Table of Contents for the Tulare Lake Region Report

Tulare Lake Hydrologic Region 1

Tulare Lake Hydrologic Region Summary 1
Current State of the Region 1
Setting 1
Watersheds 1
Groundwater Aquifers 2
Aquifer Description 2
Well Infrastructure and Distribution 5
California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization 6
Tulare Lake Hydrologic Region Groundwater Monitoring Efforts 7
Ecosystems 10
Flood 12
Climate 12
Demographics 13
Population 13
Tribal Communities 13
Disadvantaged Communities 14
Land Use Patterns 14
Regional Resource Management Conditions 15
Water in the Environment 15
Water Supplies 15
Agricultural Water 16
Recycled Municipal Water 16
Groundwater 16
Water Uses 19
Drinking Water 19
Water Conservation Act of 2009 (SB x7-7) Implementation Status and Issues 20
Water Balance Summary 20
Project Operations 22
Levee and Channel System 23
Water Quality 23
Surface Water Quality 24
Groundwater Quality 25
Drinking Water Quality 27
Land Subsidence 27
California Aqueduct Elevation Surveys 28
Borehole Extensometer Monitoring 29
USGS InSAR Monitoring 29
Caltrans Highway 198 Elevation Monitoring 29
GPS Array Monitoring 29
Groundwater Level Monitoring and Subsidence 30
Groundwater Conditions and Issues 31
Groundwater Occurrence and Movement 31
Depth to Groundwater 32
Change in Groundwater Storage 36
Flood Management 38

Risk Characterization 39
Levee Performance and Risk Studies 39
Water Governance 39
Flood Governance 40
Groundwater Governance 41
State Funding Received from IRWM 45
Current Relationships with Other Regions and States 45
Regional Water Planning and Management 45
Integrated Regional Water Management Coordination and Planning 45
Implementation Activities (2009-2013) 46
Water Board Implementation 46
Surface Water 47
Groundwater 48
Accomplishments 49
Challenges 50
Looking to the Future 51
Future Conditions 51
Future Scenarios 51
Water Conservation 51
Tulare Lake Growth Scenarios 52
Tulare Lake 2050 Water Demands 53
Integrated Water Management Plan Summaries 54
Resource Management Strategies 55
Regional Resource Management Strategies 56
Climate Change 59
Observations 59
Projections and Impacts 60
Adaptation 61
Mitigation 63
References 65
References Cited 65
Additional References 70
Personal Communications 70

Tables

PLACEHOLDER Table TL-1 Alluvial Groundwater Basins and Subbasins within the Tulare Lake Hydrologic Region 3
PLACEHOLDER Table TL-2 Number of Well Logs by County and Use for the Tulare Lake Hydrologic Region (1977-2010) 5
PLACEHOLDER Table TL-3 CASGEM Groundwater Basin Prioritization for the Tulare Lake Hydrologic Region 7
PLACEHOLDER Table TL-4 Groundwater Level Monitoring Wells by Monitoring Entity in the Tulare Lake Hydrologic Region 8
PLACEHOLDER Table TL-5 Sources of Groundwater Quality Information 9
PLACEHOLDER Table TL-6 Selected Regionally Endemic Endangered Plant Species 11
PLACEHOLDER Table TL-7 Selected California Endemic Endangered Plant Species 11
PLACEHOLDER Table TL-8 Endangered Wildlife Species 11
PLACEHOLDER Table TL-9 Region Population by County 13
PLACEHOLDER Table TL-10 2010 Top Ten Populous Incorporated Cities 13

PLACEHOLDER Table TL-11 Federally Recognized Tribes in Tulare Lake Hydrologic Region 14
PLACEHOLDER Table TL-12 Disadvantaged Communities by County with Populations of 2,000 or more 14
PLACEHOLDER Table TL-13 Tulare Lake Hydrologic Region 20 Crop Type Acreages 2005-2010 . 15
PLACEHOLDER Table TL-14 Tulare Lake Hydrologic Region 2004-2010 Change in Urban Area (acres)........ 15
PLACEHOLDER Table TL-15 Surface Water Deliveries to Kern National Wildlife Refuge, 2010 (thousand acre-feet) 15
PLACEHOLDER Table TL-16 Surface Water Deliveries to Mendota wildlife Area, 2010 (thousand acre-feet) 15
PLACEHOLDER Table TL-17 Dedicated Natural Flows........ 15
PLACEHOLDER Table TL-18 Tulare Lake Hydrologic Region Average Annual Groundwater Supply by Planning Area and by Type of Use (2005-2010) 17
PLACEHOLDER Table TL-19 Tulare Lake Hydrologic Region Average Annual Groundwater Supply by County and by Type of Use (2005-2010) 18
PLACEHOLDER Table TL-20 Tulare Lake Hydrologic Region Water Demands........ 19
PLACEHOLDER Table TL-21 Community Water Systems by Size and Population Served 20
PLACEHOLDER Table TL-22 List of 2010 Urban Water Management Plan Updates by Urban Water Supplier........ 20
PLACEHOLDER Table TL-23 Tulare Lake Hydrologic Region Water Balance Summary, 2001-2010 22
PLACEHOLDER Table TL-24 Summary of Community Drinking Water Systems in the Tulare Lake Hydrologic Region that Rely on One or More Contaminated Groundwater Well that Exceeds a Primary Drinking Water Standard 27
PLACEHOLDER Table TL-25 Summary of Contaminants Affecting Community Drinking Water Systems in Tulare Lake Basin........ 27
PLACEHOLDER Table TL-26 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Tulare Lake Hydrologic Region........ 38
PLACEHOLDER Table TL-27 Selected Organizations in Tulare Lake Hydrologic Region Involved in Water Governance 40
PLACEHOLDER Table TL-28 Groundwater Management Plans in the North Coast Hydrologic Region 42
PLACEHOLDER Table TL-29 Assessment for SB 1938 GWMP Required Components, SB 1938 GWMP Voluntary Components, and Bulletin 118-03 Recommended Components........ 43
PLACEHOLDER Table TL-30 Factors Contributing to Successful Groundwater Management Plan Implementation in the Tulare Lake Hydrologic Region 44
PLACEHOLDER Table TL-31 Factors Limiting Successful Groundwater Management Plan Implementation in the Tulare Lake Hydrologic Region 44
PLACEHOLDER Table TL-32 Groundwater Ordinances that Apply to Counties in the Tulare Lake Hydrologic Region........ 44
PLACEHOLDER Table TL-33 Groundwater Adjudications in the Tulare Lake Hydrologic Region ... 45
PLACEHOLDER Table TL-34 Integrated Regional Water Management Grants Awarded 45
PLACEHOLDER Table TL-35 Conceptual Growth Scenarios........ 52
PLACEHOLDER Table TL-36 Growth Scenarios (Urban) – Tulare Lake........ 52
PLACEHOLDER Table TL-37 Growth Scenarios (Agriculture) – Tulare Lake 53
PLACEHOLDER Table TL-38 Resource Management Strategies addressed in IRWMP's in the Tulare Lake Hydrologic Region........ 55

Figures

PLACEHOLDER Figure TL-1 Tulare Lake Hydrologic Region 1
PLACEHOLDER Figure TL-2 Tulare Lake Hydrologic Region Watersheds 2
PLACEHOLDER Figure TL-3 Alluvial Groundwater Basins and Subbasins within the Tulare Lake Hydrologic Region 3
PLACEHOLDER Figure TL-4 Number of Well Logs by County and Use for the Tulare Lake Hydrologic Region (1977-2010) 5
PLACEHOLDER Figure TL-5 Percentage of Well Logs by Use for the Tulare Lake Hydrologic Region (1977-2010) 6
PLACEHOLDER Figure TL-6 Number of Well Logs Filed per Year by Use for the Tulare Lake Hydrologic Region (1977-2010) 6
PLACEHOLDER Figure TL-7 CASGEM Groundwater Basin Prioritization for the Tulare Lake Hydrologic Region 7
PLACEHOLDER Figure TL-8 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity in the Tulare Lake Hydrologic Region 8
PLACEHOLDER Figure TL-9 Percentage of Monitoring Wells by Use in the Tulare Lake Hydrologic Region 8
PLACEHOLDER Figure TL-10 Tulare Lake Hydrologic Region Disadvantaged Communities and Integrated Regional Water Management 14
PLACEHOLDER Figure TL-11 Tulare Lake Regional Inflows and Outflows in 2010........ 16
PLACEHOLDER Figure TL-12 Total Agricultural Applied Water Supply Source (thousand acre-feet) (with Supply Source as a Percentage of total Agricultural Applied Water) 16
PLACEHOLDER Figure TL-13 Contribution of Groundwater to the Tulare Lake Hydrologic Region Water Supply by Planning Area (2005-2010)........ 17
PLACEHOLDER Figure TL-14 Tulare Lake Hydrologic Region Annual Groundwater Water Supply Trend (2002-2010) 18
PLACEHOLDER Figure TL-15 Tulare Lake Hydrologic Region Annual Groundwater Supply Trend by Type of Use (2002-2010) 18
PLACEHOLDER Figure TL-16 Tulare Lake Regional Water Balance by Water Year, 2001-2010 22
PLACEHOLDER Figure TL-17 South of Delta CVP and SWP Deliveries........ 22
PLACEHOLDER Figure TL-18 Land Subsidence in the San Joaquin Valley – 1926 to 1970 (Adapted from Ireland, 1984) 28
PLACEHOLDER Figure TL-19 Land Subsidence along the California Aqueduct 29
PLACEHOLDER Figure TL-20 Depth to Groundwater Hydrograph for Well 30S25E16L14 and Land Subsidence Graph for Kern Water Bank Extensometer........ 29
PLACEHOLDER Figure TL-21 Land Subsidence Results from Caltrans Highway 198 Elevation Monitoring 29
PLACEHOLDER Figure TL-22 UNAVCO GPS Land Surface Displacement Monitoring Stations and Station Data Summary Graphs........ 30
PLACEHOLDER Figure TL-23 Depth to Groundwater Hydrograph and Vertical Land Surface Displacement at UNAVCO GPS Site 304, near the City of Madera 30
PLACEHOLDER Figure TL-24 Relationship between Changing Groundwater Levels and Land Subsidence in the Tulare Lake Hydrologic Region (Composite Hydrograph for Wells 16S15E34N001M, 16S15E34N004M, and 16S115E32Q001M) 30
PLACEHOLDER Figure TL-25 Spring 2010 Depth to Groundwater Contours for the Tulare Lake Hydrologic Region........ 32
PLACEHOLDER Figure TL-26 Spring 2010 Groundwater Elevation Contours for the Tulare Lake Hydrologic Region........ 34
PLACEHOLDER Figure TL-27 Groundwater Level Trends in Selected Wells in the Tulare Lake Hydrologic Region........ 36

PLACEHOLDER Figure TL-28 Spring 2005 – Spring 2010 Change in Groundwater Elevation Contour Map for the Tulare Lake Hydrologic Region.......38
PLACEHOLDER Figure TL-29 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Tulare Lake Hydrologic Region.......38
PLACEHOLDER Figure TL-30 Flood Exposure to the 100-Year Floodplain, Tulare Lake Hydrologic Region.......39
PLACEHOLDER Figure TL-31 Flood Exposure to the 500-Year Floodplain, Tulare Lake Hydrologic Region.......39
PLACEHOLDER Figure TL-32 Location of Groundwater Management Plans in the North Coast Hydrologic Region (Figure is being updated).......42
PLACEHOLDER Figure TL-33 Groundwater Adjudications in the Tulare Lake Hydrologic Region..45
PLACEHOLDER Box TL-3 Figure TL-A Range of Urban and Agricultural Reliability Results across Scenarios for the Tulare Lake Region.......51
PLACEHOLDER Box TL-3 Figure TL-B Range of Change in Groundwater Results across Scenarios for the Tulare Lake region.......51
PLACEHOLDER Box TL-3 Figure TL-C Climate Conditions Leading to Low Urban Reliability Results in the Tulare Lake Region.......51
PLACEHOLDER Box TL-3 Figure TL-D Climate Conditions Leading to Low Agricultural Reliability Results in the Tulare Lake Region.......51
PLACEHOLDER Figure TL-34 Change in Tulare Lake Agricultural and Urban Water Demands for 117 Scenarios from 2006-2050 (thousand acre-feet).......53
PLACEHOLDER Figure TL-35 Integrated Water Management Planning in the Tulare Lake Region .54
PLACEHOLDER Figure TL-36 Conjunctive Management Program Goals and Objectives.......58
PLACEHOLDER Figure TL-37 Constrains Towards Development of Conjunctive Management and Water Banking Programs.......58
PLACEHOLDER Figure TL-38 Energy Intensity of Raw Water Extraction and Conveyance in the Tulare Lake Hydrologic Region.......65

Boxes

PLACEHOLDER Box TL-1 California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization Data Considerations.......7
PLACEHOLDER Box TL-2 Other Groundwater Management Planning Efforts in the Tulare Lake Hydrologic Region.......45
PLACEHOLDER Box TL-3 Evaluation of Water Management Vulnerabilities – Tulare Lake Region51
PLACEHOLDER Box TL-4 Statewide Conjunctive Management Inventory Effort in California.......57

Tulare Lake Hydrologic Region

Tulare Lake Hydrologic Region Summary

While the Tulare Lake Hydrologic 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. And, the urban population continues to grow, gaining 8% from 2005 to 2010. However, most of the region's agricultural, urban including Disadvantaged Communities, environmental, and other interest are realizing that integrated water management 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 southern portion of the San Joaquin Valley is subdivided into two separate basins, the San Joaquin and the Tulare, by a rise in the valley floor resulting from an accumulation of alluvium between the San Joaquin River and the Kings River fan. The valley floor in this region had been a complex series of interconnecting natural sloughs, canals, and marshes.

PLACEHOLDER Figure TL-1 Tulare Lake Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

The economic development of the region is closely linked to the surface water and groundwater resources of the Tulare Lake Hydrologic Region (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 Range to the west; the Tehachapi Mountains to the south; and the southern Sierra Nevada to the east.

The Tulare Lake Hydrologic 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/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 Sierras. Los Gatos creek is the one substantial creek entering from the Coast Range, 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; and 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 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.

PLACEHOLDER Figure TL-2 Tulare Lake Hydrologic Region Watersheds

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Groundwater Aquifers

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

Aquifer Description

Alluvial Aquifers

The Tulare Lake Hydrologic Region contains 19 DWR Bulletin 118-2003 recognized alluvial groundwater basins and subbasins which underlie approximately 8,400 square miles, or 50 percent of the region. Most 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 six of the seven subbasins within the southern San Joaquin Valley groundwater basin – Kings, Westside, Kaweah, Tulare Lake, Tule, and Kern County. As shown in Figure TL-3, the remaining twelve alluvial basins are outside the San Joaquin Valley.

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

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

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the chapter.]

Aquifer systems within the southern San Joaquin Valley of the region consist mostly of continental sediments eroded from the nearby surrounding mountains and deposited in the valley. The alluvial aquifer system is a complex set of interbedded aquifers and aquitards that function regionally as a single water-yielding unit (Poland 1972, quoted in Sneed 2001). The San Joaquin Valley aquifers are generally quite thick with groundwater wells extending to depths of more than 1,000 feet (Page 1986). The aquifers consist of gravel, sand, silt, and clay lenses, which become increasingly interbedded towards the center of the valley with fine-grained lake bed deposits (USGS 2011). The maximum thickness of freshwater deposits is about 4,400 feet and occurs at the south end of the valley. On a regional scale, the aquifer systems of the San Joaquin Valley Groundwater Basin can be divided into an upper unconfined to semi-confined aquifer, a series of geographically extensive confining clay layers, and a deep confined aquifer.

Alluvial deposits comprising the unconfined to semi-confined aquifers may be grouped into the Coast Range alluvium along the west side of the valley, Sierran alluvium on the east side of the valley, flood-basin deposits in the center of the valley (Faunt 2005), and buried river channel deposits within the alluvial fan and Pleistocene river courses.

Although a number of highly productive coarse-grained aquifers exist in the San Joaquin Valley of the region, fine-grained sediments comprise more than 50 percent of the valley fill deposits (Faunt 2005). Nearly continuous lake and/or marsh sediments have been present in the Tulare, Kern and Buena Vista Lake beds since Pliocene and Pleistocene time. These lake and marsh sediments formed thick clay plugs in the lake bed areas. The largest of these clay plugs is in the Tulare Lake area. Now drained, the clay marks the presence of a succession of lakes that periodically spread from the Tulare Lake area, extending outward into greater or lesser sized lakes. In the center of the spreading areas, the presence of thick (up to 3,000 feet) and extensive clay layers limit the amount of available groundwater for water supply. Six distinct lake clay layers have been identified in the geologic record. The largest of the ancestral lakes formed the “E-clay” or Corcoran Clay. The lake was geographically extensive, covering the western half of the San Joaquin Valley from the Kern Lake bed north to an area north of Modesto (Faunt, 2009). The Corcoran Clay is up to 150 feet thick, occurs at a depth of about 250 feet below land surface along Highway 99 near Goshen and Pixley, and at a depth of 800 feet in the Tulare Lake bed area (Croft, 1972). It is commonly described as “blue clay” on driller’s logs and is one of the identifier’s for the clay. The Corcoran Clay has formed a nearly impermeable barrier, separating the unconfined to semi-confined groundwater above from the confined groundwater below.

Several alluvial aquifers exist in basins outside the southern San Joaquin Valley portion of the region. Although the overall groundwater supply of these aquifers is minor when compared to the groundwater supplies of the southern San Joaquin Valley basins, these aquifers serve as an important source of local groundwater supplies, for example, Pleasant Valley, Tehachapi Valley West, and Cummings Valley.

Pleasant Valley Subbasin is located along the west side of the valley, between the folded marine sediments of the Diablo Range. Groundwater in the subasin is produced from a Holocene alluvial aquifer consisting of sand, gravel, and cobbles, interbedded with sandy clay, silt, and clay. Aquifer depth is variable, ranging from a few feet to as much as 1000 feet (Schmidt, 2000). The valley lies in the rain shadow of the Coast Ranges and receives only seven to nine inches of precipitation per year – which severely limits aquifer recharge.

The Tehachapi Valley is located in the southeast portion of Kern County at the southern end of the Sierra Nevada in the Tehachapi Mountains. The Tehachapi Valley Groundwater Basin has been subdivided into two groundwater basins - the Tehachapi Valley West subbasin in the Tulare Lake Hydrologic Region and the Tehachapi Valley East subbasin is in the South Lahontan Hydrologic Region. The Valley fill consists of a heterogeneous mixture of alluvial sediments (clay, silt, sand and gravel) eroded from the bedrock of the surrounding mountains (St. Clair and Kirk, 2000). The sediments thin out around the basin rim and thicken toward the axis of the valley and overlay granitic bedrock. Several faults that cut the valley act as impediments to groundwater flow, resulting in significant water level differences on either side of the faults (St. Clair and Kirk, 2000). Recharge occurs as a result of precipitation on the valley floor, stream bed leakage, irrigation return flows recharge of State Water Project Water in conjunctive use programs, recharge from wastewater effluent, and groundwater recharge operations. Wells are typically drilled to depths of 300 to 500 feet and consist of solid casing through the overburden and are screened or open below 25 to 100 feet (Fram and Belitz, 2012). The basin is adjudicated and has contracted with the Kern County Water Agency for entitlements to 20,000 acre-feet of water from the State Water Project to supplement groundwater supplies.

The Cummings Groundwater Basin consists of alluvial sediments eroded from the surrounding Tehachapi and Sierra granitic mountains - a heterogeneous mixture of clay, silt, sand and gravel. Coarser material (sand, gravel and cobbles) exists in the upper fans at the valley margins and finer grained materials (clay and sandy clay) near the valley center. The thickness of the sediments varies from 50 feet on the southwest side of the valley to 450 feet on the northeast side of the valley (Michael and McCann, 1962). The upper and lower portions of the aquifer are connected and considered a single aquifer system. The basin receives recharge from direct precipitation on the valley floor, from surface water flow from several small mountain streams, and from agricultural irrigation seepage. The average agricultural well yield in the basin ranges from 60 to 1,500 gpm and domestic wells range from 3 to 300 gpm. The basin is adjudicated. The State Water Project, completed in this area in 1973, provides a contracted 20,000 acre-feet of surface water to the basin (DWR, 2006).

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 serve as the sole source of water and a critically important water supply for many communities. Information related to fractured-rock aquifers in the region was not developed as part of the CWP Update 2013.

More detailed information regarding the aquifers in the Tulare Lake Hydrologic Region is available online from Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013 and DWR Bulletin 118-2003.

Well Infrastructure and Distribution

Well logs submitted to DWR for water supply wells completed during 1977 through 2010 were used to evaluate the distribution of water wells and the uses of groundwater in the Tulare Lake Hydrologic Region. 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 according to their location by county and according to 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).

Four counties were included in the analysis of well infrastructure for the Tulare Lake Hydrologic Region. Kings and Tulare counties are fully contained within the hydrologic region, while Fresno and Kern counties are partially contained within the region. Well log data for counties that fall within multiple hydrologic regions are assigned to the hydrologic region containing the majority of alluvial groundwater basins within the county. Because only a small portion of San Benito County is within the Tulare Lake Hydrologic Region, it was evaluated as part of the Central Coast Hydrologic Region. Well log information listed in Table TL-2 and illustrated in Figure TL-4 show that the distribution and number of wells vary widely by county and by use. The total number of wells installed in the region between 1977 and 2010 is approximately 54,000, and ranges from a high of about 27,000 in Fresno County to a little over 4,000 in Kings 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). In most counties, domestic use wells make up the majority of well logs — about 16,000 in Fresno County, followed by about 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 seven 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 indicates 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. The higher number of irrigation wells in Tulare County is interesting because both counties use approximately the about the same amount of groundwater as indicated later in the report.

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

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

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the chapter.]

Figure TL-5 shows that domestic wells make up the majority of well logs (52 percent) for the region, followed by irrigation wells which account for 23 percent of well logs. Statewide, domestic and irrigation wells account for about 54 and 10 percent per hydrologic region based on the total number of wells in the state. The larger percentage of irrigation wells in the region relative to the statewide average points to a higher reliance on groundwater supplies to meet agricultural water uses in the region. Monitoring wells account for about six percent, which is significantly lower than the statewide average of 24 percent per hydrologic region.

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

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Figure TL-6 shows a cyclic pattern of well installation for the region, with new well construction ranging from about 800 to 3,900 wells per year, with an average of about 1,600 wells per year. The large fluctuation of domestic well drilling is likely associated with population booms and residential housing construction. The increase in domestic well drilling in the region during the late 1980s and early 1990s as well as early through mid-2000s is likely due to increases in housing construction during this time. Similarly, the 2007 to 2010 decline in domestic well drilling is likely due to declining economic conditions and related drop in housing construction.

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

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Monitoring wells in the region were first recorded in significant numbers in 1987, with slightly over 100 wells installed. The onset of monitoring well installation in the mid- to late-1980s is likely associated with federal underground storage tank programs signed into law in the mid-1980s. Since 1984, monitoring well installation in the region has averaged approximately 280 wells per year. Between 2004 and 2008, monitoring well installation in the region increased to approximately 500 monitoring wells per year. Overall, the total number and average number of monitoring well records for the region appears to be low considering the number of remedial action sites within the region by the California State Water Resources Control Board (www.geotracker.ca.gov).

More detailed information regarding assumptions and methods of reporting well log information is available online from Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013.

California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization

The Legislature in 2009, as part of a larger package of water-related bills, passed Senate Bill 7x 6 (SBx7 6; Part 2.11 to Division 6 of the California Water Code § 10920 et seq.), requiring that groundwater elevation data be collected in a systematic manner on a statewide basis and be made readily and widely available to the public. DWR was charged with administering the program, which was later named the "California Statewide Groundwater Elevation Monitoring" or "CASGEM" Program. The new legislation requires DWR to identify the current extent of groundwater elevation monitoring within each of the alluvial groundwater basins defined under Bulletin 118-2003. The legislation also requires DWR to prioritize groundwater basins to help identify, evaluate, and determine the need for additional groundwater level monitoring by considering available data. Box TL-1 provides a summary of these data considerations and resulting possible prioritization category of basins.

More detailed information on groundwater basin prioritization is available online from Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013.

PLACEHOLDER Box TL-1 California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization Data Considerations

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the chapter.]

Figure TL-7 shows the groundwater basin prioritization for the region. Of the 19 basins within the region, seven basins were identified as high priority, one as medium priority, one as low priority, and the remaining 10 basins as very low priority. Table TL-3 lists the high, medium, and low CASGEM priority groundwater basins for the region. The seven high and one medium priority basins account for about 97 percent of the population and about 98 percent of groundwater supply in the region. The basin prioritization could be a valuable tool to help evaluate, focus, and align limited resources for effective groundwater management, and reliability and sustainability of groundwater resources.

PLACEHOLDER Figure TL-7 CASGEM Groundwater Basin Prioritization for the Tulare Lake Hydrologic Region

PLACEHOLDER Table TL-3 CASGEM Groundwater Basin Prioritization for the Tulare Lake Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the chapter.]

Tulare Lake Hydrologic Region Groundwater Monitoring Efforts

Groundwater resource 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 (§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 degradation, inelastic land subsidence, and changes in surface water flow and quality that directly affect groundwater levels or quality. This section summarizes some of the groundwater level, groundwater quality, and land subsidence monitoring efforts within the Tulare Lake Hydrologic Region. Groundwater level monitoring well information includes only active monitoring wells — those wells that have been measured since January 1, 2010.

Additional information regarding the methods, assumptions, and data availability associated with the groundwater monitoring is available online from Water Plan Update 2013 Vol. 4 Reference Guide –

California's Groundwater Update 2013.

Groundwater Level Monitoring

A list of the number of monitoring wells in the region by monitoring agencies, cooperators, and CASGEM monitoring entities is provided in Table TL-4. The locations of these monitoring wells by monitoring entity and monitoring well type are shown in Figure TL-8. Tulare Lake Hydrologic Region has by far the largest number of groundwater level monitoring wells of the ten hydrologic regions. Table TL-GW-4 shows that a total of 3342 wells in the region have been actively monitored for groundwater levels since 2010. DWR monitors a total of 268 wells in five basins, with the majority of wells in Kings and Kern County Subbasins. The USBR monitors 104 wells – 91 of which are located in the Kings Subbasin; four of the USBR monitoring wells are located outside the Bulletin 118-03 alluvial groundwater basins. The USGS monitors groundwater levels in four wells within the Westside Subbasin. In addition to the State and federal agency, 23 cooperators and 14 CASGEM monitoring entities combined monitor a total of 2,966 wells in nine basins and subbasins. A comparison of Figure TL-7 discussed previously and Figure TL-8 indicate that except the Cummings Valley and Tehachapi Valley West priority basins, all other basins identified as having a high or medium priority are under the CASGEM groundwater basin prioritization.

PLACEHOLDER Table TL-4 Groundwater Level Monitoring Wells by Monitoring Entity in the Tulare Lake Hydrologic Region

PLACEHOLDER Figure TL-8 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity in the Tulare Lake Hydrologic Region

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The groundwater level monitoring wells are categorized by the type of well use and include domestic, irrigation, observation, public supply, and other. Groundwater level monitoring wells identified as "other" include a combination of the less common well types, such as stock wells, test wells, industrial wells, or unidentified wells (no information listed on the well log). Wells listed as "observation" also include those wells described by drillers in the well logs as "monitoring" wells. Well depths in the region tend to be deeper than other hydrologic regions. Declining groundwater levels, poor quality shallow aquifers, and highly productive deeper confined aquifer zones all contribute to the need for deeper well construction in the region relative to other hydrologic regions. Domestic wells are typically relatively shallow and are in the upper portion of the aquifer system, while irrigation wells tend to be deeper and are in the middle-to-deeper portion of the aquifer system. Some observation wells are constructed as a nested or clustered set of dedicated monitoring wells, designed to characterize groundwater conditions at specific and discrete production intervals throughout the aquifer system. Figure TL-9 shows that wells identified as other and irrigation account for 54 and 35 percent, respectively, of the monitoring wells in the region, while wells listed as observation comprise 8 percent of the total; public supply wells comprise only about 3 percent of the total.

PLACEHOLDER Figure TL-9 Percentage of Monitoring Wells by Use in the Tulare Lake Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the chapter.]

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 Water Boards 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.

PLACEHOLDER Table TL-5 Sources of Groundwater Quality Information

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the chapter.]

Land Subsidence Monitoring

Land subsidence has been shown to occur in areas experiencing significant declines in groundwater levels. Land subsidence investigations in the Tulare Lake Hydrologic Region include monitoring efforts such as,

- California Aqueduct elevation surveys,
- Borehole extensometer monitoring,
- Satellite remote sensing studies using interferometric synthetic aperture radar (InSAR),
- Caltrans highway 198 elevation monitoring, and
- GPS array monitoring.

DWR conducts periodic elevation surveys along the California Aqueduct to measure land subsidence along the canal and guide maintenance repairs as needed. DWR surveys compare elevations along portions of the aqueduct in Fresno and Kings Counties for years 2000, 2006 and 2009.

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 twelve 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.

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 (USGS, 2000). In cooperation with DWR and the U.S. Bureau of Reclamation, the USGS is currently evaluating 2007 to 2011 InSAR data for evidence of subsidence in the San Joaquin River and Tulare Lake Hydrologic Regions.

As part of Highway Elevation Monitoring, Caltrans periodically resurveys their network of existing benchmarks along key sections of highway. In 2004, Caltrans surveyed a section of Highway 198 across the San Joaquin Valley from the Diablo Range to Visalia. Prior surveys along this section of Highway 198 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.

A university-governed consortium for geosciences research using geodesy (UNAVCO) operates the Plate Boundary Observatory (PBO) and uses precision GPS monitoring sites for western United States plate tectonics studies. The UNAVCO GPS stations provide continuous monitoring of the land surface elevation providing a potential direct measurement of subsidence. There are 13 GPS stations in the San Joaquin Valley. Several of these are close to the edge of the valley and provide only partial insight into the regional magnitude of subsidence, while others lie outside of areas susceptible to subsidence (see http://pbo.unavco.org).

The results from the above subsidence monitoring are provided 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 mountain range (Sierra Nevada), foothills, San Joaquin Valley floor, and desert.

The Tulare Lake Hydrologic 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 (Ornduff, 2003). 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 Hydrologic Region in the form of rain and snow. The Sierra Nevada is the principal source of water for the foothills and the San Joaquin Valley floor.

The snowmelt and associated runoff flows from the Sierra Nevada through the foothills sustaining the watershed. The foothills are comprised of foothill woodland and riparian woodland alongside chaparral and valley grassland. The foothill woodland area is dominated by the following tree species: California buckeye, oak, walnut and gray pine (Ornduff, 2003). The understory of foothill woodland is comprised of species found in chaparral and valley grasslands (Ornduff, 2003). Chaparral is comprised of mostly woody species with sparse oaks (chamise, mahogany, manzanita, California-lilac, California-holly, sumac, and yucca) and has evolved to conserve water during hot, dry summers (Ornduff, 2003). 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(Ornduff, 2003). The old-growth foothill woodland community 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 in the foothills, riparian woodland is comprised of big leaf maple, black cottonwood and white alder (Ornduff, 2003) and is found adjacent to foothill woodland. This part of the watershed is characterized by woodland and chaparral species which contribute to water storage and collection (Ornduff, 2003).

The watershed terminates in the San Joaquin valley floor. The San Joaquin valley floor 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. Rivers and sloughs in the valley are lined with riparian woodland comprised of the following tree species: California sycamore, California box elder, Fremont cottonwood, and willows (Ornduff, 2003). 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 (Ornduff, 2003). Freshwater marshes alongside valley grassland exist in the southern portion of what was once Tulare lake and contain sedge, tule and cattail (Ornduff, 2003). Alkali sink scrub is found in the southern portion of the historic Tulare lake bed and in other surrounding saline soils that have not been converted for agricultural purposes. Alkali sink scrub is comprised of saltbush, iodine bush, pickleweed, greasewood and seep weed (Ornduff, 2003). Creosote bush scrub is found in the vicinity of Bakersfield as well as in Tulare County alongside alkali sink scrub. Creosote bush scrub is characterized by antelope bush, sagebrush and California buckwheat (Ornduff, 2003). The San Joaquin valley floor receives little rain. Rivers that flow from the Sierra Nevada and foothills are the primary source of the water in the San Joaquin valley floor. The San Joaquin valley floor accumulates water from the watershed, and after it 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 and 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 as they come closer to extinction (see Tables TL-6, 7, & 8).

PLACEHOLDER Table TL-6 Selected Regionally Endemic Endangered Plant Species

PLACEHOLDER Table TL-7 Selected California Endemic Endangered Plant Species

PLACEHOLDER Table TL-8 Endangered Wildlife Species

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

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 Hydrologic 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 Hydrologic 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.

Major flood events in the Tulare hydrologic region include:

- In December 1955 through January 1956, a storm caused by a family of cyclones from the mid-Pacific Ocean that 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.
- In early 1969, heavy precipitation plus a prodigious snowpack melt in January and February caused flooding throughout the region and reinundated 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 the Panoche Creek watershed, the creek re-aligns itself during these flash floods.
- 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, a heavy snowpack and warm rains produced flooding of the White River that inundated the city of Earlimart and closed U.S. 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. A list of recorded major flood events in the Tulare Lake Hydrologic Region is provided.

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 hydrologic 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.

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 San Joaquin Valley’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 degrees Fahrenheit 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 %. Among the larger counties in the Tulare Lake HR (Table TL-9), Kern County grew the fastest both from 2000-2005 and 2005-2010 with population increases of 15.7% and 10.7%, 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 ten populous cities (Table TL-10) are inhabited by about 1.29 million people or 56.7 % of the region's total population.

PLACEHOLDER Table TL-9 Region Population by County

PLACEHOLDER Table TL-10 2010 Top Ten Populous Incorporated Cities

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Tribal Communities

Under the Clean Water Act, the US Environmental Protection Agency (US EPA) administers programs that support federally recognized tribes to address nonpoint source (NPS) 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% of the total nationally.

Section 319 of the CWA authorizes federal grants to states and tribes in order to implement approved programs and on-the-ground projects to reduce nonpoint source pollutions problems. In the Tulare Lake Hydrologic Region, there are three tribes with 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 CWA authorizes federal grants to assist state and interstate agencies in administering water pollution control programs. Tribes with TAS status can receive Section 106 funding. This program allows tribes to address water quality issues by developing monitoring 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.

PLACEHOLDER Table TL-11 Federally Recognized Tribes in Tulare Lake Hydrologic Region

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Disadvantaged Communities

The region's economy hasn't grown as quickly as the population. Approximately 51% of the region's population lived in Disadvantaged Communities (DACs) in 2010. Out of the 113 DACs, 54 had a population greater than 2,000 (shown in Figure TL-10 and listed in Table TL-12).

PLACEHOLDER Figure TL-10 Tulare Lake Hydrologic Region Disadvantaged Communities and Integrated Regional Water Management

PLACEHOLDER Table TL-12 Disadvantaged Communities by County with Populations of 2,000 or more

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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). Previously, 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% 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 largest 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% 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 - http://www.conservation.ca.gov/DLRP/fmmp/Pages/Index.aspx

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

PLACEHOLDER Table TL-14 Tulare Lake Hydrologic Region 2004-2010 Change in Urban Area (acres)

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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 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-13 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 US Bureau of Land Management due to outstanding resource value.

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 CVPIA. Reported deliveries for 2006-2010 are in Table TL-15 and TL-16.

At Pine Flat Dam on the Kings River, the Kings River Fisheries Management Program was established in 1999 and renewed in 2009 for another 10 years. The program is a collaborative effort between the Kings River Conservation District, the Kings River Water Asssociation, the California Department of Fish and Wildlife 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 (See Table TL17).

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

PLACEHOLDER Table TL-16 Surface Water Deliveries to Mendota wildlife Area, 2010 (thousand acre-feet)

PLACEHOLDER Table TL-17 Dedicated Natural Flows

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Water Supplies

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

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

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Agricultural Water

During a normal water year like 2005, surface water supplies (primarily river water delivered through projects) approximately 70% 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% of the applied water demand being met by groundwater (see Figure TL-12).

PLACEHOLDER Figure TL-12 Total Agricultural Applied Water Supply Source (thousand acre-feet) (with Supply Source as a Percentage of total Agricultural Applied Water)

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Recycled Municipal Water

According to the 2009 Municipal Wastewater Recycling Survey, compiled by the State Water Resources Control Board, 126,320 acre feet per year are being recycled in the Tulare Lake Region. Most of the recycled water was used for agricultural irrigation with a relatively small quantity used for groundwater recharge and landscape irrigation. (SWRCB. 2011a) State policy (SWRCB. 2009) 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.

In the Central Valley, of which the Tulare Lake Region is a part, the Central Valley Water Board and the State Water Board, as part of a stakeholder effort, are developing a 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 ground waters 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. For the Central Valley, the only acceptable process to develop the salt and nutrient management plans that are required under state policy (SWRCB. 2009) is through CV-SALTS.

Groundwater

The amount and timing of groundwater extraction, along with the location and type of its use, are fundamental components for building a groundwater basin budget and identifying effective options for groundwater management. Although some types of groundwater extractions are reported for some California basins, the majority of groundwater pumpers are not required to monitor, meter, or publicly record their annual groundwater extraction amounts. Groundwater supply estimates furnished herein are based on water supply and balance information derived from DWR land use surveys, and from groundwater supply information voluntarily provided to DWR by water purveyors or other State agencies.

Groundwater supply is reported by water year (October 1 through September 30) and categorized according to agriculture, urban, and managed wetland uses. The associated information is presented by planning area (PA), county, and by the type of use. Reference to total water supply represents the sum of surface water and groundwater supplies in the region, and local reuse.

2005-2010 Average Annual Groundwater Supply and Trend

With a 2005-2010 average annual extraction volume of 6.3 million acre-foot (maf), 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 in groundwater extraction – San Joaquin River Hydrologic Region with 19 percent and Sacramento River Hydrologic Region with 17 percent of the total.

Table TL-18 provides the 2005-2010 average annual groundwater supply by PA and by type of use, while Figure TL-13 depicts the PA locations and the associated 2005-2010 groundwater supply in the region. The estimated average annual 2005-2010 total water supply for the region is about 11.7 maf. Out of the 11.7 maf total supply, groundwater supply is 6.3 maf and represents 54 percent of the region's total water supply; 82 percent (0.6 maf) of the overall urban water use and 52 percent (5.7 maf) of the overall agricultural water use being met by groundwater. Thus more than 90 percent of the groundwater supply in the region is used to meet agricultural water use and only 10 percent is used to meet urban water use (5.7 maf versus 0.6 maf). Groundwater contributes to 37 percent (29 taf) for meeting managed wetland uses in the region.

PLACEHOLDER Table TL-18 Tulare Lake Hydrologic Region Average Annual Groundwater Supply by Planning Area and by Type of Use (2005-2010)

PLACEHOLDER Figure TL-13 Contribution of Groundwater to the Tulare Lake Hydrologic Region Water Supply by Planning Area (2005-2010)

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As shown in Table TL-18 and Figure TL-13, two of the largest groundwater PAs in the region, lower Kings-Tulare and Kaweah Delta, rely on more than 3 maf of combined groundwater pumping to meet 70 and 60 percent of their agricultural water use, respectively. The annual pumping volumes and reliance on groundwater supplies are also quite high (approximately 500 TO 700 TAF) for the San Luis West Side, Alta-Orange Cove, Semitropic-Buena Vista, and Kern Delta PAs. Groundwater status reports from groundwater management agencies overlying many of these PAs acknowledge that the average annual groundwater extraction commonly exceeds sustainable aquifer yield. The smallest groundwater user, Western Uplands PA, is 100 percent dependent on groundwater supply to meet its urban and agricultural water uses. Most of the PAs in the region are highly dependent on groundwater to meet their urban water uses, with 42 to 100 percent of the use being met by groundwater.

Regional totals for groundwater based on county area will vary from the PA estimates shown in Table TL-18 because county boundaries do not necessarily align with PA or hydrologic region boundaries. Kings and Tulare counties are fully contained with the Tulare Lake Hydrologic Region, while Fresno and Kern counties are partially contained within the region. For the Tulare Lake Hydrologic Region, groundwater supply is reported for these four counties (Table TL-19). Overall, groundwater contributes to about one half of the total water supply for the four-county area; the range varies from a little less than 50 percent to a little over 60 percent for individual counties. Although most of the groundwater extraction in the four-county area occurs for agricultural water use, groundwater supplies meet only about half of the agricultural water use. In contrast, although overall groundwater extraction for urban water use is significantly less, groundwater supplies meet more than 80 percent of the urban water use.

More detailed information regarding groundwater water supply and use analysis is available online from Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013.

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

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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-14 and TL-15 summarize the 2002 through 2010 groundwater supply trends for the Tulare Lake Hydrologic Region. The right side of Figure TL-14 illustrates the annual amount of groundwater versus surface water supply, while the left side identifies the percent of the overall water supply provided by groundwater relative to surface water. 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. Figure TL-15 shows the annual amount and percentage of groundwater supply trends for meeting urban, agricultural, and managed wetland uses.

PLACEHOLDER Figure TL-14 Tulare Lake Hydrologic Region Annual Groundwater Water Supply Trend (2002-2010)

PLACEHOLDER Figure TL-15 Tulare Lake Hydrologic Region Annual Groundwater Supply Trend by Type of Use (2002-2010)

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Figure TL-14 indicates that the annual water supply for the region has remained relatively stable between 2002 and 2010. However, the percent to which groundwater or surface water contributed to the total supply during this same period was widely variable. 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. Between 2002 and 2010, annual groundwater supply fluctuated from about 3.5 maf in 2005 to about 8.7 maf in 2009 and provided between 35 and 70 percent of the total water supply for the region. The persistent fluctuation in groundwater water 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-15 illustrates that in areas of high water uses, relatively small changes in the percent of groundwater supply required can result in larges 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 91 percent. The eight percent increase in groundwater towards the total supply for the region resulted in more than doubling the amount of groundwater extraction - from 3.5 maf in 2005 to 8.7 maf in 2009. Groundwater pumping to meet urban water uses remained fairly stable during the 2002 to 2010 period - between 550 taf and 650 taf; groundwater supply meeting urban use ranged from 7 to 16 percent of the annual groundwater extraction. Although the volume of groundwater supply to meet managed wetlands use is relatively small (between 25 and 65 TAF), groundwater contribution to total managed wetland water supply ranged from 35 to 45 percent.

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 of certain constituents in the water and declining groundwater levels underlying some of the larger metropolitan areas is resulting in more 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 2005 to 2009)

Normally, all native surface water supplies, imported water supplies, and direct precipitation percolate into valley groundwater if they are not lost through consumptive use, evapotranspiration, or evaporation. Because of its closed nature, Tulare Lake Hydrologic Region has little subsurface outflow. Thus, salts accumulate within the basin due to importation and evaporation of the water.

PLACEHOLDER Table TL-20 Tulare Lake Hydrologic Region Water Demands

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Drinking Water

The region has an estimated 355 community drinking water systems. The majority (over 80%) 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 (see 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 lack 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 (USEPA 2012).

In contrast, medium and large water systems account for less than 20% of region's drinking water systems; however these systems deliver drinking water to over 90% of the region's population (see Table TL-21 below for CWS details). 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.

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

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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 to DWR. The Water Conservation Law of 2009 (SBx7-7) 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 for individual Tulare Lake urban water suppliers is available on the Department of Water Resources (DWR) Urban Water Use Efficiency website.

The Water Conservation Law of 2009 (SBx7-7) required agricultural water suppliers to prepare and adopt agricultural water management plans by December 31, 2012, and update those plans by December 31, 2015, and every 5 years thereafter. Nine Tulare Lake agricultural water suppliers have submitted 2012 agricultural water management plans to DWR.

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

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

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Water Balance Summary

Tulare Lake Hydrologic Region consists of ten planning areas.

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

Planning Area 701, Western Uplands, has little urban or agricultural water use, with urban applied water averaging 2 TAF per year and agricultural applied water of 300 acre-feet (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 million acre-feet annually. Water Supply comes primarily from the Central Valley Project (0.4-1.1 MAF). The State Water Project provides about 46-110 TAF per year and groundwater makes up the difference in supply, with pumpage exceeding 1 MAF in years 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, Central Valley Project and State Water project 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 2/3 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.

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 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 average is applied to managed wetlands.

Most of the water applied comes from the State Water Project, with about 10 to 15 percent from local sources and the Central Valley Project. 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 every year. 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 Central Valley Project, with just a little State Water Project 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 Central Valley Project and the State Water Project with some reuse thrown in. As with PA 708 and 709, banked groundwater is used to make up deficiencies in drier years.

PLACEHOLDER Table TL-23 Tulare Lake Hydrologic Region Water Balance Summary, 2001-2010

PLACEHOLDER Figure TL-16 Tulare Lake Regional Water Balance by Water Year, 2001-2010

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Project Operations

From 2005 to 2013 (Figure TL-17), CVP agricultural deliveries to south of the Delta contractors varied from a high of 100% of contracted amounts once in 2006 which was a wet year to a low of just 10% in 2009 at the tail end of the 2007-2009 drought period. CVP deliveries to south of the Delta urban contractors were 100% in 2005, 2006, and 2011, but they also dropped in the 2009 dry year to 60% of contracted amounts. For CVP Friant Class 1 contracts, the USBR delivered 100% of contracted amounts except in 2007, 2012, and 2013.

PLACEHOLDER Figure TL-17 South of Delta CVP and SWP Deliveries

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SWP contractors saw similar reductions from 2005 to 2013 and only received 100% of requested supplies in 2006. They much lower amounts from 2007 to 2013 with a low of 35% 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 14,000 Acre-Feet starting in January 2010 with the final reduction in 2020 when the Mojave Water Agency will assume the contract for the 14,000 acre-feet. 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 Turnout, located at Milepost238.04 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 storage dams, Success and Isabella, had their storage capacities reduced due to safety concerns by the United States Army Corps of Engineers. In 2004, the Corps 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 dam on Success Lake. Additionally, they also were concerned about dam failure due to overtopping or seepage through the earthen dam. As a result, the Corps which operates the reservoir, reduced the storage capacity from 82,291 acre-feet to 29,200 acre-feet from 2007 to 2008 and then 41,000 acre-feet from 2009 to 2011. They further increased the restricted pool to 65,000 acre-feet in 2012. In November 2012, the Corps determined that the dam was unlikely to collapse in an earthquake or slump due to seepage. Later, in 2013, they will release a report assessing the risks and what can be done about them. On the Kern River in 2006, the Corps reduced the storage capacity of Lake Isabella from 568,100 acre-feet to 361,250 acre-feet 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, they 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 Corps plans to 1) Raise the main dam crest by 16 ft.; 2) Raise the auxiliary dam crest by 16 ft. 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 to $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 lake bed farm lands. Installations include the Kings River Flood Control Project, four multi-purpose 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 ground water for municipal, agricultural, and industrial purposes, and the use of water from deeper formations and outside the basin, which further concentrates salts within remaining ground water. (CVRWQCB. 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 and 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. (CV-SALTS. 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 (SWRCB, 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 Hydrologic 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 (SWRCB, 2010). Pesticides are man-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 since its use has been banned since 1990 (USEPA, 2012b).

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 (SWRCB, 2010 and USEPA, 2012a). 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 (SWRCB

2012a).

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 (CVRWQCB, 2001).

Erosion is one of the greatest problems in the foothills and mountain areas of this region. Erosion is a natural occurrence, but most activities of man accelerate the process. Erosion causes discoloration of streams, and the suspended matter settles to form a smothering blanket on the stream bed. 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 (CVRWQCB, 2004).

Groundwater Quality

Generally, the quality and the beneficial uses of the deep ground waters remain the same as before man entered the valley. A few areas within the Basin have ground waters that are naturally unusable or of marginal quality for certain beneficial uses. (CVRWQCB. 2004) However, anthropogenic sources have impacted many of the shallower zones. Ground water 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. 2008) The following are the contaminants of concern in groundwater for this region:

- Salinity (CVRWQCB. 2004)
- Nitrate (Dubrovsky. 1998, Burow. 2008, CWS. 2012)
- DBCP (1,2-dibromo-3-chloropropane) (Dubrovsky. 1998, Burow. 2008, SWRCB. 2012b)
- Arsenic (SWRCB. 2012b)
- Gross Alpha Particle Activity and Uranium (SWRCB. 2012b)
- Chromium 6 (SWRCB. 2011b)
- Localized contamination by (SWRCB. 2012b):
    - Organic Compounds (Benzene, tetrachloroethylene (PCE), trichloroethylene (TCE), and perchlorate)
    - Fluoride

Degradation of ground water 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 ground water 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 man’s 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. (CVRWQCB. 2004)

In a 1998 USGS study, nitrate concentrations in 24 percent (21 of 88) of the domestic wells sampled during 1993–95 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 USEPA. Pesticides were detected in 61 of the 88 domestic wells sampled during 1993–95 (69 percent), but concentrations of most pesticides were low—less than 0.1 mg/L. (Dubrovsky. 1998) 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 ground-water flow system. (Burow. 2008) The recent UC 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, gold 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. (CWS. 2012)

Concentrations of DBCP, a soil fumigant banned since 1977, exceeded the USEPA drinking-water standard of 0.2 mg/L in 18 of the 88 (or 20 percent) domestic wells sampled during 1993–95. (Dubrovsky. 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 2001-02. (Burow. 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. (SWRCB. 2012b) Arsenic has been linked to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate. (USEPA. 2012)

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. (SWRCB. 2012b)

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 allows such as stainless steel; protective coatings on metal; magnetic tapes, and pigments for paints, cement, paper, rubber, composition floor covering, etc. Elevated levels (above the detection limit of 1 µg/l) of hexavalent chromium have been detected in many active and standby public supply wells along the west or valley floor portion of the Central Valley. (SWRCB. 2011b)

Benzene, perchlorate, tetrachloroethylene (PCE) and trichloroethylene (TCE) have been detected at levels exceeding MCLs in the source water of a few water systems in the Tulare Lake Hydrologic 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. (SWRCB. 2012b) Benzene and perchlorate occur in the environment both naturally and due to man-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. (SWRCB. 2012b) 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. (USEPA. 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 disadvantaged communities, 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 and which may be unaffordable for rate payers in disadvantaged communities.

In January of 2013, the Water Boards completed a statewide assessment of community water systems that rely on contaminated groundwater. Contamination of local groundwater resources results in higher costs for rate payers and consumers due to the need for additional water treatment. This draft report identified 146 community drinking water systems in the region that rely on at least one contaminated groundwater well as a source of supply (See Table TL-24). A total of 159 community drinking water wells are affected by groundwater contamination, and the most prevalent contaminants are arsenic, nitrate, gross alpha particle activity, 1,2-Dibromo-3-chloropropane (DBCP), and uranium (See 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, UC 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).

PLACEHOLDER Table TL-24 Summary of Community Drinking Water Systems in the Tulare Lake Hydrologic Region that Rely on One or More Contaminated Groundwater Well that Exceeds a Primary Drinking Water Standard

PLACEHOLDER Table TL-25 Summary of Contaminants Affecting Community Drinking Water Systems in Tulare Lake Basin

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Land Subsidence

Land subsidence was first noted in the San Joaquin Valley in 1935 in the Delano area (Galloway and others, 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 west 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-18, by the late 1960s more than 5,000 square miles of farm land or one-half the entire San Joaquin Valley had subsided by at least one foot (Ireland, 1986).

PLACEHOLDER Figure TL-18 Land Subsidence in the San Joaquin Valley – 1926 to 1970 (Adapted from Ireland, 1984)

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Surface water deliveries from the State Water Project 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 towards 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 (see Figure TL-19). The survey also indicates an accelerated level of subsidence from 2006 to 2009.

PLACEHOLDER Figure TL-19 Land Subsidence along the California Aqueduct

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Borehole Extensometer Monitoring

There are currently seven active extensometers in the San Joaquin Valley being monitored for groundwater levels and land subsidence. Figure TL-20 shows results from the extensometer located in the Kern Water Bank and installed in 1966; the extensometer is 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 show relatively large changes in water levels as the water bank is recharged and extracted. The aquifer compaction and subsidence monitored by the extensometer show a small elastic response to changes in the water levels. Elastic subsidence is reversible and will typically not develop into inelastic (irreversible) subsidence until groundwater drop below a level that results in irreversible aquifer compaction.

PLACEHOLDER Figure TL-20 Depth to Groundwater Hydrograph for Well 30S25E16L14 and Land Subsidence Graph for Kern Water Bank Extensometer

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USGS InSAR Monitoring

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

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 towards 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 (see Figure TL-21). 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 two feet in the last few years.

PLACEHOLDER Figure TL-21 Land Subsidence Results from Caltrans Highway 198 Elevation Monitoring

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GPS Array Monitoring

The university-governed consortium for geosciences research using geodesy's (UNAVCO) continuously monitored precision GPS stations in western United States provide partial but important insight into the regional magnitude of subsidence in the San Joaquin and Tulare Lake Hydrologic Regions (http://pbo.unavco.org). For example, many of the 13 land surface displacement summary graphs show a significant trend of declining land surface within the Tulare Lake Hydrologic Region (see Figure TL-22). Similarly, Figure TL-23 shows the obvious correlation between the post-2007 decline in groundwater levels beneath the Corcoran Clay and the decline in land surface elevations near the City of Mendota. Between 2007 and 2010, groundwater levels in the Mendota area have declined by approximately 30 feet, while the vertical displacement in the land surface has declined by about 0.2 feet.

PLACEHOLDER Figure TL-22 UNAVCO GPS Land Surface Displacement Monitoring Stations and Station Data Summary Graphs

PLACEHOLDER Figure TL-23 Depth to Groundwater Hydrograph and Vertical Land Surface Displacement at UNAVCO GPS Site 304, near the City of Madera

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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-24 includes a composite hydrograph showing groundwater levels for three wells located adjacent to Westlands Water District. The figure also includes historic 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-24 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 show 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.

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.

PLACEHOLDER Figure TL-24 Relationship between Changing Groundwater Levels and Land Subsidence in the Tulare Lake Hydrologic Region (Composite Hydrograph for Wells 16S15E34N001M, 16S15E34N004M, and 16S115E32Q001M)

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Groundwater pumping at unsustainable rates and volumes has resulted in 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 was not replenished by actively recharging the aquifer via conjunctive management practices. These economic benefits have not gone 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 short 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.

Additional information regarding the aquifers in the San Francisco Bay Hydrologic Region is available online from Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013.

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 and, depending on annual recharge conditions, 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.

Lowering of groundwater levels can also impact the surface water–groundwater interaction by inducing additional infiltration and recharge from surface water systems, thereby reducing the groundwater discharge to surface water base flow and wetlands areas. Extensive lowering of groundwater levels can also result in land subsidence due to the dewatering, compaction, and loss of storage within finer grained aquifer systems.

During years of normal or above normal precipitation, or during periods of low groundwater extraction, aquifer systems tend to recharge and respond with rising groundwater levels. As groundwater levels rise, they reconnect to surface water systems, contributing to surface water base flow or wetlands, seeps, and springs. However, for 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 base flow. In 1980, DWR Bulletin 118-80 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 management plans and more recent studies for 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 influenced 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

The depth to groundwater has a direct bearing on the costs associated with well installation and groundwater extraction operations. Understanding the local depth to groundwater can also provide a better understanding of the local interaction between the groundwater table and the surface water systems, and the contribution of groundwater aquifers to the local ecosystem.

Figure TL-25 is a spring 2010 depth to groundwater contour maps for the region. Groundwater contour maps were developed using groundwater level data that is 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. Precipitation for water year 2010 was 116 percent of the previous 30-year average; however, precipitation for the preceding three years averaged less than 70 percent of average. 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. Due to the largely confined nature of the Westside Subbasin aquifer systems, no contours were developed for that area. Depth to groundwater contours were also not developed for the Tulare Lake lakebed area due to thick clay layers limiting groundwater production and lack of groundwater level data in the area.

PLACEHOLDER Figure TL-25 Spring 2010 Depth to Groundwater Contours for the Tulare Lake Hydrologic Region

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Figure TL-25 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.

Further 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 shallower 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 becomes increasingly irregular and variable. Figure TL-25 shows depth to groundwater increases to about 150 feet near the City of Lindsay and Tulare. The City of Tulare is entirely dependent on groundwater supplies to meet urban uses. Poor quality groundwater currently limits 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, however, 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 ground water banking projects. A significant rise in ground surface topography toward the surrounding mountains result in depths to groundwater of 300 to 500, or more along the edges of the valley.

Additional groundwater level information for the region is available from the USGS National Water Information System (http://waterdata.usgs.gov/nwis/gw) and some groundwater management agencies in the region. Groundwater contour maps for the region are also generated by DWR and by various groundwater management agencies in the region, as 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

Groundwater Elevations

Groundwater elevation contours can help estimate the direction of groundwater movement and the gradient, or rate, of groundwater flow. Figure TL-26 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. Due to the largely confined nature of the Westside Subbasin aquifer systems, no contours were developed for that area. Depth to groundwater contours were also not developed for the Tulare Lake lakebed area due to thick clay layers limiting groundwater production and lack of groundwater level data in the area.

PLACEHOLDER Figure TL-26 Spring 2010 Groundwater Elevation Contours for the Tulare Lake Hydrologic Region

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Figure TL-26 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. Several local groundwater management agencies have begun to address the ongoing groundwater level declines by implementing conjunctive management programs that include groundwater banking, water exchange programs, and importation of alternative water supplies.

Although groundwater contours were not developed for the west side of the hydrologic region (Westside, Tulare Lake, and Kern County Subbasins), the direction of groundwater movement along the west side is generally from the Diablo Range eastward towards the axis of the valley. The influence of recharge from the west side streams is much less than that of the rivers originating from the Sierra Nevada.

Figure TL-26 also illustrates several patterns of groundwater recharge associated with key surface water systems flowing into the region. Recharge areas can be seen along the larger rivers such as the San Joaquin, Kings, and Tule Rivers.

Additional references and links to DWR and other local agencies with information on groundwater levels and contours in the region have been provided in the previous section.

Groundwater Level Trends

Plots of depth-to-water measurements in wells over time (groundwater level hydrographs) allow analysis of seasonal and long-term groundwater level variability and trend over time. Because of the highly variable nature of the physical aquifer systems within each groundwater basin, and because of the variable nature of annual groundwater availability, recharge, and surrounding land use practices, the hydrographs presented herein do not attempt to illustrate or depict average aquifer conditions over a broader region. Rather, the selected hydrographs are intended to help tell a story about how the local aquifer systems respond to changing groundwater pumping quantity and to the implementation of resource management practices. The hydrographs are designated according to the State Well Number System (SWN), which identifies each well by its location using the public lands survey system of township, range, section, and tract.

<u>Hydrograph 15S18E30L001M</u>

Hydrograph 15S18E30L001M (Figure TL-27A) is from a well located near Raisin City, approximately 10 miles southwest of the City of Fresno in Kings Subbasin. The hydrograph demonstrates a persistent decline in groundwater levels over the last 50 years for the western Kings Subbasin. The well is screened in the unconfined to semi-confined portion of the aquifer. The area surrounding the well is predominantly agricultural land use, characterized by a mix of permanent crops (vines and tree fruit) and row crops. The hydrograph shows that groundwater levels remained relatively stable during the 1920s and 1930s. After

World War II, agriculture land use reliance on groundwater intensified and water levels began a steady decline, with groundwater elevations reaching 100 feet below mean sea level during the 1977 drought. Groundwater levels stabilized over the 10-year period (1978-1988) of above normal precipitation, before declining approximately another 50 feet during the 1989 to 1994 drought. Groundwater levels show some increase during the wet years of the late 1990s, but have since continued declining by approximately another 25 feet. Starting in 2007, groundwater level monitoring efforts have periodically failed to obtain a groundwater level reading, indicating possible dry well conditions.

The hydrograph clearly demonstrates the imbalance between aquifer recharge and groundwater extraction for this portion of the Kings Subbasin, and the unsustainability of maintaining existing level of groundwater extraction. With groundwater levels at all-time lows and declines projected to continue, land subsidence in this area is also projected to continue. The Kings Subbasin is designated a CASGEM high priority basin.

<u>Hydrograph 20S23E12A001M</u>

Hydrograph 20S23E12A001M (Figure TL-27B) is from an irrigation well located five miles west of the City of Tulare, along the western edge of the Kaweah Subbasin. 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 well is screened in the unconfined to semi-confined portion of the aquifer. Land use surrounding the well is characterized by permanent agricultural crops (vines and fruit trees), row crops, and dairies.

Tulare Irrigation District (TID) receives surface water supplies from the Central Valley Project via the Friant-Kern Canal. Historically, surface water deliveries have provided about one-half of TID's total water supply, with the remaining one-half provided by groundwater extraction (TID personal communication). Local aquifers are recharged predominantly through precipitation, canal seepage, and infiltration from applied irrigation water.

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 declines in groundwater levels are attributed to increased groundwater extraction due to surface water supply cutbacks. The hydrograph indicates that recent increases in groundwater pumping appears to have tipped the groundwater budget towards net aquifer depletion rather than recharge, resulting in rapidly declining groundwater levels between 2007 and 2009. The recent purchase and installation of a new water regulation and recharge basin in the TID area is expected to enable TID to replenish groundwater at increased rates (TID, 2011).

<u>Hydrograph 26S18E18G001M</u>

Hydrograph 26S18E18G001M (Figure TL-27C) is from an inactive irrigation well located along the western edge of the Kern County Subbasin. The hydrograph illustrates the positive effects of in-lieu recharge associated with increases in imported surface water supply and reduced groundwater pumping. The well is screened in the unconfined to semi-confined portion of the aquifer. Land use surrounding the well is characterized by permanent agricultural crops (orchards) and annual row crops.

Groundwater recharge in this area is derived from streams flowing through the upland marine sediments and infiltrating low quality water into the underlying aquifer. Prior to imported surface water from the

California Aqueduct, some farms in the area used groundwater to meet agricultural demand, despite the poor quality. Construction of the California Aqueduct has increased the quality and water supply reliability of water applied for agricultural uses. The hydrograph shows that in-lieu recharge associated with imported surface water supply and reduced groundwater pumping has resulted in about 65 feet of groundwater level recovery since the mid-1970s.

Hydrographs 30S24E02C001M and 30S27E05D001M

Hydrograph 30S24E02C001M (Figure TL-27D) is from an irrigation well while hydrograph 30S27E05D001M (Figure TL-GW-20E) is from a municipal well located in western Bakersfield in the Kern County Subbasin. Both hydrographs illustrate the successful stabilization of sharply declining groundwater levels through implementation of in-lieu and managed groundwater recharge projects via conjunctive management practices. The wells are constructed in the unconfined to semi-confined portion of the aquifer, overlying the confined aquifer beneath the Corcoran Clay. Land use surrounding the irrigation well is a combination of permanent agricultural crops (orchards) and annual row crops, while land use surrounding the municipal well is predominantly urban residential, with the Kern River located just north and the California State University Bakersfield campus just south of the well.

Post-World War II expansion of agricultural in this area resulted in increased use of groundwater and a corresponding steady 120 to 140 foot decline of groundwater levels through 1978, regardless of the precipitation or water year type. Construction of the California Aqueduct and Cross Valley Canal in the mid 1907s 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 was designed and developed to conjunctively manage the municipal water supply by using surface water to either replenish the underlying groundwater aquifer or deliver for municipal water use, and to pump groundwater during years of surface water supply cutbacks.

Between 1988 through 1994, a combination of lower than normal precipitation, increased population growth, and expanding agricultural requirements for water 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 normal precipitation between and groundwater recharge activities resulted in groundwater levels rebounding almost 30 feet. Over the last ten years groundwater levels have again declined somewhat; however, it appears that current groundwater management practices are helping to stabilize groundwater levels through implementation of wet year groundwater banking and dry year pumping.

PLACEHOLDER Figure TL-27 Groundwater Level Trends in Selected Wells in the Tulare Lake Hydrologic Region

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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, or groundwater management over time. If the change in storage is negligible over a period represented by average hydrologic and land use conditions, the basin is considered to be in equilibrium under the existing water use scenario and current management practices. However, declining storage over a period characterized by average hydrologic and land use conditions does not necessarily mean that the basin is being managed unsustainably or subject to conditions of 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 Water Plan Update 2013 Vol. 3 Ch. 9 Conjunctive Management and Groundwater Storage Resource Management Strategy.

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. Groundwater level data from the spring 2005 was used instead of 2006 because the hydrology for 2005 more closely approximated long term average conditions than that of 2006. Beginning the change in storage calculation in 2005, approximately an average water year, yields a more realistic assessment of the annual and cumulative change in storage values in subsequent years.

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 Sprig 2010 Change in Aquifer Storage

Figure TL-28 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 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, and Tule Subbasins, and in the Kern County Subbasin. The maximum decline in 2005-2010 groundwater levels in these areas ranges from 40 to 90 feet. Although contours do not extend into the Westside Subbasin, the pattern and degree of 2005-2010 groundwater level change in adjacent basins indicate that groundwater levels in the Westside Subbasin have likely declined by similar amounts.

Table TL-26 and Figure TL-29 show that the average annual change in groundwater elevation and related change in groundwater storage generally follows the annual precipitation or water year type. Figure TL-29 shows that the annual variability in groundwater storage change for the region is large. The spring 2005 – spring 2010 cumulative groundwater level decline over the region is estimated at about 18 feet with corresponding changes in storage. For example, the single year maximum increase in groundwater storage occurred during the 2005-2006 period and ranged between 1.5 and 3.5 million acre-feet. The maximum single year decline in groundwater storage occurred during the 2007-2008 period and ranged between 3.2 and 7.7 million acre feet. The 2007-2008 decline in groundwater storage is estimated to be between 50 to 120 percent of the average annual groundwater extraction for the region (see Table TL-18). The cumulative change in groundwater storage over the 2005-2010 period is estimated between 3.5 and 9 million acre feet. These numbers represent 55 to 140 percent of the average annual groundwater extraction for the region and 20 to55 percent of the average annual groundwater extraction for the entire state (see Figure TL-13). The large annual variation in groundwater storage changes points to high reliance on groundwater and active conjunctive management practices that occur in the 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 their 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 (KRCD, 2012). The estimated decrease in storage over the 2003-2011 period was estimated by KCRD to be about 1.2 million acre-foot. The 2005-2010 change in storage for the Kings Subbasin was estimated to range between 0.7 and 1.7 million acre-foot. 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.

PLACEHOLDER Figure TL-28 Spring 2005 – Spring 2010 Change in Groundwater Elevation Contour Map for the Tulare Lake Hydrologic Region

PLACEHOLDER Table TL-26 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Tulare Lake Hydrologic Region

PLACEHOLDER Figure TL-29 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Tulare Lake Hydrologic Region

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Additional information regarding the methods and assumptions for calculating change in groundwater storage is available online from Water Plan Update 2013 Vol. 4 Reference Guide – 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 Integrated Water Management (IWM) approach, that incorporates natural hydrologic, geomorphic, and ecological processes to reduce flood risk by influencing the cause of the harm, including the probability, extent, or depth of flooding (flood hazard). Some agencies are transitioning to an IWM approach. IWM changes the implementation approach based on the understanding that water resources are an integral component for sustainable ecosystems, economic growth, water supply reliability, public health and safety, and other interrelated elements. Additionally, IWM acknowledges that a broad range of stakeholders 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, half of the residents and 34 percent of the agricultural crops, totaling $2.3 billion –the most of any hydrologic region,-- are exposed to the 500-year flood event. To address the higher risk of flooding in this hydrologic region, more than 4,000 miles of levees, and 55 dams, reservoirs and weirs have been constructed. This hydrologic region also has two reservoirs—Lake Isabella and Lake Success—that are in need of a seismic retrofit.

Figures TL-30 and TL-31 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 the Tulare Lake Hydrologic Region.

PLACEHOLDER Figure TL-30 Flood Exposure to the 100-Year Floodplain, Tulare Lake Hydrologic Region

PLACEHOLDER Figure TL-31 Flood Exposure to the 500-Year Floodplain, Tulare Lake Hydrologic Region

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Levee Performance and Risk Studies

The Tulare Lake Hydrologic Region contains floodwater storage facilities and channel improvements funded and/or built by the State and Federal agencies. Flood management agencies are responsible for operating and maintaining approximately 4,100 miles of levees and more than 50 dams and reservoirs, and other facilities within the Tulare Lake hydrologic region. For a list of major infrastructure, refer California’s Flood Future Report Attachment E: Information Gathering Technical Memorandum.

In the Tulare Lake Hydrologic Region, 30 local flood management projects or planned improvements were identified. Twenty-seven of those projects have costs totaling approximately $240 million while the remaining projects do not have costs associated with them at this time. The local flood management projects for the Tulare Lake Hydrologic Region are listed in California’s Flood Future Report Attachment E: Information Gathering Technical Memorandum. Eighteen locally planned projects use an Integrated Water Management (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.

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's 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, US Forest Service, National Park Service, and the US Bureau of Land Management.

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 for the Fresno Irrigation District, Alta ID, Consolidated ID; 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.

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

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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.

In 2007 the California legislature passed and the Governor signed into law a series of laws regarding flood management including Senate Bill (SB) 5. Known as the Central Valley Flood Protection Act (Act), these laws set the framework and guidance for preparation of the Central Valley Flood Protection Plan (CVFPP). The plan focuses on areas of the Central Valley currently receiving protection from the State Plan of Flood Control facilities. The adoption of the CVFPP, as modified by Central Valley Protection Board Resolution 2012-25, provides conceptual guidance to reduce the risk of flooding for about one million people and $70 billion in infrastructure, homes and businesses with a goal of providing 200-year (1 chance in 200 of flooding in any year) protection to urban areas, and reducing flood risks to small communities and rural agricultural lands.

SB 5 also required the Department of Water Resources (DWR) to propose improvements to the California Building Standards Code that reduce flood damage risk and protect lives and property in the Central Valley floodplain. Once implemented, these changes will apply to "construction in areas protected by the facilities of the Central Valley Flood Protection Plan where flood levels are anticipated to exceed three feet for the 200-year flood event." DWR is also required to consult with the Central Valley Flood Protection Board, the Division of the State Architect, and the Office of the State Fire Marshal in preparing these recommendations

The same package of legislation directed cities and counties to establish a specified level of flood protection in defined urban areas when making some land use and related decisions. The Department of Water Resources (DWR) is charged with developing criteria that cities and counties may use when either making such decisions or when developing their own criteria in lieu of using DWR criteria. A Criteria for Providing the Urban Level of Flood Protection Handbook (Handbook) will document DWR's guidance. DWR anticipates a high level of interest in document development.

To ensure that areas that are not threatened by flooding were not burdened with unnecessary regulations, SB 5 exempted areas "lying within the Tulare Lake basin, including the Kings River". However, despite this explicit exemption, DWR, upon their implementation of SB 5, referred to a federal map of the area which excludes the City of Fresno from the Tulare Lake Basin. As a result Fresno was determined to be subject to the flood control mandates of the Board.

After working with officials from the City of Fresno, DWR ultimately agreed that the intent of the legislative language was to exempt the entire Tulare Lake Basin, including the City of Fresno from the mandates of the CVFPP and the mandates of the Board.

Although all parties agree that the City of Fresno should be exempt from the requirements of SB 5, the differing definitions of Tulare Lake Basin could lead to confusion. Therefore, the City of Fresno has requested legislation that would clarify that the DWR map, which defines the Tulare Lake Basin Hydrologic Region, should be used for the purpose of implementing CVFPP.

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 agencies utilize their local police powers to manage groundwater through adoption of groundwater ordinances. Groundwater management also occurs through other avenues such as basin adjudication, IRWMPs, Urban Water Management plans, and Agriculture Water Management plans.

Groundwater Management Assesment

Figure TL-32 shows the location and distribution of the GWMPs within the Tulare Lake Hydrologic Region 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 2011-2012. Table TL-28 furnishes a list of the same. GWMPs prepared in accordance with the 1992 AB 3030 legislation, as well as those prepared with the additional required components listed in the 2002 SB 1938 legislation are shown. Information associated with the GWMP assessment is based on data that was readily available or received through August 2012. Requirements associated with the 2011 AB 359 (Huffman) legislation, related to groundwater recharge mapping and reporting, did not take effect until January 2013 and are not included in the current GWMP assessment.

PLACEHOLDER Figure TL-32 Location of Groundwater Management Plans in the North Coast Hydrologic Region (Figure is being updated)

PLACEHOLDER Table TL-28 Groundwater Management Plans in the North Coast Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

The GWMP inventory indicates that 27 groundwater management plans exists within the region. Collectively, the 27 GWMPs cover 5,800 square miles or 69 percent of the Bulletin 118-2003 alluvial groundwater basin area in the region. Seventeen of the 27 GWMPs have been developed or updated to include the SB 1938 requirements and are considered active for the purposes of the California Water Plan Update 2013 GWMP assessment. The active GWMPs cover 4,100 square miles or 49 percent of the Bulletin 118-2003 alluvial groundwater basin area in the region. As of August 2012, all seven of the San Joaquin Valley groundwater subbasins in the Tulare Lake Hydrologic Region are identified as high priority under the CASGEM Basin Prioritization (see Table TL-3). These seven high priority basins account for about 97 percent of the population and about 98 percent of groundwater supply in the region.

Based on the information compiled through inventory of the GWMPs, an assessment was made to understand and help identify groundwater management challenges and successes in the region, and provide recommendations for improvement. Information associated with the GWMP assessment is based on data that were readily available or received through August 2012 by DWR. The assessment process is briefly summarized below.

The California Water Code §10753.7 requires that six components be included in a groundwater management plan for an agency to be eligible for state funding administered by DWR for groundwater projects, including projects that are part of an integrated regional water management program or plan (see Table TL-29). Three of the components also contain required subcomponents. 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 GWMP assessment.

In addition to the six required components, Water Code §10753.8 provides a list of twelve components that may be included in a groundwater management plan (Table TL-29). Bulletin 118-2003, Appendix C provides a list of seven recommended components related to management development, implementation, and evaluation of a GWMP, that should be considered to help ensure effective and sustainable groundwater management plan (Table TL-29).

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

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

PLACEHOLDER Table TL-29 Assessment for SB 1938 GWMP Required Components, SB 1938 GWMP Voluntary Components, and Bulletin 118-03 Recommended Components

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

In summary, assessment of the groundwater management plans in the North Coast Hydrologic Region indicates the following:

- Five of the 17 active GWMPs adequately address all of the required components listed under Water Code §10753.7. These five GWMPs cover only 18 percent of the Bulletin 118-2003 alluvial groundwater basin area in the region. Of the rest, ten plans did not identify activities to evaluate surface water and groundwater interaction. These same 10 plans also did not develop sufficient monitoring protocols that would help ensure correctness and consistency when measuring, recording, and presenting field data. Two plans provided monitoring protocols for the surface and groundwater interaction but did not sufficiently establish Basin Management Objectives (BMOs) or identify the necessary management actions that would be implemented in the event that BMOs were exceeded. The plans that fail to meet all the required components, does not address the BMO and Monitoring Protocol subcomponents for surface water-groundwater interaction. Analysis of the GWMPs for other regions also reveals that when a plan lacks BMO details for surface water and groundwater interaction, it generally lacks details for Monitoring Protocols as well.
- Nine of the 17 active GWMPs incorporate the 12 voluntary components listed in Water Code §10753.8; the remaining plans incorporate eleven or fewer of the voluntary components.
- Ten of the 17 active GWMPs include all seven components, while the remaining plans include six of the seven components recommended in Bulletin 118-03.

The DWR/ACWA survey asked respondents to identify key factors that contributed to the successful implementation of the agency's GWMP. Eleven agencies from the region participated in the survey. 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 along with 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. About 50 percent of the respondents also 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 to consider.

Survey participants were also asked to identify factors that impeded implementation of the GWMP. Six survey participants responded. Overall, respondents pointed to a lack of adequate funding as the greatest impediment to GWMP implementation. Funding is a challenging factor for many agencies because implementation and operation of groundwater management projects typically are 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.

Finally, the survey asked if the respondents were confident in the long-term sustainability of their current groundwater supply. Sixty percent of the respondents felt long-term sustainability of their groundwater supply was not feasible.

The responses to the survey are furnished in Tables TL-GW-30 and TL-31. *More detailed information on the DWR/ACWA survey and assessment of the GWMPs are available online from Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013.*

PLACEHOLDER Table TL-30 Factors Contributing to Successful Groundwater Management Plan Implementation in the Tulare Lake Hydrologic Region

PLACEHOLDER Table TL-31 Factors Limiting Successful Groundwater Management Plan Implementation in the Tulare Lake Hydrologic Region

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Groundwater Ordinances

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

There are a number of groundwater ordinances that have been adopted by counties in the region (Table TL-32). The region includes Fresno, Kern, Kings, and Tulare Counties. The three Fresno County ordinances 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. However, none of the ordinances provide for comprehensive groundwater management.

PLACEHOLDER Table TL-32 Groundwater Ordinances that Apply to Counties in the Tulare Lake Hydrologic Region

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Special Act Districts

Greater authority to manage groundwater has been granted to a few local agencies or districts created through a special act of the Legislature. The specific authority of each agency varies, but the agencies can be grouped into two general categories: (1) agencies having authority to limit export and extraction (upon evidence of overdraft or threat of overdraft) or (2) agencies lacking authority to limit extraction, but having authority to require reporting of extraction and to levy replenishment fees.

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 (Table TL-33 and Figure TL-33). The Brite, Tehachapi East, Tehachapi West, and

Cummings basins are collectively managed by The Tehachapi-Cummings County Water District.

PLACEHOLDER Table TL-33 Groundwater Adjudications in the Tulare Lake Hydrologic Region

PLACEHOLDER Figure TL-33 Groundwater Adjudications in the Tulare Lake Hydrologic Region

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Other Groundwater Management Planning Efforts

Groundwater management also occurs through other avenues such as IRWMPs, Urban Water Management plans, and Agriculture Water Management plans. Box TL-2 summarizes these other planning efforts.

PLACEHOLDER Box TL-2 Other Groundwater Management Planning Efforts in the Tulare Lake Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

State Funding Received from IRWM

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 (Table TL-34). 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 Water Forum IRWM 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 Water Forum received $755,000 in Local Groundwater Assitance 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.

PLACEHOLDER Table TL-34 Integrated Regional Water Management Grants Awarded

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Current Relationships with Other Regions and States

This section is under development.

Regional Water Planning and Management

Integrated Regional Water Management Coordination and Planning

Integrated Regional Water Management (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 integrated water management 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 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 many 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 pumping. One of their Disadvantaged Communities (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 group will be expanding the capacity of the city of Clovis surface water treatment plant which will reduce the city's reliance of mainly 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. Through the Kings Basin Disadvantaged Communities Pilot Project Study, they are developing an inventory of the DACs within the basin and their water needs while learning how to better integrate and engage the DACs in the IRWM planning process.

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 acre-feet per year by adding delivery flexibility and enhanced flood control to water districts that receive SWP and CVP supplies delivered from the CA 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 Regional Water Boards 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 Water Boards adopt water quality control plans or basin plans that lay out the framework for how the Board will protect water quality in its region. The basin plans designate the beneficial uses of surface and ground water in the region, water quality objectives to meet the beneficial uses and establish an implementation program to achieve the water quality objectives and protect the beneficial uses. The implementation program describes how the Board will coordinate its regulatory and non-regulatory programs to address specific water quality concerns.

Overarching all the Central Valley Water Board's 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 basin-wide salt and nitrate management. The regulatory structure will have four key elements: (1) refinement of the agricultural supply (AGR), municipal and domestic supply (MUN) and groundwater recharge (GWR) beneficial uses; (2) revision of water quality objectives for these uses; (3) establishment of policies for assessing compliance with the beneficial uses and water quality objectives; and (4) establishment of management areas where there are large scale differences in baseline water quality, land use, climate conditions, soil characteristics and existing infrastructure and where short and long term salt and/or nitrate management is needed. For the Tulare Lake Hydrologic Region, CV-SALTS plans to implement pilot projects to demonstrate refinement of beneficial uses in the groundwater in the Tulare Lake Bed; 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. (CV-SALTS. 2012a and CV-SALTS, 2012b) CV-SALTS is coordinating and building off the salinity reduction and control efforts described under the Accomplishments section.

Surface Water

The Central Valley Water Board 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. (CVRWQCB. 2011a)
- In the west side of the Tulare Lake Hydrologic Region, there are farm lands 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 Basin, 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. (CVRWQCB. 2004)
- The Discharge to Land Program oversees the investigation and cleanup of impacts of current and historic unauthorized discharges including discharges from historic mining activities.

Historic mine impacts include mercury impairments from mercury mines found on the Coast Range side of the Central Valley and mercury impairments from the use of mercury to amalgamate gold in the mines on the Sierra side.

- 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. Nonpoint 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, the Central Valley Water Board has specific regulatory programs. The Nonpoint Source Program addresses sources where the Central Valley Water Board has not developed a specific program. This program has assisted stakeholders obtain funding to address nonpoint 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

The Central Valley Water Board 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 Water 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. The Central Valley Water Board 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 (CVRWQCB. 2010b):

- The Central Valley Water Board has a program to regulate discharges from confined animal operations. Water quality issues associated with confined animal operations are salt and nutrients. In 2007, the Central Valley Water Board adopted Waste Discharge Requirements General Order for Existing Milk Cow Diaries (R5-2007-0035) which includes requirements for both the dairy production area and land application area and requires each dairy to fully implement their Waste Management Plan by 2011 and Nutrient Management Plan by 2012. [When the Water Plan is updated, these dates will be in the past, so we should include a status report on the number (percentage) of dairies in compliance.] The requirements for the Waste and Nutrient Management Plans are designed to protect both surface and ground water. In the Tulare Lake Hydrologic Region, there are 559 dairies with over 919,000 cows regulated under this general order.
- The Central Valley Water Board’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 and groundwater. Irrigated lands may be a source of salt, nitrates and pesticides to

ground water.

- The State Water Board 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. The Central Valley Water Board plans to update its guidelines and establish a program based on the new regulations. In the past, the Central Valley Water Board has prohibited discharge in problematic service areas. In the Tulare Lake Hydrologic Region, the Central Valley Water Board 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 oil fields are located in the Tulare Lake Basin. 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 which is used directly or blended with other waters for agricultural supply. Discharge to sumps is allowed when the quality meets basin plan requirements. Produced water is also re-injected into aquifers that have received an exemption pursuant to 40 CFR section 261.3.
- The Central Valley Water Board has established the Groundwater Monitoring Advisory Workgroup (GMAW) whose primary goal is to provide input on matters related to groundwater monitoring. Specifically, the GMAW will advise and provide comments to Central Valley Water Board staff on technical issues related to how groundwater monitoring studies are conducted and evaluation of monitoring data.

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.

During this time period, the Central Valley Water Board approved the Groundwater Quality Protection Strategy and Workplan to establish a long-term strategy that will identify high priority activities (CVRWQCB. 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 and ground waters of the State. The Central Valley Water Board has successfully implemented its general order for existing milk cow dairies. In the Tulare Lake Hydrologic Region, 559 dairies are covered by this general order that requires implementation of waste and nutrient management plans. In addition, the Central Valley Water Board has successfully made improvements to its land discharge program to increase groundwater monitoring and reduce the backlog of waste discharge requirements.

In October 2011, the Glennville Mutual Water Company community water supply system began making 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 the Central Valley Water Board (a litigation settlement fund), the State Water Board (Emergency, Abandoned and

Recalcitrant Fund), and the California Department of Public Health (grant funds). Discovery of the MTBE contamination was not made until after the Central Valley Water Board settlement was finalized, thus making the Central Valley Water Board responsible for providing the residents with suitable drinking water. Central Valley Water Board 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. (CV-SALTS. 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, the Central Valley Water Board amended the General Order in April 2009 to allow an additional year for dairies to submit certain elements of the Waste Management Plan. The Central Valley Water Board also approved the Central Valley Dairy Representative Monitoring Program as an alternative to installing individual groundwater monitoring systems at each dairy facility. (CVRWQCB. 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. (CVRWQCB. 2011b)

A major challenge is the ability of small communities to address water quality issues. Small communities with wastewater treatment plants face increasingly stringent wastewater requirements and have difficulty meeting these requirements due to the cost of compliance. The Central Valley has approximately 600,000 individual 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.

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

For Update 2013, the Water Plan 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 comprised of factors related to future population growth and factors related to future climate change. Growth factors for the Tulare Lake are described below. Climate change factors are described in general terms in Chapter 5, Volume 1.

PLACEHOLDER Box TL-3 Evaluation of Water Management Vulnerabilities – Tulare Lake Region

PLACEHOLDER Box TL-3 Figure TL-A Range of Urban and Agricultural Reliability Results across Scenarios for the Tulare Lake Region

PLACEHOLDER Box TL-3 Figure TL-B Range of Change in Groundwater Results across Scenarios for the Tulare Lake region

PLACEHOLDER Box TL-3 Figure TL-C Climate Conditions Leading to Low Urban Reliability Results in the Tulare Lake Region

PLACEHOLDER Box TL-3 Figure TL-D Climate Conditions Leading to Low Agricultural Reliability Results in the Tulare Lake Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the chapter.]

Water Conservation

The Water Plan 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 Memorandum of Understanding (CUWCC 2004). 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, such as population growth, planting decisions by farmers, and size and type of urban landscapes. See Table TL-35 for a conceptual description of the growth scenarios used in the CWP. The CWP 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 the CWP uses three different but plausible population growth estimates when determining future urban water demands. In addition, the CWP considers up to three different alternative views of future development density. Population growth and development density will reflect how large the urban landscape will become in 2050 and are used by the CWP to quantify encroachment into agricultural lands by 2050 in the Tulare Lake region.

PLACEHOLDER Table TL-35 Conceptual Growth Scenarios

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

For Update 2013, DWR worked with researchers at the University of California, Davis, to quantify how much growth might occur in the Tulare Lake 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-36 describes the amount of land devoted to urban use for 2006 and 2050, and the change in the urban footprint under each scenario. As shown in the table, the urban footprint grew by about 150 thousand acre under low population growth scenario (LOP) by 2050 relative to 2006 base-year footprint of about 500 thousand acres. Urban footprint under high population scenario (HIP), however, grew by about 330 thousand acres. The effect of varying housing density on the urban footprint is also shown.

PLACEHOLDER Table TL-36 Growth Scenarios (Urban) – Tulare Lake

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Table TL-37 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.

PLACEHOLDER Table TL-37 Growth Scenarios (Agriculture) – Tulare Lake

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Tulare Lake 2050 Water Demands

In this section a description is provided for how future water demands might change under scenarios organized around themes of growth and climate change described earlier in this chapter. The change in water demand from 2006 to 2050 is estimated for the Tulare Lake 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 CAT scenarios described in Chapter 5, Volume 1 and a 13th scenario representing a repeat of the historical climate (1962-2006) to evaluate a “without climate change” condition.

Figure TL-34 shows the change in water demands for the urban and agricultural sectors under nine growth scenarios, with variation shown across 13 climate scenarios. The nine growth scenarios include three alternative population growth projections and three alternative urban land development densities, as shown in Table TL-35. 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. The solid blue dot in Figure TL-34 represents the change in water demand under a repeat of historical climate, while the open circles represent change in water demand under 12 scenarios of future climate change.

PLACEHOLDER Figure TL-34 Change in Tulare Lake Agricultural and Urban Water Demands for 117 Scenarios from 2006-2050 (thousand acre-feet)

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Urban demand increased under all 9 growth scenarios tracking with population growth. On average, it increased by about 510 thousand acre-feet under the three low population scenarios, 770 thousand acre-feet under the three current trend population scenarios and about 1040 thousand acre-feet under the three high population scenarios when compared to historical average of about 670 thousands-acre-feet. The results show change in future urban water demands are less sensitive to housing density assumptions or climate change than to assumptions about future population growth.

Agricultural water demand decreases under all future scenarios due to reduction in irrigated lands as a result of urbanization and background water conservation when compared with historical average water demand of about 9470 thousand acre-feet. Under the three low population scenarios, the average reduction in water demand was about 570 thousand acre-feet while it was about 860 thousand acre-feet for the three high population scenarios. For the three current trend population scenarios, this change was about 750 thousand acre-feet. The results show that low density housing would result in more reduction in agricultural demand since more lands are lost under low-density housing than high density housing.

Integrated Water Management Plan Summaries

Inclusion of the information contained in IRWMP's into the CWP 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 Integrated Water Management Plan in a consistent format for each of the regional reports. This collection of information will not be used to determine IRWM grant eligibility. This effort is ongoing and will be included in the final CWP updates and will include up to 4 pages for each IRWMP in the regional reports.

In addition to these summaries being used in the regional reports we intend to provide all of the summary sheets in one IRWMP Summary "Atlas" as an article included in Volume 4. 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.

All IRWMP's are different in how are organized and 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 IRWMP's, 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 the CWP Update 2013 and will continue to be part of the process of the update process for Update 2018. This process will also allow for continuous updating of the content of the atlas as new IRWMP's are released or existing IRWMP's are updated.

As can be seen in Figure TL-35 there are 7 IRWM planning efforts ongoing in the Tulare Lake Hydrologic Region.

PLACEHOLDER Figure TL-35 Integrated Water Management Planning in the Tulare Lake Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

Placeholder Text: At the time of the Public Review Draft the collection of information out of the IRWMP's in the region has not been completed. Below are the basic types of information this effort will summarize and present in the final regional report for each IRWMP available. An opportunity will be provided to those with responsibility over the IRWMP to review these summaries before the reports are final.

Region Description: This section will provide a basic description of the IRWM region. This would include location, major watersheds within the region, status of planning activity, and the governance of the IRWM. In addition, a IRWM grant funding summary will be provided.

Key Challenges: The top five challenges identified by the IRWM would be listed in this section.

Principal Goals/Objective: The top five goals and objectives identified in the IRWMP will be listed in this section.

Major IRWM Milestones and Achievements: Major milestones (Top 5) and achievements identified in the IRWMP would be listed in this section.

Water Supply and Demand: A description (one paragraph) of the mix of water supply relied upon in the region along with the current and future water demands contained in the IRWMP will be provided in this section.

Flood Management: A short (one paragraph) description of the challenges faced by the region and any actions identified by the IRWMP will be provided in this section.

Water Quality: A general characterization of the water quality challenges (one paragraph) will be provided in this section. Any identified actions in the IRWMP will also be listed.

Groundwater Management: The extent and management of groundwater (one paragraph) as described in the IRWMP will be contained in this section.

Environmental Stewardship: Environmental stewardship efforts identified in the IRWMP will be summarized (one paragraph) in this section.

Climate Change: Vulnerabilities to climate change identified in the IRWMP will be summarized (one paragraph) in this section.

Tribal Communities: Involvement with tribal communities in the IRWM will be described (one paragraph) in this section of each IRWMP summary.

Disadvantaged Communities: A summary (one paragraph) of the discussions on disadvantaged communities contained in the IRWMP will be included in this section of each IRWMP summary.

Governance: This section will include a description (less than one paragraph) of the type of governance the IRWM is organized under.

Resource Management Strategies

Volume 3 contains detailed information on the various strategies which can be used by water managers to meet their goals and objectives. A review of the resource management strategies addressed in the available IRWMP's are summarized in Table TL-38.

PLACEHOLDER Table TL-38 Resource Management Strategies addressed in IRWMP's in the Tulare Lake Hydrologic Region

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Regional Resource Management Strategies

The Water Boards are responsible for the coordination and control of water quality in California. The Central Valley Water Board is responsible for the Tulare Lake Basin. The following are programmatic level recommendations to improve water quality in the Tulare Lake Hydrologic Region: CV-SALTS: Throughout the Central Valley, and particularly in the Tulare Lake Basin which is an essentially closed basin, participating in the development of salt and nitrate management plans is very important to improving water quality in the region and providing for a sustainable economic and environmental future. 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 ground waters 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 Hydrologic Region, it is important that all stakeholders participate in CV-SALTS to be part of the development and have input on the implementation of salt and nitrate management within the Tulare Lake area. For the Central Valley, the only acceptable process to develop the salt and nutrient management plans that are required under state policy (SWRCB. 2009) is through CV-SALTS. Groundwater Quality Protection Strategy: To protect groundwater quality, the Central Valley Water Board approved a strategy which recommends the following actions:

- Develop Salt & Nutrient Management Plan
- Implement Groundwater Quality Monitoring Program
- Implement Groundwater Protection Programs through IRWM Plan Groups
- Broaden Public Participation in all programs
- Coordinate with local agencies to implement Well Design & Destruction Program
- Groundwater Database
- Alternative Dairy Waste Disposal
- Develop individual and general orders for Poultry, Cattle Feedlots and other types CAFOs
- Implementation of Long-term ILRP
- Coordinate with CDFA 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 Water Code section 13291)
- Develop methods to reduce backlog and increase facilities regulated

Salt and Salinity Management

In March 2010, a Memorandum of Agreement (MOA) was finalized between Central Valley Regional Water Quality Control Board, Central Valley Salinity Coalition (a legal stakeholder entity), and the State Water Resources Control Board 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. The State Water Board 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 disadvantaged communities within the Tulare Lake Basin 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 survey undertaken in 2011-2012 jointly by DWR and ACWA to inventory and assess conjunctive management projects in California is summarized in Box TL-GW-3. *More detailed information about the survey results and a statewide map of the conjunctive management projects and operational information, as of July 2012, is available online from Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013.*

PLACEHOLDER Box TL-4 Statewide Conjunctive Management Inventory Effort in California

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Conjunctive Management Inventory Results

Of the 89 conjunctive management programs identified in California as part of the DWR/ACWA survey, 37 projects 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, while the most recent project was developed in 2002 by the Kings County Water District. Although the majority of the surveyed agencies did not indicate the year their conjunctive management program was developed, based on data received, 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 region, the largest capital expenditure to develop a local conjunctive management project was reported to be $5 million by the Kings County Water District. The Tehachapi-Cummings County Water District indicated capital costs of about $700,000 for their conjunctive management project.

Survey responses by two agencies for the region indicate the annual operation cost for a local conjunctive management projects ranged from $30,000 for the Tehachapi-Cummings County project to about $250,000 per year by the Kings County Water District.

Based on the information reported in the survey, the administrator/operator of a conjunctive management project is generally the lead agency of the project.

According to the survey results from data furnished 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 million acre-foot. The capacity for the Kern Water Bank Authority is one million acre-foot, while City of Bakersfield's program reported a capacity of 800 taf. The Arvin-Edison Water Storage District, the Kings County Water District, and the Tehachapi-Cummings County Water District have groundwater recharge programs of 500, 20 and 10 taf, respectively.

Out of nine agencies reporting, seven use water from the State Water Project, six use water from the Central Valley Project, 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 from any of the nine agencies.

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

Most of the survey respondents included multiple goals and objectives. As shown in Figure TL-36, overdraft correction was identified by about 80 percent of the 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.

PLACEHOLDER Figure TL-36 Conjunctive Management Program Goals and Objectives

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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. As shown in Figure TL-37, 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).

PLACEHOLDER Figure TL-37 Constrains Towards Development of Conjunctive Management and Water Banking Programs

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More details on the conjunctive management survey results is available online from Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013 and DWR Bulletin 118-2003.Additional information regarding conjunctive management in California as well as discussion on associated benefits, costs, and issues can be found online from Water Plan Update 2013 Vol. 3 Ch. 9 Conjunctive Management and Groundwater Storage Resource Management Strategy.

Climate Change

For over two decades, the State and federal governments have been preparing for climate change effects on natural and built systems with a strong emphasis on water supply. Climate change is already impacting many resource sectors in California, including water, transportation and energy infrastructure, public health, biodiversity, and agriculture (USGRCP, 2009; CNRA, 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. 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 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).

Currently, enough data exists to warrant the importance of contingency plans, mitigation (reduction) of greenhouse gas (GHG) emissions, and incorporating adaptation strategies; 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 (CARB, 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 (IPCC, 2007).

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. (EPA/DWR, 2011; Cal-EMA/CNRA, 2012).

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 (WRCC). The Western Regional Climate Center (WRCC) has temperature and precipitation data for the past century. Through an analysis of National Weather Service Cooperative Station and PRISM Climate Group gridded data, scientists from the Western Regional Climate Center have identified 11 distinct regions across the state for which stations located within a region vary with one another in a similar fashion. These 11 climate regions are used when describing climate trends within the state (Abatzoglou, J.T., et al, 2009). DWR's hydrologic regions do not correspond directly to WRCC's climate regions. A particular hydrologic may overlap more than one climate region, and hence have different climate trends in different areas. For the purpose of this regional report, climate trends of overlapped climate regions are considered to be relevant trends for respective portions of the overlapping hydrologic region.

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 (0.5-1.0 °C), with minimum temperatures increasing 2-3 °F (1.1-1.6 °C) compared to the mean maximum temperature trend, which was relatively stable. The WRCC Sierra region also had an increasing mean temperature trend of 0.8-1.9 °F (0.4-1.1 °C), and again more warming was observed at night than in daytime [1.7-2.7 °F (0.9-1.5 °C) compared to -0.3-1.3 °F (-0.2-0.7 °C)].

Projections and Impacts

While historic data is a measured indicator of how the climate is changing, it can't project what future conditions may be like under different GHG emissions scenarios. Current climate science uses modeling methods to simulate and develop future climate projections. A recent study by Scripps Institution of Oceanography uses the most sophisticated methodology to date, and indicates that by 2060-2069, temperatures will be 3.4 - 4.9oF (1.9 - 2.7oC) higher across the state than they were from 1985 to1994 (Pierce et al, 2012). By 2060-69, 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 temperatures over 100 °F (55.6 °C), are expected to increase three to five times by 2050 and seven to ten times by 2100 (Cal-EMA/CNRA, 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 (Cal-EMA and CNRA, 2012b).

Changes in annual precipitation across California, either in timing or total amount, will result in changes to the type of precipitation (rain or snow) in a given area and to the timing and volume of surface runoff. 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 expected to continue to decline as warmer temperatures raise the elevation of snow levels, reduce spring snowmelt, and increase winter runoff. Based upon historical data and modeling, researchers at Scripps Institution of Oceanography project that, by the end of this century, the Sierra snowpack will experience a 48 to 65 percent loss from its average at the end of the previous century (van Vuuren 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.

A recent study that explores future climate change and flood risk in the Sierra using downscaled simulations (computer projections refined to a scale smaller than global models), from three global climate models (GCMs) under a GHG scenario which is reflective of current trends, indicates a tendency toward increased 3-day flood magnitude. By the end of the 21st century, all three projections yield larger floods for both the moderate elevation northern Sierra Nevada watershed and for the high elevation southern Sierra Nevada watershed, even for GCM simulations with 8–15% 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 increase to 110% to 150% 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).

Changes in climate and runoff patterns may create increased competition among sectors that utilize water. The region is economically dependent on a thriving agricultural industry, which will be affected by a more variable hydrologic regime, reduced chill-hours in winter, increased evapotranspiration, and other indirect effects of rising temperatures. 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 a anticipated increase in extreme heat days and reduced water availability (Cal-EMA/CNRA, 2012). Agricultural water use efficiency will become increasingly important under these conditions. Additional climate change impacts will occur in surrounding watersheds. Wildfires in the Sierra foothills may increase in number and intensity (Westerling, 2008), impacting habitat and water quality in the region.

Adaptation

Climate change has the potential to increase the vulnerability of natural and built systems in the region, which the State depends upon for its economic and environmental benefits. Impacts to natural systems will challenge aquatic and terrestrial species with diminished water quantity and quality, and shifting eco-regions. Built systems will be impacted by changing hydrology and runoff timing, as well as loss of natural snowpack storage, making the region more dependent on surface storage in reservoirs and groundwater sources. Increased future 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 (EPA/DWR, 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.

Integrated Regional Water Management (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 (DWR, 2010). IRWM regions must identify and prioritize their specific vulnerabilities, and identify adaptation strategies that are most appropriate for sub-regions. Planning strategies to address vulnerabilities and adaptation to climate change should be both proactive and adaptive, starting with low-regrets 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 (EPA/DWR, 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 of California has developed additional tools and resources to assist resource managers and local agencies in adapting to climate change, including:

- *California Climate Adaptation Strategy (2009)* - California Natural Resources Agency (CNRA) at: http://www.climatechange.ca.gov/adaptation/strategy/index.html
- *California Climate Change Adaptation Planning Guide (2012)* - California Emergency Management Agency (Cal-EMA) and CNRA at: http://resources.ca.gov/climate_adaptation/local_government/adaptation_planning_guide.html
- *Cal-Adapt* website at: http://cal-adapt.org/
- *Urban Forest Management Plan (UFMP) 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* website at: http://www.water.ca.gov/climatechange/resources.cfm
- *The Governor's Office of Planning and Research (OPR)* website at: http://www.opr.ca.gov/m_climatechange.php

Many of the Resource Management Strategies from California Water Plan Update 2009 (Volume 3) provide benefits for adapting to climate change in addition to meeting water management objectives. These include:

- Agricultural/Urban Water Use Efficiency;
- Conveyance – Regional/local;
- System Reoperation;
- Conjunctive Management and Groundwater Storage;
- Precipitation Enhancement;
- Surface Storage – Regional/Local;
- Pollution Prevention;
- Agricultural Land Stewardship;
- Ecosystem Restoration;
- Forest Management;
- Land Use Planning and Management;
- Recharge Area Protection;
- Watershed Management
- Flood Risk and Integrated Flood 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/LGC, 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 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.

Mitigation

California's water sector has a large energy footprint, consuming 7.7% of statewide electricity (CPUC, 2010). Energy is used in the water sector to extract, convey, treat, distribute, use, condition, and dis-pose of water. Figure 3-26, Water-Energy Connection in Volume 1, CA Water Today 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 the 2013 California Water Plan Update are the first to provide detailed information on the water-energy connection, including energy intensity (EI) information at the regional level. This 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 related to Greenhouse Gas (GHG) emissions, this information can support measures to reduce GHG's, as mandated by the State.

Figure TL-38 shows the amount of energy associated with the extraction and conveyance of 1 acre-foot of water for each of the major sources in this region. The quantity used is also included, as a percent. For reference, Figure 3-26, Water-Energy Connection in CA Water Today, Volume 1 highlights which water-energy connections are illustrated in Figure TL-38; only extraction and conveyance of raw water. 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 by gravity to the delivery location and therefore do not require any energy to extract or convey (represented by a white light bulb).

Recycled water and water from desalination used within the region are not show in Figure TL-38 because their energy intensity differs in important ways from those water sources. The energy intensity 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-38. For these reasons, discussion of energy intensity of desalinated water and recycled water are included in Volume 3, Resource Management Strategies.

Energy intensity, sometimes also known as embedded energy, is the amount of energy needed to extract and convey (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 no energy for extraction, while others like groundwater or sea water 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, typically but not always a water treatment facility. Conveyance can include pumping of water up hills and mountains or can occur by gravity) an acre-foot of water from its source (e.g. groundwater or a river) to a delivery location, such as a water treatment plant or a State Water Project (SWP) delivery turnout (In-conduit generating facilities refer to hydroelectric turbines that are placed along pipelines to capture energy as water runs downhill in a pipeline (conduit)). Energy intensity should not be confused with total energy—that is, the amount of energy (e.g. kWh) required to deliver all of the water from a water source to customers within the region. Energy intensity focuses not on the total amount of energy used to deliver water, but rather the energy required to deliver a single unit of water (in kWh/acre-foot). In this way, energy intensity gives a normalized metric which can be used to compare alternative water sources.

In most cases, this information will not be of 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 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. It's important to note that water supply planning must take into consideration a myriad of different factors in addition to energy impacts; costs, water quality, opportunity costs, environmental impacts, reliability and other many other factors.

Energy intensity is closely related to Greenhouse Gas (GHG) emissions, but not identical, depending on the type of energy used (see CA Water Today, Water-Energy, Volume 1). In California, generation of 1 megawatt-hour (MWh) of electricity results in the emission of about 1/3 of a metric ton of GHG, typically referred to as carbon dioxide equivalent or CO2e (eGrid, 2012). This estimate takes into account the use of GHG-free hydroelectricity, wind, and solar and fossil fuel sources like natural gas and coal. The GHG emissions from a specific electricity source may be higher or lower than this estimate.

Reducing GHG emissions is a State mandate. Water managers can support this effort by considering energy intensity factors, such as those presented here, in their decision making process. Water use efficiency and related best management practices can also reduce GHGs (See Volume 2, Resource Management Strategies).

Accounting for Hydroelectric Energy

Generation of hydroelectricity is an integral part of many of the state's large water projects. In 2007, hydroelectric generation accounted for nearly 15% of all electricity generation in California. The State Water Project, Central Valley Project, Los Angeles Aqueduct, Mokelumne Aqueduct, and Hetch Hetchy Aqueducts 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. Hydroelectricity is also generated at hundreds of smaller reservoirs and run-of-the-river turbine facilities.

Hydroelectric generating facilities at reservoirs provide unique benefits. Reservoirs like the State Water Project's Oroville Reservoir are operated to build up water storage at night when demand for electricity is low, and release the water during the day time hours when demand for electricity is high. This operation, common to many of the state's hydropower reservoirs, helps improve energy grid stabilization and reliability and reduces GHG emissions by displacing the least efficient electricity generating facilities. Hydroelectric facilities are also extremely effective for providing back-up power supplies for intermittent renewable resources like solar and wind power. Because the sun can unexpectedly go behind a cloud or the wind can die down, intermittent renewables need back up power sources that can quickly ramp up or ramp down depending on grid demands and generation at renewable power installations.

Despite these unique benefits and the fact that hydroelectric generation was a key component in the formulation and approval of many of California's water systems, accounting for hydroelectric generation in energy intensity calculations is complex. In some systems like the SWP and CVP, water generates electricity and then flows back into the natural river channel after passing through the turbines. In other systems like the Mokelumne aqueduct water can leave the reservoir by two distinct out flows, one that generates electricity and flows back into the natural river channel and one that does not generate electricity and flows into a pipeline flowing into the East Bay Municipal Utility District service area. In both these situations, experts have argued that hydroelectricity should be excluded from energy intensity calculations because the energy generation system and the water delivery system are in essence separate (Wilkinson, 2000).

DWR has adopted this convention for the energy intensity for hydropower in the regional reports. All hydroelectric generation at head reservoirs has been excluded from Figure TL-38. 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 San Francisquito, San Fernando, Foothill and other power plants on the system (downstream of the Owen's River Diversion Gates). DWR 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 energy intensity is reported as zero (0). I.e., no water system is reported as a net producer of electricity, even though several systems do produce more electricity in the conveyance system than is used (e.g., Los Angeles Aqueduct, Hetch Hetchy Aqueduct). (For detailed descriptions of the methodology used for the water types presented, see Technical Guide, Volume 5).

PLACEHOLDER Figure TL-38 Energy Intensity of Raw Water Extraction and Conveyance in the Tulare Lake Hydrologic Region

[Any draft tables, figures, and boxes that accompany this text for the public review draft are included at the end of the report.]

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Additional References

Personal Communications

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

(Note: This is a DRAFT Table and is subject to further review before going final)

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

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

(Note: This is a DRAFT table and is subject to further review before going final)

County	Total Number of Well Logs by Well Use						Total Well Records
	Domestic	Irrigation	Public Supply	Industrial	Monitoring	Other	
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**

Table TL-3 CASGEM Groundwater Basin Prioritization for the Tulare Lake Hydrologic Region

(Note: This is a draft table and is subject to further review before going final)

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 *Water Plan Update 2013 Vol. 4 Reference Guide – California's Groundwater Update 2013*			
Totals:	**19**		**Population of Groundwater Basin Area =**		**2,216,590**

Table TL-4 Groundwater Level Monitoring Wells by Monitoring Entity in the Tulare Lake Hydrologic Region

(Note: This is a DRAFT table and is subject to further review before going final)

State and Federal Agencies	Number of Wells
DWR	268
USGS	4
USBR	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**
(See a full listing of the CASGEM Monitoring Entities on the following page)	
Total CASGEM Monitoring Entities:	**1,894**
Grand Total:	**3,342**

Note: Table includes groundwater level monitoring wells having publically available online data as of July 2012.

Table TL-GW-4 (continued) Tulare Lake Region Groundwater Level Monitoring Wells by Monitoring Entities

(Note: This is a DRAFT table and is subject to further review before going final)

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 Wate District	5
Kings River Conservation District	101
Semitropic Water Storage District	46
Shafter-Wasco Irrigation District	44
Tulare Irrigation District	138
Total CASGEM Monitoring Entities:	1,894

Note: Table includes groundwater level monitoring wells having publically available online data as of July 2012.

Table TL-5 Sources of Groundwater Quality Information for the Tulare Lake Hydrologic Region

(Note: This is a DRAFT table and is subject to further review before going final)

Agency	Links to Information
State Water Resources Control Board	Groundwater • Communities that Rely on a Contaminated Groundwater Source for Drinking Water • Nitrate in Groundwater: Pilot Projects in Tulare Lake Basin/Salinas Valley • Hydrogeologically Vulnerable Areas • Aquifer Storage and Recovery • Central Valley Salinity Alternatives for Long-Term Sustainability (CV-Salts) GAMA • GeoTracker GAMA (Monitoring Data) • Domestic Well Project • Priority Basin Project • Special Studies Project • California Aquifer Susceptibility Project Contaminant Sites • Land Disposal Program • Department of Defense Program • Underground Storage Tank Program • Brownfields
California Department of Public Health	Division of Drinking Water and Environmental Management • Drinking Water Source Assessment and Protection (DWSAP) Program • Chemicals and Contaminants in Drinking Water • Chromium-6 • Groundwater Replenishment with Recycled Water
Department of Water Resources	Groundwater Information Center • Bulletin 118 Groundwater Basins • California Statewide Groundwater Elevation Monitoring (CASGEM) • Groundwater Level Monitoring • Groundwater Quality Monitoring • Well Construction Standards • Well Completion Reports
Department of Toxic Substances Control	• EnviroStor
Department of Pesticide Regulation	Groundwater Protection Program • Well Sampling Database • Groundwater Protection Area Maps
U.S. Environmental Protection Agency	US EPA STORET Environmental Data System
United States Geological Survey	USGS Water Data for the Nation

Table TL-6 Selected Regionally Endemic Endangered Plant Species

Common name	Scientific name	Fed. status	CA status	CA NPS 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: Table shows only Federally Endangered and/or State Endangered and/or CA Native Plant Society Rank 1B.1 plant species.

[a] State and Federal Status Legend

SE = State-listed as Endangered

ST = State-listed as Threatened

FP = Fully Protected under the CA Dept. of Fish & Game

FE = Federally-listed as Endangered

SCE = Candidate for State Listing as Endangered

FC = Candidate for Federal Listing

[b] California Native Plant Society Rank

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

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

1B.3 = Plants Rare, or More or Less Threatened or Endangered in CA and elsewhere

Table TL-7 Selected California Endemic Endangered Plant Species

Common Name	Scientific Name	Fed. Status [a]	CA Status [a]	CA NPS Rank [b]
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: Table shows only Federally Endangered and/or State Endangered and/or CA Native Plant Society Rank 1B.1 plant species.

[a] State and Federal Status Legend

SE = State-listed as Endangered

ST = State-listed as Threatened

FP = Fully Protected under the CA Dept. of Fish & Game

FE = Federally-listed as Endangered

SCE = Candidate for State Listing as Endangered

FC = Candidate for Federal Listing

[b] California Native Plant Society Rank

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

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

1B.3 = Plants Rare, or More or Less Threatened or Endangered in CA and elsewhere

Table TL-8 Endangered Wildlife Species

Common Name	Scientific Name	Fed. Status [a]	CA Status [a]	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: Table shows only Federally Endangered or State Endangered wildlife species. There are no FE or SE fish species in the TL HR.

State and Federal Status Legend

SE = State-listed as Endangered

ST = State-listed as Threatened

FP = Fully Protected under the CA Dept. of Fish & Game

FE = Federally-listed as Endangered

SCE = Candidate for State Listing as Endangered

FC = Candidate for Federal Listing

Table TL-9 Tulare Lake Hydrologic Region Population by County

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
HR TOTAL	1,876,351	2,093,306	2,267,335

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

Table TL-10 Tulare Lake Hydrologic Region 2010 Top Ten Populous Incorporated Cities

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

Table TL-11 Federally Recognized Tribes in 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

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

Map Number (Red Dot)	Name	Place Type [a]	Population	MHI	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
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

Map Number (Red Dot)	Name	Place Type [a]	Population	MHI	County
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:

[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	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:

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 brussel sprouts

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

Table TL-14 Tulare Lake Hydrologic Region 2004-2010 Change in Urban Area (acres)

County	2004	2010	Change in Area	Change in Area (%)
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 TL HR portion of each county. 2004 was chosen instead of 2005

because the data is only updated in even years.

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

Table TL-15 Surface Water Deliveries to Kern National Wildlife Refuge (Thousand Acre-Feet)

Source	2005	2006	2007	2008	2009	2010
CVPIA	19.9	21.8	21.6	17.7	19.6	21.8

Table TL-16 Surface Water Deliveries to Mendota Wildlife Area (Thousand Acre-Feet)

Source	2005	2006	2007	2008	2009	2010
CVPIA	25.5	21.8	29.8	26.4	25.5	26.6

Table TL-17 Dedicated Natural Flows

	2006	2007	2008	2009	2010	Dedicated Section
Kings River	1727	405	724	809	1220	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 pt. at elev.1595' m.s.l.
Kern River - North Fork	885	242	445	413	700	from segment of main stem from Tulare-Kern Co. line to its headwaters in Sequoia Nat'l Park
Kern River - South Fork	146	22	58	41	96	from headwaters in Inyo Nat'l Forest to southern boundary of the Domelands Wilderness in Sequoia Nat'l Forest

Table TL-18 Tulare Lake Hydrologic Region Average Annual Groundwater Supply by Planning Area (PA) and by Type of Use (2005-2010)

(Note: This is a DRAFT table and is subject to further review before going final)

Tulare Lake Hydrologic Region		Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groundwater	
PA Number	PA Name	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	1,466.9	70%	44.5	100%	1.1	4%	1,512.4	69%
704	Fresno - Academy	56.1	11%	204.5	78%	0.0	0%	260.6	34%
705	Alta - Orange Cove	435.8	46%	59.3	97%	0.0	0%	495.1	49%
706	Kaweah Delta	1,547.5	60%	112.8	97%	3.2	100%	1,663.5	62%
707	Uplands	32.6	97%	14.3	76%	0.0	0%	46.9	89%
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%
2005-10 Annual Average HR Total:		5,662.5	52%	604.1	82%	28.9	37%	6,295.5	54%

Note: 1) TAF = thousand acre-feet

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

3) 2005-10 Precipitation equals 99% of the 30-yr average for the North Coast Region

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

(Note: This is a DRFAT table and is subject to further review before going final)

Tulare Lake Hydrologic Region	Agriculture Use Met by Groundwater		Urban Use Met by Groundwater		Managed Wetlands Use Met by Groundwater		Total Water Use Met by Groundwater	
County	**TAF**	**%**	**TAF**	**%**	**TAF**	**%**	**TAF**	**%**
Fresno	1,705.2	46%	272.4	80%	1.1	4%	1,978.6	48%
Kern	1,549.2	46%	185.6	72%	24.7	55%	1,759.5	48%
Kings	937.7	58%	39.6	94%	0.0	0%	977.3	59%
Tulare	1,652.3	60%	131.3	98%	3.2	100%	1,786.8	62%
2005-10 Annual Avg. Total:	5,844.3	51%	628.9	81%	29.0	37%	6,502.1	53%

Note: 1) TAF = thousand acre-feet

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

3) 2005-10 Precipitation equals 99% of the 30-yr average for the North Coast Region

Table TL-20 Tulare Lake Hydrologic Region Water Demands

AW Demand Type	2005	2006	2007	2008	2009	2010
Total Ag AW as % of Total AW	92.7%	93.3%	92.5%	92.8%	93.5%	93.4%
Total Wildlife Refuge AW as % of Total AW	0.7%	0.6%	0.7%	0.7%	0.6%	0.7%
Total M & I AW as % of Total AW	6.6%	6.0%	6.9%	6.5%	5.9%	5.9%

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

Water System Size	No. of Community Systems	Percent of Community Systems in Region	Population Served	Percent of Population Served
Large (> 10,000 Pop)	35	10%	2,036,266	88%
Medium (3301 - 10,000 Pop)	22	6%	153,154	7%
Small (500 - 3300 Pop)	63	18%	81,840	4%
Very Small (< 500 Pop)	234	66%	31,477	1%
CWS that Primarily Provide Wholesale Water	1	0%	---	---
Total	355		2,302,737	

Note: FCWWD #37/MILE HIGH (System No. 1000040) service area is in both the Tulare Lake Basin & San Joaquin River Regions. To avoid duplication it is only included in the Tulare Lake Hydrologic Region.

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

Table TL-24 Summary of Community Drinking Water Systems in the Tulare Lake Hydrologic Region That Rely on One or More Contaminated Groundwater Well That Exceeds a Primary Drinking Water Standard

Community Drinking Water Systems and Groundwater Wells Grouped by Water System Population	No. of Affected Community Drinking Water Systems	No. of Affected Community Drinking Water Wells
Small System ≤ 3,300	110	163
Medium System 3,301 - 10,000	12	29
Large System ≥ 10,000	24	137
Total	146	329

Source: Water Boards 2012 Draft Report on "Communities that Rely on Contaminated Groundwater"

Table TL-25 Summary of Contaminants Affecting Community Drinking Water Systems in the Tulare Lake Basin Hydrologic Region

Principal Contaminant (PC)	Community Drinking Water Systems where PC exceeds the Primary MCL	No. of Community Drinking Water Wells where PC exceeds the Primary 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: Water Boards 2012 Draft Report on "Communities that Rely on Contaminated Groundwater"

Notes:

Only the 5 most prevalent contaminants are shown.

Wells with multiple contaminants

13 wells are affected by Arsenic and Gross alpha particle activity

11 wells are affected by Nitrate and 1,2-Dibromo-3-chloropropane (DBCP)

10 wells are affected by Nitrate and Gross alpha particle activity

Table TL-26 Spring 2005 – Spring 2010 Annual Change in Groundwater Storage for the Tulare Lake Hydrologic Region

(Note: This is a DRFAT table and is subject to further review before going final)

Tulare Lake Hydrologic Region Spring 2005-10 Change in Storage Estimates			
Reporting Area (Acres):	2,981,955		
Non-Reporting Area (Acres):	2,018,490		
Period Spring - Spring	**Average Change in GW Elevation (feet)**	**Estimated Change in Storage in TAF**	
		Assuming Specific Yield = 0.07	**Assuming Specific Yield = 0.17**
2005-2006	6.9	1,449	3,519
2006-2007	1.1	237	576
2007-2008	-15.4	-3,206	-7,785
2008-2009	-7.7	-1,601	-3,888
2009-2010	-2.6	-539	-1,309
2005-2010 (total)	-17.5	-3,659	-8,887

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

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

Entity	Task
Federal	
Friant-Kern Canal (CVP)	Interregional water supply
US Bureau of Reclamation	Operation of Friant Dam
US Corps of Engineers	Operation of Pine Flat, Isabella, & Kaweah dams
State	
Kern County Water Agency	Water supply and flood control
State Water Project	Interregional water supply
Local	
Alpaugh Joint Powers Authority	Alpaugh ID and Tulare Co. 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	SWP 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, water quality
Panoche Drainage District	Maintain internal drainage
Pinedale County Water District	Water, wastewater, solid waste
So. San Joaquin Municipal Utility District	Agricultural water from CVP, WAPA Power
Tulare Lake Basin Water Storage District	Delivery, storage of SWP water
Tulare Lake Drainage District	Drainage Management

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

(Note: This is a DRAFT table and is subject to further review before going final)

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				
TL-9	**James Irrigation District**	2010	Fresno	5-22.08	Kings
	City of San Joaquin				

Map Label	Agency Name	Date	County	Basin Number	Basin/Subbasin Name
TL-10	**Kaweah Delta Water Conservation District**	2006	Tulare	5-22.11	Kaweah
	No Signatories on File				
TL-11	**Kern Delta Water District**	Pre-2003	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				
	Rasin 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				
TL-17	**Orange Cove Irrigation District**	2006	Tulare	5-22.08	Kings
	Hills Valley Irrigation District				
	Tri-Valley Water District				
TL-18	**NOTE: Missing GWMP Info for TL-18**				
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

Map Label	Agency Name	Date	County	Basin Number	Basin/Subbasin Name
	Kern County Water Agency				
	Southern San Joaquin Municipal Utility				
	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**	1999	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
	No Signatories on File				
TL-26	**Wheeler Ridge-Maricopa Water Storage**	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				

Table TL-29 Assessment for SB 1938 GWMP Required Components, SB 1938 GWMP Voluntary Components, and Bulletin 118-03 Recommended Components

(Note: This is a DRAFT table and is subject to further review before going final)

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 & Affects to Groundwater Levels & 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 (1/1/2013)	Not Assessed
Monitoring Protocols	35%
MP: Changes in groundwater levels	88%
MP: Changes in groundwater quality	88%
MP: Subsidence	76%
MP: SW/GW Interaction & Affects to Groundwater Levels & Quality	41%
SB 1938 Voluntary Components	**Percent of plans that include component**
Saline Intrusion	82%
Wellhead Protection & Recharge	65%
Groundwater Contamination	76%
Well Abandonment & Destruction	94%
Overdraft	88%
Groundwater Extraction & Replenishment	100%
Monitoring	100%
Conjunctive Use Operations	94%
Well Construction Policies	94%
Construction and Operation	59%
Regulatory Agencies	53%
Land Use	76%
Bulletin 118-03 Recommended Components	**Percent of plans that include component**
GMP Guidance	82%
Management Area	94%
BMOs, Goals, & Actions	94%
Monitoring Plan Description	59%
IRWM Planning	88%
GMP Implementation	94%
GMP Evaluation	88%

Table TL-30 Factors Contributing to Successful Groundwater Management Plan Implementation in the Tulare Lake Hydrologic Region

(Note: This is a draft table and is subject to further review before going final)

Key components	Respondents
Data collection and sharing	10
Outreach and education	9
Developing an understanding of common interest	9
Sharing of ideas and information with other water resource managers	8
Broad stakeholder participation	8
Adequate surface water supplies	6
Adequate regional and local surface storage and conveyance systems	5
Water budget	5
Funding	8
Time	6

Table TL-31 Factors Limiting Successful Groundwater Management Plan Implementation in the Tulare Lake Hydrologic Region

(Note: This is a DRAFT table and is subject to further review before going final)

Limiting Factors	Respondents
Funding for groundwater management projects	6
Funding for groundwater management planning	3
Unregulated Pumping	1
Groundwater Supply	4
Participation across a broad distribution of interests	-
Lack of Governance	-
Surface storage and conveyance capacity	5
Understanding of the local issues	2
Access to planning tools	1
Outreach and education	1
Data collection and sharing	-
Funding to assist in stakeholder participation	2

Table TL-32 Groundwater Ordinances that Apply to Counties in the Tulare Lake Hydrologic Region

(Note: This is a draft table and is subject to further review before going final)

County	Groundwater Management	Guidance Committees	Export Permits	Recharge	Well Abandonment & Destruction	Well Construction Policies
Fresno	-	-	Y	-	Y	Y
Kern	-	-	Y	-	-	Y
Kings	-	-	-	-	-	-
Tulare	-	-	-	-	-	-

Table TL-33 Groundwater Adjudications in the Tulare Lake Hydrologic Region

(Note: This is a DRAFT table and is subject to further review before going final)

Court Judgment	Basin Number	County	Judgment Date	Watermaster
Brite Basin	5-80	Kern	1970	Tehachapi-Cummings County Water District
Tehachapi Basin	5-28 6-45	Kern	1973	Tehachapi-Cummings County Water District
Cummings Basin	5-27	Kern	1972	Tehachapi-Cummings County Water District

Note: Table Represents information as of April, 2013

Table TL-34 IRWM Funding

Map No.	Integrated Regional Water Management (IRWM) Region *and Grantee*	Prop. 50 - 2006 Planning Award	Prop. 50 - 2006 Impl. Award	Prop. 50 - 2010 Impl. Supplemental Award	Prop. 84 Round 1 - 2011 Planning Award	Prop. 84 Round 1 - 2011 Impl. Award	Prop. 84 - 2011 Inter-regional Award	Prop. 84 Round 2 - 2012 Planning Award	Prop. 84 2013 Local Groundwater Assistance Award	Prop. 1E Round 1 - 2011 SWFM Award	Prop. 1E Round 2 - 2013 SWFM Award
14	Kaweah River Basin										
	Kaweah Delta Water Conservation District					$4,643,000		$235,254			$3,109,856
	County of Tulare						$2,000,000				
24	Poso Creek										
	Semitropic Water Storage District	$459,900				$8,215,000					
33	Southern Sierra										
	Sequoia Riverlands Trust							$519,987			
38	Upper Kings Basin Water Forum										
	Kings River Conservation District	$500,000	$6,064,375								
	Upper Kings Basin IRWM Authority			$2,099,868	$269,890	$8,496,000	$500,000				
	Fresno Metropolitan Flood Control District								$ 225,000	$2,231,086	$6,891,010
	Kings County Water District								$ 200,000		
	Tranquility Irrigation District								$ 200,000		
	Consolidated Irrigation District								$ 157,370		

SWFM = Stormwater Flood Management

Table TL-35 Conceptual Growth Scenarios

Scenario	Population Growth	Development Density
LOP-HID	Lower than Current Trends	Higher than Current Trends
LOP-CTD	Lower than Current Trend	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

Source: California Department of Water Resources 2012.

Table TL-36 Growth Scenarios (Urban) — Tulare Lake

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

Source: California Department of Water Resources 2012.

Notes:

[a] See Table TL-35 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.

Table TL-37 Growth Scenarios (Agriculture) —Tulare Lake

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	2882.9	3065.1	182.1	-76.8
LOP-CTD	2869.2	3050.4	181.3	--91.5
LOP-LOD	2856.5	3037.0	180.5	-104.9
CTP-HID	2826.9	3005.4	178.6	-136.5
CTP-CTD	2805.6	2982.9	177.3	--159.0
CTP-LOD	2784.6	2960.5	175.9	-181.4
HIP-HID	2790.8	2967.2	176.3	-174.7
HIP-CTD	2760.5	2934.9	174.4	-207.0
HIP-LOD	2729.2	2901.6	172.4	-240.3

Source: California Department of Water Resources 2012.

Notes:

[a] See Table TL-35 for scenario definitions

[b] 2006 Irrigated land area was estimated by the California Department of Water Resources (DWR) to be 2955.2 thousand acres.

[c] 2006 Irrigated crop area was estimated by DWR to be 3141.9 thousand acres.

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

Figure TL-1 Tulare Lake Hydrologic Region

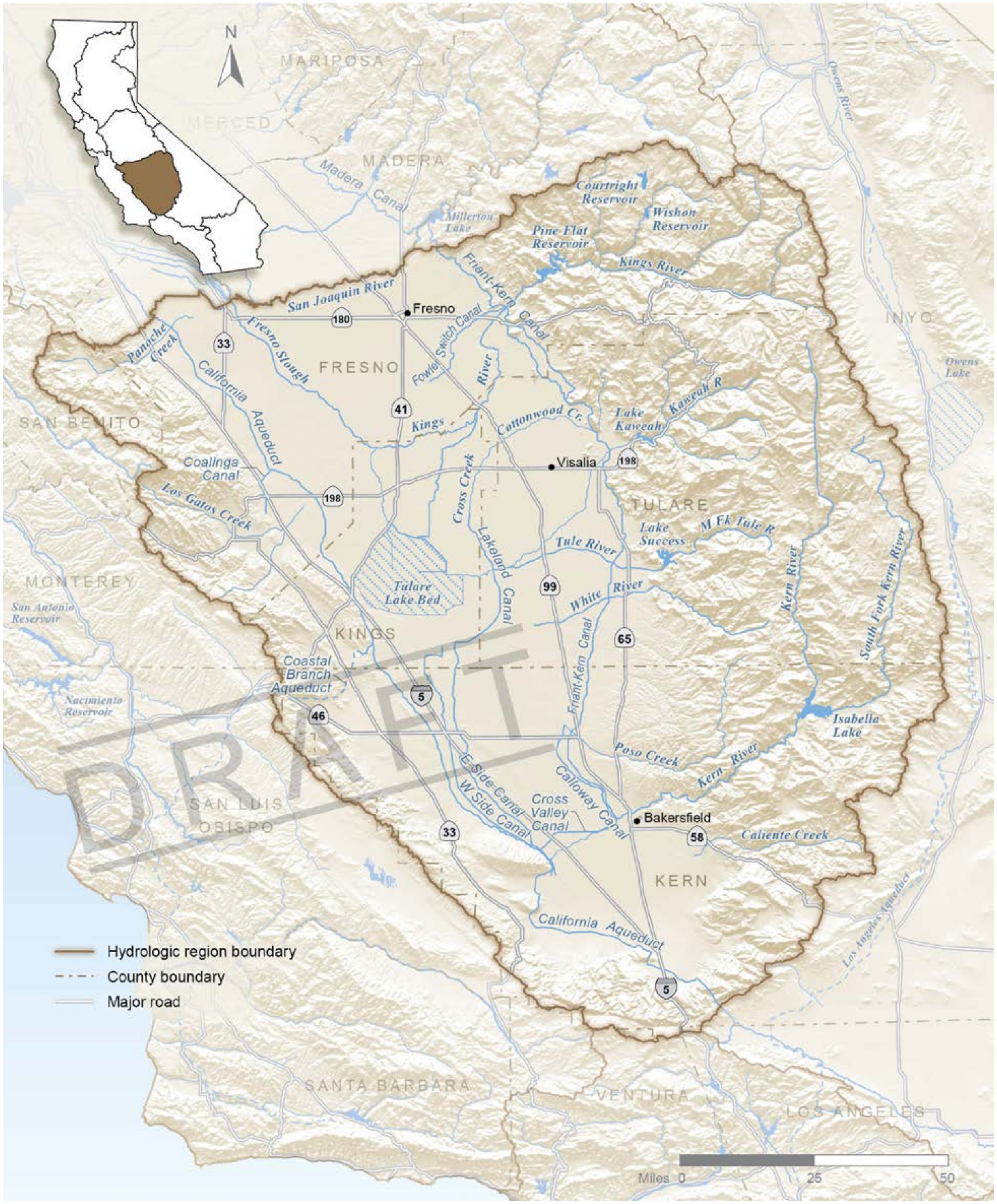


Figure TL-3 Alluvial Groundwater Basins and Subbasins within the Tulare Lake Hydrologic Region

(Note: This is a DRAFT Figure. Final map from Graphics is pending)

Source: Department of Water Resources, CWP 2013

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

(Note: This is a DRAFT figure. Final figure from Graphics is pending)

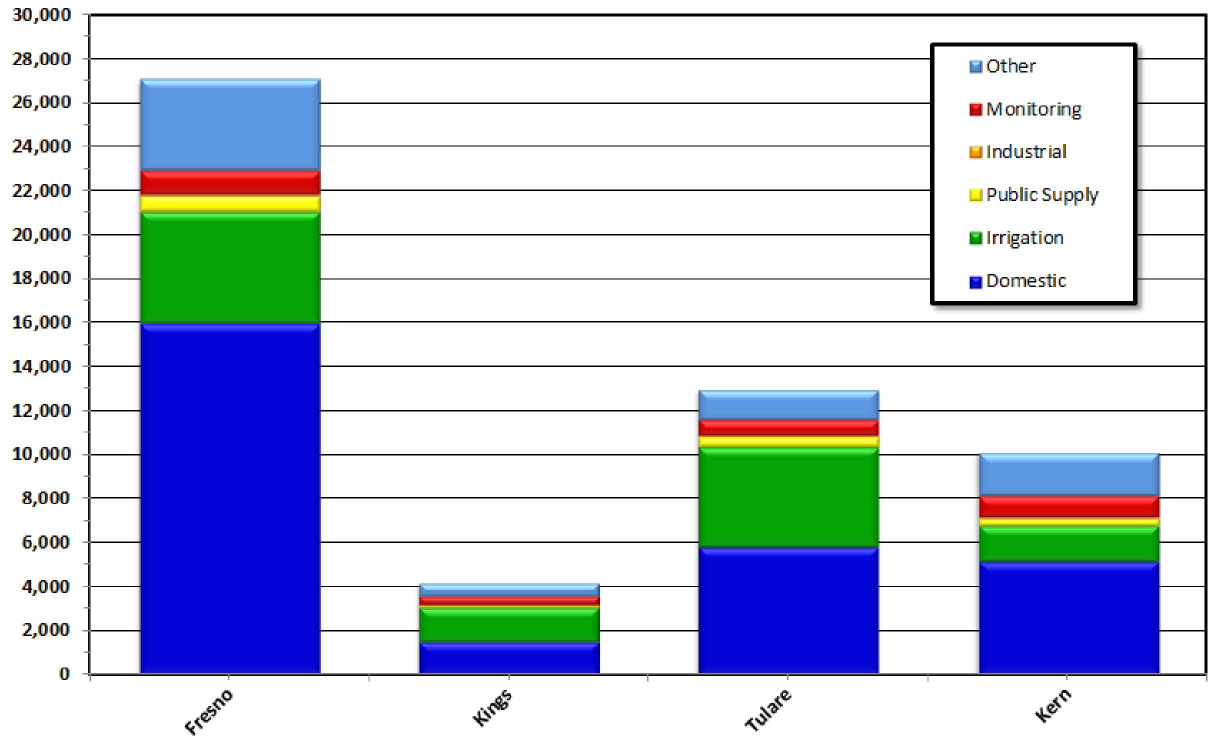


Figure TL-5 Percentage of Well Logs by Use for the Tulare Lake Hydrologic Region (1977–2010)

(Note: This is a DRAFT figure. Final figure from Graphics is pending)

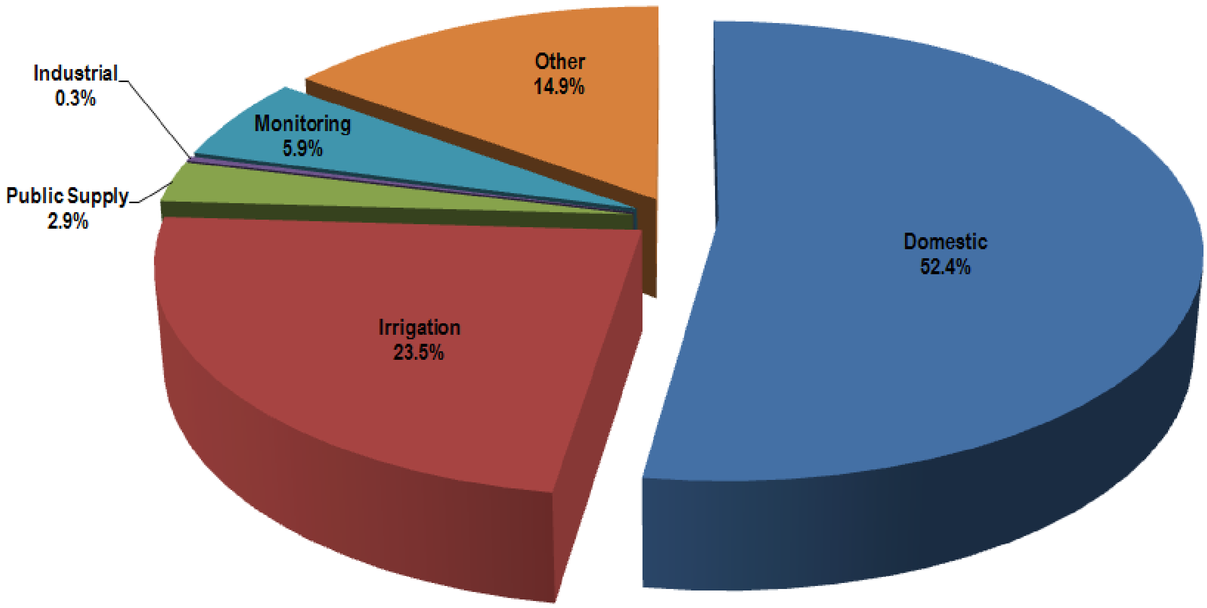


Figure TL-6 Number of Well Logs Filed per Year by Use for the Tulare Lake Hydrologic Region (1977–2010)

(Note: This is a DRAFT figure. Final figure from Graphics is pending)

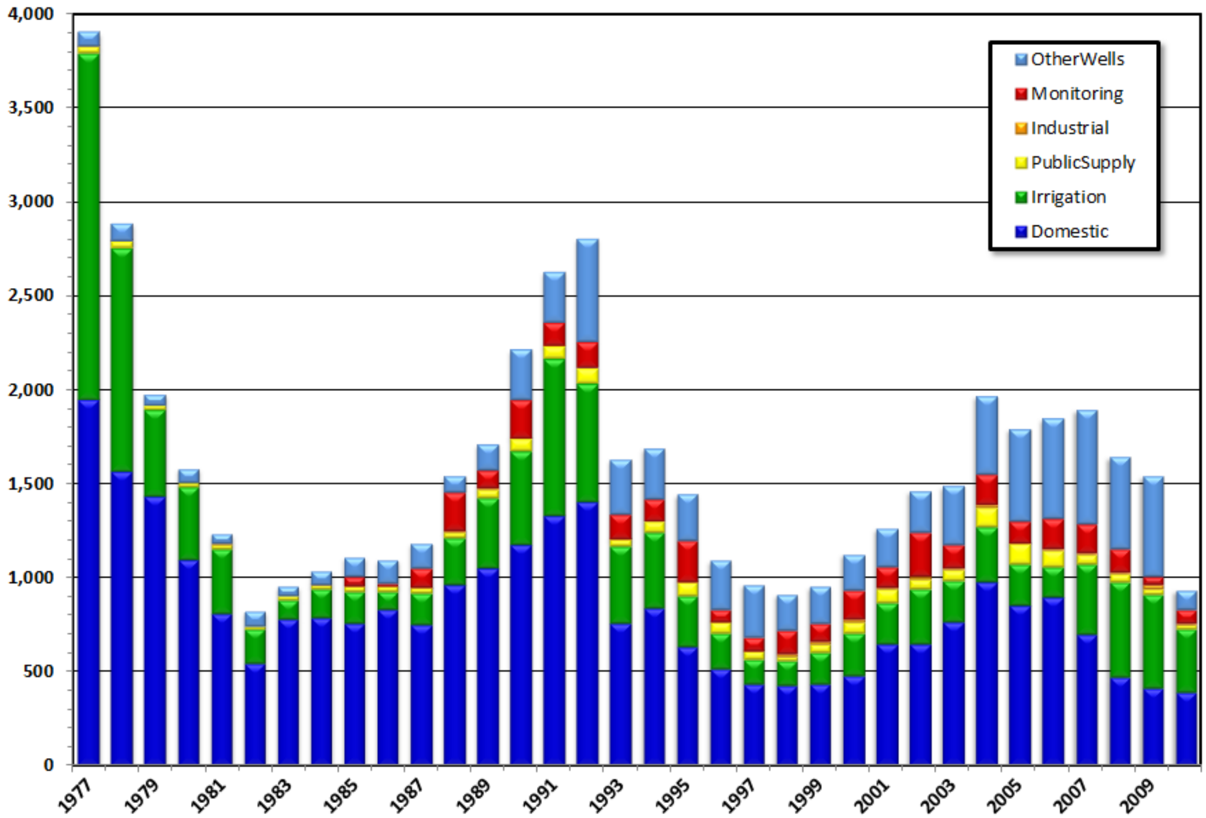


Figure TL-7 CASGEM Groundwater Basin Prioritization for the Tulare Lake Hydrologic Region

(Note: This is a DRAFT figure. Final figure from Graphics is pending)

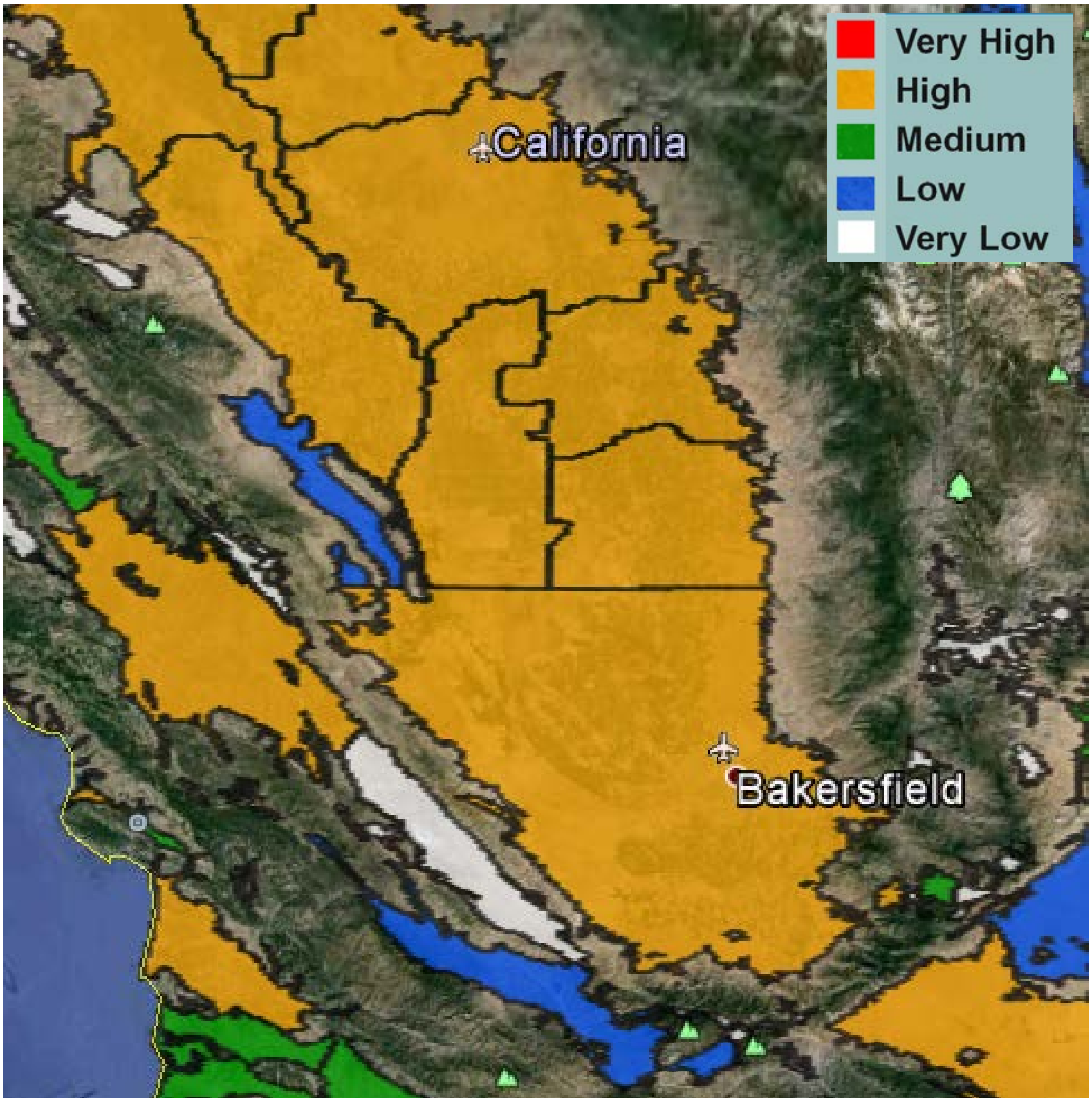
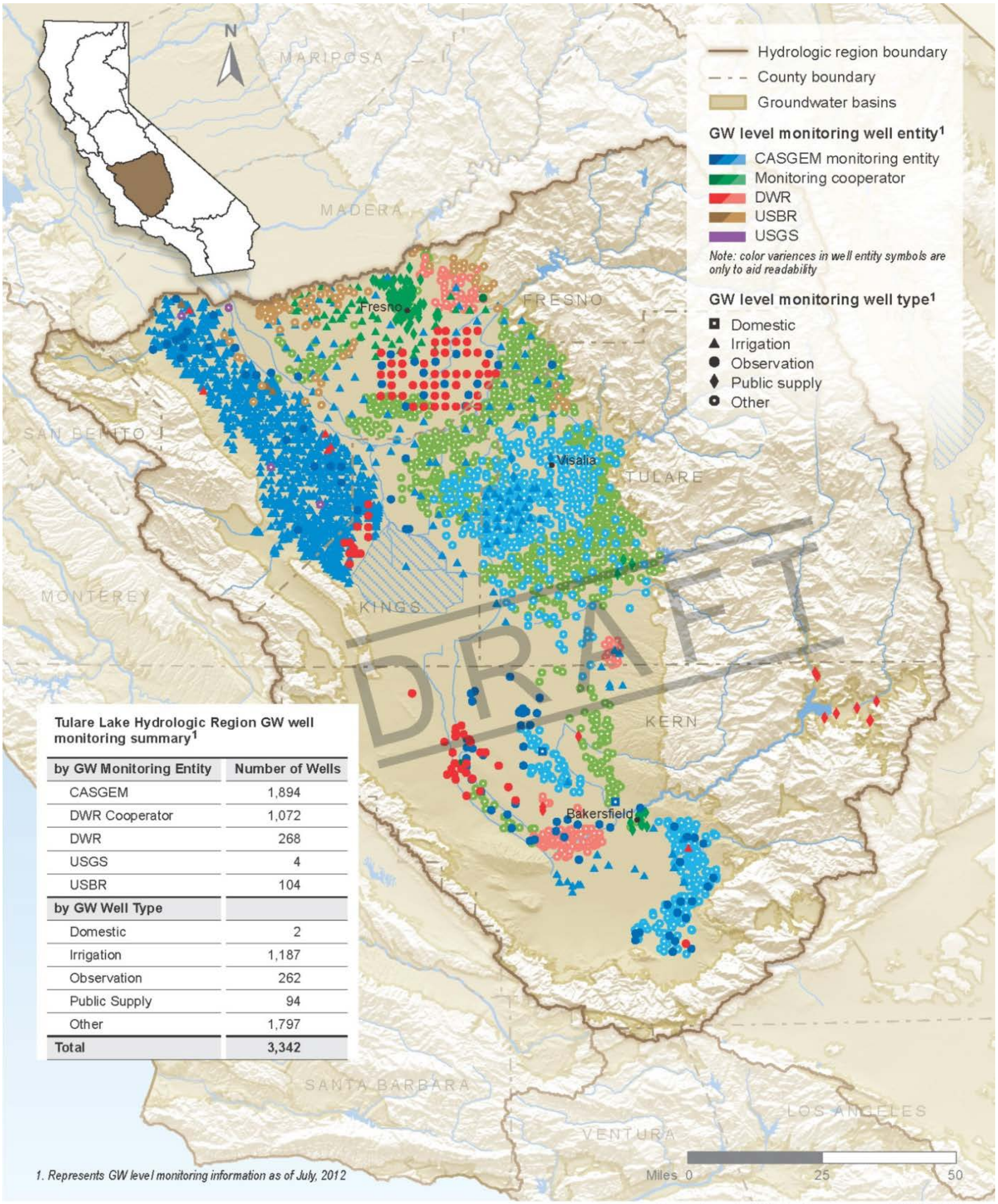


Figure TL-8 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity in the Tulare Lake Hydrologic Region

(Note: This is a DRAFT figure. Final figure from Graphics is pending)



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**

Source: Department of Water Resources, CWP 2013

Figure TL-9 Percentage of Monitoring Wells by Use in the Tulare Lake Hydrologic Region

(Note: This is a DRAFT figure. Final figure from Graphics is pending)

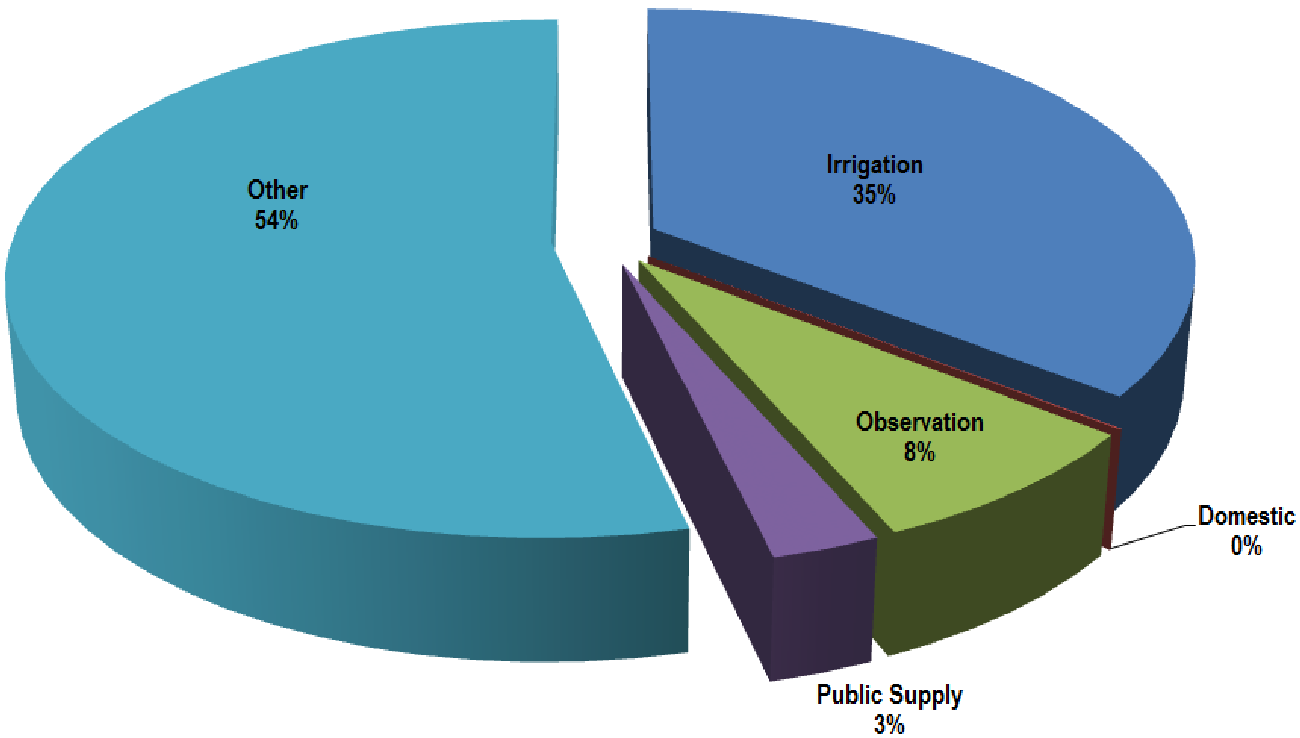


Figure TL-10 Tulare Lake Hydrologic Region Disadvantaged Communities and Integrated Regional Water Management

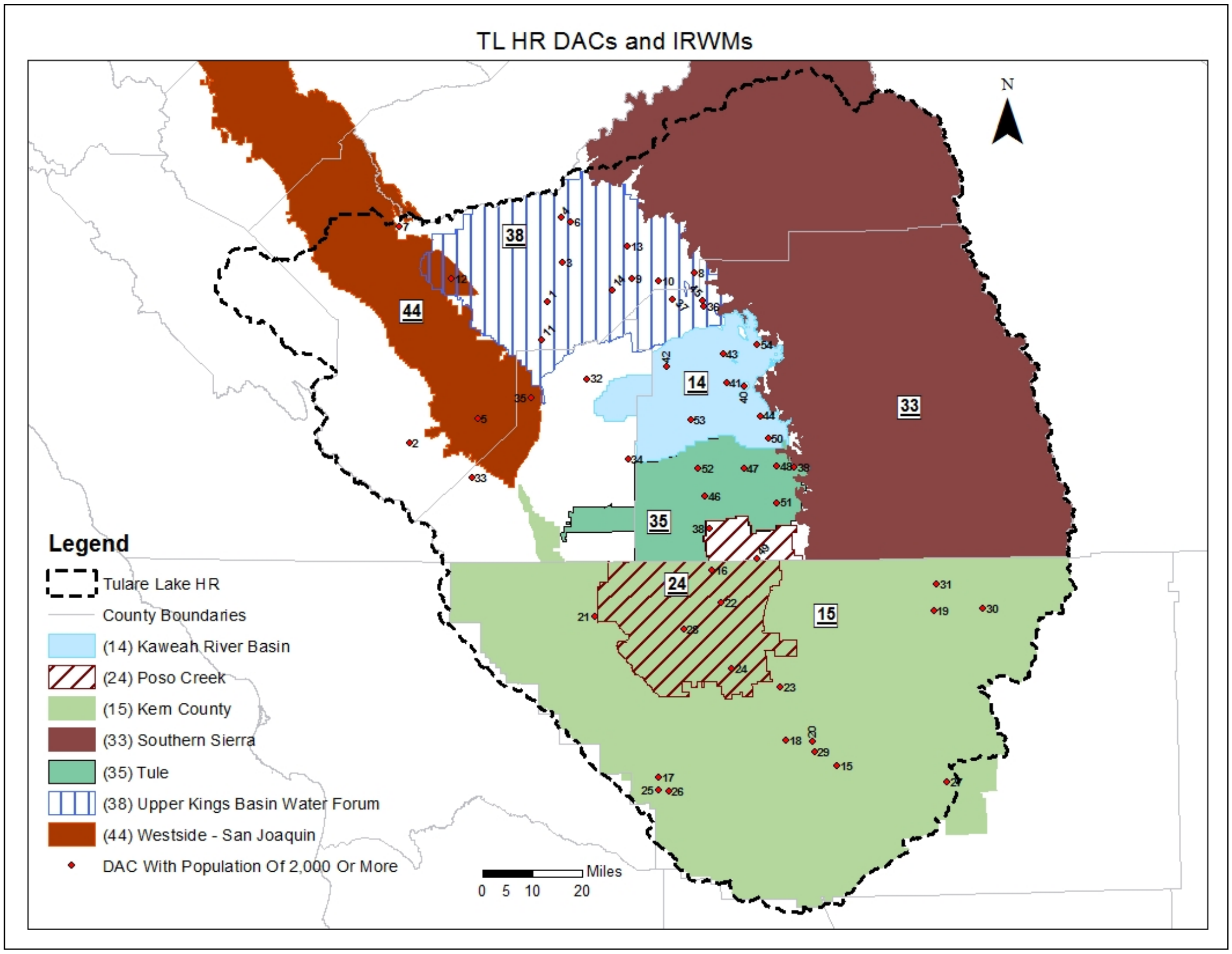


Figure TL-11 Tulare Lake Regional Inflows and Outflows in 2010

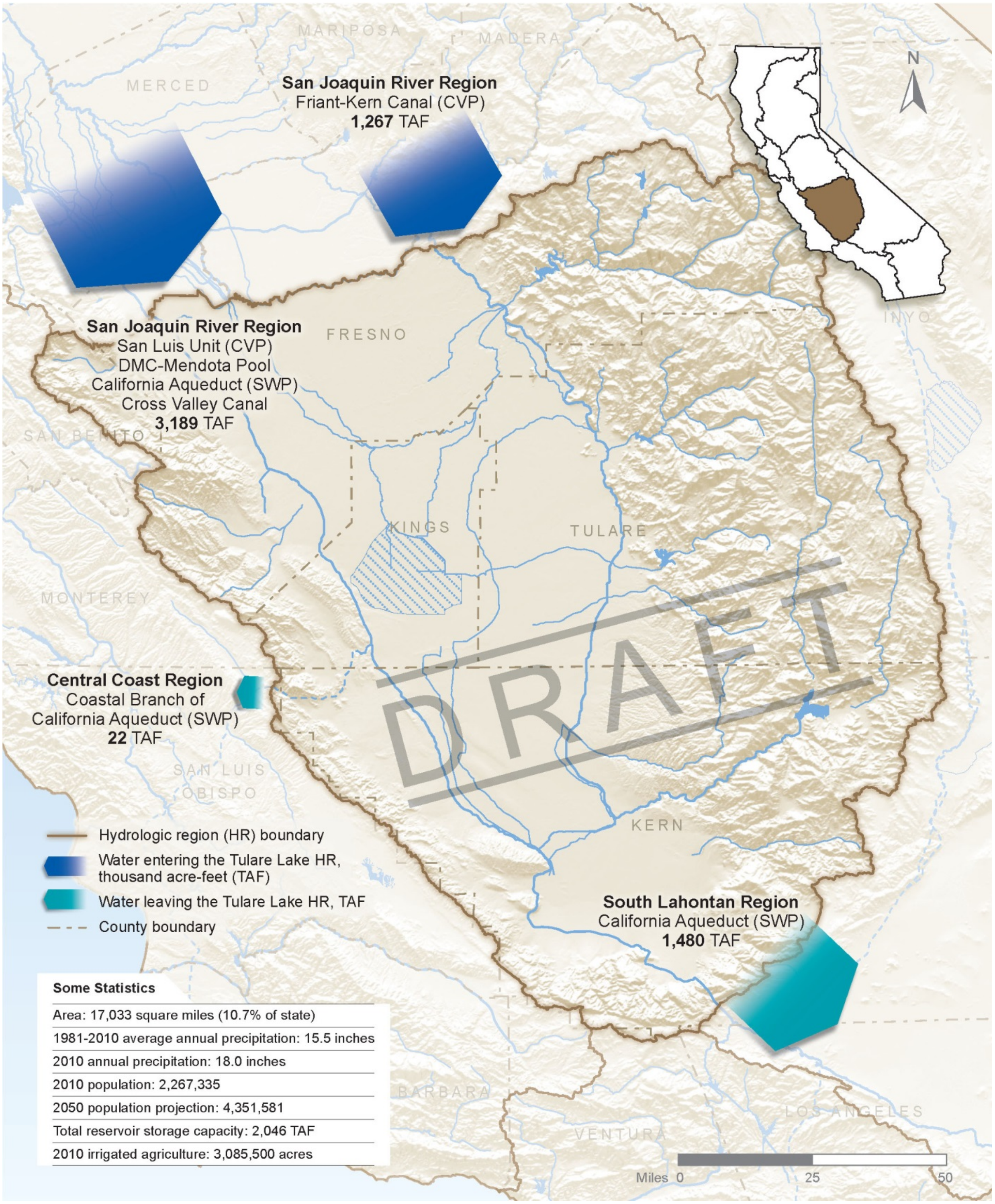


Figure TL-12 Total Agricultural Applied Water by Supply Source (thousand acre-feet) (with Supply as Percentage of Total Agricultural Applied Water)

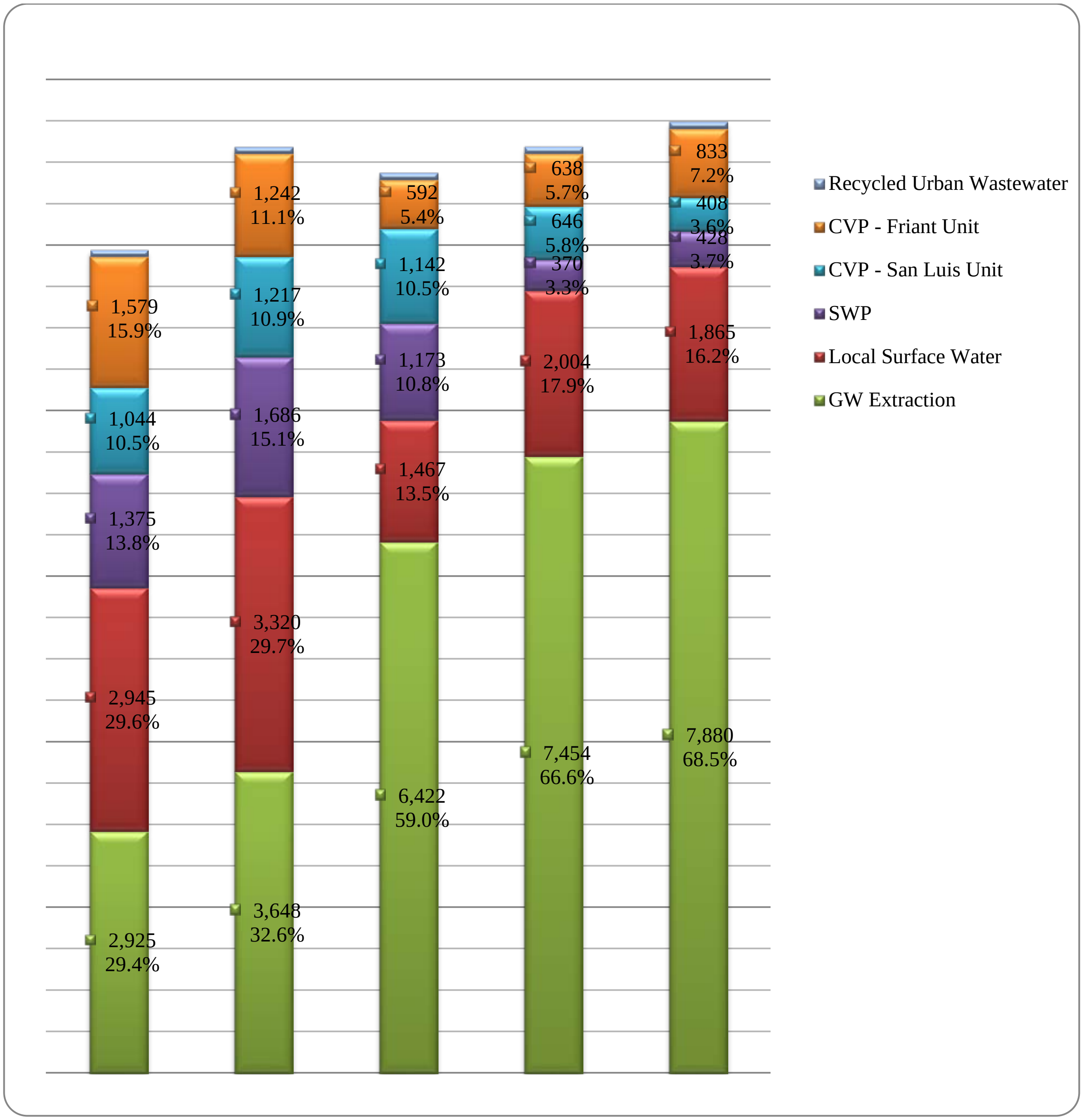


Figure TL-13 Contribution of Groundwater to the Tulare Lake Hydrologic Region Water Supply by Planning Area (2005-2010)

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

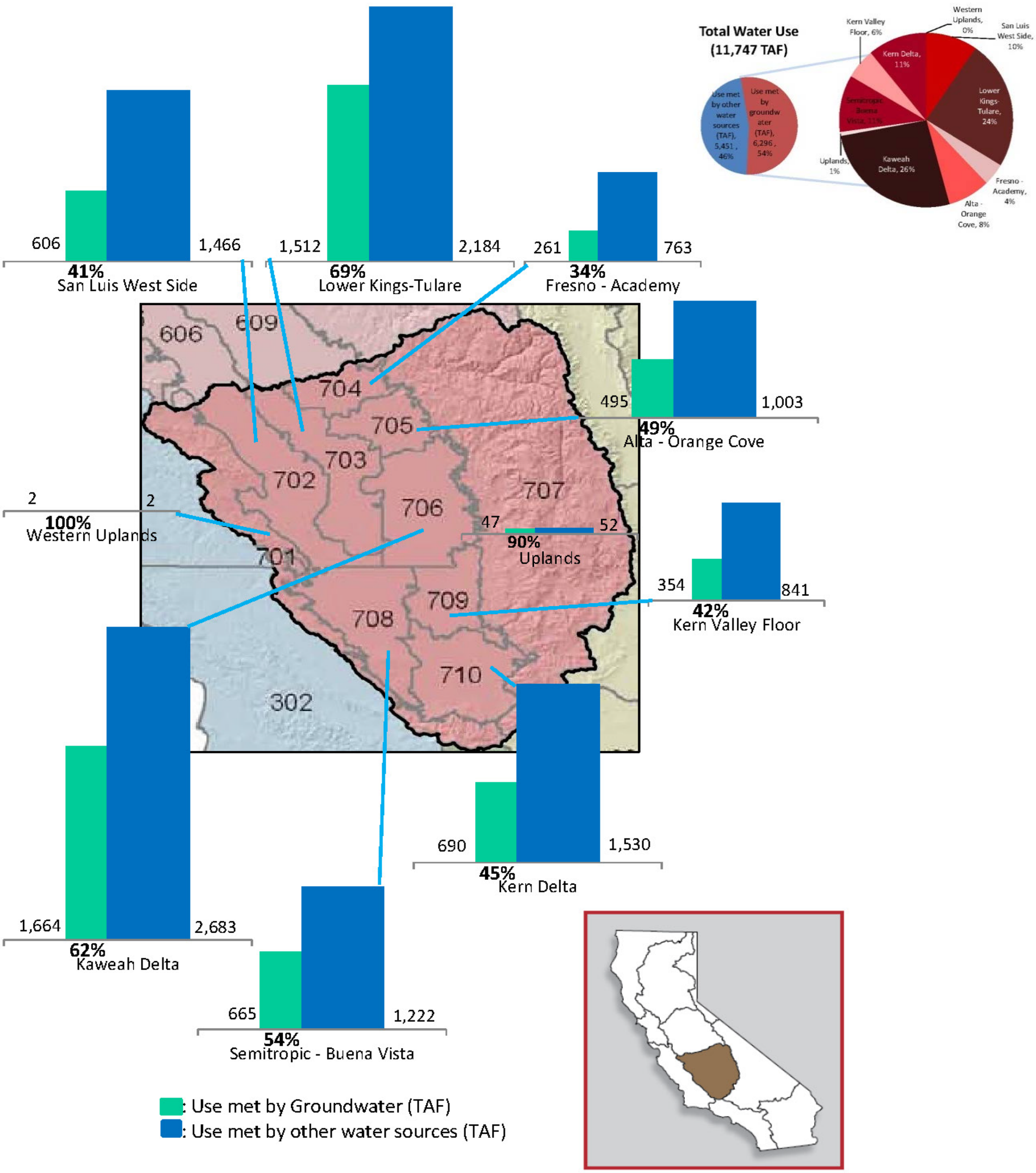


Figure TL-14 Tulare Lake Hydrologic Region Annual Groundwater Water Supply Trend (2002-2010)

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

To be Updated

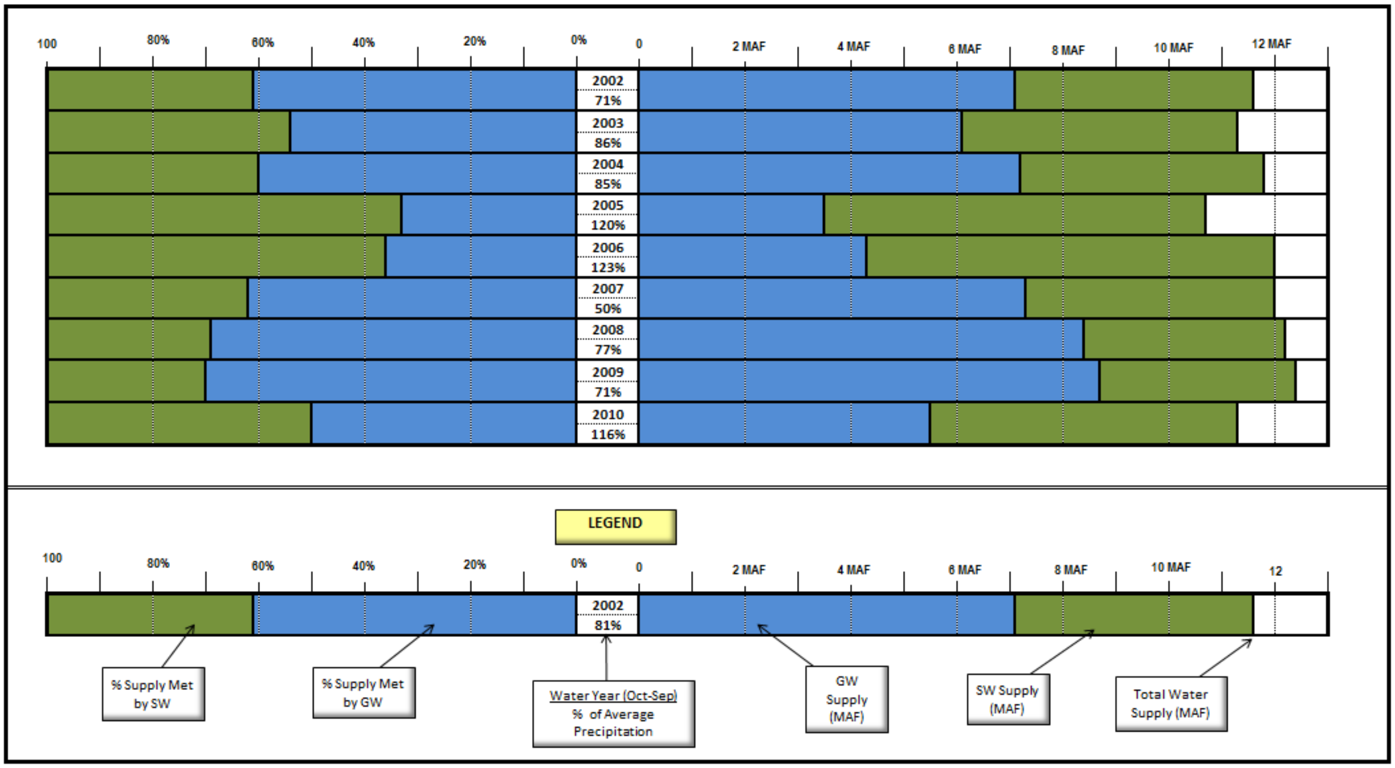


Figure TL-15 Tulare Lake Hydrologic Region Annual Groundwater Supply Trend by Type of Use (2002-2010)

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

To be Updated

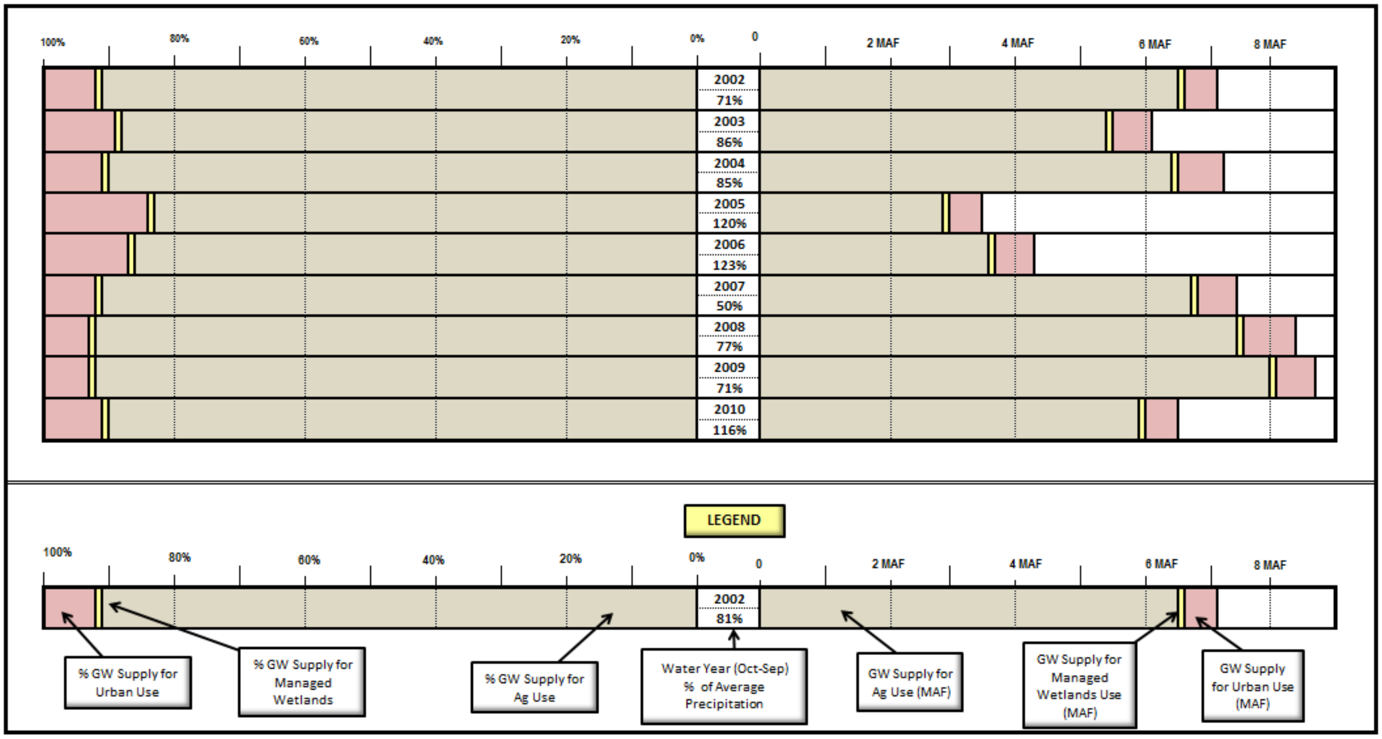


Figure TL-17 South of Delta CVP & SWP Deliveries

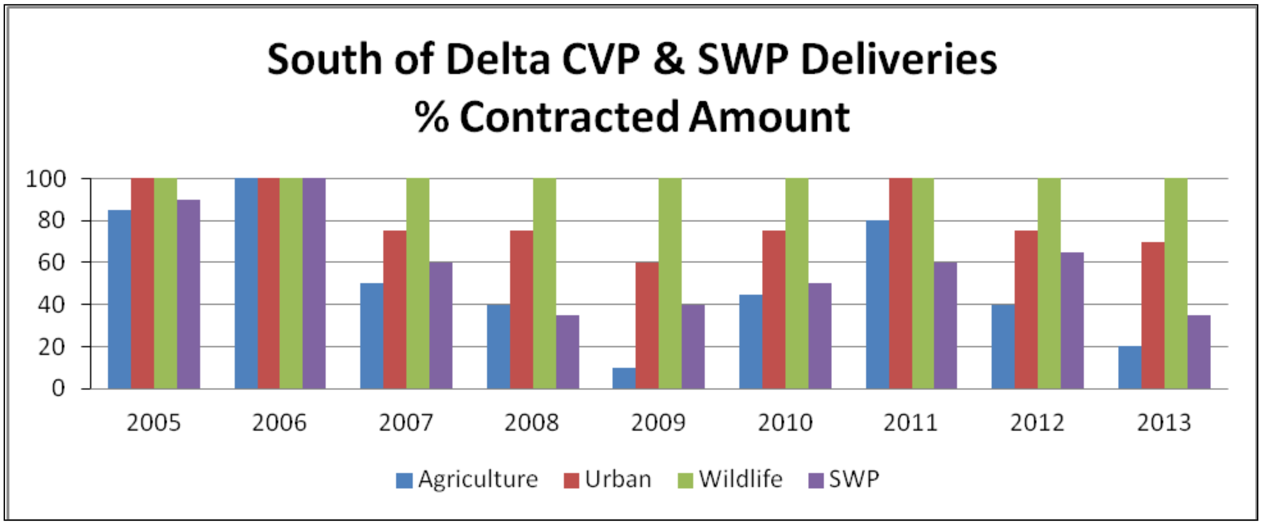


Figure TL-18 Land Subsidence in the San Joaquin Valley - 1926 to 1970 (Adapted from Ireland, 1984)

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

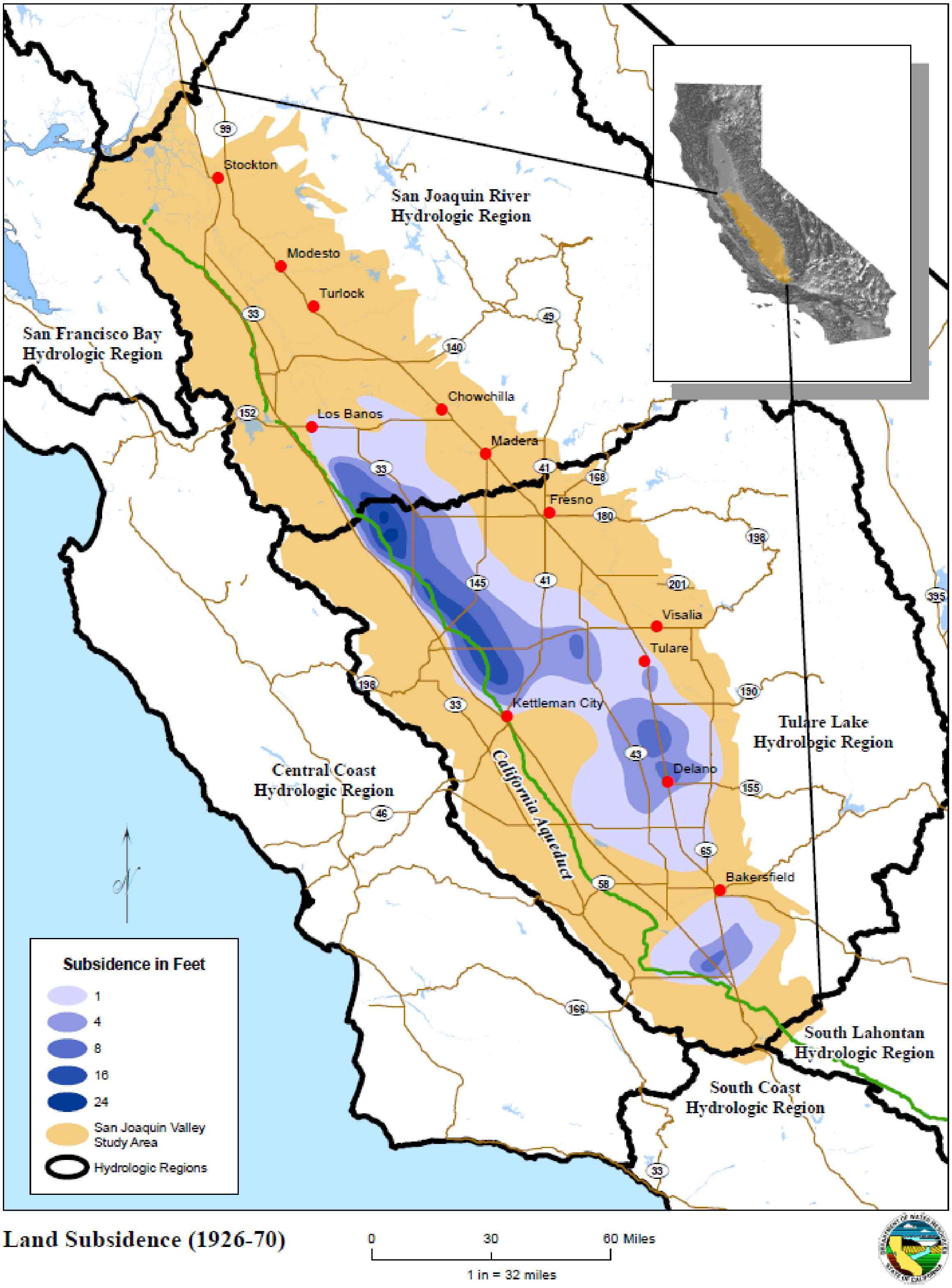


Figure TL-19 Land Subsidence Along the California Aqueduct

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

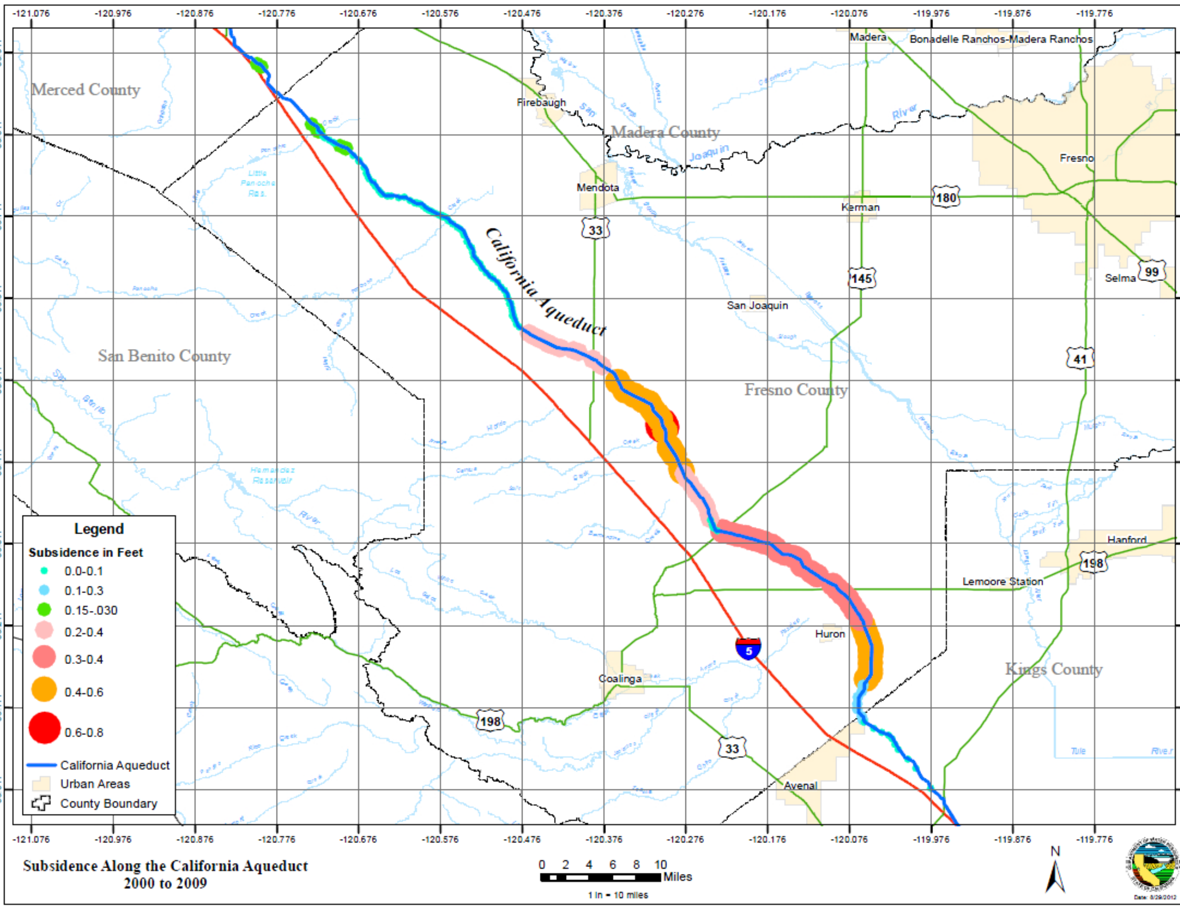


Figure TL-20 Depth to Groundwater Hydrograph for Well 30S25E16L14 and Land Subsidence Graph for the Kern Water Bank Extensometer

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

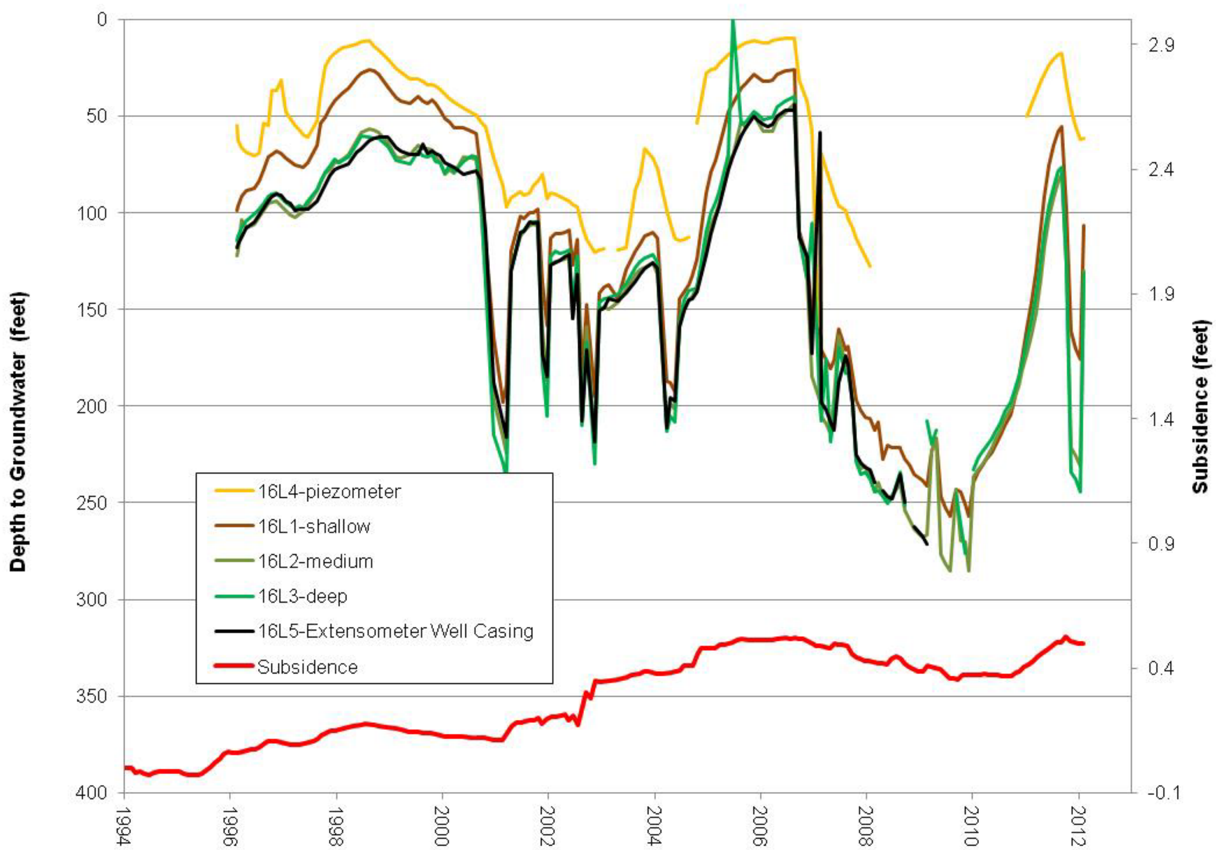


Figure TL-21 Land Subsidence Results from Caltrans Highway 198 Elevation Monitoring

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

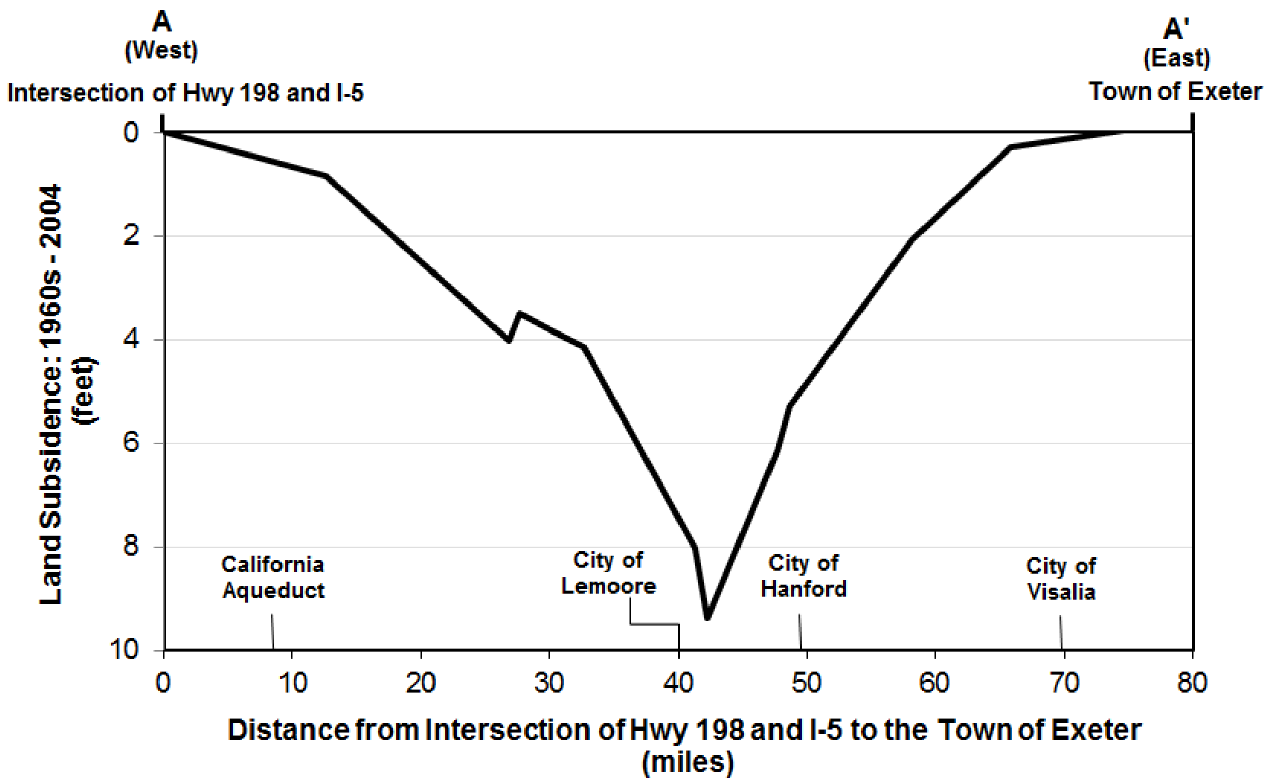


Figure TL-22 UNAVCO GPS Land Surface Displacement Monitoring Stations and Station Data Summary Graphs

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

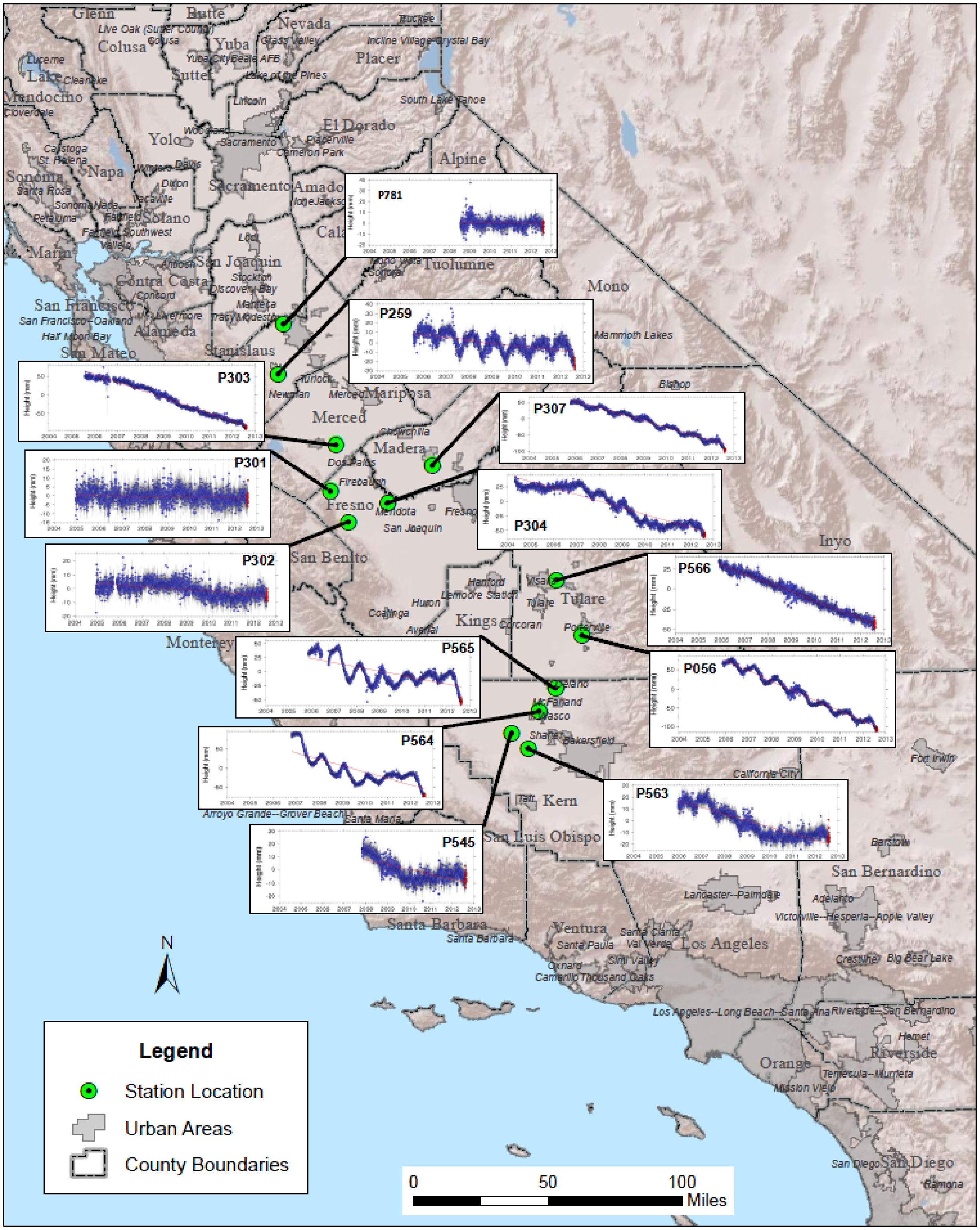


Figure TL-23 Depth to Groundwater Hydrograph and Vertical Land Surface Displacement at UNAVCO GPS Site 304, near the City of Madera

(Reference: 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)

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

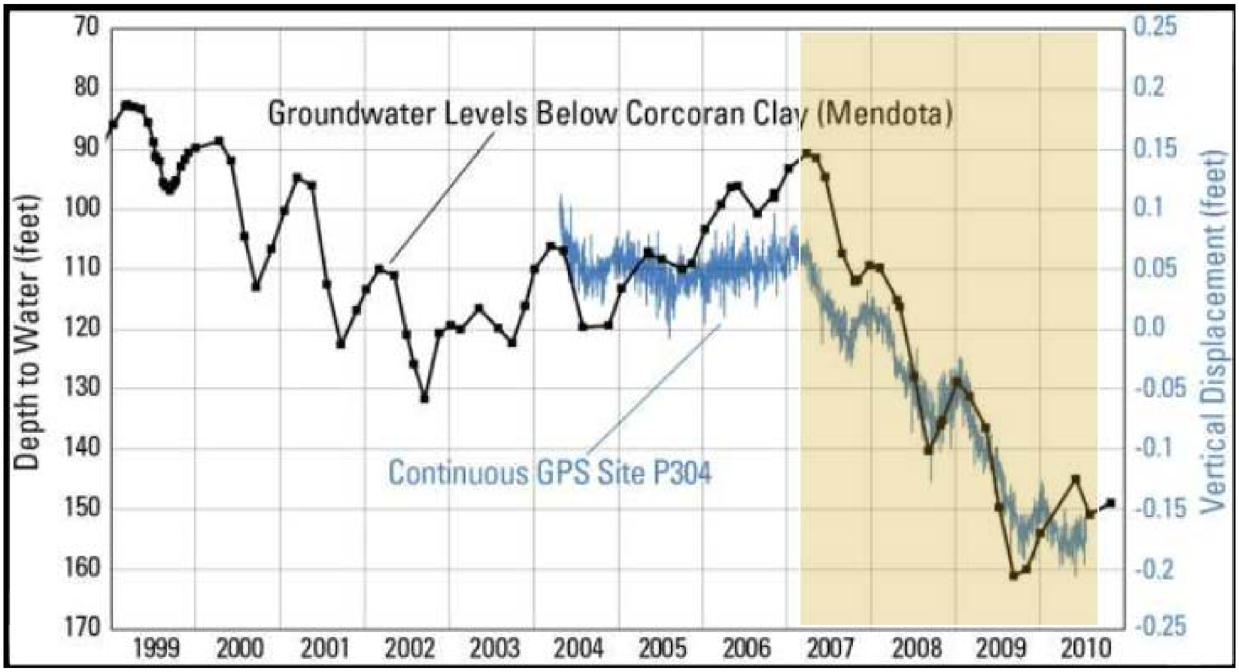


Figure TL-24 Relationship between Changing Groundwater Levels and Land Subsidence in the Tulare Lake Hydrologic Region (Composite Hydrograph for Wells 16S15E34N001M, 16S15E34N004M, and 16S15E32Q001M)

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

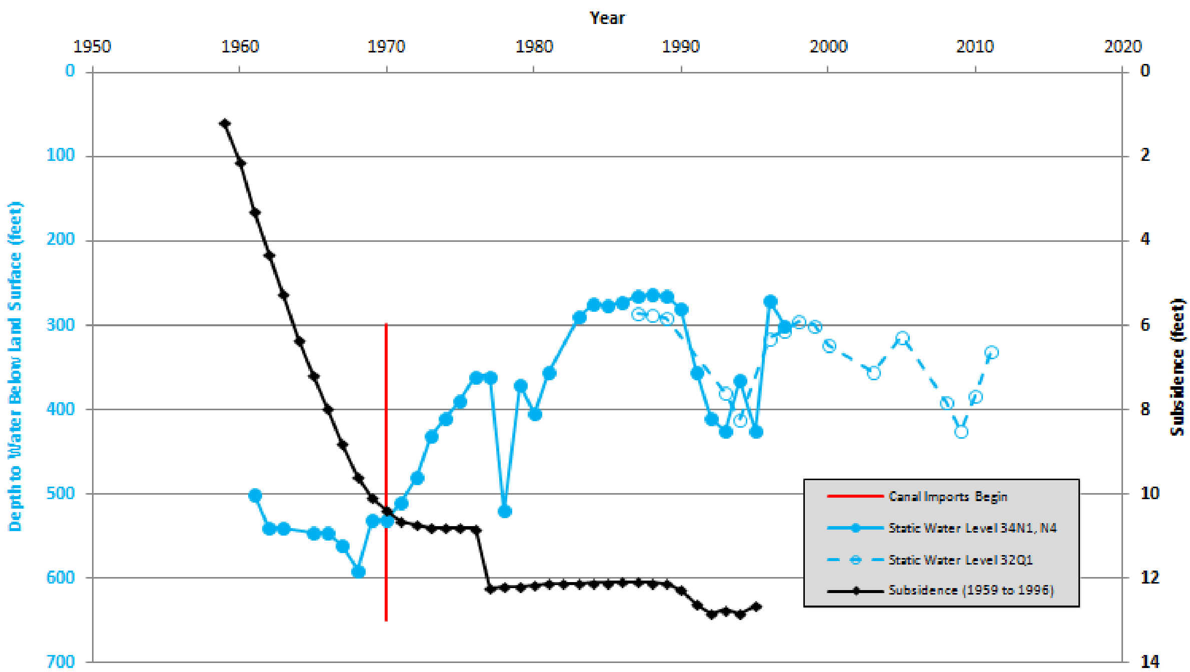


Figure TL-25 Spring 2010 Depth to Groundwater Contours for the Tulare Lake Hydrologic Region

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

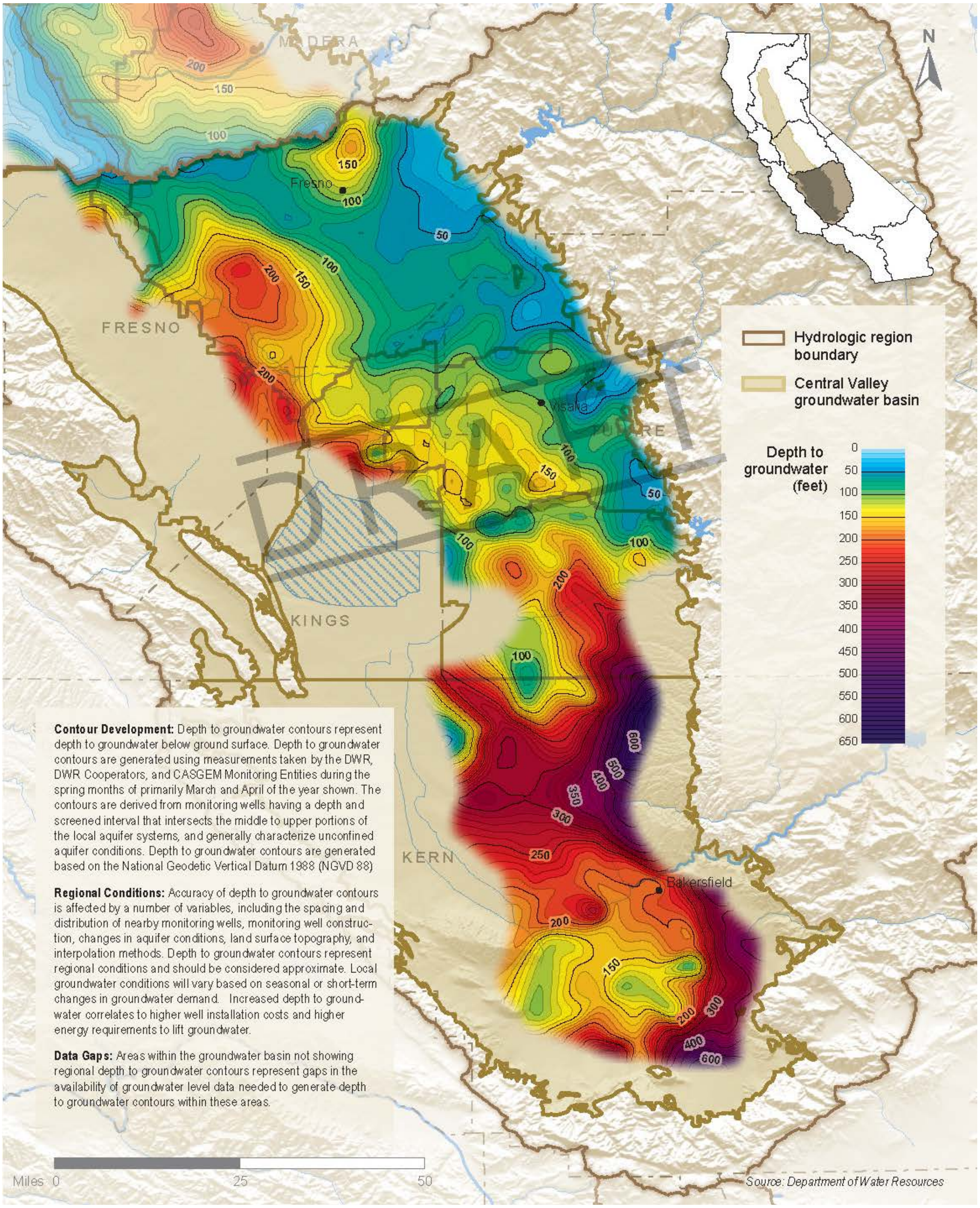
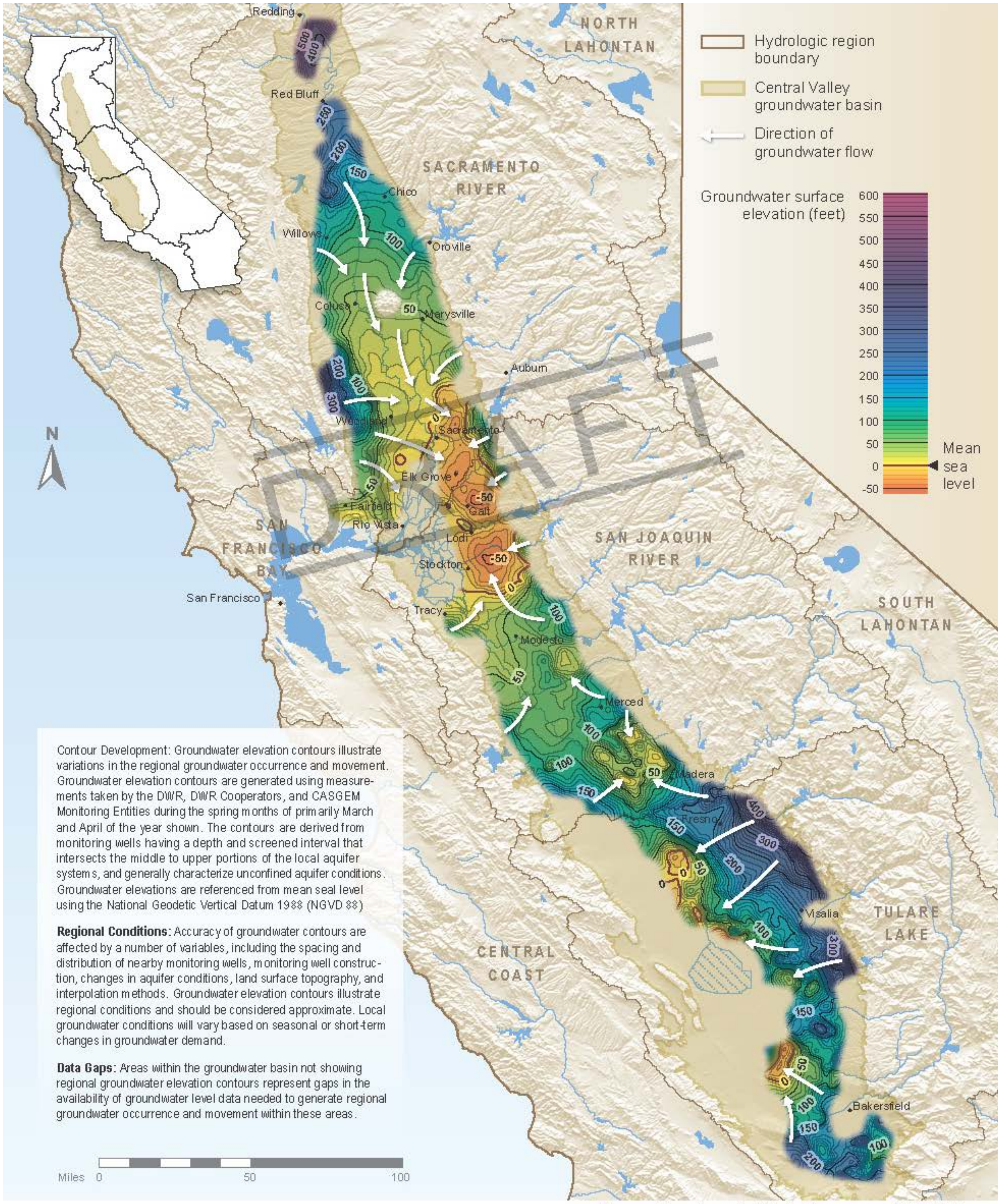


Figure TL-26 Spring 2010 Groundwater Elevation Contours for the Tulare Lake Hydrologic Region

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

This figure is for the Central Valley; needs to be updated with figure for the Tulare Lake Hydrologic Region



Source: Department of Water Resources, CWP 2013

Figure TL-27 Groundwater Level Trends in Selected Wells in the Tulare Lake Hydrologic Region

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

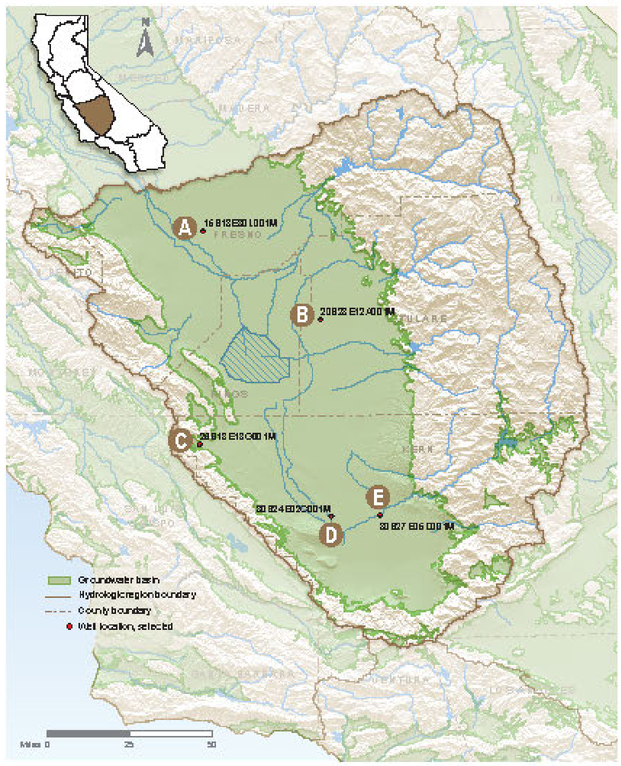
Volume X - The Volume Title

Figure X-x Tulare Lake hydrographs

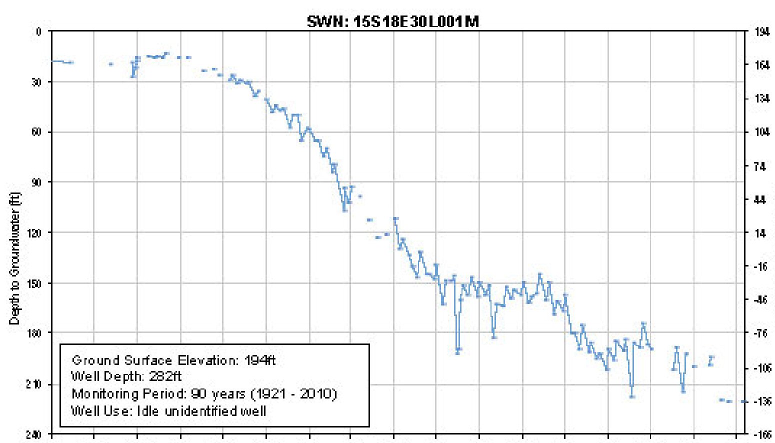
Aquifer response to changing demand and management practices

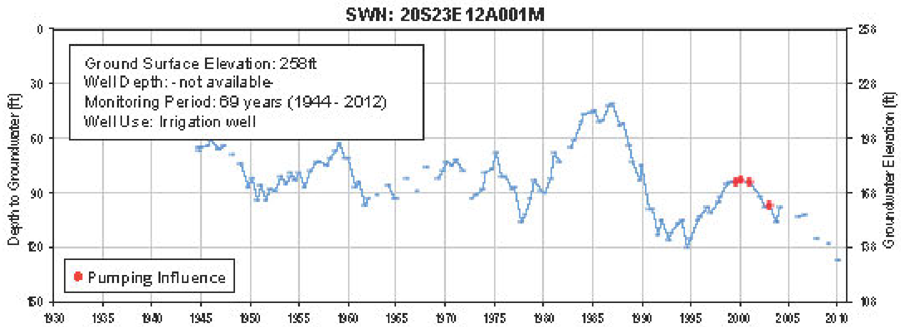
Hydrographs were selected to help tell a story of how local aquifer systems respond to changing groundwater demand and resource management practices. Additional detail is provided within the main text of the report.

Regional locator map

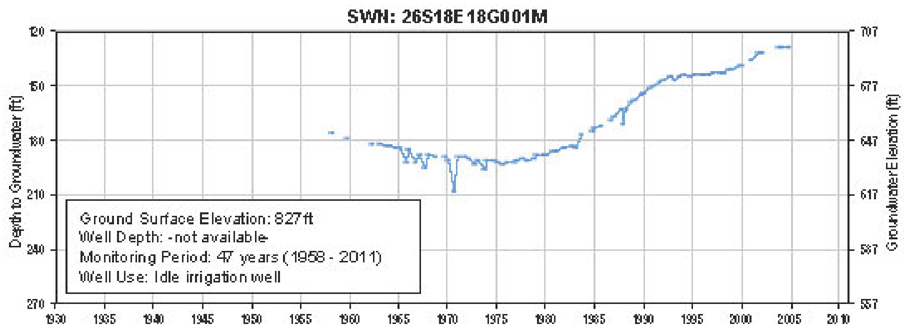


Ⓐ Hydrograph 15S18E30L001M: illustrates the long-term declining groundwater levels and an ongoing imbalance between the annual amounts of groundwater extraction versus recharge for this area. With current groundwater levels at or below sea level, the hydrograph also points to unsustainable management of the aquifer.





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

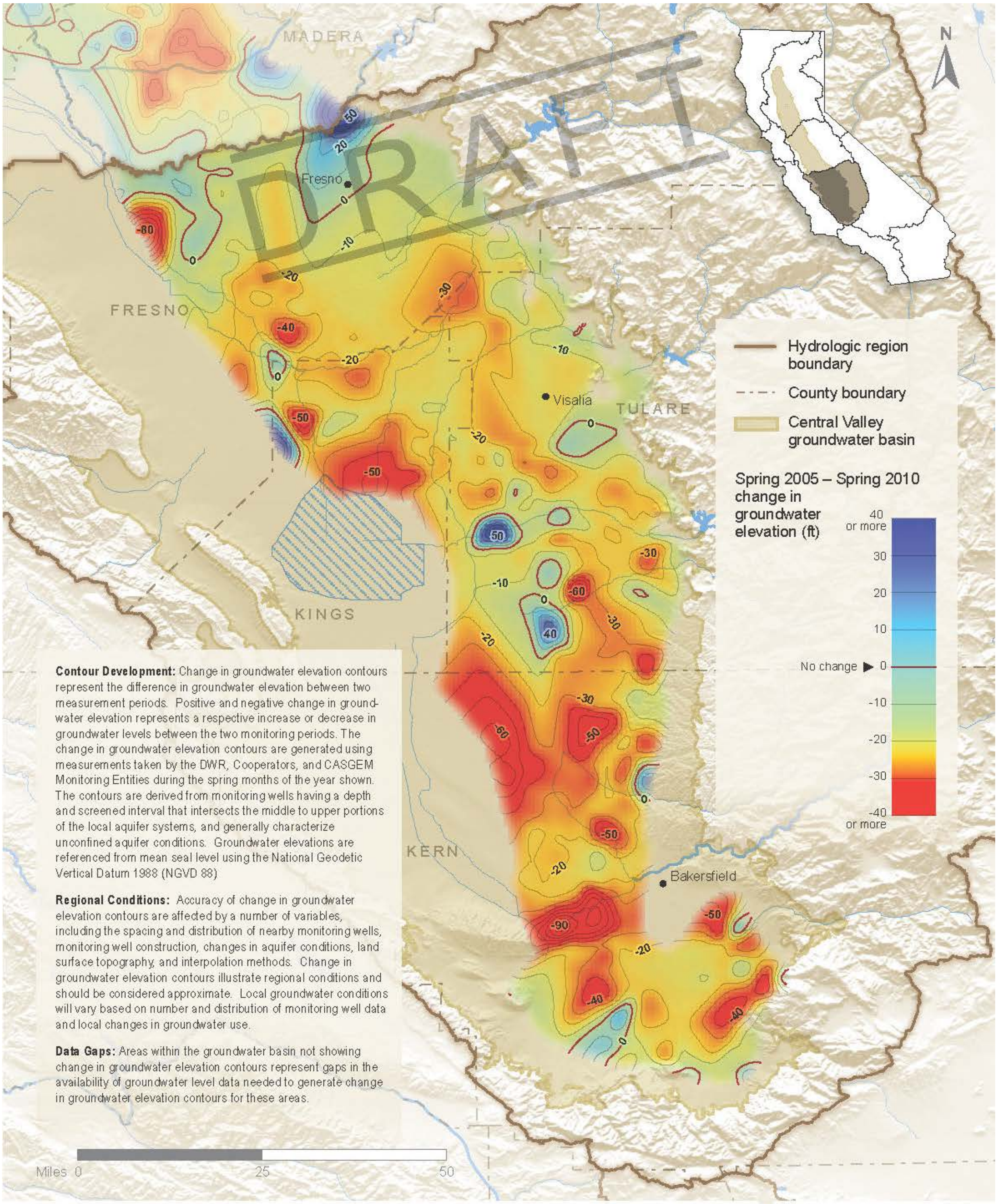


C Hydrograph 26S18E18G001M: highlights recovering groundwater levels associated with the introduction of imported surface water from the California Aqueduct, which resulted in decreasing groundwater demand and facilitating in-lieu groundwater recharge.

D, E Hydrographs 30S24E02C001M and 30S27E05D001M: illustrate the successful stabilization of sharply declining groundwater levels through implementation of in-lieu and active groundwater recharge projects via active conjunctive management practices.

Figure TL-28 Spring 2005 - Spring 2010 Change in Groundwater Elevation Contour Map for the Tulare Lake Hydrologic Region

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)



Source: Department of Water Resources, CWP 2013

Figure TL-29 Spring 2010 Annual Change in Groundwater Storage for the Tulare Lake Hydrologic Region

(Note: This is a PLACEHOLDER figure. Final figure from Graphics is pending)

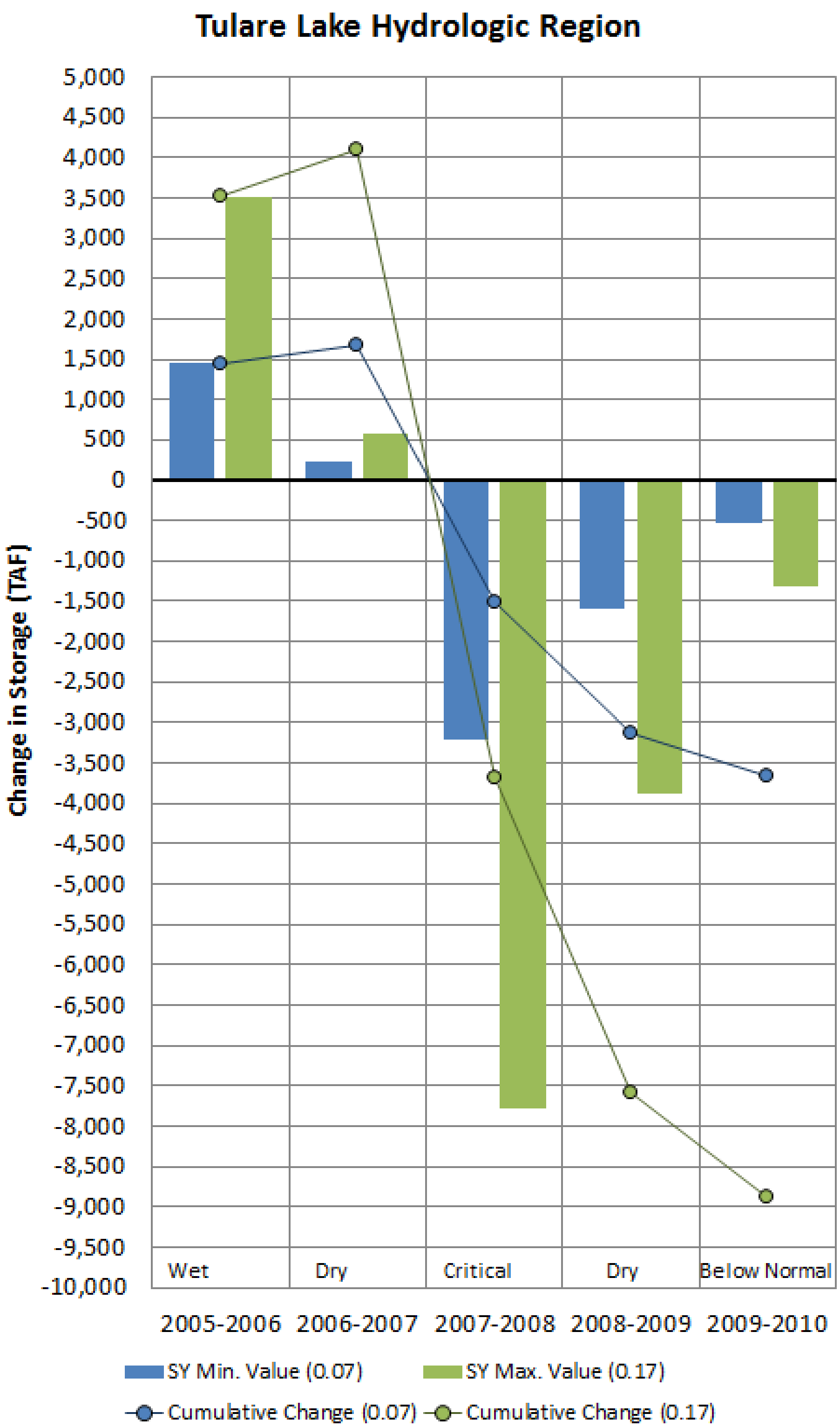
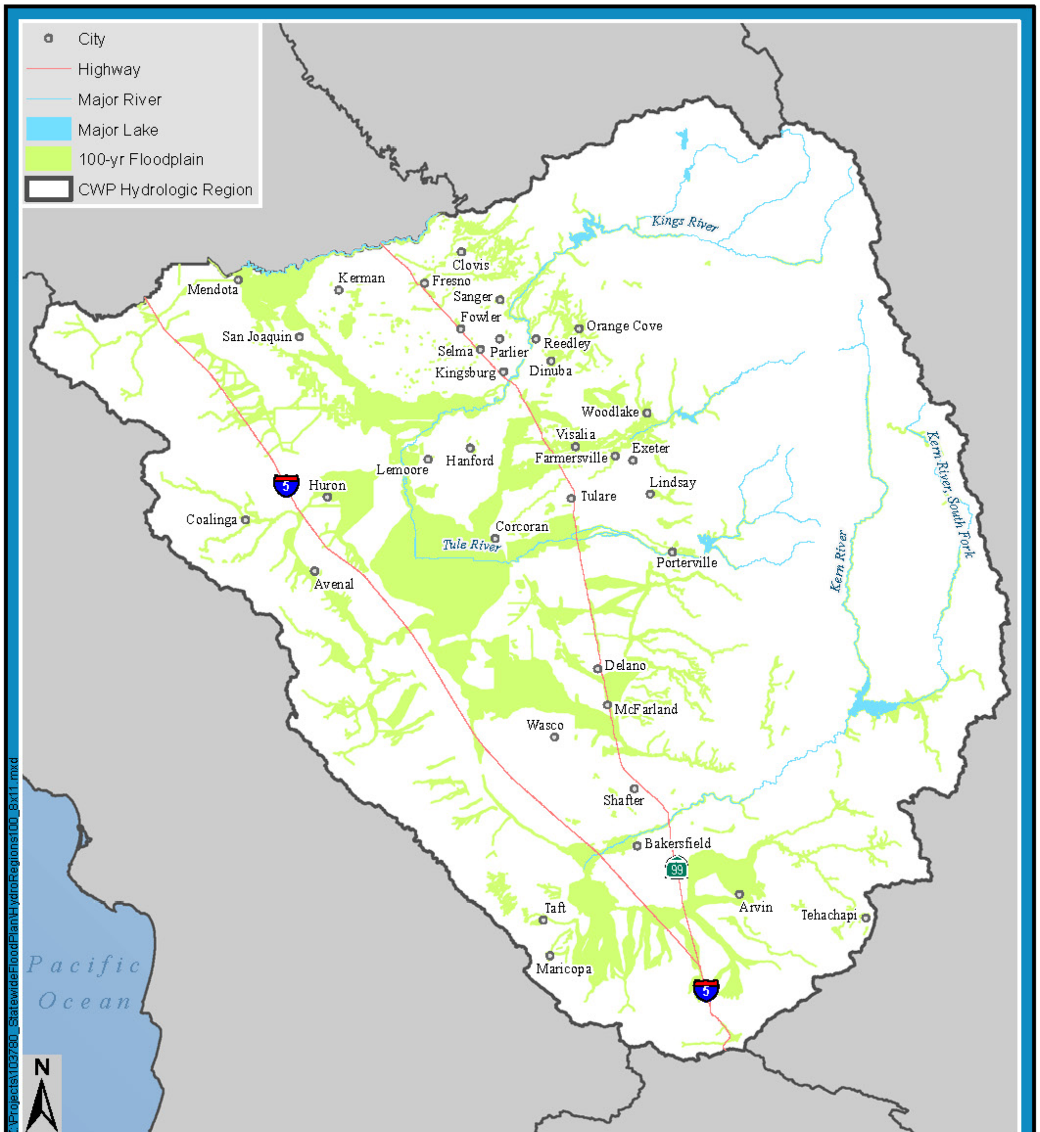


Figure TL-30 **Flood Exposure to the 100-Year Floodplain, Tulare Lake Hydrologic Region**



Tulare Lake Key Results

Total Population:	1,870,500	Transportation Facilities:	538
Population Exposed:	134,100	Transportation Segments (miles):	487
Percent of Population Exposed:	7	Essential Facilities:	71
Exposed Structures:	41,200	Lifeline Utilities:	11
Value of Exposed Structure and Contents:	$8.3 Billion	Dept. of Defense Facilities:	7
Total Area (acres)	10.8 Million	Dept. of Defense Facilities (acres):	25,143
Exposed Area (acres)	1,211,100	High Potential Loss Facilities:	50
Percent of Area Exposed:	11	Native American Tribes:	2
Exposed Ag.Crops (acres):	802,200	Native American Tribal Lands (acres):	109
Percent of Ag. Crops Exposed:	23	Sensitive Animal Species Exposed:	101
Value of Exposed Ag. Crops:	$1.8 Billion	Sensitive Plant Species Exposed:	94

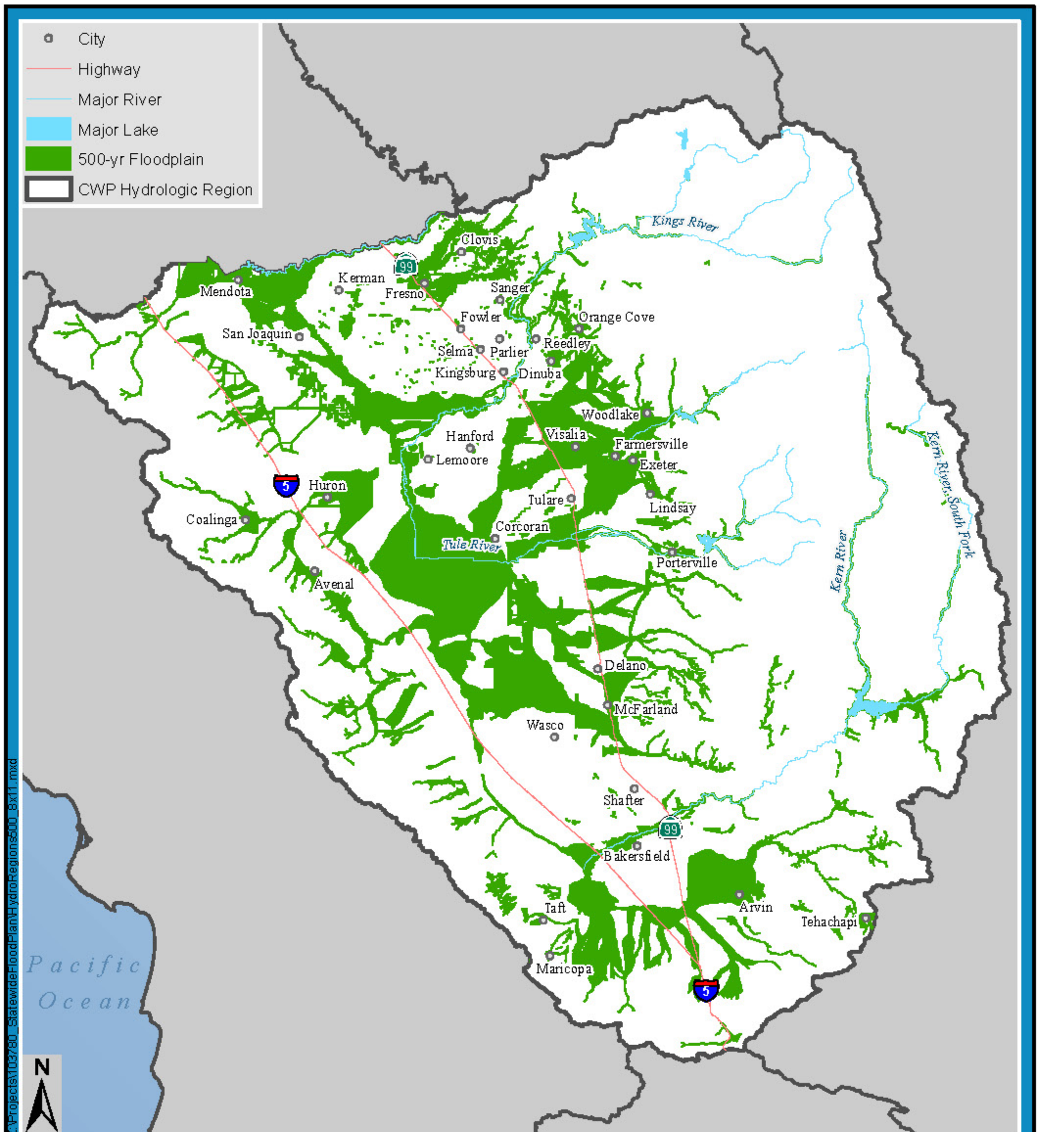
Statewide Flood Hazard Exposure Summary for the Tulare Lake Hydrologic Region 100-year Floodplain

STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Jan 28, 2013

Figure TL-31 Flood Exposure to the 500-Year Floodplain, Tulare Lake Hydrologic Region



Tulare Lake Key Results

Total Population:	1,870,500	Transportation Facilities:	808
Population Exposed:	498,200	Transportation Segments (miles):	744
Percent of Population Exposed:	27	Essential Facilities:	254
Exposed Structures:	152,200	Lifeline Utilities:	25
Value of Exposed Structure and Contents:	$32.0 Billion	Dept. of Defense Facilities:	7
Total Area (acres)	10.8 Million	Dept. of Defense Facilities (acres):	25,396
Exposed Area (acres)	1,491,800	High Potential Loss Facilities:	71
Percent of Area Exposed:	14	Native American Tribes:	2
Exposed Ag.Crops (acres):	990,800	Native American Tribal Lands (acres):	109
Percent of Ag. Crops Exposed:	29	Sensitive Animal Species Exposed:	103
Value of Exposed Ag. Crops:	$2.3 Billion	Sensitive Plant Species Exposed:	94

Statewide Flood Hazard Exposure Summary for the Tulare Lake Hydrologic Region 500-year Floodplain

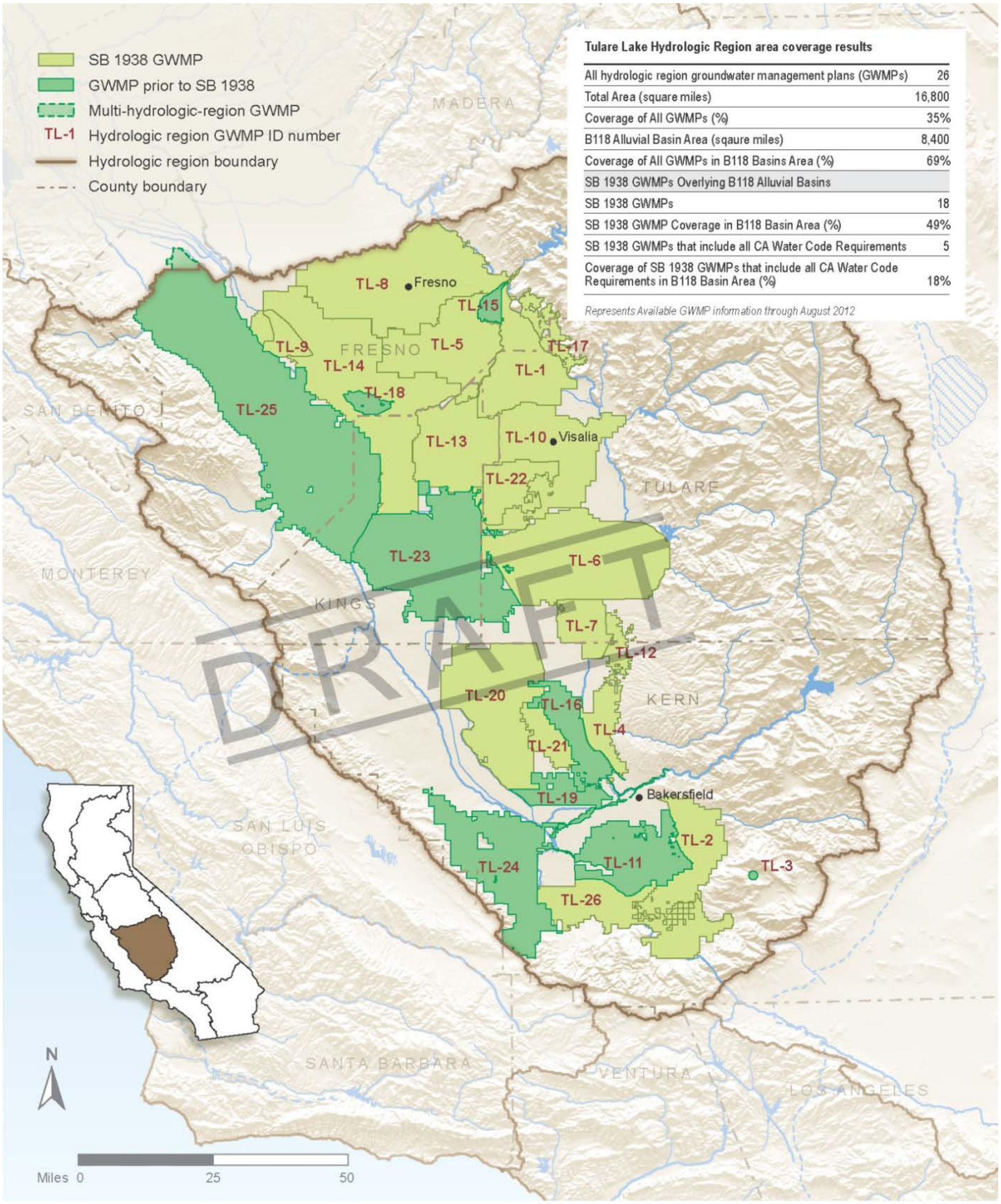
STATEWIDE FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Jan 28, 2013

Figure TL-32 Location of Groundwater Management Plans in the Tulare Lake Hydrologic Region

(Note: This map is DRAFT. Final map from Graphics is pending)



Source: Department of Water Resources, CWP 2013

Figure TL-33 Groundwater Adjudications in the Tulare Lake Hydrologic Region

(Note: This map is DRAFT. Final map from Graphics is pending)

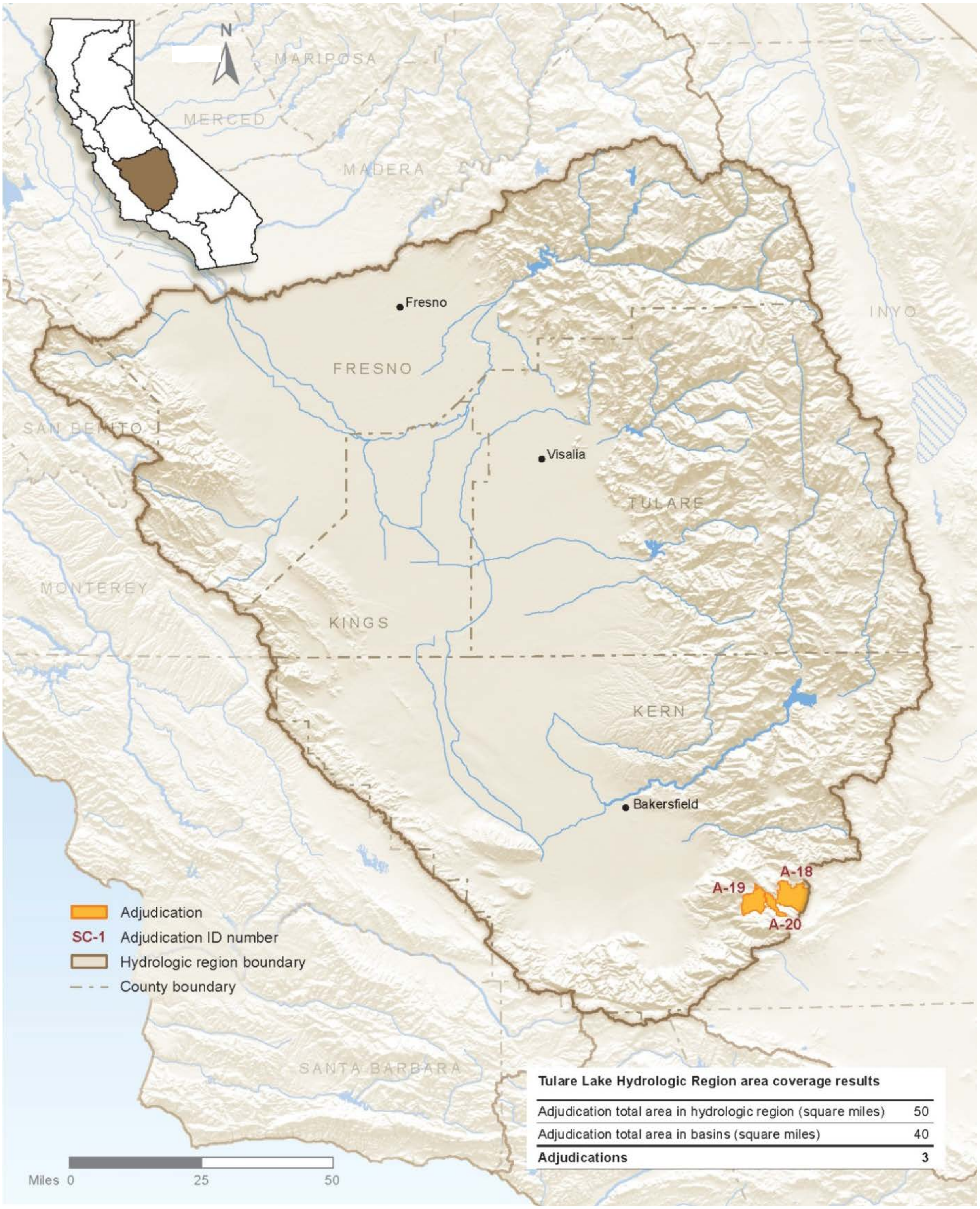


Figure TL-34 Change in Tulare Lake Agricultural and Urban Water Demands for 117 Scenarios from 2006-2050 (thousand acre-feet per year)

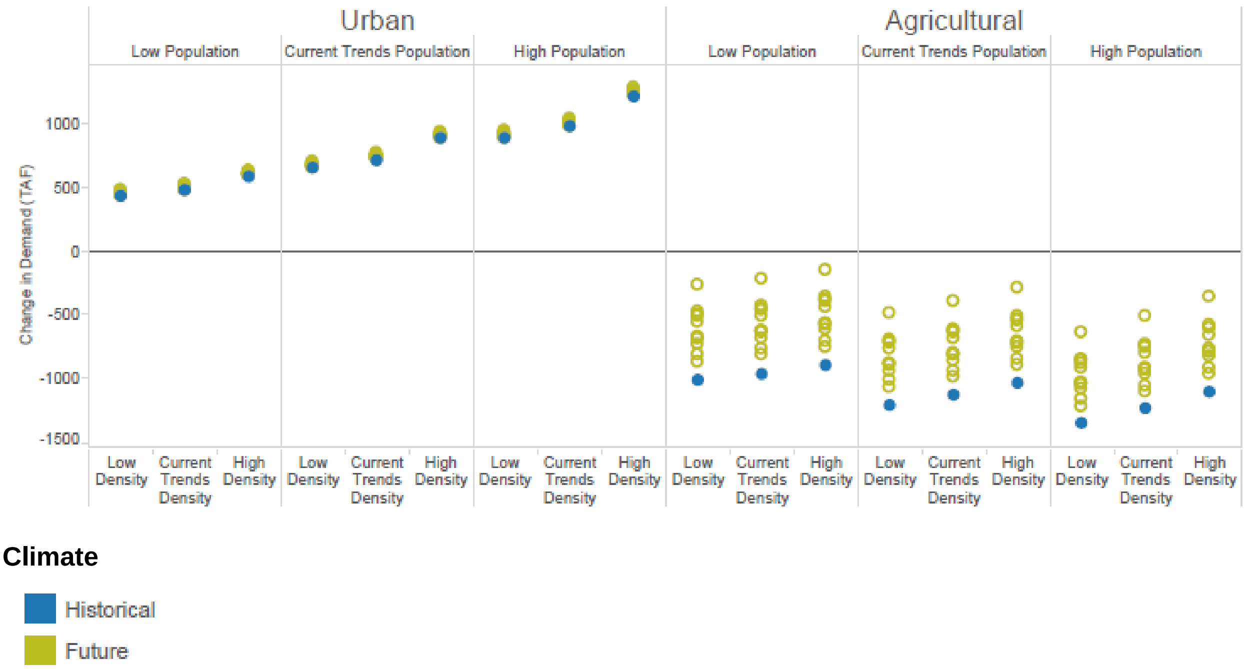


Figure TL-35 Integrated Water Management Planning in the Tulare Lake Region

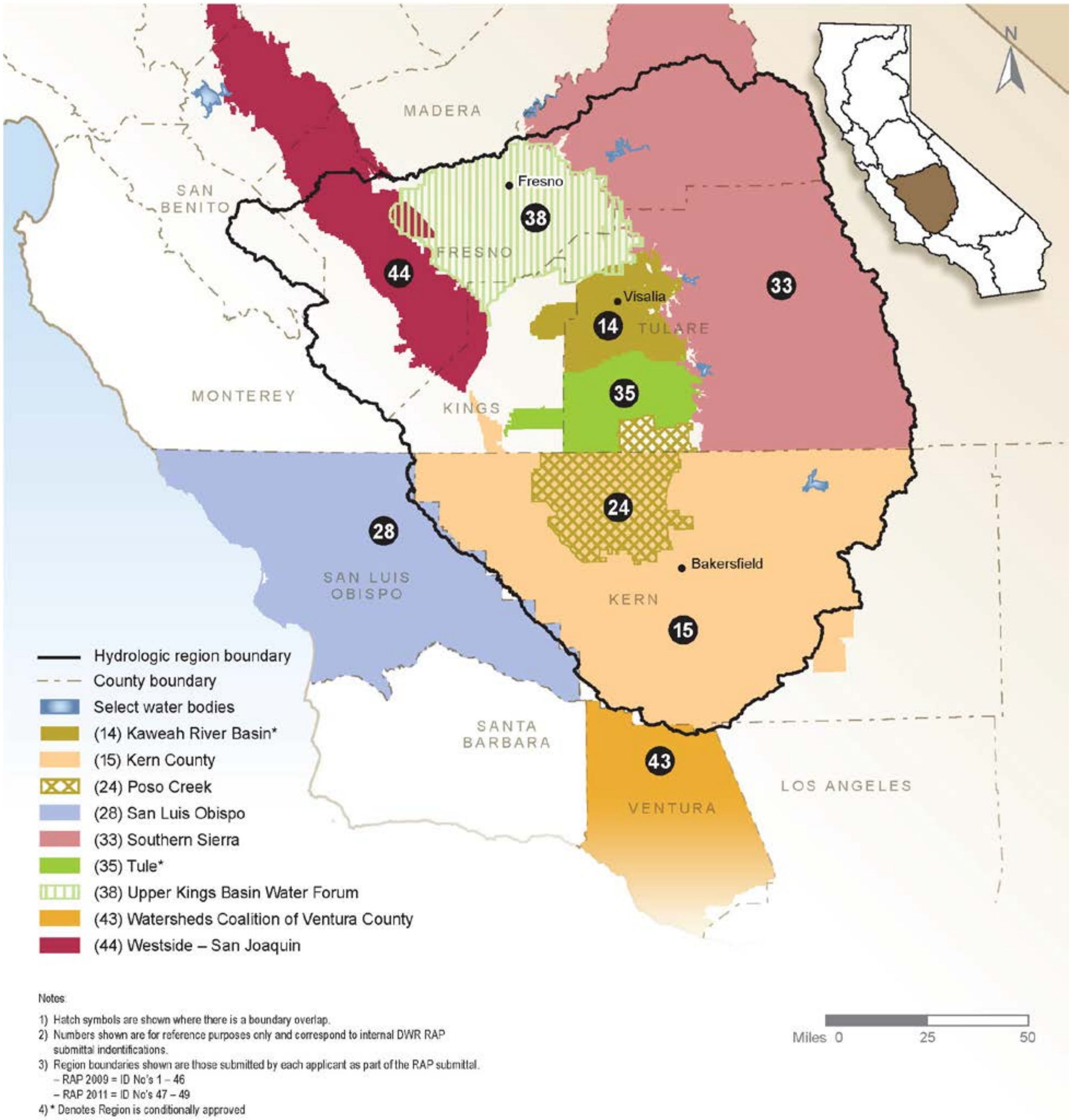


Figure TL-36 Conjunctive Management Program Goals and Objectives

(Note: This map is DRAFT. Final map from Graphics is pending)

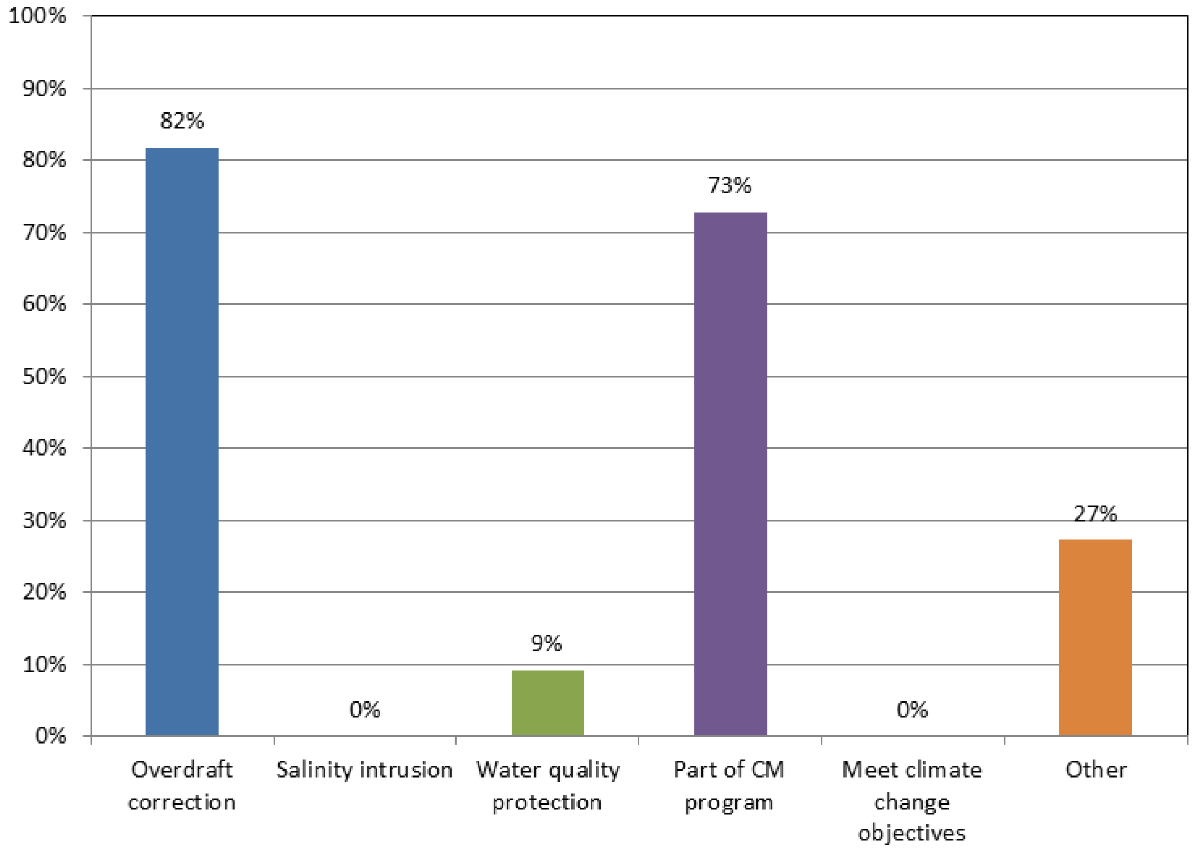


Figure TL-37 Constraints towards Development of Conjunctive Management and Water Banking Programs

(Note: This map is DRAFT. Final map from Graphics is pending)

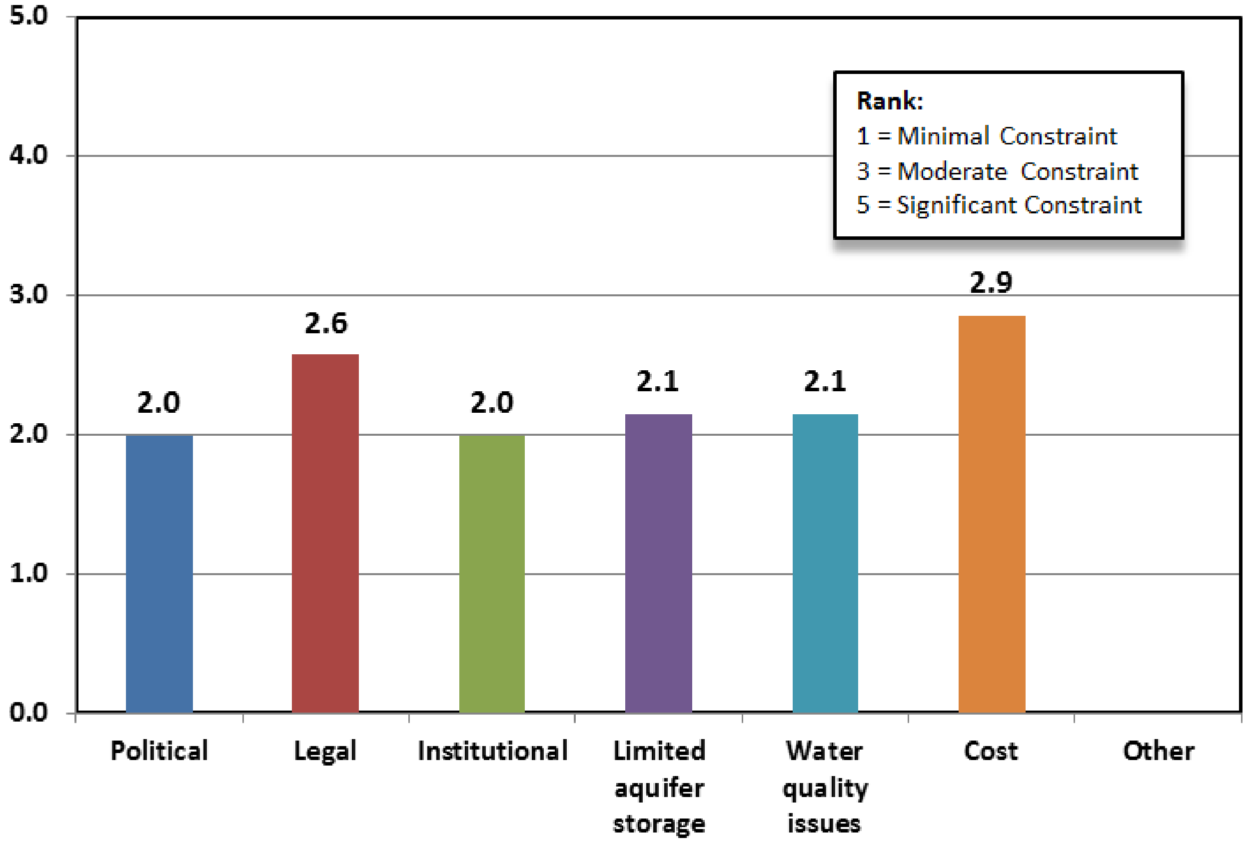


Figure TL-38 Energy Intensity of Raw Water Extraction and Conveyance in the Tulare Lake Hydrologic Region

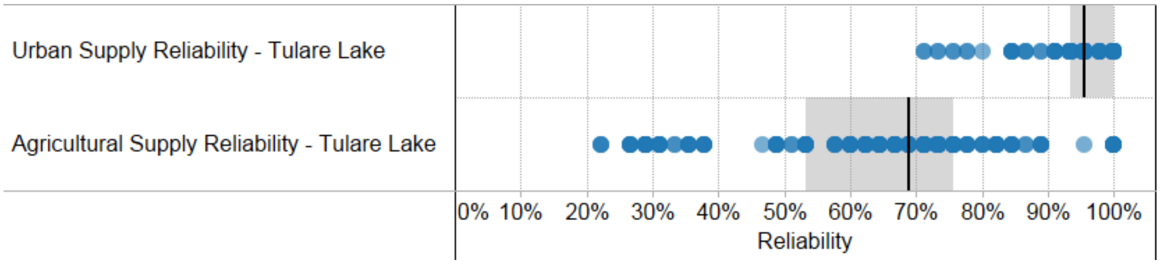
Figure x: Tulare Lake energy intensity per acre foot of water

Type of Water	Energy Intensity (yellow bulb = 1-500 kWh/AF)	% 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%

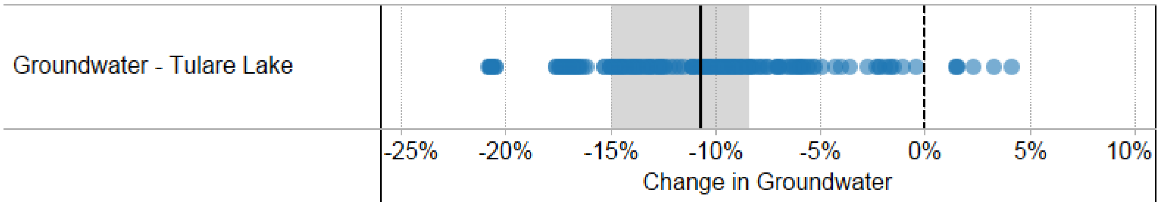
Energy intensity per acre foot of water

Energy intensity (EI) in this figure is the total amount of energy required for the extraction and conveyance of one acre-foot of water and does not include treatment, distribution to point of use, or end use energy (e.g., water heating). These figures should be seen as ranges within which the EI of different sources of each water type would likely fall i.e., a water type with four bulbs should be interpreted to mean that most sources of that water type in the region would have an EI of between 1,501-2,000 kWh/ acre-ft of water. Smaller light bulbs represent an EI of greater than zero, and less than250 kWh/acre-ft. EI of desalinated and recycled water is not shown, but is covered in Resource Management Strategies #XX and #YY respectively, Volume 3. (For detailed description of the methodology used to calculate EI in this figure, see Technical Guide, Volume 5 or References Guide, Volume 4 (TBD)).

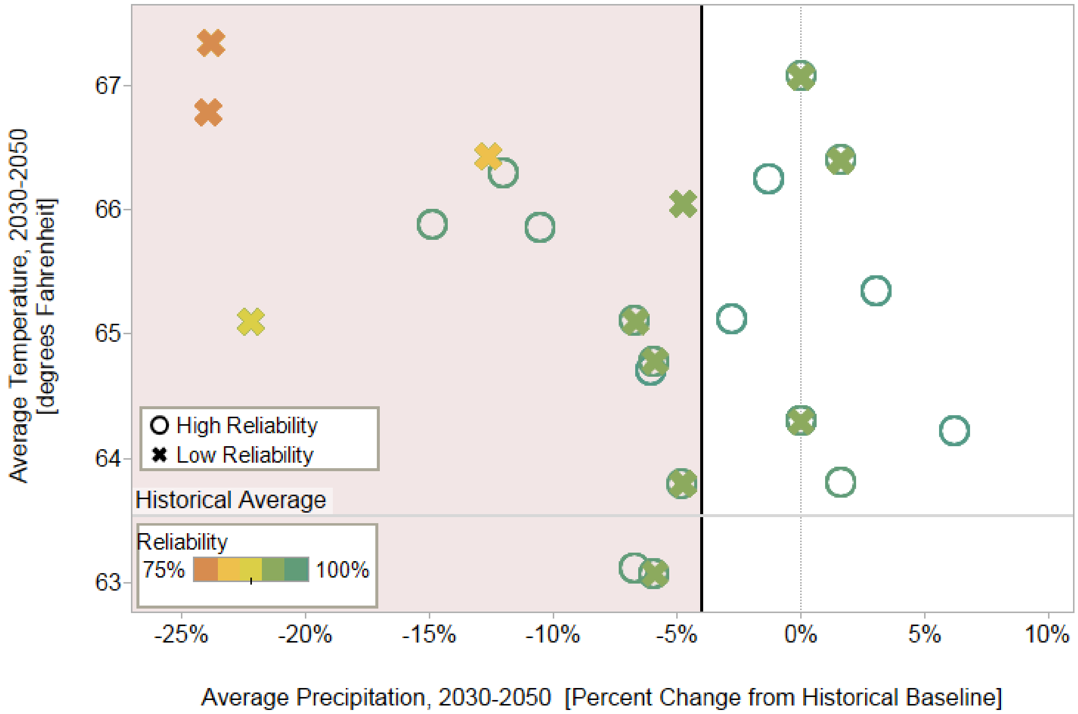
Box TL-3 Figure TL-A Range of urban and agricultural reliability results across scenarios for the Tulare Lake region



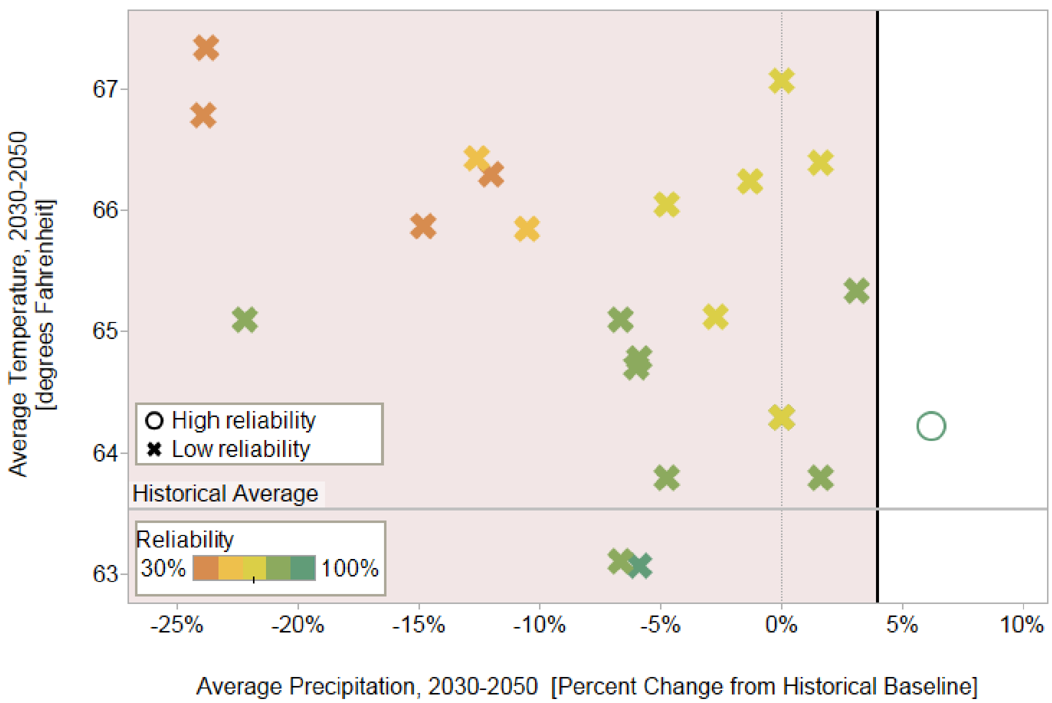
Box TL-3 Figure TL-B Range of changes in groundwater results across scenarios for the Tulare Lake region



Box TL-3 Figure TL-C Climate conditions leading to low urban reliability results in the Tulare Lake region



Box TL-3 Figure TL-D Climate conditions leading to low agricultural reliability results in the Tulare Lake region



Box TL-1 California Statewide Groundwater Elevation Monitoring (CASGEM) Basin Prioritization Data Considerations

Senate Bill 7x 6 (SBx7 6; Part 2.11 to Division 6 of the California Water Code § 10920 et seq.) requires, as part of the CASGEM program, DWR to prioritize groundwater basins to help identify, evaluate, and determine the need for additional groundwater level monitoring by considering available data listed below:.

1. The population overlying the basin,
2. The rate of current and projected growth of the population overlying the basin,
3. The number of public supply wells that draw from the basin,
4. The total number of wells that draw from the basin,
5. The irrigated acreage overlying the basin,
6. The degree to which persons overlying the basin rely on groundwater as their primary source of water,
7. Any documented impacts on the groundwater within the basin, including overdraft, subsidence, saline intrusion, and other water quality degradation, and
8. 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
- Very Low

Box TL-2 Other Groundwater Management Planning Efforts in the Tulare Lake Hydrologic Region

The Integrated Regional Water Management plans, Urban Water Management plans, and Agriculture Water Management plans 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 seven 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 GWMPs 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 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

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

Agricultural Water Management Plans

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

Box TL-3 **Evaluation of Water Management Vulnerabilities – Tulare Lake Region**

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

Results are presented here for the Tulare Lake Region evaluated over 198 combinations of future population growth and climate scenarios. The growth scenarios are defined in Table TL-35. Future climate conditions were evaluated over 22 alternative climate scenarios including five derived from historical temperature are precipitation estimates, five from historical conditions with an added temperature trend, and twelve 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 CWP summarizes the projections of future urban and agricultural conditions. Figure TL-A shows the range of reliability results for urban and agricultural sectors in the Tulare Lake 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 region, urban reliability is defined as the percentage of years for a given simulation in which 98% of urban demand is met with supply. Agricultural reliability is defined as the percentage of years in which 80% 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% in about 50% of the futures evaluated. For the agricultural sector reliability is below 95% in all but 5% of the futures.

PLACEHOLDER Figure TL-A Range of urban and agricultural reliability results across scenarios for the Tulare Lake region

Groundwater resources were evaluated for performance under the plausible futures. Figure TL-B shows the change in groundwater storage from the present to 2050 across the 198 scenarios. About 97% of the scenarios lead to groundwater declines in the Tulare Lake region and more than 50% of the scenarios lead to declines greater than 10%.

PLACEHOLDER Figure TL-B Range of changes in groundwater results across scenarios for the Tulare Lake region

The CWP next evaluated which future conditions would lead to low reliability in the Tulare Lake region. For the urban sector, reliability would be below 95% in 34% all of the scenarios evaluated. In the agricultural sector, reliability would be low in 95% 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% of historical account for 85% of the low reliability outcomes. Not all futures with these low precipitation conditions would yield low reliability—only about 45% of the futures would. Figure TL-C 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% reliable and Os are those that are more than 95% reliable. The color of the symbols indicates the reliability.

PLACEHOLDER Figure TL-C Climate conditions leading to low urban reliability results in the Tulare Lake region

In the agricultural sector, a larger number of futures lead to low reliability. Figure TL-D shows that low reliability outcomes correspond to climate conditions that are less than 4% wetter than historical conditions. X's indicate results that are less than 95% reliable. Circles indicate results that are more than 95% reliable. The reliability decreases significantly below the 95% level as conditions are drier and warmer (i.e. towards 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.

PLACEHOLDER Figure TL-D Climate conditions leading to low agricultural reliability results in the Tulare Lake region

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 will be unreliable if precipitation declines more than 4% over historical period. For the agricultural sector, conditions must be 4% wetter to be reliable.

Box TL-4 **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 DWR-ACWA survey. The survey requested the following conjunctive use program information:

1. Location of conjunctive use project;

2. Year project was developed;

3. Capital cost to develop the project;

4. Annual operating cost of the project;

5. Administrator/operator of the project; and

6. Capacity of the project in units of acre-feet.

To build on the DWR/ACWA survey, DWR staff contacted by telephone and email 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.