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Regional Reports

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Contents

Tables

Figures

Boxes

Acronyms and Abbreviations Used in This Report

µg/L	micrograms per liter
af	acre-feet
af/yr.	acre-feet per year
AB	Assembly Bill
ACWA	Association of California Water Agencies
AGR	agricultural supply
CABY	Cosumnes, American, Bear, and Yuba region
CAFO	concentrated animal feeding operation
CASGEM	California Statewide Groundwater Elevation Monitoring
CDFA	California Department of Food and Agriculture
CDP	Census Designated Place
CDPH	California Department of Public Health
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CVFPP	Central Valley Flood Protection Plan
CVJV	Central Valley Joint Venture
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CV-SALTS	Central Valley Salinity Alternatives for Long-Term Sustainability
CWA	Clean Water Act
CWC	California Water Code
CWI	California Water Institute
CWP	California Water Plan
DAC	disadvantaged community
DBCP	1,2-Dibromo-3-chloropropane
DBP	disinfection by-products
Delta	Sacramento-San Joaquin River Delta

DFW	California Department of Fish and Wildlife
DMC	Delta-Mendota Canal
DPR	Department of Pesticide Regulation
DWR	California Department of Water Resources
EBMUD	East Bay Municipal Utility District
ECCC	East Contra Costa County
ECWMA	East County Water Management Association
EFT	environmental flow target
EI	energy intensity
EPA	U.S. Environmental Protection Agency
ESRWMP	East Stanislaus Regional Water Management Partnership
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
Framework	Framework for the Implementation of Water Planning
FWUA	Friant Water Users Authority
GAMA	Groundwater Ambient Monitoring and Assessment
GBA	Northeastern San Joaquin County Groundwater Banking Authority
GBR	Governing Board Representatives
GCM	global climate model
GHG	greenhouse gas
GIS	geographic information system
gpcd	gallons per capita per day
gpm	gallons per minute
GPS	global positioning system
GWMP	groundwater management plan
GWR	groundwater recharge
HCP	habitat conservation plan
HIP	high population scenario

ILRP	Irrigated Lands Regulatory Program
InSAR	Interferometry Synthetic Aperture Radar
IRWM	integrated regional water management
IRWM plan	integrated regional water management plan
IWM	integrated water management
LLNL	Lawrence Livermore National Laboratory
LOP	low-population growth scenario
maf	million acre-feet
MAC	Mokelumne-Amador-Calaveras region
MAGPI	Merced Area Groundwater Pool Interests
MCL	maximum contaminant level
MHI	median household income
MHMP	multi-hazard mitigation plan
MOA	memorandum of agreement
MOU	memorandum of understanding
MUN	municipal and domestic supply
NCCP	Natural Community Conservation Plan
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
OHV	off-highway vehicle
OWTS	onsite wastewater treatment systems
PA 601	Upper West Side Uplands Planning Area
PA 602	San Joaquin Delta
PA 603	Eastern Valley Floor Planning Area
PA 604	Sierra Foothills Planning Area
PA 605	West Side Uplands Planning Area
PA 606	Valley West Side Planning Area
PA 607	Upper Valley East Side Planning Area

PA 608	Middle Valley East Side Planning Area
PA 609	Lower Valley East Side Planning Area
PA 610	East Side Uplands Planning Area
PBO	Plate Boundary Observatory
PCE	tetrachloroethylene
PGC	planning grant committee
ppm	parts per million
RAC	Regional Advisory Committee
RAP	Region Acceptance Process
ROD	Record of Decision
RPC	Regional Participant Community
RWA	Regional Water Authority
RWMG	regional water management group
RWQCB	regional water quality control board
SAFCA	Sacramento Area Flood Control Agency
San Luis Canal	San Luis Unit Project
SB	Senate Bill
SB X7-7	Water Conservation Act of 2009
SEWD	Stockton East Water District
SJAFCA	San Joaquin Area Flood Control Agency
SJRFP	San Joaquin River Flood Protection
SJRRP	San Joaquin River Restoration Program
SJVR	San Joaquin Valley Regional
SPFC	State Plan of Flood Control
SSJID	South San Joaquin Irrigation District
State Parks	California Department of Parks and Recreation
SWP	State Water Project
SWRCB	State Water Resources Control Board

Sy	specific yield
taf	thousand acre-feet
taf/yr.	thousand acre-feet per year
TAS	treatment-in-a-manner-similar-to-a-State
TCE	trichloroethylene
TMDL	total maximum daily load
UAIC	United Auburn Indian Community of the Auburn Rancheria
UMRWA	Upper Mokelumne River Watershed Authority
UNAVCO	university-governed consortium for geosciences research using geodesy
Update 2013	California Water Plan Update 2013
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VAMP	Vernalis Adaptive Management Program
WRCC	Western Regional Climate Center

San Joaquin River, near Fresno, CA.
Originating near the 14,000-foot crest of the Sierra Nevada, the river winds northwest across the San Joaquin Valley floor toward the Delta. Planning for restoration of the San Joaquin River system addresses flood protection, water quality and supply, wildlife, fisheries, and recreation. Here, the river passes near the Chowchilla Bifurcation Structure; reoperation of the structure is being investigated as part of the river restoration effort.

San Joaquin River Hydrologic Region

San Joaquin River Hydrologic Region Summary

The San Joaquin River Hydrologic Region remains one of the largest agricultural regions in California with irrigated acreage increasing slightly from 2005 to 2009, at the same time that overall water supplies declined. The 2007-2009 drought caused reduced surface water supplies, leading to increased groundwater pumping. Agricultural groundwater use increased from a little more than 1.6 million acre-feet (maf) in 2005 to more than 3.2 maf in 2009. Nonetheless, agricultural values increased from 2005 to 2008, declined somewhat in 2009, but bounced back in 2010. Furthermore, the urban population continues to grow, gaining 5 percent from 2005 to 2010. While agriculture is a stable economic sector, disadvantaged communities (DACs) still exist in the region, with four of the most populous cities in the region also qualifying as DACs: Stockton, Merced, Lodi, and Madera. To address the issues of lower water supplies and higher demands, as well as attempt to ameliorate water problems for DACs, local stakeholder groups are accelerating their use of resource management strategies via integrated regional water management group efforts.

Current State of the Region

Setting

The San Joaquin River Hydrologic Region is in California's great Central Valley and is generally the northern portion of the San Joaquin Valley. The region is south of the Sacramento River Hydrologic Region and north of the Tulare Lake Hydrologic Region (Figure SJR-1). The region includes approximately half of the Sacramento-San Joaquin River Delta (the Delta) — those areas that are in Contra Costa, Alameda, and San Joaquin counties. The region also contains portions of Alpine, Amador, Benito, El Dorado, Fresno, Sacramento, and San Joaquin counties; and all of Calaveras, Madera, Mariposa, Merced, Stanislaus, and Tuolumne counties.

The hydrologic region is bordered on the east by the Sierra Nevada and on the west by the coastal mountains of the Diablo Range. It includes all of the San Joaquin River drainage area extending south from the southern boundaries of the Delta to include the headwaters of the San Joaquin River in Madera County and its southern drainage in Fresno County. The region is hydrologically separated from the Tulare Lake Hydrologic Region by a low broad ridge that extends across the San Joaquin Valley between the San Joaquin and Kings rivers.

At roughly 300 miles long, the San Joaquin River is one of the state's longest rivers. The upper San Joaquin River has an average annual unimpaired runoff of approximately 1.8 maf, and its eight major tributaries drain about 32,000 square miles of watershed. The headwaters of the San Joaquin River begin near the 14,000-foot crest of the Sierra Nevada. The river flows from the western slope of the Sierra Nevada and turns northwestward on the San Joaquin Valley floor toward the Delta where it meets the Sacramento River. The two rivers converge in the Delta, which encompasses an area of more than 1,300 square miles. The Delta is a series of islands formed by a maze of channels receiving freshwater inflow from its major tributaries; smaller streams; and the Cosumnes, Mokelumne, and Calaveras rivers. Historically, more than 40 percent

Figure SJR-1 San Joaquin River Hydrologic Region

of the state's annual runoff flows to the Delta via the Sacramento, San Joaquin, and Mokelumne rivers. (See more information in the Sacramento-San Joaquin Delta Regional Report in Volume 2).

Watersheds

The San Joaquin River is the principal river of the region, and all other streams of the region are tributary to it (see Figure SJR-2). The Mokelumne River and its tributary, the Cosumnes River, originate in the central Sierra Nevada, along with the more southern Stanislaus and Tuolumne rivers. The Merced River flows from the south central Sierra Nevada and enters the San Joaquin River near the City of Newman. The Chowchilla and Fresno rivers also originate in the Sierra Nevada south of the Merced River and trend westward toward the San Joaquin River. Creeks originating in the Coast Ranges and draining eastward into the San Joaquin River include Del Puerto Creek, Orestimba Creek, and Panoche Creek. Del Puerto Creek enters the San Joaquin River near the City of Patterson, and Orestimba Creek enters north of the City of Newman. During flood years, Panoche Creek may enter the San Joaquin River or the Fresno Slough near the town of Mendota. The Kings River is a stream of the Tulare Lake Hydrologic Region; but in flood years it may contribute to the San Joaquin River, flowing northward through the James Bypass and Fresno Slough to enter near the City of Mendota. The Mud, Salt, Berrenda, and Ash sloughs also add to the San Joaquin River. Numerous lesser streams and creeks also enter the system, originating in both the Sierra Nevada and the Coast Ranges. The entire San Joaquin River system drains northwesterly through the Delta to Suisun Bay.

Groundwater Aquifers and Wells

Groundwater resources in the San Joaquin River Hydrologic Region are supplied by both alluvial and fractured rock aquifers. Alluvial aquifers are composed of sand and gravel or finer grained sediments, with groundwater stored within the voids, or pore space, between the alluvial sediments. Fractured-rock aquifers consist of impermeable granitic, metamorphic, volcanic, and hard sedimentary rocks, with groundwater being stored within cracks, fractures, or other void spaces. The distribution and extent of alluvial and fractured-rock aquifers and water wells vary within the region. A brief description of the aquifers for the region is provided below.

Alluvial Aquifers

The San Joaquin River Hydrologic Region contains 11 alluvial groundwater basins and subbasins recognized under *Bulletin 118* Update 2003 by the California Department of Water Resources (DWR). They underlie approximately 5,800 square miles, or 38 percent of the region. Most of the groundwater in the region is stored in alluvial aquifers. Figure SJR-3 shows the location of the alluvial groundwater basins and subbasins. Table SJR-1 lists the associated names and numbers. Pumping from the alluvial aquifers in the region accounts for about 19 percent of California's total average annual groundwater extraction. The most heavily used groundwater basins in the region include the seven subbasins within the northern San Joaquin Valley groundwater basin — Eastern San Joaquin, Modesto, Turlock, Merced, Chowchilla, Madera, and Delta-Mendota groundwater basins. The basins account for more than 90 percent of the average 3.2 maf of groundwater pumped annually during the 2005-2010 period. The two remaining groundwater basins within the San Joaquin Valley, Tracy and Cosumnes, account for the rest of the groundwater supply in the region. Groundwater wells in the San Joaquin Valley extend to depths

Figure SJR-2 San Joaquin River Hydrologic Region Watersheds

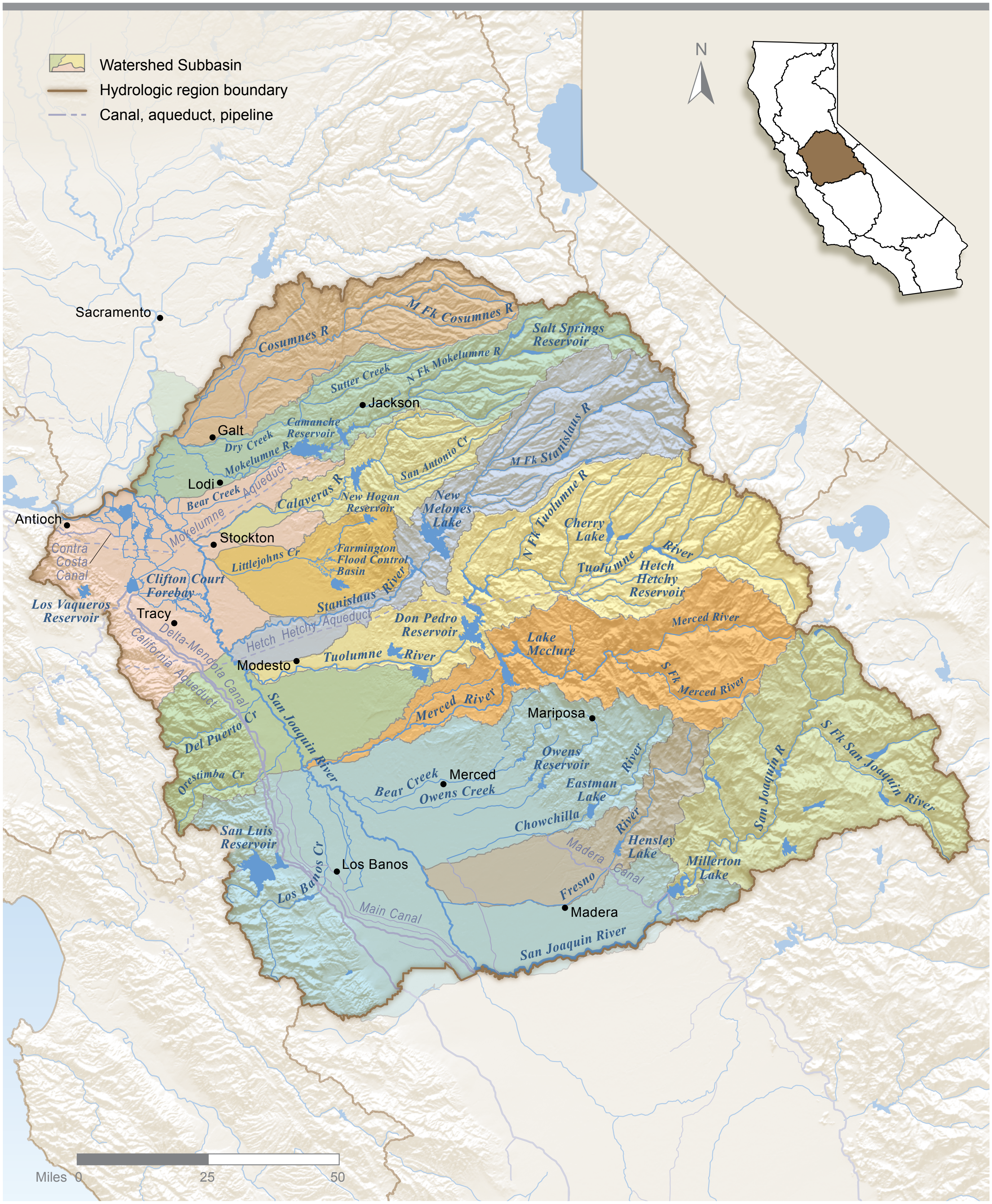


Figure SJR-3 **Alluvial Groundwater Basins and Subbasins within the San Joaquin River Hydrologic Region**

Table SJR-1 Alluvial Groundwater Basins and Subbasins within the San Joaquin River Hydrologic Region

Basin/Subbasin		Basin Name
5-22		San Joaquin Valley
	5-22.01	Eastern San Joaquin
	5-22.02	Modesto
	5-22.03	Turlock
	5-22.04	Merced
	5-22.05	Chowchilla
	5-22.06	Madera
	5-22.07	Delta-Mendota
	5-22.15	Tracy
	5-22.16	Cosumnes
5-69		Yosemite Valley
5-70		Los Banos Creek Valley

of more than 1,000 feet (Page 1986). Based on a series of irrigation pump tests, groundwater pumping rates in the various subbasins were determined to range from about 650 gallons per minute (gpm) to about 1,500 gpm (Burt 2011).

The two alluvial basins outside the San Joaquin Valley are Yosemite Valley, managed by the U.S. National Park Service, and Los Banos Creek Valley, where no known wells appear to exist based on a review of well completion reports.

Fractured-Rock Aquifers

Fractured-rock aquifers are typically found in the mountain and foothill areas adjacent to the Cosumnes, Eastern San Joaquin, Modesto, Turlock, Merced, and Madera groundwater basins. Due to the highly variable nature of the void spaces within fractured-rock aquifers, wells drawing from fractured-rock aquifers tend to have less capacity and less reliability than wells drawing from alluvial aquifers. On average, wells drawing from fractured-rock aquifers yield less than 10 gpm. There are notable exceptions, with deep wells (900 to 1,000 feet) producing yields of more than 100 gpm from fractured rock. In unweathered rock, about 5 to 15 percent of the wells have median yields of less than 8 gpm; 10 percent have yields of 50 gpm or more (Davis and Turk 1964).

Although fractured-rock aquifers are less productive compared to alluvial aquifers, groundwater from fractured rock aquifers within the Sierra Nevada foothills and mountains tend to supply individual domestic and stock wells, or small community water systems. The fractured rock is also an avenue for septic system biota to rapidly pass through areas of source water supply. Increasing development and growth in the foothills and mountains pose a risk to both supply and health due to the interconnected nature of rock fractures and fissures.

More detailed information regarding the aquifers in the San Joaquin River Hydrologic Region is available online from *California Water Plan Update 2013 (*Update 2013*)*, the Volume 4, *Reference Guide,* article, "California's Groundwater Update 2013" and in DWR *Bulletin 118-2003*.

Well Infrastructure and Distribution

Well logs submitted to DWR for water supply wells completed from 1977 to 2010 were used to evaluate the distribution and uses of water wells in the San Joaquin River region. Many wells could have been drilled prior to 1977 or without submitting well logs. As a result, the total number of wells in the region is probably higher than what is reported here. DWR does not have well logs for all the wells drilled in the region. For some well logs, information regarding well location or use is inaccurate, incomplete, ambiguous, or missing. Hence, some well logs could not be used in the current assessment but for a regional scale evaluation of well installation and distribution, the quality of the data is considered adequate and informative.

The number and distribution of wells in the region are grouped by county and by the six most common well-use types: domestic, irrigation, public supply, industrial, monitoring, and other. Public supply wells include all wells identified in the well completion report as municipal or public. Wells identified as "other" include a combination of the less common well types, such as stock wells, test wells, or unidentified wells (no information listed on the well log).

Well log data for counties that fall within multiple hydrologic regions were assigned to the hydrologic region containing the majority of alluvial groundwater basins within the county. The well log information listed in Table SJR-2 and illustrated in Figure SJR-4 show that the distribution and number of wells vary widely by county and by use.

The total number of wells installed in the region between 1977 and 2010 is approximately 73,500, and ranges from about 3,800 in Amador County to about 12,900 in Madera County. Well logs in San Joaquin and Stanislaus counties are also high at about 10,900 and 10,700, respectively. The large proportion of wells in the three counties (47 percent) is related in part to the high proportion of the region's population living in these counties. Domestic use wells make up the majority of well logs in all counties except Contra Costa County. The number of monitoring well logs (about 5,800) greatly exceeds the number of domestic well logs (about 1,900) in Contra Costa County. The lower number of domestic versus monitoring wells logs in Contra Costa County is likely the result of a more urban setting with residents mostly relying on public water systems, coupled with groundwater contamination monitoring because of the presence of agriculture and industry.

The three counties with the highest number of irrigation well logs are Merced (about 2,000), Madera (about 1,600) and Stanislaus (about 1,500), which are located in the heart of the agricultural region of the northern San Joaquin Valley.

Figure SJR-5 shows that domestic wells make up the majority of well logs (65 percent) in the region, followed by monitoring wells (15 percent), and irrigation wells (about 10 percent).

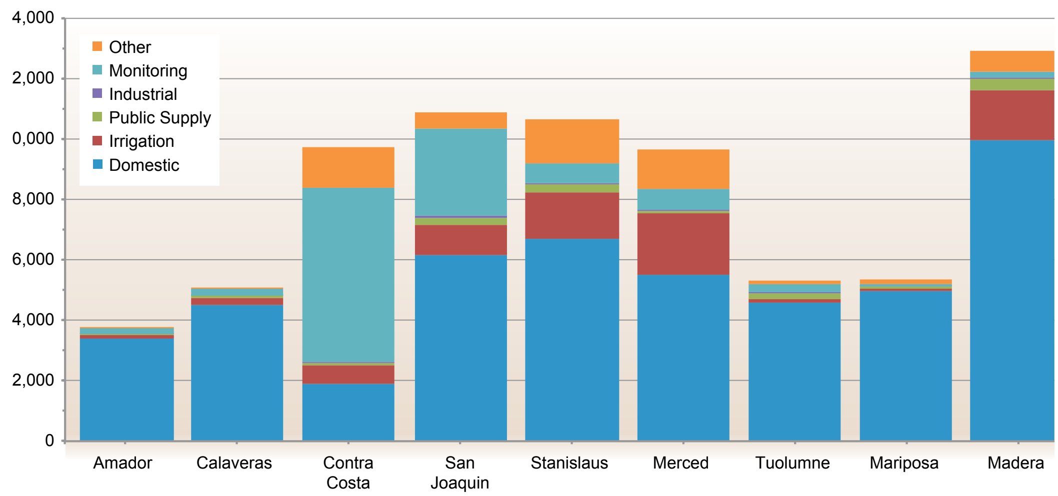
Figure SJR-6 shows a cyclic pattern of well installation in the region, with new well construction ranging from about 1,300 to 3,700 wells per year. The average number of new wells constructed is about 2,200 wells per year.

Table SJR-2 Number of Well Logs by County and Use for the San Joaquin River Hydrologic Region (1977-2010)

Total Number of Well Logs by Well Use							
County	Domestic	Irrigation	Public supply	Industrial	Monitoring	Other	Total Well records
Amador	3,415	83	40	6	206	17	3,767
Calaveras	4,514	217	79	14	237	37	5,098
Contra Costa	1,911	620	72	22	5,773	1,355	9,753
San Joaquin	6,193	980	229	76	2,894	528	10,890
Stanislaus	6,715	1,520	269	39	657	1,452	10,652
Merced	5,513	2,032	87	22	718	1,301	9,673
Tuolumne	4,575	124	215	14	260	145	5,333
Mariposa	4,977	74	74	1	76	164	5,366
Madera	9,986	1,630	396	31	210	662	12,915
Total well records	47,789	7,280	1,461	225	11,031	5,661	73,447

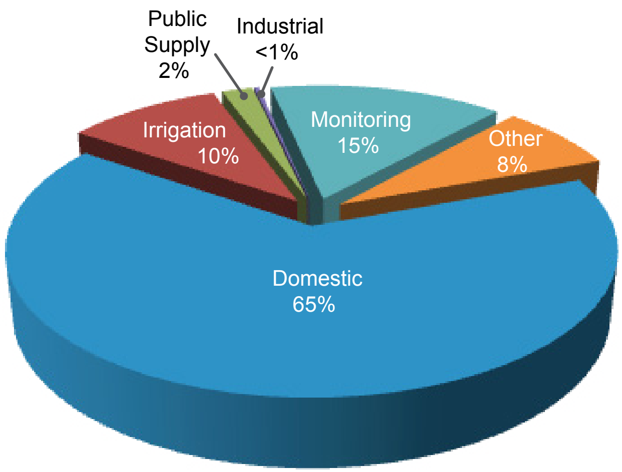
Note: Table represents well log data as of July, 2012.

Figure SJR-4 Number of Well Logs by County and Use for the San Joaquin River Hydrologic Region (1977-2010)



As shown in Figure SJR-6, irrigation well installation tends to closely follow changes in hydrology, cropping patterns, and availability of alternate agricultural water supplies. Irrigation well installation in the region peaked at around 900 wells per year following the 1976-1977 drought, and continued at an installation rate between 100 and 500 wells per year through 1982. Irrigation well installation dropped to approximately 50 wells in 1986, which corresponds with the wet years of the mid-1980s, before increasing again to about 300 wells per year during the 1989-1994 and 2008-2009 droughts.

Figure SJR-5 Percentage of Well Logs by Use for the San Joaquin River Hydrologic Region (1977-2010)



The large fluctuation in domestic well drilling is likely associated with population booms and residential housing construction. The increase in the number of domestic wells drilled during the late 1980s and early 1990s as well as early through mid-2000s is likely due to growth in housing construction. Similarly, the decrease in the number of domestic wells drilled from 2008 to 2010 is likely due to declining economic conditions and the related drop in housing construction.

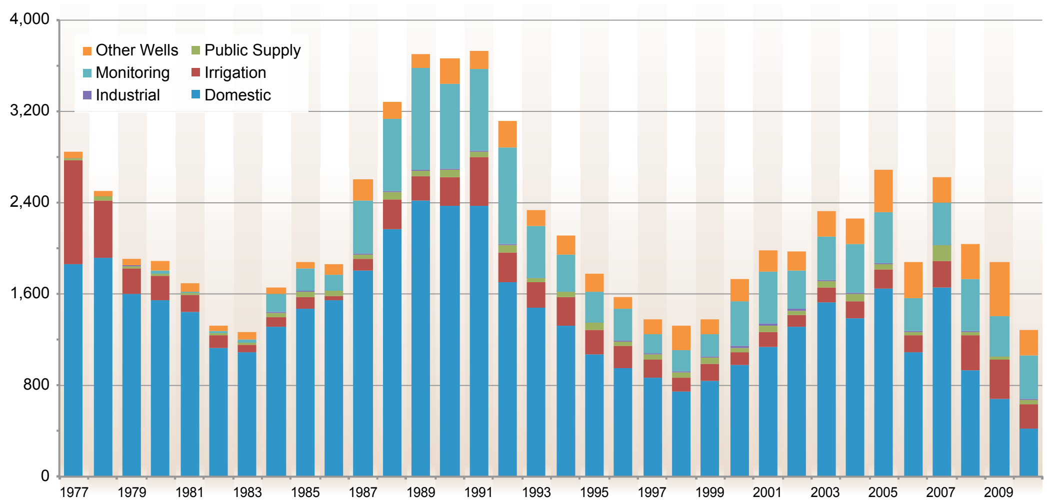
The onset of monitoring well installation in the mid- to late-1980s is likely associated with federal underground storage tank programs signed into law in the mid-1980s. The installation of monitoring wells in the region peaked in 1989 at about 890 wells, with an average of about 420 monitoring wells installed per year from 1984 through 2010. The total number of monitoring well records for the region appears to be low considering the number of remedial action sites within the region by the State Water Resources Control Board (SWRCB) (http://geotracker.waterboards.ca.gov/).

More detailed information regarding assumptions and methods of reporting well log information is available online from Update 2013, in Volume 4, *Reference Guide,* the article, "California's Groundwater Update 2013."

San Joaquin River Hydrologic Region Groundwater Monitoring

Groundwater monitoring and evaluation is a key aspect to understanding groundwater conditions, identifying effective resource management strategies, and implementing sustainable resource management practices. California Water Code (CWC) Section 10753.7 requires local agencies seeking State funds administered by DWR to prepare and implement groundwater management plans that include monitoring of groundwater levels, groundwater quality, inelastic land subsidence, and changes in surface water flow and quality that directly affect groundwater levels or quality. This section summarizes some of the groundwater level, groundwater quality, and land subsidence monitoring efforts within the San Joaquin River Hydrologic Region.

Figure SJR-6 Number of Well Logs Filed per Year by Use for the San Joaquin River Hydrologic Region (1977-2010)



Additional information regarding the methods, assumptions, and data availability associated with the groundwater monitoring is available online from Update 2013, the Volume 4 *Reference Guide*, article, "California's Groundwater Update 2013."

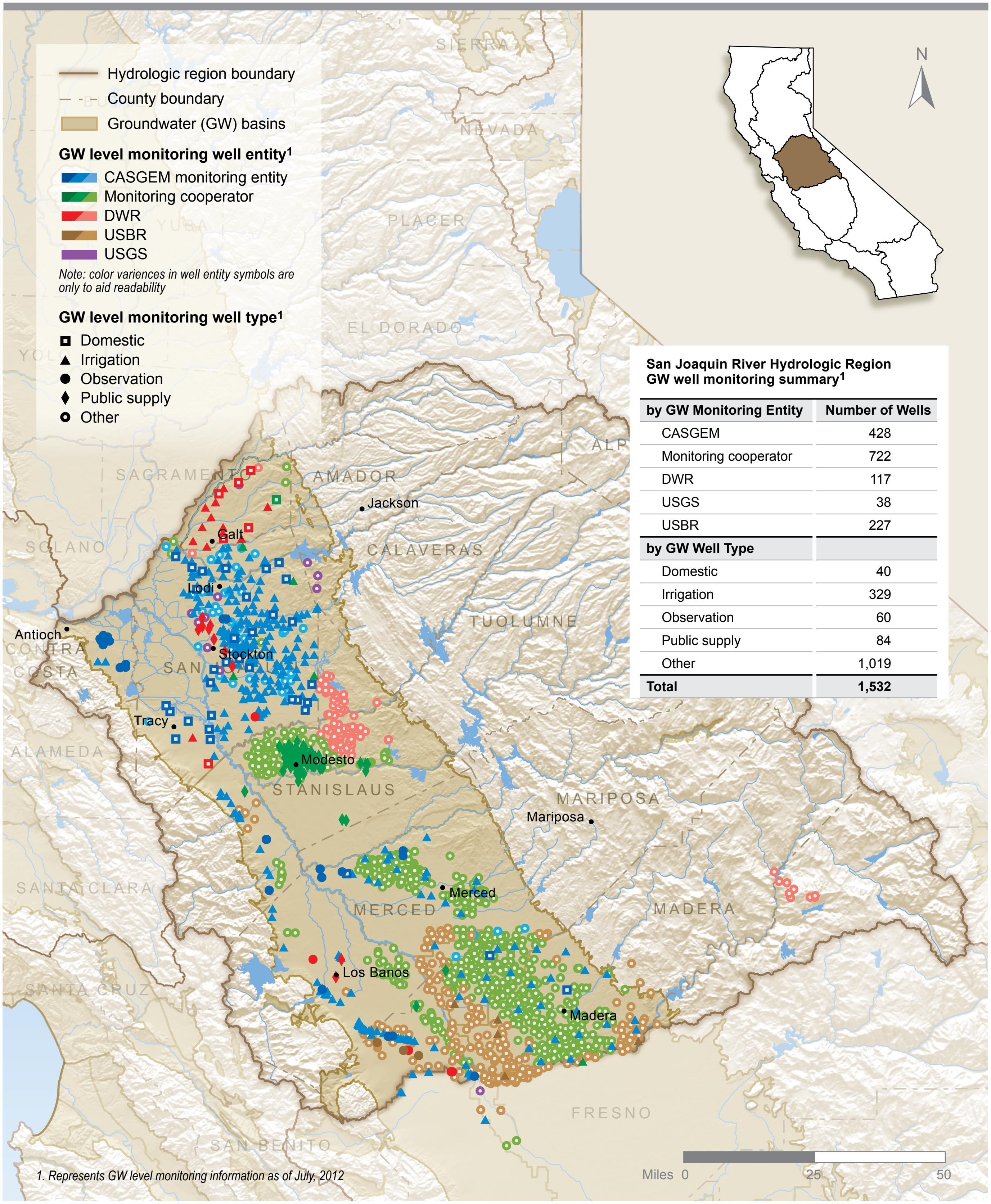
Groundwater Level Monitoring

To strengthen existing groundwater level monitoring in the state by DWR, the U.S. Geological Survey (USGS), U.S. Bureau of Reclamation (USBR), local agencies and communities, the California Legislature passed Senate Bill X7 6 in 2009. The law requires that groundwater elevation data be collected in a systematic manner on a statewide basis and be made readily and widely available to the public. DWR was charged with administering the program, which is now known as California Statewide Groundwater Elevation Monitoring (CASGEM).

The locations of monitoring wells by monitoring entity and monitoring well type in the San Joaquin River region are shown in Figure SJR-7. Other wells account for 67 percent while irrigation wells account for 21 percent of the monitoring wells in the region, respectively. Public supply wells, observation wells, and domestic wells each compromise 5 percent or less of the monitoring wells.

A list of the number of monitoring wells in the region is provided in Table SJR-3. Groundwater levels have been actively monitored in 1,532 wells in the region since 2010. DWR monitors 117 wells in five subbasins and non-basin areas; the USGS monitors 38 wells in three subbasins; and the USBR monitors 227 wells in four subbasins and non-basin areas. In addition to the State and federal agencies, 11 cooperators and six CASGEM monitoring entities monitor 1,150 wells in nine subbasins and non-basin areas.

Figure SJR-7 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity in the San Joaquin River Hydrologic Region



San Joaquin River Hydrologic Region GW well monitoring summary[1]

by GW Monitoring Entity	Number of Wells
CASGEM	428
Monitoring cooperator	722
DWR	117
USGS	38
USBR	227
by GW Well Type	
Domestic	40
Irrigation	329
Observation	60
Public supply	84
Other	1,019
Total	**1,532**

1. Represents GW level monitoring information as of July, 2012

Table SJR-3 Groundwater Level Monitoring Wells by Monitoring Entity in the San Joaquin River Hydrologic Region

State and Federal Agencies	Number of Wells
Department of Water Resources	117
U.S. Geological Survey	38
U.S. Bureau of Reclamation	227
Total State and federal wells	**382**
Monitoring Cooperators	**Number of Wells**
Central California Irrigation District	41
Chowchilla Water District	147
Fresno Irrigation District	1
James Irrigation District	5
Madera Irrigation District	189
Merced Irrigation District	146
Modesto Irrigation District	87
City of Modesto	74
Sacramento County	3
San Joaquin County	8
San Luis Canal Company	21
Total cooperator wells	**722**
CASGEM Monitoring Entities	**Number of Wells**
Diablo Water District	20
Madera-Chowchilla Basin Regional Monitoring Group[a]	26
Merced Area Groundwater Pool Interests[a]	34
San Joaquin County Flood Control and Water Conservation District[a]	257
San Luis and Delta Mendota Water Authority[a]	85
Westlands Water District	6
Total CASGEM monitoring wells	**428**
Grand total	**1,532**

Notes:
CASGEM = California Statewide Groundwater Elevation Monitoring
[a] Designation as CASGEM Monitoring Entity pending for Madera-Chowchilla Basin Regional Monitoring Group, Merced Area Groundwater Pool Interests, San Joaquin County Flood Control and Water Conservation District, and San Luis and Delta Mendota Water Authority.
Table includes groundwater level monitoring wells having publicly available online data.
Table represents monitoring information as of July 2012.

CASGEM Basin Prioritization

Figure SJR-8 shows the groundwater basin prioritization for the region. Of the 11 basins within the region, seven basins were identified as high priority, two basins as medium priority, and the remaining two basins as very low priority. Table SJR-4 lists the high, medium, and very low CASGEM priority groundwater basins. The seven basins designated as high priority include 82 percent of the population and account for 92 percent of groundwater supply in the region. Except the Modesto and Turlock subbasins, all the other subbasins identified as having a high or medium priority are being monitored for groundwater levels by CASGEM monitoring entities. Basin prioritization could be a valuable tool to help evaluate, focus, and align limited resources for effective groundwater management, and reliable and sustainable groundwater resources.

More detailed information on groundwater basin prioritization is available at www.water.ca.gov/groundwater/casgem/basin_prioritization.cfm.

Groundwater Quality Monitoring

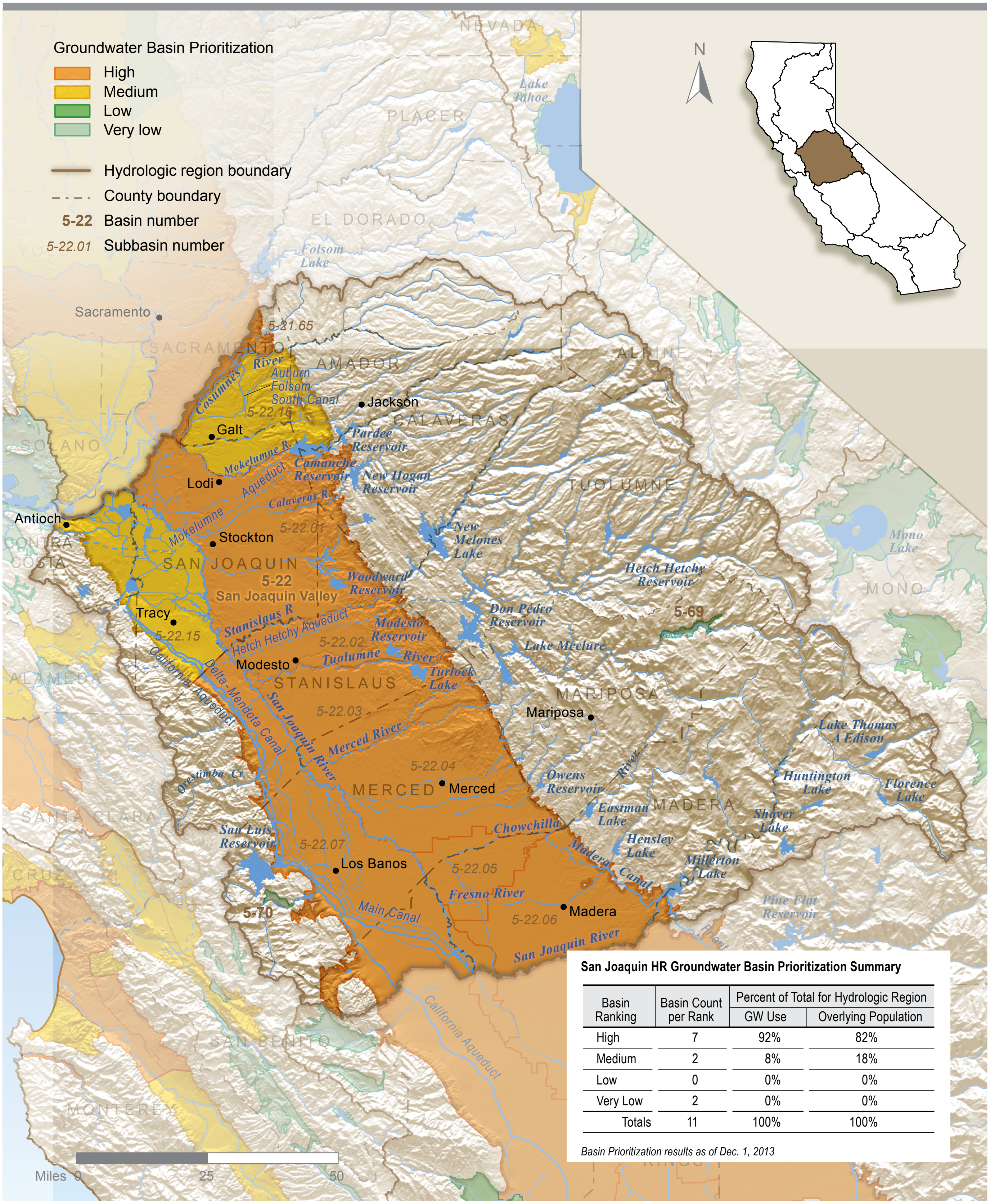
Groundwater quality monitoring is an important aspect to effective groundwater basin management and is one of the components required to be included in groundwater management planning in order for local agencies to be eligible for State funds. Numerous State, federal, and local agencies participate in groundwater quality monitoring efforts throughout California. A number of the existing groundwater quality monitoring efforts were initiated as part of the Groundwater Quality Monitoring Act of 2001, which implemented goals to improve and increase the statewide availability of groundwater quality data.

Regional and statewide groundwater quality monitoring information and data are available on the SWRCB Groundwater Ambient Monitoring and Assessment (GAMA) Web site and the GeoTracker GAMA groundwater information system developed as part of the Groundwater Quality Monitoring Act of 2001. The GAMA Web site describes GAMA program and provides links to all published GAMA and related reports. The GeoTracker GAMA groundwater information system geographically displays information and includes analytical tools and reporting features to assess groundwater quality. This system currently includes groundwater data from the SWRCB, regional water quality control boards (RWQCBs), California Department of Public Health (CDPH), Department of Pesticide Regulation (DPR), DWR, USGS, and Lawrence Livermore National Laboratory (LLNL). In addition to groundwater quality data, GeoTracker GAMA has more than 2.5 million depth-to-groundwater measurements from the Water Boards (SWRCB and RWQCBs) and DWR, and also has oil and gas hydraulically fractured well information from the California Division of Oil, Gas, and Geothermal Resources. Table SJR-5 provides Web information and links to agencies organized by specific groundwater quality information. Additional information regarding assessment and reporting of groundwater quality information is furnished later in this report.

Land Subsidence Monitoring

Land subsidence occurs in areas experiencing significant declines in groundwater levels. When groundwater is extracted from aquifers in sufficient quantity, the groundwater level is lowered and the water pressure, which supports the sediment grains structure, decreases. In unconsolidated deposits, as aquifer pressures decrease, the increased weight from overlying sediments may compact the fine-grained sediments and permanently decrease the porosity of the aquifer and the ability of the aquifer to store water. Elastic land subsidence is the reversible

Figure SJR-8 CASGEM Groundwater Basin Prioritization for the San Joaquin River Hydrologic Region



San Joaquin HR Groundwater Basin Prioritization Summary

Basin Ranking	Basin Count per Rank	Percent of Total for Hydrologic Region	
		GW Use	Overlying Population
High	7	92%	82%
Medium	2	8%	18%
Low	0	0%	0%
Very Low	2	0%	0%
Totals	11	100%	100%

Basin Prioritization results as of Dec. 1, 2013

Table SJR-4 CASGEM Groundwater Basin Prioritization for the San Joaquin River Hydrologic Region

Basin Prioritization	Count	Basin/Subbasin Number	Basin Name	Subbasin Name	2010 Census Population
High	1	5-22.05	San Joaquin Valley	Chowchilla	15,820
High	2	5-22.06	San Joaquin Valley	Madera	116,919
High	3	5-22.01	San Joaquin Valley	Eastern San Joaquin	582,662
High	4	5-22.02	San Joaquin Valley	Modesto	294,872
High	5	5-22.07	San Joaquin Valley	Delta-Mendota	107,879
High	6	5-22.04	San Joaquin Valley	Merced	173,731
High	7	5-22.03	San Joaquin Valley	Turlock	197,605
Medium	1	5-22.15	San Joaquin Valley	Tracy	268,175
Medium	2	5-22.16	San Joaquin Valley	Cosumnes	59,163
Very Low	1	5-69	Yosemite Valley		1,016
Very Low	2	5-70	Los Banos Creek Valley		
Totals	**11**	**Population of groundwater basin area**			**1,817,842**

Notes:

Senate Bill X7 6 (SB X7 6; Part 2.11 to Division 6 of the California Water Code Sections 10920 et seq.) requires, as part of the CASGEM program, DWR to prioritize groundwater basins to help identify, evaluate, and determine the need for additional groundwater level monitoring by considering available data that include the population overlying the basin, the rate of current and projected growth of the population overlying the basin, the number of public supply wells that draw from the basin, the total number of wells that draw from the basin, the irrigated acreage overlying the basin, the degree to which persons overlying the basin rely on groundwater as their primary source of water, any documented impacts on the groundwater within the basin, including overdraft, subsidence, saline intrusion, and other water quality degradation, and any other information determined to be relevant by the DWR."

Using groundwater reliance as the leading indicator of basin priority, DWR evaluated California's 515 alluvial groundwater basins and categorized them into five groups - very high, high, medium, low, and very low.

and temporary fluctuation of earth's surface in response to seasonal groundwater extraction and recharge. Inelastic land subsidence is the irreversible and permanent decline in the earth's surface due to the collapse or compaction of the pore structure within the fine-grained portions of an aquifer system (U.S. Geological Survey 1999). Land subsidence thus results in irreversible compaction of the aquifer and permanent loss of aquifer storage capacity, and has serious effects on groundwater supply and development. Land subsidence due to aquifer compaction causes costly damage to the gradient and flood capacity of conveyance channels, to water system infrastructure (including wells), and to farming operations.

Table SJR-5 Sources of Groundwater Quality Information for the San Joaquin River Hydrologic Region

Agency	Links to Information
State Water Resources Control Board http://www.waterboards.ca.gov/	Groundwater http://www.waterboards.ca.gov/water_issues/programs/#groundwater • Communities that Rely on a Contaminated Groundwater Source for Drinking Water http://www.waterboards.ca.gov/water_issues/programs/gama/ab2222/index.shtml • Hydrogeologically Vulnerable Areas http://www.waterboards.ca.gov/gama/docs/hva_map_table.pdf • Aquifer Storage and Recovery http://www.waterboards.ca.gov/water_issues/programs/asr/index.shtml GAMA http://www.waterboards.ca.gov/gama/index.shtml • GeoTracker GAMA (Monitoring Data) http://www.waterboards.ca.gov/gama/geotracker_gama.shtml • Domestic Well Project http://www.waterboards.ca.gov/gama/domestic_well.shtml • Priority Basin Project http://www.waterboards.ca.gov/water_issues/programs/gama/sw_basin_assesmt.shtml • Special Studies Project http://www.waterboards.ca.gov/water_issues/programs/gama/special_studies.shtml • California Aquifer Susceptibility Project http://www.waterboards.ca.gov/water_issues/programs/gama/cas.shtml Contaminant Sites Land Disposal Program http://www.waterboards.ca.gov/water_issues/programs/land_disposal/ Department of Defense Program http://www.waterboards.ca.gov/water_issues/programs/dept_of_defense/ Underground Storage Tank Program http://www.waterboards.ca.gov/ust/index.shtml Brownfields http://www.waterboards.ca.gov/water_issues/programs/brownfields/
California Department of Public Health http://www.cdph.ca.gov/Pages/DEFAULT.aspx	Division of Drinking Water and Environmental Management http://www.cdph.ca.gov/programs/Pages/DDWEM.aspx • Drinking Water Source Assessment and Protection (DWSAP) Program http://www.cdph.ca.gov/certlic/drinkingwater/Pages/DWSAP.aspx • Chemicals and Contaminants in Drinking Water http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chemicalcontaminants.aspx • Chromium-6 http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chromium6.aspx • Groundwater Replenishment with Recycled Water http://www.cdph.ca.gov/HealthInfo/environhealth/water/Pages/Waterrecycling.aspx

Land subsidence investigations in the San Joaquin River Hydrologic Region include monitoring efforts such as:

- **California Aqueduct Elevation Surveys:** DWR conducts periodic elevation surveys along the California Aqueduct to measure land subsidence along the canal and guide maintenance

Agency	Links to Information
California Department of Water Resources http://www.water.ca.gov/	Groundwater Information Center http://www.water.ca.gov/groundwater/index.cfm Bulletin 118 Groundwater Basins http://www.water.ca.gov/groundwater/bulletin118/gwbasin_maps_descriptions.cfm California Statewide Groundwater Elevation Monitoring (CASGEM) http://www.water.ca.gov/groundwater/casgem/ Groundwater Level Monitoring http://www.water.ca.gov/groundwater/data_and_monitoring/gw_level_monitoring.cfm Groundwater Quality Monitoring http://www.water.ca.gov/groundwater/data_and_monitoring/gw_quality_monitoring.cfm Well Construction Standards http://www.water.ca.gov/groundwater/well_info_and_other/well_standards.cfm Well Completion Reports http://www.water.ca.gov/groundwater/well_info_and_other/well_completion_reports.cfm
California Department of Toxic Substances Control http://www.dtsc.ca.gov/	EnviroStor http://www.envirostor.dtsc.ca.gov/public/
California Department of Pesticide Regulation http://www.cdpr.ca.gov/	Groundwater Protection Program http://www.cdpr.ca.gov/docs/emon/grndwtr/index.htm Well Sampling Database http://www.cdpr.ca.gov/docs/emon/grndwtr/gwp_sampling.htm Groundwater Protection Area Maps http://www.cdpr.ca.gov/docs/emon/grndwtr/gwpa_maps.htm
U.S. Environmental Protection Agency http://www.epa.gov/safewater/	US EPA STORET Environmental Data System http://www.epa.gov/storet/
U.S. Geological Survey http://ca.water.usgs.gov/	USGS Water Data for the Nation http://waterdata.usgs.gov/nwis)

repairs as needed. DWR surveys compared elevations along portions of the aqueduct in Fresno and Kings counties for years 2000, 2006, and 2009.

- **Borehole Extensometer Monitoring:** A borehole extensometer is designed to act as benchmark anchored to a geologically stable portion of the lower aquifer. Most of the borehole extensometers in the region were constructed in the 1950s and 1960s during the planning and construction of the State and federal water projects. After completion of the water projects, it was commonly thought that the threat of land subsidence had largely been eliminated. As a result, land subsidence investigations became less of a priority, and the borehole extensometer monitoring wells fell into disrepair. In 2009, the USGS evaluated 12 of the inactive borehole extensometers for potential repair and reuse (Sneed 2011). Four extensometers were selected to be rehabilitated. There are currently seven active borehole extensometers in the area — six in Tulare Lake Hydrologic Region and one in San Joaquin River Hydrologic Region.
- **Satellite Remote Sensing Studies using Interferometry Synthetic Aperture Radar (InSAR):** InSAR is a remote sensing tool that uses satellite radar signals to measure deformation of the Earth's crust at a high degree of spatial detail and measurement resolution

(U.S. Geological Survey 2000). In cooperation with DWR and USBR, the USGS is currently evaluating 2007 to 2011 InSAR data for evidence of subsidence in the San Joaquin River and Tulare Lake hydrologic regions.

- **Caltrans Highway 152 Elevation Monitoring:** As part of Highway Elevation Monitoring, Caltrans periodically resurveys its network of existing benchmarks along key sections of highway. In 1998 and again in 2004, Caltrans performed elevation surveys along State Route 152 across the San Joaquin Valley from the San Luis Dam to State Route 99 with the aim to compare these new data with 1972 survey results. Prior surveys have been done at approximately 16-year intervals. The surveys are typically limited to the highway right-of-way and likely miss some of the larger land subsidence areas.
- **GPS Array Monitoring:** A university-governed consortium for geosciences research using geodesy (UNAVCO) operates the Plate Boundary Observatory (PBO) and uses precision GPS monitoring sites for western United States plate tectonics studies. The UNAVCO GPS stations provide continuous monitoring of the land surface elevation providing a potential direct measurement of subsidence. There are 13 GPS stations in the San Joaquin Valley. Several of these are close to the edge of the valley and provide only partial insight into the regional magnitude of subsidence, while others lie outside of areas susceptible to subsidence (see http://pbo.unavco.org).

Results associated with the land subsidence monitoring activities are provided under the "Land Subsidence" section later in this report.

Ecosystems

Government and privately held forested lands in the Sierra Nevada consist of pine, mixed conifer, and fir forests. The Sierra foothills and rangelands consist of chaparral communities, oak woodlands, riparian habitat, and grass savannas. These areas have been significantly influenced by rural inhabitation and livestock grazing. Riparian habitats exist along rivers, streams, lakes, and ponds.

The Diablo Range contains oak woodlands, grasslands, and chaparral (shrub and brush) communities. Much of these areas have also been used for livestock grazing.

The San Joaquin Valley floor is mostly developed for agricultural production, but has pockets of expanding urbanized areas. Riparian areas exist in the Delta and along rivers, streams, ditches and canals, sloughs, and flood channels. Wetlands are primarily located in private waterfowl hunting areas and government-managed refuges and wildlife areas. Vernal pools are found primarily along the edges of the valley.

According to the Grasslands Water District in Merced County, only 5 percent of the Central Valley's historical 4 million acres of wetlands exist today. Habitat also includes riparian forests, native grasslands, and vernal pools. The remaining wetlands in the Central Valley must be intensively managed to support waterfowl populations that depend on the Central Valley for wintering habitat. The Central Valley Project Improvement Act (CVPIA) Section 3406(d) (Refuge Water Supply) establishes the primary goal of providing a firm water supply for wildlife refuges. This firm water supply has helped to create new wetlands and enhance existing wetlands, resulting in increases in populations of federal- and State-listed species — particularly avian species — and other wildlife species such as the giant garter snake (*Thamnophis gigas*). The firm water supply has helped to reduce the concentration of salts and other contaminants, thereby improving water quality on the refuges and the quality of water discharged from the refuges.

Table SJR-6 shows critical species in the San Joaquin River Hydrologic Region. Table SJR-7 shows critical plant species that are endemic to the San Joaquin River Hydrologic Region.

Flood

Common types of floods in the San Joaquin River Hydrologic Region include stormwater, slow-rise, and flash flooding. Floods in the San Joaquin Valley originate principally from melting of the Sierra snowpack and from rainfall. Flooding from snowmelt typically occurs in the spring and has a lengthy runoff period. Flooding from rainfall occurs in the winter and early spring.

Major floods occur regularly in the San Joaquin River Hydrologic Region. The more damaging floods are usually caused by spring snowmelt. The flatness of the valley floor contributes to the areal extent of these floods. Flooding in the mountainous upper watersheds is rarer due to well-developed watercourses, but might still occur, especially in intermontane valleys. These floods take a variety of forms and can be classified into six categories (slow-rise, flash, stormwater, debris flow, alluvial fan, and engineered structure failure flooding).

Historic Floods

Floods have been recorded in the San Joaquin Valley for more than 175 years. Most notable in the 19th century was the Great Flood of 1861-1862. Central Valley floods of 1907 and 1909 revised flood management plans of the time and led to development of the San Joaquin River flood management system. The San Joaquin River Hydrologic Region experiences some urban and small-stream flooding in every large storm. The Great Flood of 1861-1862 inundated large areas of the West Coast states from Canada to Mexico.

In December 1955 through January 1956, heavy rainfall and snowmelt occurred in the upper watersheds of the east side tributaries to the San Joaquin River. This caused extensive flooding along the river and all its major east side tributaries, as well as flooding on the larger west side tributaries. This flood caused extensive damage to agriculture, homes, and public facilities. Thousands of people were evacuated from their homes during the Christmas holiday season and several people died of heart attacks during the flood. Unusually high tides aggravated the situation by impeding the passage of floodwater through the Delta.

In January 1997, 14 levee breaches occurred on the San Joaquin River between Fresno and the Chowchilla Bypass, inundating agricultural lands that included many vineyards north of the river. The San Joaquin River also flooded a mobile home park in Madera County and damaged the bridge on State Highway 145. There was extensive damage in Yosemite Valley from Merced River overflow. Yosemite National Park was closed, and highways in the region sustained damage. Multiple levee breaches occurred on the San Joaquin River near Vernalis, flooding agricultural lands.

For a complete record of floods, refer to the California's Flood Future Report Attachment C: History of Flood Management in California (California Department of Water Resources and U.S. Army Corps of Engineers 2013a).

Table SJR-6 Critical Species in the San Joaquin River Hydrologic Region

Category	Common Name	Scientific Name	Federal Status	State Status
Invertebrates	Lange's metalmark butterfly	*Apodemia mormo langei*	FE	
	Conservancy fairy shrimp	*Branchinecta conservatio*	FE	
	Longhorn fairy shrimp	*Branchinecta longiantenna*	FE	
	San Bruno elfin butterfly	*Callophrys mossii bayensis*	FE	
	Vernal pool tadpole shrimp	*Lepidurus packardi*	FE	
Fish	Delta smelt	*Hypomesus transpacificus*	FT	SE
Amphibians	Sierra Nevada yellow-legged frog	*Rana sierrae*	FC	SCE
Reptiles	Blunt-nosed leopard lizard	*Gambelia sila*	FE	SE
Birds	Golden eagle	*Aquila chrysaetos*		FP
	Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	FC	SE
	White-tailed kite	*Elanus leucurus*		FP
	Willow flycatcher	*Empidonax traillii*		SE
	American peregrine falcon	*Falco peregrinus anatum*		FP
	Bald eagle	*Haliaeetus leucocephalus*		SE, FP
	Great gray owl	*Strix nebulosa*		SE
	Least Bell's vireo	*Vireo bellii pusillus*	FE	SE
Mammals	Giant kangaroo rat	*Dipodomys ingens*	FE	SE
	Fresno kangaroo rat	*Dipodomys nitratoides exilis*	FE	SE
	Riparian (San Joaquin Valley) woodrat	*Neotoma fuscipes riparia*	FE	
	Salt-marsh harvest mouse	*Reithrodontomys raviventris*	FE	SE
	Riparian brush rabbit	*Sylvilagus bachmani riparius*	FE	SE
	San Joaquin kit fox	*Vulpes macrotis mutica*	FE	ST

Notes:

SE = State Endangered, ST = State Threatened, FP = Fully Protected under the California Department. of Fish and Wildlife, FE = Federally Endangered, FT = Federally Threatened, SCE = Candidate for State listing as Endangered, FC = Candidate for Federal listing

Climate

The Coast Ranges isolate the San Joaquin Valley from the coastal California marine effects. Although coastal temperatures often are mild in the summer, the maximum average daily temperature in the valley reaches a high of 101 °F in late July. Daily temperatures during

Table SJR-7 Critical Plant Species Endemic to the San Joaquin River Hydrologic Region

Common Name	Scientific Name	Federal Status	State Status	CNPS Rank
Antioch Dunes buckwheat	*Eriogonum nudum var. psychicola*			1B.1
Chinese Camp brodiaea	*Brodiaea pallida*	FT	ST	1B.1
Contra Costa wallflower	*Erysimum capitatum var. angustatum*	FE	SE	1B.1
Delta button-celery	*Eryngium racemosum*			1B.1
El Dorado bedstraw	*Galium californicum ssp. sierrae*	FE	SR	1B.2
Ione buckwheat	*Eriogonum apricum var. apricum*	FE	SE	1B.1
Irish Hill buckwheat	*Eriogonum apricum var. prostratum*	FE	SE	1B.1
Large-flowered fiddleneck	*Amsinckia grandiflora*	FE	SE	1B.1
Lime Ridge navarretia	*Navarretia gowenii*			1B.1
Mariposa pussypaws	*Calyptridium pulchellum*	FT		1B.1
Merced clarkia	*Clarkia lingulata*		SE	1B.1
Pine Hill ceanothus	*Ceanothus roderickii*	FE	SR	1B.2
Red Hills vervain	*Verbena californica*	FT	ST	1B.1
Sacramento Orcutt grass	*Orcuttia viscida*	FE	SE	1B.1
Stebbins' lomatium	*Lomatium stebbinsii*			1B.1
Succulent owl's-clover	*Castilleja campestris ssp. succulenta*	FT	SE	1B.2

Notes:

SE = State Endangered, ST = State Threatened, SR = State Rare, FE = Federally Endangered, FT = Federally Threatened, CNPS = California Native Plant Society:

1B.1 = Plants Rare, or Seriously Threatened or Endangered in California and elsewhere

1B.2 = Plants Rare, or Fairly Threatened or Endangered in California and elsewhere

the warmest months range between 76 °F and 115 °F. The northern part of the San Joaquin Hydrologic River Region benefits from Delta breezes during hot summers, leading to evening cooling, which does not reliably occur in the southern portion of this region.

Winter temperatures on the valley floor are usually mild, but drop below freezing during occasional cold spells. Frost occurs in most fall/winter seasons, typically between late November and early March. This region experiences a wide range of precipitation that varies from low rainfall amounts on the valley floor to extensive snowfall in the higher elevations of the Sierra Nevada. The snow that remains after winter serves as stored water before it melts in the spring and summer. The average annual precipitation of several Sierra Nevada stations is about 35 inches. Snowmelt from the mountains is a major contributor to local eastern San Joaquin Valley water supplies. The San Joaquin River and storage at Lake Millerton provide water for the Friant Unit of the federal Central Valley Project (CVP).

The upland climate on the west side of the valley resembles that of the eastern Sierra Nevada foothills: long, hot, and often dry summers with mild winters. In the winter, tule fog occurs in the region's southern portion more often than in its northern portion. Average annual precipitation ranges from about 22 inches near Stockton in the north to about 11 inches in the southern portion; it decreases to about 6.5 inches near the drier southwestern corner of the region.

Demographics

Population

The estimated population of the San Joaquin River Hydrologic Region was approximately 2.1 million people in 2010, according to the U.S. Census Bureau. Approximately 5 percent of the state's total population lives in this region, and 70 percent of the region's population lives in incorporated cities. Between 2005 and 2010, the region grew by about 105,200 people, a growth of about 5 percent over the 5-year period. Table SJR-8 shows San Joaquin River Hydrologic Region population by county for 2005 and 2010.

The most populous city in the San Joaquin River Hydrologic Region is Stockton, with a 2010 estimated population of 291,707. Table SJR-9 lists the top 10 most populous cities within the San Joaquin River Hydrologic Region. These cities account for about half of the population of the entire region.

Tribal Communities

Table SJR-10 shows the federally recognized tribes in the San Joaquin River Hydrologic Region.

Federal Clean Water Act Programs and Tribes

Under the federal Clean Water Act (CWA), the U.S. Environmental Protection Agency (EPA) administers programs that support federally recognized tribes to address non-point-source pollution, water pollution control programs, and watershed-based planning efforts. Because of unique and extremely complex historical circumstances, there are a large number of non-recognized tribes in California, including terminated tribes that may be seeking restoration or recognition by the United States. Tribal existence and identity do not depend on federal recognition or acknowledgement of a tribe. However, in order to be eligible for CWA programs, a tribe must be federally recognized, along with additional requirements. One of the requirements is receiving "Treatment-in-a-manner-similar-to-a-State" (TAS) authorization pursuant to Section 518(e) of the CWA.

Section 319 of the CWA authorizes federal grants to States and tribes in order to implement approved programs and on-the-ground projects to reduce non-point-source pollutions problems. In the San Joaquin River Hydrologic Region, four tribes have TAS status and are eligible for Section 319 program funding: Big Sandy Rancheria of Mono Indians, Picayune Rancheria of Chukchansi Indians, Shingle Springs Band of Miwok Indians, and Table Mountain Rancheria.

Section 106 of the CWA authorizes federal grants to assist State and interstate agencies in administering water pollution control programs. Tribes with TAS status can receive Section 106 funding. This program allows tribes to address water quality issues by developing monitoring

Table SJR-8 San Joaquin River Hydrologic Region Population by County for 2005 and 2010

County	2005 Population	2010 Population
Alameda	412	403
Contra Costa	191,096	211,304
San Joaquin	651,625	685,306
Amador	37,632	38,030
Calaveras	44,773	45,578
Sacramento	43,326	45,409
Alpine	129	121
El Dorado	59,224	65,212
Tuolumne	56,452	55,365
Madera	139,868	150,865
Merced	240,600	255,793
Stanislaus	498,020	514,453
Mariposa	18,057	18,251
Fresno	17,794	18,116
Total	1,999,008	2,104,206

Note: Population numbers for Alameda, Alpine, Amador, Benito, Contra Costa, El Dorado, Fresno, Sacramento, and San Joaquin counties reflect only that portion of each county within the San Joaquin River Hydrologic Region boundary. All of Calaveras, Madera, Mariposa, Merced, Stanislaus, and Tuolumne counties are within this region.

programs, water quality assessment, standards development, planning, and other activities intended to manage reservation water resources. In the San Joaquin River Hydrologic Region, six tribes are involved in Section 106 programs and activities: Big Sandy Rancheria of Mono Indians, Buena Vista Rancheria, Picayune Rancheria of Chukchansi Indians, Shingle Springs Band of Miwok Indians, Table Mountain Rancheria, and Tuolumne Band of Me-Wuk Indians.

Table SJR-11 shows tribes within integrated regional water management (IRWM) regions in the San Joaquin River Hydrologic Region.

Disadvantaged Communities

Disadvantaged communities (DACs) are defined as those communities having a Median Household Income (MHI) of 80 percent of the statewide MHI. While the smaller towns, such as Chowchilla, Gustine, and Firebaugh, are mainly rural and engaged in the farming industry, the larger cities, such as Stockton, Merced, and Madera are only about 20 to 30 percent rural versus urban. Furthermore, the residents of these larger cities are mainly employed in the educational services and healthcare sectors.

Table SJR-9 Top 10 Most Populous Cities within the San Joaquin River Hydrologic Region

City	Population
Stockton	291,707
Modesto	201,165
Antioch	102,372
Tracy	82,922
Merced	78,958
Turlock	68,549
Manteca	67,096
Lodi	62,134
Pittsburg	63,264
Madera	61,416

Table SJR-10 Federally Recognized Tribes in the San Joaquin River Hydrologic Region

Tribal Land	Acres	Cultural Affiliation	County of Location
Shingle Springs Rancheria	160	Maidu, Miwok	El Dorado
Jackson Rancheria	331	Mewuk (Miwok)	Amador
Buena Vista Rancheria	67	Miwok (Mewuk)	Amador
Tuolumne Rancheria	335	Me-Wuk, Miwok, Yokut	Tuolumne
Chicken Ranch Rancheria	3	Me-Wuk	Tuolumne
Picayune Rancheria	160	Chukchansi	Madera
North Fork Rancheria	80	Western Mono	Madera
Big Sandy Rancheria	228	Western Mono (Monache) Indians	Fresno
Table Mountain Rancheria	61	Yokuts	Fresno
California Valley Miwok Tribe	Unknown	Miwok	Calaveras
Ione Band of Miwok Indians of California	228	Miwok	Amador

Note:
Data taken from the San Diego State University's online library and information access.

Table SJR-11 Tribes within Integrated Regional Water Management Regions in the San Joaquin River Hydrologic Region

Region Number	Integrated Regional Water Management (IRWM) Region	Tribe
1	American River	Wilton Rancheria
4	Yosemite-Mariposa	No Tribes in this IRWM Region
6	Cosumnes American Bear Yuba (CABY)	Shingle Springs Band of Miwok Indians
7	East Contra Costa County	No Tribes in this IRWM Region
8	Eastern San Joaquin	No Tribes in this IRWM Region
16	Madera	Picayune Rancheria of Chukchansi Indians
17	Merced	No Tribes in this IRWM Region
19	Mokelumne/Amador/ Calaveras	Buena Vista Rancheria Me-Wuk Indians of California
		California Valley Miwok Tribe
		Ione Band of Miwok Indians
33	Southern Sierra	Big Sandy Rancheria of Mono Indians of California
		Table Mountain Rancheria of California
36	Tuolumne-Stanislaus	Chicken Ranch Rancheria of Me-wuk
		Tuolumne Band of Me-Wuk Indians
44	Westside-San Joaquin	No Tribes in this IRWM Region
47	East Stanislaus	No Tribes in this IRWM Region

Table SJR-12 lists the region's DACs by cities and their population and MHI based on the U.S. Census 2010 data. Figure SJR-9 displays the MHI for these cities graphically.

Another census entity used in the identification of DACs is Census Designated Place (CDP). A CDP is a statistical entity, defined for each decennial census according to Census Bureau guidelines, comprising a densely settled concentration of population that is not within an incorporated place, but is locally identified by a name. Table SJR-13 lists the poorest 20 CDPs (also considered DACs) within the San Joaquin River Hydrologic Region by population (greater than 2,000) and MHI. Figure SJR-10 shows these places by MHI.

Land Use Patterns

Agriculture remains the dominant economic sector of the San Joaquin River Hydrologic Region. Agricultural production, processing, packaging, handling, shipping, and the sales of goods and services supporting agriculture represent a major economic and land use activity. Urban development has increased over the last two decades and, in turn, has encroached into the surrounding agricultural lands. Significant population growth cities include Stockton, Tracy,

Table SJR-12 Disadvantaged Communities (Cities) within the San Joaquin River Hydrologic Region

City	Population	Median Household Income
Firebaugh	7,373	$30,000
Sonora	4,914	$30,893
Plymouth	903	$31,250
Merced	77,080	$36,269
Chowchilla	18,090	$39,902
Dos Palos	4,904	$40,121
Angels	3,790	$40,690
Gustine	5,438	$40,818
Madera[a]	59,006	$40,889
Atwater	27,587	$42,226
Livingston	12,733	$46,198
Jackson	4,625	$46,932
Newman	9,806	$47,416
Sutter Creek	2,827	$47,909
Stockton	287,377	$47,946
Lodi	62,225	$48,695

Note: State median household income: $60,883

[a] City of Madera excluding Bonadelle Ranchos-Madera Ranchos.

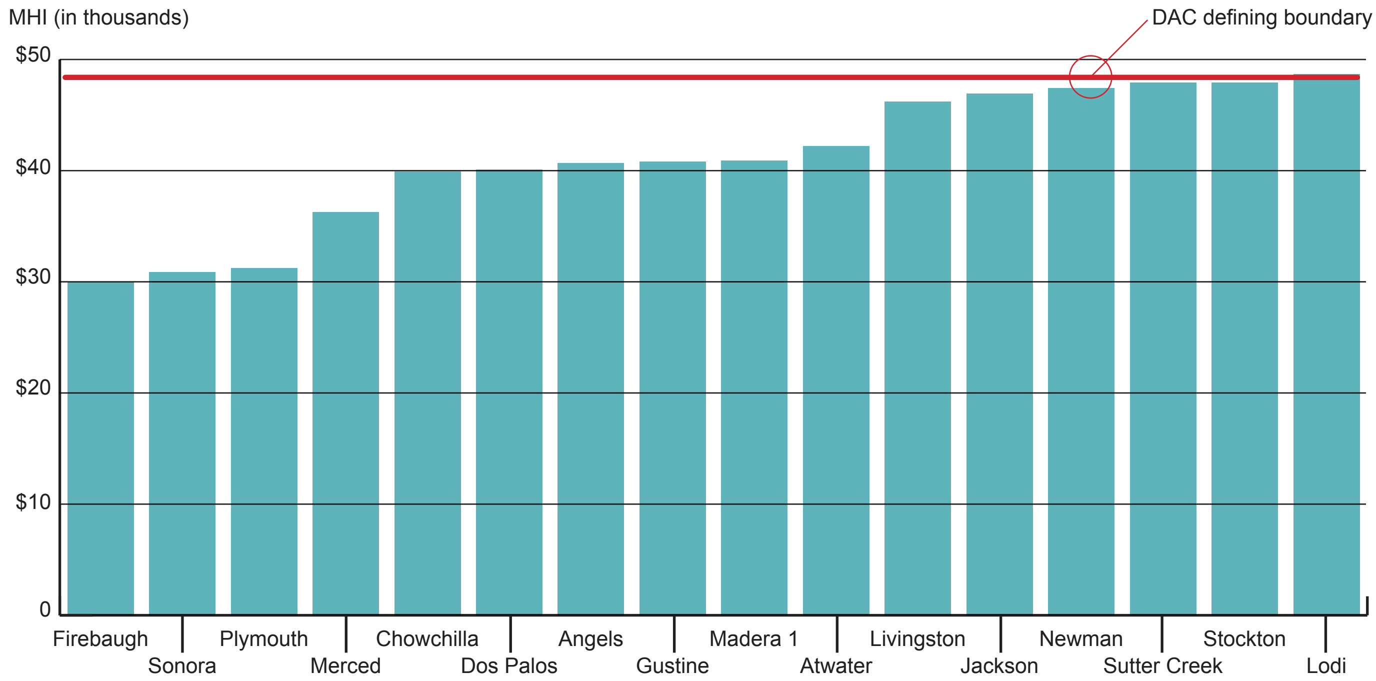
Manteca, Galt, Lodi, Modesto, Turlock, Merced (University of California, Merced, which opened in September 2005, has a student population of about 5,800), Los Banos, and Madera. The Pacheco and Altamont passes serve as commuting corridors into the Bay Area and contribute to the growth of valley communities. Nonetheless, vast tracts of productive agricultural land continue to surround these cities.

More people are settling in the Sierra Nevada foothills and mountains; and a greater number of visitors are taking advantage of the area's recreational activities, such as golfing, sightseeing, camping, backpacking, boating, cycling, fishing, and water- and snow-skiing.

The valley portion of the region constitutes about 3.5 million acres, the eastern foothills and mountains total about 5.8 million acres, and the western coastal mountains comprise about 900,000 acres.

The San Joaquin Valley is recognized as one of the most important and productive agricultural areas in the United States. It contains roughly 2 million acres of irrigated cropland with an annual agricultural output valued at more than $ 9.3 billion (from the 2010 Stanislaus, San Joaquin,

Figure SJR-9 Median Household Income (MHI) for Disadvantaged Communities (DACs) within the San Joaquin River Hydrologic Region Cities



Merced, Madera, and Fresno county agricultural commissioner reports). Figure SJR-11 shows gross agricultural value for the San Joaquin River Hydrologic Region for 2005-2010 by county.

The San Joaquin River Hydrologic Region has a high diversity of crops with the top five single-crop types in acreage being almonds, corn, alfalfa, grapes, and processing tomatoes. Although higher in acreage, "other field" and "other deciduous" crops can be assorted types, and no single crop is probably greater in acreage than processing tomatoes. Figure SJR-12 shows the top 10 crop types in the San Joaquin River region by acreage by water year (October 1 through September 30) for 2005-2009.

In addition to agriculture, other important industries in the region include food processing, chemical production, lumber and wood products, glass, textiles, paper, machinery, fabricated metal products, and variety of other goods.

Although the valley floor is primarily privately owned agricultural land, much of the Sierra Nevada is national forest. Government-owned public lands include the El Dorado, Stanislaus, and Sierra National Forests and Yosemite National Park. Public lands amount to about one-third of the region's total land area. The national forest and park lands include more than 2.9 million acres. U.S. Bureau of Land Management and military properties occupy more than 200,000 and 5,100 acres, respectively. State parks, recreational areas, and other State property occupy about 80,000 acres.

Table SJR-13 Poorest 20 Census Designated Places within the San Joaquin River Hydrologic Region with Populations Greater than 2,000

Census Designated Place	Population	Median Household Income
Shackelford	3,748	$19,302
South Dos Palos	2,271	$28,931
Winton	11,103	$29,586
Firebaugh[a]	7,373	$30,000
August	8,332	$30,469
West Modesto	6,222	$30,767
Sonora[a]	4,914	$30,893
Empire	3,763	$32,198
Columbia	2,504	$33,494
Jamestown	3,684	$33,988
Bystrom	4,010	$34,464
Keyes	5,079	$35,130
Oakhurst	3,263	$35,155
Kennedy	3,293	$35,450
Planada	4,295	$35,880
Merced[a]	77,080	$36,269
Bethel Island	2,191	$36,515
Parkwood	2,025	$37,208
Bret Harte	5,102	$38,087
Parksdale	2,977	$38,895

Notes:

State median household income: $60,883

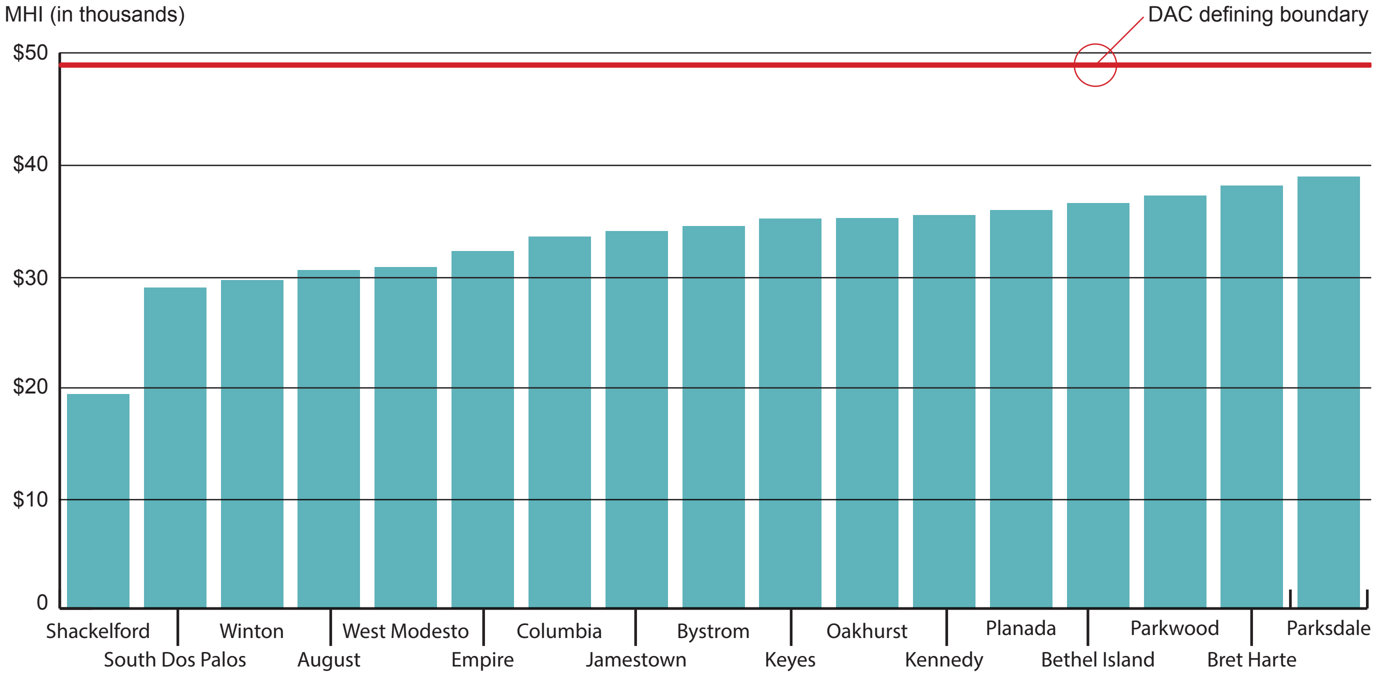
[a] Firebaugh, Sonora, and Merced are cities. All others are Census Designated Places.

Regional Resource Management Conditions

The Merced, Tuolumne, Stanislaus, Calaveras, Mokelumne, and Cosumnes rivers are tributaries of the San Joaquin River and drain the central Sierra Nevada. The lower portions of the watersheds provide runoff from rainfall. The higher elevations of the watersheds supply snowmelt runoff during the late spring and early summer. These tributaries supply significant surface water for local use.

The Chowchilla and Fresno rivers in Madera County receive water from the lower elevations of the Sierra Nevada foothills. Most of the runoff comes directly from rainfall. Buchanan Dam on the Chowchilla River forms Eastman Lake; Hidden Dam on the Fresno River forms Hensley

Figure SJR-10 Median Household Income (MHI) for Disadvantaged Communities (DACs) within the San Joaquin River Hydrologic Region: Poorest 20 Census Designated Places



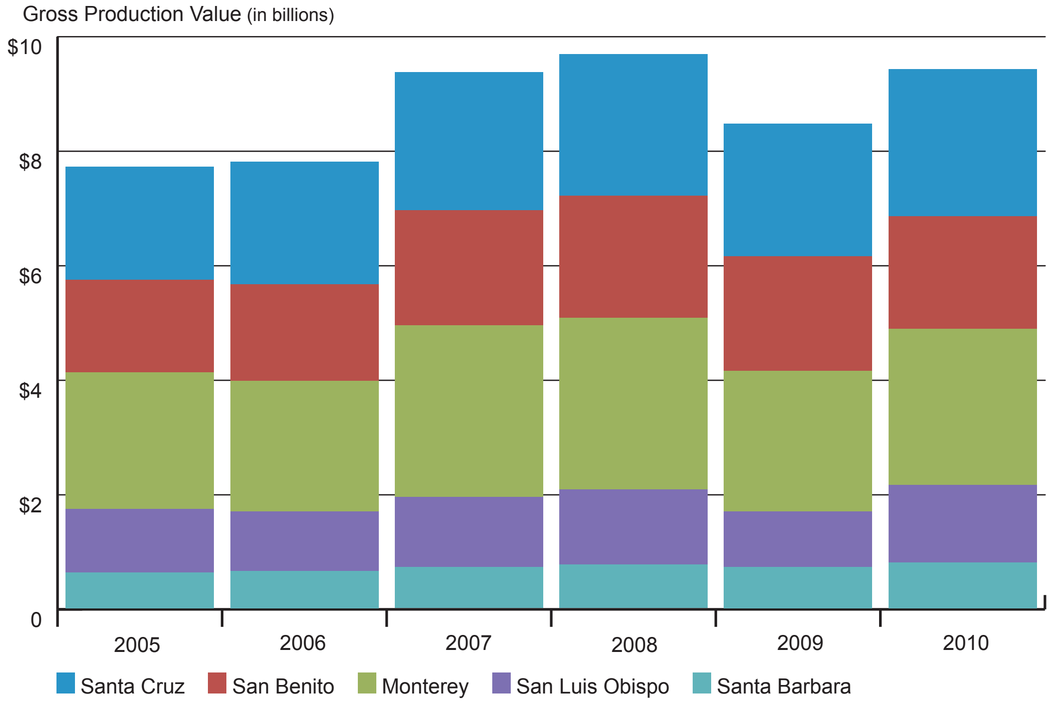
Lake. The CVP's Friant Unit provides surface water to the southeastern valley floor via the Madera Canal from Lake Millerton, but the largest share of CVP supplies from Lake Millerton is sent to the Friant Water Users Authority in the Tulare Lake Hydrologic Region. Delta waters are brought into the region along the west side of the valley by the State Water Project (SWP) California Aqueduct, and the federal San Luis Unit Project (San Luis Canal), and Delta-Mendota Canal.

Surface water from the Sierra Nevada is of high quality and reasonably dependable. The available water meets roughly half of the local water needs. Imported water adds to the surface water supply, and groundwater meets the remainder water use needs. Reductions of imported supplies from drought, legal actions, and other compliance requirements are a concern for local suppliers who seek long-term availability, stability, and reliability of imported supplies. Existing local surface water supplies are also strained by increases in local demand, environmental needs, and water needed for restoration purposes.

Water in the Environment

Restoration of Central Valley wetlands and habitat is critical to the preservation of many species of fish and wildlife in the San Joaquin Valley. Beginning in the 1990s, agencies made progress in their efforts to set aside and restore wetland habitat acreage. In 1990, the San Joaquin River Management Program was formed to restore the river system, which led to completion of the San Joaquin River Management Plan in 1995. The management plan identified nearly 80 consensus-based actions intended to benefit the San Joaquin River system, addressing six problem areas: flood protection, water quality, water supply, wildlife, fisheries, and recreation. These actions

Figure SJR-11 San Joaquin River Hydrologic Region Gross Agricultural Value for 2005-2010, in Millions of Dollars

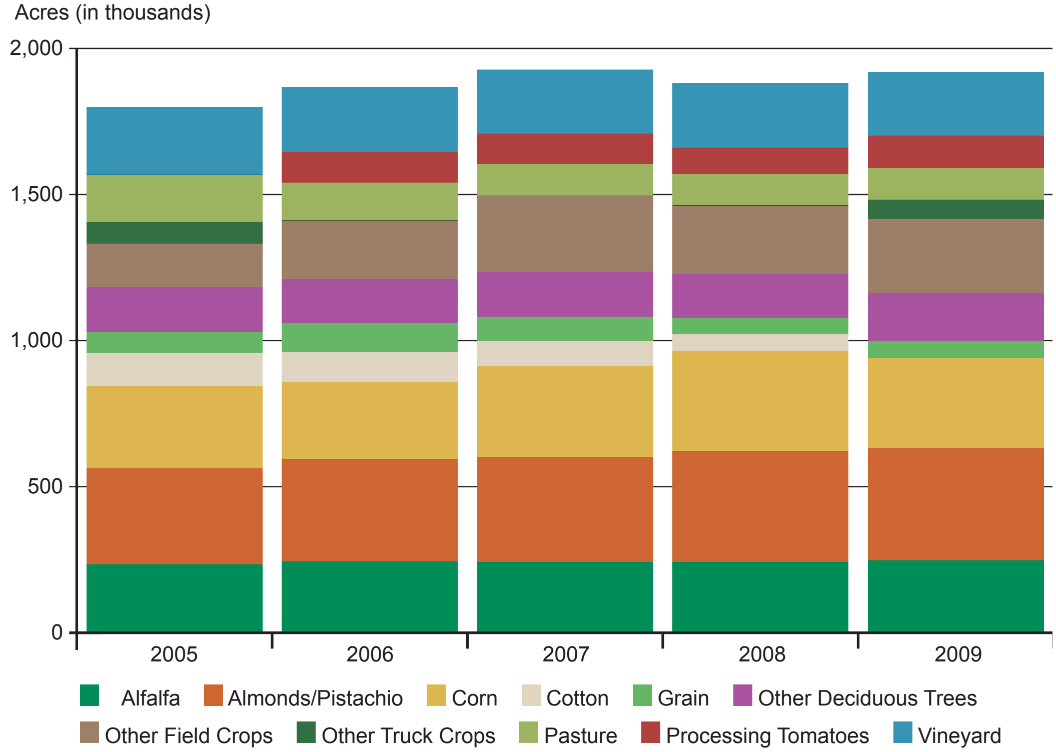


are organized into projects, feasibility studies, and riparian habitat acquisitions. Agencies participating in the program included U.S. Fish and Wildlife Service (USFWS), USBR, U.S. Army Corps of Engineers (USACE), and DWR. An advisory council was created that included representatives from counties and cities in the area, water user interests, and wildlife groups. The management program concluded in 2007, and some restoration activities are now managed through the San Joaquin River Restoration Program.

In 2002, River Partners began a restoration project west of Modesto along the San Joaquin River. A riparian habitat area of 777 acres was restored on the West Unit of the San Joaquin River National Wildlife Refuge. Since then, 2,350 acres of habitat on the refuge have been restored by River Partners.

The San Joaquin Valley is a major stop on the Pacific Flyway, a north/south pathway along the West Coast for migratory birds. The birds travel between their breeding grounds in the north and their wintering grounds in the south. Within the San Joaquin River Hydrologic Region, wildlife refuges, managed by the USFWS, and wildlife areas, managed by the California Department of Fish and Wildlife (DFW), include San Luis National Wildlife Refuge, which encompasses 26,600 acres; the San Joaquin River National Wildlife Refuge, 7,000 acres; Merced National Wildlife Refuge, 10,262 acres; Los Banos Wildlife Area, 6,217 acres; Volta Wildlife Area, 2,891 acres; the North Grasslands Wildlife Area, 7,069 acres; the White Slough Wildlife Area, 969 acres; and the Isenberg Sandhill Crane Reserve (managed by DFW), 361 acres. The Cosumnes River Preserve in the northern region is managed by the Nature Conservancy. At 46,000 acres, it has become the largest refuge area in the region. The main source of surface water supplies for many of the wildlife refuges within the San Joaquin River region is the CVP (via CVPIA). Table SJR-14 shows CVP supplies for wildlife refuges in the region.

Figure SJR-12 Top 10 Crop Types by Acreage for the San Joaquin River Hydrologic Region for Water Years 2005-2009



Private hunting clubs and other privately held lands also provide wetland habitat. The Grasslands Resources Conservation District includes about 70,000 acres, of which 36,068 acres are irrigated habitat, encompassing gun and duck clubs in the Grasslands area near Merced. The Grasslands Water District provides these clubs with CVP surface water supplies. The Merced National Wildlife Refuge receives water via the Merced Irrigation District.

Various rivers and streams with instream flow requirements and wild and scenic designations are within the San Joaquin River Hydrologic Region. The Mokelumne, Stanislaus, Tuolumne, Merced, and San Joaquin rivers have instream flow requirements. DFW is required by the Public Resources Code Sections 10000-10005 to develop flow recommendations for watercourses and streams throughout the state for which minimum flow levels need to be established in order to assure the continued viability of fish and wildlife resources. These flow recommendations are considered by SWRCB in regulatory actions related to appropriation of water and other planning activities.

The Tuolumne and Merced rivers also have wild and scenic designations. The Tuolumne River from its source to the Don Pedro Reservoir (83 miles) is designated wild and scenic; and the Merced River from its source to Lake McClure, as well as on the South Fork from its source to the main stem, is designated as wild and scenic. The National Wild and Scenic Rivers System was created by Congress in 1968 to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. While the designation neither prohibits development nor gives the federal

Table SJR-14 Central Valley Project Supplies for Select Wildlife Refuges in the San Joaquin River Region, 2005-2009

Refuge	Central Valley Project Deliveries (acre-feet)				
	2005	2006	2007	2008	2009
Grassland Water District[a]	154,456	191,821	162,907	150,284	134,287
Los Banos WA	3,542	21,798	24,171	18,255	19,025
North Grasslands WA	8,008	22,191	24,540	21,550	18,984
San Luis NWR	14,808	48,364	55,466	53,039	56,958
Volta WA	47,057	11,164	13,129	10,501	10,896
Total San Joaquin River Hydrologic Region	228,863	296,273	281,065	254,341	241,125

Notes:

WA= Wildlife Area, NWR= National Wildlife Refuge

[a] Grasslands Water District receives Central Valley Project water supplies and applies them to habitat in the district (gun and duck clubs).

government control over private property, it does prohibit federal support for actions, such as the construction of dams or other instream activities that would harm a river's free-flowing condition, water quality, or outstanding resource values. Recreation, agricultural practices, residential development, and other uses may continue. Protection of the river is provided through voluntary stewardship by landowners and river users and through regulation and programs of federal, State, local, or tribal governments. For more information, see http://www.rivers.gov/rivers/.

Water Supplies

Surface

On the valley floor, many agricultural and municipal users receive water supply from large irrigation districts, such as the Modesto, Merced, Oakdale, South San Joaquin, Madera, and Turlock irrigation districts. Most of this region's imported surface water supplies are delivered by the CVP, which averages about 1.9 maf per year (maf/yr.). In addition, Oak Flat Water District receives about 4,500 acre-feet per year (af/yr.) from the SWP. Most of the surface water in the upper San Joaquin River is stored and diverted at Friant Dam and is then conveyed north through the Madera Canal and south through the Friant-Kern Canal. Average annual diversions from the San Joaquin River through the Friant-Kern and Madera canals total about 1.3 maf — 260,000 maf for the Madera Canal and 1.03 maf for the Friant-Kern Canal.

The tributaries of the San Joaquin River provide the region with high-quality water that constitutes most of the surface water supplies for local uses. Much of this water is regulated by reservoirs and used on the east side of the San Joaquin Valley.

The availability and use of groundwater is of critical importance in the San Joaquin Valley. Water use requirements are met through a three-pronged supply strategy. Water use is first met by developed local surface water supplies. In areas where insufficient surface water exists, imported surface water is contracted through the SWP and the CVP. Where no surface water is available or where needs can be met by groundwater, local groundwater is pumped. Shortfalls in surface supplies can be made up with groundwater where it is available and of sufficient quality. Figure SJR-13 shows water supplies for the San Joaquin River region for water years 2005-2010. Total supply by source is shown, as well as percent of supply by source for a given year. The figure shows declining surface water supplies and increasing groundwater supplies over time due to the drought of 2007-2009. Total supplies are less during the years leading up to the drought because more rain fell during this time, which required less surface supplies for a given application. For a summary of the regional water inflows and outflows in 2010, see Figure SJR-14.

Figure SJR-15 shows annual deliveries by the CVP south of the Delta and SWP systems by percentage of contracted amounts for the years 2005-2010. During the drought years of 2007-2009, agricultural surface water supplies were the most severely impacted. Table SJR-15 displays the annual deliveries by percentage of contracted amounts for the years 1998-2010. CVPIA began in 2001, as shown in the table (Wildlife column), and has since seen all of its requests for CVP supplies fulfilled.

Federal land reservations for tribes have an associated reserved federal water right. This federal water right may predate existing State water rights or fall outside the jurisdiction of State water rights law. These federally reserved water rights are not subject to loss due to non-use. Water use associated with these reserved rights requires that federal and state systems for assigning water rights be reconciled.

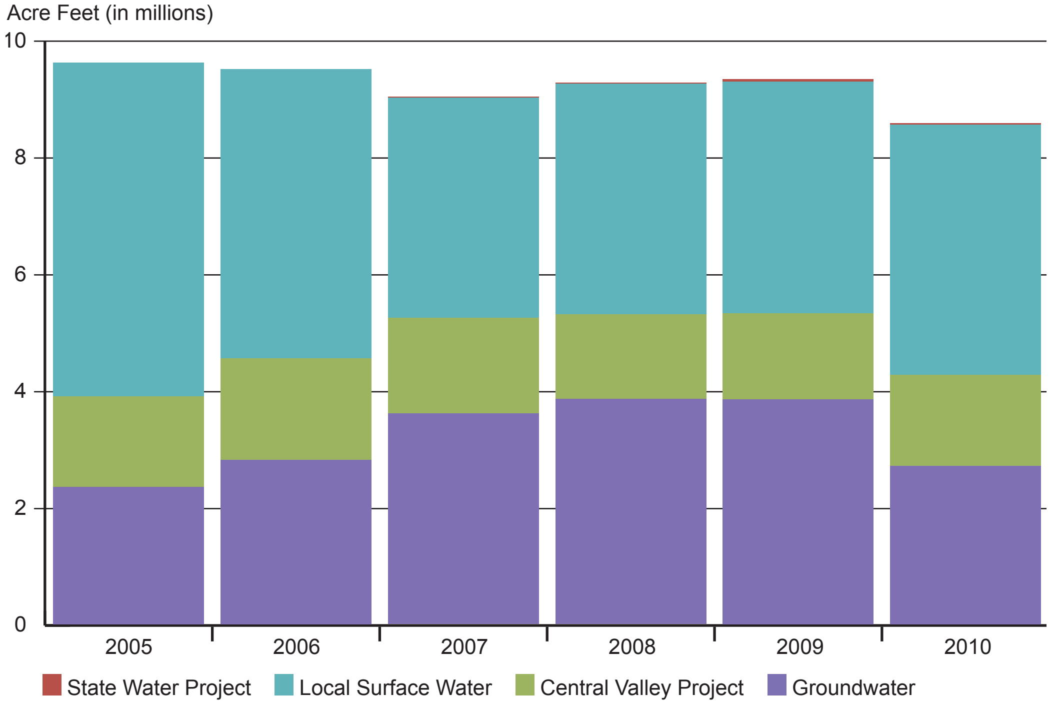
In 2006, the North Fork Rancheria of Mono Indians entered into a 20-year memorandum of understanding (MOU) with Madera Irrigation District. This MOU provides mechanisms to address and offset water-related impacts of rancheria development. Among the issues it covers are aquifer recharge, monitoring water usage, “right to farm,” and creation of a water advisory committee.

Recycled Municipal Water

According to the 2009 Municipal Wastewater Recycling Survey, compiled by the SWRCB and DWR, 36,700 acre-feet (af) of recycled water were beneficially recycled each year in the San Joaquin Hydrologic Region. The survey shows that most of the recycled water was used for agricultural irrigation. Some of the recycled water was used for landscape irrigation, industrial uses, commercial uses, natural systems, and golf course irrigation (State Water Resources Control Board 2011a). State policy encourages increased use of recycled water, but recognizes the potential of recycled water to contribute to exceeding or threatening to exceed water quality objectives due to salt and nutrients (State Water Resources Control Board 2009). Therefore, the policy requires stakeholders to work together to develop salt and nutrient management plans.

In the Central Valley, of which the San Joaquin River Hydrologic Region is a part, the Central Valley RWQCB (CVRWQCB) and the SWRCB, as part of a stakeholder effort, are developing a comprehensive salt and nitrate management plan for the Central Valley. The Central Valley Salinity Alternatives for Long-Term Sustainability (CV-SALTS) is a strategic initiative to address problems with salinity and nitrates in the surface water and groundwater of the Central

Figure SJR-13 San Joaquin River Hydrologic Region Water Supplies for Water Years 2005-2010



Valley. See further discussion of the CV-SALTS initiative below under section "Implementation Activities (2009-2013)."

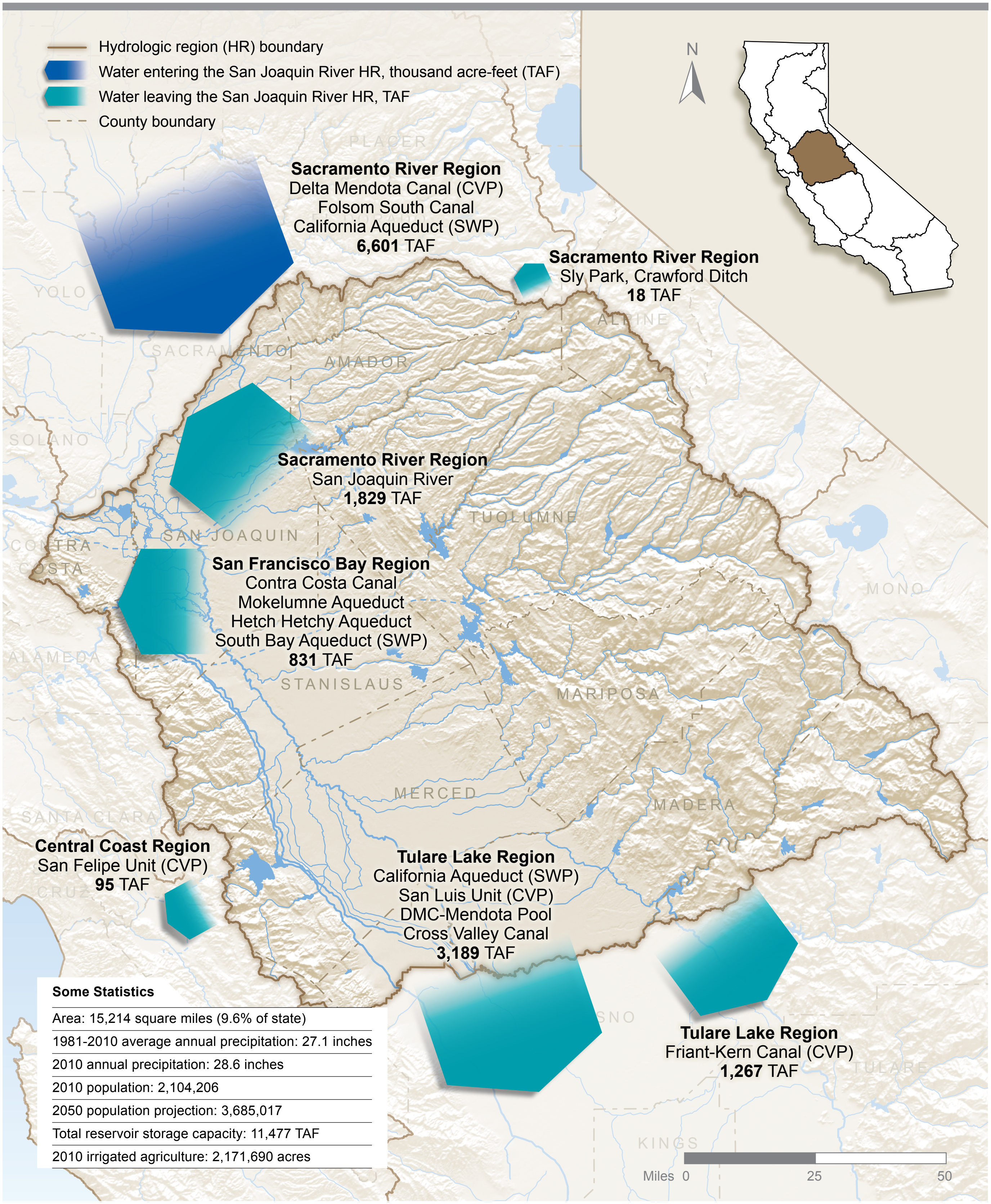
Additional information on statewide municipal recycled water is included in *Resource Management Strategies* (Volume 3, Chapter 12). Additional information on specific recycled water uses in the San Joaquin River region can be found in Volume 4.

Groundwater

Groundwater supply estimates are based on water supply and balance information derived from DWR land use surveys, and from groundwater supply information that water purveyors or other State agencies voluntarily provide DWR. Groundwater supply is reported by water year (October 1 through September 30) and is categorized according to agriculture, urban, and managed wetland uses. The groundwater information is presented by planning area, county, and by the type of use. Although groundwater accounts for about two-fifths of the region's total water supply, the majority of groundwater supplies (81 percent) are used to meet agricultural use while 13 percent goes to urban use. The rest of the groundwater supply (6 percent) is used to meet managed wetlands use in the region.

Figure SJR-16 depicts the planning area locations and the associated 2005-2010 groundwater supply in the region. The estimated average annual 2005-2010 total water supply for the region is about 8.3 maf of which 3.2 maf is from groundwater supply (38 percent). (Reference to total water supply represents the sum of surface water and groundwater supplies in the region, and

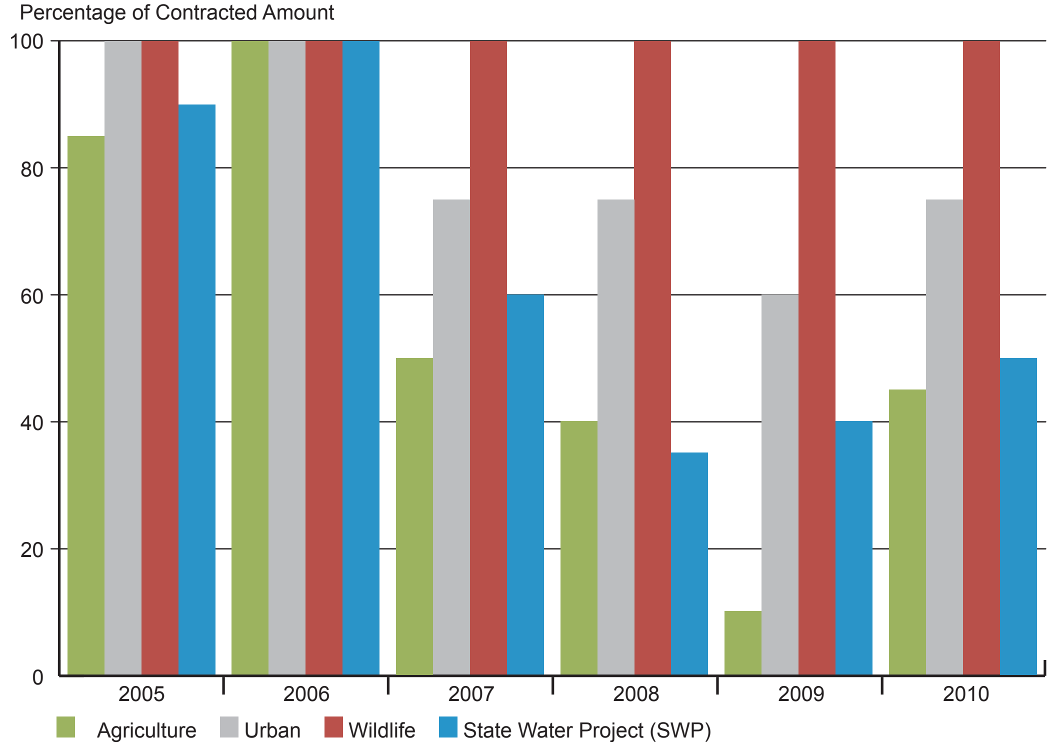
Figure SJR-14 San Joaquin River Hydrologic Region Inflows and Outflows in 2010



Some Statistics

Area: 15,214 square miles (9.6% of state)	
1981-2010 average annual precipitation: 27.1 inches	
2010 annual precipitation: 28.6 inches	
2010 population: 2,104,206	
2050 population projection: 3,685,017	
Total reservoir storage capacity: 11,477 TAF	
2010 irrigated agriculture: 2,171,690 acres	

Figure SJR-15 South of Delta Central Valley Project and State Water Project Annual Deliveries (Percentage of Contracted Amount), 2005-2010



local use.) Groundwater pumping in the San Joaquin River Hydrologic Region accounts for 19 percent of all the groundwater extraction in California, which is the second highest among the 10 hydrologic regions, behind the Tulare Lake Hydrologic region with 38 percent of the total groundwater extraction.

Figure SJR-16 also shows that Lower Valley East Side is the largest user of groundwater in the region; an average annual supply of 1,253 thousand acre-feet (taf) (39 percent of the total groundwater supply in the region). The average annual groundwater pumping is also high in Valley West Side with 761 taf, Eastern Valley Floor with 479 taf, and Middle Valley East Side with 405 taf. Groundwater status reports from groundwater management agencies overlying the region acknowledge that the average annual groundwater extraction commonly exceeds sustainable aquifer yield.

Table SJR-16 provides the 2005-2010 average annual groundwater supply by planning area and type of use. Groundwater supplies meet 58 percent (415 taf) of the overall urban water use; 36 percent (2,592 taf) of the overall agricultural water use, and 38 percent (191 taf) of the managed wetlands use in the region. Lower Valley East Side and Eastern Valley Floor rely on groundwater to meet about 60 percent of their agricultural water use. Many of the planning areas are also heavily dependent on groundwater to meet their urban water uses. Although on average of about only 18 taf of groundwater is pumped annually in East Side Uplands, groundwater accounts for 98 percent of its total water supply. The smallest groundwater user, West Side Uplands, is 100 percent dependent on groundwater supply to meet its water use — entirely urban.

Table SJR-15 South of Delta Central Valley Project and State Water Project Deliveries (Percentage of Contracted Amounts), 1998-2010

Year	Agriculture	Urban	Wildlife	State Water Project
1998	100	100	0	100
1999	70	95	0	100
2000	65	90	0	90
2001	49	77	100	39
2002	70	77	100	70
2003	75	100	100	90
2004	70	95	100	65
2005	85	100	100	90
2006	100	100	100	100
2007	50	75	100	60
2008	40	75	100	35
2009	10	60	100	40
2010	45	75	100	50

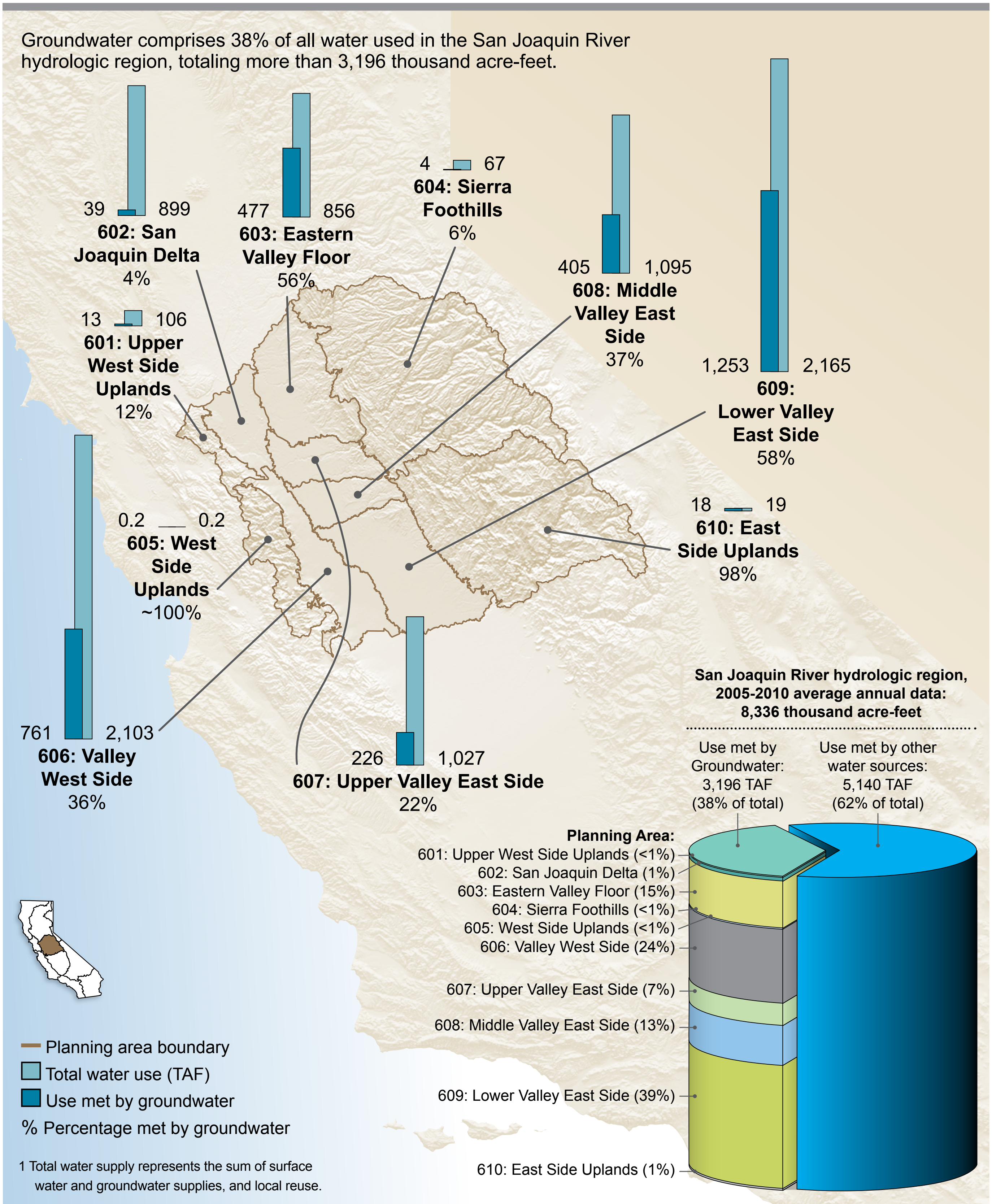
Regional totals for groundwater based on county area will vary from the planning area estimates because county boundaries do not necessarily align with planning area or hydrologic region boundaries.

For the San Joaquin River Hydrologic Region, county groundwater supply is reported for Amador, Calaveras, Contra Costa, Madera, Mariposa, Merced, San Joaquin, Stanislaus, and Tuolumne counties. Groundwater supply for Alpine, Fresno, Alameda, Sacramento, El Dorado, and San Benito counties are discussed in the regional reports for the relevant hydrologic regions. Table SJR-17 shows that groundwater contributes about 37 percent of the total water supply in the nine-county area, ranging from less than one percent to 68 percent for individual counties. Although most of the groundwater in the nine-county area is pumped for agricultural water use, groundwater supplies are used to meet only about one-third of the agricultural water use. In contrast, although overall pumping for urban water use is significantly less, groundwater supplies are used to meet about half of the urban water use. Almost all of managed wetlands use in the nine-county area is in Merced County.

Changes in annual groundwater supply and type of use may be related to a number of factors, such as changes in surface water availability, urban and agricultural growth, market fluctuations, and water use efficiency practices. Figures SJR-17 and SJR-18 summarize the 2002 through 2010 groundwater supply trends for the region.

The right side of Figure SJR-17 illustrates the annual amount of groundwater versus other water supplies, while the left side identifies the percent of the overall water supply provided by groundwater relative to other water supplies. The center column in the figure identifies the water year along with the corresponding amount of precipitation, as a percentage of the 30-year running

Figure SJR-16 Contribution of Groundwater to the San Joaquin River Hydrologic Region Water Supply by Planning Area (2005-2010)



1 Total water supply represents the sum of surface water and groundwater supplies, and local reuse.

Table SJR-16 San Joaquin River Hydrologic Region Average Annual Groundwater Supply by Planning Area (PA) and by Type of Use (2005-2010)

San Joaquin River Hydrologic Region		Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Use Met by Groundwater	
PA NUMBER	PA NAME	TAF	%	TAF	%	TAF	%	TAF	%
601	Upper West Side Uplands	5.4	17	7.4	10	0.0	0	12.8	12
602	San Joaquin Delta	0.8	0	37.8	35	0.0	0	38.6	4
603	Eastern Valley Floor	427.2	58	51.7	44	0.1	17	479.1	56
604	Sierra Foothills	1.7	8	2.6	6	0.0	0	4.3	6
605	West side Uplands	0.0	0	0.2	100	0.0	0	0.2	100
606	Valley West Side	554.7	34	27.8	88	178.1	41	760.6	36
607	Upper Valley East Side	121.9	13	102.9	69	1.4	13	226.3	21
608	Middle Valley East Side	330.3	32	74.9	100	0.0	0	405.2	37
609	Lower Valley East Side	1,146.7	57	95.4	100	11.1	25	1,253.1	58
610	East Side Uplands	3.1	100	15.3	97	0.0	0	18.4	98
2005-10 annual average region total		**2,591.8**	**36**	**414.9**	**58**	**190.7**	**38**	**3,198.4**	**38**

Notes:

PA = planning area, TAF = thousand acre-feet

Percent use is the percentage of the total water supply that is met by groundwater, by type of use.

2005-2010 precipitation equals 97 percent of the 30-year average for the San Joaquin River Hydrologic Region.

Table SJR-17 San Joaquin River Hydrologic Region Average Annual Groundwater Supply by County and by Type of Use (2005-2010)

San Joaquin River Hydrologic Region	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Use Met by Groundwater	
COUNTY	TAF	%	TAF	%	TAF	%	TAF	%
Amador	3.5	23	1.6	15	0.0	0	5.1	20
Calaveras	1.3	16	1.6	13	0.0	0	2.8	14
Contra Costa	0.8	1	24.9	9	0.0	0	25.7	6
Madera	673.1	66	40.7	100	0.0	0	713.7	68
Mariposa	3.1	0	4.6	1	0.0	0	7.7	0
Merced	764.6	38	84.6	97	189.2	39	1,038.3	40
San Joaquin	354.1	22	81.8	44	0.0	0	435.8	25
Stanislaus	512.4	29	162.8	85	1.4	13	676.6	35
Tuolumne	0.4	7	1.3	10	0.0	0	1.7	9
2005-2010 annual average total	**2,313.2**	**35**	**402.1**	**48**	**190.6**	**39**	**2,907.5**	**37**

Notes:

TAF = thousand acre-feet

Percent use is the percentage of the total water supply that is met by groundwater, by type of use.

Groundwater supply for Alpine, Fresno, Alameda, Sacramento, El Dorado, and San Benito counties are discussed in the Regional Reports for the relevant hydrologic regions.

2005-2010 precipitation equals 97 percent of the 30-year average for the San Joaquin River Hydrologic Region.

average for the region. The figure indicates that between 2002 and 2010, the annual water supply for the region has fluctuated between 7.5 maf and 9.1 maf depending on annual precipitation amounts. The annual groundwater supply has fluctuated between 2.4 maf and 3.9 maf, providing between 31 and 43 percent of the total water supply.

Figure SJR-18 shows the annual amount and percentage of groundwater supply to meet urban, agricultural, and managed wetland uses. The figure illustrates that in areas of high water uses, relatively small changes in percent of groundwater supply required can result in large changes in the volume of groundwater extraction. For example, between 2005 and 2009, the percentage of groundwater supply to meet agricultural water use increased from 72 to 84 percent. The 12 percent increase almost doubled the amount of groundwater extraction for agricultural use — from 1.7 maf in 2005 to 3.2 maf in 2009. Groundwater pumping to meet urban water use remained fairly stable during the 2002 to 2010 period — between 390 and 470 taf, ranging from 10 to 20 percent of the annual groundwater extraction. The rest of the groundwater supply, between 140 and 210 taf, was used to meet managed wetlands use.

Figure SJR-17 San Joaquin River Hydrologic Region Annual Groundwater Water Supply Trend (2002-2010)

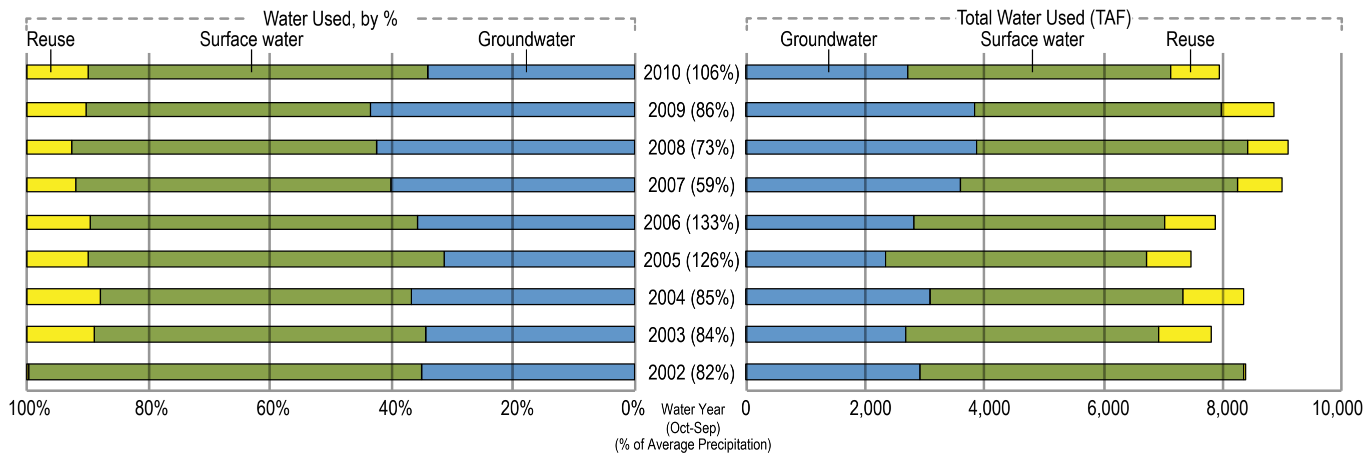
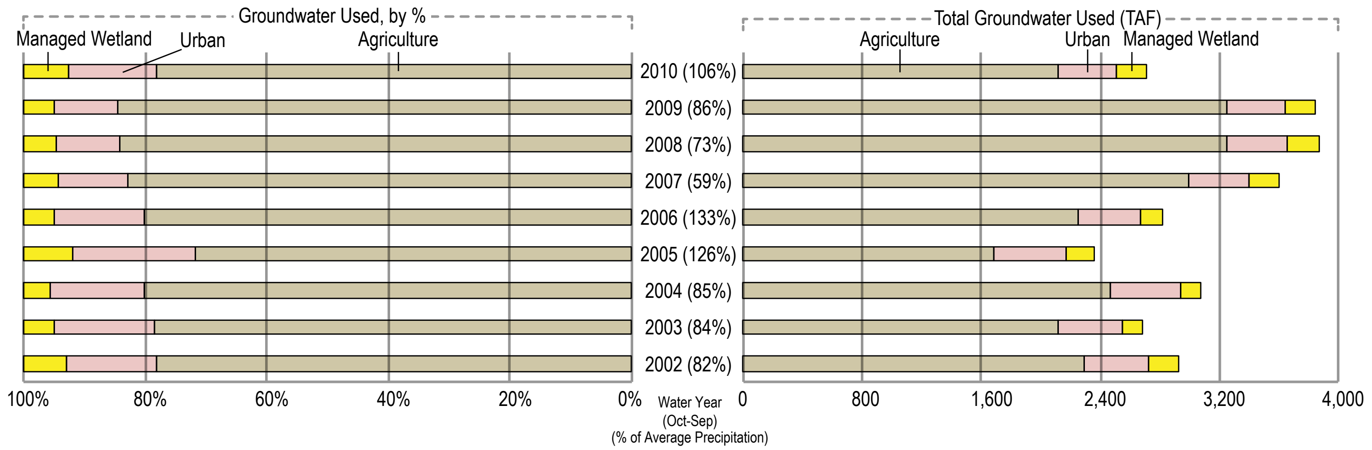


Figure SJR-18 San Joaquin River Hydrologic Region Annual Groundwater Supply Trend by Type of Use (2002-2010)



More detailed information regarding groundwater water supply and use analysis is available online from Update 2013, the Volume 4, *Reference Guide,* article, “California’s Groundwater Update 2013.”

Water Uses

At higher elevations in the Sierra Nevada, reservoirs capture water to produce hydroelectric power. In some locations, a sequence of plants produces power. Some diversions occur for local use. A network of canals, ditches, tunnels, and flumes was constructed in the 1850s for mining and timber purposes. Some of the remnants of those systems remain in use today. As surface water moves closer to the foothills/valley floor, larger reservoirs provide storage for flood control and other purposes, such as power production, diversion, conservation storage, fish and habitat releases, and salinity control. Conservation storage is most often used for urban and agricultural purposes. This lower and larger storage is often operated by or in conjunction with valley irrigation districts that hold water rights and distribute the surface water to their users. Reservoirs and downstream releases also provide recreational opportunities.

Cities in the San Joaquin Valley predominately developed groundwater to supply residents. As a consequence, many of the major population areas experienced groundwater depressions. The stress on the groundwater system and costs, limitations, and uncertainties of treating water at each wellhead has created a gradual movement toward using treated surface water.

Throughout the region, individual and private owners maintain groundwater wells to meet individual needs. In the foothill and mountain areas, groundwater is the primary supply. Well interference problems have resulted from larger-capacity water system wells that are close to other wells and are pumped at relatively high rates for prolonged periods. In other areas, further large-scale dense development may require a supplemental water supply to augment the available groundwater.

Drinking Water

The region has an estimated 438 community drinking water systems. A community water system is a public water system that supplies water to the same population year-round. The majority (over 80 percent) of these community water systems are considered small (serving fewer than 3,300 people), with most small water systems serving fewer than 500 people (Table SJR-18). Small water systems face unique financial and operational challenges in providing safe drinking water. Given their small customer base, many small water systems cannot develop or access the technical, managerial, and financial resources needed to comply with new and existing regulations. These water systems may be geographically isolated, and their staff often lacks the time or expertise to make needed infrastructure repairs, install or operate treatment processes, or develop comprehensive source water protection plans, financial plans, or asset management plans (U.S. Environmental Protection Agency 2012).

In contrast, medium and large water systems account for less than 20 percent of region's drinking water systems; however, these systems deliver drinking water to over 90 percent of the region's population (see Table SJR-18). These water systems generally have the financial resources to hire staff to oversee daily operations and maintenance needs and hire staff to plan for future infrastructure replacement and capital improvements. This helps to ensure that existing and future drinking water standards can be met.

In the Central Valley, many rural homes maintain wells for domestic purposes. These domestic wells tend to be more shallow than agricultural wells due to the lower necessary flow rates. However, due to their shallow nature, they tend to draw water from nearer the ground surface, which subjects them to potential contamination from percolating water or other sources.

Water Conservation Act of 2009 (SB X7-7) Implementation Status and Issues

Seventeen San Joaquin River urban water suppliers have submitted 2010 urban water management plans to DWR. The Water Conservation Act of 2009 (Senate Bill X7-7) required urban water suppliers to calculate baseline water use and set 2015 and 2020 water use targets. San

Table SJR-18 Drinking Water Systems in the San Joaquin River Hydrologic Region

Water System Size by Population	Number of Community Water Systems (CWS)	Percent of Community Water Systems in Region	Population Served	Percent of Population Served
Large > 10,000	29	7	1,501,338	82
Medium 3301-10,000	35	8	186,402	10
Small 500-3300	72	16	96,257	5
Very Small < 500	297	68	44,133	2
CWS that primarily provide wholesale water	5	1		
Total	438	---	1,828,130	---

Source: California Department of Public Health (CDPH) Permits, Inspection, Compliance, Monitoring and Enforcement Database, June 2012.

Note: Population estimates are as reported by each water system to CDPH and may include seasonal visitors.

Joaquin River Hydrologic Region had a population-weighted baseline average water use of 237 gallons per capita per day (gpcd) with an average population-weighted 2020 target of 196 gpcd. The baseline and target data for the San Joaquin River urban water suppliers is available on DWR Urban Water Use Efficiency Web site located at http://www.water.ca.gov/wateruseefficiency/.

The Water Conservation Act of 2009 required agricultural water suppliers to prepare and adopt agricultural water management plans by December 31, 2012, and update those plans by December 31, 2015, and every five years thereafter. Seven San Joaquin River agricultural water suppliers have submitted 2012 agricultural water management plans to DWR.

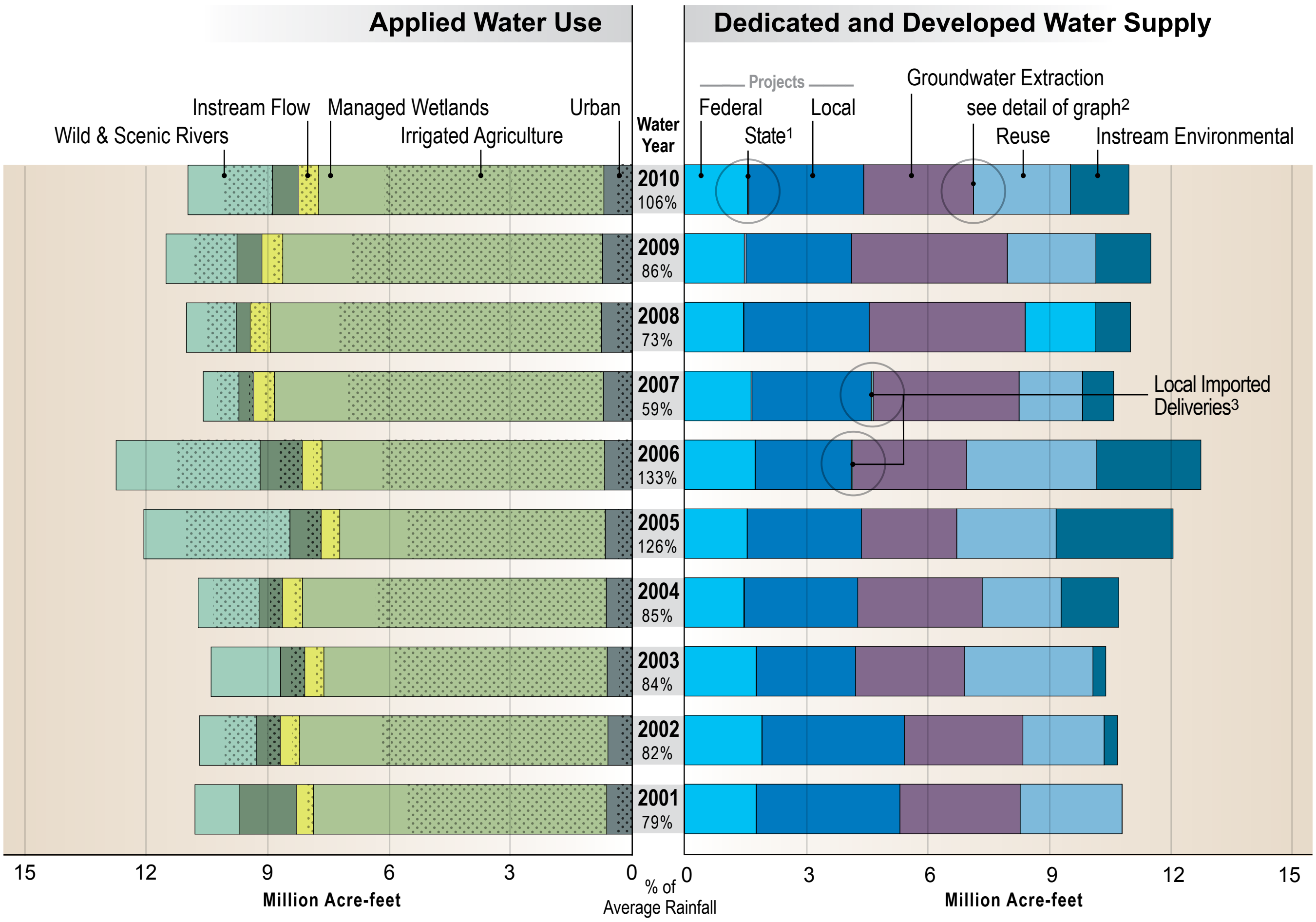
Water Balance Summary

Figure SJR-19 summarizes the total developed water supplies and distribution of the dedicated water uses within this hydrologic region for the 10 years from 2001 through 2010. As indicated by the variations in the horizontal bars, the distribution of the dedicated supply to various uses can change significantly based on the wetness or dryness of the water year. The more detailed numerical information about the developed water supplies and uses is presented in the Volume 5 *Technical Guide*, which provides a breakdown of the components of developed supplies used for agricultural, urban, and environmental purposes and Water Portfolio data.

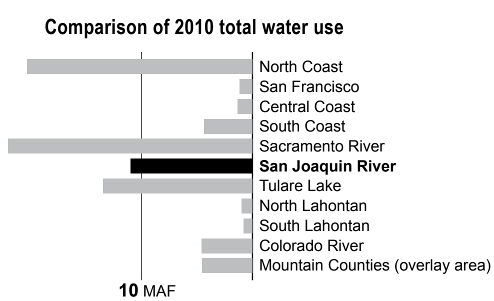
For the San Joaquin River Hydrologic Region, agricultural water uses are the largest component of the developed water uses; urban water use is a very small portion of the total. Dedicated water required for instream flows and managed wetlands is also a significant component of water use in this region. Groundwater is a significant source of supply for this region. The reuse of agricultural water runoff is a major source of supply to downstream water users. The specific water balances for these areas is contained in Update 2013, Volume 5, *Technical Guide*.

Figure SJR-19 San Joaquin Hydrologic Water Balance by Water Year, 2001-2010

California's water resources vary significantly from year to year. Ten recent years show this variability for water use and water supply. Applied Water Use shows how water is applied to urban and agricultural sectors and dedicated to the environment and the Dedicated and Developed Water Supply shows where the water came from each year to meet those uses. Dedicated and Developed Water Supply does not include the approximately 125 million acre-feet (MAF) of statewide precipitation and inflow in an average year that either evaporates, are used by native vegetation, provides rainfall for agriculture and managed wetlands, or flow out of the state or to salt sinks like saline aquifers (see Table SJR-19). Groundwater extraction includes annually about 2 MAF more groundwater used statewide than what naturally recharges – called groundwater overdraft. Overdraft is characterized by groundwater levels that decline over a period of years and never fully recover, even in wet years.



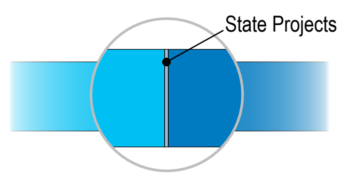
Stippling in bars indicates **depleted (irrecoverable) water use** *(water consumed through evapotranspiration, flowing to salt sinks like saline aquifers, or otherwise not available as a source of supply)*



[1] **Detail of bar graph:** *For water years 2001-2010, State projects water varied from 4.3 to 46 TAF of the water supply.*

[2] *For water years 2001-2010, Inflow and Storage water varied from 0 to 5 TAF of the water supply.*

[3] *For water years 2006-2007, local imported deliveries varied from 36 to 46 TAF of the water supply.*



For further details, refer to Volume 5, *Technical Guide*, and the Volume 4 article, "California's Groundwater Update 2013."

Key Water Supply and Water Use Definitions

Applied water. The total amount of water that is diverted from any source to meet the demands of water users without adjusting for water that is depleted, returned to the developed supply or considered irrecoverable (see water balance figure).

Consumptive use is the amount of applied water used and no longer available as a source of supply. Applied water is greater than consumptive use because it includes consumptive use, reuse, and outflows.

Instream environmental. Instream flows used only for environmental purposes.

Instream flow. The use of water within its natural watercourse as specified in an agreement, water rights permit, court order, FERC license, etc.

Groundwater Extraction. An annual estimate of water withdrawn from banked, adjudicated, and unadjudicated groundwater basins.

Recycled water. Municipal water which, as a result of treatment of waste, is suitable for a direct beneficial use or a controlled use that would not otherwise occur and is therefore considered a valuable resource.

Reused water. The application of previously used water to meet a beneficial use, whether treated or not prior to the subsequent use.

Urban water use. The use of water for urban purposes, including residential, commercial, industrial, recreation, energy production, military, and institutional classes. The term is applied in the sense that it is a kind of use rather than a place of use.

Water balance. An analysis of the total developed/dedicated supplies, uses, and operational characteristics for a region. It shows what water was applied to actual uses so that use equals supply.

San Joaquin River Water Balance by Water Year Data Table (TAF)

	2001 (79%)	2002 (82%)	2003 (84%)	2004 (85%)	2005 (126%)	2006 (133%)	2007 (59%)	2008 (73%)	2009 (86%)	2010 (106%)
APPLIED WATER USE										
Urban	629	601	618	640	665	678	714	757	733	700
Irrigated Agriculture	7,243	7,613	6,998	7,505	6,559	6,982	8,124	8,177	7,899	7,045
Managed Wetlands	415	477	473	492	458	484	516	503	516	497
Req Delta Outflow	0	0	0	0	0	0	0	0	0	0
Instream Flow	1,424	583	600	582	772	1,046	361	345	614	644
Wild & Scenic R.	1,091	1,420	1,714	1,504	3,611	3,557	883	1,232	1,755	2,090
Total Uses	**10,802**	**10,694**	**10,403**	**10,723**	**12,065**	**12,748**	**10,598**	**11,014**	**11,517**	**10,976**
DEPLETED WATER USE (STIPPLING)										
Urban	400	297	311	337	347	330	347	387	386	378
Irrigated Agriculture	4,938	5,605	5,270	5,687	4,922	5,484	6,304	6,515	6,248	5,421
Managed Wetlands	138	190	186	207	155	206	242	472	241	474
Req Delta Outflow	0	0	0	0	0	0	0	0	0	0
Instream Flow	0	323	318	304	249	553	98	0	0	0
Wild & Scenic R.	0	797	0	1,123	2,555	2,077	532	708	1,044	1,184
Total Uses	**5,476**	**7,211**	**6,085**	**7,657**	**8,227**	**8,650**	**7,523**	**8,082**	**7,919**	**7,457**
DEDICATED AND DEVELOPED WATER SUPPLY										
Instream	0	329	318	1427	2890	2506	771	858	1357	1446
Local Projects	3,549	3,511	2,439	2,800	2,823	2,441	2,946	3,101	2,613	2,841
Local Imported Deliveries	0	0	0	0	0	36	46	0	0	0
Colorado Project	0	0	0	0	0	0	0	0	0	0
Federal Projects	1,764	1,906	1,765	1,461	1,542	1,736	1,640	1,445	1,472	1,552
State Project	4	9	17	14	5	7	24	10	46	30
Groundwater Extraction	2,969	2,929	2,688	3,073	2,351	2,815	3,604	3,864	3,848	2,709
Inflow & Storage	0	6	0	0	0	3	3	1	0	5
Reuse & Seepage	2,516	2,005	3,176	1,949	2,454	3,202	1,563	1,734	2,180	2,392
Recycled Water	2	0	0	0	0	2	2	2	2	1
Total Supplies	**10,802**	**10,694**	**10,403**	**10,723**	**12,065**	**12,748**	**10,598**	**11,014**	**11,517**	**10,976**

The Upper West Side Uplands Planning Area (PA 601) contains more urban applied water (95-105 taf annually), including substantial industrial and large landscape uses, than agricultural use (30-40 taf). There is no environmental water use (managed wetlands or instream) in this planning area. Most of the water supply comes from local sources (about 60-110 taf annually). Some CVP deliveries are made (13-22 taf). Although some groundwater is extracted, more is recharged into the basin so there has been a net recharge in recent years. About 5,000 af of water is reused annually.

The San Joaquin Delta (PA 602) is both more populated (87-132 taf urban applied water) and much more agricultural (0.75 to 1.1 maf applied water) than PA 601. From 0.5 to 0.6 taf is applied to managed wetlands. Most of the water supply comes from local deliveries and drainage from upstream (660-960 taf). Smaller amounts are delivered through the CVP, SWP, and other federal projects (34-70 taf total). The remainder of the supply comes from groundwater (25-50 taf) and reuse (100-165 taf).

The Eastern Valley Floor Planning Area (PA 603) applies about the same amount of water for urban uses and maybe 10 percent less for agricultural uses as PA 602. There is about one taf applied water for managed wetlands, but no environmental instream requirements. About 60 percent of the water supply comes from groundwater and forty percent from various surface water sources.

In the Sierra Foothills Planning Area (PA 604), urban applied water ranges from about 40-55 taf; and applied water for agricultural uses from 17-37 taf. There are both instream requirements (95-300 taf per year [taf/yr.]), and wild and scenic river designations (0.5-2.1 maf), but no managed wetlands. The instream requirement water supply (wild and scenic and instream requirements) comes from local sources, of course. The supplies for the agricultural and urban applied water come about equally from surface water and groundwater.

In the West Side Uplands Planning Area (PA 605), recordable water use (over about 50 af/yr.) did not start appearing until 2008. Urban use has grown from 0.1 taf in 2008 to 0.4 taf in 2010. There is no recordable agricultural or environmental use in this planning area. The water supply comes entirely from groundwater.

The Valley West Side Planning Area (PA 606) is primarily agricultural with about 30-35 taf urban applied water and 1.5-1.9 maf of agricultural applied water. There are no instream environmental requirements, but substantial managed wetlands with 426-454 taf/yr. of applied water. Supply is primarily from the CVP (1.1-1.3 maf) with substantial groundwater use (533-980 taf/yr.). Limited local supplies, inflow drainage, and SWP deliveries make up the difference.

The Upper Valley East Side Planning Area (PA 607) uses about 150 taf/yr. for urban uses and 0.9-1.1 maf for agriculture. There is an instream requirement that takes about 100-470 taf/yr. and some managed wetlands using about 13 taf/yr. Most of the water supply comes from local sources and drainage from upstream sources. About 200-280 taf comes from groundwater pumping and a small amount from the CVP.

The Middle Valley East Side Planning Area (PA 608) uses from about 66-79 taf of urban water and 0.9-1.2 maf of agricultural applied water per year. There is no environmental water use in this planning area. Between one-half and two-thirds of the water supply comes from local sources and the rest from pumping groundwater.

The Lower Valley East Side Planning Area (PA 609) urban areas apply 92-102 taf annually for primarily residential uses. Agricultural applied water is higher here also, at about 1.9-2.2 maf/yr.. There are instream requirements of about 68-84 taf/yr., all of which is reused downstream. Flows to managed wetlands equal about 45 taf/yr. Most of the water supplies for PA 609 come from groundwater (1.0-1.6 maf), with substantial amounts (30 to nearly 50 percent) returning to the groundwater basin. The rest of the supply comes from surface water sources (local supplies, inflow drainage from upstream, and CVP) with the reuse from the instream requirements.

The East Side Uplands Planning Area (PA 610) is located on the west side of the Sierra Nevada, which makes the area a source of supply for the valley but limits it as either an agricultural or urban area. This shows up in the annual urban use of 15-17 taf and the agricultural use of 3-4 taf. There is substantial wild and scenic river flow through there, all of which is reused downstream in other planning areas. The supply for the agricultural and urban uses comes from groundwater.

Table SJR-19 presents information about the total water supply available to this region for the 10 years from 2001 through 2010, and the estimated distribution of these water supplies to all uses. The annual change in the region's surface water and groundwater storage is also estimated, as part of the balance between supplies and uses. In wetter water years, water will usually be added to storage; during drier water years, storage volumes may be reduced. Of the total water supply to the region, more than half is either used by native vegetation; evaporates to the atmosphere; provides some of the water for agricultural crops and managed wetlands (effective precipitation); or flows to the Pacific Ocean and salt sinks like saline groundwater aquifers. The remaining portion, identified as consumptive use of applied water, is distributed among urban and agricultural uses and for diversions to managed wetlands. For some of the data values presented in Table SJR-19, the numerical values were developed by estimation techniques because actual measured data are not available for all categories of water supply and use.

Project Operations

The East Bay Municipal Utility District (EBMUD) and San Francisco Public Utilities Commission move water originating in the San Joaquin River Hydrologic Region across the valley for use in the San Francisco Bay Area. EBMUD transports water from the Mokelumne River via the Mokelumne Aqueduct. This water goes to Alameda and Contra Costa counties in the East Bay. The City/County of San Francisco and other nearby cities receive water through the Hetch Hetchy Aqueduct from the Tuolumne River.

Other facilities in this region include Camanche Dam/Reservoir on the Mokelumne River, Donnells and Beardsley dams/reservoirs on the Middle Fork of the Stanislaus River, Tulloch Dam/Reservoir, and New Melones Dam/Lake on the Stanislaus River, New Don Pedro Dam/Lake on the Tuolumne River, and New Exchequer Dam/Lake McClure on the Merced River.

USACE projects on the east side of the San Joaquin River watershed that impound streams tributary to the river are primarily flood dams and include Hidden Dam on the Fresno River, Buchanan Dam on the Chowchilla River, Mariposa Dam on Mariposa Creek, Owens Dam on Owens Creek, Bear Dam on Bear Creek, and Burns Dam on Burns Creek. Although these are flood control projects, this group of reservoirs has provided an average annual outflow over the last 35 years of about 230,000 af.

Table SJR-19 San Joaquin RIver Hydrologic Region Water Balance for 2001-2010 (in taf)

San Joaquin River (taf)	Water Year (Percent of Normal Precipitation)									
	2001 (79%)	**2002** (82%)	**2003** (84%)	**2004** (85%)	**2005** (126%)	**2006** (133%)	**2007** (59%)	**2008** (73%)	**2009** (86%)	**2010** (106%)
WATER ENTERING THE REGION										
Precipitation	16,120	18,069	18,469	18,695	27,903	29,259	13,082	16,009	18,965	23,328
Inflow from Oregon/Mexico	0	0	0	0	0	0	0	0	0	0
Inflow from Colorado River	0	0	0	0	0	0	0	0	0	0
Imports from Other Regions	4,572	6,527	7,460	7,216	7,739	6,770	5,686	3,170	3,060	6,601
Total	**20,692**	**24,596**	**25,929**	**25,911**	**35,642**	**36,029**	**18,768**	**19,179**	**22,025**	**29,929**
WATER LEAVING THE REGION										
Consumptive use of applied water[a] (Ag, M&I, Wetlands)	5,256	5,627	5,306	5,744	4,879	5,305	6,174	6,309	6,085	5,361
Outflow to Oregon/Nevada/ Mexico	0	0	0	0	0	0	0	0	0	0
Exports to other regions	4,496	6,349	7,492	7,085	10,733	14,579	6,876	4,785	4,550	7,297
Statutory required outflow to salt sink	0	75	86	86	0	0	0	0	0	0
Additional outflow to salt sink	183	276	276	282	263	283	290	302	288	291
Evaporation, evapotranspiration of native vegetation, groundwater subsurface outflows, natural and incidental runoff, ag effective precipitation & other outflows	13,452	14,097	13,761	15,690	18,244	17,637	10,994	11,794	12,887	17,718
Total	**23,387**	**26,424**	**26,921**	**28,887**	**34,119**	**37,804**	**24,334**	**23,190**	**23,810**	**30,667**
CHANGE IN SUPPLY										
[+] Water added to storage [-] Water removed from storage										
Surface reservoirs	-1,435	-166	760	-977	2,774	164	-2927	-970	1189	1148
Groundwater[b]	-1,260	-1,662	-1,752	-1,999	-1,251	-1939	-2639	-3041	-2974	-1886
Total	**-2,695**	**-1,828**	**-992**	**-2,976**	**1,523**	**-1775**	**-5566**	**-4011**	**-1785**	**-738**
Applied water[a] (ag, urban, wetlands) (compare with consumptive use)	8,287	8,691	8,089	8,637	7,682	8,145	9,354	9,437	9,148	8,242

Notes:

taf = thousand acre-feet, M&I = municipal and industrial

[a] Definition: Consumptive use is the amount of applied water used and no longer available as a source of supply. Applied water is greater than consumptive use because it includes consumptive use, reuse, and outflows.

[b] Definition: Change in Supply: Groundwater – The difference between water extracted from and water recharged into groundwater basins in a region. All regions and years were calculated using the following equation: change in supply: groundwater = intentional recharge + deep percolation of applied water + conveyance deep percolation and seepage - withdrawals.

This equation does not include unknown factors such as natural recharge and subsurface inflow and outflow. For further details, refer to Volume 4, *Reference Guide*, the article “California’s Groundwater Update 2013,” and Volume 5, *Technical Guide*.

The SWP and the CVP transfer Delta water into the San Joaquin Valley along the west side. The federal pumping plant near Tracy pumps into the Delta-Mendota Canal, which travels to San Luis Reservoir then toward the trough of the valley to Mendota Pool. The State pumping plant near Byron pumps into the California Aqueduct, which travels to San Luis Reservoir and then continues southward serving Kern County and Southern California. A portion of the California Aqueduct is a State-federal joint-use facility serving the San Luis Unit of the federal project. San Luis Reservoir is a joint-use pump storage facility.

Contra Costa Water District diverts from the Delta. Its Contra Costa Canal is fed from the Rock Slough Intake. Los Vaqueros Reservoir is filled using the Old River Intake. Current construction of the Alternate Intake Project is occurring in and around Victoria Island.

Most of the San Joaquin River is diverted at Lake Millerton/Friant Dam for use by federal water contractors. Water is moved northwestward in the Madera Canal and southeastward in the Friant-Kern Canal. Downstream, water reaching the Mendota Pool through the Delta-Mendota Canal may be released below the pool for contractual users. Previously, releases downstream into the river were primarily flood flows or to meet minimum flow requirements for prior water rights holders. For many decades, stretches of the river between Gravelly Ford and Mendota Pool and from Mendota Pool to the Merced River had minimal or no flows. However, in October 2009, interim flows began as part of the San Joaquin River restoration program; and in the fall of 2010, the often dry San Joaquin was reconnected to the Pacific Ocean. Full restoration flows are scheduled to begin no later than January 2014.

Levee and Channel System

Constructed facilities in the San Joaquin River Hydrologic Region consist of the San Joaquin River Flood Protection (SJRFP) system and other flood protection works. Regional facilities include eight major multipurpose reservoirs with flood management reservations, eight major flood management reservoirs, six smaller flood management reservoirs, bypasses, diversions, levees, channels and channel improvements, control structures, clearing and snagging, and bank protection. The following lists the major reservoirs in the SJRFP system.

The SJRFP system includes eight projects consisting of Farmington Flood Control Basin on Littlejohns Creek; Canal Creek Flood Detention Reservoir on Canal Creek; Bear Creek Flood Detention Reservoir on Bear Creek; Burns Creek Flood Detention Reservoir on Burns Creek; Owens Creek Flood Detention Reservoir on Owens Creek; Mariposa Creek Flood Detention Reservoir on Mariposa Creek; smaller reservoirs on Mustang Creek, Deer Creek, Dry Creek, the North Fork Tuolumne River, and Bear Creek; and bypasses, diversions, levees, channels, channel improvements, control structures, clearing and snagging, and bank protection on the San Joaquin River and many of its major tributaries.

Regional multipurpose reservoirs with flood control reservations are Millerton Lake on the San Joaquin River, Camanche Reservoir on the Mokelumne River, New Hogan Lake on the Calaveras River, New Melones Lake on the Stanislaus River, Don Pedro Lake on the Tuolumne River, Lake McClure on the Merced River, Eastman Lake on the Chowchilla River, and Hensley Lake on the Fresno River. Other major flood control reservoirs are Los Banos Reservoir on Los Banos Creek and Marsh-Kellogg Creeks Debris Reservoir on Marsh and Kellogg creeks. Smaller reservoirs are on the Mokelumne and North Fork Mokelumne rivers, and Deer, Dry, Bear, and Mustang creeks.

A substantial portion of the San Joaquin River Hydrologic Region is within the implementation area of the 2012 Central Valley Flood Protection Plan (CVFPP) (California Department of Water Resources 2012), which is available online at http://www.water.ca.gov/cvfmp/docs/2012%20CVFPP_June.pdf. The CVFPP proposes a systemwide investment approach for sustainable, integrated flood management in areas currently protected by facilities of the State Plan of Flood Control (SPFC). (Find more information about the CVFPP report in the "Levee Performance and Risk Studies" section.)

Major SPFC facilities along the San Joaquin River and tributaries include:

- Chowchilla Bypass (and levees), which begins at the San Joaquin River downstream from Gravelly Ford, diverts San Joaquin River flows, and discharges the flows into the Eastside Bypass.
- Eastside Bypass (and levees), which begins at the Fresno River, collects drainage from the east, and discharges to the San Joaquin River between Fremont Ford and Bear Creek.
- Mariposa Bypass, which begins at the Eastside Bypass and discharges to the San Joaquin River (and levees).
- Approximately 99 miles of levees along the San Joaquin River.
- Approximately 135 miles of levees along San Joaquin River tributaries and distributaries.
- Six instream control structures (Chowchilla Bypass Control Structure, San Joaquin River Control Structure, Mariposa Bypass Control Structure, Eastside Bypass Control Structure, Sand Slough Control Structure, and San Joaquin River Structure).
- Two major pumping plants.

The SPFC represents a portion of the Central Valley flood management system for which the State has special responsibilities, as defined in the CWC Section 9110 (f). The SPFC Descriptive Document provides a detailed inventory and description of the levees, weirs, bypass channels, pumps, dams, and other structures included in the SPFC (California Department of Water Resources 2010c).

Over the last century, the Central Valley, including large portions of the San Joaquin River Hydrologic Region, has experienced intensive urban development to meet the needs of a growing population. A complex water supply and flood risk management system supports and protects a vibrant agricultural economy, several cities, and numerous small communities.

Much of the Central Valley levee system was built over many years using the sands, silts, clays, and soils, including organic soils that were conveniently available and were often poorly compacted over permeable foundations. The system was designed to contain the record floods of the early 20th century with the aim of fostering development of an agriculturally oriented economy and promoting public safety. The subsequent construction of a series of multipurpose reservoirs with substantial flood control capability significantly augmented the capacity of the flood management system and contributed greatly to the state's economic development and public safety objectives. These reservoirs constituted the principal response to the mid-century recognition that extreme floods that were much larger than those that guided design of the levee system were reasonably foreseeable.

Although the SPFC has prevented billions of dollars in flood damages since its construction, a better understanding of the risk assessment and engineering standards has made it clear that some SPFC facilities face an unacceptably high chance of failure. Combined with continued urbanization in the floodplains, this has increased the estimated level of flood risk. While the chance and frequency of flooding have decreased since construction of the SPFC and multipurpose reservoirs, the damages that would occur if a levee were to fail in one of the urban areas are much greater, resulting in a net long-term increase in cumulative damages if no action is taken to improve the flood management system and limit further development in these areas.

Water Quality

Salt management is the most serious long-term water quality issue in the San Joaquin River basin. (Central Valley Regional Water Quality Control Board 2011b). Water quality throughout the San Joaquin River basin varies dependent upon source, geologic influences, and land uses.

Flows from the west side of the river basin are dominated by agricultural return flows because west side streams are ephemeral and their downstream channels are used to transport agricultural return flows to the main river channel. Poorer quality (higher salinity) water is imported from the Delta for irrigation along the west side of the river to replace water lost through diversion of the upper San Joaquin River flows. Flows from the east side of the river basin originate with snowmelt and springs in the Sierra Nevada and therefore generally contain higher quality and volume of surface water. Water quality issues for the San Joaquin River Hydrologic Region include the following (State Water Resources Control Board 2010).

- Salinity.
- Boron.
- Selenium.
- Pesticides (chlorpyrifos, diazinon, pyrethroids, and organochlorine pesticides).
- Localized pesticide impairments identified for the following:
  - Dieldrin in Del Puerto Creek, Hospital Creek, Ingram Creek, Orestimba Creek, and San Creek.
  - Dimethoate in Ramona Lake, Del Puerto Creek, Hospital Creek, Ingram Creek, Orestimba Creek, and Westley Wasteway.
  - Diuron in Lone Tree Creek, Miles Creek, Del Puerto Creek, Orestimba Creek, and the San Joaquin River.
  - Simazine in Highline Canal, Mustang Creek and Newman Wasteway.
- Metals (mercury, copper, and zinc).
- Nutrients (low dissolved oxygen).
- Bacteria/*E. coli*.
- Erosion and sediment.
- Temperature.

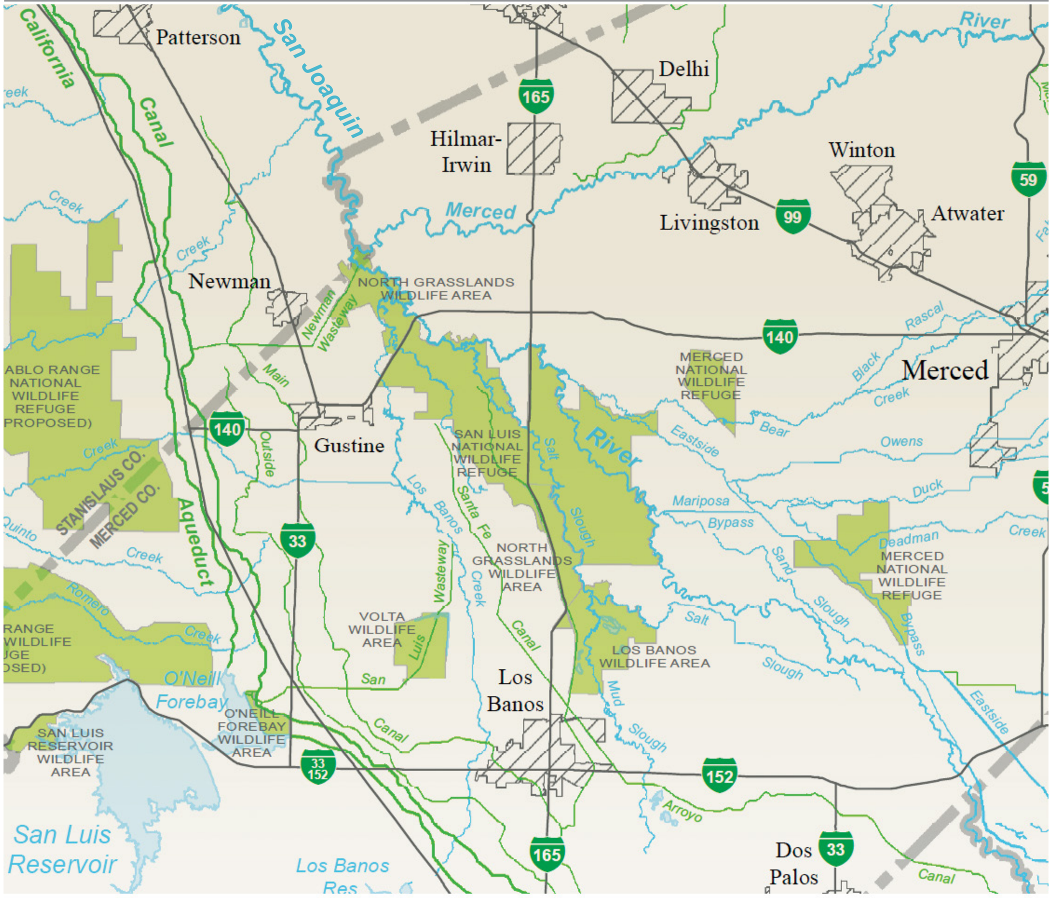
Since the 1940s, mean annual salt concentrations in the lower San Joaquin River at the Airport Way Bridge near Vernalis have doubled, and boron levels have increased significantly. Water quality monitoring data collected by the CVRWQCB and others indicate that water quality objectives for salinity and boron are frequently exceeded in the lower San Joaquin River during certain times of the year and under certain flow regimes. The salt and boron water quality impairment in the lower San Joaquin River has occurred, in large part, as a result of large-scale water development coupled with extensive agricultural land use and associated agricultural discharges in the watershed. Lower San Joaquin River flows have been severely diminished by the construction and operation of dams and diversions and the resulting consumptive use of water. Most of the natural flows from the upper San Joaquin River and its headwaters are diverted at the Friant Dam via the Friant-Kern Canal to irrigate crops outside the San Joaquin River Basin. Diverted natural-river flows have been replaced with poorer quality (higher salinity) imported water from the Delta, which is primarily used to irrigate crops on the west side of the lower San Joaquin River basin. Surface and subsurface agricultural discharges are the largest sources of salt and boron loading to the lower San Joaquin River, and river water quality is therefore heavily influenced by irrigation return flows during the irrigation season. Water quality generally improves downstream as higher quality flows from the Merced, Tuolumne, and Stanislaus rivers dilute salt and boron concentrations in the main channel of the lower San Joaquin River (Central Valley Regional Water Quality Control Board 2004).

Soils on the west side of the San Joaquin River Basin are derived from rocks of marine origin in the Coast Ranges that are high in selenium and salts. Dry conditions make irrigation necessary for nearly all crops grown commercially in the watershed. Irrigation of the soils derived from these marine sediments leaches selenium and salt into the shallow groundwater. Subsurface drainage is produced when farmers drain the shallow groundwater from the root zone to protect their crops. This subsurface agricultural drainage water is high in naturally occurring salts and selenium. The discharge of subsurface drainage from the west side has resulted in violations of water quality objectives in Salt Slough, the San Joaquin River, and other water bodies in the area (Figure SJR-20). Selenium is a highly bioaccumulative trace element, which under certain conditions can be mobilized through the food chain and cause both acute and chronic toxicity to waterfowl. Deformities and deaths of waterfowl have been linked to toxic concentrations of selenium (Central Valley Regional Water Quality Control Board 1999, 2000, 2001).

Pesticides causing impairment of the San Joaquin River Hydrologic Region waterways are human-made chemicals used to control pests, insects, and undesirable vegetation in urban and agricultural landscapes. A fraction of the applied pesticides can enter waterways during rainfall or irrigation events when residual pesticides migrate in stormwater runoff or irrigation return water or migrate with sediment carried in stormwater runoff or irrigation return water and cause unintended toxicity to aquatic life.

Inorganic mercury enters waterways when soils erode, atmospheric dust falls to the ground, and mineral springs discharge. Another significant source is cinnabar ore (mercury sulfide) that was mined in the Inner Coast Ranges for elemental mercury (quicksilver). This liquid form of mercury was transported from the Coast Ranges to the Sierra Nevada for gold recovery where several million pounds of mercury were lost to the environment during the Gold Rush. In various aquatic environments, inorganic mercury can be converted to methylmercury, which is a potent neurotoxin. Methylmercury is readily absorbed from water and food; therefore, concentrations multiply greatly between water and top predators of aquatic food chains. The production of methylmercury and uptake in the food chain is influenced by natural factors and by many human activities. Fish with elevated concentrations of methylmercury pose a risk to people and wildlife that eat the fish. Many streams and reservoirs in the San Joaquin River Hydrologic Region contain fish with elevated concentrations of methylmercury.

Figure SJR-20 Salt Slough and Mud Slough



The "copper belt" in the lower Sierra Nevada foothills is an area with natural copper deposits and spans roughly from Amador County to Tuolumne County. Discharges from abandoned mines contain levels of copper, arsenic, pH, and salts, which are a concern for aquatic life.

Low dissolved oxygen and nutrient enrichment issues have been identified in the south and eastern Delta and in the upper Fresno River, Los Banos Creek, and Kellogg Creek. Low dissolved oxygen concentrations in the Delta may act as a barrier to upstream spawning migration of salmonids. In the Delta and elsewhere, low dissolved oxygen concentrations may stress and kill resident aquatic organisms. Oxygen-demanding substances are generally the likely cause of low dissolved oxygen impairments, although in the Deep Water Ship Channel portion of the San Joaquin River, channel geometry and reduced flows have also been identified as causes of the impairment (Central Valley Regional Water Quality Control Board 2005a).

High levels of indicator organisms were found in the south Delta and in various water bodies in the San Joaquin River watershed. Indicator organisms are used to infer the potential for the presence of disease-causing pathogens because pathogenic organisms are difficult to identify and isolate. High levels of the indicator organisms show an increased potential for human health risks. Water quality criteria have been established to protect recreational use in ambient waters (U.S. Environmental Protection Agency 1986).

Erosion and sedimentation is a water quality concern in the San Joaquin River Hydrologic Region. Agricultural, forest management, mining, land development, and dredging activities can result in excessive erosion and discharge of sediments to surface waters. Sedimentation impairs fisheries and, by virtue of the characteristics of many organic and inorganic compounds to bind to soil particles, serves to distribute and circulate toxic substances through the riparian, estuarine, and marine systems (Central Valley Regional Water Quality Control Board 2011c).

Temperature impairments have been identified for the Lower Merced River, the Lower Stanislaus River, the Lower Tuolumne River, and the Lower San Joaquin River (State Water Resources Control Board 2010). The activities of fish are controlled by temperatures in the aquatic environment. Extremes of temperature, whether hot or cold, produce adverse effects in fish. The tolerance of fish to temperature extremes varies with the life stage, whether it is egg, fry, fingerling, smolt, or adult. In addition to direct effects of temperature on fish, indirect effects due to temperature also occur that can limit fish populations. Such effects include altered food abundance and conversion efficiency, increased predation, temperature-mediated disease, dissolved oxygen, and increased toxicity of various compounds (California Department of Water Resources 1988). In the San Joaquin River basin, one critical factor limiting anadromous salmon and steelhead population abundance is high-water temperatures, which exist during critical life-stages in the tributaries and the main stem. This results largely from water diversions, hydroelectric power operations, water operations, and other factors. (Loudermilk 2007).

Drinking Water Quality

In general, drinking water systems in the region deliver water to their customers that meet federal and State drinking water standards. Nonetheless, local groundwater supplies have been found to be contaminated. In January 2013, the SWRCB completed a statewide assessment of community water systems that rely on contaminated groundwater (State Water Resources Control Board 2013). This report identified 104 community drinking water systems in the region that rely on at least one contaminated groundwater well as a source of supply, and 208 community drinking water wells that are affected by groundwater contamination (Table SJR-20). Common naturally occurring contaminants arsenic, gross alpha particle activity, and uranium are the most prevalent groundwater contaminants affecting community drinking water wells in the region. A number of community drinking water wells are also affected by nitrate and 1, 2-Dibromo-3-chloropropane (DBCP) which are attributed to anthropogenic sources of contamination (Table SJR-21). The majority of the affected systems are small water systems that often need financial assistance to construct a water treatment plant or alternate solution to meet drinking water standards.

Public water systems that use surface waters must comply with increasingly stringent laws and regulations designed to provide increasing protection for public health. In August 2000, the CALFED Bay-Delta Program issued a Record of Decision (ROD) requiring the California Bay-Delta Authority, with the assistance of the Department of Public Health (DPH), to coordinate a comprehensive Source Water Protection Program. One element of this Source Water Protection Program is to establish a Drinking Water Policy for the Delta and upstream tributaries.

The CVRWQCB has been working with a workgroup made up of interested stakeholders including federal and State agencies; drinking water agencies; and wastewater, municipal stormwater and agricultural interests to develop a drinking water policy to help protect drinking water supplies. These efforts resulted in a Drinking Water Policy for Surface Waters of the Delta and its Upstream Tributaries that was adopted by the CVRWQCB in July 2013. The policy

Table SJR-20 Summary of Community Drinking Water Systems in the San Joaquin River Hydrologic Region that Rely on One or More Contaminated Groundwater Wells That Exceeds a Primary Drinking Water Standard

Community Drinking Water Systems and Groundwater Wells Grouped by Water System Population	Number of Affected Community Drinking Water Systems	Number of Affected Community Drinking Water Wells
Large System (>10,000 population)	16	91
Medium System (3,300-10,000 population)	8	18
Small System (<3,000 population)	80	119
Total	104	228

Source: *Communities That Rely on a Contaminated Groundwater Source for Drinking Water*. State Water Resources Control Board 2013.

Table SJR-21 Summary of Contaminants Affecting Community Drinking Water Systems in the San Joaquin River Hydrologic Region

Principal Contaminant (PC)	Community Drinking Water Systems Where PC Exceeds the Primary Maximum Contaminant Level (MCL)	Number of Community Drinking Water Wells Where PC Exceeds the Primary Maximum Contaminant Level (MCL)
Arsenic	58	120
Gross alpha particle activity	38	76
Uranium	23	40
Nitrate	17	26
1,2-Dibromo-3-chloropropane (DBCP)	12	28
Tetrachloroethylene (PCE)	4	4

Source: *Communities That Rely on a Contaminated Groundwater Source for Drinking Water*. State Water Resources Control Board 2013.

Notes:

Only the 6 most prevalent contaminants are shown.

Wells with multiple contaminants:

- 40 wells are affected by gross alpha particle activity and uranium.
- 13 wells are affected by arsenic and gross alpha particle activity/uranium.
- 6 wells are affected by nitrate and gross alpha particle activity/uranium.
- 6 wells are affected by both arsenic and nitrate.

includes narrative water quality objectives for the pathogens *Cryptosporidium* and *Giardia*, along with implementation provisions, and clarification that the narrative water quality objective for chemical constituents includes drinking water constituents of concern. The workgroup evaluated land use changes and potential control measures that could be expected to occur in the next 20 years. The workgroup concluded that organic carbon would not increase at drinking water intakes based on the cumulative effect of several factors that included reduction in agricultural lands and increasing regulations as well as increased urbanization. While pathogens were not specifically modeled in this effort, current monitoring indicates that the new narrative water quality objective is being met. Additional information is available at http://www.waterboards.ca.gov/centralvalley/water_issues/drinking_water_policy/index.shtml.

Groundwater Quality

The following are the contaminants of concern in groundwater for this region:

- Salinity.
- Nitrate.
- Arsenic.
- Gross alpha particle activity and uranium.
- Chromium 6.
- Localized contamination by tetrachloroethylene (PCE) and trichloroethylene (TCE).

Salt management is the most serious long-term water quality issue in the San Joaquin River basin. The causes include increased urban and agricultural development, over allocation of surface water supplies, diversion of high quality flows to outside the basin, salty return flows from agriculture, and higher salinity water being imported into the basin. Approximately 600,000 tons of salt are imported annually into the western portion of the San Joaquin Basin (west of the San Joaquin River) for crop irrigation and wetland management via federal, State, and local water projects. An additional 160,000 tons are applied through irrigation from San Joaquin River diversions. Some of this salt is returned to the river through tail water return flows, and some is stored in the soil. Most, however, is purposefully leached below the root zone to maintain salt balance in the root zone. Much of this leached salt ends up in the groundwater. Degradation of groundwater in the San Joaquin River basin by salts is unavoidable without a plan to remove salts from the basin (Central Valley Regional Water Quality Control Board 2011b).

Nitrate concentrations in 24 percent (21 of 88) of the domestic wells sampled during 1993-1995 in the regional aquifer survey and land-use studies of the eastern San Joaquin Valley exceeded the drinking-water standard of 10 micrograms per liter (mg/L) established by the EPA. Pesticides were detected in 61 of the 88 domestic wells sampled during 1993-1995 (69 percent), but concentrations of most pesticides were low — less than 0.1 mg/L (Dubrovsky et al. 1998). Concentrations of nitrate and pesticides in the shallow part of the aquifer system at depths of domestic wells in the study area have increased over time due to continued contributions of nitrates and current use pesticides in the recharge water. Also, concentrations of nitrates and pesticides in the shallow part of the aquifer are likely to move to deeper parts of the groundwater flow system (Burow et al. 2008). Public supply wells with impacted source water are generally located on the valley floor (State Water Resources Control Board 2012).

Public supply wells with levels of arsenic in the raw and untreated water that exceed the maximum contaminant level (MCL) were found in the eastern portion of the valley floor and in the foothills of Madera County. Arsenic is generally considered to be naturally occurring (State Water Resources Control Board 2012; U.S. Geological Survey 2012). Arsenic has been linked to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate (U.S. Environmental Protection Agency 2012a).

Gross alpha particle activity and uranium were found in raw and untreated water for many of the public water systems in the foothills and mountain parts of this hydrologic region. These radionuclides are typically naturally occurring but are a concern because of the potential for health effects (State Water Resources Control Board 2012; U.S. Geological Survey 2012).

Chromium is a metal found in natural deposits of ores containing other elements, mostly as chrome-iron ore. It is also widely present in soil and plants. Recent sampling of drinking water throughout California suggests that hexavalent chromium may occur naturally in groundwater at many locations. Chromium may also enter the environment from human uses. Chromium is used in metal alloys such as stainless steel, protective coatings on metal, magnetic tapes, and pigments for paints, cement, paper, rubber, composition floor covering, etc. Elevated levels (above the detection limit of 1 µg/L) of hexavalent chromium have been detected in many active and standby public supply wells along the west or valley floor portion of the Central Valley (State Water Resources Control Board 2011b).

There were very few occurrences of organic compounds in public supply wells in the San Joaquin River Hydrologic Region. Organic compounds of concern found at levels above the MCLs in raw and untreated water from public supply wells were PCE and TCE in one well in Madera County, two wells in San Joaquin County, and one well in Stanislaus County.

Groundwater Conditions and Issues

Groundwater Occurrence and Movement

Aquifer conditions and groundwater levels change in response to varying supply, demand, and climate conditions. During dry years or periods of increased groundwater extraction, seasonal groundwater levels tend to fluctuate more widely. Subject to annual recharge conditions, this may result in a long-term decline in groundwater levels, both locally and regionally. Depending on the amount, timing, and duration of groundwater level decline, nearby well owners may need to deepen wells or lower pumps to regain access to groundwater.

As groundwater levels fall, they can impact the surface water-groundwater interaction by inducing additional infiltration and recharge from surface water systems, which reduces groundwater discharge to surface water baseflow and wetlands areas. Extensive lowering of groundwater levels also can cause land subsidence due to the dewatering, compaction, and loss of storage within finer grained aquifer systems.

During years of normal or above normal precipitation, or during periods of low groundwater extraction, aquifer systems tend to recharge and respond with rising groundwater levels.
As groundwater levels rise, they reconnect to surface water systems, contributing to surface water base flow or wetlands, seeps, and springs. However, for some areas of the San Joaquin River Hydrologic Region, due to extensive pumping over the years the groundwater table has

been disconnected from the surface water system for decades and provides no contribution to base flow. In 1980, DWR *Bulletin 118-80* (California Department of Water Resources 1980) identified three of the seven southern San Joaquin Valley groundwater subbasins (Eastern San Joaquin, Chowchilla, and Madera), as being subject to conditions of critical overdraft. Thirty years later, overdraft conditions have not changed much. Although efforts have been made by local groundwater management agencies to reduce overdraft conditions in the region, a number of the groundwater management plans and more recent studies of key groundwater subbasins acknowledge that groundwater overdraft continues.

The movement of groundwater is from areas of higher hydraulic potential to areas of lower hydraulic potential, typically from higher elevations to lower elevations. Under predevelopment conditions, the occurrence and movement of groundwater in the region was largely controlled by the surface and the subsurface geology, the size and distribution of the natural surface water systems, the average annual hydrology, and the regional topography. However, decades of high-volume groundwater extraction to meet the region's agricultural and urban water uses has impacted the natural occurrence and movement of groundwater. Areas of high groundwater extraction tend to redirect and capture groundwater underflow that may otherwise have contributed to nearby surface water systems. Thousands of high-capacity wells screened over multiple aquifer zones also lend themselves to vertical aquifer mixing, which can result in further deviation from natural groundwater flow conditions. In addition, infiltration along miles of unlined water conveyance canals, percolation of applied irrigation water, and direct recharge programs create significant groundwater recharge areas where none previously existed.

Depth to Groundwater and Groundwater Elevation Contours

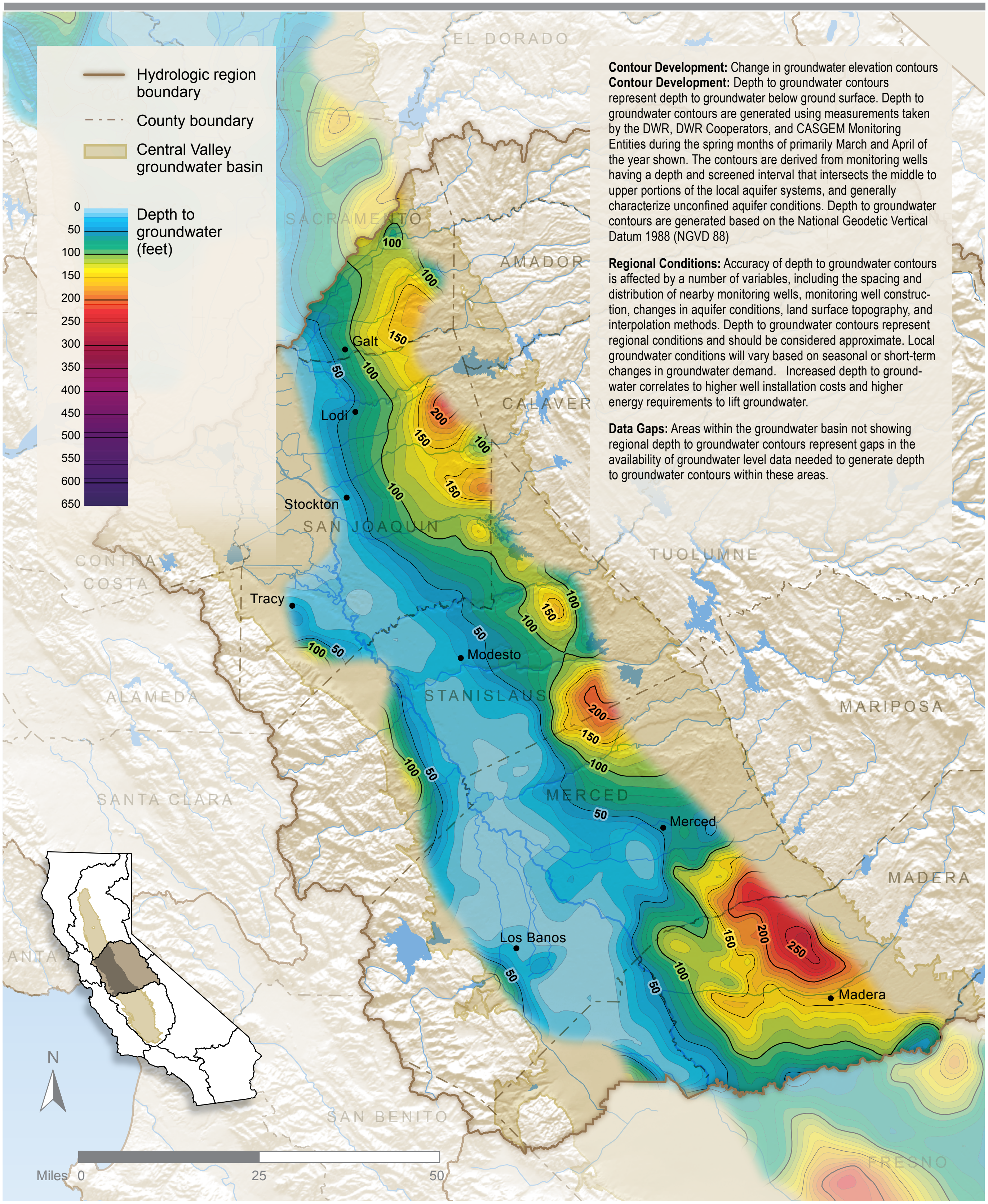
Groundwater monitoring makes data available to prepare the depth to groundwater and groundwater elevation contours. The depth to groundwater has a direct bearing on the costs associated with well installation and groundwater extraction. Knowing the local depth to groundwater can also provide a better understanding of the interaction between the groundwater table and the surface water systems and the contribution of groundwater aquifers to the local ecosystem.

Figure SJR-21 is a spring 2010 depth-to-groundwater contour maps for the region using groundwater level data available online from DWR's Water Data Library (http://www.water.ca.gov/waterdatalibrary/) and DWR's CASGEM system (http://www.water.ca.gov/groundwater/casgem/).

The contour lines in the figure represent areas having similar spring 2010 depth-to-groundwater values. Contour lines were developed for only those areas having sufficient groundwater level data and for only those aquifers characterized by unconfined to semi-confined groundwater conditions. Depth-to-groundwater contours were not developed for Yosemite Valley or Los Banos Creek Valley due to a lack of groundwater level data.

Figure SJR-21 shows that the depth to groundwater in the western half of the region is shallowest along the valley floor adjacent to the San Joaquin River and its associated tributaries, and deepest along the eastern side of the valley where it abuts the lower foothills of the Sierra Nevada. On the east side of the region, wide spread agriculture and a lack of surface water supplies have resulted in significant declines to the water table and cones of depression exceeding 250 feet in the northeastern Madera Subbasin, 200 feet in the eastern Turlock Subbasin, and up to 150

Figure SJR-21 Spring 2010 Depth to Groundwater Contours for the San Joaquin River Hydrologic Region



feet in the northeastern Cosumnes Subbasin. The declines are more pronounced in the southern portion of the region due to multiple factors including higher annual temperatures and less annual precipitation, which results in more groundwater pumping for crop irrigation.

Moving west, the groundwater elevation rises and ranges between 5 and 20 feet below ground surface adjacent to the San Joaquin River throughout the region. While intensive agricultural practices are predominant in this area as well, the volume of water transported by the tributaries of the San Joaquin River (Merced, Tuolumne, and Stanislaus rivers) has resulted in a higher water table that is near surface due to the recharging of the shallow aquifers.

Groundwater elevation contours can help estimate the direction gradient, and the rate of groundwater flow. Figure SJR-22 is a spring 2010 groundwater elevation contour map for the region. Groundwater movement direction is shown as a series of arrows along the groundwater flow path; these flow direction arrows do not provide information regarding vertical flow within the aquifer system. Similar to the spring 2010 depth-to-groundwater contours, groundwater elevation contours were developed for only those areas having sufficient groundwater level data and for only those aquifers characterized by unconfined to semi-confined aquifer conditions.

Figure SJR-22 shows that the spring 2010 groundwater movement is generally from the eastern and western edges of the basins to the axis of the valley and then flows north following the San Joaquin River. In areas receiving little or no surface water, large pumping centers have developed cones-of-depression, reducing water levels to near sea level. A good example is the large pumping depression that has formed in the eastern Madera and Chowchilla subbasins, where historical groundwater flow directions have been altered and now groundwater flows toward the cone formed around the area. Although of lesser scope and size, similar cones have formed around the eastern portions of the Cosumnes and Eastern San Joaquin subbasins. The figure also shows recharge areas along the larger rivers such as the San Joaquin, Merced, and Tuolumne rivers.

Groundwater Level Trends

Groundwater levels within groundwater basins in the San Joaquin River Hydrologic Region can be highly variable because of the physical variability of aquifer systems, the variability of surrounding land use practices, and the variability of groundwater availability and recharge. Plots of depth-to-water measurements in wells over time (groundwater level hydrographs) allow analysis of seasonal and long-term groundwater level variability and trends. The hydrographs presented in Figures SJR-23A to SJR-23E help explain how local aquifer systems respond to changing groundwater pumping quantities and to resource management practices. The hydrograph name refers to the well location (township, range, section, and tract.)

Figure SJR-23A shows hydrograph 05S09E07B001M, which is located on the west side of the Turlock subbasin, approximately four miles east of the San Joaquin River. The well is believed to be in an unconfined to semi-confined aquifer, although exact depth is unknown. Groundwater at the well site is shallow, occurring at depths ranging from 5 to 10 feet below ground surface, which is typical for groundwater levels on the western portion of the groundwater basin. Groundwater levels have been relatively stable during the monitoring period, varying in depth by no more than about 10 feet. During a highly wet year (1983), water levels rose near the ground surface at a depth of 2.5 feet. Water dropped by 10 feet during the drought years of 1987 to 1992, but it returned to the average level during subsequent wet years.

Figure SJR-22 Spring 2010 Groundwater Elevation Contours for the San Joaquin River Hydrologic Region

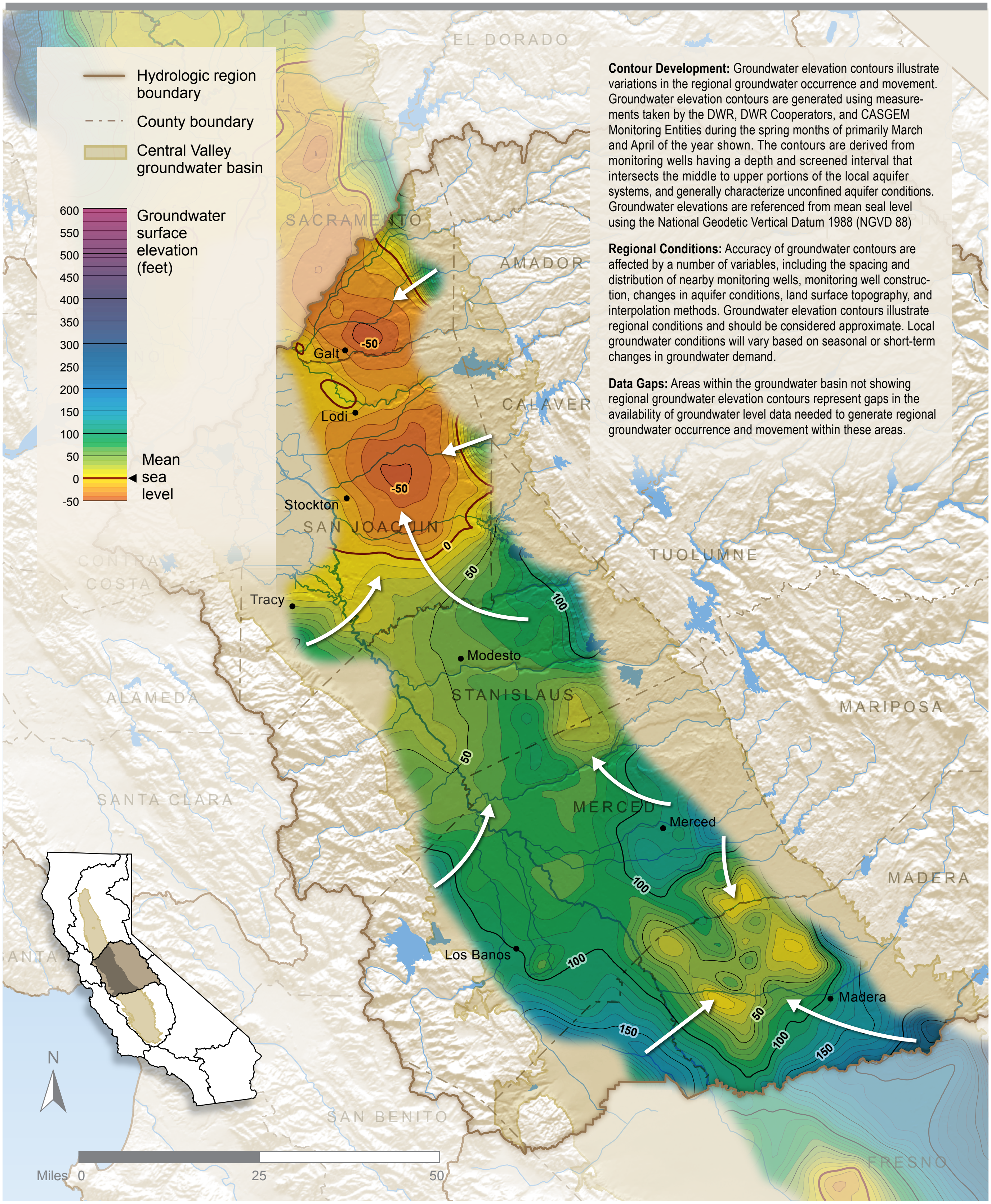
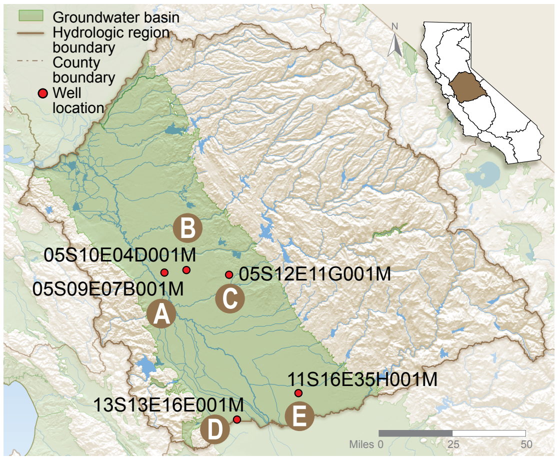


Figure SJR-23 Groundwater Level Trends in Selected Wells in the San Joaquin River Hydrologic Region

Aquifer response to changing demand and management practices

Hydrographs were selected to help tell a story of how local aquifer systems respond to changing groundwater demand and resource management practices. Additional detail is provided within the main text of the report.

Regional locator map



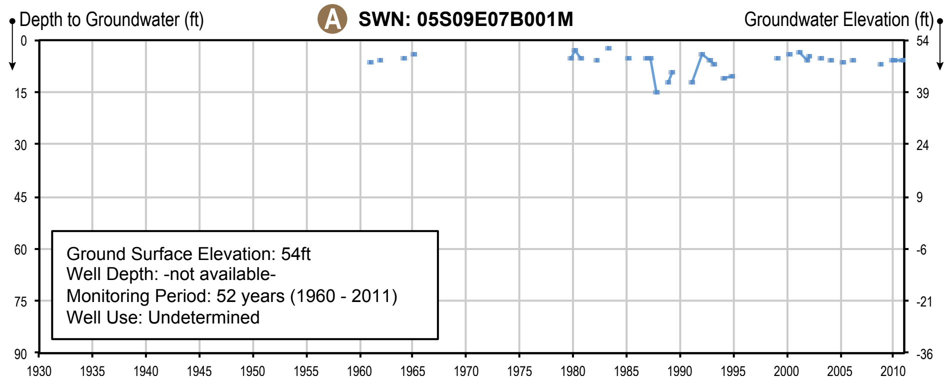
A Hydrograph 05S09E07B001M: illustrates an example of a typical well in the western portion of the Turlock Groundwater Basin. The wells extract water from the shallow unconfined to semi-confined aquifers which readily respond to the local hydrologic conditions.

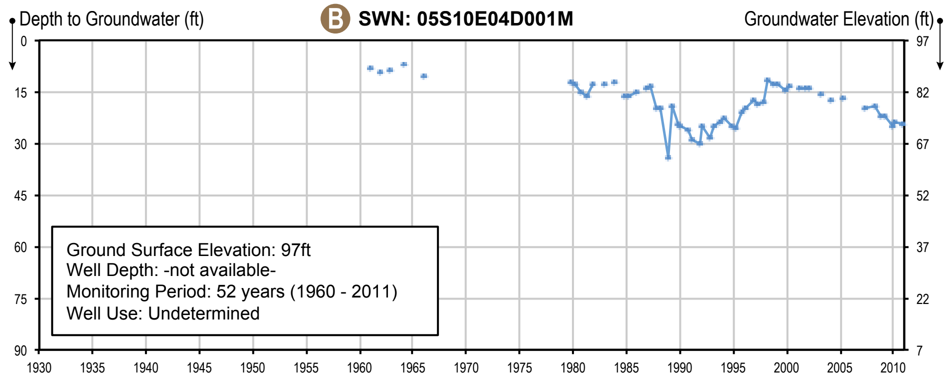
B Hydrograph 05S10E04D001M: highlights the successful role of conjunctive management of surface water and groundwater supplies in meeting the increasing urban water demands while keeping the long-term aquifer conditions stable.

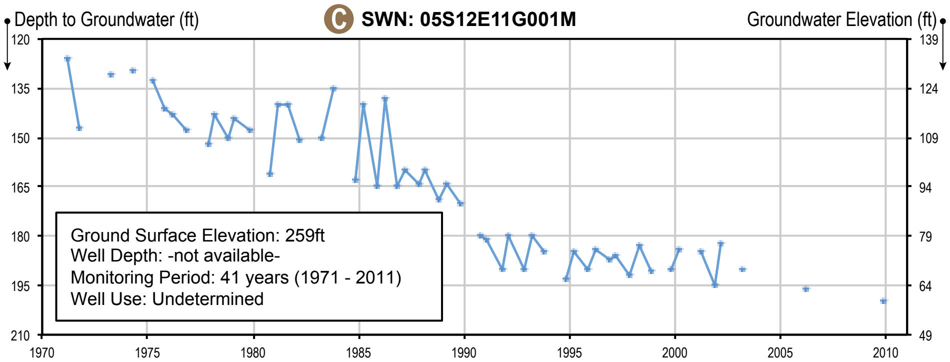
C Hydrograph 05S12E11G001M: shows the successful stabilization of declining groundwater levels associated with the technological advancement in the irrigation systems. The declining trend resumed, however, due to expansion of agricultural lands into previously non-irrigated lands.

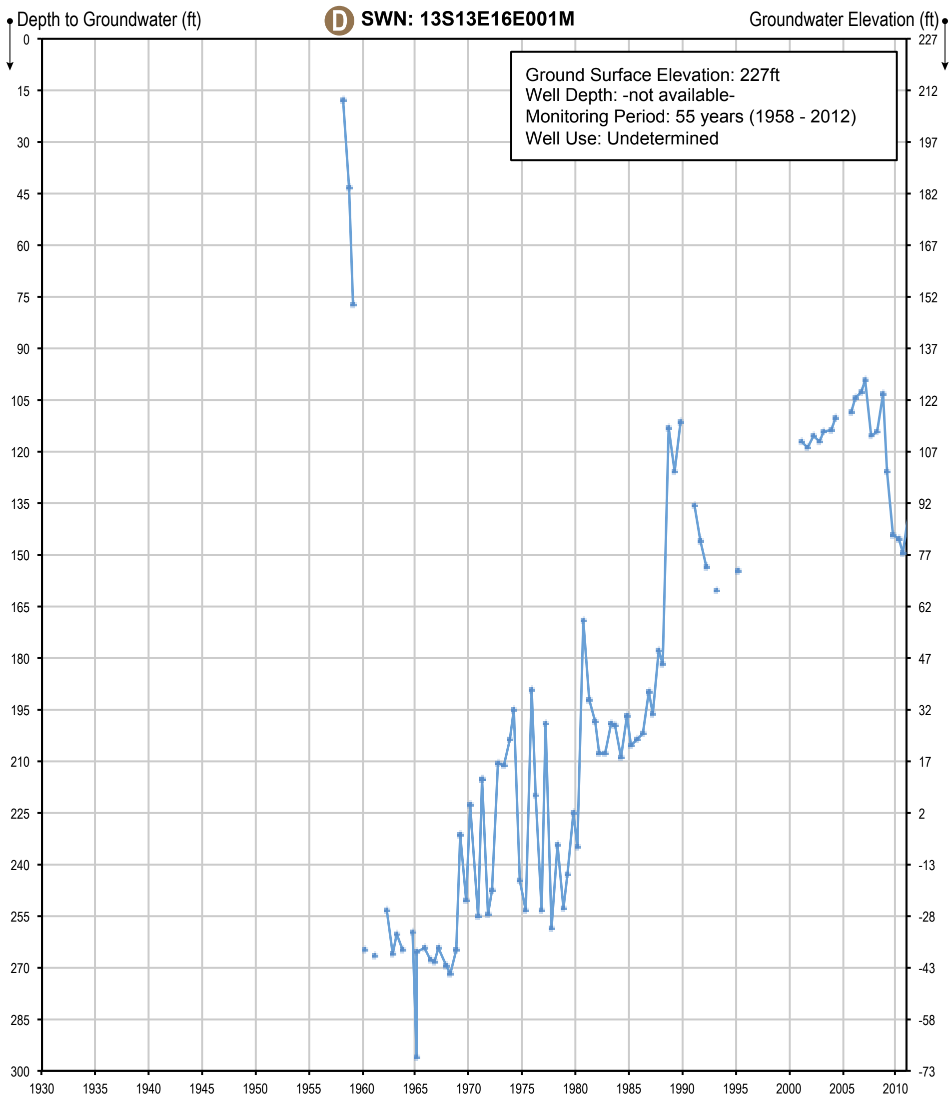
D Hydrographs 13S13E16E001M: highlights the successful recovery of declining groundwater conditions associated with the introduction of imported water.

E Hydrographs 11S16E35H001M: shows an imbalance between aquifer recharge and groundwater extraction as a result of unsustainable reliance on the local groundwater resources in absence of surface water supplies.








Depth to Groundwater (ft)
D SWN: 13S13E16E001M
Groundwater Elevation (ft)
Ground Surface Elevation: 227ft
Well Depth: -not available-
Monitoring Period: 55 years (1958 - 2012)
Well Use: Undetermined
0 15 30 45 60 75 90 105 120 135 150 165 180 195 210 225 240 255 270 285 300
227 212 197 182 167 152 137 122 107 92 77 62 47 32 17 2 -13 -28 -43 -58 -73
1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010

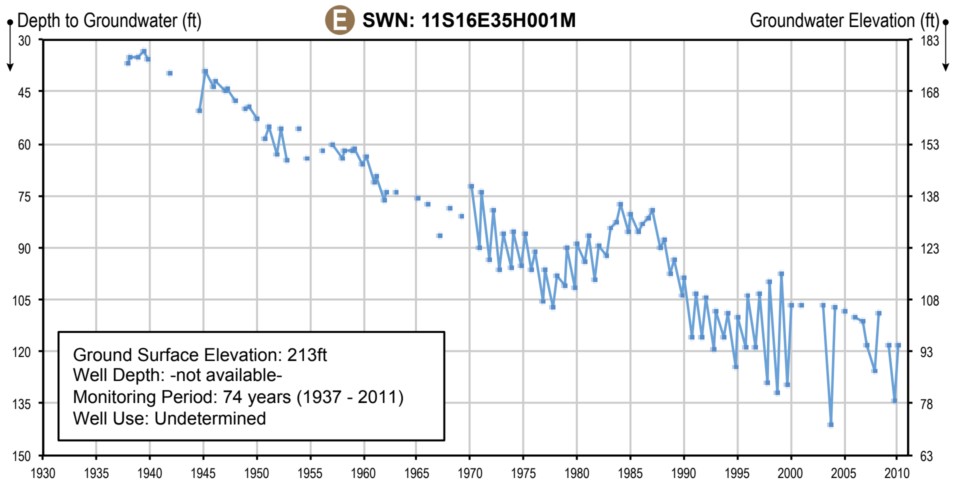

Depth to Groundwater (ft)
E SWN: 11S16E35H001M
Groundwater Elevation (ft)
Ground Surface Elevation: 213ft
Well Depth: -not available-
Monitoring Period: 74 years (1937 - 2011)
Well Use: Undetermined
30 45 60 75 90 105 120 135 150
183 168 153 138 123 108 93 78 63
1930 1935 1940 1945 1950 1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010

Figure SJR-23B shows hydrograph 05S10E04D001M, which is from a well located immediately northeast of the City of Turlock in Stanislaus County within the Turlock subbasin. The well is believed to be screened in an unconfined to semi-confined aquifer, although exact depth is unknown. Groundwater at the well site has been in a gradual decline associated with urban growth in the City of Turlock. Drought in 1987 to 1992 resulted in a 20-foot drop in groundwater levels due to an increased reliance on pumping and a decreased availability of surface water supplies from the Tuolumne River. Water levels stabilized and underwent a multiyear rise during a period of increased precipitation and resumption of surface water supplies between 1992 and 1998. Declining water levels beginning in 1999 have been associated with an increase in urban land development. However, a conservation effort combined with slowing economic growth stabilized water levels beginning in 2009.

Figure SJR-23C shows hydrograph 05S12E11G001M, which is located in the Eastside Water District, approximately 10 miles east of the City of Turlock, in the Turlock subbasin. The well is believed to be in an unconfined to semi-confined aquifer, although exact depth is unknown. Eastside Irrigation District has no surface water allocations. As a result of agricultural growth in the 1970s increased groundwater pumping for irrigation led to a steady decline in groundwater water levels. A shift in irrigation practices from sprinkler to drip and micro-irrigation stabilized water levels from 1990 to 2002. Declining water levels in 2003 and 2004 are attributed to the increased agricultural development in areas that were previously non-irrigated rangeland.

Figure SJR-23D shows hydrograph 13S13E16E001M, which is located in Fresno County, approximately 10 miles west of the San Joaquin River in the Delta-Mendota Subbasin. The well is believed to be in an unconfined to semi-confined aquifer, although exact depth is unknown. The well is located in an area that experienced 16 feet of subsidence from 1926 to 1970. With the construction of the California Aqueduct, farms in the area received surface water, and groundwater pumping was substantially reduced. The hydrograph shows groundwater level recovery of more than 150 feet after completion of the SWP and beginning of water deliveries in the early 1960s. Dry years in 1992 and 2007 to 2009 and reduced water supplies have resulted in falling groundwater levels; and renewed impacts from subsidence have been observed in a number of areas.

Figure SJR-23E shows hydrograph 11S16E35H001M, which is located about 5 miles southwest of the City of Madera in Madera County within the Madera subbasin. The well is believed to be in an unconfined to semi-confined aquifer, although exact depth is unknown. Water levels were more or less stable through the 1930s. After World War II, agricultural development intensified; and water levels began a steady decline. Groundwater is replenished by subsurface inflow from surrounding areas, recharge, and infiltration of applied irrigation water. The hydrograph shows the imbalance between recharge from subsurface inflow and groundwater extraction with water levels declining approximately 90 feet since 1940.

Change in Groundwater Storage

Change in groundwater storage is the difference in stored groundwater volume between two time periods. Examining the annual change in groundwater storage over a series of years helps identify the aquifer response to changes in climate, land use, and groundwater management. If the change in storage is negligible over a period of average hydrologic and land use conditions, then the basin is considered to be in equilibrium under the existing water use scenario and current management practices. Declining storage over a relatively short period of average hydrologic and land use conditions does not necessarily mean that the basin is being managed unsustainably or is subject to overdraft. Utilization of groundwater in storage during years of diminishing surface water supply, followed by active recharge of the aquifer when surface water or other alternative supplies become available, is a recognized and acceptable approach to conjunctive water management.

Additional information regarding the risks and benefits of conjunctive management can be found online from Update 2013, Volume 3, Chapter 9, "Conjunctive Management and Groundwater."

Annual and cumulative change in groundwater storage for the San Joaquin River Hydrologic Region was calculated between 2005 and 2010 using spring groundwater elevation data, a range of specific yield (Sy)values for the aquifer, and a geographic information system (GIS) analytical tool. Based on published literature, minimum and maximum Sy values of 0.07 and 0.17 were determined to be a good approximation of the range of regional aquifer storage parameters. For depth to water and groundwater elevation contour maps discussed previously, groundwater basins having insufficient data to contour and compare year-to-year changes in groundwater elevations were identified as "non-reporting" areas. Change in storage was also not estimated for these "non-reporting" areas.

Spring 2005 to Spring 2010 Change in Aquifer Storage

Figure SJR-24 shows an overall decline in groundwater levels for much of the region. Groundwater level declines up to 50 feet are seen mostly in the southeastern portion of the region in the Madera and Chowchilla subbasins. Groundwater level declines from 10 to 20 feet are also seen along the eastern edge of the region, which includes the Merced, Turlock, Modesto, and Eastern San Joaquin subbasins. Additionally, groundwater elevation declines ranging up to 40 feet are observed along some areas in the western portion of the region in the Delta-Mendota Subbasin.

Table SJR-22 and Figure SJR-25 show that the average annual change in groundwater elevation and related change in groundwater storage generally follow the annual precipitation or water year type. The spring 2005 - spring 2010 cumulative groundwater level decline over the region is estimated to be about 6 feet. Figure SJR-25 shows that the annual variability in groundwater storage change for the region is large. For example, the maximum single-year increase in groundwater storage between 190 and 460 taf occurred during the 2005-2006 period. The maximum single-year decline in groundwater storage between approximately 610 and 1,470 taf occurred during the 2008-2009 period and represents between 20 and 45 percent of the average annual groundwater extraction for the region. The cumulative change in groundwater storage over the 2005-2010 period is estimated between approximately 1.1 maf and 2.6 maf, which represents between approximately 35 and 80 percent of the average annual groundwater extraction for the region. The large annual variation in groundwater storage changes points to high reliance on groundwater in the region.

Additional information regarding the methods and assumptions for calculating change in groundwater storage is available online from Update 2013, the Volume 4 *Reference Guide,* article, "California's Groundwater Update 2013."

Figure SJR-24 **Spring 2005 — Spring 2010 Change in Groundwater Elevation Contour Map for the San Joaquin River Hydrologic Region**

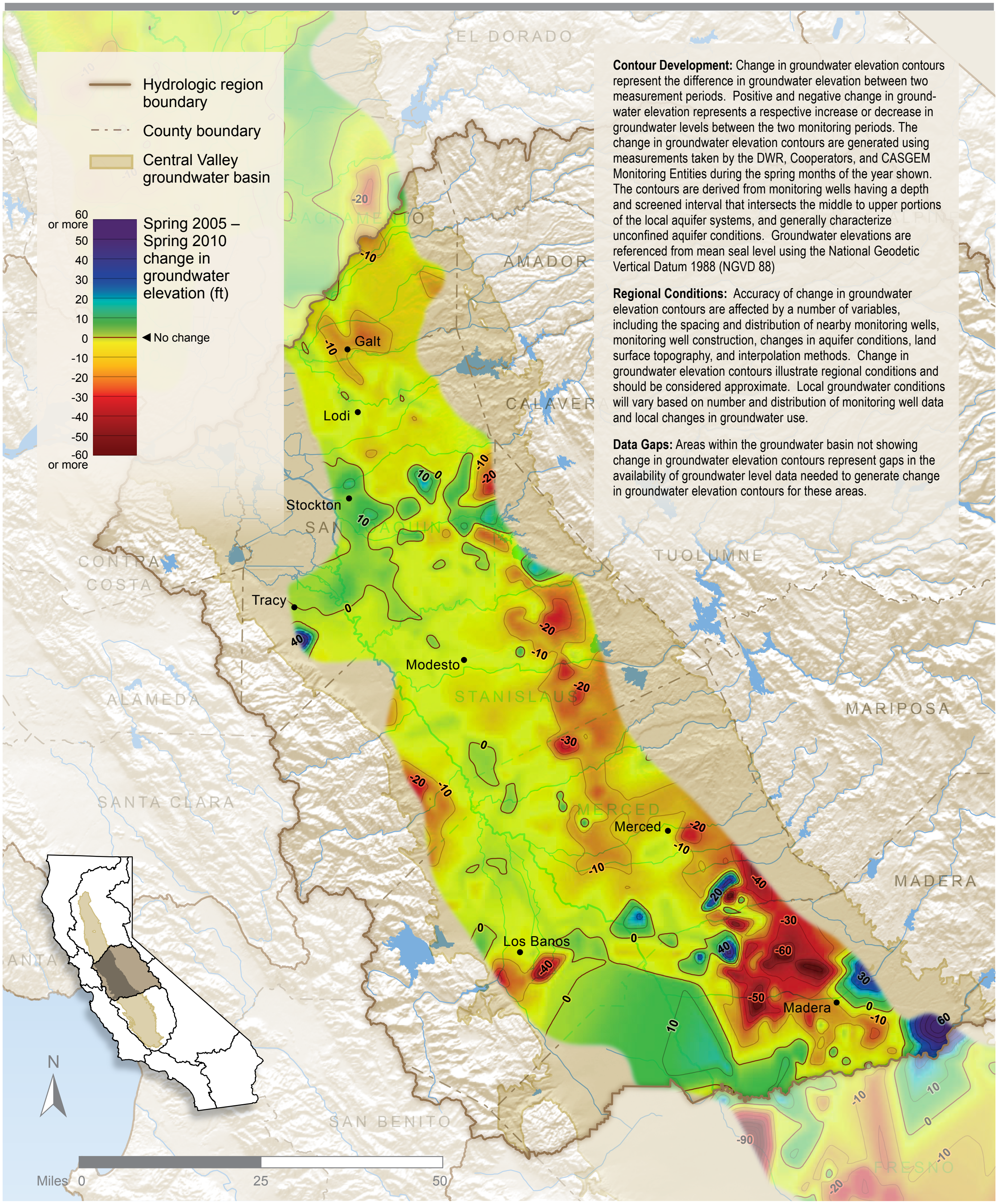


Table SJR-22 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the San Joaquin River Hydrologic Region

San Joaquin River Hydrologic Region Spring 2005-2010 Change in Storage Estimates			
Reporting area (acres):	2,535,865		
Non-reporting area (acres):	1,180,392		
Period Spring - Spring	**Average Change in Groundwater Elevation (feet)**	**Estimated Change in Storage (taf)**	
		ASSUMING SPECIFIC YIELD = 0.07	**ASSUMING SPECIFIC YIELD = 0.17**
2005-2006	1.1	188.5	457.7
2006-2007	-2.7	-487.2	-1,183.2
2007-2008	-0.4	-73.5	-178.5
2008-2009	-3.4	-606.3	-1,472.5
2009-2010	-0.5	-83.4	-202.5
2005-2010 (total)	-6.0	-1,062.0	-2,579.0

Notes:

taf = thousand acre-feet

Changes in groundwater elevation and storage are calculated for reporting area only.

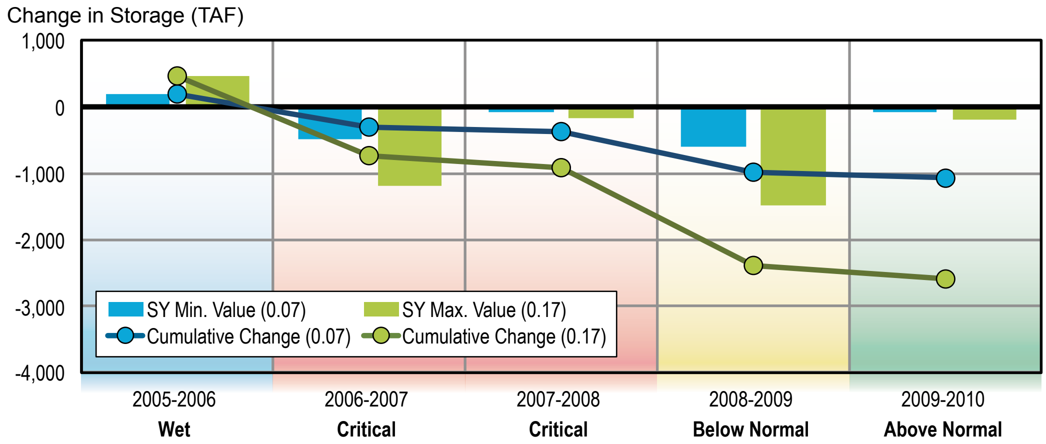
Land Subsidence

Land subsidence was first noted in the San Joaquin Valley in 1935 in the Delano area (Galloway et al. 1999). In 1955, about one-fourth of the total groundwater extracted for agricultural uses in the United States was pumped from the San Joaquin Valley; and regional aquifer compaction was occurring at a rate of about 1 foot per year (Swanson 1995). As of 1960, water levels in the deep aquifer system were declining at a rate of about 10 feet per year. In western Fresno County, during the highest pumping years of the 1960s maximum subsidence exceeded 30 feet; and the regional ground surface was sinking at rates of one to one-half foot per year. As shown in Figure SJR-26, by the late 1960s more than 5,000 square miles of farmland or one-half the entire San Joaquin Valley had subsided by at least one foot (Ireland 1986).

Surface water deliveries from the SWP and other regional conveyance facilities in the 1970s and 1980s significantly reduced the demand for groundwater for agricultural water use. Between 1967 and 1974, groundwater levels in the deep aquifer recovered as much as 200 feet (Galloway et al. 1999). Although reduced groundwater pumping and imported surface water largely diminished the subsidence problem, subsidence continued in some areas but at a slower rate, due to the time lag involved in the redistribution of pressures in the confined aquifers.

A combination of drought conditions, regulatory restrictions of imported surface water, increasing population, and agricultural trend toward the planting of more permanent crops has incrementally led to a renewed reliance on groundwater pumping in the San Joaquin River Hydrologic Region

Figure SJR-25 Spring 2005 — Spring 2010 Annual Change in Groundwater Storage for the San Joaquin River Hydrologic Region



over the last few decades. Swanson (1995) conducted a land subsidence update for the San Joaquin Valley and concluded that (1) subsidence is continuing in all subsidence areas but at lower rates than before the completion of the California Aqueduct; (2) subsidence centers have probably shifted to areas where groundwater pumping is concentrated; (3) subsidence rates are expected to increase in the near future as groundwater pumping replaces surface water diverted for environmental uses; and (4) subsidence may contribute to lost channel capacity and flooding in areas where these problems have been previously attributed entirely to different causes.

Beginning in 1987 and lasting through 1992, there was a surge in the number of new wells drilled due to the drought conditions. Wet years from 1995 to 1998 again provided sufficient surface water, and fewer new wells were drilled. Beginning with the reduction in surface water supplies in 2007, farmers increased their use of groundwater to meet irrigation demand. This included increased pumping from existing deep wells and nearly tripling the number of new irrigation wells drilled. The consequences of additional online groundwater pumping have been an intensification of declining water levels, a renewal of subsidence in areas where water levels declined below the historic low levels of 1967, and a spread of subsidence to areas formerly showing little or no subsidence. Results from recent land subsidence monitoring activities are discussed below.

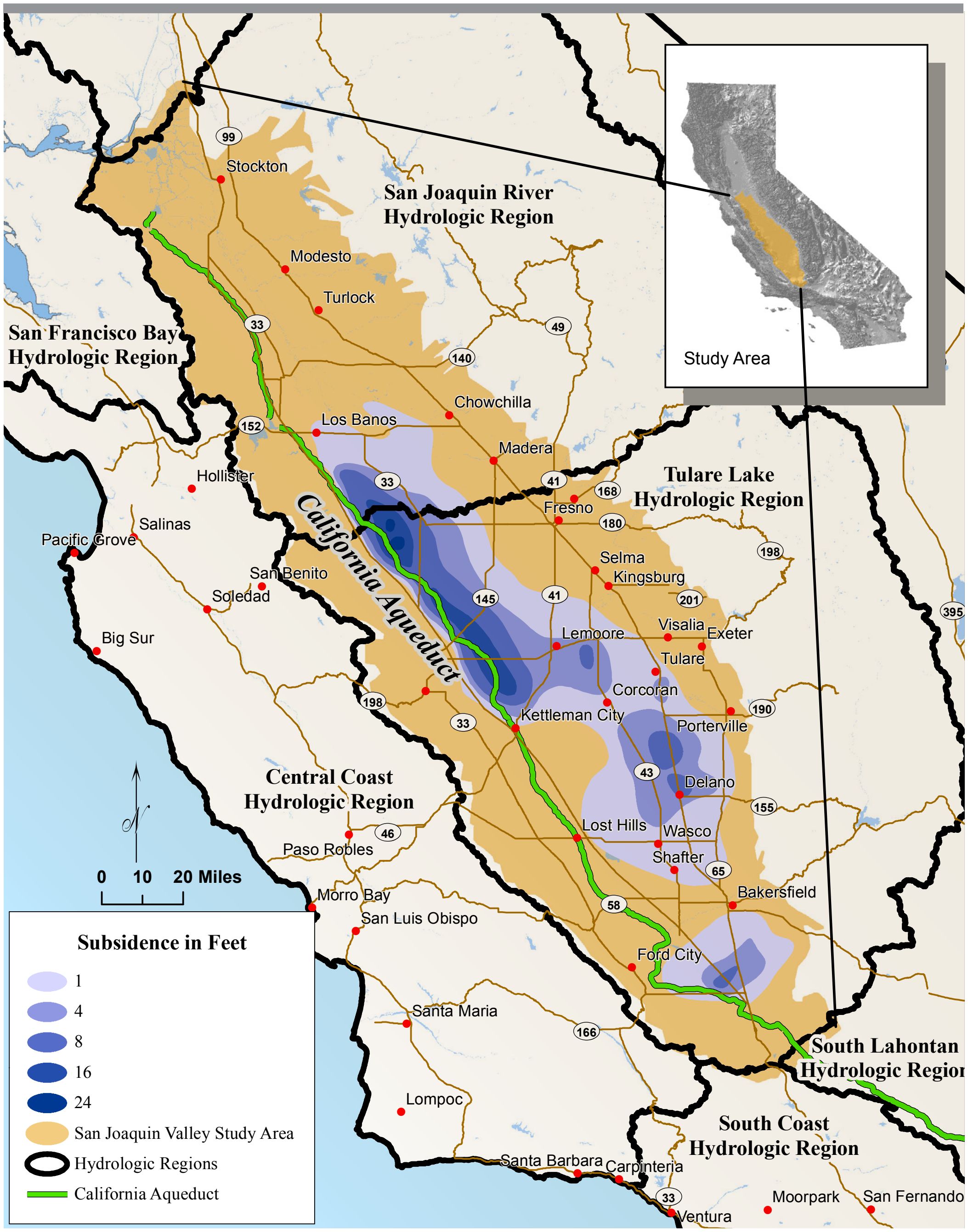
California Aqueduct Elevation Surveys

DWR's California Aqueduct elevation survey conducted in Merced, Fresno, and Kings County for years 2000, 2006, and 2009 show subsidence of as much as 0.8 feet from 2000 to 2009 (Figure SJR-27). The survey also indicates an accelerated level of subsidence from 2006 to 2009.

Borehole Extensometer Monitoring

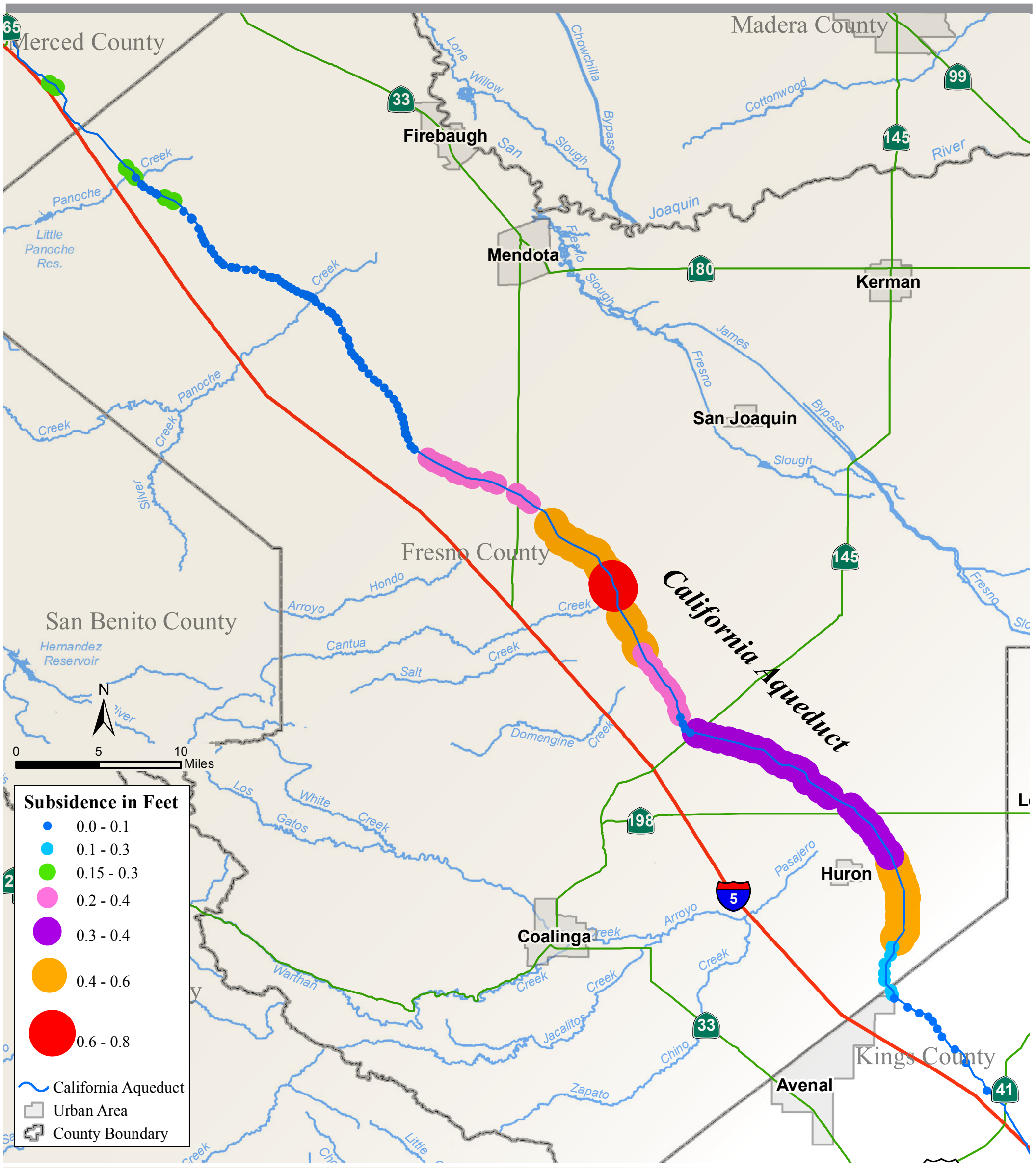
There are currently seven active extensometers in the San Joaquin Valley being monitored for groundwater levels and land subsidence. The extensometer located in the Kern Water Bank and installed in 1966 and actively monitored by DWR includes four groundwater level monitoring

Figure SJR-26 Land Subsidence in the San Joaquin Valley — 1926 to 1970 (Adapted from Ireland 1984)



wells that are constructed to monitor various depth intervals within the aquifer system. The extensometer well cluster show relatively large changes in water levels as the water bank is recharged and extracted. The aquifer compaction and subsidence monitored by the extensometer show a small elastic response to changes in the water levels. Elastic subsidence is reversible and will typically not develop into inelastic (irreversible) subsidence until groundwater drops below a level that causes irreversible aquifer compaction.

Figure SJR-27 Land Subsidence Along the California Aqueduct



USGS InSAR Monitoring

Preliminary results from USGS evaluation of 2007-2011 InSAR survey data show two areas of subsidence — an area in western Madera County (just north of the Tulare Lake Hydrologic Region) and a broad area in central Tulare Lake Hydrologic Region located approximately west of Highway 99 within Kings and Tulare counties. Additional information related to subsidence in the San Joaquin Valley is included in the Tulare Lake Hydrologic Region report. Data from the InSAR survey is being evaluated, and the amount and rate of subsidence has not yet been determined.

Caltrans Highway 152 Elevation Monitoring

The 2004 survey by Caltrans of Highway 152 across the San Joaquin Valley from the San Luis Dam to State Route 99 shows that land subsidence at the western ends of the Highway 152 is negligible. However, moving toward the center of the valley near the San Joaquin River channel, a land subsidence trough of approximately 2.8 feet developed between 1972 and 1988. From 1988 to 2004, the rate of subsidence increased; and the land in this area subsided by approximately another 3.1 feet. The cumulative decline in land surface elevation between 1972 and 2004 in the area was about 5.3 feet (Figures SJR-28 and SJR-29).

GPS Array Monitoring

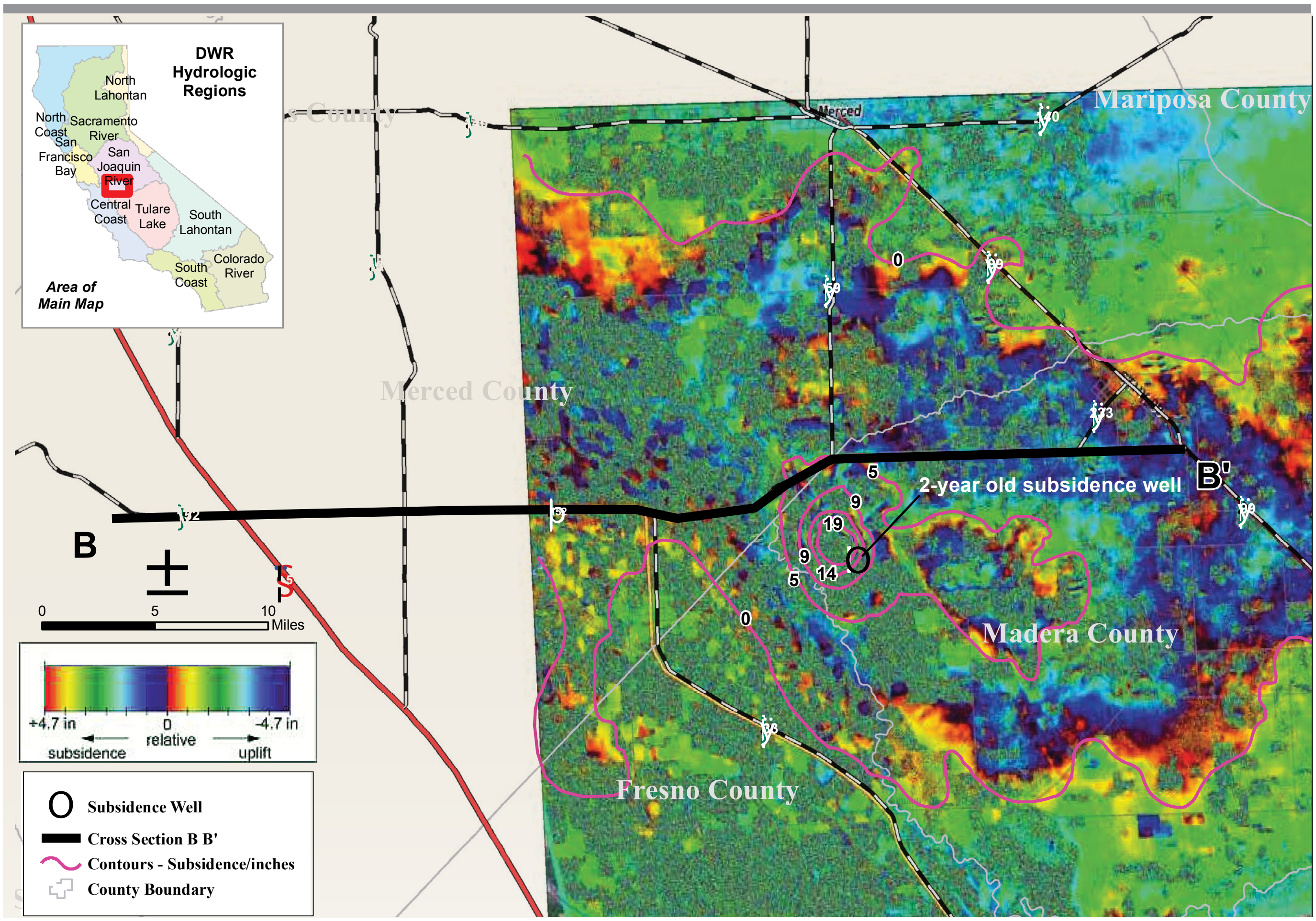
UNAVCO continuously monitored precision GPS stations in western United States provide partial but important insight into the regional magnitude of subsidence in the Tulare Lake and San Joaquin River hydrologic regions (http://pbo.unavco.org). For example, many of the 13 land surface displacement summary graphs show a significant trend of declining land surface within the region (Figure SJR-30). Similarly, Figure SJR-31 shows the obvious correlation between the post-2007 decline in groundwater levels beneath the Corcoran Clay and the decline in land surface elevations near the City of Mendota. Between 2007 and 2010, groundwater levels in the Mendota area have declined by approximately 30 feet, while the vertical displacement in the land surface has declined by about 0.2 feet.

Groundwater Level Monitoring and Subsidence

The rate, extent, and type (elastic versus inelastic) of land subsidence is directly related to the rate and extent of declining groundwater levels. If areas have undergone historical subsidence, the threat for renewed subsidence is commonly considered to be minimized if current groundwater levels can be maintained above historical lows. Droughts in 2007 and 2008 and the court settlement of San Joaquin River water rights resulted in reduced surface water allocations for irrigation. The result was an increased reliance on groundwater to meet water needs including the reactivation of old wells and an increase to the number of new wells drilled. There is a big concern that increasing groundwater pumping and declining groundwater levels would initiate land subsidence again.

Groundwater pumping to meet ever increasing agricultural water demand has led to a long-term economic boom for California's agriculture economy and allowed the San Joaquin Valley to become one of the world's most productive agricultural regions. However, the groundwater extraction far exceeds natural aquifer recharge in the region, and the depleted system has not been replenished by actively recharging the aquifer via conjunctive water management. These economic benefits have not been gained without a broader cost to the infrastructure affected by land subsidence, to the quantity and quality of groundwater resources, to the increased energy required to pump groundwater, and to the decline in ecosystem services provided by the interaction of groundwater-surface water systems. In water deficit regions, implementing effective groundwater management can be extremely challenging. Local water resource managers in the region currently utilize conjunctive management and water conservation measures to help reduce unsustainable stress on the aquifer systems; however, in many cases groundwater levels continue to decline and evidence of renewed land subsidence remains. It is very important for existing agricultural and urban development to critically evaluate the broader and longer-term costs associated with unsustainable groundwater pumping and take more aggressive actions to

Figure SJR-28 Location of Caltrans Highway 152 Elevation Monitoring



Source: USGS ALOS Interferogram, 8 January 2008-13. January 2010

balance between water resource management and land use practices, and help mitigate against escalation of future grim consequences.

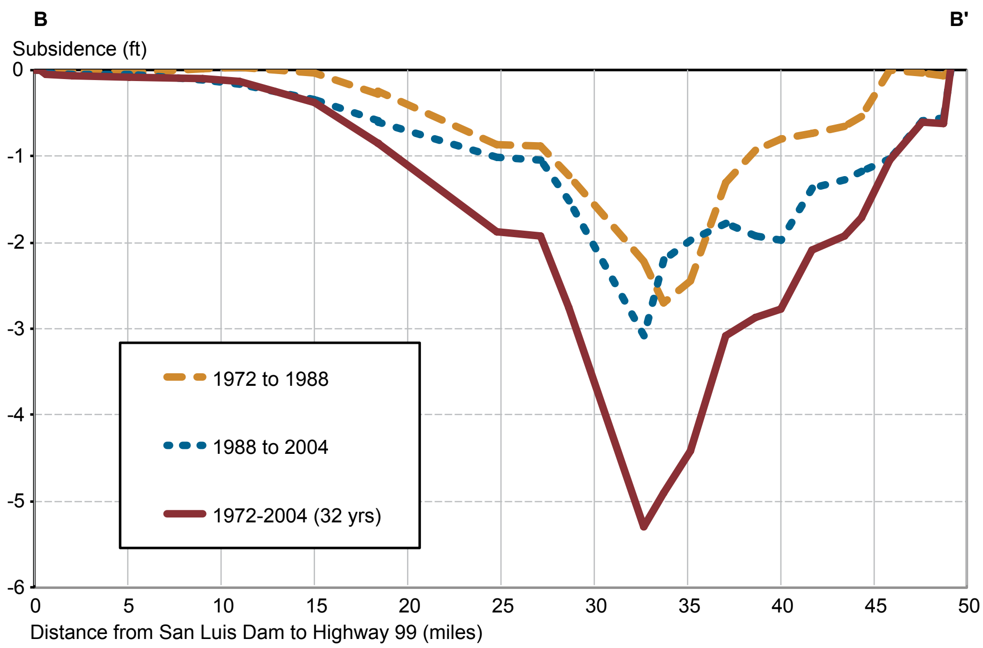
Additional information regarding the land subsidence in aquifers in the San Joaquin River Hydrologic Region is available online from Update 2013, the Volume 4 *Reference Guide,* article, "California's Groundwater Update 2013."

Flood Management

Traditionally, the approach to flood management was to develop narrowly focused flood infrastructure projects. This infrastructure often altered or confined natural watercourses, which reduced the chance of flooding and thereby minimizing damage to lives and property. This traditional approach looked at floodwater primarily as a potential risk to be mitigated instead of as a natural resource that could provide multiple societal benefits.

Today, water resources and flood planning involves additional demands and challenges, such as multiple regulatory processes and permits, coordination with multiple agencies and stakeholders,

Figure SJR-29 Land Subsidence Results from Caltrans Highway 152 Elevation Monitoring, between San Luis Dam and Highway 99 (1972-2004)



and increased environmental awareness. These additional complexities call for an integrated water management (IWM) approach that incorporates natural hydrologic, geomorphic, and ecological processes to reduce flood risk by influencing the cause of the harm, including the probability, extent, or depth of flooding (flood hazard). Some agencies are transitioning to an IWM approach. IWM changes the implementation approach based on the understanding that water resources are an integral component for sustainable ecosystems, economic growth, water supply reliability, public health and safety, and other interrelated elements. Additionally, IWM acknowledges that a broad range of stakeholders may have interests and perspectives that could positively influence planning outcomes.

Damage Reduction Measures

Flood exposure in the San Joaquin River Hydrologic Region occurs primarily along the San Joaquin River. However, significant flooding has also occurred on the Fresno, Merced, Mokelumne, and Stanislaus rivers. Floods within the San Joaquin River Hydrologic Region originate principally from melting of the Sierra snowpack and from rainfall. Most flood events occur in December and January as a result of multiple storms and saturated soil conditions, but floods can occur in October and November or during the late winter or early spring months.

In the San Joaquin River Hydrologic Region, more than 535,000 people and around $40 billion in structures are exposed to the 500-year flood event. There is also more than $1.9 billion in agriculture crop value exposed in the region. Figures SJR-32 and SJR-33 provide a snapshot of people, structures, crops, infrastructure exposed to flooding in the region. Over 260 State and federal threatened, endangered, listed, or rare plant and animal species exposed to flood hazards are distributed throughout the San Joaquin River Hydrologic Region.

Figure SJR-30 UNAVCO GPS Land Surface Displacement Monitoring Stations and Station Data Summary Graphs

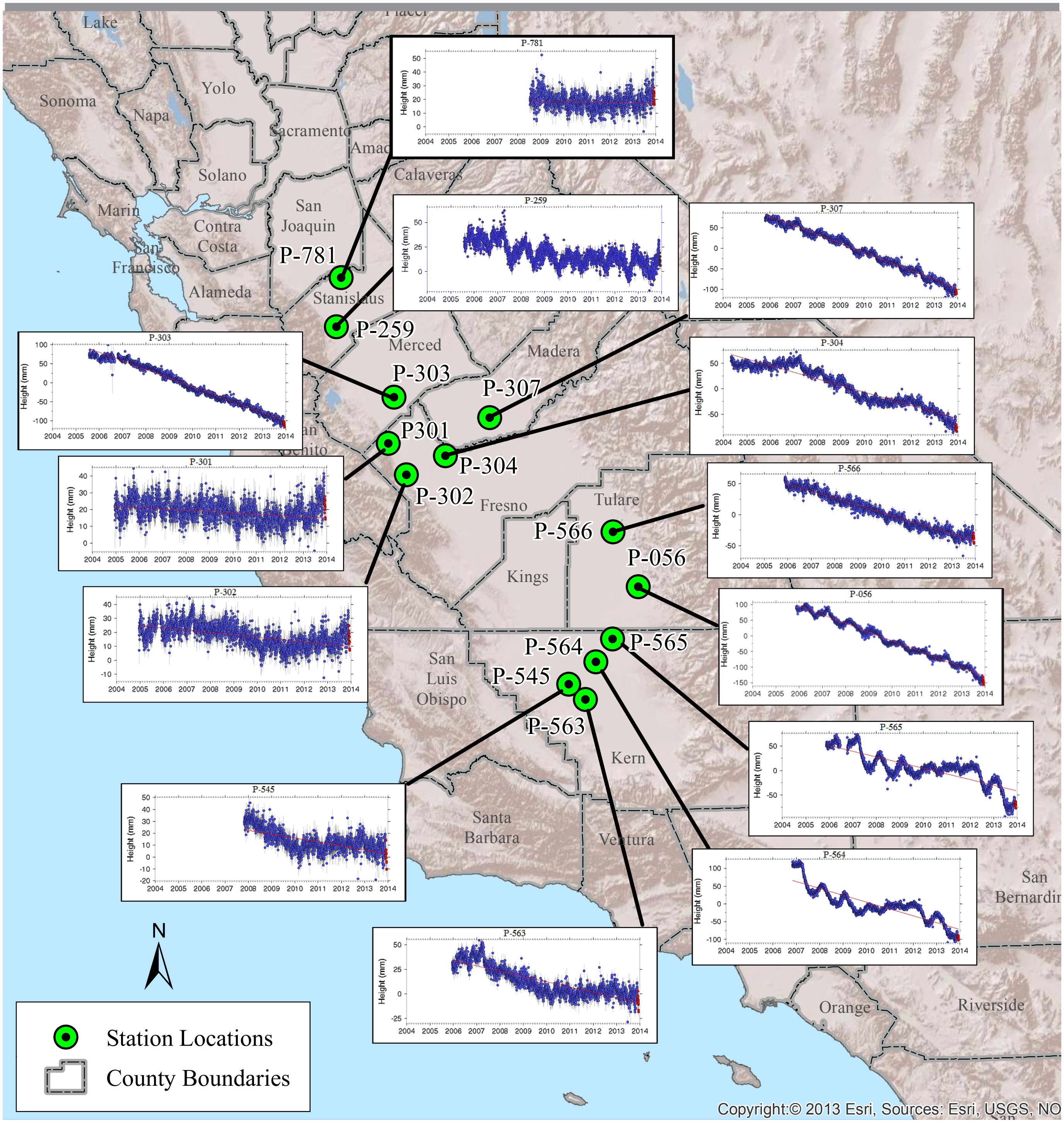
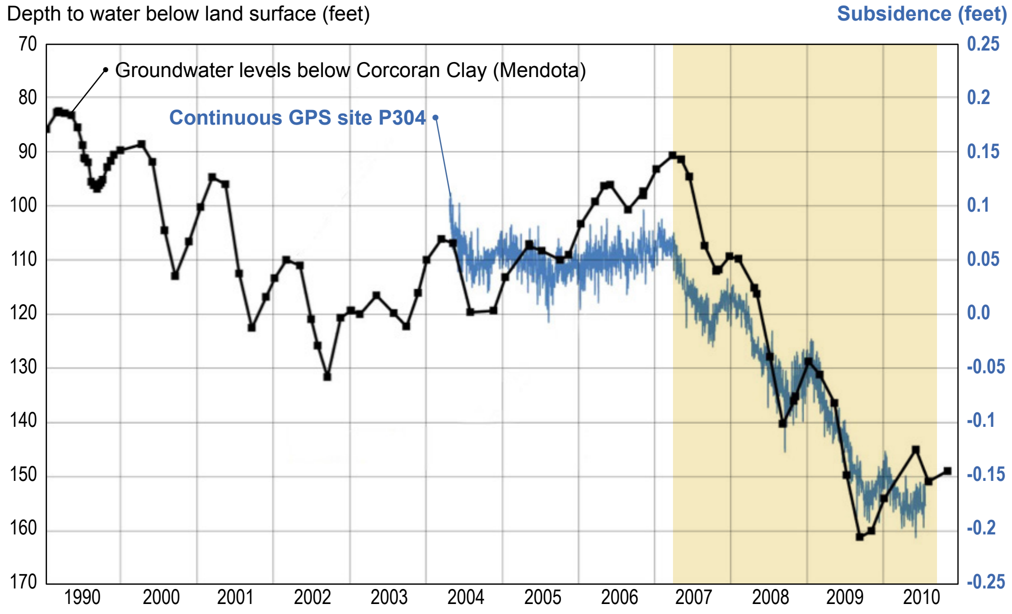


Figure SJR-31 Depth to Groundwater Hydrograph and Vertical Land Surface Displacement at UNAVCO GPS Site 304, near the City of Mendota



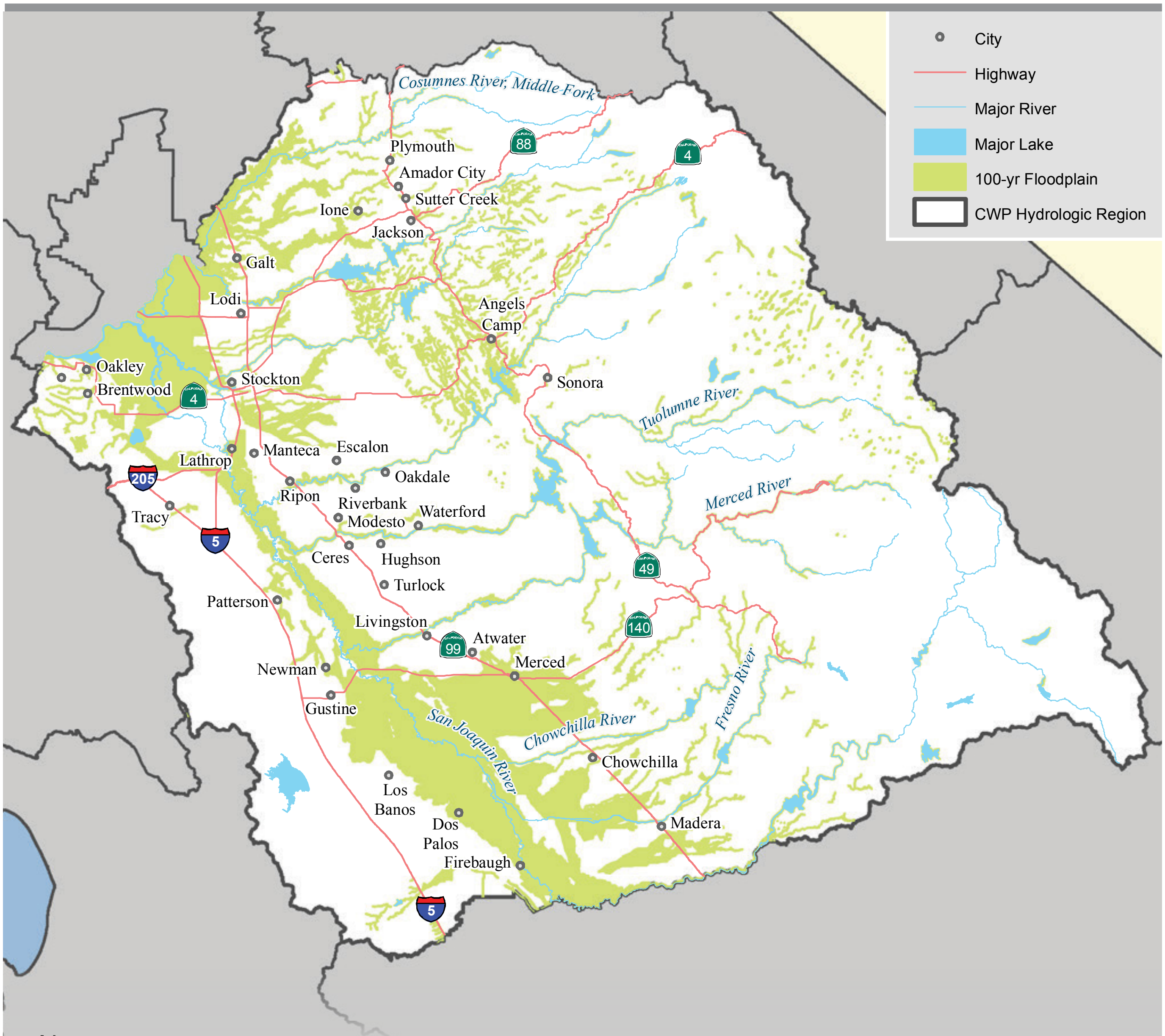
Source: USGS 2011 presentation on Central Valley subsidence. Land surface elevation data from UNAVCO Station 304; depth to water data provided by Luhdorff and Scalmanini Consulting Engineers

Levee Performance and Risk Studies

Flood hazard mitigation planning is an important part of emergency management planning for floods and other disasters. Hazard mitigation is defined as any sustained action taken to reduce or eliminate long-term risk to human life and property from hazards. Hazard mitigation planning is the process through which natural hazards that threaten communities are identified; likely impacts of those hazards are determined; mitigation goals are set; and appropriate strategies that would lessen the impacts are determined, prioritized, and implemented. Hazard mitigation planning is required for State and local governments to maintain their eligibility for certain federal disaster assistance and hazard mitigation funding programs.

Multi-hazard mitigation plans (MHMPs) are required by the Federal Emergency Management Agency (FEMA) as a condition of pre- and post-disaster assistance. The Stafford Act, as amended by the Disaster Mitigation Act of 2000, provides for States, tribes, and local governments to undertake a risk-based approach to reducing risks to natural hazards through mitigation planning. The National Flood Insurance Act reinforced the need and requirement for mitigation plans linking flood mitigation assistance programs to State, tribal, and local mitigation plans. FEMA-approved MHMPs are on file for a number of counties in this hydrologic region. Other risk assessment studies have been prepared by various entities including USACE, FEMA, and the State Reclamation Board of California. For a complete list of studies, see *California's Flood Future Report Attachment G: Risk Information Inventory* (California Department of Water Resources and U.S. Army Corps of Engineers 2013c).

Figure SJR-32 Flood Exposure to the 100-Year Floodplain, San Joaquin River Hydrologic Region

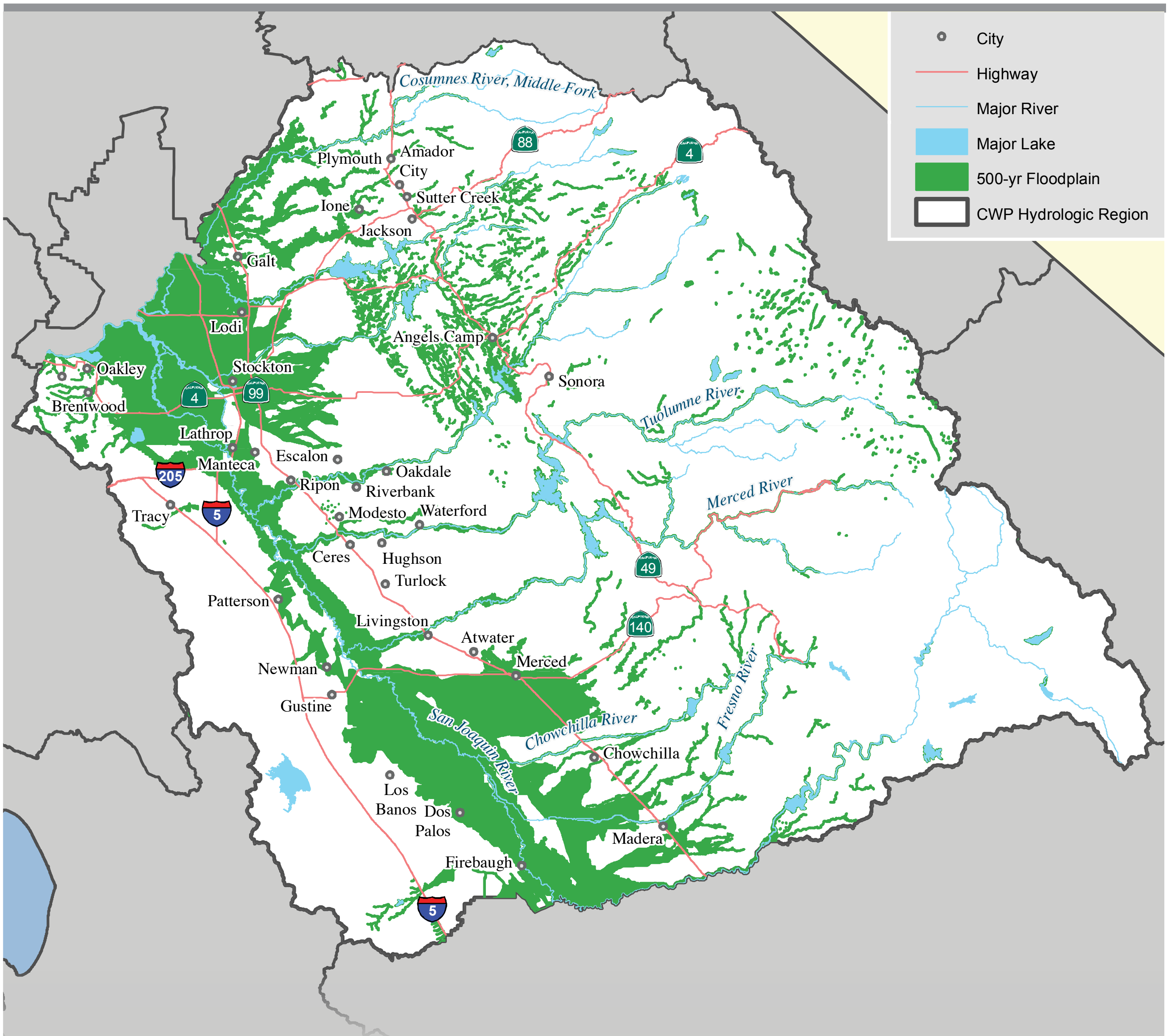


San Joaquin River key results

Total population	1,752,400	Transportation facilities	646
Population exposed	157,100	Transportation segments (miles)	428
Percent of population exposed	9	Essential facilities	93
Exposed structures	54,200	Lifeline utilities	12
Value of exposed structure and contents	$11.3 billion	Department of Defense facilities	2
Total area (acres)	9.8 million	Department of Defense facilities (acres)	597
Exposed area (acres)	1,149,200	High potential loss facilities	92
Percent of area exposed	12	Native American federally recognized tribes	1
Exposed agricultural crops (acres)	682,100	Native American fed. recognized tribal lands (acres)	3
Percent of agricultural crops exposed	32	Sensitive animal species exposed	131
Value of exposed agricultural crops	$1.4 billion	Sensitive plant species exposed	130

Source: California's Flood Future Report 2013

Figure SJR-33 Flood Exposure to the 500-Year Floodplain, San Joaquin River Hydrologic Region



San Joaquin River key results

Total population	1,752,400	Transportation facilities	901
Population exposed	535,300	Transportation segments (miles)	718
Percent of population exposed	31	Essential facilities	298
Exposed structures	172,300	Lifeline utilities	29
Value of exposed structure and contents	$39.6 billion	Department of Defense facilities	2
Total area (acres)	9.8 million	Department of Defense facilities (acres)	831
Exposed area (acres)	1,418,400	High potential loss facilities	134
Percent of area exposed	14	Native American federally recognized tribes	1
Exposed agricultural crops (acres)	878,700	Native American fed. recognized tribal lands (acres)	3
Percent of agricultural crops exposed	41	Sensitive animal species exposed	131
Value of exposed agricultural crops	$1.9 billion	Sensitive plant species exposed	131

Source: California's Flood Future Report 2013

One specific study, the CVFPP, was developed to address flood risk. The Central Valley Flood Protection Act of 2008 directed DWR to prepare this report. The CVFPP is a flood management planning effort that addresses flood risks and ecosystem restoration opportunities in an integrated manner while concurrently improving ecosystem functions, operations and maintenance practices, and institutional support for flood management. It specifically proposes a systemwide approach to flood management for the areas currently protected by SPFC facilities. Under this approach, California will prioritize investments in flood-risk reduction projects and programs that incorporate ecosystem restoration and multi-benefit projects. The CVFPP was adopted by the Central Valley Flood Control Board on June 29, 2012. It is expected that the CVFPP will be updated every five years thereafter. The CVFPP proposes a systemwide approach to address the following issues:

- Physical improvements in the Sacramento and San Joaquin River basins.
- Urban flood protection.
- Small community flood protection.
- Rural/agricultural area flood protection.
- System improvements.
- Non-SPFC levees.
- Ecosystem restoration opportunities.
- Climate change considerations.

In the San Joaquin River Hydrologic Region, 54 local flood management projects or planned improvements are identified. The local flood management projects can be found in *California's Flood Future Report*. Of this total, 47 projects have identified costs totaling about $735 million while the remaining projects do not have costs associated with them at this time. Twenty-four local planned projects implement IWM approach. Example projects include the Big Bend Floodplain Protection and Restoration Project, the Farmington Groundwater Recharge and Seasonal Habitat Program, and the Lower San Joaquin River Flood Bypass Project. For a complete list of projects, see *California's Flood Future Report*, Attachment G: Risk Information Inventory (California Department of Water Resources and U.S. Army Corps of Engineers 2013c).

Water Governance

The San Joaquin River Hydrologic Region's water management activities are generally governed by counties, cities, and special districts created to perform specific water-related functions. Federal entities within the region with water management responsibilities include the USBR and the USACE.

The interregional water conveyance systems of the CVP and SWP are operated by federal and State governments, respectively. The Madera Canal is part of the Friant Division of the USBR and is operated by the Madera-Chowchilla Power and Water Authority, while the Delta-Mendota Canal is part of the Delta Division of the USBR and operated by the San Louis Delta Mendota Water Authority. The San Luis Canal/California Aqueduct (a joint federal-State project), which runs from the O'Neill Forebay to Kettleman City, is operated by the San Luis Unit of the USBR.

Local developed surface water systems include the Calaveras River waterworks for the Calaveras County Water District; Mokelumne River diversion points/canals for North San Joaquin Water

Conservation District, Amador Water Agency, and Calaveras County Water District; Stanislaus River diversion points/canals for Calaveras County Water District, Tuolumne Utilities District , Oakdale Irrigation District, and South San Joaquin Irrigation District; Tuolumne River waterworks for the Turlock Irrigation District, Modesto Irrigation District, and Tuolumne Utilities District; Fresno River diversion points/canals for Madera Irrigation District; Chowchilla River diversion points/canals for the Chowchilla Water District; Merced River diversion points for Merced Irrigation District; and San Joaquin River diversion points/canals for Patterson Water District, West Stanislaus Irrigation District, and the San Joaquin River Exchange Contractors (Central California Irrigation District, San Luis Canal Co., Firebaugh Canal Co., and Columbia Canal Co.).

Table SJR-23 lists a selection of organizations involved in water governance in the region. A list of regional flood management participants is included in the “Flood Management” section, and an integrated regional water management discussion can be found in the “Regional Water Planning and Management” section.

Changes to IRWM within the San Joaquin River Hydrologic Region since *California Water Plan Update 2009* include the following:

- The conditionally approved Central California IRWM group dissolved after the Round 1 Region Acceptance Process (RAP) and split into three IRWM groups: the Yosemite-Mariposa, Madera, and Merced, with each receiving full approval as IRWM regions in round 2 of RAP in 2010-2012.
- The Madera, Merced, and Southern Sierra IRWM groups moved from conditionally approved to fully approved IRWM regions during round 2 of RAP 2010-2011.
- The East Stanislaus IRWM group was formed and approved as an IRWM region during round 2 of RAP 2010-2011.

Flood Governance

California’s water resource development has resulted in a complex, fragmented, and intertwined physical and governmental infrastructure. Although primary water management responsibility might be assigned to a specific local entity, aggregate responsibilities are spread among 280 agencies and cities in the San Joaquin River Hydrologic Region with many different governance structures. For a list of agencies, see *California’s Flood Future Report*, Attachment E: Information Gathering Findings (California Department of Water Resources and U.S. Army Corps of Engineers 2013b). Agency roles and responsibilities can be limited by how the agency was formed, which may include enabling legislation, a charter, an MOU with other agencies, or facility ownership.

The San Joaquin River Hydrologic Region contains floodwater storage facilities and channel improvements funded and/or built by the State and federal agencies. Flood management agencies are responsible for operating and maintaining water management facilities, including more than 4,750 miles of levees, more than 260 dams and reservoirs, and other facilities in the hydrologic region. For a list of major infrastructure, see *California’s Flood Future Report*.

CWC Division 5, Sections 8,000-9,651 have special significance to flood management activities in the Delta and are summarized in *California’s Flood Future Report*, Attachment E: Information Gathering Findings (California Department of Water Resources and U.S. Army Corps of Engineers 2013b).

Table SJR-23 Selection of Organizations in the San Joaquin River Hydrologic Region Involved in Water Governance

Entity	Role/Responsibilities
FEDERAL	
Madera-Chowchilla Water and Power Association (Madera Canal (CVP))	Provide regional water supply
U.S. Bureau of Reclamation	Operation of Friant Dam, Delta Mendota and San Luis canals
U.S. Army Corps of Engineers	Operation of New Hogan, Burns, Owens, Buchanon, Bear, Mariposa, and Hidden dams
STATE	
State Water Project	Interregional water supply
LOCAL	
Madera Irrigation District	Deliver CVP supplies from Friant Dam, as well as local supplies
Chowchilla Water District	Deliver CVP supplies from Friant Dam, as well as local supplies
Cities of Madera, Merced, Turlock, Modesto, and Stockton	Municipal water supplies
Merced Irrigation District	Deliver Merced River supplies
Turlock Irrigation District	Deliver Tuolumne River supplies
Modesto Irrigation District	Deliver Tuolumne River supplies
Friant Water Authority	Madera Canal CVP deliveries
San Luis and Delta Mendota Water Authority	Maintain and operate Delta-Mendota Canal
Patterson Water District	Deliver San Joaquin River supplies
West Stanislaus Irrigation District	Deliver San Joaquin River supplies
Grasslands Water District	Distribute CVP supplies to area wildlife refuges
San Joaquin River Exchange Contractors	Deliver San Joaquin River supplies
Oakdale Irrigation District	Deliver Stanislaus River supplies
South San Joaquin Irrigation District	Deliver Stanislaus River supplies
South Delta WA	Charged with protecting the in-channel water supply for Delta-area farmers
Central Delta WA	Charged with protecting the in-channel water supply for Delta-area farmers
North San Joaquin WCD	Deliver Mokelumne River supplies
Amador WA	Deliver Mokelumne River municipal supplies, as well as provide wastewater services
Calaveras County WD	Deliver Mokelumne, Stanislaus, and Calaveras rivers municipal supplies, as well as provide wastewater services
Tuolumne Utilities District	Deliver Stanislaus River supplies, as well as provide wastewater services

Notes: CVP = Central Valley Project, WA= Water Agency, WCD= Water Conservation District, WD= Water District

Groundwater Governance

California does not have a statewide management program or statutory permitting system for groundwater. However, one of the primary vehicles for implementing local groundwater management in California is a groundwater management plan (GWMP). Some local agencies manage groundwater through adoption of groundwater ordinances, and others manage groundwater through authorities granted by special acts of the Legislature. Additional avenues of groundwater management include basin adjudications, IRWM plans, urban water management plans, and agricultural water management plans.

A summary assessment of some of the GWMPs in the region is provided below, while a detailed assessment is available online from Update 2013, the Volume 4, *Reference Guide,* article, "California's Groundwater Update 2013." The assessment was based on a GWMP inventory developed through a joint DWR/Association of California Water Agencies (ACWA) online survey and follow-up communication by DWR in 2011 and 2012.

Groundwater Management Assessment

Table SJR-24 lists the GWMPs in the region while Figure SJR-34 shows the location and distribution of the GWMPs. GWMPs prepared in accordance with the 1992 Assembly Bill (AB) 3030 legislation, as well as those prepared with the additional required components listed in the 2002 Senate Bill (SB) 1938 legislation are shown.

The GWMP inventory shows 21 groundwater management plans in the San Joaquin region, thirteen of which have been developed or updated to include the SB 1938 requirements and are considered active for the purposes of the GWMP assessment.

CWC Section 10753.7 requires that six components be included in a GWMP for an agency to be eligible for State funding administered by DWR for groundwater projects. The requirement associated with the 2011 AB 359 (Huffman) legislation, applicable to groundwater recharge mapping and reporting, did not take effect until January 2013 and was not included in the current assessment. In addition, the requirement for local agencies outside of recognized groundwater basins is noted, as applicable for any of the GWMPs in the region.

In addition to the 6 required components, CWC Section 10753.8 provides a list of 12 voluntary components that may be included in a GWMP. DWR *Bulletin 118-2003*, Appendix C (California Department of Water Resources 2003) provides a list of seven recommended components related to management development, implementation, and evaluation of a GWMP, that should be considered to help ensure effective and sustainable groundwater management.

As a result, the GWMP assessment was conducted using the following criteria:

- How many of the post-SB 1938 GWMPs meet the six required components included in SB 1938 and incorporated into CWC Section 10753.7?
- How many of the post-SB 1938 GWMPs include the 12 voluntary components included in CWC Section 10753.8?
- How many of the implementing or signatory GWMP agencies are actively implementing the seven recommended components listed in DWR *Bulletin 118-2003*?

A summary of the GWMP assessment is provided in Table SJR-25.

Table SJR-24 Groundwater Management Plans in the San Joaquin River Hydrologic Region

Map Label	Agency Name	Date	County	Basin Number	Basin Name
SJ-1	Calaveras County Water District No signatories on file	2007	Calaveras	5-22.01	Eastern San Joaquin Subbasin
SJ-2	Chowchilla Water District-Red Top Resource Conservation District Joint Powers Authority No signatories on file	1997	Madera	5-22.05	Chowchilla Subbasin
			Merced	5-22.04	Merced Subbasin
SJ-3	City of Tracy	2007	San Joaquin	5-22.15	Tracy Subbasin
	Banta Carbona Irrigation District				
	Del Puerto Water District				
	Patterson Water District				
	Plain View Water District				
	West Stanislaus Irrigation District				
	Westside Irrigation District				
	San Joaquin County Flood Control & Water Conservation District				
SJ-4	Diablo Water District	2007	Contra Costa	5-22.15	Tracy Subbasin
	City of Brentwood				
	Town of Discovery Bay				
	East Contra Costa Irrigation District				
SJ-5	Madera County	1997	Madera	5-22.06	Madera Subbasin
	Chowchilla Water District-Red Top Resource Conservation District JPA				
	San Joaquin River Exchange Contractors Water Authority				
	Madera Irrigation District				
	Gravelly Ford Water District				
	Madera Water District				
	Aliso Water District				
	Root Creek Water District				
SJ-6	Madera Irrigation District No signatories on file	1999	Madera	5-22.06	Madera Subbasin

Map Label	Agency Name	Date	County	Basin Number	Basin Name
SJ-7	Madera Water District No signatories on file		Madera	5-22.06	Madera Subbasin
SJ-8	Merced Area Groundwater Pool Interests (MAGPI)	2008	Merced	5-22.04	Merced Subbasin
	Stevinson Water District			5-22.05	Chowchilla Subbasin
SJ-9	North San Joaquin Water Conservation District No signatories on file	1995	San Joaquin	5-22.01	Eastern San Joaquin Subbasin
				5-22.16	Cosumnes Subbasin
SJ-10	Northeastern San Joaquin County Groundwater Banking Authority	2004	San Joaquin	5-22.01	East San Joaquin Subbasin
	City of Lodi			5-22.16	Cosumnes Subbasin
	Woodbridge Irrigation District				
	North San Joaquin Water Conservation District				
	Central San Joaquin Water Conservation District				
	Stockton East Water District				
	Central Delta Water Agency				
	South Delta Water Agency				
	San Joaquin County Flood Control and Water Conservation District				
	California Water Service Company				
	San Joaquin Farm Bureau Federation				
SJ-11	Root Creek Water District No signatories on file	1997	Madera	5-22.06	Madera Subbasin
SJ-12	San Joaquin River Exchange Contractors Water Authority	2008	Madera	5-22.07	Delta-Mendota Subbasin
	Central California Irrigation District		Stanislaus		
	Firebaugh Canal Water District		Merced		
	Columbia Canal Company		Madera		
	San Luis Canal Company				
SJ-13, 14	San Luis & Delta Mendota Water Authority-North & South	2007	Merced	5-22.15	Tracy Subbasin

Map Label	Agency Name	Date	County	Basin Number	Basin Name
	Banta Carbona Irrigation District		Stanislaus	5-22.07	Delta-Mendota Subbasin
	Del Puerto Water District		San Joaquin		Non-B118 Basin
	Patterson Irrigation District		Merced		
	Byron-Bethany Irrigation District (only the CVPSA)				
	West Stanislaus Irrigation District				
	Westside Irrigation District				
	City of Tracy				
	San Joaquin County Flood Control and Water Conservation District				
	Panoche Water District	2009			
	Eagle Field Water District				
	Oro Loma Water District				
	Widren Water District				
	Mercy Springs Water District				
	Broadview Water District				
	San Luis Water District				
SJ-15	South San Joaquin Irrigation District	1994	San Joaquin	5-22.01	Eastern San Joaquin Subbasin
	No signatories on file				
SJ-16	Southeast Sacramento County Agricultural Water Authority	2002	Sacramento		
	Clay Water District		San Joaquin	5-22.16	Cosumnes Subbasin
	Omochumne-Hartnell Water District			5-21.65	South American Subbasin
SJ-17	Stanislaus and Tuolumne Rivers Groundwater Basin Association	2005	Stanislaus	5-22.02	Modesto Subbasin
	Oakdale Irrigation District			5-22.01	East San Joaquin Subbasins
	Modesto Irrigation District				
	Stanislaus County				
	City of Riverbank				
	City of Modesto				
	City of Oakdale				

Map Label	Agency Name	Date	County	Basin Number	Basin Name
SJ-18	Turlock Groundwater Basin Association	2008	Stanislaus	5-22.03	Turlock Subbasin
	City of Turlock		Merced		
	City of Ceres				
	City of Modesto				
	Hilmar County Water District				
	Denair Community Services District				
	Eastside Water District				
	Ballico-Cortez Water District				
	Turlock Irrigation District				
	Keyes Community Services District				
	Delhi County Water District				
NL-1	Alpine County No signatories on file	2007	Alpine	6-6	Carson Valley Basin
					Non-B118 Basin
TL-25	Westlands Water District No signatories on file	1996	Fresno	5-22.09	Westside Subbasin
			Kings		
SR-24	Sacramento Central County Water Agency	2006	Sacramento	5-21.65	South American Subbasin
	City of Elk Grove			5-22.16	Cosumnes Subbasin
	City of Folsom				
	City of Rancho Cordova				
	City of Sacramento				
	County of Sacramento				

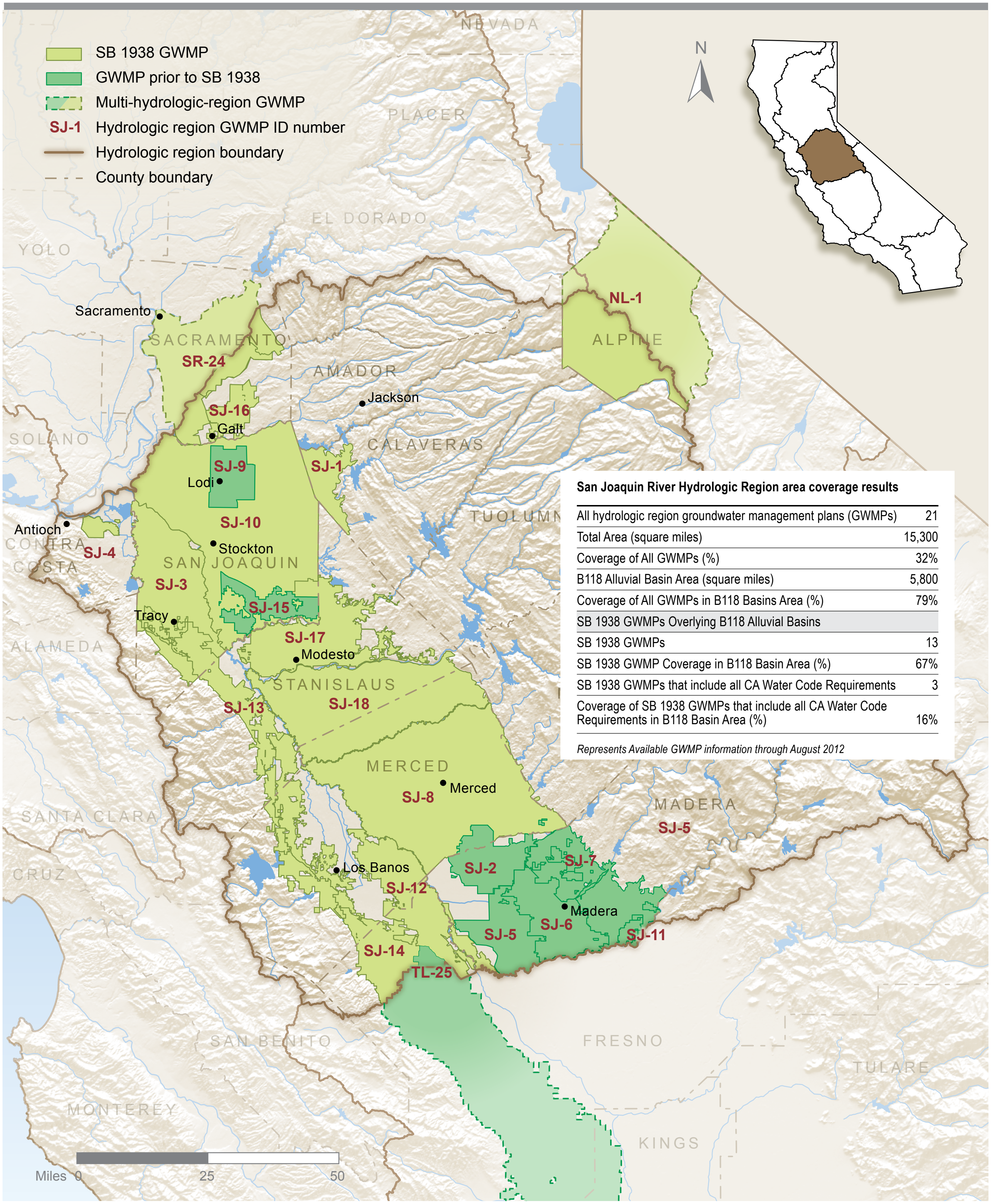
Note: Table represents information as of August, 2012.

Factors Contributing to Success and Impediment to Groundwater Management

The survey participants were also asked to identify key factors that promoted or impeded successful groundwater management.

Five responding agencies identified data collection and sharing, understanding of common interest, sharing of ideas and information, and water budgets as key factors for successful GWMP implementation while four of the five respondents also identified other components as key factors.

Figure SJR-34 Location of Groundwater Management Plans in the San Joaquin River Hydrologic Region



San Joaquin River Hydrologic Region area coverage results

All hydrologic region groundwater management plans (GWMPs)	21
Total Area (square miles)	15,300
Coverage of All GWMPs (%)	32%
B118 Alluvial Basin Area (square miles)	5,800
Coverage of All GWMPs in B118 Basins Area (%)	79%
SB 1938 GWMPs Overlying B118 Alluvial Basins	
SB 1938 GWMPs	13
SB 1938 GWMP Coverage in B118 Basin Area (%)	67%
SB 1938 GWMPs that include all CA Water Code Requirements	3
Coverage of SB 1938 GWMPs that include all CA Water Code Requirements in B118 Basin Area (%)	16%

Represents Available GWMP information through August 2012

Overall, survey respondents pointed to a lack of adequate funding as the greatest impediment to GWMP implementation. Funding is a challenging factor for many agencies because the implementation and the operation of groundwater management projects are generally expensive and because the sources of funding for projects typically are limited to either locally raised monies or to grants from State and federal agencies. Lack of surface storage and conveyance capacity and data collection and sharing were also considered key limiting factors by three of the five respondents. Unregulated pumping, groundwater supply, participation, and governance were also identified as factors that impede successful implementation of GWMPs.

Four out of five respondents felt long-term sustainability of their groundwater supply was not feasible.

More detailed information on the survey and assessment of the GWMPs are available online from Update 2013, the Volume 4 *Reference Guide,* article, "California's Groundwater Update 2013."

Groundwater Ordinances

Groundwater ordinances are laws adopted by local authorities, such as cities or counties, to manage groundwater. In 1995, the California Supreme Court declined to review a lower court decision (*Baldwin v. Tehama County*) that says that State law does not occupy the field of groundwater management and does not prevent cities and counties from adopting ordinances to manage groundwater under their police powers. Since 1995, the Baldwin v. Tehama County decision has remained untested; thus the precise nature and extent of the police power of cities and counties to regulate groundwater is still uncertain.

A number of counties in the region have adopted groundwater ordinances. The most common ordinances regulate well construction, abandonment, and destruction. Several counties also have ordinances that require permits pertaining to water exports. San Joaquin County has an additional ordinance regarding guidance committees while Madera County has an additional ordinance for recharge. None of the ordinances provide for comprehensive groundwater management.

Special Act Districts

Special acts of the Legislature have granted greater authority to manage groundwater to a few local agencies or districts. These agencies generally have authority to:

1. Limit groundwater export and extraction (upon evidence of overdraft or threat of overdraft), or

2. Require reporting of groundwater extraction and to levy replenishment fees.

There are many Special Act Districts established by the California State Legislature consisting of different authorities that may or may not have groundwater management authority. It is not part of the scope for Update 2013 to identify Special Act Districts in the region or the established agencies. This report includes the GWMPs that were prepared by these agencies and submitted to DWR, as discussed in the preceding section.

Table SJR-25 Assessment of Groundwater Management Plan Components

SB 1938 GWMP Required Components	Percent of Plans that Meet Requirement
Basin management objectives	54
BMO: Monitoring/management groundwater levels	85
BMO: Monitoring groundwater quality	85
BMO: Inelastic subsidence	77
BMO: SW/GW interaction and affects to groundwater levels and quality	62
Agency Cooperation	92
Map	69
Map: Groundwater basin area	77
Map: Area of local agency	77
Map: Boundaries of other local agencies	77
Recharge areas (1/1/2013)	Not Assessed
Monitoring protocols	31
MP: Changes in Groundwater Levels	100
MP: Changes in Groundwater Quality	100
MP: Subsidence	69
MP: SW/GW Interaction and Affects to Groundwater Levels & Quality	38
SB 1938 Voluntary Components	**Percent of Plans that Include Component**
Saline intrusion	69
Wellhead protection and recharge	92
Groundwater contamination	85
Well abandonment and destruction	85
Overdraft	85
Groundwater extraction and replenishment	77
Monitoring groundwater levels and Storage	85
Conjunctive use operations	92
Well construction policies	77
Construction and operation	54
Regulatory agencies	85
Land use	62

Bulletin 118-03 Recommended Components	Percent of Plans that Include Component
GWMP guidance	92
Management area	92
BMOs, goals, and actions	85
Monitoring plan description	62
IRWM planning	62
GWMP implementation	85
GWMP evaluation	85

Notes: BMO=basin management objective, IRWM=integrated regional water management, GWMP=groundwater management plan, MP=monitoring rotocols, SW/GW= surface water/groundwater

Court Adjudication of Groundwater Rights

Another form of groundwater management in California is through the courts. There are currently 24 groundwater adjudications in California. The San Joaquin River Hydrologic Region contains none of those adjudications.

Other Groundwater Management Planning Efforts

Groundwater management also occurs through other avenues such as integrated regional water management plans (IRWM plans), urban water management plans, and agricultural water management plans. Box SJR-1 summarizes groundwater management aspects included in these planning efforts.

Current Relationships with Other Regions and States

Interregional and Interstate Planning Activities

The San Joaquin River Hydrologic Region provides water to other regions and receives water as well. CVP water is brought in from the Delta and distributed to San Joaquin River Exchange Contractors. This makes water available at Friant Dam for distribution in the Friant Unit of the CVP. State water is brought into the region through the SWP's California Aqueduct. The existence of major water project transport facilities traversing the region enhances the potential for water exchanges and transfers. Water for the federal San Felipe Project is transported through the west side of San Luis Reservoir to coastal areas. During periods of high runoff, San Joaquin River water can be transported to the Tulare Lake Hydrologic Region in the Friant-Kern Canal to the Kern River. From the Kern River, water can be placed into the California Aqueduct via the Kern River Intertie.

During periods of high flows, Kings River water may be diverted from the Tulare Lake Hydrologic Region into the San Joaquin River via Fresno Slough and the James Bypass. At these

Box SJR-1 Other Groundwater Management Planning Efforts in the San Joaquin River Hydrologic Region

The integrated regional water management (IRWM) plans, urban water management plans, and agricultural water management plans in the San Joaquin River Hydrologic Region that also include components related to groundwater management are briefly discussed below.

Integrated Regional Water Management Plans

The San Joaquin River Hydrologic Region includes 12 of the 48 IRWM plans that have been accepted or conditionally accepted statewide. Five of the 12 IRWM plans are actively implemented, while 7 are in various stages of implementation. One of the established plans extends northward into the Sacramento River Hydrologic Region and one southward into the Tulare Lake Hydrologic Region.

Two of the active IRWM regions, Mokelumne/Amador/Calaveras, and Westside, rely on local entities that actively manage groundwater resources and implement projects that help improve groundwater management in their respective areas. One IRWM region identifies groundwater management as one of its planning objectives; the other IRWM region states that its main goal is to minimize regional conflict by addressing problems such as water supply reliability, overdraft, drainage, and water quality.

The plan adopted by Eastern San Joaquin IRWM region was developed to define and integrate key water management strategies and establish protocols and course of actions for implementing conjunctive use programs. This followed the establishment of a groundwater banking authority and a groundwater management plan for the area. Individual agencies within the IRWM region that manage groundwater resources found it difficult to exert the political and financial power necessary to mitigate the conditions of overdraft in their groundwater basins. They concluded that a regional consensus-based approach to water resources planning and conjunctive water management would increase their chance for success. The IRWM group developed basin management objectives for groundwater levels, groundwater quality, and inelastic land subsidence. They also developed basin operations criteria consisting of a series of groundwater levels triggers that correspond to basin condition levels to indicate the effectiveness of conjunctive use projects.

The Cosumnes, American, Bear, and Yuba Watersheds IRWM planning group states that groundwater in the IRWM region is poorly understood due to geological conditions dominated by faults and fractured rocks, and thus the IRWM group defers groundwater management to city and county agencies and to irrigation districts. Among the objectives of the IRWM plan are to identify suitable groundwater management practices to prevent groundwater contamination, assure that groundwater recharge and extraction are balanced and support efforts to understand groundwater movement and quantities in the Sierra Nevada fractured rock systems through additional studies and analyses.

The American River basin IRWM planning group relies on four local agencies or authorities with active groundwater management plans for groundwater management in the area. The IRWM plan states that groundwater management is important to reduce water rights disputes and conflicts due to heavy reliance on groundwater by agricultural and residential users. Among the IRWM plan's objectives are identify and resolve issues connected with conjunctive use water management practices and groundwater contamination and evaluate effectiveness of regional groundwater monitoring systems and make recommendations to improve groundwater monitoring systems.

Urban Water Management Plans

Urban water management plans are prepared by California's urban water suppliers to support their long-term resource planning and to ensure adequate water supplies are available to meet existing and future water uses. Urban use of groundwater is one of the few uses that meter and report annual groundwater extraction volumes. The groundwater extraction data is currently submitted with the urban water management plan and then manually translated by California Department of Water Resources (DWR) staff into a database. Online methods for urban water managers to directly enter their water use along with their plan updates is currently under evaluation and review by DWR. Because of the time-line, the plans could not be reviewed for assessment for *California Water Plan Update 2013*.

Agricultural Water Management Plans

Agricultural water management plans are developed by water and irrigation districts to advance the efficiency of farm water management while benefitting the environment. New and updated agricultural water management plans addressing several new requirements were submitted to DWR by December 31, 2012, for review and approval. These new or updated plans provide another avenue for local groundwater management; but because of the time-line, the plans could not be reviewed for assessment for *California Water Plan Update 2013.*

times, the Kings River Water Association coordinates closely with USACE and operators of the reservoirs on San Joaquin River tributaries. All parties participate in daily operators' conferences sponsored by DWR's Flood Operations Center. The regional map in Figure SJR-15 above depicts these regional imports and exports.

The Folsom South Canal originates at Lake Natoma near Folsom Dam, originally part of the USBR's CVP intended to transport American River water nearly to Stockton. Approximately 14.5 taf of tail water per year flows through the facility into the region to Galt Irrigation District. The southern portion of the canal will be used in the Freeport Regional Water Project to transport water in dry years to EBMUD.

The San Francisco Bay Hydrologic Region receives surface water that originates in the San Joaquin River Hydrologic Region. EBMUD serves communities on the east side of San Francisco Bay with water from the Mokelumne River via the Mokelumne Aqueduct. The Mokelumne River supplies more than 96 percent of the water supply to EBMUD, serving almost 1.3 million people. The San Francisco Water Department provides water from the Tuolumne River through the Hetch Hetchy Aqueduct. This is the sole source water supply for 1.3 million people and a partial source for an additional 1.4 million people. Nearly 4 million Bay Area people receive water from these two San Joaquin River Hydrologic Region watersheds/projects.

In November 2004, DWR and the California Department of Parks and Recreation reviewed the many Hetch Hetchy Valley restoration studies prepared during the previous 20 years. Hetch Hetchy Valley is inundated by the waters of the Tuolumne River behind O'Shaughnessy Dam in Yosemite National Park, Tuolumne County. The review included local, State, and federal resource plans to assist in the evaluation of water supply and quality, operational considerations, flood and drought impacts, and environmental and energy issues. The review concluded that many other aspects of restoration needed in-depth study. These included a replacement water supply, public input, other stakeholder interests, a dam removal plan, and public use and benefits evaluation. Although no recommendation was made as to the restoration, cost estimates (making broad assumptions) ranged from $3 billion to $10 billion. The results were documented in the Hetch Hetchy Restoration Study (California Department of Water Resources and California Department of Parks and Recreation 2006).

In 1998, Contra Costa Water District completed Los Vaqueros Reservoir, which can store 100 taf. This is an offstream reservoir in the northwest corner of the San Joaquin River Hydrologic Region. The reservoir stores Contra Costa Water District water that has been diverted from the Delta in winter and spring. Water is typically withdrawn from Los Vaqueros Reservoir in the summer and fall to improve the quality of water delivered to the district's service areas. The reservoir also provides emergency storage. A portion of the Contra Costa Water District service area is in the San Francisco Bay Hydrologic Region. The reservoir area provides recreational opportunities such as multi-use trails (hiking, bicycling, and equestrian), animal and bird sighting, fishing, and rental boating.

In December 2010, Contra Costa Water District contracted to expand the reservoir to 160 taf by raising the dam by 34 feet. Construction began in April 2011, and the expanded reservoir/dam was dedicated in July 2012.

Regional Water Planning and Management

Water agencies, cities and counties, utility organizations, and other stakeholders are planning individually and collectively to address growth, water supply, flood management, water management, and ecosystem issues. Efforts to increase effective use of groundwater storage, surface storage, and conveyance facilities are apparent in planning documents throughout the region. Conjunctive management, increased efficiency, conservation, reclamation, recycling, and reuse are themes throughout urban and agricultural water management plans.

The San Joaquin Valley Water Coalition was established in 1998 to promote the water interests of its valley members. Among its major members were counties within the San Joaquin Valley. Much of the counties' efforts has been shifted to the San Joaquin Valley Regional (SJVR) Blueprint Planning Process and the SJVR Water Plan. The SJVR Blueprint Planning Process was started by the Councils of Government from each of the San Joaquin Valley's counties including Merced, Madera, San Joaquin, and Stanislaus in the San Joaquin River Hydrologic Region. One of its aims is to provide a comprehensive and integrated decision-making tool that combines separate and distinct data sets into a single set. This will allow for scenario planning, more efficient use of resources, and an understanding of regional impacts and solutions. The SJVR Water Plan was initiated by valley lawmakers who were interested in creating a comprehensive, integrated plan for the valley's water resources. The California Water Institute (CWI) at California State University, Fresno was tasked with coordinating the eight-county planning effort. The CWI developed the Framework for the Implementation of Water Planning for long-term San Joaquin Valley water management. The effort is critical for identifying the valley water needs and determining water management solutions for a 50-year planning horizon. The framework was unanimously adopted by the California Partnership for the San Joaquin Valley Board of Directors on October 22, 2009.

California Partnership for the San Joaquin Valley was established in 2005 to identify potentially effective projects and programs, identify critical needs, review State policies and regulations, and make recommendations to the governor. The partnership includes eight State government members, eight local government members, and eight private sector members. The partnership was extended for one additional year by an executive order in December 2008. Then in July 2010, Executive Order S-10-10 extended the Partnership indefinitely and established governance guidelines. For more information see http://sjvpartnership.org/.

The Grasslands Bypass Project is an ongoing activity and example of planning and implementation of a program dealing with water quality, environmental concerns, and San Joaquin River conditions. Prior to 1996, agricultural drainage water passed through wetland areas in western Merced County. The drainage water contains constituents harmful to wildlife. Subsequently, this drainage water has been routed around the Grasslands wetlands into Mud Slough and discharged into the San Joaquin River upstream of the Merced River. The water is monitored for constituents to meet discharge requirements considering the assimilative capacity of the river.

The San Joaquin River Parkway and Conservation Trust was created in 1988. One purpose of the trust was to create a 22-mile parkway along the San Joaquin River in the Fresno/Madera area. The trust restores, preserves, and maintains the ecological, scenic, and historical aspects of the area. It also provides educational and recreational opportunities and experiences in the parkway. For more information, see http://riverparkway.org/index.php.

Integrated Regional Water Management Coordination and Planning

IRWM promotes the coordinated development and management of water, land, and related resources to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Historically, this has been a challenging task because the agencies involved with IRWM and flood management tend to have different regional boundaries with sometimes conflicting goals and objectives. More reliable funding and improved agency alignment are required at all levels to achieve the goals of IRWM. In the San Joaquin River Hydrologic Region a number of plans have been developed, and new ones like the East Stanislaus IRWM plans are expected to be completed in 2014.

Figure SJR-35 shows the regional water management groups (RWMGs) and plans that are in the San Joaquin River Hydrologic Region. Table SJR-26 is a review of strategies and elements that RWMGs have in their plans. A summary of the available IRWM plans in the region is presented in the "Looking to the Future" section of the report.

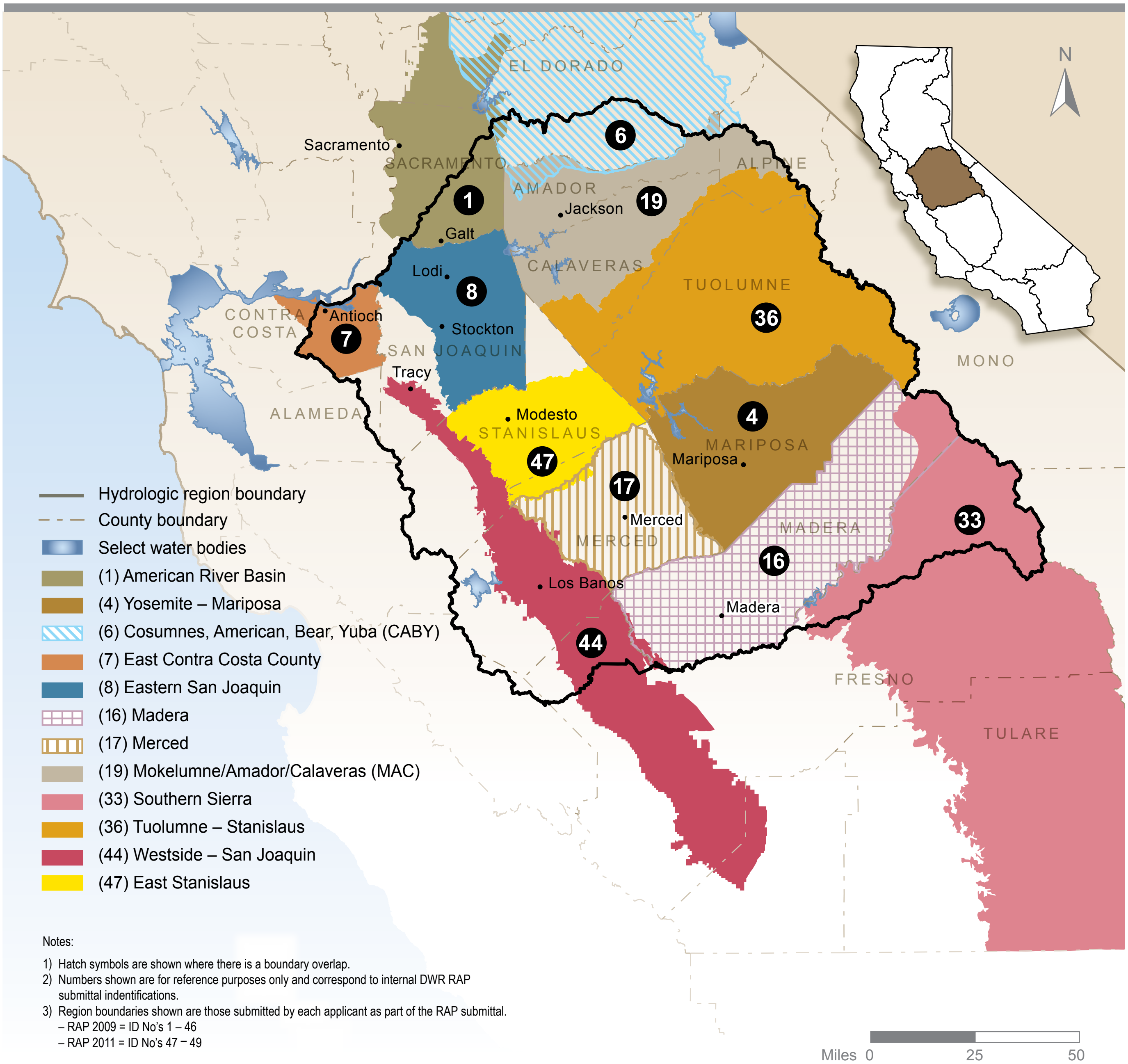
Implementation Activities (2009-2013)

Surface Water Quality and Central Valley Region Water Quality Control Board Implementation

The RWQCBs are responsible for protecting the water quality of the waters of the state and have regulatory and non-regulatory programs that can address the water quality concerns of this area. The individual RWQCBs adopt water quality control plans or basin plans that lay out the framework for how the board will protect water quality in each region. The basin plans designate the beneficial uses of surface water and groundwater in the region and water quality objectives to meet the beneficial uses and establish an implementation program to achieve the water quality objectives and protect the beneficial uses. The implementation program describes how the board will coordinate its regulatory and non-regulatory programs to address specific water quality concerns.

Overarching all the CVRWQCB's programs and activities is the development of a comprehensive salt and nitrate management plan for the Central Valley. The CVRWQCB and the SWRCB, as part of a stakeholder coalition, are working on CV-SALTS, a strategic initiative to address problems with salinity and nitrates in the surface water and groundwater of the Central Valley. The long-term plan developed under CV-SALTS will identify and require discharger implementation of management measures aimed at the reduction and/or control of major sources of salt and nitrate as well as support activities that alleviate known impairments to drinking water supplies. The eventual salt and nitrate management plan will provide guidance across all the CVRWQCB's regulatory and non-regulatory programs on how to address salinity and nitrate concerns. As this issue impacts all users (stakeholders) of water within the San Joaquin River Hydrologic Region, it is important that all stakeholders participate in CV-SALTS to be part of the development and have input on the implementation of salt and nitrate management within the San Joaquin River Hydrologic Region., The only acceptable process to develop the salt and nutrient management plans that are required under State policy for the Central Valley is through CV-SALTS (State Water Resources Control Board 2009).

Figure SJR-35 **Regional Water Management Groups in the San Joaquin River**



CV-SALTS will include basin plan amendments that establish regulatory structure and policies to support basin-wide salt and nitrate management. The regulatory structure will have four key elements: (1) refinement of the agricultural supply (AGR), municipal and domestic supply (MUN) and groundwater recharge (GWR) beneficial uses (2) revision of water quality objectives for these uses; (3) establishment of policies for assessing compliance with the beneficial uses and water quality objectives; and (4) establishment of management areas where there are large-scale differences in baseline water quality, land use, climate conditions, soil characteristics, and existing infrastructure and where short- and long-term salt or nitrate management is needed. CV-SALTS plans to implement pilot projects to demonstrate revision of water quality objectives for salt and boron in the San Joaquin River and evaluate beneficial uses and water quality objectives for agricultural water bodies (Central Valley Salinity Alternatives for Long-Term Sustainability 2012a, 2012b).

Surface Water

The CVRWQCB has adopted basin plan implementation programs that include total maximum daily load (TMDL) to address salt and boron in the San Joaquin River at Vernalis; selenium in the San Joaquin River that also addresses impairments in Salt Slough and the Grasslands Marshes; diazinon and chlorpyrifos in the San Joaquin River and the Delta; mercury in the Delta and dissolved oxygen in the Stockton Deep Water Ship Channel (Central Valley Regional Water Quality Control Board 1999, 2000, 2001, 2004, 2005a, 2005b, 2006, 2010). Outside of the basin plan, the CVRWQCB has adopted a TMDL for pathogens in the Stockton urban water bodies (Central Valley Regional Water Quality Control Board 2008). The basin plan implementation programs describe how CVRWQCB will use its authority to regulate controllable factors to restore water quality.

The CVRWQCB has regulatory programs to protect and restore the quality of surface waters. These programs include:

- The Irrigated Lands Regulatory Program, which regulates discharges from irrigated agriculture through surface water monitoring and the development and implementation of management plans to address water quality problems identified in the surface water monitoring. This program addresses materials used in agricultural production that may end up in surface water such as pesticides as well as pollutants that may be concentrated or mobilized by agricultural activities such as salt. In this program, coalition groups representing growers monitor to identify constituents of concern. Management plans are developed to identify management practices that individual growers implement to reduce the concentrations of the constituents of concern in surface water. Follow-up monitoring is conducted to confirm that water quality standards are met. Growers work together under a coalition group to meet the program requirements (Central Valley Regional Water Quality Control Board 2011d).
- Water quality coalitions currently active in the San Joaquin River basin include the East San Joaquin Water Quality Coalition, San Joaquin County and Delta Water Quality Coalition, and Westside San Joaquin River Watershed Coalition. In addition to addressing the basin plan implementation programs for salt and boron, organophosphate pesticides and dissolved oxygen, management plans have been developed and implemented to address chlorpyrifos, diazinon, diuron, dimethoate, methyl-parathion, simazine, malathion, thiobencarb, water column and sediment toxicity, and *E. coli* (Central Valley Regional Water Quality Control Board 2011a, 2012a).
- The Grasslands Bypass Project was established to implement the basin plan selenium control program for the San Joaquin River. The project routes subsurface agricultural drainage water with elevated levels of selenium, salts, and other constituents of concern away from wildlife refuges and wetlands. The goal is to reduce and reuse high selenium subsurface agricultural drainage to comply with the basin plan load limits for the San Joaquin River and its tributaries.
- The National Pollutant Discharge Elimination System (NPDES) permit program regulates the discharge of point-source wastewaters and urban runoff to surface waters. Point-source wastewater can contain elevated levels of salt and nitrates, pesticides, mercury and other metals, oxygen-demanding substances, and bacteria. Urban runoff can contain pesticides,

Table SJR-26 Strategies of Integrated Regional Water Management Efforts in the San Joaquin River Hydrologic Region

Plan Element/ Resource Management Strategy	Regional Water Management Group						
	WESTSIDE-SAN JOAQUIN	AMERICAN RIVER BASIN	COSUMNES, AMERICAN, BEAR, YUBA WATERSHED	MOKELUMNE/ AMADOR/ CALAVERAS	MADERA	EASTERN SAN JOAQUIN	EAST CONTRA COSTA COUNTY
Agricultural and urban water management planning and water use efficiency			X		X	X	
Climate change			X				
Conjunctive management and groundwater storage		X		X	X	X	X
Conservation				X			
Conveyance			X			X	
Desalination							X
Economic incentives (Loans, grants, and water pricing)						X	
Environmental restoration and preservation; habitat protection and improvement	X	X	X	X	X	X	X
Flood management	X	X	X	X			X
Groundwater management	X	X	X	X		X	X
Groundwater monitoring					X	X	

Plan Element/ Resource Management Strategy	Regional Water Management Group						
	WESTSIDE-SAN JOAQUIN	AMERICAN RIVER BASIN	COSUMNES, AMERICAN, BEAR, YUBA WATERSHED	MOKELUMNE/ AMADOR/ CALAVERAS	MADERA	EASTERN SAN JOAQUIN	EAST CONTRA COSTA COUNTY
Groundwater quality protection					X	X	
Imported water				X	X	X	X
Interregional cooperation					X		
Land use planning and coordination		X	X	X	X	X	X
Levee and channel restoration					X		
Matching water quality to water use						X	
Pollution monitoring, control, and prevention		X	X	X		X	X
Recharge areas protection					X	X	
Recreation and public access	X	X	X			X	X
Reduce groundwater pumping and overdraft; increase surface water supplies			X	X	X	X	

Plan Element/ Resource Management Strategy	Regional Water Management Group						
	WESTSIDE-SAN JOAQUIN	AMERICAN RIVER BASIN	COSUMNES, AMERICAN, BEAR, YUBA WATERSHED	MOKELUMNE/ AMADOR/ CALAVERAS	MADERA	EASTERN SAN JOAQUIN	EAST CONTRA COSTA COUNTY
Reduction of invasive species					X		
Resource mapping			X				
Storm water capture and management	X	X		X	X		X
System reoperation						X	
Water transfer and exchange					X	X	X
Water and wastewater treatment		X		X	X	X	X
Water conservation and recycling	X	X	X	X	X	X	X
Water quality protection and improvement	X	X	X	X			X
Water supply reliability	X	X	X	X	X	X	X
Watershed management and planning		X		X	X	X	X
Wetland enhancement and creation	X	X	X				X

mercury and other metals, oxygen-demanding substances, bacteria, and sediment. Permits prevent the discharge of elevated concentrations of these constituents. In cases where elevated levels of constituents of concern are being discharged, permits require dischargers to develop and implement measures to reduce the levels of these constituents.

- The Discharge to Land Program oversees the investigation and cleanup of impacts of current and historical unauthorized discharges including discharges from historic mining activities. Historic mine impacts include mercury impairments from mercury mines found on the Coast Ranges side of the Central Valley and mercury impairments from the use of mercury to amalgamate gold in the mines on the Sierra side. Other metal impairments result from the copper mining that occurred in the foothills area of the Sierra. Sedimentation can be a problem in the construction and operation of many mines. There are mine site where remedial actions have improved and/or lowered the threat to water quality. The CVRWQCB was a significant partner in making sure water quality was improved or protected by being the regulatory agency for compliance with water quality laws and regulations, design review and evaluation, establishing water quality goals, and in some cases implementing of the remedial action. Several success stories are at http://www.waterboards.ca.gov/centralvalley/water_issues/mining/region5_success_stories/calfed_copper_mine/index.shtml.
- The Timber Program provides review, oversight, and enforcement of timber harvest activities on both private and U.S. Forest Service lands. The primary responsibility of the program is review and inspection of harvest activities. Timber harvest activities pose a threat to water quality through the potential for sediment and herbicide discharges and temperature increases to surface waters. During the past five years, private timberland owners in the San Joaquin River Hydrologic Region have submitted 136 timber harvest plans that allow harvesting on over 53,000 acres.
- The Water Quality Certification Program evaluates discharges of dredge and fill materials to ensure that the activities do not violate State and federal water quality standards. One of the goals of the program is to protect wetlands and riparian areas from dredge and fill activities and to implement State and federal “no net loss” policies for wetlands. Constituents of concern addressed by this program are salts and nutrients, methylmercury, and temperature.
- The Nonpoint Source Program supports local and regional watershed assessment, management, and restoration to enhance watershed conditions that provide for improved flow properties and water quality. Non-point-sources include agriculture, forestry, urban discharges, discharges from marinas and recreational boating, hydromodification activities, wetlands, riparian areas, and vegetated treatment systems. For some of these sources, such as irrigated agriculture and forestry, the CVRWQCB has specific regulatory programs. The Nonpoint Source Program addresses sources where CVRWQCB has not developed a specific program. This program has assisted stakeholders in obtaining funds to address non-point-source pollution as well as conduct riparian and habitat restoration activities. Impacts from recreational activities, such as off-highway vehicle (OHV) use, fall under this program. In 2012, CVRWQCB found that sediment disturbed by recreational vehicle activity and transported in stormwater runoff to Corral Hollow Creek was a water quality problem at the Carnegie State Vehicle Recreation Area. The board also identified metals, such as copper and lead, as a potential concern. To address these problems, the board issued a Cleanup and Abatement Order to the California Department of Parks and Recreation. The order recognized that State Parks had developed a stormwater management plan that describes the best management practices that need to be implemented

Jackson, CA. Mine waste from the Argonaut Mine. Photograph courtesy of Central Valley Regional Water Quality Control Board to address erosion and sedimentation. The order required State Parks to update and implement the Storm Water Management Plan (Central Valley Regional Water Quality Control Board 2012b).

Monitoring the San Joaquin River for flow and quality has been fairly regular over the past years, but recently monitoring of the San Joaquin River watershed has decreased. However, the need for monitoring information remains as strong as ever. Entities involved in monitoring and the entities using the monitoring information agreed it would be useful to collaborate to achieve efficiencies in current and anticipated monitoring efforts to ensure that collected flow and water quality information satisfies both individual project needs as well as those mandated by State and federal agencies. An effort is under way to develop a regional monitoring program for the San Joaquin River watershed. Stakeholders that generate or use water quality monitoring data are encouraged to participate (State Water Resources Control Board 2012).

Groundwater

CVRWQCB has regulatory programs meant to prevent groundwater contamination by controlling the quality of discharges to land. In cases where groundwater quality has been affected, CVRWQCB's cleanup programs work with the entities responsible for the contamination to assess the extent of contamination and develop and implement a plan to clean up the contamination. CVRWQCB has developed programs that regulate specific discharge types when there are a large number of dischargers of that type and the water quality of the discharge is similar. The following are programs addressing specific discharge types (Central Valley Regional Water Quality Control Board 2010):

- The Confined Animal Program regulates discharges from confined animal operations, which are typically high in salt and nutrients. In 2007, CVRWQCB adopted Waste Discharge Requirements General Order for Existing Milk Cow Diaries (R5-2007-0035), which includes requirements for both the dairy production area and land application area and requires each dairy to fully implement its waste management plan by 2011 and a nutrient management plan by 2012. The requirements for the waste and nutrient management plans are designed to protect both surface water and groundwater. In the San Joaquin River Hydrologic Region, 739 dairies with over 658,000 cows are regulated under this general order.
- The Irrigated Lands Regulatory Program, which has been focused on surface water, has been transitioning to a long-term program that will address both surface water and groundwater. Irrigated lands may be a source of salt, nitrates, and pesticides going into groundwater.
- The SWRCB has adopted regulations for the operation of on-site wastewater treatment systems (Resolution No. 2012-0032). Water quality concerns associated with individual disposal systems include salt, nitrates, and pathogens. CVRWQCB plans to update its guidelines and establish a program based on the new regulations. In the past, CVRWQCB has prohibited discharge in problematic service areas. In the San Joaquin River Hydrologic Region, CVRWQCB has adopted 13 prohibitions of discharge from individual sewage disposal systems. Currently, all of these areas are served by community sewage systems.

Accomplishments

Recent Initiatives to Improve Water Quality

CVRWQCB recently adopted and implemented a basin plan control program that included TMDLs to address mercury in the Delta. CVRWQCB implemented previously adopted basin plan control programs to address salt and boron in the San Joaquin River at Vernalis, selenium in the San Joaquin River, diazinon and chlorpyrifos in the San Joaquin River and the Delta, and dissolved oxygen in the Stockton Deep Water Ship Channel. Improvements in water quality allowed for Clean Water Act 303(d) de-listings for selenium for the San Joaquin River from Merced River to the Delta. CVRWQCB approved the Groundwater Quality Protection Strategy and Workplan to establish a long-term strategy that will identify high priority activities (Central Valley Regional Water Quality Control Board 2010).

Through the Irrigated Lands Regulatory Program, dischargers have addressed pH, diazinon, and toxicity in Duck Slough; dieldrin in French Camp Slough; copper and lead in Grant Line Canal; dissolved oxygen and copper in the Mokelumne River; toxicity in Terminous Tract Drain; and diuron, oryzalin, electrical conductivity, and total dissolved solids (TDS) in the Modesto Irrigation District (Central Valley Regional Water Quality Control Board 2012a). Also, the Irrigated Lands Program has made the transition from an interim program that imposes requirements on discharges from irrigated lands to surface waters of the state to the long-term program that addresses discharges to both surface water and groundwater of the state, including increased enforcement for dischargers that create conditions of pollution or nuisance.

CVRWQCB has successfully implemented its general order for existing milk cow dairies, and over 95 percent of the dairies in the San Joaquin River Hydrologic Region are in compliance with the general order.

In addition, CVRWQCB has successfully made improvements to its land discharge program to increase groundwater monitoring and reduce the backlog of waste discharge requirements.

- Under the South County Water Supply Program, South San Joaquin Irrigation District (SSJID) in cooperation with local cities built a treatment plant at Woodward Reservoir, which was dedicated in 2005. Treated water from the Stanislaus River is delivered to Manteca, Tracy, and Lathrop. The water supply program is expanding under Phase 2, and treated water is anticipated for Escalon in 2012. SSJID intends to construct solar panels on 14 acres adjacent to the water treatment plant to provide power for the plant and other purposes.
- The Modesto Regional Water Treatment Plant was completed in 1994 and is operated by Modesto Irrigation District. Treated water from the Tuolumne River is delivered to the City of Modesto to supplement groundwater supplies. An expansion of the treatment plant is under way including storage and pipeline facilities for the City of Modesto.
- Turlock Irrigation District is proposing to build a surface water treatment plant. Its Regional Surface Water Supply Project would treat Tuolumne River water and deliver it in Stanislaus County to Ceres, Hughson, Keyes, South Modesto, and Turlock. The final environmental impact report is dated December 2006.
- The City of Stockton designed a project to treat Delta water for municipal supply. The Delta Water Supply Project takes surface water from the west side of Empire Tract and transports it approximately 6 miles eastward along Eight Mile Road to the new treatment plant. The project was completed in 2012. The Delta Water Supply Project Intake and Pump Station

Facility is funded in part by a $12.5 million Proposition 84 grant from DWR under the Safe Drinking Water, Water Quality and Supply, Flood Control, River, and Coastal Protection Bond Act of 2006.

- Yosemite Spring Park Utility Company's plan will make a number of improvements, which include replacing existing water meters with an automatic meter reading system to better record usages and identify water losses due to customer side leaks, replacing failing infrastructure to preserve the integrity and safety of the water supply and reduce the loss of water due to catastrophic failures in the distribution system, constructing a uranium removal system to recover well(s) lost due to detected uranium levels above the drinking water standard, and constructing a surface water treatment plant to provide alternate supply source for Yosemite Lakes Park.

Ecosystem Restoration

A host of other environmental water issues within the region require attention: water quality, water temperature, salinity, and dissolved oxygen sufficient for fish and habitat and other uses are of concern as is the availability of water to supply habitat areas. Environmental water issues and activities within the region include:

- Vernalis Adaptive Management Program.
- Central Valley Project Improvement Act.
- Anadromous Fish Restoration Program.
- Riparian Habitat Protection Program.
- Spawning Gravel Replenishment Program.
- Refuge Water Supply.
- Central Valley Joint Venture.
- San Joaquin River Restoration Program.

Vernalis Adaptive Management Program

The Vernalis Adaptive Management Program (VAMP) is a large-scale, long-term (12-year), experimental/management program initiated in 2000 that is designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Delta. VAMP is also a scientifically recognized experiment to determine how salmon survival rates change in response to alterations in San Joaquin River flows and SWP/CVP exports with the installation of the Head of Old River Barrier. For more information, see http://www.sjrg.org/default.html.

Central Valley Project Improvement Act

The CVPIA, passed by Congress in 1992, requires the Secretary of the Interior to implement a wide variety of CVP operation modifications and structural repairs in the Central Valley for the benefit of the wildlife and anadromous fish resources including the goal of a sustainable level of natural anadromous fish production of at least twice the levels from 1967 to 1991. This is in addition to the Anadromous Fish Restoration Program and Anadromous Fish Screening Program. Provisions within the CVPIA address operational improvements to support fisheries restoration through a combination of timed increases in flows, water banking, conservation, and transfers, and modified operations and new or improved control structures.

One of the primary effects of the CVPIA was the dedication of project yield for fish and wildlife purposes. The combined total amount of water dedicated to the environment by the CVPIA suggests an annual amount of up to 1.2 maf including reallocation of 800 taf — called (b)(2) water — and dedicated deliveries to wildlife refuges of about 250 taf — called Level 2 Refuge water. See Table SJR-14 above for CVP deliveries to refuges within the San Joaquin River region.

Central Valley Joint Venture

Formally organized in 1988, the Central Valley Joint Venture (CVJV) is one of the original six priority joint ventures formed under the North American Waterfowl Management Plan. Formerly named the Central Valley Joint Venture Implementation Plan, it focuses on reversing the decline of California wetlands and works collaboratively to protect, restore, and enhance wetlands and associated habitats for waterfowl, shorebirds, water birds, and riparian songbirds. See http://www.centralvalleyjointventure.org/.

San Joaquin River Restoration Program

The San Joaquin River Restoration Program (SJRRP) is a comprehensive long-term effort to restore flows to the San Joaquin River from Friant Dam to the confluence of Merced River, ensure irrigation supplies to Friant Water Users, and restore a self-sustaining fishery in the river. SJRPP is a direct result of a settlement of an 18-year lawsuit reached in September 2006 to provide sufficient fish habitat in the San Joaquin River below Friant Dam (near Fresno) by the U.S. Department of the Interior, the U.S. Department of Commerce, the Natural Resources Defense Council, and the Friant Water Users Authority. Federal legislation was reintroduced on January 4, 2007, to authorize federal agencies to implement the settlement. Interim flows began October 1, 2009, and full restoration flows were scheduled to begin no later than January 2014. Initially, salmon were to be reintroduced in the upper reaches no later than December 31, 2012, but the timeline for introducing salmon into the river was extended by about three years to 2016. In the summer of 2012, USBR estimated the cost of the program to be between $892 million and $2 billion. There is more information at the SJRRP Web site at http://www.restoresjr.net/.

Challenges

Flooding

Flood management challenges in the San Joaquin River Hydrologic Region include:

- Inadequate accurate and up-to-date FEMA maps.
- Inadequate agency alignment and inconsistent agency roles and responsibilities.
- Regulatory constraints that prevent maintenance of existing infrastructure.
- Undersized and outdated infrastructure.
- Inadequate assistance for developing and monitoring data including aerial images, mapping, river gauges.

The identified issues were based upon interviews with 25 agencies of varying levels of flood management responsibilities in each county of the hydrologic region. For a list of agencies with flood management responsibility in the San Joaquin River Hydrologic Region that participated in these meetings, see *California's Flood Future Report*. The information gathered from local agencies was used to help improve the process and better understand the local needs throughout the state.

- Recurrent flooding is a problem in many places in the San Joaquin River Hydrologic Region. Providing better protection for lives and property remains the definitive flood management challenge. Some particularly vulnerable locations in the region are at Lathrop; Manteca; Merced; Modesto; Stockton; and at Interstate 5 crossings of Panoche Creek, Orestimba Creek, and Del Puerto Creek. Existing facilities are inadequate on the west side of the San Joaquin River from Orestimba Creek to the Delta and on North Fork Jackson Creek in Jackson. Capacity of leveed waterways of the Lower San Joaquin Levee Project has been reduced by regional subsidence.
- Throughout the state, including this region, increased urbanization brings greater runoff due to increases of impervious areas, making retention of flood protection levels a challenging issue. Urbanization often causes increases in erosion and sedimentation. In this hydrologic region, the embankments of irrigation canals that carry floodwater through urban areas need to be strengthened.
- Completion of floodplain mapping, both the FEMA Flood Insurance Rate Maps and the State's complementary Awareness Floodplain Mapping will provide much needed information for evaluating flood risk. In the San Joaquin River Hydrologic Region, a current need is improvement of high-water coordination for the San Joaquin River and tributaries, including Kings River inflow, use of coordination agreements, forecast-coordinated operations, and reservoir reoperation.
- Local funding for flood maintenance and construction projects has become more difficult to find. This is due, in large part, to new environmental restrictions/conditions and, in the bigger picture, two particularly tough challenges in the region —overcoming the technical and environmental hurdles associated with increasing the capacity of the San Joaquin River from the Merced River into the Delta and removing *Arundo donax* and other invasive species that significantly restrict waterflows.
- Wildfires, which are predicted to become more frequent due to climate change, may denude steep erodible slopes in canyons and upland areas that are located above urban developments in the foothills and mountainous areas of the region. Ensuing winter rains, which are also predicted to replace snow storms, may threaten these areas not only with high water, but also with debris flows.

Funding

- Securing resources to complete local projects where funding and economic conditions are only sufficient to meet a small percentage of those projects.

Licensing and Infrastructure

- Federal Energy Regulatory Commission (FERC) relicensing of New Exchequer Dam on the Merced River and New Don Pedro Dam on the Tuolumne River.
- Finding resources to construct, repair, and maintain infrastructure.

Water Quality

A major challenge will be the development of the CV-SALTS basin plan amendments within the time frame set by the State Recycled Water Policy. Without action to improve salts management for the Central Valley, the economic vitality of the region is threatened. A 2009 University of California, Davis study found that salts and nitrates are already costing Central Valley residents $544 million annually for treatment and lost production (Howitt et al. 2009). Freshwater supplies will be used more often to dilute salts, reducing supplies for people and the environment, especially during droughts (Central Valley Salinity Alternatives for Long-Term Sustainability 2012a).

In the next five years, CVRWQCB expects to adopt TMDLs and control programs for chlorpyrifos, diazinon, and pyrethroid pesticides that will cover most valley floor waters. These TMDLs will address 100 current impairments and provide the framework for addressing future listings. In addition, CVRWQCB is taking the lead in coordinating a multi-region/SWRCB effort to develop a statewide mercury TMDL control program for reservoirs.

The dairy industry in the Central Valley has been affected by economic factors such as the variability in milk and feed prices. The cost of complying with the General Order for Existing Milk Cow Dairies can be a disproportionate burden on smaller, less economically competitive dairies. In response, CVRWQCB amended the General Order in April 2009 to allow an additional year for dairies to submit certain elements of the waste management plan. CVRWQCB also approved the Central Valley Dairy Representative Monitoring Program as an alternative to installing individual groundwater monitoring systems at each dairy facility (Central Valley Regional Water Quality Control Board 2011e).

As the irrigated lands program transitions to addressing groundwater quality, the most significant issues that will be addressed will include establishing the groundwater quality monitoring networks necessary to identify problem areas, assess trends, and evaluate effectiveness of practices (Central Valley Regional Water Quality Control Board 2011e).

There are thousands of abandoned mines in California, and a significant portion is in the Central Valley. Remediation of abandoned mines is very costly, and determining responsible parties is difficult. State agencies have insufficient staff resources to identify responsible parties. Although any past or present owner of the site is a responsible party, some of the owners may never have mined the site; or the owners are not financially viable and are not able to conduct investigations and cleanup activities. Mine waste may even be located on land that was not part of the mined property because in the past mine waste was commonly discharged wherever it was convenient.

Due to the serious threat of both public safety and environmental hazards posed by abandoned mines, many volunteers are interested in helping restore watersheds impaired by abandoned mines. However, the threat of liability pursuant to the CWA or the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) discourages such third party cleanups. A volunteer conducting a partial cleanup could become liable for the entire cleanup or could be obligated to obtain a discharge permit, which requires compliance with strict water quality standards in streams that are already in violation of these standards. Liability may occur even though the volunteer did not cause the pollution (U.S. Environmental Protection Agency 2012b).

Timber harvest activities may pose a threat to water quality due to the discharge of sediment, herbicides, petroleum products, and increases in surface water temperatures. Currently, several legislative measures and EPA policy decisions are being considered that have the potential to add a substantial workload to the program. Pre-project and active operations field inspections by water quality regulatory staff allows for proactively locating sediment sources so that appropriate management measures may be taken to reduce or eliminate those threats though the life of the project. However, funding for State agency oversight has steadily decreased in recent years, and further reductions are anticipated that will make implementation of this program challenging (Central Valley Regional Water Quality Control Board 2011e).

OHV use is a popular form of recreation in California. State and federal agencies provide recreational areas for this purpose. These OHV recreation areas need to implement a range of stormwater best management practices to protect water quality. Additionally, unauthorized and unmanaged OHV areas can become erosion problems and discharge polluted stormwater. With limited resources, maintaining and policing these areas can be a challenge.

A major challenge is the ability of small communities to address water quality issues. Small communities with wastewater treatment plants face increasingly stringent wastewater requirements and have difficulty meeting these requirements due to the cost of compliance. The Central Valley has approximately 600,000 individual on-site disposal systems within its boundaries, which collectively discharge approximately 120 million gallons per day to the subsurface. Water quality impacts can occur if these systems are not properly sited or properly maintained. It can be difficult for owners of these systems to fund repairs if these systems fail.

Other water quality issues include:

- Coordinating upper watershed programs to maintain water quality and ecosystems, minimize harmful sedimentation and flooding, and equitably maintain the beneficial use of water.
- Maintaining or improving water quality, water temperature, and dissolved oxygen conditions sufficient for environmental needs.
- Combating saline water intrusion into confined aquifers and the movement of saline groundwater fronts encroaching into usable groundwater.
- Maintaining groundwater quality sufficient to meet rural domestic use.

Drought and Flood Planning

The San Joaquin Valley has traditionally used a combination of surface water and groundwater. The San Joaquin River region has significant surface water resources due to Sierra snowpack and reservoir storage on major eastside rivers. Imported surface water supplies may suffer the highest degree of variability. In years where surface water supplies are significantly reduced, additional groundwater is often used to fill the gap between needs and available surface water.

DWR's *Bulletin 118-80, Ground Water Basins in California* (California Department of Water Resources 1980), identifies eastern San Joaquin County, Chowchilla, and Madera subbasins as being in a critical condition of overdraft. In these subbasins and others, part of the drought preparedness philosophy is to maintain as much groundwater storage as possible. This can be achieved by intentional recharge, water banking, in-lieu recharge, water transfers, shifts to available surface water, etc. See discussions in Volume 3, *Resource Management Strategies*.

FloodSAFE

California is a DWR strategic initiative that seeks a sustainable integrated flood management and emergency response system throughout California that improves public safety, protects and enhances environmental and cultural resources, and supports economic growth by reducing the probability of destructive floods, promoting beneficial floodplain processes, and lowering the damages caused by flooding. FloodSAFE is guiding the development of regional flood management plans, which will encourage regional cooperation in identifying and addressing flood hazards. Regional flood plans will include flood hazard identification, risk analyses, review of existing measures, and identification of potential projects and funding strategies. The plans will emphasize multiple objectives, system resiliency, and compatibility with State goals and IRWM plans.

FloodSAFE is responsible for the CVFPP. Its purpose is to improve integrated flood management in the Sacramento and San Joaquin valleys. The program study area includes the watersheds of the Sacramento and San Joaquin rivers. The program is charged with the development of three documents: (1) the SPFC, describing the flood management facilities, land, programs, conditions, and modes of operation and maintenance for the State-federal flood protection system in the Central Valley, published in the spring of 2010, (2) the Flood Control System Status Report, which assesses the status of facilities in the SPFC, identifying deficiencies, and making recommendations for improvement, was completed in December 2011, and (3) the CVFPP, approved by the Central Valley Flood Protection Board on June 29, 2012, describing a sustainable, integrated flood management plan that reflects a systemwide approach for protecting areas of the Central Valley currently receiving protection from flooding by the existing facilities of the SPFC. Updates of the CVFPP are required every five years.

Drought Contingency Plans

CWC Sections 10601 et seq. require urban suppliers to prepare and update urban water management plans every five years and serve as a drought preparedness planning tool for the state's larger water systems. As part of urban water management plan preparation, urban water suppliers must provide a water shortage contingency analysis that addresses how they would respond to supply reductions of up to 50 percent, and must estimate supplies available to their systems in a single dry year and in multiple dry years. Implementing enhanced water conservation programs and calling for customers to achieve either voluntary or mandatory water use reduction targets are common urban agency drought response actions. For example, during the recent 2007-2009 drought, the City of Stockton urged voluntary conservation, instituted rate increases (surcharges), and restricted outdoor water use (California Department of Water Resources 2010a).

In 2002 the City of Modesto implemented Stage I of its Water Shortage Contingency Plan, which called for a 10 to 20 percent reduction in water use. The city has remained in Stage I since then. Some of the requested/mandated consumer actions include prohibiting outdoor watering from noon to 7 p.m., repairing identified water leaks within 24 hours, and encouraging restaurants to only serve water upon customer request.

Looking to the Future

Already being implemented is the Friant Water Users Authority (FWUA)/Natural Resources Defense Council agreement to restore the San Joaquin River, the region's namesake. The agreement was reached in 2006, and on March 30, 2009, President Obama signed Public Law 111-11, the Omnibus Public Land Management Act of 2009 that contains the San Joaquin River Restoration Settlement Act. The act authorizes implementation of the San Joaquin River Restoration Program. Water deliveries to FWUA members could be reduced by about 15 percent on average, but the program has provisions for recapture of a portion of the water used for restoration. Interim flows began October 1, 2009; and full restoration flows are scheduled to begin no later than January 2014. Although salmon were to be reintroduced in the upper reaches no later than December 31, 2012, the timeline for introducing salmon was extended to 2016.

Many farmers in the San Joaquin River depend on the Delta for delivery of surface water supplies. In 2009, the governor and Legislature approved a comprehensive water package that included a Delta Governance/Delta Plan. It establishes the framework to achieve the coequal goals of providing a more reliable water supply to California and restoring and enhancing the Delta ecosystem. The coequal goals are to be achieved in a manner that protects the unique cultural, recreational, natural resource, and agricultural values of the Delta. On May 16, 2013, the Delta Stewardship Council unanimously adopted the Delta Plan, a long-term management plan for the Delta. The plan and its 14 regulatory policies became effective with legally-enforceable regulations on September 1, 2013.

The following list represents a DFW perspective of priority areas and needs specific to the San Joaquin River Hydrologic Region in relation to California water supply.

- Protection or restoration of fish habitat through the improvement of fish passage conditions, gravel augmentation, hydrology, fish screens, minimum/maximum flow, etc.
- Restoration of floodplain process, including hydrodynamic process, to benefit listed species.
- Restoration projects that facilitate the improvement of nesting and foraging habitat for listed and migratory bird species.
- Increased food web productivity.
- Development, collection, and publication of instream flow data, including recommended instream flow levels and minimum instream flow requirements.
- Restoration of perennial grasslands.
- Reduce predation loss of juvenile fish, including fish entrapment.
- Restoration projects that facilitate the increase of populations and improvement of habitat for salmon, especially coho.
- Restoration or modification to allow for a more natural regime of hydrology and hydraulics.
- Restoration of riparian habitat, including conservation of riparian corridors.
- Restoration projects that facilitate the improvement of aquatic habitat, including deep and shallow open water.
- Restoration of saline emergent wetlands and tidal marshes.
- Restoration of tributary creeks and streams.
- Improvements in coordination, management and implementation of watersheds.

- Water quality improvements (sediment, oxygen saturation, pollution, temperature, etc.) to support healthy ecosystems.
- Restoration projects that improve upon existing wetlands, or create new wetlands in appropriate areas.
- Restoration, preservation, and protection of wildlife corridors.

Future Conditions

Future Scenarios

For Update 2013, the California Water Plan (CWP) evaluates different ways of managing water depending on alternative future conditions and different regions of the state. The ultimate goal is to evaluate how different regional response packages, or combinations of resource management strategies from Volume 3, perform under alternative possible future conditions. The alternative future conditions are described as future scenarios. Together the response packages and future scenarios show what management options could provide for sustainability of resources and ways to manage uncertainty and risk at a regional level. The future scenarios are composed of factors related to future population growth and factors related to future climate change. Growth factors for the San Joaquin River Hydrologic Region are described below. Climate change factors are described in general terms in Volume 1, Chapter 5, "Managing an Uncertain Future."

Water Conservation

Update 2013 scenario narratives include two types of water use conservation. The first is conservation that occurs without policy intervention (called background conservation). This includes upgrades in plumbing codes and end user actions such as purchases of new appliances and shifts to more water efficient landscape absent a specific government incentive. The second type of conservation expressed in the scenarios is through efficiency measures under continued implementation of existing best management practices in the California Urban Water Conservation Council's Memorandum of Understanding Regarding Urban Water Conservation in California (last amended in 2011).These are specific measures that have been agreed upon by urban water users and are being implemented over time. Any other water conservation measures that require additional action on the part of water management agencies are not included in the scenarios, and would be represented as a water management response.

Growth Scenarios

Future water demand in the San Joaquin River Hydrologic Region is affected by a number of growth and land use factors, including population growth, planting decisions by farmers, and size and type of urban landscapes. Table SJR-27 has a conceptual description of the growth scenarios used in Update 2013. The CWP quantifies several factors that provide a description of future growth and how growth could affect water demand for the urban, agricultural, and environmental sectors in the San Joaquin River region. Growth factors are varied among the scenarios to describe some of the uncertainty faced by water managers. For example, it is impossible to predict future population growth accurately, so the CWP uses three different but plausible population growth estimates when determining future urban water demands. In addition, the CWP considers up to three different alternative views of future development density. Population

Table SJR-27 Conceptual Growth Scenarios

Scenario	Population Growth	Development Density
LOP-HID	Lower than Current Trends	Higher than Current Trends
LOP-CTD	Lower than Current Trends	Current Trends
LOP-LOD	Lower than Current Trends	Lower than Current Trends
CTP-HID	Current Trends	Higher than Current Trends
CTP-CTD	Current Trends	Current Trends
CTP-LOD	Current Trends	Lower than Current Trends
HIP-HID	Higher than Current Trends	Higher than Current Trends
HIP-CTD	Higher than Current Trends	Current Trends
HIP-LOD	Higher than Current Trends	Lower than Current Trends

growth and development density will reflect how large the urban landscape will become in 2050 and are used by the CWP to quantify encroachment into agricultural lands by 2050 in the San Joaquin River Hydrologic Region.

For Update 2013, DWR worked with researchers at the University of California, Davis, to quantify how much growth might occur in the San Joaquin River Hydrologic Region through 2050. The UPlan model was used to estimate an urban footprint in 2050 under the scenarios of alternative population growth and development density (see http://ice.ucdavis.edu/project/uplan for information on the UPlan model). UPlan is a simple rule-based urban growth model intended for regional or county-level modeling. The needed space for each land use type is calculated from simple demographics and is assigned based on the net attractiveness of locations to that land use (based on user input), locations unsuitable for any development, and a general plan that determines where specific types of development are permitted. Table SJR-28 describes the amount of land devoted to urban use for 2006 and 2050, and the change in the urban footprint under each scenario. As shown in the table, the urban footprint grew by about 160,000 acres under low-population growth scenario (LOP) by 2050 relative to 2006 base-year footprint of about 410,000 acres. The urban footprint under the high population scenario (HIP), however, grew by about 380,000 acres. The effect of varying housing density on the urban footprint is also shown.

Table SJR-29 describes how future urban growth could affect the land devoted to agriculture in 2050. Irrigated land area is the total agricultural footprint. Irrigated crop area is the cumulative area of agriculture, including multiple crop area, where more than one crop is planted and harvested each year. Each of the growth scenarios shows a decline in irrigated acreage over existing conditions, but to varying degrees. As shown in the table, irrigated crop acreage declines, on average, by about 130,000 acres by year 2050 as a result of low population growth and urbanization in the San Joaquin River region, while the decline under high population growth was higher by about 240,000 acres.

Table SJR-28 Growth Scenarios (Urban) — San Joaquin River Hydrologic Region

Scenario[a]	2050 Population (thousand)	Population Change (thousand) 2006[b] to 2050	Development Density	2050 Urban Footprint (thousand acres)	Urban Footprint Increase (thousand acres) 2006[c] to 2050
LOP-HID	3,396.9[d]	1,367.4	High	550.1	141.2
LOP-CTD	3,396.9	1,367.4	Current trends	570.7	161.8
LOP-LOD	3,396.9	1,367.4	Low	591.4	182.5
CTP-HID	3,685.0[e]	1,655.5	High	626.8	217.9
CTP-CTD	3,685.0	1,655.5	Current trends	653.8	244.9
CTP-LOD	3,685.0	1,655.5	Low	681.0	272.1
HIP-HID	4,941.1[d]	2,911.6	High	736.3	327.4
HIP-CTD	4,941.1	2,911.6	Current trends	788.6	379.7
HIP-LOD	4,941.1	2,911.6	Low	841.6	432.7

Notes:

[a] See Table SJR-27 for scenario definitions.

[b] 2006 population was 2,029.5 thousand.

[c] 2006 urban footprint was 408.9 thousand acres.

[d] Values modified by the California Department of Water Resources (DWR) from the Public Policy Institute of California.

[e] Values provided by the California Department of Finance.

San Joaquin River - 2050 Water Demands

In this section a description is provided for how future water demands may change under scenarios organized around themes of growth and climate change described above. The change in water demand from 2006 to 2050 is estimated for the San Joaquin River Hydrologic Region for the agriculture and urban sectors under 9 growth scenarios and 13 scenarios of future climate change. The climate change scenarios included the 12 scenarios identified by the Governor's Climate Action Team, (described in Volume 1, Chapter 5, "Managing an Uncertain Future") and a 13th scenario representing a repeat of the historical climate (1962-2006) to evaluate a "without climate change" condition.

Figure SJR-36 shows the change in water demands for the urban and agricultural sectors under 9 growth scenarios, with variation shown across 13 climate scenarios. The nine growth scenarios include three alternative population growth projections and three alternative urban land development densities, as shown in Table SJR-27. The change in water demand is the difference between the historical average for 1998 to 2005 and future average for 2043 to 2050. Urban demand is the sum of indoor and outdoor water demand where indoor demand is assumed not to be affected by climate. Outdoor demand, however, depends on such climate factors as the amount of precipitation and the average air temperature.

Table SJR-29 Growth Scenarios (Agriculture) — San Joaquin River Hydrologic Region

Scenario[a]	2050 Irrigated Land Area[b] (thousand acres)	2050 Irrigated Crop Area[c] (thousand acres)	2050 Multiple Crop Area[d] (thousand acres)	Change in Irrigated Crop Area (thousand acres) 2006 to 2050
LOP-HID	1,831.9	1,951.4	119.4	-117.0
LOP-CTD	1,819.0	1,937.6	118.6	-130.8
LOP-LOD	1,806.7	1,924.5	117.8	-143.9
CTP-HID	1,791.5	1,908.3	116.8	-160.1
CTP-CTD	1,776.8	1,892.6	115.8	-175.8
CTP-LOD	1,762.6	1,877.5	114.9	-190.9
HIP-HID	1,740.3	1,853.8	113.5	-214.6
HIP-CTD	1,714.0	1,825.7	111.7	-242.7
HIP-LOD	1,686.5	1,796.5	110.0	-271.9

Notes:

[a] See Table SJR-27 for scenario definitions.

[b] 2006 Irrigated land area was estimated by the California Department of Water Resources (DWR) to be 1,943.3 thousand acres.

[c] 2006 irrigated crop area was estimated by DWR to be 2,068.4 thousand acres.

[d] 2006 multiple crop area was estimated by DWR to be 125.1 thousand acres.

Urban demand increased under all 9 growth scenarios tracking with population growth. On average, it increased by about 400 taf under the three low population scenarios, 500 taf under the three current trend population scenarios, and about 800 taf under the three high population scenarios when compared to historical average of about 590 taf. The results show change in future urban water demands are less sensitive to housing density assumptions or climate change than to assumptions about future population growth.

Agricultural water demand decreases under all future scenarios due to reduction in irrigated lands as a result of urbanization and background water conservation when compared with historical average water demand of about 6,350 taf. Under the three low population scenarios, the average reduction in water demand was about 570 taf, while it was about 910 taf for the three high population scenarios. For the three current trend population scenarios, this change was about 710 taf. The results show that low density housing would result in more reduction in agricultural demand because more lands are lost under low-density housing than with high-density housing.

Evaluation of Water Management Vulnerabilities

The Water Plan is evaluating how implementing alternative mixes of resource management strategies could reduce the Central Valley vulnerabilities. Management response packages are each comprised of a mix of resource management strategies selected from Volume 3 and

Figure SJR-36 Change in San Joaquin River Agricultural and Urban Demands for 117 Scenarios from 2006-2050

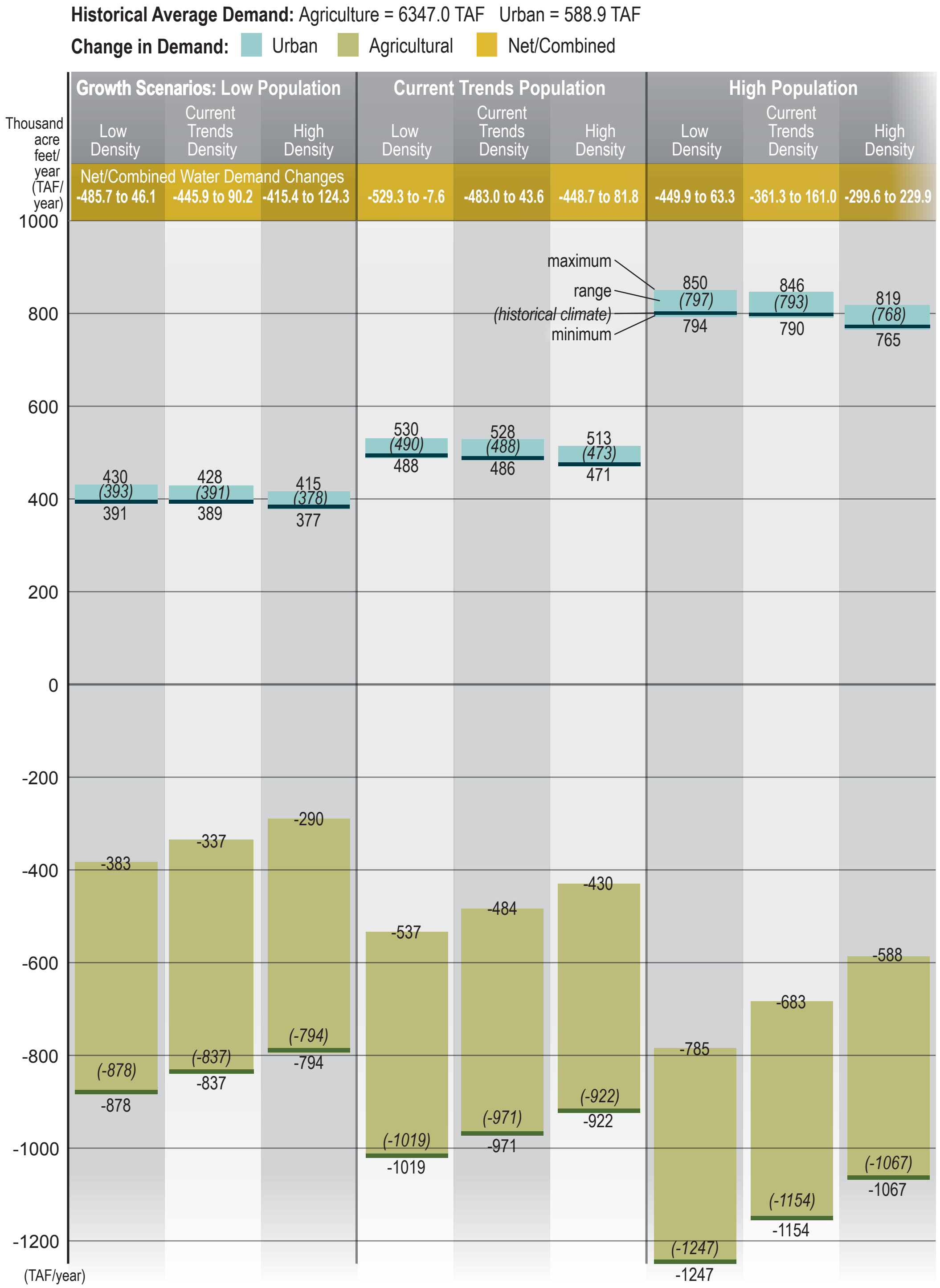
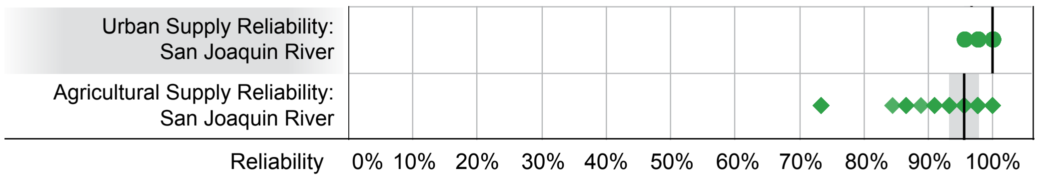


Figure SJR-37 Range of Urban and Agricultural Reliability Results across Futures for the San Joaquin River Hydrologic Region



implemented at investment levels and locations, as described in the Plan of Study (see Volume 4, *Reference Guide*, the article "Evaluating Response Packages for the *California Water Plan Update 2013* Plan of Study").

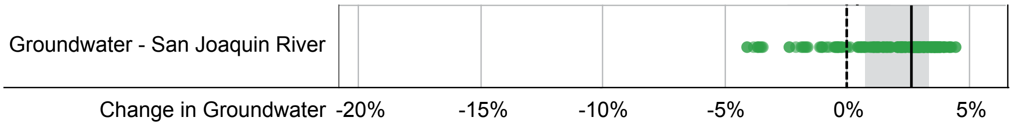
Results are presented here for the San Joaquin River region evaluated over 198 combinations of future population growth and climate scenarios. The growth scenarios are defined in Table SJR-27. Future climate conditions were evaluated over 22 alternative climate scenarios including 5 derived from historical temperature as precipitation estimates, 5 from historical conditions with an added temperature trend, and 12 downscaled global climate model estimates described in Volume 1, Chapter 5, "Managing an Uncertain Future." For each scenario, an assessment of water supply, demand, and unmet demand in the urban and agricultural sectors was performed. The model also reported on changes in groundwater and how frequently instream flow requirements were met.

Reliability, defined as the percentage of years in which demand is sufficiently met by supply for the urban and agricultural sector and the percentage of months in which flows meet objectives for the environmental sector, is one of several different ways the Water Plan summarizes the projections of future urban and agricultural conditions. For the San Joaquin River region, urban reliability is defined as the percentage of years for a given simulation in which 98 percent of urban demand is met with supply. Agricultural reliability is defined as the percentage of years in which 85 percent of agricultural demand is met with supply. Figure SJR-37 shows the range of reliability results for both sectors in the San Joaquin River Hydrologic Region. In the figure, each dot indicates the reliability for one of the 198 simulations, but many of the dots overlap. The vertical lines indicate the half-way point of each distribution, and the shaded areas indicate the results that fall within the middle half of the distribution (between the 25th and 75th percentiles). The figure clearly shows that reliability in the urban sector is high — all futures lead to reliabilities of greater than 95 percent. For the agricultural sector, however, reliability is below 95 percent in about half of the futures evaluated.

Groundwater resources and environmental flows were evaluated for performance under the plausible futures. Figure SJR-38 shows the change in groundwater storage from the present to 2050 across the 198 scenarios. About 81 percent of futures show slight increases in groundwater. Declines of up to about 5 percent are seen in the other 19 percent of futures.

Figure SJR-39 shows the reliability across the 45-year simulation period for the required instream flows and targets included in the response packages for the San Joaquin River region across the 198 futures. Monthly reliability for all instream flow requirement are high (greater than 95 percent). The monthly reliability for the environmental flow target on the Stanislaus at Goodwin, however, is below 50 percent for almost all futures.

Figure SJR-38 Range of Groundwater Storage Changes Across Futures for the San Joaquin River Region



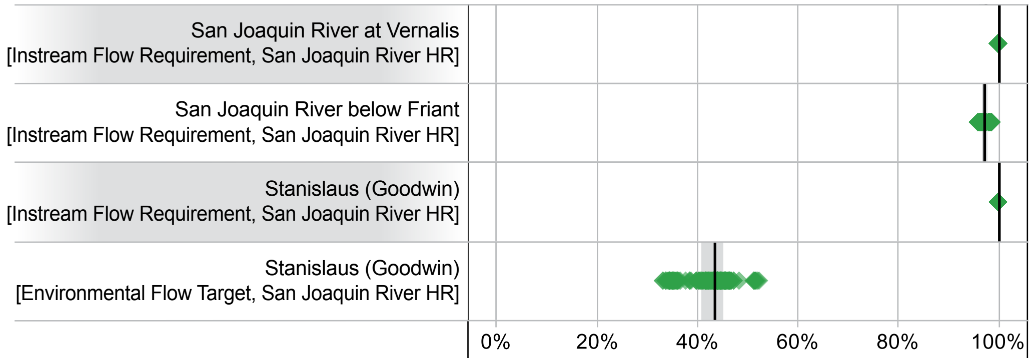
The Water Plan next evaluated which future conditions would lead to low reliability in the San Joaquin River Hydrologic Region. For the urban sector, reliability would exceed 95 percent in all of the futures evaluated. In the agricultural sector, however, 68 of the 198 futures (34 percent) would lead to low reliability. Using statistical analysis, the Water Plan identified that the most important factors driving low agricultural reliability outcomes is change in future precipitation and temperature. Futures in which the average precipitation in 2030-2050 is less than 4.8 percent of historical and average annual temperature from 2030-2050 is higher than 62.9 °F account for all the low reliability outcomes. Additionally, 84 percent of these futures would lead to low agricultural reliability. Figure SJR-40 shows these results graphed against the temperature trend (vertical axis) and change from historical precipitation levels (horizontal axis) of each simulation. In this graph, Xs are those results that are less than 95 percent reliable and green Os are those that are more than 95 percent reliable. The color of the Xs indicates the reliability.

Figure SJR-41 summarizes results for each diversification level for the key metrics for the San Joaquin River Hydrologic Region. The number and color within each square indicates the percentage of futures that do not meet the specified vulnerability thresholds — 95 percent annual reliability for urban and agricultural supply reliability, no groundwater change, and 95 percent monthly reliability for instream flow requirements and environmental flow targets. Therefore, cases in which there are few vulnerable futures are highlighted in green, and cases in which there are many vulnerable futures are highlighted in red. Note that the analysis of response packages evaluated 88 futures — 22 climate scenarios times 4 growth scenarios (CTD-CTD, HIP-LOD, LOP-HID, CTP-HID). See Table SJR-27 "Conceptual Growth Scenarios."

For the San Joaquin River region, urban supply reliability is high for all futures across all diversification levels. The management strategies included in the first two diversification levels — efficiency, conjunctive use, and recycling — lead to marked improvements in the percentage of futures in which agricultural supply is reliable and groundwater storage does not decline. The addition of environmental flow and groundwater recovery targets in Diversification Level 3 leads to a bit more improvement in groundwater storage and leads to high reliability for the Stanislaus (Goodwin) environmental flow targets (EFTs) for all futures. These improvements in groundwater and environmental flows come at the expense of agricultural supply reliability and, to a lesser extent, urban supply reliability. The additional conservation and conjunctive use in Diversification Levels 4 and 5 partially mitigate these effects. Implementation costs increase with the significant conservation and recycling implemented in Diversification Levels 2 and higher. Note that the cost of adding environmental flow requirements and groundwater reduction targets in Diversification Level 3 are not accounted for in the figure.

The implementation of response packages will influence the climatic conditions under which the Central Valley management system is resilient. Figure SJR-42 illustrates this effect by showing the vulnerability results in terms of temperature and precipitation for San Joaquin River

Figure SJR-39 Range of Instream Flow Reliability for the San Joaquin River Hydrologic Region across Scenarios



agricultural reliability, across several response packages for 88 futures. The coloring highlights those results in which reliability is high.

Figure SJR-42 shows how the implementation of the strategies in Diversification Level 2 increases the range of climate conditions in which San Joaquin River agricultural sector reliability is high. In the figure, each circle represents the climate conditions and reliability outcomes for one future — combination of one of the 22 climate scenarios and one of 4 growth scenarios. The green circles represent high reliability results, and the gray circles represent low reliability results. Resilience to climate condition extends to all but the warmest and driest two climate projections. Implementation of Diversification Level 3, however, reduces the range of climate conditions to which the sector is resilient. The additional strategies in Diversification Level 5 again increase resilience to more extreme climatic changes.

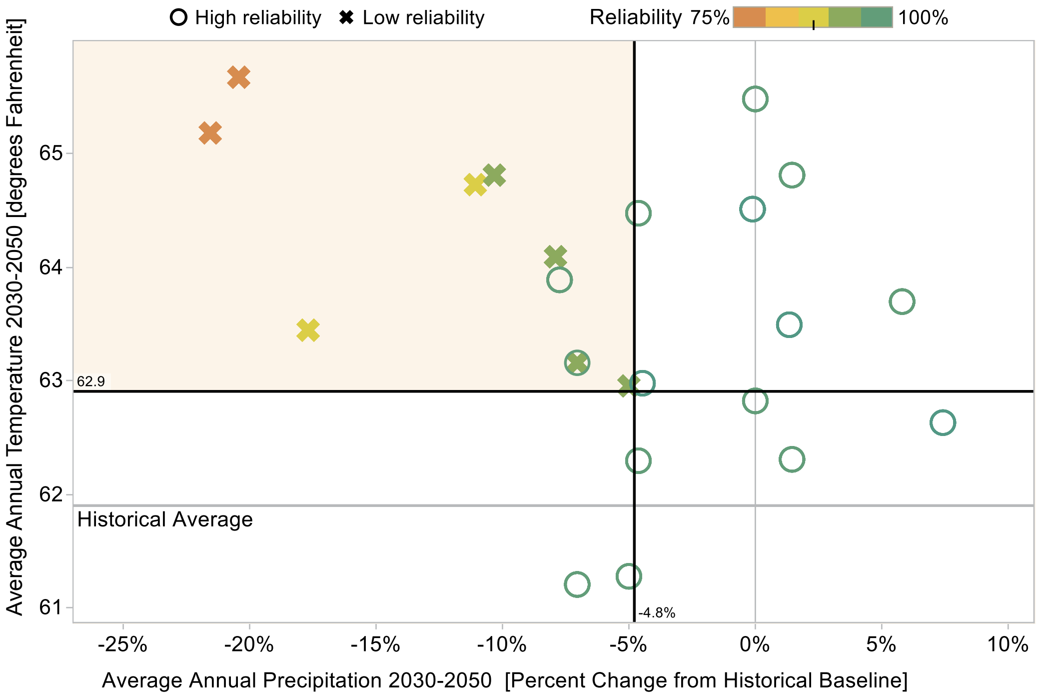
Note: Each circle represents results for a single future — combination of growth and climate scenario. Concentric circles correspond to the four different growth scenarios ordered from smallest to largest as follows: LOP-HID, CTP-HID, CTP-CTD, and HIP-LOD. Green circles indicate reliability greater than or equal to 95 percent.

In summary, the San Joaquin River region is projected to be highly resilient to climate and demographic changes in the urban sector but less so in the agricultural sector. Groundwater storage is projected to change only modestly across the uncertain futures. Instream flows on the Merced River will maintain high reliability for most futures but be unreliable under all projections for the San Joaquin River. Supply in the agricultural sector will not reliably meet demand if future conditions are about one degree warmer than historical and more than 5 percent drier than historical. Implementation of response packages increases groundwater levels, ensures high reliability for an additional environmental flow target, but also reduces reliability in the agricultural sector for some futures.

Integrated Regional Water Management Plan Summaries

Inclusion of the information contained in IRWM plans into Update 2013 regional reports has been a common suggestion by regional stakeholders at the regional outreach meetings since the inception of the IRWM program. To this end, the CWP has taken on the task of summarizing

Figure SJR-40 Climate Conditions Leading to Low Agricultural Supply Reliability Results in the San Joaquin River Hydrologic Region



readily available IRWM plans in a consistent format for each of the regional reports. (This collection of information will not be used to determine IRWM grant eligibility.)

All IRWM plans are different in how they are organized. Therefore, finding and summarizing the content in a consistent way proved difficult. It became clear through these efforts that a process is needed to allow those with the most knowledge of the IRWM plans, those that were involved in the preparation, to have input on the summary. It is the intention that this process be initiated following release of Update 2013 and continue to be part of the process for Update 2018. This process will also allow for continuous updating of the content of the "atlas" (explained below) as new IRWM plans are released or existing IRWM plans are updated.

In addition to these summaries, all summary sheets will be provided in one IRWM Plan Summary "Atlas" as an article included in Volume 4, *Reference Guide*. This atlas will, under one cover, provide an "at-a-glance" understanding of each IRWM region and highlight each region's key water management accomplishments and challenges. The atlas will showcase how the dedicated efforts of individual RWMGs have individually and cumulatively transformed water management in California.

As can be seen in Figure SJR-35 above, there are 12 regional water management planning groups in the San Joaquin River Hydrologic Region.

Figure SJR-41 Percent of Vulnerable Futures for Each Response Package for the San Joaquin River Hydrologic Region

	Urban Supply Reliability	Agricultural Supply Reliability	Groundwater Change	San Joaquin River at Vernalis [IFR]	San Joaquin River below Friant [IFR]	Stanislaus (Goodwin) [IFR]	Stanislaus (Goodwin) [EFT]	Average Annual Cost Above Current Plan
Currently Planned	0%	36%	19%	0%	0%	0%	100%	$0.0M
Diversification Level 1	0%	14%	11%	0%	0%	0%	100%	$103.3M
Diversification Level 2	0%	9%	9%	0%	0%	0%	100%	$146.8M
Diversification Level 3	5%	34%	6%	0%	0%	0%	0%	$147.0M
Diversification Level 4	5%	27%	6%	0%	0%	0%	0%	$227.7M
Diversification Level 5	5%	14%	1%	0%	0%	0%	0%	$396.6M

[IFR] = instream flow requirement [EFT] = environmental flow target

Region Description

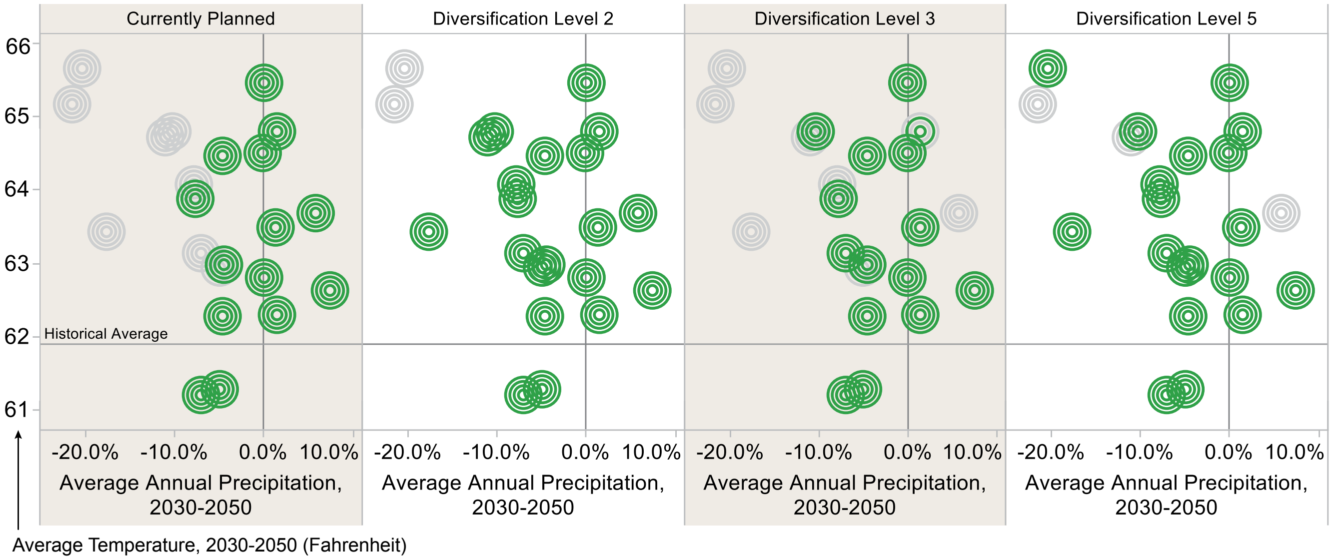
As of late 2013, the RWMGs in the San Joaquin River Hydrologic Region have received a total of about $436.5 million in funding from both State and non-State sources: $127,978,327 from the State and $308,571,016 from non-State sources. Table SJR-30 provides a funding source breakdown for the region. (Note: Grant figures represent money awarded to specific regional water management groups and do not represent the total amount of money spent on each hydrologic region, as some regional water management groups straddle two or more hydrologic regions.) Information for Yosemite-Mariposa and Southern Sierra regions was not available for Update 2013.

The following are short descriptions of each of the IRWM areas and plans in the San Joaquin River Hydrologic Region.

American River Basin

The American River basin IRWM region encompasses most of Sacramento County and portions of western Placer and El Dorado counties. Most of the American River basin IRWM region is within the lower American River and lower Sacramento River watersheds, with a portion of the southern American River basin IRWM region in the lower Cosumnes River watershed. There is a minor overlap between the American River basin IRWM region and the Cosumnes, American, Bear, and Yuba (CABY) region.

Figure SJR-42 Climate Trends for Each Future for Currently Planned Management and Three Additional Response Packages for San Joaquin Agricultural Reliability



Note: Each circle represents results for a single future — combination of growth and climate scenario. Concentric circles correspond to the four different growth scenarios ordered from smallest to largest as follows: LOP-HID, CTP-HID, CTP-CTD, and HIP-LOD. Green circles indicate reliability greater than or equal to 95 percent.

Cosumnes American Bear Yuba

The CABY region consists of four watersheds (Cosumnes, American, Bear, and Yuba) and 12 sub-watersheds situated within the north central Sierra Nevada region. All or portions of nine counties are within the CABY region, including El Dorado, Placer, Nevada, Yuba, Sierra, Plumas, Alpine, and Amador counties. The region extends from the northern parts of the Yuba River watershed to the southern part of the Cosumnes River watershed. The region includes headwaters that drain large volumes of water into the Sacramento and Mokelumne rivers, ultimately serving the Sacramento Delta system.

East Contra Costa County

The East Contra Costa County (ECCC) IRWM region is bounded by the ridge lines of Mount Diablo to the south and west and by the banks of the Delta water system to the north and east. The four cities within the region are Antioch, Brentwood, Oakley, and Pittsburg. Unincorporated communities include Bay Point, Bethel Island, Byron, Discovery Bay, and Knightsen. The entire region drains to the Delta, occurring primarily through the Marsh Creek, Kirker Creek, and Kellogg Creek watersheds.

Eastern San Joaquin

The Eastern San Joaquin IRWM region is located in the central portion of the Central Valley geomorphic province, which is bordered by the Sierra Nevada to the east and the Central Coast Ranges to the west. The region is located in the eastern portion of the San Joaquin River Hydrologic Region. Major rivers within this portion of the unit are the San Joaquin, Mokelumne,

Table SJR-30 San Joaquin River IRWM Plan Funding

IRWM Region	Prop. 50 Planning Grant	Prop. 50 Implementation Grant	Prop. 84 Planning Grant	Prop. 84 Implementation Grant[a]	Prop. 1E Stormwater Grant	Regional Totals[b]
American River basin	**$500,000** $919,224	**$25,000,000** $125,800,161	**$403,848** $134,616	**$16,030,766** $37,622,702	**$9,096,834** $9,785,891	$225,294,042
Consumes, American, Bear, Yuba	**$999,640** $515,742		**$647,593** $300,342	**$3,197,503** $183,524	**$770,000** $2,011,400	$8,625,744
East Contra Costa County		**$12,500,000** $61,472,034	**$901,661** $1,191,384	**$1,775,000** $1,495,000	**$14,997,300** $25,076,300	$119,408,679
Eastern San Joaquin	**$498,468** $390,663		**$545,925** $182,875			$1,617,931
Madera	**$500,000** $225,000		**$271,438** $98,636	**$9,413,947** $4,286,817		$14,795,838
Merced			**$719,010** $366,503			$1,085,513
Mokelumne/ Amador/ Calaveras	**$145,500** $48,500		**$1,129,514** $477,256	**$2,298,000** $771,634		$4,870,404
Tuolumne – Stanislaus			**$636,380** $397,812			$1,034,192
Westside – San Joaquin		**$25,000,000** $34,817,000				$59,817,000
Total	**$2,643,608** $2,099,129	**$62,500,000** $222,089,195	**$5,255,369** $3,149,424	**$32,715,216** $44,359,677	**$24,864,134** $36,873,591	
			Grand Total $436,549,343			

Notes:

This table is up-to-date as of late 2013. Information on the East Stanislaus, Southern Sierra and Yosemite-Mariposa IRWM plans was not available for Update 2013.

Grant figures in **bold** are State-funded. Grant figures in regular type are non-State funded.

[a] Does not include Proposition 84 Implementation Grant Round 2 Awards.

[b] Grant figures represent money awarded to specific regional water management groups and do not represent the total amount of money spent on each hydrologic region because some regional water management groups straddle two or more hydrologic regions.

Calaveras, and Stanislaus rivers. The Calaveras, Mokelumne, and Stanislaus rivers flow through or border San Joaquin County and discharge directly into the Delta or into the San Joaquin River, which flows to the Delta.

Madera

The Madera County IRWM region encompasses all of Madera County located in Central California. It is bordered on the south and west by Fresno County, on the north by Mariposa and Merced counties, and on the east by Mono County. The region includes two distinct hydrogeologic areas, including the flat-lying western third of the county and the remaining eastern two-thirds, which consist of the foothills and mountains of the Sierra Nevada. Communities within the region include the incorporated cities of Chowchilla and Madera and a number of unincorporated communities including Oakhurst, Bass Lake, and Ahwahnee.

Merced

The Merced IRWM region, approved by DWR in 2011, encompasses the northeastern portion of Merced County. It is generally bounded by the Merced Groundwater Subbasin to the east, the San Joaquin River to the west, the Dry Creek watershed to the north, and the Chowchilla River to the south. The region includes the incorporated cities of Atwater, Livingston, and Merced and the unincorporated communities of Cressey, El Nido, Franklin/Beachwood, Le Grand, Planada, Snelling, Stevinson, and Winton.

Mokelumne/Amador/Calaveras

The Mokelumne-Amador-Calaveras (MAC) region includes all of Amador County and portions of Calaveras and Alpine counties. The region includes all of the Upper Mokelumne River and Upper Calaveras watersheds and portions of the South Fork American, Lower Mokelumne and Cosumnes, and Lower Calaveras watersheds. The Mokelumne River watershed forms the eastern border, while the Calaveras River watershed forms the southern boundary. The Amador County boundary roughly defines the northern border, while the western border extends to the intersection of the San Joaquin County and Calaveras County boundaries.

Tuolumne-Stanislaus

The Tuolumne-Stanislaus region boundary spans a portion of the western slope of the Sierra Nevada, rising from the lower Sierra foothills to the crest of the Sierra Nevada. It includes all of the Upper Tuolumne River, Upper Stanislaus River, and Upper Rock Creek-French Camp Slough watersheds and includes all of Tuolumne County and portions of Calaveras and Alpine counties. There are a number of alpine lakes and human-made reservoirs throughout the region, including Lake Don Pedro and New Melones Reservoir. The region is sparsely populated and consists of communities situated in the foothills including Sonora, Angels Camp, Murphys, and Groveland.

Westside-San Joaquin

The Westside-San Joaquin region encompasses the west side of the San Joaquin Valley and the Central Coast. It stretches from the City of Tracy in San Joaquin County at the north to Highway 41 and Kettleman City in Kings County to the south. On the east, the region is generally bounded by the San Joaquin River and to the west by the Coast Ranges. The region also encompasses portions of Monterey, San Benito, Santa Clara, and Santa Cruz counties.

East Stanislaus

The East Stanislaus IRWM region boundary is largely defined by surrounding IRWM regions. By using the existing boundaries, the East Stanislaus region was formed to cover an area of California that lacked coverage by other integrated regional water planning efforts. The region is generally bounded by the Stanislaus River to the north, the San Joaquin River and the Westside-

San Joaquin IRWM region to the west, the Stanislaus-Tuolumne County line to the east, and the Merced River and Merced IRWM region to the south. Ceres, Hughston, Modesto, and Turlock are the major cities within the region.

Key Challenges and Goals

American River Basin

The American River basin region faces the following challenges:

- Maintaining sustainable water resources for all uses under all hydrologic conditions.
- Maintaining reliable groundwater resources with the presence of several extensive contaminant plumes.
- Preserving and improving habitat in a highly urbanized environment.
- Protecting a large urban population in a flood-prone environment.

To address these challenges, the American River basin region has identified the following goals/objectives:

- Provide reliable and sustainable water resources to meet existing and future needs.
- Protect and enhance the quality of surface water and groundwater.
- Protect and enhance the environmental resources of the watersheds within the region.
- Protect people, property, and environmental resources of region from damaging floods.
- Promote community stewardship of the region's water resources.

Cosumnes American Bear Yuba (CABY)

The CABY region faces the following challenges:

- Water supply.
- Water quality.
- Environment and habitat.
- Climate change.
- Human-landscape interaction.

To address these challenges, the CABY region has identified the following goals/objectives:

- Achieve sustainable surface and ground water supply.
- Reduce impacts from catastrophic fire.
- Provide multiple benefits from management of water resources, diversions, and infrastructure.
- Protect infrastructure, equipment, and property from flooding.
- Protect and improve watershed resources through land use practices.
- Manage sediment for water resources, infrastructure and habitat value.
- Reduce mercury contamination in waterways.
- Protect and improve fisheries and aquatic biota through water resources management.
- Reduce contamination of surface and ground water resources.

East Contra Costa County

The East Contra Costa County region faces the following challenges:

- Water-quality-related regulations and water supply reliability.
- Protection, restoration, and enhancement of Delta ecosystem and other environmental resources.
- Funding for water-related planning and implementation.
- Stormwater and flood management.
- Water-related outreach and equitable distribution of resources in the region.

To address these challenges, the region has identified the following goals/objectives:

- Maximize water supply reliability and meet future demands.
- Maintain regulatory compliance.
- Protect against flooding.
- Maximize use of local supplies/reduce dependence on imported supplies.
- Maximize environmental sustainability.
- Protect and enhance source water quality.
- Protect against overdraft.
- Protect public health and environmental resources.
- Minimize environmental impacts.
- Maximize environmental sustainability.

Eastern San Joaquin

The Eastern San Joaquin region faces the following challenges:

- Flood protection.
- Groundwater overdraft.
- Water quality (surface and groundwater).
- Saline groundwater intrusion.

To address these challenges, the region has identified the following goals/objectives:

- Ensure the long-term sustainability of water resources in the San Joaquin region.
- Distribute benefits and costs equitably.
- Minimize adverse impacts to agriculture, communities, and the environment.
- Maximize efficiency and beneficial use of supplies.
- Protect and enhance water rights and supplies.

Madera

The Madera region faces the following challenges:

- Overdrafted groundwater basins.
- Stormwater flooding.

- Water quality.
- Water supply.

To address these challenges, the region has identified the following goals/objectives:

- Substantially reduce or eliminate the current groundwater overdraft through improved management of existing water supplies and development of additional water supplies.
- Develop processes to better manage groundwater pumping.
- Incorporate flood protection into the water management strategy.
- Maintain and/or improve groundwater quality.
- Develop a groundwater monitoring program.
- Create realistic, practical, implementable, and enforceable policies governing groundwater management to sustain the supply.
- Assess the feasibility of surface water supply development.
- Assess the potential for conservation, wastewater reuse/recycling, and watershed management.
- Create realistic land development policies and practices.
- Develop and implement a groundwater monitoring program.

Merced

The Merced region faces the following challenges:

- Inadequate flood control.
- Failure to protect water supply and quality.
- Impacts to sensitive ecosystems.
- Funding.
- Inefficient water use practices.

To address these challenges, the region has identified the following goals/objectives:

- Manage flood flows for public safety, water supply, recharge, and natural resource management.
- Meet demands for all uses, including agriculture, urban, and environmental resource needs.
- Correct groundwater overdraft conditions.
- Improve coordination of land use and water resources planning.
- Maximize water use efficiency.
- Protect and improve water quality for all beneficial uses, consistent with the Basin Plan.
- Protect, restore, and improve natural resources.

Mokelumne/Amador/Calaveras

The MAC region faces the following challenges:

- Land use and water use conflicts.
- Environmental protection.

- Water quality and supply management.
- Forest and fire management.
- Economic impacts.

To address these challenges, the region has identified the following goals/objectives:

- Reduce sources of contaminants.
- Manage stormwater flows and transport of sediments and contaminants.
- Ensure sufficient firm yield water supply.
- Maintain and improve water infrastructure reliability.
- Promote water conservation, recycling, and reuse for urban and agricultural uses.
- Develop appropriate drought mitigation measures.
- Protect, conserve, enhance, and restore the region's natural resources.
- Maintain or improve watershed ecosystem health and function.
- Minimize adverse effects on cultural resources.
- Identify opportunities for public access, open spaces, and other appropriate recreational benefits and avoid harm to existing or planned recreational uses.

Tuolumne-Stanislaus

The Tuolumne-Stanislaus region faces the following challenges:

- Efficient use and distribution of water.
- Reliable and affordable water supply.
- Water quality.
- Resource stewardship and ecosystem needs.
- Stormwater capacity and climate change.

To address these challenges, the region has identified the following goals/objectives:

- Improve water supply infrastructure within DAC and urban areas that have declining water quantity/quality or other water system reliability issues (e.g., fire flow, contamination, etc.).
- Reduce contamination in groundwater, natural streams, raw water conveyance systems, and reservoirs from the negative impacts of stormwater, urban runoff, and nuisance water.
- Improve infrastructure to meet wastewater discharge/disposal requirements and deliver drinking water that meets drinking water standards and customer expectations.
- Improve watershed health in support of increased water yield and ecosystem function.
- Improve efficiency and reliability of human-made water conveyance systems.
- Develop sufficient reliable and affordable water supplies to meet regional demands of existing and projected water supply needs under a multi-year drought now and into the future.
- Improve integrated land use and natural resource planning to support watershed management actions that restore, sustain and enhance watershed functions.

Westside-San Joaquin

The Westside-San Joaquin region faces the following challenges:

- Ecosystem restoration.
- Water supply reliability.
- Flood management.
- Groundwater management.
- Stormwater management.

To address these challenges, the region has identified the following goals/objectives:

- Provide reasonable opportunity to advance ecosystem restoration through balance project implementation.
- Develop regional solutions that protect environmental and habitat concerns and provide potential for improvement.
- Improve south-of-Delta water supply reliability by an average of 25 percent.
- Minimize risk of loss of life, infrastructure, and resources caused by significant storm event by utilizing uncontrolled flow beneficially.
- Maximize utility of regional aquifers while reducing potential for overdraft.
- Consider recreational potential in project development.
- Capture stormwater for higher beneficial use whenever practicable.
- Always promote and enhance water conservation.
- Develop regional solutions that provide opportunity for water quality improvement.
- Always promote and enhance water recycling.

East Stanislaus

The East Stanislaus region faces the following challenges:

- Water supply reliability.
- Drinking water quality and water quality protection.
- Groundwater overdraft, contamination, and recharge.
- Protection and enhancement of aquatic, riparian, and watershed resources.
- Water-related needs for DACs.

To address these challenges, the region has identified the following goals/objectives:

- Protect existing water supplies and water rights, and improve regional water supply reliability.
- Ensure flood protection strategies are developed and implemented through a collaborative process, utilizing both local and watershed-wide approaches designed to maximize opportunities for comprehensive water resource management.
- Protect and improve water quality for beneficial uses consistent with regional interests and the RWQCB Basin Plan in cooperation with local, state and federal agencies and regional stakeholders.

- Protect the environmental resources of the Stanislaus, Tuolumne, Merced and San Joaquin River watersheds by identifying, promoting, and implementing opportunities to assess, restore, and enhance natural resources of these watersheds.
- Implement and promote the IRWM plan through regional communication, cooperation, and education.
- Promote development and implementation of projects, programs, and policies that are socially impartial and economically sound.

Water Supply and Demand

American River Basin

The American River basin IRWM region primarily relies on a mixture of surface water, groundwater, and recycled water to meet water demands. In 2010, water demands in the region were estimated at 785,831 af/yr. The American River basin IRWM plan projected 2020 water demands to increase to 859,013 af/yr. based on land use and population projections.

Cosumnes American Bear Yuba

Water supplies within the region are predominantly local in origin and thus the region is dependent on local precipitation patterns. Groundwater is generally inadequate and unreliable for large-scale use. The CABY region relies heavily on rain and snowmelt stored in reservoirs and redistributed in time and location to provide reliable water supply year round. It is estimated that supply will increase from 753,623 af/yr. in 2015 to 836,942 af/yr. by 2030. Demand is projected to increase from 418,344 af/yr. in 2015 to 500,190 af/yr. by 2030.

East Contra Costa County

The majority of the region's supply originates from imported Delta surface water and, to a lesser extent, recycled water, groundwater, and local surface water. Water supply is expected to increase from 122,000 af/yr. in 2010 to 143,900 af/yr. by 2030. Due to population growth, urban demand within the region is expected to increase from 49,381 af/yr. in 2010 to 69,168 af/yr. in 2030.

Eastern San Joaquin

The major water supply sources to the region are surface water and groundwater. Wastewater recycling has been implemented for the City of Lodi's wastewater treatment facility and has supplemented agricultural water supplies. In return, a surface water treatment plant for Lodi utilizes the irrigation district's diversion facilities to tap an in-kind amount of surface water supplies, alleviating some groundwater demand. Despite several urban centers within the region, agriculture is the largest water user. Urban water demands are projected to increase from roughly 130,000 af/yr. in 2005 to 270,000 af/yr. by 2030 due to population increases. Agricultural water demands are projected to decrease from over 1 million af/yr. in 2005 to 910,000 af/yr. by 2030.

Madera

Groundwater is the primary water source within the region, supplying almost the entire urban and rural water demand and about 75 percent of the agricultural water demand. Surface water comprises the rest of the region's supply and averages roughly 300,000 af/yr. Agriculture uses roughly 97 percent of the supply. Water demands within the region are anticipated to grow from 1.2 maf/yr. in 2006 to 1.3 maf/yr. by 2030.

Merced

The region primarily relies on groundwater pumped from the Merced, Turlock, and Chowchilla subbasins. Supply is also supplemented from local surface waters. In 2010, demand within the region was 412,330 af/yr. The Merced IRWM plan projects that by 2020, demand will increase to 433,487 af/yr.

Mokelumne/Amador/Calaveras

Nearly all of the region's supply comes from local surface water from the Mokelumne and Calaveras River watersheds. In Amador County, 97 percent of domestic supply is from the Mokelumne River with the remaining 3 percent from groundwater. It is estimated that demand within the region will grow from 25,273 af/yr. to 42,970 af/yr. by 2030. EBMUD is the primary user of the Mokelumne River outside the region, with water rights allowing for delivery of up to 364,000 af/yr.

Tuolumne-Stanislaus

Over 95 percent of the water supply in the region is from surface water. The remaining supply is groundwater. Supply is anticipated to increase from 109,159 af/yr. in 2015 to 112,864 af/yr. by 2035. Demands are expected to increase from 43,416 af/yr. in 2015 to 93,017 af/yr. in 2035. Water exports for consumptive use outside the region comprise approximately 98 percent of the overall water deliveries from the Stanislaus and Tuolumne rivers on an average annual basis, about 1,737,000 af/yr.

Westside-San Joaquin

The San Luis and Delta Mendota Water Authority is responsible for delivery of approximately 3 maf/yr. to its member agencies. The Westside water supply is comprised of CVP water, groundwater, and local surface water. Since 1989, CVP water supply allocations have decreased significantly for Westside CVP contractors. Today, the long-term average CVP allocation has been reduced to approximately 70 percent. The current municipal and industrial long-term average supply allocation has been reduced to approximately 90 percent under current conditions. In addition to reduced CVP supply allocations, groundwater supplies in the region are declining due to a long-term overdraft condition caused by over-pumping. To protect the long-term sustainability of this resource, groundwater pumping has been significantly reduced, especially when compared to historic use. This, however, has further reduced available water supplies in the region. Current and projected demand information is not available in the region's IRWM plan.

East Stanislaus

Surface water and groundwater are the two primary sources of water for the region. In 2010, demand for the Cities of Modesto, Turlock, and Ceres was just over 95,000 af/yr. This demand has been met by approximately one-third surface water supply and two-thirds groundwater supply. Demand is projected to grow to over 150,000 af/yr. by 2030; and supply in the region is expected to be increase to 152,000 af/yr. in that same time period, through a mix of increased groundwater and new surface water supplied by the Turlock Irrigation District.

Water Quality

American River Basin

The region's surface and recycled water are generally of good quality and meet regulatory standards. There are numerous industrial groundwater contamination plumes that have directly impacted or continue to threaten groundwater quality for consumptive uses. Throughout the region, groundwater contamination plumes have forced some wells to be taken out of service and continue to threaten other local groundwater supplies as the plumes migrate.

Cosumnes American Bear Yuba

The region has generally high quality drinking water that meets or exceeds State and federal standards. Water quality concerns for ecosystems, however, include methyl mercury, temperature, and sediments, as well as other legacy mining contaminants. Aquatic invasive species also threaten water quality within the region. There are 14 water bodies within the region that are listed by the EPA as impaired, mostly due to mercury contamination. The region is committed to improving water quality to support healthy ecosystems and dependent organisms.

East Contra Costa County

Delta water quality is highly variable and can suffer from TDS, chloride, bromide, and total organic carbon. During spring and early summer months when Delta quality is low, Delta supplies are blended with the high-quality water stored in Los Vaqueros Reservoir. Groundwater quality generally meets drinking water standards with some exceptions. High manganese and TDS levels have been observed in several wells in the region. To address some of these quality concerns, the region identifies a number of strategies to meet water quality objectives outlined in the IRWM plan. These strategies include reducing storm drain discharges to the Delta and meeting all recycled and drinking water quality requirements.

Eastern San Joaquin

Both surface water and groundwater quality within the region are diminished from a variety of constituents. Surface water within the region is generally of good quality, but can be impacted by elevated levels of turbidity during flood events and times of elevated flow and by TDS during periods of low river flows when brackish water travels deeper into the Delta and irrigation return flows are less diluted. Historically, the most prevalent water quality issue for groundwater has been saline intrusion from the west resulting from high pumping demand. However, while historical water quality samples have shown a number of wells with increasing salinity concentrations, recent trends have been relatively stable, possibly due to major surface water projects coming on line in the past several years (e.g., Delta Water Supply Project – Phase 1 and Stockton East Water District's and City of Lodi's surface water treatment plants) that have significantly reduced groundwater pumping in the Cities of Stockton and Lodi.

Madera

Both surface water and groundwater within the region are generally of good quality. Groundwater quality contaminants of concern vary throughout the region, and include high salinity (TDS), nitrate, uranium, arsenic, iron, and manganese. Despite the water quality issues noted above, most of the groundwater within the region is of suitable quality for irrigation. The surface water quality of the San Joaquin River at lower elevations contains high levels of organic matter, resulting in elevated disinfection by-products (DBP), which have caused individual water systems to violate DBP MCLs.

Merced

While surface water quality within the region varies, it is moderately impacted by salinity, with higher impacts in the western portion of the region. There are five water bodies within the region that are classified as impaired, with TMDLs either in place or being drafted. Groundwater quality is affected by both natural and human-made constituents, some of which either currently impact or have the potential to impact groundwater use in the future.

Mokelumne/Amador/Calaveras

Surface water from the Mokelumne River is of generally very high quality, with some turbidity during storm events. There are eight surface water bodies listed as impaired by SWRCB, including Camanche Reservoir and Lower Calaveras River. Contaminants listed include mercury, pesticides, pathogens, and copper. Groundwater quality within the region varies considerably. Currently, the two groundwater subbasins within the region are in a state of overdraft, causing a concentration of contaminants.

Tuolumne-Stanislaus

Surface water quality within the region is generally considered very good and more than sufficient for most intended beneficial uses. Eight water bodies including Hetch Hetchy Reservoir and Curtis Creek are listed as impaired. Mercury and E. coli are the two primary pollutants identified within the region. Surface water quality issues can be linked to current or historical land use practices such as mining, septic systems, and livestock grazing. Groundwater quality within the region is highly variable depending on localized factors including high salinity, nitrate, iron, and manganese. Leaking septic tanks can also cause groundwater quality issues, leading to bacteriological contamination that can become problematic for domestic use of local groundwater.

Westside-San Joaquin

Water quality within the region is generally good; however, groundwater quality can suffer from drainage and soil salinity problems. Drainage problems are a result of irrigated agriculture in an area with shallow groundwater tables and little or no drainage outlet. In a large part of the valley in the west, shallow groundwater tables, salts imported by water deliveries, and accumulation of natural salts in soil and groundwater from irrigation threaten sustained agriculture. In addition to drainage, problems have occurred with the accumulation of toxic metals, such as arsenic, boron, and selenium, that have leached from natural deposits through the application of irrigation water.

East Stanislaus

Surface water quality within the region is impacted by pesticides, specifically diazinon and chlorpyrifos, which are found at levels toxic to invertebrate species. These pesticides are most often found in winter storm runoff from crops and irrigation return flows. The San Joaquin, Merced, and Tuolumne rivers are listed on the EPA's 303d list as impaired due to pesticides and various other constituents. Other surface water quality concerns are bacteria, oil and grease, dissolved oxygen, and mercury. Groundwater quality is impacted by high salinity, nitrates, iron, and arsenic. Some wells within the region have been discontinued due to high levels of arsenic and nitrate. Average nitrate levels have increased from 12 parts per million (ppm)to 21 ppm over the last 20 years.

Flood Management

American River Basin

Flood management has been identified as one of the region's major challenges. The primary flood management entity within the American River basin region is Sacramento Area Flood Control Agency (SAFCA). Currently, the Sacramento region has the lowest level of flood protection of any major U.S. metropolitan area. Therefore, one of the key strategies of the American River basin IRWM plan is to achieve a 200-year flood protection in applicable urban areas by 2025.

Cosumnes American Bear Yuba

Flooding is not a widespread issue within the CABY region; however, there are some localized concerns. The City of Placerville experiences severe flooding in the downtown commercial areas almost annually as a result of overflow from nearby Hangtown Creek. The City of Placerville Stormwater Management Plan is designed to help restore effective drainage and improve the creek to avoid flooding. Regional projects such as the City of Placerville Water Quality and Habitat Protection: Hangtown Creek Sewer Line Replacement help facilitate the implementation of the Stormwater Management Plan.

East Contra Costa County

A large portion of the region is floodplain, subject to 100-year flood events. Both localized floods from stormwater runoff and regional/catastrophic flooding due to levee failure are real threats to communities and the region as a whole. Several flood planning and management documents have been completed including the 50-Year Plan "From Channels to Creeks" in 2009, which identified opportunities and benefits for enhancing stormwater and flood management systems. Flood management is incorporated in the IRWM plan through several objectives, including managing local stormwater and improving regional flood risk management. The IRWM plan seeks to achieve a 200-year level of protection for urban areas and a 100-year level of protection for small communities.

Eastern San Joaquin

Flood management is a major issue for the region. Specifically, the region is concerned about urbanization of areas historically in a floodplain, financial feasibility, climate uncertainty, flood risk reduction, and levee decertification. The San Joaquin Area Flood Control Agency (SJAFCA), a joint powers authority created in May 1995 between the City of Stockton, San Joaquin

County, and the San Joaquin County Flood Control and Water Conservation District, addresses flood protection for the City of Stockton and surrounding county areas. SJAFCA is facing a number of challenges to assure flood protection facilities meet both State and federal regulatory requirements. Other challenges involve State legislation that went into effect in 2007 (SB 5), which proposes a 200-year level of flood protection for urbanized or urbanizing areas. New State and USACE levee standards and criteria are imminent as DWR is currently undertaking intensive levee investigations. These activities, new mandates, and evolving levee standards will continue to impact SJAFCA's priorities. The region has an early warning ALERT Flood Warning System in place and is looking to map additional flood prone areas to inform and expand flood management projects and programs.

Madera

The western valley portion of the region has a long history of flooding, mainly associated with the Fresno and Chowchilla rivers and their tributaries. Floodway obstructions, limited channel capacity, and poor levee maintenance are the main factors which cause flooding. The primary agency responsible for flood management within the region is the Madera County Flood Control and Water Conservation Agency. Although flood management is a large concern for the region, the agency does not have sufficient staff and funding to adequately address flood control in the region.

Merced

Flooding within the region is typically caused by infrequent, severe winter storms, coupled with snowmelt runoff. Flood is potentially being worsened by ground subsidence due to over-pumping of deep, confined aquifer zones in the southwestern portion of the region. Several streams within the region swell during these storms, causing floodwaters to spread out over large areas. Flood management in the region dates back to the 1940s with the establishment of the Merced County Streams Group, a network of identified streams within the region. A number of projects have been undertaken to address flooding within the Streams Group.

Mokelumne/Amador/Calaveras

Flooding is a concern for many areas within the region. Many cities and communities, including Sutter Creek, Jackson, Ione, and Mokelumne Hill, include areas within the 100-year floodplain of both the Mokelumne River and its tributaries. More severe/flashier storm events, earlier springtime runoff, and an increase in impervious surfaces are expected to increase the number and severity of floods. An objective within the IRWM plan is to promote development of community-based flood protection, measured by the number of acres affected by adopted protection strategies and the presence of floodplain development avoidance in planning documents.

Tuolumne-Stanislaus

Due to elevation variation and existence of multiple upper watershed reservoirs, severe flooding has not historically been a major concern. However, management and containment of localized flooding of creeks and tributaries, particularly in urban areas, is needed to reduce the potential for catastrophic flooding. Flood management within the region includes varied approaches, including maintaining flood infrastructure such as dams and conserving mountain meadows, which help attenuate floods.

Westside-San Joaquin

The region has identified flood management as a focus area and is committed to minimizing the risk of loss of life, infrastructure, and resources caused by significant storm events by utilizing uncontrolled flow beneficially. The West Stanislaus Flood Control Project studies the use of multi-purpose detention basins to reduce flood damage in Newman, Patterson, and the surrounding agriculture lands. Similarly, the Arroyo Pasajero Flood Control Project considers a mix of existing feature modification and construction of new facilities to better control periodic flooding.

East Stanislaus

Within the region, storm flooding is a result of a combination of factors including high groundwater, low percolation, and topography. There are several areas within the region that fall within the 100-year flood zone, including near the Modesto and Tuolumne rivers and large portions of land surrounding the San Joaquin River. Currently, flood management within the region includes reservoirs to regulate snowmelt, bypasses at lower elevations, and levees that line major rivers within the region. The region is also actively participating in the development of a regional flood management plan to identify potential projects that may improve flood management.

Groundwater Management

American River Basin

Groundwater is actively managed in the American River basin region. From north to south, the American River basin region is covered by four GWMPs: Western Placer County GWMP adopted in 2007 by the cities of Roseville and Lincoln, Cal American Water, and Placer County Water Agency; northern Sacramento County GWMP adopted in 2008 by the Sacramento Groundwater Authority; central Sacramento County GWMP adopted in 2006 by the Sacramento Central Groundwater Authority; southern Sacramento County GWMP adopted in 2011 by the South Area Water Council.

Cosumnes American Bear Yuba

No groundwater management agencies service the CABY region, and as such, there are no GWMPs, groundwater supply projections, or guidelines. The interaction between surface and groundwater resources is not well understood, though nearly all of the homes not served by a water purveyor are on private wells. The region has identified groundwater as a primary issue and seeks to prepare a summary of requirements for approving development projects that rely exclusively on groundwater.

East Contra Costa County

The region partially overlies the Pittsburg Plain and Clayton Valley groundwater basins, as well as a portion of the Tracy Subbasin of the San Joaquin Valley Groundwater Basin. Groundwater is an important source of supply for agricultural and domestic uses, and to a lesser extent, municipal and industrial uses. While there is currently no GWMP for the region, an objective of the IRWM plan is to increase understanding of groundwater quality and potential threats to groundwater quality through the completion of a GWMP.

Eastern San Joaquin

The region overlies the Eastern San Joaquin Groundwater Subbasin of the greater San Joaquin Valley Groundwater Basin. In 2004, the Northeastern San Joaquin County Groundwater Banking Authority (GBA) completed and adopted the Eastern San Joaquin GWMP, which outlines actions for implementing an overall integrated conjunctive use program. In average years, almost 870,000 af of groundwater is pumped per year within the region. The Eastern San Joaquin Subbasin has been identified as critically overdrafted by DWR. Saline intrusion and saline migration eastward toward the Stockton area has the potential to affect groundwater quality.

Madera

The region overlies the Madera, Chowchilla, and Delta-Mendota subbasins of the larger San Joaquin Valley Groundwater Basin. Madera Irrigation District adopted a GWMP that promotes active pursuit of groundwater recharge facilities and conjunctive use projects. Groundwater is an important water source for the region and satisfies approximately 97 percent of the region's total supply. Much of the region's groundwater basins are identified as overdrafted. The estimated total amount of groundwater overdraft is about 100,000 af/yr. based on data from 1970 to 2006. This is expected to grow to 155,000 af/yr. by 2030 if mitigation measures are not taken. Despite high levels of uranium and arsenic found in portions of the basin, most of the groundwater within the region is suitable for use.

Merced

While there are three groundwater basins underlying the Merced region, the Merced Subbasin comprises most of the area. Groundwater management is primarily dictated by the Merced GWMP, which is overseen by the Merced Area Groundwater Pool Interests (MAGPI), a group comprised of 15 member agencies. Based on collected data, the average levels in the Merced Subbasin have declined roughly 14 feet. As such, the Merced Subbasin is considered to be in a state of mild long-term groundwater level decline.

Mokelumne/Amador/Calaveras

The region overlies two groundwater basins, the Eastern San Joaquin Subbasin and the Cosumnes Subbasin, both of which are part of the larger San Joaquin Valley Basin. Use of groundwater for irrigation and municipal purposes has resulted in a continuous decline of available groundwater over the past 40 years. As of 1990, annual groundwater extractions in San Joaquin County had exceeded the estimated safe yield. Overdraft within the Eastern San Joaquin Subbasin has created groundwater depressions in areas near Stockton and East of Lodi. There are a number of GWMPs currently in place within the region, with the purpose of sustainably managing groundwater resources. The IRWM plan also addresses groundwater management through promoting conjunctive management and groundwater storage.

Tuolumne-Stanislaus

Groundwater quantity within the region is largely unquantified and contained within the Sierra Nevada Geomorphic province, where water is transient and found in fractured rock, volcanic, and metaphoric fissures. The region is located within the foothills and higher elevations of the Sierra Nevada where the subsurface material consists primarily of impermeable granite and greenstone bedrock, which often results in low groundwater yield. The only exception is a small area in the northwestern corner of the region that is within the Eastern San Joaquin Groundwater Subbasin, which has been determined to be in an overdraft condition.

Westside-San Joaquin

Groundwater is an important resource for the region, supplying water for municipal and agricultural uses. The Pleasant Valley GWMP seeks to identify programs and projects that will provide sufficient groundwater recharge and conservation. Groundwater supplies within the region are declining due to a long-term overdraft condition caused by over-pumping. To protect the long-term sustainability of this resource, groundwater pumping has been significantly reduced, especially when compared to historical use. Groundwater quality within the region suffers from high salinity.

East Stanislaus

The region overlies the entire Turlock and Modesto groundwater subbasins and a portion of the Delta-Mendota Groundwater Subbasin, all three of which are included in the larger San Joaquin Valley Groundwater Basin. Groundwater levels within the region have been fluctuating in the last several decades due to periods of intense pumping and some periods of heavy rainfall and percolation. GWMPs have been prepared for both the Modesto and Turlock subbasins, which outline methods for groundwater monitoring both for groundwater levels and groundwater quality.

Environmental Stewardship

American River Basin

Environmental stewardship is practiced through ongoing efforts to meet regional environmental strategies identified in the IRWM plan. Such efforts include projects for the Lower Cosumnes River. The American River basin region has projects and management plans, as well as the CVPIA, that aim to improve aquatic and wildlife habitat. Habitat conservation plans (HCPs) have been created for the Lower American River, South Sacramento, Natomas, and Placer.

Cosumnes American Bear Yuba

The region supports a wide variety of vegetation and wildlife, as it encompasses a broad spectrum of environmental conditions such as elevation, slope, aspect, soils, and precipitation. Thirteen wildlife species are endemic to the Sierra Nevada region, many of which can be found within the CABY region. Preserving and restoring watershed health is a priority for the region. The region has committed to make an additional 15 miles of fish spawning habitat by 2020 and conduct fuels management on at least 10,000 acres by 2017.

East Contra Costa County

There are a number of environmental stewardship plans within the region, including the East Contra Costa County HCP and Natural Community Conservation Plan (NCCCP), which began implementation in 2008. Since then, more than 9,000 acres have been acquired to fulfill requirements within the HCP/NCCP. The region continues to promote environmental stewardship through its goal to protect, restore, and enhance the Delta ecosystem and other environmental resources. There are a number of projects promoted in the IRWM plan that address environmental needs including the Dutch Slough Wetlands Restoration project and the Knightsen Wetland Restoration and Flood Control project and support collaboration with DWR on the Dutch Slough Wetlands Restoration project.

Eastern San Joaquin

The region plays an important role in the health of the Delta, which is home to over 750 plant and animal species, many of which are threatened or endangered. The region understands the importance of habitat conservation and is actively working to support and encourage stewardship and proactive management of the region's natural resources. There are a number of habitat and species conservation plans which cover the region, including the Lower Mokelumne River Stewardship Plan and the San Joaquin County Multi-Species Habitat Conservation and Open Space Plan.

Madera

The region is committed to environmental stewardship and is actively pursuing a number of projects that will increase wildlife habitat. The Upper Finegold Creek Watershed Planning effort will develop a watershed assessment and management plan to identify priority projects that will both improve water quality and quantity and protect habitat in the Finegold Creek watershed. Also, the Madera Irrigation District Groundwater Bank project ensures that the largest remaining tract of undisturbed upland grassland habitat in the Central Valley will be preserved. At least 6,000 acres of contiguous, occupied habitat within the region will be included.

Merced

Impact to sensitive ecosystems was one of the issues identified as part of the Merced IRWM planning process. As such, the IRWM plan has several objectives and performance measures which target environmental needs including increasing acres of habitat protection, meeting instream flow requirements, and slowing development trends in the largest and most ecologically sensitive areas of Merced County.

Mokelumne/Amador/Calaveras

The region is a largely natural area with significant portions designated as rural or open space, including large portions of two national forests. There are over 50 species listed as threatened, endangered, candidate, or sensitive by California or federal governments. Environmental stewardship is included in the IRWM plan, which calls for practicing resource stewardship. Goals in the plan include protecting, conserving, enhancing, and restoring region's natural resources and maintaining or improving watershed ecosystem function and health.

Tuolumne-Stanislaus

The region is home to vibrant environmental communities with lakes, creeks, meadows, and other water features providing key habitat for many of California's most important aquatic and terrestrial species. Over 50 special status species are found in the region. Native forest is the dominant vegetation in the region, covering roughly two-thirds of the land area. Riparian areas found along the banks of the rivers and creeks are arguably the most productive and diverse part of the region and serve an important water resource function in their ability to stabilize stream banks and provide filtering. Protecting and restoring these environmental communities is a priority for the region.

Westside-San Joaquin

The region is home to a wide variety of plant and animal species, with varying habitat needs. Both San Benito and Santa Clara counties have initiated the preparation of HCPs, which aim to protect and restore habitat for a variety of identified federally listed species. The region is committed to restoring habitat through balanced project implementation and by developing regional solutions that protect environmental and habitat concerns. For instance, the Westside Regional Drainage Plan will eliminate agricultural discharge to the San Joaquin River, thereby improving water and habitat quality along its course.

East Stanislaus

The region is home to a number of wildlife species and the habitat that supports those species. The rivers and floodplains within the region provide habitat for salmon and steelhead while also providing wintering areas for migratory birds on the Pacific Flyway. The Stanislaus River National Wildlife Refuge covers nearly 8,000 acres, with roughly three-quarters of this area specifically acquired to allow floodwater to temporarily move out into the floodplain. The region is committed to protecting the environmental resources within its borders by identifying opportunities for open spaces and incorporating opportunities to enhance or restore natural resources when developing water management strategies.

Climate Change

Climate change is already affecting the hydrologic region and will have significant impacts on water and other resources in the future. Changes in timing, amount, and type of precipitation and runoff will affect the availability of water supplies and hydropower generation. Increasing temperatures, more increased winter runoff, and prolonged droughts will increase flood and wildfire risk, and impact ecosystem services, recreation, and public health in the San Joaquin River Hydrologic Region.

The effects of climate change such as increased temperatures, reduced snowpack, and earlier snowmelt will increase the vulnerability of both natural and built systems in the region. Impacts to natural systems such as diminished water quality and quantity, and shifting ecoregions will challenge aquatic and terrestrial species. Built infrastructure will be impacted by changes in hydrology and runoff timing, which could entail increased flood risk as well as periods of severe drought.

American River Basin

The region faces a number of vulnerabilities to climate change associated with the variety of physical and cultural landscapes that make up the region. Instream temperature changes would impact fish and wildlife habitat. Changes in mountain snowpack and runoff amounts and seasonality would have impacts relating to water supply as well as flood risk. The region's connection to the Delta is cause for sea level rise concerns.

Cosumnes American Bear Yuba

The region is addressing climate change concerns by completing a vulnerabilities assessment and identifying adaptation strategies as part of the IRWM plan update process.

East Contra Costa County

Sea level rise and larger storm events will also threaten Delta levees with potential impacts to water quality, supply reliability, and public health and safety. The region is addressing these concerns by completing a vulnerability assessment and identifying adaptation strategies as part of the IRWM plan update process.

Eastern San Joaquin

Increasing temperatures, more extreme floods, and prolonged droughts will impact agriculture and public health and safety in the region. The climate change vulnerabilities will be considered as part of the IRWM plan update process.

Madera

Climate change has the potential to impact the region's economy, which depends on the natural environment. Built infrastructure will be impacted by changes in hydrology and runoff timing, which could entail increased flood risk as well as periods of severe drought. The loss of natural snowpack storage, which has already been measured and will continue as temperatures warm and precipitation patterns change, will make the region more dependent on surface storage on reservoirs and groundwater sources.

Merced

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Mokelumne/Amador/Calaveras

Climate change vulnerabilities will be considered as part of the upcoming IRWM plan update process.

Tuolumne-Stanislaus

Climate change has the potential to impact the region's economy, which depends on the natural environment. Built infrastructure will be impacted by changes in hydrology and runoff timing, which could entail increased flood risk as well as periods of severe drought. The loss of natural snowpack storage, which has already been measured and will continue as temperatures warm and precipitation patterns change, will make the region more dependent on surface storage on reservoirs and groundwater sources.

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East Stanislaus

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Tribal Communities

American River Basin

The American River basin region has two federally recognized tribes. These include the United Auburn Indian Community of the Auburn Rancheria (UAIC) and the Wilton Rancheria. The Regional Water Authority (the RWMG for the region) contacted these tribes via invitation letter in June 2011 and extended an invitation to participate in the IRWM plan development. Additionally, RWA contacted a consultant to discuss UAIC water resource-related issues in May 2011. No issues were identified at that time. RWA intends to continue direct outreach to these tribes to identify opportunities to collaborate during implementation of the American River basin IRWM plan.

Cosumnes American Bear Yuba

Initial tribal outreach efforts in the region included direct outreach to federally recognized tribes, but did not result in sustained communication or collaboration. The tribal entities contacted during the outreach process include the Buena Vista Rancheria, Wilton Rancheria, Miwok Tribe of the El Dorado Rancheria, Ione Band of Miwok Indians, Jackson Band of the Mi-Wuk, Nashville-El Dorado Miwok, Strawberry Valley Rancheria, Colfax-Todds Valley Consolidated Tribe, Tsi-Akim Maidu, Shingle Springs Band of Miwok, Washoe Tribe of Nevada and California, Nevada City Rancheria: Nisenan Tribe, and the Tyme Maidu/Berry Creek Rancheria.

A second round of outreach focused on project development and involved both federally and non-federally recognized tribe members. This effort produced several tribal-designed projects.

However, participation in project development did not translate into participation in the planning committee meetings, resulting in a lack of tribal representation in this decision-making body. A third round of outreach was designed and coordinated by the California Environmental Indian Alliance. This third effort included outreach to not only tribal members resident to the CABY region, but also to tribal members with ancestral links to the region. This round of outreach did not meet the desired outcomes and did not result in ongoing working relationships between the CABY planning committee and tribal members. A fourth round of collaboration will be undertaken with the objective of identifying meaningful options of engaging CABY tribal members in the planning process.

East Contra Costa County

There are no tribal communities currently identified in the region. However, there is a rich history of Native American occupation in the region, including the Kellogg Creek National Historic District located on the Los Vaqueros watershed.

Eastern San Joaquin

No Tribes are identified within the region, and no further Tribal information is available in the region's IRWM plan.

Madera

The IRWM plan references an agreement between Madera County and the Chukchansi Tribe of the Picayune Rancheria to conduct an evaluation of groundwater, but there is no indication that they or any other tribes are involved in the IRWM planning efforts.

Merced

There are no California Native American tribal communities within the Merced region. As such, implementation of the Merced IRWM plan will not directly benefit or impact California Native American tribal communities. Plan and project implementation does, however, have the potential to benefit or impact lands that were historically occupied by California Native American tribal communities.

Mokelumne/Amador/Calaveras

Focused outreach to Native American tribes within the MAC region was completed as part of the plan update. The three federally recognized tribes within the MAC region include the Ione Band of Miwok Indians, the Jackson Rancheria of Me-wuk Indians, and the California Valley Miwok Tribe (also known as the Sheep Ranch Tribe). The region has created a Community Outreach Plan to supplement its IRWM planning efforts. One major aspect of the Outreach Plan includes ensuring that the interests of tribes are represented and accounted for in the IRWM plan by soliciting involvement of tribal representatives in the Regional Participant Community (RPC). RPC members are also encouraged to advocate for tribes that do not have designated RPC representatives but lie within the RPC member's jurisdiction, and inform tribes of the IRWM program through fliers and newspaper notices. Although none of the federally recognized tribes are actively engaged in the planning process, the RPC has sought to minimize impacts to these communities and provide for equitable benefits associated with project implementation.

Tuolumne-Stanislaus

Tribes in the region include the federally recognized Chicken Ranch Band of Me-Wuk Indians of California and Tuolumne Band of Me-Wuk Indians of the Tuolumne Rancheria, along with the non-federally recognized Tuolumne Algerine Band of Yokut. An initial tribal meeting was held with the Tuolumne Band of Me-Wuk Indians at which representatives of the Chicken Ranch Rancheria were present. This meeting was used to discuss tribal issues and concerns, tribal water-related needs, and identify opportunities to improve conditions for the tribes. Since the initial meeting, the Tuolumne Band of Me-Wuk Indians has been an active attendee at the planning grant committee (PGC) meetings and submitted two projects for inclusion in the plan.

Westside-San Joaquin

There are an estimated 300 descendants of the Coastanona (Ohlone) Tribes in the Santa Clara and San Benito counties near Mission San Jose, Mission San Juan Bautista, and Watsonville. No further information is available in the region's IRWM plan.

East Stanislaus

No tribal communities have been identified within the region to date. Formal letters were sent to two tribes with possible ties to areas within the region, but no response has been received to date. Outreach to Native American communities will continue through future outreach efforts.

Disadvantaged Communities

American River Basin

DACs in the American River basin region are generally not isolated communities with particular water supply or water quality concerns and are generally served effectively by water purveyor efforts to provide high-quality water supplies. Some DACs or individuals that would be considered disadvantaged reside in very small pockets of the region, served by a small water system and/or private wells. The region prepared and maintains a DAC contact and mailing list to encourage participation through direct solicitation, such as mailings, e-mail, or phone calls. Also, American River basin stakeholders and project proponents are encouraged to identify projects with the potential to address DAC needs.

Cosumnes American Bear Yuba

DACs in the CABY region include River Pines, Plymouth, Kirkwood, Grizzly Flats, Soda Springs, Graniteville, Washington, North San Juan, Grass Valley, Rough and Ready, Penn Valley, Newcastle, North Auburn, Downieville, Alleghany, Pike, Dobbins, and Camptonville. Four of the 18 DACs in the region are part of the region's IRWM Planning Committee, while the rest were encouraged to participate in meetings and project development activities. Outreach to DACs has included face-to-face meetings with DAC staff, boards of directors, and volunteer representatives on a regular basis. The IRWM plan includes 12 projects that originate from and/or benefit DACs in the region. CABY also created a DAC Work Group that now includes representatives from most of the DACs in the region. CABY staff continues ongoing outreach to expand participation.

East Contra Costa County

The region faces special challenges as there are many DACs in the region. Census tract groups that qualify as DACs cover an area of 41,079 acres, or approximately 19 percent of the geographic area of the region and approximately 23 percent of the total population. DACs include the Beacon West community on Bethel Island, as well as portions of Bay Point, and the Cities of Antioch and Pittsburg. The primary water supply and water quality issues facing DACs relate to a strong reliance on Delta supplies, a need to maintain compliance with applicable drinking water standards, and the threat of damage from flooding. The ECCC region has maintained a transparent and open process in which DAC representatives are always welcome, and the project Web site allows 24-hour access to information.

Eastern San Joaquin

According to 2010 Census data and DWR, approximately 59 percent of households in the region can be classified as a DAC, including portions of Thornton, Walnut Grove, the City of Lodi, the City of Stockton, Lathrop, and Manteca. Although the region's adopted IRWM plan does not describe specific targeted outreach to DACs, the region regularly provides information to stakeholders and the general public through many avenues, including paper mailings, e-mail, Web site announcements, newsletters, and press releases. In addition, the current IRWM plan update process has expanded DAC outreach with specific efforts to contact and involve recognized DAC leaders to discern DAC water and flood protection needs, as well as developed a user-friendly Web site that includes DAC content.

Madera

No DACs are identified within the region.

Merced

The majority of the region is currently considered a DAC. DACs in the region include the incorporated cities of Atwater, Livingston, and Merced, and the unincorporated communities of El Nido, Le Grand, Planada, Snelling, and Winton. Additionally, although the communities of Cressey, Franklin/Beachwood, and Stevinson are not recognized as DACs by the State's definition, they are considered to be DACs for the purposes of the Merced IRWM plan due to local knowledge of economic conditions. From the beginning stages of Merced IRWM plan development, the RWMG worked to include DAC representation in the planning process. DAC and environmental justice interests were identified as specific interest groups recruited for participation on the interim Regional Advisory Committee (RAC) and are recommended to continue under the future long-term governance structure. As part of the IRWM planning process, the RWMG also secured the services of a local consultant to provide targeted outreach to DACs and ensure that information about the IRWM program was presented during regular sessions of the City of Merced City Council, the City of Atwater City Council, and the City of Livingston City Council.

Mokelumne/Amador/Calaveras

The cities or communities of Jackson, Plymouth, Sutter Creek, Drytown, Sutter Creek, Martell, Buena Vista, Camanche North Shore, Lake Camanche Village, West Point, Rail Road Flat, San Andreas, and Dorrington, are DACs. Kirkwood, Avery, Angels, and Murphys are DACs that are partially located in the MAC region. The region has created a community outreach plan to supplement its IRWM planning efforts. One major aspect of the outreach plan includes ensuring that the interests of DACs are represented and accounted for in the IRWM plan by soliciting involvement of DAC representatives in the RPC. Its members are encouraged to advocate for DACs that do not have designated RPC representatives but lie within the RPC member's jurisdiction and to inform DACs of the IRWM program through fliers and newspaper notices.

Tuolumne-Stanislaus

Involvement of DACs was an important component throughout the planning process through a focused DAC outreach process. A significant portion of the region qualifies as a DAC. One of the challenges of engaging with DACs in the region is that they are generally fairly widespread and many do not have resources available to be actively engaged in many of the public processes. A DAC outreach subcommittee was established to identify and develop a list of DACs throughout the region to improve DAC engagement in the IRWM planning process.

Westside-San Joaquin

Three of the 5 counties and 12 of the 23 census tracts in the west San Joaquin Valley region are considered DACs. Improving the water supply reliability and otherwise enhancing the conditions for production agriculture in this region has been identified as a way to expand the source of employment opportunities for these disadvantaged populations. No further information is available in the region's IRWM plan.

East Stanislaus

Within the East Stanislaus Region, the communities of Keyes, Bret Harte, Bystrom, Empire, Grayson, Shackelford, West Modesto, Riverdale Park, Cowan, Parklawn, Rouse, and portions of Modesto, Turlock, Denair, Hughson, Oakdale, Waterford, and Ceres are classified as DACs. A stakeholder outreach and communications plan was developed by the region to guide dissemination of information and outreach to stakeholders, including targeted outreach to DACs. Outreach to DACs included discussions and meetings with representatives from DACs, encouragement of RWMG committee members to advocate for DACs, and distribution of fliers and newspaper notices about opportunities to get involved with the IRWM planning process.

Governance

American River Basin

The RWA (Regional Water Authority) is a joint powers authority formed in 2001 to assist local water suppliers with protecting and enhancing the reliability, availability, affordability, and quality of water resources. RWA was officially recognized as the RWMG by DWR in 2009.

Cosumnes American Bear Yuba

A charter and an MOU have guided the governance of the CABY region. Since 2006, the charter has been used to define roles, responsibilities, and participation in the CABY group. The 2007 MOU describes a management structure that created and assigned roles to a planning committee, a coordinating committee, and various work groups. The planning committee is tasked with management decision-making authority, and the coordinating committee is responsible for assisting consultants and providing guidance on a more regular basis. The coordinating committee is comprised of four water agencies and four non-governmental representatives. In addition, work groups are convened as needed to address specific management topics and concerns.

East Contra Costa County

The East County Water Management Association (ECWMA) governance structure was originally established by a 1997 agreement between 12 member agencies. The ECWMA is governed and operated by the Governing Board Representatives (GBR), composed of one elected official representative from each of the member agencies. In addition to the GBR, the joint managers committee is the primary administrative body for implementing ECWMA activities, while subcommittees are formed to handle specific water management activities.

Eastern San Joaquin

The Northeastern San Joaquin County GBA is an 11-member agency established in 2001 as a joint powers authority to collectively develop locally supported projects to strengthen water supply reliability in Eastern San Joaquin County. The GBA employs a mutual interest-based governance structure that creates a stakeholder group of common interest with the power to undertake specific goals and objectives. The GBA is responsible for the overall development and implementation of the IRWM plan.

Madera

While Madera County acts as the lead agency for developing and implementing the IRWM plan, a number of advisory committees were formed to assist the county. These committees help the county in the deliberation of issues addressed in the plan and include over 80 individuals representing community organizations, municipalities, irrigation and water districts, and non-district areas. Public input was also solicited to ensure that the process included local knowledge and addresses local concerns.

Merced

In 1997, the MAGPI was formed to manage the region's groundwater. In 2012, MAGPI formed the RWMG under an MOU between the Merced Irrigation District, Merced County, and the City of Merced, to oversee the planning of the Merced IRWM plan. The IRWM plan recommends that the long-term RWMG also include the Cities of Atwater and Livingston in the governance structure (current governance structure is temporary).

Mokelumne/Amador/Calaveras

In 2005, the Upper Mokelumne River Watershed Authority (UMRWA), a joint powers authority made up of nine member agencies, was appointed as the RWMG for the MAC region. UMRWA is responsible for the planning, development, and implementation of the region's IRWM plan. The board advisory committee, established by UMRWA, performs a prescribed set of functions related to the regional planning process and development of the IRWM plan.

Tuolumne-Stanislaus

The RWMG includes 14 agencies within the region. The RWMG adopted an IRWM plan development governance structure with governance principles, a financial agreement, and an MOU. The governance body of the IRWM plan development process is the PGC, which is comprised of all entities that have executed the MOU. PGC members include the majority of water management agencies and most of the land and resource management agencies within the region. The RWMG is a component of the members of the PGC, but does not hold separate decision-making authority or meet independently.

Westside-San Joaquin

The San Luis and Delta-Mendota Water Authority consists of 32 member agencies and is responsible for the planning and implementation of the region's IRWM plan. The governing body of the water authority consists of a 19-member board of directors, which is supported by standing committees that synthesize various technical and policy issues and make recommendations for the board's consideration.

East Stanislaus

In 2011, the Cities of Modesto, Hughston, Ceres, and Turlock signed an MOU, which formed the East Stanislaus Regional Water Management Partnership (ESRWMP). The ESRWMP acts as the lead voice in the IRWM plan development and implementation and receives support from the steering committee, the public advisory committee, and the general public. The steering committee, comprised generally of those that are actively managing projects, leads preparation and implementation of the IRWM plan and manages the work.

Resource Management Strategies

Volume 3, *Resource Management Strategies*, contains detailed information on the various strategies which can be used by water managers to meet their goals and objectives. A review of the resource management strategies addressed in the available IRWM plans is summarized in Table SJR-31.

Conjunctive Management and Groundwater Storage

Conjunctive management, or conjunctive use, refers to the coordinated and planned use and management of both surface water and groundwater resources to maximize the availability and reliability of water supplies in a region to meet various management objectives. Managing both resources together, rather than in isolation, allows water managers to use the advantages of both resources for maximum benefit.

A DWR/ACWA survey was undertaken in 2011 and 2012 to inventory and assess conjunctive management projects in California. Box SJR-2 is a summary of the inventory effort.

The DWR/ACWA survey identified 89 agencies or programs that operate conjunctive management or groundwater recharge programs in California of which five projects are in the San Joaquin River Hydrologic Region: Stockton East Water District, Northeastern San Joaquin

Table SJR-31 Resource Management Strategies Addressed in IRWM Plans in the San Joaquin River Hydrologic Region

Resource Management Strategy	American River Basin	CABY	East Contra Costa County	Eastern San Joaquin	Madera	Merced	MAC	Tuolumne-Stanislaus	Westside-San Joaquin	East Stanislaus
Agricultural Water Use Efficiency	X	X	X	X	X	X	X	X	X	X
Urban Water Use Efficiency	X	X	X	X	X	X	X	X	X	X
Flood Management	X	X	X		X	X	X	X	X	X
Conveyance – Delta			X	X					X	
Conveyance – Regional/Local		X	X	X	X	X	X	X	X	X
System Reoperation		X	X	X	X	X	X	X		X
Water Transfers		X	X	X		X	X	X	X	X
Conjunctive Management and Groundwater	X	X	X	X	X	X	X	X	X	X
Desalination - Brackish Water and Seawater			X							

Resource Management Strategy	American River Basin	CABY	East Contra Costa County	Eastern San Joaquin	Madera	Merced	MAC	Tuolumne-Stanislaus	Westside-San Joaquin	East Stanislaus
Precipitation Enhancement							X			X
Recycled Municipal Water	X	X	X	X	X	X	X	X	X	X
Surface Storage – CALFED			X			X				
Surface Storage – Regional/Local		X	X	X	X	X	X	X	X	X
Drinking Water Treatment and Distribution	X	X	X	X		X	X	X		X
Groundwater/ Aquifer Remediation	X			X	X	X	X			X
Match Water Quality to Use	X		X	X		X	X	X		X
Pollution Prevention	X	X	X	X		X	X	X	X	X
Salt and Salinity Management	X	X	X			X	X			X

Resource Management Strategy	American River Basin	CABY	East Contra Costa County	Eastern San Joaquin	Madera	Merced	MAC	Tuolumne-Stanislaus	Westside-San Joaquin	East Stanislaus
Urban Stormwater Runoff Management	X	X	X			X	X	X	X	X
Agricultural Lands Stewardship		X	X		X	X	X	X		X
Ecosystem Restoration	X	X	X	X	X	X	X	X	X	X
Forest Management		X			X	X	X	X		X
Land Use Planning and Management		X	X	X	X	X	X	X		X
Recharge Area Protection			X	X		X	X	X		X
Watershed Management	X		X	X	X	X	X	X	X	X
Economic Incentives - Loans, Grants, and Water Pricing	X	X	X	X		X	X	X	X	X
Water-Dependent Recreation	X		X	X		X	X	X	X	X

Notes:

Information of the Yosemite-Mariposa and Southern Sierra IRWM plans was not available for Update 2013.

CABY= Consumes, American, Bear, Yuba; MAC= Mokelumne/Amador/Calaveras

Box SJR-2 Statewide Conjunctive Management Inventory Effort in California

The effort to inventory and assess conjunctive management projects in California was conducted through literature research, personal communication, and documented summary of the conjunctive management projects. The information obtained was validated through a joint California Department of Water Resources – Association of California Water Agencies (DWR/ACWA) survey. The survey requested the following conjunctive use program information:

1. Location of conjunctive use project.
2. Year project was developed.
3. Capital cost to develop the project.
4. Annual operating cost of the project.
5. Administrator/operator of the project.
6. Capacity of the project in units of acre-feet.

To build on the DWR/ACWA survey, DWR staff contacted by telephone and e-mail the entities identified to gather the following additional information:

1. Source of water received.
2. Put and take capacity of the groundwater bank or conjunctive use project.
3. Type of groundwater bank or conjunctive use project.
4. Program goals and objectives.
5. Constraints on development of conjunctive management or groundwater banking (recharge) program.

Statewide, 89 conjunctive management and groundwater recharge programs were identified. Conjunctive management and groundwater recharge programs that are in the planning and feasibility stage are not included in the inventory.

County GBA, Madera Ranch Water Bank, Madera Irrigation District, and Root Creek Water District.

Stockton East Water District (SEWD) began the Farmington Groundwater Recharge Program in 2003 in the Eastern San Joaquin groundwater subbasin. The Farmington Program has a recharge capacity of approximately 35,000 af/yr. using surface spreading basins for direct percolation. SEWD also has an in-lieu groundwater recharge program. SEWD receives approximately 50,000 af of water from the CVP and approximately 31,500 af of water from local surface water sources. SEWD recharges 5,500 af of surface water annually with a total possible capacity of about 50,000 af. The extraction volume is estimated to be 300 af annually, with dry-year take up to 3,500 af. In-lieu recharge is estimated to be 76,000 af annually and 630,000 af cumulatively, while cumulative extraction volume from SEWD's in-lieu program is estimated to be 1.26 maf. SEWD indicates that the goals and objectives of its recharge program include reversing groundwater overdraft and salinity intrusion, addressing water quality protection, meeting climate change challenges, and providing a sustainable water supply. The most significant constraints identified by SEWD are regulatory and cost issues. Moderate constraints include political, legal, and institutional issues, while limited aquifer storage and water quality are identified as minimal constraints. The Northeastern San Joaquin County GBA partners with SEWD on its groundwater recharge programs.

Limited information was provided by Root Creek Irrigation District about its in-lieu groundwater recharge program. The only notable information available is annual recharge volume of 6,000 af.

The Madera Ranch Water Bank, operated by Madera Irrigation District, indicates that its program goals and objectives are to integrate groundwater recharge with flood management. The estimated capacity of the program's direct percolation and in-lieu recharge effort is 250,000 af. More details about this project are provided in the following section.

More details on the conjunctive management survey results is available online from Update 2013, the Volume 4, *Reference Guide,* article, "California's Groundwater Update 2013." Additional information regarding conjunctive management in California as well as discussion on associated benefits, costs, and issues can be found online from Update 2013, Volume 3, Chapter 9, "Conjunctive Management and Groundwater."

Regional Resource Management Strategies

Central Valley Salinity Alternatives for Long-Term Sustainability

Throughout the Central Valley, participating in the development of salt and nitrate management plans is very important to improving water quality in the region and providing for a sustainable economic and environmental future. CV-SALTS is a strategic initiative to address problems with salinity and nitrates in the surface and groundwater of the Central Valley. See more discussion about this initiative under "Implementation Activities (2009-2013)" subhead above.

Groundwater Quality Protection Strategy

To protect groundwater quality, CVRWQCB recommends the following actions:

- Develop salt and nutrient management plan.
- Implement groundwater quality monitoring program.
- Implement groundwater protection programs through IRWM plan groups.
- Broaden public participation in all programs.
- Coordinate with local agencies to implement a well design and destruction program.
- Create a groundwater database.
- Develop alternative dairy waste disposal methods.
- Develop individual and general orders for Poultry, Cattle Feedlots and other types of Concentrated Animal Feeding Operations.
- Implementation of Long-term Irrigated Lands Regulatory Program.
- Coordinate with California Department of Food and Agriculture to identify methods to enhance fertilizer program.
- Reduce site cleanup backlog.
- Draft waiver following new regulation adopted based on AB 885 (passed in 2000 and requires SWRCB to adopt regulations or standards for the operation of on-site wastewater treatment systems.
- Update guidelines for waste disposal for land developments consistent with the Water Quality Control Policy for Siting, Design, Operation and Maintenance of Onsite Wastewater

Treatment Systems (State Water Board Resolution 2012-0032 adopted in compliance with CWC Section 13291)

Salt and Salinity Management

In March 2010, a memorandum of agreement was finalized between CVRWQCB, Central Valley Salinity Coalition (a legal stakeholder entity), and SWRCB that documents the roles and responsibilities of the parties to coordinate salinity planning, management and regulation throughout the Central Valley in order to insure a sustainable future. SWRCB provided $5 million in seed money that is being matched by stakeholder contributions. Some activities completed to date to help develop a sustainable salt and nitrate management plan include: pilot studies to document water balances and salt and nitrate source and fate (between 2009 and 2011); initiation of a management practices tool box that assists dischargers in identifying practices that will help reduce salt and nitrate impacts (2010); initiation of a conceptual model to prioritize management areas for detailed study and implementation plans (2012); and development of a long-term funding plan (2012).

South of Delta SWP/CVP Aqueduct Intertie

A shared federal-State water system improvement project, the Intertie connects the Delta-Mendota Canals (federal facility) and the California Aqueduct (State facility) and pumping station via two 108-inch-diameter pipes. Jones Pumping Plant and the Delta-Mendota canals are the primary federal water delivery facilities that provide water to Central Valley Operations (CVP) contractors south of the Bay-Delta. The Intertie provides redundancy in the water distribution system, allows for maintenance and repair activities that are less disruptive to water deliveries, and provides the flexibility to respond to CVP and SWP emergencies. The contract was awarded in July 2010, and construction was completed in April 2012.

The Intertie will primarily be used in the fall and winter to fill the CVP's San Luis Reservoir earlier in the year to support South-of-Delta allocations. On a long-term annual average basis the Intertie is expected to provide a 35,000 af increase in CVP deliveries.

The Intertie cost $29 million, which includes planning, design, permitting, mitigation, and construction management in addition to the pumping plant and transmission line construction cost. The Intertie was constructed using American Recovery and Reinvestment Act and other federally appropriated funds, as well as water user-contributed funds. Federal costs are being recovered from water contractors who benefit according to Reclamation rate-setting policy. (Visit http://www.usbr.gov/mp/PA/docs/fact_sheets/Aquaduct_Delta_Mendota_Intertie.pdf.)

Madera Ranch Water Bank

Farmers in the Madera Irrigation District service area use a combination of groundwater and surface water. During dry years, surface water is no adequate to meet water demand, and groundwater pumping increases substantially. The amount of groundwater that has been pumped from the aquifer in the vicinity of Madera Ranch has exceeded the amount of water that has recharged the aquifer, resulting in groundwater overdraft. Even in wet years, the groundwater basin is in severe overdraft because groundwater pumping is steadily increasing for agricultural use as well as municipal and industrial use. This overdraft has caused the water table to decline and groundwater quality to degrade and has resulted in excess space in the aquifer that could be used to bank surface water (U.S. Bureau of Reclamation 2011).

In the vicinity of Madera Ranch, the water table has declined more than 90 feet over the last 60 years. These conditions have made it increasingly expensive for farmers to pump groundwater. Additionally, in many years, the Madera Irrigation District has been unable to deliver sufficient surface water to farmers because water is available primarily during the early months of the year when irrigation demand is low, and often water is available only for short periods of time during the growing season (U.S. Bureau of Reclamation 2011).

In 2005 the Madera Irrigation District acquired the 13,000 acre+ Madera Ranch property that will be used for groundwater banking. The Madera Ranch Water Bank will be able to store up to 250,000 af with recharge/recovery rates of up to 55,000 af/yr. The majority of the recharge will be through natural swales and existing unlined canals. Only 323 acres of conventional recharge basins will be built for the project. The purposes of the project are to enhance water supply reliability and flexibility, reduce groundwater overdraft, reduce groundwater pumping costs, improve groundwater quality, and encourage conjunctive use (Madera Irrigation District Press Release 8/2/2011).

Grasslands Bypass

The Grasslands Bypass Project was established to implement the basin plan selenium-control program for the San Joaquin River. The project routes subsurface agricultural drainage water with elevated levels of selenium, salts, and other constituents of concern away from wildlife refuges and wetlands. The goal is to reduce and reuse high selenium subsurface agricultural drainage to comply with the basin plan load limits for the San Joaquin River and its tributaries.

Between 1998 and 2009, best management practices implemented by Grasslands Area Farmers prevented more than 22,300 pounds of selenium and 80,735 af of drainage from discharging to waters. These load reductions brought Salt Slough into compliance with the 2.0 µg/L selenium monthly mean objective, and reduced selenium loading in the lower San Joaquin River below the four-day average of 5.0 µg/L. As a result, California removed several water bodies from its impaired waters list, including Salt Slough (10 miles) in 2008 and three segments (a combined 40.4 miles) of the San Joaquin River — Merced River to Tuolumne River (29 miles), Tuolumne River to Stanislaus River (8.4 miles), and Stanislaus River to the Delta Boundary (3 miles)—in 2010 (U.S. Environmental Protection Agency 2011).

Although the Grasslands Bypass Project has made significant progress, additional work is required to achieve the ultimate project goal of zero discharge. To this end, USBR signed a record of decision on December 22, 2009, for the Grassland Bypass Project to execute a new use agreement with the San Luis and Delta Mendota Water Authority for continued use of the San Luis Drain from January 1, 2010, through December 31, 2019.

Climate Change

For over two decades, the State and federal governments have been preparing for climate change effects on natural and built systems with a strong emphasis on water supply. Climate change is already impacting many resource sectors in California, including water, transportation, and energy infrastructure, public health, biodiversity, and agriculture (U.S. Global Change Research Program 2009; California Natural Resources Agency 2009). Climate model simulations based on the Intergovernmental Panel on Climate Change's 21st Century scenarios project increasing temperatures in California, with greater increases in the summer (Intergovernmental Panel on

Climate Change 2013). Projected changes in annual precipitation patterns in California will result in changes to surface runoff timing, volume, and type (Cayan 2008). Recently developed computer downscaling techniques (model simulations that refine computer projections to a scale smaller than global models) indicate that California flood risks from warm-wet, atmospheric river-type storms may increase beyond those that we have known historically, mostly in the form of occasional more-extreme-than-historical storm seasons (Dettinger 2011).

Enough data currently exists to warrant the importance of contingency plans, mitigation (i.e., reduction) of greenhouse gas (GHG) emissions, and incorporation of adaptation strategies (i.e., methodologies and infrastructure improvements that benefit the region at present and into the future). While the State is taking aggressive action to mitigate climate change through reducing emissions from greenhouse gases and implementing other measures (California Air Resources Board 2008), global impacts from carbon dioxide and other GHGs that are already in the atmosphere will continue to impact climate through the rest of the century (Intergovernmental Panel on Climate Change 2013).

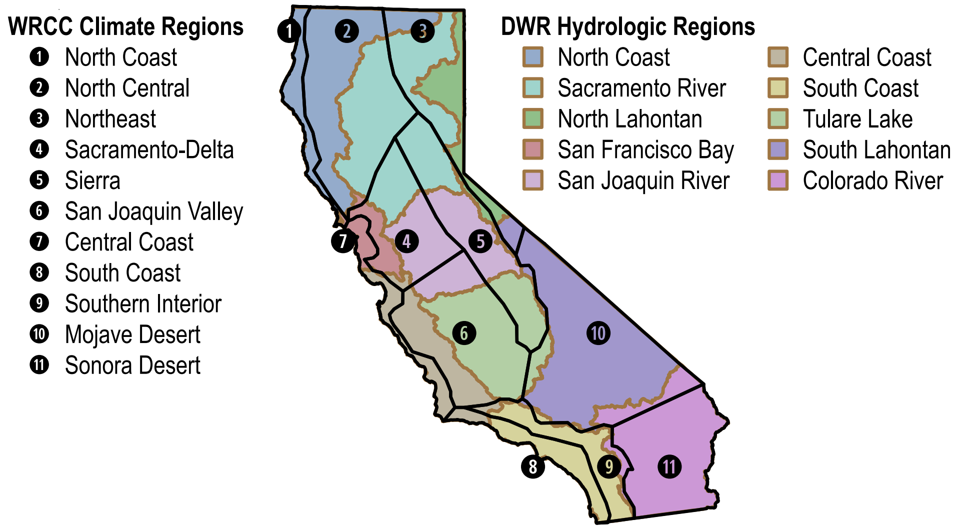
Resilience to an uncertain future can be achieved by implementing adaptation measures sooner rather than later. Due to the economic, geographical, and biological diversity of the state, vulnerabilities and risks due to current and future anticipated changes are best assessed on a regional basis. Many resources are available to assist water managers and others in evaluating their region-specific vulnerabilities and identifying appropriate adaptive actions (U.S. Environmental Protection Agency and California Department of Water Resources 2011; California Emergency Management Agency and California Natural Resources Agency 2012). The most comprehensive report to date on climate change observations, impacts and projections for the southwestern United States, including California, is *The Assessment of Climate Change in the Southwest United States* (Garfin et al. 2013).

Observations

The region's observed temperature and precipitation vary greatly due to complex topography and relation to the Pacific Ocean. Regionally specific air temperature trends for the past century are available from the Western Regional Climate Center (Western Regional Climate Center 2013). The WRCC acts as a repository of historical climate data and information. Air temperature records for the past century were summarized by the WRCC into distinct climate regions (Abatzoglou et al. 2009). DWR's hydrologic regions do not correspond directly to WRCC's climate regions. A particular hydrologic region may overlap more than one WRCC climate region, and hence have different climate trends in different areas. For the purposes of this regional report, however, climate trends within climate regions are considered to be relevant trends for respective portions of this hydrologic region (Figure SJR-43).

The San Joaquin River Hydrologic Region overlaps with three WRCC regions — the Sierra, Sacramento-Delta, and San Joaquin Valley. Temperatures in the WRCC Sacramento-Delta region during the period of record indicate that a mean increase of about 1.5-2.4 °F (0.9 -1.3 °C) has occurred, with minimum values increasing more than maximums (2.1-3.1 °F [1.2-1.7 °C] and 0.8-2.0 °F [0.4-1.1 °C], respectively). Temperatures in the WRCC San Joaquin Valley region show a similar trend. A mean increase of 0.9-1.9 °F (0.5-1.1 °C) was recorded, with minimum temperatures increasing 2-3 °F (1.1-1.7 °C) compared to the mean maximum temperature trend, which was relatively stable. The WRCC Sierra region also had an increasing mean temperature

Figure SJR-43 DWR Hydrologic and Western Region Climate Center Climate Regions



Note: The Western Region Climate Center (WRCC) divides California into 11 separate climate regions, and generates historic temperature time-series and trends for these regions (http://www.wrcc.dri.edu/monitor/cal-mon/frames_version.html). DWR maintains 10 hydrologic regions, with the Delta and Mountain Counties being overlays of other DWR hydrologic regions. Each DWR hydrologic region spans one or more of the WRCC climate regions.

trend of 0.8-2.0 °F (0.5-1.1 °C), and again more warming was observed at night than in daytime (1.7-2.8 °F [0.9-1.5 °C] compared to -0.2-1.3 °F [-0.1-0.7 °C]).

The San Joaquin River Hydrologic Region also is currently experiencing impacts from climate change through changes in statewide precipitation and surface runoff volumes, which in turn affect availability of local and imported water supplies. During the last century, the average early snowpack in the Sierra Nevada decreased by about 10 percent, which equates to a loss of 1.5 maf of snowpack storage (California Department of Water Resources 2008).

Projections and Impacts

Although historical data is a measured indicator of how the climate is changing, it can't project what future conditions may be like under different GHG emissions scenarios. Current climate science uses modeling methods to simulate and develop future climate projections. A recent study by Scripps Institution of Oceanography uses the most sophisticated methodology to date, and indicates that by 2060-2069, temperatures will be 3.4-4.9 °F (1.9-2.7 °C) higher across the state than they were from 1985 to 1994 (Pierce et al. 2012). By 2060-2029, the annual mean temperature in the San Joaquin River region is projected to increase by 4.1 °F (2.3 °C) for the annual mean, with an increase of 3.2 °F (1.8 °C) in mean winter temperatures and 5.2 °F (2.9 °C) in summer. Two or three additional heat waves, defined as five days with temperatures more than 102 °F, are expected annually by 2050, with five to eight more by 2100 (California Emergency Management Agency and California Natural Resources Agency 2012). Climate projections for the San Joaquin region from Cal-Adapt indicate that the temperatures between 1990 and 2100 are projected to increase 7-10 °F (3.9-5.6 °C) during winter and 9-11 °F (5-6.1 °C) during summer (California Emergency Management Agency and California Natural Resources Agency 2012b).

Changes in precipitation across California due to climate change could result in changes in type of precipitation (rain or snow) in a given area, in timing or total amount, and in surface runoff timing and volume. Precipitation projections from climate models for California are not all in agreement, but most anticipate drier conditions in the southern part of California, with heavier and warmer winter precipitation in the north (Pierce et al. 2012). Because there is less scientific detail on localized precipitation changes, there is a need to adapt to this uncertainty at the regional level (Qian et al. 2010).

The Sierra Nevada snowpack is projected to continue to decline as warmer temperatures raise the elevation of snow levels, reduce spring snowmelt, and increase winter runoff. Based upon historical data and modeling, researchers at Scripps Institution of Oceanography project that, by the end of this century, the Sierra snowpack will experience a 48 to 65 percent loss from its average at the end of the previous century (Pierce and Cayan 2013). Snowmelt dominated watersheds in the region will each have a unique snowmelt response depending on elevation and the amount of warming that occurs. Climate projections indicate that temperatures may continue to rise through the end of the century, diminishing April 1 snowpack (Table SJR-32). DWR projects that with a 1.8 °F (1 °C) rise, the Stanislaus and Tuolumne basins April 1st snow covered area drops from 60 percent to 55 percent and 54 percent, respectively (2006). The San Joaquin basin drops from 72 percent to 67 percent. A projected temperature rise of 9 °F (5 °C) would leave the San Joaquin basin with 43 percent snow covered area and the Stanislaus basin with 26 percent, while the Cosumnes basin would drop from a current average April 1st snow covered area of 25 percent down to 1 percent.

A recent study that explores future climate change and flood risk in the Sierra using downscaled simulations (computer projections refined to a scale smaller than global models), from three global climate models (GCMs) under a GHG scenario which is reflective of current trends, indicates a tendency toward increased 3-day flood magnitude. By the end of the 21st century, all three projections yield larger floods for both the moderate elevation northern Sierra Nevada watershed and for the high elevation southern Sierra Nevada watershed — even for GCM simulations with 8 percent to 15 percent declines in overall precipitation. The increases in flood magnitude are statistically significant for all three GCMs for the period 2051–2099. By the end of the 21st century, the magnitudes of the largest floods are projected to increase to 110 percent to 150 percent of historical magnitudes. These increases appear to derive jointly from increases in heavy precipitation amount, storm frequencies, and days with more precipitation falling as rain and less as snow (Das et al. 2011). In addition, earlier seasonal flows will reduce the flexibility in how the state manages its reservoirs to protect communities from flooding while ensuring a reliable water supply.

Changes in climate and runoff patterns may create increased competition among sectors that utilize water. Currently, Delta pumping restrictions are in place to protect endangered aquatic species. Climate change is likely to further constrain the management of these endangered species and the State's ability to provide water for other uses. Environmental water supplies would need to be retained in reservoirs for managing instream flows to maintain habitat for aquatic species throughout the dry season. For the San Joaquin region, this would further reduce supplies available for import through the SWP during the non-winter months (Cayan 2008; Hayhoe et al. 2004).The region is economically dependent on the thriving agricultural industry, which

Table SJR-32 San Joaquin River Hydrologic Region Snow Covered Area Changes with Temperature

Basin	Mean Elevation (ft)	Average April 1 Snow Line (ft)	Total Area (sq. mi)	Snow Covered Area	1 °C (1.8 °F) Rise	2 °C (3.6 °F) Rise	3 °C (5.4 °F) Rise	4 °C (7.2 °F) Rise	5 °C (9 °F) Rise
				SNOW COVERAGE IN PERCENT OF BASIN					
Cosumnes	3,100	4,500	530	25	15	9	6	3	1
Mokelumne	5,030	5,000	575	50	43	38	31	26	20
Stanislaus	5,530	5,000	935	60	55	48	42	33	26
Tuolumne	5,960	5,000	1,530	60	54	49	44	39	35
Merced	5,470	5,500	1,020	47	43	42	38	32	26
San Joaquin	7,130	5,500	1,640	72	67	62	57	49	43

Source: California Department of Water Resources 2006.

would be affected by a more variable hydrologic regime, reduced chill-hours in winter, increased evapotranspiration, and other indirect effects of rising temperatures (Hayhoe et al. 2004). In some instances, a longer growing season will be beneficial, but productivity of stone-fruit and nut trees may decline. The dairy industry will be affected by an anticipated increase in extreme heat days and reduced water availability (California Natural Resources Agency 2013). Agricultural water use efficiency would become increasingly important under these conditions.

Additional climate change impacts will occur in surrounding watersheds. Influenced by an earlier arrival of spring, wildfires in western U.S. forests will likely increase in number and intensity (Westerling 2008) and negatively impacting habitat and water quality. Under a high GHG emissions scenario, as much as a 300-400 percent increase in burned area is projected for the upper watershed and lower foothills in the region by 2085 (Westerling 2009).

Another potential climate change impact from increasing temperatures is that net evaporation from reservoirs is projected to increase by 15 to 37 percent (Medellin-Azuara et al. 2009).

Adaptation

Climate change has the potential to impact the region, which the state depends upon for its economic and environmental benefits. These changes would increase the vulnerability of natural and built systems in the region. Impacts to natural systems will challenge aquatic and terrestrial species with diminished water quantity and quality, and shifting ecoregions. Built systems would be impacted by changing hydrology and runoff timing, loss of natural snowpack storage, making the region more dependent on surface storage in reservoirs and groundwater sources. Increased future water demand for both natural and built systems may be particularly challenging with less natural storage and less overall supply.

The San Joaquin River Hydrologic Region contains a diverse landscape with different climate zones, making it difficult to find one-size-fits-all adaptation strategies. Water managers and local agencies must work together to determine the appropriate planning approach for their operations and communities. While climate change adds another layer of uncertainty to water planning, it does not fundamentally alter the way water managers already address uncertainty (U.S. Environmental Protection Agency and California Department of Water Resources 2011). However, stationarity (the idea that natural systems fluctuate within an unchanging envelope of variability) can no longer be assumed, so new approaches will likely be required (Milly et al. 2008).

IRWM planning is a framework that allows water managers to address climate change on a smaller, more regional scale. Climate change is now a required component of all IRWM plans, and IRWM regions should begin addressing climate change by performing a vulnerability assessment (California Department of Water Resources 2010b, 2012). This assessment will help each IRWM region to identify and prioritize their specific vulnerabilities and identify adaptation strategies that are most appropriate for each region and sub-regions. Planning strategies to address vulnerabilities and adaptation to climate change should be both proactive and adaptive, starting with strategies that benefit the region in the present-day while adding future flexibility and resilience under uncertainty.

Local agencies, as well as federal and State agencies, face the challenge of interpreting climate change data and determining which methods and approaches are appropriate for their planning needs. The *Climate Change Handbook for Regional Water Planning* (U.S. Environmental Protection Agency and California Department of Water Resources 2011) provides an analytical framework for incorporating climate change impacts into a regional and watershed planning process and considers adaptation to climate change. This handbook provides guidance for assessing the vulnerabilities of California's watersheds and regions to climate change impacts, and prioritizing these vulnerabilities.

The State has developed additional tools and resources to assist resource managers and local agencies in adapting to climate change, including:

- *Safeguarding California: Reducing Climate Risk, An Update to the 2009 California Climate Adaptation Strategy, Public Draft (2013)* - California Natural Resources Agency at http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf.
- *California Climate Change Adaptation Planning Guide (2012)* - California Emergency Management Agency and California Natural Resources Agency at http://resources.ca.gov/climate_adaptation/local_government/adaptation_planning_guide.html.
- Cal-Adapt Web *site* at http://cal-adapt.org/.
- Urban Forest Management Plan Toolkit - sponsored by the California Department of Forestry and Fire Management at http://ufmptoolkit.com/.
- California Climate Change Portal at http://www.climatechange.ca.gov/.
- *DWR Climate Change Web site* at http://www.water.ca.gov/climatechange/resources.cfm.
- The Governor's Office of Planning and Research Web site at http://www.opr.ca.gov/m_climatechange.php.

Several of the resource management strategies from Update 2013 (Volume 3) provide benefits for adapting to climate change in addition to meeting water management objectives in the San Joaquin River region. These include:

- Chapter 2, "Agricultural Water Use Efficiency."
- Chapter 3, "Urban Water Use Efficiency."
- Chapter 4, "Flood Management."
- Chapter 6, "Conveyance — Regional/Local."
- Chapter 7, "System Reoperation."
- Chapter 9, "Conjunctive Management and Groundwater Storage."
- Chapter 11, "Precipitation Enhancement."
- Chapter 14, "Surface Storage — Regional/Local."
- Chapter 18, "Pollution Prevention."
- Chapter 21, "Agricultural Land Stewardship."
- Chapter 22, "Ecosystem Restoration."
- Chapter 23, "Forest Management."
- Chapter 24, "Land Use Planning and Management."
- Chapter 25, "Recharge Area Protection."
- Chapter 27, "Watershed Management."

The myriad of resources and choices available to managers can seem overwhelming, and the need to take action given uncertain future conditions is daunting. However, there are many actions that water managers in the San Joaquin River region can take to prepare for climate change, regardless of the magnitude of future warming. These actions often provide economic and public health co-benefits. Water and energy conservation are examples of strategies that make sense with or without the additional pressures of climate change. Promoting healthy urban forests can reduce the urban heat island effect by decreasing ambient air temperature. Restoration of flood control and riparian corridors is an important adaptation strategy for both water management flexibility and ecosystem protection. Conjunctive management projects that manage surface water and groundwater in a coordinated fashion could provide a buffer against variable annual water supplies. Forecast-coordinated operations would provide flexibility for water managers to respond to weather conditions as they unfold.

Regardless of the specific strategies selected, increased coordination across sectors will be imperative for successful climate adaptation. Water managers will need to consider both the natural and built environments as they plan for the future. Stewardship of natural areas and protection of biodiversity are critical for maintaining ecosystem services important for human society such as carbon sequestration, storm-water pollution remediation, as well as habitat for pollinators of the natural and agricultural landscapes. Increased cross-sector collaboration between water managers, land use planners, and ecosystem managers provides opportunities for identifying common goals and actions needed to achieve resilience to climate change and other stressors (Sierra Nevada Alliance 2011).

Mitigation

California's water sector consumes about 12 percent of total statewide energy (19 percent of statewide electricity, about 32 percent of statewide natural gas, and negligible amounts of crude oil). As shown in Figure 3-28, "Energy Use Related to Water" (Volume 1), water conveyance and extraction accounts for about 2 percent of energy consumption in the state, with 10 percent of total statewide energy use attributable to end-users of water (California Energy Commission 2005, 2013; California Public Utilities Commission 2010). Energy is used in the water sector to extract, convey, treat, distribute, use, condition, and dispose of water and wastewater. Figure 3-29, "Water and Energy Connection" (Volume 1) shows all of the connections between water and energy in the water sector; both water use for energy generation and energy use for water supply activities. The regional reports in Update 2013 are the first to provide detailed information on the water-energy connection, including energy intensity (EI) information at the regional level. EI information is designed to help inform the public and water utility managers about the relative energy requirements of the major water supplies used to meet demand. Since energy usage is closely related to GHG emissions, this information can support measures to reduce GHG, as mandated by the State.

Figure SJR-44 Energy Intensity per Acre-Foot of Water

Type of Water	Energy Intensity (= 1-250 kWh/AF = 251-500 kWh/AF)	Percent of Regional Water Supply*
Colorado (Project)	*This type of water not available*	0%
Federal (Project)	<250 kWh/AF	16%
State (Project)		<1%
Local (Project)	<250 kWh/AF	29%
Local Imports	*This type of water not available*	0%
Groundwater	<250 kWh/AF	31%

Energy intensity (EI) in this figure is the estimated energy reuired for the extraction and conveyance of one acre-foot of water. This figure reflects only the amount of energy needed to move from a supply source to a centralized delivery location ,not all the way to the point of use. Small light bulbs are for EI greater than zero, and less than 250 kilowatt hours per acre-foot (kWh/af). Large light bulbs represent 251-500 kWh/af of water (e.g., four light bulbs indicate that the water source has EI between 1,501-2,000 kWh/af).

*The percent of regional water supply may not add up to 100% because not all water types are shown in this figure EI values of Desalinated and Recycled Water are covered in Volume 3, *Resource Management Strategies*. For detailed descriptions of the methodology used to calculate EI in this figure, see Volume 5, *Technical Guide*.

Figure SJR-44, "Energy Intensity per Acre-Foot of Water," shows the amount of energy associated with the extraction and conveyance of one af of water for each of the major water sources in this region. The quantity of each water source used in the region is also included, as a percentage. For reference, only extraction and conveyance of raw water in Figure 3-29 "The Water and Energy Connection" in Volume 1, Chapter 3, "California Water Today," are illustrated in Figure SJR-44. Energy required for water treatment, distribution, and end uses of the water are not included. Not all water types are available in this region. Some water types flow mostly by gravity to the delivery location and may require little or no energy to extract and convey. As a default assumption, a minimum EI less than 250 kilowatt hours per acre foot (kWh/af) was assumed for all water types).

Box SJR-3 Energy Intensity

Energy Intensity (EI), as defined in *California Water Plan Update 2013*, is the amount of energy needed to extract and convey an acre-foot (af) of water from its source to a delivery location. Extraction refers to the process of moving water from its source to the ground surface. Many water sources are already at ground surface and require little or no energy for extraction, whereas others, such as groundwater or seawater for desalination, require energy to move the water to the surface. Conveyance refers to the process of moving water from a location at the ground surface to a different location. Conveyance can include pumping of water up and over hills and mountains or can occur via gravity. EI should not be confused with total energy — that is, the *amount* of energy (e.g., kilowatt hours [kWh]) required to deliver all of the water from a water source to customers within the region. EI focuses not on the total amount of energy used to deliver water to customers, but instead the portion of energy required to extract and convey a single unit of water (in kWh/af). In this way, EI gives a normalized metric that can be used to compare alternative water sources. (For detailed descriptions of the EI methodology and the delivery locations assumed for the water types presented, see Volume 5, *Technical Guide*).

In most cases, this information will not have sufficient detail for actual project-level analysis. However, these generalized, region-specific metrics provide a range in which energy requirements fall. The information can also be used in more detailed evaluations by using tools such as WeSim (http://www2.pacinst.org/publication/wesim/), which allows modeling of water systems to simulate outcomes for energy, emissions, and other aspects of water supply selection.

Although not identical, EI is closely related to greenhouse gas (GHG) emissions (for more information, see “Climate Change and the Water-Energy Nexus” in Volume 1, Chapter 3, “California Water Today”). On average in California, generation of 1 megawatt-hour (MWh) of electricity results in the emission of about one-third of a metric ton of GHG (eGrid 2012). This estimate takes into account all types of energy generation throughout the state and electricity imported to the state.

Reducing GHG emissions is a State mandate. Water managers can support this effort by considering EI in their decision-making process. It’s important to note that water supply planning must take into consideration myriad different factors in addition to energy impacts, such as public safety, water quality, firefighting, ecosystems, reliability, energy generation, recreation, and costs.

Accounting for Hydroelectric Energy

Generation of hydroelectricity is an integral part of many of the state’s large water projects. The State Water Project (SWP), Central Valley Project (CVP), Los Angeles Aqueduct, Mokelumne Aqueduct, and Hetch Hetchy Aqueduct all generate large amounts of hydroelectricity at large multi-purpose reservoirs at the heads of each system. In addition to hydroelectricity generation at head reservoirs, several of these systems also generate hydroelectric energy by capturing the power of water falling through pipelines at in-conduit generating facilities. In-conduit generating facilities refer to hydroelectric turbines placed along pipelines to capture energy as water runs downhill in a pipeline (conduit). Hydroelectricity is also generated at hundreds of smaller reservoirs and run-of-the-river turbine facilities.

Because of the many ways hydroelectric generation is integrated into water systems, accounting for hydroelectric generation in EI calculations is complex. In some systems, such as the SWP and CVP, water generates electricity and then flows back into the natural river channel after passing through the turbines. In other systems, such as the Mokelumne Aqueduct, water can leave the reservoir by two distinct outflows, one that generates electricity and flows back into the natural river channel, and one that does not generate electricity and flows into a pipeline leading to water users. In both situations, experts have argued that hydroelectricity should be excluded from EI calculations because the energy generation system and the water delivery system are, in essence, separate (Wilkinson 2000).

DWR has adopted this convention for its EI calculations. All hydroelectric generation at head reservoirs has been excluded. Consistent with Wilkinson (2000) and others, DWR has included in-conduit and other hydroelectric generation that occurs as a consequence of water deliveries, such as the Los Angeles Aqueduct’s hydroelectric generation at plants on the system downstream of the Owen’s River diversion gates. The California Department of Water Resources has made one modification to this methodology to simplify the display of results: energy intensity has been calculated at each main delivery point in the systems. If the hydroelectric generation in the conveyance system exceeds the energy needed for extraction and conveyance, the EI is reported as zero. That means no water system is reported as a net producer of electricity, even though several systems (e.g., Los Angeles Aqueduct, Hetch Hetchy Aqueduct) produce more electricity in the conveyance system than is used.

This methodology does not account for several unique benefits that hydroelectric generating facilities at reservoirs provide, including grid stabilization, back up for intermittent renewable energy sources, and large amounts of GHG free energy.

Recycled water and water from desalination used within the region are not show in Figure SJR-44 because their EI differs in important ways from those water sources. The EI of both recycled and desalinated water depend not on regional factors but rather on much more localized-, site-, and application-specific factors. Additionally, the water produced from recycling and desalination is typically of much higher quality than the raw (untreated) water supplies evaluated in Figure SJR-44. For these reasons, discussion of the EI of recycled and desalinated water are found separately in Volume 3, *Resource Management Strategies*. Energy Intensity is discussed in Box SJR-3.

References

References Cited

Abatzoglou JT, Redmond KT, Edwards LM. 2009. "Classification of Regional Climate Variability in the State of California." Journal of Applied Meteorology and Climatology, 48, 1527-1541.

Burow KR, Shelton JL, Dubrovsky NM. 2008. "Regional Nitrate and Pesticide Trends in Ground Water in the Eastern San Joaquin Valley, California." Journal of Environmental Quality 37:S-249-S-263. Viewed online at: http://www.ncbi.nlm.nih.gov/pubmed/18765770.

Burt C. 2011. *Characteristics of Irrigation Pump Performance in Major Irrigated Areas of California.* Sacramento (CA): California Energy Commission. 24 pp. Viewed online at: http://www.itrc.org/reports/pdf/characteristics.pdf.

California Air Resources Board. 2008. AB32 *Climate Change Scoping Plan.* Sacramento (CA): California Air Resources Board. California Environmental Protection Agency. 152 pp. Viewed online at: http://www.arb.ca.gov/cc/scopingplan/document/scopingplandocument.htm.

California Department of Water Resources. 1980. *Ground Water Basins in California: Bulletin 118-80.* Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 85 pp. Viewed online at: http://www.water.ca.gov/pubs/groundwater/bulletin_118/ground_water_basins_in_california__bulletin_118-80_/b118_80_ground_water_ocr.pdf.

———. 1988. *Water Temperature Effects on Chinook Salmon: With Emphasis on the Sacramento River.* Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 97 pp. Viewed online at: http://www.water.ca.gov/pubs/environment/fish/water_temperature_effects_on_chinook_salmon-emphasis_on_the_sacramento_river__a_literature_review/watertempeffecchinooksalmon.pdf.

———. 2003. *California's Groundwater - Bulletin 118, Update 2003*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 265 pp. Viewed online at: http://www.water.ca.gov/groundwater/bulletin118/bulletin118update2003.cfm.

———. 2006. *Progress on Incorporating Climate Change into Management of California's Water Resources.* Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. Viewed online at: http://baydeltaoffice.water.ca.gov/climatechange/DWRClimateChangeJuly06.pdf.

———. 2008. *Managing an Uncertain Future.* Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 34 pp. Viewed online at: http://www.water.ca.gov/climatechange/docs/ClimateChangeWhitePaper.pdf.

———. 2010a. *California's Drought of 2007-2009: An Overview*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 128 pp. Viewed online at: http://www.water.ca.gov/waterconditions/drought/docs/DroughtReport2010.pdf.

———. 2010b. *Proposition 84 & Proposition 1E Integrated Regional Water Management Guidelines.* Sacramento (CA): California Department of Water Recourses. California Natural Resources Agency. Viewed online at: http://www.water.ca.gov/irwm/grants/guidelines.cfm.

———. 2010c. *State Plan of Flood Control: Descriptive Document.* Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 154 pp. Viewed online at: http://www.water.ca.gov/cvfmp/docs/SPFCDescriptiveDocumentNov2010.pdf.

———. 2012. *2012 Central Valley Flood Protection Plan: A Path for Improving Public Safety, Environmental Stewardship, and Long-Term Economic Stability*. Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 192 pp. Viewed online at: http://www.water.ca.gov/cvfmp/docs/2012%20CVFPP_June.pdf.

California Department of Water Resources and California Department of Parks and Recreation. 2006. *Hetch Hetchy Restoration Study.* Sacramento (CA): California Department of Water Resources and California Department of Parks and Recreation. California Natural Resources Agency. 68 pp. Viewed online at: http://www.water.ca.gov/pubs/environment/hetch_hetchy_restoration_study/hetch_hetchy_restoration_study_report.pdf.

California Department of Water Resources and the U.S. Army Corps of Engineers. 2013a. *California's Flood Future: Recommendations for Managing the State's Flood Risk*. Final. Attachment C: History of Flood Management in California. Sacramento (CA): California Department of Water Resources and the U.S. Army Corps of Engineers. Viewed online at: http://www.water.ca.gov/sfmp/flood-future-report.cfm.

———. 2013b. *California's Flood Future: Recommendations for Managing the State's Flood Risk.* Final. Attachment E: Existing Conditions of Flood Management (Information in Gathering Findings). Sacramento (CA): California Department of Water Resources and the U.S. Army Corps of Engineers. Viewed online at: http://www.water.ca.gov/sfmp/flood-future-report.cfm.

———. 2013c. *California's Flood Future: Recommendations for Managing the State's Flood Risk.* Final. Nov 2013. Technical Attachment G: Risk Information Inventory. Sacramento (CA): California Department of Water Resources and the U.S. Army Corps of Engineers. Viewed online at: http://www.water.ca.gov/sfmp/resources.cfm#floodreport.

California Emergency Management Agency and California Natural Resources Agency. 2012a. *Adaptation Planning Guide for Local Governments.* Sacramento (CA): California Emergency Management Agency/California Natural Resources Agency. 60 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/local_government/adaptation_planning_guide.html.

California Energy Commission. 2005. *Integrated Energy Policy Report*. Sacramento (CA): California Energy Commission. 208 pp. Viewed online at: http://www.energy.ca.gov/2005publications/CEC-100-2005-007/CEC-100-2005-007-CMF.PDF.

———. 2013. *Integrated Energy Policy Report*. Sacramento (CA): California Energy Commission. 322 pp. Viewed online at: http://www.energy.ca.gov/2013publications/CEC-100-2013-001/CEC-100-2013-001-LCF.pdf.

California Natural Resources Agency. 2009. *California Climate Adaptation Strategy*. Sacramento (CA): California Natural Resources Agency. 200 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/Statewide_Adaptation_Strategy.pdf.

———. 2013. *Safeguarding California: Reducing Climate Risk. An Update to the 2009 California Climate Adaptation Strategy (Public Draft)*. Sacramento (CA): California Natural Resources Agency. 289 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf.

California Public Utilities Commission. 2010. *Embedded Energy in Water Studies, Studies 1, 2, and 3.* Sacramento (CA): California Public Utilities Commission. Prepared by GEI Consultants and Navigant Consulting, Inc. Viewed online at: http://www.cpuc.ca.gov/PUC/energy/Energy+Efficiency/EM+and+V/Embedded+Energy+in+Water+Studies1_and_2.htm.

California Urban Water Conservation Council. 2011. *Memorandum of Understanding Regarding Urban Water Conservation in California.* Sacramento (CA): California Urban Water Conversation Council. 83 pp. Viewed online at: http://www.cuwcc.org/WorkArea/showcontent.aspx?id=18274.

Cayan DR, Maurer EP, Dettinger MD, Tyree M, and Hayhoe K. 2008. "Climate Change Scenarios for the California Region." Climatic Change. 87: 21-42 pp. [Journal.] Viewed online at: http://tenaya.ucsd.edu/~dettinge/cccc08_scenarios.pdf.

Central Valley Regional Water Quality Control Board. 1999. *Selenium TMDL for Salt Slough*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 10 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/salt_slough_se/index.shtml.

———. 2000. *Selenium TMDL for Grasslands Marshes.* Sacramento (CA): Central Valley Water Quality Control Board. 14 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/grasslands_se/index.shtml.

———. 2001. *Total Maximum Daily Load for Selenium in the Lower San Joaquin River*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 40 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/san_joaquin_se/se_tmdl_rpt.pdf.

———. 2004. *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Salt and Boron Discharges into the Lower San Joaquin River*. Sacramento (CA): Central Valley Water Quality Control Board. 122 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/vernalis_salt_boron/staffrptdec04.pdf.

———. 2005a. *Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control Program for Factors Contributing to the Dissolved Oxygen Impairment in the Stockton Deep Water Ship Channel*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 104 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/san_joaquin_oxygen/final_staff_report/do_tmdl_final_draft.pdf.

———. 2005b. *Amending the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the San Joaquin River*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 34 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/resolutions/r5-2005-0138.pdf.

———. 2006. *Amendment to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins for the Control of Diazinon and Chlorpyrifos Runoff into the Sacramento-San Joaquin Delta.* Sacramento (CA): Central Valley Regional Water Quality Control Board. 129 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/delta_op_pesticide/draft_amendment_report/del_dc_bpa_rpt_pub.pdf.

———. 2008. *Total Maximum Daily Load Report for Pathogens in: Five-Mile Slough, Lower Calaveras River, Mormon Slough, Mosher Slough, Smith Canal and Walker Slough*. San Joaquin County (CA): Central Valley Regional Water Quality Control Board. California Environmental Protection Agency. 42 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/central_valley_projects/stockton_urban_do_pathogen/march08_final_pathtmdl_stfrpt.pdf.

———. 2010. *Groundwater Quality Protection Strategy. A "Roadmap" for the Central Valley Region*. Sacramento (CA): Central Valley Regional Water Quality Control Board. California Environmental Protection Agency. 100 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/groundwater_quality/2010aug_gwq_protect_strat_approved.pdf.

———. 2011a. "Final Program Environmental Impact Report for the Long-term Irrigated Lands Regulatory Program." [Web site]. Sacramento (CA): Central Valley Region Water Quality Control Board. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/long_term_program_development/program_environmental_impact_report/index.shtml.

———. 2011b. *Issue List and Work Plan for the 2011 Triennial Review of the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins.* Sacramento (CA): Central Valley Regional Water Quality Control Board. 48 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/2011_tr_workplan.pdf.

———. 2011c. "Water Quality Control Plan for the Sacramento River and San Joaquin River Basins." [Web site]. Sacramento (CA): Central Valley Water Quality Control Board. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/basin_plans/index.shtml.

———. 2011d. *Long-Term Irrigated Lands Regulatory Program Questions and Answers*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 4 pp .Viewed online at: http://www.waterboards.ca.gov/rwqcb5/water_issues/irrigated_lands/new_waste_discharge_requirements/lilrp_cost_est.pdf.

———. 2011e. *The State of the Central Valley Region Address. A Five-Year Review Reflection and Projection*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 110 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/board_info/exec_officer_reports/state_of_cvrwqcb_dec_2011.pdf.

———. 2012a. "Irrigated Lands Regulatory Program - Management Plans/Reviews." [Web site]. Sacramento (CA): Central Valley Regional Water Quality Control Board. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/irrigated_lands/management_plans_reviews/index.shtml.

———. 2012b. *Cleanup and Abatement Order No. R5-2012-0700 for California Department of Parks and Recreation Carnegie State Vehicle Recreation Area, Alameda and San Joaquin Counties*. Sacramento (CA): Central Valley Regional Water Quality Control Board. 86 pp. Viewed online at: http://www.waterboards.ca.gov/centralvalley/board_decisions/adopted_orders/alameda/r5-2012-0700_enf.pdf.

Central Valley Salinity Alternatives for Long-Term Sustainability. 2012a. *CV-SALTS Brochure*. [Pamphlet]. Rancho Cordova (CA): Central Valley Salinity Alternatives for Long-term Sustainability. 2 pp. Viewed online at: http://www.cvsalinity.org/index.php/news/86-salt-story.html.

———. 2012b. *CV-SALTS – Strategy and Framework.* Rancho Cordova (CA): Central Valley Salinity Alternatives for Long-term Sustainability. 29 pp. Viewed online at: http://www.cvsalinity.org/index.php/component/docman/doc_download/918-cv-salts-program-work-plan-v-8-approved-3912.

Das T, Dettinger MD, Cayan DR, and Hidalgo HG. 2011. "Potential Increase in Floods in California's Sierra Nevada Under Future Climate Projections." California Energy Commission. 51 pp. Viewed online at: http://tenaya.ucsd.edu/~tdas/data/publications/submitted/das_et_al_2010/floods_California_Tapash_Das_etal_2010_merged.pdf.

Davis SN, and Turk LJ. 1964. "Optimum Depth of Wells in Crystalline Rocks." [Journal]. Groundwater Vol. 2(2): 6-11 pp. Viewed online at: https://info.ngwa.org/GWOL/pdf/640900742.PDF.

Dettinger M. 2011. "Climate Change, Atmospheric Rivers, and Floods in California - A Multimodal Analysis of Storm Frequency and Magnitude Changes." Journal of the American Water Resources Association. 47: 514-523 pp. [Journal.] Viewed online at: http://tenaya.ucsd.edu/~dettinge/md_jawra2011.pdf.

Dubrovsky NM, Kratzer CR, Brown LR, Gronberg JM, Burow KR. 1998. *Water Quality in the San Joaquin-Tulare Basins, California, 1992-95*. Sacramento (CA): U.S. Geological Survey. 43 pp. Viewed online at: http://pubs.usgs.gov/circ/circ1159/circ1159.pdf.

eGrid. 2012. *Version 1.0 Year 2009 GHG Annual Output Emission Rates*. Washington (DC): United States Environmental Protection Agency. 1 pp. Viewed online at: http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2012V1_0_year09_GHGOutputrates.pdf.

Galloway D, Jones DR, and Ingebritsen SE. 1999. *Land Subsidence in the United States*. Denver (CO): U.S. Geological Survey. 177 pp. Viewed online at: http://pubs.usgs.gov/circ/circ1182/#pdf.

Grafin G, Jardine A, Merideth R, Black M, LeRoy S. 2013. *Assessment of Climate Change in the Southwest United States: A Report Prepared for the National Climate Assessment*. Washington (DC): Island Press. 531 pp. Viewed online at: http://swccar.org/sites/all/themes/files/SW-NCA-color-FINALweb.pdf.

Hayhoe K, Cayan D, Field CB, Frumhoff PC, Maurer EP, et al. 2004. "Emissions Pathways, Climate Change, and Impacts on California." Proceedings of the National Academy of Science Vol. 101(34): 12422-12427. Viewed online at: http://www.pnas.org/content/101/34/12422.abstract.

Howitt RE, Kaplan J, Larson D, MacEwan D, Medellin-Azuara J, Horner G, Lee NS. 2009. *The Economic Impacts of Central Valley Salinity*. Sacramento (CA): State Water Resources Control Board. 154 pp. Viewed online at: http://www.waterboards.ca.gov/rwqcb5/water_issues/salinity/library_reports_programs/econ_rpt_final.pdf.

Intergovernmental Panel on Climate Change. 2013. *Climate Change 2013: The Physical Science Basis.* Geneva (SW): 2216 pp. Viewed online at: http://www.climatechange2013.org/images/uploads/WGIAR5_WGI-12Doc2b_FinalDraft_All.pdf.

Ireland RL. 1986. *Land Subsidence in the San Joaquin Valley, California, as of 1983*. Denver (CO): U.S. Geological Survey. 55 pp. Viewed online at: http://pubs.usgs.gov/wri/1985/4196/report.pdf.

Loudermilk WE. 2007. Letter from W. E. Loudermilk to Joe Karkoski. Viewed online at: http://www.waterboards.ca.gov/centralvalley/water_issues/tmdl/impaired_waters_list/cdfg_303d.pdf.

Madera Irrigation District. 2011. "Press Release: Madera Ranch Water Bank Record of Decision Signed." Madera(CA): Madera Irrigation District. 1 pp .Viewed online at: http://www.madera-id.org/images/Pdf/MaderaRanch/mrpress.pdf.

Medellin-Azuara J, Connell CR, Madani K, Lund JR, Howitt RE. 2009. *Water Management Adaptation with Climate Change*. Sacramento (CA): California Energy Commission. California Climate Change Center. 34 pp. Viewed online at: http://www.energy.ca.gov/2009publications/CEC-500-2009-049/CEC-500-2009-049-F.PDF.

Milly PCD, Betancourt J, Falkenmark M, Hirish RM, Kundzewicz ZW, Letternmainer DP, and Stouffer RJ. 2008. "Stationarity is Dead: Whither Water Management?" Science. 319: 573-574 pp. [Journal.] Viewed online at: http://wwwpaztcn.wr.usgs.gov/julio_pdf/milly_et_al.pdf.

Page RW. 1986. *Geology of the Fresh Ground-Water Basin of the Central Valley, California with Texture Maps and Sections.* Denver (CO): U.S. Geological Survey. Viewed online at: http://ngmdb.usgs.gov/Prodesc/proddesc_4831.htm.

Pierce DW, and Cayan DR. 2013. "The Uneven Response of Different Snow Measures to Human-Induced Climate Warming." Journal of Climate, Vol. 26: 4148-41-67 pp. Viewed online at: http://journals.ametsoc.org/doi/abs/10.1175/JCLI-D-12-00534.1?journalCode=clim.

Pierce DW, Das T, Cayan DR, Maurer EP, Miller NL, Bao Y, Kanamitsu M, Yoshimura K, Snyder MA, Sloan LC, Franco G, and Tyree M. 2012. "Probabilistic Emissions of Future Changes in California Temperature and Precipitation Using Statistical and Dynamical Downscaling." Climate Dynamics Vol. 40(3-4): 839-856 pp. Viewed online at: http://meteora.ucsd.edu/cap/pdffiles/Pierce_etal_2012_CD.pdf.

Qian Y, Ghan SJ, Leung LR. 2010. "Downscaling Hydroclimatic Changes Over the Western US Based on CAM Subgrid Scheme and WRF Regional Climate Simulations." International Journal of Climatology Vol. 30(5): 675-693 pp. Viewed online at: http://onlinelibrary.wiley.com/doi/10.1002/joc.1928/abstract.

Sierra Nevada Alliance. 2011. *Sierra Climate Change Toolkit.* South Lake Tahoe (CA): Sierra Nevada Alliance. 126 pp. Viewed online at: http://www.sierranevadaalliance.org/publications/db/pics/1303760072_12034.f_pdf.pdf.

Sneed M. 2011. "Extensometer Rehabilitation: Selection Letter." [Letter communication]. U.S. Geological Survey.

San Joaquin River Restoration Program. 2010. *2009-2013 Interim Flow Release Program, Water Quality Monitoring Plan*. Sacramento (CA): San Joaquin River Restoration Program. 44 pp. Viewed online at: http://www.restoresjr.net/activities/if/20100108SJRRPWQMP2010-2013.pdf.

State Water Resources Control Board. 2009. *Recycled Water Policy*. Sacramento (CA): State Water Resources Control Board. 14 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/water_recycling_policy/docs/recycledwaterpolicy_approved.pdf.

———. 2010. *2010 Integrated Report (Clean Water Act Section 303(d) List/305(b) Report)*. Sacramento (CA): State Water Resources Control Board. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/tmdl/integrated2010.shtml.

———. 2011a. *Municipal Wastewater Recycling Survey*. Sacramento (CA): State Water Resources Control Board. California Department of Water Resources. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/grants_loans/water_recycling/munirec.shtml.

———. 2011b. *Groundwater Information Sheet: Hexavalent Chromium*. Sacramento (CA): State Water Resources Control Board. 8 pp. Viewed online at: http://www.swrcb.ca.gov/water_issues/programs/gama/docs/coc_hexchromcr6.pdf.

———. 2012. *Strawman Proposal for a San Joaquin River Regional Monitoring Program.* Sacramento (CA): State Water Resources Control Board. 4 pp. Viewed online at: http://www.mywaterquality.ca.gov/monitoring_council/meetings/2012feb/sjr_strawman.pdf.

———. 2013. *Report to the Legislature: Communities that Rely on a Contaminated Groundwater Source for Drinking Water.* Sacramento (CA): State Water Resources Control Board. California Environmental Protection Agency. 121 pp. Viewed online at: http://www.swrcb.ca.gov/water_issues/programs/gama/ab2222/index.shtml.

Swanson A. 1995. *Land Subsidence in the San Joaquin Valley, Updated 1995*. Sacramento (CA): California Department of Water Resources. 6 pp .Viewed online at: https://getinfo.de/app/Land-Subsidence-in-the-San-Joaquin-Valley-Updated/id/BLCP%3ACN031922100.

United Nations Environment Program. 2009. Climate Change Science Compendium. Washington D.C.: United Nations Environment Programme. 92 pp. Viewed online at: http://www.unep.org/compendium2009/.

U.S. Bureau of Reclamation. 2011. *Reclamation: Managing Water in the West. Madera Irrigation District Water Supply Enhancement Project. Final EIS.* Fresno (CA): U.S. Bureau of Reclamation. 316 pp. Viewed online at: http://www.usbr.gov/mp/nepa/documentShow.cfm?Doc_ID=7711.

U.S. Environmental Protection Agency. 1986. *Water Quality Standards Handbook.* Washington (DC): U.S. Environmental Protection Agency. Viewed online at: http://water.epa.gov/scitech/swguidance/standards/handbook/chapter03.cfm.

———. 2011. *Section 319 Nonpoint Source Program Success Story: Grasslands Bypass Project Reduces Selenium in the San Joaquin Basin*. Washington (DC): U.S. Environmental Protection Agency. 1 pp. Viewed online at: http://water.epa.gov/polwaste/nps/success319/upload/ca_sanjoaquin.pdf.

———. 2012a. "Water: Small Systems and Capacity Development, Basic Information." [Web site]. Washington D.C.: U.S. Environmental Protection Agency. Viewed online at: http://water.epa.gov/type/drink/pws/smallsystems/basicinformation.cfm.

———. 2012b. "Arsenic in Drinking Water." [Web site]. U.S. Environmental Protection Agency. Viewed online at: http://water.epa.gov/lawsregs/rulesregs/sdwa/arsenic/index.cfm.

———. 2012c. "Outline of the Good Samaritan Clean Watershed Act." [Web site]. U.S. Environmental Protection Agency. Viewed online at: http://water.epa.gov/action/adopt/legislation.cfm.

U.S. Environmental Protection Agency and California Department of Water Resources. 2011. *Climate Change Handbook for Regional Water Planning*. Sacramento (CA): U.S. Environmental Protection Agency and California Department of Water Resources. 246 pp. Viewed online at: http://www.water.ca.gov/climatechange/CCHandbook.cfm.

U.S. Geological Survey. 1999. *Land Subsidence in the United States*. Denver (CO): U.S. Geological Survey. Viewed online at: http://pubs.usgs.gov/circ/circ1182/#pdf.

———. 2000. *Measuring Land Subsidence from Space.* Denver (CO): U.S. Geological Survey. 4 pp .Viewed online at: http://pubs.usgs.gov/fs/fs-051-00/pdf/fs-051-00.pdf.

———. 2012. *Groundwater Quality in the Southeast San Joaquin Valley, California*. Denver (CO): U.S. Geological Survey. 4 pp. Viewed online at: http://pubs.usgs.gov/fs/2011/3151/pdf/fs20113151.pdf.

U.S. Global Change Research Program. 2009. *Global Climate Change Impacts in the United States.* Cambridge (NY): U.S. Global Change Research Program. National Oceanic and Atmospheric Administration. 196 pp. Viewed online at: http://nca2009.globalchange.gov/.

Westerling AL. 2008. "Climate and Wildfire in the Western United States, California Application Program White Paper." Merced (CA): UC Merced. 25 pp. Viewed online at: http://meteora.ucsd.edu/cap/pdffiles/westerling_fire08.pdf.

Westerling AL, Bryant BP, Preisler HK, Hidalgo HG, Das T, and Shrestha SR. 2009. *Climate Change, Growth, and California Wildfire*. Sacramento (CA): California Climate Change Center. 43 pp. Viewed online at: http://www.energy.ca.gov/2009publications/CEC-500-2009-046/CEC-500-2009-046-D.PDF.

Western Region Climate Center. 2013. "Climate Variability in the State of California." Journal of Applied Meteorology and Climatology Vol. 48: 1527-1541 pp. Viewed online at: http://www.wrcc.dri.edu/.

Wilkinson RC. 2000. *Methodology for Analysis of the Energy Intensity of California's Water Systems and an Assessment of Multiple Potential Benefits through Integrated Water-Energy Efficiency Measures*. Sacramento (CA): California Institute for Energy Efficiency. 89 pp. Viewed online at: http://large.stanford.edu/courses/2012/ph240/spearrin1/docs/wilkinson.pdf.

Additional References

Bureau of Indian Affairs. 2013. "Frequently Asked Questions." [Web site]. Department of Interior. Viewed online at: http://www.bia.gov/FAQs/index.htm.

California Air Resources Board. 2013. *Climate Change Scoping Plan: First Update (Public Draft)*. Sacramento (CA): Air Resources Board. 123 pp. Viewed online at: http://www.arb.ca.gov/cc/scopingplan/2013_update/discussion_draft.pdf.

California Climate Action Team. 2010. State of California *Sea-Level Rise Interim Guidance Document, Appendix A*. Sacramento (CA): California Climate Action Team. 13 pp. Viewed online at: http://www.opc.ca.gov/webmaster/ftp/pdf/docs/2013_SLR_Guidance_Update_FINAL1.pdf.

———. 2013. *State of California Sea-Level Rise Guidance Document: March 2013 Update.* Sacramento (CA): California Action Team. 13 pp. Viewed online at: http://scc.ca.gov/files/2013/04/2013_SLR_Guidance_Update_FINAL.pdf.

California Department of Water Resources. 2012. *Proposition 84 & Proposition 1E Integrated Regional Water Management Guidelines.* Sacramento (CA): California Department of Water Resources. California Natural Resources Agency. 88 pp. Viewed online at: http://www.water.ca.gov/irwm/grants/docs/Guidelines/GL_2012_FINAL.pdf.

California Emergency Management Agency and California Natural Resources Agency. 2012. *California Adaptation Planning Guide: Understanding Regional Characteristics*. Sacramento (CA): California Emergency Management Agency and California Natural Resources Agency. 114 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/APG_Understanding_Regional_Characteristics.pdf.

———. 2012. *California Adaptation Planning Guide: Identifying Adaptation Strategies*. Sacramento (CA): California Emergency Management Agency and California Natural Resources Agency. 68 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/APG_Identifying_Adaptation_Strategies.pdf.

California Energy Commission. 2006. *Refining Estimates of Water-Related Energy Use in California.* Sacramento (CA): California Energy Commission. 95 pp. Viewed online at: http://www.energy.ca.gov/2006publications/CEC-500-2006-118/CEC-500-2006-118.PDF.

———. 2013. "Cal-Adapt." [Web site]. Sacramento (CA): California Energy Commission. Viewed online at: http://cal-adapt.org/.

———. 2013. "Hydroelectric Power in California." [Web site]. Sacramento (CA): California Energy Commission. Viewed online at: http://www.energy.ca.gov/hydroelectric/.

California Natural Resources Agency. 2013. *Safeguarding California: Reducing Climate Risk. An Update to the 2009 California Climate Adaptation Strategy (Public Draft)*. Sacramento (CA): California Natural Resources Agency. 289 pp. Viewed online at: http://resources.ca.gov/climate_adaptation/docs/Safeguarding_California_Public_Draft_Dec-10.pdf.

Hanak E, Lund, JR. 2011. "Adapting California's Water Management to Climate Change." Climatic Change Vol. 111(1): 17-44 pp. Viewed online at: http://www.waterlawsymposium.com/sites/default/files/Hanak&Lund_climatic_change.pdf.

Intergovernmental Panel on Climate Change. 2007. *Climate Change 2007 - Synthesis Report*. Geneva (Switzerland). 104 pp. Viewed online at: http://www.ipcc.ch/publications_and_data/ar4/syr/en/contents.html.

Jackson L, Haden VR, Wheeler SM, Hollander AD, Perman J, O'Green T, Mehta VK, Clark V, Williams J, and Trupp A. 2012. *Vulnerability and Adaptation to Climate Change in California Agriculture*. Sacramento (CA): California Energy Commission. 113 pp. Viewed online at: http://www.energy.ca.gov/2012publications/CEC-500-2012-031/CEC-500-2012-031.pdf.

Janetos A, Hansen L, Inouye D, Kelly BP, Meyerson L, Peterson B, and Shaw R. 2008. *The Effects of Climate Change on Agriculture, Land Resources, Water Resources, and Biodiversity in the United States: Biodiversity*. Washington D.C.: U.S. Climate Change Science Program. 252 pp. Viewed online at: http://www.usda.gov/oce/climate_change/SAP4_3/CCSPFinalReport.pdf.

Knowles N, Dettinger M, Cayan D. 2007. *Trends in Snowfall versus Rainfall for the Western United States, 1949-2001.* Sacramento (CA): California Energy Commission, Public Interest Energy Research Program. 39 pp. Viewed online at: http://water.usgs.gov/nrp/proj.bib/Publications/2007/knowles_dettinger_etal_2007.pdf.

Lenihan JM, Bachelet D, Drapek R, Neilson RP. 2006. *The Response of Vegetation Distribution, Ecosystem Productivity, and Fire in California to Future Climate Scenarios Simulated by the MC1 Dynamic Vegetation Model.* Sacramento (CA): California Climate Change Center, California Energy Commission. 25 pp. Viewed online at: http://www.energy.ca.gov/2005publications/CEC-500-2005-191/CEC-500-2005-191-SF.PDF.

Moser S, Franco G, Pittiglio S, Chou W, and Cayan D. 2008. *The Future is Now: An Update on Climate Change Science Impacts and Response Options for California*. Sacramento (CA): California Energy Commission 114 pp. Viewed online at: http://www.energy.ca.gov/2008publications/CEC-500-2008-071/CEC-500-2008-071.PDF.

National Research Council. 2012. *Sea-Level Rise for the Coasts of California, Oregon, and Washington: Past, Present, and Future*. Washington D.C.: National Research Council. 201 pp. Viewed online at: http://www.nap.edu/catalog.php?record_id=13389.

U.S. Environmental Protection Agency. 2010. *Handbook for Developing and Managing Tribal Nonpoint Source Pollution Programs Under Section 319 of the Clean Water Act.* Washington (DC): U.S. Environmental Protection Agency. 182 pp. Viewed online at: http://water.epa.gov/polwaste/nps/tribal/upload/2010_02_19_nps_tribal_pdf_tribal_handbook2010.pdf.

———. 2011. *Tribal Office Water Pollution Control Program Grants Clean Water Act §106.* Washington (DC): U.S. Environmental Protection Agency. 37 pp. Viewed online at: http://www.epa.gov/region9/water/tribal/pdf/cwa-reporting/2012/FundingOpp-Tribal-WtrPollutCtrl-ProgGrants2012.pdf.

———. 2012. *List of Tribes Eligible for Section 319 Funding.* Washington (DC): U.S. Environmental Protection Policy. 5 pp. Viewed online at: http://water.epa.gov/polwaste/nps/tribal/upload/tribes319funding.pdf.

U.S. Geological Survey. 2010. *Groundwater Quality Data for the Sierra Nevada Study Unit, 2008: Results from the California GAMA Program*. Denver (CO): U.S. Geological Survey. 119 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/gama/docs/dsr_sierra_regional.pdf.

———. 2010. *Groundwater Quality in the Central Eastside San Joaquin Valley, California. Fact Sheet 2010-3001*. Denver (CO): U.S. Geological Survey. 4 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/gama/docs/gw_cesjv2010_factsheet.pdf.

———. 2010. *Groundwater Quality in the Northern San Joaquin Valley, California*. Fact Sheet 2010-3079. Denver(CO): U.S. Geological Survey. 138 pp. Viewed online at: http://www.waterboards.ca.gov/water_issues/programs/gama/docs/nsjv_dsr.pdf.

van Vuuren DP, Edmonds J, Kainuma M, Riahi K, Thomson A, Hibbard K, et al. 2011. "The Representative Concentration Pathways: An Overview." Climatic Change Vol. 109(1-2): 5-31 pp. Viewed online at: http://link.springer.com/article/10.1007%2Fs10584-011-0148-z# .

Water Education Foundation. 2011. *A Briefing on the San Joaquin River Restoration Program*. Sacramento (CA): Water Education Foundation. 16 pp. Viewed online at: http://www.restoresjr.net/program_library/01-General_Outreach/WEFSJRRPpaper201104.pdf.

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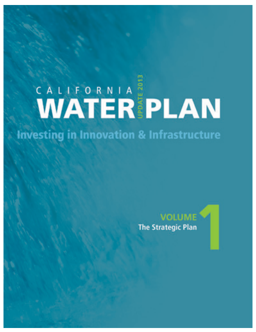

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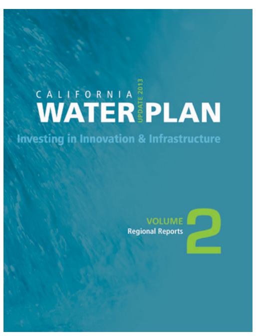

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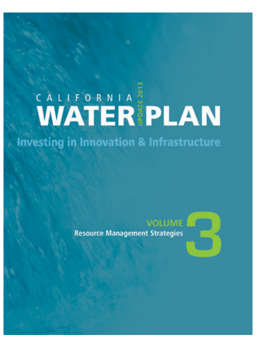

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