management of water supply, while improving ecosystem condition in upper watershed areas.

Diversion of Water from Rivers and Streams During High Flow Conditions

Diversion of flood flows from rivers and streams during high flow conditions can reduce flood stage at downstream locations and provide flood risk reduction benefits. In the San Joaquin Valley, water diverted from rivers and streams can be used to replenish groundwater using a variety of techniques (on-farm application, recharge basins, percolation through stream channels, injection wells, etc.,). Diversion of flood water from the Kings River can contribute to reduced flows from the Kings River to the San Joaquin River and also contribute to reducing flood risk in San Joaquin Valley Flood Planning regions. Diverted flood waters can also be routed to regional and statewide conveyance facilities, such as the Friant-Kern Canal, Delta-Mendota Canal, San Luis Canal, the Kern River Intertie, and the California Aqueduct. The use of these regional conveyance facilities to intercept

and convey flood flows increases the management of water supplies for delivery to areas both within and outside of the San Joaquin Valley.

California Water Code Section 1242.1 was codified to allow for temporary diversion of flood flows for the benefit of groundwater recharge if certain conditions are met. DWR's Flood Diversion and Recharge Enhancement (FDRE) Initiative is working to create incentives and streamline the process for temporary diversions of flood flows on river systems in the San Joaquin Valley, and beyond, with the aim of increasing diversion for the benefit of recharge.

Modification of Reservoir Flood Storage Operations

Modification of reservoir flood storage rules can improve real time decision making on the management of water during wet hydrologic periods. All major reservoirs in the San Joaquin Valley have rules that specify required flood storage capacity to be preserved during the winter and spring to accommodate flood flows and operational requirements to release water from flood storage. Climate change studies project increased precipitation as rainfall, rather than snow, and come earlier in the year. Resulting changes in the magnitude of inflow for specified return-frequency flood events may reduce the effectiveness of existing flood management rules to provide expected levels of flood protection.

Improvements in weather forecasting and the application of more dynamic decision making can allow adaptive management of reservoir operations to improve the flood management and provide water supply benefits. Forecast-Informed Reservoir Operations (FIRO) is a management strategy that uses data from watershed monitoring and modern weather and water forecasting to help water managers selectively retain or release water from reservoirs in a manner that reflects current and forecasted conditions. This allows water managers to better balance flood control, water supply, and environmental needs by retaining water when a storm is small and releasing it strategically ahead of a larger storm to reduce flood risk and also using available storage to capture more water in reservoirs.

FIRO relies on more accurate and longer-range weather forecasts, including those for atmospheric rivers, to predict precipitation and water inflows. Instead of following rigid, historically based rules, It creates a linkage between research, applications, technology, reservoir operations and water control manuals to enable continuous improvement based on state-of-the-science to enable operators to adapt their actions based on real-time and future forecast data. FIRO allows water to be retained in the reservoir when forecasts indicate low projected precipitation, which can be released in a controlled manner to make space for more significant incoming storms. This helps capture more water for supply during dry periods.

FIRO has the potential to optimize reservoir management to achieve multiple goals. Flood control can be improved by making proactive water releases prior to forecasted flood events, which enables reservoirs to capture more inflow and release less flood flow to downstream areas. Water supplies can be increased through the delivery of pre-evacuated reservoir storage for ground recharge and subsequent capture and storage of water during flood events For example, DWR and Merced Irrigation District recently completed the Merced River Watershed Flood-MAR Reconnaissance Study which identified FIRO as a key strategy for improving water management and highlighted the benefits of increased groundwater storage in the watershed (DWR 2024). River ecosystem

conditions can be enhanced through improved management in the timing and volume of releases for ecosystem needs. Conversely, during periods when less precipitation is forecasted, water could be held in storage within designated flood space while minimizing the risk of potential flood spills.

Increasing Conveyance Capacity of Designated Floodways

Increasing conveyance capacity of designated floodways includes the restoration and expansion of the existing built flood system of bypasses as well as the expansion of floodplains. Historically the conventional strategy for managing flood has been to build levees along rivers to narrowly contain and convey flood flows. But rivers in their natural state continually evolve - depositing sediment, cutting into banks, and changing course as they meander downstream, connecting to floodplains. Actions to increase conveyance capacity of floodways should also consider integrating with associated floodplains to realize the ecosystem benefits associated with highly productive shallow water habitat for fish and nutrients for riverine ecosystems.

Achieving a balance between future water supplies and demands, as discussed in Chapter 2, may involve retiring agricultural lands, creating an opportunity to repurpose land in historic flood plains. Increasing floodplain areas in the San Joaquin Valley would provide ecosystem benefits by improving habitat and water quality, while providing flood management benefits and potentially increase groundwater replenishments.

Like many of the conveyance facilities throughout the San Joaquin Valley, many flood bypass facilities are aging and investments to maintain and update the system have not kept pace with the needs. In addition, some floodways and bypasses have been affected by differently land subsidence, thereby reducing their water conveyance effectiveness. Restoring the design conveyance capacity of these systems would maintain their ability to manage flood flows and reduce risks to communities on or near these rivers and streams.

Development of Additional Surface Water Storage

The development of additional surface water storage can be achieved by expanding transitory storage in the Valley as well as expansion or development of water storage on existing river systems. Transitory storage refers to temporary surface storage of water, generally within historical floodplain locations, until it can be used at a later time meet water demands, delivered to groundwater storage, or released to river systems after flood flows have dissipated. While not suitable for long term storge in the San Joaquin Valley due to high evaporation loses, transitory storage can provide strategic opportunities for regulating surface water, reducing flood damages, and providing ecosystem benefits.

Several transitory storage projects have been proposed in Groundwater Sustainability Plans, particularly in areas not well-suited to groundwater recharge through percolation. The expanded use of transitional storage in key areas of the San Joaquin Valley, such as in and around Tulare Lake, offer unique opportunities to achieve multiple benefits. Increasing the capacity of storage along the rivers and streams throughout the San Joaquin Valley can improve the ability to manage inflows during wet hydrologic periods.

Reservoir modifications, such as the recently completed Tule River Spillway Enlargement Project, increased the capacity of Lake Success on the Tule River by 28,000 acre-feet. This project enhanced flood risk management, increased water storage for irrigation use, and increased recreational opportunities.

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