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TULARE LAKE HYDROLOGIC REGION

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Regional Reports

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Acronyms and Abbreviations Used in This Report

AB	Assembly Bill
ACWA	Association of California Water Agencies
af	acre-feet
af/yr.	acre-feet per year
AGR	agricultural supply
ASR	aquifer storage and recovery
AWMP	agricultural water management plan
CASGEM	California Statewide Groundwater Elevation Monitoring
CDPH	California Department of Public Health
cfs	cubic feet per second
CVC	Cross Valley Canal
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
CWC	California Water Code
DAC	disadvantaged community
DBCP	1,2-dibromo-3-chloropropane
DFW	California Department of Fish and Wildlife
DOGGR	Division of Oil, Gas, and Geothermal Resources
DPR	Department of Pesticide Regulation
DWR	California Department of Water Resources
EI	energy intensity
EPA	U.S. Environmental Protection Agency
FMFCD	Fresno Metropolitan Flood Control District
GAMA	Groundwater Ambient Monitoring and Assessment
GCM	global climate model

GHG	greenhouse gas
GIS	geographic information system
GMAW	Groundwater Monitoring Advisory Workgroup
gpm	gallons per minute
GPS	global positioning system
GWMP	groundwater management plan
GWR	groundwater recharge
HIP	high population scenario
ID	irrigation district
InSAR	Interferometrict Synthetic Aperture Radar
IRWMP	integrated regional water management plan
IWM	integrated water management
KCWD	Kings County Water District
KRCD	Kings River Conservation District
kWh/af	kilowatt hours per acre-foot
LLNL	Lawrence Livermore National Laboratory
LOP	low-population growth scenario
M&I	municipal and industrial
maf	million acre-feet
MCL	maximum contaminant level
MHI	median household income
MTBE	methyl tertiary butyl ether
MUN	municipal and domestic supply
NPDES	National Pollutant Discharge Elimination System
NPS	non-point-source
OHV	off-highway vehicle
PA	planning area
PBO	Plate Boundary Observatory

RMG	Resource Management Group
RWMG	regional water management group
RWQCB	regional water quality control board
SB	Senate Bill
SDAC	severely disadvantaged community
SWP	State Water Project
SWRCB	State Water Resources Control Board
Sy	specific yield
taf	thousand acre-feet
TAS	treatment as a State
TCE	trichloroethylene
TCWD	Tehachapi-Cummings County Water District
TID	Tulare Irrigation District
TDS	total dissolved solids
TMDL	total maximum daily load
Update 2013	California Water Plan Update 2013
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
UWMP	urban water management plan
WRCC	Western Regional Climate Center

Vineyard near Bakersfield, CA. Along State Route 58, this vineyard is one of many in the area that thrive at the base of the western Sierra Nevada foothills, beyond which lies Sequoia National Park. The Tulare Lake Hydrologic Region has a diverse mix of water uses, from agriculture and ranching to recreation in the lakes, streams, and wetlands of the southern San Joaquin Valley and the mountains.

Tulare Lake Hydrologic Region

Tulare Lake Hydrologic Region Summary

While the Tulare Lake Hydrologic Region (Tulare Lake region) remains the largest agricultural region in California with irrigated acreage declining only slightly from 2005 to 2010, it is facing many issues. The 2007-2009 drought along with reduced imported surface water supplies from the Delta, led to increased groundwater pumping. Older water storage and delivery facilities are affecting flood management and distribution reliability. Along with more agricultural reliance on groundwater, many smaller communities have to deal with aging municipal wells and sewage treatment facilities that have difficulty meeting water quality standards. Additionally, the urban population continues to grow, gaining 8 percent from 2005 to 2010. However, most of the region's agricultural, urban including disadvantaged communities (DACs), environmental, and other interests are realizing that integrated water management (IWM) strategies are the most effective way to deal with these challenges.

Current State of the Region

Setting

The Tulare Lake Hydrologic Region covers approximately 10.9 million acres (17,050 square miles) and includes all of Kings and Tulare counties and most of Fresno and Kern counties (Figure TL-1). The San Joaquin Valley is divided into the San Joaquin River and the Tulare Lake regions by the San Joaquin River with the Tulare Lake region in the southern portion. Historically, the valley floor in this region had been a complex series of interconnecting natural sloughs, canals, and marshes.

The economic development of the region is closely linked to the surface water and groundwater resources of the Tulare Lake region. Major rivers draining into the Tulare Lake region include the Kings, Kaweah, Tule, and Kern rivers. The original ecological character of the area has been changed dramatically, largely from the taming of local rivers for farming. In the southern portion of the region, significant geographic features include the lakebeds of the former Buena Vista/Kern and Tulare lakes, comprising the southern half of the region; the Coast Ranges to the west; the Tehachapi Mountains to the south; and the southern Sierra Nevada to the east.

The Tulare Lake region is one of the nation's leading agricultural production areas, growing a wide variety of crops on about 3 million irrigated acres. Agricultural production has been a mainstay of the region since the late 1800s. However, since the mid-1980s, other economic sectors, particularly the service sector, have been growing.

Watersheds

The Tulare Lake region is divided into several main hydrologic subareas: the alluvial fans from the Sierra foothills and the basin subarea (in the vicinity of the Kings, Kaweah, and Tule rivers and their distributaries); the Tulare Lake bed; and the southwestern uplands. The alluvial fan/

Figure TL-1 Tulare Lake Hydrologic Region

basin subarea is characterized by southwest to south flowing rivers, creeks, and irrigation canal systems that convey surface water originating from the Sierra Nevada. The dominant hydrologic features in the alluvial fan/basin subarea are the Kings, Kaweah, Tule, and Kern rivers and their major distributaries from the western flanks of the Sierra. Los Gatos Creek is the one substantial creek entering from the Coast Ranges, flowing southeast. The largest river in terms of runoff is the Kings River, which originates high in Kings Canyon National Park and generally trends southwest into Pine Flat Lake. Downstream of Pine Flat Dam, the river flows south and west toward Tulare Lake. During flood release events from Pine Flat Reservoir, the majority of the Kings River flow is diverted northwest into the Fresno Slough/James Bypass system (along the historically high-water outlet of Tulare Lake), emptying first into the Mendota Pool, and from there, into the San Joaquin River. The Kaweah River begins in Sequoia National Park, flows west and southwest, and is impounded by Terminus Dam. It subsequently spreads into many distributaries around Visalia and Tulare trending toward Tulare Lake. The Tule River begins in Sequoia National Forest and flows southwest through Lake Success toward Tulare Lake.

The Kern River has the largest drainage basin area and produces the second highest runoff. It originates in Inyo and Sequoia national forests and Sequoia National Park, flowing southward into Lake Isabella. The river downstream of Isabella Dam flows southwest. In high discharge years, water will spill into the ancient Buena Vista/Kern Lake bed. In very high discharge years, Buena Vista Lake historically spilled into Tulare Lake via sloughs and floodwater channels. In addition, some Kern River water may be allowed to flow into the State Water Project (SWP) via the Kern River Intertie. There are many smaller creeks that feed into the main rivers, which can present a localized flooding threat during specific storm conditions. See Figure TL-2 for an overview of the region's watersheds.

Groundwater Aquifers and Wells

Groundwater resources in the Tulare Lake 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 significantly within the region. A brief description of the aquifers for the region is provided below.

Alluvial Aquifers

The Tulare Lake Hydrologic Region contains 12 groundwater basins and 7 subbasins recognized in California Department of Water Resources (DWR) *Bulletin 18-2003* (California Department of Water Resources 2003) and underlie approximately 8,400 square miles, or about 50 percent of the region. The majority of the groundwater in the region is stored in alluvial aquifers. Figure TL-3 shows the location of the alluvial groundwater basins and subbasins and Table TL-1 lists the associated names and numbers. Pumping from the alluvial aquifers in the region accounts for about 38 percent of California's total average annual groundwater extraction. The most heavily used groundwater basins in the region include Kings, Westside, Kaweah, Tulare Lake, Tule, and Kern County. These basins account for approximately 98 percent of the average 6.3 million acre-feet (maf) of groundwater pumped annually during the 2005-2010 period. Groundwater wells in the San Joaquin Valley extend to depths of more than 1,000 feet (Page 1986). Based on a series

Figure TL-2 Tulare Lake Hydrologic Region Watersheds

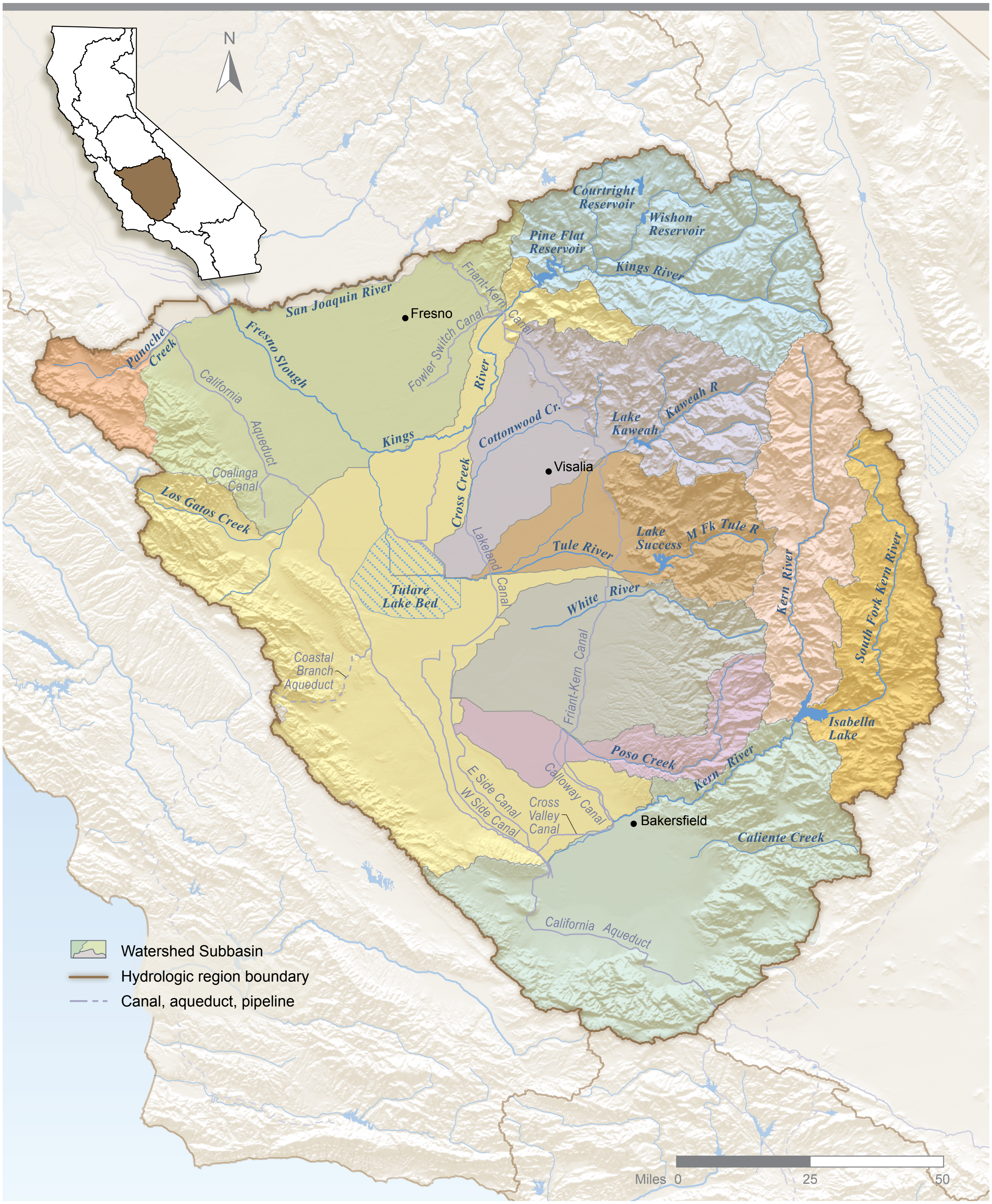


Figure TL-3 Alluvial Groundwater Basins and Subbasins within the Tulare Lake Hydrologic Region

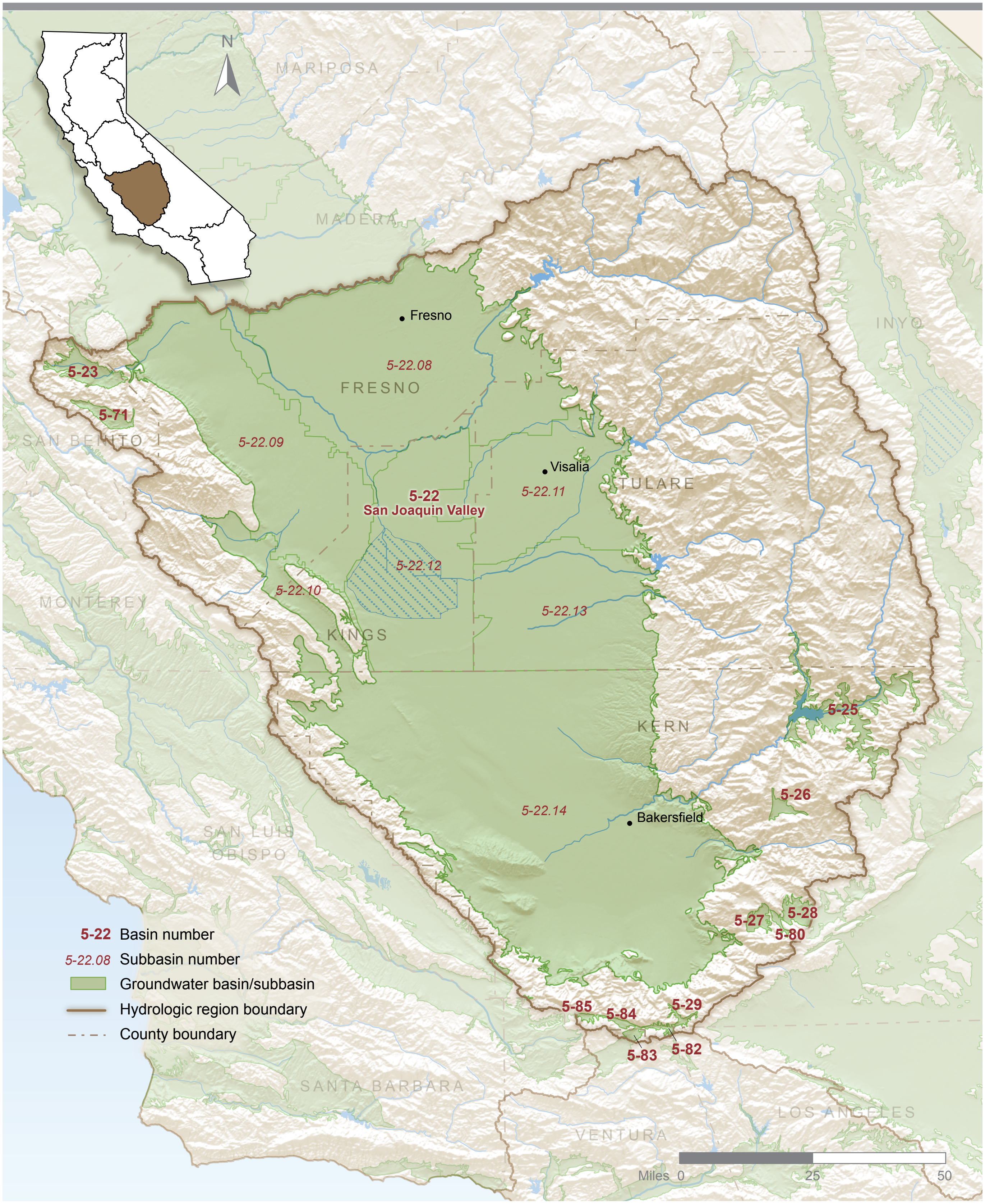


Table TL-1 Alluvial Groundwater Basins and Subbasins within the Tulare Lake Hydrologic Region

Basin	Subbasin	Basin/Subbasin Name
5-22		San Joaquin Valley
	5-22.08	Kings
	5-22.09	Westside
	5-22.10	Pleasant Valley
	5-22.11	Kaweah
	5-22.12	Tulare Lake
	5-22.13	Tule
	5-22.14	Kern County
5-23		Panoche Valley
5-25		Kern River Valley
5-26		Walker Basin Creek Valley
5-27		Cummings Valley
5-28		Tehachapi Valley West
5-29		Castac Lake Valley
5-71		Vallecitos Creek Valley
5-80		Brite Valley
5-82		Cuddy Canyon Valley
5-83		Cuddy Ranch Area
5-84		Cuddy Valley
5-85		Mil Potrero Area

Note: The seven subbasins listed comprise the entire San Joaquin Valley Basin.

of irrigation pump tests, groundwater pumping rates in the various subbasins were determined to range from about 650 gallons per minute (gpm) to about 1,650 gpm (Burt 2011).

The 12 alluvial basins outside the San Joaquin Valley Basin are Panoche Valley and Vallecitos Creek Valley in the Coast Ranges; Kern River Valley and Walker Basin Creek Valley in the Sierra Nevada; and Cummings Valley, Tehachapi Valley West, Castaic Lake Valley, Brite Valley, Cuddy Canyon Valley, Cuddy Ranch Area, Cuddy Valley, and Mil Potrero Area in the Tehachapi Mountains.

Fractured-Rock Aquifers

Fractured-rock aquifers are generally found in the mountain and foothill areas adjacent to alluvial 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 10 gpm or less. Although fractured-rock aquifers are less productive compared to alluvial aquifers, they commonly are the critical sole source of water for many communities. Information related to fractured-rock aquifers in the region was not developed as part of Update 2013.

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

Well Infrastructure and Distribution

Well logs submitted to DWR for water supply or monitoring wells completed from 1977 to 2010 were used to evaluate the distribution and uses of water wells in the Tulare Lake region. Many wells could have been drilled prior to 1977 or without submitting well logs. As a result, the total number 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; and 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. However, 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 TL-2 and illustrated in Figure TL-4 shows that the distribution and number of wells vary widely by county and by use. The well log information is reported for Fresno, Kings, Tulare, and Kern counties. Well log information for San Benito County is reported in the Central Coast Hydrologic Region.

The total number of wells installed in the region between 1977 and 2010 is approximately 54,300, ranging from about 4,200 in Kings County to about 27,100 in Fresno County. The large proportion of wells in Fresno County (50 percent) is related in part to the high proportion of the region's population living in Fresno County (over 40 percent). Domestic use wells make up the majority of well logs in most counties (16,000 in Fresno County, followed by 5,800 in Tulare County and 5,200 in Kern County). The lower number of domestic versus irrigation wells in Kings County is most likely the result of the rural setting (only 7 percent of the region's population lives in Kings County) and the greater agricultural demand for groundwater. A comparison of data for Tulare and Kern counties shows that domestic well numbers are relatively close for the two counties; however, the number of irrigation wells in Tulare County is almost three times greater than that in Kern County even though both counties use approximately the same amount of groundwater, as indicated later in this report.

Table TL-2 Number of Well Logs by County and Use for the Tulare Lake Hydrologic Region (1977 - 2010)

Total Number of Well Logs by Well Use							
County	Domestic	Irrigation	Public Supply	Industrial	Monitoring	Other	Total Well Records
Fresno	15,957	5,050	743	45	1,092	4,183	27,070
Kings	1,536	1,549	86	19	410	550	4,150
Tulare	5,791	4,584	447	59	739	1,355	12,975
Kern	5,182	1,603	305	58	970	2,009	10,127
Total well records	28,466	12,786	1,581	181	3,211	8,097	54,322

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

Figure TL-4 Number of Well Logs by County and Use for the Tulare Lake Hydrologic Region (1977-2010)

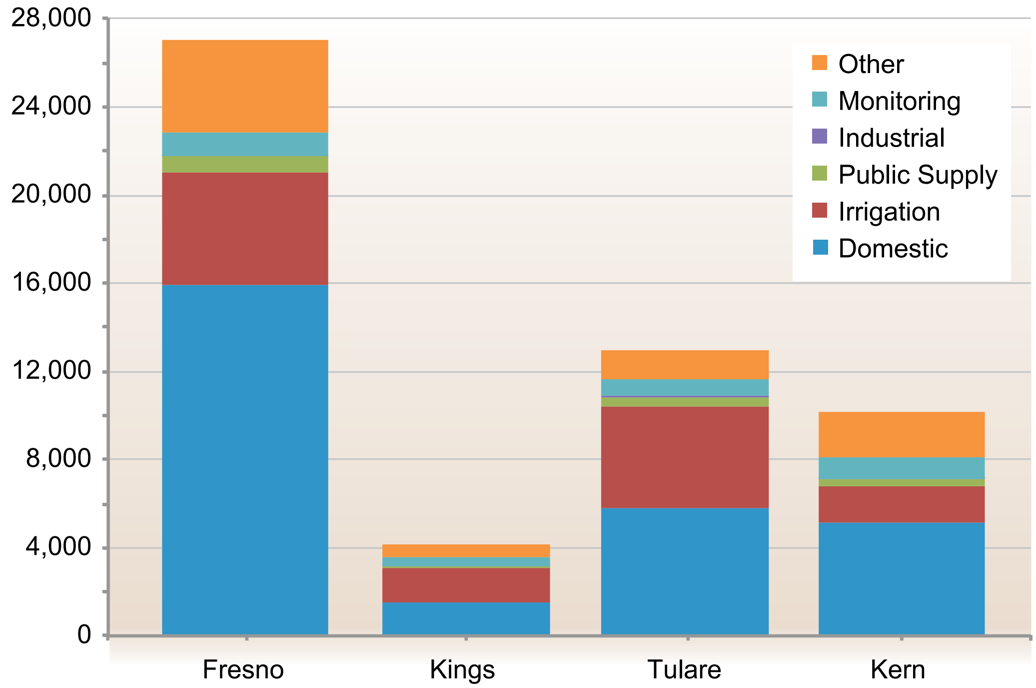


Figure TL-5 shows that domestic wells make up the majority of well logs in the region (52 percent), followed by irrigation wells which account for 23 percent. Monitoring wells account for only about 6 percent of well logs.

Figure TL-5 Percentage of Well Logs by Use for the Tulare Lake Hydrologic Region (1977-2010)

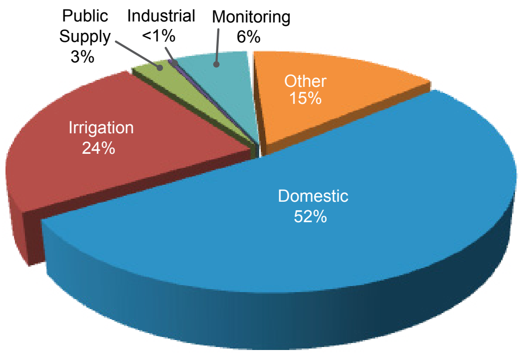


Figure TL-6 shows a cyclic pattern of well installation in the region, with new well construction ranging from about 800 to 3,900 wells per year. The average number of new wells constructed is about 1,600 wells per year.

As shown in Figure TL-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 1,900 wells per year following the 1976-1977 drought, and continued at an installation rate between 200 and 1,200 wells per year through 1982. Irrigation well installation dropped to approximately 150 wells per year during the wet years of the mid-1980s, before increasing again to an average of 500 wells per year during the 1989-1994 and 2008-2009 droughts.

The large fluctuation of domestic well drilling, as shown in Figure TL-6, is likely associated with population booms and residential housing construction. The increases in domestic well drilling in the region during the late 1980s and early 1990s as well as early through mid-2000s are likely due to cyclical housing booms during these times. Similarly, the 2007 to 2010 decline in domestic well drilling is likely due to declining economic conditions and related drop in housing construction.

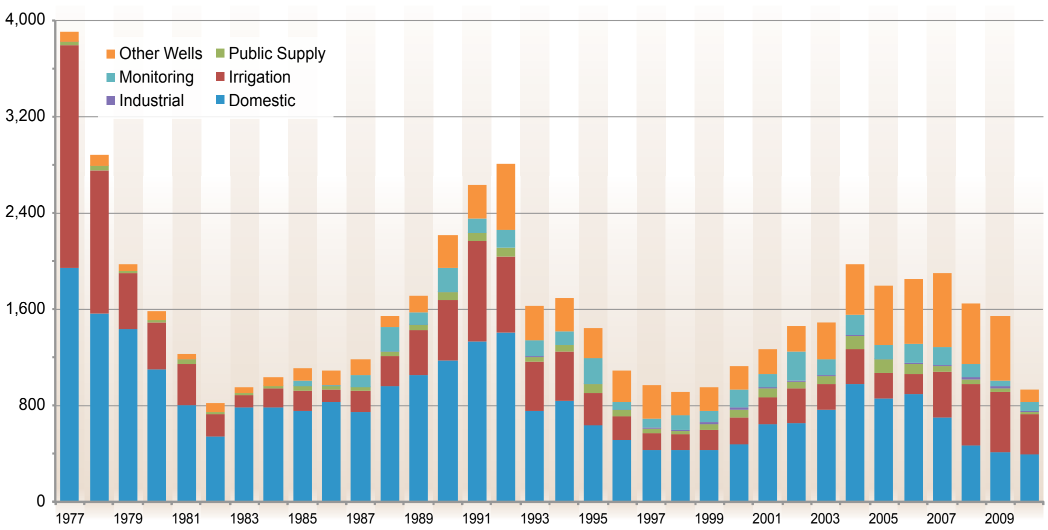
The onset of monitoring well installations in the mid- to late-1980s is likely associated with federal underground storage tank programs signed into law in the mid-1980s. Since 1987, monitoring well installation in the region has averaged approximately 140 wells per year. The total number of monitoring well records for the region appears to be low considering the number of remedial action sites within the region by California's 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*,* Volume 4, *Reference Guide,* the article, "California's Groundwater Update 2013."

Tulare Lake 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

Figure TL-6 Number of Well Logs Filed per Year by Use for the Tulare Lake Hydrologic Region (1977-2010)



or quality. This section summarizes some of the groundwater level, groundwater quality, and land subsidence monitoring efforts within the Tulare Lake Hydrologic Region.

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

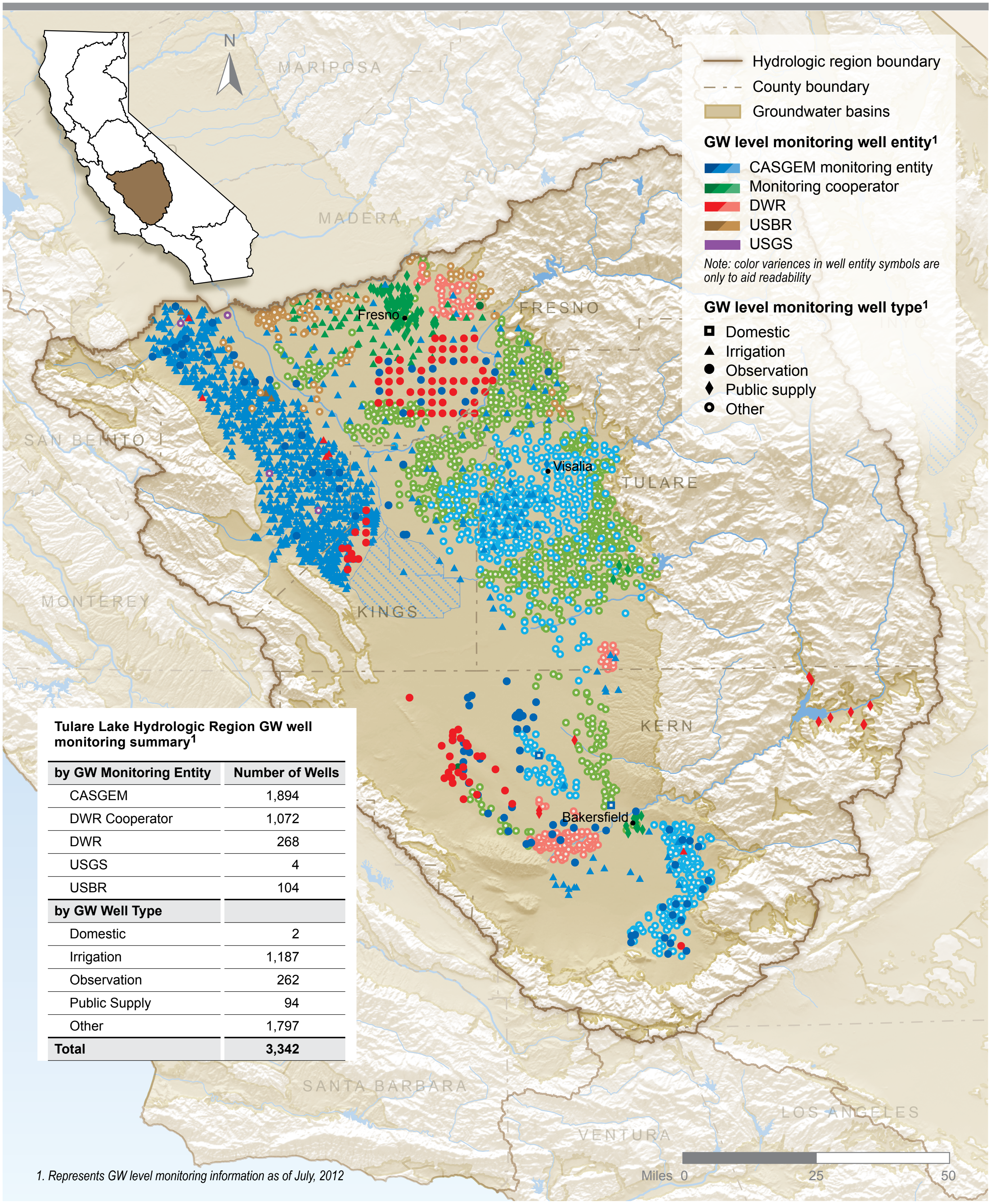
Groundwater Level Monitoring

To strengthen existing groundwater level monitoring in the state by DWR, U.S. Geological Survey (USGS), U.S. Bureau of Reclamation (USBR), local agencies and communities, the California Legislature passed Senate Bill (SB) X7 6 in 2009 that requires 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 Tulare Lake region are shown in Figure TL-7. Other wells and irrigation wells account for 54 and 35 percent of the monitoring wells in the region, respectively. Observation wells and public supply wells compromise only 8 and 3 percent of the monitoring wells, respectively.

A list of the number of monitoring wells in the region is provided in Table TL-3. Groundwater levels have been actively monitored in 3,342 wells in the region since 2010. DWR monitors 268 wells in five basins, with the majority of wells in the Kings and Kern County subbasins. The USBR monitors 104 wells — 91 of which are located in the Kings subbasin and 4 of which are located in non-basin areas. The USGS monitors four wells in the Westside subbasin. In addition to the State and federal agencies, 23 cooperators and 14 CASGEM monitoring entities monitor 2,966 wells in nine groundwater basins and subbasins.

Figure TL-7 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity in the Tulare Lake Hydrologic Region



Tulare Lake Hydrologic Region GW well monitoring summary[1]

by GW Monitoring Entity	Number of Wells
CASGEM	1,894
DWR Cooperator	1,072
DWR	268
USGS	4
USBR	104
by GW Well Type	
Domestic	2
Irrigation	1,187
Observation	262
Public Supply	94
Other	1,797
Total	**3,342**

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

Table TL-3 Groundwater Level Monitoring Wells by Monitoring Entity in the Tulare Lake Hydrologic Region

State and Federal Agencies	Number of Wells
Department of Water Resources	268
U.S. Geological Survey	4
U.S. Bureau of Reclamation	104
Total State and federal wells	**376**
Monitoring Cooperators	**Number of Wells**
Fresno Irrigation District	48
James Irrigation District	26
Alta Irrigation District	114
Buena Vista Water Storage District	19
California Water Service Company	12
Cawelo Water District	46
Exeter Irrigation District	51
Fresno, City	79
Ivanhoe Irrigation District	38
Kings County Water District	118
Lakeside Irrigation Water District	45
Lewis Creek Water District	9
Liberty Water District	43
Lindmore Irrigation District	142
Lindsay-Strathmore Irrigation District	17
Orange Cove Irrigation District	34
Pixley Irrigation District	24
Porterville Irrigation District	12
Riverdale Irrigation District	13
San Joaquin, Southern, Municipal Utility District	10
Saucelito Irrigation District	13
Tule River Association	30
Tule River, Lower, Irrigation District	129
Total cooperator wells:	**1,072**

CASGEM Monitoring Entities	Number of Wells
Westlands Water District	1,043
Arvin-Edison Water Storage District	197
Consolidated Irrigation District	8
Deer Creek & Tule River Authority	47
Delano Earlimart Irrigation District	7
Kaweah Delta Water Conservation District	205
Kern County Water Agency Improvement District No. 4	4
Kern River Fan Group	34
Kern Water Bank Authority	15
Kern-Tulare Water District	5
Kings River Conservation District	101
Semitropic Water Storage District	46
Shafter-Wasco Irrigation District	44
Tulare Irrigation District	138
Total CASGEM monitoring wells	**1,894**
Grand total	**3,342**

Notes:

CASGEM = California Statewide Groundwater Elevation Monitoring

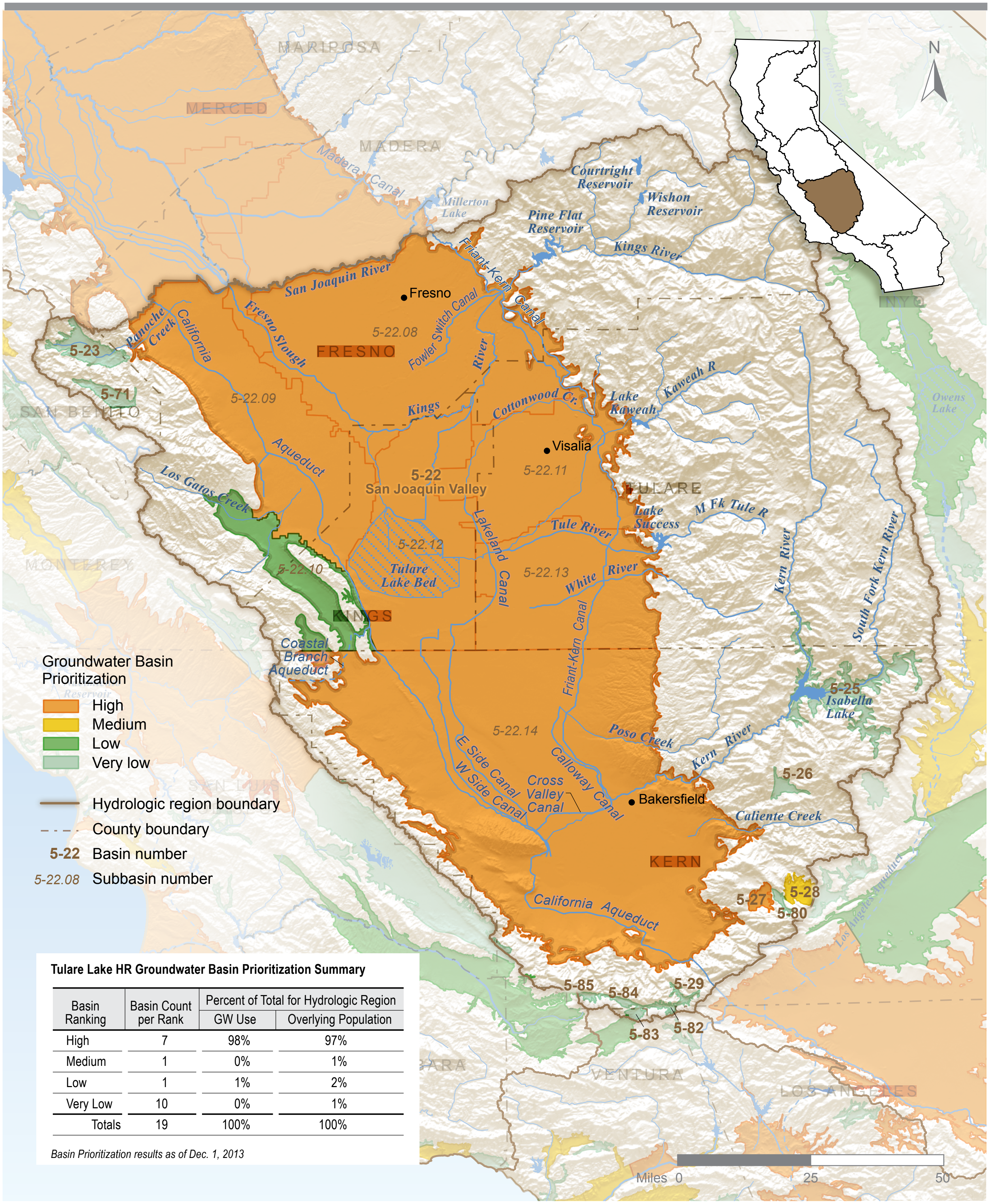
Table includes groundwater level monitoring wells having publicly available online data as of July 2012.

CASGEM Basin Prioritization

Figure TL-8 shows the CASGEM groundwater basin prioritization for the region. Of the 19 basins within the region, 7 basins were identified as high priority, one basin as medium priority, one basin as low priority, and the remaining 10 basins as very low priority. Table TL-4 lists the high, medium, and low CASGEM priority groundwater basins. The seven basins designated as high priority include 97 percent of the population and account for 98 percent of groundwater supply in the region. Except the Cummings Valley and Tehachapi Valley West priority basins, all other basins identified as having a high or medium priority are being monitored for groundwater levels. 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.

Figure TL-8 CASGEM Groundwater Basin Prioritization for the Tulare Lake Hydrologic Region



Tulare Lake HR Groundwater Basin Prioritization Summary

Basin Ranking	Basin Count per Rank	Percent of Total for Hydrologic Region	
		GW Use	Overlying Population
High	7	98%	97%
Medium	1	0%	1%
Low	1	1%	2%
Very Low	10	0%	1%
Totals	19	100%	100%

Basin Prioritization results as of Dec. 1, 2013

Table TL-4 CASGEM Groundwater Basin Prioritization for the Tulare Lake Hydrologic Region

Basin Prioritization	Count	Basin/ Subbasin Number	Basin Name	Subbasin Name	2010 Census Population
High	1	5-22.11	San Joaquin Valley	Kaweah	271,700
High	2	5-27	Cummings Valley	NA	7,665
High	3	5-22.13	San Joaquin Valley	Tule	108,660
High	4	5-22.08	San Joaquin Valley	Kings	906,544
High	5	5-22.14	San Joaquin Valley	Kern County	700,323
High	6	5-22.12	San Joaquin Valley	Tulare Lake	125,701
High	7	5-22.09	San Joaquin Valley	Westside	27,285
Medium	1	5-28	Tehachapi Valley West	NA	17,313
Low	1	5-22.10	San Joaquin Valley	Pleasant Valley	34,213
Very Low	10	See *California Water Plan Update 2013*, Volume 4, *Reference Guide* article "California's Groundwater Update 2013"			
Total:	19	Total Population of Groundwater Basin Area			2,216,590

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, that DWR 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.

Groundwater Quality Monitoring

Groundwater quality monitoring is an important aspect to effective groundwater basin management and is one of the components that are 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. A summary of the larger groundwater quality monitoring efforts and references for additional information are provided below.

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 RWQCBs and DWR, and also has oil and gas hydraulically fractured well information from the California Division of Oil, Gas, and Geothermal Resources. Table TL-5 provides agency-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 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 (USGS 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.

The following lists the notable land subsidence monitoring efforts in the Tulare Lake Hydrologic Region:

- **California Aqueduct Elevation Surveys:** DWR conducts periodic elevation surveys along the California Aqueduct to measure land subsidence along the canal and guide maintenance repairs as needed. Recent 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 Interferometric 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 the 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 198 Elevation Monitoring:** As part of its Highway Elevation Monitoring program, Caltrans periodically resurveys its network of existing benchmarks along key sections. In 2004, Caltrans surveyed a section of Highway 198 across the San Joaquin Valley from the Diablo Range to Visalia. Prior surveys have been done at approximately 16-year intervals. Although the surveys are typically limited to the highway right-of-way and likely miss some of the larger land subsidence areas, the highway survey data have identified significant subsidence between survey intervals.
- **Global Positioning System (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 continuously monitor land surface elevation, providing a potential direct measurement of subsidence. There are 13 GPS stations in the San Joaquin Valley. However, several are close to the edge of the valley and can only offer partial insight into the regional magnitude of subsidence, while others lie outside of areas susceptible to subsidence (see http://pbo.unavco.org).

The results associated with land subsidence monitoring are provided in the "Land Subsidence" section later in this report.

Ecosystems

The Tulare Lake Hydrologic Region encompasses several different communities. The communities that are in the watershed of the Tulare Lake Hydrologic Region include montane forest, valley and foothill woodland, riparian woodland, mixed chaparral, valley grassland, freshwater marsh, alkali sink scrub, and creosote bush scrub found within the Sierra Nevada, foothills, San Joaquin Valley floor, and desert.

The Tulare Lake region watershed originates in the Sierra Nevada. The Sierra Nevada is characterized as a montane forest dominated by mixed conifers. It includes over 20,000 acres of giant sequoia tree groves, as well as other tree species: pines, firs, oaks, big-cone spruce, and alders. The montane forest understory is very diverse and includes mountain misery, gooseberry, currant, blackberries, manzanitas, and California-lilacs (Ornduff 2003). The Sierra Nevada receives most of the precipitation in the Tulare Lake region in the form of rain and snow. The Sierra Nevada is the principal source of water for the foothills and the valley floor.

The snowmelt and associated runoff flows from the Sierra Nevada through the foothills, sustaining the watershed. The foothills are composed of foothill woodland and riparian woodland alongside chaparral and valley grassland. These communities, as characterized by Ornduff (2003), are described as follows. The foothill woodland area is dominated by four tree species: California buckeye, oak, walnut and gray pine. The understory of foothill woodland is composed of species found in chaparral and valley grasslands. Chaparral is composed of mostly woody

Table TL-5 Sources of Groundwater Quality Information for the Tulare Lake 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 • Nitrate in Groundwater: Pilot Projects in Tulare Lake Basin/Salinas Valley http://www.waterboards.ca.gov/water_issues/programs/nitrate_project/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 • Central Valley Salinity Alternatives for Long-Term Sustainability (CV-Salts) http://www.waterboards.ca.gov/centralvalley/water_issues/salinity/ Groundwater Ambient Monitoring and Assessment (GAMA) Program 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 Contaminants • 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 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

Agency	Links to Information
California Department of Public Health http://www.cdph.ca.gov/	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
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 Substance Control http://www.dtsc.ca.gov/	EnviroStor http://www.envirostor.dtsc.ca.gov/public/
U.S. Environmental Protection Agency http://www.epa.gov/safewater/	EPA Storage and Retrieval (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

species with sparse oaks (chamise, mahogany, manzanita, California-lilac, California-holly, sumac, and yucca) and has evolved to conserve water during hot, dry summers. The valley grassland is dominated by non-native wild oats, brome grass, and fescue because of grazing, but maintains remnants of native three-awn, bunch grass and needle grass. The old-growth foothill woodland community often is used for grazing livestock, which inhibits new generations of trees from being established and facilitates the establishment of non-native species over native species in the understory. Along rivers adjacent to foothill woodland, the woodland is composed of big leaf maple, black cottonwood, and white alder, which contribute to water storage and collection.

The watershed terminates in the valley floor, which maintains small pockets of riparian woodland, valley grassland, freshwater marsh, alkali sink scrub, and creosote bush scrub where urbanization and agricultural development have not replaced them. Ornduff (2003) characterizes the valley floor communities as follows. Rivers and sloughs in the valley are lined with riparian woodland composed of the following tree species: California sycamore, California box elder, Fremont cottonwood, and willows. Where rivers have become channelized with levees and riparian woodland has been removed, invasive species including giant cane have become established. Valley grassland forms a mosaic of grassland, wetland, and vernal pool microhabitats. The valley grassland microhabitats include plants such as meadowfoam, *downingia*, and goldfields as well as previously mentioned valley grassland species. Freshwater marshes alongside valley grassland exist in the southern portion of what was once Tulare Lake and contain sedge, tule, and cattail. Alkali sink scrub — composed of saltbush, iodine bush, pickleweed, greasewood, and seep weed — is also found in this area and in other surrounding saline soils that have not been converted for agricultural purposes. Creosote bush scrub — characterized by antelope bush, sagebrush, and California buckwheat — is found in the vicinity of Bakersfield as well as in Tulare County alongside alkali sink scrub. The valley floor of the region receives little rain, but it does accumulate water from the watershed. After the water is diverted for agricultural and urban uses, it is stored in sloughs, freshwater marshes, and wetlands.

Much of the valley floor that was once riparian forest, valley grassland, freshwater marsh, and alkali sink scrub has been converted for urban and agricultural uses. The rivers that flow through the valley have been channelized; only remnants of each community remain. The conversion of land to agriculture and urbanization has caused many of the native species found in the San Joaquin valley to be listed as threatened or endangered (Tables TL-6, TL-7, and TL-8).

Flood

Floods in the Tulare Lake Hydrologic Region can be caused by heavy rainfall; by dams, levees, or other engineered structures failing; or by extreme wet-weather patterns. Historically, in the Tulare Lake region flooding originates 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 in the region was intermittent, with severe flooding some years and drought in other years. Flash and slow-rise flooding are the most commonly experienced types of flooding in this hydrologic region. Floods that occur in the Tulare Lake region take a variety of forms and can be classified into flash, alluvial fan, debris flow, stormwater, slow-rise, and engineered structure failure flooding. For a complete record of floods, refer *California Flood Future Report, Attachment C: Flood history of California* technical memorandum (California Department of Water Resources and the U.S. Army Corps of Engineers 2013a).

Major flood events in the Tulare Lake Hydrologic Region include:

- In December 1955 through January 1956, a storm caused by a family of cyclones from the mid-Pacific Ocean poured rain and induced snowmelt on low elevations of the Tulare Lake Hydrologic Region, inundating 183,000 acres of mostly agricultural land and the towns of Visalia, Three Rivers, and Exeter.
- In 1966 and 1967 region-wide floods claimed three lives and inundated about 142,000 acres.

Table TL-6 Selected Regionally Endemic Endangered Plant Species in the Tulare Lake Hydrologic Region[a]

Common Name	Scientific Name	Federal Status	California Status	California Native Plant Society Rank
Caper-fruited Tropidocarpum	*Tropidocarpum capparideum*			1B.1
Diamond-petaled California Poppy	*Eschscholzia rhombipetala*			1B.1
Fort Tejon Woolly Sunflower	*Eriophyllum lanatum* var. *hallii*			1B.1
Greene's Tuctoria	*Tuctoria greenei*	FE	SR	1B.1
Hispid Bird's-beak	*Chloropyron molle* ssp. *hispidum*			1B.1
Hoover's Spurge	*Chamaesyce hooveri*	FT		1B.2
Keck's Checkerbloom	*Sidalcea keckii*	FE		1B.1
Lesser Saltscale	*Atriplex minuscula*			1B.1
Mason's Neststraw	*Stylocline masonii*			1B.1
Mojave Tarplant	*Deinandra mohavensis*		SE	1B.3
Pale-yellow Layia	*Layia heterotricha*			1B.1
Palmate-bracted Bird's-beak	*Chloropyron palmatum*	FE	SE	1B.1
Piute Mountains Navarretia	*Navarretia setiloba*			1B.1
Prostrate Vernal Pool Navarretia	*Navarretia prostrata*			1B.1
San Joaquin Valley Orcutt Grass	*Orcuttia inaequalis*	FT	SE	1B.1
San Joaquin Woollythreads	*Monolopia congdonii*	FE		1B.2
Showy Golden Madia	*Madia radiata*			1B.1
Slough Thistle	*Cirsium crassicaule*			1B.1
Succulent Owl's-clover	*Castilleja campestris* ssp. *succulenta*	FT	SE	1B.2

Notes:

FE = federally listed as endangered, FT = federally listed as threatened, SE = State-listed as endangered, SR = State-listed as rare, 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, 1B.3 = plants rare, or more or less threatened or endangered in California and elsewhere

[a] Table shows only federally endangered and/or State endangered and/or California Native Plant Society Rank 1B.1 plant species.

- In early 1969, heavy precipitation plus a prodigious snowpack melt in January and February caused flooding throughout the region and re-inundated 89,000 acres in the bed of Tulare Lake.
- In 1995, flash flooding occurred on the Arroyo Pasajero. A severe storm flooded I-5 and threatened the California Aqueduct.
- In January 1997, heavy precipitation flooded the region, causing a levee on the Tule River to break, which submerged 50,000 acres of agricultural lands in the bed of Tulare Lake. In 1998,

Table TL-7 Selected California Endemic Endangered Plant Species Found in the Tulare Lake Hydrologic Region[a]

Common Name	Scientific Name	Federal Status	California Status	California Native Plant Society Rank
Bakersfield Cactus	*Opuntia basilaris* var. *treleasei*	FE	SE	1B.1
California Jewel-flower	*Caulanthus californicus*	FE	SE	1B.1
Comanche Point Layia	*Layia leucopappa*			1B.1
Hall's Tarplant	*Deinandra halliana*			1B.1
Kaweah Brodiaea	*Brodiaea insignis*		SE	1B.2
Kern Mallow	*Eremalche kernensis*	FE		1B.1
Kings Gold	*Tropidocarpum californicum*			1B.1
Oil Neststraw	*Stylocline citroleum*			1B.1
Ramshaw Meadows Abronia	*Abronia alpina*	FC		1B.1
Rayless Layia	*Layia discoidea*			1B.1
San Benito Evening-primrose	*Camissonia benitensis*	FT		1B.1
San Joaquin Adobe Sunburst	*Pseudobahia peirsonii*	FT	SE	1B.1
Shevock's Rockcress	*Boechera shevockii*			1B.1
Springville Clarkia	*Clarkia springvillensis*	FT	SE	1B.2
Striped Adobe-lily	*Fritillaria striata*		ST	1B.1
Tehachapi Buckwheat	*Eriogonum callistum*			1B.1
Tejon Poppy	*Eschscholzia lemmonii* ssp. *kernensis*			1B.1
Vasek's Clarkia	*Clarkia tembloriensis* ssp. *calientensis*			1B.1
Coulter's Goldfields	*Lasthenia glabrata* ssp. *coulteri*			1B.1
Horn's Milk-vetch	*Astragalus hornii* var. *hornii*			1B.1
Round-leaved Filaree	*California macrophylla*			1B.1

Notes:

FC = candidate for federal listing, FE = federally listed as endangered, FT = federally listed as threatened, SE = State-listed as endangered, ST = State-listed as threatened, 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, 1B.3 = plants rare, or more or less threatened or endangered in California and elsewhere

[a] The table shows only federally endangered and/or State endangered and/or California Native Plant Society Rank 1B.1 plant species.

a heavy snowpack and warm rains produced flooding of the White River that inundated the city of Earlimart and closed U.S. Highway 99 for a week.

- In January of 1997, heavy precipitation flooded the region, causing a levee on the Tule River to break, which submerged 50,000 acres of agricultural lands in the Tulare Lake bed.

Table TL-8 Endangered Wildlife Species Found in the Tulare Lake Hydrologic Region[a]

Common Name	Scientific Name	Federal Status	California Status	Type
Sierra Madre Yellow-legged Frog	*Rana muscosa*	FE	SCE	Amphibian
Sierra Nevada Yellow-legged Frog	*Rana sierrae*	FC	SCE	Amphibian
Bald Eagle	*Haliaeetus leucocephalus*	FD	SE, FP	Bird
California Condor	*Gymnogyps californianus*	FE	SE	Bird
Golden Eagle	*Aquila Chrysaetos*		FP	Bird
Great Gray Owl	*Strix nebulosa*		SE	Bird
Least Bell's Vireo	*Vireo bellii pusillus*	FE	SE	Bird
Southwestern Willow Flycatcher	*Empidonax traillii extimus*	FE	SE	Bird
Western Yellow-billed Cuckoo	*Coccyzus americanus occidentalis*	FC	SE	Bird
White-tailed Kite	*Elanus Leucurus*		FP	Bird
Willow Flycatcher	*Empidonax traillii*		SE	Bird
Vernal Pool Tadpole Shrimp	*Lepidurus packardi*	FE		Invertebrate
Buena Vista Lake Shrew	*Sorex ornatus relictus*	FE		Mammal
Fresno Kangaroo Rat	*Dipodomys nitratoides exilis*	FE	SE	Mammal
Giant Kangaroo Rat	*Dipodomys ingens*	FE	SE	Mammal
San Joaquin Kit Fox	*Vulpes macrotis mutica*	FE	ST	Mammal
Sierra Nevada Bighorn Sheep	*Ovis canadensis sierrae*	FE	SE, FP	Mammal
Tipton Kangaroo Rat	*Dipodomys nitratoides nitratoides*	FE	SE	Mammal
Blunt-nosed Leopard Lizard	*Gambelia sila*	FE	SE, FP	Reptile

Notes:

FC = candidate for federal listing, FD = federally delisted, FE = federally listed as endangered, FP = fully protected under the California Department of Fish & Wildlife, SCE = candidate for State listing as endangered, SE = State-listed as endangered, ST = State-listed as threatened

[a] The table shows only federally endangered or State endangered wildlife species. There are no FE or SE fish species in the Tulare Lake Hydrologic Region.

The Tulare Lake Hydrologic Region is divided into several main hydrologic subareas — the alluvial fans for the Sierra foothills and basin subarea, bed of Tulare Lake, and the southwestern uplands. The dominant hydrologic features in the alluvial fan/basin subareas are Tulare Lake and the Kings, Kaweah, Tule, and Kern rivers and their major distributaries. All of the larger streams in Tulare Lake region are diverted for irrigation or other purposes. The valley floor is flat, and the entire volume of most of the larger streams flows into multiple channels and irrigation canals, reaching Tulare Lake only in years of extremely high runoff. This weather pattern is known as an Atmospheric River. For a complete record of floods, refer to *California Flood Future Report,* *Attachment C: Flood history of California* technical memorandum (California Department of Water Resources and the U.S. Army Corps of Engineers 2013a).

Climate

The climate in combination with the fertile soil in the valley portion of the region is well suited for farming. Runoff from the adjacent Sierra Nevada provides good quality water for irrigation along with local groundwater. The region's long growing season (April through October), warm/hot summers, and a fall harvest period usually sparse in rain provides a near ideal environment for production of many crops. Winters are moist and often blanketed with tule fog. The valley floor is surrounded on three sides by mountain ranges, resulting in a comparative isolation of the valley from marine effects. Because of this and the comparatively cloudless summers, normal maximum temperature advances to a high of 101 °F during the latter part of July. Valley winter temperatures are usually mild, but during infrequent cold spells air temperature occasionally drops below freezing. Heavy frost occurs during the winter in most years, and the geographic orientation of the valley generates prevailing winds from the northwest.

The mean annual precipitation in the valley portion of the region ranges from about 6 to 11 inches, with 67 percent falling from December through March, and 95 percent falling from October through April. The region receives more than 70 percent of the possible amount of sunshine during all but four months, November through February. In the winter months, tule fog, which can last up to two weeks, reduces sunshine to a minimum.

Demographics

Population

Tulare Lake Hydrologic Region had almost 2.27 million people according to the 2010 Census. Between 2005 and 2010, the region's population grew by 174,029 people or about 8.3 percent. Among the four larger counties in the Tulare Lake region (Table TL-9), Kern County grew the fastest both from 2000-2005 and 2005-2010 with population increases of 15.7 percent and 10.7 percent, respectively. About 6 percent of the state's total population lives in this region, and 71 percent of the region's population lives in incorporated cities. The top 10 populous cities (Table TL-10) are inhabited by about 1.29 million people or 56.7 percent of the region's total population.

Tribal Communities

Under the Clean Water Act, 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. In the United States, there are approximately 565 federally recognized tribes. In California, there are 110 federally recognized tribes, 20 percent of the total nationally.

Section 319 of the Clean Water Act 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 Tulare Lake Hydrologic Region, there are three tribes with Treatment-as-a-

Table TL-9 County Populations in the Tulare Lake Hydrologic Region

County	July 2000	July 2005	April 2010
Fresno	784,514	854,116	912,334
Kern	593,130	686,039	759,693
Kings	129,764	144,601	152,982
Los Angeles	8	3	2
San Benito	77	74	72
San Luis Obispo	43	41	38
Tulare	368,805	408,403	442,179
Ventura	10	29	35
Hydrologic Region Total	1,876,351	2,093,306	2,267,335

Source: California Department of Finance 2010.

Note: County populations are for areas in the Tulare Lake Hydrologic Region only.

Table TL-10 Ten Most Populous Incorporated Cities in 2010, Tulare Lake Hydrologic Region

City	County	2010 Population
Fresno	Fresno	484,008
Bakersfield	Kern	331,868
Visalia	Tulare	119,312
Clovis	Fresno	91,166
Tulare	Tulare	56,938
Porterville	Tulare	52,762
Hanford	Kings	52,315
Delano	Kern	51,310
Wasco	Kern	25,143
Corcoran	Kings	25,136

Source: California Department of Finance 2010.

State (TAS) status (Table TL-11) and are eligible for Section 319 program funding: Cold Springs Rancheria of Mono Indians, Santa Rosa Rancheria, and Tule River Indian Tribe.

Section 106 of the Clean Water Act 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 TL-11 Federally Recognized Tribes in the Tulare Lake Hydrologic Region

Name of Tribe	Acres	Cultural Affiliation
Cold Springs Reservation	155	Western Mono Indians
Santa Rosa Rancheria	1,803	Tache, Tachi, and Yokuts Indians
Tule River Reservation	55,395	Yokuts Indians

Source: U.S. Bureau of Indian Affairs

programs, water quality assessment, standards development, planning, and other activities intended to manage reservation water resources. In California, 68 tribes and one inter-tribal consortium are involved in Section 106 programs.

Disadvantaged Communities

The region's economy hasn't grown as quickly as the population. Approximately 51 percent of the region's population lived in DACs in 2010. The DAC definition is provided in DWR's Proposition 84 and 1E Integrated Regional Water Management guidelines. The median household income (MHI) for DACs is 80 percent or less than the statewide MHI. Out of the 113 DACs identified in this region, 54 had a population greater than 2,000 (shown in Figure TL-9 and listed in Table TL-12).

Land Use Patterns

The Tulare Lake Hydrologic Region has the most land dedicated to agricultural crops in the state. Total irrigated land was 2,892,700 acres in 2010 while the total crop production was 3,085,500 acres. As shown in Table TL-13, almonds/pistachios (499,700 acres) were the top crop type by acreage followed by vineyards (346,800 acres) and corn (342,800 acres). In 2005, the total irrigated land was 2,956,600 acres, and the total crop production was 3,130,100 acres. Cotton had the most acreage planted in 2005 (542,800 acres) followed by alfalfa (353,900 acres) and then vineyards (339,600 acres). Due to lower commodity prices and concerns about imported water availability, cotton acreage decreased to a low of 142,800 acres in 2009. After better water availability and higher demand, cotton rebounded slightly in 2010 to 219,800 acres. Still, many farmers in the region replaced some of their cotton fields with almonds and/or pistachios, leading to a 53.4 percent increase in these tree crops' acreages. With the closing of the last sugar beet processors in the region, sugar beet acreage dropped from 13,100 acres in 2005 to barely 300 acres in 2010. Also, alfalfa acreage decreased by 38,200 acres between 2005 and 2010 while grain grew by 41,700 acres from 2005 to 2010.

Urban acreage increased in Fresno, Kern, Kings and Tulare counties from 2004 to 2010 (Table TL-14). Kern County had the greatest amount of land converted to urban use during this period, increasing from 101,900 acres in 2004 to 119,660 acres in 2010. Overall, urban land use increased by 13.0 percent or 38,450 acres in the region. More information about the amount of land converted to urban use can be found at the California Department of Conservation Farmland Mapping and Monitoring Program, at http://www.conservation.ca.gov/DLRP/fmmp/Pages/Index.aspx.

Figure TL-9 Tulare Lake Hydrologic Region Disadvantaged Communities and Integrated Regional Water Management

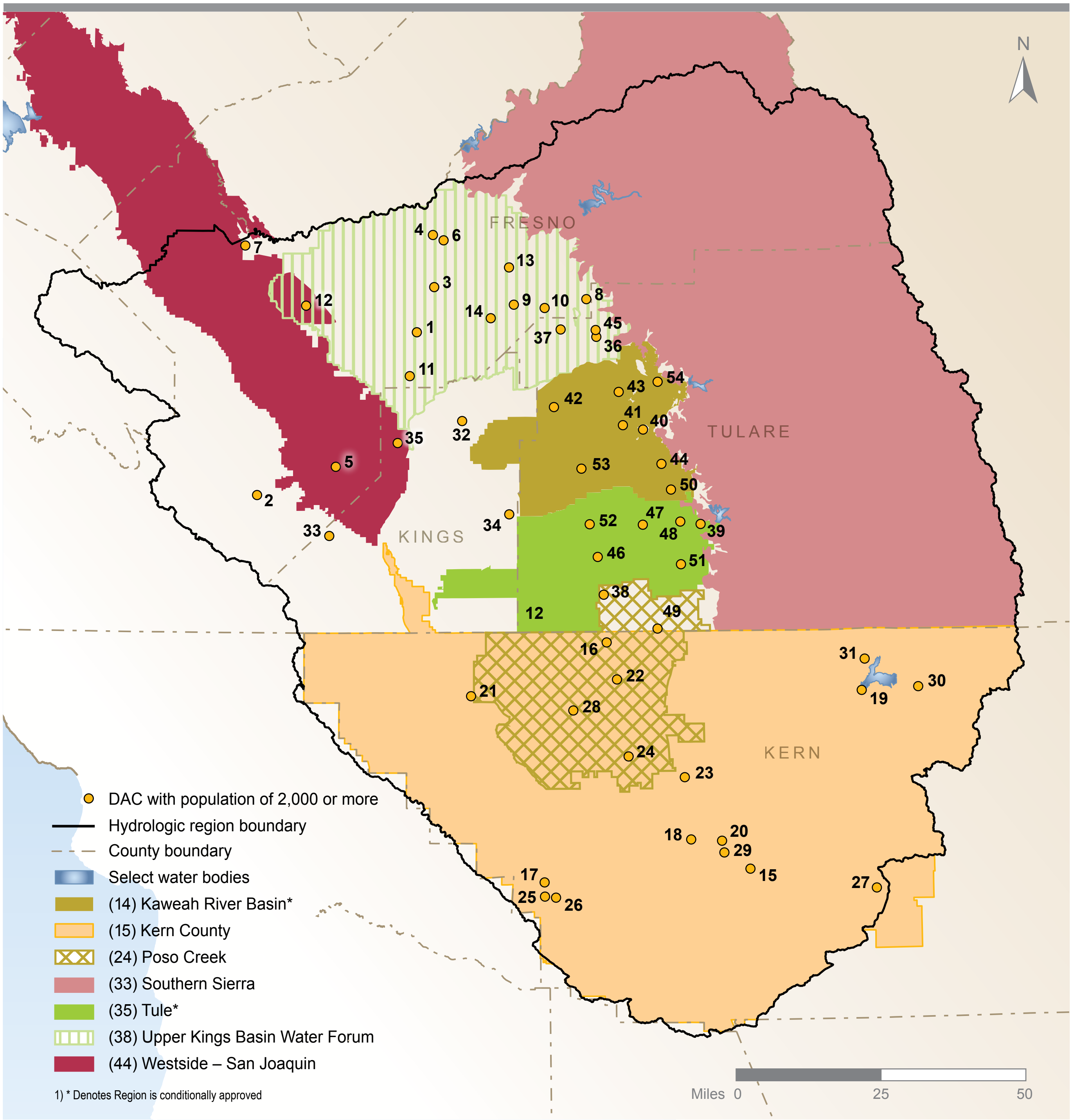


Table TL-12 Disadvantaged Communities by County with Populations of 2,000 or More, Tulare Lake Hydrologic Region

Map Number (Red Dot)	Community	Place Type[a]	Population	Median Household Income	County
1	Caruthers	CDP	2,883	$44,545	Fresno
2	Coalinga	City	13,086	$46,229	Fresno
3	Easton	CDP	2,017	$44,390	Fresno
4	Fresno[b]	City	484,008	$43,124	Fresno
5	Huron	City	6,691	$20,410	Fresno
6	Mayfair	CDP	4,046	$40,288	Fresno
7	Mendota	City	10,459	$25,216	Fresno
8	Orange Cove	City	8,718	$26,942	Fresno
9	Parlier	City	13,928	$34,405	Fresno
10	Reedley	City	23,669	$46,693	Fresno
11	Riverdale	CDP	3,193	$48,333	Fresno
12	San Joaquin	City	3,927	$26,731	Fresno
13	Sanger	City	23,370	$42,444	Fresno
14	Selma	City	22,617	$44,778	Fresno
15	Arvin	City	18,329	$32,949	Kern
16	Delano	City	51,310	$35,673	Kern
17	Ford City	CDP	3,684	$26,053	Kern
18	Greenfield	CDP	3,996	$45,851	Kern
19	Lake Isabella	CDP	3,287	$19,627	Kern
20	Lamont	CDP	15,365	$33,799	Kern
21	Lost Hills	CDP	2,143	$29,632	Kern
22	McFarland	City	12,302	$35,656	Kern
23	Oildale	CDP	32,754	$35,538	Kern
24	Shafter	City	16,378	$35,915	Kern
25	South Taft	CDP	2,177	$36,250	Kern
26	Taft	City	9,370	$46,324	Kern
27	Tehachapi	City	14,080	$46,067	Kern
28	Wasco	City	25,143	$40,054	Kern
29	Weedpatch	CDP	2,429	$24,324	Kern
30	Weldon	CDP	2,304	$32,690	Kern

Map Number (Red Dot)	Community	Place Type[a]	Population	Median Household Income	County
31	Wofford Heights	CDP	2,497	$25,224	Kern
32	Armona	CDP	3,046	$43,609	Kings
33	Avenal	City	15,749	$33,350	Kings
34	Corcoran	City	25,136	$35,051	Kings
35	Lemoore Station	CDP	7,890	$42,151	Kings
36	Cutler	CDP	5,058	$30,062	Tulare
37	Dinuba	City	20,823	$39,165	Tulare
38	Earlimart	CDP	6,596	$25,236	Tulare
39	East Porterville	CDP	6,498	$27,765	Tulare
40	Exeter	City	10,139	$43,690	Tulare
41	Farmersville	City	10,283	$32,886	Tulare
42	Goshen	CDP	3,214	$34,653	Tulare
43	Ivanhoe	CDP	4,315	$35,603	Tulare
44	Lindsay	City	11,528	$30,085	Tulare
45	Orosi	CDP	8,745	$34,846	Tulare
46	Pixley	CDP	2,949	$35,759	Tulare
47	Poplar-Cotton Center	CDP	2,095	$33,556	Tulare
48	Porterville	City	52,762	$39,838	Tulare
49	Richgrove	CDP	2,694	$28,261	Tulare
50	Strathmore	CDP	3,298	$19,983	Tulare
51	Terra Bella	CDP	3,551	$26,585	Tulare
52	Tipton	CDP	2,172	$37,171	Tulare
53	Tulare	City	56,938	$46,647	Tulare
54	Woodlake	City	7,178	$29,417	Tulare

Notes:

Population and median household income are from 2010 U.S. Census data.

[a] CDP = Census Designated Place.

[b] Excludes Fort Washington, Old Fig Garden, and Sunnyside CDPs.

Table TL-13 Tulare Lake Hydrologic Region 20 Crop Type Acreages 2005-2010

Crop Type[a]	2005	2006	2007	2008	2009	2010
Grain	181,700	200,000	168,700	238,900	205,500	223,400
Rice	0	0	0	0	0	0
Cotton	542,800	430,100	340,300	190,000	142,800	219,800
Sugar Beets	13,100	11,500	7,100	5,100	400	300
Corn	326,400	335,100	358,600	397,500	383,200	342,800
Dry Beans	13,700	17,300	13,900	8,600	19,800	18,400
Safflower	5,100	5,600	12,400	54,500	9,200	8,000
Other Field Crops	228,000	233,600	221,200	268,400	291,700	285,500
Alfalfa	353,900	336,900	313,800	338,900	352,900	315,700
Pasture	21,100	17,400	13,400	30,200	45,600	48,100
Processing Tomatoes	119,500	119,400	135,600	128,900	133,100	135,100
Market Tomatoes	9,900	7,400	2,900	6,600	7,200	5,300
Cucurbits	33,500	25,900	28,100	26,000	24,300	28,000
Onions and Garlic	38,100	42,700	41,700	40,900	42,000	50,200
Potatoes	23,500	26,900	16,000	15,500	14,000	14,000
Other Truck Crops	124,700	128,600	120,400	104,200	92,400	95,500
Almonds/Pistachio	325,700	417,900	443,300	467,200	475,900	499,700
Other Deciduous Trees	210,500	204,800	218,300	217,900	210,900	217,900
Subtropical	219,300	226,900	231,300	221,600	210,900	231,000
Vineyard	339,600	353,100	354,300	361,000	348,500	346,800
Subtotal	3,130,100	3,141,100	3,041,300	3,121,900	3,010,300	3,085,500
Double crop	173,500	186,700	170,500	209,600	157,700	192,800
Total land acres	**2,956,600**	**2,954,400**	**2,870,800**	**2,912,300**	**2,852,600**	**2,892,700**

Notes:

[a] Based on DWR Land and Water Use Standard 20 Crop Types

Other Field Crops: Flax, hops, grain sorghum, sudan, castor beans, miscellaneous fields, sunflowers, hybrid sorghum/sudan, millet and sugar cane.

Cucurbits: Melons, squash and cucumbers.

Other Truck Crops: Artichokes, asparagus, beans (green), carrots, celery, lettuce, peas, spinach, flowers nursery and tree farms, bush berries, strawberries, peppers, broccoli, cabbage, cauliflower and Brussels sprouts.

Other Deciduous Trees: Apples, apricots, cherries, peaches, nectarines, pears, plums, prunes, figs, walnuts and miscellaneous deciduous.

Table TL-14 Tulare Lake Hydrologic Region Change in Urban Area, 2004-2010

County	2004	2010	Change in Area (Acres)	Change in Area (Percentage)
Fresno	108,177	117,770	9,593	8.9%
Kern	101,900	119,660	17,760	17.4%
Kings	30,767	35,847	5,080	16.5%
Tulare	53,927	59,944	6,017	11.2%
Total	294,771	333,221	38,450	13.0%

Notes:

Based on GIS data analysis for the Tulare Lake Hydrologic Region portion of each county. 2004 was chosen instead of 2005 because the data is only updated in even years.

Source: California Dept. of Conservation, Division of Land Resource Protection, Farmland Mapping and Monitoring Program - http://www.conservation.ca.gov/DLRP/fmmp/Pages/Index.aspx.

Regional Resource Management Conditions

Water in the Environment

The natural communities in the Tulare Lake region include the mountain and foothill valley, the riverine (intermittent and continuous), lacustrine, and estuarine (wetland) communities. Efforts continue to secure water for riverine and wetland environments, as well as, protect areas containing remaining natural vernal pools (valley and terrace).

The Omnibus Public Land Management Act provided settlement of the San Joaquin River Restoration effort and designates wilderness areas in the Sierra watershed for the Tulare Lake region (see San Joaquin River Regional Report).

Surface water is delivered to the Kern National Wildlife Refuge and Mendota Wildlife Area. The surface water received by the refuges is a direct result of the Central Valley Project Improvement Act (CVPIA). Reported deliveries for 2006-2010 are in Tables TL-15 and TL-16.

The wild and scenic water dedications in the Tulare Lake region are for designated stretches along the Kings and Kern rivers and are based on unimpaired runoff or natural flows. Table TL-17 presents flows for water years 2006-2010. In the region, the lower Kern River and the North, Middle and East forks of the Kaweah River have been determined eligible for wild and scenic designation status by the U.S. Bureau of Land Management due to outstanding resource value.

At Pine Flat Dam on the Kings River, the Kings River Fisheries Management Program was established in 1999. The program is a collaborative effort between the Kings River Conservation District, the Kings River Water Association, the California Department of Fish and Wildlife (DFW), and an active public advisory group. The program endeavors to enhance the fishery and wildlife resources below the dam and protect the water rights held by Kings River water users (Table TL-17).

Table TL-15 Surface Water Deliveries to Kern National Wildlife Refuge, 2006-2010 (thousand acre-feet)

Source	2006	2007	2008	2009	2010
Central Valley Project	21.8	21.6	17.7	19.6	21.8

Table TL-16 Surface Water Deliveries to Mendota Wildlife Area (thousand acre-feet)

Source	2006	2007	2008	2009	2010
Central Valley Project	21.8	29.8	26.4	25.5	26.6

Water Supplies

For an overview of the region's water inflows and outflows see Figure TL-11.

Agricultural Water

During a normal water year like 2005, surface water supplies (primarily river water delivered through projects) approximately 70 percent of the agricultural water demand in the Tulare Lake Hydrologic Region. However, during critically dry periods such as 2009, farmers rely on groundwater supplies with almost 69 percent of the applied water demand being met by groundwater (Figure TL-10).

Recycled Municipal Water

According to the 2009 Municipal Wastewater Recycling Survey, compiled by the SWRCB and DWR, approximately 130,000 af of recycled were beneficially used in the Tulare Lake Hydrologic Region during 2009. Over 96 percent of the recycled water in the Tulare Lake region was used for agricultural 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. Therefore, the policy requires stakeholders to work together to develop salt and nutrient management plans (State Water Resources Control Board 2009).

In the Central Valley, of which the Tulare Lake region is a part, the Central Valley Regional Water Quality Control Board (CVRWQCB) and the SWRCB, as part of a stakeholder effort, are developing comprehensive salt and nitrate management plans 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 waters and groundwaters 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. As this issue impacts all users (stakeholders) of water within the Tulare Lake 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 Tulare Lake region.

Table TL-17 Dedicated Natural Flows, 2006-2010

River	Deliveries (in taf)					Dedicated Section
	2006	2007	2008	2009	2010	
Kings River	1,727	405	724	809	1,220	Middle Fork-from headwaters at Lake Helen to main. South Fork from its headwaters at Lake 11599 to main. Main stem from confluence of middle and south forks to the point. at elevation 1,595 feet above mean sea level.
Kern River - North Fork	885	242	445	413	700	From segment of main stem from Tulare-Kern Co. line to its headwaters in Sequoia National Park.
Kern River - South Fork	146	22	58	41	96	From headwaters in Inyo National Forest to southern boundary of the Domelands Wilderness in Sequoia National Forest.

Note:

taf = thousand acre-feet

For the Central Valley, the only acceptable process to develop the salt and nutrient management plans that are required under State policy (State Water Resources Control Board 2009) is through CV-SALTS.

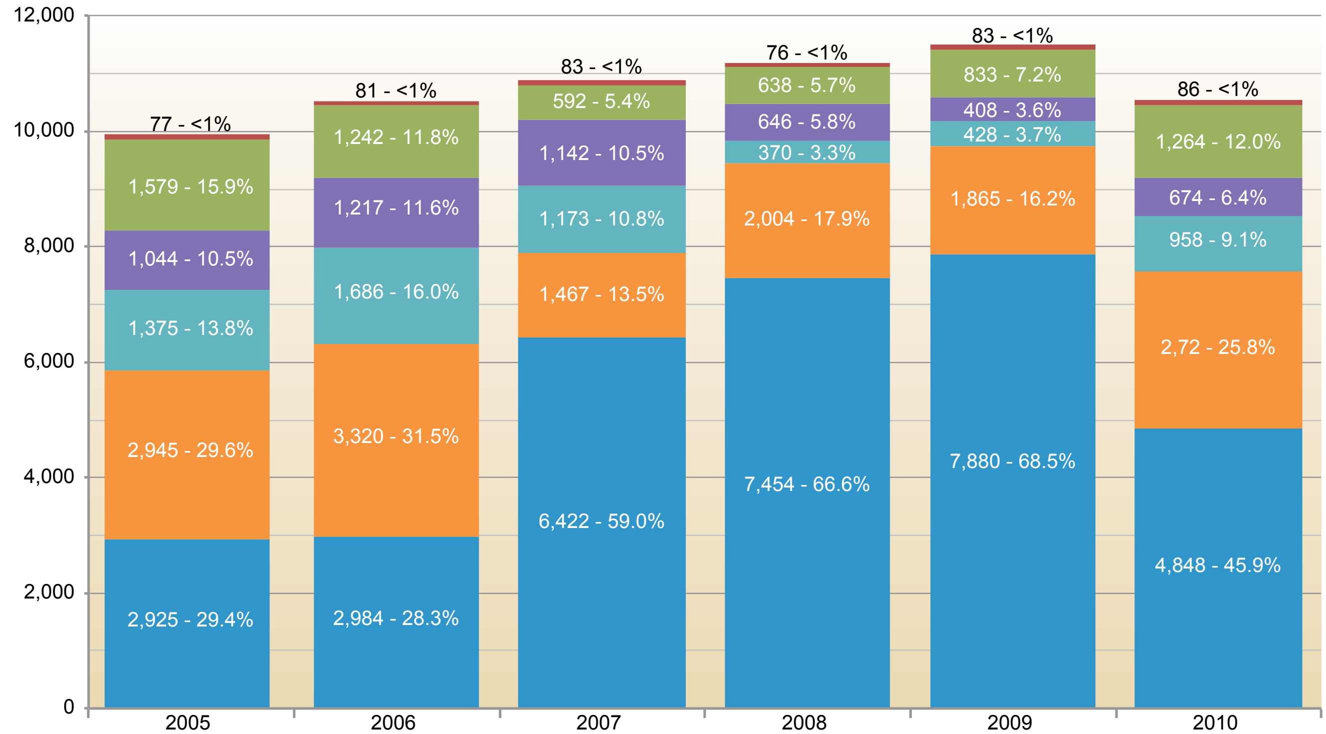
Additional information on statewide municipal recycled water is included in Volume 3, *Resource Management Strategies*, Chapter 12 "Recycled Municipal Water." Additional information on specific recycled water uses in the Tulare Lake Hydrologic Region can be found in Volume 4, *Reference Guide*.

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 (PA), county, and by the type of use. Although groundwater accounts for more than one-half of the region's total water supply, the majority of groundwater supplies (almost 90 percent) are used to meet agricultural use while over 9 percent goes to urban use. About one-half percent of the groundwater supply is used to meet managed wetlands use in the region.

Figure TL-12 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 11.7 maf, of which 6.2 maf is from groundwater supply (53 percent). Groundwater pumping in the Tulare Lake Hydrologic Region accounts for 38 percent of all the groundwater extraction in California — double the amount of the two hydrologic regions coming second and third, San

Figure TL-10 Total Agricultural Applied Water Supply Source (thousand acre-feet) (with Supply Source as a Percentage of Total Agricultural Applied Water)

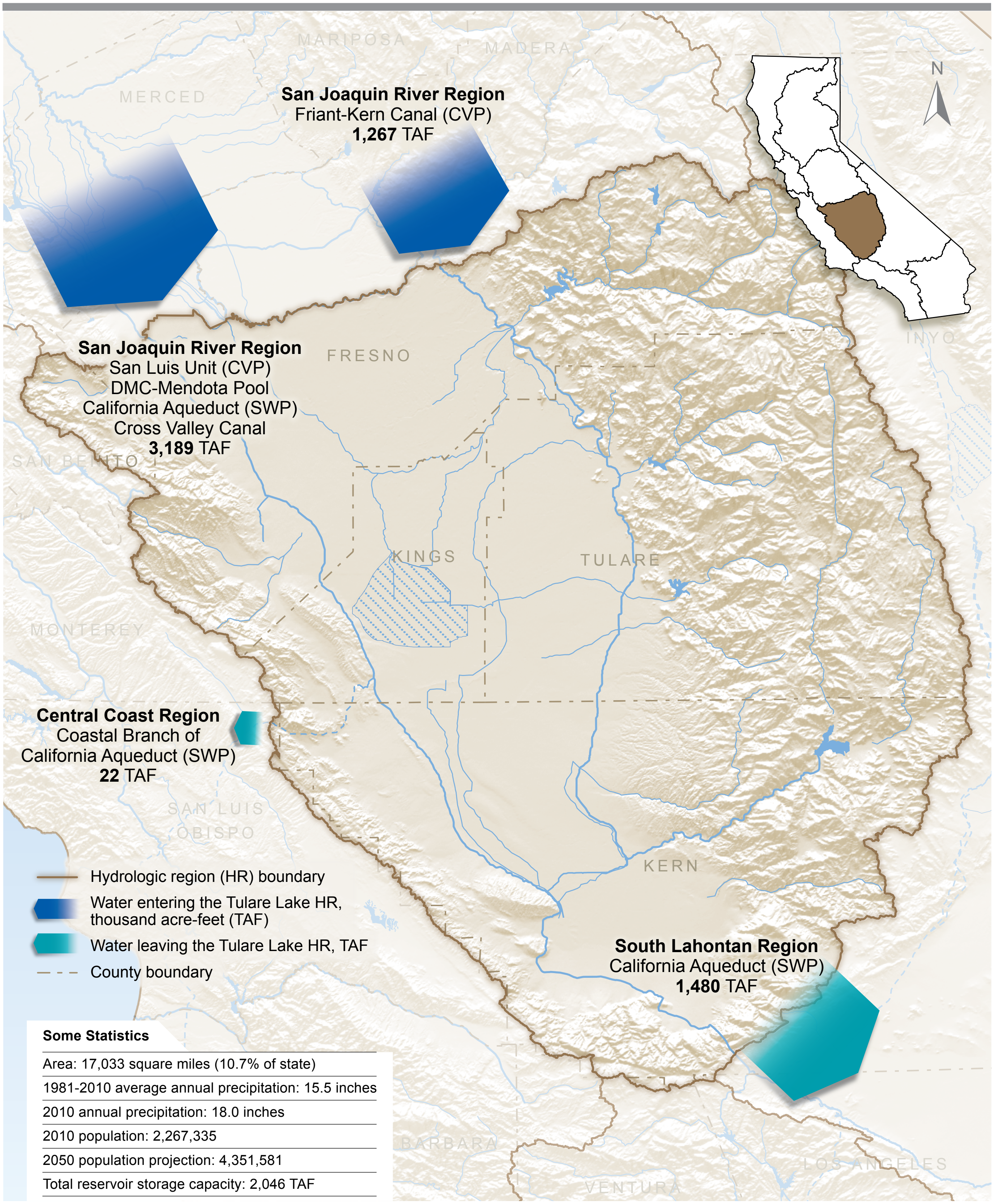


Joaquin River Hydrologic Region with 19 percent and Sacramento River Hydrologic Region with 17 percent of the total groundwater extraction.

Figure TL-12 also shows that Lower Kings-Tulare and Kaweah Delta planning areas are the two largest users of groundwater in the region, being supplied with an average of about 3.08 maf combined (50 percent of the total groundwater supply in the region). The average annual groundwater pumping are also quite high (approximately 500 to 700 thousand acre-feet [taf]) in the San Luis West Side, Alta-Orange Cove, Semitropic-Buena Vista, and Kern Delta planning areas. Groundwater status reports from groundwater management agencies overlying these planning areas acknowledge that the average annual groundwater extraction commonly exceeds sustainable aquifer yield.

Table TL-18 provides the 2005-2010 average annual groundwater supply by planning area and by type of use. Groundwater supplies meet 82 percent (0.60 maf) of the overall urban water use, 51 percent (5.55 maf) of the overall agricultural water use, and 37 percent (29 taf) of the managed wetlands use in the region. The lower Kings-Tulare and Kaweah Delta rely on groundwater to meet between 60 and 70 percent of their agricultural water use. Most of the planning areas are also highly dependent on groundwater to meet their urban water uses, with between 40 and 100 percent of the use being met by groundwater. The smallest groundwater user, Western Uplands, is 100 percent dependent on groundwater supply to meet its urban and agricultural water uses.

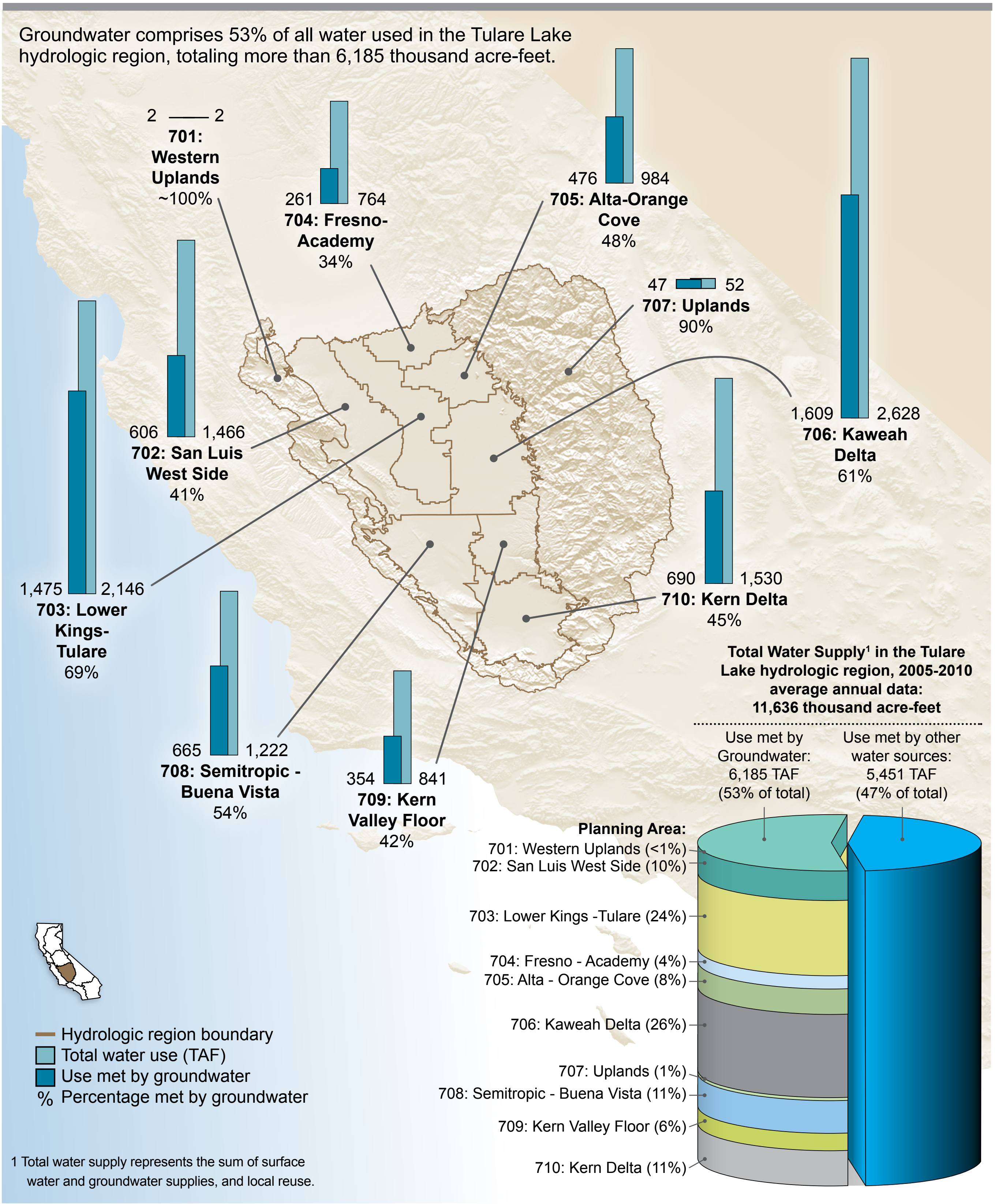
Figure TL-11 Tulare Lake Regional Inflows and Outflows in 2010



Some Statistics

Area: 17,033 square miles (10.7% of state)
1981-2010 average annual precipitation: 15.5 inches
2010 annual precipitation: 18.0 inches
2010 population: 2,267,335
2050 population projection: 4,351,581
Total reservoir storage capacity: 2,046 TAF

Figure TL-12 Contribution of Groundwater to the Tulare Lake 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 TL-18 Tulare Lake Hydrologic Region Average Annual Groundwater Supply by Planning Area and by Type of Use, 2005-2010

Planning Area Number	Planning Area Name	Agriculture Use Met by Groundwater		Urban Use Met by Groundwate		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groundwater	
		TAF	%	TAF	%	TAF	%	TAF	%
701	Western Uplands	0.3	100	2.0	100	0.0	0	2.3	100
702	San Luis West Side	598.5	41	7.5	42	0.0	0	606.0	41
703	Lower Kings-Tulare	1,429.0	69	44.5	100	1.1	4	1,474.6	69
704	Fresno - Academy	56.8	11	204.5	78	0.0	0	261.2	34
705	Alta - Orange Cove	417.2	45	59.3	97	0.0	0	476.5	48
706	Kaweah Delta	1,492.6	59	112.8	97	3.2	100	1,608.7	61
707	Uplands	32.6	97	14.3	76	0.0	0	46.9	90
708	Semitropic - Buena Vista	622.7	54	17.7	74	24.7	55	665.0	54
709	Kern Valley Floor	322.0	40	31.9	97	0.0	0	353.9	42
710	Kern Delta	580.3	42	109.7	68	0.0	0	690.0	45
2005-2010 annual average region total		5,551.8	51	604.1	82	28.9	37	6,184.8	53

Notes:

taf = thousand acre-feet

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

2005-2010 precipitation equals 91 percent of the 30-year average for the Tulare Lake Hydrologic Region

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 Tulare Lake Hydrologic Region, county groundwater supply is reported for Fresno, Kern, Kings, and Tulare counties. Table TL-19 shows that groundwater contributes to more than 50 percent of the total water supply in the four-county area, ranging from less than 50 percent to over 60 percent for individual counties. Groundwater supplies in the four-county area are used to meet about 50 percent of the agricultural water use and about 80 percent of the urban water use.

Table TL-19 Tulare Lake Hydrologic Region Average Annual Groundwater Supply by County and by Type of Use, 2005-2010

County	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groundwater	
	TAF	%	TAF	%	TAF	%	TAF	%
Fresno	1,657.6	45	272.4	80	1.1	4	1,931.0	48
Kern	1,549.2	46	185.6	72	24.7	55	1,759.5	48
Kings	939.8	58	39.6	94	0.0	0	979.4	59
Tulare	1,587.1	59	131.3	98	3.2	100	1,721.6	61
2005-2010 Annual Average Total	5,733.6	51	628.9	81	29.0	37	6,391.4	52

Notes:

taf = thousand acre-feet

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

2005-2010 precipitation equals 91 percent of the 30-year average for the Tulare Lake Hydrologic Region.

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 TL-13 and TL-14 summarize the 2002 through 2010 groundwater supply trends for the region.

The right side of Figure TL-13 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 average for the region. The figure indicates that the annual water supply for the region has remained relatively stable between 2002 and 2010, between a low of 10.6 maf in 2005 and a high of 12.4 maf in 2009. However, periodic cutbacks in surface water deliveries in the region during this period have resulted in large fluctuations in the annual amount of groundwater pumping required to meet existing water uses. The annual groundwater supply has fluctuated between 3.5 maf in 2005 and 8.7 maf in 2009, providing between 33 and 70 percent of the total water supply. The persistent fluctuation in groundwater supply points to a limited surface water supply reliability for the region and highlights the value of applying conjunctive water management practices to meet local water use during times of reduced surface water supply.

Figure TL-14 shows the annual amount and percentage of groundwater supply to meet urban, agricultural, and managed wetlands 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 83 to 92 percent. The 8 percent increase more than doubled the amount of groundwater extraction for agricultural use — from 3.5 maf in 2005 to 8.7 maf in 2009. Groundwater pumping to meet urban water use remained fairly stable during the 2002 to 2010 period — between 550 taf and 690 taf, ranging from 7 to 16 percent of the annual groundwater extraction. Although groundwater supply to meet managed wetlands use is relatively small (between 25 and 65 taf), groundwater contribution to total managed wetlands water supply ranged from 35 to 45 percent.

More detailed information regarding groundwater water supply and use analysis is available online in Update 2013*,* Volume 4*, Reference Guide,* the article, "California's Groundwater Update 2013."

Water Uses

Agricultural water use is the region's largest user of water, followed by environmental and urban. Irrigation using both groundwater and surface water dominates water use volume, but municipal water use has grown along with the rising population. Communities and rural homes in the valley floor historically have used groundwater directly, but rising concern about certain constituents in the water and declining groundwater levels underlying some of the larger metropolitan areas is resulting in greater use of treated surface water for municipal supplies. Management of the major streams benefits environmental instream uses, primarily fisheries.

In the higher elevations of the Sierra Nevada, water is directed into reservoirs and pipelines where it is used to produce electricity as the water moves to lower elevations. The water eventually reaches the large reservoirs in the foothills where it is managed for flood control, to produce power, to provide irrigation water, and for recreational opportunities.

On average, agriculture applied water use is approximately 93 percent; wildlife refuges, 1 percent; urban water use, 6 percent. The percentage of urban applied water use has been increasing over the years, climbing from 3.4 percent in 1980 to 5.9 percent in 2009. The volume of agricultural applied water use has slightly declined since 1980 along with total irrigated land. See Table TL-20 for the yearly distribution from 2006 to 2010.

Drinking Water

The region has an estimated 355 community drinking water systems. The majority (over 80 percent) of these community drinking water systems are considered small (serving fewer than 3,300 people) with most small water systems serving fewer than 500 people (Table TL-21). 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; or develop comprehensive source water protection plans, financial plans or asset management plans (U.S. Environmental Protection Agency 2012d).

In 2013, the Pacific Institute released a study (Christian-Smith et al. 2013) that looked at water affordability for more than 13,000 water connections in small communities in the Tulare Lake Basin (Fresno, Kings, and Tulare counties). Water affordability was defined as annual water bills that cost less than 2 percent of MHI. If needed infrastructure replacement costs were also included in the water bill, the study concluded that 51 percent of the study households had unaffordable water rates.

Figure TL-13 Tulare Lake Hydrologic Region Annual Groundwater Water Supply Trend (2002-2010)

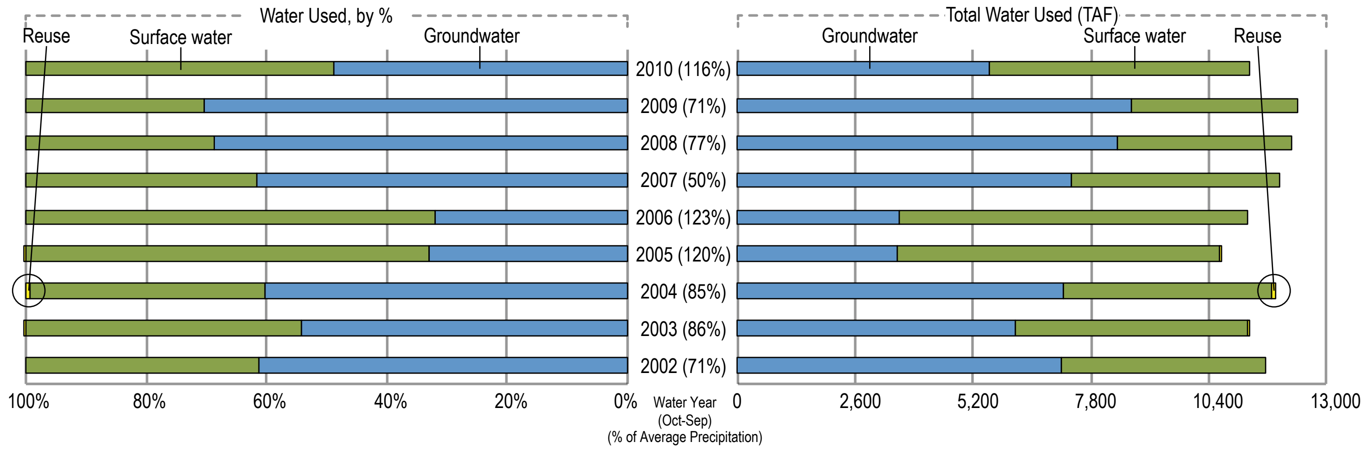
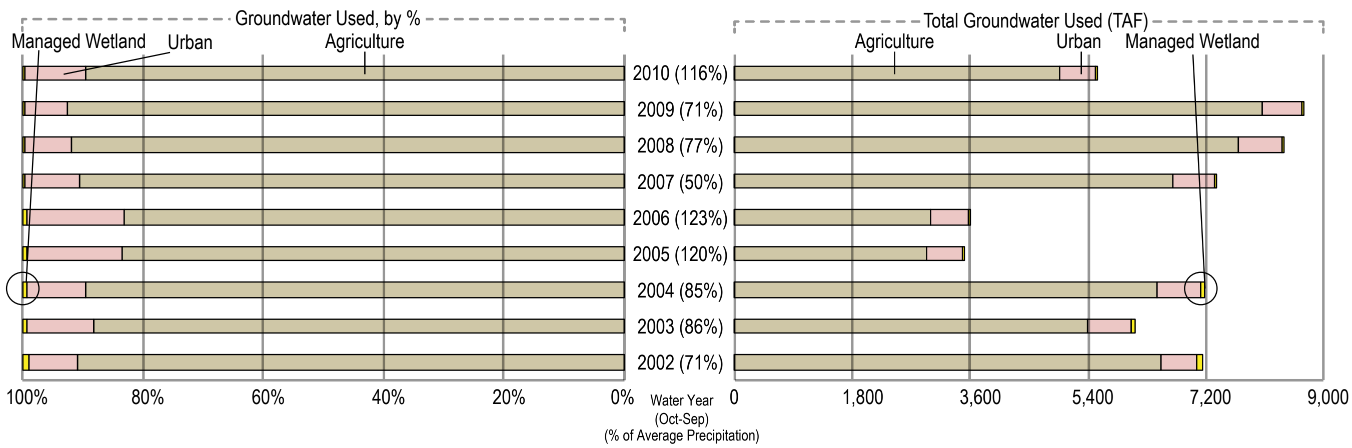


Figure TL-14 Tulare Lake Hydrologic Region Annual Groundwater Supply Trend by Type of Use (2002-2010)



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 TL-21). These water systems generally have 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.

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

Twenty-three Tulare Lake urban water suppliers have submitted 2010 urban water management plans (UWMPs) to DWR. The Water Conservation Act of 2009 (SB X7-7) required urban water suppliers to calculate baseline water use and set 2015 and 2020 water use targets. Based on data submitted in the 2010 urban water management plans, Tulare Lake Hydrologic Region had a population-weighted baseline average water use of 285 gallons per capita per day and an average population-weighted 2020 target of 229 gallons per capita per day. The Baseline and Target Data

Table TL-20 Tulare Lake Hydrologic Region Applied Water Demands

Applied Water Demand Type	2006	2007	2008	2009	2010
Total agricultural AW as % of total AW	93.3	92.5	92.8	93.5	93.4
Total wildlife refuge AW as % of total AW	0.6	0.7	0.7	0.6	0.7
Total M&I AW as % of total AW	6.0	6.9	6.5	5.9	5.9

Note:

AW = applied water, M&I = municipal and industrial

Applied water is 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.

Table TL-21 Community Water Systems by Size and Population Served

Water System Size by Population	Number of Community Water Systems (CWS)	Percent of Community Water Systems in Region	Population Served	Percentage of Population Served
Large > 10,000	35	10	2,036,266	88
Medium 3,301 - 10,000	22	6	153,154	7
Small 500 - 3,300	63	18	81,840	4
Very Small < 500	234	66	31,477	1
CWS that primarily provide wholesale water	1	0	---	---
Total	**355**	**---**	**2,302,737**	**---**

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

Note: Population estimates are as reported by each water system to CHPH Permits, Inspection, Compliance, Monitoring and Enforcement database and may contain seasonal visitors.

for individual Tulare Lake urban water suppliers is available on the DWR Urban Water Use Efficiency Web site located at http://www.water.ca.gov/wateruseefficiency/.

The Water Conservation Act of 2009 (SB X7-7) required agricultural water suppliers to prepare and adopt agricultural water management plans (AWMPs) by December 31, 2012, and update those plans by December 31, 2015, and every five years thereafter. Nine Tulare Lake agricultural water suppliers have submitted 2012 AWMPs to DWR.

Table TL-22 shows which urban water suppliers have submitted their 2010 UWMP updates.

Water Balance Summary

Tulare Lake Hydrologic Region consists of 10 planning areas. Table TL-23 provides a hydrologic water balance summary for the Tulare Lake region. Figure TL-15 illustrates a water balance for dedicated and developed supply by year. For more information on the water balances and portfolios, go to Volume 5*, The Technical Guide*.

Environmental water use is limited in the Tulare Lake region. There are no instream requirements in the region and wild and scenic requirements in the Uplands Planning Area (PA 707). There are managed wetlands in three other planning areas: PAs 702, 706, and 708.

Western Uplands, PA 701, has little urban or agricultural water use, with urban applied water averaging 2 taf per year and agricultural applied water of 300 af (0.3 taf) per year. There is no environmental applied water. The water supply comes from groundwater pumping.

San Luis West Side Planning Area (PA 702) is primarily an agricultural area, with urban applied water decreasing from 21 taf in earlier years to 14 taf in 2010. Agricultural applied water ranges from 1.3 to 1.7 maf annually. Water supply comes primarily from the Central Valley Project (0.4-1.1 maf). The SWP provides about 46-110 taf per year; and groundwater makes up the difference in supply, with pumpage exceeding 1 maf in years that CVP and SWP water availability is reduced.

Water use in the Lower Kings-Tulare Planning Area (PA 703) is also primarily agricultural. Urban applied water averages about 45 taf, while agricultural applied water ranges from 1.9 to 2.3 maf. Managed wetlands use is around 30 taf per year. Supply comes from a number of sources. Surface water includes local, CVP, and SWP deliveries, which vary depending on the water year type and amounts available for delivery. The remainder of the water supply comes from groundwater, which in dry years can exceed 1.2 maf.

In the Fresno-Academy Planning Area, PA 704, there is substantial urban water use (210 to 290 taf) Agricultural applied water averages about 500 taf. Most of the supply comes from surface water sources (local deliveries and CVP), but groundwater also makes up between a third and half of the water used.

The Alta-Orange Cove Planning Area (PA 705) has an average urban applied water of a little more than 60 taf. The agricultural applied water is about 0.9 to 1.1 maf. Water supplies are a combination of surface water when available (local and CVP) and groundwater. In “a-little-wetter-than-average” years (such as 2010), about two-thirds of the supply is surface water; in drier years (2007), three-quarters of the supply comes from groundwater.

Planning Area 706, Kaweah Delta, is a primarily agricultural area. Urban applied water averages about 118 taf per year, while the agricultural water applied water is 2.5-2.8 maf. The managed wetlands use about 1.4 taf per year. The supply situation is similar to that in PA 705, with as much as 2.1 maf of needs being met with groundwater pumping in dry years and supplies being split fairly equally between surface and groundwater in average years.

Table TL-22 List of 2010 Urban Water Management Plan Updates by Urban Water Supplier

Urban Water Suppliers
Bear Valley Community Services District
California Water Service Company Bakersfield
California Water Service Company Kern River Valley
California Water Service Company Selma
California Water Service Company Visalia
City of Clovis
City of Delano
East Niles Community Service District
City of Exeter
City of Fresno
Golden Hills Community Services District
City of Hanford
Kern County Water Agency Improvement District No 4
North of The River Municipal Water District
Oildale Mutual Water Company
City of Shafter
Stallion Springs Community Services District
City of Tehachapi
Tehachapi-Cummings County Water District
City of Tulare
Vaughn Water Company
City of Wasco
West Kern Water District

Uplands Planning Area (PA 707) contains three sections of wild and scenic rivers — the Kings River and both the North and South Forks of the Kern River. The water that flows through these rivers gets reused downstream. As is usually the case with areas containing wild and scenic rivers, the urban and agricultural uses are much lower than those in the valley floor areas, with about 19 taf urban applied water per year and 30-40 taf agricultural applied water. The supply for these uses comes from reused surface water and groundwater pumping.

Semitropic Planning Area (PA 708) contains a number of groundwater banks so some of the agricultural applied water is used to recharge the basins in years with average or greater than average water availability. About 1.1 maf is applied to crops, with up to 200 taf additional being recharged when available. About 25 taf per year is applied to urban uses. An additional 46 taf on

Table TL-23 Tulare Lake Hydrologic Region Water Balance for 2001-2010 (in taf)

Tulare Lake (taf)	Water Year (Percent of Normal Precipitation)									
	2001 (87%)	2002 (71%)	2003 (86%)	2004 (85%)	2005 (120%)	2006 (123%)	2007 (50%)	2008 (77%)	2009 (71%)	2010 (116%)
WATER ENTERING THE REGION										
Precipitation	11,564	10,021	12,137	11,964	16,939	17,135	7,031	10,724	9,945	16,185
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	3,696	4,239	5,174	4,816	5,909	5,944	4,434	2,797	2,704	4,456
Total	**15,260**	**14,260**	**17,311**	**16,780**	**22,848**	**23,079**	**11,465**	**13,521**	**12,649**	**20,641**
WATER LEAVING THE REGION										
Consumptive use of applied water[a] (Ag, M&I, Wetlands)	7,986	8,124	7,667	8,221	6,953	7,376	8,214	8,592	8,684	7,668
Outflow to Oregon/Nevada/ Mexico	0	0	0	0	0	0	0	0	0	0
Exports to other regions	1,093	1,643	1,898	1,961	1,724	2,269	2,053	1,215	1,204	1,502
Statutory required outflow to salt sink	0	0	0	0	0	0	0	0	0	0
Additional outflow to salt sink	458	305	458	457	300	468	456	514	456	456
Evaporation, evapotranspiration of native vegetation, groundwater subsurface outflows, natural and incidental runoff, ag effective precipitation & other outflows	9,979	8,276	10,090	10,342	13,297	13,241	5,303	8,528	7,667	13,095
Total	**19,516**	**18,348**	**20,113**	**20,981**	**22,274**	**23,350**	**16,026**	**18,849**	**18,011**	**22,721**
CHANGE IN SUPPLY										
[+] Water added to storage [-] Water removed from storage										
Surface reservoirs	-141	-161	173	-199	680	-108	-473	-59	101	259
Groundwater[b]	-4,115	-3,927	-2,975	-4,002	-106	-163	-4088	-5269	-5463	-2339
Total	**-4,256**	**-4,088**	**-2,802**	**-4,201**	**574**	**-271**	**-4561**	**-5328**	**-5362**	**-2080**
Applied water[a] (ag, urban, wetlands) (compare with consumptive use)	11,320	11,722	11,343	11,977	10,731	11,347	12,036	12,310	12,470	11,408

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*.

average is applied to managed wetlands. Most of the water applied comes from the SWP, with about 10 to 15 percent from local sources and the CVP. In dry years, this is supplemented with extraction of banked groundwater.

Planning Area 709 is the Kern Valley Floor. There is about 34 taf urban applied water in this planning area annually. Agricultural applied water ranges from 780-880 taf per year. Some of the agricultural applied water is recharged to groundwater basins in this planning area also. The majority of the water supply is local or CVP, with just a little SWP water and reuse. Up to two-thirds of the supply is groundwater in dry years, with net recharge in average or wet years.

The Kern Delta Planning Area (PA 710) also contains recharge areas. The urban applied water (150-180 taf) and agricultural applied water (about 1.4 maf) uses are supplied by local sources, the CVP, and the SWP, with some reuse thrown in. As with PA 708 and 709, banked groundwater is used to make up deficiencies in drier years.

Project Operations

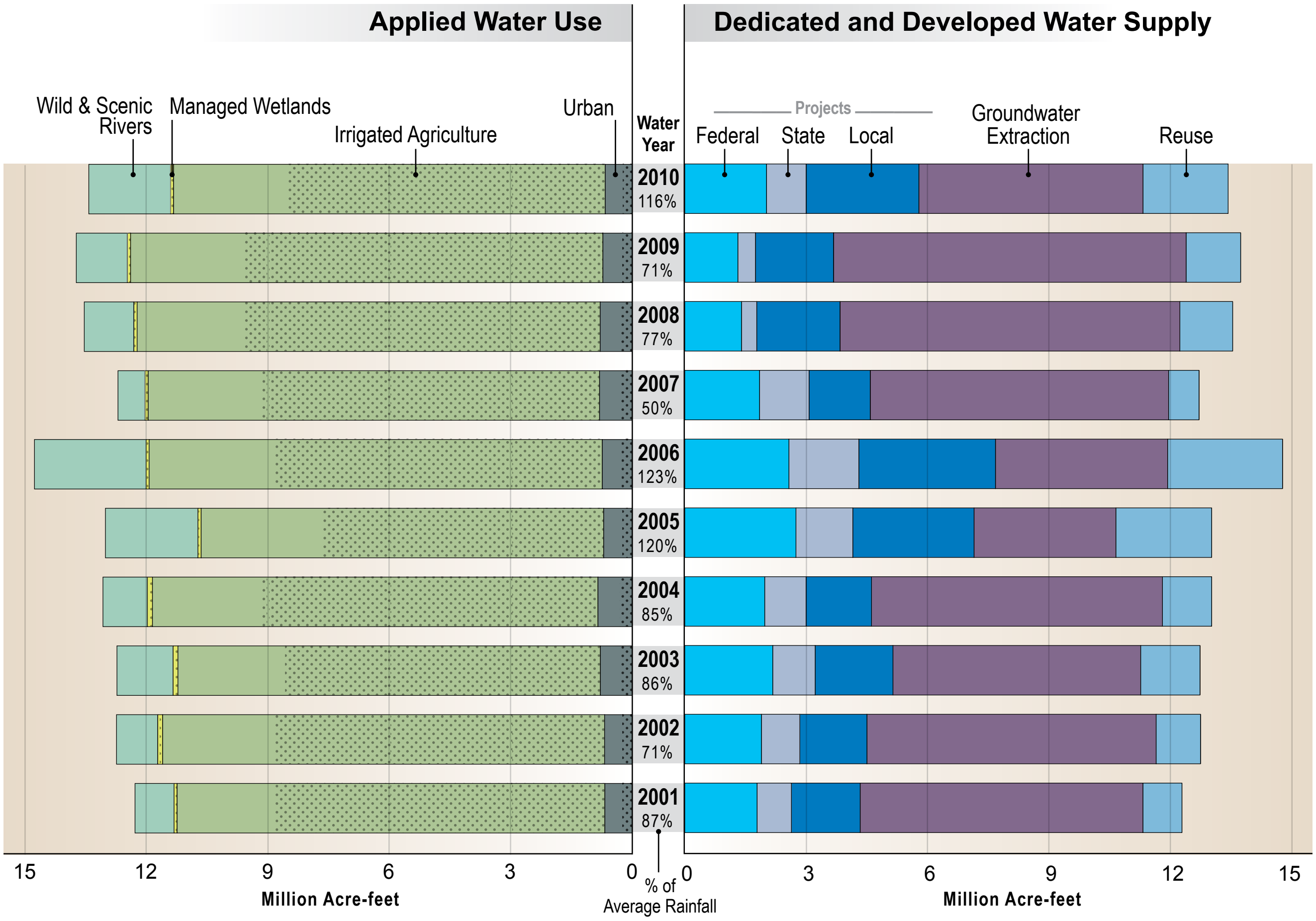
From 2005 to 2013, CVP agricultural deliveries to south-of-the-Delta contractors varied from a high of 100 percent of contracted amounts in 2006, which was a wet year, to a low of just 10 percent in 2009 at the tail end of the 2007-2009 drought period (Figure TL-16). CVP deliveries to south of the Delta urban contractors were 100 percent in 2005, 2006, and 2011; but they also dropped in the 2009 dry year to 60 percent of contracted amounts. For CVP Friant Class 1 contracts, the USBR delivered 100 percent of contracted amounts except in 2007, 2012, and 2013.

SWP contractors saw similar reductions from 2005 to 2013 and only received 100 percent of requested supplies in 2006. They saw much lower amounts from 2007 to 2013, with a low of 35 percent in both 2008 and 2013. Also, one permanent transfer of SWP Table A amounts in the Tulare Lake region was executed. Dudley Ridge Water District agreed to permanently decrease its SWP supply by 14 taf starting in January 2010 with the final reduction in 2020, when the Mojave Water Agency will assume the contract for the 14 taf. Finally, two new turnout construction agreements were executed. On August 29, 2007, DWR executed an agreement with Kern County Water Agency and Semitropic Water Storage District for construction, operation, and maintenance of the Semitropic No. 3 Turnout, a new turn-in/turnout facility located at Milepost 206.99 of the California Aqueduct. In addition to water supply, the facility will increase the rate at which water that is stored in the Semitropic Groundwater Bank can be recovered by the water agencies that have placed the water into storage. On January 17, 2008, DWR executed an agreement with Kern County Water Agency for construction, operation, and maintenance of the Cross Valley Canal (CVC) Turnout, located at Milepost 238.04 of the California Aqueduct. With a design capacity of 500 cubic feet per second (cfs), this turnout structure (along with other modifications to the CVC) is necessary to increase the capacity of the CVC from approximately 900 cfs to approximately 1,400 cfs.

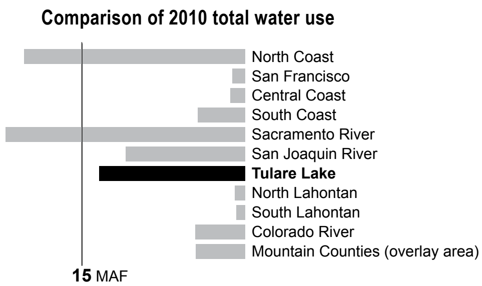
Two local reservoirs, Success Lake on the Tule River and Lake Isabella on the Kern River, had their storage capacities reduced due to safety concerns by the U.S. Army Corps of Engineers (USACE). In 2004, the USACE feared that a magnitude 8.0 earthquake on the San Andreas fault, or a 6.8 on the Premier fault near Bakersfield would collapse the earthen dam on Success Lake. Additionally, they were concerned about dam failure due to overtopping or seepage through the dam. As a result, the USACE, which operates the reservoir, reduced the storage capacity from

Figure TL-15 Tulare Lake Regional 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 TL-23). 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)*



For further details, refer to Vol. 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.

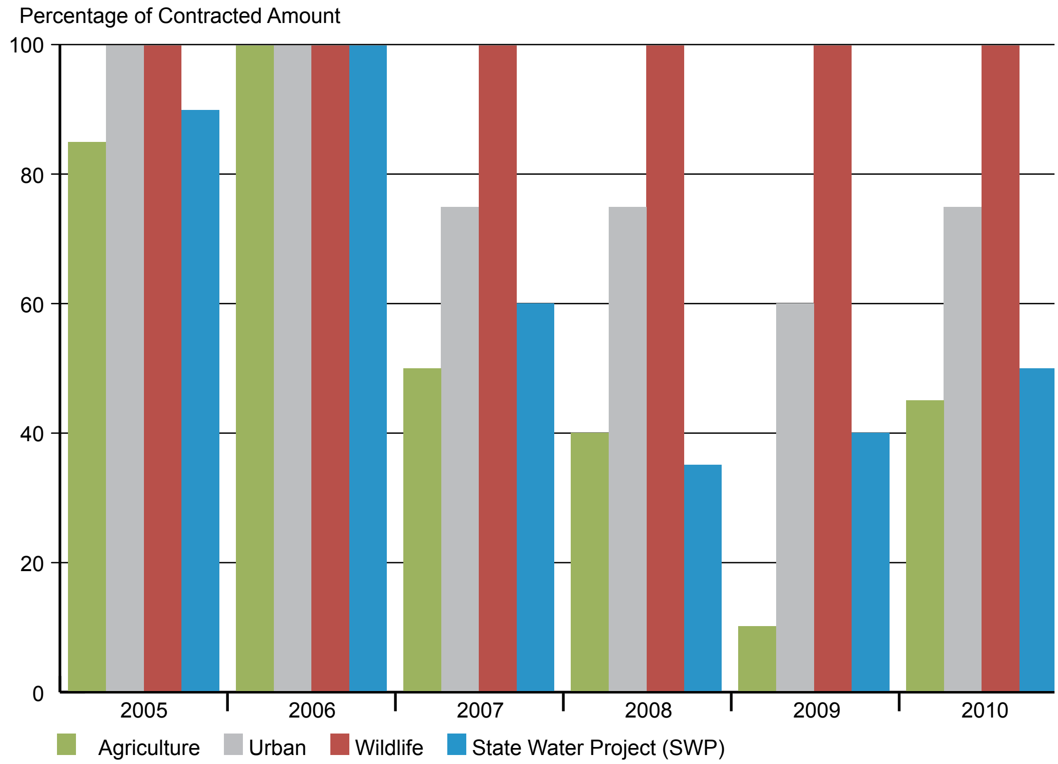
Urban water use. The use of water for urban purposes, including residential, commercial, industrial, recreation, energy production, military, and institutional classes. The term is applied in the sense that it is a kind of use rather than a place of use.

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.

Tulare Lake Water Balance by Water Year Data Table (TAF)

	2001 (87%)	2002 (71%)	2003 (86%)	2004 (85%)	2005 (120%)	2006 (123%)	2007 (50%)	2008 (77%)	2009 (71%)	2010 (116%)
APPLIED WATER USE										
Urban	677	684	787	847	706	740	808	793	725	668
Irrigated Agriculture	10,567	10,917	10,437	11,006	9,944	10,530	11,150	11,439	11,668	10,663
Managed Wetlands	76	121	119	124	80	76	79	78	78	78
Req Delta Outflow	0	0	0	0	0	0	0	0	0	0
Instream Flow	0	0	0	0	0	0	0	0	0	0
Wild & Scenic R.	964	1,019	1,387	1,099	2,285	2,757	668	1,228	1,264	2,017
Total Uses	**12,285**	**12,741**	**12,730**	**13,075**	**13,015**	**14,104**	**12,705**	**13,537**	**13,734**	**13,425**
DEPLETED WATER USE (STIPPLING)										
Urban	246	240	286	303	246	253	271	277	245	228
Irrigated Agriculture	8,160	8,128	7,781	8,310	6,952	7,537	8,340	8,768	8,840	7,845
Managed Wetlands	39	62	58	66	55	49	59	60	56	51
Req Delta Outflow	0	0	0	0	0	0	0	0	0	0
Instream Flow	0	0	0	0	0	0	0	0	0	0
Wild & Scenic R.	0	0	0	0	0	0	0	0	0	0
Total Uses	**8,444**	**8,429**	**8,124**	**8,678**	**7,253**	**7,840**	**8,670**	**9,105**	**9,140**	**8,124**
DEDICATED AND DEVELOPED WATER SUPPLY										
Instream	0	0	0	0	0	0	0	0	0	0
Local Projects	1,698	1,658	1,922	1,618	2,995	3,375	1,511	2,056	1,928	2,785
Local Imported Deliveries	0	0	0	0	0	0	0	0	0	0
Colorado Project	0	0	0	0	0	0	0	0	0	0
Federal Projects	1,788	1,896	2,175	1,977	2,749	2,575	1,849	1,403	1,314	2,021
State Project	849	948	1,048	1,021	1,404	1,727	1,223	377	434	979
Groundwater Extraction	6,985	7,144	6,120	7,187	3,504	3,588	7,371	8,397	8,711	5,537
Inflow & Storage	0	0	0	57	0	0	0	0	0	0
Reuse & Seepage	964	1,096	1,464	1,214	2,365	2,838	751	1,304	1,347	2,103
Recycled Water	0	0	0	0	0	0	0	0	0	0
Total Supplies	**12,285**	**12,741**	**12,730**	**13,075**	**13,015**	**14,104**	**12,705**	**13,537**	**13,734**	**13,425**

Figure TL-16 South of Delta Central Valley Project and State Water Project Deliveries, Percent of Contracted Amount



82,291 af to 29,200 af from 2007 to 2008 and then increased it to 41,000 af from 2009 to 2011. They further increased the restricted pool to 65,000 af in 2012. In November 2012, the USACE determined that the dam was unlikely to collapse in an earthquake or slump due to seepage. In 2014, they are expected to release a report assessing the risks and what can be done about them.

In 2006, the USACE reduced the storage capacity of Lake Isabella from 568,100 af to 361,250 af after finding seepage under the auxiliary earthen dam and discovering that Isabella Dam sits on the active Kern Canyon earthquake fault, which was thought inactive when the dam was built in the 1950s. Also, USACE found the dam at risk of overtopping during extreme flood events. After completing a Dam Safety Modification Report and a final environmental impact statement in 2012, the USACE plans to (1) raise the main dam crest by 16 feet, (2) raise the auxiliary dam crest by 16 feet and add buttressing, (3) add an emergency spillway, and (4) realign the Borel Canal. Primary construction is expected to begin in 2017 and cost between $400 million and $600 million.

Levee and Channel System

The Tulare Lake Hydrologic Region has flood management facilities for the protection of cities and agricultural areas, particularly for the valuable lakebed farm lands. Installations include the Kings River Flood Control Project, four multipurpose reservoirs with flood management reservoirs, four major single-purpose flood management reservoirs, five smaller flood management reservoirs, a sedimentation basin, diversions, weirs, levees, and channel improvements.

The Kings River Flood Control Project uses weirs, levees, and channel improvements to contain the flows of the Kings River, Crescent Bypass, North Fork Kings River, Fresno Slough, South Fork Kings River, Clarks Fork Kings River, Cole Slough, and Dutch John Cut and direct the flows toward irrigation facilities, Tulare Lake, or the San Joaquin River as needed.

Water Quality

Due to the essentially closed nature of the Tulare Lake Basin, the impact of contaminants on water quality will be a continuing threat to beneficial uses of surface water and groundwater. The paramount water quality problem in the basin is the accumulation of salts, including nitrates. This problem is compounded by the overdraft of groundwater for municipal, agricultural, and industrial purposes; the reuse of deeper formation groundwater from oil pumping; and the import of surface water from outside the basin, which further concentrates salts within remaining groundwater (Central Valley Regional Water Quality Control Board 2004).

High salt concentrations can affect crop growth, cause health and taste problems in drinking water, and damage water delivery, conveyance, and treatment systems. Thousands of acres in the Tulare Lake Basin can no longer be farmed due to high salinity in the soils. In some parts of the Central Valley, drinking water does not meet State or federal standards for human consumption due to nitrate concentrations. The environment is also vulnerable to salt impacts — increasing salts in rivers and streams can alter the plants and fish that can survive there (Central Valley Salinity Alternatives for Long-Term Sustainability 2012a).

Development and adoption of a comprehensive salt and nitrate management plan for the Central Valley, including an implementation plan, is a high priority for this region.

Surface Water Quality

Generally, flows from the east side of the basin are considered to be excellent quality, fed by Sierra snowmelt and springs from granitic bedrock. Flows from the west side are considered to be poor quality due to naturally occurring constituents such as selenium and salinity from the marine sediments. Water quality issues for the Tulare Lake Hydrologic Region include:

- Salinity.
- Pesticides (chlorpyrifos, dimethoate, and toxaphene) from agriculture.
- Metals (mercury, selenium, and molybdenum).
- Erosion and sediment (State Water Resources Control Board 2010).

Salinity is the primary contaminant affecting water quality and habitat in the Tulare Lake region. When water is used, salts are left behind. Sometimes this salt is intentionally added (e.g., home water softeners, plant fertilizers), but even when no salts are added to the system, evaporation and consumptive use act to concentrate unused salts. Additionally, salts move with water so salts originating in one basin will turn up in another. This is a significant problem when the receiving basin has no reliable way of disposing the salt, as is the case in the Tulare Lake region. Salinity increases can affect municipal, agricultural, and industrial beneficial uses of water and the ability to recycle and reuse municipal wastewater.

In the Tulare Lake region, pesticide impairments due to chlorpyrifos, dimethoate, and toxaphene have been identified in areas of agricultural production (State Water Resources Control Board 2010). Pesticides are human-made chemicals used to control insects. A fraction of the applied pesticides can enter surface waters 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. Toxaphene is considered a legacy pesticide because its use has been banned since 1990 (U.S. Environmental Protection Agency 2012c).

In this region, mercury impairments are found downstream of New Idria Mine, which was the second most productive mercury mine in North America, and in Pine Flat Reservoir and Kaweah Lake (State Water Resources Control Board 2010; U.S. Environmental Protection Agency 2012b). Inorganic mercury enters reservoirs and other water bodies through a variety of sources including atmospheric deposition; through tributary streams carrying runoff from mercury and gold mining sites; from urban and industrial discharges; and from erosion of soils naturally enriched with mercury. Methylmercury is a concern because it bioaccumulates through the aquatic food web to potentially harmful amounts found in larger fish that can be consumed by humans and wildlife (State Water Resources Control Board 2012).

Molybdenum was found in the Kings River at levels high enough to cause concern for agricultural use. 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 (Central Valley Regional Water Quality Control Board 2001).

Erosion is one of the greatest problems in the foothills and mountain areas of this region. Erosion is a natural occurrence, but most human activities accelerate the process. Erosion causes discoloration of streams, and the suspended matter settles to form a smothering blanket on the streambed. Sedimentation impairs fisheries; and, by virtue of the characteristics of many organic and inorganic compounds to bind to soil particles, it serves to distribute and circulate toxic substances through the riparian, estuarine, and marine systems. Erosion is accelerated by poor drainage and soil stabilization associated with road building, clearing land, leveling land, construction, logging, brush clearing, off-road vehicle use, agriculture, overgrazing, and fires (Central Valley Regional Water Quality Control Board 2004).

Groundwater Quality

Generally, the quality and the beneficial uses of the deep groundwaters remain the same as before humans entered the valley. A few areas within the Tulare Lake Basin have groundwaters that are naturally unusable or of marginal quality for certain beneficial uses. (Central Valley Regional Water Quality Control Board 2004) However, anthropogenic sources have impacted many of the shallower zones. Groundwater in the shallower part of the aquifer generally contains higher concentrations of anthropogenic contaminants, such as nitrates and pesticides, than the deeper part of the aquifer. The shallower part of the aquifer is generally younger water that indicates more recently recharged water. So, shallower wells, such as domestic supply wells, may provide better indication of pollutants from current land use activities. Pollutants from current land use activities may eventually impact deeper wells such as public supply wells (Burow et al. 2008). The following are the contaminants of concern in groundwater for this region:

- Salinity (Central Valley Regional Water Quality Control Board 2004).
- Nitrate (Dubrovsky et al. 1998, Burow et al. 2008, Center for Watershed Sciences 2012).
- DBCP (1,2-dibromo-3-chloropropane) (Dubrovsky et al. 1998, Burow et al. 2008, State Water Resources Control Board 2013).
- Arsenic (State Water Resources Control Board 2013).
- Gross Alpha Particle Activity and Uranium (State Water Resources Control Board 2013).
- Chromium 6 (State Water Resources Control Board 2011b).
- Localized contamination by (State Water Resources Control Board 2013):
    - Organic Compounds (Benzene, tetrachloroethylene (PCE), trichloroethylene (TCE), and perchlorate).
    - Fluoride.

Degradation of groundwater in the Tulare Lake Basin by salts is unavoidable without a plan for removing salts from the basin. Some of the salt load to the groundwater resource is primarily the result of natural processes within the basin, but some also occurs due to water imported from other basins to supply agricultural irrigation water. Natural processes include salt loads leached from the soils by precipitation, valley floor runoff, and native surface waters. Salts that are not indigenous to the basin water resources results from human activity. Salts come from imported water, soil leached by irrigation, animal wastes, fertilizers, and other soil amendments, municipal use, industrial wastewaters, and oil field wastewaters. These salt sources, all contributors to salinity increases, should be managed to the extent practicable to reduce the rate of ground water degradation. (Central Valley Regional Water Quality Control Board 2004)

In a 1998 USGS study, 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 mg/L established by the EPA. A subsequent USGS study found that 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). The recent University of California, Davis report also found that travel times of nitrates from source to wells range from a few years to decades in domestic wells, and from years to many decades and even centuries in deeper production wells. While the quality of the shallower part of the aquifer is the result of past land use activities, the soil profile contains a stockpile of these contaminants that will continue to recharge the shallow aquifer and cause migration of contaminants to the deeper aquifer. Human-generated nitrate sources to groundwater include nitrogen applied to croplands, percolation of wastewater treatment plant and food processing wastes, leachate from septic system drain fields, urban parks, lawns, golf courses, leaky sewer systems, recharge from animal corrals and manure storage lagoons, and downward migration of nitrate-contaminated water via wells. Agricultural fertilizers and animal wastes applied to cropland are by far the largest regional sources of nitrate in groundwater; although, other sources can be locally relevant (Center for Watershed Sciences 2012).

Concentrations of DBCP, a soil fumigant banned since 1977, exceeded the EPA drinking-water standard of 0.2 mg/L in 18 of the 88 (or 20 percent) domestic wells sampled during 1993-1995 (Dubrovsky et al. 1998). DBCP concentrations were above the drinking-water standard in 16 of 50 (or 32 percent) of domestic wells samples in orchards and vineyards from 2001-2002 (Burow et al. 2008).

Public supply wells with levels of arsenic in the raw and untreated water that exceed the maximum contaminant level (MCL) were found in the south and western part of the Tulare Lake. Arsenic is generally considered to be naturally occurring (State Water Resources Control Board 2013). 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 Tulare Lake Basin. These radionuclides are typically naturally occurring but are a concern because of the potential for health effects (State Water Resources Control Board 2013).

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, 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).

Benzene, perchlorate, PCE, and TCE have been detected at levels exceeding MCLs in the source water of a few water systems in the Tulare Lake region. Benzene was found in public supply wells in Arvin and Kettleman City. Perchlorate was found in wells in Tehachapi, Stallion Springs, East Tulare, and Exeter. PCE was found in public supply wells in the Fresno metropolitan area, Sanger, Arvin, Golden Hills, Oildale, Bakersfield, and Goshen areas. TCE was found in the Fresno and Bakersfield metropolitan areas (State Water Resources Control Board 2013). Benzene and perchlorate occur in the environment both naturally and due to human-made sources. PCE was the main solvent used for dry cleaning. Its occurrence in the environment is also associated with textile operations and metal degreasing operations. TCE is most associated with metal degreasing operations.

Fluoride was found at levels exceeding MCLs in raw and untreated water in the Sierra and San Emigdio Mountains areas of Kern County (State Water Resources Control Board 2013). While fluoride is added to public drinking water supplies as a public health measure for reducing cavities among the treated population, it can also occur naturally as a result of the geological composition of soils and bedrock (U.S. Environmental Protection Agency 2011).

Drinking Water Quality

In general, drinking water systems in the region deliver water that meets federal and State drinking water standards. However, there are some small community water systems in the region that fail to meet drinking water standards. Most of these water systems serve DACs, and most are seeking financial assistance from State and federal agencies to find viable solutions to correct their problem. A major obstacle in finding a viable solution is the affordability of operation and maintenance costs associated with the selected solution. These additional costs can sometimes double or triple the water rates, which may be unaffordable for ratepayers in DACs.

In January of 2013, the Water Boards completed a statewide assessment of community water systems that rely on contaminated groundwater (State Water Resources Control Board 2013). Contamination of local groundwater resources results in higher costs for ratepayers and consumers due to the need for additional water treatment. This final report identified 146 community drinking water systems in the region that rely on at least one contaminated groundwater well as a source of supply, and 329 community drinking water wells that are affected by groundwater contamination (Table TL-24). The most prevalent groundwater contaminants are arsenic, nitrate, gross alpha particle activity, DBCP, and uranium (Table TL-25). The majority of the affected systems are small water systems, which often need financial assistance to construct a water treatment plant or alternate solution to meet drinking water standards.

In addition to the Water Boards study, University of California, Davis completed a study in 2012 on nitrate contamination affecting drinking water systems in the Tulare Lake Basin and Salinas Valley. The study found that in the Tulare Lake Basin the largest percentage of nitrate MCL exceedances is in the eastern portion of the basin (Harter et al. 2012).

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 baseflow or wetlands, seeps, and springs. However, for much of the Tulare Lake 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 baseflow. In 1980, DWR *Bulletin 118-80* (California Department of Water Resources 1980) identified five of the seven southern San Joaquin Valley groundwater subbasins (Kings, Kaweah, Tulare Lake, Tule, and Kern County) as being subject to conditions of critical overdraft. Thirty years later, things do not appear to have changed much. Although efforts have been made by local groundwater management agencies to reduce overdraft conditions in the region, a number of the groundwater

Table TL-24 Summary of Community Drinking Water Systems in the Tulare Lake Hydrologic Region That Rely on One or More Contaminated Groundwater Wells That Exceed 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
Small < 3,300	110	163
Medium 3,301 - 10,000	12	29
Large > 10,000	24	137
Total	**146**	**329**

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

Table TL-25 Summary of Contaminants Affecting Community Drinking Water Systems in the Tulare Lake 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 Maxium Contaminant Level (MCL)
Arsenic	62	131
Nitrate	54	75
Gross alpha particle activity	46	78
Uranium	21	29
1,2-Dibromo-3-chloropropane (DBCP)	17	61

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

Notes:

Only the five most prevalent contaminants are shown.

13 wells are affected by arsenic and gross alpha particle activity.

11 wells are affected by nitrate and DBCP.

10 wells are affected by nitrate and gross alpha particle activity.

management plans and more recent studies of these five 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 also can 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.

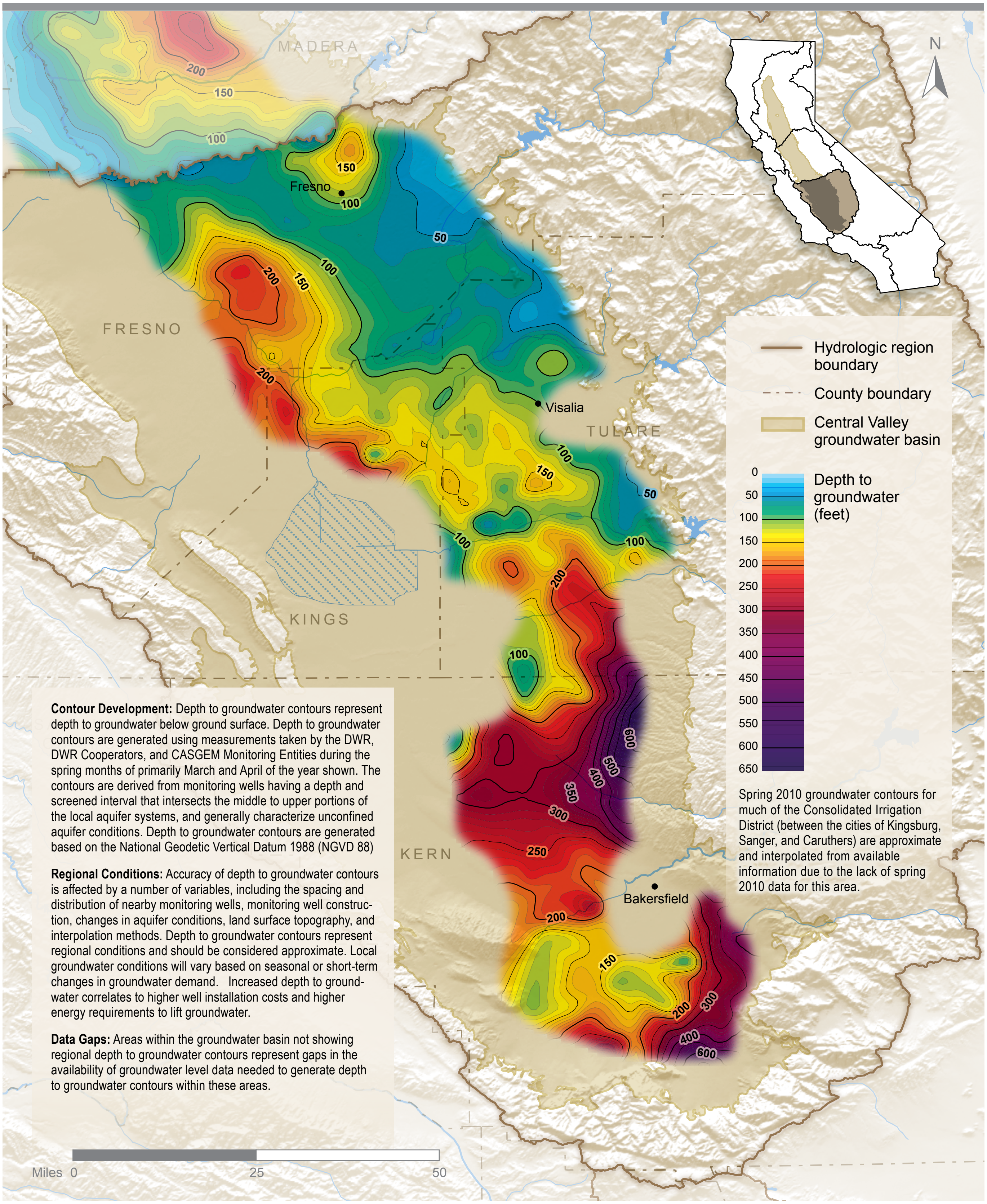
Figure TL-17 is a spring 2010 depth to groundwater contour map for the region using groundwater level data available online from DWR's Water Data Library (http://www.water.ca.gov/waterdatalibrary/) and CASGEM system (http://www.water.ca.gov/groundwater/casgem/).

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. Thus no contours were developed for Westside subbasin aquifer and the Tulare Lake lakebed area.

Figure TL-17 shows that the depth to groundwater in the northeastern one-third of the region (Kings and Kaweah subbasins) is shallowest along the valley floor adjacent to the Sierra foothills. Groundwater recharge along the eastside drainages, such as the Kings River, helps maintain spring 2010 groundwater levels at 20 to 60 feet. Seepage from the Friant-Kern Canal also likely contributes to maintaining shallower groundwater levels along the eastern Kings subbasin. Moving west, groundwater levels deepen to more than 250 feet along the western edge of the Kings subbasin.

Farther to the south in the Kaweah subbasin, recharge along the eastern edge of the valley and in areas adjacent to the Kaweah and Tule rivers results in shallow groundwater depths at 30 to 50 feet. Moving to the west, as groundwater extraction for urban and agricultural uses increases, the depth to groundwater contours become increasingly irregular and variable. The depth to groundwater increases to about 150 feet near the cities of Lindsay and Tulare. The City of Tulare

Figure TL-17 **Spring 2010 Depth to Groundwater Contours for the Tulare Lake Hydrologic Region**



Contour Development: Depth to groundwater contours represent depth to groundwater below ground surface. Depth to groundwater contours are generated using measurements taken by the DWR, DWR Cooperators, and CASGEM Monitoring Entities during the spring months of primarily March and April of the year shown. The contours are derived from monitoring wells having a depth and screened interval that intersects the middle to upper portions of the local aquifer systems, and generally characterize unconfined aquifer conditions. Depth to groundwater contours are generated based on the National Geodetic Vertical Datum 1988 (NGVD 88)

Regional Conditions: Accuracy of depth to groundwater contours is affected by a number of variables, including the spacing and distribution of nearby monitoring wells, monitoring well construction, changes in aquifer conditions, land surface topography, and interpolation methods. Depth to groundwater contours represent regional conditions and should be considered approximate. Local groundwater conditions will vary based on seasonal or short-term changes in groundwater demand. Increased depth to groundwater correlates to higher well installation costs and higher energy requirements to lift groundwater.

Data Gaps: Areas within the groundwater basin not showing regional depth to groundwater contours represent gaps in the availability of groundwater level data needed to generate depth to groundwater contours within these areas.

Spring 2010 groundwater contours for much of the Consolidated Irrigation District (between the cities of Kingsburg, Sanger, and Caruthers) are approximate and interpolated from available information due to the lack of spring 2010 data for this area.

is entirely dependent on groundwater supplies to meet urban uses. High DBCP levels are another limit on groundwater use by the City of Lindsay.

For areas in Tule and Kern County subbasins receiving surface water, depth to groundwater ranges from 200 to 300 feet. For groundwater dependent areas along the east side of the Friant-Kern Canal, the depth to groundwater ranges from 450 to 600 feet. In the southern and southeastern portion of the Kern County subbasin, the depth to groundwater becomes more variable and complicated due to nearby groundwater pumping, imported surface water, and large groundwater banking projects.

Groundwater elevation contours can help estimate the direction, gradient, and rate of groundwater flow. Figure TL-18 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 TL-18 shows that the spring 2010 groundwater movement is generally from the eastern edge of the basin to the axis of the valley. The spring 2010 pumping depressions along the western edge of the Kings and Kaweah subbasins tend to capture groundwater from adjacent areas and prevent groundwater from further moving in a normal down-gradient direction. Additional pumping depressions occur in other subbasins; however, the extent and depth of these depressions are not as large. The figure also shows recharge areas along the larger rivers such as the San Joaquin, Kings, and Tule rivers.

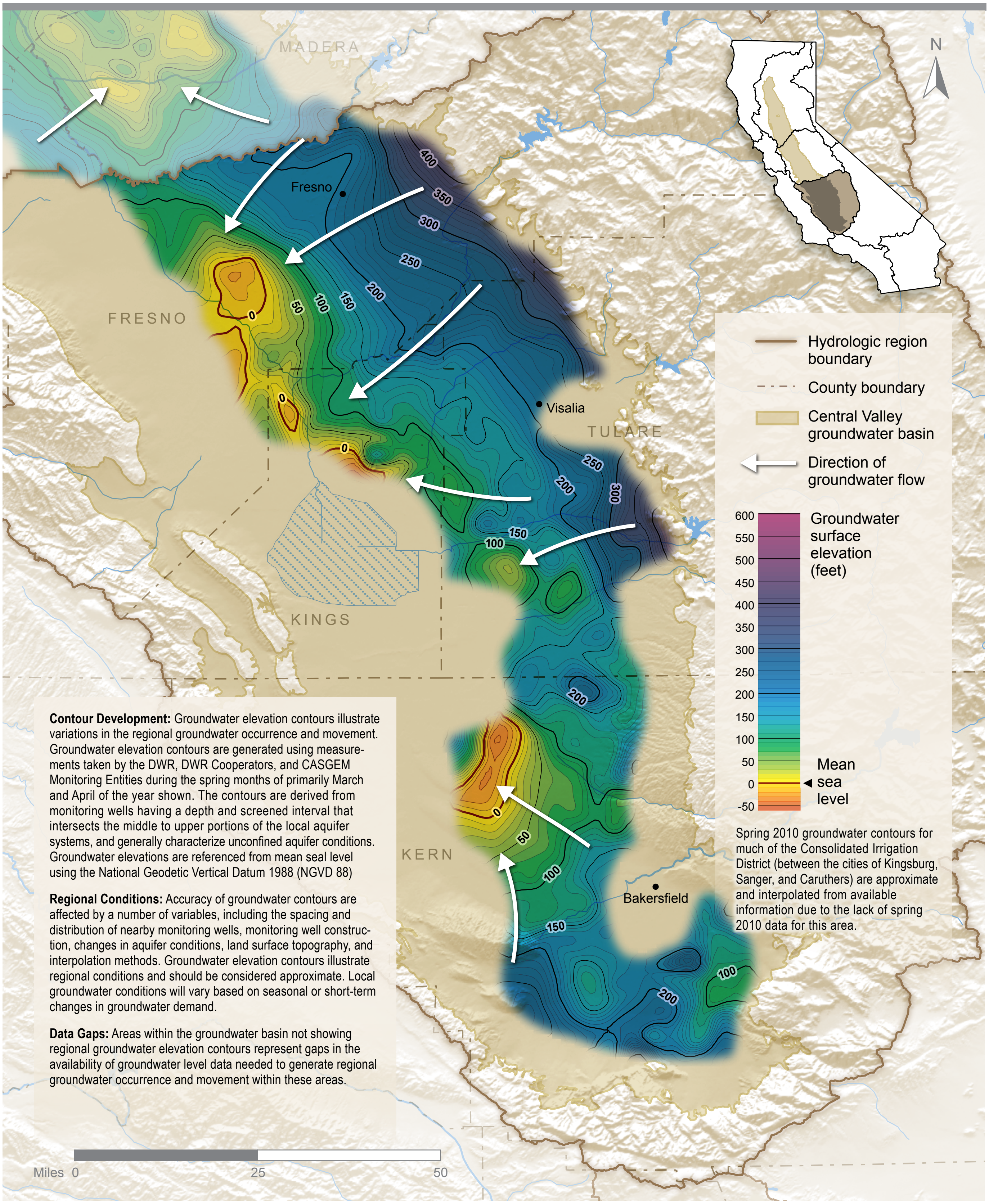
Additional references and links to USGS, DWR, and other agencies with information on groundwater elevation data and contours in the region are listed below:

- DWR South Central Region Office: http://www.water.ca.gov/groundwater/data_and_monitoring/south_central_region/GroundwaterLevel/gw_level_monitoring.cfm.
- Kings River Conservation District: http://www.krcd.org/water/groundwater_management/annual_report.html.
- Kaweah Delta Water Conservation District: http://www.kdwcd.com/kdwcdweb_005.htm.
- Semitropic Water Storage District: http://www.semitropic.com/pdfs/Semitropic%20Draft%20GW%20Management%20Plan_10%201%202012.pdf.
- Improvement District No. 4: http://www.water.ca.gov/urbanwatermanagement/2010uwmps/CA%20Water%20Service%20Co%20-%20Bakersfield/Appendix%20K%20-%20ID-4%20ROWC.pdf.
- Westlands Water District: http://www.westlandswater.org/wwd/pages/general.asp?title=Maps&page=Maps&index=1&cwide=1280.

Groundwater Level Trends

Groundwater levels within groundwater basins in the 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 TL-19A to

Figure TL-18 Spring 2010 Groundwater Elevation Contours for the Tulare Lake Hydrologic Region



TL-19E 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 TL-19A shows hydrograph 15S18E30L001M, which is from a well located in an agricultural area near Raisin City, approximately 10 miles southwest of the City of Fresno in the Kings subbasin. The well is in the unconfined to semi-confined portion of the aquifer. The hydrograph demonstrates a persistent decline in groundwater levels over the last 50 years for this specific area of the western Kings subbasin. Groundwater levels remained relatively stable during the 1920s and 1930s. After World War II, as agriculture land use reliance on groundwater intensified, water levels declined steadily and, groundwater elevations reached 100 feet below mean sea level during the 1977 drought. Groundwater levels stabilized over the 10-year period of above normal precipitation (1978-1988), but then declined approximately another 50 feet during the 1989 to 1994 drought. Groundwater levels somewhat increased during the wet years of the late 1990s, but have since declined further by approximately 25 feet. The hydrograph demonstrates the imbalance between aquifer recharge and groundwater extraction, and the unsustainability of maintaining existing level of groundwater extraction in the area.

Figure TL-19B shows hydrograph 20S23E12A001M, which is from an irrigation well located 5 miles west of the City of Tulare, along the western edge of the Kaweah subbasin. The well is in the unconfined to semi-confined portion of the aquifer. The hydrograph illustrates local aquifer response to changes in groundwater recharge and extraction, due to changes in precipitation and surface water supply deliveries in the Kaweah subbasin. The hydrograph shows several patterns of increasing and decreasing groundwater levels in response to periods of above normal (early to mid-1980s and late 1990s) and below normal (1976-77 and 1987-1994) hydrology. More recent, rapidly declining groundwater levels are attributed to increased groundwater extraction due to surface water supply cutbacks. The purchase and installation of a new water regulation and recharge basin in the Tulare Irrigation District (TID) area is expected to replenish groundwater at increased rates (Tulare Irrigation District 2011).

Figure TL-19C shows hydrograph 26S18E18G001M, which is from an inactive irrigation well located along the western edge of the Kern County subbasin. The well is in the unconfined to semi-confined portion of the aquifer. The hydrograph illustrates the positive effects of in-lieu recharge associated with increases in imported surface water supply and reduced groundwater pumping. Prior to imported surface water from the California Aqueduct, some farms in the area used groundwater to meet agricultural demand, despite the poor quality. The hydrograph shows that in-lieu recharge associated with imported surface water supply and reduced groundwater pumping increased groundwater level by about 65 feet since the mid-1970s.

Figure TL-19D shows hydrograph 30S24E02C001M, which is from an irrigation well, and Figure TL-19E shows hydrograph 30S27E05D001M, which is from a municipal well, both located in western Bakersfield in the Kern County subbasin. The wells are in the unconfined to semi-confined portion of the aquifer, overlying the confined aquifer beneath the Corcoran Clay. The hydrographs illustrate the successful stabilization of sharply declining groundwater levels through implementation of in-lieu and managed groundwater recharge projects via conjunctive water management.

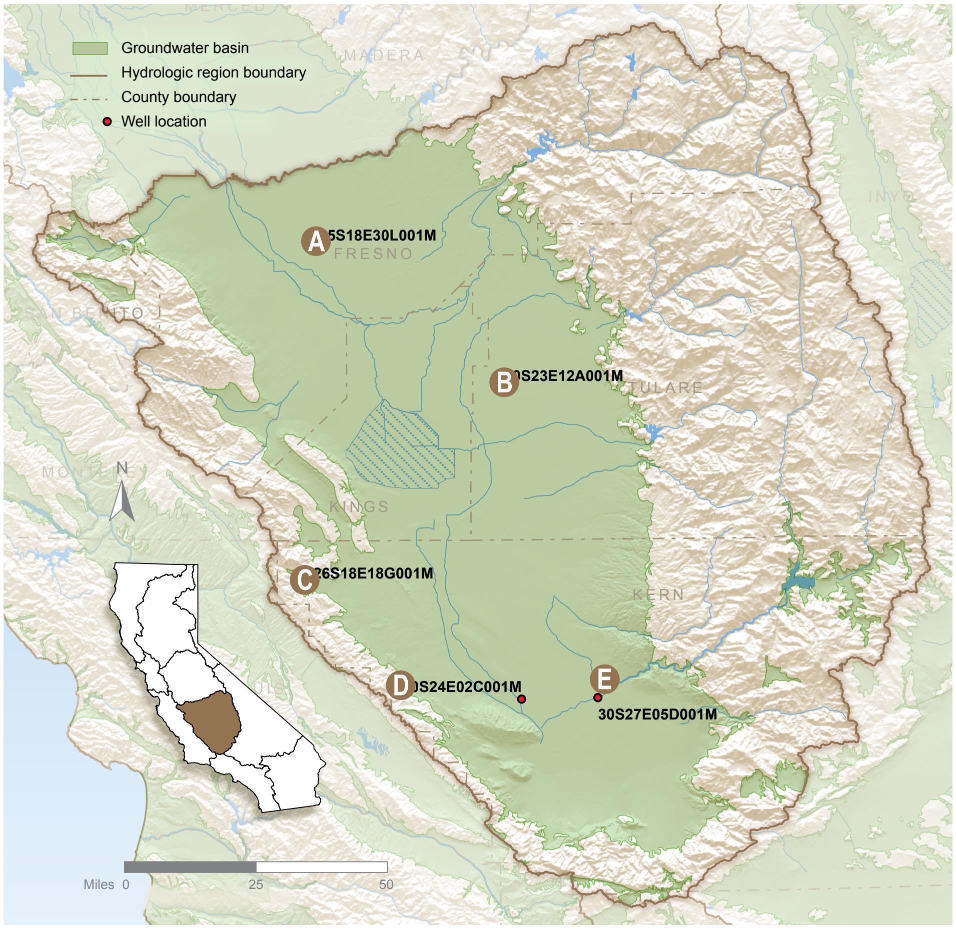
Post-World War II expansion of agricultural activity in the area resulted in increased use of groundwater and a corresponding steady 120 to 140 foot decline of groundwater levels through

Figure TL-19 Groundwater Level Trends in Selected Wells in the Tulare Lake Hydrologic Region

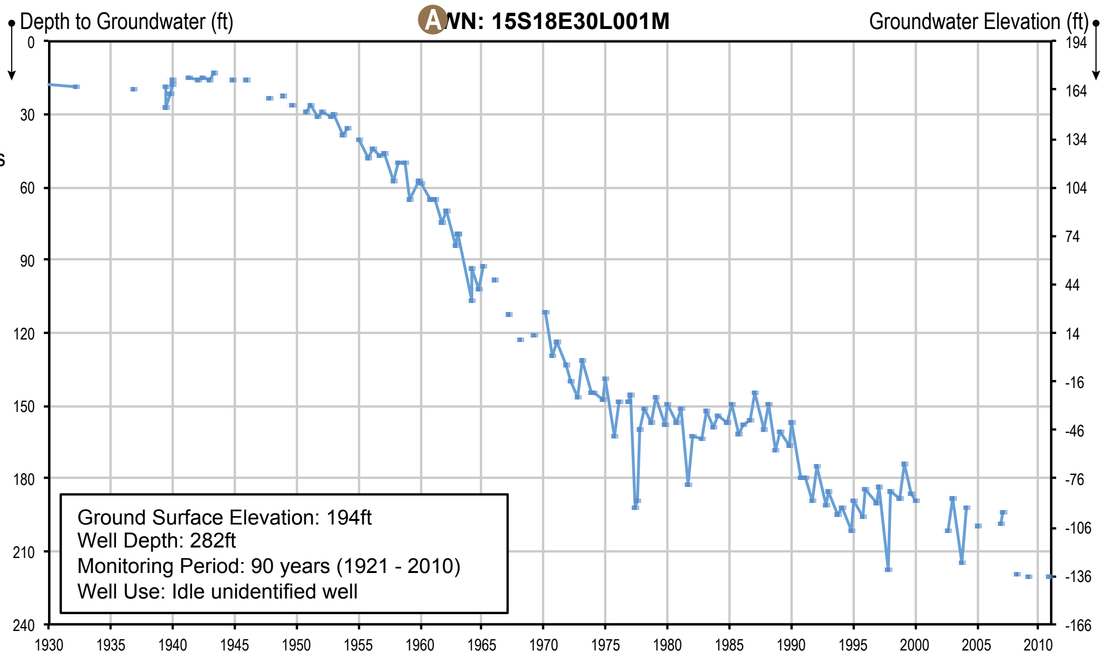
Aquifer response to changing demand and management practices

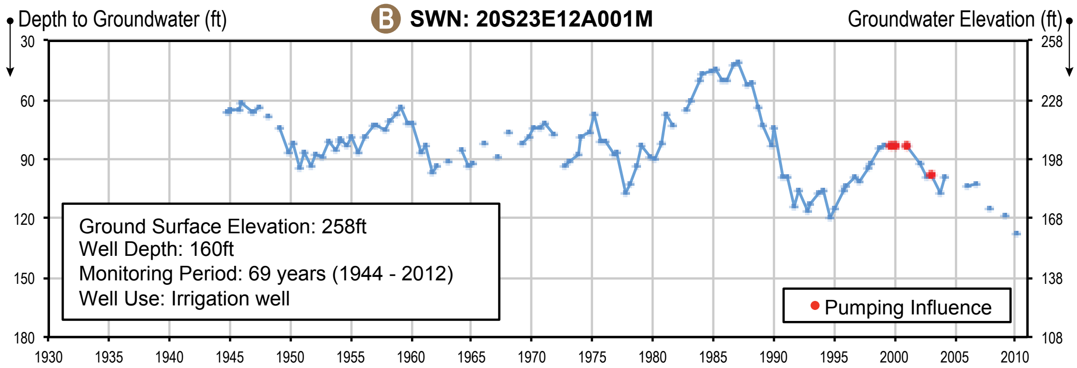
Hydrographs were selected to help tell a story of how local aquifer systems respond to changing groundwater demand and resource management practices. Additional detail is provided within the main text of the report.

Regional locator map

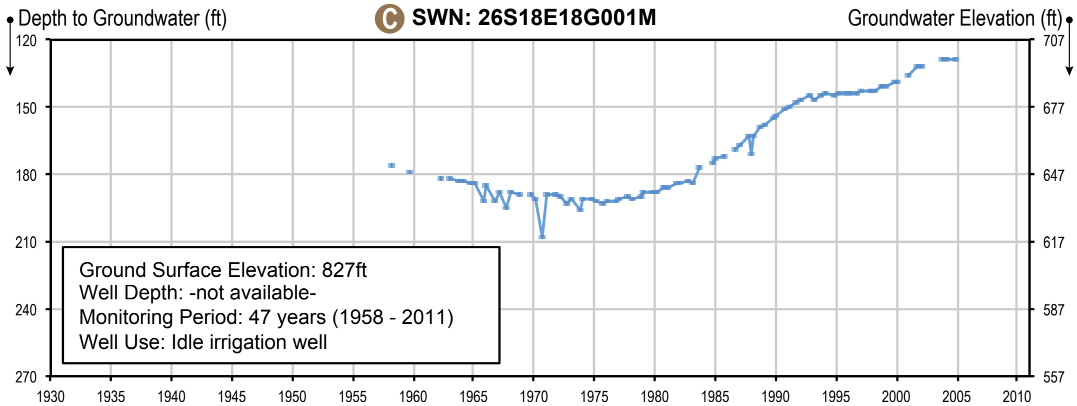


A Hydrograph 15S18E30L001M: shows an imbalance between aquifer recharge and groundwater extraction as a result of unsustainable reliance on the local groundwater resources.

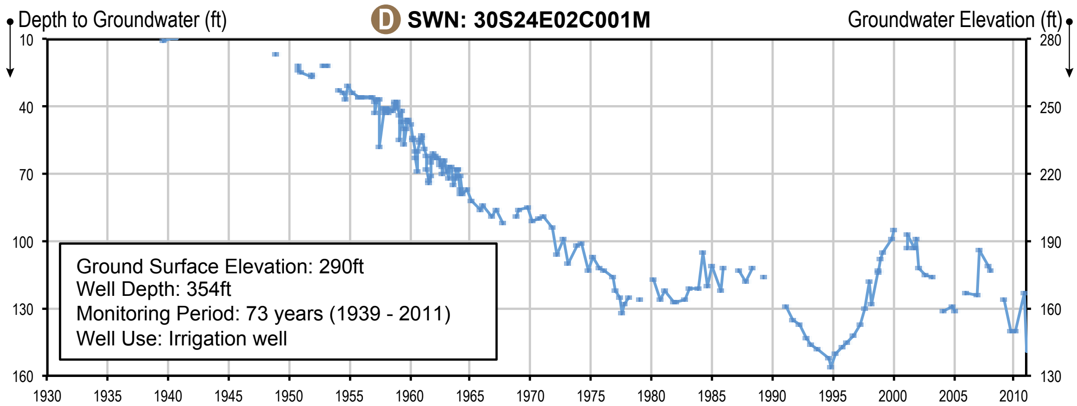




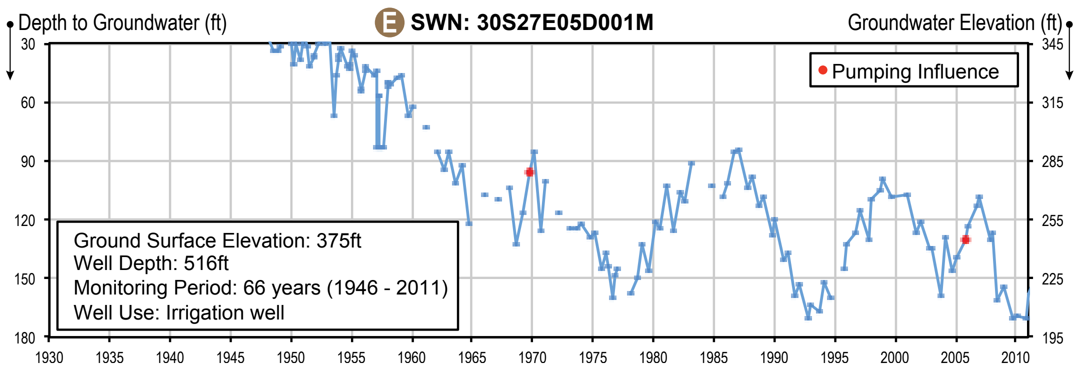
B Hydrograph 20S23E12A001M: illustrates the local aquifer response to changes in aquifer recharge and groundwater extraction, due to changes in precipitation and surface water supply deliveries.



C Hydrograph 26S18E18G001M: highlights recovering groundwater levels associated with the introduction of imported surface water from the California Aqueduct, which resulted in decreasing groundwater demand and facilitating in-lieu groundwater recharge.



D, E Hydrographs 30S24E02C001M and 30S27E05D001M: illustrate the successful stabilization of sharply declining groundwater levels through conjunctive management of surface water and groundwater supplies.



1978, regardless of the precipitation or water year type. Construction of the California Aqueduct and Cross Valley Canal in the mid-1970s stabilized groundwater levels as farmers switched to lower cost surface water in-lieu of groundwater. During this time, Improvement District No. 4 was created to more fully utilize the imported surface water and provide a supplemental water supply for the City of Bakersfield. Improvement District No. 4 utilizes conjunctive management by using surface water to either replenish the underlying groundwater aquifer or deliver for municipal water use and by pumping groundwater during years of surface water supply cutbacks.

Between 1988 through 1994, a combination of lower than average precipitation, increased population growth, and expanding agricultural activity resulted in renewed groundwater extraction and an additional 25 to 40 foot decline in groundwater levels. Since 1995, groundwater levels have been strongly influenced by the construction and operation of several large groundwater banking projects such as the Kern Water Bank, the Pioneer groundwater banking projects, and the Buena Vista Water Storage District. Above average precipitation between 1994 and 1998 and groundwater recharge activities resulted in groundwater levels rebounding almost 30 feet, although over the last 10 years, groundwater levels have again declined somewhat. Current groundwater management practices appear to be stabilizing groundwater levels through wet year groundwater banking and dry year pumping.

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, *Resource Management Strategies*, Chapter 9, "Conjunctive Management and Groundwater."

Annual and cumulative change in groundwater storage for the southern San Joaquin Valley portion of the Tulare Lake Hydrologic Region was calculated between 2005 and 2010 using spring groundwater elevation data, a range of specific yield values for the aquifer, and a Geographic Information Systems (GIS) analytical tool. Based on published literature, minimum and maximum specific yield (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 Groundwater Storage

Figure TL-20 shows an overall decline in groundwater levels for much of the region. Isolated locations showing 40- to 50-foot increases in 2005-2010 groundwater levels largely correspond

Figure TL-20 **Spring 2005 – Spring 2010 Change in Groundwater Elevation Contour Map for the Tulare Lake Hydrologic Region**

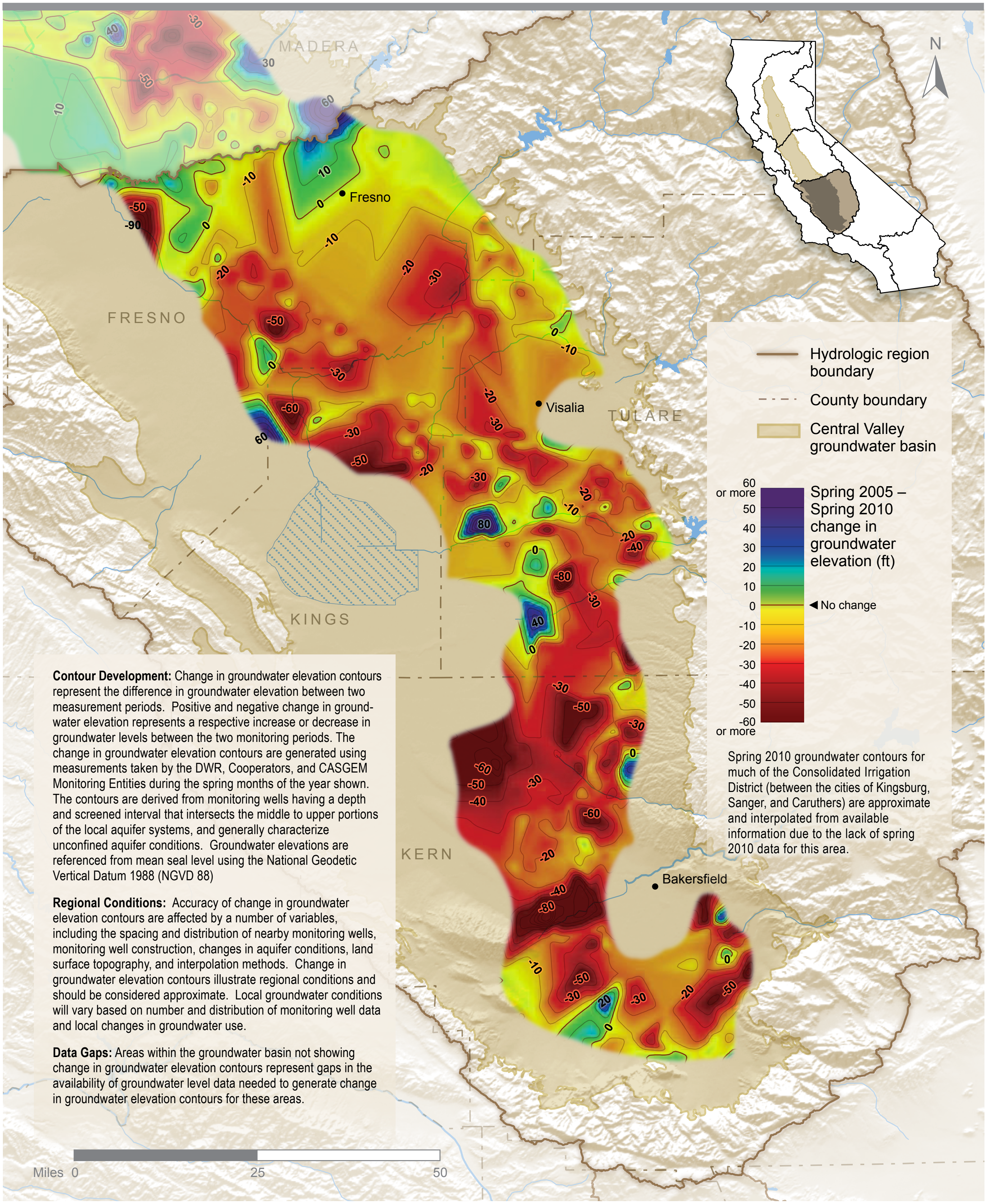


Table TL-26 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the San Joaquin Valley Portion of the Tulare Lake Hydrologic Region

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	7.0	1,457.4	3,539.3
2006-2007	1.1	237.1	575.9
2007-2008	-15.4	-3,212.6	-7,801.9
2008-2009	-7.7	-1,600.0	-3,885.8
2009-2010	-2.5	-517.2	-1,256.0
2005-2010 Total	**-17.5**	**-3,635.3**	**-8,828.6**

Notes:

taf = thousand acre-feet

Reporting area: 2,981,955 acres

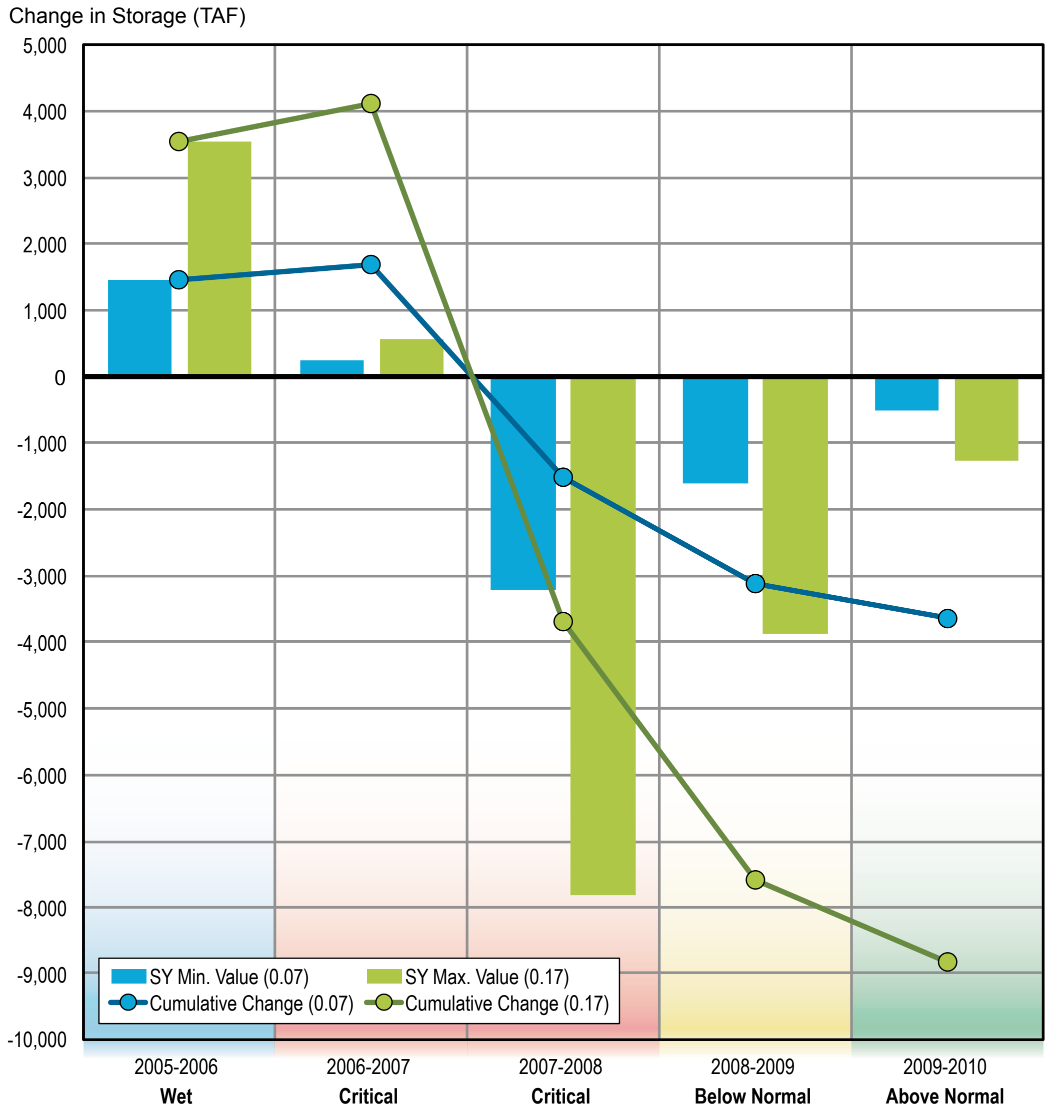
Non-reporting area: 2,018,490 acres

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

to nearby recharge basins within the Kaweah and Tule subbasins. The largest decline in groundwater levels is along the axis of the valley, in the western Kings, Kaweah, Tule, and Kern County subbasins. The maximum decline in 2005-2010 groundwater levels in these areas ranges from 40 to 90 feet.

Table TL-26 and Figure TL-21 show that the average annual change in groundwater elevation and related change in groundwater storage generally follows the annual precipitation or water year type. The spring 2005 – spring 2010 cumulative groundwater level decline over the region is estimated to be about 18 feet. Figure TL-21 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 1.5 and 3.5 maf occurred during the 2005-2006. The maximum single-year decline in groundwater storage between 3.2 and 7.8 maf occurred during the 2007-2008 period and represents between 50 and 125 percent of the average annual groundwater extraction for the region. The cumulative change in groundwater storage over the 2005-2010 period is estimated between 3.6 and 8.8 maf, which represents between 60 and 140 percent of the average annual groundwater extraction for the region. The large annual variation in groundwater storage changes points to high reliance on groundwater and active conjunctive management practices that occur in the region.

Figure TL-21 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Tulare Lake Hydrologic Region



Change in groundwater levels and associated change in storage are also estimated by the Kings River Conservation District (KRCD) for the Kings River service area, which closely approximates the Kings subbasin. In its 2009-2011 annual groundwater report, KRCD reports that the majority of the basin over the 2003-2011 time period experienced declines in groundwater elevations of about 20 feet, with limited areas of recovery in the southwest corner of the Kings subbasin (Kings River Conservation District 2012). The estimated decrease in storage over the 2003-2011 period was estimated by KRCD to be about 1.2 maf. The 2005-2010 change in storage for the Kings subbasin was estimated to range between 0.7 maf and 1.7 maf. Although the time period and areas of the current analysis and the KRCD analysis are slightly different, groundwater storage change estimates appear to be consistent with each other.

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

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 feet per year. As shown in Figure TL-22, 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 still continued in some areas — but at a slower rate, due to the time lag involved in the redistribution of pressures in the confined aquifers.

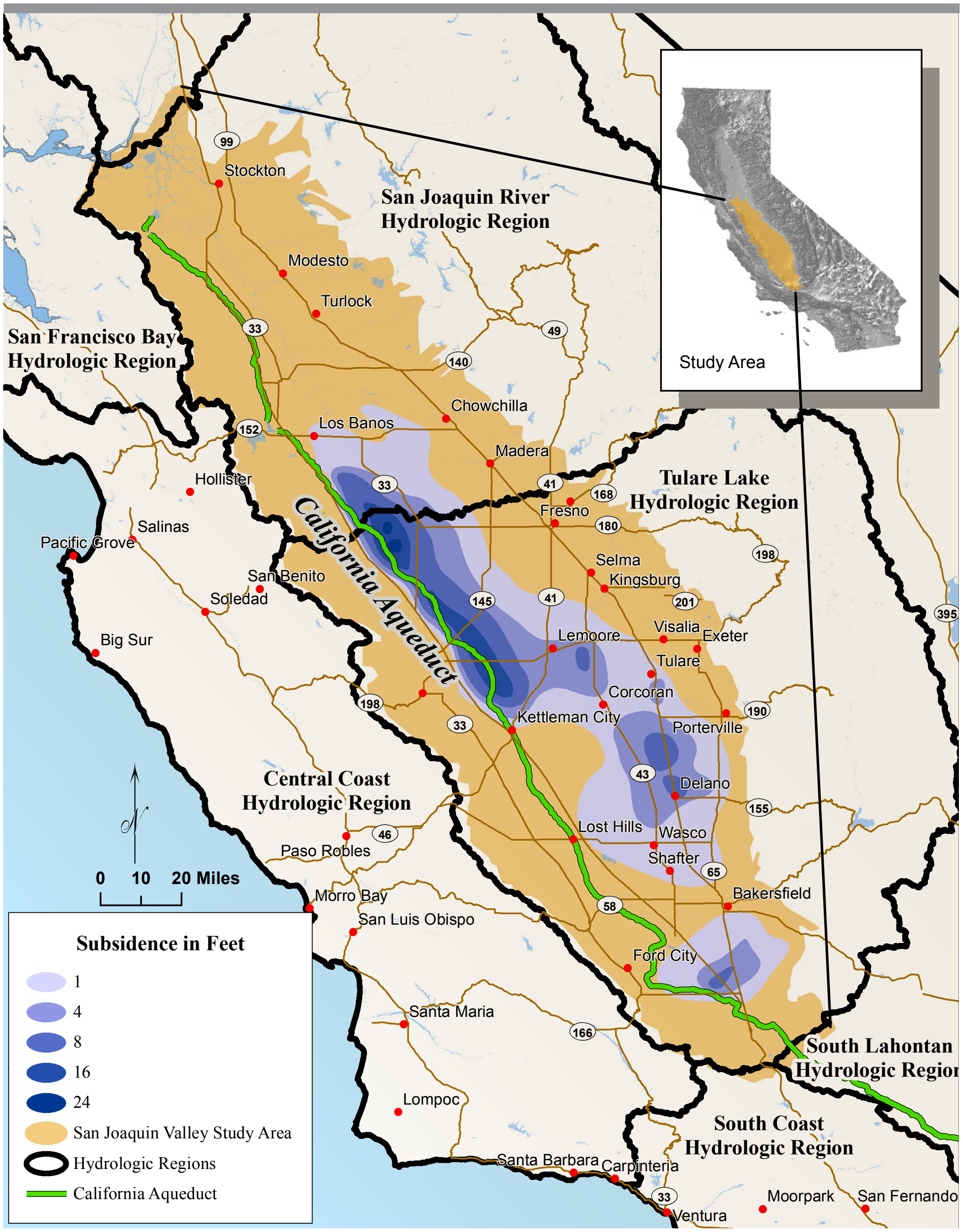
A combination of drought conditions, regulatory restrictions of imported surface water, increasing population, and agricultural trend toward the planting of more permanent crops has incrementally led to a renewed reliance on groundwater pumping in the Tulare Lake Hydrologic Region over the last few decades. Swanson (1995) conducted 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.

In order to meet the rapidly increasing demand for groundwater supplies during the 2007-2009 period, the annual installation of new agricultural wells nearly tripled. As new and existing agricultural wells extracted groundwater to meet increased permanent crop demand, deep aquifer pumping increased; confined aquifer pressures decreased; and groundwater levels in some regional areas reached historic lows. Recent studies indicate that land subsidence rates of 1 foot per year have returned to San Joaquin Valley basins that are highly reliant on groundwater supplies. Results from recent land subsidence monitoring activities are discussed below.

California Aqueduct Elevation Surveys

DWR's California Aqueduct elevation survey conducted in Fresno and Kings County for years 2000, 2006, and 2009 shows subsidence of as much as 0.8 feet from 2000 to 2009 (Figure TL-23). The survey also indicates an accelerated level of subsidence from 2006 to 2009.

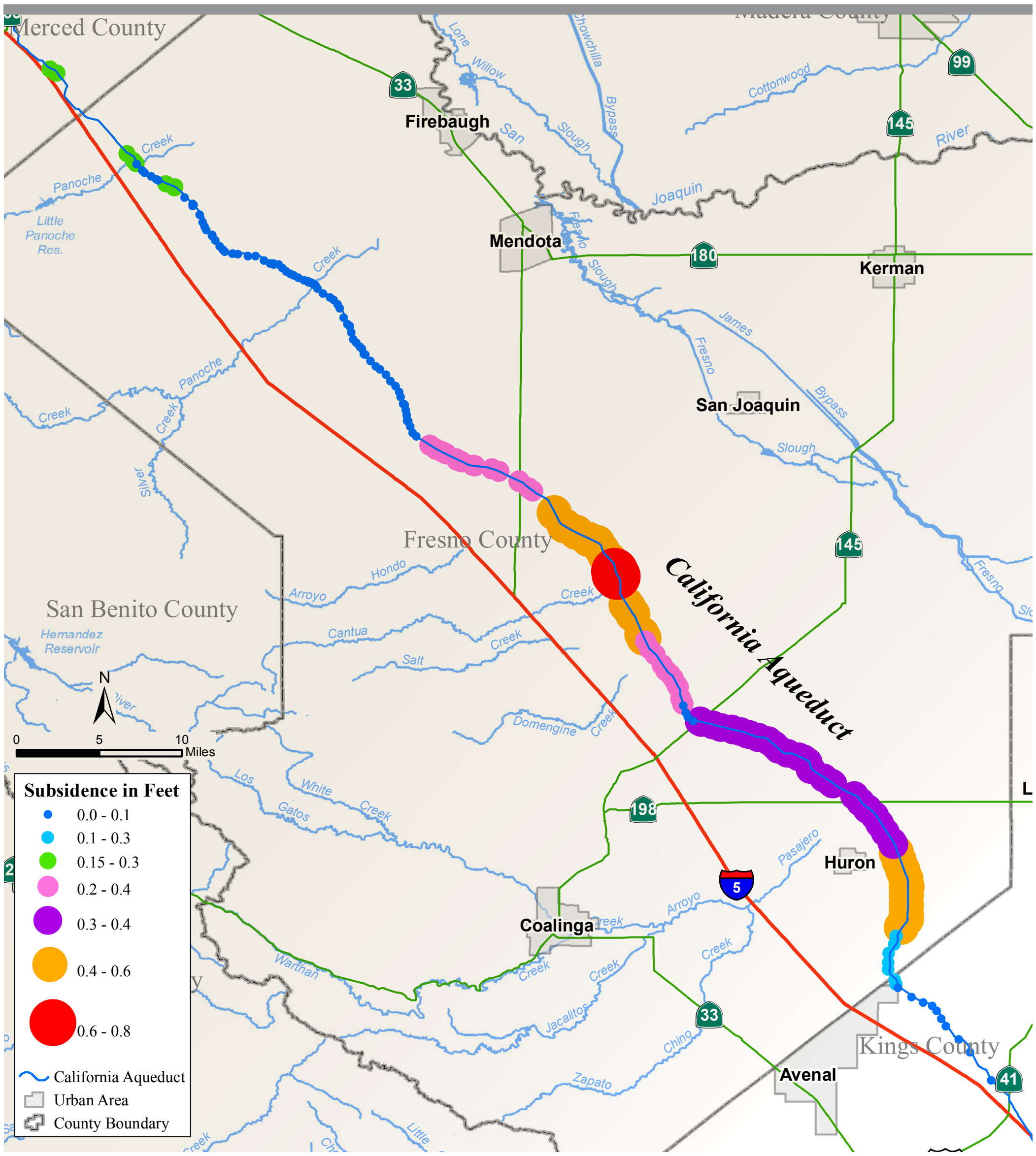
Figure TL-22 Land Subsidence in the San Joaquin Valley — 1926 to 1970 (Adapted from Ireland 1984)



Borehole Extensometer Monitoring

There are currently seven active extensometers in the San Joaquin Valley being monitored for groundwater levels and land subsidence. Figure TL-24 shows results from the extensometer installed in 1966, located in the Kern Water Bank, and actively monitored by DWR. The extensometer site also includes four groundwater level monitoring wells that are constructed to monitor various depth intervals within the aquifer system. The extensometer well cluster shows

Figure TL-23 **Land Subsidence along the California Aqueduct**

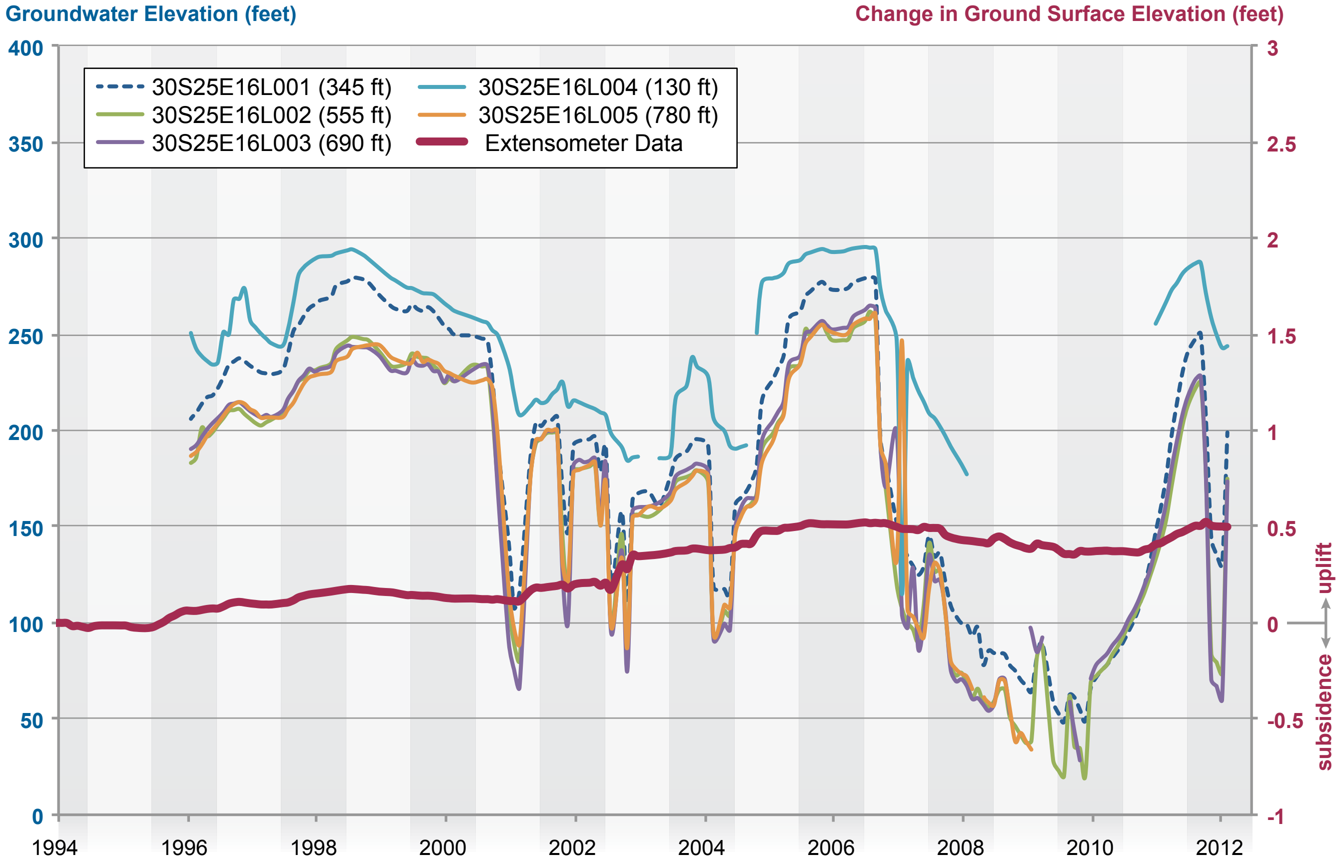


relatively large changes in water levels as the water bank is recharged and extracted. The aquifer compaction and subsidence monitored by the extensometer show a small elastic response to changes in the water levels. Elastic subsidence is reversible and will typically not develop into inelastic (irreversible)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

USGS InSAR Monitoring

Preliminary results from a USGS evaluation of 2007-2011 Interferometry Synthetic Aperture Radar (InSAR) survey data show a broad area of subsidence in the central Tulare Lake region located approximately west of Highway 99 within Kings and Tulare counties. Data from the InSAR survey are being evaluated, and the amount and rate of subsidence have not yet been determined.

Figure TL-24 Depth to Groundwater Hydrograph for Well 30S25E16L14 and Land Subsidence Graph for Kern Water Bank Extensometer



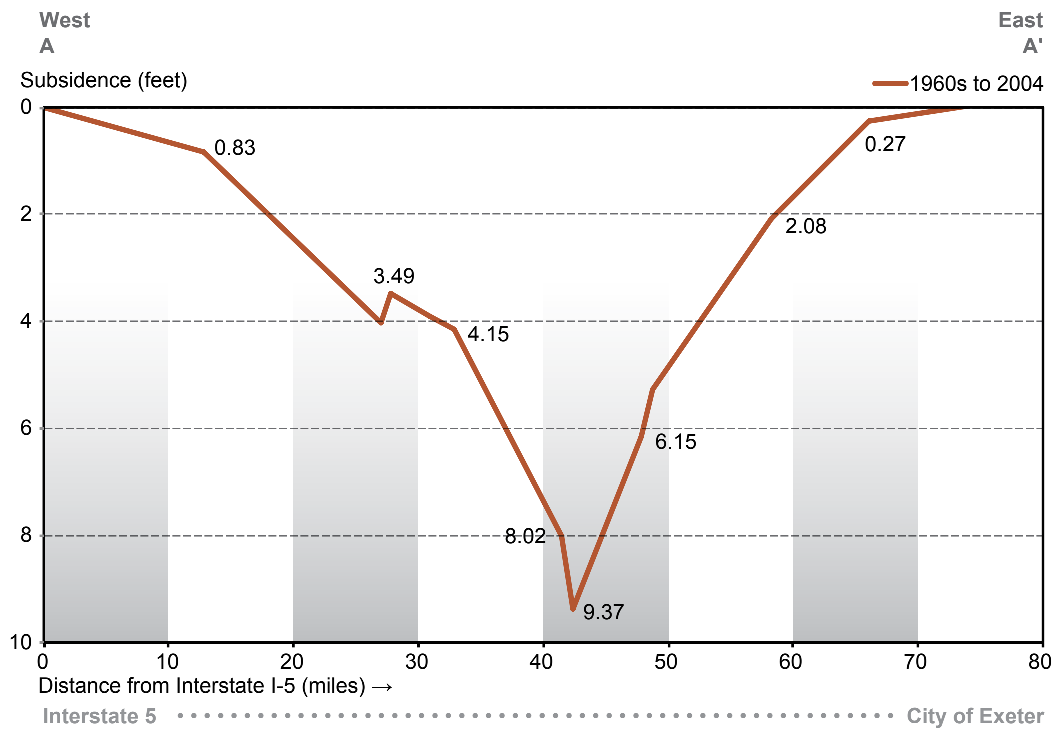
Caltrans Highway 198 Elevation Monitoring

The 2004 survey by Caltrans of Highway 198 across the San Joaquin Valley from the junction of Interstate 5 (I-5) to the town of Exeter, just east of Visalia shows that land subsidence at the eastern and western ends of the Highway 198 survey is negligible. However, results show that toward the center of the valley between the City of Lemoore and Hanford, a land subsidence trough of nearly 10 feet has developed between 1960s and 2004 (Figure TL-25). Subsidence in the area is continuing beyond 2004 as city officials in Corcoran confirm that deep wells have been pushed out of the ground by about 2 feet in the last few years.

GPS Array Monitoring

UNAVCO, an university-governed consortium for geosciences research using geodesy, has continuously monitored precision GPS stations in the western United States that provide partial but important insight into the regional magnitude of subsidence (http://pbo.unavco.org). Many of the 13 land surface displacement summary graphs show a significant decline within the Tulare Lake region (Figure TL-26). Similarly, Figure TL-27 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

Figure TL-25 Land Subsidence Results from Caltrans Highway 198 Elevation Monitoring



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 west side of the San Joaquin Valley has historically experienced large amounts of land subsidence. Westlands Water District lies within this area and has maintained water level records since 1955. Figure TL-28 includes a composite hydrograph showing groundwater levels for three wells located adjacent to Westlands Water District. The figure also includes historical land subsidence between 1960 and 1995, as recorded from a borehole extensometer and demonstrates that the rate, extent, and type (elastic versus inelastic) of land subsidence is directly related to the rate and extent of declining groundwater levels. For example, Figure TL-28 illustrates how imported surface water supplies during the late 1960s and 1970s contributed to the recovery of nearby groundwater levels from their historic low of 600 feet below land surface and the corresponding near elimination of land subsidence by 1975. The figure shows that during the 1976-1977 drought, a rapid return to groundwater pumping and the associated rapid lowering of groundwater levels by about 150 feet, resulted in a fairly rapid response of renewed subsidence — even though groundwater levels were 80 feet above historic lows. The wet decade of the 1980s shows recovery of groundwater levels and a small inelastic rebound of the land surface elevation. Once again however, during the drought of the early 1990s, a drop in groundwater levels show a corresponding renewal of several feet of land subsidence even though groundwater levels are about 180 feet above the historic low. Unfortunately, the collection of land subsidence data from the extensometer in this area was discontinued in the mid-1990s.

Figure TL-26 UNAVCO GPS Land Surface Displacement Monitoring Stations and Station Data Summary Graphs

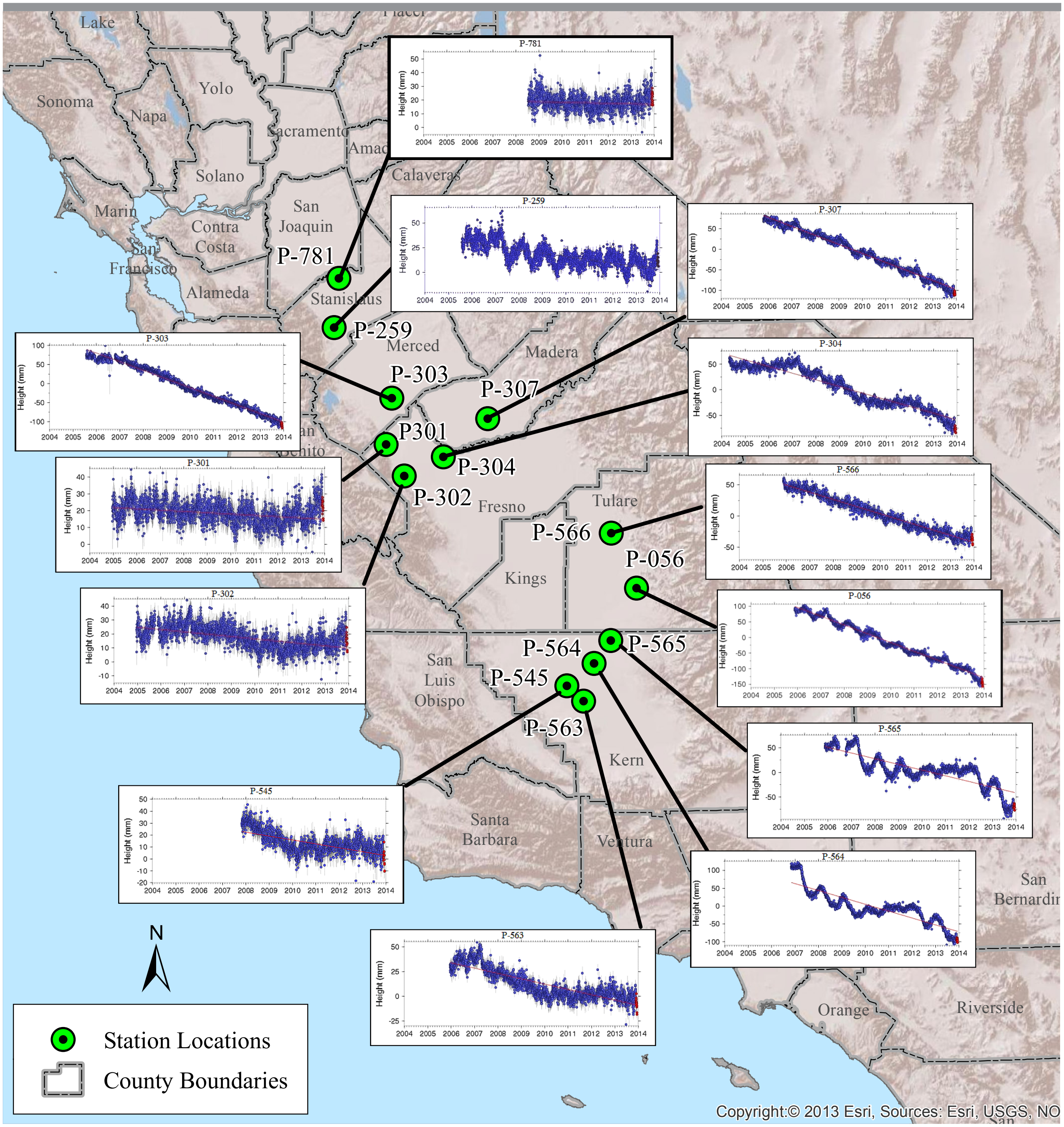
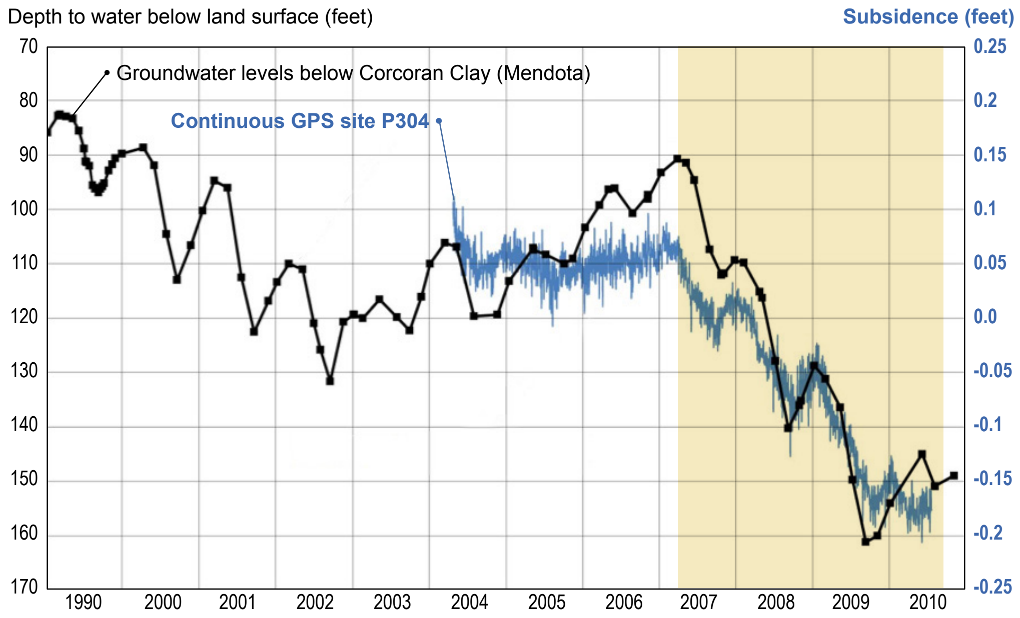


Figure TL-27 Depth to Groundwater Hydrograph and Vertical Land Surface Displacement at UNAVCO GPS Site 304, near the City of Mendota

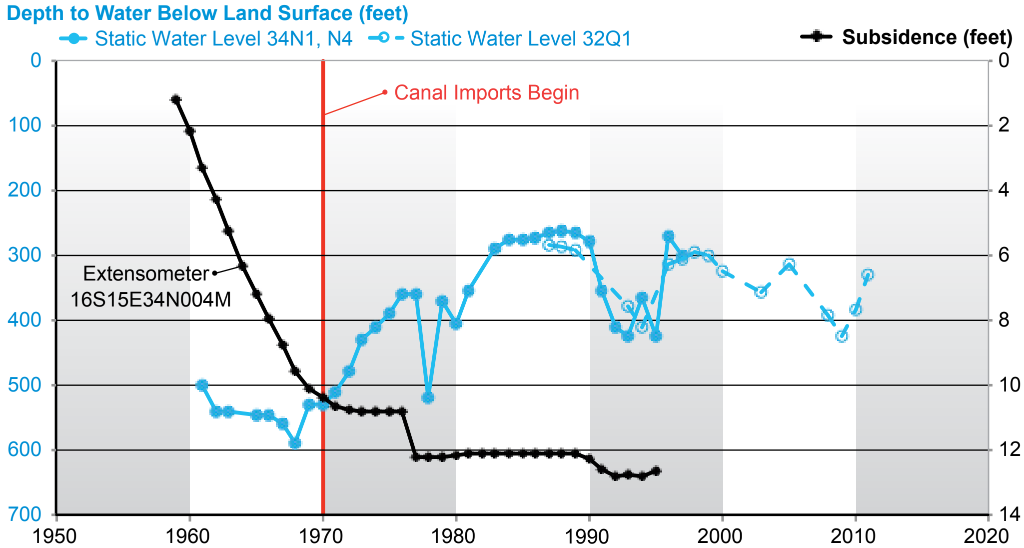


Source: USGS 2011 presentation on Central Valley subsidence. Land surface elevation data from UNAVCO Station 304; depth to water data provided by Luhdorff and Scalmanini Consulting Engineers

Overall, the hydrograph illustrates that maintaining groundwater levels above historic lows can help reduce the near-term risk for nearby land subsidence. However, maintaining groundwater levels above historic lows does not completely safeguard against continued subsidence in the future. Rapidly declining groundwater levels and confined aquifer pressures can lead to renewed subsidence even when groundwater levels remain well above historic lows.

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

Figure TL-28 Relationship between Changing Groundwater Levels and Land Subsidence in the Tulare Lake Hydrologic Region



16S15E32Q001M
Ground Surface Elevation: 356ft
Well Depth: 2,301ft
Monitoring Period: 40 years (1969 - 2008)
Well Use: Irrigation well

16S15E34N001M, 16S15E34N004M
Ground Surface Elevation: 334ft
Well Depth: 503ft (N1), 2,000ft (N4)
Monitoring Period: 21 years (1962 - 1982)
Well Use: Observation well (N1, N4)
Well Use: Extensometer (N4)

Note: Composite groundwater level hydrograph created from data collected from wells 16S15E34N001M, 16S15E34N004M, and 16S15E32Q001M.

Additional information regarding the land subsidence in aquifers in the Tulare Lake Hydrologic Region is available online from Update 2013, Volume 4, *Reference Guide,* the 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 thereby minimizing damage to lives and property. This traditional approach looked at floodwaters 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, and increased environmental awareness. These additional complexities call for an 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 might have interests and perspectives that could positively influence planning outcomes.

For example, in Tulare County, the Paregien Basin Project consists of a 78-acre groundwater recharge basin, associated structures, and monitoring wells that would capture floodwaters for groundwater recharge.

Risk Characterization

In the Tulare Lake Hydrologic Region, more than half a million residents, $32 billion in assets (buildings, public infrastructure, and crops), and over 190 sensitive species are exposed to a 500-year flood event. More specifically, in Tulare County alone, half of the residents and 34 percent of the agricultural crops, totaling $2.3 billion — the most of any California county — are exposed to the 500-year flood event. To address the higher risk of flooding, more than 4,000 miles of levees, and 55 dams, reservoirs and weirs have been constructed.

Figures TL-29 and TL-30 provide a snapshot of people, structures, crops, infrastructure, and sensitive species exposed to flooding in the region. Threatened or endangered plant and animal species exposed to flood hazards are distributed throughout.

Levee Performance and Risk Studies

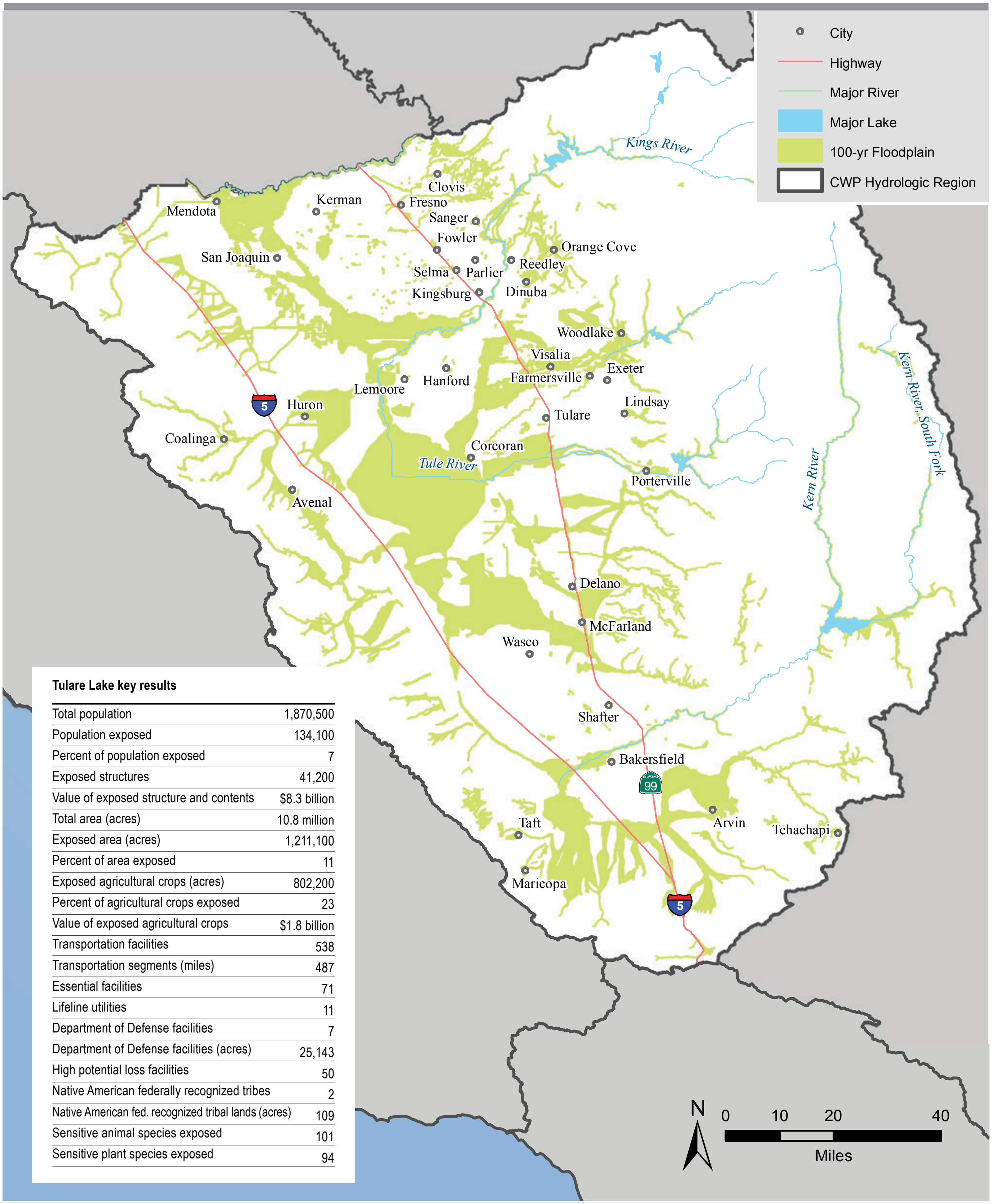
The Tulare Lake region contains floodwater storage facilities and channel improvements funded and/or built by the State and federal agencies. For a list of major infrastructure, refer to *California's Flood Future Report Attachment E: Information Gathering Technical Memorandum* (California Department of Water Resources and the U.S. Army Corps of Engineers 2013b). Eighteen locally planned projects use an IWM approach. Examples of local IWM projects include the Eastside Water Quality and Urban Reliability Project in Fresno County and Caliente Creek Habitat Restoration - Feasibility Study in Kern County. For a complete list of projects, refer to *California's Flood Future Report Attachment G: Risk Information Inventory Technical Memorandum* (California Department of Water Resources and the U.S. Army Corps of Engineers 2013c).

Water Governance

Today's water governance in the Tulare Lake region is strongly tied to the period following the Gold Rush, reclamation law, the passage of the Wright Act in the 1860s, the Municipal Utility District Act of 1921, and various related historical legislation. Most of the large irrigation districts can trace their origins to private investor efforts to build water distribution systems to divert local rivers and streams to outlying land and expansion of farmland, land reclamation, and levee maintenance.

The region's water management, planning, and flood control activities are generally governed by counties, cities, private companies, and special districts created to perform specific functions. In addition, some federal entities involved in the Tulare Lake region include the Department of the Navy, USDA Forest Service, National Park Service, and the U.S. Bureau of Land Management.

Figure TL-29 Flood Exposure to the 100-Year Floodplain, Tulare Lake Hydrologic Region

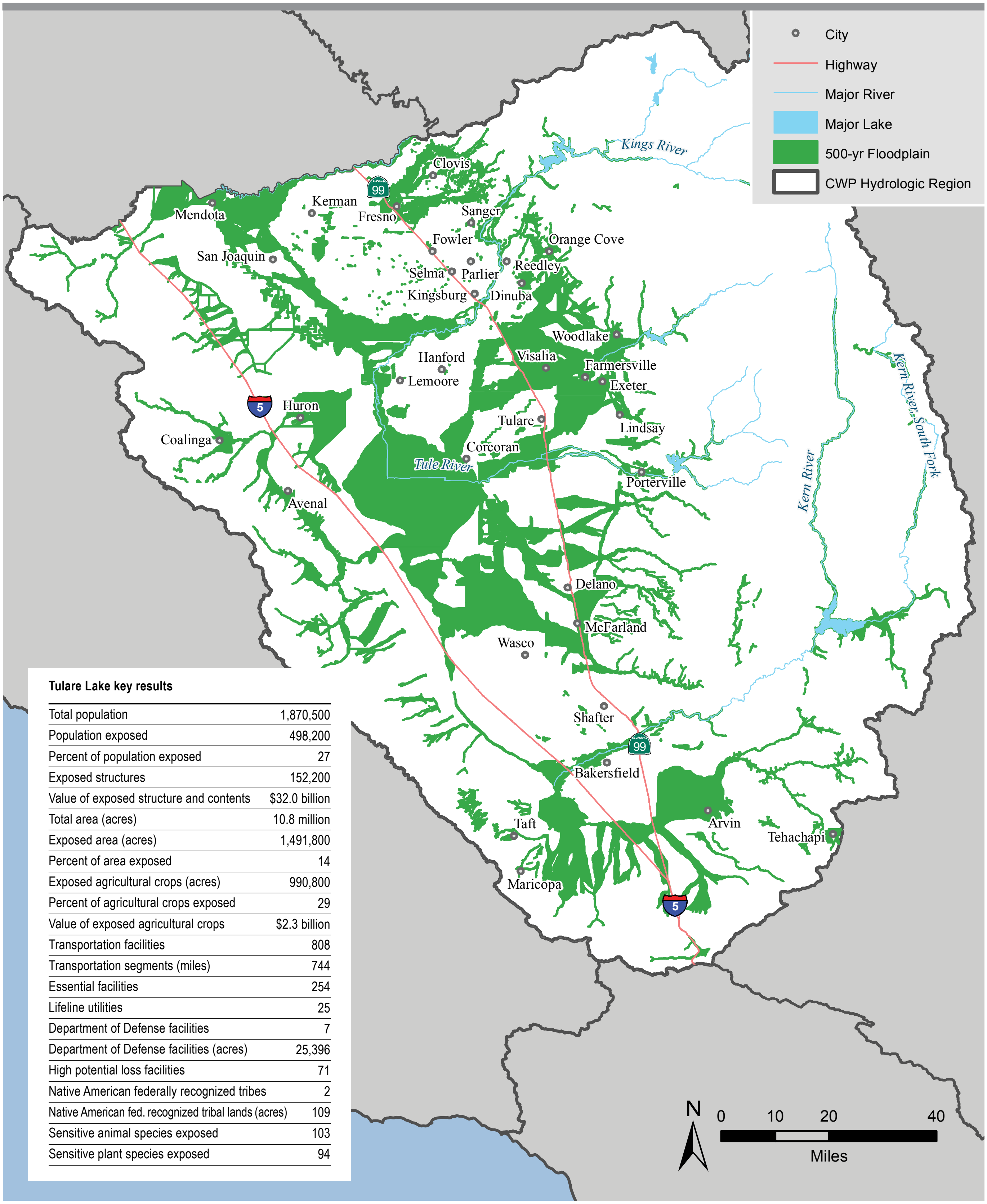


Tulare Lake key results

Total population	1,870,500
Population exposed	134,100
Percent of population exposed	7
Exposed structures	41,200
Value of exposed structure and contents	$8.3 billion
Total area (acres)	10.8 million
Exposed area (acres)	1,211,100
Percent of area exposed	11
Exposed agricultural crops (acres)	802,200
Percent of agricultural crops exposed	23
Value of exposed agricultural crops	$1.8 billion
Transportation facilities	538
Transportation segments (miles)	487
Essential facilities	71
Lifeline utilities	11
Department of Defense facilities	7
Department of Defense facilities (acres)	25,143
High potential loss facilities	50
Native American federally recognized tribes	2
Native American fed. recognized tribal lands (acres)	109
Sensitive animal species exposed	101
Sensitive plant species exposed	94

Source: California's Flood Future Report 2013

Figure TL-30 Flood Exposure to the 500-Year Floodplain, Tulare Lake Hydrologic Region



Tulare Lake key results

Total population	1,870,500
Population exposed	498,200
Percent of population exposed	27
Exposed structures	152,200
Value of exposed structure and contents	$32.0 billion
Total area (acres)	10.8 million
Exposed area (acres)	1,491,800
Percent of area exposed	14
Exposed agricultural crops (acres)	990,800
Percent of agricultural crops exposed	29
Value of exposed agricultural crops	$2.3 billion
Transportation facilities	808
Transportation segments (miles)	744
Essential facilities	254
Lifeline utilities	25
Department of Defense facilities	7
Department of Defense facilities (acres)	25,396
High potential loss facilities	71
Native American federally recognized tribes	2
Native American fed. recognized tribal lands (acres)	109
Sensitive animal species exposed	103
Sensitive plant species exposed	94

Source: California's Flood Future Report 2013

The interregional water conveyance systems of the CVP and SWP are operated by the federal and State governments, respectively. Local developed surface water systems include the diversion points and canals along the Kings River of the 28-member entities of the Kings River Water Association; along the Tule River for Porterville ID and Lower Tule River ID; and along the Kern River for Kern Delta ID and North Kern Water Storage District to name a few.

Many organizations are involved in the sale, delivery, management, maintenance, planning, reuse, and flood control aspects of water in the Tulare Lake region. Table TL-27 lists a selection of organizations involved in water governance in the region.

Flood Governance

California's water resource development has resulted in a complex, fragmented, and intertwined physical and governmental infrastructure. Although primary responsibility might be assigned to a specific local entity, aggregate responsibilities are spread among more than 165 agencies in the Tulare Lake Hydrologic Region with many different governance structures.

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, integrated regional water management plans (IRWMP), urban water management plans (UWMP), and agricultural water management plans (AWMP).

A summary assessment of some of the GWMPs in the region is presented below, while a detailed assessment is available online from Update 2013, Volume 4, *Reference Guide,* the article, "California's Groundwater Update." 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 TL-28 lists the GWMPs in the region, while Figure TL-31 shows their location and distribution. 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 SB 1938 legislation are shown.

The GWMP inventory shows 26 GWMPs in the region, seventeen of which have been developed or updated to include the SB 1938 requirements and are considered active for the purposes of the GWMP assessment.

The 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

Table TL-27 Selected Organizations in Tulare Lake Hydrologic Region Involved in Water Governance

Entity	Task
FEDERAL	
Friant-Kern Canal (CVP)	Interregional water supply
U.S. Bureau of Reclamation	Operation of Friant Dam
U.S. Corps of Engineers	Operation of Pine Flat, Isabella, and Kaweah dams
STATE	
Kern County Water Agency	Water supply and flood control
State Water Project	Interregional water supply
LOCAL	
Alpaugh Joint Powers Authority	Alpaugh Irrigation District and Tulare County Water Works District
Bear Valley Springs Community Services District	Water, police, roads, wastewater, solid waste
City of Fresno, Water Division	Water
Deer Creek and Tule River Authority	Water conservation, groundwater management
Dudley Ridge Water District	State Water Project contractor
Fresno Metro Flood Control District	Local flood control
Friant Water Authority	Friant-Kern Canal maintenance
Henry Miller Recreation District 2131	Evacuate runoff and maintain internal drainage
Kaweah Delta Water Cons District	Management of Kaweah River water
Kings River Conservation District	Flood protection, water supply, power
Kings River Water Association	Kings River entitlements, deliveries, environment
Panoche Drainage District	Maintain internal drainage
Pinedale County Water District	Water, wastewater, solid waste
Southern San Joaquin Municipal Utility District	Agricultural water from Central Valley Project, Western Area Power Administration Power
Tulare Lake Basin Water Storage District	Delivery, storage of State Water Project water
Tulare Lake Drainage District	Drainage management

assessment. In addition, the requirement for local agencies outside of the recognized groundwater basins was not applicable for any of the GWMPs in the region.

In addition to the 6 required components, Water Code Section 10753.8 provides a list of 12 components that may be included in a GWMP. DWR *Bulletin 118-2003*, Appendix C provides a list of 7 recommended components related to management development, implementation, and evaluation of a GWMP, that should be considered to help ensure effective and sustainable groundwater management (California Department of Water Resources 2003).

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

- How many of the post SB 1938 GWMPs meet the 6 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 7 recommended components listed in DWR *Bulletin 118-2003*?

A summary of the GWMP assessment is provided in Table TL-29.

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.

Ten respondents identified data collection and sharing of information as a key factor for successful GWMP implementation while nine respondents identified developing an understanding of common interest and outreach and education as key factors. The sharing of ideas and information, broad stakeholder participation, and funding were identified as important factors by eight respondents. Four to six respondents thought that surface water supplies, storage and conveyance systems, water budgets, and adequate time were important factors toward successful groundwater management. One agency stated that land conservation program for overdraft mitigation should be considered a key factor, while a different agency indicated that unregulated groundwater pumping was an important factor.

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 was also considered a key limiting factor by five respondents. Four of the respondents stated that groundwater supply was a potential impediment. Unregulated pumping, lack of understanding of local issues, access to planning tools, and outreach and education were also identified as factors that impede successful implementation of GWMPs.

Six out ten respondents felt long-term sustainability of their groundwater supply was not feasible.

More detailed information on the DWR/ACWA survey and assessment of the GWMPs are available online from Update 2013, Volume 4, *Reference Guide,* the 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

Table TL-28 Groundwater Management Plans in the Tulare Lake Hydrologic Region

Map Label	Agency Name	Date	County	Basin Number	Basin/Subbasin Name
TL-1	Alta Irrigation District	2010	Tulare	5-22.08	Kings
	No signatories on file				
TL-2	Arvin Edison Water Storage District	2003	Kern	5-22-08	Kern County
	No signatories on file				
TL-3	Bear Valley Community Services District	1998	Kern	5-69	Cummings Valley
	No signatories on file				
TL-4	Cawelo Water District	2007	Kern	5-22.14	Kern County
	No signatories on file				
TL-5	Consolidated Irrigation District	2009	Fresno	5-22.08	Kings
	No signatories on file				
TL-6	Deer Creek and Tule River Authority	2006	Tulare	5-22.13	Kings
	Lower Tule River Irrigation District				
	Pixley Irrigation District				
	Porterville Irrigation District				
	Saucelito Irrigation District				
	Stone Corral Irrigation District				
	Tea Pot Dome Water District				
	Terra Bella Irrigation District				
TL-7	Delano Earlimart Irrigation District	2007	Tulare	5-22.13	Tule
	No signatories on file		Kern	5-22.14	Kern
TL-8	Fresno Area Regional	2006	Fresno	5=22-08	Kings
	County of Fresno				
	City of Fresno				
	City of Clovis				
	City of Kerman				
	Malaga County Water District				
	Pinedale County Water District				
	Fresno Metropolitan Flood Control District				
	Bakman Water Company				
	Garfield Water District				
	Fresno Irrigation District				

Map Label	Agency Name	Date	County	Basin Number	Basin/Subbasin Name
TL-9	James Irrigation District	2010	Fresno	5-22.08	Kings
	City of San Joaquin				
TL-10	Kaweah Delta Water Conservation District	2006	Tulare	5-22.11	Kaweah
	No signatories on file				
TL-11	Kern Delta Water District	1996	Tulare	5-22.14	Kern County
	No signatories on file				
TL-12	Kern-Tulare Water District and Rag Gulch Water District	2006	Kern	5-22.14	Kern County
	No signatories on file				
TL-13	Kings County Water District	2011	Kings	5-22.11	Kaweah
	No signatories on file			5-22.12	Tulare Lake
TL-14	Kings River Conservation District – Lower Kings	2005	Fresno	5-22.08	Kings
	Burrel Ditch Company			5-22.12	Tulare Lake
	Clark Forks Reclamation District #2069				
	Corcorn Irrigation District				
	Crescent Canal Company				
	Empire West Side Irrigation District				
	John Heinlen Mutual Water Company				
	Laguna Irrigation District				
	Last Chance Water Ditch Company				
	Lemoore Canal and Irrigation Company				
	Liberty Canal Company				
	Liberty Mill Race Company				
	Peoples Ditch Company				
	Raisin City Water District				
	Reed Ditch Company				
	Riverdale Irrigation District				
	Stratford Irrigation District				
TL-15	Kings River Water District	1995	Fresno	5-22.08	Kings
	No signatories on file				
TL-16	North Kern Water Storage District and Rosedale Ranch Improvement District	1993	Kern	5-22.14	Kern County
	No signatories on file				

Map Label	Agency Name	Date	County	Basin Number	Basin/Subbasin Name
TL-17	Orange Cove Irrigation District	2006	Tulare	5-22.08	Kings
	Hills Valley Irrigation District				
	Tri-Valley Water District				
TL-18	Not used				
TL-19	Rosedale-Rio Bravo Water Storage District	1997	Kern	5-22.14	Kern County
	No signatories on file				
TL-20	Semitropic Water Storage District	2003	Kern	5-22.14	Kern County
	Kern County Water Agency				
	Southern San Joaquin Municipal Utility District				
	North Kern Water Storage District				
	Shafter-Wasco Irrigation District				
	Rosedale-Rio Bravo Water Storage District				
	Buena Vista Water Storage District				
TL-21	Shafter-Wasco Irrigation District	2007	Kern	5-22.14	Kern County
	No signatories on file				
TL-22	Tulare Irrigation District	2010	Tulare	5-22.11	Kaweah
	No signatories on file				
TL-23	Tulare Lake Bed	1998[a]	Kings	5-22.12	Tulare Lake
	Alpaugh Irrigation District				
	Angiola Water District				
	Atwell Island Water District				
	City of Corcoran				
	Corcoran Irrigation District				
	Melga Water District				
	Tulare Lake Basin Water Storage District				
	Private landowners				
TL-24	West Kern Water District	1997	Kern	5-22.14	Kern County
	No signatories on file				
TL-25	Westlands Water District	1996	Fresno	5-22.09 Westside	Westside
	No signatories on file				

Map Label	Agency Name	Date	County	Basin Number	Basin/Subbasin Name
TL-26	Wheeler Ridge-Maricopa Water Storage District	2007	Kern	5-22.14	Kern County
	No signatories on file				
TL-27	Buena Vista Water Storage District	2002	Kern	5-22.14	Kern County
	No signatories on file				

Notes:

Table represents information as of August, 2012.

[a] For TL-23, an updated plan was received after the August 2012 cutoff date. The updated plan was not included in the groundwater management plan assessment.

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 commonly adopted ordinances regulate well construction, abandonment, and destruction. Fresno County has three ordinances that require permits pertaining to water exports or transfers, well abandonment and destruction, and well construction. Kern County has two groundwater ordinances pertaining to water exports or transfers, and well construction. None of the ordinances provide for comprehensive groundwater management.

Special Act Districts

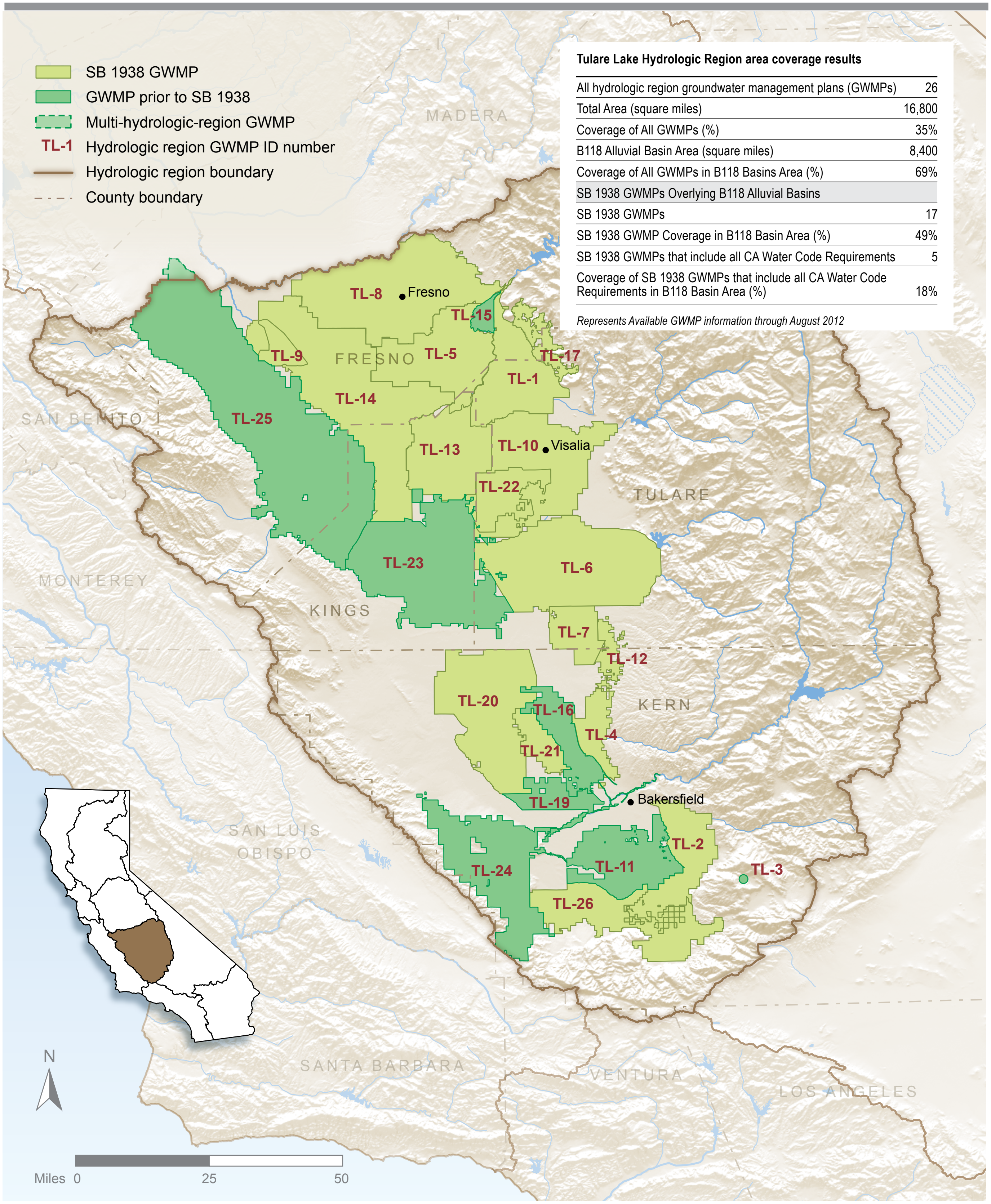
Special acts of the Legislature have granted greater authority to manage groundwater to a few local agencies or districts. These agencies generally have authority to: (1) limit groundwater export and extraction (upon evidence of overdraft or threat of overdraft); or (2) require reporting of extraction and 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.

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 Tulare Lake Hydrologic Region contains three of those adjudications. The Brite, Tehachapi East, Tehachapi West, and Cummings basins are collectively managed by The Tehachapi-Cummings County Water District.

Figure TL-31 Location of Groundwater Management Plans in the Tulare Lake Hydrologic Region



Tulare Lake Hydrologic Region area coverage results

All hydrologic region groundwater management plans (GWMPs)	26
Total Area (square miles)	16,800
Coverage of All GWMPs (%)	35%
B118 Alluvial Basin Area (square miles)	8,400
Coverage of All GWMPs in B118 Basins Area (%)	69%
SB 1938 GWMPs Overlying B118 Alluvial Basins	
SB 1938 GWMPs	17
SB 1938 GWMP Coverage in B118 Basin Area (%)	49%
SB 1938 GWMPs that include all CA Water Code Requirements	5
Coverage of SB 1938 GWMPs that include all CA Water Code Requirements in B118 Basin Area (%)	18%

Represents Available GWMP information through August 2012

Other Groundwater Management Planning Efforts

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

State Funding Received through IRWM Grants

DWR has solicited and awarded several rounds of IRWM Planning and Implementation grants with Propositions 50, 84, and 1E funding. Since 2006, the region has received more than $47 million in various IRWM grants (Tables TL-30 and TL-31). All four major IRWM regions have received some of the $1.985 million in planning grants. Poso Creek, Kaweah River Basin, and Upper Kings Basin IRWM Authority groups have received $29.518 million in Implementation grants. Both the County of Tulare and the Upper Kings Basin IRWM Authority received part of the $2.5 .million in special inter-regional grants awarded in the region. Recently, four entities in the Upper Kings Basin IRWM Authority received $755,000 in Local Groundwater Assistance grants. Finally, the Kaweah Delta Water Conservation District was awarded $3.109 million, and the Fresno Metropolitan Flood Control District was awarded $9.122 million in Stormwater Flood Management grants. More information on IRWM grant funding for the region is provided in the “Looking to the Future” section under the "Integrated Regional Water Management Summaries" subsection.

Regional Water Planning and Management

Integrated Regional Water Management Coordination and Planning

IRWM promotes the coordinated development and management of water, land, and related resources to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. Flood management is a key component of an IWM strategy.

There are seven IRWM regions in the Tulare Lake Hydrologic Region. Four of them – the Upper Kings Basin Water Forum, Kaweah River Basin, Tule, and Poso Creek are completely contained within the hydrologic region. Both the Westside-San Joaquin and Southern Sierra IRWM regions share part of their boundaries with the San Joaquin River Hydrologic Region. The Kern County region falls mainly in the Tulare Lake Hydrologic Region, but it has a small portion in the South Lahontan Hydrologic Region. All of the IRWM regions are implementing or are in the process of creating or updating their IRWM plans.

The IRWM groups have agreed to projects that have received State funding — increasing groundwater recharge, improving surface and groundwater supplies, protect groundwater quality, enhancing environmental resources, and upgrading flood control facilities. Some of the more significant projects are:

1. The Kaweah IRWM group will be constructing stormwater retention basins that will be used to recharge groundwater outside (upgradient) of Visalia and Tulare. They are also building a water reuse pipeline in Visalia that will allow the recycling and reuse of up to 26 million gallons per day for landscaping and other non-potable purposes to offset groundwater

Table TL-29 Assessment of Groundwater Management Plan Components

SB 1938 GWMP Required Components	Percent of Plans that Meet Requirement
Basin management objectives	29
BMO: Monitoring/management groundwater levels	88
BMO: Monitoring groundwater quality	88
BMO: Inelastic subsidence	71
BMO: SW/GW interaction and effects to groundwater levels and quality	29
Agency cooperation	100
Map	76
Map: Groundwater basin area	76
Map: Area of local agency	82
Map: Boundaries of other local agencies	76
Recharge areas (Jan. 1, 2013)	Not assessed
Monitoring protocols	35
MP: Changes in groundwater levels	88
MP: Changes in groundwater quality	88
MP: Subsidence	76
MP: SW/GW interaction and effects to groundwater levels and quality	41
SB 1938 Voluntary Components	**Percent of Plans that Include Component**
Saline intrusion	82
Wellhead protection and recharge	65
Groundwater contamination	76
Well abandonment and destruction	94
Overdraft	88
Groundwater extraction and replenishment	100
Monitoring groundwater levels and storage	100
Conjunctive use operations	94
Well construction policies	94
Construction and operation	59
Regulatory agencies	53
Land use	76

Bulletin 118-2003 Recommended Components	Percent of Plans that Include Component
GWMP guidance	82
Management area	94
BMOs, goals, and actions	94
Monitoring plan description	59
IRWM planning	88
GWMP implementation	94
GWMP evaluation	88

Notes:

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

pumping. One of their DAC projects will help finance the abandonment or destruction of private wells where the owner can't afford to properly do so.

2. The Upper Kings Basin IRWM Authority group will be expanding the capacity of the City of Clovis surface water treatment plant, which will reduce the city's reliance of groundwater supplies and allow some additional "in-lieu" recharge of the aquifer. They are also nearing completion on the redesigned Fancher Creek detention that will improve flood control in southeast Fresno. To assist the DAC of East Orosi, the group will rehabilitate two municipal water wells that have nitrate levels exceeding the MCL and low production rates.
3. The Poso Creek IRWM group will be constructing the Cross Valley Canal to Calloway Canal Intertie which will provide a water supply benefit of up to 5,700 af per year by adding delivery flexibility and enhanced flood control to water districts that receive SWP and CVP supplies delivered from the California Aqueduct. They are also adding riparian wildlife and wetland habitat around the Pond-Poso Spreading Basins. Finally, the group will address critical water supply needs in five DACs by providing funding to perform feasibility studies, environmental, and engineering work necessary to construct facilities to solve defined water quality and supply problems.

Implementation Activities (2009-2013)

Water 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 RWQCBs adopt water quality control plans or basin plans that lay out the framework for how each RWQCB will protect water quality in its region. The basin plans designate the beneficial uses of surface water and groundwater in the region, water quality objectives to

Box TL-1 Other Groundwater Management Planning Efforts in the Tulare Lake Hydrologic Region

The Integrated regional water management plans (IRWMs), urban water management plans (UWMPs), and agricultural water management plans (AWMPs) in the Tulare Lake Hydrologic Region that also include components related to groundwater management are briefly discussed below.

Integrated Regional Water Management Plans

The Tulare Lake Hydrologic Region includes 7 of the 48 IRWM plans that have been accepted or conditionally accepted statewide. Four of the seven IRWM plans are actively implemented, while three are in various stages of implementation. Two of the established plans extend northward into the San Joaquin River Hydrologic Region.

The Poso Creek and Kern County IRWM plans rely on member entities to implement groundwater management plans that are consistent with existing California Water Code requirements. Common groundwater management themes identified in the Poso Creek and Kern County IRWM plans are to preserve and maximize groundwater quantity and quality, and protect against land surface subsidence. Common management practices include monitoring groundwater quantity and quality, and participation in groundwater recharge activities.

The Westside IRWM plan relies on local groundwater management entities to implement groundwater-related projects to help improve local groundwater management. One of the main goals of the Westside IRWM is to minimize regional conflict by addressing problems such as water supply reliability, overdraft, drainage, and water quality.

While similarly relying on local management entities to implement local groundwater management plans, the Upper Kings IRWM plan also seeks to integrate existing local groundwater management plans into a single comprehensive management plan at the IRWM-regional scale. The Upper Kings IRWM plan has established conjunctive use and effective groundwater management as a prevailing theme, and identifies groundwater overdraft in the basin as the highest priority problem and being the greatest potential source of conflicts among water users, economic losses to both urban and agricultural economies, and impacts to the environment. The Upper Kings IRWM plan also recognizes that each of the overlying water districts need to continue working with stakeholders in their respective jurisdictions to update and implement their individual groundwater management plans. Overall, the Upper Kings IRWM plan outlines an effective approach for integrating local groundwater management objectives into the broader IRWM planning for the area.

Urban Water Management Plans

UWMPs 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 UWMPs and then manually translated by California Department of Water Resources 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 timeline, the plans could not be reviewed for assessment for *California Water Plan Update 2013*.

Agricultural Water Management Plans

AWMPs are developed by water and irrigation districts to advance the efficiency of farm water management while benefiting the environment. New and updated AWMPs 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 timeline, the plans could not be reviewed for assessment for *California Water Plan Update 2013*.

Table TL-30 Proposition 50 and Proposition 1E Integrated Regional Water Management Grants Awarded

		Proposition 50			Proposition 1E	
Map Number	IRWM Region and Grantee	2006 Planning Award	2006 Impl. Award	2010 Impl. Supplemental Award	Round 1 2011 SWFM Award	Round 2 2013 SWFM Award
14	KAWEAH RIVER BASIN					
	Kaweah Delta Water Conservation District					$3,109,856
	County of Tulare					
24	POSO CREEK					
	Semitropic Water Storage District	$459,900				
33	SOUTHERN SIERRA					
	Sequoia Riverlands Trust					
38	KINGS BASIN WATER AUTHORITY					
	Kings River Conservation District	$500,000	$6,064,375			
	Upper Kings Basin IRWM Authority			$2,099,868		
	Fresno Metropolitan Flood Control District				$2,231,086	$6,891,010
	Kings County Water District					
	Tranquility Irrigation District					
	Consolidated Irrigation District					

Notes:

Impl. = implementation, IRWM = integrated regional water managment, SWFM = stormwater flood management

Table TL-31 Proposition 84 Integrated Regional Water Management Grants Awarded

		Proposition 84				
Map Number	IRWM Region and Grantee	Round 1 2011 Planning Award	Round 1 2011 Implementation Award	2011 Interregional Award	Round 2 2012 Planning Award	2013 Local Groundwater Assistance Award
14	KAWEAH RIVER BASIN					
	Kaweah Delta Water Conservation District		$4,643,000		$235,254	
	County of Tulare			$2,000,000		
24	POSO CREEK					
	Semitropic Water Storage District		$8,215,000			
33	SOUTHERN SIERRA					
	Sequoia Riverlands Trust				$519,987	
38	KINGS BASIN WATER AUTHORITY					
	Kings River Conservation District					
	Upper Kings Basin IRWM Authority	$269,890	$8,496,000	$500,000		
	Fresno Metropolitan Flood Control District					$225,000
	Kings County Water District					$200,000
	Tranquility Irrigation District					$200,000
	Consolidated Irrigation District					$157,370

Note: IRWM = Integrated RegionalWater Mangement, 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 RWQCB will coordinate its regulatory and non-regulatory programs to address specific water quality concerns.

Overarching all CVRWQCB programs and activities is the development of a comprehensive salt and nitrate management plan for the Central Valley. CV-SALTS will implement basin plan amendments that establish regulatory structure and policies to support basinwide salt and nitrate management. The regulatory structure will have five key elements: (1) refinement of the agricultural supply, municipal and domestic supply, and groundwater recharge 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; (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 and/or nitrate management is needed; and (5) an overarching framework to provide consistency for the development of management plans within the management areas to facilitate implementation efforts to insure a sustainable future . For the Tulare Lake Hydrologic Region, CV-SALTS plans to implement pilot projects to demonstrate refinement of beneficial uses in the groundwater; beneficial uses and water quality objectives for agricultural water bodies; and development of a management plan to assist areas with inadequate economic capacity to address high levels of nitrate contamination in drinking water (Central Valley Salinity Alternatives for Long-Term Sustainability 2012a, 2012b) CV-SALTS is coordinating and building off the salinity reduction and control efforts described under the Accomplishments section.

Surface Water

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

- The Irrigated Lands Regulatory Program 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 which 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. Water quality coalitions currently active in the region are the Westlands Water District and Southern San Joaquin Valley Water Quality Coalition. Management plans have been developed and implemented to address water column and sediment toxicity and E. coli (Central Valley Regional Water Quality Control Board 2011a).
- In the west side of the Tulare Lake Hydrologic Region, there are farmlands with naturally poor drainage. In these areas, there is a need for agricultural subsurface collection systems (tile drains) that are placed below the root zone of crops to drain water from soils that would otherwise stay saturated. Through evaporation and crop transpiration, the tile drain water has salt levels that are many times higher than the salt levels in the applied water. Also through evaporation and crop transpiration, the tile drains concentrate trace elements found naturally

in the soils to levels that are a concern to wildlife. In some areas of the region evaporation basins are used to collect and concentrate the tile drainage. The Irrigated Lands Regulatory Program oversees the operations at these evaporation basins to assure that they do not adversely impact wildlife or other beneficial uses (Central Valley Regional Water Quality Control Board 2004).

- The Discharge to Land Program oversees the investigation and cleanup of impacts of current and historical unauthorized discharges including discharges from historical mining activities.
- 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. Urban runoff can contain pesticides, mercury and other metals, 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 Water Quality Certification Program evaluates discharges of dredge and fill materials to assure that the activities do not violate State and federal water quality standards.
- 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 and wetlands, riparian areas, and vegetated treatment systems. For some of these sources, such as irrigated agriculture and forestry, CVRWQCB has specific regulatory programs. The Nonpoint Source Program addresses sources where the board has not developed a specific program. This program has assisted stakeholders obtain funding 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.

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, the Board'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 2010a):

- CVRWQCB has a program to regulate discharges from confined animal operations. Water quality issues associated with confined animal operations are salt and nutrients. In 2007, CVRWQCB adopted Waste Discharge Requirements General Order for Existing Milk Cow Dairies (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 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 Tulare Lake Hydrologic Region, there are 559 dairies with more than 919,000 cows regulated under this general order.

- CVRWQCB's 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 to groundwater.
- SWRCB has adopted regulations for the operation of onsite wastewater treatment systems. (Resolution 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 Tulare Lake Hydrologic Region, CVRWQCB has adopted four prohibitions of discharge from individual sewage disposal systems. Currently, all of these areas are served by community sewage systems.
- The Discharge to Lands program provides oversight of the discharges from oil fields. In the Central Valley, the only oilfields are located in the Tulare Lake region. Produced water from the extraction of oil is a water quality concern due to high levels of salt, oil and grease, metals and organics. Discharge to surface waters is allowed with higher quality produced water that is used directly or blended with other waters for agricultural supply. Discharge to sumps is allowed when the quality meets basin plan requirements. Re-injection of produced water is regulated by the Division of Oil, Gas, and Geothermal Resources (DOGGR) under the California Department of Conservation. To prevent duplication, CVRWQCB coordinates with the DOGGR to protect water quality. Re-injection of produced water is also allowed into aquifers that have received an exemption pursuant to 40 CFR Section 261.3.
- CVRWQCB has established the Groundwater Monitoring Advisory Workgroup whose primary goal is to provide input on matters related to groundwater monitoring. Specifically, the Groundwater Monitoring Advisory Workgroup (GMAW) will advise and provide comments to CVRWQCB staff on technical issues related to how groundwater monitoring studies are conducted and evaluation of monitoring data.

Accomplishments

Disadvantaged Communities Accomplishments

In August 2013, the Kings Basin Water Authority completed the Kings Basin Disadvantaged Communities Pilot Study (Kings Basin Water Authority 2013) which developed an inventory of the DACs and their water-related needs (drinking water, wastewater, and stormwater/drainage) in the Kings Basin Region (portions of Fresno, Kings, and Tulare counties). Besides increasing DAC IRWM plan involvement, the study developed conceptual pilot projects with cost estimates to meet a key water issue in each of the five subregions.

Water Quality Accomplishments

Local groups have begun efforts to address salt management. The City of Fresno has initiated an outreach program to inform residents on ways to reduce salt loads to water that passes through the Regional Wastewater Reclamation Facility and ultimately to their underground water supply. Also, the Red Rock Ranch, located at Five Points in Fresno County, has initiated an integrated on-farm drainage management system, which includes low-pressure pivot sprinklers and minimum tillage.

In 2010, the 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 2010b). The Irrigated Lands Regulatory Program has transitioned 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 in the state. CVRWQCB has successfully implemented its general order for existing milk cow dairies. In the Tulare Lake region, 559 dairies are covered by this general order that requires implementation of waste and nutrient management plans. In addition, the CVRWQCB has successfully made improvements to its land discharge program to increase groundwater monitoring and reduce the backlog of waste discharge requirements.

Water Supply Accomplishments

In October 2011, the Glennville Mutual Water Company community water supply system began its first deliveries of water to consumers. Approximately 30 households were connected to the new water supply system, which replaced individual private wells that had been impacted by gasoline releases in the 1980s (gasoline) and 1990s (gasoline/MTBE) at the former Glennville Shopping Center. Funding to install the $2 million community water supply system was a multi-agency joint effort by CVRWQCB (a litigation settlement fund), SWRCB (Emergency, Abandoned, and Recalcitrant Fund), and the CDPH (grant funds). Discovery of the MTBE contamination was not made until after CVRWQCB settlement was finalized, thus making CVRWQCB responsible for providing the residents with suitable drinking water. CVRWQCB staff has been coordinating the delivery of trucked and bottled water to affected residents since the late 1990s. Completion of this system is the culmination of more than a decade of staff's efforts at attaining a permanent water supply for the affected residents of Glennville.

Challenges

A major challenge will be the development of the CV-SALTS basin plan amendments within the timeframe 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 study (Howitt et al. 2009) found that salts and nitrates are already costing Central Valley residents $544 million annually for treatment and lost production. Increasingly, freshwater supplies will be used to dilute salts, reducing supplies for people and the environment, especially during droughts (Central Valley Salinity Alternatives for Long-Term Sustainability 2012a).

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 an 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 2011b).

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 2011b).

Water Quality

A major challenge is the ability of small communities to address water quality issues. Many small communities are trying to meet stricter drinking water quality standards, but they have aging wells and infrastructure that will be difficult to upgrade with limited resources. Other 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 onsite 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.

Flood Management

Typically, flood management agencies in large urban areas tend to be highly organized. Agencies in more rural counties or with low exposure to flooding are often handled by emergency responders or a single contact at the county. This can present a unique set of challenges when developing a project.

Flood management in the Tulare Lake Hydrologic Region of California has a unique set of challenges that were identified during meetings with local agencies in the hydrologic region. These challenges include:

- Levee recertification.
- Maintenance of channels restricted and difficult because of permitting and environmental regulations.
- Inconsistent agency roles in some parts of the region.
- Inconsistent and unreliable funding sources, especially for operations and maintenance.
- Inadequate data and flood information, including aerial images and mapping.
- Federal flood insurance programs that allow too much construction in floodplains.
- Cost of collecting adequate data to design flood control structures is financially infeasible.
- Environmental regulations that make projects difficult to implement.
- Lack of storage for flood events.
- Undersized and deteriorating flood infrastructure (seismic retrofit of dams).
- Need for clarity on who is responsible for upstream/downstream impacts.
- Need more accurate weather forecasts.

Looking to the Future

Future Conditions

Future Scenarios

Update 2013 evaluates different ways of managing water in California 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 climate change. Growth factors for the Tulare Lake 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 Conservation in California (last amended September 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.

Tulare Lake Growth Scenarios

Future water demand in the Tulare Lake 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 TL-32 displays a conceptual description of the growth scenarios used in this update. Update 2013 quantifies several factors that together provide a description of future growth and how growth could affect water demand for the urban, agricultural, and environmental sectors in the Tulare Lake region. Growth factors are varied between the scenarios to describe some of the uncertainty faced by water managers. For example, it is impossible to predict future population growth accurately so Update 2013 uses three different, but plausible population growth estimates when determining future urban water demands. In addition, Update 2013 considers up to three different alternative views of future development density. Population growth and development density will reflect how large the urban landscape will become in 2050 and are used to quantify encroachment into agricultural lands by 2050 in the Tulare Lake Hydrologic Region.

Table TL-32 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

For Update 2013, DWR worked with researchers at the University of California, Davis, to quantify how much growth might occur in the Tulare Lake Hydrologic Region through 2050. The UPlan model was used to estimate a year 2050 urban footprint 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 TL-33 describes the amount of land devoted to urban use for 2006 and 2050, and change in the urban footprint under each scenario. As shown in the table, the urban footprint grew by about 150,000 acres under low-population growth scenario (LOP) by 2050 relative to the 2006 base-year footprint of about 500,000 acres. The urban footprint under high population scenario (HIP), however, grew by about 330,000 acres. The effect of varying housing density on the urban footprint is also shown.

Table TL-34 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 multi-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 90 thousand acres by year 2050 as a result of low population growth and urbanization in Tulare Lake region, while the decline under high population growth was higher by about 200 thousand acres.

Tulare Lake 2050 Water Demands

This section provides a description for how future water demands might change under scenarios organized around themes of growth and climate change described earlier in this report. The change in water demand from 2006 to 2050 is estimated for the Tulare Lake Hydrologic Region for the agriculture and urban sectors under nine growth scenarios and 13 scenarios of future climate change. The climate change scenarios included the 12 Climate Action Team scenarios

Table TL-33 Growth Scenarios (Urban) — Tulare Lake 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	3,588.5[d]	1,445.6	High	627.0	129.3
LOP-CTD	3,588.5	1,445.6	Current Trends	647.5	149.8
LOP-LOD	3,588.5	1,445.6	Low	667.3	169.6
CTP-HID	4,351.6[e]	2,208.7	High	727.1	229.4
CTP-CTD	4,351.6	2,208.7	Current Trends	756.8	259.1
CTP-LOD	4,351.6	2,208.7	Low	787.1	289.4
HIP-HID	5,345.9[f]	3,203.0	High	785.9	288.2
HIP-CTD	5,345.9	3,203.0	Current Trends	829.3	331.6
HIP-LOD	5,345.9	3,203.0	Low	873.7	376.0

Notes:

[a] See Table TL-32 for scenario definitions.

[b] 2006 population was 2,142.9 thousand.

[c] 2006 urban footprint was 497.7 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.

[f] Values modified by DWR from the Public Policy Institute of California.

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 TL-32 shows the change in water demands for the urban and agricultural sectors under nine growth scenarios shown in Table TL-32, with variation shown across 13 climate scenarios. 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 falling and the average air temperature. Change in water demand is shown under a repeat of historical climate conditions and for 12 scenarios of future climate change.

Urban demand increased under all nine growth scenarios tracking with population growth. On average, it increased by about 320 taf under the three low population scenarios, 520 taf under the three current trend population scenarios and about 730 taf under the three high population scenarios when compared to historical average of about 675 taf. The results show change in

Table TL-34 Growth Scenarios (Agriculture) — Tulare Lake 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	2,882.9	3,065.1	182.1	-76.8
LOP-CTD	2,869.2	3,050.4	181.3	-91.5
LOP-LOD	2,856.5	3,037.0	180.5	-104.9
CTP-HID	2,826.9	3,005.4	178.6	-136.5
CTP-CTD	2,805.6	2,982.9	177.3	-159.0
CTP-LOD	2,784.6	2,960.5	175.9	-181.4
HIP-HID	2,790.8	2,967.2	176.3	-174.7
HIP-CTD	2,760.5	2,934.9	174.4	-207.0
HIP-LOD	2,729.2	2,901.6	172.4	-240.3

Notes:

[a] See Table TL-32 for scenario definitions.

[b] 2006 irrigated land area was estimated by the California Department of Water Resources (DWR) to be 2,955.2 thousand acres.

[c] 2006 irrigated crop area was estimated by DWR to be 3,141.9 thousand acres.

[d] 2006 multiple crop area was estimated by DWR to be 186.7 thousand acres.

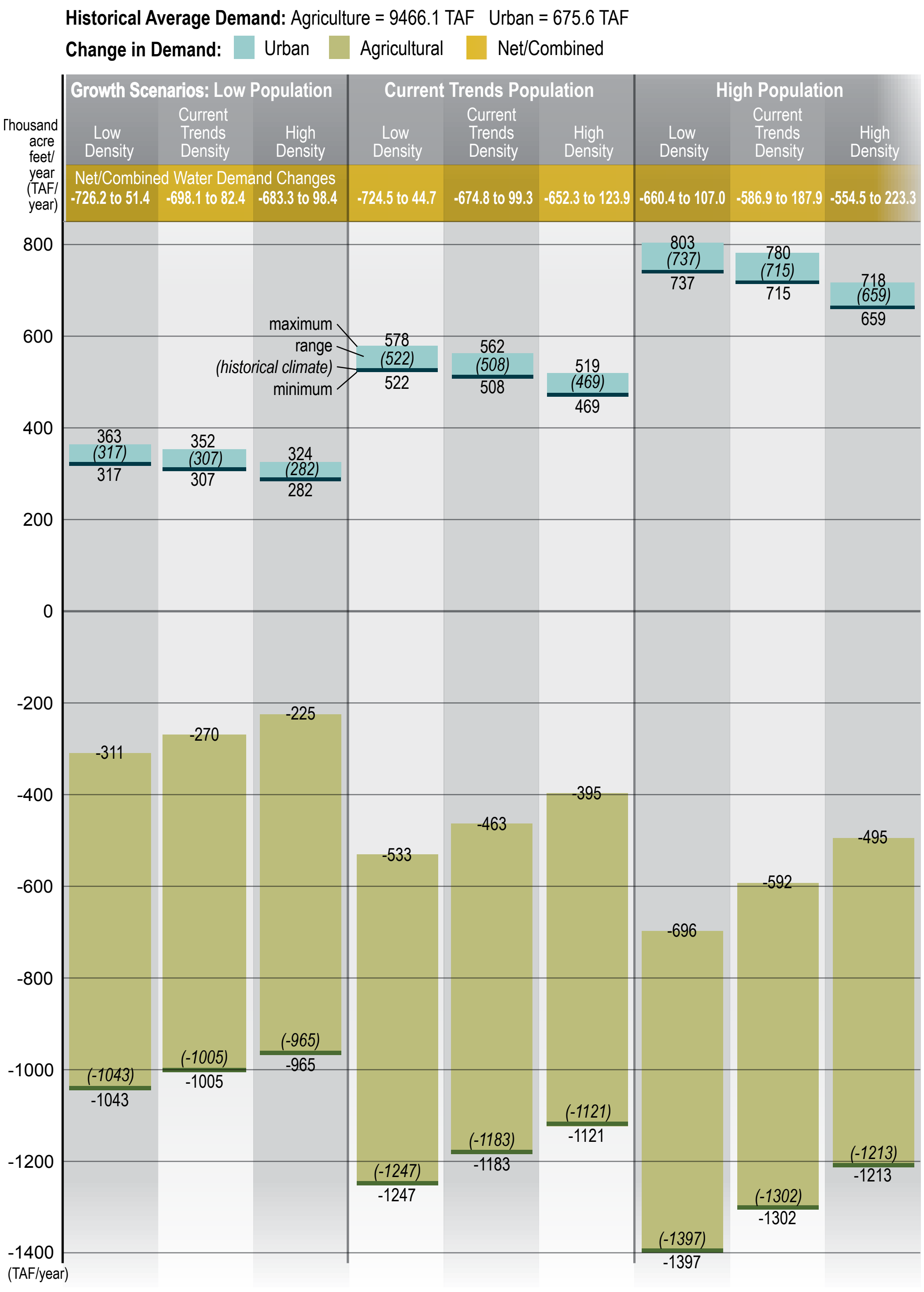
future urban water demands are less sensitive to housing density assumptions or climate change than to assumptions about future population growth.

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 9.4 maf. Under the three low population scenarios, the average reduction in water demand was about 625 taf while it was about 940 taf for the three high population scenarios. For the three current trend population scenarios, this change was about 810 taf. The results show that agricultural water demands are sensitive to assumptions about climate, and to assumptions about growth and housing density, which reduce the amount of lands for irrigated agriculture.

Evaluation of Water Management Vulnerabilities in the Tulare Lake Hydrologic Region

The Water Plan is evaluating how implementing alternative mixes of resource management strategies could reduce the Central Valley vulnerabilities. Management response packages each comprise a mix of resource management strategies selected from Volume 3 and are implemented at investment levels and locations as described in the Plan of Study (see Volume 4, *Reference Guide,* the article, "Evaluating Response Packages for Update 2013, Plan of Study").

Figure TL-32 Change in Tulare Lake Hydrologic Region Agricultural and Urban Water Demands for 117 Scenarios from 2006-2050



Results are presented here for the Tulare Lake Hydrologic Region evaluated over 198 combinations of future population growth and climate scenarios. The growth scenarios are defined in Table TL-32. 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 Chapter 5, Volume 1. 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 conditions.

Reliability, defined as the percentage of years in which demand is sufficiently met by supply, is one of several ways the Water Plan summarizes the projections of future urban and agricultural conditions. Figure TL-33 shows the range of reliability results for urban and agricultural sectors in the Tulare Lake Hydrologic Region. In the figure, each dot indicates the reliability for one of the 198 simulations, but many of the dots overlap. For the Tulare Lake Hydrologic 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 80 percent of agricultural demand is met with supply. 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 there are many futures in which reliability is low. For the urban sector, reliability is below 95 percent in about 50 percent of the futures evaluated. For the agricultural sector, reliability is below 95 percent in all but 5 percent of the futures.

Groundwater resources were evaluated for performance under the plausible futures. Figure TL-34 shows the change in groundwater storage from the present to 2050 across the 198 scenarios. About 95 percent of the futures lead to groundwater declines in the Tulare Lake Hydrologic Region and about 50 percent of the futures lead to declines greater than 10 percent.

The Water Plan next evaluated which future conditions would lead to low reliability in the Tulare Lake Hydrologic Region. For the urban sector, reliability would be below 95 percent in 34 percent all of the scenarios evaluated. In the agricultural sector, reliability would be low in 95 percent of all scenarios (189 of the 198). Using statistical analysis, the Water Plan identified that the most important factors driving low agricultural reliability outcomes is change in future precipitation. For the urban sector, futures in which the average precipitation in 2030-2050 is less than 4 percent of historical account for 85 percent of the low reliability outcomes. Not all futures with these low precipitation conditions would yield low reliability — only about 45 percent of the futures would. Figure TL-35 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 Os are those that are more than 95 percent reliable. The color of the symbols indicates the reliability.

In the agricultural sector, a larger number of futures lead to low reliability. Figure TL-36 shows that low reliability outcomes correspond to climate conditions that are less than 4 percent wetter than historical conditions. X's indicate results that are less than 95 percent reliable. O's indicate results that are more than 95 percent reliable. The reliability decreases significantly below the 95 percent level as conditions are drier and warmer (i.e., toward the upper-left of the figure). Note that the color of each symbol summarizes the average reliability across the four land-use scenarios evaluated for each climate scenario.

Figure TL-33 Range of Urban and Agricultural Reliability Results across Futures for the Tulare Lake Hydrologic Region

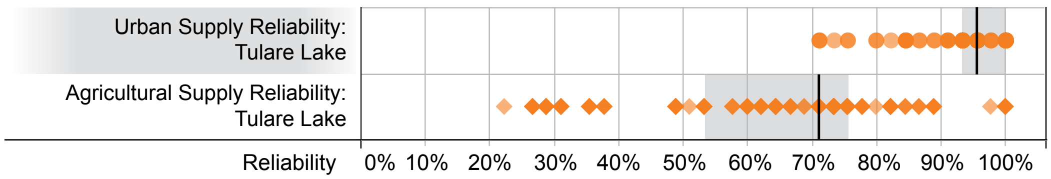


Figure TL-34 Range of Groundwater Storage Change across Futures for the Tulare Lake Hydrologic Region

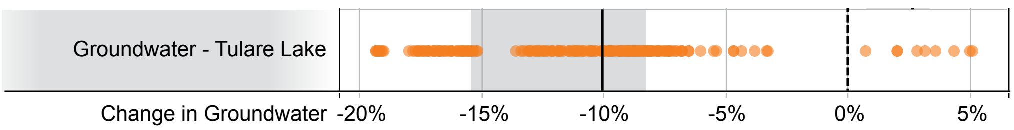


Figure TL-37 summarizes results for each diversification level for the key metrics for the Tulare Lake Hydrologic Region. The number and color within each square indicates the percentage of futures that do not meet the specified vulnerability thresholds — 95 percent annual reliability for urban and agricultural supply reliability and no groundwater change. 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 TL-32).

For the Tulare Lake region, urban supply reliability is low for some futures across all diversification levels, and agricultural supply reliability is low in the majority of 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 urban and agricultural supply is reliable and groundwater storage does not decline. The figure shows the trade-offs between urban and agricultural reliability and groundwater levels are also clearly evident. Improvements in urban and agricultural supply reliability are realized through Diversification Level 2. While groundwater storage improves considerably with the implementation of groundwater recovery targets and more efficiency in Diversification Levels 3 to 5, vulnerability in the agricultural sector remains high. 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. Figures TL-38 and TL-39 illustrate this effect by showing the vulnerability results in terms of temperature and precipitation for Tulare Lake urban and agricultural reliability, across several response packages for 88 futures. In each figure, each circle represents the climate conditions and reliability outcomes for one future — combination of

Figure TL-35 Climate Conditions Leading to Low Urban Reliability Results in the Tulare Lake Hydrologic Region

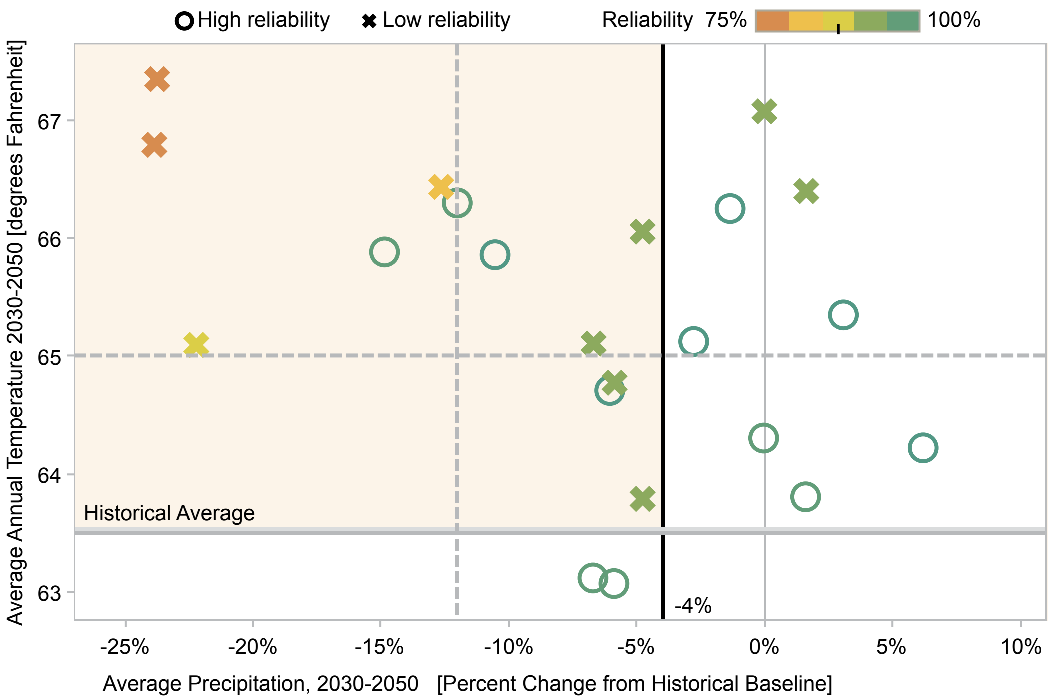


Figure TL-36 Climate Conditions Leading to Low Agricultural Reliability Results in the Tulare Lake Hydrologic Region

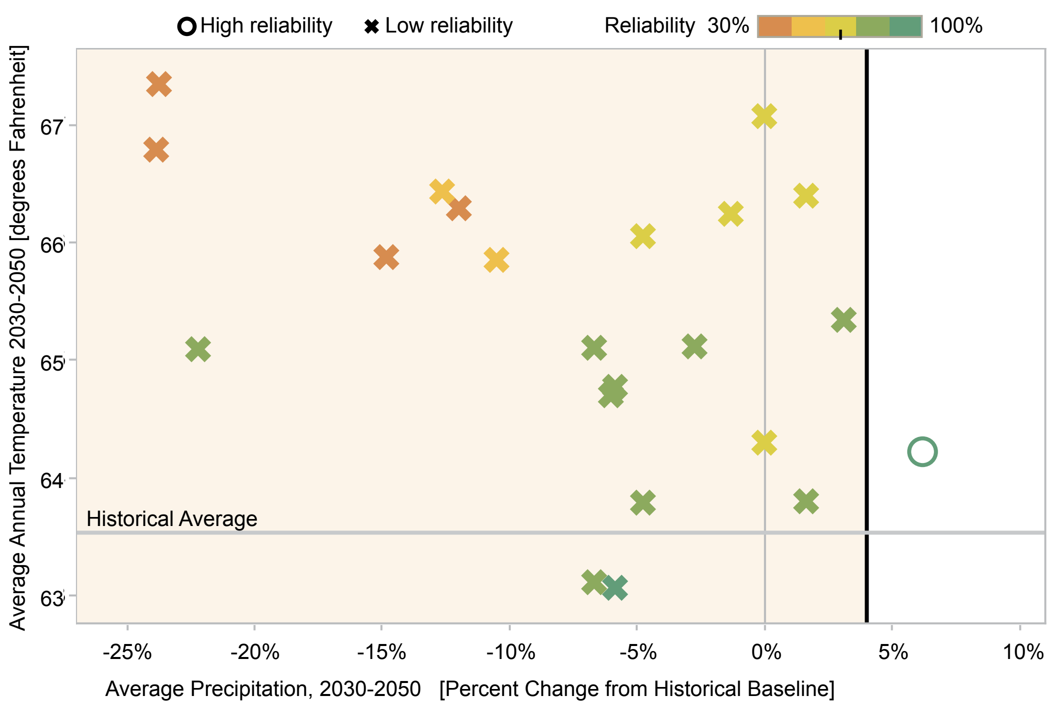


Figure TL-37 Percent of Vulnerable Futures for Each Response Package for the Tulare Lake Hydrologic Region

	Urban Supply Reliability	Agricultural Supply Reliability	Groundwater Change	Average Annual Cost Above Current Plan
Currently Planned	32%	95%	95%	$0.0M
Diversification Level 1	18%	89%	94%	$171.1M
Diversification Level 2	7%	68%	69%	$212.3M
Diversification Level 3	23%	89%	32%	$212.1M
Diversification Level 4	23%	86%	31%	$350.7M
Diversification Level 5	22%	78%	19%	$546.5M

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.

Figure TL-38 shows that Diversification Level 2 increases resilience — there is at least one growth scenario in which the sector is resilient for each climate scenario. Note that the additional groundwater storage targets in Diversification Level 3 reduce resilience for agricultural reliability slightly.

Figure TL-39 shows the same results for the Tulare Lake agricultural sector. For this sector, the response packages do increase resilience to the cooler and wetter climate projections, but the vulnerability of the sector to many of the plausible climate conditions is seen clearly.

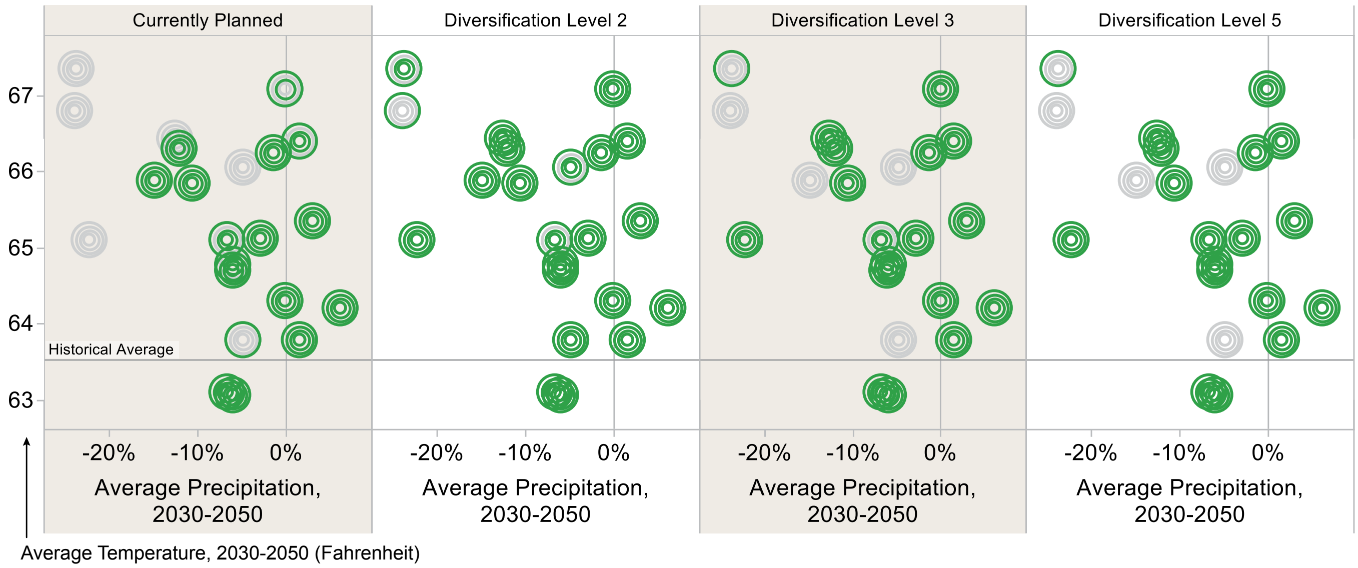
In summary, the Tulare Lake region is projected to be quite vulnerable to climate and demographic changes in the urban and agricultural sector. Groundwater storage is projected to decline across most uncertain futures. We found that the supply in the urban and agricultural sectors is most vulnerable to drying conditions. The urban sector water supply will be unreliable if precipitation declines more than 4 percent over historical period. For the agricultural sector, conditions must be 4 percent wetter to be reliable. Implementation of response packages without new groundwater recovery targets increases urban and agricultural reliability and groundwater levels across the futures, representing increased resilience. However, the inclusion of groundwater recovery targets reduces reliability for these two sectors, which is partially reversed through additional efficiency and groundwater banking.

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 California Water Plan has taken on the task of summarizing 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.)

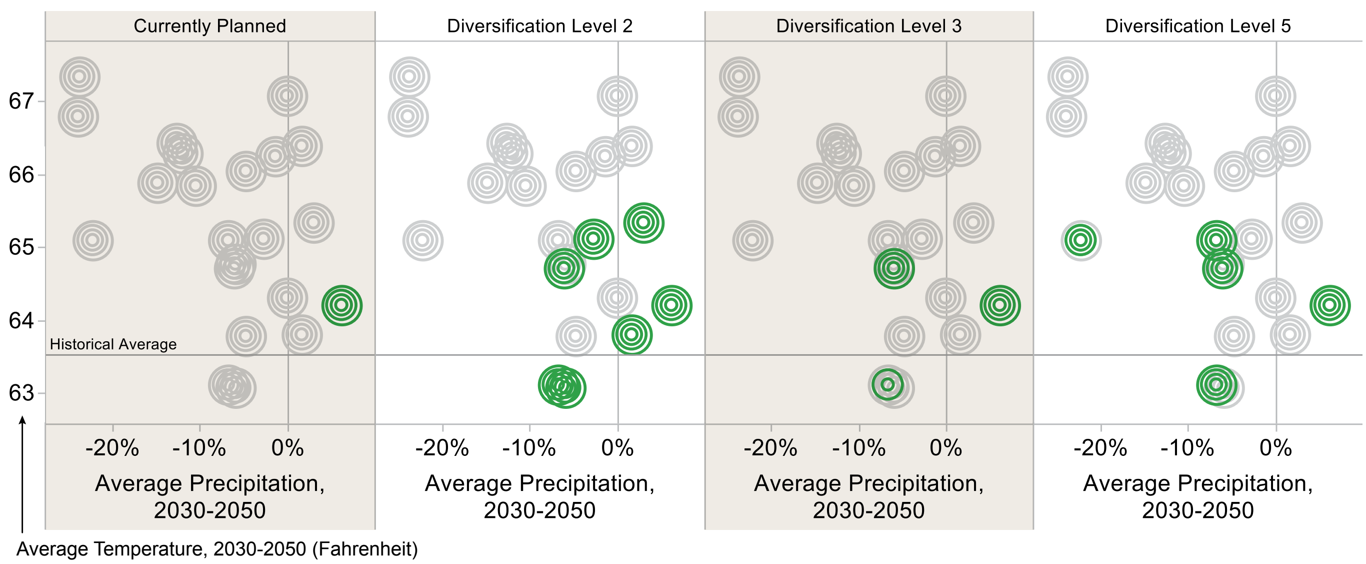
All IRWM plans are different in how they are organized. Therefore, finding and summarizing the content in a consistent way proved difficult. It became clear through these efforts that a process is needed to allow those with the most knowledge of the IRWM plans, those that were involved in the preparation, to have input on the summary. It is the intention that this process be initiated following release of Update 2013 and will continue to be part of the process of the update process

Figure TL-38 Climate Trends for Each Future for Currently Planned Management and Three Additional Response Packages for Tulare Lake Urban 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.

Figure TL-39 Climate Trends for Each Future for Currently Planned Management and Three Additional Response Packages for Tulare Lake 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.

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 regional water management groups (RWMGs) have individually and cumulatively transformed water management in California.

As can be seen in Figure TL-40, there are seven regional water management groups in the Tulare Lake Hydrologic Region. Although small portions of the San Luis Obispo and Ventura County IRWM Plans overlap the Tulare Lake Hydrologic Region, they are discussed in the Central Coast and South Coast hydrologic region reports, respectively.

Region Description

As of late 2013, the RWMGs in the Tulare Lake Hydrologic Region have received a total of about $135 million in funding from both State and non-State sources: $60,233,664 from the State and $74,764,156 from non-State sources. Table TL-35 provides a funding source breakdown for the region. (Grant figures represent money awarded to specific RWMGs and do not represent the total amount of money spent on each hydrologic region, as some RWMGs straddle two or more hydrologic regions.) Information for Kaweah River Basin, Southern Sierra, and Tule regions was not available for Update 2013.

The following are short descriptions of the available IRWM areas and plans in Tulare Lake Hydrologic Region.

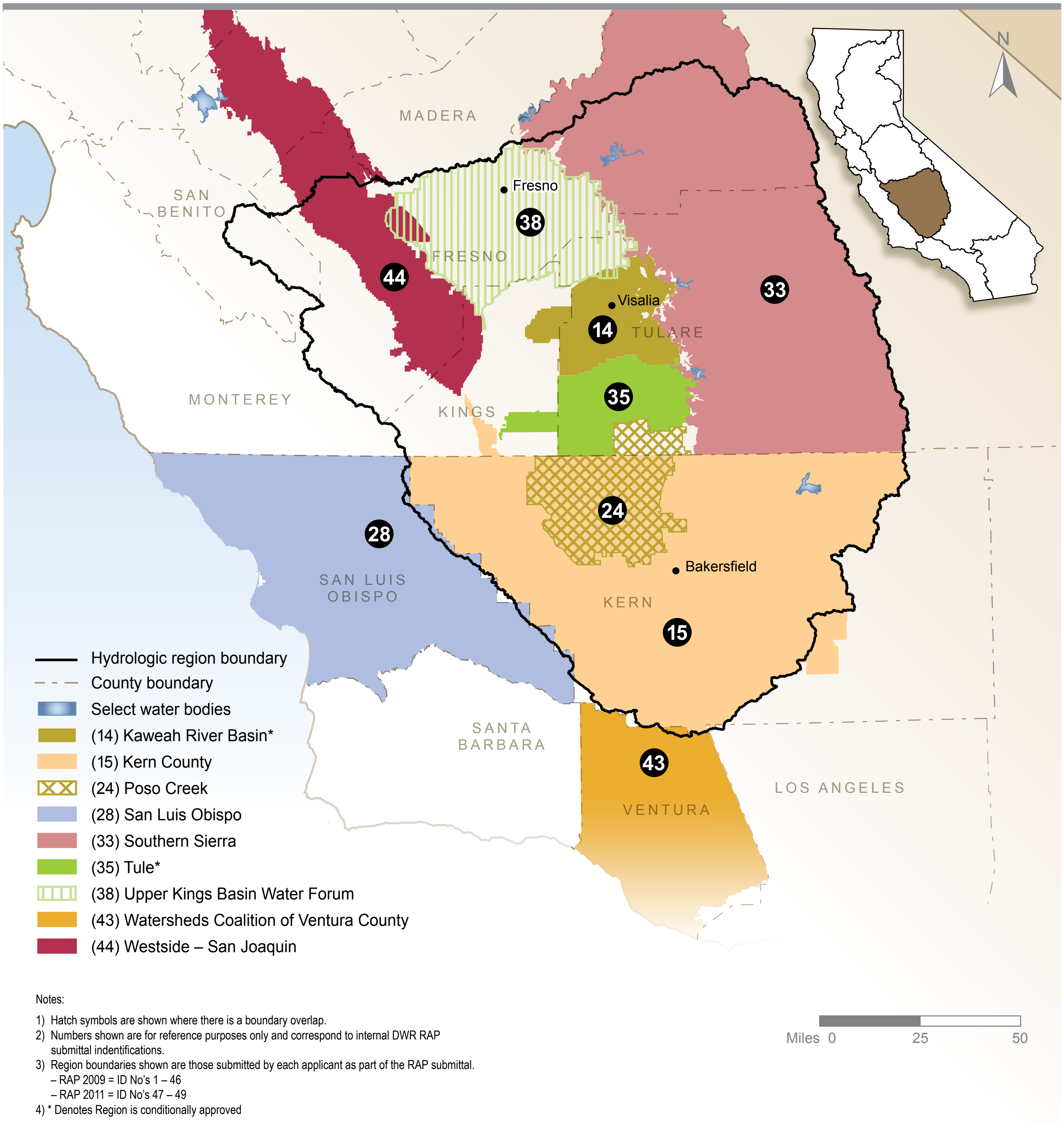
Kern County

The majority of the Kern IRWM plan region is the portion of the Tulare Lake Basin hydrologic region that falls within Kern County and a small portion of Kings County. It includes the southern half of the San Joaquin Valley, part of the Temblor Range, the Tehachapi Mountains, and a portion of the southern Sierra Nevada. The region is broken up into nine subregions, acknowledging the variation in geography, agency boundaries, and water management strategies within the larger region. The region is adjacent to nine other existing or developing IRWM planning regions and overlaps with a portion of the Poso Creek IRWM planning region.

Poso Creek Watershed

The Poso Creek region is located in the northerly portion of Kern County and comprises the eight agricultural districts that overlie the groundwater basin in the Tulare Lake Basin Hydrologic area. The region is predominately agriculture, with a current annual gross value of agricultural commodities estimated at $2 billion. Communities within the region include Delano, Wasco, Lost Hills, and Richgrove.

Figure TL-40 Regional Water Management Groups in the Tulare Lake Hydrologic Region



Notes:

1) Hatch symbols are shown where there is a boundary overlap.
2) Numbers shown are for reference purposes only and correspond to internal DWR RAP submittal indentifications.
3) Region boundaries shown are those submitted by each applicant as part of the RAP submittal.
– RAP 2009 = ID No's 1 – 46
– RAP 2011 = ID No's 47 – 49
4) * Denotes Region is conditionally approved

Table TL-35 Tulare Lake Hydrologic Region 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
Kern County[b]						
Poso Creek Watershed	**$499,435** $214,600			**$8,215,000** $4,147,440		$13,076,475
Upper Kings Basin	**$500,000** $9,771,469	**$8,164,243** $9,771,469	**$236,890** $99,960	**$8,496,000** $6,820,390	**$9,122,096** $9,122,098	$62,104,615
Westside-San Joaquin		**$25,000,000** $34,817,000				$59,817,000
Total	**$999,435** $9,986,069	**$33,164,243** $44,588,469	**$236,890** $99,690	**$16,711,000** $10,967,830	**$9,122,096** $9,122,098	
Grand total $134,998,090						

Notes:

IRWM = integrated regional water management

This table is up-to-date as of late 2013. Information on Kaweah River Basin, Southern Sierra, and Tule IRWM plans was not available for *California Water Plan 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 Kern County received $8,011,898 in Prop. 84 Implementation Grant Award Round 2.

Upper Kings Basin

The Upper Kings Basin IRWM region is the Kings Groundwater Basin, which includes parts of Fresno, Kings, and Tulare counties. Much of the region is developed for agriculture, with many crops requiring irrigation during the dry season. Irrigated lands cover about 480,000 acres in the region. An extensive network of canals is used to deliver water. The Kings River provides the main corridor for fish and wildlife movement in the region.

Westside-San Joaquin

The Westside-San Joaquin region encompasses the west side of the San Joaquin Valley and 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.

Key Challenges and Goals

Kern County

Kern County faces the following challenges:

- Aging and/or duplicative infrastructure.
- Urban growth and water demand.
- Groundwater overdraft and urban growth in key recharge areas.
- Decreased imported water supply.
- Flood management.

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

- Increase water supply.
- Improve operational efficiency.
- Improve water quality.
- Promote land use planning and resource stewardship.
- Improve regional flood management.

Poso Creek Watershed

Poso Creek faces the following challenges:

- Water supply reliability.
- Water costs.
- Water quality.

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

- Help ensure that an adequate water supply is maintained and improved to meet current and future regional and local water needs.
- Help insure that groundwater levels will be maintained or enhanced with economically viable pumping lifts through increased conjunctive use operations.
- Protect the existing quality of groundwater and enhance water quality where practical.
- Maintain water supply costs at a level commensurate with the continued viability of the agricultural economy that has developed in the Poso Creek IRWM Region.
- Enhance ongoing monitoring of groundwater levels and water quality as needed as part of the implementation of projects.
- Maintain and enhance environmental resources within and outside the regions.
- Enhance flood control to provide flood protection for the health and safety of the region's population.

Upper Kings Basin

The Upper Kings Basin faces the following challenges:

- Groundwater overdraft.
- Surface water storage in dry years.

- Groundwater quality.
- Water quality.
- Water reliability.

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

- Halt, and ultimately reverse, the current overdraft and provide for sustainable management of surface and groundwater.
- Increase the water supply reliability, enhance operational flexibility, and reduce system constraints.
- Improve and protect water quality.
- Provide additional flood protection.
- Protect and enhance aquatic ecosystems and wildlife habitat.

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.

Water Supply and Demand

Kern County

Groundwater is the primary source of supply within the region, which is augmented with imported water from the SWP and the CVP, local surface water, and recycled water. It is estimated that groundwater accounts for roughly 40 percent of the supply within the region; however, it is estimated to be as much as 60 percent during dry years. Urban demand for the Tulare Lake Basin portion of the Kern IRWM plan region in 2010 was 195,949 acre-feet per year (af/yr.), which is estimated to grow to 281,284 af/yr. by 2030. Agricultural demand is estimated at 2,669,713 af/yr., which is assumed to remain constant into the future.

Poso Creek Watershed

The region relies primarily on groundwater, imported water, and local surface water. Major demands within the region include agricultural and municipal and industrial uses. It is estimated that the long-term average annual availability of surface water supplies to the region is roughly 700,000 af. Groundwater reliability is projected to decrease into the future. Municipal and industrial demand is expected to double over the next fifteen years, from 40,000 af/yr. to 80,000 af/yr.

Upper Kings Basin

The main sources of water supply for the region are surface water from Kings River and San Joaquin River, groundwater, and recycled water. In recent years, average annual surface water supply was 1,235,000 af/yr. from Kings River and 282,000 af/yr. from San Joaquin River. Recycled water from the Fresno Metropolitan Wastewater Treatment Plan was 80,000 af/yr. Groundwater extraction was 1,623,000 af/yr. for agricultural use and 206,000 af/yr. for municipal and industrial use. Urban water demand was 240,000 af/yr., and agricultural water demand was 2,224,000 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 composed of CVP water, groundwater, and local surface water. Since 1989, CVP water supply allocations have decreased significantly for Westside Central Valley Project (CVP) contractors. Today, the long-term average CVP allocation has been reduced to approximately 70 percent. The current municipal and industrial (M&I) 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.

Water Quality

Kern County

Surface water quality from the Kern River is generally considered to be high quality, with some areas experiencing degraded water quality issues. Isabella Lake suffers from high dissolved oxygen and high pH levels, for which the total maximum daily loads (TMDLs) will be completed by 2021 for EPA compliance. Groundwater quality throughout the region is typically suitable for most urban and agricultural uses with only localized impairments including high total dissolved solids (TDS) (salts), sodium chloride, sulfate, nitrate, organic compounds, and arsenic.

Poso Creek Watershed

Surface and imported water quality within the region is generally good, however there are some instances of high levels of TDS and nutrients. Groundwater quality within the region is also currently very good. The region is committed to maintaining this level of quality through conjunctive use, water banking, and other exchange activities. The region is currently piloting an arsenic treatment plant which will ensure water quality criteria are met for pumping into the California Aqueduct.

Upper Kings Basin

The Kings River generally has high water quality, slightly degrading downstream as it receives agricultural return flows in the Valley. The lower reaches in the Kings River, from the Island Weir to the Stinson and Empire Weirs, have elevated levels of salinity, molybdenum, and toxaphene. Groundwater quality suffers from nitrate, which frequently exceeds drinking water standards, and a number of pesticides including DBCP, atrazine, diazinon, and propazine. While DBCP has not been applied since the late 1970s, it is still the most widely detected pesticide in the region.

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.

Flood Management

Kern County

The most severe flooding occurs on the Kern River near Kern City, generally occurring as result of high intensity winter rainstorms from November to April. There are a number of flood management efforts being performed by local jurisdictions within their particular areas. However there is no regional entity that coordinates flood control for the entire Kern County IRWM region. Flood management challenges in the region include a lack of coordination, poor water quality of runoff, nuisance water and dry weather runoff, and difficulty providing flood control without interfering with groundwater recharge. Improving regional flood management is identified as an objective within the IRWM plan and includes reducing flood flows by an average of 2 percent per year through 2020.

Poso Creek Watershed

The region is committed to increasing flood management through enhancing flood control. Increased flood control will help provide flood protection to ensure the health and safety of the region's population, while minimizing flood damage losses and seeking balanced management solutions with respect to cost and monetized and non-monetized benefits.

Upper Kings Basin

Currently, flood management activities within the region are conducted by the Kings River Conservation District (KRCD) and the Fresno Metropolitan Flood Control District (FMFCD). There have been a number of flood management activities in the past including the Kings River Channel Improvement Project which was designed to protect local infrastructure from large flood events and the FMFCD Service Plan which describes regional and local storm drainage and flood control facilities. The IRWM plan also integrates flood management by making it a priority, with several projects dedicated to increasing flood protection.

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.

Groundwater Management

Kern County

The San Joaquin Valley Groundwater Basin covers the majority of Kern County. Other groundwater basins within the region include the Kern River Valley Basin, Walker Basin Creek Valley Basin, Cummings Valley Basin, and Tehachapi Valley West Basin. With groundwater providing roughly 40 percent of the local water needs, one of the longest standing issues within the Kern region is groundwater overdraft. It is estimated that nearly 30,000 acres are used for groundwater recharge operations in the region and there are a number of Groundwater Management Plans within the region. The region is incorporating groundwater management by proposing a number of groundwater recharge and remediation projects.

Poso Creek Watershed

Groundwater is vital to the region, as it provides the majority of water for irrigated agriculture. Most of the lands within the region are underlain by usable groundwater, and as a result, most of the irrigated agriculture was developed with reliance on pumped groundwater. All agencies within the Regional Management Group have adopted GWMPs, which help to monitor groundwater levels and promote management activities. Groundwater levels within the region have varied depending on water year, with increases in wet years and decreases in dry years.

Upper Kings Basin

The Kings Groundwater Basin has been operating under overdraft conditions for many years, with an average annual overdraft of roughly 100,000 to 150,000 af. Storage in the basin is estimated at 93 maf. The Kings River Conservation District (KRCD) obtains water level data from over 1,000 monitoring wells in the region. Groundwater management plays a large role in the region's IRWM plan, with several objectives geared towards decreasing overdraft and protecting groundwater quality.

Westside-San Joaquin

Groundwater is an important resource for the region, supplying water for municipal and agricultural uses. The Pleasant Valley Groundwater Management Plan 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 historic use. Groundwater quality within the region suffers from high salinity.

Environmental Stewardship

Kern County

The region is ecologically diverse, with such notable resources as the Kern River, Sequoia National Forest, and the Tulare Lake Basin. A section of the South Fork of the Kern River has the largest populations of Southwestern willow flycatchers and yellow-billed cuckoos in California. There are a number of resource conservation plans either implemented or being drafted within the region including the Metropolitan Bakersfield Habitat Conservation Plan, the Upper Kern Basin Fishery Management Plan, and the Kern County Valley Floor Habitat Conservation Plan. The IRWM plan identifies the importance of environmental stewardship, listing it as an objective within the Plan. A number of proposed projects also address environmental and resource stewardship within the region.

Poso Creek Watershed

The region is committed to protecting and enhancing its environmental resources. The Metro Bakersfield and the Kern Valley Floor Habitat Conservation Plans are currently in place. These plans have helped establish endangered species recovery programs within the region to promote species recovery. The region engages in bank stabilization, riparian planting, and hydrologic improvements to maintain and protect their environmental resources.

Upper Kings Basin

An Environmental Baseline Conditions document was prepared to provide a baseline of existing biological and habitat resources within the region, including biotic regions, plant and wildlife habitats, and special status species. This information was collected and compiled in an effort to guide planning and siting of projects to avoid impacts to biological resources. In the IRWM plan, there are several elements which promote resource stewardship including practicing ecosystem restoration, providing economic incentives, and engaging in forest management.

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 habitat conservation plans, 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.

Climate Change

Kern County

The Kern IRWM region is already experiencing some of the effects of climate change, such as increased temperatures, reduced snowpack, and earlier snowmelt. These changes will increase the vulnerability of both natural and built systems in the region. Climate change has the potential to impact the region's economy, which depends on the natural environment. 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. 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.

Poso Creek Watershed

The Poso Creek IRWM region is already experiencing some of the effects of climate change, such as increased temperatures, reduced snowpack, and earlier snowmelt. These changes will increase the vulnerability of both natural and built systems in the region. Climate change has the potential to impact the region's economy, which depends on the natural environment. 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. 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.

Upper Kings Basin

The Upper Kings Basin IRWM region is already experiencing some of the effects of climate change, such as increased temperatures, reduced snowpack, and earlier snowmelt. These changes will increase the vulnerability of both natural and built systems in the region. Climate change has the potential to impact the region's economy, which depends on the natural environment. 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. 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. The region is addressing these concerns by completing a vulnerability assessment and identifying adaptation strategies as part of the IRWM plan update process.

Westside-San Joaquin

The Westside-San Joaquin IRWM region is already experiencing some of the effects of climate change, such as increased temperatures, reduced snowpack, and earlier snowmelt. These changes will increase the vulnerability of both natural and built systems in the region. Climate change has the potential to impact the region's economy, which depends on the natural environment. 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. 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.

Tribal Communities

Kern County

Local Tribes include the Tubatulabals, the Paiutes, the Chumash, and the Yokuts. The Tubatulabals are participants in the IRWM plan. In May 2009, DWR, Tubatulabals of Kern Valley and North Fork Mono Tribe hosted a Tribal Water Regional Planning day. Due to non-federally recognized status for many of the local Tribes, federal and state funding is very limited.

Poso Creek Watershed

Approximately 1.5 percent of the population of Kern County is of Native American decent. No further Tribal information is available in the region's IRWM plan.

Upper Kings Basin

There are no Native American Tribes located within the region, therefore no involvement or collaboration was directly conducted.

Westside-San Joaquin

There are an estimated three-hundred 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.

Disadvantaged Communities

Kern County

The RWMG contracted with a professional facilitation consultant for outreach to DACs, underserved communities, traditionally isolated communities or rural communities, SDACs, and Native American Tribes. The IRWM plan identifies 27 DACs, two-third of which are severely disadvantaged communities (SDACs - defined as having household incomes of less than 60 percent of the state MHI). Many of the DACs that have been contacted have had continuous representation at the stakeholder meetings. Additionally, representatives from the Kern region are participating actively in the Tulare Lake Basin DAC Water Study to help develop regional solutions to DAC water and wastewater challenges and will be incorporating the findings into the IRWM plan.

Poso Creek Watershed

Much of the Poso Creek region qualifies as a disadvantaged community (DAC). Specific DACs in the region include Delano, Earlimart, Lost Hills, McFarland, Richgrove, Shafter and Wasco. None of these communities serve as members of the region's Resource Management Group (RMG), but the region has developed a specific project as part of the IRWM plan to help DACs qualify for grant funding by being participants in this regional planning process and to assist them by identifying and informing them of funding opportunities.

Upper Kings Basin

Due to the lower income levels found in the San Joaquin Valley and the region, most communities meet the definition of a DAC. However, there is a significant difference in capacity between a large DAC such as the city of Fresno and a small severely disadvantaged community such as East Orosi or Hardwick. The Kings Basin includes approximately 90 unique DACs. An emphasis has been placed on understanding the needs of the smaller DACs and SDACs. DAC representatives were identified and invited to attend the RWMG meetings. The opportunity to join the RWMG was also extended to DACs. The region also formed a DAC Work Group to prepare grant applications for DAC projects, perform studies to help DACs with water resources problems, and perform outreach to DACs.

Westside-San Joaquin

Three of the five counties and twelve 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.

Governance

Kern County

A Participation Agreement was signed by a number of groups from each of the nine designated sub-regions within the larger Kern IRWM plan region, creating the Kern Regional Water Management Group. The group is involved in the decision-making process during the IRWM plan development. An executive committee was formed of a composite of 10 stakeholders representing the various subregions. A stakeholder group was formed, allowing any organization or individual within the region to become involved in the IRWM plan process.

Poso Creek Watershed

The Poso Creek Regional Management Group comprises seven agricultural water districts and one resource conservation district. This group was tasked with the preparation and development of the IRWM plan, with guidance and insight from a number of regional stakeholders.

Upper Kings Basin

In 2009, the Upper Kings Basin Integrated Regional Water Management Authority was formed as a joint powers authority, composed of 17 official members and 37 interested parties. The authority is responsible for overseeing the planning, development, and implementation of the IRWM plan. It is governed by a board of directors, which is made up of one representative from each member agency. An advisory committee and numerous work groups were formed to assist the board of directors with development, technical studies, project evaluation, and administrative efforts.

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.

Resource Management Strategies

Volume 3, *Resource Management Strategies*, contains detailed information on the various strategies that 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 TL-36.

Regional Resource Management Strategies

The following are programmatic-level recommendations by the CVRWQCB to improve water quality in the Tulare Lake region through CV-SALTS. (See more discussion of this program in above subsection Water Board Implementation.) For the Central Valley, the only acceptable process to develop the salt and nutrient management plans that are required under State policy (State Water Resources Control Board 2009) is through CV-SALTS. 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.

Table TL-36 Resource Management Strategies Addressed in IRWM Plans in the Tulare Lake Hydrologic Region

Resource Management Strategy	Kern County	Poso Creek	Upper Kings Basin	Westside-San Joaquin
Agricultural Water Use Efficiency	X	X	X	X
Urban Water Use Efficiency	X	X	X	X
Flood Management	X	X	X	X
Conveyance – Delta	X	X		X
Conveyance – Regional/Local	X	X	X	X
System Reoperation	X			
Water Transfers	X	X	X	X
Conjunctive Management and Groundwater	X	X	X	X
Desalination - Brackish Water and Seawater				
Precipitation Enhancement			X	
Recycled Municipal Water	X	X	X	X
Surface Storage – CALFED		X		
Surface Storage – Regional/Local	X	X	X	X
Drinking Water Treatment and Distribution	X	X	X	
Groundwater/Aquifer Remediation	X	X	X	
Match Water Quality to Use	X		X	
Pollution Prevention	X	X	X	X
Salt and Salinity Management			X	
Urban Stormwater Runoff Management	X		X	X
Agricultural Lands Stewardship	X		X	
Ecosystem Restoration	X	X	X	X
Forest Management			X	
Land Use Planning and Management	X	X	X	
Recharge Areas Protection	X		X	
Watershed Management	X	X	X	X
Economic Incentives - Loans, Granta, and Water Pricing	X		X	
Water-Dependent Recreation	X	X	X	X

Note: Information on the Kaweah River Basin, Southern Sierra, and Tule IRWM plans was not available for *California Water Plan Update 2013*.

- Coordinate with local agencies to implement well design and destruction program.
- Develop a groundwater database.
- Alternative dairy waste disposal.
- 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.
- 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).
- Develop methods to reduce backlog and increase facilities regulated.

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); coordination with DACs within the region to identify early implementation projects to provide safe drinking water to groups impacted by elevated nitrate in groundwater (2012); and development of a long-term funding plan (2012).

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 TL-2 is a summary of the inventory effort.

The DWR/ACWA survey identified 89 agencies or programs that operate a conjunctive management or groundwater recharge program in California, of which 37 are in the Tulare Lake Hydrologic Region. The earliest reported conjunctive use project in the region was in 1992 by the Tehachapi-Cummings County Water District (TCWD), while the most recent project was developed in 2002 by the Kings County Water District (KCWD). The majority of the surveyed

Box TL-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 survey by the California Department of Water Resources (DWR) and Association of California Water Agencies (ACWA). 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; and
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; and
5. Constraints on development of conjunctive management or groundwater banking (recharge) program.

Statewide, a total of 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.

agencies did not indicate the year their conjunctive management program was developed. But based on data, it was concluded that the majority of programs were developed in the 1990s and 2000s. This timeframe coincides with the enactment of the Groundwater Management Act (AB 3030) in 1992 and the approval of Proposition 13 in 1999, which funded groundwater storage and conjunctive use grants and loans program administered by DWR.

According to the survey responses provided by two agencies in the Tulare Lake region, the largest capital expenditure to develop a local conjunctive management project was $5 million, as reported by KCWD. The TCWD indicated capital costs of about $700,000 for their conjunctive management project. Survey responses by the two agencies also indicate that the annual operation cost for a local conjunctive management project ranged from $30,000 for the Tehachapi-Cummings County project to $250,000 by KCWD.

Based on data provided by six agencies, the largest conjunctive use program in the region is operated by the Semitropic Water Storage District, with a reported capacity of 2.1 maf. The capacity for the Kern Water Bank is on 1.0 maf, while City of Bakersfield's program reported a capacity of 800 taf. The Arvin-Edison Water Storage District, the KCWD, and the TCWD have groundwater recharge programs of 500, 20 and 10 taf, respectively.

Out of nine agencies reporting, seven use water from the SWP, six use water from the CVP, and seven use local surface water for recharge. Several agencies utilize water from multiple sources. Recycled water was not indicated to be a source of recharge water by any of the nine agencies.

Information regarding the put (recharge) and take (extraction) capacity of conjunctive management programs were provided by 18 agencies. Groundwater recharge using spreading or percolation basins was reported by all 18 responding agencies, while in-lieu recharge method was reported by 8 agencies. Aquifer Storage and Recovery (ASR) method was not identified as a recharge method by any of the programs in the region.

As shown in Figure TL-41, overdraft correction was identified by about 80 percent of the 11 survey participants as being the primary goal and objective for their conjunctive management program. A rather obvious goal, being part of a conjunctive management program, was also noted by about 70 percent of respondents. An additional objective of water quality protection was identified by about 25 percent of the survey respondents. Some additional goals include minimizing water costs to farmers and drought protection. Most of the survey respondents included multiple goals and objectives for their programs.

Survey participants were asked to rank a list of seven potential constraints encountered when developing a conjunctive management or water banking program — with a "1" for minimal constraint, a "3" for moderate constraint, or a "5" for significant constraint. Eight agencies responded to this survey question. As shown in Figure TL-42, cost was indicated to be the single greatest constraint, with an average ranking of 2.9 (moderate constraint). The next highest ranking constraint was identified to be legal, with a score of 2.6 (moderate constraint).

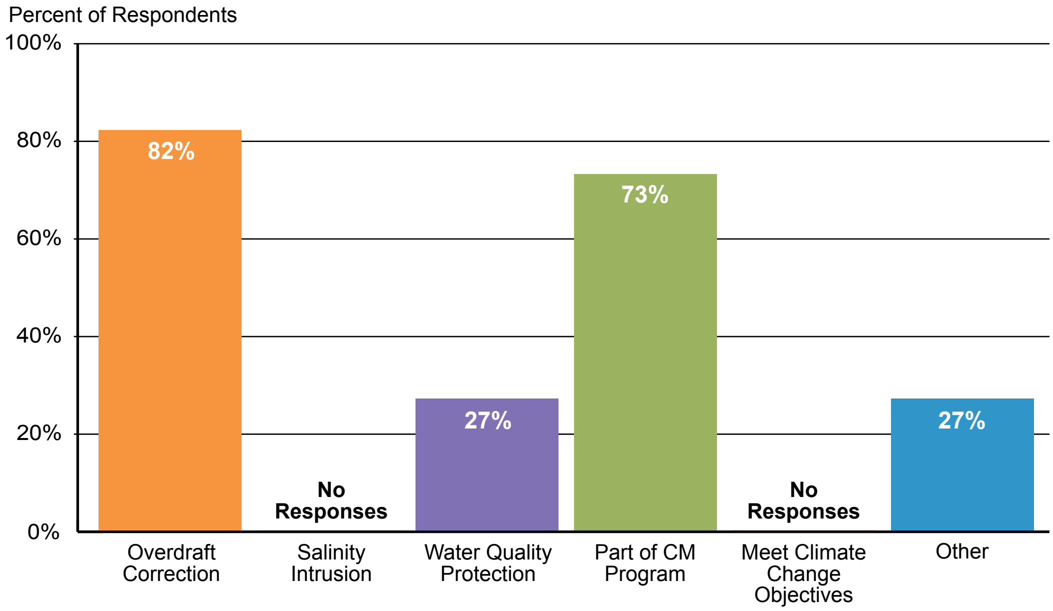
More details on the conjunctive management survey results is available online from Update 2013, Volume 4, *Reference Guide,* the article, "California's Groundwater Update 2013." Additional information regarding conjunctive management in California as well as discussion on associated benefits, costs,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

Climate Change

For more than 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).

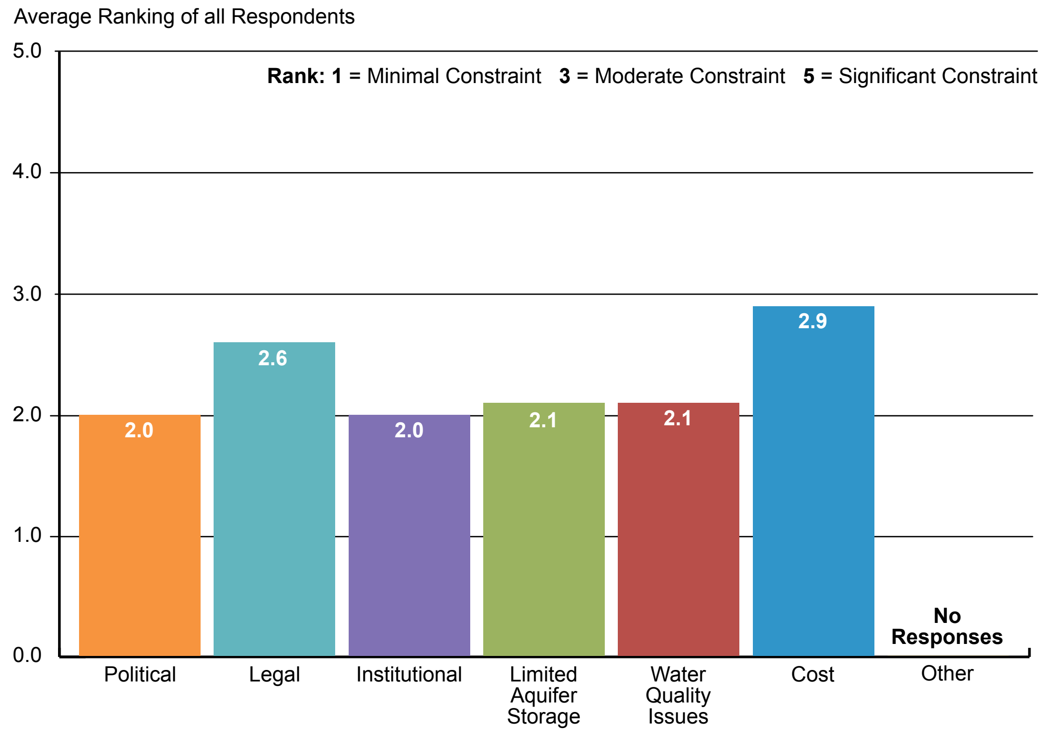
Enough data currently exists to warrant the importance of contingency plans, mitigation (reduction) of greenhouse gas (GHG) emissions, and incorporation of adaptation strategies and

Figure TL-41 Conjunctive Management Program Goals and Objectives



Note: Based on 11 of 37 agencies/projects reporting data.

Figure TL-42 Constraints Toward Development of Conjunctive Management and Water Banking Programs



Note: Based on 8 of 37 agencies/projects reporting data.

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 GHG reduction and 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. Because of the economic, geographical, and biological diversity of California, vulnerabilities and risks from 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

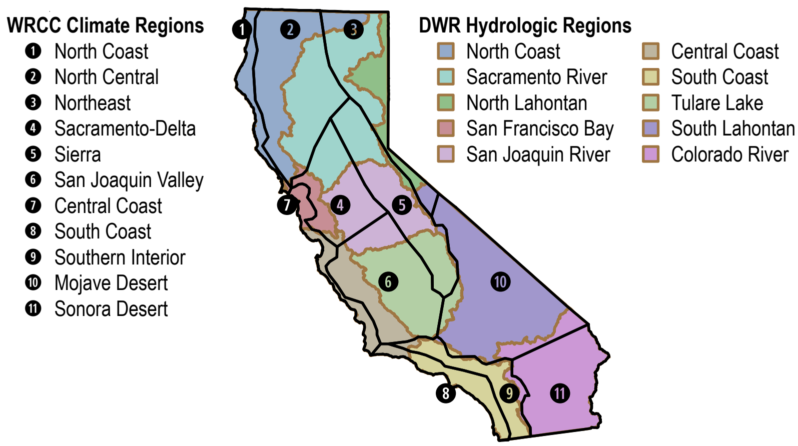
The region's observed temperature and precipitation vary greatly due to complex topography and relation to the Pacific Ocean. Regionally specific air temperature trends for the past century are available from the Western Regional Climate Center (Western Regional Climate Center 2013). The WRCC acts as 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, see Figure TL-43.

Two WRCC regions overlap with the Tulare Lake Hydrologic Region — the Sierra and San Joaquin Valley regions. Temperatures in the WRCC San Joaquin Valley region show a mean increase of 0.9-1.9 °F (0.5-1.1 °C), 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 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]).

Projections and Impacts

Although historical data is a measured indicator of how the climate is changing, it cannot 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 2060-2069, the Tulare region could experience an increase of 4.1 °F (2.3 °C) in annual means, with an increase of 3.2 °F (1.8 °C) in mean winter temperatures and 5.2 °F (2.9 °C) in summer (Pierce et al. 2012). Heat waves, defined as five days with temperatures more than 100 °F (55.6 °C), are expected to increase

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



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.

three to five times by 2050 and seven to ten times by 2100 (California Emergency Management Agency and California Natural Resources Agency 2012). Climate projections 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 2012).

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 exists 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 could 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 will continue to rise by the end of the century, diminishing April 1st snowpack (Table TL-37). DWR projects that with a 1.8°F (1°C) rise, the Kern basin April 1st snow covered area drops from 73 percent to 65 percent and the Tule basin drops from 23 percent to 15 percent (2006). The Kaweah and Kings basins are less impacted due to higher mean elevations. A projected temperature rise of 9°F (5°C) would leave the Kern basin with an average of 33 percent snow covered area, the Kaweah with

Table TL-37 Tulare Lake 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					
Kings	7,700	5,500	1,540	76	73	69	64	59	54
Kaweah	5,600	6,000	563	44	39	34	27	23	18
Tule	3,950	6,000	390	23	15	13	8	6	3
Kern	7,410	6,000	2,080	73	65	56	49	41	33

Source: California Department of Water Resources 2006.

18 percent, and the Tule basin with approximately 3 percent. The higher elevation Kings basin will still have about 54 percent snow covered area.

A recent study 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 that is reflective of current trends (Das et al. 2011). The study indicates a tendency toward increased three-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 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. Environmental water supplies would need to be retained in reservoirs for managing instream flows to maintain habitat for aquatic species throughout the dry season. 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. For the Tulare 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 a thriving agricultural industry, which 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 Emergency Management Agency and California Natural Resources

Agency 2012). Agricultural water use efficiency will 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), 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 Tulare Lake 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). Whatever approach is used, it is necessary for water managers and communities to start implementing adaptation measures sooner than later in order to be prepared for an uncertain future.

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 2010, 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 subregions. 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* provides an analytical framework for incorporating climate change impacts into a regional and watershed planning process and considers adaptation to climate change (U.S. Environmental Protection Agency and California Department of Water Resources 2011). 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 Tulare Lake Hydrologic Region. These include:

- Chapter 2, "Agricultural Water Use Efficiency."
- Chapter 3, "UrbanWater 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 "low-regrets" actions that water managers in the Tulare Lake region can take to prepare for climate change, regardless of the magnitude of future warming (GEOS Institute/Local Government Commission 2011). 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 could 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, pollution remediation, and habitat for pollinators. 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 and 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 GHGs, as mandated by the State.

Figure TL-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-Energy Connection" (Volume 1, Chapter 3, "California Water Today") are illustrated in Figure TL-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

Figure TL-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	15%
State (Project)		8%
Local (Project)	<250 kWh/AF	16%
Local Imports	*This type of water not available*	0%
Groundwater		50%

Energy intensity (EI) in this figure is the estimated energy required for the extraction and conveyance of one acre-foot of water. These figures reflect 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 percent 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 Voume 5, *Technical Guide*.

assumption, a minimum EI less than 250 kilowatt hours per acre foot (kWh/af) was assumed for all water types).

Recycled water and water from desalination used within the region are not shown in Figure TL-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 TL-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 TL-3.

Box TL-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://www.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.

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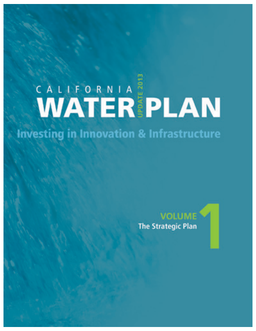
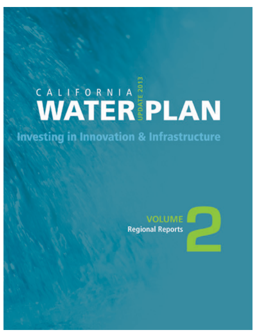
Navigating Water Plan Update 2013

Update 2013 includes a wide range of information, from a detailed description of California's current and potential future conditions to a "Roadmap For Action" intended to achieve desired benefits and outcomes. The plan is organized in five volumes — the three volumes outlined below; Volume 4, *Reference Guide*; and Volume 5, *Technical Guide*.



VOLUME 1, The Strategic Plan

- Call to action, new features for Update 2013, progress toward implementation.
- Update 2013 themes.
- Comprehensive picture of current water, flood, and environmental conditions.
- Strengthening government alignment and water governance.
- Planning (data, analysis, and public outreach) in the face of uncertainty.
- Framework for financing the California Water Plan.
- Roadmap for Action — Vision, mission, goals, principles, objectives, and actions.



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- State of the region — watersheds, groundwater aquifers, ecosystems, floods, climate, demographics, land use, water supplies and uses, governance.
- Current relationships with other regions and states.
- Accomplishments and challenges.
- Looking to the future — future water demands, resource management strategies, climate change adaptation.

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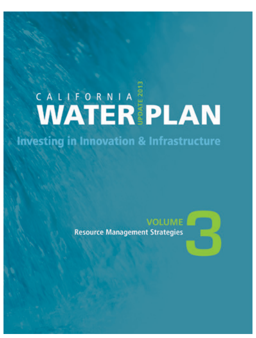

Integrated Water Management Toolbox,
30+ management strategies to:

- Reduce water demand.
- Increase water supply.
- Improve water quality.
- Practice resource stewardship.
- Improve flood management.
- Recognize people's relationship to water.

All five volumes are available for viewing and downloading at DWR's Update 2013 Web site:
http://www.waterplan.water.ca.gov/cwpu2013/final/ or http://www.waterplan.water.ca.gov/cwpu2013/final/index.cfm.

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Integrated water management *is a comprehensive and collaborative approach for managing water to concurrently achieve social, environmental, and economic objectives. In the California Water Plan, these objectives are focused toward improving public safety, fostering environmental stewardship, and supporting economic stability. This integrated approach delivers higher value for investments by considering all interests, providing multiple benefits, and working across jurisdictional boundaries at the appropriate geographic scale. Examples of multiple benefits include improved water quality, better flood management, restored and enhanced ecosystems, and more reliable water supplies.*

Edmund G. Brown Jr.
Governor
State of California

John Laird
Secretary for Natural Resources
Natural Resources Agency

Mark Cowin
Director
Department of Water Resources

October 2014