

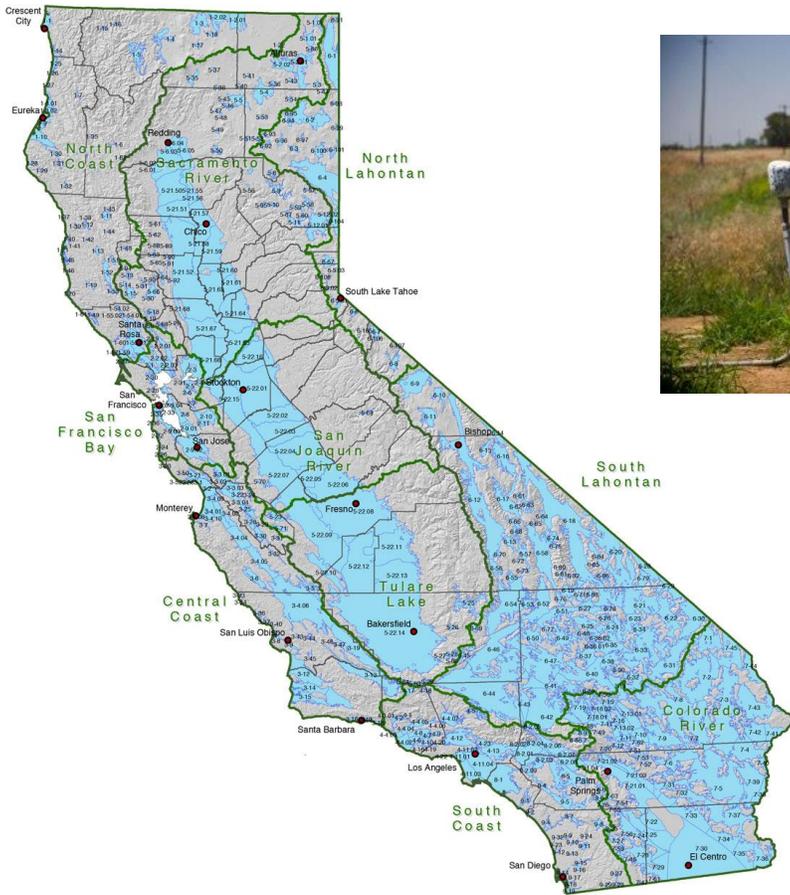
# California Water Plan Update 2013

## Groundwater Enhancements and Recommendations

October 29, 2013



## Workbook



Name: \_\_\_\_\_

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**CALIFORNIA WATER PLAN, UPDATE 2013**  
**PLENARY 2013**  
**OCTOBER 29, 2013, 1:50 PM – 3:50 PM**  
**GROUNDWATER ENHANCEMENTS AND RECOMMENDATIONS**

Session Key Topics

1. Groundwater Supply
2. Groundwater Conditions
3. Groundwater Governance and Conjunctive Management
4. Groundwater Recommendations

**AGENDA**

#	TIME	ITEM	PRESENTERS/GROUP DISCUSSION LEADS
1.	1:50 PM	WELCOME, AND INTRODUCTIONS	Abdul Khan, Dan McManus, and Elizabeth Patterson (Facilitator), Department of Water Resources (DWR)
2.	1:55	SESSION OVERVIEW & SUMMARY OF WORK CONDUCTED 1. Purpose 2. Key contents 3. Key messages 4. Recommendations 5. Questions for reviewers	Abdul Khan, DWR
3.	2:05	TOPIC 1: GROUNDWATER SUPPLY – TULARE LAKE HYDROLOGIC REGION AS AN EXAMPLE – <b>Average</b> – <b>Trends</b>	Dan McManus, DWR
	2:15	TOPIC 2: GROUNDWATER CONDITIONS – TULARE LAKE HYDROLOGIC REGION AS AN EXAMPLE – <b>Groundwater Level Trends</b> – <b>Changes in Groundwater Levels &amp; Storage</b> – <b>Land Subsidence</b>	Bill Brewster, DWR
	2:25	TOPIC 3: GROUNDWATER GOVERNANCE AND CONJUNCTIVE MANAGEMENT – TULARE LAKE HYDROLOGIC REGION AS AN EXAMPLE – <b>Groundwater Management Inventory &amp; Assessment</b> – <b>Conjunctive Management Inventory &amp; Assessment</b>  <i>(Ref: CWP 2013,v2, Tulare Lake Hydrologic Region; pg TL-17 to 19, TL-28 to 39, TL-42 to 45, TL-57 to 59; Tables TL-18 to 19, TL-26, TL-28 to 33; Figures TL-13 to 15, TL-18 to 29, TL-32 to 33, TL-36 to 37; Box TL-2, TL-4)</i>	Mark Nordberg, DWR
	2:35	GROUP REVIEW AND DISCUSSION (TOPICS 1, 2, & 3)	Dan McManus, Dane Mathis, Chris Bonds, Tim Ross, Bill Brewster, John Kirk, Jack Tung, Mark Nordberg, Roy Hull, and Mike McKenzie, DWR; Facilitator; All
	3:00	GROUP REPORT	Facilitator, All



**CALIFORNIA WATER PLAN, UPDATE 2013**

**PLENARY 2013**

**OCTOBER 29, 2013, 1:50 PM – 3:50 PM**

**GROUNDWATER ENHANCEMENTS AND RECOMMENDATIONS**

<b>#</b>	<b>TIME</b>	<b>ITEM</b>	<b>PRESENTERS/GROUP DISCUSSION LEADS</b>
4.	3:10	TOPIC 4: GROUNDWATER RECOMMENDATIONS – STATEWIDE  <i>(Ref: CWP 2013,v1, Ch 8; pg 8-7 to8-9; Tables8-3)</i>	Dan McManus, DWR
	3:15	GROUP REVIEW AND DISCUSSION (TOPIC 4)	Dan McManus and Mary Scruggs, DWR; Facilitator; All
	3:35	GROUP REPORT	Facilitator, All
5.	3:45	NEXT STEPS	Abdul Khan, DWR
6.	3:50	ADJOURN	Abdul Khan, DWR

# California Water Plan Update 2013

## Groundwater Enhancements and Recommendations

October 29, 2013



## Presentations

### **1. Session Overview and Summary of Work – Abdul Khan**

Questions:

- a. What key contents/messages do you think should be included in the CWP 2013 Highlights document?
- b. What are your suggestions to present the key contents/messages in a more compelling way?

### **2. Groundwater Supply – Dan McManus**

Key Points:

- a. Tulare Lake groundwater use accounts for 38% of CA average, twice as much as next highest hydrologic region
- b. 90% of Tulare Lake groundwater goes toward agricultural use

### **3. Groundwater Conditions – Bill Brewster**

Key Points:

- a. Well depth has increased to 282 ft. from 1921 – 2010
- b. Between 1926 and 1970 subsidence rates were as high as 1 foot per year
- c. Recent studies show renewed land subsidence

### **4. Groundwater Management and Conjunctive Management – Mark Nordberg**

Key Points:

- a. Tulare Lake and South Coast regions account for 78% of statewide conjunctive management programs
- b. Minimal information was reported by local agencies when contacted by DWR
- c. More details are needed to fully evaluate California's conjunctive management operations

### **5. Groundwater Recommendations – Statewide – Dan McManus**

Questions:

- a. Which among the recommendations would you like to see included in the Highlights document?
- b. Are we missing any critical recommendations that should be included?

# Public Review Draft Groundwater Enhancement and Recommendations

## California Water Plan Plenary

October 29, 2013

## Session Overview Summary of Work

### Navigating Water Plan Update 2013

California Water Plan Update 2013 (Update 2013) provides a wide range of information, from a detailed description of California's current and potential future conditions to a "Roadmap For Action" intended to achieve desired benefits and outcomes. Update 2013 applies at statewide, regional, and local scales, and serves to advise a diverse audience, including elected officials, planners and resource managers, tribal governments and communities, academics, and the general public. The plan is organized in five volumes. Volumes 1, 2, and 3 are outlined below. The *Highlights* booklet, Volume 4, *Reference Guide*, and Volume 5, *Technical Guide*, will be released with the Final Update 2013 document in March 2014.

#### Volume 1, The Strategic Plan

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



#### Volume 2, Regional Reports

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



#### Volume 3, Resource Management Strategies

- Integrated Water Management Toolbox  
30+ management strategies to:
- Reduce water demand
  - Increase water supply
  - Improve water quality
  - Practice resource stewardship
  - Improve flood management
  - People & water



## Update 2013 Public Review Draft Groundwater Enhancements - Purpose

- Expand information about statewide and regional groundwater conditions
- Compile and summarize groundwater data and analysis
- Better inform groundwater management actions

## Update 2013 Public Review Draft Key Contents - Expanded Features

- Aquifers, wells, and GW monitoring
- GW supply
- GW quality
- Land subsidence
- GW conditions
- GW governance
- Conjunctive management

1. Statewide groundwater summary - Vol. 1
2. HR groundwater summary - Vol. 2
3. CM & GW Storage RMS - Vol. 3
4. Standalone GW report - Vol. 4

## Update 2013 Public Review Draft Groundwater Enhancements - Key Messages

1. California - highly dependent on groundwater, 40 percent of supply.
2. Groundwater extraction varies by hydrologic region (avg. 16 maf):  
*Tulare L. (38%); San Joaquin R (19%); Sac R (17%); South Coast (10%).*
3. 1980 DWR Bulletin 118: 11 basins subject to critical overdraft; 31 basins with evidence of overdraft; 5 basins with special problems.  
*Today - 30 years later - many of these basins show signs of continued depletion and impacts have not yet been adequately addressed.*
4. Renewed land subsidence threatens buildings, infrastructure, water delivery & flood protection systems, and long-term water supply capacity.
5. Only 17% of B118 groundwater basin area (61,900 sq. miles) covered by GWMPs that include all SB 1938 CA Water Code requirements.
6. Significant efforts have been made to improve gw management, but Bolder Actions are needed.

## Update 2013 Public Review Draft Groundwater Enhancements – Recommendations

- Promote public education regarding groundwater.
- Improve collaboration and coordination among agencies.
- Increase availability and sharing of groundwater information.
- Strengthen/expand CASGEM Program for long-term sustainability.
- Under CASGEM, improve understanding of California GW basins.
- Assess SB 1938 GWMPs and develop guidelines to promote best practices in groundwater management.
- Develop better analytical tools to assess conjunctive management strategies.
- Increase statewide groundwater recharge and storage.
- Advance IRWM to improve alignment with GWM Planning.
- Develop and adopt stronger standards for GWM Planning.
- Consider legislation to provide needed local/regional authority.

## Update 2013 Public Review Draft Questions for Reviewers

### Groundwater Enhancements

1. What key contents/messages do you think should be included in the CWP 2013 Highlights document?
2. What are your suggestions to present the key contents/messages in a more compelling way?

### Groundwater Recommendations

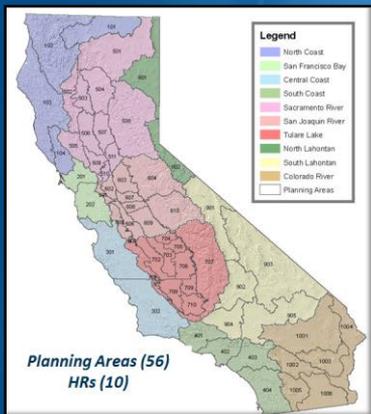
1. Which among the recommendations would you like to see included in the Highlights document?
2. Are we missing any critical recommendations that should be included?



# Topic 1. Groundwater Supply

Information is Presented by:

- Planning Area
- Hydrologic Region
- County Area
- Type of Use: Ag, Urban, and Managed Wetlands



Key Message: See handout or report for additional information

<http://www.waterplan.water.ca.gov/cwpu2013/index.cfm>



# Topic 1. Groundwater Supply

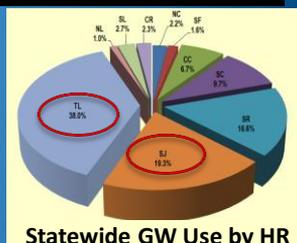
2005-10 Average Annual Groundwater Supply: Volume & % Total Supply Met by GW

PA Number	PA Name	Ag		Urban		Managed Wetlands		Total	
		TAF	%	TAF	%	TAF	%	TAF	%
701	Western Uplands	0.3	13%	2.0	87%	0.0	0%	2.3	100%
702	San Luis West Side	598.5	41%	7.5	1%	0.0	0%	606.0	41%
703	Lower Kings-Tulare	1,466.9	67%	44.5	2%	1.1	0%	1,512.4	69%
704	Fresno - Academy	56.1	7%	204.5	27%	0.0	0%	260.6	34%
705	Alta - Orange Cove	435.8	43%	59.3	6%	0.0	0%	495.1	49%
706	Kaweah Delta	1,547.5	58%	112.8	4%	3.2	0%	1,663.5	62%
707	Uplands	32.6	62%	14.3	27%	0.0	0%	46.9	89%
708	Semitropic - Buena Vista	622.7	51%	17.7	1%	24.7	2%	665.0	54%
709	Kern Valley Floor	322.0	38%	31.9	4%	0.0	0%	353.9	42%
710	Kern Delta	580.3	38%	109.7	7%	0.0	0%	690.0	45%
2005-10 Ave Total:		5,662.5	48%	604.1	5%	28.9	0%	6,295.5	54%

Note: TL HR 2005-10 Precip. = 93% of the 30-yr average

### Key Messages:

- TL GW Use: 38% of CA average annual
- Twice as much as next highest HR
- One-half TL GW is from PA 703 & 706
- 48% of TL Agricultural Water Use is from GW
- 54% of TL total supply is from GW...highly dependent
- 87% of Western Uplands Urban supply is from GW



# Topic 1. Groundwater Supply

2005-10 Average Annual Groundwater Supply: % GW Use by PA and HR

Tulare Lake Hydrologic Region		Groundwater for Agricultural Use	Groundwater for Urban Use	Groundwater for Managed Wetlands Use	GW Use by PA
PA Number	PA Name	%	%	%	%
701	Western Uplands	13%	87%	0%	0%
702	San Luis West Side	99% <span style="color:red">★</span>	1%	0%	10%
703	Lower Kings-Tulare	97% <span style="color:red">★</span>	3%	0%	24%
704	Fresno - Academy	22%	78%	0%	4%
705	Alta - Orange Cove	88%	12%	0%	8%
706	Kaweah Delta	93% <span style="color:red">★</span>	7%	0%	26%
707	Uplands	69%	31%	0%	1%
708	Semitropic - Buena Vista	94% <span style="color:red">★</span>	3%	4%	11%
709	Kern Valley Floor	91% <span style="color:red">★</span>	9%	0%	6%
710	Kern Delta	84%	16%	0%	11%
<b>2005-10 Annual Average HR Total:</b>		<b>90%</b>	10%	0%	100%

**Note:** 1) Percent use is average annual groundwater use by planning area and type of use, compared to the total groundwater use for the hydrologic region.

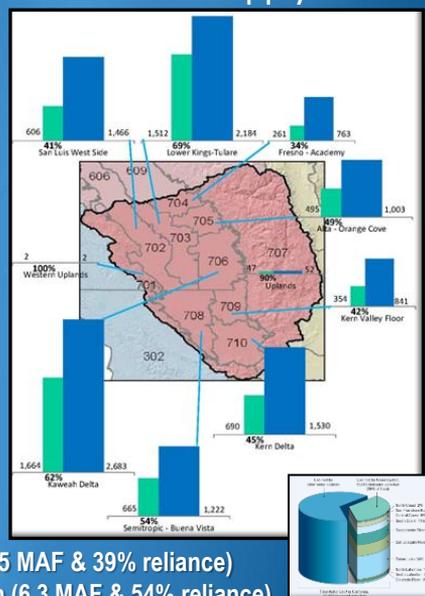
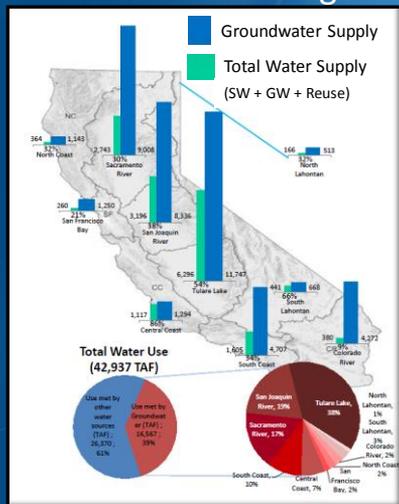
### Key Messages:

- 90% of TL groundwater goes toward Agricultural Use
- One-half the TL PAs use > 90% of gw for Agricultural Use
- PAs 703 & 706 comprise 50% of TL average annual GW Use



# Topic 1. Groundwater Supply

2005-10 Average Annual Groundwater Supply:

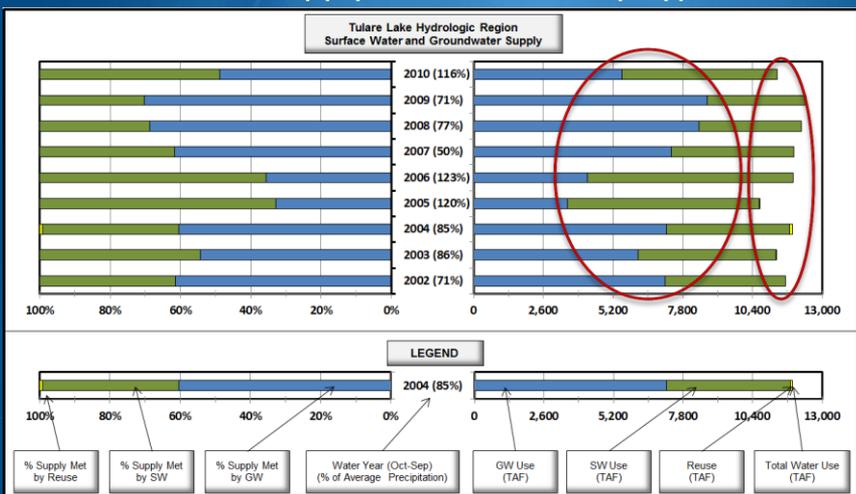


### Key Messages:

- Statewide GW Use & Reliance = High (16.5 MAF & 39% reliance)
- TL Region GW Use & Reliance = Very High (6.3 MAF & 54% reliance)

# Topic 1. Groundwater Supply

## Groundwater Supply Trends: Butterfly-Type Chart

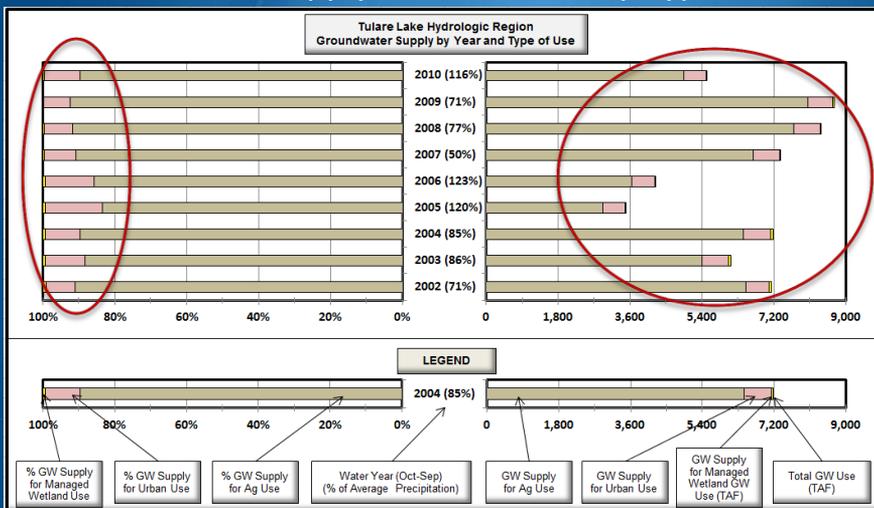


**Key Messages:**

- Small Variability in Total Supply (15% of ave.): Indication of increasing permanent crops
- Highly Variable SW & GW Supply :GW = 30 - 70% of the total water supply

# Topic 1. Groundwater Supply

## Groundwater Supply Trends: Butterfly-Type Chart



**Key Messages:**

- Highly Variable Volume of GW Use...but
- Relatively stable division by type of use (90% Ag., 10% Urban)

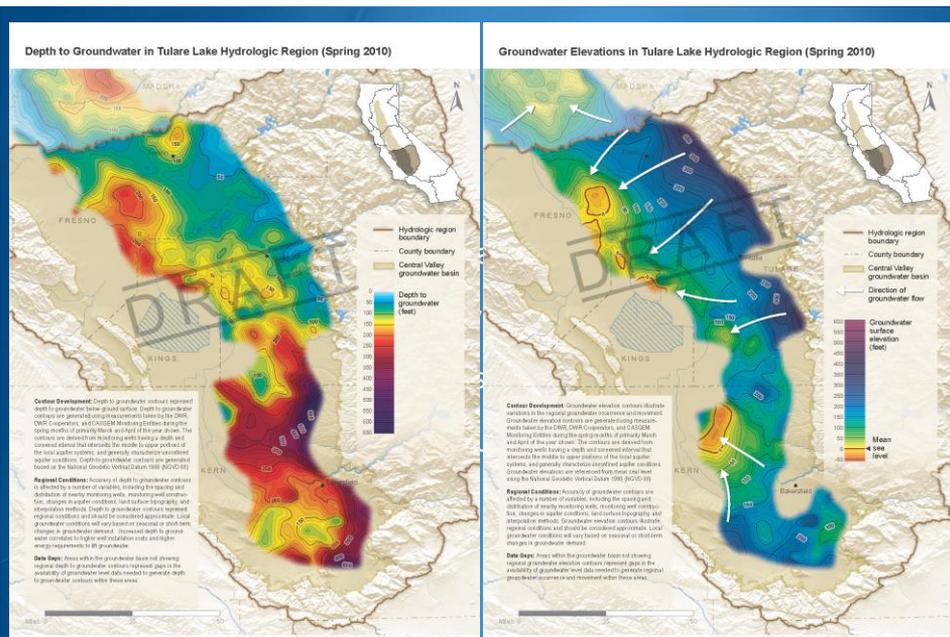




# Topic 2. Groundwater Conditions

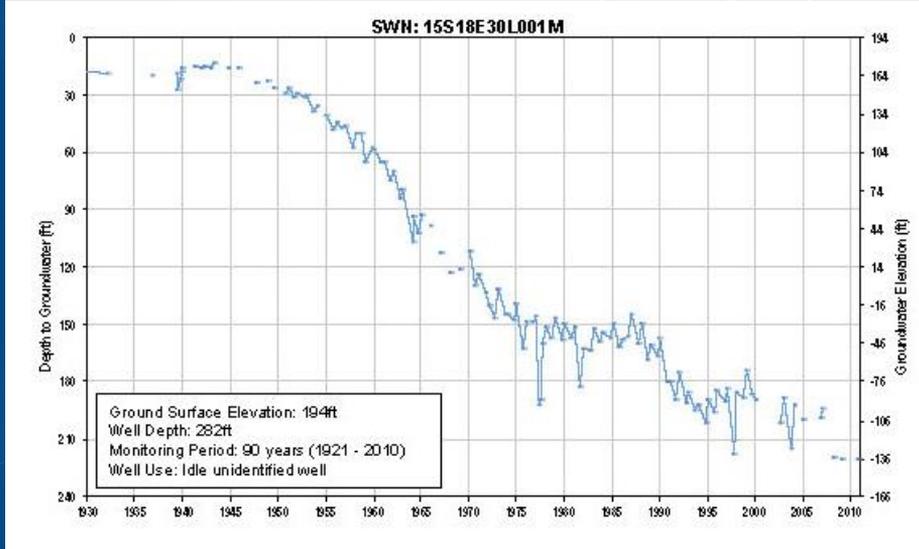
- Groundwater Levels and Trends
- Change in Groundwater Storage
- Land Subsidence

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# Groundwater Level Hydrographs



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## Change in Groundwater Storage

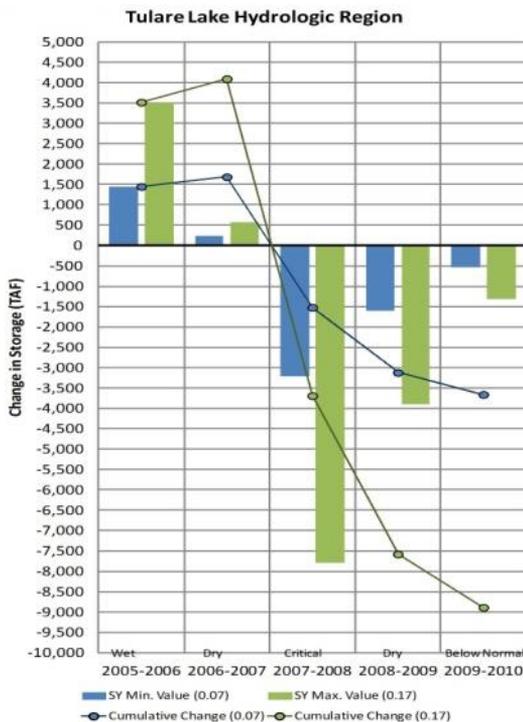
...begin with change in groundwater levels

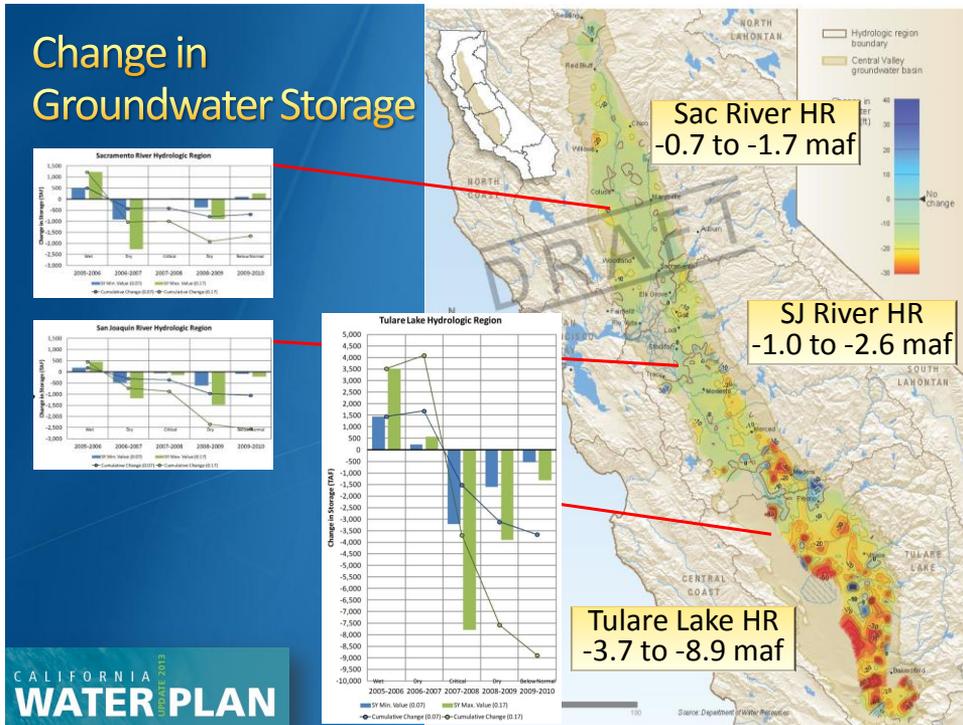
...then factor in aquifer characteristics

Estimated change in groundwater storage in the Tulare Lake Hydrologic Region:

Min: -3.7 million acre-feet  
Max: -8.9 million acre-feet

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## Land Subsidence

- Declining groundwater levels in aquifers with fine grained material can lead to inelastic subsidence
- Land subsidence can damage infrastructure, such as water supply and flood protection systems
- There is a long history of subsidence in the Tulare Lake Hydrologic Region:
  - First documented in 1935
  - Subsidence rates decreased after building major water delivery infrastructure (CVP, SWP, others)
  - Subsidence rates in some areas have increased recently

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# Land Subsidence

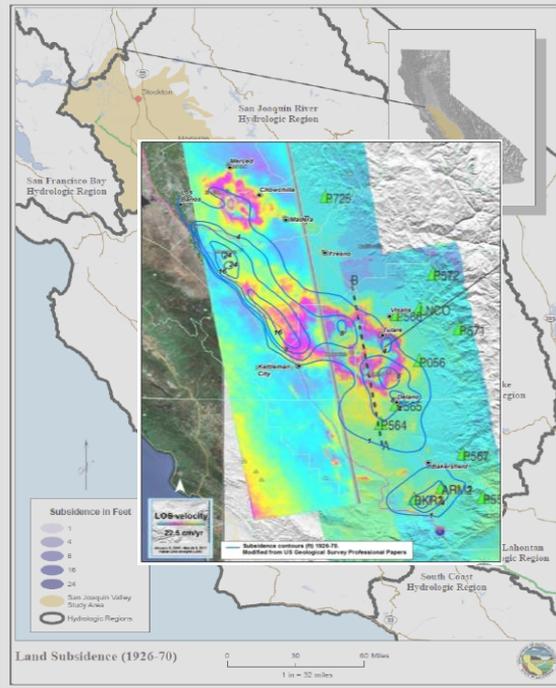
...between 1926 and 1970 there was more than 24 feet of land subsidence in some areas (Ireland, 1984)

...subsidence rates were as high as 1 foot per year

...recent studies show renewed land subsidence (USGS)



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

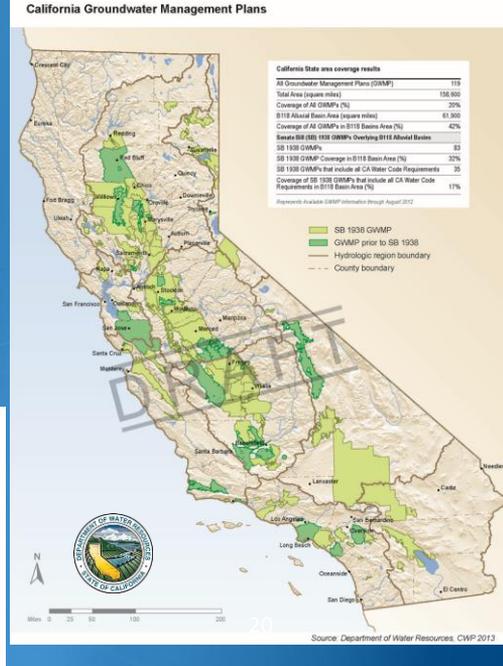




## Topic 3 California Groundwater Management Plans

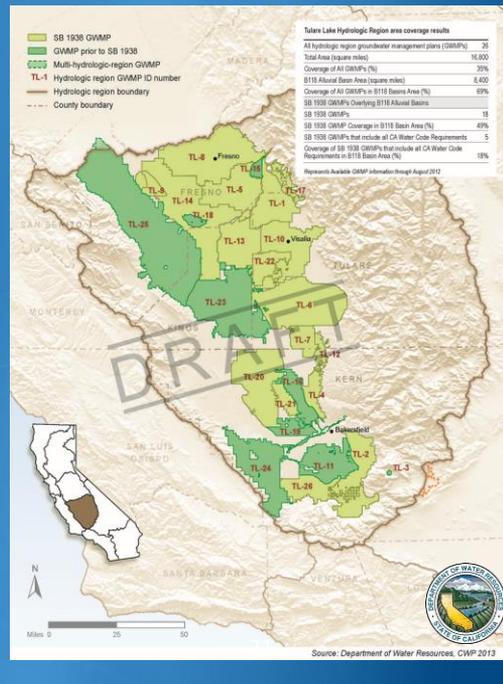
- GWMP assessment collected all plans and compared them to the California Water Code (GWMPs received by August 2012)
- GWMPs prepared after the SB 1938 legislation was passed in 2002 are considered “active” plans
- DWR recommends all GWMPs be updated to comply with CWC §10753.7

All Groundwater Management Plans (GWMP)	119
Total Area (square miles)	158,600
Coverage of All GWMPs (%)	20%
B118 Alluvial Basin Area (square miles)	61,900
Coverage of All GWMPs in B118 Basins Area (%)	42%
<b>Senate Bill (SB) 1938 GWMPs Overlying B118 Alluvial Basins</b>	
SB 1938 GWMPs	83
SB 1938 GWMP Coverage in B118 Basin Area (%)	32%
SB 1938 GWMPs that include all CA Water Code Requirements	35
Coverage of SB 1938 GWMPs that include all CA Water Code Requirements in B118 Basin Area (%)	17%



## Tulare Lake Region Groundwater Management Plans

- 26 GWMPs in Tulare Lake Region
  - 69% of B-118-03 basin area
- 18 GWMPs are post-SB 1938 (2002)
  - 49% of B-118-03 basin area
- 5 GWMPs include all CWC §10753.7 requirements
  - 18% of B-118-03 basin area
- 19 GW basins and subbasins in Tulare Lake Region
  - 7 high use basins
  - 1 medium use basin
  - 1 low use basin





## Topic 3 (cont.)

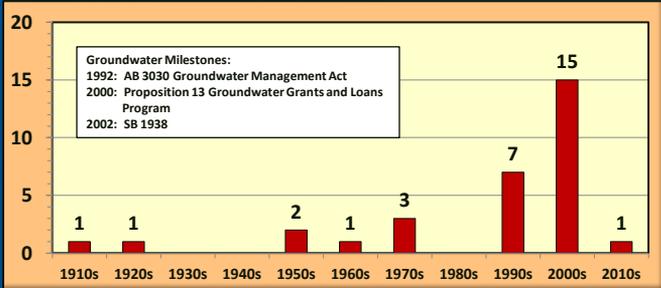
# Conjunctive Management in California

- DWR conducted a statewide survey to gather conjunctive management program information
- 89 (operating) conjunctive management programs identified statewide
  - 37 programs in Tulare Lake Region
  - 32 programs in South Coast Region
  - TL + SC = 78% of programs Statewide
- Minimal information was reported by local agencies when contacted by DWR
- More details are needed to fully evaluate California's conjunctive management operations
- *Vol. 3, Ch. 9: Conjunctive Management and Groundwater Storage Resource Management Strategy*



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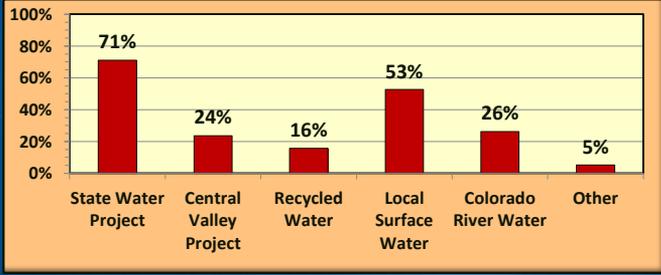
## Statewide Conjunctive Management Summary



Decade	Number of Projects
1910s	1
1920s	1
1930s	0
1940s	0
1950s	2
1960s	1
1970s	3
1980s	0
1990s	7
2000s	15
2010s	1

Projects Developed per Decade

(Note: 31 out of 89 programs reporting data)



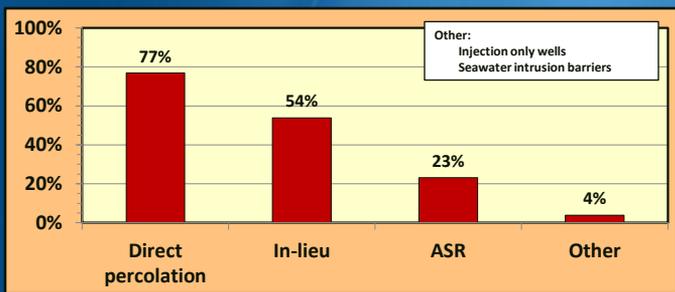
Source	Percentage
State Water Project	71%
Central Valley Project	24%
Recycled Water	16%
Local Surface Water	53%
Colorado River Water	26%
Other	5%

Source of Recharge Water

(Note: 38 out of 89 programs reporting data)

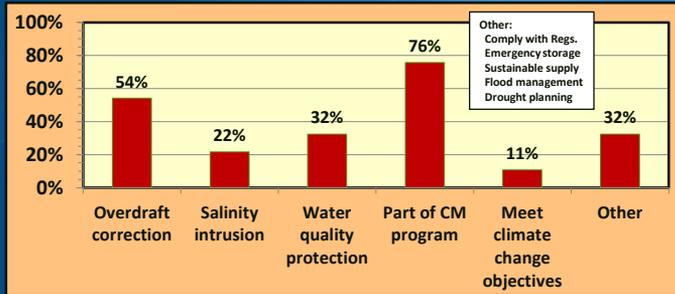
23

## Statewide Conjunctive Management Summary



### Method of Groundwater Recharge

(Note: 52 out of 89 programs reporting data)



### Program Goals and Objectives

(Note: 37 out of 89 programs reporting data)

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## Update 2013 Public Review Draft Questions for Reviewers

### Groundwater Enhancements

1. What key contents/messages do you think should be included in the CWP 2013 Highlights document?
2. What are your suggestions to present the key contents/messages in a more compelling way?



## Topic 4. Groundwater Recommendations *Statewide*

1. Promote public education regarding groundwater
2. Improve collaboration and coordination among agencies
3. Increase availability and sharing of groundwater information
4. Strengthen/expand CASGEM for long-term implementation
5. Under CASGEM, improve understanding California's high use groundwater basins
6. Assess GWMPs and develop guidelines to promote best practices in groundwater management



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## Topic 4. Groundwater Recommendations *Statewide*

7. Develop better analytical tools to assist conjunctive management strategies
8. Increase statewide groundwater recharge and storage
9. *Advance IRWM to improve alignment with GW Mgmt. Planning*
10. *Develop and adopt stronger standards for GW Mgmt. Planning*
11. *Consider legislation to provide needed local/regional authority*

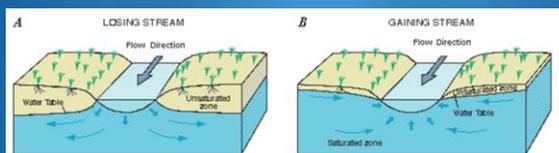


Figure 6. Interaction of streams and groundwater. Losing streams (A) lose water to the groundwater system, whereas gaining streams (B) receive water from the groundwater system (adapted from Winter et al., USGS Circular 1139, 1998)

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## Topic 4. Groundwater Recommendations

### Additional Recommendation to improve Standards for Sustainable Groundwater Mgmt.

1. Implementation of GWMPs
2. Goals, objectives, performance measures, and periodic updates
3. Detailed groundwater budgets
4. Addition of ecosystem services into basin management objectives.
5. Annual reporting of GWMP implementation and performance,
6. Forecasting of current trends for improvements/impacts
7. Online posting of GWMPs, annual reports, and lead entity POC



## Update 2013 Public Review Draft Questions for Reviewers

### Group Review and Discussion Topic 4 - Groundwater Recommendations

1. Which among the recommendations would you like to see included in the Highlights document?
2. Are we missing any critical recommendations that should be included?



# California Water Plan Update 2013

Groundwater Enhancements and Recommendations

October 29, 2013



## Handouts

- a. **Groundwater Supply Overview**
- b. **Groundwater Conditions and Land Subsidence Overview**
- c. **Groundwater Management Overview**
- d. **Conjunctive Management Survey Overview**
- e. **Groundwater Recommendations – Statewide**

**CALIFORNIA WATER PLAN 2013 UPDATE – PLENARY MEETING – OCTOBER 29, 2013**

**GROUNDWATER SUPPLY OVERVIEW**

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 groundwater extraction estimates 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 Groundwater Supply:** Groundwater supplies in the Tulare Lake region play a significant role in meeting annual water demands. The 2005-2010 average annual groundwater extraction for the Tulare Lake region is estimated at 6,300 thousand acre-feet (TAF), or 54 percent of the total water supply for the region. Annual groundwater use in the Tulare Lake region accounts for 38 percent of California’s total groundwater pumping—double the amount of the next largest hydrologic region groundwater user.

Approximately 90 percent (5,663 TAF) of the Tulare Lake region annual groundwater extraction is applied for agricultural use— making up 52 percent of the total annual agricultural water supply. In contrast, only 10 percent (604 TAF) of the annual groundwater extraction is applied for urban use. Less than one percent of the groundwater extraction goes towards managed wetland use. Statewide, about 76 percent of the average annual groundwater pumping goes towards agricultural groundwater uses, with 22 and 2 percent going towards urban and managed wetland uses.

Groundwater use by PA shows that two of the largest groundwater users in the region, lower Kings-Tulare and Kaweah Delta, rely on about 3,000 TAF of combined groundwater pumping to meet 69 and 62 percent of their total water supply. The annual pumping volume and reliance on groundwater supplies is also quite high for the San Luis West Side, Kern Delta, Alta-Orange Cove, and Semitropic-Buena Vista PAs. Groundwater status reports from groundwater management groups overlying many of these PA acknowledge that the average annual groundwater extraction commonly exceeds safe aquifer yield. The smallest groundwater user by PA, Western Uplands, is completely reliant on groundwater to meet about urban and agricultural water supply.

**2002-2010 Groundwater Supply Trends:** Total water supply for the Tulare Lake 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, total water supply for the region ranged from 10,600 to 12,400 TAF, a fluctuation of about 15 percent of the annual average. During this same period, Tulare Lake groundwater supplies ranged from 3,500 TAF (2005) to 8,700 TAF (2009)—a fluctuation of about 80 percent of the annual average use, resulting in a contribution of between 33 and 70 percent of the regions overall annual supply. The 250 percent increase in Tulare Lake groundwater extraction between 2005 and 2009 represents more groundwater use than is annually pumped by all of the remaining Central Valley groundwater basins combined. The large fluctuations in groundwater water extraction points to a limited surface water supply reliability and the aggressive application of conjunctive management practices to help meet hardening demands for water.

Groundwater pumping to meet urban water needs remained fairly stable during 2002 to 2010 period. Urban groundwater use ranged from about 550 TAF to about 650 TAF, and contributed between 7 and 16 percent towards the total urban water supply. Compared to agricultural and urban uses, the application of groundwater supplies for managed wetlands use is fairly minor. Managed wetland use of groundwater ranged from 25 to 65 TAF; however, groundwater does contribute between 35 and 45 percent of the total managed wetland water supply.

**Findings:** Groundwater extraction at rates and volumes that far exceed natural aquifer recharge, or the ability to actively recharge via conjunctive management practices, has resulted in a long-term economic benefits and allowed the San Joaquin Valley to become one of the world's most productive agricultural regions. 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 resources.

Although significant improvements have been made to provide the authority and tools for local groundwater management, and significant efforts have been made by local managers to implement these groundwater management improvements, 30 years after DWR's reporting of basins in overdraft, California's reliance on groundwater continues to increase and the implementation of effective and sustainable groundwater management practices in water short regions continues to pose major challenges to local resource managers.

Existing agricultural and urban developments should critically evaluate the broader long-term costs and risks associated with unsustainable groundwater pumping versus the short-term value that it provides. Mitigation against further escalation of groundwater pumping-related impacts will require additional and more aggressive actions to adjust current land and water resource management practices in high-use areas characterized by unsustainable groundwater extraction.

## CALIFORNIA WATER PLAN 2013 UPDATE – PLENARY MEETING – OCTOBER 29, 2013

### GROUNDWATER CONDITIONS AND LAND SUBSIDENCE OVERVIEW

*The Groundwater Conditions Section*, as presented in the California Water Plan Update 2013 Regional Reports, describes depth to groundwater, groundwater occurrence and movement, and changes in groundwater elevation and groundwater storage over time. *Land Subsidence*, another important issue related to groundwater conditions (and more specifically to declining groundwater levels) is described in a separate section.

*The importance of data when determining groundwater conditions and land subsidence:* Collecting groundwater level measurements from wells is the most direct method of determining depth to groundwater level and changes in groundwater elevation. Groundwater level monitoring occurs throughout California; however, the design, intent and implementation of monitoring programs vary widely. The monitoring network currently available to DWR is described in the Regional Report *Setting, Groundwater Aquifer Section*. Note that the quality and completeness of the information presented in the *Groundwater Conditions Section* has a direct correlation to the quality, consistency, and extent of the groundwater level data collected by and made available to DWR.

Within the Tulare Lake Hydrologic Region, land subsidence is directly correlated to declining groundwater levels. Land subsidence is measured using a variety of methods, including satellite-based remote sensing techniques (InSAR), GPS Array Monitoring, direct measurement of soil compaction at depth (extensometer well), and traditional surveying methods. Land subsidence monitoring techniques and surveys is described in the Regional Report *Land Subsidence* section.

### GROUNDWATER OCCURRENCE IN THE TULARE HYDROLOGIC REGION

*Depth to groundwater* for 2010 is depicted as a contour map developed from groundwater level measurements collected in late-winter/early-spring from wells intersecting the unconfined aquifer. Depths to groundwater range from about 20 feet to over 500 feet below ground surface and is not depicted in areas along the west side and in the Tulare Lake basin due to a lack of data. Groundwater levels are shallowest in the northeast areas and along areas of recharge from rivers, streams and canals. Deeper groundwater levels are found in the northwestern and southern areas where there is less recharge and more groundwater pumping, and in areas where the topography rises rapidly at the edge of the groundwater basin.

*Groundwater elevation* contour maps can illustrate the general direction of groundwater movement. Groundwater elevations measured in spring 2010 indicate that groundwater flows from the groundwater basin margins towards the axis of the valley. Groundwater pumping depressions exist along the western edge of the Kings and Kaweah subbasin. In these areas groundwater elevations decline below sea level. As previously mentioned, water level measurements were not available in all parts of the groundwater basin. Where groundwater level measurements were collected, as shown on the spring 2010 groundwater elevation contour map, groundwater elevation varied from over 400 feet

above sea level west and southwest of Fresno to below sea level in areas southwest of Fresno and northwest of Bakersfield. The spring 2010 contour map also shows patterns of recharging groundwater along the San Joaquin, Kings, and Tulare Rivers.

*Groundwater level trends* are depicted using groundwater level hydrographs. Many hydrographs from the Tulare Lake HR show a long history of declining groundwater levels with slower rates of decline during wetter years. Some hydrographs do, however, show periods of stable or increasing groundwater levels due to changes in local water management practices and/or importation of surface water supplies (such as from the California Aqueduct).

#### **CHANGES IN GROUNDWATER STORAGE**

Changes in groundwater storage can be calculated by comparing groundwater levels from different time periods and accounting for aquifer storage parameters. Comparison of spring 2005 water levels to spring 2010 shows that groundwater levels declined for most of the monitored area within the Tulare Lake HR. For this five year time period two years showed an increase in groundwater storage while three years show a storage decline; 2005 - 2006 had the greatest one year increase in groundwater storage, while 2007 - 2008 showed the greatest decrease in groundwater storage. Maximum cumulative groundwater level declines tended to be located near the valley axis in areas with limited recharge.

#### **LAND SUBSIDENCE**

Land subsidence is caused by the compaction of aquifer materials due to groundwater withdrawal and was first documented within the San Joaquin Valley in 1935. In some areas, such as west Fresno County, subsidence rates were as high as one foot per year during times of heavy pumping. Land subsidence is an ongoing problem. By 1960, about half of the Tulare Lake HR valley portion had subsided more than one foot. Maximum total subsidence has occurred east of Interstate 5, north of Kettleman City, and between Delano and Tulare, along Highway 99. Land subsidence rates slowed after the construction of new conveyance facilities and importation of water, but because of renewed demand on groundwater supplies, subsidence rates have returned to their previous rates of up to one foot per year in some areas.

## CALIFORNIA WATER PLAN 2013 UPDATE – PLEARNY MEETING – OCTOBER 29, 2013

### GROUNDWATER MANAGEMENT OVERVIEW

California State law does not require local agencies to adopt or implement groundwater management programs. However, legislation has been created to provide incentives for local agencies to manage groundwater resources in a manner that promotes efficient, effective, and sustainable use of groundwater resources. One of the primary vehicles for implementing local groundwater management in California is a Groundwater Management Plan (GWMP).

Groundwater management information included in this assessment is based on GWMP documents that were readily available or submitted to DWR as of August 2012. The inventory identified how many GWMPs were developed based on older 1992 AB 3030 legislation versus GWMPs developed or updated to meet the 2002 SB 1938 legislative requirements. GWMPs prepared after 2002 that incorporate the requirements of CWC §10753.7 are considered “active” for the purposes of the CWP Update 2013 assessment. The overall intent of the GWMP assessment is to help identify groundwater management successes and challenges, and provide recommendations for regional and statewide improvement.

### TULARE LAKE REGION – GWMP ASSESSMENT FINDINGS

- There are 26 GWMPs within the boundaries of the Tulare Lake region
- 18 GWMPs have been prepared to incorporate the SB 1938 legislative requirements
- 5 GWMPs include all requirements found in **CWC §10753.7**
- The Tulare Lake region includes about 8,400 square miles of alluvial groundwater basins, defined in DWR’s Bulletin 118-2003
  - The 26 GWMPs cover about 69 percent of the Bulletin 118-2003 groundwater basin area
    - About 35 percent of the entire regional land area
  - The 18 active GWMPs cover 49 percent of the Bulletin 118-2003 groundwater basin area
  - The 5 GWMPs that meet all CWC requirements cover 18 percent of the Bulletin 118-2003 groundwater basin area
- Voluntary GWMP components are found in CWC §10753.8
  - Well abandonment and destruction, groundwater extraction and replenishment, groundwater monitoring, conjunctive use, and well construction policies were included in greater than 90 percent of the active GWMPs in the region. Saline intrusion and overdraft policies were addressed in over 80 percent of the GWMPs.
  - The least incorporated of the voluntary components was the development of relationships with State and federal regulatory agencies (53 percent).
- Recommended GWMP components are found in Bulletin 118-2003, Appendix C
  - Most GWMPs addressed at least 6 of 7 recommended components
  - Monitoring plan descriptions was the criteria that was least included in GWMPs

**STATEWIDE – GWMP ASSESSMENT FINDINGS**

- 119 GWMPs were compiled for California (as of August 2012)
- 83 GWMPs have been prepared to incorporate the SB 1938 legislative requirements
- 35 GWMPs include all requirements found in **CWC §10753.7**
- Alluvial groundwater basins in California cover about 61,900 square miles
  - The 119 GWMPs cover about 42 percent of the Bulletin 118-2003 groundwater basin areas
    - About 20 percent of the California land area
  - The 83 active GWMPs cover 32 percent of the Bulletin 118-2003 groundwater basin area
  - The 35 GWMPs that meet all CWC requirements cover 17 percent of the Bulletin 118-2003 groundwater basin area
- Voluntary GWMP components are found in CWC §10753.8
  - *Monitoring*: 96 percent of the active GWMPs incorporate groundwater level monitoring
  - *Conjunctive Use*: 88 percent of the active GWMPs address conjunctive use to some degree
  - *Well Construction, Destruction, and Abandonment*: 88 percent and 87 percent of the active GWMPs address well construction and abandonment, while 65 percent of the counties have ordinances that address abandonment and destruction of unused wells
  - *Overdraft*: About 75 percent of active GWMPs address overdraft issues, coordinating with regulatory agencies, and wellhead protection
- Recommended GWMP components are found in Bulletin 118-2003, Appendix C
  - *Management Area*: 94 percent of agencies provided reasonable content for defining their management area
  - *GWMP Implementation*: 87 percent of active plans discuss GWMP implementation, although the activities and information was limited and not readily available
  - *Evaluation*: 87 percent of active plans include statements that periodic evaluation will occur
  - *BMOs, Goals, and Actions*: 82 percent of the active plans attempt to create a relationship between the groundwater management actions, BMOs, and GWMP goals. However, many of the objectives were broad, not measurable, and with no timeline. BMOs regarding surface water-groundwater interaction were very limited.
  - *GWMP Guidance*: About 80 percent of active plans established advisory committees
  - *IRWM Planning*: 78 percent of the active plans indicated that they participate in IRWM planning
  - *Monitoring Plans*: Only 63 percent of active plans provided a monitoring plan description. descriptions was the criteria that was least included in GWMPs

## RECOMMENDATIONS TO IMPROVE GROUNDWATER MANAGEMENT

- Improve coordination and alignment of federal, state, and local governments to assist in implementing sustainable groundwater management
- Create a Statewide GWMP Advisory Committee to: 1) evaluate and approve the completeness of existing GWMPs; 2) develop a guidance document of groundwater management best practices; and 3) identify tools and data sharing needed to improve groundwater management.
- Improve standards for sustainable groundwater management. Improved groundwater management standards should include:
  - a. GWMP verification and implementation;
  - b. Goals, objectives, performance measures, and a clear description of additional management steps to be taken if performance measures are not met – including potential reduction of groundwater demand;
  - c. Detailed groundwater budget;
  - d. Addition of ecosystem services into Basin Management Objectives;
  - e. Annual reporting of GWMP implementation activities and performance;
  - f. Reporting of groundwater quantity and quality sustainability under current and projected (10 & 20 year) groundwater budgets;
  - g. Identify impacts (economic and environmental) under current and projected groundwater budgets; and
  - h. Online posting of GWMPs, annual reports with groundwater budget, key studies, lead GWMP entity and point of contact.
- Encourage IRWM plans to identify and include the goals and objectives of local GWMPs
- Continue to implement and improve CASGEM Program
- Utilize CASGEM Basin Prioritization to conduct assessments of high and medium priority groundwater basins
- Provide funding and technical assistance to improve local groundwater monitoring and management, and promote multi-benefit projects that improve groundwater sustainability
- Develop a statewide groundwater management planning site for local agencies to post and download groundwater management documents and information
- Consider changes to the Water Code to allow public access to groundwater information in well completion reports

## CALIFORNIA WATER PLAN 2013 UPDATE – PLEARNY MEETING – OCTOBER 29, 2013

### CONJUNCTIVE MANAGEMENT SURVEY OVERVIEW

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.

As part of the CWP Update 2013, an inventory and assessment of conjunctive management operations in California was conducted. The overall intent of this effort was to provide a statewide summary of conjunctive water management program locations, operational methods, and capacities, and identify their successes, challenges, and opportunities for growth to share with policy makers and other stakeholders to enable an informed decision making process regarding groundwater and its management. The conjunctive management inventory and assessment consisted of literature research, an online survey, personal communication with local agencies, and a documented summary of the conjunctive management programs in California. The following questions were asked of local agencies regarding their conjunctive management operations:

- Location of conjunctive use project
- Year project was developed
- Capital cost to develop the project
- Annual operating cost of the project
- Administrator/operator of the project
- Capacity of the project
- Source of water received
- Put and take capacity of the project
- Type of groundwater bank or project
- Program goals and objectives
- Constraints on development of program

Statewide, a total of 89 conjunctive management and groundwater recharge programs were identified as part of the conjunctive management project inventory. Due to confidentiality concerns expressed by some local agencies, information for some existing conjunctive management programs were not reported. Also, conjunctive management and groundwater recharge programs that are in the planning and feasibility stage are not included in the inventory.

### PURPOSE OF THE CONJUNCTIVE MANAGEMENT INVENTORY

- CWP Update 2009 recommended a statewide inventory
- There is no comprehensive data monitoring network for conjunctive management or groundwater recharge programs

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- Collect information to enable an informed decision making process for legislators and policy makers
- Identify areas where local agencies may need technical or financial assistance from state or local agencies
- To achieve better coordination among existing and future planning activities and to avoid potential conflict

#### TULARE LAKE REGION AND STATEWIDE – CONJUNCTIVE MANAGEMENT SURVEY FINDINGS

- 89 conjunctive management or groundwater recharge programs were identified Statewide
  - 37 conjunctive management programs were identified in the Tulare Lake region
  - 32 programs were identified in the South Coast region
  - TL + SC = 78% of statewide conjunctive management programs
- For some of the survey questions, minimal information was reported by local agencies that were contacted by DWR staff
- More details are needed to fully evaluate California’s conjunctive management operations

#### RECOMMENDATIONS TO IMPROVE CONJUNCTIVE MANAGEMENT AND GROUNDWATER RECHARGE

- Encourage local agency cooperation
- Continue to implement and improve CASGEM
- Continue funding for local groundwater monitoring and management programs, as well as feasibility studies
- Encourage local agencies to establish water budgets
- Establish a System Reoperation Task Force
- Develop a statewide comprehensive data management system about groundwater and conjunctive management programs
- Assess existing groundwater management programs
- Improve inter-agency coordination for groundwater programs
- Promote multi-benefit projects that generate new water for recharge programs
- Evaluate opportunities to reduce runoff and increase recharge
- Link flood control and groundwater recharge goals
- Streamline the environmental permitting process
- Streamline the water rights permitting process
- Consider changes to the Water Code to allow public access to groundwater information in well completion reports

**CALIFORNIA WATER PLAN 2013 UPDATE – PLEARNY MEETING – OCTOBER 29, 2013**

**STATEWIDE GROUNDWATER RECOMMENDATIONS**

**1. Promote public education about California’s groundwater.**

DWR and SWRCB should work with other State, tribal, local, and IRWM regional water management groups (RWMG) to develop a groundwater education program and materials for use in the schools and public outreach. Key educational concepts should include:

- A. Groundwater supply variability.
- B. Interconnection of surface water and groundwater.
- C. Groundwater recharge benefits and challenges.
- D. Importance of protecting groundwater quality and recharge areas.
- E. Seasonal versus long-term changes in groundwater quantity.
- F. Importance of developing a groundwater budget.
- G. Potential impact of climate change on groundwater resources.

**2. Improve collaboration and coordination.**

DWR and the SWRCB should coordinate with State, federal, tribal, local, and regional agencies and organizations to conduct the following activities.

- A. Provide State incentives to local water management agencies to coordinate with Tribes and other agencies involved in activities that may affect long-term sustainability of water supply and water quality.
- B. Outline and implement process to improve coordination and cooperation among State, federal, tribal, and local agencies to improve the process for timely regulatory approval, alignment of rules or guidelines, and environmental permitting for the development, implementation, and operation of conjunctive management, recharge, and water banking facilities.
- C. Expedite environmental permitting for implementation of conjunctive management, recharge, and water banking facilities when facility operations increase ecosystem services, and includes predefined benefits/mitigation for wildlife and wildlife habitat.
- D. Establish a process led by the SWRCB to identify measures whereby agencies proposing to use peak surface water flow for groundwater recharge are not subject to potential protest of their existing water right, in order to stipulate groundwater recharge as a reasonable beneficial use of their surface water right.

**3. Increase availability and sharing of groundwater information.**

DWR should coordinate with State, federal, tribal, local, and IRWM agencies and organizations to conduct the following activities.

- A. Work with the Governor’s Office of Planning and Research (OPR) to develop a coordinated plan to disseminate groundwater information.
- B. Consider changes to Section 13752 of the California Water Code to improve public access to Well Completion Reports, while addressing key infrastructure security and private ownership concerns and appropriately funding agencies to implement the legislature changes.
- C. Work with State agencies, local permitting agencies, and driller organizations to 1) develop an on-line Well Completion Report submittal system, 2) digitize and make publically available existing Well Completion Reports to allow improved analysis of groundwater data, and 3) build upon efforts begun in 2012 to update well drilling, construction, and abandonment standards.
- D. Work with SWRCB to implement a web-based Water Planning and Information Exchange (Water PIE) system that will provide on-line access to groundwater supply and demand

information, groundwater level and quality data, groundwater recharge and conjunctive management activities, groundwater management planning, land subsidence information, and groundwater basin studies.

**4. Strengthen and expand the CASGEM Program for its long-term sustainability.**

- A. The State of California should commit long-term, dedicated funding to the CASGEM Program to implement monitoring, assessment, and maintenance of baseline groundwater levels data, and expand the program to include the fractured rock hydrogeology in areas deemed important.
- B. The State should continue funding for local groundwater monitoring and management activities, and feasibility studies that increase the coordinated use of groundwater and surface water by giving priority to projects that include filling regional and Statewide data gaps and conjunctive management conducted in accordance with IRWM planning. Provide incentives to local water management agencies to implement groundwater monitoring programs to provide additional data and information needed to adequately characterize a groundwater basin, subbasin, aquifer or aquifers under the jurisdiction of the agency or adopted groundwater management plan.
- C. The State should expand and fund CASGEM by including and implementing above recommendations as integral components of the Program, and thus use CASGEM as the vehicle to update and maintain groundwater information in the future.

**5. Under the CASGEM Program, improve understanding of California groundwater basins by conducting groundwater basin assessments of CASGEM high priority basins in conjunction with the California Water Plan (CWP) five-year production cycle.**

DWR should coordinate with State, federal, tribal, local, and regional agencies to utilize the CASGEM Basin Prioritization information to conduct the following groundwater basin assessment activities.

- A. Develop the initial and reoccurring schedule and scope for groundwater basin assessments that will allow data and information sharing under the CWP five-year production cycle.
- B. Compile and evaluate new and existing groundwater supply and demand information, groundwater level and quality data, groundwater recharge and conjunctive management activities, surface water/groundwater interaction, groundwater management planning, land subsidence information, and existing groundwater basin studies, in accordance with the scope identified in (a).
- C. Develop detailed groundwater basin assessment reports by Hydrologic Region and groundwater basin. The reports will characterize sustainability of groundwater resources in terms of historical and existing trends and future scenario projections, and will identify recommended incentives to establish basin-wide groundwater budgets and adaptive management practices which will promote sustainable groundwater quantity, quality, and the maintenance of groundwater ecosystem services.
- D. Develop a summary report to California Legislature depicting the State of California's Groundwater which will highlight key findings and recommendations associated with detailed groundwater basin assessments by Hydrologic Region.

**6. Assess post-SB 1938 groundwater management plans and develop guidelines to promote best practices in groundwater management.**

In coordination with State, federal, tribal, local, and regional agencies, DWR should conduct the following activities.

- A. Request legislature to amend the appropriate code(s) to authorize DWR to evaluate and assess groundwater management and planning, and to develop groundwater management and implementation guidelines.
- B. Conduct outreach to local and regional agencies to supplement and verify Groundwater Management Plans (GWMP) inventory and information initiated by DWR as part of Update 2013.
- C. Work with regional and local agencies to assess their GWMP implementation and practices, in accordance with existing California Water Code requirements to i) identify technical, legal, institutional, physical, and fiscal constraints associated with existing groundwater management programs, ii) identify opportunities associated with groundwater management and planning activities, and iii) gain an understanding of how agencies are implementing actions to use and protect groundwater.
- D. Work with regional and local agencies to develop groundwater management and planning and program implementation guidelines. The guidelines will provide a clear roadmap for GWMP development and implementation by identifying and clarifying components, processes, and standards and by establishing provisions for periodic review, report, update, and amendment as necessary to facilitate effective and sustainable groundwater management. The guidelines will also emphasize groundwater management as a fundamental component of the overlying IRWM plan and local land use plan(s).
- E. Convene a GWMP Advisory Committee and begin coordination with regional and local agencies and tribal communities that have not developed basin-wide GWMPs, to develop such plans with assistance and guidance from the GWMP Advisory Committee. The GWMP Advisory Committee will help guide the development, educational outreach, and implementation of the GWMPs. Advanced tools development should be pursued as part of this activity to help quantify benefits and assess robustness of alternative management strategies.

**7. Develop analytical tools to assess conjunctive management and groundwater management strategies.**

DWR and the SWRCB, in collaboration with State, federal, tribal, local, and regional agencies should conduct the following activities.

- A. Develop a conjunctive management tool that will help identify conjunctive management opportunities (projects) and evaluate implementation constraints associated with the i) availability of water for recharge, ii) available means to convey water from source to destination, iii) water quality issues, iv) environmental issues, v) jurisdictional issues, vi) costs and benefits, and vii) the potential interference between a proposed project and existing projects.
- B. The State will encourage or require local and regional agencies to develop or adopt analytical tools to support integrated groundwater/surface water modeling and scenario analysis for assessing alternative groundwater management strategies as part a fundamental component of their IRWM plan.

**8. Increase groundwater recharge and storage by 2 million acre-feet.**

- A. Revise legislation to include disincentives to overdraft groundwater basins and incentives for increasing storage.
- B. DWR will compile, assess, and provide status update on statewide aquifer recharge area delineation and mapping required. DWR and SWRCB will compile available data, identify missing data needed to evaluate natural groundwater recharge, discharge, related ecosystems, and groundwater recharge and storage projects, and develop a plan to fill identified data gaps to support evaluation of groundwater recharge and storage.

- C. State agencies will work with federal, Tribal, local, and regional agencies to i) develop guidelines clarifying interagency alignment and improved interagency coordination to facilitate local groundwater recharge and storage projects, ii) develop guidelines for coordinating and aligning land use planning with groundwater recharge area protection, and iii) catalogue best science and technologies applied to groundwater recharge and storage.
- D. State agencies will work with federal, Tribal, local, and regional agencies to i) develop guidelines clarifying interagency alignment and improved interagency coordination to facilitate local groundwater recharge and storage projects, ii) develop guidelines for coordinating and aligning land use planning with groundwater recharge area protection, and iii) catalogue best science and technologies applied to groundwater recharge and storage.
- E. State of California will encourage local and regional agencies - when technically, legally, and environmentally feasible – to manage the use of available aquifer space for managed recharge and develop multi-benefit projects that generate source water for groundwater storage by capturing water not used by other water users or the environment.
- F. State of California will encourage and fund local and regional agencies, and tribal communities to i) identify and evaluate local and regional opportunities to reduce runoff and increase recharge on residential, school, park, and other unpaved areas, ii) coordinate groundwater recharge and multi-benefit flood control projects to enhance recharge using storm flows, and iii) conduct pilot studies to identify additional opportunities and needs for advancing recharge opportunities.

**9. Advance Integrated Water Management.**

- A. No transfer of impacts between Regions:
- B. Regions accept responsibility for assessing risk due to climate change, population growth, groundwater overdraft, etc.
- C. Develop IRWM Plans to manage risk appropriately
- D. Improve alignment of federal, state and local government to assist in implementing plans.

**10. Develop and adopt stronger standards for local/regional groundwater management plans for sustainable groundwater management.**

**11. Consider legislation needed to provide needed local/regional authority.**

# California Water Plan Update 2013

Groundwater Enhancements and Recommendations

October 29, 2013



## Figures and Boxes

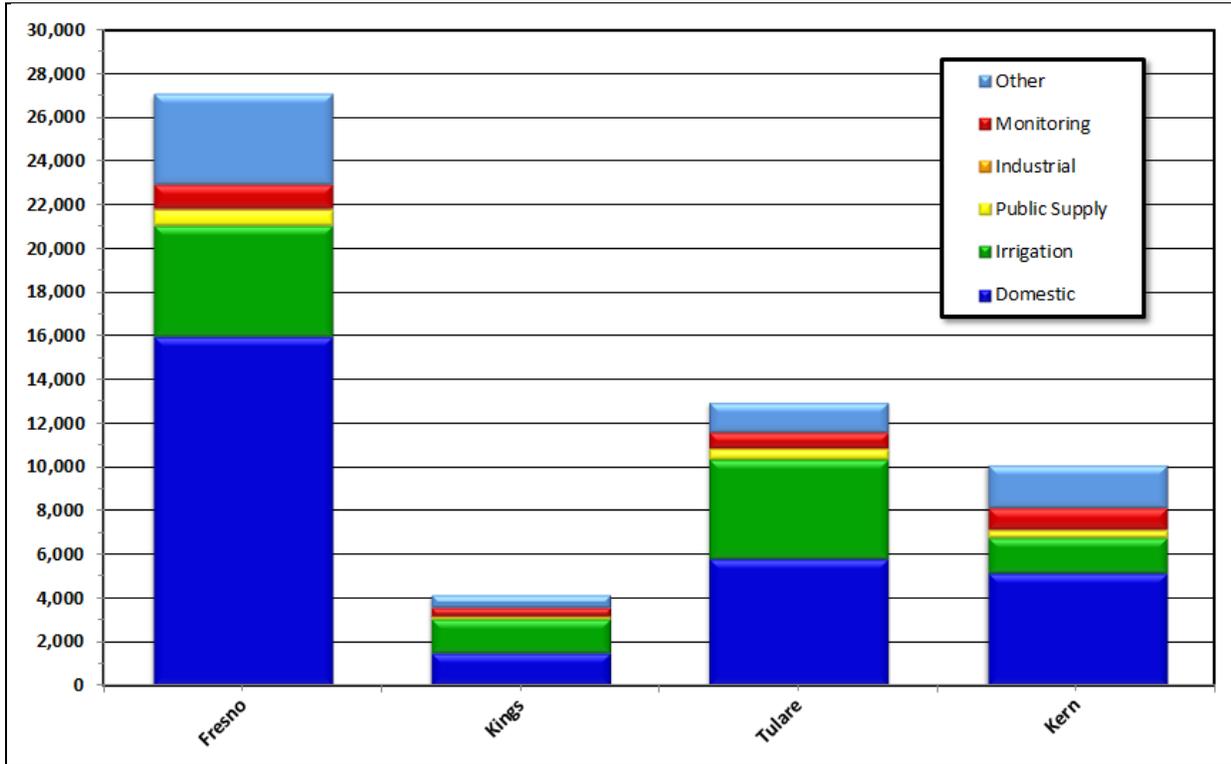
**1. Tulare Lake Hydrologic Region Figures**

**2. Tulare Lake Hydrologic Region Boxes**

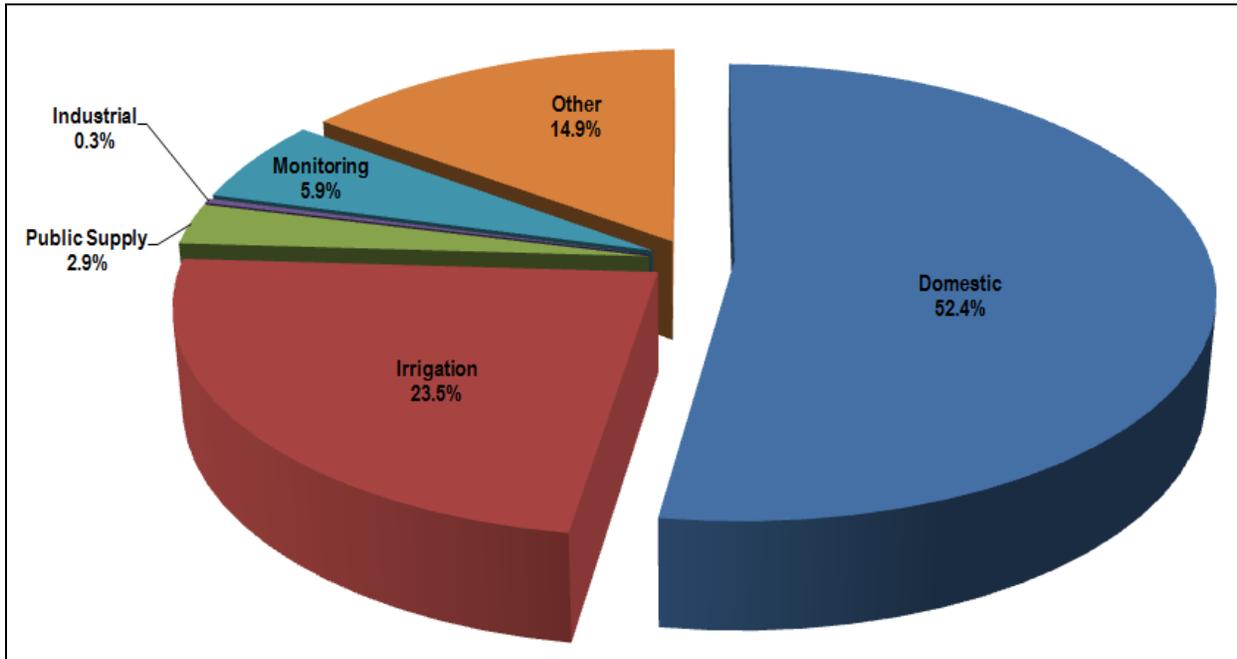
**Figure TL-3 Alluvial Groundwater Basins and Subbasins within the Tulare Lake Hydrologic Region**



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



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



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

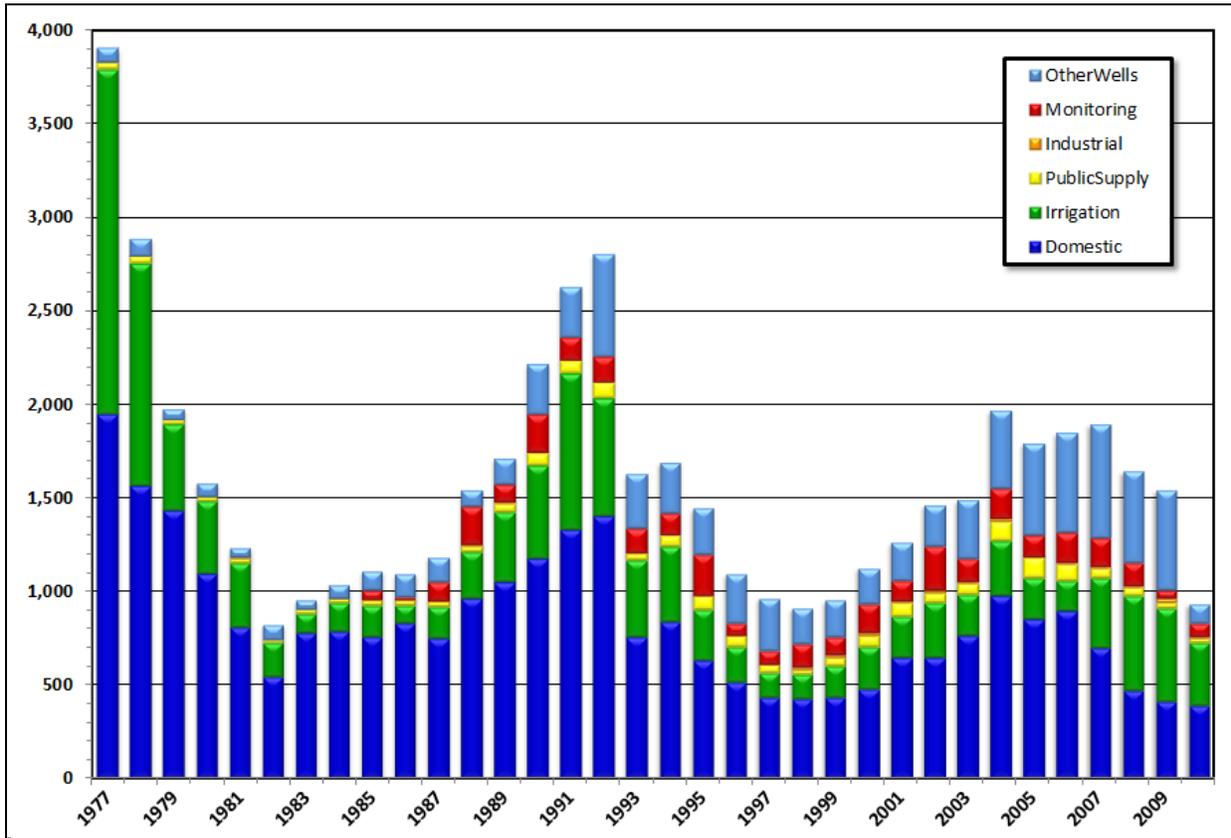
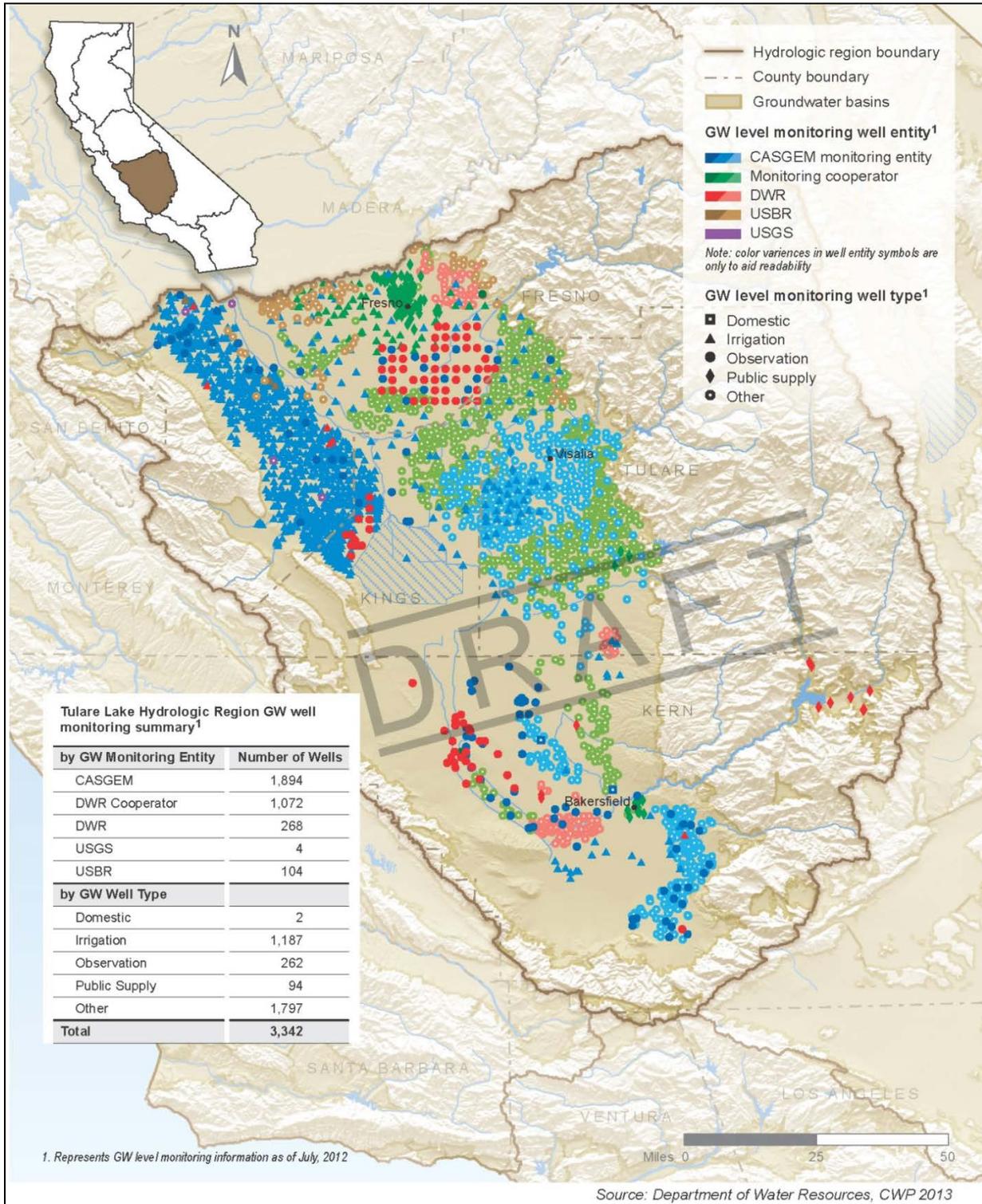


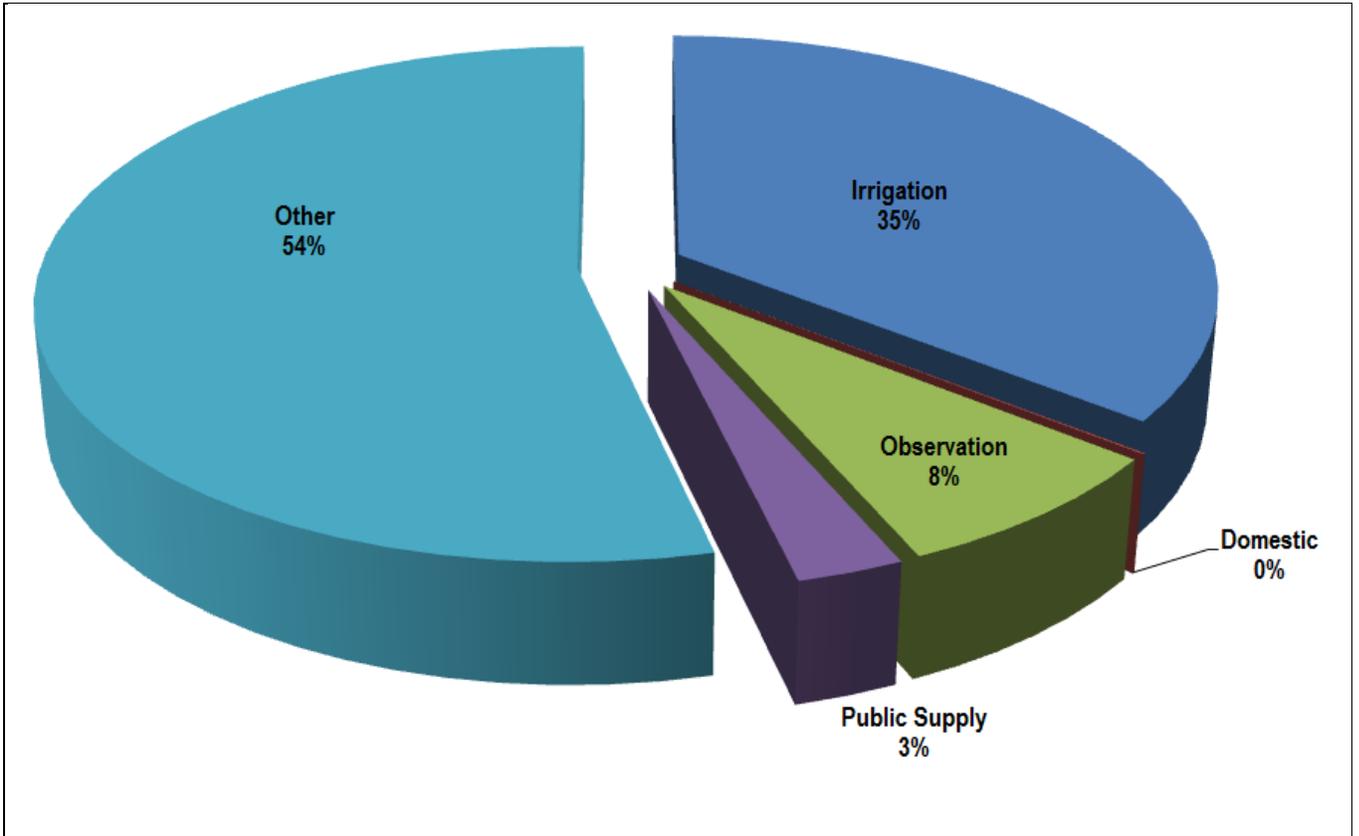
Figure TL-7 CASGEM Groundwater Basin Prioritization for the Tulare Lake Hydrologic Region



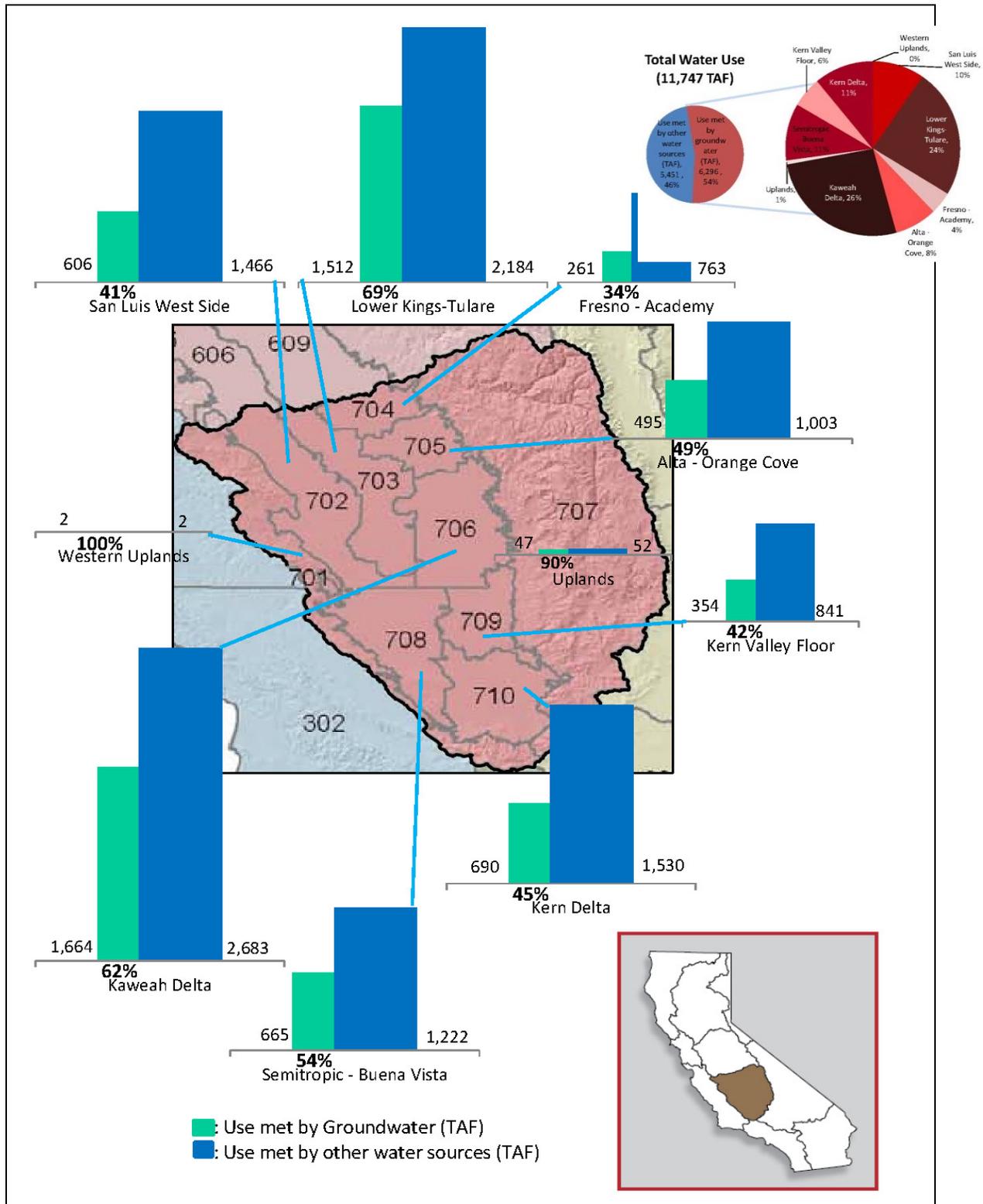
**Figure TL-8 Monitoring Well Location by Agency, Monitoring Cooperator, and CASGEM Monitoring Entity in the Tulare Lake Hydrologic Region**



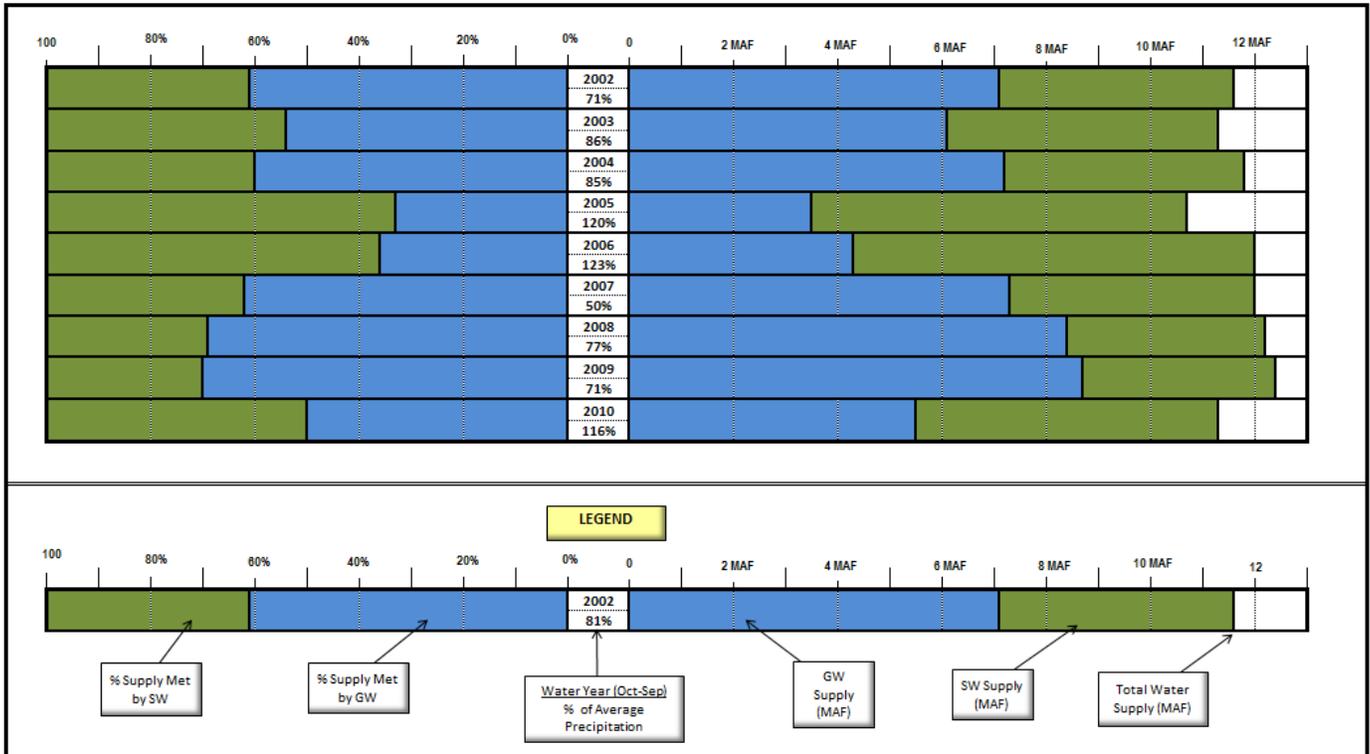
**Figure TL-9 Percentage of Monitoring Wells by Use in the Tulare Lake Hydrologic Region**



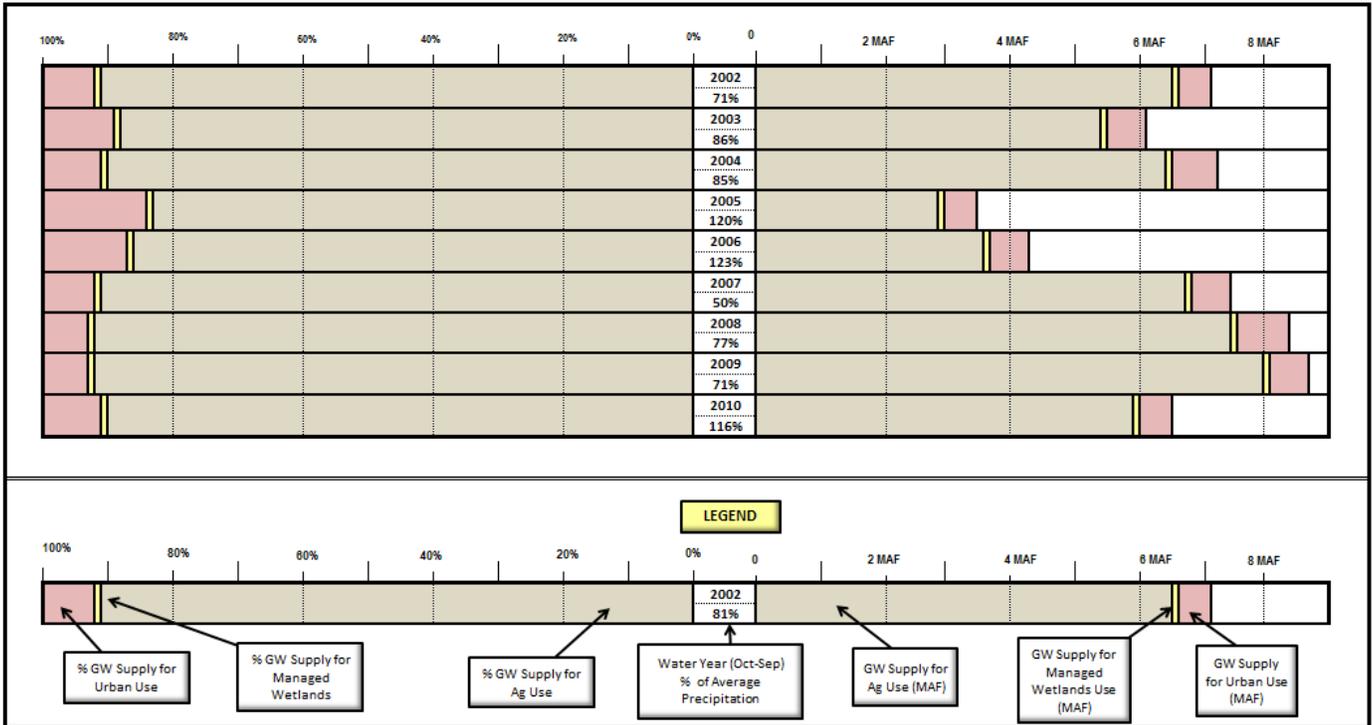
**Figure TL-13 Contribution of Groundwater to the Tulare Lake Hydrologic Region Water Supply by Planning Area (2005-2010)**



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



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



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

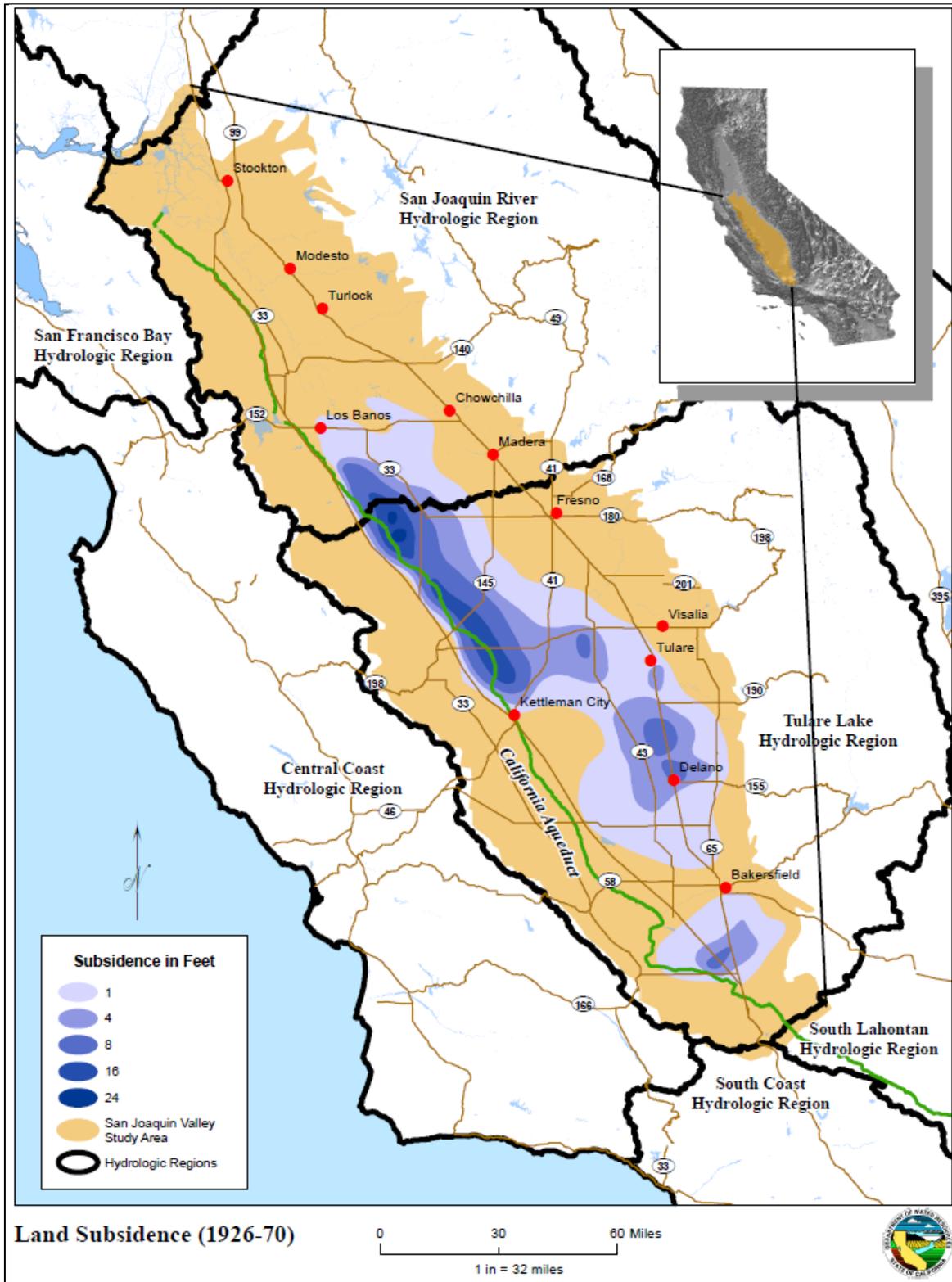
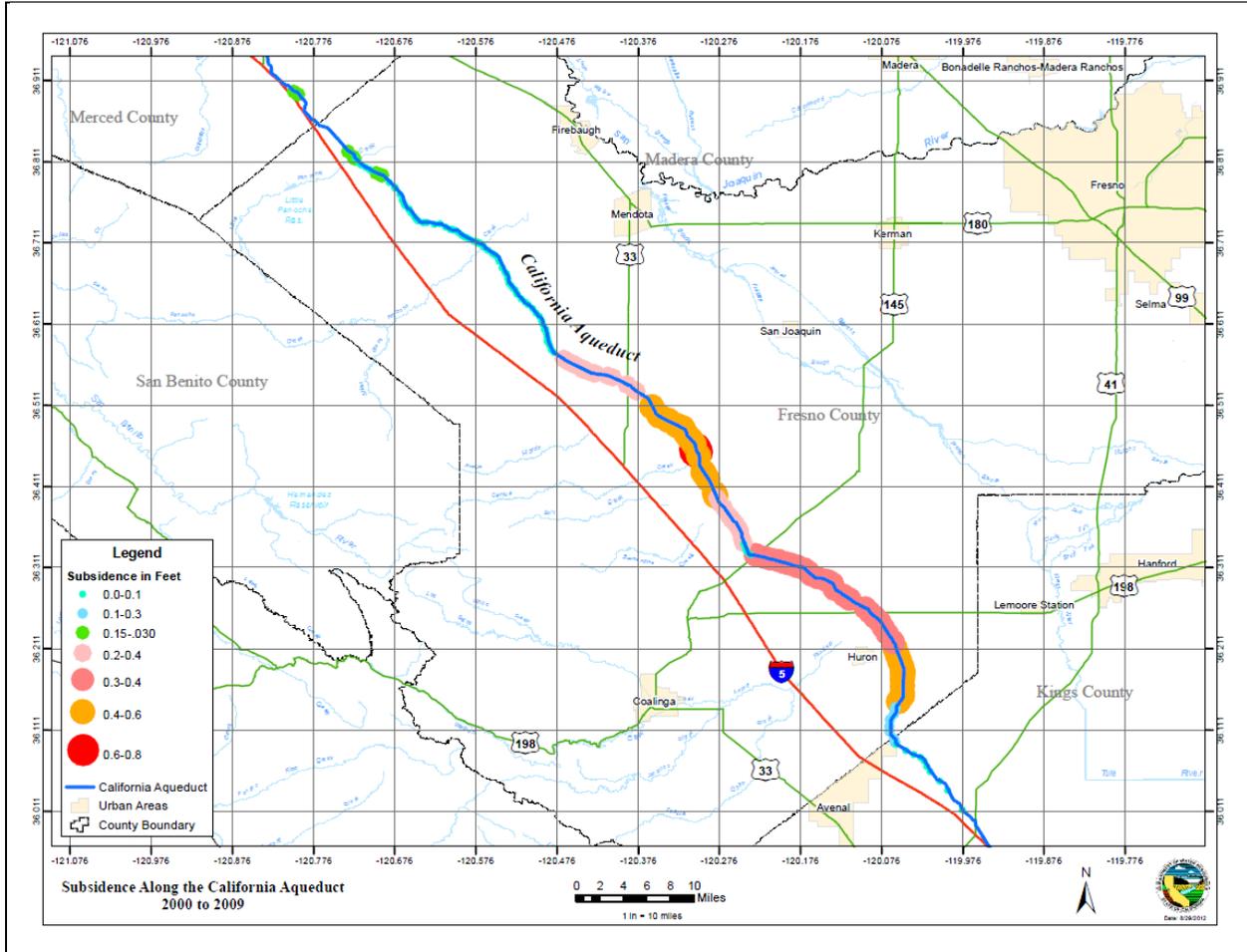


Figure TL-19 Land Subsidence Along the California Aqueduct



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

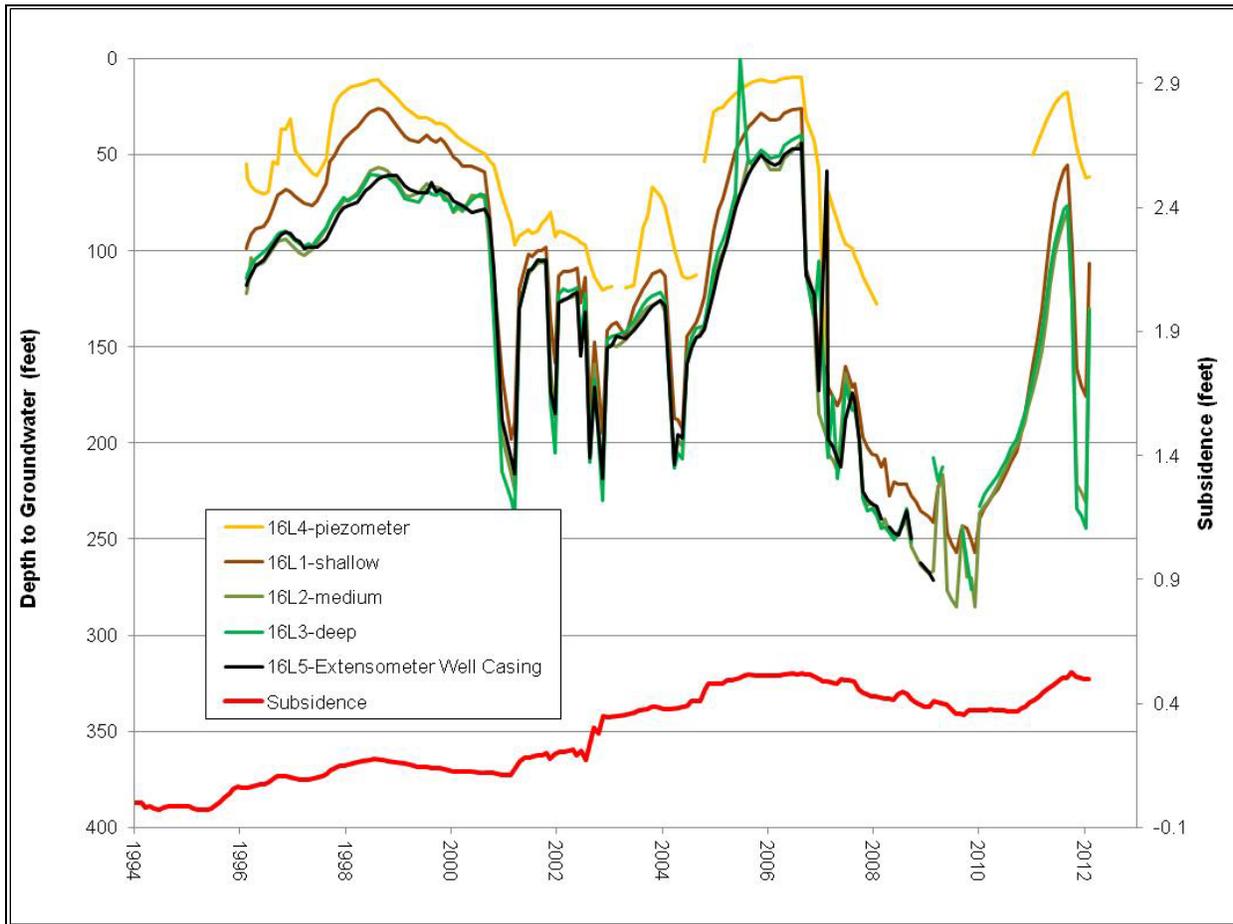
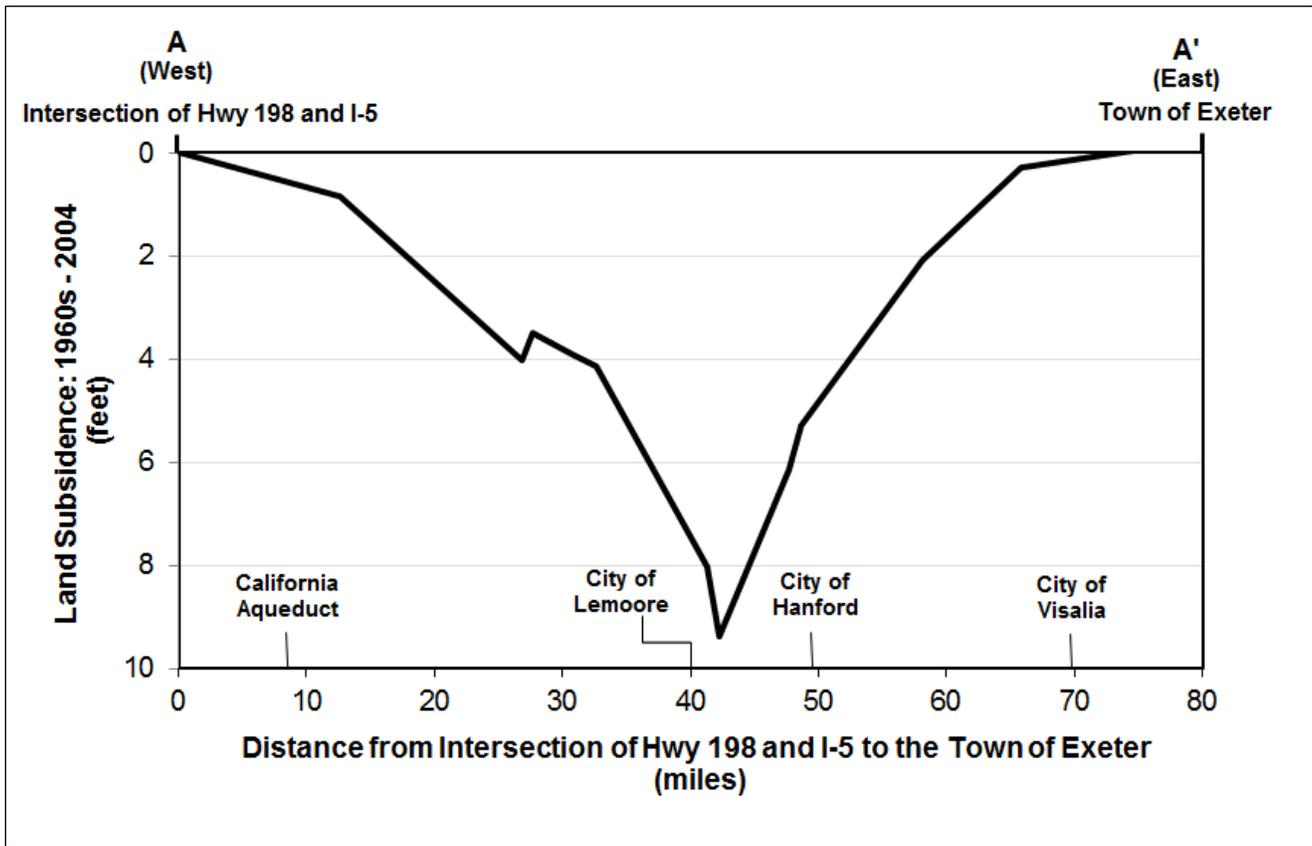
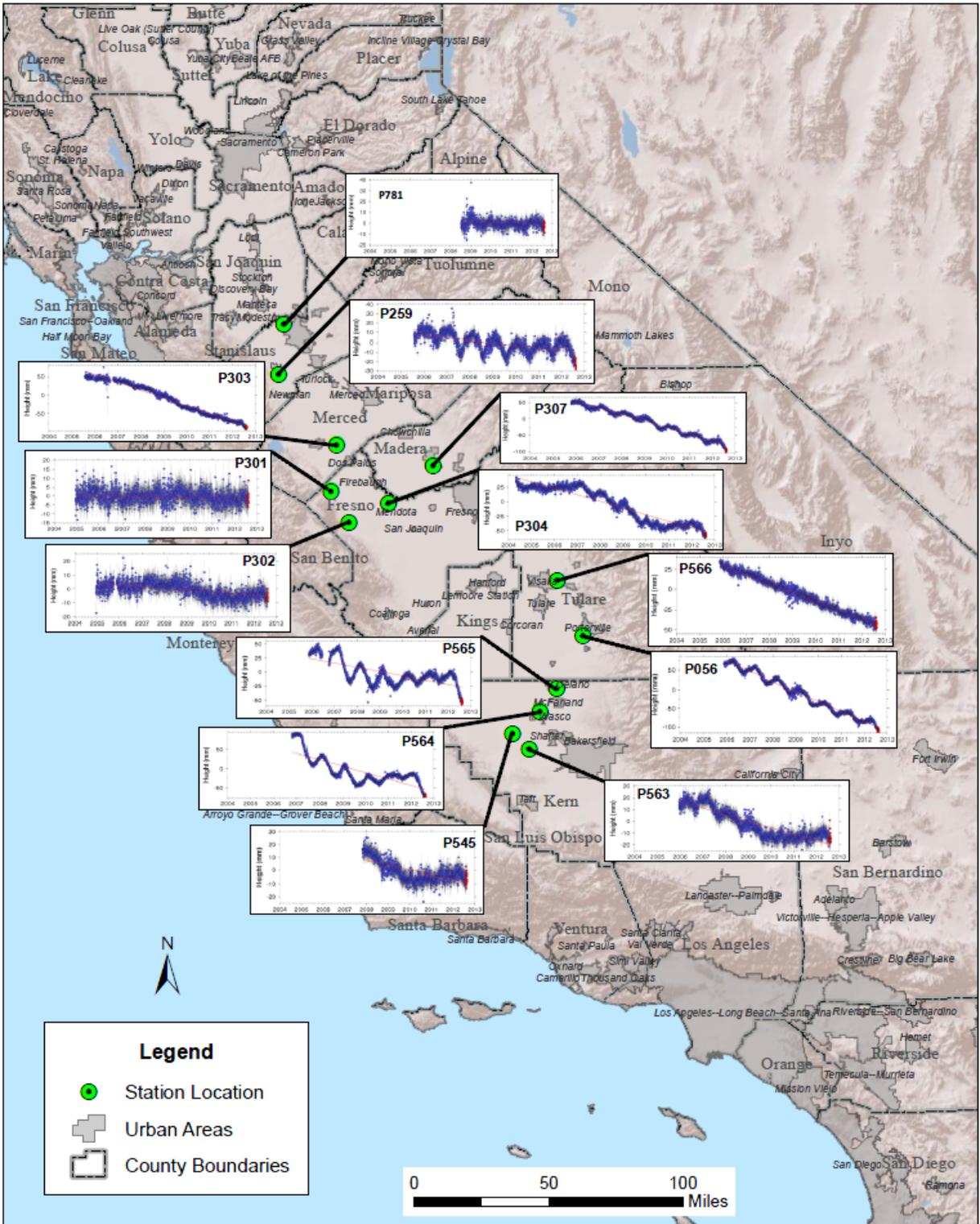


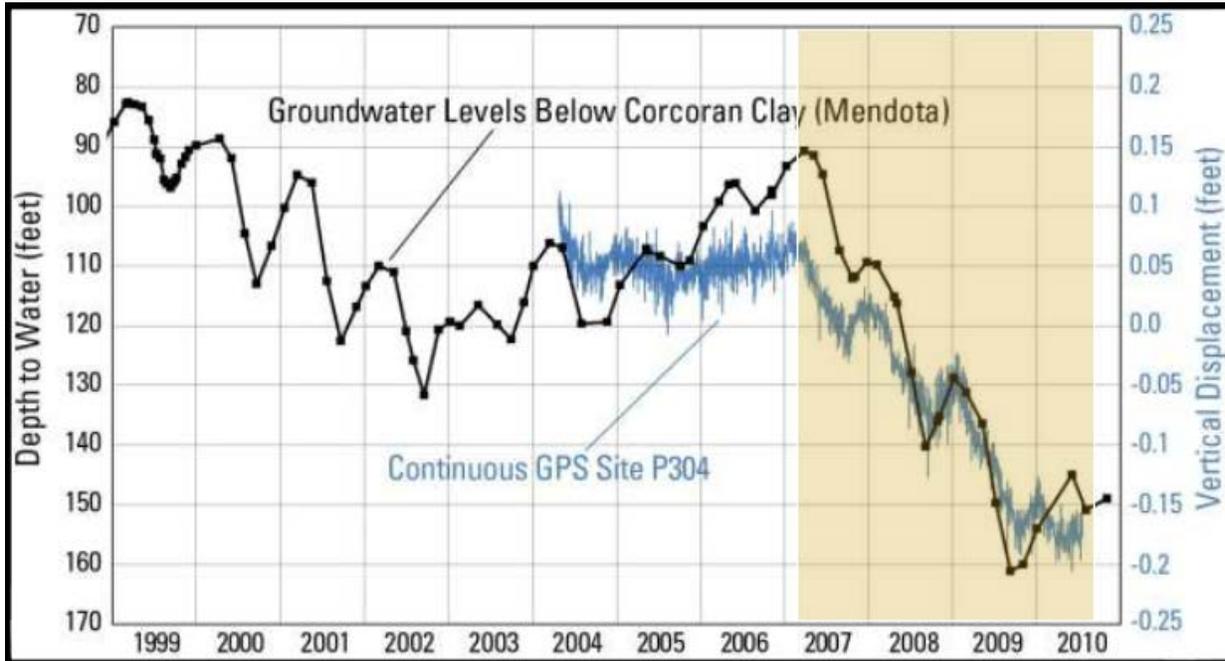
Figure TL-21 Land Subsidence Results from Caltrans Highway 198 Elevation Monitoring



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

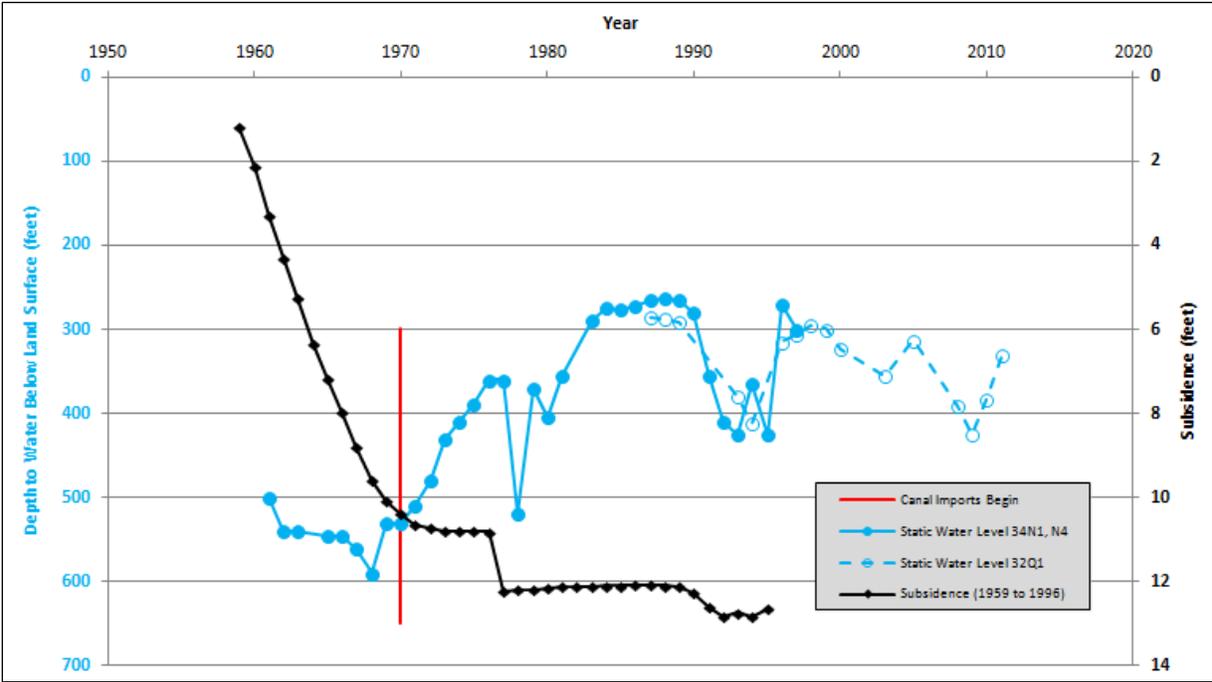


**Figure TL-23 Depth to Groundwater Hydrograph and Vertical Land Surface Displacement at UNAVCO GPS Site 304, near the City of Madera**

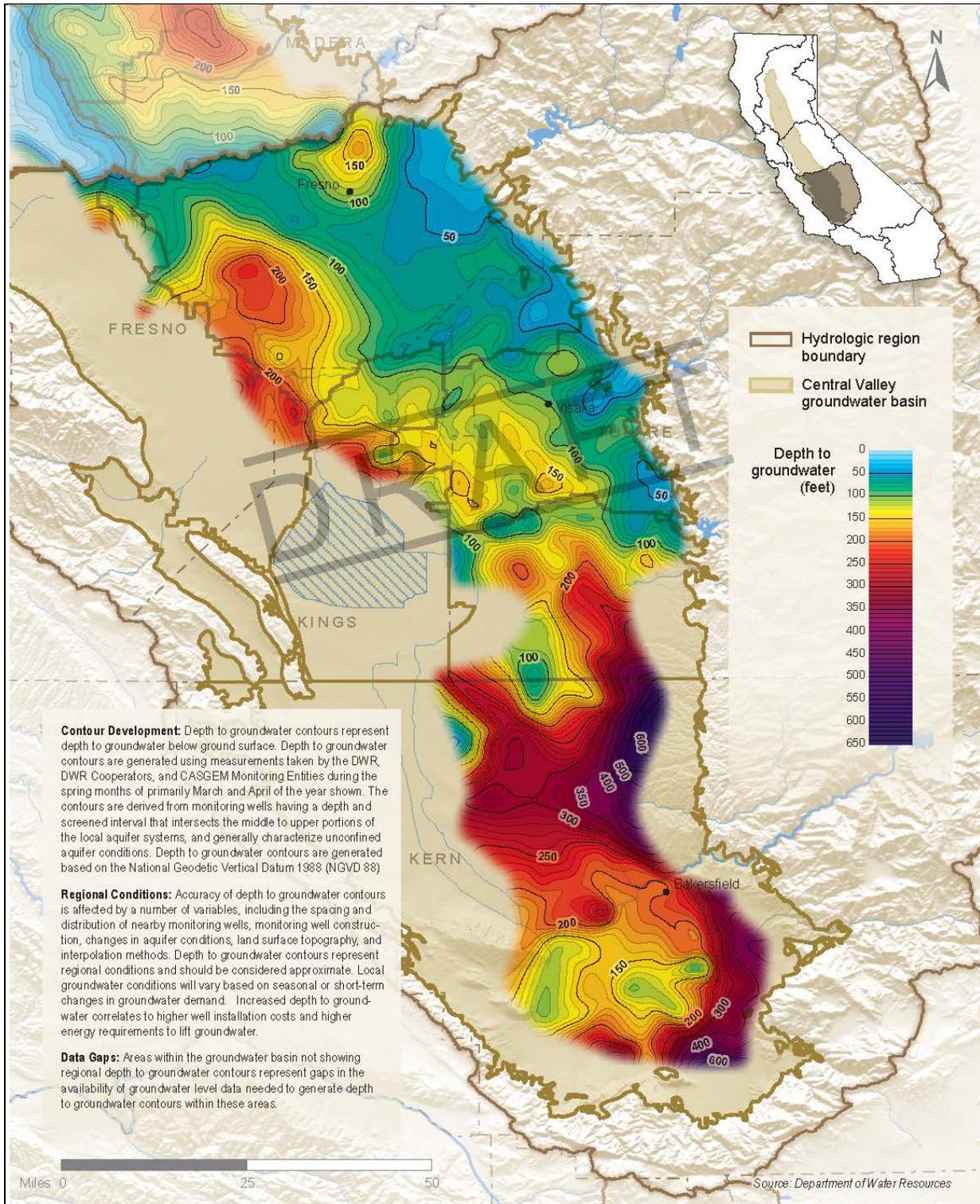


Source: USGS 2011 presentation on Central Valley subsidence. Land surface elevation data from UNAVCO Station 304; depth to water data provided by Luhdorff and Scalmanini Consulting Engineers

**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)**



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



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

[This figure is for the Central Valley; it will be updated with figure for the Tulare Lake Hydrologic Region]

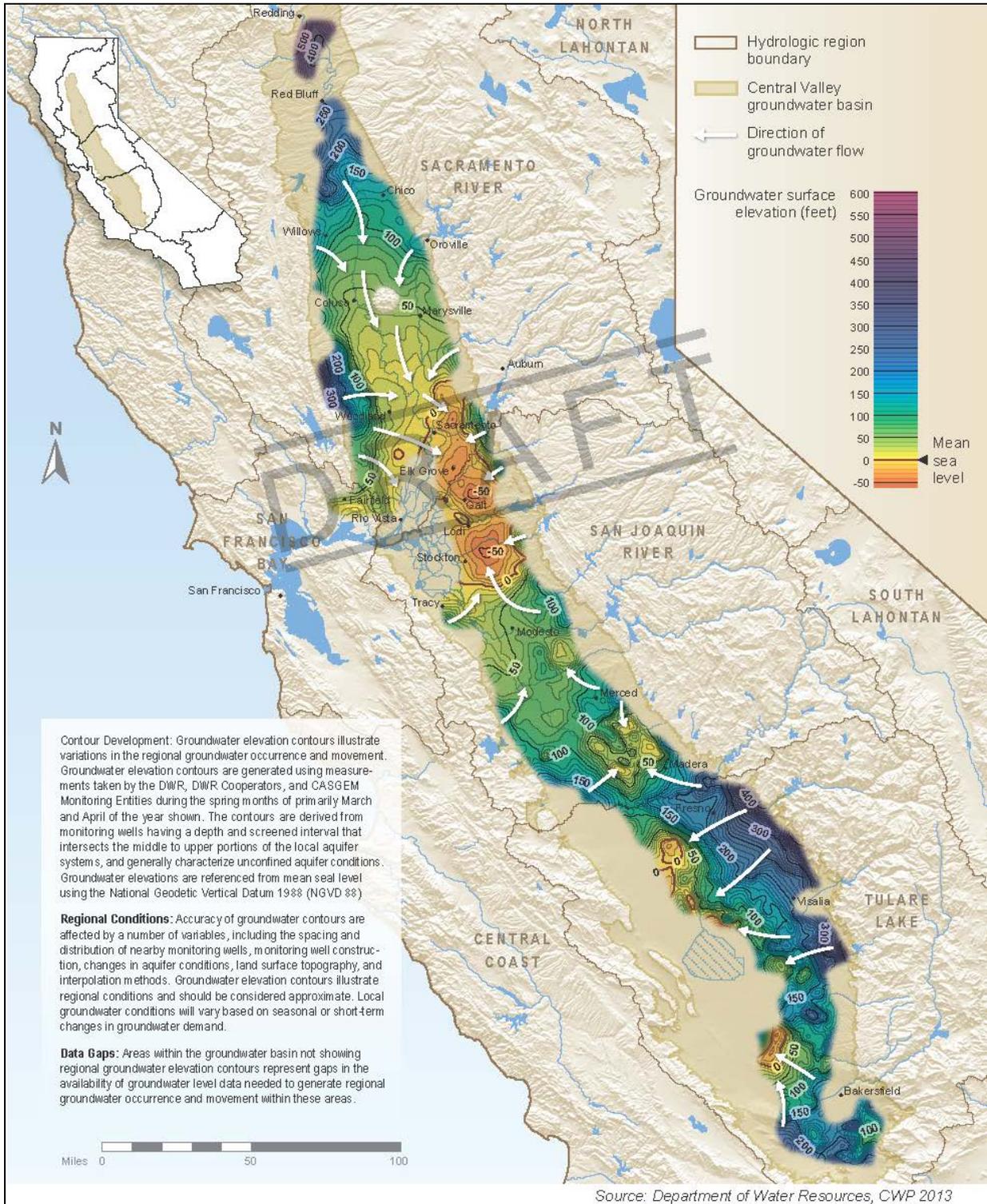


Figure TL-27 Groundwater Level Trends in Selected Wells in the Tulare Lake Hydrologic Region

Figure X-x Tulare Lake hydrographs

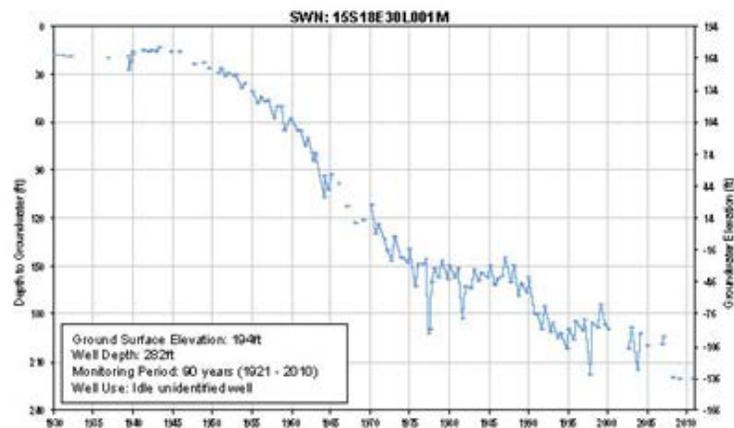
**Aquifer response to changing demand and management practices**

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



**A 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**  
**20S23E 12A001M:** illustrates the local aquifer response to changes in groundwater recharge and extraction, due to changes in precipitation and surface water supply deliveries.



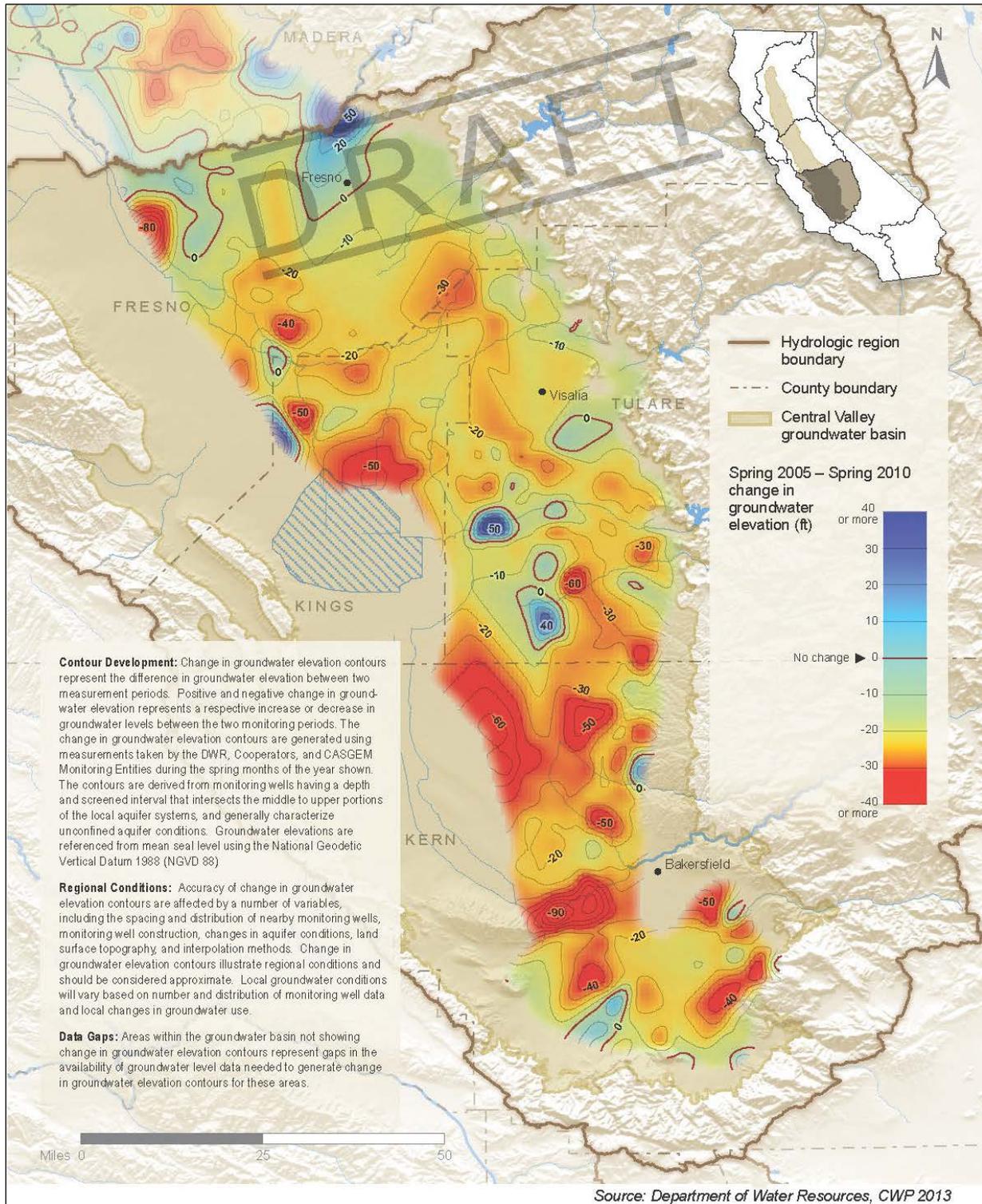
**C Hydrograph**  
**26S18E 18G001M:** highlights recovering groundwater levels associated with the introduction of imported surface water from the California Aqueduct, which resulted in decreasing groundwater demand and facilitating in-lieu groundwater recharge.



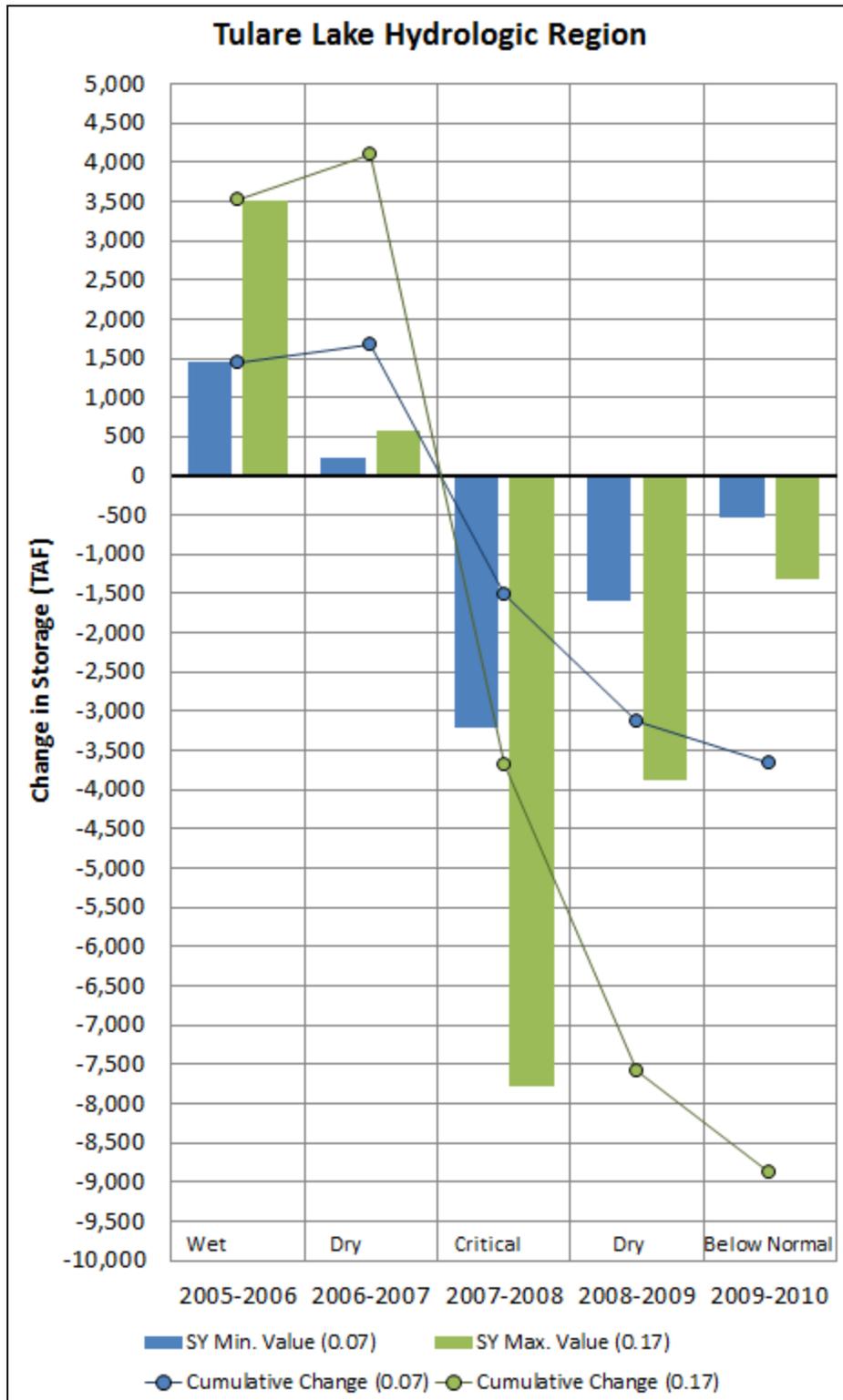
**D, E Hydrographs**  
**30S24E02C001M and 30S27E05D001M:** illustrate the successful stabilization of sharply declining groundwater levels through implementation of in-lieu and active groundwater recharge projects via active conjunctive management practices.



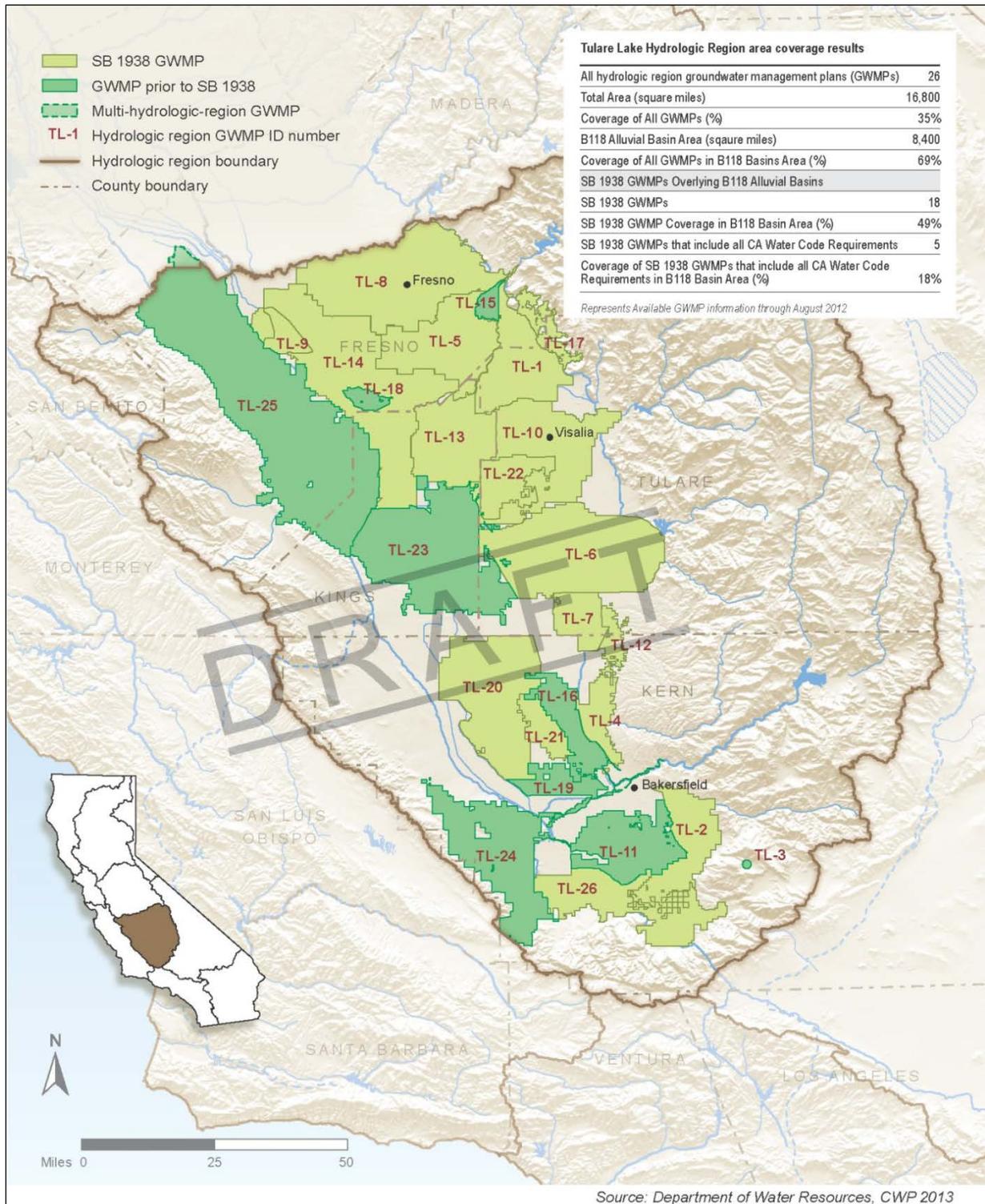
**Figure TL-28 Spring 2005 - Spring 2010 Change in Groundwater Elevation Contour Map for the Tulare Lake Hydrologic Region**



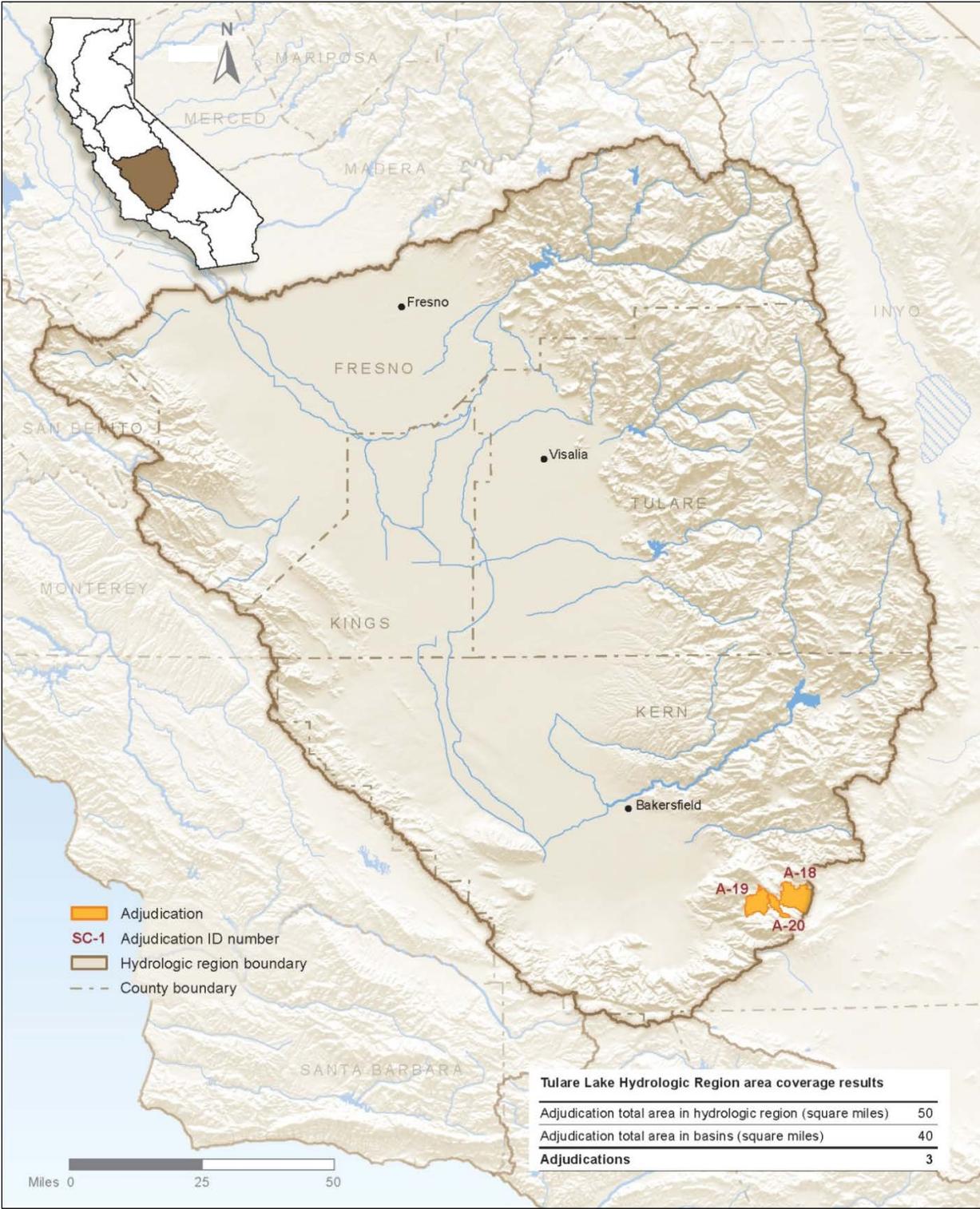
**Figure TL-29 Spring 2010 Annual Change in Groundwater Storage for the Tulare Lake Hydrologic Region**



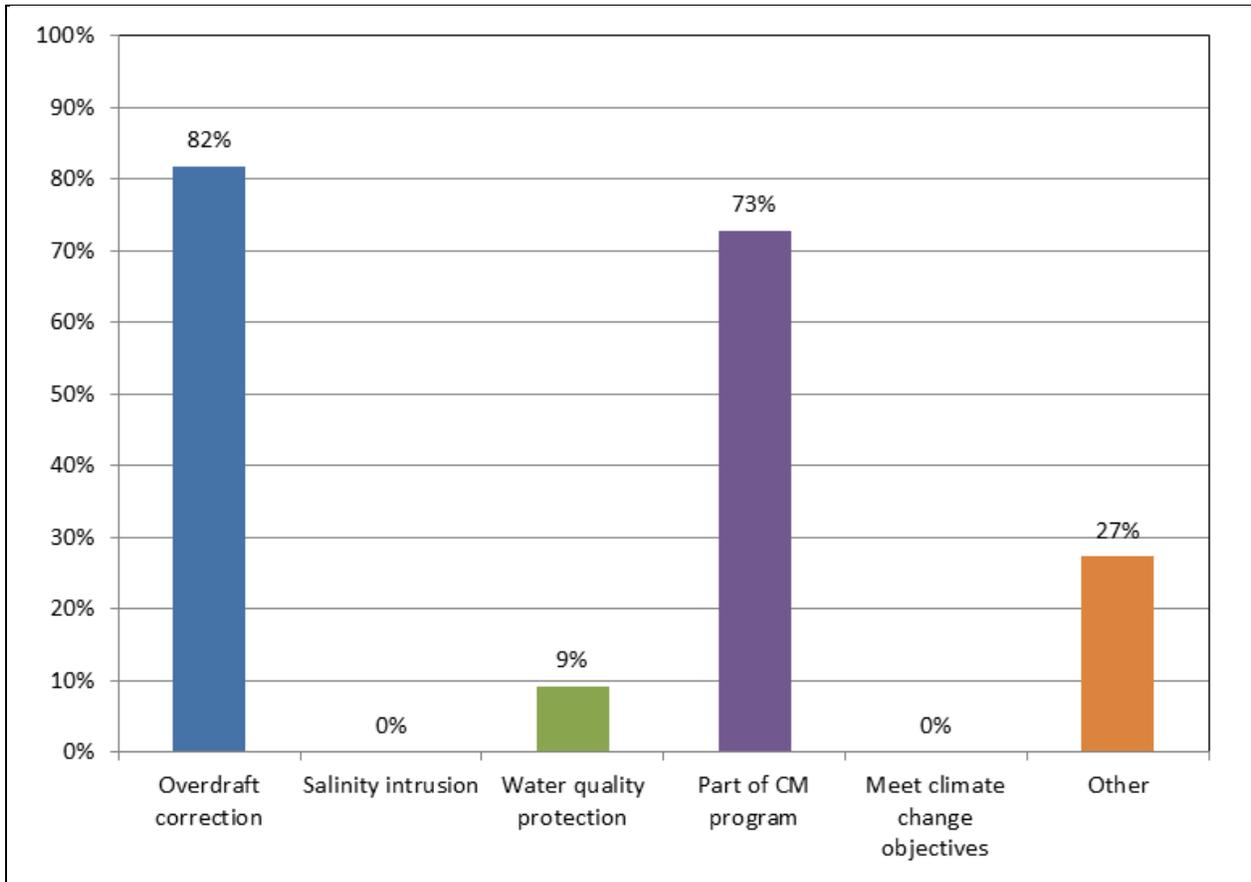
**Figure TL-32 Location of Groundwater Management Plans in the Tulare Lake Hydrologic Region**



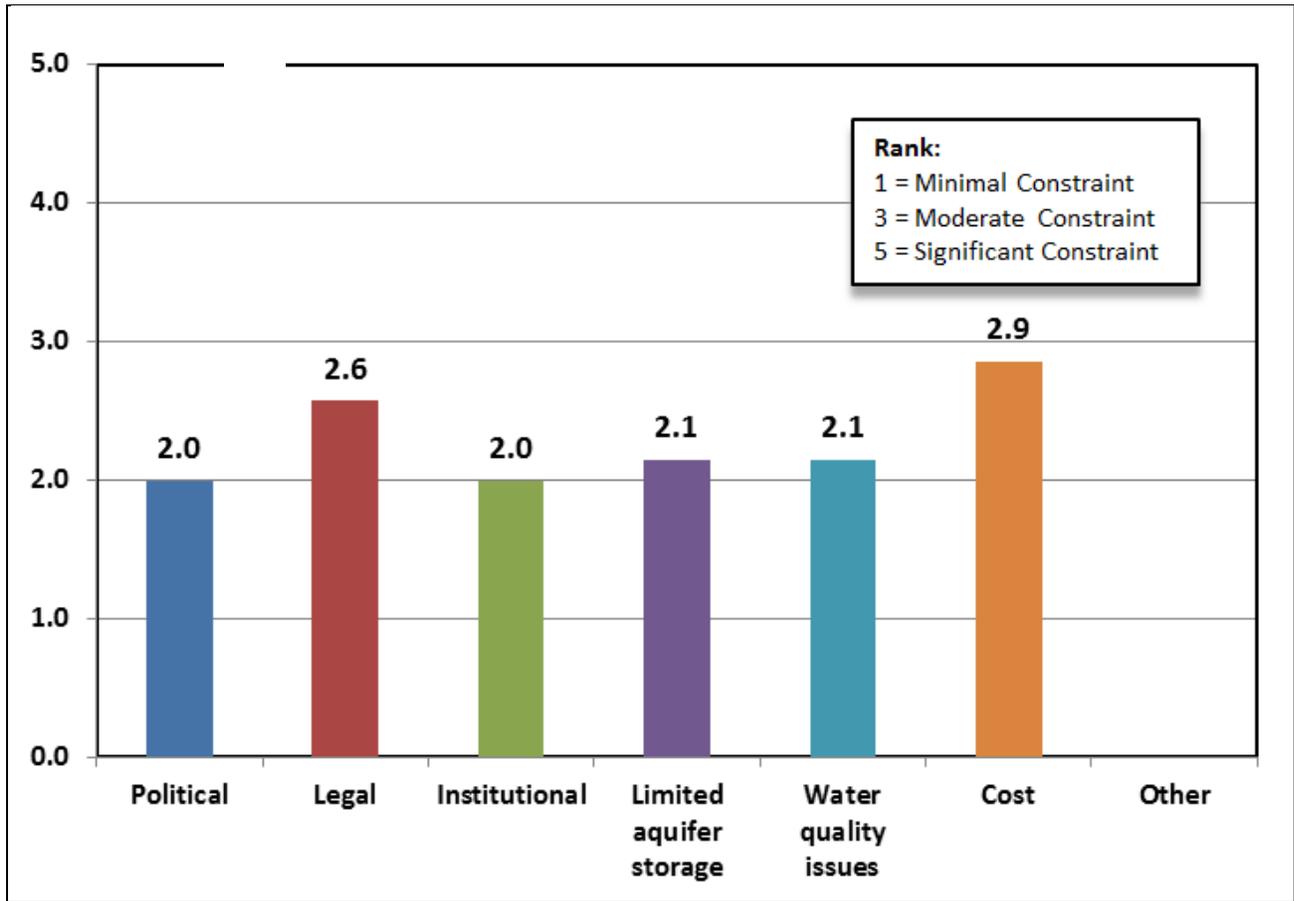
**Figure TL-33 Groundwater Adjudications in the Tulare Lake Hydrologic Region**



**Figure TL-36 Conjunctive Management Program Goals and Objectives**



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



1 **Box TL-4 Statewide Conjunctive Management Inventory Effort in California**

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2 The effort to inventory and assess conjunctive management projects in California was conducted through literature research,  
3 personal communication, and documented summary of the conjunctive management projects. The information obtained was  
4 validated through a joint DWR-ACWA survey. The survey requested the following conjunctive use program information:

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

11 To build on the DWR/ACWA survey, DWR staff contacted by telephone and email the entities identified to gather the  
12 following additional information:

- 13 7. Source of water received;  
14 8. Put and take capacity of the groundwater bank or conjunctive use project;  
15 9. Type of groundwater bank or conjunctive use project;  
16 10. Program goals and objectives; and  
17 11. Constraints on development of conjunctive management or groundwater banking (recharge) program.

18 Statewide, a total of 89 conjunctive management and groundwater recharge programs were identified. Conjunctive  
19 management and groundwater recharge programs that are in the planning and feasibility stage are not included in the  
20 inventory.