boundaries on an individual basis for direct input and feedback during the GSP development and public review phases, and will continue to do so during the implementation phase.

Oil Production

Oil production is a main industry in certain areas of Kings County and the Tulare Lake Subbasin, primarily within in the Kettleman City area. Oil was discovered in the Kettleman Hills in 1928 at the Kettleman North Dome Oil Field. This oil field became one of the most productive oil fields in the United States in the early 1930s. Within this region, oil and agricultural production share the land surface, and will continue with joint usage of well drilling rigs and agricultural production activities such as grazing. The oil industry is considered a beneficial user of groundwater, and Tulare Lake Subbasin GSAs engaged with the oil companies within their GSA boundaries on an individual basis for direct input and feedback during the GSP development and public review phases, and will continue to do so during implementation phases.

C.3.2 DACs

Communication and educational outreach efforts with disadvantaged communities (**DAC**) and severely disadvantaged communities (**SDAC**) was needed for the development and implementation of the Tulare Lake Subbasin's GSP according to the Department of Water Resources' Best Management Practices. Information used to communicate to and engage the DACs in the GSP process, included an explanation of SGMA and soliciting feedback. GSA representatives regularly communicated with DACs and gave presentations on SGMA to community representatives, while gathering their feedback and input.

By including DACs and SDACs in communication efforts during the development, public review and implementation phases of the GSP, residents were more likely to participate and provide feedback that could be crucial to long-term solutions for groundwater sustainability within their communities. Any feedback received from DAC/SDAC residents was reviewed and evaluated by the Tulare Lake Subbasin GSAs during the GSP development and public review phases.

C.4 GSA-Specific Stakeholders

The GSAs worked cooperatively with their respective stakeholders throughout the development and public review of the GSP, and will continue to do so through the implementation phase.

C.4.1 El Rico GSA Stakeholders

The interests of the parties identified in **Table 1** were considered in the operation of the El Rico GSA and the development and implementation of the GSP. The primary industry within the El Rico GSA is agriculture. Other industries within the boundary include food processing, as well as warehousing and distribution, and standard commerce industry that is standard in a community of 10,000 people (automotive shops, supermarkets, etc.).

Table 1. Stakeholder Groups with Interests in the El Rico GSA

Stakeholder Group	Description
Agricultural Users	Represented through many of the GSA member agencies and/or by the County of Kings.
Domestic Well Owners	Represented through member agencies including the County of Kings or via exemption for small amounts of groundwater extraction.
Municipal Well Operators	City of Corcoran
Public Water Systems	City of Corcoran
Local Land Use Planning Agencies	City of Corcoran, County of Kings
Surface Water Users	Represented through GSA member agencies
Disadvantaged Communities	City of Corcoran
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	Represented by GSA member agencies including Tulare Lake Basin Water Storage District that collects and reports data for multiple members of the agency via the Tulare Lake Coordinated Groundwater Management Plan.

C.4.2 Mid-Kings River GSA Stakeholders

The interests of all beneficial uses and users of groundwater within the MKRGSA are identified in **Table 2**. The primary industries within the Mid-Kings River GSA is agriculture and food processing.

Table 2. Stakeholder Groups with Interests in the Mid-Kings River GSA

Stakeholder Group	Description
Agricultural Users	Service area is composed of mostly agricultural lands and agricultural users
Domestic Well Owners	There are domestic wells within the MKRGSA area, and it is understood that many rural domestic users will fall into the “de minimis extractor” category, so further work is being conducted to understand to what extent domestic users will be affected by GSP requirements.
Public Water Systems	Armona CSD, Home Garden CSD and Hardwick Water Company, as well as several transient public water systems for school districts are included in this category (Kings River-Hardwick, Pioneer, Hanford Christian).
Municipal Water Systems	City of Hanford
Local Land Use Planning Agencies	City of Hanford and County of Kings
California Native American Tribes	See **Section C.2**.
Disadvantaged Communities	Armona, Home Garden, Hardwick
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	Kings County Water District monitors groundwater levels within its service area and is providing a subset of that information to the Kings River Conservation District for submission to the CASGEM system.

C.4.3 South Fork Kings GSA Stakeholders

An initial list of stakeholders within the South Fork Kings GSA is described in **Table 3**. The primary industries within the South Fork Kings GSA is agriculture and food processing.

Table 3. Stakeholder Groups with Interests in the South Fork Kings GSA

Stakeholder Group	Description
Agricultural Users	Service area is composed of mostly agricultural lands and agricultural users
Domestic Well Owners	There are domestic wells within the SFKGSA, and it is understood that many domestic users will fall into the "de minimis extractor" category. Further work is being conducted to understand to what extent domestic users will be affected by GSP requirements.
Municipal Well Operators	City of Lemoore, Stratford Public Utility District
Local Land Use Planning Agencies	City of Lemoore, County of Kings
California Native American Tribes	See **Section C.2**.
Disadvantaged Communities	Community of Stratford
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	KRCD is the designated monitoring entity for the Kings and Tulare Lake Subbasins under CASGEM program. SFKGSA will coordinate its SGMA monitoring efforts with the CASGEM monitoring effort led by KRCD.

C.4.4 Southwest Kings GSA Stakeholders

The interests of all beneficial uses and users of groundwater within the Southwest Kings GSA are described in **Table 4**. The primary industries within the Southwest Kings GSA are agriculture, oil production and commercial usage specific to Kettleman City.

Table 4. Stakeholder Groups with Interests in the Southwest Kings GSA

Stakeholder Group	Description
Agricultural Users	Approximately 99 percent of the GSA's area is composed of agricultural lands. Representatives of the agricultural community are currently involved on the GSA Board of Directors.
Domestic Well Owners	Only one or two landowners utilize a domestic well, and are represented on the Board of Directors through member agencies.
Municipal Well Operators	Kettleman City CSD relies solely on surface water supply (effective October 2019). Their municipal wells are a back-up source to provide well water to residential and commercial customers within the GSA boundary in emergency situations when surface water is not accessible.
Local Land Use Planning Agencies	County of Kings
California Native American Tribes	See **Section C.2**.
Disadvantaged Communities	Kettleman City
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	KRCD is the designated monitoring entity for the Kings and Tulare Lake Subbasins under CASGEM program. SWKGSA will coordinate its SGMA monitoring efforts with the CASGEM monitoring effort led by KRCD.

C.4.5 Tri-County Water Authority GSA Stakeholders

The Tri-County Water Authority provided stakeholder groups identified in **Table 5** with opportunities to provide input throughout the process of developing, operating and implementing the GSA and GSP. The primary industry within the Tri-County Water Authority GSA is almost entirely agriculture.

Table 5. Stakeholder Groups with Interests in the Tri-County Water Authority GSA

Stakeholder Group	Description
Agricultural Users	Composed almost entirely of agricultural users, including nut grower commodity groups and other agricultural use growers
Domestic Well Owners	There are domestic wells within the GSA area, but because SGMA excludes "de minimis extractors," it is anticipated that the GSP will exclude domestic wells from such requirements.
Local Land Use Planning Agencies	County of Kings
Federal Government	Bureau of Land Management
Entities monitoring and reporting groundwater elevations in all or part of a groundwater basin	Angiola Water District, Tulare Lake Basin Water Storage District

D. Public Outreach Meetings/Stakeholder Involvement Opportunities

D.1 Communication & Outreach Methods

There were a variety of opportunities, venues and methods for the Tulare Lake Subbasin GSAs to connect with and engage stakeholders throughout GSA formation, GSP development, GSP review, and will continue to be utilized through the GSP implementation phases. Stakeholder groups identified in **Section C** were engaged through communication methods outlined in this section.

D.1.1 Printed Communication

Printed materials incorporated the visual imagery established through individual GSA branding efforts and was tailored for specific means of communication throughout the phases of GSP development, public review and implementation. Printed materials were also translated into Spanish, when necessary for thorough, diverse stakeholder education.

- **Fliers –** Fliers designed and tailored for stakeholder audiences, encompassed infographics and text with key messages that were pertinent for that phase of GSP development. Distribution was via GSA-website posting, direct mail, email, and direct distribution as handouts throughout communities, GSA and subbasin outreach meetings. For outreach to DACs/SDACs, fliers were available in both English and Spanish languages.

- **Letter Correspondence –** When letter correspondence was necessary, particularly during the public review and implementation phases, letters were distributed via email and/or direct mail. Letters included pertinent facts and explanations that needed to be communicated to specific stakeholder groups.

- **Presentation Materials –** Power Point presentations were utilized at educational/outreach public meetings. For a consistent message subbasin-wide, a draft presentation was developed for the GSP development and public review phases, with placeholder slides for GSAs to update with GSA-specific information. Handouts of presentations and smaller versions of display boards were distributed to stakeholders in attendance, emailed to the Interested Parties list, and posted on individual GSAs' websites for stakeholders to access, particularly if they were unable to attend.

D.1.2 Digital Communication

Digital communication outlets were also designed to incorporate Tulare Lake Subbasin GSAs' branding and was a significant mode of communication through the GSP development and public review phases, and will continue to be crucial during the implementation phase.

- **Websites –** Public meeting notices, agendas and minutes of the Board of Directors and Stakeholder/Advisory Committee meetings were posted on the individual GSAs' websites. These websites serve as integral resources for stakeholders within the Tulare Lake Subbasin boundary. Electronic files of printed materials, presentations and other educational resources, and direct links to stakeholder surveys (English and Spanish versions) were also accessible via the websites.

  As printed materials were created, PDFs of the same information were added to the GSAs' websites. This served as a way for stakeholders to easily educate themselves on the GSP process and phases.

  Table 6. Tulare Lake Subbasin GSAs' Websites

GSA	Website
El Rico GSA	None – Meetings posted at kingsgroundwater.info
Mid-Kings River GSA	www.midkingsrivergsa.org
South Fork Kings GSA	southforkkings.org
Southwest Kings GSA	www.swkgsa.org
Tri-County Water Authority GSA	tcwater.org
Kings River Regional Groundwater Info Portal *(an additional online informational resource)*	kingsgroundwater.info

- **Interested Parties List –** As required by SGMA 10723.4 "Maintenance of Interested Persons List," the Tulare Lake Subbasin GSAs maintain contact lists and regularly distribute emails to those who have expressed interest in the GSAs' progress. These emails consist of meeting notices and other documents that are pertinent to the Tulare Lake Subbasin GSAs and their communication efforts. This process will continue through the GSP implementation phase.

- **Email Blasts –** Email blasts for meeting notices, stakeholder surveys, public review notices, and other crucial information were coordinated with community organizations and stakeholder groups by utilizing their distribution lists. Examples of these organizations are Kings County Farm Bureau, and water/irrigation districts within the individual GSAs' boundaries.

D.1.3 Media Coverage

Press releases were written and distributed to the media list of local newspaper publications. These press releases focused on notification of public engagement opportunities such as targeted stakeholder meetings, public review/comment processes and opportunities, and will be distributed for meetings and notifications during the GSP implementation.

D.1.4 Stakeholder Surveys

Stakeholder surveys were used for the deliberate polling of stakeholders to give them a direct voice in the GSP development phase. The South Fork Kings GSA and Southwest Kings GSA circulated physical surveys, while the remaining three GSAs conducted verbal surveys through one-on-one discussions with stakeholders within their GSA boundaries. For the GSAs who administered physical stakeholder surveys, they developed both online and printed versions of their surveys. Survey links were posted as Google Forms on the individual GSAs' websites and were utilized in email blasts to the Interested Parties Lists. Hard copies were also available for distribution throughout the respective GSA. An outline of the survey questions is provided in **Table 7**.

Table 7. GSAs Circulating Stakeholder Surveys

GSA	Survey Questions
El Rico GSA	Conducted verbal stakeholder survey discussions.
Mid-Kings River GSA	Conducted verbal stakeholder survey discussions.
South Fork Kings GSA	1. How important are the following uses of water to you personally? *Please rank the categories with 1 being the most important use of water and 6 being the least important. (Municipal, Agricultural, Recreational, Mining/Petroleum, Manufacturing, Wildlife/Fisheries)* 2. How important are the following uses of water to the region? *Please rank the categories with 1 being the most important use of water and 6 being the least important. (Municipal, Agricultural, Recreational, Mining/Petroleum, Manufacturing, Wildlife/Fisheries)* 3. Please rank the categories with 1 being the most important for reason for managing groundwater and 5 being the least important. *(Ensure drinking water supply for domestic uses; My ability to earn a living is directly linked; Future economic growth for region; Ensure water supply for future generations; Provide reliable water for industry/business; Other)* 4. How knowledgeable do you consider yourself of local water issues? *(Circle one – Extremely Knowledgeable to Not Very Knowledge)* 5. How knowledgeable do you consider yourself of the new groundwater regulation, the Sustainable Groundwater Management Act? *(Circle one – Extremely Knowledgeable to Not Very Knowledge)* 6. Are you currently engaged in activity or discussions regarding groundwater management in your area? 7. How important to you is information on anticipated impacts of new state regulations. *(Circle one – Extremely Important to Not Very Important)* 8. Which format or formats would you prefer for receiving information about groundwater management planning process? *(Check all that apply – Newsletters, phone number to call for information, regular public meetings, electronic media, news stories, information through interest groups, don't know)* 9. Which applies to you? I am a stakeholder representing pumping for… (*Check all that apply – business use, small community use, domestic use, school use, agricultural use, federal use, industrial use, municipal use, tribal use, environmental use, does not apply)* 10. Which best describes the community in which you or your industry/business resides? *(Circle all that apply – Rural Kings County, within the City of Lemoore, within the Community of Stratford, outside of the South Fork Kings GSA service area, don't know)* 11. Please indicate your age range? *(Circle one – 25 and under, 26-35 years, 36-45 years, 46-55 years, 56-65 years, over 65 years, no answer)*
Southwest Kings GSA	1. Are you familiar with Sustainable Groundwater Management Act (SGMA) regulations? 2. Are you currently engaged in activity of discussions regarding groundwater management in this region? 3. Do you own or manage/operate land in this region? 4. Do you manage water resources? If yes, what is your role? 5. What is your primary interest in land or water resources management? 6. Do you have concerns about groundwater management? If so, what are they? 7. Do you have recommendations regarding groundwater management? If so, what are they?
Tri-County Water Authority GSA	Conducted verbal stakeholder survey discussions.

D.2 Tulare Lake Subbasin-Wide Outreach Efforts

The Tulare Lake Subbasin GSAs maintained a timeline of communication and outreach efforts completed throughout the GSA development and GSP development and public review phases, both on a subbasin-wide level and on the individual GSA level. Subbasin-wide public outreach meetings and presentations are shown in **Table 8**. **Figure 1**, **Figure 2** and **Figure 3** demonstrate a visual guide for consolidated subbasin and individual GSA stakeholder involvement completed since the GSAs were formed.

Table 8. Tulare Lake Subbasin-Wide Public Meetings, Notifications, Presentations & One-on-One Meetings

Event	Date
Kings County Water Commission Meeting – SGMA Update Presentation	May 21, 2018
Kings County Farm Bureau Board Meeting – SGMA Update Presentation	June 19, 2018
Kings County Ag/Water Commissions Joint Meeting – SGMA Update Presentation	March 25, 2019
Kings County Farm Bureau Meeting – GSP Public Review Presentation	August 20, 2019
Subbasin-Wide Public Review Outreach Meeting – Lakeside Community Church, Hanford	5:30 p.m., October 9, 2019
Subbasin-Wide Public Review Outreach Meeting – Lemoore Civic Auditorium, Lemoore	5:30 p.m., October 15, 2019
Subbasin-Wide Meeting regarding GSP with five GSA managers and County of Kings representatives (County Counsel SGMA liaison, CAO, Board of Supervisor Verboon)	November 6, 2019 at the TLBWSD office in Corcoran
Tulare Lake Subbasin GSP Public Hearing – Kings County Board of Supervisors Chambers	10 a.m., December 2, 2019

D.2.1 Public Noticing

I.D.2.1.1 Phase 1: GSA Formation and Coordination

During Phase 1: GSA Formation and Coordination, the five individual GSAs published public notices to notify stakeholders within their boundaries of the public hearings held prior to the official formation of the agencies. These notices are documented in **Table 9**.

Table 9. Public Notices for GSA Formation Public Hearings

GSA	Publication	Date Published	Date Public Hearing Held
El Rico GSA	The Corcoran Journal Visalia Times Delta The Bakersfield Californian	January 19, 2017; January 26, 2017 January 19, 2017; January 26, 2017 January 20, 2017; January 26, 2017	February 7, 2017
Mid-Kings River GSA	Hanford Sentinel	December 20, 2016; December 27, 2016	January 5, 2017
South Fork Kings GSA	Hanford Sentinel	February 15, 2017; February 22, 2017	March 8, 2017
Southwest Kings GSA	The Corcoran Journal	February 16, 2017; February 23, 2017; March 2, 2017	March 8, 2017
Tri-County Water Authority GSA	The Hanford Sentinel	January 17, 2017; January 24, 2017	January 31, 2017

I.D.2.1.2 Phase 3: GSP Review and Evaluation

A 90-day comment period was held the last quarter of 2019, with the GSP draft posted on the Tulare Lake Subbasin GSAs' websites for all stakeholders to conveniently download and review and provide comments. Public notices were published in local newspapers to notify stakeholders of the start of the public review period 90 days prior to the public hearing, and published again within 45 days of the public hearing (**Table 10**).

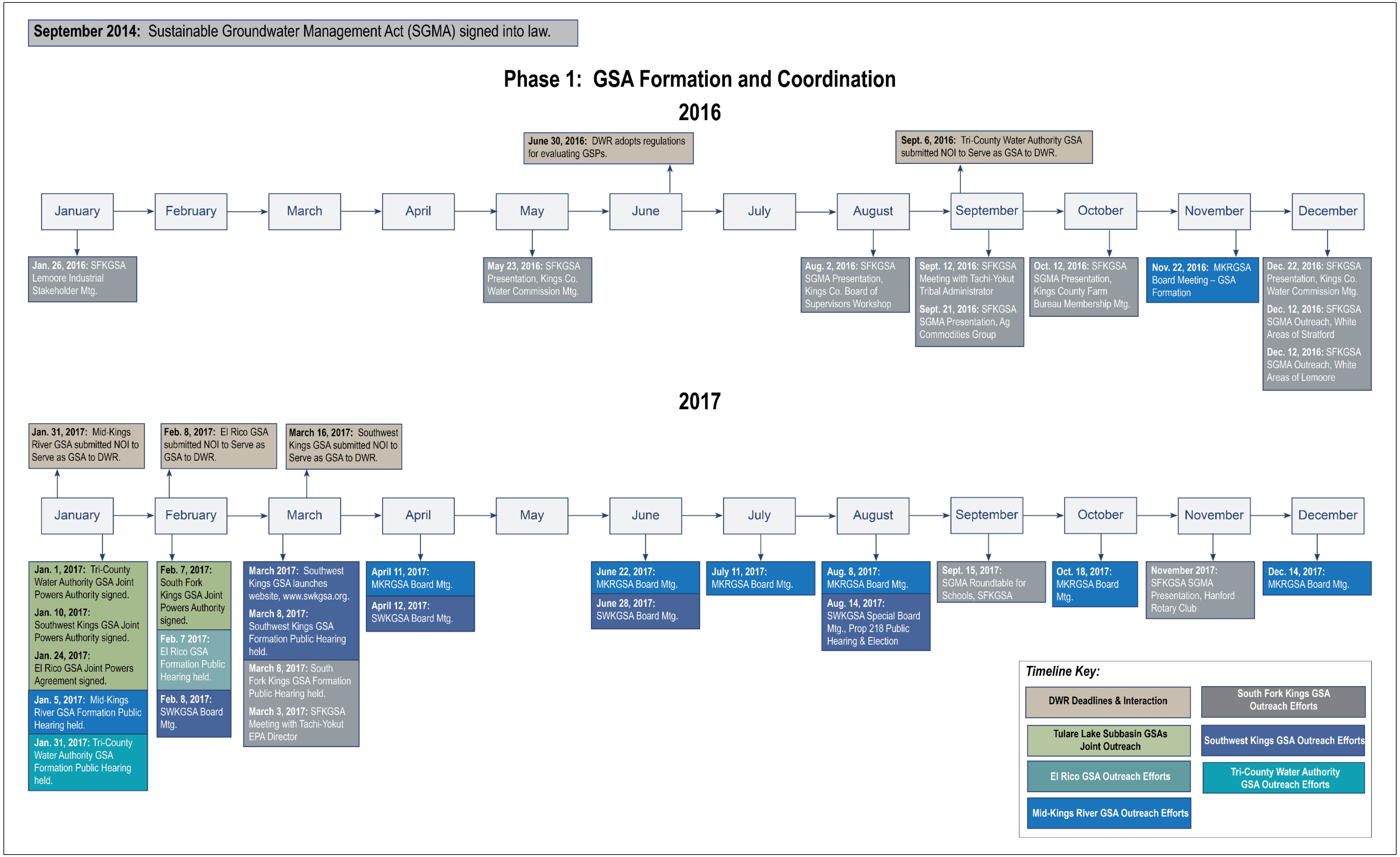
Table 10. Public Notices for GSP Public Review & Public Hearing

Publication	Date Published	Purpose of Notice
The Bakersfield Californian	September 3, 2019; September 10, 2019	Notice of Public Review of Tulare Lake Subbasin Draft GSP
The Corcoran Journal	September 5, 2019; September 12, 2019	
Hanford Sentinel	September 3, 2019; September 10, 2019	
Visalia Times Delta	September 3, 2019; September 10, 2019	
The Bakersfield Californian	October 19, 2019; October 25, 2019	Notice of Public Hearing on Tulare Lake Subbasin Draft GSP, scheduled for December 2, 2019
The Corcoran Journal	October 24, 2019; October 31, 2019	
Hanford Sentinel	October 18, 2019; October 25, 2019	
Visalia Times Delta	October 31, 2019; November 7, 2019	

D.2.2 Interbasin Coordination Efforts

Tulare Lake Subbasin GSAs and technical consultants met with surrounding subbasins throughout the development of the GSP to discuss how to achieve sustainability on a regional level, develop interbasin agreements, address boundary issues, discuss groundwater monitoring and groundwater modeling, and share data when possible. Between the five GSAs, meetings were held periodically with other GSAs within the Kern, Tule, Kaweah, Kings and Westside subbasins. GSA managers were also involved with other GSA boards and technical committees in other subbasins due to some member agencies' boundaries crossing into other subbasins. This allowed the managers to communicate a regional perspective in sustainability discussions, as their stakeholders hold interests in more than one subbasin.

While inter-basin issues were communicated and discussed during these numerous meetings, due to time constraints and each subbasin progressing at a different pace in the development of their GSPs, resolutions to conflicts are acknowledged but impractical to fully analyze prior to the GSP submittal deadline of January 31, 2020. These discussions will continue, and resolutions will be addressed in annual reports and/or the 2025 Tulare Lake Subbasin GSP Update.



September 2014: Sustainable Groundwater Management Act (SGMA) signed into law.

Phase 1: GSA Formation and Coordination

2016

January → February → March → April → May → June → July → August → September → October → November → December

- **Jan. 26, 2016:** SFKGSA Lemoore Industrial Stakeholder Mtg.
- **May 23, 2016:** SFKGSA Presentation, Kings Co. Water Commission Mtg.
- **June 30, 2016:** DWR adopts regulations for evaluating GSPs.
- **Aug. 2, 2016:** SFKGSA SGMA Presentation, Kings Co. Board of Supervisors Workshop
- **Sept. 6, 2016:** Tri-County Water Authority GSA submitted NOI to Serve as GSA to DWR.
- **Sept. 12, 2016:** SFKGSA Meeting with Tachi-Yokut Tribal Administrator
- **Sept. 21, 2016:** SFKGSA SGMA Presentation, Ag Commodities Group
- **Oct. 12, 2016:** SFKGSA SGMA Presentation, Kings County Farm Bureau Membership Mtg.
- **Nov. 22, 2016:** MKRGSA Board Meeting – GSA Formation
- **Dec. 22, 2016:** SFKGSA Presentation, Kings Co. Water Commission Mtg.
- **Dec. 12, 2016:** SFKGSA SGMA Outreach, White Areas of Stratford
- **Dec. 12, 2016:** SFKGSA SGMA Outreach, White Areas of Lemoore

2017

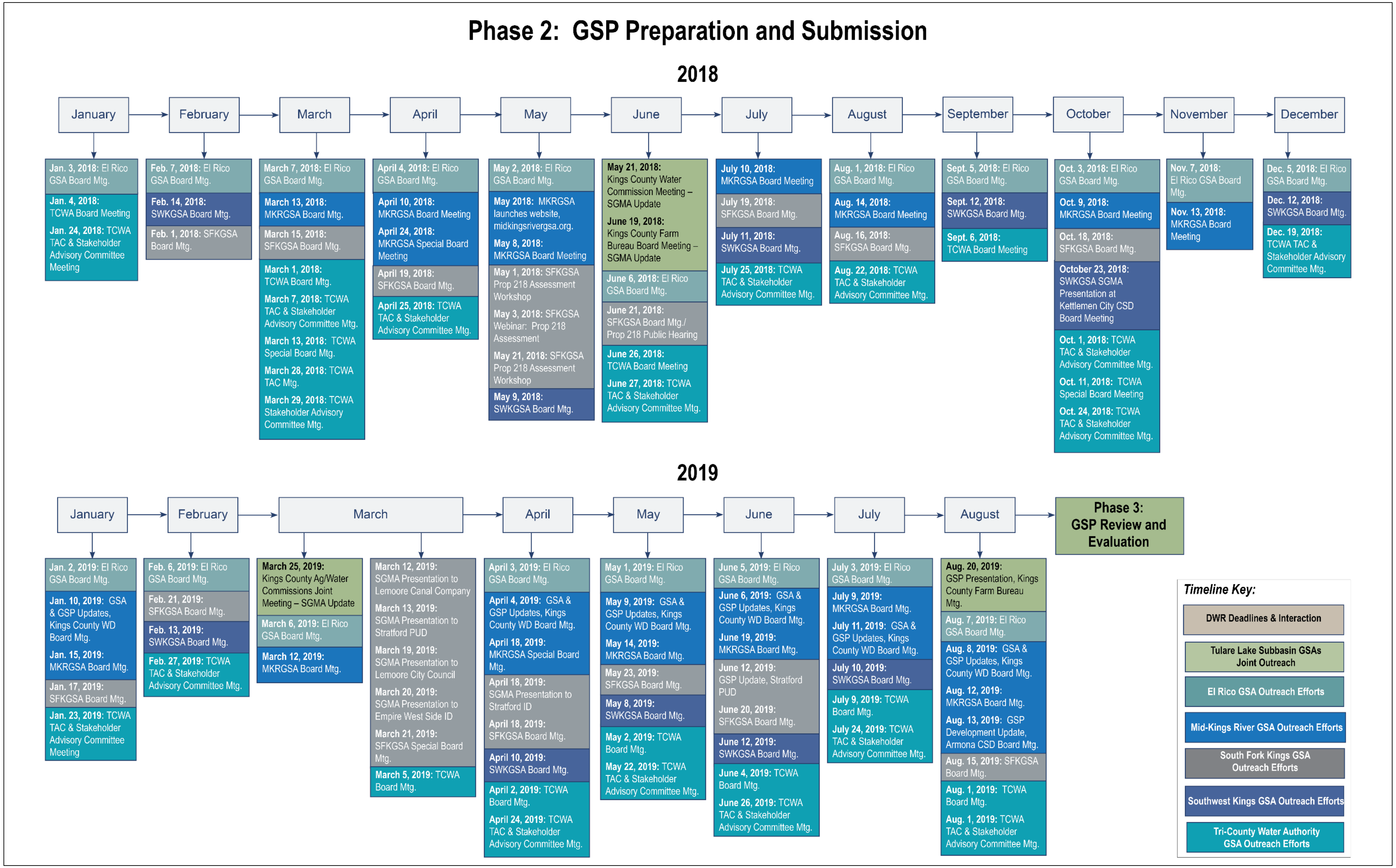
January → February → March → April → May → June → July → August → September → October → November → December

- **Jan. 31, 2017:** Mid-Kings River GSA submitted NOI to Serve as GSA to DWR.
- **Jan. 1, 2017:** Tri-County Water Authority GSA Joint Powers Authority signed.
- **Jan. 10, 2017:** Southwest Kings GSA Joint Powers Authority signed.
- **Jan. 24, 2017:** El Rico GSA Joint Powers Agreement signed.
- **Jan. 5, 2017:** Mid-Kings River GSA Formation Public Hearing held.
- **Jan. 31, 2017:** Tri-County Water Authority GSA Formation Public Hearing held.
- **Feb. 8, 2017:** El Rico GSA submitted NOI to Serve as GSA to DWR.
- **Feb. 7, 2017:** South Fork Kings GSA Joint Powers Authority signed.
- **Feb. 7 2017:** El Rico GSA Formation Public Hearing held.
- **Feb. 8, 2017:** SWKGSA Board Mtg.
- **March 16, 2017:** Southwest Kings GSA submitted NOI to Serve as GSA to DWR.
- **March 2017:** Southwest Kings GSA launches website, www.swkgsa.org.
- **March 8, 2017:** Southwest Kings GSA Formation Public Hearing held.
- **March 8, 2017:** South Fork Kings GSA Formation Public Hearing held.
- **March 3, 2017:** SFKGSA Meeting with Tachi-Yokut EPA Director
- **April 11, 2017:** MKRGSA Board Mtg.
- **April 12, 2017:** SWKGSA Board Mtg.
- **June 22, 2017:** MKRGSA Board Mtg.
- **June 28, 2017:** SWKGSA Board Mtg.
- **July 11, 2017:** MKRGSA Board Mtg.
- **Aug. 8, 2017:** MKRGSA Board Mtg.
- **Aug. 14, 2017:** SWKGSA Special Board Mtg., Prop 218 Public Hearing & Election
- **Sept. 15, 2017:** SGMA Roundtable for Schools, SFKGSA
- **Oct. 18, 2017:** MKRGSA Board Mtg.
- **November 2017:** SFKGSA SGMA Presentation, Hanford Rotary Club
- **Dec. 14, 2017:** MKRGSA Board Mtg.

Timeline Key:

- DWR Deadlines & Interaction
- South Fork Kings GSA Outreach Efforts
- Tulare Lake Subbasin GSAs Joint Outreach
- Southwest Kings GSA Outreach Efforts
- El Rico GSA Outreach Efforts
- Tri-County Water Authority GSA Outreach Efforts
- Mid-Kings River GSA Outreach Efforts

Figure 1. Tulare Lake Subbasin Communication & Engagement Timeline – Phase 1: GSA Formation and Coordination



Phase 2: GSP Preparation and Submission

2018

January → February → March → April → May → June → July → August → September → October → November → December

January
- **Jan. 3, 2018:** El Rico GSA Board Mtg.
- **Jan. 4, 2018:** TCWA Board Meeting
- **Jan. 24, 2018:** TCWA TAC & Stakeholder Advisory Committee Meeting

February
- **Feb. 7, 2018:** El Rico GSA Board Mtg.
- **Feb. 14, 2018:** SWKGSA Board Mtg.
- **Feb. 1, 2018:** SFKGSA Board Mtg.

March
- **March 7, 2018:** El Rico GSA Board Mtg.
- **March 13, 2018:** MKRGSA Board Mtg.
- **March 15, 2018:** SFKGSA Board Mtg.
- **March 1, 2018:** TCWA Board Mtg.
- **March 7, 2018:** TCWA TAC & Stakeholder Advisory Committee Mtg.
- **March 13, 2018:** TCWA Special Board Mtg.
- **March 28, 2018:** TCWA TAC Mtg.
- **March 29, 2018:** TCWA Stakeholder Advisory Committee Mtg.

April
- **April 4, 2018:** El Rico GSA Board Mtg.
- **April 10, 2018:** MKRGSA Board Meeting
- **April 24, 2018:** MKRGSA Special Board Meeting
- **April 19, 2018:** SFKGSA Board Mtg.
- **April 25, 2018:** TCWA TAC & Stakeholder Advisory Committee Mtg.

May
- **May 2, 2018:** El Rico GSA Board Mtg.
- **May 2018:** MKRGSA launches website, midkingsrivergsa.org.
- **May 8, 2018:** MKRGSA Board Meeting
- **May 1, 2018:** SFKGSA Prop 218 Assessment Workshop
- **May 3, 2018:** SFKGSA Webinar: Prop 218 Assessment
- **May 21, 2018:** SFKGSA Prop 218 Assessment Workshop
- **May 9, 2018:** SWKGSA Board Mtg.

June
- **May 21, 2018:** Kings County Water Commission Meeting – SGMA Update
- **June 19, 2018:** Kings County Farm Bureau Board Meeting – SGMA Update
- **June 6, 2018:** El Rico GSA Board Mtg.
- **June 21, 2018:** SFKGSA Board Mtg./ Prop 218 Public Hearing
- **June 26, 2018:** TCWA Board Meeting
- **June 27, 2018:** TCWA TAC & Stakeholder Advisory Committee Mtg.

July
- **July 10, 2018:** MKRGSA Board Meeting
- **July 19, 2018:** SFKGSA Board Mtg.
- **July 11, 2018:** SWKGSA Board Mtg.
- **July 25, 2018:** TCWA TAC & Stakeholder Advisory Committee Mtg.

August
- **Aug. 1, 2018:** El Rico GSA Board Mtg.
- **Aug. 14, 2018:** MKRGSA Board Meeting
- **Aug. 16, 2018:** SFKGSA Board Mtg.
- **Aug. 22, 2018:** TCWA TAC & Stakeholder Advisory Committee Mtg.

September
- **Sept. 5, 2018:** El Rico GSA Board Mtg.
- **Sept. 12, 2018:** SWKGSA Board Mtg.
- **Sept. 6, 2018:** TCWA Board Meeting

October
- **Oct. 3, 2018:** El Rico GSA Board Mtg.
- **Oct. 9, 2018:** MKRGSA Board Meeting
- **Oct. 18, 2018:** SFKGSA Board Mtg.
- **October 23, 2018:** SWKGSA SGMA Presentation at Kettlemen City CSD Board Meeting
- **Oct. 1, 2018:** TCWA TAC & Stakeholder Advisory Committee Mtg.
- **Oct. 11, 2018:** TCWA Special Board Meeting
- **Oct. 24, 2018:** TCWA TAC & Stakeholder Advisory Committee Mtg.

November
- **Nov. 7, 2018:** El Rico GSA Board Mtg.
- **Nov. 13, 2018:** MKRGSA Board Meeting

December
- **Dec. 5, 2018:** El Rico GSA Board Mtg.
- **Dec. 12, 2018:** SWKGSA Board Mtg.
- **Dec. 19, 2018:** TCWA TAC & Stakeholder Advisory Committee Mtg.

2019

January → February → March → April → May → June → July → August → **Phase 3: GSP Review and Evaluation**

January
- **Jan. 2, 2019:** El Rico GSA Board Mtg.
- **Jan. 10, 2019:** GSA & GSP Updates, Kings County WD Board Mtg.
- **Jan. 15, 2019:** MKRGSA Board Mtg.
- **Jan. 17, 2019:** SFKGSA Board Mtg.
- **Jan. 23, 2019:** TCWA TAC & Stakeholder Advisory Committee Meeting

February
- **Feb. 6, 2019:** El Rico GSA Board Mtg.
- **Feb. 21, 2019:** SFKGSA Board Mtg.
- **Feb. 13, 2019:** SWKGSA Board Mtg.
- **Feb. 27, 2019:** TCWA TAC & Stakeholder Advisory Committee Mtg.

March
- **March 25, 2019:** Kings County Ag/Water Commissions Joint Meeting – SGMA Update
- **March 6, 2019:** El Rico GSA Board Mtg.
- **March 12, 2019:** MKRGSA Board Mtg.
- **March 12, 2019:** SGMA Presentation to Lemoore Canal Company
- **March 13, 2019:** SGMA Presentation to Stratford PUD
- **March 19, 2019:** SGMA Presentation to Lemoore City Council
- **March 20, 2019:** SGMA Presentation to Empire West Side ID
- **March 21, 2019:** SFKGSA Special Board Mtg.
- **March 5, 2019:** TCWA Board Mtg.

April
- **April 3, 2019:** El Rico GSA Board Mtg.
- **April 4, 2019:** GSA & GSP Updates, Kings County WD Board Mtg.
- **April 18, 2019:** MKRGSA Special Board Mtg.
- **April 18, 2019:** SGMA Presentation to Stratford ID
- **April 18, 2019:** SFKGSA Board Mtg.
- **April 10, 2019:** SWKGSA Board Mtg.
- **April 2, 2019:** TCWA Board Mtg.
- **April 24, 2019:** TCWA TAC & Stakeholder Advisory Committee Mtg.

May
- **May 1, 2019:** El Rico GSA Board Mtg.
- **May 9, 2019:** GSA & GSP Updates, Kings County WD Board Mtg.
- **May 14, 2019:** MKRGSA Board Mtg.
- **May 23, 2019:** SFKGSA Board Mtg.
- **May 8, 2019:** SWKGSA Board Mtg.
- **May 2, 2019:** TCWA Board Mtg.
- **May 22, 2019:** TCWA TAC & Stakeholder Advisory Committee Mtg.

June
- **June 5, 2019:** El Rico GSA Board Mtg.
- **June 6, 2019:** GSA & GSP Updates, Kings County WD Board Mtg.
- **June 19, 2019:** MKRGSA Board Mtg.
- **June 12, 2019:** GSP Update, Stratford PUD
- **June 20, 2019:** SFKGSA Board Mtg.
- **June 12, 2019:** SWKGSA Board Mtg.
- **June 4, 2019:** TCWA Board Mtg.
- **June 26, 2019:** TCWA TAC & Stakeholder Advisory Committee Mtg.

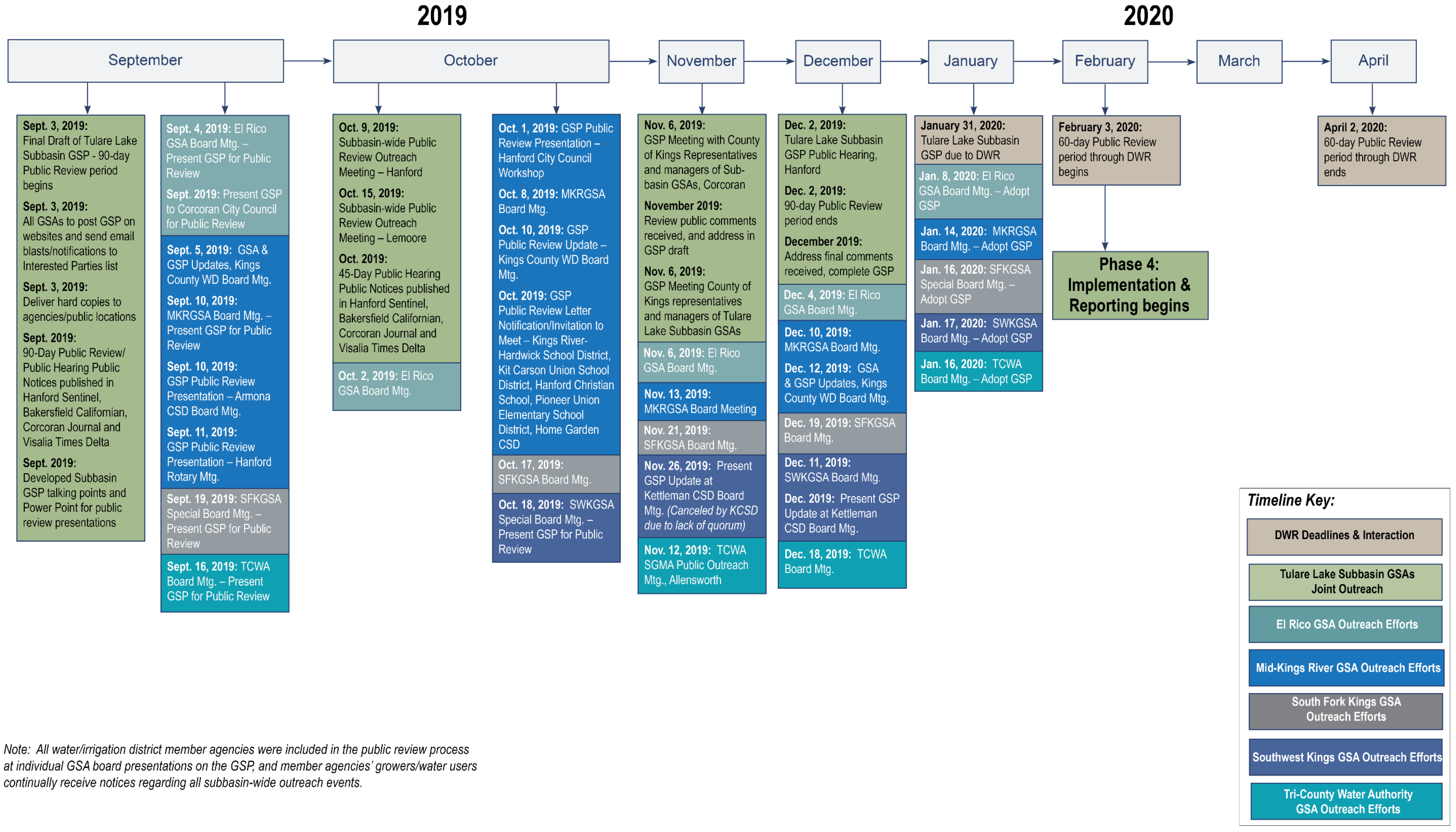
July
- **July 3, 2019:** El Rico GSA Board Mtg.
- **July 9, 2019:** MKRGSA Board Mtg.
- **July 11, 2019:** GSA & GSP Updates, Kings County WD Board Mtg.
- **July 10, 2019:** SWKGSA Board Mtg.
- **July 9, 2019:** TCWA Board Mtg.
- **July 24, 2019:** TCWA TAC & Stakeholder Advisory Committee Mtg.

August
- **Aug. 20, 2019:** GSP Presentation, Kings County Farm Bureau Mtg.
- **Aug. 7, 2019:** El Rico GSA Board Mtg.
- **Aug. 8, 2019:** GSA & GSP Updates, Kings County WD Board Mtg.
- **Aug. 12, 2019:** MKRGSA Board Mtg.
- **Aug. 13, 2019:** GSP Development Update, Armona CSD Board Mtg.
- **Aug. 15, 2019:** SFKGSA Board Mtg.
- **Aug. 1, 2019:** TCWA Board Mtg.
- **Aug. 1, 2019:** TCWA TAC & Stakeholder Advisory Committee Mtg.

Timeline Key:
- DWR Deadlines & Interaction
- Tulare Lake Subbasin GSAs Joint Outreach
- El Rico GSA Outreach Efforts
- Mid-Kings River GSA Outreach Efforts
- South Fork Kings GSA Outreach Efforts
- Southwest Kings GSA Outreach Efforts
- Tri-County Water Authority GSA Outreach Efforts

Figure 2. Tulare Lake Subbasin Communication & Engagement Timeline – Phase 2: GSP Preparation and Submission

Phase 3: GSP Review and Evaluation



2019

September

Sept. 3, 2019: Final Draft of Tulare Lake Subbasin GSP - 90-day Public Review period begins

Sept. 3, 2019: All GSAs to post GSP on websites and send email blasts/notifications to Interested Parties list

Sept. 3, 2019: Deliver hard copies to agencies/public locations

Sept. 2019: 90-Day Public Review/ Public Hearing Public Notices published in Hanford Sentinel, Bakersfield Californian, Corcoran Journal and Visalia Times Delta

Sept. 2019: Developed Subbasin GSP talking points and Power Point for public review presentations

Sept. 4, 2019: El Rico GSA Board Mtg. – Present GSP for Public Review

Sept. 2019: Present GSP to Corcoran City Council for Public Review

Sept. 5, 2019: GSA & GSP Updates, Kings County WD Board Mtg.

Sept. 10, 2019: MKRGSA Board Mtg. – Present GSP for Public Review

Sept. 10, 2019: GSP Public Review Presentation – Armona CSD Board Mtg.

Sept. 11, 2019: GSP Public Review Presentation – Hanford Rotary Mtg.

Sept. 19, 2019: SFKGSA Special Board Mtg. – Present GSP for Public Review

Sept. 16, 2019: TCWA Board Mtg. – Present GSP for Public Review

October

Oct. 9, 2019: Subbasin-wide Public Review Outreach Meeting – Hanford

Oct. 15, 2019: Subbasin-wide Public Review Outreach Meeting – Lemoore

Oct. 2019: 45-Day Public Hearing Public Notices published in Hanford Sentinel, Bakersfield Californian, Corcoran Journal and Visalia Times Delta

Oct. 2, 2019: El Rico GSA Board Mtg.

Oct. 1, 2019: GSP Public Review Presentation – Hanford City Council Workshop

Oct. 8, 2019: MKRGSA Board Mtg.

Oct. 10, 2019: GSP Public Review Update – Kings County WD Board Mtg.

Oct. 2019: GSP Public Review Letter Notification/Invitation to Meet – Kings River-Hardwick School District, Kit Carson Union School District, Hanford Christian School, Pioneer Union Elementary School District, Home Garden CSD

Oct. 17, 2019: SFKGSA Board Mtg.

Oct. 18, 2019: SWKGSA Special Board Mtg. – Present GSP for Public Review

November

Nov. 6, 2019: GSP Meeting with County of Kings Representatives and managers of Sub-basin GSAs, Corcoran

November 2019: Review public comments received, and address in GSP draft

Nov. 6, 2019: GSP Meeting County of Kings representatives and managers of Tulare Lake Subbasin GSAs

Nov. 6, 2019: El Rico GSA Board Mtg.

Nov. 13, 2019: MKRGSA Board Meeting

Nov. 21, 2019: SFKGSA Board Mtg.

Nov. 26, 2019: Present GSP Update at Kettleman CSD Board Mtg. *(Canceled by KCSD due to lack of quorum)*

Nov. 12, 2019: TCWA SGMA Public Outreach Mtg., Allensworth

December

Dec. 2, 2019: Tulare Lake Subbasin GSP Public Hearing, Hanford

Dec. 2, 2019: 90-day Public Review period ends

December 2019: Address final comments received, complete GSP

Dec. 4, 2019: El Rico GSA Board Mtg.

Dec. 10, 2019: MKRGSA Board Mtg.

Dec. 12, 2019: GSA & GSP Updates, Kings County WD Board Mtg.

Dec. 19, 2019: SFKGSA Board Mtg.

Dec. 11, 2019: SWKGSA Board Mtg.

Dec. 2019: Present GSP Update at Kettleman CSD Board Mtg.

Dec. 18, 2019: TCWA Board Mtg.

2020

January

January 31, 2020: Tulare Lake Subbasin GSP due to DWR

Jan. 8, 2020: El Rico GSA Board Mtg. – Adopt GSP

Jan. 14, 2020: MKRGSA Board Mtg. – Adopt GSP

Jan. 16, 2020: SFKGSA Special Board Mtg. – Adopt GSP

Jan. 17, 2020: SWKGSA Board Mtg. – Adopt GSP

Jan. 16, 2020: TCWA Board Mtg. – Adopt GSP

February

February 3, 2020: 60-day Public Review period through DWR begins

Phase 4: Implementation & Reporting begins

March

April

April 2, 2020: 60-day Public Review period through DWR ends

Note: All water/irrigation district member agencies were included in the public review process at individual GSA board presentations on the GSP, and member agencies' growers/water users continually receive notices regarding all subbasin-wide outreach events.

Timeline Key:

- DWR Deadlines & Interaction
- Tulare Lake Subbasin GSAs Joint Outreach
- El Rico GSA Outreach Efforts
- Mid-Kings River GSA Outreach Efforts
- South Fork Kings GSA Outreach Efforts
- Southwest Kings GSA Outreach Efforts
- Tri-County Water Authority GSA Outreach Efforts

Figure 3. Tulare Lake Subbasin Communication & Engagement Timeline – Phase 3: GSP Review and Evaluation

D.3 El Rico GSA

Table 11. El Rico GSA Public Meetings, Presentations & One-on-One Meetings

Event	Date
One-on-one meetings with landowners of over 85 percent of the GSA area	Ongoing
SGMA & GSP Update meetings and negotiations with City of Corcoran personnel	Ongoing
GSA board meeting notices sent to all interested parties	Ongoing
Monthly meetings with “Un-districted Dairy Owners”	Ongoing
El Rico GSA Board Meeting	1 p.m., January 3, 2018
El Rico GSA Board Meeting	1 p.m., February 7, 2018
El Rico GSA Board Meeting	1 p.m., March 7, 2018
El Rico GSA Board Meeting	1 p.m., April 4, 2018
El Rico GSA Board Meeting	1 p.m., May 2, 2018
El Rico GSA Board Meeting	1 p.m., June 6, 2018
El Rico GSA Board Meeting	1 p.m., August 1, 2018
El Rico GSA Board Meeting	1 p.m., September 5, 2018
El Rico GSA Board Meeting	1 p.m., October 3, 2018
El Rico GSA Board Meeting	1 p.m., November 7, 2018
El Rico GSA Board Meeting	1 p.m., December 5, 2018
El Rico GSA Board Meeting	1 p.m., January 2, 2019
El Rico GSA Board Meeting	1 p.m., February 6, 2019
El Rico GSA Board Meeting	1 p.m., March 6, 2019
El Rico GSA Board Meeting	1 p.m., April 3, 2019
El Rico GSA Board Meeting	1 p.m., May 1, 2019
El Rico GSA Board Meeting	1 p.m., June 5, 2019
El Rico GSA Board Meeting	1 p.m., July 3, 2019
El Rico GSA Board Meeting	1 p.m., August 7, 2019
El Rico GSA Board Meeting	1 p.m., September 4, 2019
El Rico GSA Board Meeting	1 p.m., October 2, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	5:30 p.m., October 9, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	5:30 p.m., October 15, 2019
El Rico GSA Board Meeting	1 p.m., November 6, 2019
GSP Meeting with County of Kings representatives and managers of Tulare Lake Subbasin GSAs	1:30 p.m., November 6, 2019
Tulare Lake Subbasin GSP Public Hearing – Hanford	10 a.m., December 2, 2019
El Rico GSA Board Meeting	1 p.m., December 4, 2019
El Rico GSA Board Meeting	1 p.m., January 8, 2020

D.4 Mid-Kings River GSA

D.4.1 Website – www.midkingsrivergsa.org

The Mid-Kings River GSA's website went live in May 2018 for the purpose of informing stakeholders about the GSA, public outreach opportunities, and as a resource with SGMA-related information. A site map is outlined below:

- **Homepage –** Introduction of Mid-Kings River GSA; GSA News
- **About Us –** Overview of SGMA; About the Mid-Kings River GSA; Member Agencies; Mid-Kings River GSA Information (links to Notice of Intent, JPA Members Agreement, GSA Boundary Map, Subbasin Boundary Map)
- **Board & Committees –** Board of Directors; (Agendas, Minutes, List of Board Members)
- **GSA Resources –** SGMA-Related Resources; Other Tulare Lake Subbasin GSAs (links); Partnering Agencies (links)
- **Contact Us –** Questions (telephone and email); Location/Mailing Address; Interested Parties List Sign-Up Form

Mid-Kings River Groundwater Sustainability Agency

GSA & SGMA News

Picture 1. Screenshot of www.midkingsrivergsa.org Homepage

D.4.2 Mid-Kings River GSA Outreach Tracking

Table 12. Mid-Kings River GSA Public Meetings, Notifications, Presentations & One-on-One Meetings

Event	Date
Landowner Meetings for requested updates on SGMA	Ongoing
Greater Kaweah GSA Collaboration – Updates to TAC and BOD on Tulare Lake Subbasin efforts	Ongoing
Participation in local DWR meetings	Ongoing
Coordination meetings with other subbasins and South Valley Practitioners Group	Ongoing
MKRGSA Board Meeting – GSA Formation	1 p.m., December 13, 2016
MKRGSA Board Meeting & Public Hearing to Become GSA	10 a.m., January 5, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., April 11, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., June 22, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., July 11, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., August 8, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., October 18, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., December 14, 2017
MKRGSA Board Meeting – SGMA and GSP Development Updates	3 p.m., March 13, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	3 p.m., April 10, 2018
MKRGSA Special Board Meeting	9:30 a.m., April 24, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., May 8, 2018
Kings County Water Commission Meeting – SGMA Update	May 21, 2018
Kings County Farm Bureau Board Meeting – SGMA Update	June 19, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., July 10, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., August 14, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., October 9, 2018
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., November 13, 2018
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., January 10, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., January 15, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., March 12, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., April 4, 2019
MKRGSA Special Board Meeting – SGMA and GSP Development Updates	1 p.m., April 18, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., May 9, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., May 14, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., June 6, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., June 19, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., July 9, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., July 11, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., August 8, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., August 12, 2019
Armona CSD Board Meeting Presentation – SGMA and GSP Development Updates	6 p.m., August 13, 2019
GSA & GSP Development Updates – Kings County Water District Board Meeting	1:30 p.m., September 5, 2019

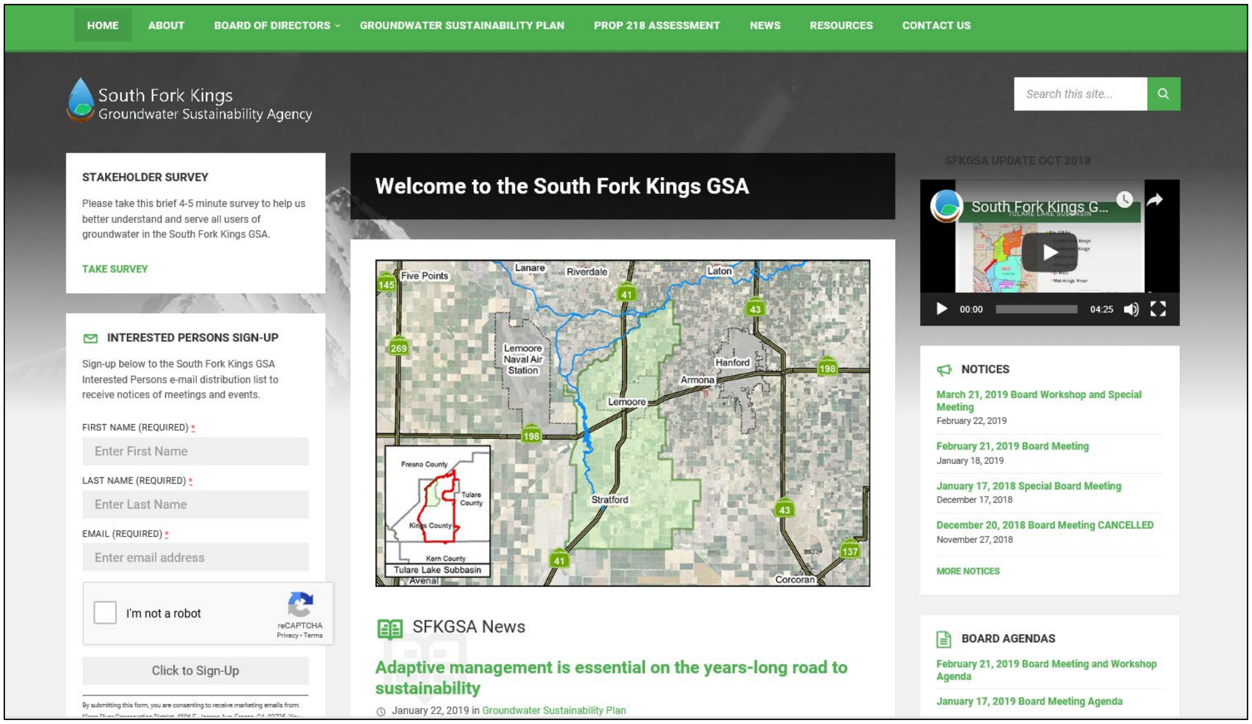
Event	Date
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., September 10, 2019
GSP Public Review Presentation at Armona CSD Board Meeting	6 p.m., September 10, 2019
GSP Public Review Presentation at Hanford Rotary Meeting	5:30 p.m., September 11, 2019
GSP Public Review Update – Kings County Water District Board Meeting	1:30 p.m., October 10, 2019
GSP Public Review Presentation at Hanford City Council Workshop	5:30 p.m., October 1, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., October 8, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	5:30 p.m., October 9, 2019
Home Garden CSD – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Kings River-Hardwick School District – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Kit Carson Union School District – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Hanford Christian School – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Pioneer Union Elementary School District – Draft Tulare Lake Subbasin Groundwater Sustainability Plan Public Review Letter Notification & Invitation to Meet	Mailed via USPS and emailed October 11, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	5:30 p.m., October 15, 2019
GSP Meeting with County of Kings representatives and other GSA managers, Corcoran	1:30 p.m., November 6, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., November 13, 2019
Tulare Lake Subbasin GSP Public Hearing – Hanford	10 a.m., December 2, 2019
MKRGSA Board Meeting – SGMA and GSP Development Updates	1 p.m., December 10, 2019
GSA & GSP GSP Public Review Update – Kings County Water District Board Meeting	1:30 p.m., December 12, 2019
MKRGSA Board Meeting – Adoption of GSP	1 p.m., January 14, 2020

D.5 South Fork Kings GSA

D.5.1 Website – https://southforkkings.org/

The South Fork Kings GSA's website is a solid source of information for SGMA and the impacts within the GSA boundary. A site map is outlined below:

- **Homepage –** Welcome page with quick links to Stakeholder Survey, Interested Persons Sign-Up, GSA News, Notices, Board Agendas/Minutes, Proposition 218 Groundwater Assessment Resources
- **About Us –** About the South Fork Kings GSA; Quick links to Stakeholder Survey, Interested Persons Sign-Up, Board Agendas/Minutes, Documents
- **Board of Directors –** Board of Directors; Quick links to Stakeholder Survey, Interested Persons Sign-Up, Board Agendas/Minutes, Documents; Upcoming Events
- **Groundwater Sustainability Plan Portal –** Calendar, Projects, Coordination, Resources; Groundwater Sustainability Plan Development; GSP Implementation Roles (GSA, Stakeholder, DWR, SWRCB); GSP Schedule
- **Proposition 218 Assessment –** Election Results; Prop 218 Frequently Asked Questions; Prop 218 Election Documents; Overview of Groundwater Assessment
- **News**
- **Resources**
- **Contact Us –** Contact Us Inquiry Form; SGMA Update E-News Sign-Up; Quick links to Stakeholder Survey and Interested Persons Sign-Up



STAKEHOLDER SURVEY

Please take this brief 4-5 minute survey to help us better understand and serve all users of groundwater in the South Fork Kings GSA.

TAKE SURVEY

INTERESTED PERSONS SIGN-UP

Sign-up below to the South Fork Kings GSA Interested Persons e-mail distribution list to receive notices of meetings and events.

FIRST NAME (REQUIRED) *
Enter First Name
LAST NAME (REQUIRED) *
Enter Last Name
EMAIL (REQUIRED) *
Enter email address

☐ I'm not a robot reCAPTCHA Privacy - Terms

Click to Sign-Up

By submitting this form, you are consenting to receive marketing emails from:

Welcome to the South Fork Kings GSA

SFKGSA News

Adaptive management is essential on the years-long road to sustainability
January 22, 2019 in Groundwater Sustainability Plan

NOTICES

March 21, 2019 Board Workshop and Special Meeting
February 22, 2019

February 21, 2019 Board Meeting
January 18, 2019

January 17, 2018 Special Board Meeting
December 17, 2018

December 20, 2018 Board Meeting CANCELLED
November 27, 2018

MORE NOTICES

BOARD AGENDAS

February 21, 2019 Board Meeting and Workshop Agenda

January 17, 2019 Board Meeting Agenda

Picture 2. Screenshot of https://southforkkings.org/ Homepage

Table 13. 2017 SFKGSA Website Views

Month	Views
January	N/A
February	N/A
March	N/A
April	N/A
May	N/A
June	355
July	203
August	126
September	231
October	134
November	98
December	84

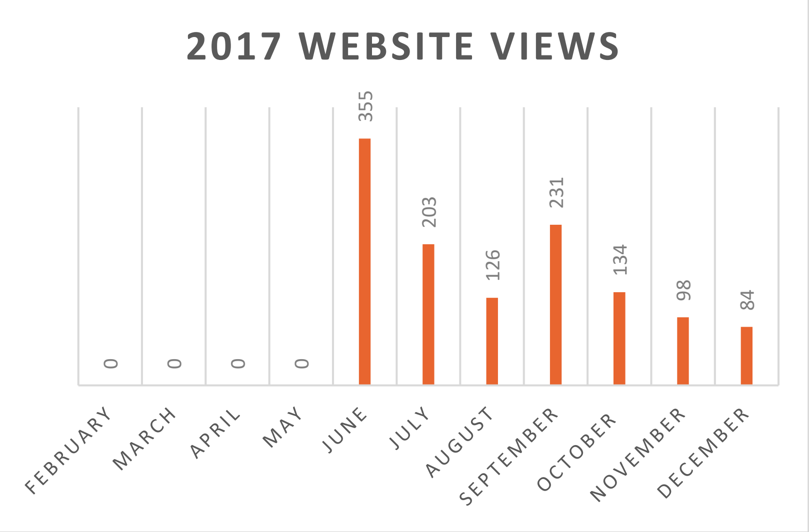


Table 14. 2018 SFKGSA Website Views

Month	Views
January	197
February	203
March	158
April	302
May	418
June	332
July	359
August	248
September	216
October	373
November	182
December	237

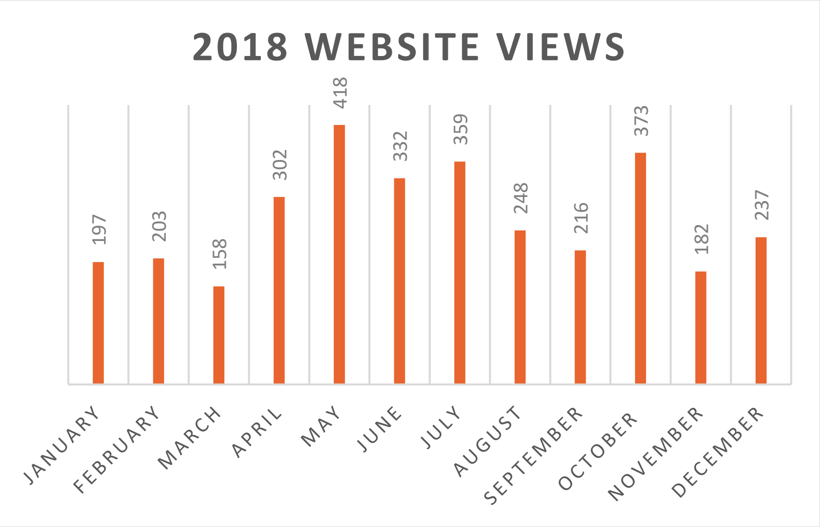
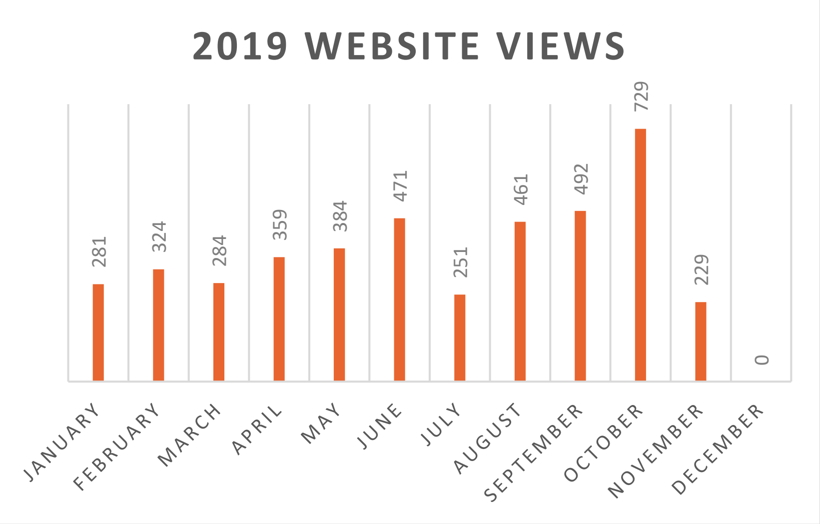


Table 15. 2019 SFKGSA Website Views

Month	Views
January	281
February	324
March	284
April	359
May	384
June	471
July	251
August	461
September	492
October	729
November	458
December	318



D.5.2 South Fork Kings GSA Outreach Tracking

Table 16. South Fork Kings GSA Public Meetings, Presentations & One-on-One Meetings

Event	Date	Attendance	Audience
Lemoore City Council Study Session	4/22/2015	15	Stakeholders
Empire Westside Water District Board Meeting	9/16/2015	7	Stakeholders
Stratford PUD Board Meeting	11/18/2015		Stakeholders (DAC)
Kings County Water Commission Meeting	11/23/2015	20	Stakeholders
Lemoore Industrial Stakeholder Meeting	1/26/2016	9	Stakeholders
Kings County Water Commission Meeting	5/23/2016	20	Stakeholders
Kings County Board of Supervisors Workshop	8/2/2016	30	Stakeholders
Janice Cuara, Tribal Administrator Tachi-Yokut	9/12/2016		Stakeholders – Native American
Ag Commodities Group Update	9/21/2016	8	
Kings County Farm Bureau Membership	10/12/2016	30	Stakeholders, Landowners
SFK White Areas – Stratford	12/12/2016		Stakeholders (DAC)
SFK White Areas – Lemoore	12/12/2016	35	Stakeholders
Kings County Water Commission Meeting	12/22/2016		Stakeholders
Noah Ignacio, EPA Director Tachi-Yokut	3/3/2017		Stakeholders – Native American
SGMA Roundtable for Schools SFK	9/15/2017	30	Stakeholders
SGMA Presentation, Hanford Rotary Club	11/2017	40	Stakeholders
Board Meeting, Lemoore City Council Chambers	02/1/2018	20	Stakeholders
Board Meeting, Lemoore City Council Chambers	3/15/2018	10	Stakeholders
Board Meeting, Lemoore City Council Chambers	4/19/2018	13	Stakeholders
Proposition 218 Assessment Workshop, Lemoore	5/1/2018	20	Landowners, City of Lemoore residents
Webinar: Proposition 218 Assessment	5/3/2018	1	Landowners

Event	Date	Attendance	Audience
Prop 218 Assessment Workshop, Lemoore	5/21/2018	21	Landowners, City of Lemoore residents
Board Meeting/Public Hearing for Proposition 218 Election	6/21/2018	25	Landowners, stakeholders
Board Meeting, Lemoore City Council Chambers	7/19/2018	19	Stakeholders
Board Meeting, Lemoore City Council Chambers	8/16/2018	16	Stakeholders
Board Meeting, Lemoore City Council Chambers	10/18/2018	19	Stakeholders
Board Meeting, Lemoore City Council Chambers	01/17/2019	24	Stakeholders
Board Meeting, Lemoore City Council Chambers	02/21/2019	14	Stakeholders
Presentation to Lemoore Canal Company	03/12/2019		Stakeholders
Presentation to Stratford Public Utility District	03/13/2019		Stakeholders
Presentation to Lemoore City Council	03/19/2019		Stakeholders
Presentation to Empire West Side Irrigation District	03/20/2019		Stakeholders
Special Board Meeting, Lemoore City Council Chambers	03/21/2019	19	Stakeholders
Presentation to Stratford Irrigation District	04/18/2019		Stakeholders
Board Meeting, Lemoore City Council Chambers	04/18/2019	13	Stakeholders
Board Meeting, Lemoore City Council Chambers	05/23/2019	14	Stakeholders
GSP Update, Stratford Public Utility District	06/12/2019		Stakeholders
Board Meeting, Lemoore City Council Chambers	06/20/2019	12	Stakeholders
Board Meeting, Lemoore City Council Chambers	08/15/2019	18	Stakeholders
Board Meeting – Lemoore City Council Chambers	09/19/2019	14	Stakeholders
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	10/9/2019	27	Stakeholders
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	10/15/2019	35	Stakeholders
Board Meeting, Lemoore City Council Chambers	10/17/2019	12	Stakeholders
Board Meeting, Lemoore City Council Chambers	11/21/2019	13	Stakeholders
Tulare Lake Subbasin GSP Public Hearing – Hanford	12/2/2019		Stakeholders
Board Meeting, Lemoore City Council Chambers	12/19/2019		Stakeholders
Special Board Meeting – Adoption of GSP, Lemoore City Council Chambers	01/16/2020		Stakeholders

Table 17. South Fork Kings GSA Website Articles

Title/Topic	Date	Views
Kings County Farm Bureau newsletter article	Jul-15	N/A
SFK Board Approves Contract with Hydrogeological Consultant	6/20/2017	26
Board Supports Effort to Develop a Single GSP for the Tulare Lake Subbasin	7/20/2017	16
Contract Approved with Geosyntec Consultants	8/21/2017	28
Board Approves Preparation of Engineering Report for 218 Election	9/25/2017	23
Board Approves Data Sharing Agreements with North Fork Kings GSA, Westlands Water District	2/9/2018	17
The Model, the Data and Groundwater Sustainability	2/9/2018	225
Board Approves Engineer's Report, Moves Forward with Prop 218 Assessment	3/27/2018	84
Proposition 218 Election to Fund Local Groundwater Management Passes	6/22/2018	29
Consultants update Board on the groundwater model, a Groundwater Sustainability Plan foundation	7/24/2019	31
Groundwater Sustainability Plan schedule update	10/11/2018	28
Project and management action concepts discussed at Board workshop	10/22/2018	76
Adaptive management is essential on the years-long road to sustainability	1/22/2019	46
Preliminary Monitoring Network Identified	3/15/2019	49
Creativity and adaptive management will reduce 45,000 AF of estimated overdraft in the South Fork Kings	4/24/2019	70
Twelve Wells will Monitor Groundwater	6/7/2019	67
Board Approves $9.80 Assessment	6/25/2019	25

Table 18. Email Correspondence with Interested Persons List - Email Blasts

Message/Topic	Date Sent	Open Rate	Click Rate	Reach/Quantity
Board Agenda Packet	6/20/2017	43.5%	20.0%	24
Board Agenda Packet	7/21/2017	60.7%	5.9%	29
Board Agenda Packet	8/21/2017	46.4%	7.7%	30
Board Agenda Packet	9/25/2017	46.7%	7.1%	32
Board Agenda Packet	11/3/2017	53.3%	56.3%	32
Model, Data, Sustainability Tech Consultant; Data-Sharing Agreements Approved	2/9/18	49.2%	51.6%	67
Model, Data, Sustainability tech consultant; data sharing agreements approved	3/12/18	49%	51%	67
Board Agenda Packet	3/27/18	46%	50%	65
Engineer's Report Adopted; Prop 218 Election; Board meeting schedule update	4/16/18	44%	27%	68
Board Agenda Packet	5/2/18	48%	57%	76
Prop 218 Workshop Highlight, State Intervention, Groundwater Fee	5/7/18	N/A	N/A	0
Ballots mailed, local vs. state control, prop 218 resources, public hearing date	5/31/18	60%	33%	91
Submit your ballot by June 21 hearing date	7/27/18	47%	34%	106

Message/Topic	Date Sent	Open Rate	Click Rate	Reach/Quantity
Update to landowner on the overdraft number for the Tulare Lake Subbasin	7/16/18	N/A	N/A	1
Board Agenda Packet	7/24/18	57%	57%	113
Groundwater Model, Technical Services Continued with Geosyntec	8/13/18	52%	33%	117
Board Agenda Packet	10/15/18	54%	46%	119
Board Agenda Packet	10/23/18	46%	33%	120
Project and management actions discussed at workshop, DWR funding opportunity, Tulare Lake Subbasin Communication & Engagement Plan adopted, Stakeholder Survey, #SGMAMadeSimple	12/13/18	47%	42%	121
Meeting Cancellation Notice	12/17/18	44%	N/A	126
Board Agenda	1/17/2019	56%	44%	126
Adaptive management for sustainability, GSP Portal Updates, Stakeholder Survey, Water Budget video	1/23/2019	54%	35%	128
Board Agenda	2/15/2019	52%	33%	134
Meeting notice	2/22/2019	40%	8%	N/A
Timeline to GSP completion, Board appoints officers, monitoring network identified, water quality infographic	3/15/2019	50%	28%	141
Board Agenda	3/18/2019	44%	34%	141
Board Agenda	4/15/2019	43%	28%	142
Creativity and adaptive management will reduce overdraft, land subsidence infographic, board workshop slides	4/25/2019	51%	28%	142
Board Agenda, Budget Committee Agenda	5/20/2019	43%	24%	154
Twelve Wells will monitor groundwater, groundwater storage infographic	6/7/2019	41%	37%	153
Board Agenda	6/17/2019	39%	27%	152
Board approves &9.80 assessment, SGMA Made Simple video, June 20th workshop presentation	6/25/2019	35%	37%	153
Board Agenda	8/12/2019	51%	43%	209
Board Agenda	9/16/2019	45%	40%	218
GSP available for download, upcoming GSP workshops	10/2/2019	41%	18%	219
Board Agenda	10/14/2019	41%	24%	222
Upcoming GSP workshop promo	11/5/2019	42%	22%	222
Upcoming Irrigation Technology event at CSU Fresno	11/5/2019	36%	7%	224

Table 19. Direct Mailings to Stakeholders

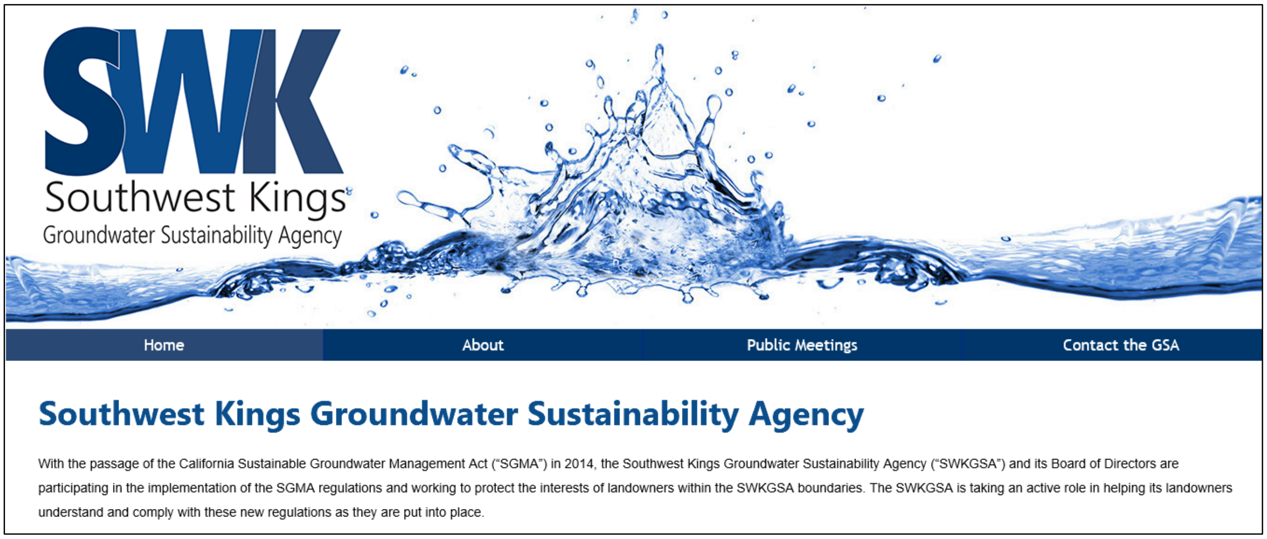
Date	Title	Audience	Quantity
April 2018	Prop 218 Informational Mailer	Landowners	897
April 2018	Prop 218 Informational Mailer (Spanish)	Residents	317
May 2018	Postcard: Final Workshop notice	Landowners	897
May 2018	Postcard: Final Workshop notice (Spanish)	Residents	317
June 2018	Postcard: final ballot reminder	Landowners	897
June 2018	Postcard: final ballot reminder (Spanish)	Residents	317
October 2018	Fall Mailer: Prop 28 results and GSP update	Landowners	897
October 2018	Fall Mailer: Prop 28 results and GSP update (Spanish)	Residents	317
July 2019	Contact Form and GSP education mailer	Landowners	1,089
July 2019	Contact Form and GSP education mailer (Spanish)	Residents	Online
October 2019	GSP Workshop promo mailer	Landowners	1,089
October 2019	GSP Workshop promo mailer (Spanish)	Residents	Online

D.6 Southwest Kings GSA

D.6.1 Website – www.swkgsa.org

The Southwest Kings GSA launched a website in March 2017 as a key avenue to inform stakeholders about the GSA, public outreach opportunities, and as a resource with SGMA-related information. A site map is outlined below:

- **Homepage –** Introduction of Southwest Kings GSA; Important Dates; News & Press Releases; and Quick Links to GSA Boundary Map and SGMA-Related Resources
- **About SGMA & SWKGSA –** What is SGMA?; SGMA and the Southwest Kings GSA; SWKGSA Information (links to boundary map, Bylaws & Policies, JPA Members Agreement, Cost-Sharing Agreement); Governance (Board of Directors, Alternate Directors, GSA Members, Management/Consultant Team)
- **Public Meetings –** Public Hearings; Board Meetings (agendas and minutes); Public Outreach Workshops
- **Contact the GSA –** Questions; Location; Interested Parties List Sign-Up Form



Southwest Kings Groundwater Sustainability Agency

With the passage of the California Sustainable Groundwater Management Act ("SGMA") in 2014, the Southwest Kings Groundwater Sustainability Agency ("SWKGSA") and its Board of Directors are participating in the implementation of the SGMA regulations and working to protect the interests of landowners within the SWKGSA boundaries. The SWKGSA is taking an active role in helping its landowners understand and comply with these new regulations as they are put into place.

Picture 3. Screenshot of www.swkgsa.org Homepage

D.6.2 Outreach Tracking

Table 20. Southwest Kings GSA Public Meetings, Presentations & One-on-One Meetings

Meeting/Event	Date
Southwest Kings GSA Board Meeting – SGMA and GSA Formation	3 p.m., February 8, 2017
Southwest Kings GSA Board Meeting – SGMA and GSA Formation	3 p.m., March 8, 2017
Southwest Kings GSA Board Meeting – SGMA and GSP Development	3 p.m., April 12, 2017
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., June 28, 2017
Southwest Kings GSA Special Board Meeting – Proposition 218 Public Hearing & Election	10 a.m., August 14, 2017
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., February 14, 2018
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., May 9, 2018
Southwest Kings GSA Board Meeting with special presentation on Preliminary Water Budget	3 p.m., July 11, 2018
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., September 12, 2018
Kettleman City Community Services District Board Meeting – SGMA/GSA Presentation	6 p.m., October 23, 2018
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., December 12, 2018
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., February 13, 2019
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., May 8, 2019
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., July 10, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	5:30 p.m., October 9, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	5:30 p.m., October 15, 2019
Southwest Kings GSA Special Board Meeting – GSP Public Review Update	3 p.m., October 18, 2019
GSP Meeting with County of Kings representatives and other GSA managers	1:30 p.m., November 6, 2019
GSP Public Review Presentation – Kettleman Community Services District Board Meeting *(Note: Presentation scheduled for Nov. 19, rescheduled for Nov. 26, but board meeting canceled by KCSD both dates due to lack of quorum)*	6 p.m., November 26, 2019
Tulare Lake Subbasin GSP Public Hearing – Hanford	10 a.m., December 2, 2019
Southwest Kings GSA Board Meeting – SGMA and GSP Development Updates	3 p.m., December 11, 2019
Special Board Meeting – Adoption of GSP	9 a.m., January 17, 2020

D.7 Tri-County Water Authority

D.7.1 Website – http://tcwater.org

The Tri-County Water Authority launched a website to aid in achieving the Authority's goal of world class groundwater management in the Tulare Lake Hydrologic Region. A site map of the website is outlined below:

- **Homepage –** Primary goal of Tri-County Water Authority; Updates/Reports; Notifications; Quick Links to SGMA Overview; Tri-County Water Authority Map; News; Calendar; About the Water Authority
- **SGMA –** What is The SGMA?; SGMA Purpose; What Are Your Rights?; Overview of The Water Problem; Frequently Asked Questions; Tri-County Water Authority Territory
- **About Us –** About Us Overview; Board of Directors; Trusted News Sources Links – http://tcwater.org/news/ ; Calendar – http://tcwater.org/events/
- **Contact the GSA**

"A COOPERATIVE, COLLECTIVE GROUP OF LOCAL WATER AGENCIES DEDICATED TO ACHIEVING THE PATH TO SUCCESS FOR WORLD CLASS GROUNDWATER MANAGEMENT IN THE TULARE LAKE HYDROLOGIC REGION"

Picture 4. Screenshot of http://tcwater.org Homepage

D.7.2 Outreach Tracking

Table 21. Tri-County Water Authority Public Meetings, Presentations & One-on-One Meetings

Tri-County Water Authority Meetings/Presentations/One-on-One Discussions	
Meeting/Event	**Date**
TCWA Board Meeting	1 p.m., January 4, 2018
TCWA Technical Advisory Committee Meeting	10 a.m., January 24, 2018
TCWA Stakeholder Advisory Committee Meeting	1 p.m., January 24, 2018
TCWA Board Meeting	1 p.m., March 1, 2018
TCWA Technical Advisory Committee Meeting	10 a.m., March 7, 2018

Tri-County Water Authority Meetings/Presentations/One-on-One Discussions	
Meeting/Event	**Date**
TCWA Stakeholder Advisory Committee Meeting	1 p.m., March 7, 2018
TCWA Special Board Meeting	1 p.m., March 13, 2018
TCWA Technical Advisory Committee Meeting	10 a.m., March 28, 2018
TCWA Stakeholder Advisory Committee Meeting	1 p.m., March 29, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., April 25, 2018
TCWA Board Meeting	1 p.m., June 26, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., June 27, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., July 25, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., August 22, 2018
TCWA Board Meeting	1 p.m., September 6, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., October 1, 2018
TCWA Special Board Meeting	1 p.m., October 11, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., October 24, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	9 a.m., December 19, 2018
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., January 23, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., February 27, 2019
TCWA Board Meeting	1 p.m., March 5, 2019
TCWA Board Meeting	1 p.m., April 2, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., April 24, 2019
TCWA Board Meeting	1 p.m., May 2, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., May 22, 2019
TCWA Board Meeting	1 p.m., June 4, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., June 26, 2019
TCWA Board Meeting	1 p.m., July 9, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., July 24, 2019
TCWA Technical Advisory Committee/Stakeholder Advisory Committee Meeting	10 a.m., August 1, 2019
TCWA Board Meeting	1 p.m., August 1, 2019
TCWA Board Meeting – Public Review of GSP Presentation	1 p.m., September 16, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Hanford	5:30 p.m., October 9, 2019
Tulare Lake Subbasin-Wide Public Outreach Meeting: GSP for the Subbasin, Lemoore	5:30 p.m., October 15, 2019
GSP Meeting with County of Kings representatives and other GSA managers	1:30 p.m., November 6, 2019
TCWA & SGMA – Public Outreach Meeting, Allensworth	2 p.m., November 12, 2019
Tulare Lake Subbasin GSP Public Hearing – Hanford	10 a.m., December 2, 2019
TCWA Board Meeting	1 p.m., December 18, 2019
TCWA Board Meeting – Adoption of GSP	1 p.m., January 16, 2020

APPENDIX C

STAKEHOLDER COMMENTS AND RESPONSES

APPENDIX C – PUBLIC COMMENTS ON THE DRAFT GSP

The Groundwater Sustainability Agencies (GSAs) solicited public and stakeholder comments on the draft Tulare Lake Subbasin (Subbasin) Groundwater Sustainability Plan (GSP) from September 6, 2019, to December 2, 2019. During this period, the GSAs received comments transmitted to them in six letters and in one email. During the Public Hearing on December 2, 2019, one verbal comment was received. This section provides summaries of the comments contained in the letters and email and as presented verbally on the draft GSP and the responses to each comment.

Each letter, email, and verbal comment received is listed in Table C-1 and identified by comment author and date received by the GSAs.

Table C-1. List of Commenters

Comment ID	Comment Author	Comment Date
Organizations		
0-1	The Nature Conservancy	November 26, 2019
0-2	California Poultry Federation	November 27, 2019
0-3	Clean Water Action/Clean Water Fund; Local Government Commission; Audubon/California; The Nature Conservancy	December 2, 2019
0-4	Westlands Water District	December 2, 2019
Individuals		
I-1	Colleen Courtney	October 11,2019
I-2	Bill Miguel	October 15,2019
I-3	Bill Toss	December 2, 2019
I-4	Doug Verboon	December 2, 2019

Each of the comments is summarized below followed by responses from the GSAs. Hard copies of the comment correspondence received by the GSAs and a written summary of the verbal comment are compiled and presented following the comments and responses section.

Comment O-1

In The Nature Conservancy's letter to the South Fork Kings (SFK) GSA, they address the GSP's consideration of the beneficial uses and users of groundwater including environmental uses and users. The comment letter states:

> *Although there is a robust description of the confined (lower) and unconfined/semiconfined (upper) aquifers there is no explicit description with supporting data and information of how groundwater above the A- and C- clays in the upper aquifer interacts with the unconfined aquifer or is influenced by pumping in the unconfined portion of the aquifer. DWR's definition of a principal aquifer, is defined as an "aquifer of aquifer system that stores, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems."*
>
> *These shallow and perched areas within the upper aquifer range from near surface to 30 feet below ground surface and likely provide water supply to GDEs and ISWs. As such, they yield significant quantities of groundwater to surface water systems and beneficial users, and should not be dismissed because they do not yield groundwater for human use.*

These statements are the basis for the other resulting comments in their letter that request additional data and information, suggest that the GSA's and GSP recognize groundwater dependent ecosystems (GDEs) and interconnected surface water (ISW), and suggest a need for monitoring of these potential areas.

Response: Thank you for your letter and comments. Related to the Hydrologic Conceptual Model as presented in Section 3.1.8 of the draft GSP, there are geologic deposits in the Subbasin that are lacustrine clays named the A- through F-Clays. The A- through D-Clays may be more important locally in restricting the downward movement of groundwater. Figure 3-17 shows the areal extent of the A-Clay and the depth to groundwater above the A-Clay. Comparing this figure with your web-based GDE Pulse indicates an area along the South Fork Kings River where there would be the most interest in evaluating whether GDEs and ISWs occur.

From Section 4.0 of the draft GSP "Indicators for the sustainable management of groundwater were established under Sustainable Groundwater Management Act of 2014 (SGMA) based on factors that have the potential to impact the health and general well-being of the public. The following indicators were evaluated within the Subbasin: groundwater levels, groundwater storage volume, land subsidence, water quality, interconnected surface water, and seawater intrusion." ISW and seawater intrusion are not present within the Subbasin and were omitted from further consideration in the draft GSP. GDEs are not one of the sustainability indicators but rather dependent on ISW systems. Section 3.2.8 describes more fully the conditions found within the plan area.

It is also recognized that the GSP is adaptive in nature and will be updated as more information becomes available. It is noted in Section 5.4.1.2 that the ability to add and/or alter the existing monitor programs is envisioned. The individual GSAs will determine if or when additional attempts will be made to collect that data. Temporal adjustments may be made for the different aquifer zones or in certain areas. For example, semi-annual water level readings in above the A-Clay wells is probably sufficient to capture seasonal and long-term trends in most of that aquifer zone because water levels in the aquifer are relatively stable in most of the area. Near the Kings River it may be desirable to collect more frequent data from above the A-Clay to better understand the relationship between the river and shallow groundwater.

Comment O-2

The California Poultry Federation (CPF) is the trade association for California's poultry industry. In their letter to the Southwest Kings (SWK) GSA, they expressed their support for effective measures to assure reliable water supplies. CPF's comments largely focused on 2 main issues:

1. Supply augmentation should be a top priority of the GSP.
2. Regarding demand management, the GSP does not explain precisely how it will be done and the public will need to have opportunities to participate in the development of demand management measures. Also, the GSAs should do their best to ameliorate economic impacts by adopting demand management measures that are cost-effective.

Response: Thank you for your letter and comments. The GSAs agree that supply augmentation should be a top priority for this Subbasin. Several supply augmentation projects and their implementation are described in Chapters 6 and 7.

The draft GSP has been revised to remove demand management or demand reduction as a definitive programmatic action. The potential for demand management is described in Section 6.4 only as an option for the GSAs should it be needed to meet the Sustainability Goal. If implementation is necessary, the GSAs are committed to executing such programs in a cost effective manner and with the input of the local communities.

Comment O-3

This letter was submitted to the Tri-County Water Authority GSA on behalf of the Clean Water Action/Clean Water Fund, Local Government Commission, Audubon/California, and The Nature Conservancy in the interests of disadvantaged communities (DACs), drinking water, and the environment. The letter presented a checklist of GSP review criteria and summary comments addressing 9 elements as indicated in the response.

Response: Thank you for your letter and comments. Responses to the summary comments in the letter are provided below.

1. **How the DACs were determined and engaged in the GSP development process.**

   DACs were identified using the California Department of Water Resources (DWR) DAC online mapping tool and associated Geographic Information System data (2018) and the Tulare Lake Basin DAC Water Study (published 2013). The GSAs conducted a substantial amount of stakeholder engagement, including outreach to DACs, during the development of the GSP. These efforts are described in detail in Appendix B.

2. **Financial assistance for DACs.**

   SGMA did not intend for the GSAs to provide financial assistance to entities in the Subbasin. Representatives of the GSAs will reasonably assist entities in identifying potential sources of financial assistance, if requested and necessary, and will provide other non-financial assistance to the extent that it is required in the SGMA regulations and the GSAs have the resources to do so.

3. **The development of Measurable Objectives and Minimum Thresholds Sustainable Management Criteria needs to be explained.**

   The development of Measurable Objectives and Minimum Thresholds are described in Chapter 4 of the draft GSP. The methods used and the rational for selecting these criteria are described in this chapter.

4. **There should be stakeholder engagement during GSP implementation.**

   The GSAs conducted a substantial amount of stakeholder engagement during the development of the GSP. These efforts are described in detail in Appendix B. The GSAs intend to continue stakeholder engagement efforts through GSP implementation.

5. **The potential for impacts to domestic water supply wells from GSP implementation.**

   Domestic water supply wells in the Subbasin typically are the shallowest wells in the Subbasin and have historically been subject to a dynamic groundwater system whereby water levels change frequently due to seasonal fluctuations and climatic changes (such as drought). Prior to SGMA, these wells also experienced gradual long-term decline of water levels due to the curtailment of federal and state surface water deliveries to the Subbasin. In this environment, owners of these wells have successfully adjusted by modifying the wells or drilling new wells. Under SGMA, water levels will continue to change frequently due to seasonal fluctuations and climatic changes and until the GSP is fully implemented, the wells may also experience gradual decline of water levels. However, as the GSP is implemented, shallow water levels are expected to stabilize, thereby providing a positive benefit to domestic well owners.

6. **Groundwater Dependent Ecosystems should be addressed.**
   From Section 4.0 of the draft GSP "Indicators for the sustainable management of groundwater were established under SGMA based on factors that have the potential to impact the health and general well-being of the public. The following indicators were evaluated within the Subbasin: groundwater levels, groundwater storage volume, land subsidence, water quality, interconnected surface water, and seawater intrusion." Interconnected surface water and seawater intrusion are not present within the Subbasin and were omitted from further consideration in the draft GSP. GDEs are not one of the sustainability indicators but rather dependent on interconnected surface water systems. Section 3.2.8 describes more fully the conditions found within the plan area.

   It is also recognized that the GSP is adaptive in nature and will be updated as more information becomes available. It is noted in Section 5.4.1.2 that the ability to add and/or alter the existing monitor programs is envisioned. The following is offered; "The individual GSAs will determine if or when additional attempts will be made to collect that data. Temporal adjustments may be made for the different aquifer zones or in certain areas. For example, semi-annual water level readings in above the A-Clay wells is probably sufficient to capture seasonal and long-term trends in most of that aquifer zone because water levels in the aquifer are relatively stable in most of the area. Near the Kings River it may be desirable to collect more frequent data from above the A-Clay to better understand the relationship between the river and shallow groundwater."

7. **Climate change must be considered in development of the GSP.**
   As required by DWR, climate change is accounted for in the groundwater model (Appendix D) using assumptions and parameters provided by DWR.

8. **Drinking water should be considered in the water budget.**
   Municipal water use throughout the Subbasin is accounted for in the water budget. Water use from private domestic wells is not known nor is well construction known. The amount of water from domestic wells is estimated to be a *de minimis* amount in the overall water budget.

9. **Continued groundwater level decline during GSP implementation.**
   Per SGMA requirements, the GSAs have developed a GSP the implementation of which will result in groundwater sustainability for the Subbasin by 2040. At that point, average groundwater levels will become stable.

Comment O-4

Westlands Water District (Westlands) occupies the Westside Subbasin located to the southwest and adjacent to the Subbasin and is the GSA for this subbasin. In the Westland's letter to the SWK GSA, they commented on 7 findings presented in the GSP, identified 3 discrepancies within the text, and offered 1 general comment.

Thank you for your letter and comments. Responses are provided below.

Finding 1 Comment
Finding 1 is in regard to groundwater flows into and out of the Subbasin and adjoining subbasins as described in Section 3.2.2 of the draft GSP. The letter states "*there is no substantial evidence to support the statements regarding groundwater flow directions out of the Subbasin to the Westside Subbasin."*

Response: Potentiometric surface maps prepared by DWR from 1990 through 2016 clearly show that heads in the unconfined aquifer in the SFK GSA area are decreasing towards the southwest from the Subbasin into the Westside Subbasin. The winter 2014/2015 potentiometric surface map for the lower (confined) aquifer provided by Westlands in the comment letter also shows that groundwater from the SWK GSA is flowing towards the northwest towards a pumping depression southeast of Huron and to the southeast towards what appears to be a pumping center at the border between SFK GSA and SWK GSA with a contour of -160 feet. A review of the available water level elevation data for lower aquifer monitoring wells (some of it provided by Westlands) in this area of the Subbasin show between 1990 and 2016 the heads typically ranged from -100 feet to +100 feet. During this same period, wells in the Westside Subbasin typically ranged from -130 to +100 feet, generally lower than the wells in the Subbasin. A few new deep El Rico GSA wells started pumping in the 2014/2015 time range and had water level elevation in the -230 feet range, and may possibly be the source for the -160 foot contour shown on the map. However, these wells only operated in the last couple of years and are not representative of the long-term groundwater levels along the boundary between Subbasin and Westside Subbasin. In summary, there is evidence that between 1990 and 2016, the general direction of groundwater flow was from the Subbasin towards the Westside Subbasin both in the unconfined and confined aquifers.

Finding 2 Comment

The letter states *Figures 3-28b to 3-28d shows long term hydrographs for wells within the Tulare Lake Subbasin. Unfortunately, the data displayed by the hydrographs is pixelated, therefore unreviewable. Westlands GSA recommends revising the mentioned figures to display hydrographs using a higher resolution to allow the public to review.*

Response: These figures have been revised to show the hydrographs at a higher resolution.

Finding 3 Comment

Finding 3 is in regard to groundwater quality, as described in Section 3.2.5 in the draft GSP and shown on Figures 3-30 through 32. The letter states *We recommend that the draft GSP be revised to accurately convey groundwater quality data by aquifer and by the timeframe the data represents. In addition, we recommend that the groundwater quality data be reviewed for accuracy.*

Response: The groundwater quality data have been reviewed for accuracy and have been corrected where needed. Figures 3-30, 3-31, 3-32, and 3-33 have been revised to show the highest concentration of the constituents reported and the most recent concentrations. The source for the groundwater quality data used in these figures does not indicate the aquifer from which the data were collected.

Finding 4 Comment

The letter states *Figures 3-34 contains a legend that is incomplete and is unable to be reviewed. Westlands GSA recommends applying the corresponding color scheme to the vertical displacement legend to allow readers to be able to review the presented information.*

Response: The figure has been revised as recommended.

Finding 5 Comment

Finding 5 is in regard to the Sustainable Management Criteria presented in the draft GSP, specifically with respect to future water level decline. The letter states *The potential for curtailing historic underflow into the Westside Subbasin may be a substantial factor in contributing to significant and unreasonable subsidence and frustrate the Westlands' GSA ability to achieve the sustainability goal.*

Response: Thank you for your comment.

To evaluate your concern, the data developed within the draft GSP's was placed on a map showing the location of representative wells, aquifer representation, measurable objective, and minimum thresholds. It should be noted that within the Tulare Lake GSP, there is a shallow zone above the A-Clay that is an additional aquifer that was not identified in the Westside Subbasin GSP. Thus the above E-Clay and Below E-Clay values were identified. Upon comparison for the above E-Clay designation, there are few wells in this zone in the westside basin. From the information, the data suggest that flow is from the Subbasin to the Westside Subbasin. For the below E-Clay aquifer, the data also suggest that the flow is from the Subbasin to the Westside Subbasin. So your initial suggestion that continued lowering of groundwater levels in the Tulare Lake GSP allows groundwater levels to become lower than levels established at 2015 is not supported. With the gradients that would result from these levels, it is recognized that groundwater outflow would continue to the Westside Subbasin. Per your point in your comment letter "The department shall evaluate whether a groundwater sustainability plan adversely affects the ability of an adjacent basin to implement their groundwater sustainability plan or impedes achievement of sustainability goals in an adjacent basin".

As to historical underflow that you mention in your comments, we would refer you to Figures 3-23 and 3-24. Historical groundwater flows have historically flown from the Westside Subbasin into the Subbasin. It is believed that groundwater pumping from within the Westside Subbasin has altered these flow paths and it appears that the Westlands GSP is proposing to continue this practice. As you stated, overlying and appropriative uses of groundwater within the Subbasin are entitled to legal and equitable protection against infringement by an action that deprives them of their historical inflows. More coordination is warranted between our subbasins to reach a resolution. We look forward to discussing with you more thoroughly these boundary conditions and how we might develop a solution.

Finding 6 Comment

Finding 6 is in regard to the Sustainable Management Criteria presented in the draft GSP, specifically with respect to future subsidence. The letter states *Westlands GSA is concerned that allowing subsidence rates as proposed may impact critical infrastructure such as roads, railroads, and may increase flood risks to existing land uses, especially near Corcoran where subsidence rates are critical, in the Westside Subbasin and other neighboring subbasins.*

Response: Thank you for your comment. The GSA's within the Subbasin are concerned about lowering of groundwater levels as well as land subsidence. To this end, it is recognized that land subsidence is a regional concern and based upon historical information, is thought to be a result of groundwater pumping beneath the Corcoran Clay. The historical data and model developed for the basin suggests that regionally the largest change in land subsidence is located Southeast of the Subbasin and within the Tule Subbasin. The rate of subsidence continues into the Subbasin with rates experienced in Lemoore being approximately half of the rate at the Corcoran site.

Section 4.4.1.3 has been revised to reflect this historic information and set a minimum threshold of 8 feet of subsidence at the Lemoore site. To quote from the revised GSP, “These values have been selected using historical subsidence data. There has been no information suggesting that there has been local significant damage to infrastructure in both these areas. At each five-year milestone, information from the groundwater model suggests subsidence will continue for the first five years until project and management actions are fully implemented.”

Finding 7 Comment

Finding 7 is in regard to analysis in the groundwater model report presented in Appendix D of the draft GSP indicate the General Head Boundary (GHB) is driving groundwater flow out of the Westside Subbasin and into the Subbasin. The letter states *Westlands recommends reanalyzing the water level contour data from the numerical model and GSP.*

Response: The GHBs in the Westside Subbasin basically follows the boundary between Fresno and Kings Counties. The GHB heads were interpolated from water level elevation data provided by DWR and Westlands for wells near the edge of the model on both side of the county line. The resulting GHB heads have historically tended to decrease from north and southwest to a low area near the bend in the county line. The winter 2014/2015 potentiometric surface map for the lower (confined) aquifer provided by Westlands in the comment letter also shows that the water level elevation contours along the county (GHB) line are also converging towards a low area near the bend in the county line. We believe the GHBs heads utilized in the Westside Subbasin are a reasonable interpretation of historical water level elevation in the area.

Reporting Discrepancy #1

The letter states *Total lateral subsurface inflow into the Westside Subbasin shown in Figure D5-5 averages 72,296 AFY (67,347 from the Tulare Lake Subbasin and 4,948 AFY from the Kings Subbasin). Table 3-6 of the GSP shows average annual subsurface flow from the Tulare Lake Subbasin to the Westside Subbasin of 41,390. What is the source of this discrepancy?*

Response: The figure was referencing an incorrect cell and has been corrected.

Reporting Discrepancy #2

The letter states *In the graphic depicting aquifer specific fluxes in Figure D5-5, the sum of the "Net GW Flux" (which presumably is lateral subsurface flow between adjacent subbasins) totals 4,936 AFY while the total in the table shown in Figure D5-5 is 72,296 AFY. What is the source of this discrepancy?*

Response: The figure was referencing an incorrect cell and has been corrected.

Reporting Discrepancy #3

The letter states *Figure numbers in the Appendix D text do not correspond to the correct figures. Figure DS-10 is titled "Simulated Subsidence 1990-2016". Figure D5-8 shows "Groundwater Mass Balance Tule Subbasin".*

Response: The figure numbers have been corrected.

General Comment

Westlands recommended that GSA representatives from the two subbasins meet and confer at the earliest opportunity to determine whether an interbasin agreement can be reached. The agreement would be used to reach a cooperative resolution of important issues that will enable coordinated sustainable management in our GSAs.

Response: The GSAs in the Subbasin agree that efforts should be made to develop and interbasin agreement and look forward to the opportunity following submittal of the respective GSPs.

Comment I-1

In her email of October 11, 2019, Ms. Courtney made clear her opposition to the GSP and using groundwater for agriculture.

Response: Thank you for your email and comments. The comments do not pertain to the GSP's analysis. Opposition to the GSP has been noted and the email is included in full herein and will be forwarded to the DWR for consideration.

Comment I-2

The comment letter from Mr. Miguel has a number of points related to surface water supplies and the Kings River Water Association. While the letter recognizes that the GSP and GSA's have no authority, he goes on to assert that the GSP could be used to be a proponent of change and public awareness. The letter suggests that there has been an opportunity missed in the capture and use of surface water flows from the Kings River and that storage contemplated and permitted has not been fully utilized.

Response: Thank you for your letter and comments. As is recognized in the letter, the GSA's and GSP have no authority of surface water rights, diversion and beneficial uses of these rights. These surface water rights have historic origins, were initially exercised in the 1800s, predate statehood and more recently have been permitted by the State Water Resources Control Board. A watermaster has been charged with oversight of the river and assuring that the surface water diversions are in accordance with the licenses for diversion. As to your suggestion that additional surface supplies could be utilized to offset overdraft, that is the plan. Please review Section 6.0 that identifies the projects envisioned to increased surface diversion and use. You will note that all the GSA's are planning on projects to divert and either recharge (where possible and the geologic conditions allow) or storage and reregulation of supply. These are most notable in the South Fork, and El Rico, and Tri-County Water Agency GSA's. We look forward to the planning and implementation of these projects to allow for the continued farming and prosperity for the area.

Comment I-3

Mr. Toss provided a verbal comment at the Public Hearing on December 2, 2019, in which he stated that the demand reduction presented in Chapter 6 of the GSP as a management action to help achieve groundwater sustainability in the subbasin would be very damaging to Kings County and its growers. He requested that this management action be changed.

Response: Thank you for your comment. The draft GSP has been revised to remove demand management or demand reduction has a definitive programmatic action. The potential for demand management is described in Section 6.4 only as an option for the GSAs should it be needed to meet the Sustainability Goal. If implementation is necessary, the GSAs are committed to executing such programs in a cost effective manner and with the input of the local communities.

Comment I-4

Mr. Verboon is a Kings County Supervisor, but clarified that his comments were from him individually and "not on behalf of the Board of Supervisors". In his letter to the five GSAs, Mr. Verboon, on behalf of other signatories to the letter, made 3 main comments:

Comment 1: There were procedural defects that limited Kings County and its water uses in their opportunity to review and comment on the draft GSP.

Response: Thank you for your letter and comments. The GSAs understand that they have met their notice and other obligations to Kings County under Section 10728.4. The GSAs view that there were no procedural defects in the notice provided to the County. Consultation with Kings County took place at a meeting on November 6, 2019, roughly a month prior to the comment period close. Kings County chose to not submit any written or verbal comments on the draft GSP.

Comment 2: The projects presented in the draft GSP are too vague and non-committal.

Response: The draft GSP indicates that there exist a number of legal and practical uncertainties regarding project identification and adoption. Projects referenced in the draft GSP, and possibly others, will be identified and adopted by the GSAs, but only after sufficient data are collected, adequate analysis conducted, and funds are appropriated for the projects. Refer to Chapter 7 for further details on project implementation.

Comment 3: Land fallowing should be used as a demand reduction management action only as a last resort and after other demand reduction strategies and water recharge projects have been implemented.

Response: It appears that Mr. Verboon has interpreted the details of some groundwater model evaluations as planned GSA management strategies, and that is incorrect. Also, upon review, there were descriptions of land fallowing that were misleading and likely added to the confusion. These portion of the GSP have been revised. Also, the GSAs agree that supply augmentation should be a top priority for this Subbasin. Several supply augmentation projects and their implementation are described in Chapters 6 and 7.

Public Comment Letters

From: Colleen Courtney <colleencourtney66@gmail.com>

Sent: Saturday, October 12, 2019 1:01 AM

To: Colleen Courtney <colleencourtney66@gmail.com>; comments@southforkkings.org; jwyrick@jgboswell.com; kcwdh20@sbcglobal.net

Subject: GSAS-Kings County Resident STATES NO ON GROUND WATER FOR AGRICULTURAL PURPOSES!

Colleen Courtney
14234 16th Avenue
Lemoore, CA 93245-9517
Email: colleencourtney66@gmail.com

October 11,2019

To: GSAS Commissioners Board;

HELL NO! These sod Busters DO NOT DRAIN the Valleys Ground Water for their crops that ships out of State or over seas for your personal Padding Their wallets!

NOT AT this Valleys populations expense for their personal gains!

We need that water for drinking for people, animales we eat and other business endeavors other than these Sod Busters causing our lungs to fill with their crop dirt, pesticides from those dam planes or choppers that keep sprayers on to do a turns. Bull shit!

You sod Busters use your homes water well resource to water your acreages! Or drill more water wells on your own property or truck in tankers of water from the Rockies or Serras!

Or tap into your local City water line. Their water line is petty much secured source for your crop of your own choice of Occupational decision of becoming a FATCAT Farmer! At the other people's thirst expense!

We are already breathing your property's dirt and pesticides! Your surface soil covers our house and vechicals in one month! And pushing your sludge mixed with our water down that dam drive away!

I am about to phone the Sheriffs Department on that sod buster's property that constantly trespasses and squats on our property and buries everything!
We accumulated more of his farm land than he actually possesses!

These sodbusters are like city slumlords just purchased cheap property sell high, cut costs, don't maintain, rape the earth, suck it out of every earthly nutrients, minerals possible drain others water for your sole purposes to pad your wallets. And in the end abandon the worthless property your raped the hell out of. To go to another place to fu ck up for the next generation to overhaul that damage you caused in the first place!

NO GROUND WATER To SOD BUSTERS!
And SOD BUSTERS are NOT in the
AGRICULTURAL COMMUNITIES!

The Real Farmers know how to take care of the earth and would not ever think of asking people to give up their drinking water for themselves and their animals. For his crops. This Farmer would sacrifice his crops for those people when it came to water rights. And not directed by padding his wallet!

VOTE NO ON GROUND WATER! Let these sod busters truck in their water from Rockies or Serras! Just a cheap expense compared to Shipping crops to New York or Over Seas!

Cheap son of a bitches! Go dry up!

Colleen Courtney

RECEIVED K.R.C.D.

OCT 15 2019

File No. ____________

South Fork Kings Groundwater Sustainability Agency
4886 E Jensen Avenue
Fresno, CA 93725

TO: SFKGSA Board Members and members of the Public.

RE: Response to SFKGSA Sustainability Plan.

I use this opportunity to respond to the South Fork Kings Groundwater Sustainability Plan. I understand that the SFKGSA is limited in its scope of responsibility and governance, however I feel the SFKGSA can become a useful proponent and informational resource for public awareness.

The primary source of groundwater recharge is the sandy bottom of the Kings River. Domestic wells, agriculture wells, groundwater dependent ecosystems, and other beneficial users are dependent upon the river's natural surface water flows to recharge underground aquifers. These surface water flows are managed by the Kings River Water Association (KRWA) whose 28 member districts receive water from a designated "point of diversion" on the Kings River. It has become common practice to divert surface water from lower stream points of diversion to upper stream diversion points to reduce what is commonly termed "channel loss". However, channel loss is also groundwater recharge. These diversions have a direct and negative impact on holders of overlying groundwater rights by diminishing groundwater recharge and adding to groundwater overdraft.

PART 1.
GROUNDWATER RIGHT HOLDERS:
SUSTAINABLE GROUNDWATER MANAGEMENT ACT: 10723.2.

"The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans. These interests include, but are not limited to, all of the following:"
(a) Holders of overlying groundwater rights, including:
(1) Agricultural users.
(2) Domestic well owners.
(b) Municipal well operators.
(c) Public water systems.
(d) Local land use planning agencies.
(e) Environmental users of groundwater.

Excerpts from CALIFORNIA WATER CODE:

§ 1706. The person entitled to the use of water by virtue of an appropriation other than under the Water Commission Act or this code may change the point of diversion, place of use, or purpose of use if others are not injured by such change...

§ 1707. (a) (1) Any person entitled to the use of water, whether based upon an appropriative, riparian, or other right, may petition the board pursuant to this chapter, Chapter 6.6 (commencing with Section 1435) or Chapter 10.5 (commencing with Section 1725) for a change for purposes of preserving or enhancing wetlands habitat, fish and wildlife resources, or recreation in, or on, the water.

Being a public entity, it is incumbent on the SFKGSA monitor and quantify the amount of groundwater recharge lost due to points of diversion changes. Further, it is an inherent responsibility of the SFKGSA to challenge any such diversions per California Water Code Sections 1706 and 1707, and by other codes sections not mentioned, and to advocate on behalf of those harmed by such diversions.

PART 2.

DECISION 1290

In 1967 the State of California State Water Rights Board issued its Decision 1290, a pivotal benchmark for Kings River water management. The following are excerpts from the Decision:

Page 16: "The primary source of all ground water in the Kings River service area is the river and its distributaries...".

Page 21: "The contracts with members of the KRWA result in the controlled release of water from these reservoirs* (Courtright, Wishon, Pine Flat) *to satisfy downstream requirements for irrigation and ground-water recharge."

Page 35-36: "...the association* (KRWA) *members have planned their overall project to take maximum advantage of all storage facilities available to them. This includes recharge of ground water and underground storage as well as the storage of flood waters in Tulare Lake Basin and maximum retention in Pine Flat Reservoir. Consulting Engineer Henry Karrer testified to the effect that under certain ideal conditions, about 2,000,000 acre-feet could be stored and regulated in Pine Flat Reservoir in any one year (RT192). He also said that up to 1,000,000 acre-feet of water could be stored in the cellular dyke system in Tulare Lake Basin (RT 192)."

This position was reaffirmed in a July 30, 2019 letter to Mitchell Moody of the State Water Resource Control Board when stating; "Decision 1290 expressly recognized the KRWA member units planned their overall project to take maximum advantage of all available storage facilities...".

Present estimate of King River Basin groundwater overdraft is 120,000 acre-feet per year, while average annual floodwater diverted to the San Joaquin River is 100,000 acre-feet. Opportunities of using Tulare Lake as a storage facility have been repeatedly missed as it has become common practice to redirect flood release water away from the ***cellular dyke system in Tulare Lake Basin*** to the San Joaquin. The beneficial use of this un-stored water is then lost to all.

It is understandable that stakeholders who would be harmed by the flooding of the Tulare Lake Basin would wish that flood release waters be diverted. The flooding of the Tulare Lake Basin would cause economic hardship to business interests. However, as noted in Decision 1290 and empirically known, the Kings River waters do naturally flow to the Tulare Lake Basin, into what is known as Tulare Lake.

It is likewise understandable that this diversion of flood release water comes at an equal price to stakeholders outside the Tulare Lake Basin. Water diverted away from the dyke system storage facility is water waisted and unused for negating groundwater overdraft and recharge. If full usage of the cellular dyke system were utilized as stated in Decision 1290, groundwater overdraft could be diminished by as much as 100,000 per year.

With SGMA deadlines approaching, stakeholders up-stream of the Tulare Lake Basin find themselves mired in a groundwater overdraft problem. They face the economic consequence of fallowed land and tax surcharges for groundwater pumping, while 100,000 acre-feet of Kings River surface water is re-routed to the San Joaquin River. Simply put; until the cellular dyke system in Tulare Lake Basin is fully utilized as intended, upstream right-holders and stakeholders a will pay the price for the problem Tulare Lake Basin interests pass on.

As stated, SFKGSA is a public entity and has an inherent responsibility to monitor, quantify and make publicly known the amount of groundwater recharge lost and the groundwater overdraft resulting from the non-use of the cellular dyke storage system as stated in Decision 1290. Additionally, it is requested that the SFKGSA study and make known the impact changes in points of diversion (Part 1) and non-use of the cellular dyke storage system in Tulare Lake Basin (Part 2) have upon groundwater recharge and overdraft prior to implementation of overdraft enforcement procedures.

Thank you for your consideration.

Bill Miguel
21425 Grangeville Blvd
Lemoore, California
October 11, 2019

The Nature Conservancy
Protecting nature. Preserving life.

CALIFORNIA WATER | **GROUNDWATER**

555 Capitol Mall, Suite 1290
Sacramento, California 95814
[916] 449-2850

nature.org
GroundwaterResourceHub.org

November 26, 2019

South Fork Kings Groundwater Sustainability Agency
4886 E. Jensen Avenue
Fresno, CA 93725
comments@southforkkings.org

Submitted online via: https://southforkkings.org/wp-content/uploads/2019/09/2019-0906-tulare-lake-subbasin-gsp-prelim-draft_for-upload.pdf

Re: Tulare Lake Subbasin Groundwater Sustainability Plan, Preliminary Draft

Dear Agency Staff,

The Nature Conservancy (TNC) appreciates the opportunity to comment on the Groundwater Sustainability Plan (GSP) for the Tulare Lake Subbasin that is being prepared under the Sustainable Groundwater Management Act (SGMA).

TNC as a Stakeholder Representative for the Environment

TNC is a global, nonprofit organization dedicated to conserving the lands and waters on which all life depends. We seek to achieve our mission through science-based planning and implementation of conservation strategies. For decades, we have dedicated resources to establishing diverse partnerships and developing foundational science products for achieving positive outcomes for people and nature in California. TNC was part of a stakeholder group formed by the Water Foundation in early 2014 to develop recommendations for groundwater reform and actively worked to shape and pass SGMA.

Our reason for engaging is simple: California's freshwater biodiversity is highly imperiled. We have lost more than 90 percent of our native wetland and river habitats, leading to precipitous declines in native plants and the populations of animals that call these places home. These natural resources are intricately connected to California's economy providing direct benefits through industries such as fisheries, timber and hunting, as well as indirect benefits such as clean water supplies. SGMA must be successful for us to achieve a sustainable future, in which people and nature can thrive within the Tulare Lake Groundwater Subbasin and California.

We believe that the success of SGMA depends on bringing the best available science to the table, engaging all stakeholders in robust dialog, providing strong incentives for beneficial outcomes and rigorous enforcement by the State of California.

Given our mission, we are particularly concerned about the inclusion of nature, as required, in GSPs. TNC has developed a suite of tools based on best available science to help Groundwater Sustainability Agencies (GSAs), consultants, and stakeholders efficiently incorporate nature into GSPs. These tools and resources are available online at

GroundwaterResourceHub.org. TNC's tools and resources are intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

Addressing Nature's Water Needs in GSPs

SGMA requires that all beneficial uses and users, including environmental users of groundwater, be considered in the development and implementation of GSPs (Water Code § 10723.2).

The GSP Regulations include specific requirements to identify and consider groundwater-dependent ecosystems (GDEs) [23 CCR §354.16(g)] when determining whether groundwater conditions are having potential effects on beneficial uses and users. GSAs must also assess whether sustainable management criteria may cause adverse impacts to beneficial uses and users, which include environmental uses, such as plants and animals. TNC has identified each part of GSPs where consideration of beneficial uses and users are required. That list is available here: https://groundwaterresourcehub.org/importance-of-gdes/provisions-related-to-groundwater-dependent-ecosystems-in-the-groundwater-s. Please ensure that environmental beneficial users are addressed accordingly throughout the GSP. Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decision, and using data collected through monitoring to revise decisions in the future. Over time, GSPs should improve as data gaps are reduced and uncertainties addressed.

To help ensure that GSPs adequately address nature as required under SGMA, TNC has prepared a checklist (**Attachment A**) for GSAs and their consultants to use. TNC believes the following elements are foundational for 2020 GSP submittals. For detailed guidance on how to address the checklist items, please also see our publication, *GDEs under SGMA: Guidance for Preparing GSPs*[1].

1. Environmental Representation

SGMA requires that GSAs consider the interests of all beneficial uses and users of groundwater. To meet this requirement, we recommend actively engaging environmental stakeholders by including environmental representation on the GSA board, technical advisory group, and/or working groups. This could include local staff from state and federal resource agencies, nonprofit organizations and other environmental interests. By engaging these stakeholders, GSAs will benefit from access to additional data and resources, as well as a more robust and inclusive GSP.

2. Basin GDE and ISW Maps

SGMA requires that GDEs and interconnected surface waters (ISWs) be identified in the GSP. We recommend using the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) provided online[2] by the Department of Water Resources (DWR) as a starting point for the GDE map. The NC Dataset was developed through a collaboration between DWR, the California Department of Fish and Wildlife (CDFW) and TNC. We also recommend using GDE Pulse, which is also available on the internet at https://gde.codefornature.org/#/home. We also recommend using the California Natural

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[1] GDEs under SGMA: Guidance for Preparing GSPs is available at: https://groundwaterresourcehub.org/public/uploads/pdfs/GWR_Hub_GDE_Guidance_Doc_2-1-18.pdf

[2] The Department of Water Resources' Natural Communities Commonly Associated with Groundwater dataset is available at: https://gis.water.ca.gov/app/NCDatasetViewer/

Diversity Database (CNDDB) provided by CDFW to look up species occurrences within your area.

3. Potential Effects on Environmental Beneficial Users

SGMA requires that potential effects on GDEs and environmental surface water users be described when defining undesirable results. In addition to identifying GDEs in the basin, TNC recommends identifying beneficial users of surface water, which include environmental users. This is a critical step, as it is impossible to define "significant and unreasonable adverse impacts" without knowing *what* is being impacted. For your convenience, we've provided a list of freshwater species within the boundary of the Tulare Lake Groundwater Subbasin (Subbasin) in **Attachment C**. Our hope is that this information will help your GSA better evaluate the impacts of groundwater management on environmental beneficial users of surface water. We recommend that after identifying which freshwater species exist in your basin, especially federal- and state-listed species, that you contact staff at CDFW, United States Fish and Wildlife Service (USFWS) and/or National Marine Fisheries Services (NMFS) to obtain their input on the groundwater and surface water needs of the organisms on the GSA's freshwater species list. We also refer you to the Critical Species Lookbook[3] prepared by TNC and partner organizations for additional background information on the water needs and groundwater reliance of critical species. Since effects to plants and animals are difficult and sometimes impossible to reverse, we recommend erring on the side of caution to preserve sufficient groundwater conditions to sustain GDEs and ISWs.

4. Biological and Hydrological Monitoring

If sufficient hydrological and biological data in and around GDEs is not available in time for the 2020/2022 plan, data gaps should be identified along with actions to reconcile the gaps in the monitoring network.

TNC has reviewed the Tulare Lake Preliminary Draft GSP and appreciates the use of some our relevant resources in addressing GDE-related topics. However, we consider it to be **inadequate** under SGMA since key environmental beneficial uses and users are not adequately identified and considered. In particular, 1) ISWs and GDEs are not adequately identified and evaluated for ecological importance or adequately considered in the basin's sustainable management criteria, and 2) connectivity and extent of the of ISWs and GDEs with the shallow / perched zones of the unconfined / semiconfined aquifer were not characterized. **Please present a more thorough analysis of the 1) connectivity of the shallow and perched portions of the unconfined aquifer, 2) extent of the perched and shallow areas within the aquifer, and 3) identification and evaluation of ISWs and GDEs in subsequent drafts of the GSP. Once potential GDEs and ISWs are identified, they must be considered when defining undesirable results and evaluated for further monitoring needs until data gaps are filled in the future. If they are not adequately defined, then they need to be identified as a data gap in the interim.**

Our specific comments related to the Tulare Lake GSP are provided in detail in **Attachment B** and are in reference to the numbered items in **Attachment A. Attachment C** provides a list of the freshwater species located in the Subbasin. **Attachment D** describes six best practices that GSAs and their consultants can apply when using local groundwater data to confirm a connection to groundwater for DWR's NC Dataset. **Attachment E** provides an overview of a new, free online tool (i.e., GDE Pulse) that allows GSAs to assess changes in GDE health using satellite, rainfall, and groundwater data.

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[3] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

Thank you for fully considering our comments as you develop your GSP.

Best Regards,

Sandi Matsumoto
Associate Director, California Water Program
The Nature Conservancy

Attachment A

Environmental User Checklist

The Nature Conservancy is neither dispensing legal advice nor warranting any outcome that could result from the use of this checklist. Following this checklist does not guarantee approval of a GSP or compliance with SGMA, both of which will be determined by DWR and the State Water Resources Control Board.

GSP Plan Element*		**GDE Inclusion in GSPs: Identification and Consideration Elements**	**Check Box**
Admin Info	**2.1.5** **Notice & Communication** *23 CCR §354.10*	**Description of the types of environmental beneficial uses of groundwater that exist within GDEs and a description of how environmental stakeholders were engaged throughout the development of the GSP.**	1
Planning Framework	**2.1.2 to 2.1.4** **Description of Plan Area** *23 CCR §354.8*	**Description of jurisdictional boundaries, existing land use designations, water use management and monitoring programs; general plans and other land use plans relevant to GDEs and their relationship to the GSP.**	2
		Description of instream flow requirements, threatened and endangered species habitat, critical habitat, and protected areas.	3
		Summary of process for permitting new or replacement wells for the basin, and how the process incorporates any protection of GDEs	4
Basin Setting	**2.2.1** **Hydrogeologic Conceptual Model** *23 CCR §354.14*	**Basin Bottom Boundary:** Is the bottom of the basin defined as at least as deep as the deepest groundwater extractions?	5
		Principal aquifers and aquitards: Are shallow aquifers adequately described, so that interconnections with surface water and vertical groundwater gradients with other aquifers can be characterized?	6
		Basin cross sections: Do cross-sections illustrate the relationships between GDEs, surface waters and principal aquifers?	7
	2.2.2 **Current & Historical Groundwater Conditions** *23 CCR §354.16*	**Interconnected surface waters:**	8
		Interconnected surface water maps for the basin with gaining and losing reaches defined (included as a figure in GSP & submitted as a shapefile on SGMA portal).	9
		Estimates of current and historical surface water depletions for interconnected surface waters quantified and described by reach, season, and water year type.	10
		Basin GDE map included (as figure in text & submitted as a shapefile on SGMA Portal).	11

		If NC Dataset *was* used:	Basin GDE map denotes which polygons were kept, removed, and added from NC Dataset (Worksheet 1, can be attached in GSP section 6.0).	12
			The basin's GDE shapefile, which is submitted via the SGMA Portal, includes two new fields in its attribute table denoting: 1) which polygons were kept/removed/added, and 2) the change reason (e.g., why polygons were removed).	13
			GDEs polygons are consolidated into larger units and named for easier identification throughout GSP.	14
		If NC Dataset *was not* used:	Description of why NC dataset was not used, and how an alternative dataset and/or mapping approach used is best available information.	15
		Description of GDEs included:		16
		Historical and current groundwater conditions and variability are described in each GDE unit.		17
		Historical and current ecological conditions and variability are described in each GDE unit.		18
		Each GDE unit has been characterized as having high, moderate, or low ecological value.		19
		Inventory of species, habitats, and protected lands for each GDE unit with ecological importance (Worksheet 2, can be attached in GSP section 6.0).		20
	2.2.3 **Water Budget** *23 CCR §354.18*	Groundwater inputs and outputs (e.g., evapotranspiration) of native vegetation and managed wetlands are included in the basin's historical and current water budget.		21
		Potential impacts to groundwater conditions due to land use changes, climate change, and population growth to GDEs and aquatic ecosystems are considered in the projected water budget.		22
Sustainable Management Criteria	**3.1** **Sustainability Goal** *23 CCR §354.24*	**Environmental stakeholders/representatives were consulted.**		23
		Sustainability goal mentions GDEs or species and habitats that are of particular concern or interest.		24
		Sustainability goal mentions whether the intention is to address pre-SGMA impacts, maintain or improve conditions within GDEs or species and habitats that are of particular concern or interest.		25
	3.2 **Measurable Objectives** *23 CCR §354.30*	**Description of how GDEs were considered and whether the measurable objectives and interim milestones will help achieve the sustainability goal as it pertains to the environment.**		26
	3.3 **Minimum Thresholds** *23 CCR §354.28*	**Description of how GDEs and environmental uses of surface water were considered when setting minimum thresholds for relevant sustainability indicators:**		27
		Will adverse impacts to GDEs and/or aquatic ecosystems dependent on interconnected surface waters (beneficial user of surface water) be avoided with the selected minimum thresholds?		28
		Are there any differences between the selected minimum threshold and state, federal, or local standards relevant to the species or habitats residing in GDEs or aquatic ecosystems dependent on interconnected surface waters?		29
	3.4 **Undesirable Results** *23 CCR §354.26*	**For GDEs, hydrological data are compiled and synthesized for each GDE unit:**		30
		If hydrological data *are available* within/nearby the GDE	Hydrological datasets are plotted and provided for each GDE unit (Worksheet 3, can be attached in GSP Section 6.0).	31
			Baseline period in the hydrologic data is defined.	32

			GDE unit is classified as having high, moderate, or low susceptibility to changes in groundwater.	33
			Cause-and-effect relationships between groundwater changes and GDEs are explored.	34
		If hydrological data *are not available* within/nearby the GDE	Data gaps/insufficiencies are described.	35
			Plans to reconcile data gaps in the monitoring network are stated.	36
		For GDEs, biological data are compiled and synthesized for each GDE unit:		37
		Biological datasets are plotted and provided for each GDE unit, and when possible provide baseline conditions for assessment of trends and variability.		38
		Data gaps/insufficiencies are described.		39
		Plans to reconcile data gaps in the monitoring network are stated.		40
		Description of potential effects on GDEs, land uses and property interests:		41
		Cause-and-effect relationships between GDE and groundwater conditions are described.		42
		Impacts to GDEs that are considered to be "significant and unreasonable" are described.		43
		Known hydrological thresholds or triggers (e.g., instream flow criteria, groundwater depths, water quality parameters) for significant impacts to relevant species or ecological communities are reported.		44
		Land uses include and consider recreational uses (e.g., fishing/hunting, hiking, boating).		45
		Property interests include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.		46
Sustainable Management Criteria	**3.5 Monitoring Network** *23 CCR §354.34*	Description of whether hydrological data are spatially and temporally sufficient to monitor groundwater conditions for each GDE unit.		47
		Description of how hydrological data gaps and insufficiencies will be reconciled in the monitoring network.		48
		Description of how impacts to GDEs and environmental surface water users, as detected by biological responses, will be monitored and which GDE monitoring methods will be used in conjunction with hydrologic data to evaluate cause-and-effect relationships with groundwater conditions.		49
Projects & Mgmt Actions	**4.0. Projects & Mgmt Actions to Achieve Sustainability Goal** *23 CCR §354.44*	Description of how GDEs will benefit from relevant project or management actions.		50
		Description of how projects and management actions will be evaluated to assess whether adverse impacts to the GDE will be mitigated or prevented.		51

* In reference to DWR's GSP annotated outline guidance document, available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/GD_GSP_Outline_Final_2016-12-23.pdf

Attachment B

TNC Evaluation of the
Tulare Lake Subbasin Groundwater Sustainability Plan, Preliminary Draft

A complete draft of the Tulare Lake Subbasin GSP is available at https://southforkkings.org/wp-content/uploads/2019/09/2019-0906-tulare-lake-subbasin-gsp-prelim-draft_for-upload.pdf for public review and comment and is dated August 2019. This attachment summarizes our comments on the complete public draft GSP. Comments are provided in the order of the checklist items included as Attachment A.

Checklist Item 1 - Notice & Communication (23 CCR §354.10)

[Section 2.5.3 Beneficial Uses and Users (p. 2-28)]

- The flow chart on p. 2-28 shows the engagement process with groundwater users during the development and implementation of the GSP. Table 2-4 (pp. 2-47 to 2-49) identifies all the beneficial uses and users of groundwater within the Subbasin by GSA in greater detail, but does not include environmental uses and users. Users identified include agricultural, public water systems, domestic well owners, municipal water systems, planning agencies, Native American Tribes, Disadvantaged Communities, monitoring entities, and surface water users (as represented by GSA members). California Water Code §1305(f) defines that beneficial uses of waters of the State include "preservation and enhancement of fish, wildlife, and other aquatic resources and preserves". **Please expand Table 2-4 to include environmental uses and users that are present in the Subbasin, such as:**
    - **ecological areas; preserves; potential ISWs and GDEs; managed wetlands;**
    - **Protected Lands, including conservation areas; and**
    - **Public Trust Uses including wildlife, aquatic habitat, fisheries, and recreation.**

Checklist Items 2 to 4 - Description of the Plan Area (23 CCR §354.8)

[Section 2.0 Plan Area (pp. 2-1 to 2-2)]

- The types and locations of environmental uses, species and habitats supported, and the designated beneficial environmental uses and users of surface waters that may be affected by groundwater extraction in the Subbasin should be specified in the section and in Table 2-4. **Please elaborate on the "surface water uses and users" by identifying the environmental uses and users of surface water for all GSAs in Table 2-4. Please explicitly identify the environmental users and take particular note of the species with protected status and any critical habitat that exists within the Subbasin.** The following are resources that can be used:
    - Natural Communities Commonly Associated with Groundwater dataset (NC Dataset) - https://gis.water.ca.gov/app/NCDatasetViewer/

  - The list of freshwater species located in the Tulare Lake Subbasin in Attachment C of this letter.
  - The California Department of Fish and Wildlife's California Natural Diversity Database (CNDDB) for species occurrences.
  - The USFWS's Environmental Conservation Online System (ECOS) for mapping critical habitat, wildlife and contaminants - https://ecos.fws.gov/ecp/
- The GSP addresses state and federal land ownership to some degree, but there is no mention of uses related to open space areas, managed wetlands, natural preserve areas, or other protected lands that contain natural resources. Per the USFWS ECOS website the Kern National Wildlife Refuge Complex, Tulare Basin Wildlife Management Area (on southern boundary), and Pixley National Wildlife Refuge (to the east of Highway 43) abut the GSP area. Within these areas there is critical habitat mapped for the Buena Vista Lake ornate shrew (*Sorex ornatus relictus*) near the Lemoore Naval Air Station and in the Kern National Wildlife Refuge, and the vernal pool fairy shrimp (*Branchinecta lynchyi*) in the Pixley National Wildlife Refuge. These habitat areas or species are not addressed in the description of the plan area, nor are sensitive habitats within the plan area acknowledged.
  - **Please identify the natural resources within the plan area and elaborate on any and all state, federal or other land ownership that exists within the plan area that provide protection of natural resources.**
  - **Please address how the GSP will address natural resource management on a regional scale since management within the GSP could affect neighboring sensitive resources.**
- The GSP goes on to state on p. 2-2 that the primary land use designations are for agricultural, urban, residential, commercial and industrial lands; however, the figure on that page shows riparian vegetation and water surface land use classifications that amount to more than residential and semi-agricultural. **Please revise the statement concerning primary land use designations to accurately reflect the percentages on the chart (i.e., agricultural, urban, riparian vegetation, water surface, etc.). Please identify the natural resources within the plan area and elaborate on any and all state, federal or other land ownership that exists within the plan area that provide protection of natural resources.**
- On page 2-2, it is stated that it was not possible to differentiate types of well uses between irrigation and domestic extractors because DWR does not have that data. However, these data are available on well completion reports which may be accessed on line through the GeoTracker GAMA website (https://gamagroundwater.waterboards.ca.gov/gama/gamamap/public/Default.asp). This is the approach taken in almost every other GSP we have reviewed and is an important distinction of use as it relates to prioritization of project needs and management decisions. _**Please either address this issue or identify this as a data gap to reconcile in the 5-year GSP update.**

[Section 2.1 Summary of Jurisdictional Areas and Other Features (pp. 2-3 to 2-10)]

- The Plan summarizes the GSP Area and describes the jurisdictional areas and entities of the GSAs, but does not say anything about the jurisdictional areas of the resource agencies. **Please elaborate on the jurisdictional areas of the resource agencies and what resources they are in place to protect.**
- With exception of a short description of the Kings River Fisheries Management Program in Section 2.2.2.4, the GSP does not provide a description of other instream flow requirements, if any, or how the water infrastructure is in compliance with regulatory requirements set to protect species of concern. **Please provide a description of any current and planned instream flow requirements for Tulare Subbasin streams / rivers including Kings, Tule, White, Kaweah, and St. John's Rivers; and undammed streams including Deer, Dry, Mill, Cottonwood, and Poso Creeks. If there are no other instream flow requirements in place or planned, then please state that in the document.**

[Section 2.2.1 Monitoring and Management Programs (pp. 2-11 to 2-12)]

- This section addresses the water resources management actions that are being undertaken to monitor groundwater level, extraction and quality; subsidence; irrigated lands; and surface water. Management of natural resources is not considered in this section but should be described in order to provide a context for how groundwater management actions will be coordinated with environmental requirements to prevent undesirable results. **Please include a description of the natural resource management and monitoring programs occurring within the GSP area that affects instream, wetland and riparian ecosystems that have the potential to be groundwater dependent (i.e., interconnected surface water [ISWs] and groundwater dependent ecosystems [GDEs]).**

[Section 2.3 Relation to General Plans (pp. 2-14 to 2-17)]

- The GSP includes a very short description of the general plans within the GSP area but fails to specifically elaborate on the goals and policies outlined in the plans, and how the GSP will fit in with or affect the general plans' goals and policies related to the protection and management of GDEs, ISWs and aquatic resources that could be affected by groundwater withdrawals. **Please include a discussion of how implementation of the GSP may affect and be coordinated with General Plan policies and procedures regarding the protection of wetlands, aquatic resources, other GDEs and ISWs, and related threatened or endangered species.**
- This section should identify other land use plans, including Habitat Conservation Plans (HCPs) or Natural Community Conservation Plans (NCCPs) within the Subbasin and if they are associated with areas with instream flow requirements; or critical, GDE or ISW habitats. **Please identify all relevant HCPs and NCCPs within the Subbasin, and any reaches with instream flow and critical habitat requirements. Please elaborate on the natural resources within the Subbasin and address how GSP implementation will coordinate with the**

goals of these plans and requirements. If there are no HCPs, NCCPs, or preservation areas that could be affected, then that should be stated. The Critical Species Lookbook[4] includes the potential groundwater reliance of critical species in the basin. **Please include a discussion regarding the management of critical species and their habitats for these aquatic ecosystems and its relationship to the GSP.**

- **Please describe how the GSP will coordinate with the General Plan elements within the GSP area. Specifically, please elaborate on conservation, recreation and open space elements.**
- This section states (p. 2-15) that "It is considered unlikely that any Kern County General Plan Policies have any practical relevance to the plan area". The Kern National Wildlife Refuge Complex abuts the GSP area and it is difficult to understand that the General Plan for Kern County does not address habitat concerns and conservation that could be directly or indirectly affected by potential groundwater management actions within and adjacent to the Kern Subbasin. **Please 1) elaborate on the Kern County General Plan's conservation elements, 2) how the Tulare Lake Subbasin's GSP will comply with or not impact conservation elements being employed within protected habitat areas adjacent to the Tulare Subbasin, and 3) expand this conversation to include other neighboring habitat areas, such as Pixley National Wildlife Refuge.**

[Section 2.3.4 Permitting Process for New or Replacement Wells (pp. 2-17 to 2-19)]

- This section summarizes well permitting requirements and county ordinances for the counties of Kings, Kern and Tulare. **Please include a discussion of the following in this section:**
  - Future well permitting must be coordinated with the GSP to assure achievement of the Plan's sustainability goals.
  - How the well permitting process incorporates protection of GDEs within the Subbasin.
  - The State Third Appellate District recently found that Counties have a responsibility to consider the potential impacts of groundwater withdrawals on public trust resources when permitting new wells near streams with public trust uses (ELF v. SWRCB and Siskiyou County, No. C083239). **The need for well permitting programs to comply with this requirement should be stated in the text.**

Checklist Items 5 to 7 – Hydrogeologic Conceptual Model (23 CCR §354.14)

[Section 3.1.7 Definable Bottom of the Basin (pp. 3-16 to 3-19)]

- The GSP uses two methods (Water Quality and Geologic) to define the bottom of the basin but which method, or combination of the methods, that is being relied on for this GSP is not clearly stated. **Please explicitly state the final decision on how the bottom of the basin was determined, and what it was determined to be.**

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[4] Available online at: https://groundwaterresourcehub.org/sgma-tools/the-critical-species-lookbook/

- Defining the bottom of the Subbasin based on geochemical properties is a suitable approach for defining the base of freshwater, however, as noted on page 9 of DWR's Hydrogeologic Conceptual Model BMP (https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_HCM_Final_2016-12-23.pdf) "the definable bottom of the basin should be at least as deep as the deepest groundwater extractions". **Thus, groundwater extraction well depth data should also be included in the determination of the basin bottom.** This will prevent the possibility of extractors with wells deeper than the basin boundary (defined by the base of freshwater) from claiming exemption of SGMA due to their well residing outside the vertical extent of the basin boundary. **Please characterize groundwater well extractions from the deepest wells in relation to defining the basin bottom**.

[Section 3.1.8 Hydrogeologic Setting: Principal Groundwater Aquifers and Aquitards (pp. 3-19 to 3-23)]

- Although there is robust description of the confined (lower) and unconfined / semi-confined (upper) aquifers there is no explicit description with supporting data and information of how groundwater above the A- and C-clays in the upper aquifer interacts with the unconfined aquifer, or is influenced by pumping in the unconfined portion of the upper aquifer. DWR's definition of a principal aquifer, is defined as an "aquifer or aquifer system that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems" [*23 CCR §351(aa)*]. These shallow and perched areas within the upper aquifer range from near surface to 30 feet below ground surface (bgs) (Figure 3-17, p. 3-74) and likely provide water supply to GDEs and ISWs. As such, they yield significant quantities of groundwater to surface water systems and beneficial users, and should not be dismissed because they do not yield groundwater for human use. **Please expand the description of the upper aquifer to include the interaction of the unconfined and shallow areas of the upper aquifer. Include cross-sections to show their connectivity and relationship to potential ISWs and GDEs.**
- Regional geologic cross sections are provided in Figures 3-14a, 3-14b and 3-14c (pp. 3-69 to 3-71). These cross-sections do not include a graphical representation of the shallow groundwater-bearing zones that may be connected to GDEs and ISWs in the GSP area, and how they are connected to the upper aquifer system. **Please include example near-surface cross section details that depict the conceptual understanding of shallow groundwater and stream interactions at different locations, including the shallow zones, any perched aquifers, and the unconfined / semi-confined upper aquifer**.
- Based on the information provided in the GSP, it appears that the confined lower aquifer is being considered a principal aquifer because of the large amount of consumption for agriculture and municipal water supply, but this is not explicitly stated. The unconfined / semi-confined aquifer is stated to have limited use because of water quality. On pages 3-18 and 3-19, there is a discussion of water quality and although water with TDS higher than 3,000 is not considered suitable for water supply or most agriculture, it is potentially suitable for livestock and production of crops with higher tolerance to salinity. Conversely, in Section 3.1.11 (pages 3-25

and 3-26), the GSP states that the upper aquifer is primarily used for domestic and municipal supplies, and agricultural pumping does occur in the deeper portion of the upper aquifer. Also, if water in the unconfined aquifer is significantly supporting GDEs and ISWs, production of salt tolerant crops, or livestock operations, then it should also be identified as a principal aquifer. Even if ultimately the GSA doesn't define shallow groundwater as a principal aquifer, the text indicates current or future use that could impact ISWs and GDEs. **Thus, disregarding this shallow groundwater as a principal aquifer due to its water quality is not supported by the data and is inadequate.** SGMA requires GSAs to sustainably manage groundwater resources in all aquifers, especially if groundwater use and management can result in impacts to beneficial uses and users. Please refer to Best Practice #1 in Attachment D for further explanation and accompanying graphics. **Please explicitly enumerate the principal aquifer(s) and intervening aquitards, their relationship to each other, and their role in supplying groundwater to all beneficial uses and users of groundwater (including environmental).**

[Section 3.2 Groundwater Conditions (pp. 3-26 to 3-28)]

- Groundwater elevation contours are shown for 1905-1907, 1952, 1990, 1995, 2000, 2005, 2010 and 2016 on Figures 3-24 through 3-27 with respect to mean sea level. However, the wells used to contour groundwater levels in the upper aquifer do not necessarily monitor shallow or perched groundwater that may be in communication with GDEs and ISWs. In addition, depth to groundwater cannot be readily assessed from the maps because they are presented with respect to sea level. **Please provide the following:**
    1) **Groundwater level contour maps representative of the uppermost aquifer where GDEs and ISWs may be reliant. If this data does not exist, then identify it as a data gap that will be addressed in the GSP when the GSP is updated.**
    2) **Depth to water contour maps that allow interpretation of beneficial groundwater uses by environmental users.**
    3) **If these data are not available, please identify this as a data gap and outline measures to address the data gap in subsequent sections of the GSP.**

[Section 3.2.5 Groundwater Quality (pp. 3-30 to 3-31)]

- There is water quality information for the upper aquifer and a statement that increases in TDS concentrations, arsenic, nitrate and volatile organic chemicals (VOCs) are largely due to agricultural practices and pumping, but there is no information regarding water quality of the perched water or other areas of the upper aquifer to understand how water quality may affect GDEs, ISWs and associated aquatic species. **Please modify this section of the GSP to include data about water quality in the zones where GDEs are present. If there are no data available, then please recognize this as a data gap and specify that additional data will be collected and analyzed for the GSP update.**

Checklist Items 8 to 10 – Interconnected Surface Waters (ISWs) (23 CCR §354.16)

[Figure 3.1.10 Groundwater Recharge and Discharge Areas (p. 3-25)]

- The text states that "Some discharge is impacted by direct soil evaporation and evapotranspiration, particularly in areas where groundwater is less than 10 feet bgs." Elsewhere the text states that agricultural drainage must be provided in some areas, indicating very shallow groundwater, or makes reference to deeper groundwater levels of about 30 feet for groundwater above the A-Clay. Earlier in this comment letter we pointed out the discrepancy between the various shallow groundwater levels that are presented (see Section 3.2 Groundwater Conditions [pp. 3-26 to 3-28]). This GSP also states that riparian and emergent marsh ecosystems are prevalent in certain areas where they have not already been degraded by land development. **Please 1) rectify the discrepancies in groundwater levels, particularly as they pertain to ISWs and GDEs; and 2) include the locations of phreatophytes and other GDEs to provide a complete representation of evapotranspiration within all groundwater discharge areas. If the regional groundwater connection of phreatophytes and other GDEs is not known, 1) please identify this data gap, 2) provide an approach to address it, and 3) include the ISWs and GDEs as potential features on a figure until they can be more conclusively evaluated.**

[Section 3.2.8 Interconnected Surface Water and Groundwater Systems (pp. 3-33 to 3-34)]

- The regulations [23 CCR §351(o)] define ISWs as "surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted". "At any point" has both a spatial and temporal component. Even short durations of interconnections of groundwater and surface water can be crucial for surface water flow and supporting environmental users of groundwater and surface water. ISWs can be either gaining or losing. The GSP disregards IWSs by stating that hydrologic conditions have been so altered that the ISWs that were historically connected are not any longer. There are inconsistencies throughout this GSP in regard to ISWs. The GSP states:
    - Section 3.1.10 (p. 3-25, also see the comment directly above): "Groundwater recharge in the Subbasin occurs primarily by two methods: 1) infiltration of surface water from the Kings River and unlined conveyances; and 2) infiltration of applied water for irrigation of crops." **ISWs can be either gaining or losing (see the definition above). If recharge primarily occurs through infiltration from rivers and streams, then these features must be included as an ISW with gaining and losing reaches defined on a map.**
    - Section 3.2.8 (p. 34): "A persistent, shallow perched water table at a depth of about 30 feet bgs is often present above the A-clay in the vicinity of surface water conveyances and below recharge facilities; however, this shallow perched zone is disconnected from the regional unconfined aquifer. Other localized shallow perched zones may exist elsewhere in the Subbasin, but these are not considered a significant source of groundwater." Section 3.1.8

states (p. 3-21) that the perched water is as shallow as 15 feet in some areas, and the groundwater elevation contour maps show it ranging from 0-20 feet AMSL. Data to support the claims about the nature of the perched aquifers is conflicting and the claims that perched units are disconnected or insignificant are not supported by data. **Please clarify the discrepancy between groundwater depths reported for the shallow perched water table that are provided in the text and on figures. If the location and size of other shallow perched zones is unknown, this information needs to be identified as a data gap, rather than a reason to completely disregard the features.** It is inadequate to assume that shallow perched zones are not a significant source of groundwater if they have not been fully characterized, and could be a significant source for GDEs and ISWs. **Please reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells) along surface water features in the Monitoring Network section of the GSP to improve identification of ISWs prior to disregarding them in the GSP.**

<u>Checklist Items 11 to 15 – Identifying and Mapping GDEs (23 CCR §354.16)</u>

[Section 3.2.8.1 Groundwater Dependent Ecosystems (GDEs) (p. 3-34 to 3-35)]

- The text states (p. 3-35): "Groundwater pumping from the principal aquifer system is not likely to impact the occurrence of perched groundwater because the two systems are separated by the A-Clay aquitard. Perched groundwater above the A-Clay is not directly interconnected with the underlying unconfined / semiconfined aquifer in that pumping from the unconfined / semiconfined aquifer does not induce increased leakage through the A-Clay aquitard." This statement is not supported by the data provided in the GSP (see comments above) and is not a valid reason to disregard potential GSPs without further evidence. The A-Clay is reported to vary significantly in thickness and to contain permeable sands in some locations. **Please:**
    1) **Explicitly identify the principal aquifers;**
    2) **Provide data regarding the competence of the A-Clay as an aquitard**
    3) **Evaluate the potential degree of connection between the perched and unconfined aquifer based on objective data;**
    4) **Acknowledge the extent of the perched aquifers throughout the Subbasin as a data gap;**
    5) **Address data gaps associated with the interconnectivity with the unconfined / semiconfined aquifer to be reconciled in the GSP update; and**
    6) **Acknowledge the potential for GDEs and ISWs to be dependent on these groundwater resources.**
- Although this GSP did use the NCCAG database to preliminarily identify GDEs (p. 3-34), all were disregarded without acknowledgment of data gaps and further characterization of the natural communities in association with potential perched aquifers, and disparities in groundwater levels that have not yet been characterized. This evaluation potentially misses GDEs due to the potential for GDEs to utilize the

shallow and perched areas of the unconfined / semi-confined aquifer. The following comments apply:

- While depth to groundwater levels within 30 feet are generally accepted as being a proxy for deciding if polygons in the NC dataset are connected to groundwater, it is highly advised that seasonal and interannual groundwater fluctuations in the groundwater regime are taken into consideration. Utilizing groundwater data from one point in time or during a discrete season can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Based on a study we recently submitted to *Frontiers in Environmental Science*, we've observed riparian forests along the Cosumnes River to experience a range in groundwater levels between 1.5 and 75 feet over seasonal and interannual timescales. Seasonal fluctuations in the regional water table can support perched groundwater near an intermittent river that seasonally runs dry due to such fluctuations. While perched groundwater itself cannot directly be managed due to its position in the vadose zone, the water table position within the regional aquifer (via pumping rate restrictions, restricted pumping at certain depths, restricted pumping around GDEs, well density rules, etc.) and its interactions with surface water (e.g., timing and duration) can be managed to prevent adverse impacts to ecosystems due to changes in groundwater quality and quantity under SGMA. **We highly recommend using depth to groundwater data from multiple seasons and water year types (e.g., wet, dry, average, drought) to determine the range of depth to groundwater around NC dataset polygons. Please refer to Attachment D of this letter for best practices for using local groundwater data to verify whether polygons in the NC Dataset are supported by groundwater in an aquifer. If insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset seasonally and interannually, or to determine conclusively whether shallow groundwater is hydraulically connected (directly or indirectly) to underlying aquifers, include those polygons in the GSP until data gaps are reconciled in the monitoring network, and include specific measures and time tables to address the data gaps.**
- If there are insufficient groundwater level data in the shallow and perched zones, then the NCCAGs in these areas should be included as GDEs in the GSP until data gaps are reconciled in the monitoring network. **Confirmation of GDEs should be based on depth to groundwater in the shallow and perched areas. Please revise the GDE analysis in the GSP to include a complete analysis and identification of data gaps.**
- **Please provide depth to groundwater contour maps and note the following best practices for doing so:**
    - Are the wells used for interpolating depth to groundwater sufficiently close (<5km) to NC Dataset polygons to reflect local conditions relevant to ecosystems?

    - Are the wells used for interpolating depth to groundwater screened within the surficial unconfined aquifer and capable of measuring the true water table?
    - Is depth to groundwater contoured using groundwater elevations at monitoring wells to get groundwater elevation contours across the landscape? This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM) to estimate depth-to-groundwater contours across the landscape. This will provide much more accurate contours of depth to groundwater along streams and other land surface depressions where GDEs are commonly found. Depth to groundwater contours developed from depth to groundwater measurements at wells assumes that the land surface is constant, which is a poor assumption to make. It is better to assume that water surface elevations are constant in between wells, and then calculate depth to groundwater using a DEM of the land surface to contour depth to groundwater.
- Groundwater requirements of GDEs vary with vegetation types and rooting depths. In identifying GDEs, care should be taken to consider rooting depths of vegetation. **Please indicate what vegetation is present in the potential GDEs, and whether the GDE was eliminated or retained based solely on a specified depth limit.** While Valley Oak (*Quercus lobata*) have been observed to have a maximum rooting depth of ~24 feet (https://groundwaterresourcehub.org/gde-tools/gde-rooting-depths-database-for-gdes/), rooting depths vary spatially and temporally based on local hydrologic conditions. Also, maximum rooting depths do not take capillary action into consideration, which will vary with soil type and is an important consideration since woody phreatophytes generally do not prefer to have their roots submerged in groundwater for extended periods of time, and hence effectively redistribute their root systems to straddle the water table as it fluctuates. Hence, many riparian, floodplain and desert ecosystem species are highly capable of accessing groundwater at much deeper depths when needed.
- Rohde, Froend and Howard (2017) acknowledged GDEs as ecosystems that can rely on groundwater for some or all their requirements. This publication can be found at: https://ngwa.onlinelibrary.wiley.com/doi/pdf/10.1111/gwat.12511. GDEs can rely on multiple water sources simultaneously and at different temporal and / or spatial scales (e.g., precipitation, river water, reservoir water, soil moisture in the vadose zone, groundwater, applied water, treated wastewater effluent, urban stormwater, irrigated return flow). SGMA (Section 351.0) defines GDEs as "ecological communities and species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface". **Hence, we recommend using depth to groundwater contour maps derived from subtracting groundwater levels from a DEM, as described above, to identify whether a connection to groundwater exists for the wetlands mapped in Figure 3-38 in the Subbasin.**

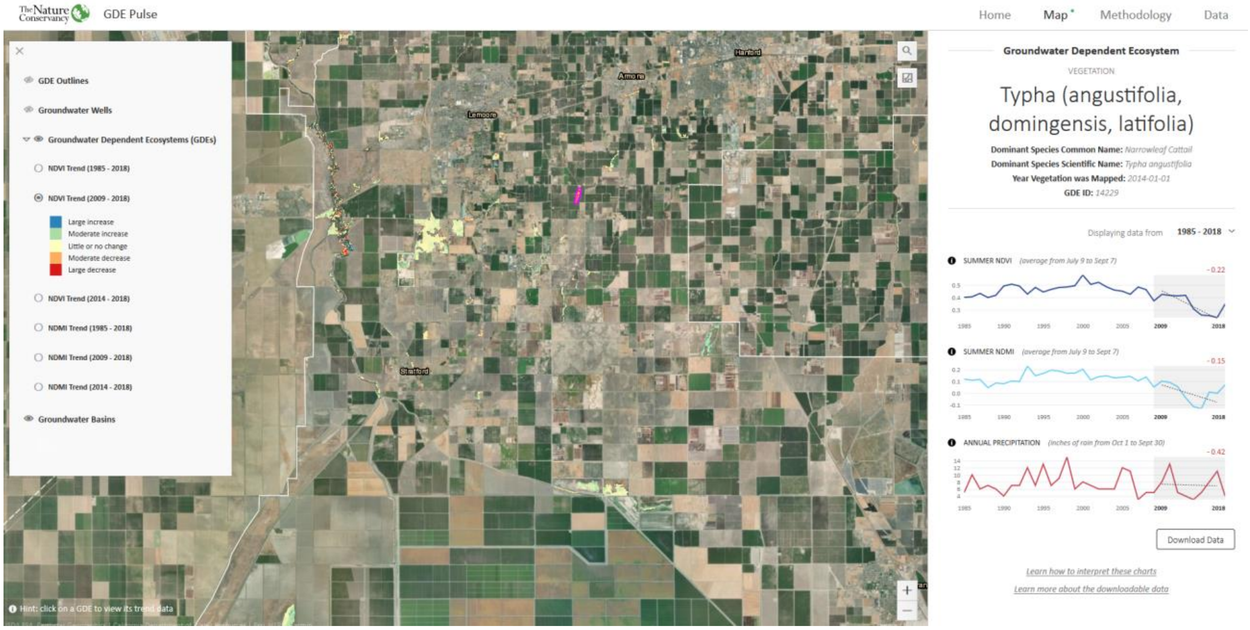
Please refer to Attachments D and E of this letter for best practices for using local groundwater data to 1) verify whether polygons in the NC Dataset are supported by groundwater in an aquifer, and 2) verify ecosystem decline or recovery is correlated with groundwater levels.

- The GSP states (p. 3-35), "Most of these vegetation types/plant species [identified in the NCCGA] are associated with riparian habitat that rely on surface water", and goes on to disregard them because they are primarily located on the perched areas above the A-Clay layer and the " A-Clay is not directly interconnected with the underlying unconfined / semi-confined aquifer". Section 354.16 of the California Code of Regulations states that "each Plan shall provide a description of current and historical groundwater conditions in the basin, including data from January 1, 2015, to current conditions, based on the best available information that includes…GDEs". Just because GDEs are <u>thought</u> to rely on surface water and the perched areas are <u>thought</u> to not be <u>directly</u> connected to the unconfined aquifer, does not make them insignificant to the environment. Many data gaps exist that could clarify these statements, for example: 1) indirect and direct connection of perched aquifers have not been fully characterized, 2) the location and extent of perched areas have not been fully characterized, and 3) species composition and potential max rooting depths have not be tabulated. Many rare and protected species reside in GDEs since they are very unique ecosystems. **Please provide further information on the analysis of GDEs and potential ISWs, including citing field studies or modeling studies that show the hydrologic nature of these systems. Specifically indicate 1) which streams and GDE polygons were excluded, 2) identify any data gaps, and 3) ensure that GDE polygons are <u>retained until data gaps are reconciled</u>.**

<u>Checklist Items 16 to 20 - Describing GDEs (23 CCR §354.16)</u>

[Section 3.2.8.1 Groundwater Dependent Ecosystems (GDEs) (p. 3-34 to 3-35)]

- **Please provide information on the historical or current groundwater conditions specifically near the GDEs or the ecological conditions present. If data gaps exist, please acknowledge them and state how they may be reconciled in the future.** Refer to GDE Pulse (https://gde.codefornature.org; See Attachment E of this letter for more details) or any other locally available data (e.g., leaf area index, evapotranspiration or other data) to describe depth to groundwater trends in and around GDE areas, as well as trends in plant growth (e.g., NDVI) and plant moisture (e.g., NDMI). Below is a screenshot example of data available in GDE Pulse for NC dataset polygons found in the Tulare Lake GSP Area.



Groundwater Dependent Ecosystem

VEGETATION

Typha (angustifolia, domingensis, latifolia)

Dominant Species Common Name: Narrowleaf Cattail
Dominant Species Scientific Name: Typha angustifolia
Year Vegetation was Mapped: 2014-01-01
GDE ID: 14229

Displaying data from 1985 - 2018

- **Please provide an ecological inventory (see Appendix III, Worksheet 2 of the GDE Guidance) for all potential GDEs that includes vegetation or habitat types and rank the GDEs as having a high, moderate or low value. Explain how each rank was characterized.**
- **Please identify whether any endangered or threatened freshwater species of animals and plants, or areas with critical habitat were found in or near any of the GDEs since some organisms rely on uplands and wetlands during different stages of their lifecycle**. Resources for this include the list of freshwater species located in the Subbasin that can be found in Attachment C of this letter, the Critical Species Lookbook, and the USFWS's ECOS and CDFW's CNDDB databases / mapping tools.

Checklist Items 21 and 22 – Water Budget (23 CCR §354.18)

[Section 3.3.1.2 Outflows (pp. 3-39 to 3-40)]

- Evapotranspiration (ET) is included as an outflow category in the water budget; however, it is only included as it pertains to crop water requirements. Groundwater outflow to the ET of natural ecosystems (i.e., GDEs, riparian areas, etc.) should be identified as a groundwater budget component. If the outflow is not known, it should be identified as a data gap and provisional information should be provided until an analysis can be performed to address the data gap. **Since natural ecosystems may be beneficial users of groundwater: 1) please provide a breakdown of ET for all land-cover types, including native and riparian vegetation (such as wetlands, riparian vegetation, phreatophytes and other communities); 2) identify any data gaps; 3) outline the actions needed to address them; 4) and the schedule for their implementation.**

Checklist Item 23-26 Sustainability Goal (23 CCR §354.24)

[Section 4.0 Sustainable Management Criteria (p. 4-1)]

- The GSP states that there is no ISW connectivity within the entire Subbasin, but data to support this broad assertion are insufficient to dismiss this sustainability indicator. It is acknowledged earlier in the GSP that recharge primarily occurs through surface streams / rivers and unlined canals; however, there isn't any quantitative analysis, monitoring data, or other information provided to support that ISWs are not present, and statements within the GSP are contradictory. **Please address ISWs in the Sustainable Management Criteria and the Sustainability Goal until sufficient data is available to conclude the status of ISWs.**
- The GSP states "Indicators for the sustainable management of groundwater were determined by SGMA based on factors that have the potential to impact the health and general well-being of the public." This chapter starts off by disregarding the environmental use and users of groundwater. Sweeping statements like this should be modified throughout the chapter to acknowledge all beneficial users. **Since GDEs and ISWs may be present in and near the GSP area due to the prevalence of shallow groundwater (please see comments under Checklist Items 16-20) they should be explicitly recognized in the establishment of sustainable management criteria for the groundwater level decline and ISW sustainability indicators. Please also update this section to recognize environmental beneficial groundwater uses as a component of the sustainable management goals.**

[Section 4.1 Sustainability Goal (pp. 4-1 to 4-3)]

- The Sustainability Goal states that "…the sustainability goal works as a tool for managing groundwater, basin-wide, on a long-term basis to protect quality of life through the continuation of existing economic industries in the area, including but not limited to agriculture". The overall theme is to protect groundwater resources for developed water users, particularly agriculture. **The narrative discussion of the sustainability goal should be expanded to include other beneficial uses and users of groundwater including environmental uses and users of groundwater.**
- The Discussion of Measures states that "management actions will be implemented to help mitigate overdraft based on the demand from beneficial uses and users", but developed users are the only parties identified in this chapter. Criteria used to evaluate the priority given to beneficial users during overdraft periods is not described. **Please update this section to provide a discussion of how human and environmental beneficial uses will be balanced in the implementation of management actions during periods of drought and overdraft.**
- **Since GDEs and ISWs may be present in the Subbasin (please see comments under Checklist Items 16-20) they should be recognized as beneficial users of groundwater and should be included in the Sustainability Goal and Discussion of Measures. In addition, a statement about any intention to address pre-SGMA impacts should be included.**

- GDEs are dependent, in part, on suitable water quality; however, the GSP focuses on subsidence, groundwater levels and changes in groundwater storage; and only considers water quality for irrigation and domestic use. **Given that there are potential GDEs and ISWs in the Subbasin, and they may be affected by water quality they should be included in the Sustainability Goal and addressed in the Sustainable Management Criteria established for the Water Quality Sustainability Indicator.**

[Section 4.2.4 Groundwater Quality Indicator (pp. 4-5 to 4-6)]

- The GSP states that the GSAs will rely on the existing programs in place for monitoring groundwater quality, and the "local GSAs will focus on water quality issues that are related to groundwater pumping rather than on issues related to contamination". However, since much of the groundwater is being used for irrigation, which then leaches back into the soil or drains elsewhere and carries nutrients and other solutes with it, the GSA should monitor constituents related to agriculture in addition to those related to pumping, such as arsenic. This includes nitrates, phosphates, salts, sodium, boron, chloride and acidification from carbonic acid which affects soil biota, structure, geochemistry, GDEs and ISWs. **Please consider revising this section to include monitoring for agricultural constituents.**

Checklist Item 26 – Measurable Objectives (23 CCR §354.30)

[Section 4.5 Measurable Objectives (pp. 4-18 to 4-20)]

- This Measurable Objectives do not consider the water quality needs of GDEs and ISWs. **Please modify this section to include impacts from degraded water quality on the plant and wildlife communities, and species they support within these habitats**.
- This GSP states that "ISWs do not exist within the Subbasin". However, this conclusion was based on well groundwater levels that are not reasonably close to the drainages, shallow or nested monitoring wells to assess potential interaction with surface water and GDEs and connectivity to underlying aquifers, or hydrogeologic data that does not fully characterize the location and extent of perched and shallow zones within the upper aquifer. In addition, there are no supporting data and information that demonstrates shallow groundwater near the streams and rivers is not supporting ISWs or GDEs. As such, the data are insufficient to dismiss this sustainability indicator under the GSP regulations. **Please modify this section of the GSP to retain ISWs as a sustainability indicator, pending the characterization of the shallow / perched zones and analysis of monitoring data or monitoring from additional wells to be installed in the future.**
- Since there are wildlife refuges and protected wildlife area that contain critical habitat directly adjacent to the GSP area, the GSP needs to address these areas, whether there are potential GDEs or ISWs, and how management actions within the Subbasin would affect these sensitive habitats. **Please explain how the measurable objectives will benefit adjacent subbasins and not hinder the**

ability of adjacent subbasins to be sustainable; and how the measurable objectives would benefit adjacent critical habitat areas. What are the mechanisms for this benefit?

- Sweeping statements, such as (p. 4-20) "interconnected surface waters do not exist within the Subbasin, so this indicator will not be further discussed in terms of Measurable Objectives" are completely dismissive with disregard for data gaps. There is not enough evidence to make statements like these. Many of the wells are screened too deep, not in the proper location to make comparisons, and / or nested wells have not been installed to inform how shallow groundwater interacts with potential ISWs, GDEs or the unconfined aquifer. **Please include all potential ISWs in the analysis and develop measurable objectives and minimum thresholds for these, to be managed until data gaps prove they are not interconnected.**

<u>Checklist Item 27-29 – Minimum Thresholds (23 CCR §354.28</u>)

[Section 4.4.1.2 Description of Minimum Thresholds and Processes to Establish [for Groundwater Level Indicator (p. 4-13), Section 4.4.1.4 Description of Minimum Thresholds and Processes to Establish [for Groundwater Quality Indicator (p. 4-14), and Section 4.4.1.5 Description of Minimum Thresholds and Processes to Establish [for Interconnected Surface Water Intrusion (p. 4-14)]

- These Minimum Thresholds do not consider GDEs and ISWs. **Please include GDEs (see comments under checklist items 8-20) in this section and whether the minimum thresholds and interim milestones will help achieve the potential sustainability goal as it pertains to the environment.**
- Section 4.4.1.5 (p. 4-14) states that "Interconnected surfaces waters are not considered present in the Subbasin are; therefore, no further discussion will occur on this indictor in terms of MTs". However, the GSP fails to provide any monitoring data, analysis or other information to substantiate this position. Based on the inconsistencies in groundwater levels presented previously in the GSP and this letter, and the unknowns associated with the extent and location of shallow and/or perched zones in the upper aquifer, it is possible that rivers, streams and GDEs may be hydraulically connected to the regional aquifer system. Minimum thresholds must be established for ISWs and GDEs unless and until sufficient data are provided to eliminate them from consideration. **Please modify this section of the GSP to 1) develop minimum thresholds for possible ISWs, including GDEs, and 2) include a statement that a data gap exists related to the interconnectedness of the of the Tulare Lakebed, rivers / streams, and shallow groundwater zones.**

[Section 4.4.4 Potential Effects to Beneficial Uses and Users (p. 4-17 to 4-18)]

- The evaluation of minimum thresholds completely disregards consideration of environmental beneficial users, such as ISWs, GDEs or the species they support. Effects to beneficial uses and users is focused on well capacity, pumping costs, extraction, and impacts from subsidence on infrastructure. There is no mention about potential impacts to GDEs or ISWs that could be affected by lowering of the

shallow portions of the unconfined or semi-confined portions of the upper aquifer since a continuity / discontinuity between the two is a data gap. Although there are many data gaps associated with ISWs and GDEs, it must be assumed that potential significant and unreasonable impacts to these beneficial users could occur. As such, they should be addressed in the evaluation of minimum thresholds. Section 4.4.4 should be modified to address how potential ISWs and GDEs would be affected by further lowering of groundwater levels. **Please address how 1) potential ISWs and GDEs would be affected by further lowering of groundwater levels, 2) these beneficial users will be protected / managed in the interim until data gaps are filled, and 3) what measures will be employed to protect GDEs and ISWs that are confirmed after data gaps are filled.**
- This Section does not include the required analysis of how the selected minimum thresholds for decline in groundwater levels could affect potential ISWs and GDEs within and near the GSP area. **Please include an analysis of the potential effect of the established minimum thresholds on ISWs and GDES within and near the GSP area, particularly in adjacent wildlife preserves / refuges.**
- Although agricultural and domestic water quality concerns have been articulated, similar concerns were not identified for environmental users. Degradation of water quality can impact terrestrial and aquatic wildlife that live in or near these ecosystems during at least part of the year even if the water is not a concern from an agricultural or municipal standpoint. **Please include a discussion about GDEs and water quality and whether the minimum thresholds and interim milestones will help achieve sustainability for environmental users.**

Checklist Item 30-46 – Undesirable Results (23 CCR §354.26)

[Section 4.3 Undesirable Results (pp. 4-6 to 4-12), and Subsection 4.3.3 Potential Effects to Beneficial Uses and Users (pp. 4-11 to 4-12)]

- The GSP states that there are no ISWs; however, this is largely based on assumptions and there are no monitoring data, analyses or other information to support this statement. In addition, the GSP indicates that 1) streams and rivers are the primary source of recharge; 2) a connection may exist between shallow and perched groundwater, but the extent and location of perched groundwater is unknown; and 3) surface and groundwater may be periodically connected in Tulare Lake. Furthermore, GDEs may exist within and near the GSP area. This is a data gap that needs to be identified and rectified by employing a monitoring network to verify the status of ISWs prior to complete dismissal of ISWs from the GSP. **Please modify this section of the GSP to include:**
    1) **A statement that there are potential ISWs and GDEs, unless adequate data can be provided to dismiss them.**
    2) **An assessment of the nature of potential undesirable results to ISWs and GDEs.**
    3) **A statement that the aquifers will be managed such there will be no depletion of ISWs that results in a significant and unreasonable impacts to ISWs or GDEs.**

4) **Data gaps and specific steps to verify the presence or absence of ISWs and GDEs with monitoring wells screened at the appropriate depths.**

- This section only describes undesirable results relating to human beneficial uses of groundwater and neglects environmental beneficial uses / users that could be adversely affected by chronic groundwater level decline or depletion of ISWs. **Please add "possible adverse impacts to potential GDEs and ISWs" to the list of potential undesirable results.**
- The GDE Pulse web application developed by TNC provides easy access to 35 years of satellite data to view trends of vegetation metrics, groundwater depth (where available), and precipitation data. This satellite imagery can be used to observe trends for NC dataset polygons within and near the GSA. Over the past 10 years (2009-2018), some NC dataset vegetation polygons have experienced adverse impacts to vegetation growth and moisture. An example screen shot of GDEs near Lemoore, California from the GDE Pulse tool is presented under Checklist items 16 to 20 above.
    - **For each potential GDE unit with supporting hydrological datasets please include the following:**
        - Plot and provide hydrological datasets for each GDE.
        - Define the baseline period in the hydrologic data.
        - Classify GDE units as having high, moderate, or low susceptibility to changes in groundwater.
        - Explore cause-and-effect relationships between groundwater changes and GDEs.
    - **For each identifiable GDE unit without supporting hydrological datasets please describe data gaps and / or insufficiencies.**
    - **Compile and synthesize biological data from CDFW's CNDDB, USFWS' ECOS Mapper, NC dataset, and / or the GDE Pulse tool (as applicable) for each GDE unit by:**
        - Characterizing biological resources for each GDE unit, and when possible provide baseline conditions for assessment of trends and variability.
        - Describing data gaps / insufficiencies.
    - **Describe possible effects on potential ISWs, GDEs, land uses, and property interests, including:**
        - Cause-and-effect relationships between potential ISWs and GDEs with groundwater conditions.
        - Impacts to potential ISWs and GDEs that are considered to be "significant and unreasonable".
        - Report known hydrological thresholds or triggers (e.g., instream flow criteria, groundwater depths, water quality parameters) for significant impacts to relevant species or ecological communities.
        - Land uses should include recreational uses (e.g., fishing/hunting, hiking, boating).
        - Property interests should include and consider privately and publicly protected conservation lands and opens spaces, including wildlife refuges, parks, and natural preserves.

- This section discusses water quality with respect to agricultural and municipal use but does not include a discussion of potential undesirable results for GDEs and ISWs. **Please modify this section to address how degraded water quality could affect vegetation and wildlife species that rely on GDEs and ISWs. Although arsenic is mentioned in this GSP, please consider adding a statement that over-pumping and dewatering of aquitards has been identified as a potential source of elevated arsenic concentrations above drinking water standards in San Joaquin Valley aquifers.** The following is a link to a paper by Smith, Knight and Fendorf (2018) titled "Overpumping leads to California groundwater arsenic threat": https://www.nature.com/articles/s41467-018-04475-3

Checklist Items 47-49 – Monitoring Network (23 CCR §354.34)

[Chapter 5 Monitoring Network (pp. 5-1 to 5-3), and Section 5.1 Description of Monitoring Network (pp. 5-3 to 5-15)]

- The GSP describes groundwater monitoring locations and states that groundwater monitoring in areas de-designated by the Tulare Lake Basin Plan amendment and associated aquifer zones is not proposed as decided by the GSAs. Although these areas (designated Management Area A and B) are not designated for municipal and agricultural uses in the Basin Plan, the groundwater could still potentially be used or is being used for livestock, crops with a higher tolerance to salt, domestic supply, public supply, and potentially other uses in the future. Since it is currently unclear how withdrawals within the unconfined aquifer will affect the perched and shallow areas of the aquifer (as associated with the A-Clay and C-Clay layers), Management Areas A and B still need to be monitored to assess effects to the unconfined aquifer as a whole. As stated above in the comments for other Checklist Items, **please reconcile data gaps (shallow monitoring wells, stream gauges, and nested/clustered wells, GDE and ISW responses to groundwater levels) along rivers, creek and the Tulare Lakebed in this section of the GSP to improve ISW and GDE mapping in future GSPs**.
- It is not acceptable to completely disregard these Management Areas based purely on a de-designation from municipal and agricultural uses only when there are still current and potential environmental uses of this groundwater. In addition, there is much uncertainty how the shallow aquifers are interacting with GDEs and ISWs. **Please add Representative Monitoring Sites (RMS) for these areas in order to better understand the interaction of the A-Clay and C-Clay layers with the unconfined aquifer, and potential GDEs and ISWs.**
- This section lists the proposed facilities for monitoring groundwater levels, storage and quality, and subsidence on pp. 5-9 through 5-15. This section proposes to use groundwater level monitoring to assess potential groundwater level and storage declines, existing programs to monitor water quality, and monitored surface conditions to evaluate land subsidence. It may acceptable to use groundwater level [in combination with assessment of vegetation response, for example by remote sensing] as a proxy for assessing potential effects on ISWs and GDEs, but the data gaps associated with the A-Clay, C-Clay, and shallow water tables need to be addressed. A set of representative wells have been selected to monitor the upper

and lower aquifer (Figures 5-1 to 5-3). There are only five wells that represent the "Above A-Clay and Shallow Groundwater Levels (i.e., Zone A)", and there are three data gaps areas identified (Figure 5-1). **Please describe 1) how these five wells are considered representative of the entire GSP Area, 2) how those data gap areas were selected, and 3) what methodologies would be used to extrapolate results to other areas where there are no wells or identified data gaps.**

- Many of the monitoring wells are not screened in the upper portion of the unconfined aquifer, where environmental beneficial users would obtain the groundwater on which they rely. Finally, there are currently no plans to monitor groundwater level declines to assess the potential for significant and unreasonable impacts to ISWs or GDEs in response to groundwater level declines. **Please modify the description of the new well network in the Proposed Facilities Section (Sections 5.1.4, p. 5-9) and Groundwater Levels Section (Section 5.1.4, p.5-9 to 5-11) to provide methodologies, data and other information to support the monitoring of GDEs and ISWs so as to assess and prevent potential significant and unreasonable impacts. This modification should include 1) locating new wells that are appropriately screened to detect connectivity of GDEs and ISWs with the unconfined aquifer and 2) identifying or installing additional stream gages in areas where there is potential for ISWs and GDEs. In addition, monitoring GDE responses to groundwater level declines should be included. GDE Pulse represents an example of how remote sensing can be used to achieve this objective. Please expand on the discussion of how the new well, stream and other data will be used to improve ISW mapping and inform an adequate analysis, and how the data will be used to verify possible GDEs and their sensitivity to groundwater level declines.**

[Section 5.1.1 Monitoring Network Objectives (p. 5-6)]

- The monitoring objectives listed include developing data to evaluate impacts to beneficial uses and users of groundwater but does not include filling data gaps as they specifically pertain to environmental users of groundwater. **Please expand this list to include monitoring to inform data gaps associated with groundwater use by potential GDEs, ISWs and the species that they support.**

[Section 5.4.1.4 Site Selection (p. 5-23)]

- This section includes the scientific rationale for the groundwater level monitoring network and the rationale used to add new wells to the monitoring system. However, evaluation and monitoring of potential GDEs and ISWs were not considered in new well site selection. **Please modify the site selection criteria to include the potential to install new wells that will provide information to support the investigation of GDEs and ISWs. This modification should include locating new / existing wells that are appropriately screened to detect connectivity of GDEs and ISWs with the shallow zones of the unconfined**

aquifer, and 2) expanding information on the extent and location of shallow / perched areas within the unconfined aquifer.

[Section 5.5 Data Storage and Reporting (pp. 5-31 to 5-32)]

- The data management system (DMS) described in this section allows for upload and storage of information related to the development and implementation of the GSP. The types of information that will be stored in the DMS are listed. Other than groundwater elevations, quality, and site information, there is no information being stored specific to the monitoring and evaluation of GDEs or ISWs. **We recommend adding remote sensing information to this list to evaluate possible correlations of ecosystem response to potential declines in groundwater level or quality due to pumping. This can be accomplished by incorporating the GDE pulse tool, Sentinel data, evapotranspiration, or leaf area index.**

<u>Checklist Items 50 and 51 – Projects and Management Actions to Achieve Sustainability Goal (23 CCR §354.44)</u>

[Chapter 6 Projects and Management Actions to Achieve Sustainability (pp. 6-1 to 6-21)]

- **This chapter should identify the specific actions and schedules proposed to address data gaps in the hydrogeologic conceptual model, water budget and monitoring network.**

[Section 6.3 Projects (pp. 6-4 to 6-17)]

- This section identifies many important types of projects, including conveyance facilities modifications and construction of new facilities, above-ground surface water storage, intentional recharge basins, on-farm recharge, and aquifer storage and recovery through injection. However, the descriptions of Measurable Objectives for these projects only identifies benefits to water level and storage through changes in allocation, imports, surface water diversions, pumping allowances; and adding recharge projects or water banking. Since maintenance or recovery of groundwater levels, or construction of recharge facilities, may have potential environmental benefits it would be advantageous to demonstrate multiple benefits from a funding and prioritization perspective.
    - **For the projects already identified, please consider stating how ISWs and GDEs will benefit or be protected, or what other environmental benefits will accrue.**
    - If ISWs will not be adequately protected by those listed, **please include and describe additional management actions and projects targeted for protecting potential ISWs.**
    - Storage and recharge projects can be designed as multiple-benefit projects to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. In some cases, such facilities have been incorporated into local HCPs and NCCPs, more fully recognizing the value of the habitat that they provide and the species they support. On-farm recharge may benefit waterfowl during migration, and recreational hunting and birdwatching depending on the time of year that fields are flooded. For

  recharge projects, **please consider identifying if there is habitat value incorporated into the design and how the recharge ponds can be managed as multiple-benefit projects to benefit environmental users. Grant and funding opportunities for SGMA-related work may be available for multi-benefit projects that can address water quantity as well as provide environmental benefits. Please include environmental benefits and multiple benefits as criteria for assessing project priorities.**
  - The GSP states that recharged water typically remains in the unconfined aquifer, above the A-Clay, C-Clay and E-Clay; and that existing wells in the area will be used for extraction of stored water. There appear to be many unknowns as to the extent and location of perched and shallow areas in the unconfined aquifer, and the connectivity of those areas with the aquifer. In addition, there are currently only five wells that will be used to monitor shallow zones throughout the entire GSP area. There remains a fair amount of uncertainty as to how this would operate or affect potential GDEs and ISWs. **Please acknowledge these uncertainties and address 1) how these recharge operations could affect environmental beneficial users, 2) how ecosystems that could be affected by recharge in the unconfined aquifer, particularly above the A- and C-Clay layers will be monitored if there are only five wells.**
  - For examples of case studies on how to incorporate environmental benefits into groundwater projects, please visit our website: https://groundwaterresourcehub.org/case-studies/recharge-case-studies/

[Section 6.5 GSA Sustainable Methods (pp. 6-18 to 6-21)]

- The Subbasin potentially includes GDEs and ISWs (see our comments under Checklist Items 8-10 and 16-20 above) that are beneficial uses and users of groundwater and may include sensitive and protected resources. Protection of these environmental users and uses should be considered in establishing project priorities. In addition, and consistent with existing grant and funding guidelines for SGMA-related work, **priority should be given to multi-benefit projects that can address water quantity and quality as well as providing environmental benefits or benefits to disadvantaged communities.**

Attachment C

Freshwater Species Located in the Tulare Lake Subbasin

To assist in identifying the beneficial users of surface water necessary to assess the undesirable result "depletion of interconnected surface waters", Attachment C provides a list of freshwater species located within the Tulare Lake Subbasin. To produce the freshwater species list, we used ArcGIS to select features within the California Freshwater Species Database version 2.0.9 within the GSA's boundary. This database contains information on ~4,000 vertebrates, macroinvertebrates and vascular plants that depend on fresh water for at least one stage of their life cycle. The methods used to compile the California Freshwater Species Database can be found in Howard et al. 2015[5]. The spatial database contains locality observations and/or distribution information from ~400 data sources. The database is housed in the California Department of Fish and Wildlife's BIOS[6] as well as on TNC's science website[7].

		Legally Protected Status		
Scientific Name	**Common Name**	**Federal**	**State**	**Other**
BIRDS				
Actitis macularius	Spotted Sandpiper			
Aechmophorus clarkii	Clark's Grebe			
Aechmophorus occidentalis	Western Grebe			
Agelaius tricolor	Tricolored Blackbird	BCC	SSC	BSSC - First priority, BLM
Aix sponsa	Wood Duck			
Anas acuta	Northern Pintail			
Anas americana	American Wigeon			
Anas clypeata	Northern Shoveler			
Anas crecca	Green-winged Teal			
Anas cyanoptera	Cinnamon Teal			
Anas discors	Blue-winged Teal			
Anas platyrhynchos	Mallard			
Anas strepera	Gadwall			
Anser albifrons	Greater White-fronted Goose			
Ardea alba	Great Egret			
Ardea herodias	Great Blue Heron			
Aythya affinis	Lesser Scaup			
Aythya americana	Redhead		SSC	BSSC - Third priority
Aythya collaris	Ring-necked Duck			

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[5] Howard, J.K. et al. 2015. Patterns of Freshwater Species Richness, Endemism, and Vulnerability in California. PLoSONE, 11(7). Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130710

[6] California Department of Fish and Wildlife BIOS: https://www.wildlife.ca.gov/data/BIOS

[7] Science for Conservation: https://www.scienceforconservation.org/products/california-freshwater-species-database

Aythya marila	Greater Scaup			
Aythya valisineria	Canvasback		SSC	
Botaurus lentiginosus	American Bittern			
Bucephala albeola	Bufflehead			
Bucephala clangula	Common Goldeneye			
Butorides virescens	Green Heron			
Calidris alpina	Dunlin			
Calidris mauri	Western Sandpiper			
Calidris minutilla	Least Sandpiper			
Chen caerulescens	Snow Goose			
Chen rossii	Ross's Goose			
Chlidonias niger	Black Tern		SSC	BSSC - Second priority
Chroicocephalus philadelphia	Bonaparte's Gull			
Cistothorus palustris palustris	Marsh Wren			
Cygnus columbianus	Tundra Swan			
Dendrocygna bicolor	Fulvous Whistling-Duck		SSC	BSSC - First priority
Egretta thula	Snowy Egret			
Empidonax traillii	Willow Flycatcher	BCC	Endangered	USFS
Fulica americana	American Coot			
Gallinago delicata	Wilson's Snipe			
Gallinula chloropus	Common Moorhen			
Grus canadensis	Sandhill Crane			
Himantopus mexicanus	Black-necked Stilt			
Icteria virens	Yellow-breasted Chat		SSC	BSSC - Third priority
Limnodromus scolopaceus	Long-billed Dowitcher			
Lophodytes cucullatus	Hooded Merganser			
Megaceryle alcyon	Belted Kingfisher			
Mergus merganser	Common Merganser			
Mergus serrator	Red-breasted Merganser			
Numenius americanus	Long-billed Curlew			
Numenius phaeopus	Whimbrel			
Nycticorax nycticorax	Black-crowned Night-Heron			
Oxyura jamaicensis	Ruddy Duck			

Pelecanus erythrorhynchos	American White Pelican		SSC	BSSC - First priority
Phalacrocorax auritus	Double-crested Cormorant			
Phalaropus tricolor	Wilson's Phalarope			
Plegadis chihi	White-faced Ibis		Watch list	
Pluvialis squatarola	Black-bellied Plover			
Podiceps nigricollis	Eared Grebe			
Podilymbus podiceps	Pied-billed Grebe			
Porzana carolina	Sora			
Rallus limicola	Virginia Rail			
Recurvirostra americana	American Avocet			
Riparia riparia	Bank Swallow		Threatened	
Setophaga petechia	Yellow Warbler			BSSC - Second priority
Tachycineta bicolor	Tree Swallow			
Tringa melanoleuca	Greater Yellowlegs			
Tringa semipalmata	Willet			
Tringa solitaria	Solitary Sandpiper			
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		SSC	BSSC - Third priority
CRUSTACEANS				
Branchinecta lindahli	Versatile Fairy Shrimp			
HERPS				
Actinemys marmorata marmorata	Western Pond Turtle		SSC	ARSSC, BLM, USFS
Ambystoma californiense californiense	California Tiger Salamander	Threatened	Threatened	ARSSC
Anaxyrus boreas boreas	Boreal Toad			
Spea hammondii	Western Spadefoot	Under Review in the Candidate or Petition Process	SSC	ARSSC, BLM
Thamnophis sirtalis sirtalis	Common Gartersnake			
INSECTS AND OTHER INVERTEBRATES				
Ameletus amador	A Mayfly			
Ameletus spp.	Ameletus spp.			

Anax walsinghami	Giant Green Darner			
Archilestes californica	California Spreadwing			
Argia emma	Emma's Dancer			
Baetis adonis	A Mayfly			
Baetis spp.	Baetis spp.			
Caudatella columbiella				Not on any status lists
Caudatella spp.	Caudatella spp.			
Cinygmula gartrelli	A Mayfly			
Cinygmula spp.	Cinygmula spp.			
Doroneuria baumanni	Cascades Stone			
Drunella coloradensis	A Mayfly			
Drunella doddsii	A Mayfly			
Drunella spinifera	A Mayfly			
Drunella spp.	Drunella spp.			
Enallagma carunculatum	Tule Bluet			
Enallagma civile	Familiar Bluet			
Epeorus albertae	A Mayfly			
Epeorus spp.	Epeorus spp.			
Ephemerella tibialis	A Mayfly			
Erythemis collocata	Western Pondhawk			
Hetaerina americana	American Rubyspot			
Heterlimnius corpulentus				Not on any status lists
Ischnura barberi	Desert Forktail			
Ischnura cervula	Pacific Forktail			
Ischnura denticollis	Black-fronted Forktail			
Libellula saturata	Flame Skimmer			
Malenka bifurcata				Not on any status lists
Malenka spp.	Malenka spp.			
Optioservus canus	Pinnacles Optioservus Riffle Beetle		SSC	
Optioservus spp.	Optioservus spp.			
Oroperla barbara	Gilltail Springfly			
Pachydiplax longipennis	Blue Dasher			
Pantala flavescens	Wandering Glider			
Pantala hymenaea	Spot-winged Glider			
Parapsyche almota	A Caddisfly			
Parapsyche elsis	A Caddisfly			

Parapsyche spp.	Parapsyche spp.			
Rhionaeschna multicolor	Blue-eyed Darner			
Rhithrogena decora	A Mayfly			
Rhithrogena spp.	Rhithrogena spp.			
Rhyacophila acuminata	A Caddisfly			Not on any status lists
Rhyacophila spp.	Rhyacophila spp.			
Simulium anduzei				Not on any status lists
Simulium spp.	Simulium spp.			
Skwala americana	American Springfly			
Skwala spp.	Skwala spp.			
Sperchon spp.	Sperchon spp.			
Sperchon stellata				Not on any status lists
Sweltsa adamantea				Not on any status lists
Sweltsa spp.	Sweltsa spp.			
Telebasis salva	Desert Firetail			
Tramea lacerata	Black Saddlebags			
Zapada columbiana	Columbian Forestfly			
MAMMALS				
Castor canadensis	American Beaver			Not on any status lists
Ondatra zibethicus	Common Muskrat			Not on any status lists
MOLLUSKS				
Anodonta californiensis	California Floater		SSC	USFS
PLANTS				
Cephalanthus occidentalis	Common Buttonbush			
Cirsium crassicaule	Slough Thistle		SSC	CRPR - 1B.1, BLM
Cyperus erythrorhizos	Red-root Flatsedge			
Cyperus squarrosus	Awned Cyperus			
Eragrostis hypnoides	Teal Lovegrass			
Euthamia occidentalis	Western Fragrant Goldenrod			
Galium trifidum	Small Bedstraw			
Juncus effusus effusus	NA			
Lasthenia ferrisiae	Ferris' Goldfields		SSC	CRPR - 4.2

Ludwigia peploides peploides	NA			Not on any status lists
Myosurus minimus	NA			
Persicaria lapathifolia				Not on any status lists
Rorippa palustris palustris	Bog Yellowcress			
Salix gooddingii	Goodding's Willow			
FISHES				
Catostomus occidentalis occidentalis	Sacramento sucker			Least Concern - Moyle 2013
Cottus asper ssp. 1	Prickly sculpin			Least Concern - Moyle 2013
Lavinia exilicauda exilicauda	Sacramento hitch		SSC	Near-Threatened - Moyle 2013
Oncorhynchus mykiss irideus	Coastal rainbow trout			Least Concern - Moyle 2013
Oncorhynchus tshawytscha - CV fall	Central Valley fall Chinook salmon	SSC	SSC	Vulnerable - Moyle 2013
Oncorhynchus tshawytscha - CV late fall	Central Valley late fall Chinook salmon	SSC		Endangered - Moyle 2013
Orthodon microlepidotus	Sacramento blackfish			Least Concern - Moyle 2013
Ptychocheilus grandis	Sacramento pikeminnow			Least Concern - Moyle 2013

Notes:
ARSSC = At-Risk Species of Special Concern
BCC = Bird of Conservation Concern
BSSC = Bird Species of Special Concern
CRPR = California Rare Plant Rank
CS = Currently Stable
IUCN = International Union for Conservation of Nature
SSC = Species of Special Concern

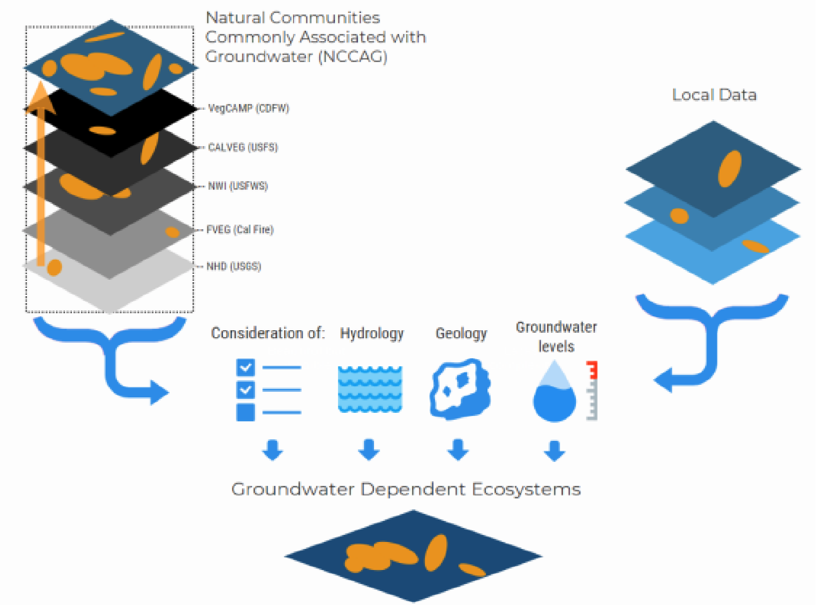
Attachment D

July 2019

IDENTIFYING GDEs UNDER SGMA

Best Practices for using the NC Dataset

The Sustainable Groundwater Management Act (SGMA) requires that groundwater dependent ecosystems (GDEs) be identified in Groundwater Sustainability Plans (GSPs). As a starting point, the Department of Water Resources (DWR) is providing the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) online[8] to help Groundwater Sustainability Agencies (GSAs), consultants, and stakeholders identify GDEs within individual groundwater basins. To apply information from the NC Dataset to local areas, GSAs should combine it with the best available science on local hydrology, geology, and groundwater levels to verify whether polygons in the NC dataset are likely supported by groundwater in an aquifer (Figure 1)[9]. This document highlights six best practices for using local groundwater data to confirm whether mapped features in the NC dataset are supported by groundwater.



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[8] *NC Dataset Online Viewer:* *https://gis.water.ca.gov/app/NCDatasetViewer/*

[9] California Department of Water Resources (DWR). 2018. Summary of the "Natural Communities Commonly Associated with Groundwater" Dataset and Online Web Viewer. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Statewide-Reports/Natural-Communities-Dataset-Summary-Document.pdf

The NC Dataset identifies vegetation and wetland features that are good indicators of a GDE. The dataset is comprised of 48 publicly available state and federal datasets that map vegetation, wetlands, springs, and seeps commonly associated with groundwater in California[10]. It was developed through a collaboration between DWR, the Department of Fish and Wildlife, and The Nature Conservancy (TNC). TNC has also provided detailed guidance on identifying GDEs from the NC dataset[11] on the Groundwater Resource Hub[12], a website dedicated to GDEs.

BEST PRACTICE #1. Establishing a Connection to Groundwater

Groundwater basins can be comprised of one continuous aquifer (Figure 2a) or multiple aquifers stacked on top of each other (Figure 2b). In unconfined aquifers (Figure 2a), using the depth-to-groundwater and the rooting depth of the vegetation is a reasonable method to infer groundwater dependence for GDEs. If groundwater is well below the rooting (and capillary) zone of the plants and any wetland features, the ecosystem is considered disconnected and groundwater management is not likely to affect the ecosystem (Figure 2d). However, it is important to consider local conditions (e.g., soil type, groundwater flow gradients, and aquifer parameters) and to review groundwater depth data from multiple seasons and water year types (wet and dry) because intermittent periods of high groundwater levels can replenish perched clay lenses that serve as the water source for GDEs (Figure 2c). Maintaining these natural groundwater fluctuations are important to sustaining GDE health.

Basins with a stacked series of aquifers (Figure 2b) may have varying levels of pumping across aquifers in the basin, depending on the production capacity or water quality associated with each aquifer. If pumping is concentrated in deeper aquifers, SGMA still requires GSAs to sustainably manage groundwater resources in shallow aquifers, such as perched aquifers, that support springs, surface water, domestic wells, and GDEs (Figure 2). This is because vertical groundwater gradients across aquifers may result in pumping from deeper aquifers to cause adverse impacts onto beneficial users reliant on shallow aquifers or interconnected surface water. The goal of SGMA is to sustainably manage groundwater resources for current and future social, economic, and environmental benefits. While groundwater pumping may not be currently occurring in a shallower aquifer, use of this water may become more appealing and economically viable in future years as pumping restrictions are placed on the deeper production aquifers in the basin to meet the sustainable yield and criteria. Thus, identifying GDEs in the basin should done irrespective to the amount of current pumping occurring in a particular aquifer, so that future impacts on GDEs due to new production can be avoided. A good rule of thumb to follow is: *if groundwater can be pumped from a well - it's an aquifer*.

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[10] *For more details on the mapping methods, refer to: Klausmeyer, K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, A. Lyons. 2018. Mapping Indicators of Groundwater Dependent Ecosystems in California: Methods Report. San Francisco, California. Available at: https://groundwaterresourcehub.org/public/uploads/pdfs/iGDE_data_paper_20180423.pdf*

[11] "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans" is available at: https://groundwaterresourcehub.org/gde-tools/gsp-guidance-document/

[12] *The Groundwater Resource Hub: www.GroundwaterResourceHub.org*

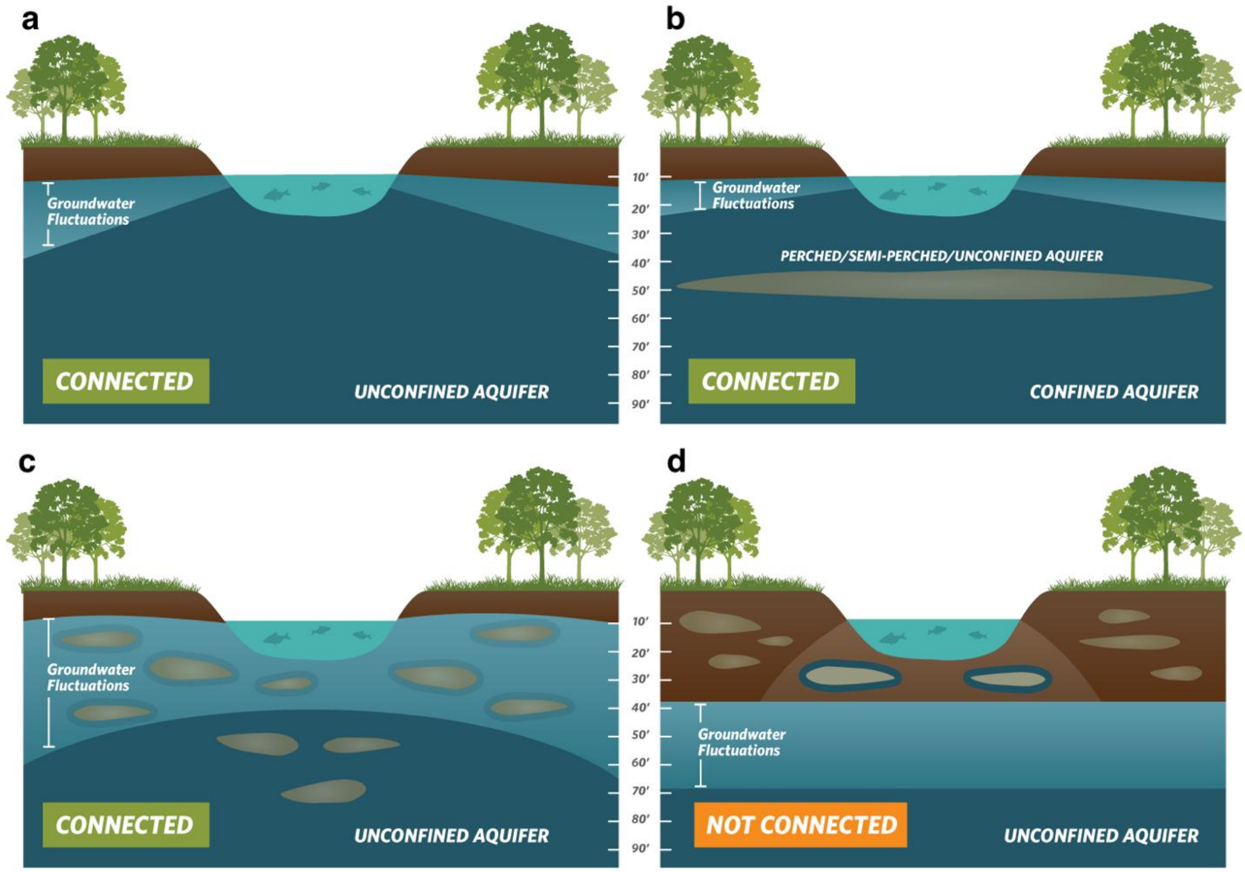

Figure 2. Confirming whether an ecosystem is connected to groundwater. Top: (a) Under the ecosystem is an unconfined aquifer with depth-to-groundwater fluctuating seasonally and interannually within 30 feet from land surface. **(b)** Depth-to-groundwater in the shallow aquifer is connected to overlying ecosystem. Pumping predominately occurs in the confined aquifer, but pumping is possible in the shallow aquifer. **Bottom: (c)** Depth-to-groundwater fluctuations are seasonally and interannually large, however, clay layers in the near surface prolong the ecosystem's connection to groundwater. **(d)** Groundwater is disconnected from surface water, and any water in the vadose (unsaturated) zone is due to direct recharge from precipitation and indirect recharge under the surface water feature. These areas are not connected to groundwater and typically support species that do not require access to groundwater to survive.

BEST PRACTICE #2. Characterize Seasonal and Interannual Groundwater Conditions

SGMA requires GSAs to describe current and historical groundwater conditions when identifying GDEs [23 CCR §354.16(g)]. Relying solely on the SGMA benchmark date (January 1, 2015) or any other single point in time to characterize groundwater conditions (e.g., depth-to-groundwater) is inadequate because managing groundwater conditions with data from one time point fails to capture the seasonal and interannual variability typical of California's climate. DWR's Best Management Practices document on water budgets[13] recommends using 10 years of water supply and water budget information to describe how historical conditions have impacted the operation of the basin within sustainable yield, implying that a baseline[14] could be determined based on data between 2005 and 2015. Using this or a similar time period, depending on data availability, is recommended for determining the depth-to-groundwater.

GDEs depend on groundwater levels being close enough to the land surface to interconnect with surface water systems or plant rooting networks. The most practical approach[15] for a GSA to assess whether polygons in the NC dataset are connected to groundwater is to rely on groundwater elevation data. As detailed in TNC's GDE guidance document[4], one of the key factors to consider when mapping GDEs is to contour depth-to-groundwater in the aquifer that is supporting the ecosystem (see Best Practice #5).

Groundwater levels fluctuate over time and space due to California's Mediterranean climate (dry summers and wet winters), climate change (flood and drought years), and subsurface heterogeneity in the subsurface (Figure 3). Many of California's GDEs have adapted to dealing with intermittent periods of water stress, however if these groundwater conditions are prolonged, adverse impacts to GDEs can result. While depth-to-groundwater levels within 30 feet[4] of the land surface are generally accepted as being a proxy for confirming that polygons in the NC dataset are supported by groundwater, it is highly advised that fluctuations in the groundwater regime be characterized to understand the seasonal and interannual groundwater variability in GDEs. Utilizing groundwater data from one point in time can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Time series data on groundwater elevations and depths are available on the SGMA Data Viewer[16]. However, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP until data gaps are reconciled in the monitoring network (see Best Practice #6).

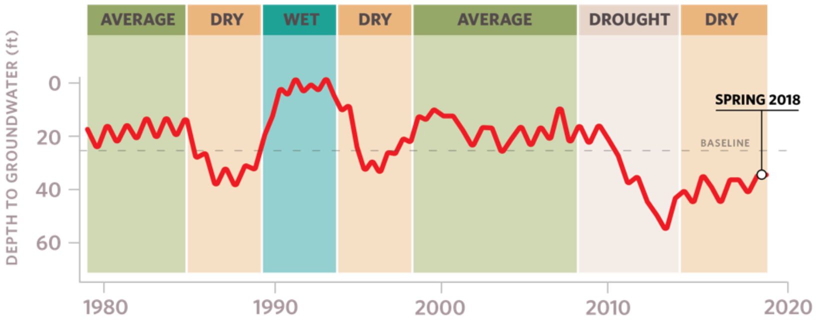

Figure 3. Example seasonality and interannual variability in depth-to-groundwater over time. Selecting one point in time, such as Spring 2018, to characterize groundwater conditions in GDEs fails to capture what groundwater conditions are necessary to maintain the ecosystem status into the future so adverse impacts are avoided.

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[13] DWR. 2016. Water Budget Best Management Practice. Available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Water_Budget_Final_2016-12-23.pdf

[14] *Baseline is defined under the GSP regulations as "historic information used to project future conditions for hydrology, water demand, and availability of surface water and to evaluate potential sustainable management practices of a basin." [23 CCR §351(e)]*

[15] Groundwater reliance can also be confirmed via stable isotope analysis and geophysical surveys. For more information see The GDE Assessment Toolbox (Appendix IV, GDE Guidance Document for GSPs[4]).

[16] *SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer*

BEST PRACTICE #3. Ecosystems Often Rely on Both Groundwater and Surface Water

GDEs are plants and animals that rely on groundwater for all or some of its water needs, and thus can be supported by multiple water sources. The presence of non-groundwater sources (e.g., surface water, soil moisture in the vadose zone, applied water, treated wastewater effluent, urban stormwater, irrigated return flow) within and around a GDE does not preclude the possibility that it is supported by groundwater, too. SGMA defines GDEs as "ecological communities and species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" [23 CCR §351(m)]. Hence, depth-to-groundwater data should be used to identify whether NC polygons are supported by groundwater and should be considered GDEs. In addition, SGMA requires that significant and undesirable adverse impacts to beneficial users of surface water be avoided. Beneficial users of surface water include environmental users such as plants or animals[17], which therefore must be considered when developing minimum thresholds for depletions of interconnected surface water.

GSAs are only responsible for impacts to GDEs resulting from groundwater conditions in the basin, so if adverse impacts to GDEs result from the diversion of applied water, treated wastewater, or irrigation return flow away from the GDE, then those impacts will be evaluated by other permitting requirements (e.g., CEQA) and may not be the responsibility of the GSA. However, if adverse impacts occur to the GDE due to changing groundwater conditions resulting from pumping or groundwater management activities, then the GSA would be responsible (Figure 4).

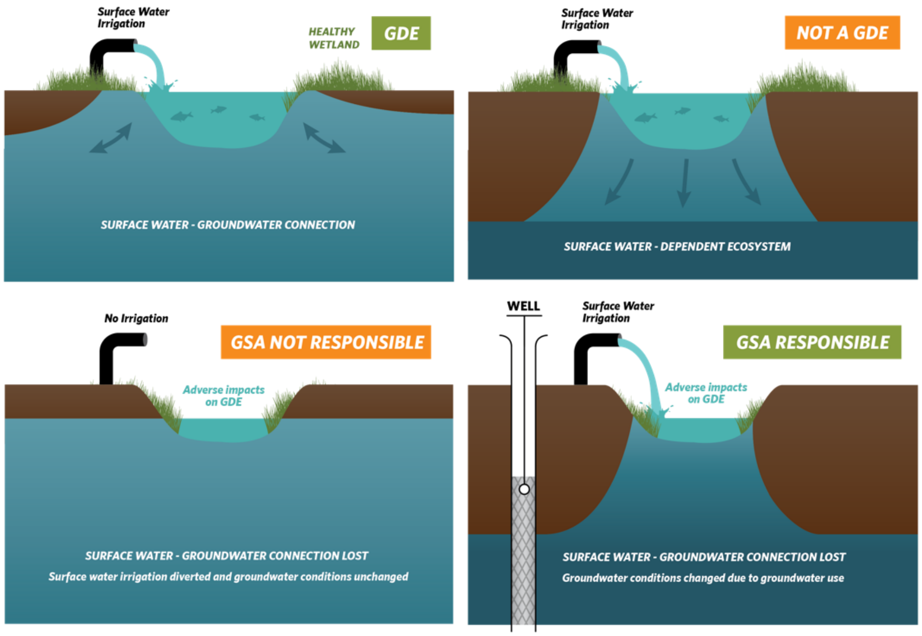

Figure 4. Ecosystems often depend on multiple sources of water. Top: (Left) Surface water and groundwater are interconnected, meaning that the GDE is supported by both groundwater and surface water. **(Right)** Ecosystems that are only reliant on non-groundwater sources are not groundwater-dependent. **Bottom: (Left)** An ecosystem that was once dependent on an interconnected surface water, but loses access to groundwater solely due to surface water diversions may not be the GSA's responsibility. **(Right)** Groundwater dependent ecosystems once dependent on an interconnected surface water system, but loses that access due to groundwater pumping is the GSA's responsibility.

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[17] *For a list of environmental beneficial users of surface water by basin, visit: https://groundwaterresourcehub.org/gde-tools/environmental-surface-water-beneficiaries/*

BEST PRACTICE #4. Select Representative Groundwater Wells

Identifying GDEs in a basin requires that groundwater conditions are characterized to confirm whether polygons in the NC dataset are supported by the underlying aquifer. To do this, proximate groundwater wells should be identified to characterize groundwater conditions (Figure 5). When selecting representative wells, it is particularly important to consider the subsurface heterogeneity around NC polygons, especially near surface water features where groundwater and surface water interactions occur around heterogeneous stratigraphic units or aquitards formed by fluvial deposits. The following selection criteria can help ensure groundwater levels are representative of conditions within the GDE area:

- Choose wells that are within 5 kilometers (3.1 miles) of each NC Dataset polygons because they are more likely to reflect the local conditions relevant to the ecosystem. If there are no wells within 5km of the center of a NC dataset polygon, then there is insufficient information to remove the polygon based on groundwater depth. Instead, it should be retained as a potential GDE until there are sufficient data to determine whether or not the NC Dataset polygon is supported by groundwater.

- Choose wells that are screened within the surficial unconfined aquifer and capable of measuring the true water table.

- Avoid relying on wells that have insufficient information on the screened well depth interval for excluding GDEs because they could be providing data on the wrong aquifer. This type of well data should not be used to remove any NC polygons.

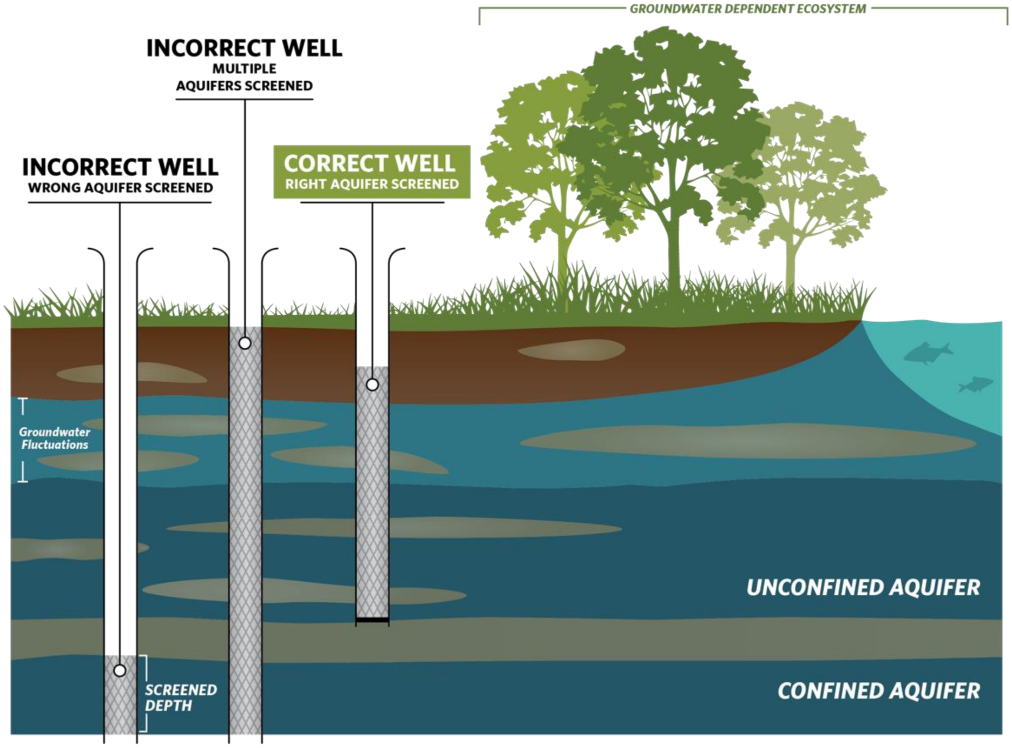

Figure 5. Selecting representative wells to characterize groundwater conditions near GDEs.

BEST PRACTICE #5. Contouring Groundwater Elevations

The common practice to contour depth-to-groundwater over a large area by interpolating measurements at monitoring wells is unsuitable for assessing whether an ecosystem is supported by groundwater. This practice causes errors when the land surface contains features like stream and wetland depressions because it assumes the land surface is constant across the landscape and depth-to-groundwater is constant below these low-lying areas (Figure 6a). A more accurate approach is to interpolate **groundwater elevations** at monitoring wells to get groundwater elevation contours across the landscape. This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM)[18] to estimate depth-to-groundwater contours across the landscape (Figure b; Figure 7). This will provide a much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found.

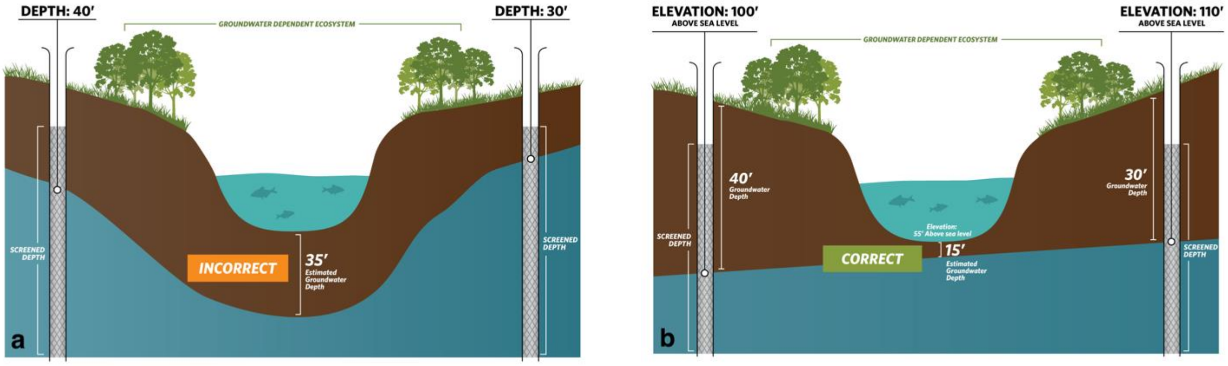

Figure 6. Contouring depth-to-groundwater around surface water features and GDEs. (a) Groundwater level interpolation using depth-to-groundwater data from monitoring wells. **(b)** Groundwater level interpolation using groundwater elevation data from monitoring wells and DEM data.

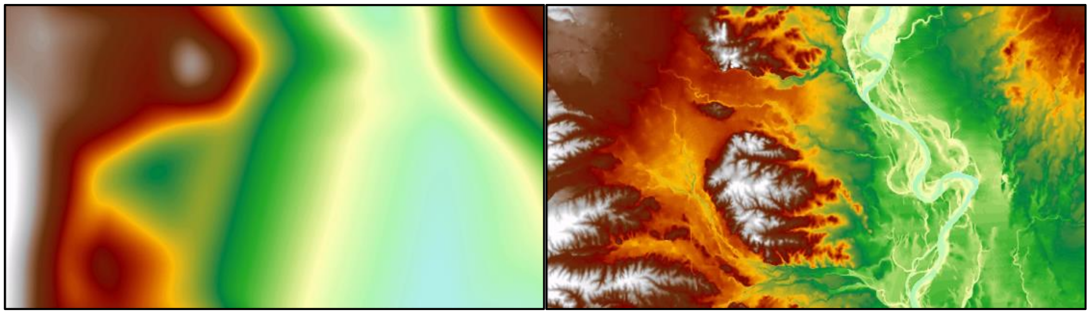

Figure 7. Depth-to-groundwater contours in Northern California. (Left) Contours were interpolated using depth-to-groundwater measurements determined at each well. **(Right)** Contours were determined by interpolating groundwater elevation measurements at each well and superimposing ground surface elevation from DEM spatial data to generate depth-to-groundwater contours. The image on the right shows a more accurate depth-to-groundwater estimate because it takes the local topography and elevation changes into account.

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[18] USGS Digital Elevation Model data products are described at: https://www.usgs.gov/core-science-systems/ngp/3dep/about-3dep-products-services and can be downloaded at: https://iewer.nationalmap.gov/basic/

BEST PRACTICE #6. Best Available Science

Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decisions, and using the data collected through monitoring programs to revise decisions in the future. In many situations, the hydrologic connection of NC dataset polygons will not initially be clearly understood if site-specific groundwater monitoring data are not available. If sufficient data are not available in time for the 2020/2022 plan, **The Nature Conservancy strongly advises that questionable polygons from the NC dataset be included in the GSP until data gaps are reconciled in the monitoring network.** Erring on the side of caution will help minimize inadvertent impacts to GDEs as a result of groundwater use and management actions during SGMA implementation.

KEY DEFINITIONS

Groundwater basin is an aquifer or stacked series of aquifers with reasonably well-defined boundaries in a lateral direction, based on features that significantly impede groundwater flow, and a definable bottom. *23 CCR §341(g)(1)*

Groundwater dependent ecosystem (GDE) are ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. *23 CCR §351(m)*

Interconnected surface water (ISW) surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted. *23 CCR §351(o)*

Principal aquifers are aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. *23 CCR §351(aa)*

ABOUT US

The Nature Conservancy is a science-based nonprofit organization whose mission is *to conserve the lands and waters on which all life depends*. To support successful SGMA implementation that meets the future needs of people, the economy, and the environment, TNC has developed tools and resources (www.groundwaterresourcehub.org) intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

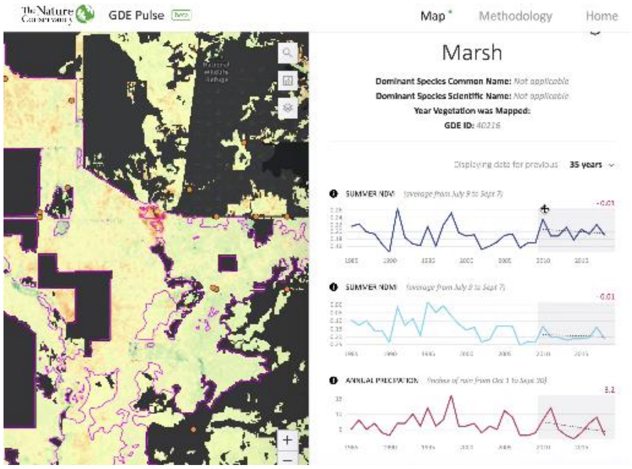
Attachment E

GDE Pulse

A new, free online tool that allows Groundwater Sustainability Agencies to assess changes in groundwater dependent ecosystem (GDE) health using satellite, rainfall, and groundwater data.

The Nature Conservancy
Protecting nature. Preserving life.®

Visit
https://gde.codefornature.org/



Marsh

Dominant Species Common Name: Not applicable
Dominant Species Scientific Name: Not applicable
Year Vegetation was Mapped:
GDE ID: 40216

Displaying data for previous 35 years

Remote sensing data from satellites has been used to monitor the health of vegetation all over the planet. GDE pulse has compiled 35 years of satellite imagery from NASA's Landsat mission for every polygon in the Natural Communities Commonly Associated with Groundwater Dataset[19]. The following datasets are included:

Normalized Difference Vegetation Index (NDVI) is a satellite-derived index that represents the greenness of vegetation. Healthy green vegetation tends to have a higher NDVI, while dead leaves have a lower NDVI. We calculated the average NDVI during the driest part of the year (July - Sept) to estimate vegetation health when the plants are most likely dependent on groundwater.

Normalized Difference Moisture Index (NDMI) is a satellite-derived index that represents water content in vegetation. NDMI is derived from the Near-Infrared (NIR) and Short-Wave Infrared (SWIR) channels. Vegetation with adequate access to water tends to have higher NDMI, while vegetation that is water stressed tends to have lower NDMI. We calculated the average NDVI during the driest part of the year (July–September) to estimate vegetation health when the plants are most likely dependent on groundwater.

Annual Precipitation is the total precipitation for the water year (October 1st – September 30th) from the PRISM dataset[20]. The amount of local precipitation can affect vegetation with more precipitation generally leading to higher NDVI and NDMI.

Depth to Groundwater measurements provide an indication of the groundwater levels and changes over time for the surrounding area. We used groundwater well measurements from nearby (<1km) wells to estimate the depth to groundwater below the GDE based on the average elevation of the GDE (using a digital elevation model) minus the measured groundwater surface elevation.

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[19] The Natural Communities Commonly Associated with Groundwater Dataset is hosted on the California Department of Water Resources' website: https://gis.water.ca.gov/app/NCDatasetViewer/#

[20] The PRISM dataset is hosted on Oregon State University's website: http://www.prism.oregonstate.edu/

California Poultry
FEDERATION
4640 Spyres Way, Suite 4 | Modesto, CA 95356 | Phone: (209) 576-6355 | Fax: (209) 576-6119 | www.cpif.org

VIA E-MAIL (lsales@ppeng.com)

November 27, 2019

Members of the Tulare Lake Subbasin Board
of Directors
c/o Laurie Sales, Project Administrator
Southwest Kings GSA
286 West Cromwell Avenue
Fresno, California 93711

Re: Tulare Lake Subbasin GSP

Dear Board Members:

The California Poultry Federation ("CPF") appreciates the opportunity to comment on the draft Tulare Lake Subbasin Groundwater Sustainability Plan (the "Draft GSP"). CPF is the trade association for California's diverse and dynamic poultry industry. Our members include growers, hatchers, breeders, and processors that work with chickens, turkeys, ducks, game birds, and squab. Water is essential for all of them—both for nutrition and for maintaining sanitary conditions. CPF therefore supports effective measures to assure reliable water supplies.

In this regard, CPF recommends that each Tulare Lake Subbasin Groundwater Sustainability Agency ("GSA") make supply augmentation its top priority. We were encouraged to see that the Draft GSP incorporated storage, recharge, and conveyance projects and that Table 7-1 listed consideration of incentives as a means of encouraging participation in augmentation. Additional extraction rights in particular would be an excellent method of increasing landowner support for supply projects.

But we are concerned that the Draft GSP also emphasized substantial demand management without explaining precisely how that would be done. The listed management actions are "conceptual" (Draft GSP page 6-2) and Appendix E, which is to contain GSA appendices, is blank. Nor does the Draft GSP appear to set out any principles—which should include minimizing economic impact, maintaining established water rights, and incentivizing investment in water supply infrastructure—for developing demand management measures. The public will need to have meaningful opportunities to participate in the development of any specific demand management measures, which means that there must be sufficient time to evaluate supporting information and submit written comments. That is especially important in light of the finding (at Draft GSP page 7-7) that "[a]t this time there is not sufficient information to develop a financial impact due to demand reduction." CPF expects all the Subbasin GSAs to do their best to ameliorate economic impacts by adopting implementation measures that are cost-effective.

One other point about public comment deserves mention. It was difficult to ascertain when written comments on the Draft GSP were due and where they should be sent. The Subbasin GSAs should establish, utilize, and publicize one central clearinghouse available through the Internet for disseminating information about further proposed actions in the Subbasin and receiving written comments.

Please contact me if you need any further information about these comments.

Very truly yours,

Bill Mattos

Bill Mattos
President

CLEAN WATER ACTION | CLEAN WATER FUND

Local Government Commission
Leaders for Livable Communities

Audubon | CALIFORNIA

The Nature Conservancy
Protecting nature. Preserving life.™

December 1, 2019

Sent via email to djackson@tcwater.org and dmelville@ppeng.com

Re: Comments on Draft Groundwater Sustainability Plan for Tri County Water Authority Tulare Lake Groundwater Basin

To Whom It May Concern,

On behalf of the above-listed organizations, we would like to offer the attached comments on the draft Groundwater Sustainability Plan for the Tri County Water Authority Tulare Lake Groundwater Basin. Our organizations are deeply engaged in and committed to the successful implementation of the Sustainable Groundwater Management Act (SGMA) because we understand that groundwater is a critical piece of a resilient California water portfolio, particularly in light of our changing climate. Because California's water and economy are interconnected, the sustainable management of each basin is of interest to both local communities and the state as a whole. This letter adopts by reference the comments and recommendations submitted by The Nature Conservancy on this draft plan.

Our organizations have significant expertise in the environmental needs of groundwater and the needs of disadvantaged communities.

- The Nature Conservancy, in collaboration with state agencies, has developed several tools[1] for identifying groundwater dependent ecosystems in every SGMA groundwater basin and has made that tool available to each Groundwater Sustainability Agency.
- Local Government Commission supports leadership development, performs community engagement, and provides technical assistance dealing with groundwater management and other resilience-related topics at the local and regional scales; we provide guidance and resources for statewide applicability to the communities and GSAs we are working with directly in multiple groundwater basins.
- Audubon California is an expert in understanding wetlands and their role in groundwater recharge and applying conservation science to develop multiple-benefit solutions for sustainable groundwater management.
- Clean Water Action and Clean Water Fund are sister organizations that have deep expertise in the provision of safe drinking water, particularly in California's small disadvantaged communities, and co-authored a report on public and stakeholder engagement in SGMA[2].

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[1] https://groundwaterresourcehub.org/

[2] https://www.cleanwater.org/publications/collaborating-success-stakeholder-engagement-sustainable-groundwater-management-act

Because of the number of draft plans being released and our interest in reviewing every plan, we have identified key plan elements that are necessary to ensure that each plan adequately addresses essential requirements of SGMA. A summary review of your plan using our evaluation framework is attached to this letter as Appendix A. Our hope is that you can use our feedback to improve your plan before it is submitted in January 2020.

This review does not look at data quality but instead looks at how data was presented and used to identify and address the needs of disadvantaged communities (DACs), drinking water and the environment. In addition to informing individual groundwater sustainability agencies of our analysis, we plan to aggregate the results of our reviews to identify trends in GSP development, compare plans and determine which basins may require greater attention from our organizations.

Key Indicators

Appendix A provides a list of the questions we posed, how the draft plan responds to those questions and an evaluation by element of major issues with the plan. Below is a summary by element of the questions used to evaluate the plan.

1. Identification of Beneficial Users. This element is meant to ascertain whether and how DACs and groundwater-dependent ecosystems (GDEs) were identified, what standards and guidance were used to determine groundwater quality conditions and establish minimum thresholds for groundwater quality, and how environmental beneficial users and stakeholders were engaged through the development of the draft plan.
2. Communications plan. This element looks at the sufficiency of the communications plan in identifying ongoing stakeholder engagement during plan implementation, explicit information about how DACs were engaged in the planning process and how stakeholder input was incorporated into the GSP process and decision-making.
3. Maps related to Key Beneficial Uses. This element looks for maps related to drinking water users, including the density, location and depths of public supply and domestic wells; maps of GDE and interconnected surface waters with gaining and losing reaches; and monitoring networks.
4. Water Budgets. This element looks at how climate change is explicitly incorporated into current and future water budgets; how demands from urban and domestic water users were incorporated; and whether the historic, current and future water demands of native vegetation and wetlands are included in the budget.
5. Management areas and Monitoring Network. This element looks at where, why and how management areas are established, as well what data gaps have been identified and how the plan addresses those gaps.
6. Measurable Objectives and Undesirable Results. This element evaluates whether the plan explicitly considers the impacts on DACs, GDEs and environmental beneficial users in the development of Undesirable Results and Measurable Objectives. In addition, it examines whether stakeholder input was solicited from these beneficial users during the development of those metrics.
7. Management Actions and Costs. This element looks at how identified management actions impact DACs, GDEs and interconnected surface water bodies; whether mitigation for impacts to DACs is discussed or funded; and what efforts will be made to fill identified data gaps in the first five years of the plan. Additionally, this element asks whether any changes to local ordinances or land use plans are included as management actions.

Conclusion

We know that SGMA plan development and implementation is a major undertaking, and we want every basin to be successful. We would be happy to meet with you to discuss our evaluation as you finalize your Plan for submittal to DWR. Feel free to contact Suzannah Sosman at suzannah@aginnovations.org for more information or to schedule a conversation.

Sincerely,

Jennifer Clary
Water Program Manager
Clean Water Action/Clean Water Fund

Samantha Arthur
Working Lands Program Director
Audubon California

Sandi Matsumoto
Associate Director, California Water Program
The Nature Conservancy

Danielle V. Dolan

Danielle V. Dolan
Water Program Director
Local Government Commission

Appendix A
Review of Public Draft GSP

Groundwater Basin/Subbasin: Tulare Lake Subbasin (DWR 5-22-12)
GSA: Five GSAs (Mid-Kings River, South Fork Kings, Southwest Kings, El Rico, and the Tri-County Water Authority GSAs)
GSP Date: August 2019 Public Review Draft

1. Identification of Beneficial Users

Were key beneficial users identified and engaged?

Selected relevant requirements and guidance:
GSP Element 2.1.5, "Notice & Communication" (§354.10):
(a) A description of the beneficial uses and users of groundwater in the basin, including the land uses and property interests potentially affected by the use of groundwater in the basin, the types of parties representing those interests, and the nature of consultation with those parties.
GSP Element 2.2.2, "Groundwater Conditions" (§354.16):
(d) Groundwater quality issues that may affect the supply and beneficial uses of groundwater, including a description and map of the location of known groundwater contamination sites and plumes.
(f) Identification of interconnected surface water systems within the basin and an estimate of the quantity and timing of depletions of those systems, utilizing data available from the Department, as specified in Section 353.2, or the best available information.
(g) Identification of groundwater dependent ecosystems within the basin, utilizing data available from the Department, as specified in Section 353.2, or the best available information.
GSP Element 3.3, "Minimum Thresholds" (§354.28):
(4) How minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests.

Review Criteria		Yes	No	N/A	Relevant Info per GSP	Location (Section, Page[1])
1. Do beneficial users (BUs) identified within the GSP area include:	a. Disadvantaged Communities (DACs)	**X**			From Table 2-4, DACs include Armona, Home Garde, Hardwick, Community of Stratford, Kettleman City, and City of Corcoran.	Table 2-4, Page 94
	b. Tribes	**X**			"The only Native American Tribe within the Tulare Lake Subbasin boundary is the Santa Rosa Rancheria Tachi-Yokut Tribe. The Tachi-Yokut Tribe was invited to participate in GSP development via a letter sent on June 28, 2016 by the then Upper Tulare Lake GSA MOU Group (now known as the South Fork Kings GSA). A copy of the letter is included in the Appendix A of the Tulare Lake Subbasin GSAs' Communication & Engagement Plan. The Tribe's EPA director attended one of the South Fork Kings GSA's board meetings, and has been on their Interested Parties List since April 2017, receiving regular updates about GSP development within the SFKGSA and the Tulare Lake Subbasin. In addition, a Sacred Lands File & Native American Contacts List Request was also sent to the Native American Heritage Commission."	Appendix B, Page 373
	c. Small community public water systems (<3,300 connections)	**X**			Public water systems such as Armona CSD and Home Garden CSD are included in Table 2-4. It is not clear from the GSP which systems have fewer than 3,300 connections.	Table 2-4, Page 94
2. What data were used to identify presence or absence	d. DWR DAC Mapping Tool[2]		**X**		Data source is not clear from the GSP.	
	i. Census Places		**X**			

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[1] Page numbers refer to the page of the PDF.
[2] DWR DAC Mapping Tool: https://gis.water.ca.gov/app/dacs/

of DACs?	ii. Census Block Groups		X			
	iii. Census Tracts		X			
	e. Other data source		X			
3. Groundwater Conditions section includes discussion of:	f. Drinking Water Quality	X			"Currently, as described in Section 5.4.3, groundwater quality in the northern portion of the Subbasin encompassing the Mid-Kings River GSA and South Fork Kings GSA is generally excellent for irrigation and satisfactory for municipal and industrial use (KCWD 2011). South of Stratford and Corcoran, groundwater quality diminishes, and portions of the Tulare Lakebed have been undesignated from being suitable for municipal, domestic, agricultural irrigation, and stock watering supply. Shallow groundwater contamination from fuel hydrocarbons, agricultural chemicals, or solvents are localized in the urbanized areas of Lemoore and Hanford and some smaller communities. Limited regional data is available for determining current nutrient concentrations based on groundwater depth and location. As discussed in Section 3.2.5, shallow groundwater can have elevated concentrations of nitrates and TDS, but the majority of the region is generally below Maximum Contaminant Levels (MCLs)."	4.4.1.4, Page 248
	g. California Maximum Contaminant Levels (CA MCLs)[3] (or Public Health Goals where MCL does not exist, e.g. Chromium VI)		X		See above. MCLs are only briefly discussed.	4.4.1.4, Page 248
4. What local, state, and federal standards or plans were used to assess drinking water BUs in the development of Minimum Thresholds (MTs)?	h. Office of Environmental Health Hazard Assessment Public Health Goal (OEHHA PHGs)[4]		X			
	i. CA MCLs[3]	X			"The basic authority of the GSAs is to locally determine the sustainable amount of groundwater that can be pumped and to manage the transition from the current groundwater usage to a groundwater usage that is sustainable. Also, GSAs do not have the authority to modify surface water rights. Federal and state agencies provide direct oversight of quality and set their own appropriate thresholds such as Maximum Contaminant Levels for drinking water. These will be utilized by the Subbasin for MOs and MTs. For these reasons, the local GSAs will focus on water quality issues that are related to groundwater pumping rather than on issues related to contamination." "MTs will follow the state, federal, and local standards related to the relevant sustainability indicators set by the coalitions."	4.2.4, Page 239 4.4.2.4, Page 249
	j. Water Quality Objectives (WQOs) in Regional Water Quality Control Plans		X			
	k. Sustainable Communities Strategies/ Regional Transportation Plans[5]		X			

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[3] CA MCLs: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html
[4] OEHHA PHGs: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLsandPHGs.html
[5] CARB: https://ww2.arb.ca.gov/resources/documents/scs-evaluation-resources

	l. County and/or City General Plans, Zoning Codes and Ordinances[6]		**X**			

Summary/ Comments
It is recommended that the GSP clearly identify the data sources that were used to identify the presence of DACs, and include as maps showing the locations of DACs. The representative monitoring networks should be shown on maps that include the location of DACs so that one can assess the networks' ability to monitor potential impacts to these sensitive beneficial users.

The GSP should provide much more thorough information on what the water quality MTs/MOs are and what standards were used in the development of MTs/MOs. Such information is crucial to the drinking water beneficial users in the subbasin.

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[6] OPR General Plan Guidelines: http://www.opr.ca.gov/planning/general-plan/

2. Communications Plan

How were key beneficial users engaged and how was their input incorporated into the GSP process and decisions?

Selected relevant requirements and guidance:
GSP Element 2.1.5, "Notice & Communication" (§354.10):
Each Plan shall include a summary of information relating to notification and communication by the Agency with other agencies and interested parties including the following:
(c) Comments regarding the Plan received by the Agency and a summary of any responses by the Agency.
(d) A communication section of the Plan that includes the following:
(1) An explanation of the Agency's decision-making process.
(2) Identification of opportunities for public engagement and a discussion of how public input and response will be used.
(3) A description of how the Agency encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin.
(4) The method the Agency shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

DWR Guidance Document for GSP Stakeholder Communication and Engagement[7]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Is a Stakeholder Communication and Engagement Plan (SCEP) included?	X			Appendix B: Stakeholder Communication and Engagement Plan (no date)	Appendix B, Page 368
2. Does the SCEP or GSP identify that ongoing engagement will be conducted during GSP implementation?	X			"During the implementation phase, communication and engagement efforts focus on educational and informational awareness of the requirements and processes for reaching groundwater sustainability as set forth in the submitted GSP. Active involvement of all stakeholders is encouraged during implementation, and public notices are required for any public meetings, as well as prior to imposing or increasing any fees. Public outreach is also completed by the individual GSAs with collaborative efforts when target audiences span more than one GSA boundary."	2.5.1, Page 73
3. Does the SCEP or GSP specifically identify how DAC beneficial users were engaged in the planning process?	X			"Communication and educational outreach efforts with disadvantaged communities (DAC) and severely disadvantaged communities (SDAC) was needed for the development and implementation of the Tulare Lake Subbasin's GSP according to the Department of Water Resources' Best Management Practices. Information used to communicate to and engage the DACs in the GSP process, included an explanation of SGMA and soliciting feedback. GSA representatives regularly communicated with DACs and gave presentations on SGMA to community representatives, while gathering their feedback and input. By including DACs and SDACs in communication efforts during the development, public review and implementation phases of the GSP, residents were more likely to participate and provide feedback that could be crucial to long-term solutions for groundwater sustainability within their communities.	Appendix B, Page 374, 377

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[7] DWR Guidance Document for GSP Stakeholder Communication and Engagement
https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Guidance-Document-for-Groundwater-Sustainability-Plan---Stakeholder-Communication-and-Engagement.pdf

				Any feedback received from DAC/SDAC residents was reviewed and evaluated by the Tulare Lake Subbasin GSAs during the GSP development and public review phases.” “For outreach to DACs/SDACs, fliers were available in both English and Spanish languages.”	
4. Does the SCEP or GSP explicitly describe how stakeholder input was incorporated into the GSP process and decisions?	X			“As active stakeholders, members of the Boards of Directors and Stakeholder/Advisory Committees are direct representatives of their districts, communities and industries, and they continually gather feedback/input, and the concerns/needs of their constituents and report back to their respective meetings. Any stakeholder input received was reviewed by the GSA and Subbasin technical teams and taken into consideration during GSP development.” “Stakeholder input was utilized during the GSA formation phase, as beneficial users and stakeholders with interests in groundwater usage within the GSAs’ boundaries were notified via public meeting notices as soon as the process began.” “With the goal of having the draft GSP before the end of the third quarter in 2019, 2018 was primarily the technical development of the plan, while working with GSA Boards of Directors, technical teams/committees, and GSA management at the subbasin level, as well as stakeholders for feedback and input. During the last quarter of 2018, the first round of public outreach meetings and interaction with stakeholder groups and other community organizations and entities was held with the purpose of educating and informing stakeholders about SGMA and the GSP process, while also soliciting feedback and input from these groups to consider and possibly include feedback and input into the GSP. Public outreach for this phase was completed by the individual GSAs.” “Once the draft of the GSP was completed in September 2019, the public review process began. A 90-day comment period was held, with the GSP draft posted on the Tulare Lake Subbasin GSAs’ websites for all stakeholders to conveniently download and review and provide comments. Outreach meetings were held during this phase both on subbasin-wide level, as well as by individual GSAs. These meetings focused on an overview of the GSP content, while giving stakeholders a public forum to provide their feedback and comments.” Outreach tracking is also presented in tables by each GSA in Appendix D.	Appendix B, Page 370

Summary/ Comment

It is important that stakeholder engagement be maintained through the development of future projects and management actions and other SGMA compliance and implementation steps.

3. Maps Related to Key Beneficial Uses

Were best available data sources used for information related to key beneficial users?

Selected relevant requirements and guidance:
GSP Element 2.1.4 “Additional GSP Elements” (§354.8):
Each Plan shall include a description of the geographic areas covered, including the following information:
(a) One or more maps of the basin that depict the following, as applicable:
(5) The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information.

GSP Element 3.5 Monitoring Network (§354.34)
(b) Each Plan shall include a description of the monitoring network objectives for the basin, including an explanation of how the network will be developed and implemented to monitor groundwater and related surface conditions, and the interconnection of surface water and groundwater, with sufficient temporal frequency and spatial density to evaluate the affects and effectiveness of Plan implementation. The monitoring network objectives shall be implemented to accomplish the following:
(c) Each monitoring network shall be designed to accomplish the following for each sustainability indicator:
(1) Chronic Lowering of Groundwater Levels. Demonstrate groundwater occurrence, flow directions, and hydraulic gradients between principal aquifers and surface water features by the following methods:
(A) A sufficient density of monitoring wells to collect representative measurements through depth-discrete perforated intervals to characterize the groundwater table or potentiometric surface for each principal aquifer.
(4) Degraded Water Quality. Collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues.
(6) Depletions of Interconnected Surface Water. Monitor surface water and groundwater, where interconnected surface water conditions exist, to characterize the spatial and temporal exchanges between surface water and groundwater, and to calibrate and apply the tools and methods necessary to calculate depletions of surface water caused by groundwater extractions. The monitoring network shall be able to characterize the following:
(A) Flow conditions including surface water discharge, surface water head, and baseflow contribution.
(B) Identifying the approximate date and location where ephemeral or intermittent flowing streams and rivers cease to flow, if applicable.
(C) Temporal change in conditions due to variations in stream discharge and regional groundwater extraction.
(D) Other factors that may be necessary to identify adverse impacts on beneficial uses of the surface water.
(f) The Agency shall determine the density of monitoring sites and frequency of measurements required to demonstrate short-term, seasonal, and long-term trends based upon the following factors:
(3) Impacts to beneficial uses and users of groundwater and land uses and property interests affected by groundwater production, and adjacent basins that could affect the ability of that basin to meet the sustainability goal.

Review Criteria		Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP Include Maps Related to Drinking Water Users?	a. Well Density		X		No maps are provided. Page 47 indicates that there are 75 public supply wells in the Subbasin and the total number of wells is about 3,871.	Section 2, Page 47
	b. Domestic and Public Supply Well Locations & Depths		X		The GSP does not appear to include information on domestic and public supply well locations and depths.	
	i. Based on DWR Well Completion Report Map Application[8]?			X		

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[8] DWR Well Completion Report Map Application: https://www.arcgis.com/apps/webappviewer/index.html?id=181078580a214c0986e2da28f8623b37

	ii. Based on Other Source(s)?				X		
2. Does the GSP include maps of monitoring networks?	a. Existing Monitoring Wells		X			Existing monitoring wells for subsidence and water quality can be found in Figure 5-4 and 5-5.	Figure 5-4, Page 301 Figure 5-4, Page 302
	b. Existing Monitoring Well Data sources:	i. California Statewide Groundwater Elevation Monitoring (CASGEM)	X			“Groundwater levels are measured in the various networks and types of wells including: […] CASGEM Wells: DWR collects groundwater levels reported by local agencies and reports them through the CASGEM program. There are currently 17 CASGEM wells in the Subbasin.”	5.1.5, Page 276
		ii. Water Board Regulated monitoring sites	X			“Water quality data will be obtained from the below-mentioned coalitions: […] RWQCB - Regional Water Quality Control Board” “Though water quality has been periodically analyzed within the Subbasin for irrigation suitability, monitoring programs are generally not in place with defined temporal and spatial distribution, except for municipal water suppliers, RWQCB sites with WDRs, and monitoring at evaporation ponds.”	4.4.2.4, Page 250 5.4.3, Page 291
		iii. Department of Pesticide Regulation (DPR) monitoring wells	X			“The California Department of Pesticide Regulation (DPR) maintains a Surface Water Database (SURF) containing data from a wide variety of environmental monitoring studies designed to test for the presence or absence of pesticides in California surface waters. As part of DPR’s effort to provide public access to pesticide information, this database provides access to data from DPR’s SURF (DPR 2019).”	2.4.3.3, Page 68
	c. SGMA-Compliance Monitoring Network		X			Figure 5-1 to Figure 5-5	Figure 5-1 to Figure 5-5, Page298-302
	i. SGMA Monitoring Network map includes identified DACs?			X		DACs are not included. However, public water systems are shown on the maps.	
	ii. SGMA Monitoring Network map includes identified GDEs?			X		GDEs are not included.	

Summary/ Comments

The draft GSP does not provide maps showing “The density of wells per square mile, by dasymetric or similar mapping techniques, showing the general distribution of agricultural, industrial, and domestic water supply wells in the basin, including de minimis extractors, and the location and extent of communities dependent upon groundwater, utilizing data provided by the Department, as specified in Section 353.2, or the best available information” as required by 23 CCR § 354.8.(a)(5). The GSP should include the density, location and depths of all domestic and public supply wells in the GSA area using the best available information, and present this information on maps along with the proposed SGMA-compliance monitoring network so that the public can evaluate how well the monitoring network addresses these key beneficial users.

Providing maps of the monitoring network overlaid with location of DACs, GDEs, and any other sensitive beneficial users will also allow the reader to evaluate adequacy of the network to monitor conditions near these beneficial users.

4. Water Budgets

How were climate change projections incorporated into projected/future water budget and how were key beneficial users addressed?

Selected relevant requirements and guidance:
GSP Element 2.2.3 “Water Budget Information” (Reg. § 354.18)
Each Plan shall include a water budget for the basin that provides an accounting and assessment of the total annual volume of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions, and the change in the volume of water stored. Water budget information shall be reported in tabular and graphical form.

*Projected water budgets shall be used to estimate future baseline conditions of supply, **demand**, and aquifer response to Plan implementation, and to identify the uncertainties of these projected water budget components. The projected water budget shall utilize the following methodologies and assumptions to estimate future baseline conditions concerning hydrology, water demand and surface water supply availability or reliability over the planning and implementation horizon:*
(b) The water budget shall quantify the following, either through direct measurements or estimates based on data:
(5) If overdraft conditions occur, as defined in Bulletin 118, the water budget shall include a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.
(6) The water year type associated with the annual supply, demand, and change in groundwater stored.
(c) Each Plan shall quantify the current, historical, and projected water budget for the basin as follows:
*(1) Current water budget information shall quantify current inflows and outflows for the basin using the most recent hydrology, water supply, **water demand**, and land use information.*

DWR Water Budget BMP[9]
DWR Guidance for Climate Change Data Use During GSP Development and Resource Guide[10]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Are climate change projections explicitly incorporated in future/ projected water budget scenario(s)?	X			“The projected water budget for the Subbasin represents a hypothetical forecast for the 54-year period from 2017 through 2070 based on an assumed “normal hydrology” period and estimated future climate change impacts.”	3.3.7, Page 141
2. Is there a description of the methodology used to include climate change?	X			“In a climate period analysis, climate change is modeled as a shift from a baseline condition, usually historically observed climate where every year or month of the simulation it is shifted in a way that represents the climate change signal at a future 30-year climate period. Climate period analysis provides advantages in this situation because it isolates the climate change signal independent of the monthly variability signal. In a climate period analysis, monthly variability is based on the reference period from which change is being measured, meaning that all differences between the future	3.3.7.3, Page 142-143

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[9] DWR BMP for the Sustainable <management of Groundwater Water Budget:
https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/BMP-4-Water-Budget.pdf

[10] DWR Guidance Document for the Sustainable Management of Groundwater Guidance for Climate Change Data Use During GSP Development:
https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final.pdf

						simulation and the reference period are the result of the climate change signal alone. Climate period analysis was utilized to modify the 54-year forecast of "normal hydrology" to account for future climate change. The 2017-2070 forecast incorporates climate period analysis using the 2030 and 2070 monthly change factors (CNRA 2018) for each forecast analog month (Figure 3-52). The 2030 monthly change factors were applied to the forecast months January 2017 through December 2030. The 2070 monthly change factors were applied to the forecast months January 2031 through December 2070. There is a notable increase in magnitude of the 2070 change factors compared to the 2030 change factors."	
3. What is used as the basis for climate change assumptions?	a. DWR-Provided Climate Change Data and Guidance[11]		X			"The DWR provides guidance on how to incorporate climate change into hydrology forecasts. There are two basic approaches that have been used to simulate climate change in water resource modeling: 1) transient analysis; and 2) climate period analysis (DWR 2018)."	3.3.7.3, Page 142
	b. Other			X			
4. Does the GSP use multiple climate scenarios?				X			
5. Does the GSP quantitatively incorporate climate change projections?			X			Based on the information presented in Figure 3-53, the GSP appears to have quantitatively incorporated climate change projections. However, no descriptions or tables are provided regarding the quantitative results of the climate change projections.	Figure 3-53, Page 219
6. Does the GSP explicitly account for climate change in the following elements of the future/projected water budget?	a. Inflows:	i. Precipitation	X			"The climate change factors were also applied to 54-year forecasts of monthly inflows (effective precipitation, surface water deliveries, lake bottom storage, and canal and river seepage) and outflows (agricultural demand) for the "normal hydrology" forecast."	3.3.7.4, Page 143
		ii. Surface Water	X				
		iii. Imported Water	X				
		iv. Subsurface Inflow	X				
	b. Outflows:	i. Evapotranspiration	X				
		ii. Surface Water Outflows (incl. Exports)			X		
		iii. Groundwater Outflows (incl. Exports)	X				
7. Are demands by these sectors (drinking water users) explicitly included in the future/projected	a. Domestic Well users (<5 connections)		X			"Municipal and domestic groundwater pumping are estimated upward based on projected population growth at an annual rate of 0.03%." It is not clear from the GSP if demands by some or all of these community and non-community water systems were considered. The GSP also does not identify the number of connections of the various	3.3.7.4, Page 143
	b. State Small Water systems (5-14 connections)			X			
	c. Small community water systems (<3,300 connections)			X			

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[11] DWR Guidance Document for the Sustainable Management of Groundwater Guidance for Climate Change Data Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Climate-Change-Guidance_Final.pdf
DWR Resource Guide DWR-Provided Climate Change Data and Guidance for Use During GSP Development: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Resource-Guide-Climate-Change-Guidance_v8.pdf

water budget?	d. Medium and Large community water systems (> 3,300 connections)		X		public water systems present in the basin.	
	e. Non-community water systems		X			

Summary/ Comments

Given the uncertainties of climate change, the GSP should include and analyze the effects of multiple climate change scenarios.

The GSP should present the results of the projected water budget in a tabulated, transparent format. The GSP should also clearly identify and quantify water demands of all drinking water users in the projected water budget, including the small and large public water systems. Such information is necessary for the public to assess whether drinking water demands were fully and appropriately considered in the GSP.

5. Management Areas and Monitoring Network

How were key beneficial users considered in the selection and monitoring of Management Areas and was the monitoring network designed appropriately to identify impacts on DACs and GDEs?

Selected relevant requirements and guidance:
GSP Element 3.3, "Management Areas" (§354.20):

(b) A basin that includes one or more management areas shall describe the following in the Plan:
(2) The minimum thresholds and measurable objectives established for each management area, and an explanation of the rationale for selecting those values, if different from the basin at large.
(3) The level of monitoring and analysis appropriate for each management area.
(4) An explanation of how the management area can operate under different minimum thresholds and measurable objectives without causing undesirable results outside the management area, if applicable.
(c) If a Plan includes one or more management areas, the Plan shall include descriptions, maps, and other information required by this Subarticle sufficient to describe conditions in those areas.

CWC Guide to Protecting Drinking Water Quality under the SGMA[12]
TNC's Groundwater Dependent Ecosystems under the SGMA, Guidance for Preparing GSPs[13]

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP define one or more Management Area?	X			"In order to facilitate implementation of the GSP, management areas have been created for the Subbasin. There are five Primary Management Areas and two Secondary Management Areas."	3.4, Page 144 Figure 3-54, Page 220
2. Were the management areas defined specifically to manage GDEs?		X		"Primary Management Areas have been formed from each of the five GSAs." "Two Secondary Management Areas have been formed for the Subbasin. These two Secondary Management Areas are different from the Primary Management Areas and each other due to distinctly different groundwater conditions in each area."	3.4, Page 144
3. Were the management areas defined specifically to manage DACs?		X			
a. If yes, are the Measurable Objectives (MOs) and MTs for GDE/DAC management areas more restrictive than for the basin as a whole?			X		
b. If yes, are the proposed management actions for GDE/DAC management areas more restrictive/ aggressive than for the basin as a whole?			X		
4. Does the GSP include maps or descriptions indicating what DACs are located in each Management Area(s)?	X			Table 2-4 describes DACs in each GSA area.	Table 2-4, Page 94
5. Does the GSP include maps or descriptions indicating what GDEs are located in each Management Area(s)?	X			Figure 3-38. Distribution of Wetlands and Phreatophyte Vegetation	Figure 3-38, Page 198

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[12] CWC Guide to Protecting Drinking Water Quality under the SGMA: https://d3n8a8pro7vhmx.cloudfront.net/communitywatercenter/pages/293/attachments/original/1559328858/Guide_to_Protecting_Drinking_Water_Quality_Under_the_Sustainable_Groundwater_Management_Act.pdf?1559328858

[13] TNC's Groundwater Dependent Ecosystems under the SGMA, Guidance for Preparing GSPs: https://www.scienceforconservation.org/assets/downloads/GDEsUnderSGMA.pdf

Summary/ Comments
It is recommended that the GSP includes maps of the identified DACs located within each Management Area.

Care should be taken so that the management areas and the associated monitoring network are designed to adequately assess and protect against impacts to all beneficial users, including GDEs and DACs.

6. Measurable Objectives, Minimum Thresholds, and Undesirable Results

How were DAC and GDE beneficial uses and users considered in the establishment of Sustainable Management Criteria?

Selected relevant requirements and guidance:

GSP Element 3.4 "Undesirable Results" (§ 354.26):

(b) The description of undesirable results shall include the following:

(3) Potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results

GSP Element 3.2 "Measurable Objectives" (§ 354.30)

(a) Each Agency shall establish measurable objectives, including interim milestones in increments of five years, to achieve the sustainability goal for the basin within 20 years of Plan implementation and to continue to sustainably manage the groundwater basin over the planning and implementation horizon.

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Are DAC impacts considered in the development of Undesirable Results (URs), MOs, and MTs for groundwater levels and groundwater quality?		X		The impacts to DACs are not explicitly considered. Water Level URs: "Exceedance of MTs leading to undesirable results related to groundwater level in the Subbasin would cause a diminished level of groundwater supplies for agricultural and municipal needs. Groundwater levels are anticipated to continue to decrease at current rates in the next several years before implemented programs have a positive effect on the stabilization of groundwater levels based on the variability of hydrology and availability of flood water. As stated above, agriculture is the main economic enterprise of the Subbasin, so effective management of groundwater for sustainable future use is critical to the continuation of current economic interests, which add value to the Subbasin's communities. Decreases in groundwater levels will continue to increase the cost of energy for pumping. If MT levels are reached or exceeded, wells have the potential to go dry and require deepening to reach the lowered water table. Alternatively, pumps may be lowered if the existing well casing is sufficiently deeper. However, once the Subbasin reaches sustainability in the future, the depth of the wells will be known and can be designed to meet those depths to prevent future wells from becoming dry." Water Level MTs: "Due to the timely process of infrastructure development and program implementation, and variability in hydrology and the availability of flood water, groundwater levels are expected to continue to decrease in the next several years before programs have a positive effect on the stabilization of groundwater levels. Decreases in groundwater levels will continue to increase the cost of energy for pumping. If MT levels are reached, there may be some wells that go dry and require deepening to reach the water table. Alternatively, pumps may be lowered if the existing well casing is sufficiently deeper. However, once the Subbasin reaches sustainability in the future, the design depth for wells will be known and will be used in planning of future	4.3.3, Page 245 4.4.4, Page 251

				well construction to minimize future wells from becoming dry.” Water Quality MTs: “If water quality is allowed to deteriorate to levels set by MTs, agricultural producers may experience a decrease in crop yield and/or crop quality. Poor water quality would cause a buildup of salts and nitrates in the surface layers of soil. The best way to treat nutrient build up is by leaching or over-irrigating enough to push soluble contaminants through the soil column.”	
2. Does the GSP explicitly discuss how stakeholder input from DAC community members was considered in the development of URs, MOs, and MTs?		X		The GSP does not explicitly discuss how stakeholder input from DACs was considered.	
3. Does the GSP clearly identify and detail the anticipated degree of water level decline from current elevations to the water level MOs and MTs?		X		The GSP does not clearly identify the anticipated degree of water level decline. However, current water levels and MOs/MTs are presented in Table 4-1. Based on this if water levels reach MTs, this will represent an average decline of approx. 100 feet below 2017 conditions, and over 200 feet below current conditions in some parts of the subbasin (i.e., wells SFK_B_1920E19A001M, SFK_C_20S20E07H001M, and SFK_C_LEM_12). Even MOs represent over 100 feet of decline below 2017 water levels in many areas of the Subbasin.	Table 4-1, Page 262
4. If yes, does it include: a. Is this information presented in table(s)?		X			
b. Is this information presented on map(s)?		X			
c. Is this information presented relative to the locations of DACs and domestic well users?		X			
d. Is this information presented relative to the locations of ISW and GDEs?		X			
5. Does the GSP include an analysis of the anticipated impacts of water level MOs and MTs on drinking water users?		X		“Due to the timely process of infrastructure development and program implementation, and variability in hydrology and the availability of flood water, groundwater levels are expected to continue to decrease in the next several years before programs have a positive effect on the stabilization of groundwater levels. Decreases in groundwater levels will continue to increase the cost of energy for pumping. If MT levels are reached, there may be some wells that go dry and require deepening to reach the water table. Alternatively, pumps may be lowered if the existing well casing is sufficiently deeper. However, once the Subbasin reaches sustainability in the future, the design depth for wells will be known and will be used in planning of future well construction to minimize future wells from becoming dry.” Impacts on drinking water users are not explicitly considered. Based on the water level declines identified above, it would be expected that such impacts could be significant.	4.4.4, Page 251
6. If yes: a. On domestic well users?		X			
b. On small water system production wells?		X			
c. Was an analysis conducted and clearly illustrated (with maps) to identify what wells would be expected to be partially and fully dewatered at the MOs?		X			
d. Was an analysis conducted and clearly illustrated (with maps) to identify what wells would be expected to be partially and fully dewatered at the MTs?		X			
e. Was an economic analysis performed to assess the increased operation costs associated with increased lift as a result of water level decline?		X			
9. Does the sustainability goal explicitly include drinking water and nature?		X		“This GSP aims to manage groundwater resources to continue to provide an adequate water supply for existing beneficial uses and users in accordance with counties and cities general plans while meeting established measurable objectives (MO) to maintain a sustainable yield. This goal aims to continue to provide adequate water supply for existing beneficial uses and users while ensuring the future, sustainable use of groundwater. Additionally, the sustainability goal works as a tool for managing groundwater, basin-wide, on a long-term basis to protect quality of life through the continuation of existing economic industries in the area including but not limited to agriculture.”	1.3.1, Page 40 Table 2-4, Page 94

				Table 2-4. Beneficial Uses and Users by GSA The sustainability goal does not include nature.	

Summary/ Comments
Based on the presented information, impacts to DACs are not explicitly considered in the discussion of URs, MOs, and MTs. More detail and specifics regarding DACs, including those that rely on smaller community drinking water systems and domestic wells, is necessary to demonstrate that these beneficial users were adequately considered. It is recommended that the GSP present a thorough and robust analysis, supported by maps, that identifies: (1) what domestic wells are likely to be impacted (including partially dewatered) at the MTs and at the MOs and (2) the location of the likely impacted wells with respect to DACs and other communities and systems dependent on groundwater.

Based on the information presented in Table 4-1 of the draft GSP, if water levels reach MTs, this will represent an average decline of approx. 100 feet below 2017 water levels, and over 200 feet below current conditions in some parts of the subbasin (i.e., wells SFK_B_1920E19A001M, SFK_C_20S20E07H001M, and SFK_C_LEM_12). Even MOs represent an average decline of over 50 feet below current conditions and over 100 feet of decline in many areas of the Subbasin. The GSP needs to explain how such water level declines represent sustainable conditions and are protective of beneficial uses and users in the Subbasin.

A proactive assistance program should be developed for potentially impacted beneficial users, including DACs, small water systems, and domestic wells, to mitigate potential future adverse impacts.

The GSP should also explicitly demonstrate whether and how the stakeholder input from DACs was considered in the development of URs, MOs, and MTs.

We recommend that the sustainability goal explicitly includes environmental beneficial uses of groundwater.

7. Management Actions and Costs

What does the GSP identify as specific actions to achieve the MOs, particularly those that affect the key BUs, including actions triggered by failure to meet MOs? What funding mechanisms and processes are identified that will ensure that the proposed projects and management actions are achievable and implementable?

Selected relevant requirements and guidance
GSP Element 4.0 Projects and Management Actions to Achieve Sustainability Goal (§ 354.44)
(a) Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin.
(b) Each Plan shall include a description of the projects and management actions that include the following:
(1) A list of projects and management actions proposed in the Plan with a description of the measurable objective that is expected to benefit from the project or management action.

Review Criteria	Yes	No	N/A	Relevant Info per GSP	Location (Section, Page)
1. Does the GSP identify benefits or impacts to DACs as a result of identified management actions?		X		The impacts to DACs are not explicitly discussed in the GSP. Recharge projects are noted in the GSP as expected to improve water quality.	6.3.3, Page 323
2. If yes: a. Is a plan to mitigate impacts on DAC drinking water users included in the proposed Projects and		X			

	Management Actions?					
	b. Does the GSP identify costs to fund a mitigation program?		X			
	c. Does the GSP include a funding mechanism to support the mitigation program?		X			
3. Does the GSP identify any demand management measures in its projects and management actions?		X			Section 6.3 and 6.4 provide potential P/MAs options that may be utilized by the GSAs. Table 6-1 to 6-4 in Section 6.5 list the P/MAs chosen for each GSA.	6.3, Page 317-330 6.4, Page 330-331 6.5, Page 331-334
4. If yes, does it include:	a. Irrigation efficiency program		X			
	b. Ag land fallowing (voluntary or mandatory)	X			Fallowing programs are identified by Mid-Kings River GSA, El Rico GSA, and South Fork Kings GSA. "The Subbasin may adopt a policy to incentive farmers to permanently fallow land. Policy will solicit volunteers first then look towards mandatory fallowing based on percentage reductions possibly on a rotation basis."	
	c. Pumping allocation/restriction	X			Groundwater allocation is listed as a potential management action in Section 6.4.	
	d. Pumping fees/fines	X			Pumping fees for groundwater allocation exceedances and groundwater extractions are listed as potential management actions in Section 6.4.	
	e. Development of a water market/credit system	X			Groundwater marketing and trade is listed as a potential management action in Section 6.4.	
	f. Prohibition on new well construction		X			
	g. Limits on municipal pumping		X		It is not clear if there would be limits on municipal pumping.	
	h. Limits on domestic well pumping		X		It is not clear if there would be limits on domestic well pumping.	
	i. Other	X			"Require new developments (non-de minimis extractors) to prove sustainable water supplies if land use conversion is not a conservation measure"	
5. Does the GSP identify water supply augmentation projects in its projects and management actions?		X			Section 6.3 and 6.4 provide potential P/MAs options that may be utilized by the GSAs. Table 6-1 to 6-4 in Section 6.5 list the P/MAs chosen for each GSA.	6.3, Page 317-330 6.4, Page 330-331 6.5, Page 331-334
6. If yes, does it include:	a. Increasing existing water supplies	X			"Each GSA is proposing to use their existing contract and rights for surface water as access to import more surface water into the Subbasin."	
	b. Obtaining new water supplies		X			
	c. Increasing surface water storage	X			Storage projects are identified by South Fork Kings GSA, El Rico GSA, and Tri-County Water GSA.	
	d. Groundwater recharge projects – District or Regional level	X			Recharge projects are identified by Mid-Kings River GSA and South Fork Kings GSA.	
	e. On-farm recharge	X			On-Farm Improvements project is identified by South Fork Kings GSA.	
	f. Conjunctive use of surface water	X			The recharge projects also involve conjunctive use of surface water.	
	g. Developing/utilizing recycled water		X			

	h. Stormwater capture and reuse		X			
	i. Increasing operational flexibility (e.g., new interties and conveyance)	X			The Mid-Kings River GSA plans to pursue improvement to conveyance systems and expanded surface water delivery system.	
	j. Other		X			
7. Does the GSP include plans to fill identified data gaps by the first five-year report?		X			Section 5.4.1.3 discusses plans to fill data gaps in groundwater level monitoring network, including plans to collect well completion reports, perform a video inspection of wells to obtain construction information, construct a dedicated monitoring well, and replace monitor point with another alternate private well. Some P/MAs in Table 7-1 are also noted in the GSP as expected to help fill data gaps, including (1) Flood Flows (Spills into the Subbasin), include, Tule River, Deer Creek, Cross-Creeks and Kings River; (2) Registration of extraction facilities; (3) Require self-reporting of groundwater extraction, water level, and water quality data; and (4) Require well meters, sounding tubes, and water quality sample ports.	5.4.1.3, Page 286 Table 7-1, Page 343
8. Do proposed management actions include any changes to local ordinances or land use planning?		X			“Require new developments (non-de minimis extractors) to prove sustainable water supplies if land use conversion is not a conservation measure”	6.4, Page 330
9. Does the GSP identify additional/contingent actions and funding mechanisms in the event that MOs are not met by the identified actions?			X		“This section identifies the proposed project and management action targets envisioned to achieve sustainability. These preliminary amounts will be reevaluated, and conditions monitored while efforts are implemented. This will allow the GSA to compare the anticipated versus resulting change in groundwater levels as well as other sustainability criteria to determine if additional measures need to be employed to achieve sustainability.” However, the GSP does not provide details on what projects and management actions will be implemented as additional measures.	6.5, Section 331
10. Does the GSP provide a plan to study the interconnectedness of surface water bodies?			X		“As discussed in Section 3.2.8, Interconnected Surface Water and Groundwater Systems, the Subbasin does not contain interconnected surface and groundwater systems based on review of groundwater potentiometric surface maps. Groundwater contours indicate the Kings River, Cross Creek, and Mill Creek are losing streams that directly recharge groundwater. Groundwater is not in contact with these streams and cannot contribute any base flow to them. Due to the lack of connected water systems, interconnected surface water will not be monitored or considered when making management decisions.”	4.2.5, Page 240
11. If yes:	a. Does the GSP identify costs to study the interconnectedness of surface water bodies?			X		
	b. Does the GSP include a funding mechanism to support the study of interconnectedness surface water bodies?			X		

Summary/ Comments
The GSP should identify the potential impacts of the proposed projects or management actions on DACs. If impacts are expected, the GSP should include plans to monitor for, prevent, and/or mitigate against such impacts, provide the estimated costs, and identify the funding sources.

The GSP does not appear to include any plans to address impacts to domestic well users if water quality in these wells is degraded in the future. The GSP should include plan to

monitor for and mitigate impacts to DAC drinking water users.

Westlands Water District
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December 2, 2019

Southwest Kings Groundwater Sustainability Agency
Kings Subbasin
Basin Number 5-22.08
Transmitted via online submission at: info@swkgsa.org

Subject: Tulare Lake Subbasin Draft Groundwater Sustainability Plan

Dear Southwest Kings GSA Group:

Westlands Water District ("Westlands GSA") appreciates the opportunity to provide comments on the Tulare Lake Subbasin Draft Groundwater Sustainability Plan ("Draft GSP"). The Westlands Groundwater Sustainability Agency ("GSA") respectfully submits the following comments.

Finding 1 (Page 3-27): Figures 3-26 and 3-27, Table 3-6, and Section 3.2.2 of the GSP states with respect to groundwater flow in the unconfined aquifer that, "[i]n general, groundwater flowed into the Subbasin from the Kings, Kaweah, and Tule Subbasins and out of the Subbasin to the Westside Subbasin." This statement is supplemented by contours of unconfined potentiometric head developed by DWR from 1990 through 2016.

Westlands' Comment: The unconfined water level data are used to make inferences about general groundwater flow directions. As stated in Section 3.2.3 of the GSP, vertical gradients can exceed 50 feet per 100 feet suggesting that flow directions can be heavily dependent on the depth horizons that are selected and therefore, change considerably with depth. Model results provided in Appendix D also highlight how groundwater flow directions vary with depth.

DWR does not provide groundwater contours for the majority of the boundary shared between the Westside and Tulare Lake Subbasin. In fact, contours from 2005, 2010 and 2016 provide almost no overlap with the shared Subbasin boundary. As a result, there is no substantial evidence to support the statements regarding groundwater flows "out of the Subbasin to the Westside Subbasin."

The spatial information for wells used to develop the DWR water level contours are readily available for 2016 (DWR, 2019). Review of these data reveals that the majority of wells used by DWR to develop contours of unconfined potentiometric head within the Westside Subbasin are screened in the Lower Aquifer (**WWD Attachment: Figure 1**). Given that groundwater level readings can vary considerably between the Upper Aquifer and Lower Aquifer, water levels from the Lower Aquifer are unlikely to be representative of unconfined water levels (even in the Spring) and should not be used to support the GSP conclusions of subsurface flow in the unconfined aquifer between the Westside and Tulare Lake Subbasins.

Therefore, the analysis is not supported by substantial evidence and we respectfully disagree with the conclusion set forth in the GSP relating to groundwater conditions in the unconfined aquifer.

<u>Finding 2 (Page 3-87):</u> Figures 3-28b, 3-28c and 3-28d display wells within the Tulare Lake Subbasin with long term hydrographs.

Westlands' Comment: Figures 3-28b to 3-28d shows long term hydrographs for wells within the Tulare Lake Subbasin. Unfortunately, the data displayed by the hydrographs is pixelated, therefore unreviewable. Westlands GSA recommends revising the mentioned figures to display hydrographs using a higher resolution to allow the public to review.

<u>Finding 3 (Page 3-93):</u> Figures 3-30 through 3-32, and Section 3.2.5 describes groundwater quality data in the Tulare Lake and Westside Subbasins. With respect to TDS, the GSP cites reports from Davis et al., 1956 and Hansen et al., 2018.

Westlands Comments: Both reports highlight how depth significantly influences TDS concentrations. However, Figure 3-30 does not report the depth of the wells or the aquifer the TDS sample represents which can substantially influence how data is interpreted. Furthermore, none of the maps shows the time period being represented. With respect to the concentration of arsenic in groundwater, neither the most recent nor the maximum arsenic concentration in the data available from GeoTracker is as high as those shown in Figure 3-31 (**WWD Attachment: Figure 2 and 3**). Furthermore, the density of wells with available arsenic data in the Geotracker GAMA database is substantially less than that shown in Figure 3-31.

The concentration of nitrate in groundwater is shown in Figure 3-32. This map shows nitrate concentration exceeding the MCL in four locations adjacent to the Westside Subbasin boundary. A review of data available from Geotracker GAMA show that samples exceeding the MCL were measured in the mid to late-1980's and likely do not reflect the current ambient nitrate concentration at these locations.

We recommend that the draft GSP be revised to accurately convey groundwater quality data by aquifer and by the timeframe the data represents. In addition, we recommend that the groundwater quality data be reviewed for accuracy.

<u>Finding 4 (Page 3-87):</u> Figures 3-34 displaying historical subsidence in the San Joaquin Valley from 1949 – 2005.

Westlands' Comment: Figures 3-34 contains a legend that is incomplete and is unable to be reviewed. Westlands GSA recommends applying the corresponding color scheme to the vertical displacement legend to allow readers to be able to review the presented information.

<u>Finding 5 (Page 4-18):</u> Section 4.5.1.1 introduces the following sustainable management criteria for Groundwater Levels paraphrased as follows: The Sustainable Management Criteria for Groundwater Level (Section 4.5.1.1) proposes the Measurable Objective to be set at a groundwater level using Method 4, which forecasts water levels to 2035 and sets the 2035 water level as the Measurable Objective. Minimum Thresholds were based on assumed stability of groundwater levels between 2035 and 2040 and are designed to be a last-resort warning before more severe measures must be taken to protect groundwater resources. Section 4.4.3 (Selection Process of Minimum Thresholds to Avoid

Undesirable Results) establishes the Minimum Thresholds as "one standard deviation of all observed head data in compliance wells or modeled forecasted data." Figure 4-2 through 4-6 describe establishment of the Minimum Thresholds as "one standard deviation or 50 feet, whichever is greater."

Westlands' Comment: Sustainable Management Criteria, which includes the measurable objectives and the minimum thresholds, allows groundwater levels in the aquifer to decline past the Westside Subbasin's Measurable Objectives and Minimum Thresholds, set at 2015 groundwater levels, and may negatively impact the Westside Subbasin's ability to achieve sustainability by reducing net inflow into the Westside Subbasin and/or reversing the groundwater flow direction. More specifically, the proposed decline of groundwater levels in the Southwest Kings GSA may alter the groundwater conditions near the boundary between the Westside Subbasin and the Kings Subbasin and result in a lowering of groundwater levels in the Westside Subbasin. This action would have the effect of shifting the burden of SGMA compliance from the Southwest Kings GSA to Westlands GSA. This is not permissible. The GSP is devoid of substantial evidence and any explanation as to how the Minimum Thresholds will avoid a significant and unreasonable reduction in groundwater storage and significant and unreasonable land subsidence contributing to the impairment of surface uses within the Westside Subbasin.

Water Code section 10733, subdivision (c) provides in relevant part:

> "The department shall evaluate whether a groundwater sustainability plan adversely affects the ability of an adjacent basin to implement their groundwater sustainability plan or impedes achievement of sustainability goals in an adjacent basin"

Further, we respectfully call your attention to Code of Regulations, title 23, section 355.4, subdivision (b)(7):

> "When evaluating whether a Plan is likely to achieve the sustainability goal for the basin, the Department shall consider . . . whether the Plan *will adversely affect the ability of an adjacent basin to implement its Plan or impede achievement of its sustainability goal.*" (emphasis added)

and Code of Regulations, title 23, section 354.28, subdivision (b)(3):

> "The description of minimum thresholds shall include . . . how minimum thresholds have been selected to *avoid causing undesirable results in adjacent basins or affecting the ability of adjacent basins to achieve sustainability goals.*" (emphasis added)

Moreover, the implementation of SGMA and a GSP cannot be used to override the protections afforded common law water rights. Overlying and appropriative uses of groundwater within the Westside Subbasin are entitled to legal and equitable protection against infringement by an action that deprives them of their historical subsurface inflows. (*City of Lodi v. East Bay Municipal Utility District* (1936) 7 Cal.2d 316, 344 [protecting groundwater levels against lowering from another party's pumping]; *Trussell v. City of San Diego* (1959) 172 Cal.App.2d 593, 611 [enjoining a party for lowering water table by interrupting surface flow].)

Practically speaking, proposing a continued decline of groundwater levels in the Lower Aquifer is not supported by substantial evidence because the GSP acknowledges that it does not have enough data to support its finding that there will be no impact to historical boundary flow conditions between the

Subbasins. The potential for curtailing historic underflow into the Westside Subbasin may be a substantial factor in contributing to significant and unreasonable subsidence and frustrate the Westlands' GSA ability to achieve the sustainability goal.

Finding 6 (Page 4-21): Section 4.5.33 Land Subsidence references Table 4-2: *Lemoore-Average Land Subsidence Interim Milestones based on Measurable Objectives for the Subbasin,* which displays modeled subsidence rates and interim milestones for those subsidence rates. The Tulare Lake Subbasin also proposes a minimum threshold of 16 ft by 2040 in Section 4.4.1.3.

Westlands' Comment: Westlands GSA is concerned that allowing subsidence rates as proposed may impact critical infrastructure such as roads, railroads, and may increase flood risks to existing land uses, especially near Corcoran where subsidence rates are critical, in the Westside Subbasin and other neighboring subbasins. Westlands GSA strongly recommend selecting Measurable Objectives and Minimum Thresholds to subsidence rates that will not negatively impact infrastructure in neighboring subbasins. The GSP fails to reference any substantial evidence that the minimum threshold will avoid significant and unreasonable land subsidence that impairs surface uses in the Westside Subbasin.

Finding 7 (Appendix D): The information provided in the GSP suggests a conceptual error leading to flows between the Westside Subbasin and Tulare Lake Subbasin to be misrepresented in the numerical model and GSP. Figure D5-5 in Appendix D shows the average model simulated net lateral subsurface flow of 158,405 AFY from the Lower Aquifer to the general head boundary (GHB) in the Westside Subbasin. Contours of simulated Lower Aquifer groundwater levels from 2015 in Figure D5-3 show a cone of depression along the GHB in the Westside Subbasin. Figure D5-5 shows pumping from the Lower Aquifer is a net positive suggesting that intraborehole flow from the Upper Aquifer to the Lower Aquifer is greater than the amount extracted from wells, suggesting the GHB is driving the flow across the boundary between the Westside and Tulare Lake Subbasins and out of the Westside Subbasin.

Westlands' Comment:
Lower Aquifer contours developed from water level data at the end of the 2014 irrigation year (one year before the simulated contour data provided) do not show a cone of depression in the location of the GHB (**WWD Attachment: Figure 4**). These contours also cannot be interpreted to suggest that groundwater flow is from the Tulare Lake Subbasin to the Westside Subbasin. Furthermore, it is unclear what physical process would cause a localized cone of depression to form in this location, especially considering that the groundwater model simulates positive net pumping from the Lower Aquifer in the Westside Subbasin.

The analysis is not supported by substantial evidence and for the reasons set forth above, Westlands recommends reanalyzing the water level contour data from the numerical model and GSP.

Lastly, the Westlands GSA identified the following reporting discrepancies within the text of the GSP and Appendix D that should be reviewed:

1. Total lateral subsurface inflow into the Westside Subbasin shown in Figure D5-5 averages 72,296 AFY (67,347 from the Tulare Lake Subbasin and 4,948 AFY from the Kings Subbasin). Table 3-6 of the GSP shows average annual subsurface flow from the Tulare Lake Subbasin to the Westside Subbasin of 41,390. What is the source of this discrepancy?

2. In the graphic depicting aquifer specific fluxes in Figure D5-5, the sum of the "Net GW Flux" (which presumably is lateral subsurface flow between adjacent subbasins) totals 4,936 AFY while the total in the table shown in Figure D5-5 is 72,296 AFY. What is the source of this discrepancy?

3. Figure numbers in the Appendix D text do not correspond to the correct figures. Figure D5-10 is titled "Simulated Subsidence 1990-2016". Figure D5-8 shows "Groundwater Mass Balance Tule Subbasin".

Westlands' General Comment: The GSP Regulations include a provision authorizing GSAs in adjacent basins to enter into interbasin agreements. The interbasin agreements can "establish compatible sustainability goals" and be included in GSPs to "support a finding that implementation of the Plan will not adversely affect an adjacent basin's ability to implement its Plan or impede the ability to achieve its sustainability goal." (Code Regs., tit. 23, § 357.2.)[1] The interbasin agreements may also address: (1) "an estimate of groundwater flow across basin boundaries;" (2) how the GSAs will reconcile differing minimum thresholds and measurable objectives in the basins to avoid undesirable results; and (3) a process for resolving conflicts between the GSAs. (*Id.*) Given the potential reduction of historical cross-boundary flow attributable to the planned operation with the Tulare Lake Subbasin Draft GSP, Westlands strongly recommends that we meet and confer at the earliest opportunity to determine whether an interbasin agreement can be reached. Our intention is to reach a cooperative resolution of these important issues that will enable coordinated sustainable management in our GSAs.

If you have any questions or concerns, regarding these comments, please contact Kiti Campbell by email at kcampbell@wwd.ca.gov or by phone at (559) 241-6226. Thank you for the opportunity to provide comments on the Tulare Lake Subbasin Draft GSP.

Sincerely,

Russ Freeman

Russ Freeman, P.E.
Deputy General Manager – Resources
Westlands Water District

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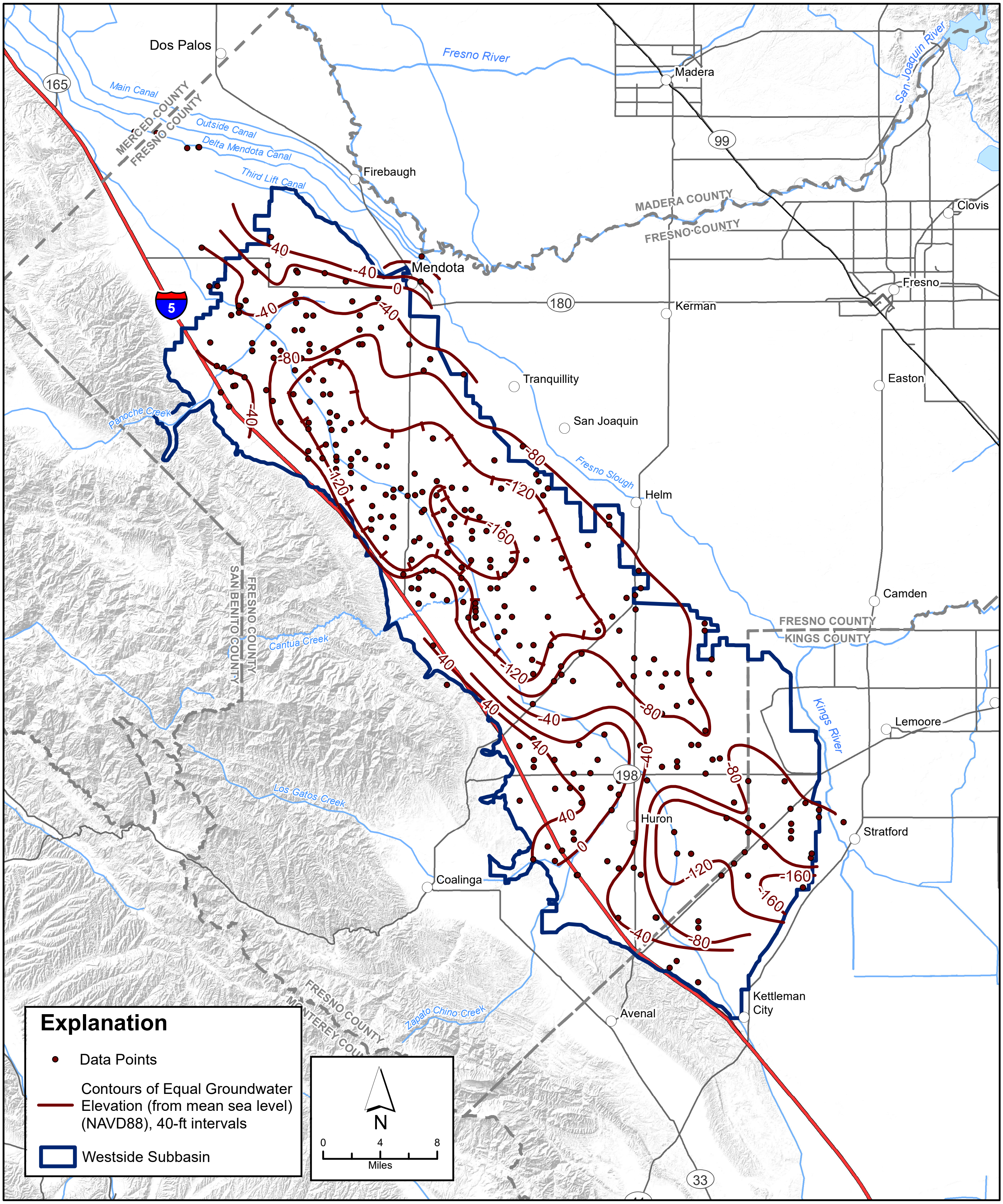
[1] See Appendix A for the complete text of the provisions of SGMA and the GSP Regulations (Code Regs., tit. 23, § 350, *et seq.*) cited herein.

Figure 4

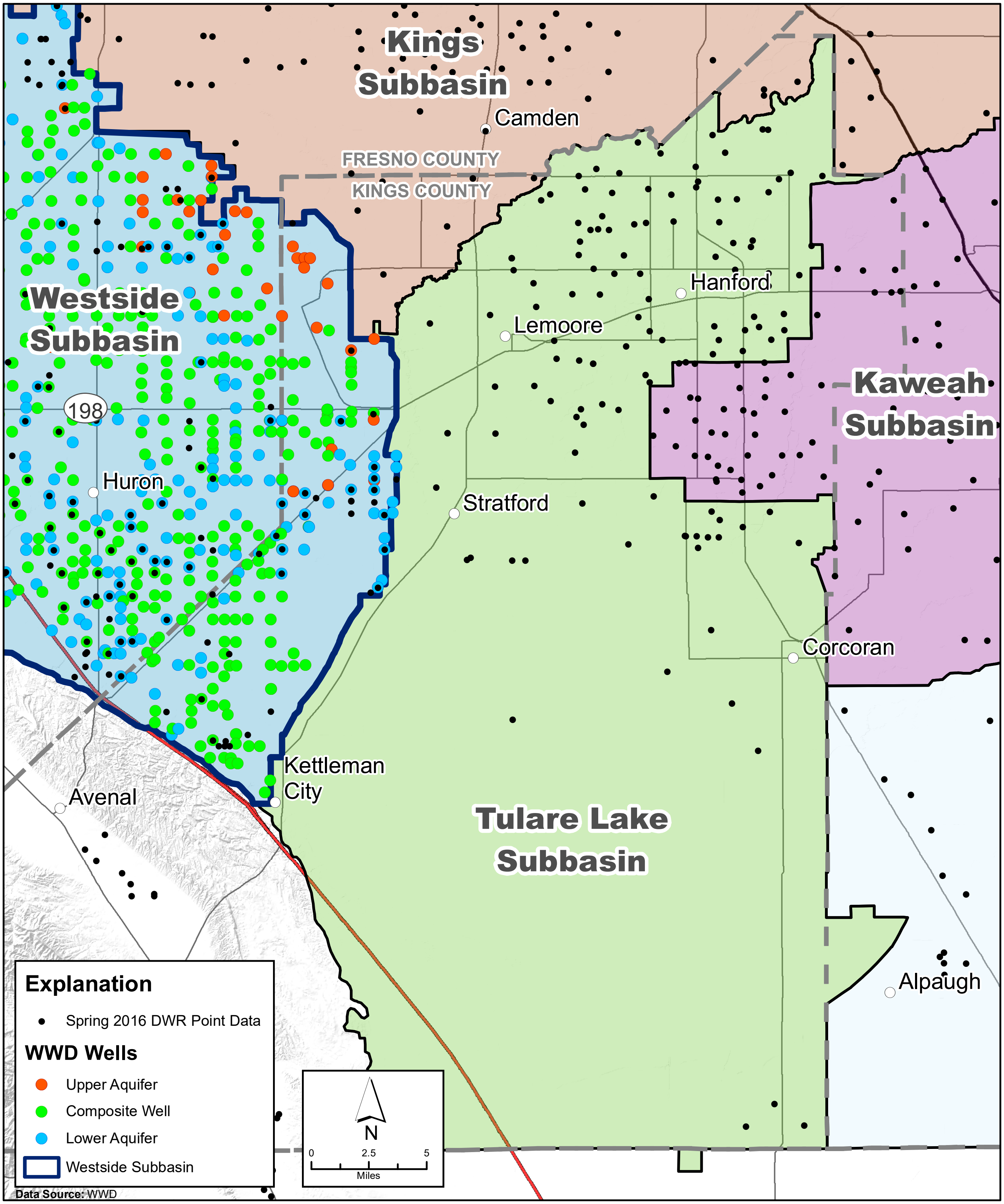


X:\2017\17-082 Westlands WD - GSP Support Services\GIS\MapFiles\Chapter_2\Figure 2-40.mxd

Luhdorff & Scalmanini
Consulting Engineers

FIGURE 2-40
Contours of Equal Groundwater Elevation Lower Aquifer, Winter 2014/2015

Groundwater Sustainability Plan
Westside Subbasin



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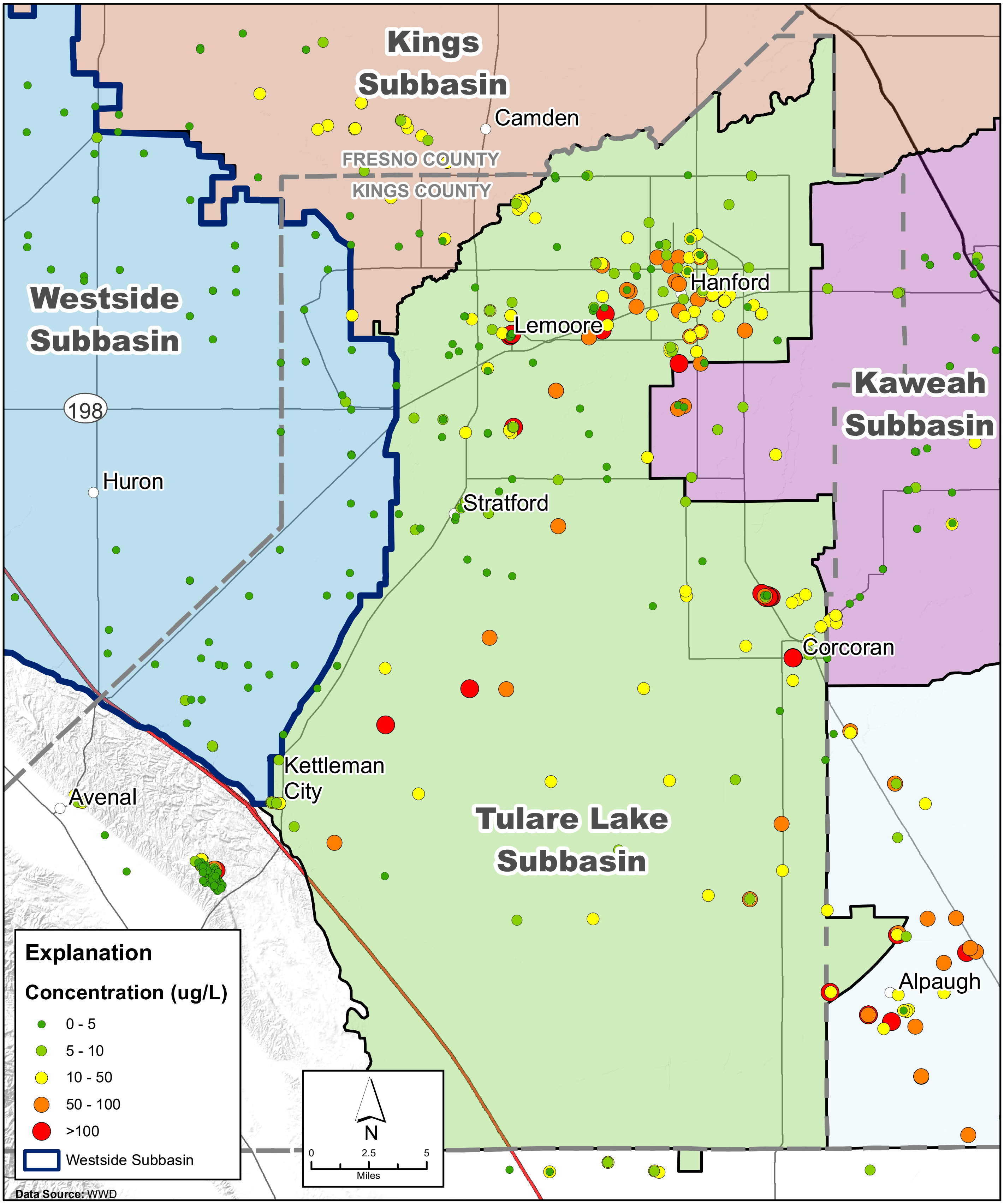
Luhdorff & Scalmanini
Consulting Engineers

FIGURE 1

DWR Point Data Used to Develop Contours of the Unconfined Aquifer vs Westlands Well Construction

Groundwater Sustainability Plan
Westside Subbasin



Data Source: WWD

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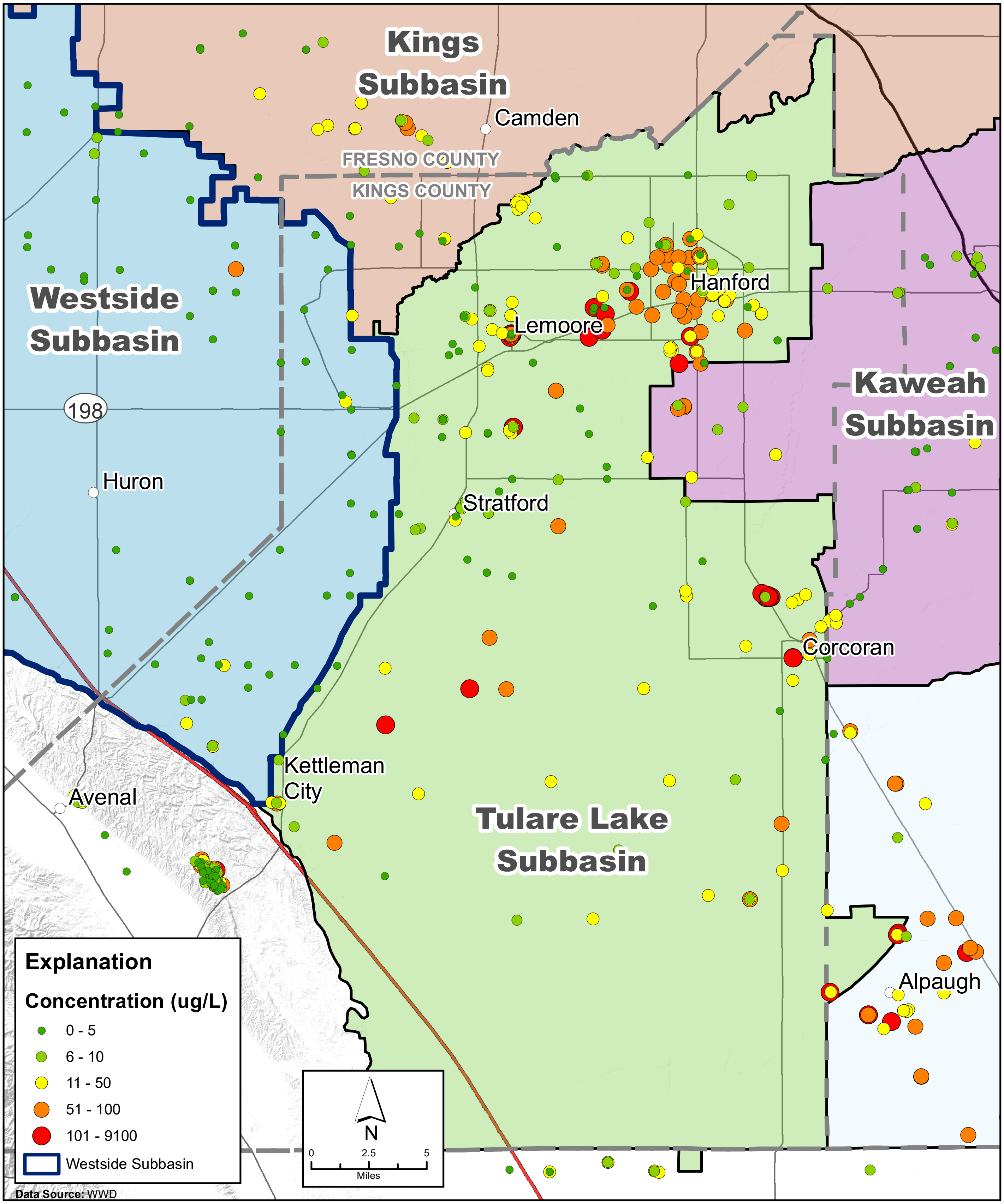
Luhdorff & Scalmanini
Consulting Engineers

FIGURE 2

Arsenic Concentration in Groundwater Wells
Most Recent Reported Value

Groundwater Sustainability Plan
Westside Subbasin



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Luhdorff & Scalmanini
Consulting Engineers

FIGURE 3
Arsenic Concentration in Groundwater Wells
Maximum Reported Value

Groundwater Sustainability Plan
Westside Subbasin

DOUG VERBOON
Supervisor
District 3

BOARD OF SUPERVISORS
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December 2, 2019

Via Hand Delivery

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Re: Comments on the Tulare Lakes Subbasin Groundwater Sustainability Plan

Dear Messrs. and Madams:

I am writing as a duly elected Supervisor for the County of Kings (the "County") and not on behalf of the Board of Supervisors. I am also writing on behalf of the other signatories to this letter, who care as deeply as I do about the issues raised in the Tulare Lakes Subbasin Groundwater Sustainability Plan (the "GSP") that has been proposed and is subject to this public hearing. I am submitting my comments and proposed changes in writing so that they may be incorporated into the GSP prior to its submission to the State Department of Water Resources ("DWR") by January 31, 2020.

Procedural Defects

The Groundwater Sustainability Agencies addressed above ("GSAs") issued a notice on September 3, 2019 for the December 2, 2019 public hearing to comment on the GSP. The narrative part of the GSP – approximately 500 pages – was not issued until three days later, on September 6, 2019. The Appendix D to the GSP – the Water Modeling Report – and the Water Model itself were not released to the public for review until October 17th, 2019, a month and half later. Even though the County requested to, and did, coordinate with the GSAs on Wednesday, November 6th, the GSAs' delay in getting the complete GSP out for the full 90-day review period set out in Section 10728.4 of the Water Code impeded any serious review and feedback on the GSP.

Under Section 10728.4, you were required to provide the County – and, consequently, the public – with at least 90-days written notice of the public hearing at which you planned to adopt the GSP. When the GSAs were told their "notice" was inadequate because of the lengthy delay in issuing the entire GSP, the responses have typically been two-fold: First, they claim the statute is ambiguous as to what it meant by "notice" of the public hearing. In other words, the statute does not say with specificity that the GSP had to be released at the same time as the notice. The second response has been, "Well, you'll get to comment at the State level once the GSP is lodged with the State in January, so it shouldn't matter whether you had adequate opportunity to comment now." Neither of these responses excuses the GSAs from giving the County and its water users a full opportunity to review and comment on the draft GSP.

For public notice to be effective, it must satisfy the requirements of administrative due process. Federal and California courts have ruled over the last half-century that adequate notice must be "reasonably calculated, under all the circumstances, to apprise the interested parties of the pendency of the action and afford them an opportunity to present their objections . . . ." (*Mullane v. Cent. Hanover Bank & Trust Co.* (1950) 339 U.S. 306, 314.) Furthermore, the notice must "convey the required information" within "a reasonable time for those interested" to be heard "at a meaningful time and in a meaningful manner." (See *id;* see also *Mathews v. Eldridge* (1976) 424 U.S. 319, 333.) From these cases and others, it is clear that the September 3rd notice needed to include at least 90-days written notice of the date, time, and location of the public hearing, as well as service of the entire GSP.

Second, regardless of whether the County or anyone else has an opportunity to comment to the State on the final GSP submission, it was the legislature's intent that all interested parties have a meaningful opportunity to comment *before* it was submitted to the State. At least the legislature believed that the GSAs should be given the benefit of substantive input on the GSP before they submitted it. Unfortunately, the GSAs' delay in getting the draft GSP prepared in time for any substantive review, feedback and opportunity to revise the draft GSP in response to the public's comments has compromised the successful adoption and implementation of the GSP.

Project Vagueness

One of the most important parts, in my view, of a successful GSP is convincing the State that the GSAs are committed to creating a sustainable source of groundwater for the region and that they can be trusted to implement an approved GSP. I am concerned that the purported "projects" set out in the GSP are too vague and non-committal and, consequently, won't convince the State to defer to the GSAs when it comes to groundwater sustainability. If the State rejects the GSP as being too vague – or for any other reason – the Sustainable Groundwater Management Act ("SGMA") makes clear that the State will take over our groundwater management and local control of that essential water resource will be history.

I attended the October 22nd, 2019, Board of Supervisors meeting when Dennis Mills addressed the Board and stated openly that the GSAs had made a judgment decision to keep the description of the GSP's proposed projects vague; he said the GSAs didn't want to commit to any specific projects in case, on further review, it was determined a project was not viable. I was also part of the delegation from the County that met with the GSAs on November 6th to consult on the draft GSP. As we discussed whether the GSAs had considered certain elements of certain projects, such as CEQA requirements, Dennis stated that none of the GSA Boards had committed to any of the projects in the GSP. The fact that the GSA Boards haven't committed to doing anything (other than perhaps a groundwater monitoring program) as part of the GSP process is not going to instill confidence in the State and I'm concerned it could lead to the State's rejection of the GSP. The "projects" that have been proposed in the GSP should be firmed up as much as possible before the plan is submitted in January.

Land Fallowing Project

Finally, and most importantly, I am very concerned about the GSP proposal to fallow significant amounts of land within the County so as to cut agricultural demand for groundwater by at least 25 percent in 12 years. When we spoke with the GSAs during the November 6th consultation meeting, Jeof Wyrick confirmed that the GSP model incorporated an assumption that two percent (2%) of the land in the subbasin – not even spread out over the entire County – would be fallowed each year until we met the 2040 compliance deadline. If that is pursued, it would result in approximately 220,000 acres of agricultural land being fallowed. A good portion of that fallowed land would have to be permanent tree crops, which would result in the destruction of a significant amount of the value of the land (as they have to be irrigated every year) as well as the County's tax base.

During our consultation meeting, Jeof said that the water model consultants had erroneously incorporated the two percent (2%) assumption into the model, thus, overstating the amount of land to be fallowed as a result of GSP implementation. He said the GSP was going to be revised to incorporate an assumption of one percent (1%) per year fallowing that would result in "only approximately 100,000 acres" in the GSAs' boundaries being fallowed. I have no idea whether that has been done already or if it actually will be done before the GSP is submitted to the State. That amount of fallowed land is certainly less by half than what was previously projected, but when there are only approximately 420,000 acres of agricultural land within the GSAs' boundaries, that is an unacceptable level of fallowing both to the farmers whose land would be fallowed and, I believe, to the residents of the County. This 25 percent of total agricultural land fallowing is consistent with representations that the GSAs made publicly at the public outreach meeting in Lemoore, California, on October 15, 2019.

I was also surprised when Jeof said at our consultation meeting that implementation of the GSP was really "farmer versus farmer warfare" and that what was going to happen is "private adjudication of water rights in a public forum" (*i.e.*, before the GSAs). We all know what's going to happen when the few large farm and agricultural interests in the County go after the small, family-owned farms: The small farms are going to lose. I'm going to do everything in my power as a member of the Board of Supervisors to make sure that doesn't happen.

For this reason alone, the GSP should be revised to clarify that land fallowing in Kings County will be deployed only as a last resort after every other possible means of demand reduction and water recharge have been fully implemented and only at the minimal levels absolutely necessary to achieve sustainability. It is important to have survivability for the small farmer so that he can be competitive with the large corporate famers when it comes to ground water pumping. The Tulare Lake Subbasin will never achieve sustainability if the exported ground water from the subbasin to surrounding areas in the region is left unaddressed.

I am available to answer questions and discuss these concerns.

Sincerely,

Doug Verboon

DOUG VERBOON
Supervisor

Name: Jerome Warmerdam
Business: Warmerdam Walnut Co.

Name:
Business: Casaca Vineyards

Name: Stanley Neves
Business: Golden Valley Farms

Name: Eddie Warmerdam
Business: Warmerdam Farms

Name:
Business: Trinity Ranches LLC

Name: Cornelius Warmer
Business:

Name: Rocky Silveira
Business: 4 S Farms

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Memorandum

To:	Tulare Lake Subbasin GSAs' Managers and Technical Team
From:	Trilby Barton, Public Outreach Coordinator, Provost & Pritchard
Subject:	Tulare Lake Subbasin GSAs' Groundwater Sustainability Plan Public Hearing Comments
Date:	December 2, 2019

December 2, 2019 Draft GSP Public Hearing Recap

The Tulare Lake Subbasin Groundwater Sustainability Agencies (GSAs) held a public hearing on the Draft Groundwater Sustainability Plan (GSP) on December 2, 2019. The hearing was held in the County of Kings Board of Supervisors' Chambers, and was called to order at 10:01 a.m. by Mid-Kings River GSA Manager, Dennis Mills.

Mr. Mills introduced himself and the other four GSA managers: Deanna Jackson with Tri-County Water Authority, Dale Melville with Southwest Kings GSA, Jeof Wyrick with El Rico GSA, and Charlotte Gallock with South Fork Kings GSA. Mr. Mills also introduced Trilby Barton, public outreach consultant with Provost & Pritchard Consultant Group. Mr. Mills and Ms. Barton explained the process for the public hearing, and Mr. Mills opened the floor for public comments.

Twenty stakeholders were in attendance, and one public comment was provided:

- **Bill Toss, Grower in Mid-Kings River GSA**
  "Reading through the plan that is available, the only thing that really struck out to me was the 25 percent set aside for reduction. That of course is most likely very damaging, and would not be sustainable economically here for Kings County or for us as growers. I hope that there is a change to that, and to make sure that is not the status quo."

Upon seeing that no other stakeholders wanted to provide oral comments, Mr. Mills thanked everyone for attending and closed the public hearing at 10:06 a.m.

APPENDIX D

GROUNDWATER MODEL REPORT

Tulare Lake Subbasin Hydrologic Model for Groundwater Sustainability Plan Development: Calibration and Predictive Simulations

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Prepared for:
Mid-Kings River Groundwater Sustainability Agency
Hanford, California

January 8, 2020
Project FR18161220

wood.

Tulare Lake Subbasin Hydrologic Model for Groundwater Sustainability Plan Development: Calibration and Predictive Simulations

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Prepared for:

Mid-Kings River Groundwater Sustainability Agency
200 North Campus Drive
Hanford, California 93230

Prepared by:

Wood Environment & Infrastructure Solutions, Inc.
1281 East Alluvial Avenue, Suite 101
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January 8, 2020
Project FR18161220

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David M. Bean, PG, CHg
Principal Hydrogeologist

PROFESSIONAL GEOLOGIST
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STATE OF CALIFORNIA

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Abbreviations and Acronyms

%	percent
AF	acre-feet
AF/D	acre-feet per day
AF/M	acre-feet per month
AF/Y	acre-feet per year
bgs	below ground surface
CID	Corcoran Irrigation District
CT	Critical Thresholds
CVHM	United States Geological Survey Central Valley Hydrologic Model
CVP	Central Valley Project
DWR	California Department of Water Resources
ER GSA	El Rico Groundwater Sustainability Agency
ETc	Crop Evapotranspiration
ft/d	feet per day
ft^2/d	square feet per day
ft/m	feet per month
GHB	General Head Boundary
GSAs	groundwater sustainability agencies
GSP	Groundwater Sustainability Plan
GUI	Graphic User Interface
GWV	Environmental Simulations Inc.’s Groundwater Vistas™ Version 7 simulation code GUI
HCM	hydrogeologic conceptual model
K	hydraulic conductivity
f_c	coarse fraction
KCWD	Kings County Water District
K_h	horizontal hydraulic conductivity
K_v	vertical hydraulic conductivity
MKR GSA	Mid-Kings River Groundwater Sustainability Agency
MO	Monitoring Objective
MODFLOW	USGS Modular finite-difference family of numerical simulation codes
NRMS	Normalized root mean square error
MNW2	Version 2 of the MODFLOW multi-node well package
msl	mean sea level
PRISM	Parameter-elevation Regressions on Independent Slopes Model
RMS	root mean square
SFK GSA	South Fork Kings Groundwater Sustainability Agency
SSR	sum of the square of the residuals
S_s	specific storage
S_y	specific yield
Subbasin	Tulare Lake Subbasin
SGMA	Sustainable Groundwater Management Act of 2014
SWK GSA	Southwest Kings Groundwater Sustainability Agency
SWP	State Water Project
TCWA GSA	Tri-County Water Authority Groundwater Sustainability Agency
TLSBHM	Tulare Lake Subbasin Hydrologic Model
USGS	United States Geological Survey
WD	Water District
Wood	Wood Environment & Infrastructure Solutions, Inc.

1.0 Introduction

Wood Environment & Infrastructure Solutions, Inc. (Wood), has been retained by the Mid-Kings River Groundwater Sustainability Agency to prepare and document a hydrologic flow model of the Tulare Lake Subbasin (Subbasin) to aid local agencies in compliance with the Sustainable Groundwater Management Act of 2014 (SGMA). The Subbasin is located primarily in Kings County, within the Tulare Lake Hydrologic Region of the San Joaquin Valley, California (Figure D1-1). This project is a cooperative effort among five Groundwater Sustainability Agencies (GSAs) within the Subbasin including: Mid-Kings River GSA (MKR GSA), El Rico GSA (ER GSA), South Fork Kings GSA (SFK GSA), Southwest Kings GSA (SWK GSA), and Tri-County Water Authority GSA (TCWA GSA). Although the Subbasin is the primary focus of this modeling study, the modeling effort encompasses portion of adjacent California Department of Water Resources (DWR)-defined groundwater subbasins including the Kings, Kaweah, Tule, Kern, and Westside subbasins.

1.1 Background

Included as part of SGMA was a requirement that the DWR identify groundwater basins and subbasins in conditions of critical overdraft. As defined by DWR, overdraft occurs where the average annual amount of groundwater extraction exceeds the long-term average annual supply of water to the basin. Effects of overdraft can include land subsidence, groundwater depletion, and/or chronic lowering of groundwater levels. DWR Bulletin 118 defines critical overdraft as "when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts."

Based on this criterion and a formal evaluation of groundwater basins across the state, the DWR found much of the Tulare Lake Hydrologic Region to be one of the most critically over-drafted regions of the state. The Subbasin sits at the lowest point of the Tulare Lake Hydrologic Region and receives both surface water inflows from several rivers and streams (including Kings River, Kaweah River, Tule River, and Deer Creek) and the State Water Project (SWP), but also irrigation return flows (tailwater) draining from irrigated lands. Nonetheless, in most years, especially during frequent drought cycles, agricultural water demand exceeds the surface water inflows, leading to the drilling of wells to develop the groundwater resources to fulfill that unmet demand. In fact, under recent historical conditions, the average annual demand on groundwater resources significantly exceeds the average existing recharge to the groundwater system, leading the DWR to declare the Subbasin critically over drafted, triggering the need to develop a Groundwater Sustainability Plan (GSP) by January 31, 2020, per SGMA requirements.

The Tulare Lake Subbasin Hydrologic Model (TLSBHM) developed for this project provides a quantitative tool for development and evaluation of alternative water management scenarios considered for the GSP. Additional model development and calibration will occur throughout the implementation of the GSP as additional data are collected.

1.2 Modeling Objectives

The objectives of the current modeling efforts were to:

1. Prepare a three-dimensional numerical surface water/groundwater flow model of the Subbasin and portions of adjoining subbasins.

2. Calibrate the surface water/groundwater flow model for the period 1990-2016, with a focus on the "normal hydrology" period 1998 through 2010, for initial calibration using available groundwater elevation observations and stream flow observations.
3. Provide a Baseline Forecast from 2017-2070 assuming continued recent land use and continued 1998 through 2010 "normal hydrology" conditions modified to account for climate change. This forecast was utilized to establish Critical Thresholds (CT) and Monitoring Objectives (MO) throughout the Subbasin.
4. Provide a Projects Forecast from 2017-2070 assuming continued recent land use, continued 1998 through 2010 "normal hydrology" conditions as modified to account for climate change, and additional Surface Water Supply and Aquifer Recharge resulting from several projects assumed to be implemented throughout the Subbasin and adjoining subbasins.
5. Compare the Baseline and Projects forecasts and estimate what additional projects and management actions (such as land fallowing) may be required to obtain sustainability by 2040 and thereafter.

2.0 Hydrogeologic Conceptual Model

A hydrogeologic conceptual model (HCM) is a simplified description of the groundwater flow system, frequently in the form of a block diagram or cross-section with an accompanying narrative description of the function and interaction of the various components that comprise the hydrogeologic system (Anderson et al., 2015). The nature of the HCM determines the dimensions of the numerical model and the design of the grid, the distribution of the hydrogeologic properties, and the definition and distribution (over space and time) of external and internal stresses and boundary conditions. The purpose of the HCM is to establish an initial understanding of the groundwater system and organize the associated data and information so that the system can be analyzed more effectively.

Figure D2-1 presents block diagrams that schematically represents key aspects of the HCM for the TLSBHM under both pre-development and current conditions. Details related to this HCM for the project include: (1) description of the model domain, (2) delineation of the hydrostratigraphic units within the model domain, (3) definition of sources and sinks and estimation of the water budget, and (4) narrative description of the flow system. Each of these items are discussed in the following subsections.

2.1 Basin Location and Study Area

The Subbasin is located primarily in Kings County in the Tulare Lake Hydrologic Region of the San Joaquin Valley, California (Figure D2-2). The Subbasin covers an area of approximately 535,869 acres or about 837 square miles (DWR, 2016b). The Subbasin in bounded by the Kings Subbasin to the north, the Kaweah Subbasin to the northeast, the Tule Subbasin to the southeast, the Kern Subbasin to the south, the Kettleman Plain Subbasin to the southwest, and the Westside Subbasin to the northwest.

As shown on the figure, the study area extends beyond the official Subbasin boundaries (as delineated by the DWR) from 3 to 6 miles into adjacent subbasins to better evaluate interactions with groundwater in those adjacent areas. The study area includes approximately 151,880 acres (~237.3 square miles) of the Kaweah Subbasin, approximately 119,360 acres (~186.5 square miles) of the Kings Subbasin, approximately 126,600 acres (~197.8 square miles) of the Tule Subbasin, approximately 81,760 acres (~127.8 square miles) of the Westside Subbasin, and approximately 78,000 acres (~121.8 square miles) of the Kern Subbasin.

The vertical extent of the study area is the freshwater hydrogeologic system, based on the United States Geological Survey (USGS) Central Valley Hydrologic Model (CVHM; Faunt et al., 2009), and modified to be consistent with the findings of Tulare Lake Bed de-designation studies (RWQCB, 2017). The depth zones that comprise the freshwater hydrogeologic system extend to a depth of about 3,000 feet below ground surface (bgs), but not reaching down into the deeper confined saline groundwater below.

2.2 Topography

The Subbasin and surrounding area is generally located in the lowest portion of the San Joaquin Valley (Figure D2-3). Ground surface gently rises to the northeast from about 180 feet above mean sea level (msl) at the Tulare Lake bottom to about 300 feet above msl near Kingsburg. To the southwest, ground surface rises rapidly from the Tulare Lake bottom to about 500 feet near the Kettleman Hills. To the south, ground surface gently rises from the lake bottom to about 220 above msl at the Kern County line.

2.3 Geology

The Subbasin is located in the south-central portion of the greater San Joaquin Valley. The valley was formed generally as a structural trough subsiding between two uplifts: the tectonically driven tilted block of the Sierra Nevada and the thrust belts of the Coast Ranges created by crustal shortening east of the San Andreas fault.

Episodic intrusion of the Pacific Ocean through land gaps along the northern and southern boundaries of the San Joaquin Valley occurred during Miocene and Pliocene times, allowing deposition of marine sediments to accumulate in the subsiding shallow sea environment of the San Joaquin basin. These deposits were subjected to deformation as the Sierra Nevada rose on the east and Coastal Range rose to the west and the valley trough subsided. The marine deposits are exposed in the west-side thrust belts, which typically reach elevations of 2,000 feet or less. Beneath the San Joaquin Valley, the top of the marine deposits are typically 3,000 feet or more below the valley floor, rising on the southeastern portion of the valley to cap the igneous rocks of the uplifted Sierra foothills.

As the land gaps closed in the mid-Pliocene, the continued uplift of the Sierra Nevada and Coast Ranges shed continental deposits to the San Joaquin Valley. These continental deposits, typically assigned to the Plio-Pleistocene Tulare Formation, have filled the valley trough in places with more than 3,000 feet of sediments. Where Pleistocene geologic features periodically cut off the route of major rivers and tributaries to the sea, wide spread and sometimes extreme thicknesses of lacustrine sediments were deposited. Significant examples of these lacustrine deposits are the Tulare Lake Bed clays, the Buena Vista clays, and the Corcoran Clay (sometimes referred to as the E-Clay or modified E-Clay).

2.3.1 Tulare Formation – Continental Deposits

Various investigators in the San Joaquin Valley have assigned ages and names to what they have identified as formations in their respective study areas. The Plio-Pleistocene Tulare Formation, which has its type section on the eastern slope of the North Dome of the Kettleman Hills (Woodring et al., 1940), has been correlated stratigraphically with other valley formations such as the Laguna Formation in the northeast portion of the valley (Woodring et al., 1940) and Kern River formations in the southeast portion of the valley (Bartow, 1991).

In the Subbasin, the primary stratigraphic units containing usable groundwater include the Tulare Formation, older alluvium, and younger alluvium. The Tulare Formation is by far the thickest of these three. The bottom of the Tulare Formation has been defined by Woodring et al. (1940) as occurring just above the Mya interval of the primarily marine San Joaquin Formation, over which it conformably lies on the North Dome, just northwest of the Tulare Lake bed. The Tulare Formation/San Joaquin Formation contact dips steeply eastward from the Kettleman Hills, lying more than 3,000 feet beneath the trough in the Tulare Lake area (Croft and Gordon, 1968). Woodring et al. (1940) have defined the Tulare as the uppermost continental deposits deformed by the folding associated with the Kettleman Hills. However, as noted by Davis et al. (1959), the upper contact of the Tulare Formation with younger continental deposits (older and younger alluvium) is not easily discerned because "at many places along the valley border the dips increase westward so gradually that only a rough separation can be effected between the valley alluvium and the Tulare Formation. Separation of the alluvium from the Tulare Formation beneath the valley is virtually impossible because of their lithologic similarity."

2.3.2 Lacustrine, Marsh, and Flood Deposits

In the Subbasin, Croft & Gordon (1968) identified a number of lacustrine clays in the subsurface that they correlated to lacustrine clays identified by Woodring et al. (1940) in the Tulare Formation in Kettleman Hills. Croft & Gordon (1968) identified these in geophysical logs and named them the A- through F-Clays, with the E-Clay being equivalent to the diatomaceous Corcoran Clay. Though the A- through D-Clays may be important locally in restricting downward movement of groundwater, by far the most important is the EC-Clay, which has been identified as a spatially extensive (about 3,500 square miles, Croft, 1972) and thick clay that separates regionally confined and unconfined groundwater zones in the southern San Joaquin Valley (Figure D2-4). The E-Clay has been age-dated as mid-Pleistocene and is considered part of the Tulare Formation (Croft & Gordon, 1968). Beneath the Tulare Lake bed, there is a thick, nearly homogeneous deposit of lacustrine clays from ground surface to the San Joaquin Formation, including the E-Clay. However, the E-Clay extends far beyond the shoreline of Tulare Lake (Croft, 1972).

2.3.3 Older and Younger Alluvium

The other continental deposits that have been identified in published reports as containing groundwater are the older and younger alluvium (Croft & Gordon, 1968). In the Tulare Lake area, these deposits are primarily Sierran in origin, being deposited by the major stream channels emanating from the Sierra Nevada. Some sediments may have Coast Range origin, but the axis of Tulare Lake bed is close to the Kettleman Hills, which leaves little room for Coast Range sediment deposition on the west side. The older alluvium is widespread throughout the San Joaquin Valley and in other areas represents deposition from both the Coast Ranges on the west side of the valley and the Sierra on the east. It typically overlies the Tulare Formation, though as mentioned earlier, there is no way to differentiate between the two in the subsurface. It is considered Pleistocene to Recent in age. Most of the groundwater withdrawn from the Subbasin comes from the older alluvium/Tulare Formation complex.

The younger alluvium is generally thinner than the older alluvium and is present in current stream channels and as a veneer over the older alluvium as the deposits stretch to the west. The younger alluvium is primarily arkosic and contains groundwater only ephemerally or where underlying clays tend to restrict downward movement of recharging water. It is considered of Recent age.

2.3.4 Tulare Lake Bed

The Tulare Lake bed is the prominent sedimentary feature in the Subbasin. It was a natural lake bed fed by streams from the east and south. Its elongate shape to the northwest reflects the subsidence of the valley trough east of the Kettleman Hills. Geologic cross sections through the Tulare Lake bed (Croft, 1972; Croft & Gordon, 1968; Davis et al., 1959) illustrate the thick and continuous nature of the clay deposits beneath the lake bed (Figure D2-5).

Cross-section A-A′ (Plate 4, Croft & Gordon, 1968) indicates uninterrupted lacustrine deposits from the surface to at least 2,200 feet bgs beneath the central portion of the lake. Cross-sections B-B′ and C-C′ (Plates 5 and 6, Croft & Gordon, 1968) illustrate the interfingering of the coarser sediments and the thinner clay zones along the periphery of the lake with the thick clay deposits beneath the lake. Though Croft & Gordon (1968) did not carry the E-Clay through the lake deposits, Davis et al. (1959, Plate 10, Section G-G′, Diatomaceous Clay) and Croft (1972, Plate 3, Section G-G′, E-Clay) felt they had enough evidence to map it beneath the lake. Davis et al. (1959) show it as being warped downward along the axis of the lake with a maximum thickness of 150 to 175 feet. These cross sections indicate the Tulare Lake deposits form a clay "plug" across the center of the San Joaquin Valley that may be 15 miles wide, 8 miles long, and over ½ mile deep at its maximum dimensions.

2.4 Hydrogeology

The hydrogeology of the Subbasin is complex in that the only physical boundaries are the Kings River and the Kettleman Hills on the southwest edge of the Subbasin. The remaining edges of the Subbasin are based on political and water management areas. The Corcoran Clay under lies most of the Subbasin, and essentially subdivides the Subbasin into two aquifer systems: an unconfined to semi-confined aquifer system above the Corcoran Clay and a confined aquifer system below the Corcoran Clay.

The Kings River appears to be a natural groundwater divide separating the Subbasin and Kings Subbasin. The Kings River is also the primary source of surface water diversion into the Subbasin. As such, the Kings River hydrologic year has a significant influence on groundwater levels in the Subbasin. In the unconfined aquifer, groundwater outflow from the Kings Subbasin into the Subbasin is primarily due to leakage from the Kings River. However, this groundwater predominantly flows along the course of the Kings River and therefore does not remain exclusive to the Subbasin. In the confined aquifer, groundwater outflow from the Kings Subbasin into the Subbasin is also due to leakage from the Kings River in the northeast portion of the Subbasin where the Corcoran Clay is not present. This groundwater has a strong downward vertical component which creates steep southward hydraulic gradients beneath the Corcoran Clay. This groundwater tends to remain resident in the Subbasin confined aquifer.

The groundwater flow system for these two aquifer systems is summarized in the following subsections.

2.4.1 Unconfined Aquifer

The unconfined and semi-confined upper portion of the regional fresh-water aquifer are found above the Corcoran Clay. This upper portion of the regional freshwater aquifer is generally comprised of coarse- to medium-grained sediments (i.e., sand and gravel) with silt and clay interbeds.

Groundwater beneath the Subbasin and surrounding areas is typically found between depths from 30 to 250 feet bgs, depending on location and time. A review was conducted of available DWR groundwater elevation contour maps of the unconfined aquifer from 1960 to 2010 and briefly described below (DWR, 2018). The maps show a persistent, large data gap beneath the Tulare Lake bed where there are few observations of groundwater levels due to a lack of wells.

- In 1990, a dry hydrologic year on the Kings River, groundwater was at an elevation of about 260 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom (Figure D2-6a). Groundwater elevations beneath Hanford were about 170 feet msl, and about 140 feet msl near Corcoran. There were several cones of depression in the water table near Hanford, north and south of Corcoran, and around Alpaugh. The Kings River appears to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kern, Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin.

- In 1995, a wet hydrologic year on the Kings River, groundwater was at an elevation of about 260 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom (Figure D2-6a). Groundwater elevations beneath Hanford were about 150 feet msl and about 110 feet msl near Corcoran. The cone of depression in the water table between Hanford and Corcoran has merged into a single large depression. The Kings River continues to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kern, Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin.

- In 2000, an average hydrologic year on the Kings River, groundwater was at an elevation of about 250 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom (Figure D2-6a). Groundwater elevations beneath Hanford were about 150 feet msl and less than 100 feet msl near Corcoran. The Kings River continues to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kings, Kaweah, and presumably the Kern subbasins and out of the Subbasin to the Tule and Westside subbasins.

- In 2005, a wet hydrologic year on the Kings River, groundwater was at an elevation of about 260 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom. Groundwater elevations beneath Hanford were about 140 feet msl, about 10 feet lower than in 2000 (Figure D2-6b). Throughout the Subbasin, groundwater levels were about 10 or more feet lower than in 2000. The Kings River continues to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kings, Kaweah, and Tule subbasins and out of the Subbasin to the Westside Subbasin.

- In 2010, an average hydrologic year on the Kings River, groundwater was at an elevation of about 250 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom. Groundwater elevations beneath Hanford were about 130 feet msl and less than 10 feet msl near Corcoran (Figure D2-6b). Throughout the Subbasin, groundwater levels were about 10 or more feet lower than in 2005. The Kings River continues to be a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kings, Kaweah, Tule, and presumably the Kern subbasins and out of the Subbasin to the Westside Subbasin.

- In 2016, a dry hydrologic year on the Kings River, groundwater was at an elevation of about 230 feet msl near Kingsburg, decreasing toward the Tulare Lake bottom. In the Hanford area, groundwater levels were about 110 feet msl, about 20 feet lower than in 2010. Cones of depression in the water table west, north, and southeast of Corcoran are still present and becoming deeper (-40 feet msl). The Kings River no longer is a natural groundwater divide. In general, the potentiometric surface map indicates that groundwater was flowing into the Subbasin from the Kings and Kaweah subbasins and out of the Subbasin to the Kern, Tule, and Westside subbasins.

2.4.2 Confined Aquifer

The sediments below the Corcoran Clay comprise the lower confined portion of the regional fresh-water aquifer. This lower portion of the regional freshwater aquifer is generally comprised of clay, silt, sandy silt and clay, sand, silty/clayey sand, gravel, and sandy, silty and clayey gravel (Page, 1983).

There are few available maps showing groundwater elevations in the confined aquifer beneath the Subbasin and surrounding areas (Harder, 2017). In fall 1998 and spring 1999, a wet hydrologic year on the Kings River, groundwater was at an elevation of about 100 feet msl near Corcoran, decreasing to the south towards an apparent pumping center near Alpaugh. In general, the potentiometric surface map (Harder, 2017) indicates that groundwater was flowing into the Subbasin from the Kaweah Subbasin and out of the Subbasin to the Tule Subbasin.

In fall 2010, an average hydrologic year on the Kings River, groundwater was at an elevation of about -50 feet msl near Corcoran, decreasing towards an apparent pumping center southwest of Corcoran. In general, groundwater was flowing into the Subbasin from the Kaweah and Tule subbasins.

2.4.3 Subsidence

Land subsidence due to groundwater drawdown associated with heavy groundwater pumping has affected large areas of the San Joaquin Valley since the 1920s, including the Subbasin (AFW, 2018). Between 1926 and 1970, there was approximately 4 feet of cumulative subsidence near Corcoran, 4 to 6 feet of subsidence near Hanford, and as much as 12 feet of subsidence near Pixley (Figure D2-7). Following the completion of the SWP and Central Valley Project (CVP), surface water became readily available and groundwater extraction was reduced and subsidence due to groundwater drawdown was temporarily slowed or stopped.

In the past 10 to 25 years, groundwater pumping has once again been increasing, with associated resumption and acceleration of groundwater drawdown and associated subsidence. The subsidence was exacerbated during a moderate to severe drought from 2007 through 2009, and a severe to exceptional drought from 2012 through 2016. A Jet Propulsion Laboratory study of subsidence between June 2007 and December 2010 (JPL, 2012) indicated subsidence rates were as high as 8.5 inches per year in the vicinity of Corcoran (Figure D2-7). A more recent study by Jet Propulsion Laboratory (JPL, 2017) indicted that subsidence rates accelerated in some areas during the recent drought, with annual subsidence rates of 1 to 1.5 feet near Corcoran in 2015-2016 (Figure D2-8). Groundwater pumping and drawdown, and consequent subsidence, are anticipated to continue into the future at least until sustainable groundwater pumping is achieved. Due to inelastic soil behavior, subsidence is mostly irreversible even if groundwater pumping decreases and groundwater level recovers.

2.5 Surface Water Occurrence

Historically, river runoff from the Sierra Nevada collected in terminal lakes on the basin floor in the San Joaquin Basin creating vast regions of Tule marshes and woodland wetlands (Figure D2-9a). Tulare Lake, the largest terminal lake, received runoff from four major rivers, the South Fork Kings, Kaweah, Tule, and Kern Rivers (ECORP, 2007). These rivers formed broad deltaic and alluvial fans as they emerged from the Sierra foothills forming multiple channels and sloughs that shifted periodically especially during flooding events (ECORP, 2007). The natural hydrology of the Tulare Lake Basin has been extensively altered over the last 130 years for flood control, irrigation, land reclamation, and water conservation. Concerns about water supplies led to the construction of large dams and reservoirs on each of the four major rivers and channelization of the rivers for flood control and water banking have further modified the Tulare Basins hydrography (ECORP, 2007). The surface water sources that supply the Subbasin are primarily from man-made canals and diverted rivers.

2.5.1 Tulare Lake

Tulare Lake was the largest freshwater lake west of the Mississippi River estimated to encompass 790 square miles at its highest overflow lever of 216 feet in 1862 and 1868 (Figure D2-9a) (ECORP, 2007). The lake was very shallow and had no natural outlet when the water levels was below 207 feet (ECORP, 2007). However, at 207 feet, the water could flow north into the San Joaquin River Basin. Increased diversion of water from the rivers and tributaries that previously flowed into Tulare Lake resulted in the lake drying up in the late 1800s except when occasionally flooded.

2.5.2 Kings River

The Kings River is a 133-mile-long river, the largest river draining the southern Sierra Nevada. The Kings River has three main tributaries, the North Fork, Middle Fork and South Fork, with the North and Middle forks flowing north to the San Joaquin River and the South Fork flowing south to the old Tulare Lake bed. Significant water development structures including the Pine Flat Dam were constructed in the last century to control and modified the rivers flow. The Kings River lies along the boundary between the Subbasin and Kings Subbasin, a portion of the boundary between the Subbasin and Westside Subbasin, and a portion of the boundary between the Subbasin and Kaweah Subbasin (Figure D2-9b). Leakage of water from the Kings River and distributary canals provides significant groundwater recharge in the Kings, Kaweah, Westside, and Tulare Lake subbasins, resulting in complex groundwater flow patterns between the subbasins.

2.5.3 Kaweah River

The Kaweah River is a 100-mile-long river in Tulare County and drains the southern Sierra Nevada (Figure D2-9a). The Kaweah River begins as four forks in Sequoia National Park, then flows in a southwest direction to Lake Kaweah – the only major reservoir on the river – and into the San Joaquin Valley, where it diverges into multiple channels across an alluvial plain around Visalia. The lower course of the river and its many distributaries – including the St. John's River and Mill Creek – form the Kaweah Delta, a productive agricultural region in the Kaweah Subbasin. Before the diversion of its waters for irrigation, the river flowed into Tulare Lake.

2.5.4 Tule River

The Tule River is a 71-mile-long river in Tulare County and drains the southern Sierra Nevada (Figure D2-8c). The Tule River has three main tributaries, the North Fork, Middle Fork and South Fork, that in the past flowed into Tulare Lake. Currently, water in the Tule River now flows into Lake Success, a reservoir constructed in 1961 near Porterville, California, and only in times of above normal precipitation or snow melt is water released onto the dry Tulare Lake bed.

2.5.5 Canals and Pipelines

There are 34 rivers, streams, canals, and diversions entering and within the Subbasin that deliver surface water to the Subbasin (Figures D2-9b-d).

Water is imported into the Subbasin using facilities of the SWP located west of the Subbasin and the CVP. Water can also be exported out of the Subbasin using the SWP and CVP facilities in combination with facilities developed by local water districts (ECORP, 2007). The CVP imports San Joaquin River water into the Subbasin through the Friant-Kern Canal and Delta water through the Delta-Mendota and San Luis Canals.

The Friant-Kern Canal is operated and maintained by the Friant Water Authority and is used to convey water from the San Joaquin River to Kern County. The canal originates at the Friant Dam, which is operated by the United States Bureau of Reclamation. The Friant-Kern Canal flows southeasterly along the western flank of the Sierra Nevada foothills through Fresno, Tulare, and Kern counties. The Friant-Kern Canal has a capacity of approximately 5,300 cubic feet per second or about 10,510 acre-feet per day (AF/D), which decreases to about 2,500 cubic feet per second or about 4,960 AF/D as demand decreases toward its end in the Kern River, near Bakersfield, California (AFW, 2018).

2.6 Climate

The climate in the Subbasin is semi-arid characterized by hot, dry summers and cool moist winters and is classified as Mediterranean steppe climate (Köppen climate classification). The wet season occurs from November through March with 80 percent (%) of precipitation falling during this time frame (ECORP, 2007). The valley floor often receives little to no rainfall in the summer months. Precipitation typically occurs from storms that move in from the northwest off the Pacific Ocean and occasionally storms from the southwest that contain warm sub-tropical moisture can produce heavy rains especially during El Nino episodes.

Historical annual precipitation at the Hanford weather Station from 1899 to 2017 (Hanford, 2017) has ranged from a low of 3.37 inches in 1947 to a maximum of 15.57 inches in 1983 (Table D2-1). Monthly precipitation in the area ranges between 0 and 6.69 inches per month and averages about 8.28 inches per year. This results in an estimated 2 inches per year of infiltration into the unconfined aquifer. Figure D2-10 provides a chart of the annual precipitation at the Hanford station from 1940 to 2017.

2.7 Land Use

Land use in the Subbasin and surrounding areas is predominately agricultural with smaller urban areas. Land use was evaluated using DWR land use maps for 1990 through 2006 (DWR, 2016a) and annual CropScape maps from 2006 through 2016 (USDA, 2016). These maps were provided in Geographic Information System formats, allowing for aggregation of similar land uses (i.e., crop types) to simplify analysis (Figure D2-11a-d). A total of 33 land uses were identified and evaluated (Table D2-2). Of these land uses, 27 were assumed to be irrigated, while 6 land uses (open water, forests, etc.) were assumed to only receive precipitation.

The Subbasin covers an area of approximately 535,869 acres or about 837 square miles (DWR 2016b). Between 1990 and 2016, the Subbasin had an average of approximately 310,800 acres of crops, 7,110 acres of riparian or open water, 137,110 acres of fallow or non-developed land, and 22,130 acres of urban and industrial development (Table D2-2, Appendix D1). The mix of crops grown and fallow lands has changed over time as agricultural practices changed in response to agricultural markets and drought conditions. A chart of area by land use shows that fallow acreage increased significantly during the 2010-2016 drought, while riparian, cotton, and pasture acreage all decreased during the drought (Figure D2-12). Cotton showed the most change with a decrease of over 85,000 acres between 1995 and 2016. The data also show that the was an overall increase in permanent crops over time, with increases in young and mature almonds from approximately 7,680 acres in 1995 to 42,300 acres in 2016. The total acreage of pistachios also increased from 4,700 to 26,900 acres between 1995 and 2016; however, there was a loss of 4,220 acres of mature pistachios with a concurrent increase of 26,400 acres of young pistachios.

Annualized tables and charts of land use for the Subbasin GSAs and the portions of the Westside, Kings, Kaweah, Tule, and Kern subbasins within the model domain are presented in Appendix D1.

2.8 Basin Water Budget

The basin water budget describes the inflows to and outflows from the Subbasin hydrogeologic system. Inflow and outflow can occur from the hydraulic boundaries of the system, from various sources within the model domain such as rainfall, lakes, and leakage from rivers and canals, and from the exit points or sinks such as wells or drainage systems. The boundaries, sources, and sinks identified within the model domain are discussed below.

2.8.1 Inflows

Inflows consist of precipitation, surface water diversions for irrigation, imported groundwater for irrigation, intentional recharge, and leakage from streams and conveyances.

2.8.1.1 Precipitation

Precipitation can be a significant source of water to the Subbasin and surrounding area. Given the large areal extent of the Subbasin and surrounding area, it was determined that using a single weather station to estimate precipitation would be inadequate to represent the entire Subbasin. Instead, the Parameter-elevation Regression on Independent Slopes Model (PRISM) database maintained by the Oregon State University was used to estimate monthly precipitation from January 1990 through December 2016 across the model domain (PRISM, 2017). The PRISM database contains monthly total precipitation for the entire United States using a 4-kilometer grid. The monthly precipitation values are statistically derived values based on local weather stations and corrections for topographic variations. A total of 304 PRISM data sets were downloaded for the model domain. The monthly precipitation data were summed by Subbasin area to estimate the potential annual precipitation volume for each subbasin (Figure D2-13a). Maps of average monthly rainfall across the model domain for the months of January, March, May, July, September, and November shows that precipitation also varies spatially across the model domain (Figure D2-13b).

Not all rainfall is available for use by crops – some fall on impervious surface, some is taken up by dry soils, some is intercepted by foliage and on evaporates before it can infiltrate, and some deep percolates and recharges groundwater. Monthly effective precipitation was estimated by multiplying the monthly PRISM data sets by the Precipitation / Effective Precipitation ratios presented in FAO 56 (Chapter 3, Table 6; Allen et al., 1998) and shown on Figure D2-14. A table and chart summarizing annual effective precipitation by subbasin within the model domain is presented on Figure D2-15. This shows that between 1990 and 2016, effective precipitation provided as little as 9,320 acre-feet (AF) in a dry year (2013) to 501,030 AF in a wet year (2010) and averaged approximately 214,720 acre-feet per year (AF/Y) of water across the model domain.

2.8.1.2 Surface Water Diversions

Surface water diversion from external sources are the most significant source of water to the Subbasin and surrounding area. There are 34 rivers, streams, canals, and diversions entering and within the Subbasin that have recorded diversions (Figure D2-9a-c). Two primary data sources were employed for the surface water inflows and deliveries to the farms within the model domain:

- For lands within the Subbasin itself, surface water delivery and diversion records were obtained by via direct contacts with the various GSAs (and member water management agencies within the

GSAs) within the Subbasin proper (Table D2-3). Those records were relatively complete from 1990 through 2016 for diversions off the Kings system and SWP. As shown on Table D2-3, during the period 1998 through 2010, the Kings River had six below normal water years, four average water years, and three above average water years. Over the 1998-2010 period is Kings River water years average 96% of normal, making this a "normal hydrology" period.

- For deliveries to lands located within the model buffer area (between the boundaries of the Subbasin as defined by the DWR and the TLSBHM model domain boundaries), a combination of data gathered for GSAs whose footprint extended into the Subbasin proper, and data mined from the C2VSIM (Brush et al., 2016) model for those GSAs and water management districts that lay completely outside the official Subbasin boundary were utilized. The C2VSIM model surface water data covered from the beginning of the TLSBHM model period through the end of 2011 and was extended through the end of 2016 by correlation of those inflows with Kings River deliveries at Peoples weir. In general, inflows into this area from Kaweah and Tule Rivers, and Deer Creek were reconstructed from a variety of disparate data.

A table and chart summarizing annual surface water diversions by subbasin within the model domain is presented on Figure D2-16. Monthly surface water diversions by subbasin by GSA and subbasin are provide in Appendix D2. This shows that between 1990 and 2016, surface water diversions provided an average of 948,370 AF/Y of water across the model domain and as much as 1,696,540 AF of water in wet years.

The surface water diversions are not delivered uniformly across the model domain spatially or temporally (Figure D2-17). During the 1990-2016 period, there are several areas that historically have not received any surface water diversions or have received intermittent deliveries of surface water (Figure D2-17).

2.8.1.3 Imported Groundwater Supply

One unique feature of the Subbasin is the importation of groundwater supplies from adjacent subbasins. The ER GSA and TCWA GSA operated well fields in the adjacent Tule Subbasin and import the pumped groundwater into the Subbasin as an additional water supply. Between 1990 and 2016, ER GSA operated up to 52 wells in the Creighton Ranch well field, which delivered up to 68,730 AF in a dry year (2014) and as little as 0 AF in wet years (1996-1999) and averaged approximately 39,320 AF/Y in non-wet years (Table D2-4). The TCWA GSA operated up to 51 wells in the Angiola Water District (WD) well field, which delivered groundwater to TCWA GSA lands in both the Subbasin (about 60%) and Tule Subbasin (about 40%). Between 1990 and 2016, the Angiola WD well field delivered up to 23,100 AF in a dry year (2009) and as little as 0 AF in wet years (1996-1999) and averaged approximately 15,950 AF/Y in non-wet years (Table D2-4).

2.8.1.4 Lake Bottom Water Storage

Another unique feature of the Subbasin is the utilization of certain portions of the historical lake bottom for storage of the excess surface water inflows that were not diverted by others. This stored surface water is later used as an irrigation supply. In some years, sufficient water can be stored in the lake bottom to eliminate the need for supplemental groundwater pumping to meet the irrigation demand.

As observed in historical aerial imagery, the area occupied and the locations of water storage changes from year to year, although certain areas to the south appear to be more regularly utilized by storage (Figure D2-18). This can result in significant volumes of stored water in some years. Permanent lakebed storage facilities have the capacity to store approximately 70,000 AF at any given time. During flood events, as an example of conjunctive use, some fields can be flooded allowing for the storage of significant volumes of water, in some years up to 450,000 AF in the ER GSA management area (Figure D2-18). When available, the storage water is typically utilized to supplement surface water deliveries in lieu of groundwater pumping. The importance of this conjunctive management capability is illustrated by the fact that the cumulative excess inflow stored in the lake bottom allowed lake bottom farmers to completely turn off their groundwater well fields between January 1995 and June 1999 (Table D2-4).

2.8.1.5 Intentional Recharge

Groundwater recharge in the Subbasin also occurs from intentional percolation of surface water in infiltration ponds and water banks. The Corcoran Irrigation District (CID) has operated nine intentional recharge basins covering approximately 2,760 acres since the 1980s (Figure D2-19). Aerial photograph analysis shows that only one or two basins are typically utilized each year between March and September when surface water is available, percolating an estimated average of 23,500 AF/Y of surface water. The other ponds are typically dry except in extremely wet years such as 2005-2006, 2010-2011, and 2017 when as much as 147,700 AF of water has been estimated to be percolated. During the 1990-2016 simulation period, the CID Ponds percolated an estimated 616,100 AF of excess surface water.

Kings County Water District (KCWD) has been infiltrating Kings River flood waters along the Old Kings River channel since the 1940s (referred to as Condition 8). Condition 8 water is surface water that naturally would have infiltrated along the Old Kings River channel during high river flow years had the river not been diverted for irrigation. Between 1990 and 2016, Condition 8 recharge has ranged from as little as 0 AF in most years and as much as 36,800 AF in flood years (1995) and averaged approximately 30,370 AF/Y in wet years (Figure D2-20).

In addition, KCWD operates 25 recharge basins totaling about 720 acres within the MKR GSA and also began operating a water bank on the Old Kings River Channel in 2002. Since 2002, approximately 73,600 AF of water has been recharged via percolation through approximately 50 acres of ponds through the water bank, and approximately 48,500 AF has been recovered utilizing five recovery wells. This leaves a positive balance of approximately 25,100 AF in the unconfined aquifer system as of 2016.

In the Chamberlain Ranch area of the ER GSA, 640 acres has been utilized for percolation basins. In 2017, approximately 5,000 AF was recharged. Immediately adjacent to the eastern boundary of the ER GSA in the Tule Subbasin, there are recharge basins that are operated by ER GSA landowners.

2.8.1.6 River and Canal Seepage

Seepage losses from river and canals provide another source of water to the Subbasin and surrounding areas. There are over 290 miles of major streams and canals within the Subbasin, in addition to many more miles of small distribution ditches on individual farms (Figures D2-9b-d). Most to the stream and canals are unlined and can have significant seepage losses. Ownership of canal and river seepage is to be determined. There was little available information on seepage losses in the Subbasin, although anecdotal reports indicate the Old River Channel, Peoples Ditch, and Lakeland Canal all have substantial losses near the head gates at Peoples Weir (personal communication, Dennis Mills).

2.8.2 Outflows

Outflows consist of evapotranspiration, agricultural pumping, municipal pumping, and agricultural drains.

2.8.2.1 Evapotranspiration

Crop evapotranspiration (ETc) or crop demand use is the largest outflow of water from the Subbasin. ETc data are based on spatial distributions of different types of crops, as well as estimated rates of evapotranspiration for the Subbasin area. Crop data comes from DWR data sets for the counties of Fresno, Kern, Kings, and Tulare (surveyed intermittently between 1990-2006) and from CropScape datasets (surveyed annually from 2007-2016). Monthly ETc varies by crop type and by season, typically peaking during the summer months. ETc rates were estimated from published ITRC rates (ITRC, 2003) under normal year conditions for the region (Table D2-5).

Annual crop demand was calculated for each crop type on a 40-acre basis as follows:

Annual Crop Acres (Acres) * *Annual Crop ETc* (Feet/Acre) = *Irrigated Crop Demand* (AF/Y)
(Table D2-2) (Table D2-5) (Table D2-6)

Note: some crop types do not receive irrigation water and thus have zero irrigated crop demand.

Between 1990 and 2016, the total irrigated crop demand in the Subbasin ranged from 564,120 AF in 2015 to 1,072,440 AF in 2007 and had an average irrigated crop demand of approximately 879,020 AF/Y (Table D2-6).

The mix of crops grown and fallow lands has changed over time as agricultural practices changed in response to agricultural markets and drought conditions. A chart of annual crop acreage shows that total crop acreage has generally decreased since 2010 (Figure D2-12). Crop demand shows a similar pattern, generally decreasing from 2009 through 2015 (Table D2-6). Cotton showed the most change with a decrease of crop demand over 50% between 1995 and 2016. The data also show that during the 2011-2016 drought, there was an overall increase in row crop demand including tomatoes, peppers, small vegetables, onion, garlic, grain, and hay. In addition, the data show a large increase in ETc demand from almonds, pistachios, and stone fruits. Annualized tables and charts of crop demand for the Subbasin GSAs and the portions of the Westside, Kings, Kaweah, Tule, and Kern subbasins within the model domain are presented in Appendix D3.

2.8.2.2 Specified Agricultural Well Field Pumping

Agricultural pumping is typically not recorded over much of California, including the Subbasin. However, there are 455 wells with reported production in 6 agricultural well fields within the model domain. A wellfield consists of a group of wells generally located in the same area and operated a single entity to provide a reliable groundwater supply. The agricultural wellfields include: ER GSA (99 wells), Creighton Ranch (52 wells), CID (98 wells), Angiola Water District (51 wells), Westlands Water District (150 wells), and Apex Ranch (5 wells) (Figure D2-21). The ER GSA and CID well fields service local areas in the Subbasin. The Creighton Ranch and Angola Water District well fields, located in the Tule Subbasin, service the Tule Subbasin and also export significant amounts of groundwater to the Subbasin. The Westlands Water District well field only services the Westside Subbasin. The specified pumping from the agricultural well fields has varied significantly over time, ranging from 23,470 AF (1998) to 370,880 AF (2016) and averaging about 202,750 AF/Y (Figure D2-22). The reduction in annual pumping coincides with the availability of surface flood waters (Figure D2-18). Appendix D4 presents an annualized summary of reported pumping by agricultural well fields within the model domain.

2.8.2.3 Specified Municipal Well Field Pumping

Municipal pumping of groundwater occurs in the Subbasin by the cities of Hanford, Lemoore, Stratford, and Corcoran (Figure D2-21). Specified pumping from the 30 identified municipal well fields has been slowly increasing over time but has remained relatively consistent (Figure D2-22). Between 1990 and 2016, reported municipal pumping has ranged from 9,110 AF (1991) to 26,700 AF (2002) and averaged 14,910 AF/Y over this 26-year period. The municipal pumping demand varies seasonally, peaking in the summer months. As noted in Section 2.4, municipal pump has created persistent cones of depression in the potentiometric surface near the cities of Hanford and Corcoran. Appendix D4 presents an annualized summary of pumping by municipal wells within the model domain as reported by the cities.

2.8.2.4 Estimated Agricultural Pumping

As noted above, agricultural pumping is typically not recorded over much of California, including the Subbasin. However, agricultural pumping by subbasin can be estimated using a simple water balance approach where:

Irrigated Crop Demand (AF/Y)- *Effective Precipitation* (AF/Y) */ Irrigation Efficiency* (%) = *Farm Demand* (AF/Y)

and

Farm Demand (AF/Y) – *Surface Water Supplies* (AF/Y) = *Estimated Agricultural Pumping Demand* (AF/Y) (Figure D2-23)

Note: Surface Water Supplies include Surface Water Deliveries, imported groundwater, and lake bottom water storage

Although this simple water balance approach does not account for subtleties in the areal distribution of effective precipitation, irrigation efficiency, and surface water deliveries, it does provide a reasonable gross estimate of agricultural pumping on the subbasin scale. Based on this analysis, gross agricultural pumping demand in the Subbasin from 1990 through 2016 has ranged from 24,730 AF (1995) to 785,260 AF (1991) and averaged approximately 469,560 AF/Y (Figure D2-23).

2.8.2.5 Agricultural Drains

Agricultural drains are used in several areas across the model domain to keep soil from becoming waterlogged in the root zone. Typically, a tile or French drain system is used, with tiles buried approximately 4 to 6 feet bgs draining to sumps. Subsurface drainage collected in the sumps is pumped via pipeline to evaporation basins. Figure D2-24 shows the approximate location of known subsurface drains within the Subbasin.

3.0 Simulation Code

In order to meet the model objectives discussed in Section 1.3, the groundwater flow model code must meet the following criteria:

- be able to simulate three-dimensional groundwater flow within the model domain,
- be well documented and verified against analytical solutions for specific flow scenarios,
- be accepted by regulatory agencies,
- be readily understandable and usable by others for simulation of future groundwater conditions, and
- have a readily available technical support structure.

The groundwater flow model codes MODFLOW2005-NWT (Niswonger et al., 2011) and MODFLOW-OWHM (Hanson et al., 2014) are two distinct versions from the well-known MODFLOW family of groundwater simulation codes. These codes were used to develop the Subbasin model.

MODFLOW is a modular, finite-difference computer code developed by the USGS to simulate three-dimensional groundwater flow (McDonald and Harbaugh, 1988, Harbaugh, A. W., 2005). The use of the MODFLOW family of codes is well documented in technical literature and is a de facto standard for groundwater flow modeling worldwide.

MODFLOW2005-NWT is a particular version of MODFLOW that implements the Newton method for handling non-linearities in flow equations, which allows for very efficient solution of the flow equation including complexities such as unsaturated zone flow, eliminated the cell draining and re-wetting problems of earlier versions of MODFLOW (Niswonger et al., 2011). MODFLOW-OWHM is a relatively new version of MODFLOW (still under development) specifically developed to provide a flexible and robust approach to simulate conjunctive management of surface water and groundwater resources in an agricultural crop production setting (Boyce et al., 2016).

3.1 Model Code Selection

Once the decision was made to develop a model using the MODFLOW family of codes, the initial plan was to develop both a MODFLOW2005-NWT model and a MODFLOW-OWHM model to provide independent, yet complementary, methods for model development. This was planned due to the fact that both codes will share many of the same input files, only differing in how the farm irrigation pumping is specified. For the NWT model, the farm irrigation pumping requirement would be calculated externally in a de-coupled modeling approach, whereas with OWHM, the farm irrigation pumping is calculated internally as a dynamic component.

The MODFLOW-NWT (“MF-NWT”) code would be employed to develop a “de-coupled” model of conjunctive surface water – groundwater management in the Subbasin. In the de-coupled approach, the following four-step procedure is used to build surface boundary processes (irrigation, crop water use, return flows, etc.), build the irrigation well pumping file, and run the model to simulate system response:

- the crop ETc demand calculated externally on a model cell-by-cell basis based on cropping patterns, crop coefficients, and reference ETc;
- effective precipitation and specified surface water deliveries are also calculated on a model cell-by-cell basis, irrigation pumping demand is calculated as the ETc demand – effective precipitation - surface water supplies;
- the resulting cell-by-cell irrigation pumping demand is subsequently summed by area, and assigned to a hypothetical pumping well in the center of the area in the de-coupled model; and
- the model is run to simulate groundwater-system response (drawdown, loss of storage, subsidence) to the stresses (including municipal and irrigation pumping, natural recharge, intentional artificial recharge, recharge from stream and canal leakage, recharge from irrigation return flows.

The MODFLOW-OWHM (“MF-OWHM”) code was investigated as a tool to dynamically simulate conjunctive management of surface water and groundwater resources in the Subbasin. The MF-OWHM model employs basically the same input data sets used to calculate the ETc and irrigation pumping demands externally for the de-coupled MF-NWT model, but the MF-OWHM simulations are dynamic in the sense that the ETc and irrigation pumping are calculated internally within the model allowing for "feedback loops" between these two key stressors on the groundwater system. The MF-NWT de-coupled model does not address these types of feedback loops that actually can be occurring in the field.

The MF-OWHM, the code is currently undergoing enhancements (from to its capabilities and numerical methods. In January 2019, the USGS indicated that updated version of the model code (OWHM v2) would be available in March 2019. The most recent communication with the USGS indicated that the updated model code might not be ready until the end of October 2019, too late for the GSP schedule. Thus, further development of the OWHM was suspended at the end of March and efforts were directed at completing the de-coupled MF-NWT model for the Subbasin within the project schedule. The remainder of this report focusses on the de-coupled model development, application, and results.

3.2 Code Assumptions and Limitations

There are certain model code assumptions and limitations that must be considered when developing, applying, and interpreting a numerical model. Some key assumptions and limitations that may affect the site models are briefly discussed below.

Porous Media: The MODFLOW family of codes is limited simulation of saturated and unsaturated flow in porous media. It does not simulate flow through fractures or relatively impermeable bedrock.

Layer Continuity: MODFLOW requires that all layer extend from edge-to-edge of the model domain. This limits the ability to explicitly simulate formation pinch-outs or unconformities. Instead these features may be simulated using a hydraulic conductivity contrast.

Unsaturated Flow: The MODFLOW Unsaturated Zone Flow (UZF1) package can simulate flow in the unsaturated zone using an approximation to Richards' equation to simulate vertical unsaturated flow. The approach is limited in that unsaturated flow occurs in response to gravity, and there must be uniform hydraulic properties in the unsaturated zone for each vertical column of model cells. This limits the ability of the MODFLOW to simulate different properties of the thick unsaturated zone. The Brooks-Corey function is used to define the relation between unsaturated hydraulic conductivity and water content. Variables used by the UZF1 Package include initial and saturated water contents, saturated vertical hydraulic conductivity (Kv), and an exponent in the Brooks-Corey function. Residual water content is calculated internally by the UZF1 Package on the basis of the difference between saturated water content and specific yield (Sy).

The UZF1 Package is also substitution for the Recharge (RCH) and Evapotranspiration (ET) Packages of MODFLOW-2005. The UZF1 Package differs from the RCH Package in that an infiltration rate is applied at land surface instead of a specified recharge rate directly to ground water. The applied infiltration rate is further limited by the saturated Kv. The UZF1 Package differs from the ET Package in that evapotranspiration losses are first removed from the unsaturated zone above the evapotranspiration extinction depth, and if the demand is not met, water can be removed directly from ground water whenever the depth to ground water is less than the extinction depth. The UZF1 Package also differs from the ET Package in that water is discharged directly to land surface whenever the altitude of the water table exceeds land surface. Water that is discharged to land surface, as well as applied infiltration in excess of the saturated Kv, may be routed directly as inflow to specified streams or lakes if these packages are active; otherwise, this water is removed from the model similar to the Drain (DRN) Package.

Stress Periods: MODFLOW requires that temporally variable data be consistent within each stress period. This results in some temporally averaging of data. For example, stream flow or municipal pumping may vary hourly or daily in response to demand, while agricultural well field may pump nearly continuously for several months in a row. The averaging of transient stress into consistent monthly stress period tends to smooth out the hydraulic impacts of the transient stresses.

3.3 Graphic Pre/Post-Processor

To facilitate the preparation and evaluation of each model simulation, Wood utilized the graphics pre/post processor GWVistas® Version 7 (GWV) by Environmental Simulations, Inc. (ESI, 2017). GWV is a Windows® program that utilizes a graphic user interface (GUI) to build and modify a database of model parameters. The model grid, hydraulic properties, and boundary conditions are input using the GUI, and then GWV creates the necessary MODFLOW and MT3DMS data input files. The input files generated by GWV are generic (standard) files compatible with USGS MODFLOW-NWT and MT3DMS. Wood also utilized some in-house utilities and Microsoft EXCEL spreadsheets to generate standard MODFLOW data input files for selected simulations and for post-processing simulation results. For example, PYTHON scripts were utilized to add and subtract the large matrices containing 27 years of monthly data worth of effective precipitation, surface water deliveries, and crop demand to estimate agricultural pumping. Similarly, an Excel spreadsheet was created to allocate the estimated agricultural pumping demand to hypothetical wells, and export file formatted for importation into GWV.

GWV was also utilized to post-process the model simulations. GWV can display the simulated head results as plan views and cross-sections. In plan view, the contour intervals and labels specified by the user and dry cells are denoted by a different color. In cross-section view, the water table surface is also plotted. Most outputs to the screen can be saved in a number of formats (DXF, WMF, PCX, SURFER, etc.) for utilization in other graphics programs.

4.0 Model Design

The following sections describe the numerical groundwater flow model for the TLSBHM. The model construction was based on the HCM presented in Section 2.0, with each of the key features described in that Section represented numerically in the TLSBHM. This modeling effort is a revision to the preliminary groundwater model of the Subbasin (Kings Model) developed in 2016-2018 on behalf of the Kings County Community Development Agency (AFW, 2018).

4.1 Model Domain/Grid

As described in Section 2.1, the TLSBHM model domain is centered on the Subbasin and extends beyond the Subbasin several miles, overlapping adjacent subbasins within the Tulare Lake Hydrologic Region (Figure D2-2). The model domain was extended beyond the Subbasin so that model boundary conditions are sufficiently far away the area of interest in the Subbasin; these areas beyond the extent of the Subbasin henceforth are referred to as the “buffer areas” (Figure D2-2). The buffer areas extend approximately 3 miles beyond the DWR-defined Subbasin boundaries on the north, south, and east sides; on the west and southwest sides, however, a large buffer area is not included because the alluvial groundwater basin is truncated by low-permeability geologic units on those side. The active model grid covers an area of approximately 1,091,320 acres (about 1,705 square miles) and is orientated due north to align the model grid with the predominant direction State Plane coordinate system of Township/Range/Sections.

The preliminary Kings Model (AFW, 2018) exhibited some boundary condition interference along the eastern edge of the model. Hence the TLSBHM model grid was extended further east approximately

2.5 miles. In addition, some of the active model grid edges were modified to yield straighter lines to simplify specified boundary conditions. The resulting TLSBHM model grid consists of 281,750 active cells with uniform dimensions of 1,320 x 1,320 feet (¼ mile x ¼ mile, or 40-acres) (Figure D4-1). The complete model grid consists of 230 rows, 175 columns, and 7 layers.

4.2 Model Layers

The purpose of model layers is to represent the hydraulic influence of stratigraphy at a scale appropriate to the model objectives. One way to think of "hydraulic influence" is how finer-grained deposits present resistance to flow, both laterally and vertically, and it is only through multiple model layers that one can simulated the vertical resistance to flow. It is understood that stratigraphic variations occur at scales that are both smaller and larger than that characterized for this model.

- Those hydrostratigraphic variations that are of the same scale or larger than the numerical grid cell size, for example the Corcoran Clay, are captured explicitly in model property variations.
- Those hydrostratigraphic variations that are much smaller than the model cell size are not treated explicitly in the model, but rather their effect is incorporated into the model via appropriate assignment of large scale "effective" properties for the model cell as described above in Section 2.1.1. For example, say three 1- to 2- foot thick clay layer or lenses extend across a large portion of the 1,320-foot x 1,320-foot plan view area of a 50-foot thick model cell. To capture the hydraulic effect of those layers in the 50-foot thick model cell requires significantly reducing the Kv as guided by this conceptual model and application of the harmonic average as a lower bracket for significantly reducing Kv compared to what is in the CVHM model data that was provided to the TLSBHM modeling team by the USGS.

In addition to direct import of the CVHM hydraulic conductivity fields (based on the USGS sediment texture study) as the starting point for the model, refinements to the conceptual and numerical models of the site were based on consideration of several types of information. Supplement information considered included both recent and older USGS literature (Croft, 1972; Page, 1986), monitoring well perforation intervals in sub-areas of the site, and qualitative and quantitative information obtained directly from the GSAs.

The initial basis for the TLSBHM model layering scheme was based on a modified version of the CVHM (AFW, 2018). The modified CVHM model had 13 layers including 5 layers above the Corcoran Clay, 3 layers representing the Corcoran Clay, and 5 layers below the Corcoran Clay. The TLSBHM layering scheme was reduced from 13 layers to 7 layers to simplify the model and make it more consistent with the 3- to 4-layer models being developed for the Tule and Kaweah subbasins. The TLSBHM layer count was reduced by combining several thin layers into a single, thicker layer. For example, the 3 layers representing the Corcoran Clay in the CVHM model were combined into a single layer in the TLSBHM. Layer elevations and thicknesses were also modified in some areas based on local information. The resulting Cross-sections showing the model layering scheme and initial hydraulic conductivity distribution are shown on Figures D4-2 and D4-3.

4.3 Model Duration and Stress Periods

The TLSBHM simulates the period from 1990 through 2016 using 324 monthly stress periods (Table D4-1). The model simulates the period from 1990 to 1995 as a "run-up" period to stabilize the model hydraulics prior to the 1998-2010 focused calibration period. The model continues from 2010 through 2016 to bring the model up to date with current hydraulic conditions as required under SGMA.

4.4 Model Hydraulic Parameters

The initial hydraulic properties assigned to the TLSBHM were extracted from CVHM. The hydraulic parameters were only modified as necessary during the model calibration process to improve the fit between simulated and observed heads. As such, the model contains no more complexity than is justified by the available data, the model objectives, and the model results to date. Section 4.4.1 briefly describes how the USGS used textural information from thousands of boring logs to develop three-dimensional maps of the hydraulic properties.

The range of final hydraulic properties, hydraulic conductivity, Kv, storage, Sy, and porosity used as a result of the calibration process are briefly summarized in the following subsections.

4.4.1 Hydraulic Conductivity

Geologically speaking, the Central Valley is a large structural trough filled with sediments of Jurassic to Holocene age. These sediments reach thicknesses on the order of 15,000 feet in the San Joaquin Valley, and as much as 30,000 feet in the Sacramento Valley. In general, the Sacramento Valley is predominantly fine-grained and reflects more fine-grained volcanic-derived sediments, and in the San Joaquin Valley the areas of coarse-grained texture are more widespread than the areas of fine-grained texture and occur along the major rivers, especially on the eastern side.

The texture (particle size) of these sediments and how that texture varies spatially strongly impacts how groundwater flows in response to recharge and discharge stresses on the system. Therefore, the textural distribution of the basin-fill sediments was used to define the initial vertical and lateral hydraulic conductivity and storage property distributions for the TLSBHM domain.

To characterize the Central Valley basin-fill deposits, scientists from the USGS developed a geologic texture model to describe the coarseness or fineness of basin-fill materials that make up the hydrogeologic system, and then used it to estimate hydraulic properties (hydraulic conductivity and storage properties) for every cell in the model grid. To create a sediment texture model for the Central Valley, the USGS compiled and analyzed data and information from approximately 8,500 drillers' logs of boreholes ranging in depth from 12 to 3,000 feet below land surface (Faunt el al., 2009). The textural characterization focused on the variability and spatial distribution of the fraction of coarse sediments (f_c) over 50-foot depth intervals. Figure D4-4 presents the f_c for several of the model layers, and Figure D4-5 presents an oblique view of f_c for the San Joaquin Valley, with the TLSBHM study area outlined in red. In general, there are two key aquifer systems, the upper unconfined and semi-confined aquifer and the deeper confined aquifer system, separated by the Corcoran Clay aquitard. On Figures D4-4 and D4-5, the Corcoran Clay horizon is found in model layers 6 through 8, with the unconfined and semi-confined shallow aquifer system in model layers 1 through 5 and the deeper confined aquifers in model layers 9 through 13.

The USGS generated estimates of hydraulic properties from their texture model developed for the CVHM. These values were imported directly into the TLSBHM to use as initial values prior to beginning model calibration. The initial hydraulic conductivity distribution utilized in the TLSBHM is shown on Figure D4-6.

Beneath the Subbasin study area, previous studies have identified extensive deposits of fine-grained materials consisting of lacustrine and marsh sediments (Croft and Gordon, 1968; Croft, 1972; Page, 1986, Williamson et.al., 1989). A cumulative thickness of as much as 3,000 feet of these fine- grained deposits have been identified and include laterally extensive clay layers (A – F Clays). The A-, C-, and E-Clays (i.e., Corcoran Clay) cover much of the TLSBHM domain. During the calibration process, these studies and input from the GSAs were utilized to adjust hydraulic properties derived from the USGS texture model to be more representative of the Tulare Lake bed and surrounding area (Figure D4-7). The following subsections provide a summary of the hydraulic properties for each of these depth intervals.

4.4.1.1 Unconfined and Semi-Confined Aquifer Zones above the Corcoran Clay

Above the Corcoran Clay is the unconfined to semi-confined upper portion of the regional fresh-water aquifer. This upper portion of the regional freshwater aquifer is generally comprised of coarse- to medium-grained sediments (i.e., sand and gravel) with silt and clay interbeds.

According to the USGS CVHM, the grid-block-scale horizontal hydraulic conductivity (K_h), ranges from 8 to 75 feet per day (ft/d). These values span the lower range of a "good aquifer" as defined by Bear (1972). Figure D4-4 presents the K_h distribution derived from the USGS texture study for selected model layers. On Figure D4-4 (as well as Figure D4-6), a broad swath of lower permeability (low sand fraction) deposits is evident that run from the northwest side of the model domain trending to the southeast toward the southeast corner of the model domain. In this zone, the hydraulic conductivities derived from the CVHM are in the 5 to 25 ft/d range, which is closer to the range of a "poor aquifer" (Bear, 1972), and which appear to be lower than values obtained from pumping tests in these areas (P&P, 2009). In fact, the averaging of sediment texture (f_c) over 50-foot depth intervals leads to "smoothing out" of permeability contrasts.

As described previously, it is important to recognize that even in the zones with a higher fraction of coarse textured sediments, clayey layers and lenses are found throughout the profile. This is especially important for estimating effective horizontal-to-vertical anisotropy of hydraulic conductivity for a numerical model layer thickness of 50 feet, which is the scale of vertical averaging that the USGS employed in their sediment texture study. For example, say the fraction of coarse-materials over a 50-foot depth interval is 90%; if the remaining 10% consists of a fine fraction that is concentrated in a few clay layers on the order of a foot thickness, then the effective K_v should tend toward the harmonic average of a clay and a sand (Freeze and Cherry, 1979). If the sand has a K_h of 90 ft/d and the clay layers have a K_h of 0.01 ft/d, then the effective K_v for that grid cell could be estimated using a layer-thickness weighted harmonic average as:

$$K_v \approx [50 / ((5/0.01) + (45/90))] = [\ 50/500.5] \approx 0.1 \text{ ft/d}$$

The effective K_h can be estimated as the layer-thickness weighted arithmetic average:

$$K_h \approx [\ (45\text{x}90) + (5\text{x}0.01)] / 50 \approx 90^* (45/50) = 81 \text{ ft/d}$$

These simple calculations indicate that it would be reasonable to expect very high anisotropy ratios (very low effective K_v), and indeed that is what was found during the model calibration process (see Section 5.0).

The storage properties above the Corcoran Clay do not vary nearly as much as the hydraulic conductivity in this portion of the aquifer. The S_y of the sediments above the Corcoran Clay (Layers 1 through 3) range from 0.08 to 0.3, while the specific storage (S_s) ranges between 1.5x10-5/feet and 7.3x10-3/feet.

4.4.1.2 Corcoran Clay Aquitard

The lateral extent and thickness of the Corcoran Clay are shown on Figure D2-4. While it is sometimes considered a continuous layer of low permeability sediments spanning across the San Joaquin Valley, in fact comparing these figures to the CVHM hydraulic conductivity maps for model layers 4 through 10 (Figures D4-4 through D4-6) clearly shows that the Corcoran Clay grades into coarse materials laterally, as well as above and below. They also show that some clay lenses exist above and throughout areas characterized as relatively "coarser" in the USGS texture study. Recognizing that the texture maps were developed from averaging f_c over 50-foot depth intervals, this impacts the effective Kv used in the TLSBHM as described in the previous section.

This is consistent with recent investigations by the USGS in the San Joaquin Valley, which indicate that the groundwater conditions grade from unconfined, or water-table, at the shallowest depths to semi-confined with increasing depth, eventually grading into fully confined conditions beneath the Corcoran Clay. Geophysical well logs indicate that the Corcoran Clay, although probably the largest single confining bed, constitutes only a small percentage of the total cumulative thickness of clay layers in the fresh-water bearing unconsolidated sediments in the Subbasin. Thus, it is more accurate to consider the confinement as the result of numerous overlapping clay lenses and beds. Further, the difference in hydraulic head directly above and below the Corcoran Clay is relatively small when compared to head differences between larger intervals of the deeper parts of the aquifer system. Again, rather than to explicitly simulate each of these thin clay layers and lenses discretely in the model, their impact on the flow system is simulated through the high anisotropy in hydraulic conductivity (very low Kv).

Hydraulic conductivity (K_h) values of the Corcoran Clay cells in the model domain from the USGS CVHM range from 0.5 to 10 ft/d, which is rather high for an aquitard material, and especially high considering that the harmonic average should be the guide for effective K_v. As mentioned in Section 4.4.1, hydraulic conductivity values at the depth horizon of the Corcoran Clay were adjusted during model calibration to improve the fit between the simulated and observed hydraulic heads over time.

In addition, as discussed in Section 2.3.4, Croft & Gordon (1968) identified uninterrupted lacustrine (clay) deposits from the surface to at least 2,200 feet bgs beneath the central portion of the Tulare Lake bed (Figure D2-5). These lacustrine deposits interfinger with coarser sediments and the thinner clay zones along the periphery of the lake with the thick clay deposits beneath the lake bed itself. The Corcoran Clay (E-Clay) has been identified as extending beneath the lake bed (Davis et al., 1959). show it as being warped downward along the axis of the lake with a maximum thickness of 150 to 175 feet. These cross sections indicate the Tulare Lake deposits form a clay "plug" across the center of the San Joaquin Valley that may be 15 miles wide, 8 miles long, and ½ mile deep at its maximum dimensions. This was incorporated into the TLSBHM (Figure D4-7).

Again, the storage properties do not vary as much as the hydraulic conductivity, with S_s of the Corcoran Clay and other sediments in this depth horizon ranging between 4.5x10-4/feet and 1.2x10-3/feet, with the S_y ranging from 0.10 to 0.15 where unconfined. Storage values were adjusted during model calibration to improve the fit between the simulated and observed hydraulic heads over time.

4.4.1.3 Confined Aquifer Beneath the Corcoran Clay

Hydraulic conductivities initially assigned to the model layers beneath the Corcoran Clay horizon were derived from the USGS CVHM. Conductivity values generally ranged from 20 to 40 ft/d, except for two broad regions of lower permeability. One of the areas with a predominance of low-K_h materials at depth is in the Westside Subbasin to the west, and the other is beneath the southeast buffer areas near where Deer Creek enters the model domain. Again, the storage properties do not vary as much as the hydraulic conductivity, with Ss of the sediments below the Corcoran Clay ranging between $6.8\text{x}10^{-4}$/feet and $1.5\text{x}10^{-3}$/feet. Storage values were adjusted during model calibration to improve the fit between the simulated and observed hydraulic heads over time.

The TLSBHM groundwater model was initially assigned variable K_h values that ranged between $4.0\text{x}10^{-4}$ ft/d for aquitard clay units to 91 ft/d for aquifers, with the spatial distribution of the properties derived from the CVHM. These values were modified as necessary during the calibration process to improve the model fit to observed groundwater elevations (Figure D4-7).

4.4.2 Storage

The TLSBHM groundwater model was initially assigned S_s values from the USGS CVHM. Initial S_s values ranged between $1.5\text{x}10^{-5}$ to $7.3\text{x}10^{-3}$ feet-1. These values are within the published range of values for the silty to sandy sediment types (Spitz and Moreno, 1996). S_s values were modified over a limited range during the model calibration process.

4.4.3 Specific Yield

The TLSBHM groundwater model was initially assigned S_y values from the USGS CVHM. Initial S_y values ranged between $7.9\text{x}10^{-2}$ to $3.0\text{x}10^{-1}$. These values are within the published range of values for the silty to sandy sediment types (Spitz and Moreno, 1996). S_y values were modified over a limited range during the model calibration process.

4.4.4 Porosity

The TLSBHM groundwater model was initially assigned porosity values from the USGS CVHM. Initial porosity values ranged between $9.1\text{x}10^{-2}$ to $2.9\text{x}10^{-1}$. These values are within the published range of values for the silty to sandy sediment types (Spitz and Moreno, 1996). Porosity values were modified over a limited range during the model calibration process.

4.5 Model Boundary Conditions

Significant hydraulic boundaries (sources and sinks) within the model domain that must be considered in the site numerical model include the inflows and outflows from surrounding subbasins, inflows and outflows of surface water, return flows and intentional recharge, and groundwater pumping. These boundaries are discussed in the following subsections.

4.5.1 General Head Boundaries

The MODFLOW General Head Boundary (GHB) package was utilized to simulate the north, south, and east edges of the model domain and represent the aquifer system beyond the model domain (Figure D4-8). For the TLSBHM, the GHBs were developed based on historical water level observations in well located within 2 miles of the model domain boundary. Figure D4-8 shows the locations of wells evaluated to develop the GHB boundary conditions. The GHBs were developed as a series of 20 GHB reaches. The GHB heads at the ends of each reach were interpolated on a monthly basis from the available hydrograph data. The GHB heads for each cell within a reach were then linearly interpolated between the end points. This resulted in a relative smooth variation in GHB heads along the length of each reach.

The GHB conductance term, which governs how much water can flow through the GHB, was calculated as:

Conductance = KLW/M in square feet per day (ft^2/d), where:

K is the hydraulic conductivity of the sediments (assumed to be 25 ft/d),
L is the GHB length or distance to the head value (assumed to be 1,320 feet),
W is the GHB width (assumed to be 1,320 feet), and
M is the saturated thickness of GHB layer (assumed to be 100 feet).

4.5.2 River and Canal Boundaries

As noted above, several rivers and streams deliver surface water to irrigated lands within the model domain. The most important of these is the Kings River, which enters the model domain on the northeast side, and it flows westward near the top of the model domain before turning southwest then southward in the western portion of the model domain. Other major surface water inflows are provided by the Kaweah River, the Tule River, Deer Creek, and Poso Creek. Figure D4-9 shows the locations of each of these surface water features; also shown are the major distributary canals that take the deliveries from the streams and rivers and distribute that water to the irrigation farmlands.

The MODFLOW River (RIV) package was utilized to simulate all the stream and canals that deliver water to irrigated lands. The streams were developed as a series of 23 RIV reaches, where each RIV reach is composed on many model cells. The RIV package is a head dependent boundary and will allow water to enter groundwater via seepage (losing stream) or exit groundwater (gaining stream) based on river stage (Head) and a steam bed conductance term:

Conductance = KLW/M in ft^2/d, where:

K is the hydraulic conductivity of the sediments (assumed to be 1 to 10 ft/d),
L is the length of the river reach (variable in feet),
W is the river width (assumed to be 10 to 40 feet), and
M is the thickness of the river bed (assumed to be 10 feet).

The rivers were assumed to leak anytime there were surface water diversions down a particular river reach. Throughout the Subbasin, almost all river are disconnected from groundwater and are losing rivers. Appendix D2 presents an annualized summary of river flow by reach within the model domain.

4.5.3 Agricultural Drains

The MODFLOW Drain (DRN) package was utilized to simulate the agricultural drains within the model domain (Figure D2-24). The DRN package is a head dependent boundary condition that only collects groundwater above a specified elevation. Similar to GHBs, the rate of removal is governed by a conductance term:

Conductance = KLW/M in ft^2/d, where:

K is the hydraulic conductivity of the sediments (assumed to be 100 ft/d),
L is the length of the drain (assumed to be 1,320 feet),
W is the width of the drain (assumed to be 1,320 feet), and
M is the thickness of the drain bed (assumed to be 1 foot).

In areas where drains were simulated, if simulated groundwater rose to within 4 feet of ground surface, then groundwater was collected by the drains and assumed to be discharged to evaporation basins where it evaporated and was removed from the model domain.

4.5.4 Groundwater Extraction

Groundwater extraction for municipal, industrial, and agricultural demand was simulated using the MODFLOW Multi-Node Well (MNW2) package. The MNW2 package is a powerful enhancement to the original MODFLOW well package in that it allows for simulation of wells screened across multiple model layers (aquifers). Thus, the MNW2 package will calculate inflows from each model layer within the screened interval as well as the calculating flow within the well casing, including flows from one layer to another when the well is not being pumped. In addition, the MNW2 package will automatically increase pumping from deeper intervals as shallower aquifers become dewatered until the pumping level in the well approaches a specified elevation (such as a pump setting).

4.5.4.1 Specified Pumping Wells

As discussed in Sections 2.8.2.2 and 2.8.2.3, there are 485 known municipal, industrial, recovery, and agricultural wells that have data on well construction as well as reported pumping rates over time (Figure D2-21). The pumping rates were specified for the municipal wells based on monthly historical pumping data obtained from the cities of Corcoran, Hanford, Lemoore, and Stratford (Table D2-3), or reported monthly pumping data from irrigation districts such as CID, ER GSA, Westlands Water District, and reported pumping from well fields like Creighton Ranch and Angiola well fields (Table D2-6).

4.5.4.2 Hypothetical Agricultural Irrigation Wells

As discussed in Section 2.8.2.4, agricultural pumping is not typically recorded throughout most of the Subbasin. As such agricultural pumping had to be estimated based on available cropping data using a water balance method. Recognizing that many more wells exist in the Subbasin than those 485 known wells, an additional 1,091 hypothetical irrigation wells were uniformly distributed across the model domain on approximately 1-mile centers for those areas with unknown well completion intervals, resulting in the final well distribution as shown on Figure D4-10. The hypothetical wells were specified to be screened in the upper (above Corcoran) or lower (below Corcoran) aquifer zones based on statistics of well completions for 238 known irrigation wells in the Subbasin. In addition, approximately 25% of the hypothetical irrigation wells were specified to be completed across the Corcoran, producing groundwater from permeable intervals both above and below the aquitard, consistent with the completion statistics for the 238 known irrigation wells in the Subbasin.

Crop Evapotranspiration Rates

Field crops (alfalfa, row crops, corn, cotton, etc.) are assigned on an annual basis in the model. For example, if the annual DWR crop survey/CropScape data (DWR, 2016a) indicate that corn was present in a particular model cell, then it was assumed that corn was the only crop within that cell for the full calendar year (12 stress periods). The applied evapotranspiration rates for that cell were assigned based on the monthly ETc rates for corn.

Permanent crops including vineyards, almonds, pistachios, pomegranates, and stone fruit (tree crops) are assumed to be fully mature at the beginning of the simulation in 1990 (based on 1994-1996 DWR crop data). As the model progresses forward in time, the available crop data changed, and the spatial distribution of crops also changed, with a recent trend to more permanent tree crops being planted.
As the permanent crop grows from seedling to full maturity, the evapotranspiration rate was assumed to

increase as well. The presence of a crop within a specific space in a cell was tracked over time by assigning crop IDs that reflect the number of years of maturity for each tree crop and using the intersect tool in ArcMap to see specific areas of overlap between year n tree crops and year n+1 tree crops. If an intersected area of the domain has almonds in year n and in year n+1, it is assumed that the almonds have matured in that particular portion of the cell.

The crop data for the Subbasin indicates that there was a substantial increase in the number of acres planted in tree crops during the 2010-2016 period (Section 2.8.2.1, Table D2-2). Rather than assuming full maturity and peak evapotranspiration rates for these new areas of tree crops, the ET rates for these areas are assumed to be a fraction of the mature ET rates.

For example, almonds are assumed to mature over a 5-year period, so the first year that almonds are present in a portion of a model cell they are assigned ET rates that are 1/5th of the mature rate. If those almonds are still in the same area the next year, then they are assigned an ET rate of 2/5ths of the mature rate, and so on. If almonds are in the same spot for 5 years, they are assumed to have the full ET rates of a mature almond tree. Anything beyond 5 years, up to 25 years, uses the full maturity ET rates. For instances where almonds have been in a portion of a cell more than 25 years, the almond trees are assumed to have been replanted, and start over at the 1-year, 1/5th mature ET rates.

Almonds were assumed to mature over a 5-year period and were assumed to be replanted after 25 years. Pistachios were assumed to mature over a 13-year period and are assumed to remain in place for 100 years once they are planted. Pomegranates were assumed to mature over a 19-year period and were assumed to be replanted after 44 years. Stone fruits were assumed to mature over a 5-year period and were assumed to be replanted after 25 years.

Irrigated Areas/Irrigated Fractions

Area fractions within cells were used to compute an area-weighted average for crop ET values within each cell and to determine the irrigated areas of each cell for use with surface water delivery matrix processing. The crop distributions for each stress period were intersected with the active domain grid in ArcMap. Each cell containing crops was subdivided into multiple pieces, one for each crop type within the cell. The areas of each crop type within the cells were calculated for each stress period. The ET demand for a single cell is computed as the area of the crop type times the rate of ET for that crop, divided by the total area of the cell.

Irrigated areas also play a part in the surface water delivery preprocessing. Surface water deliveries were assumed to be spread evenly across the entire irrigated area of each GSA Area (or farm). Not all cells within a GSA may be fully irrigated; there may be a portion of a cell which is fallow, or contains non-irrigated land uses (winter wheat, native vegetation, urban areas). Therefore, the irrigated area of a cell can be used as a weighting factor against the full area of the cell to adjust the effective rates of surface water delivered within a specific cell in a GSA.

For example, if a GSA has a surface water delivery of 30,000 AF in the month of September and the total irrigated area of the GSA is 10,000 acres, then the nominal rate of surface water delivery is 30,000 AF / 30 days = 1,000 AF/D over an irrigated area of 10,000 acres. Going a step further, this becomes (1,000 AF/D) / (10,000 acres) = 0.1 ft/d rate of surface water delivery. For a cell where only half of the area is irrigated, the weighted surface water delivery rate for that cell would be 0.05 ft/d.

Agricultural Irrigation Pumping Demand

Monthly pumping rates for the hypothetical irrigation wells were computed based on crop ETc demand (Section 2.8.2.1) minus the sum of effective precipitation (Section 2.8.1.1), surface water deliveries (Section 2.8.1.2) and Lake Bottom Water Storage (Section 2.8.1.3). The logic behind the calculation of the hypothetical irrigation well pumping rates is summarized below.

For each monthly stress period and each 40-acre model cell:

- Area Weighted Crop Acreage (acres) x Crop ETc (feet per month [ft/m]) = ET Demand (acre-feet per month [AF/M])
- [-ET Demand (AF/M) + Effective Precipitation (ft/m)] / Irrigation Efficiency = -Farm Demand (AF/M)

  (*Note: over most of the model domain, Irrigation Efficiency was assumed to be 75% from 1990 to 2000 and then increase to 85% from 2000 through 2016. Irrigation Efficiency from the lake bottom area was assumed to be 95% from 1990 through 2016. Approximately 50% of excess Effective Precipitation was assumed to infiltrate and 50% was assumed lost to evaporation. Farm Demand is the volume of water needed to irrigate a field and meet crop demand due to inefficiencies in irrigation methods*)
- -Farm Demand (AF/M) + Surface Water Deliveries (AF/M) + Lake Bottom Storage Water (AF/M) = -Unmet Demand (AF/M) and +Tailwater Flow (AF/M)

  (Note: monthly Surface Water Deliveries were summed by GSA and applied to irrigated areas within each GSA. Lake Bottom Water Storage typically occurred only during and following very wet years and was an additional water supply for the ER GSA and TCWA GSA)
- -Unmet Demand (AF/M) + Avg Tailwater Flow/GSA (AF/M) = -Ag Pumping Demand (AF/M) and +Excess Applied Water (AF/M)

  (Note: Tailwater Flows were assumed to stay within each GSA. The monthly Average Tailwater Flow/GSA (AF/M) = Sum of Tailwater flow per GSA (AF/M) divided by GSA irrigated area. Approximately 75% of excess Applied Water was assumed to infiltrate and 25% was assumed lost to evaporation.)

Typically, each hypothetical agricultural irrigation well was assigned a service area (or farm) consisting of 16 model cells totaling 1-square mile (Figure D4-11). The sum of the monthly Ag Pumping Demand (AF/M) for the 16 model cells was assigned to each hypothetical agricultural irrigation well. For some hypothetical agricultural irrigation well the cell count was more or less than 16 model cells due to boundaries no-flow boundaries or to eliminate hypothetical wells servicing only 1 or 2 cells.

In addition, there are several large areas (ER GSA, CID, SWK GSA, TCWA GSA, and Westlands Water District) that were assumed to be operated as single service areas (or farms) with equal access to surface water and pumped groundwater within the service area. Several of the service areas supplied groundwater by wells located within the service area and/or by external well fields outside of the service area. For example, ER GSA is supplied groundwater from wells within the GSA and by the Creighton Ranch well field in the Tule Subbasin. Likewise, both SWK GSA and TCWA GSA are supplied groundwater from a few wells inside the GSAs and by the Angiola well field in the Tule Subbasin. CID and Westlands Water District are assumed to be supplied groundwater from the wells within each service area.

4.5.5 Deep Percolation and Intentional Recharge

Groundwater recharge occurs within the Subbasin from deep percolation of applied water and intentional recharge. Intentional recharge occurs at specific locations including Apex Ranch, CID ponds, and the Old Kings River (Section 2.8.1.4). Deep percolation of applied water occurs almost everywhere in the TLSBHM where there is active irrigation due to inefficient irrigation practices. There are three components to deep percolation including Farm Demand, Excess Applied Water, and Intentional Recharge. Deep percolation is estimated for each monthly stress period and each 40-acre model cell or farm as follows:

- [+Farm Demand (AF/M) / (1-1/Irrigation Efficiency)] + Excess Applied Water (AF/M) + APEX/CID/Condition 8 Intentional Recharge (AF/M) = Deep Percolation (AF/M)

  (*Note: over most of the model domain 75% of Excess Applied Water was assumed to percolate and 25% was assumed to evaporate*)

Deep percolation is applied to the TLSBHM for each stress period and each model cell using the RCH Package.

4.5.6 Subsidence

Land subsidence due to extraction of groundwater was simulated using the MODFLOW Subsidence (SUB) package. The SUB Package simulates elastic (recoverable) compaction and expansion, and inelastic (permanent) compaction of compressible fine-grained beds (interbeds) within the aquifers. The compaction of the interbeds is caused by head or pore-pressure changes (changes in effective stress) within the interbeds. If the stress is less than the pre-consolidation stress of the sediments, the deformation is elastic; if the stress is greater than the pre-consolidation stress, the deformation is inelastic.

The SUB package parameters of:

Sk_e	skeletal storage elastic,
Sk_i	skeletal storage in elastic,
b_{equiv}	combine thickness of delay interbeds within a model layer, and
n_{equiv}	combine thickness of non-delay interbeds within a model layer

were derived from CVHM and modified during calibration to approximate observed subsidence during the simulation period.

5.0 Model Calibration

Calibration of a groundwater flow model is a process through which the model is demonstrated to be capable of simulating the field-measured heads and flows that comprise the calibration targets. Calibration is accomplished by selecting a set of model parameters, boundary conditions, and stresses that produce simulated heads and fluxes that match field measurements within a pre-established range of error. Because of the multiplicity of parameters involved in the calibration process, a unique solution (e.g., one set of parameters) cannot be achieved. A brief discussion of the calibration of the groundwater flow model for the site is presented in the following subsections.

5.1 Model Calibration Criteria

The quantitative fit of the model to observed water level measurements is conducted through statistical analysis of the residuals, (the difference between observed and simulated water levels or heads) at specified observation locations, and in the case of transient calibration, with time. The residual is calculated as the observed value minus the simulated value; thus, a positive residual indicates that the simulated head value is less than the observed value, and vice-versa. The principal statistical measures of the residuals of all data points combined include the following:

- the mean of the residuals,
- the mean of the absolute value of the residuals,
- the standard deviation of the residuals,
- the sum of the square of the residuals (SSR),
- the root mean square (RMS) error of the residuals,
- the min and max of the residuals,
- the range of the observed values, and
- normalized root mean square error (NRMS) (e.g., the root mean square error divided by the range of observed values or the standard deviation divided by the range in observed values).

There is no industry standard for determining when a numerical model is adequately calibrated. However, a commonly used rule of thumb criterion for acceptable calibration is a normalized RMS error of less than 10% (Anderson et al., 2015). The RMS is the square root of the SSR divided by the number of observations throughout the model divided by the range of observed water level measurements. In addition, a plot of observed versus computed head values should track close to a 45-degree line and generally fall within one standard deviation of the mean error.

A common qualitative (visual) measure of goodness of fit in numerical modeling is a comparison of observe and simulated values using hydrographs for individual wells. In addition, a map view plot of the average residuals may be used to help identify targets or areas where the residuals in the model domain are largest. Clusters or patterns of gradation of positive or negative residuals may suggest areas where model parameters need to be adjusted further.

5.2 1990-2016 Transient Model Calibration

The transient TLSBHM simulated the period January 1990 through December 2016 using 324 monthly stress periods (Table D4-1). The TLSBHM was calibrated to two data sets, one data set covering the 1990-2016 period and a second data set limited to the 1998-2010 “normal hydrology” period.

The 1990-2016 calibration period included 16,468 groundwater level observations collected from 593 observation wells across the model domain. The 1998-2010 “normal hydrology” calibration period included 7,028 groundwater level observations collected from 544 observation wells across the model domain. Most of the observation wells had little or no completion interval information, making it difficult to assign the observations to a particular model layer. Wells with known completion intervals includes 81 wells above the Corcoran Clay and 69 wells below the Corcoran Clay. The other observation wells were assigned to model layers based on the similarity of observations with nearby known wells. Although additional observation wells with groundwater elevation measurements are available, many were determined to have too short a record, too many spurious observations, or uncertain completion intervals and hence were not utilized.

Numerous model iterations were needed to calibrate the TLSBHM model. Various hydraulic parameters (K_h, K_v, S_s, S_y) and boundary conditions (RCH, GHB heads, RIV conductance) were incrementally modified using the manual trial and error method.

The calibration statistics for the entire 1990-2016 historical simulation period include a residual mean of -4.98 feet, a RMS error of 50.85 feet, a range of 575.33 feet, and a NRMS of 8.84 %, meeting the calibration criteria of a NRMS of <10% (Figure D5-1a). A scattergram of observed and simulated values shows that many values fall within one standard deviation of the perfect 45-degree fit. A residual distribution chart shows that the residual error approximates a gaussian distribution with a slight bias to over predicting heads.

The calibration statistics for 1998-2010 “normal hydrology” calibration period include a residual mean of 2.26 feet, a RMS error of 46.26 feet, a range of 545.16 feet, and a NRMS of 8.50 %, slightly better than for the 1990-2016 period, and meeting the calibration criteria of a NRMS of <10% (Figure D5-1b). A scattergram of observed and simulated values shows that most values are closer to the perfect 45-degree fit compared to the 1990-2016 period. A residual distribution chart shows that the residual error approximates a gaussian distribution with a slight bias to over predicting heads.

A qualitative comparison of observed and simulated heads in selected monitoring wells using hydrographs shows a reasonable fit for several wells, and poor fits for others (Figures D5-2a through D5-2g). In general, the hydrographs show that simulated heads are slightly under predicted above the Corcoran Clay (Figures D5-2a to D5-2c). Within the Corcoran Clay, the hydrographs show that simulated heads tend to start out lower than observed during the ramp-up period but end up with a relatively good fit after 1998 (Figure D5-2d). Below the Corcoran Clay, the hydrographs show that simulated heads are generally on trend with the observed, although seasonal variations are not simulated very well (Figures D5-2e to D5-2g). Observed and simulated heads in selected all monitoring wells used for model calibration are provided in Appendix D5.

Simulated potentiometric surface maps with groundwater flow vectors from above and below the Corcoran Clay show how the general direction of groundwater flow between the subbasins for December 2015 (Figure D5-3). In general, above the Corcoran Clay, simulated groundwater flow is entering the Subbasin from the north, east, and south, and leaving the Subbasin to the west. Below the Corcoran Clay, simulated groundwater flow is also entering the Subbasin from the north. The simulation results also show consistent cones of depression above the Corcoran Clay around pumping centers beneath the cities of Hanford, Lemoore, and Corcoran. There is also a large, persistent cones of depression beneath CID and lake bottom well fields southeast of the City of Corcoran and along the border between the Tulare Lake and Tule subbasins.

The maps also show that there is a large area in the lake bottom area where groundwater appears to be mounding slightly and the groundwater flow vectors show little movement of groundwater above and below the Corcoran Clay (Figure D5-3). This area has been described as being under lain by an extensive sequence of lacustrine and marsh deposits (i.e., Tulare Lake bed “clay plug”) which are relatively impervious. Thus, the apparent mounding may result from a zone of residual high heads that are draining more slowly than surrounding areas as groundwater levels are being drawn down due to pumping, recharge to the lake bottom, or it could result as a combination of both.

5.3 1990-2016 Water Balance Calculations

The calibrated transient TLSBHM was used to estimate the groundwater flows that occur between the Subbasin and the adjoining subbasins (Figure D2-2). The following subsection present water balances 1990-2016 simulation period and the 1998-2010 "normal hydrology" period for the Subbasin itself, as well as for each adjoining subbasin, and net flows between the Subbasin can be extracted from these results. Note that the protrusion of the Kaweah Subbasin boundary into the Subbasin and the presence of large wellfields near subbasin boundaries complicate the assessment of inter-basin flows.

5.3.1 Tulare Lake Subbasin

The 1990-2016 annualized net water balance for the Subbasin shows that overall there is a long-term net outflow of groundwater from the Subbasin to the Kings, Kaweah and Tule subbasins (Table D5-1, Figure D5-4), while there is a long-term net inflow of groundwater from the Westside and Kern subbasins. These overall results can be disaggregated to subbasin interactions above and below the Corcoran Clay. Above the Corcoran Clay, there is a net outflow of groundwater from the Subbasin to the Kings, Kaweah, and Tule subbasins, and a net inflow of groundwater from the Westside and Kern subbasins. Below the Corcoran Clay, there is a net outflow of groundwater from the Subbasin to the Westside, Kings, Kaweah and Tule subbasins and a net inflow of groundwater from the Kern Subbasin. The inflows and outflows of groundwater from below the Corcoran Clay are greater than those from above the Corcoran Clay.

The change in storage in the Subbasin has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -392,280 AF (2015) to 361,230 AF (2011) and averaged -85,690 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -2,313,740 AF. During the 1998-2010 "normal hydrology" period, the estimated change in storage has ranged from about -220,650 AF (2006) to -296,280 AF (2008) and averaged -73,770 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -958,940 AF.

5.3.2 Westside Subbasin

Annualized net water balance for the portions of the Westside Subbasin within the model domain shows that there is a long-term net outflow from the Westside Subbasin to the Tulare Lake and Kings subbasins (Figure D5-5). In general, the long-term outflow from the Westside Subbasin to the Subbasin is greater than that from the Kings Subbasin above the Corcoran Clay, while the long-term inflow to the Westside Subbasin from the Subbasin is less than that from the Kings Subbasin below the Corcoran Clay. The potentiometric surface maps (Figure D5-3) show that the outflow of groundwater from the Subbasin is due to both pumping in the Westside Subbasin and leakage from the South Fork of the Kings River.

The change in storage for the portions of the Westside Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016 the estimated change in storage has ranged from -425,290 AF (1990) to 103,573 AF (1998) and averaged -84,070 AF/Y. During 1990-2016 the estimated cumulative change in storage was about -2,269,800 AF. During the 1998-2010 "normal hydrology" period the estimated change in storage has ranged from -177,600 AF (2008) to 103,573 AF (1998) and averaged about -47,080 AF/Y. During the 1998-2010 period the estimated cumulative change in storage was about -612,040 AF.

5.3.3 Kings Subbasin

Annualized net water balance for the portions of the Kings Subbasin within the model domain shows that there is a long-term net groundwater inflow to the Kings Subbasin from the Tulare Lake, Westside, and

Kaweah subbasins (Figure D5-6). In general, the groundwater inflow to the Kings Subbasin from the Tulare Lake and Kaweah subbasins is from both above and below the Corcoran Clay, while there is a net outflow from the Kings Subbasin to the Westside Subbasin below the Corcoran Clay. The potentiometric surface maps (Figure D5-3) show that above the Corcoran Clay, the outflow of groundwater from the Subbasin is primarily due to leakage from the Kings River. Below the Corcoran Clay, the outflow of groundwater from the Subbasin to the Kings Subbasin is due to leakage from the Kings River (where the Corcoran Clay is not present).

The change in storage for the portions of the Kings Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -229,310 AF (2015) to 74,030 AF (1998) and averaged -68,220 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -1,841,980 AF. During the 1998-2010 “normal hydrology” period, the estimated change in storage has ranged from -162,950 AF (2004) to 74,030 AF (1998) and averaged about -66,520 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -864,720 AF.

5.3.4 Kaweah Subbasin

Annualized net water balance for the portions of the Kaweah Subbasin within the model domain shows that there is a long-term net groundwater inflow to the Kaweah Subbasin from the Tulare Lake and Tule subbasins and a long-term net groundwater outflow to the Kings Subbasin (Figure D5-6). In general, the groundwater outflow from the Tule Subbasin is greater than that from the Subbasin above the Corcoran Clay, while the outflow from the Subbasin is greater than that from the Tule Subbasin below the Corcoran Clay. The potentiometric surface maps (Figure D5-3) show that a portion of the Kaweah Subbasin protrudes into the Subbasin. This complicates the calculation of inter-basin groundwater flow because there is both inflow and outflow between the Tulare Lake and Kaweah subbasins through this area. In addition, there is outflow of groundwater from the Kaweah Subbasin to the Subbasin due to well field pumping in the area near the City of Corcoran.

The change in storage for the portions of the Kaweah Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -317,310 AF (2014) to 31,300 AF (2011) and averaged -156,640 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -4,229,350 AF. During the 1998-2010 “normal hydrology” period, the estimated change in storage has ranged from -239,860 AF (2004) to -2,110 AF (1998) and averaged about -128,390 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -1,669,020 AF.

5.3.5 Tule Subbasin

Annualized net water balance for the portions of the Tule Subbasin within the model domain shows that there is a log-term net groundwater inflow to the Tule Subbasin from the Tulare Lake and Kern subbasins and a log-term net groundwater outflow from the Tule Subbasin to the Kaweah Subbasin (Figure D5-8). In general, the flow from the Subbasin is greater than that from the Kaweah Subbasin both above and below the Corcoran Clay, with greater groundwater flow below the Corcoran Clay. The potentiometric surface maps (Figure D5-8) show that the outflow of groundwater from the Subbasin is primarily due to pumping wellfields southeast of the City of Corcoran and a pumping center east of the model domain in the vicinity of the City of Pixley.

The change in storage for the portions of the Tule Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -247,850 AF (1990) to -1,820 AF (2011) and averaged -143,770 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -3,881,750 AF. During the 1998-2010 "normal hydrology" period, the estimated change in storage has ranged from -224,920 AF (2008) to -46,570 AF (2006) and averaged about -140,900 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -1,831,680 AF.

5.3.6 Kern Subbasin

Annualized net water balance for the portions of the Kern Subbasin within the model domain shows that there is a long-term net groundwater outflow from the Kern Subbasin to the Tulare Lake and Tule subbasins (Figure D5-9). In general, the outflow from the Kern Subbasin to the Subbasin is greater than that to the Tule Subbasin both above and below the Corcoran Clay, with greater groundwater flow below the Corcoran Clay. The potentiometric surface maps (Figure D5-3) show that the outflow of groundwater above the Corcoran Clay from the Subbasin to the Kern Subbasin. Starting in the mid-2000s, the groundwater flow filed above the Corcoran Clay reversed and there was a net inflow from the Kern Subbasin to the Subbasin. Below the Corcoran Clay, the water balance charts and potentiometric surface maps show a general decline in the outflow of groundwater from the Subbasin to the Kern Subbasin.

The change in storage for the portions of the Kern Subbasin within the model domain has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -97,940 AF (2013) to 64,860 AF (2011) and averaged -17,490 AF/Y. During 1990-2016, the estimated cumulative change in storage was about -472,140 AF. During the 1998-2010 "normal hydrology" period, the estimated change in storage has ranged from -84,350 AF (2008) to 64,860 AF (1999) and averaged about -10,950 AF/Y. During the 1998-2010 period, the estimated cumulative change in storage was about -141,330 AF.

5.3.7 Groundwater Storage

The change in storage in the Subbasin has varied from year to year depending on the water year type. Between 1990 and 2016, the estimated change in storage has ranged from -392,280 AF (2015) to 361,230 AF (2011) and averaged -85,690 AF/Y. During the 26-year 1990-2016 simulation period, the estimated cumulative change in storage was about -2,313,740 AF (Table D5-1, Figure D5-4). During the 1998-2010 "normal hydrology" period, the estimated change in storage has ranged from about -220,650 AF (2006) to -296,280 AF (2008) and averaged -73,770 AF/Y. During the 13-year 1998-2010 "normal hydrology" period, the estimated cumulative change in storage was about -958,940 AF.

The simulated groundwater mass balance data were used to estimate the change in groundwater storage in the Subbasin on an annual basis for the simulation period. The simulation results indicate that between 1990 and 2016, the estimated annual change in storage averaged -85,690 AF/Y while during the 1998-2010 "normal hydrology" period, the estimated annual change in storage averaged -73,770 AF/Y or about 14 % less than the 1990-2016 period. Likewise, the estimated net cumulative change in storage for the 26-year 1990-2016 period was about -2,313,740 AF while the estimated net cumulative change in storage for the 13-year 1998-2010 period was about –958,940 AF or almost 60% less than during the 1990-2016 period. Note that following the wet years of 1995-1998, 2005-2006, and 2010-2011, there was a small net increase in groundwater storage in the Subbasin (Table D5-1, Figure D5-4). This indicates that the Subbasin is relatively sensitive to water year type, and that during wet years, there can be a significant increase in the amount of groundwater in storage. Likewise, as shown on Figure D5-4, extended drought periods (like 2011-2016) can results in a significant loss of groundwater in storage.

5.3.8 Subsidence

Simulated cumulative land subsidence due to extraction of groundwater was simulated for the period 1990-2015 (Figure D5-10). Throughout most of the Subbasin, simulated cumulative subsidence was less than 2 feet. However, in the vicinity of the wellfields southeast of Corcoran in the Tule Subbasin, simulated subsidence was over 9 feet. The simulation results also indicate up to 4 feet of subsidence in the Westside, Kaweah, and Kern subbasins. Charts of simulated subsidence over time was also calculated for the major municipal and agricultural wellfields in the TLSBHM (Figure D5-11). These charts show that there was 1 to 2 feet of cumulative subsidence in the vicinity of Hanford, Lemoore, and Stratford, while there was about 5 feet of subsidence at Corcoran, and up to 9 feet of subsidence at the Angiola and Creighton Ranch well fields in Tule Subbasin. The charts also show a small seasonal pattern of elastic subsidence rebound. During the early simulation period (1990-1992), the simulated subsidence occurred at all locations and then stabilized from 1993 through 2001. Simulated subsidence at that time started to increase again after 2002 in a series of steps. Additional calibration of the model to subsidence is needed as more data are collected.

6.0 Sensitivity Analysis

A sensitivity analysis was conducted to evaluate the sensitivity of the model to a change in the estimated hydraulic conductivity and storage parameters. These values in the model were systematically modified over the plausible range of values for the sediment types present beneath the site, and the model was re-run. The sensitivity model run results were compared to the calibration model result to estimate the change in model calibration due to the change in the model parameter.

The sensitivity analysis results indicate that the aquifers above and below the Corcoran Clay are relatively sensitive to changes in K_h, while the Corcoran Clay is not sensitive, as shown by the change (delta) in the sum of square residual (Figure D6-1). The results indicate that little improvement in calibration could be expected by modifying the K_h parameters.

The model sensitivity is reversed with respect to K_v, with the Corcoran Clay heads relatively sensitive to changes in K_v, while the aquifers above and below the Corcoran Clay are relatively insensitive (Figure D6-1). The results indicate that a small improvement in calibration could be obtained by decreasing the K_v above the Corcoran Clay.

The sensitivity analysis results indicate that the model is also relatively sensitive to changes in aquifer S_s, with the change in sum of squares error increasing with lower values of storage (Figure D6-1). A small improvement in calibration could be obtained by decreasing the S_s above the Corcoran Clay.

The sensitivity analysis results indicate that the model is also relatively in sensitive to changes in the Sy of the unconfined aquifer above the Corcoran Clay, with the change in sum of squares error decreasing with lower values of S_y (Figure D6-1).

7.0 Predictive Simulations

The calibrated groundwater flow model was modified to develop two 54-year transient predictive simulations from 2017 through 2070: (1) a Baseline Forecast to evaluate potential undesirable impacts from maintaining the recent land use under "normal hydrology" conditions (i.e., the status quo); and

(2) a Projects Forecast to evaluate potential impacts of implementing alternative land uses and projects to obtain groundwater sustainability. Both forecast models consist of 649 monthly stress periods starting with December 2016 and ending with December 2070. The SGMA requires that any forecast model start with current conditions. The models were started in December 2016 to permit the importation of the calibration simulations results as the start for the forecast models. The forecast models assume multiple repeating 14-year cycles of "normal hydrology" (e.g., precipitation, stream flow, surface water deliveries, and boundary conditions) from 1998 to 2010 (Figure D7-1), starting with using 2011 hydrology as an analog for 2017, which was a wet year. A summary of the forecast year and associated "normal hydrology" analog year is presented on Table D7-1. The forecast models were developed as described in the following subsections.

7.1 Baseline Forecast Scenario

The TLSBHM Baseline Forecast model represents conditions that assume land use recovering from the 2010-2015 drought conditions to "normal hydrology" conditions in the first few years of the simulation and maintaining these "normal hydrology conditions for the duration of the simulations. The Baseline Forecast model were developed as described below.

7.1.1 Baseline Forecast Land Use

A review of historical land use shows that major cropping acreage patterns have changed significantly over the past decades (Table D2-6, Figure D2-12). Acreage of cotton, pasture, and dairy fodder decreased, especially during the 2011-2016 drought. During this same period, acreage of almonds, pistachios, pomegranates, and fallow land increased. Note that the more recent plantings of almonds, pistachios, pomegranates have not yet reached maturity and associated increased water demand (Section 4.5.4.2).

During this early Baseline Forecast stress period, the acreage of corn and cotton that had been fallowed during the drought was assumed to be replanted, except for the acreage that had been converted to permanent crops. In addition, the water demand of more recently planted acreage of almonds, pistachios, and pomegranates was assumed to increase as the trees matured as discussed in Section 4.5.4.2.

For crop maturation, tree crops are assumed to continue to mature on a 25-year cycle (except for pistachios which can produce for over 100 years) and continuously mature forward in time. All other crops/land use is assumed to revert to whatever the land use was in the seed year for that particular forecast year. For example, assume there is a new patch of almonds planted in 2016 (crop zone 201). In 2021, it will be in its sixth year of existence, so it's assigned the ET rate of 6-year old almonds (crop zone 206). The other crops around this patch of almonds will revert to whatever was planted there in 2001, since 2001 is the seed year for the forecast year 2021. Three years from then, the patch of almonds is now mature and assigned an ET rate for mature almonds (crop zone 209), while the nearby crops are represented by seed year 2004 (corresponding to 2024). Further into the forecast, the almonds will be in their 25th year of existence in 2041 (crop zone 225), while the surrounding crops will be represented by seed year 2007. That same patch of almonds will be replaced, cycle back to being represented by 1st year almond ET rates (crop zone 201), and since it is 2042, the other crops are represented by whatever was planted in 2008. A chart of Baseline Forecast crop acreage is presented on Figure D7-2. Note that the crop acreage chart shows a repeating cycle of replanting of permanent tree crops.

7.1.2 Baseline Forecast Municipal Pumping

Baseline Forecast municipal water demand for the cities of Hanford, Lemoore, and Corcoran were assumed to vary seasonally at the average of 2011-2015 pumping rates. Municipal pumping was assumed to increase slowly with populations growth at a rate of 0.35% per year from about 25,060 AF (2017) to about 30,160 AF (2070).

7.1.3 Baseline Forecast Hypothetical Irrigation Pumping

As discussed in Section 4.5.4.2, the calibration model utilized the available groundwater pumping data for the individual wells and well fields servicing the ER GSA, CID, SWK GSA, TCWA GSA, and Westlands Water District, which allowed these areas to be treated as individual service area or "farms" (Figure D4-11). In the rest of the model domain, the agricultural pumping demand was calculated on approximately 40-acre spacing and assigned to hypothetical agricultural wells on approximately a 1-miles spacing. A similar process was utilized for the forecast models with a few modifications as described below.

For the forecast models, the service area or "farm" concept was extended throughout model domain by dividing the model by subbasin and GSAs into 10 services areas or "farms" (Figure D7-3). For each service area, the monthly agricultural pumping demand was calculated as follows:

- Service Area Weighted Crop Acreage (acres) x Crop ETc (ft/m) = Service Area ET Demand (AF/M)
- [-Service Area ET Demand (AF/M) + Effective Precipitation (ft/m)] / Irrigation Efficiency = -Service Area Farm Demand (AF/M)

  (*Note: over most of the model domain, Irrigation Efficiency was assumed to be 85% from 2017 to 2070. In the lake bottom area Irrigation Efficiency from was assumed to be 95% from 2017 through 2070. Approximately 50% of excess Effective Precipitation was assumed to infiltrate and 50% was assumed lost to evaporation).*
- -Service Area Farm Demand (AF/M) + Service Area Surface Water Deliveries (AF/M) + Service Area Lake Bottom Storage Water (AF/M) +Service Area Project Water (AF/M) = -Service Area Ag Pumping Demand (AF/M)

  (Note: when monthly Service Area water supplies exceeded monthly Service Area Farm Demand the excess water supply was assumed to carry over as available water supply in the following month).

The resulting service area agricultural pumping demand was then divided equally amongst the wells and well fields suppling groundwater to each servicing area. However, pumping from the Westlands Water District, CID, ER GSA, Creighton Ranch, and Angiola wells fields was limited to the maximum historical pumping from each well field (although not necessarily for each well). While this approach many not replicate the individual historical pumping from each well in a service area, it does provide a reasonable approach to allocate forecast groundwater agricultural pumping in each service area and thus a reasonable estimate of groundwater system demand.

7.1.4 Baseline Forecast GHBs

As shown on Table D7-1, the Baseline Forecast uses historical years as analogs for the hydrology conditions in the forecast. For example, 2019 is assumed to have hydrology similar to 1999. However, the GHB heads in 1999 are many feet higher than those in 2016 when the Baseline Forecast model starts. To correct for this head discrepancy, the general head boundaries for the Baseline Forecast model were developed by calculating the difference in monthly heads for each stress period of the calibration simulation, and then adding that difference to the forecast GHB head from the previous month. This allows the Baseline Forecast GHBs to have a similar change in heads between stress periods as the calibration model, but from a different initial (2016) elevation. For example, the Baseline Forecast GHB heads for simulation year 2019 are based on the heads difference for the analog year 1999. If the head difference for GHB cell 1001 between December 1998-January 1999 was 0.55 feet in the calibration model, then 0.55 feet was added to the GHB cell 1001 head for the December 2018 to yield the January 2019 GHB head. Thus the resulting Baseline Forecast GHBs exhibit a change in heads similar to that for the calibration model analog year, but from a different initial condition.

7.1.5 Baseline Forecast of Climate Change

The SGMA guidelines require that climate change be considered in any forecasts of future land uses. The California Natural Resources Association (CNRA) has developed a set of tools that can apply change factors to historical precipitation, ET demand, and surface water delivery data to make historical data consistent with forecasted conditions under climate change. The CNRA has developed two climate change factor data sets, one for 2030 and one for 2070.

7.1.5.1 Effective Precipitation

The Baseline Forecast monthly effective precipitation data set was processed through the CNRA python script/ArcGIS tool. The tool takes monthly data and processes it using change factors, which vary temporally and spatially. For model cells that cross multiple change factor grid cells, an area-weighted average change factor is applied. The change factors for a 2030 forecast were used for the forecast period January 2017-Dececember 2030 (stress periods 2 – 169) while the change factors for a 2070 forecast were used for the forecast period January 2031-December 2070 (stress periods 170 – 649).

7.1.5.2 Crop Evapotranspiration

The Baseline Forecast monthly ETc data set was processed through the CNRA python script/ArcGIS tool. The tool takes monthly data and processes it using change factors, which vary temporally and spatially. Since the “normal hydrology” Baseline Forecast scheme rotates through a series of years from 1997 to 2010 (with a 2011-based year for 2017), each ET distribution for the Baseline Forecast is unique when accounting for tree crop maturation. For model cells that cross multiple change factor grid cells, an area-weighted average change factor is applied. The change factors for a 2030 forecast were used for the forecast period January 2017-December 2030 (stress periods 2 – 169) while the change factors for a 2070 forecast were used for the forecast period January 2031-December 2070 (stress periods 170 – 649).

7.1.5.3 Surface Water Deliveries

The Baseline Forecast surface water delivery data set incorporates a reduction in historical surface water allocations to SWK GSA and TCWA GSA due the sale of water rights. The Baseline Forecast surface water delivery data set all GSAs outside of the Subbasin were not modified. CNRA change factors for surface water deliveries do not vary spatially, and are simply a multiplier applied to the historical surface water delivery volume. Different change factors are available for 2030 and 2070 climate change forecasted conditions. Like the effective precipitation and ETc data sets, the 2030 change factors were used for the forecast period January 2017-December 2030 (stress periods 2 – 169) while the change factors for a 2070 forecast were used for the forecast period January 2031-December 2070 (stress periods 170 – 649).
The Baseline Forecast of surface water deliveries is shown on Figure D7-4.

7.1.6 Baseline Forecast Simulation Results

A comparison of simulated potentiometric surface maps from above and below the Corcoran Clay for December 2015 (Figure D5-3) with simulated Baseline Forecast potentiometric surface maps from above and below the Corcoran Clay for June 2040 (Figure D7-5) show that the groundwater elevations beneath the Subbasin above and below the Corcoran clay are projected to decline about 25 feet and 50 feet, respectively during the 25-year simulation period. Dewatered areas in the upper aquifer on the east side of the model domain (mostly in the Kaweah and Tule subbasins) are projected to expanded and migrate into deeper intervals. The cones of depression above and below the Corcoran Clay in the Lemoore, Creighton Ranch, and Angiola Water District well field areas are projected to become more pronounced.

Simulated Baseline Forecast potentiometric surface maps from above and below the Corcoran Clay for December 2070 (Figure D7-6) show that the groundwater elevations beneath the Subbasin above and below the Corcoran clay are projected to decline about 50 feet and 150 feet, respectively, during the 54-year simulation period. Dewatered areas in the upper aquifer in the Kaweah and Tule subbasins are projected to expanded significantly and migrate into deeper intervals. The cones of depression above and below the Corcoran Clay in the Westside Subbasin, Creighton Ranch, and Angiola well field areas are projected to become much more pronounced.

Simulated Baseline Forecast hydrographs for selected compliance wells in the vicinity of the cities of Corcoran, Hanford, and Lemoore show a continued gradual decline in groundwater elevations in the unconfined aquifer above and below the Corcoran Clay, with seasonal variations much greater below the Corcoran Clay (Figure D7-7). Over the 54-year simulation period, the hydrographs above the Corcoran Clay show approximately 100 feet of decline in the Corcoran area, about 90 feet of decline in the Hanford area, and about 100 feet of decline in the Lemoore area. Over the same period, the hydrographs below the Corcoran Clay show about 100 feet of decline in the Corcoran area, about 100 feet of decline in the Hanford area, and about 100 feet of decline in the Lemoore area.

The Baseline Forecast simulation results indicate that subsidence will continue over the next 54 years under continued existing conditions. A map of cumulative subsidence from 2017-2040 shows that the is about 0 to 4 feet of additional subsidence over most of the Subbasin, with up to 6 feet of additional subsidence in the Lemoore area and Angiola and Creighton Ranch wells fields in the Tule Subbasin (Figure D7-8). Baseline Forecast subsidence in the lake bottom area are minimal. A map of cumulative subsidence from 2017-2070 shows that the is about 0 to 8 feet of additional subsidence over most of the Subbasin, with up to 10 feet of additional subsidence in the Lemoore area and over 10 feet of subsidence in the Angiola and Creighton Ranch wells fields in the Tule Subbasin (Figure D7-8).

Simulated Baseline Forecast subsidence hydrographs for continuous GPS compliance point near the cities of Corcoran and Lemoore wells show that under continued existing conditions, subsidence rate remain consistent during the forecast period (Figure D7-8). The minimum threshold for subsidence was specified as 11.5 feet, which was the maximum simulated subsidence within the TLSBHM domain in 2070.

The Baseline Forecast simulation groundwater mass balance data were used to estimate the change in groundwater storage in the Subbasin on an annual basis for the 54-year forecast simulation period (Figure D7-9). Similar to the 1998-2010 “normal hydrology” period in the calibration model, the period 2040-2048 represents a “normal” or “hydrologically balanced” period in the forecast model. Under the Baseline Forecast assumptions described above, the 2040-2408 “hydrologically balanced period” annual change in groundwater storage averaged about -149,430 AF/Y. During the 2017-2070 period, the annual change in groundwater storage averaged about -142,990 AF/Y, and as much as -7.72 million AF of cumulative storage depletion from the Subbasin.

In summary, the Baseline Forecast simulation results indicate continued overdraft conditions in the Subbasin, with chronic lowering of groundwater levels, continued reduction of groundwater in storage, continued land subsidence, and possibly degraded groundwater quality. Thus, the Baseline Forecast indicates that sustainable groundwater conditions in the Subbasin cannot be achieved without changes in groundwater usage and management.

7.2 Forecast Project Simulations

Multiple Projects Forecast simulations were created iteratively by modifying the Baseline Forecast and incorporating various potential projects and management actions developed by the GSAs for the Subbasin and surrounding subbasins (see Section 7.6) (Figure D7-10). The objectives of the projects and management actions are to obtain groundwater sustainability (defined as stable groundwater elevations with minimal changes in storage, land subsidence, and water quality degradation over time) by 2040 through a combination of increase water supplies and demand reduction.

Potential projects and management actions considered include:

- Above ground surface water storage projects,
- Intentional recharge basins,
- On-Farm Recharge,
- Aquifer Storage and Recovery (ASR), and
- Agricultural pumping limits in surrounding subbasins.

The combined projects were assumed to provide an annual average of 40,500 AF/Y of increases water supply and 38,000 AF/Y of groundwater recharge for a total of about 78,500 AF/Y of new water supply (Table D7-2, Figure D7-11). This is slightly more than the average overdraft (-73,760 AF/Y) observed during the 1998-2010 "normal hydrology" period and about 92% of the 1990-2016 average overdraft (-85,690 AF/Y). In addition, land use changes resulting from construction of the projects are anticipated to reduce agricultural demand by approximately 26,900 AF/Y. In total, the proposed project may yield an average of up to 104,400 AF/Y of additional water supply to the Subbasin. The proposed projects are described below by Subbasin GSAs.

Mid-Kings River Groundwater Sustainability Agency

The Mid-Kinks River GSA has proposed constructing several 40-80 acre groundwater recharge facilities in the GSA. For modeling purposes, the proposed recharge facility was assumed to be constructed on about 1,500 acres of land in the northeast portion of the GSA (Figure D7-10). The simulated facility was implemented in four 5-year phases starting in 2020. Full build out would be completed in 2035. Due to conversion of irrigated crop land to recharge basins, the recharge facility construction is estimated to result in a permanent annual agricultural demand reduction of about 4,500 AF once completed. The facility was assumed to recharge Kings River flood waters with an assumed percolation rate of approximately 1-foot per day for a 150-day period from March through July when flood waters are typically available based on the historical hydrology cycles used to construct the forecast (Figure D7-11). Flood water were assumed to be available about every 6 to 7 years. Total recharge capacity would increase in 5-year phases from an initial 50,000 AF to an estimated 200,000 AF during flood years when fully built out. Annual average project yield is estimated to be about 38,000 AF/Y over the simulation period, and about 44,440 AF/Y over the hydrologically balanced 2040-2048 period (Table D7-2). Intentional recharge was simulated in the Projects Forecast using the RCH package.

El Rico Groundwater Sustainability Agency

The ER GSA has proposed constructing an intermittent surface water storage facility to store Kings River flood water when available (Figure D7-10). The proposed surface water storage facility was assumed to be constructed by 2030 using raised 6-foot berms to enclose approximately 6,400 acres of land. The land would continue to be farmed during non-flood years, so the net average agricultural demand reduction is estimated to be about 8,400 AF/Y. The surface water storage facility was assumed to store approximately 40,000 AF of Kings River flood waters at a rate of about 8,000 AF/M during a 150-day period from March through July when flood water are typically available based on the historical hydrology cycles used to construct the forecast (Figure D7-11). Because of the clayey nature of the Lake Bottom sediments, infiltration of storage water was assumed to be de minimis. Annual average project yield is estimated to be about 8,780 AF/Y over the simulation period, and 8,890 AF/Y over the hydrologically balanced 2040-2048 period (Table D7-2). This additional surface water supply was added to the Baseline Forecast surface water deliveries for the ER GSA.

South Fork Kings Groundwater Sustainability Agency

The SFK GSA has proposed a number of small projects including aquifer storage and recovery (ASR) wells, new surface water storage facilities, and land fallowing. The potential projects for SFK GSA were very conceptual in nature. The location of the potential ASR well field(s) and potential recharge and recovery rates has not been identified. The locations of potential surface water storage facilities and land fallowing areas were also undefined. Hence, for forecast modeling purposes, a single large surface water storage facility was assumed to be constructed in the southeast portion of the GSA (Figure D7-11). The simulated surface water storage facility was assumed to be constructed by 2030 using raised 6-foot berms to enclose approximately 10,000 acres of land. Approximately half of this land was assumed to already be fallow, so the net agricultural demand reduction is estimated to be about 15,000 AF/Y after 2030. Because of the clayey nature of the sediments in this area, infiltration of storage water was assumed to be de minimis. The surface water storage facility was assumed to store approximately 60,000 AF of Kings River flood waters at a rate of about 12,000 AF/M from March through July when flood water are typically available based on the historical hydrology cycles used to construct the forecast (Figure D7-11). Annual average project yield is estimated to be about 13,170 AF/Y over the simulation period, and 13,330 AF/Y over the hydrologically balanced 2040-2048 period (Table D7-2). This additional surface water supply was added to the Baseline Forecast surface water deliveries for the SFK GSA.

Tri-County Water Authority Groundwater Sustainability Agency

The TCWA GSA has proposed constructing a new surface water storage facility over the middle portion of the GSA (Figure D7-11). The simulated surface water storage facility was assumed to be constructed by 2030 using raised 6-foot berms to enclose approximately 13,340 acres of fallow land, so there was no net agricultural demand reduction. Because of the clayey nature of the sediments in this area, infiltration of storage water was assumed to be de minimis. The surface water storage facility was assumed to store approximately 80,000 AF of Kings River flood waters at a rate of about 16,000 AF/M from March through July when flood water are typically available based on the historical hydrology cycles used to construct the forecast (Figure D7-11). Annual average project yield is estimated to be about 17,561 AF/Y over the simulation period, and 17,780 AF/Y over the hydrologically balanced 2040-2048 period (Table 7-2). This additional surface water supply was added to the Baseline surface water deliveries for the TCWA GSA and SWK GSA.

Surrounding Subbasins Projects

As shown on Figure D2-2, the Subbasin is surround by the Westside, Kings, Kaweah, Tule, and Kern subbasins. It was assumed that these surrounding subbasins would also implement projects similar in scope and yield as those proposed for the Subbasin in order to obtain groundwater sustainability. Since all the surrounding subbasins were developing potential projects as part of their GSPs, there was insufficient time to coordinate with the surrounding subbasins and implement their proposed projects into the TLSBHM Projects Forecast model. Therefore, for simplicity, it was assumed that each surrounding subbasins would implement projects that would yield additional surface water supplies similar to what is proposed for the Subbasin, or approximately 75% of the 1990-2016 annual average change in storage estimated for that portion of each subbasin within the TLSBHM (Figures D5-4 through D5-9). It was further assumed, for simplicity, that the surrounding subbasin projects would be implement outside of the TLSBHM model domain and that the additional water supply would be imported into the TLSBHM domain as addition surface water deliveries. The assumed surrounding subbasin additional water supplies include:

Westside Subbasin	60,330 AF/Y
Kings Subbasin	50,960 AF/Y
Kaweah Subbasin	114,400 AF/Y
Tule Subbasin	104,220 AF/Y
Kern Subbasin	35,720 AF/Y

This additional surface water supply was added to the Baseline surface water deliveries for each of the surrounding subbasins.

Surrounding Subbasins Pumping Limits

Another management option under consideration by the surrounding subbasins is a limitation of groundwater pumping to a prescribed number of acre-feet per acre of irrigated land. Based on review of draft GSPs and discussions with other GSA the pumping limits under consideration include:

Subbasin	GSA	Irrigated Acres in Model	Pumping Limit (af/ac)	Agricultural Pumping (AF/Y)
Kaweah	All	127,870	2.00	255,740
Kings	Central Kings	16,170	1.13	18,275
Kings	Kings River East	15,800	0.73	11,530
Kings	North Fork Kings	41,864	1.10	46,050
Kern	--	36,190	1.00	36,190
Tule	--	79,920	0.54	43,160
Westside	--	62,920	0.60	37,750

The prescribed pumping limit volumes were assumed to be uniformly distributed between all agricultural wells in each subbasin within the model domain.

7.2.1 Projects Forecast Land Use

Land use under the Projects Forecast is identical to that used in the Baseline Forecast with the exception that lands utilized for most of the Subbasin projects was assumed to go out of production as the projects are built out over time, resulting in a step-wise decrease in agricultural demand (Figure D7-10).

Land fallowing in the surrounding subbasins resulting from implementation of pumping limits was not explicitly simulated in the model. Only the reduction in agricultural pumping was specified in the forecast model.

7.2.2 Projects Forecast Municipal Pumping

The Project Forecast municipal water demand for the cities of Hanford, Lemoore, and Corcoran is identical to that used in the Baseline Forecast. Municipal pumping was assumed to increase slowly with populations growth at a rate of 0.35% per year from about 25,060 AF (2017) to about 30,160 AF (2070).

7.2.3 Projects Forecast Hypothetical Irrigation Pumping

The Projects Forecast of agricultural irrigation pumping was calculated in an identical manner as for the Baseline Forecast, assuming increased surface water deliveries from the projects and pumping limits in the surrounding subbasins. The available surface water supplies were increased by the proposed project yields as described in Section 7.2.1. During flood events, additional stored surface water was assumed to be available to supplement surface water deliveries the month following storage, less evaporative losses. For example, the volume of water stored in the proposed SFK GSA surface water pond during March 2031 (about 1.2 feet over 10,000 acres) would be available to be redistributed as additional surface water supply to SFK GSA in April 2013 minus open water evaporation for March (about 0.38 feet). This assumption allows the proposed project surface water storage to be depleted in a timely manner by both evaporation and re-use.

7.2.4 Projects Forecast GHBs

The Projects Forecast GHBs were calculated in an identical manner as for the Baseline Forecast with one modification. As described in Section 7.1.4, the general head boundaries for the Baseline Forecast model were developed by calculating the difference in monthly heads for each stress period of the calibration simulation, and then adding that difference to the forecast GHB head from the previous month. This allows the forecast GHBs to have a similar change in heads between stress periods as the calibration model, but from a different initial (2016) elevation. This same process was used for the Projects Forecast GHBs with the addition of a head change factor that assumes projects were implemented in the subbasins surrounding the Subbasin resulting in a gradual stabilization (or “soft landing”) of heads around 2040. The head change factor had a value of 100% from 2017 through 2026, and then decreased by 5% per year until 2040 where the head change factor was fixed at 25% for the duration of the simulation. The resulting Projects Forecast GHBs show a more gradual decrease in the rate of decline compared to the Baseline GHBs (Figure D7-12).

7.2.5 Projects Forecast of Climate Change

The SGMA guidelines require that climate change be considered in any forecasts of future land uses. The same CNRA climate change factor data sets for 2030 and 2070 used in the Baseline Forecast were applied to the Projects Forecast ET demand, and surface water delivery data. The CNRA corrected effective precipitation results remained identical to the Baseline Forecast.

7.2.6 Projects Forecast Simulation Results

As discussed in Section 7.2, multiple Projects Forecast simulations were created iteratively by modifying the Baseline Forecast and incorporating various potential projects and management actions developed by the Subbasin GSAs and surrounding subbasins. The Projects Forecast scenarios evolved as follows:

1. Projects Forecast Scenario 1: The Baseline Forecast was modified by added projects and associated land fallowing in the Subbasin only (discussed below). The simulation results showed a continued lowering of groundwater levels, reduction of groundwater in storage, continued land subsidence, and increased outflow to surrounding subbasins.
2. Projects Forecast Scenario 2: The Projects Forecast was further modified with GHBs that caused an asymptotic flatting (i.e., soft landing) of the GHB heads in 2040, representing the effects of assumed projects in other subbasins. The modification of the GHBs simulation results showed only a slight reduction of groundwater level declines compared to Projects Forecast Scenario 1, with continued reduction of groundwater in storage, continued land subsidence, and continued outflow to surrounding subbasins.
3. Projects Forecast Scenario 3: The Projects Forecast was further modified by assuming each surrounding subbasin implemented projects that would yield additional surface water supplies similar to what is proposed for the Subbasin, or approximately 75% of the 1990-2016 annual average change in storage estimated for that portion of each subbasin within the TLSBHM. The simulation results showed a substantial reduction of groundwater level declines over time compared to Projects Forecast Scenarios 1 and 2, but with continued declining groundwater levels, reduction of groundwater in storage, continued land subsidence, and continued outflow to surrounding subbasins, after 2040.
4. Projects Forecast Scenario 4: The Projects Forecast was further modified by implementing agricultural pumping limits in the surrounding subbasins. The simulation results showed a substantial reduction of groundwater level declines over time compared to Projects Forecast Scenarios 1 through 3, resulting in stable groundwater elevations throughout most of the Subbasin and surrounding subbasins, with significantly reduced reduction of groundwater in storage, and significantly reduced land subsidence. These results are presented below.

A comparison of simulated potentiometric surface maps from above and below the Corcoran Clay for the Baseline Forecast for June 2040 (Figure D7-5) with simulated Projects Forecast Scenario 4 (hereafter referred to simply as the Projects Forecast) potentiometric surface maps from above the Corcoran Clay for June 2040 (Figure D7-13) show that the simulated groundwater elevations beneath the Subbasin above the Corcoran Clay are about 10 feet higher under the Projects Forecast compared to the Baseline Forecast. Simulated groundwater elevations in the surrounding subbasins are substantially higher with groundwater elevation increases ranging from 20 to 30 feet in Kaweah, Kings, and Tule subbasins. The Westside Subbasin showed groundwater elevations increases in the 10 to 20 foot range, while there was little increase in the Kern Subbasin.

Simulated groundwater elevations for June 2040 beneath the Subbasin below the Corcoran Clay are about 20 to 30 feet higher under the Projects Forecast compared to the Baseline Forecast. In the Kaweah and Kings subbasins, simulated heads are 20 to 40 feet higher compared to the Baseline Forecast. In the Tule Subbasin in Creighton Ranch and Angiola well field areas, simulated heads are as much as 130 feet higher compared to the Baseline Forecast. The Westside Subbasin showed groundwater elevations increases in the 40- to 100-foot range, while the heads in the Kern Subbasin increased as much as 50 feet.

A comparison of simulated potentiometric surface maps from above and below the Corcoran Clay for the Baseline Forecast for December 2070 (Figure D7-5) with simulated Projects Forecast potentiometric surface maps from above the Corcoran Clay for December 2070 (Figure D7-14) show that the simulated groundwater elevations beneath the Subbasin above the Corcoran Clay are about 10 to 30 feet higher under the Projects Forecast compared to the Baseline Forecast. Simulated groundwater elevations in the surrounding subbasins are substantially higher with groundwater elevation increases ranging from 20 to 40 feet in Kaweah and Kings subbasins, and as much as 80 feet in the Tule Subbasin. The Westside Subbasin showed groundwater elevations increases in the 10 to 20 to 60 foot range, while the heads in the Kern Subbasin increased as much as 40 feet.

Simulated groundwater elevations for December 2070 beneath the Subbasin below the Corcoran Clay are about 30 to 40 feet higher under the Projects Forecast compared to the Baseline Forecast. In the Kaweah and Kings subbasins, simulated heads are 30 to 60 feet higher compared to the Baseline Forecast. In the Tule Subbasin in Creighton Ranch and Angiola well field areas, simulated heads are as much as 160 feet higher compared to the Baseline Forecast. The Westside Subbasin showed groundwater elevations increases in the 50-to 130-foot range, while the heads in the Kern Subbasin increased as much as 90 feet.

Simulated Projects Forecast hydrographs for selected compliance wells in the vicinity of the cities of Corcoran, Hanford, and Lemoore show a gradual stabilization of groundwater elevations in the unconfined aquifer above and confined below the Corcoran Clay, with seasonal variations much greater below the Corcoran Clay (Figure D7-15). Over the 54-year simulation period, the hydrographs above the Corcoran Clay show approximately 15 feet of decline in the Corcoran area, about 25 feet of decline in the Hanford area, and about 60 feet of decline in the Lemoore area. Over the same period, the hydrographs below the Corcoran Clay show about 30 feet of decline in the Corcoran area, about 25 feet of decline in the Hanford area, and about 20 feet of decline in the Lemoore area.

The Projects Forecast simulation results indicate that subsidence will continue over the next 54 years under the assumed forecast conditions. A map of cumulative subsidence from 2017-2040 shows that the is about 0 to 2 feet of additional subsidence over most of the Subbasin, with up to 2 feet of additional subsidence in the Lemoore area (Figure D7-16). Subsidence in the Angiola and Creighton Ranch wells fields in the Tule Subbasin is significantly less compared to the Baseline Forecast (Figure D7-7). Projects Forecast subsidence in the lake bottom area in minimal. A map of cumulative subsidence from 2017-2070 shows that the is about 2 to 4 feet of additional subsidence over the northern portion of the Subbasin, with up to 2 feet of additional subsidence in the Angiola and Creighton Ranch wells fields in the Tule Subbasin (Figure D7-16).

Simulated Projects Forecast subsidence hydrographs for continuous GPS compliance point near the cities of Corcoran and Lemoore wells show that under project conditions, the subsidence continues to occur (Figure D7-17), but at significant reduced rates compared to the Baseline Forecast (Figure D7-8).

The Projects Forecast simulation groundwater mass balance data were used to estimate the change in groundwater storage in the Subbasin on an annual basis for the 54-year forecast simulation period (Figure D7-18). Under the Projects Forecast assumptions described above, between 2017 and 2070, there would continue to be an annual average of about -36,200 AF/Y of groundwater storage depletion (a reduction of 75% compared to the Baseline Forecast), and as much as -7.72 million AF of cumulative storage depletion from the Subbasin. Most of the remaining overdraft in the Subbasin appears to result from the continued outflow of groundwater to the surrounding subbasins, which average approximately -58,610 AF/Y over the 2017-2070 simulation periods (Figure D7-18).

As discussed in Section 7.2, for simulation purposes it was assumed that the surrounding subbasins would implement projects and management actions that would increase surface water supply and decrease agricultural demand. However, until the magnitude and timing of actual projects and management actions to be implemented in the surrounding subbasins can be incorporated into the TLSBHM, the model forecasts will have a degree of uncertainty regarding future water balance and overdraft estimates.

In summary, the Projects Forecast simulation results indicate that overdraft conditions in the Subbasin will be mostly eliminated, with stable groundwater levels by 2040. While there continues to be some reduction of groundwater in storage, the forecast that groundwater levels remain relatively stable through 2070 indicates that the continued reduction in groundwater in storage is also sustainable. Likewise, although some land subsidence will continue over time, the forecast that groundwater levels remain relatively stable through 2070 indicates that the continued subsidence is also sustainable. Thus, the Projects Forecast indicates that sustainable groundwater conditions in the Subbasin can be achieved by 2040 with implementation of the proposed projects and management actions in the Subbasin and assumed projects and management actions in the surrounding subbasins.

7.2.7 Historical vs. Projects Forecast Simulation Comparison

A comparison of the 1990-2016 historical model, 2017-2070 Baseline Forecast, and 2017-2070 Projects Forecast was made using the annual average groundwater balance data for each simulation (Table D7-3). The Baseline and Projects forecast models both assume that land fallowed during the 2011-2016 drought would be put back into production, and that overall crop demand would increase due to the maturation of permanent crop as described in Section 7.1.1. The increase in ET demand was also exacerbated by climate change. Furthermore, the forecasts also assume that groundwater levels would continue to decline at historical rates for 10 or more years prior to project implementation. As a result, for the even though the Baseline Forecast 2017-2070 average annual pumping, recharge, and river leakage are similar to the Calibration 1990-2016 average values, the net change in storage increased from -85,690 AF/Y to -142,990 AF/Y because there was more interbasin outflow from the Subbasin into the surrounding subbasins. The annual average values for 1998-2010 and 2040-2048 “normal hydrology” periods have similar results, where the net change in storage increased from -73,760 AF/Y to -149,430 AF/Y.

The Projects Forecast shows a different trend. With implementation of the projects, the 2017-2070 average annual pumping decreases, groundwater recharge increases, and interbasin flow decreases. As a result, the net change in storage decreased from -85,690 AF/Y to -36,200 AF/Y (nearly a 60% decrease). The results are similar for the 1998-2010 and 2040-2048 “normal hydrology” periods, where the net change in storage decreased from -73,760 AF/Y to -19,390 AF/Y.

The results of the Projects forecast simulation indicate that under the assumed forecast conditions, implementation of the proposed projects to increase surface water supply and recharge coupled with agricultural demand reductions in the surrounding subbasins can significantly reduce overdraft to sustainable levels in the Subbasin as evidenced by the stabilization of groundwater levels throughout most of the subbasins (Figure D7-15, GSP Appendix G) and the reduction of subsidence (Figure 7-17).

8.0 Data Limitations

Groundwater models are designed to estimate changes over time in groundwater levels, flow directions, and storage given a set of inflows (precipitation, surface water, under flow in, etc.) and outflows (evapotranspiration, pumping, underflow out, etc.). Prior to the SGMA there were no requirements to manage or report groundwater usage. As a result, most GSAs do know the location, construction, and pumping history of many pumping wells within their GSAs. Furthermore, most GSAs often do not have a good historical accounting of which parcels have received surface waters and at what rates. Hence, these inputs and outputs need to be approximated by other means than direct measurement.

The data utilized for construction and calibration of the TLSBHM were provided by various private parties, public agencies, and data extracted from existing numerical models of the area including DWR's 2014 release of C2VSim in the Coarse Grid version, USGS CVHM, the Kaweah Delta Water Conservation District model (Fugro West, 2005), and the preliminary Tule Subbasin and Westside Subbasin models. Other numerical models adjacent to and/or covering portions of the TLSBHM are known to exist, but were unavailable for this effort. The data gathering effort also occurred before many GSAs were organized, so it is likely that some data were unavailable at the time the model was developed. It is anticipated that as the TLSBHM is reviewed and utilized that some corrections of input data will be necessary and that additional data, unavailable at the time, will need to be incorporated into the model.

Much of the hydrologic data used to construct and calibrate the TLSBHM are based on estimates or inferred from multiple data sources. As noted above, most GSAs do not know the historical delivery of surface water to various parcels within the GSAs. Hence it was necessary to assume that all irrigated parcels received some surface water allotment. Likewise, the location, construction, and pumping history of most of the irrigation wells in the TLSBHM domain are not known. Hence hypothetical irrigation well locations were assumed to be distributed with relatively uniform spacing across the model domain. The hypothetical irrigation wells were also assumed to have completion intervals and frequency similar to that of a small subset of wells with known constructions. Hypothetical irrigation wells pumping was estimated based on a water balance method using estimated agricultural demand based on reported crop type minus the assumed distribution of surface water supplies. While these simplifying assumptions and estimates are reasonable given the sparseness of measurements, they add uncertainty to the model.

Overtime, under the SGMA, more accurate spatial and temporal groundwater pumping, and surface water delivery data should be collected and utilized to construct and update groundwater models of the Subbasin. As the models are populated with actual measurement instead of estimate, the models will become more useful tool for managing groundwater in the Subbasin.

9.0 Summary of Model Reliability and Peer Review

The TLSBHM is an approximation of existing conditions beneath and in the vicinity of the Subbasin. It covers a large area with very dynamic hydrologic conditions that have significant changes over the simulation period. Due to a lack of historical data, much of the data utilized to construct the model had to be inferred from alternative data sets. Given the uncertainty of these estimates, the model can approximate on average, but not completely reproduce, all observations across the entire site area under all conditions. Overall, the TLSBHM can reliably predict groundwater elevations in response to various hydrologic conditions within the calibration period based on the available data and estimates. However, forecast simulations with extreme ranges in hydrologic conditions (i.e., severe drought conditions or extreme flooding) may produce less reliable results.

The TLSBHM was submitted for peer review to Dr James T McCord of GeoSystems Analysis, Inc. Dr. McCord has over 30 years of experience in hydrology, hydrogeology, and water resource investigations, with emphasis on characterization of groundwater and surface water systems, numerical modeling of hydrologic systems. He has authored numerous consulting reports and technical peer-reviewed papers, and co-authored the textbook, Vadose Zone Processes (CRC Press, 1999). He has served as an Adjunct Professor of Earth Science at New Mexico Technical University since 1991, as well as Adjunct

Professor of Civil Engineering at the University of New Mexico and of Civil and Environmental Engineering at New Mexico Tech since 2007. Dr. McCord's per review in include in Appendix D6.

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Table D2-1

Historical Precipitation - Hanford, California[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1899	M	M	M	M	M	M	M	M	0	0.67	M	0.87	M
1900	1.38	0	1.18	1.04	M	M	M	M	M	M	M	M	M
1901	M	M	M	M	M	M	M	T	1.04	T	M	0.15	M
1902	0.4	2	1.78	0.47	0.09	M	0	M	0	0.36	1.67	0.56	M
1903	1.31	0.38	1.71	0.5	0	0	0	0	0	0.05	0.47	0.15	4.57
1904	0.52	2.03	2.05	0.72	0	0	0	0	2.48	0.84	0.31	1.16	10.11
1905	1.28	1.09	2.1	0.56	0.65	0	0	0	0.07	0	1.16	0.23	7.14
1906	1.59	1.92	4.05	0.62	2.06	0.02	0	0	0	0	M	M	M
1907	M	M	M	M	M	M	M	M	M	M	M	M	M
1908	M	M	M	M	M	M	M	M	M	M	M	0.31	M
1909	M	M	M	M	M	M	M	M	M	M	M	M	M
1910	M	M	M	M	M	M	M	M	M	M	M	M	M
1911	M	M	M	M	M	M	M	M	M	M	M	M	M
1912	M	0.02	3.24	1.52	0.27	0	0	0	0	0	0.61	0.21	M
1913	1.26	1.55	0.34	0.78	0.76	0.06	0.08	0	M	M	M	1.35	M
1914	4.36	1.25	0.37	0.11	M	1.06	0	0	0	0	0.02	M	M
1915	M	M	0.3	1.37	M	M	M	M	M	M	M	M	M
1916	4.68	M	M	M	0.16	M	M	0.28	0.47	1.09	M	1.35	M
1917	M	M	M	M	0.31	M	M	M	M	M	M	M	M
1918	M	4.5	3.43	M	M	M	M	M	0.88	0.12	M	M	M
1919	M	M	1.01	0.15	0.1	M	M	M	M	M	M	M	M
1920	M	2.72	3.05	0.24	M	M	M	M	M	M	M	M	M
1921	M	0.89	M	M	0.87	M	M	M	M	M	M	M	M
1922	M	M	M	M	M	M	M	T	M	M	M	M	M
1923	M	M	M	2.43	M	M	M	M	M	M	M	0.22	M
1924	M	M	1.86	M	0	M	M	T	0	0.65	M	2.12	M
1925	M	M	1.58	M	M	M	0	M	0	M	M	M	M
1926	0.82	1.44	0.2	2.67	T	0	0	0	0	0.76	3.67	0.65	10.21
1927	1.33	2.52	2.04	0.18	0.06	T	0	0.04	T	1.67	1.63	0.78	10.25
1928	0.09	0.96	1.55	0.08	0.1	0	0	0	0	T	1.47	1.69	5.94
1929	0.81	0.61	1.4	0.81	0	0.24	T	0	0.03	0	0	0.42	4.32
1930	1.66	1	1.66	0.15	0.37	0	0	0.02	0.38	0.07	0.67	0.3	6.28
1931	2.32	0.72	0.07	0.91	0.2	1.12	0	0.08	0.08	0	1.36	2.54	9.4
1932	1.85	1.52	0.47	0.71	0.13	0	0	0	0	0	0.28	0.93	5.89
1933	3.12	0.16	0.72	0.28	0.41	0.07	0	0	0	0.15	0	1.01	5.92
1934	0.17	1.53	0.05	0	0.22	0.14	0	0	0	1.06	2.15	1.84	7.16
1935	2.5	1.77	2	2.05	0	0	0.03	0	0.06	0.51	0.4	0.89	10.21
1936	0.66	4.7	0.97	0.55	T	T	0	0	0	1.84	0	2.87	11.59
1937	1.95	2.46	2.23	0.22	0	0	0	0	0	0.11	0.21	2.16	9.34
1938	1.76	3.51	4.59	1.15	0.11	0.17	0.07	0	0.13	0.19	0.19	1.42	13.29
1939	1.54	0.77	1.44	0.82	T	0.12	0	0	0.04	0.57	0.06	0.22	5.58
1940	3.53	3.61	0.99	0.18	T	T	0	0	0	0.85	T	3.61	12.77

Table D2-1

Historical Precipitation - Hanford, California[1]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1941	1.51	3.9	2.05	2.41	T	T	0	T	0	0.9	0.57	3.11	14.45
1942	1.21	0.88	0.94	1.19	0.16	0	0	M	0	0	0.43	1.1	M
1943	2.73	1.14	3.35	0.87	0	0	0	0	0	0.03	0.22	1.03	9.37
1944	1.28	2.97	0.22	0.86	0.28	0.23	0	0	0.02	0.23	2.25	0.97	9.31
1945	0.26	2.71	1.81	0.16	0.1	0.17	0	0	T	0.71	1.15	1.51	8.58
1946	0.34	1.53	2.56	0.07	0.41	0	0.11	0	0	1.33	1.1	2.06	9.51
1947	0.41	0.49	0.56	0.11	0.41	0	0	0	T	0.59	0.29	0.51	3.37
1948	0	0.44	1.46	1.55	0.54	0	0	0	0	0.03	0.01	0.99	5.02
1949	0.51	0.85	1.94	0.07	0.53	0	0	T	0	0	0.6	0.68	5.18
1950	1.93	1.13	1.1	0.4	0	0	0.08	0	0	0.34	0.63	1.06	6.67
1951	1.24	0.76	0.22	1.17	0.07	0	0	0	0	0.08	1.11	2.39	7.04
1952	3.08	0.27	2.18	0.79	0.01	0.02	T	0	0.17	0.05	0.65	2.96	10.18
1953	1.1	0.27	0.34	0.83	0.29	0.02	T	0	0	0.02	1.01	0.09	3.97
1954	1.89	0.78	2.21	0.52	0.34	0.08	0	0	0	0	0.66	1.61	8.09
1955	3.25	1.31	M	M	0.9	0	0	M	0	0.02	0.92	4.67	M
1956	1.2	0.38	0.1	0.73	0.83	0	0	0	0	0.72	0	0.15	4.11
1957	1.39	1.17	0.56	0.67	0.63	0	0	0	0	0.2	1.39	1.41	7.42
1958	1.85	2.3	3.92	2.04	0.24	0	0	T	0.88	0	0.23	0.16	11.62
1959	0.86	1.9	0.11	0.52	T	0	0	T	0.11	0	0	0.17	3.67
1960	0.8	1.71	0.61	0.57	0	0	0.02	0	0	0.53	2.61	0.03	6.88
1961	1.34	0.22	0.67	0.22	0.37	0	0	0	0	0	1.11	1.28	5.21
1962	0.71	4.88	1.06	0	0.11	0	0	0	0.01	0.1	0	0.19	7.06
1963	1.19	1.68	1.37	2.88	0.56	0.17	0	0	0.33	0.75	1.23	0.29	10.45
1964	0.61	0.02	0.94	0.64	0.2	0	0	0.34	0	0.95	1.31	1.44	6.45
1965	1.18	0.33	0.33	1.6	0	0	0	0.05	0.07	0.05	2.15	1.97	7.73
1966	0.63	0.71	0.1	0	0.07	0.06	0.04	0	0.29	0	1.28	2.57	5.75
1967	1.41	0.05	2.42	2.95	0.07	0.23	0	0	0.31	0	1.99	0.5	9.93
1968	0.57	0.64	1	0.5	0.08	0	0	0	0	1.33	0.98	1.64	6.74
1969	6.69	4.54	0.79	0.85	0.32	0.21	0.07	0	0.15	0.05	0.51	0.7	14.88
1970	1.6	1.33	1.42	0.16	0	T	T	0	0	T	2.4	1.23	8.14
1971	0.35	0.19	0.23	0.4	1.44	0	0	T	0.04	0.06	0.41	1.87	4.99
1972	0.04	0.35	0	0.23	0	0	0	0	0.24	0.21	2.9	0.65	4.62
1973	M	2.29	2.2	0.12	M	M	0	0	0	M	M	M	M
1974	2.97	0.11	1.75	0.03	0	0	0	0	0	0.65	0.24	1.4	7.15
1975	0.09	2.26	M	0.49	0	0	0	0	0.96	M	0.05	0.22	M
1976	T	2.94	0.19	1.47	0.03	0.51	0	0.22	1.47	0	1.15	0.96	8.94
1977	0.59	0.03	0.43	0	0.91	0.07	0	0	0	0.05	0.66	2.85	5.59
1978	2.22	5.05	4.12	1.71	0	0	0	0	1.1	0	0.79	0.5	15.49
1979	2.19	1.61	1.16	0.03	0	0	0.04	0	0.08	0.41	0.62	0.41	6.55
1980	2.9	2.71	1.28	0.05	0.04	0	0	0	0	0.09	0	0.2	7.27
1981	1.77	0.86	2.1	0.68	0.17	0	0	0	0	0.76	1.08	0.29	7.71
1982	0.84	0.38	3.52	1.75	0	0.45	0.18	0	0.64	1.03	2.15	0.71	11.65
1983	3.74	2.59	3.39	1.63	0.04	0	0	0.05	0.82	0.43	1.66	1.22	15.57
1984	0.01	0.42	0.27	0.18	0	0	0	0	0	M	M	M	M
1985	0.59	M	0.7	0.12	0	0	M	0	T	M	2.11	0.66	M

Table D2-1

Historical Precipitation - Hanford, California[1]

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1986	1.46	2.6	3.43	0.5	0	0	T	T	0.15	0	0.21	0.77	9.12
1987	1.77	2.07	2.02	0.06	0.13	0.05	0	0	0	0.58	0.47	1.7	8.85
1988	1.37	0.4	0.93	1.99	0.07	0	0	0	0	0	1.31	2.29	8.36
1989	0.17	1.04	0.85	0.02	0.39	0	0	T	0.67	0.32	0.2	0	3.66
1990	1.66	1.1	0.3	0.97	0.87	0	T	T	T	0.01	0.22	0.15	5.28
1991	0.31	0.12	6.62	0.19	T	0.12	0	0	0.11	0.41	0.14	M	M
1992	1.4	2.82	0.85	0.1	T	0	0.01	0.01	T	0.58	T	2.62	8.39
1993	3.88	2.48	2.16	0.07	0.08	0.3	0	0	0	0.24	0.64	0.66	10.51
1994	0.94	1.45	1.02	0.72	0.66	0	T	0	1.06	0.35	1.54	0.33	8.07
1995	4.7	0.51	4.77	0.65	0.87	0.04	T	0	T	0	T	1.59	13.13
1996	1.68	2.89	2.27	0.85	0.1	T	0	0	0	2.43	0.69	3.27	14.18
1997	3.02	0.12	0.21	0	0	T	T	0	0.06	0.09	1.96	1.8	7.26
1998	2	4.05	2.63	1.68	1.31	0.44	0	0	T	0.68	0.63	0.65	14.07
1999	3.01	0.56	0.43	1.37	0	0	0	T	0.01	0	0.15	T	5.53
2000	1.8	3.28	1.59	0.97	0.48	0.35	0	0	0.03	1.31	T	0.05	9.86
2001	1.98	1.48	1.24	1.12	0	0	0.09	0	T	0.18	1.84	1.99	9.92
2002	0.87	0.31	1.04	0.03	0.01	0.82	0	0	0	0	1.42	1.14	5.64
2003	0.24	1.08	1.01	1.5	0.62	0	T	0.07	0	0	0.49	2	7.01
2004	2	2.18	0.29	0.02	0.01	0	0	0	0	2.06	0.52	2.23	9.31
2005	2.63	1.58	2.24	0.71	0.83	0	0	T	0.01	0.01	0.19	2.07	10.27
2006	3.54	0.55	2.72	3.39	0.53	0	0	0	0	0.06	0.22	1.01	12.02
2007	0.65	0.89	0.26	0.33	0.01	0	0	0.12	0.37	0.35	0.12	1.32	4.42
2008	2.18	1.18	T	0	0.11	0	0	0	0	0.15	1.04	1.49	6.15
2009	0.8	1.86	0.2	0.02	0.41	0.22	0	0	0.18	1.32	0.28	1.42	6.71
2010	2.64	1.91	0.34	1.65	0.17	0	0	0	0	0.64	1.32	6.46	15.13
2011	1.52	1.53	2.87	0.3	0.4	1.04	0	0.08	0.01	0.55	0.8	0.06	9.16
2012	M	M	M	1.39	0.03	M	T	0	0	0.28	0.49	1.9	M
2013	0.22	0.48	0.79	0.08	0.17	0	0	0	0.01	T	0.33	0.16	M
2014	0.3	1.38	0.27	0.35	T	0	0	0	0.03	0	0.94	2.52	5.79
2015	0.08	0.72	0.02	0.77	0.1	0	0.45	0	0	0.38	0.91	1.4	4.83
2016	2.56	0.58	1.99	0.57	0.02	0.09	0	0	0	0.76	0.4	1.6	8.57
2017	3.7	2.8	0.31	1.02	0.36	0.01	0	0.01	0.17	0.06	0.21	0.08	8.73
Mean	1.59	1.5	1.47	0.75	0.25	0.09	0.01	0.01	0.15	0.38	0.82	1.24	8.28
Min	6.69 1969	5.05 1978	6.62 1991	3.39 2006	2.06 1906	1.12 1931	0.45 2015	0.34 1964	2.48 1904	2.43 1996	3.67 1926	6.46 2010	15.57 1983
Max	0 1948	0 1900	0 1972	0 2008	0 2018	0 2015	0 2017	0 2016	0 2016	0 2014	0 1980	0 1989	3.37 1947

1. From: https://w2.weather.gov/climate/xmacis.php?wfo=hnx
   M = missing data and T = trace amount of precipitation.

Table D2-2
Historical Land Use

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Tulare Lake Subbasin[1]	1990-1995 (acres)	1996-1998 (acres)	1999-2006 (acres)	2007 (acres)	2008 (acres)	2009 (acres)	2010 (acres)	2011 (acres)	2012 (acres)	2013 (acres)	2014 (acres)	2015 (acres)	2016 (acres)	Average (acres)
Alfalfa Hay and Clover	41,604	32,564	54,301	72,459	80,600	71,504	69,685	38,789	42,131	49,318	35,820	29,665	24,245	**45,987**
Almonds (Adolescent)			2,908			5,127	7,927	3,222	4,464	7,476	6,526	6,222	5,365	**2,470**
Almonds (Mature)	7,682	5,241	4,550	12,897	11,825	9,826	8,374	10,140	10,818	11,441	12,876	15,046	15,105	**7,852**
Almonds (Young)		3,278	9,290	16,538	25,966	14,678	20,887	13,968	14,564	20,341	17,678	16,983	21,576	**9,557**
Berries	20								1	2		0		**5**
Carrot Single Crop								11	5	12	2	2	16	**2**
Citrus (no ground cover)			25		13	14	4	120	29	100	89	22	9	**21**
Corn and Grain Sorghum	14,280	38,896	29,349	39,271	31,762	34,643	23,031	33,780	29,175	27,566	22,638	18,826	17,400	**25,404**
Cotton	159,534	180,960	124,764	109,605	88,304	72,441	98,167	105,541	88,993	89,317	63,385	44,532	73,720	**118,794**
Dairy Single Crop*	3,816	4,077	4,385											**2,438**
Fallow Land*	193,695	138,392	89,606	65,169	85,144	99,688	90,192	152,391	172,697	172,486	195,172	237,790	200,972	**136,159**
Forest*	420	809	2,955	6	5	46	5			1		4	0	**952**
Grain and Grain Hay	28,708	48,533	62,962	19,266	27,870	27,406	25,980	7,758	9,968	11,194	12,213	21,196	19,069	**34,833**
Melons	250	56	284				14	2	11	7	797	18	86	**170**
Misc. field crops	17,116	12,819	51,311		2			0			2			**18,531**
Onions and Garlic	457	479	770			7	1,358	411	302	94	502	149	644	**483**
Open Water*	5,568	9,092	8,968	5,576	4,296	4,049	5,434	7,703	5,443	5,045	6,824	5,919	5,435	**6,637**
Pasture and Misc. Grasses	2,500	5,029	5,615	50,688	44,232	66,944	53,080	14,680	13,368	15,355	33,551	15,744	13,743	**14,473**
Pistachio (Adolescent)								170	218	370	882	3,575	3,836	**335**
Pistachio (Mature)	4,694	3,808	3,804	6,096	1,907	934	404	394	380	348	330	485	469	**2,888**
Pistachio (Young)		1,580	4,390	4,351	4,259	8,527	8,083	12,985	14,676	15,878	19,195	22,678	22,570	**6,247**
Pomegranates (Adolescent)											3	16	27	**2**
Pomegranates (Young)				61	1,705	545	256	5,012	804	1,395	2,207	1,312	3,111	**608**
Potatoes, Sugar beets, Turnip etc..	5,736	1	209	6		3		9		41		2	2	**1,331**
Riparian*		668	1,120	517	134	398	615	226	138	313	239	248	194	**477**
Small Vegetables	1,599	647	4,518	20	2	13	212	142	133	244	165	78	198	**1,643**
Stone Fruit (Adolescent)			1,478			14	66	100	125	69	47	191	170	**412**
Stone Fruit (Mature)	7,070	4,985	3,854	1,314	544	168	18	3	23	41	23	27	39	**3,206**
Stone Fruit (Young)		1,827	4,185	672	1,609	1,573	2,502	1,077	712	1,641	1,340	1,183	713	**1,770**
Tomatoes and Peppers	5,634	1,627	14,676	117	2	110	12	21,482	23,670	7,114	11,922	19,211	23,420	**9,203**
Urban, Industrial*	12,654	17,391	19,875	33,427	34,711	44,471	32,218	32,091	28,576	29,366	33,901	30,530	30,930	**22,128**
Wine Grapes with 80% canopy	2,948	3,226	5,779	5,588	3,499	2,240	2,746	5,361	9,228	4,655	6,472	4,672	10,985	**4,565**
Winter Wheat*				72,238	67,458	50,451	64,526	48,212	45,118	44,530	30,950	19,420	21,690	**17,207**
Tulare Lake Subbasin Irrigated Crop Acreage	**299,832**	**345,557**	**389,021**	**338,951**	**324,102**	**316,717**	**322,806**	**275,156**	**263,796**	**264,018**	**248,665**	**221,837**	**256,519**	310,792
Tulare Lake Subbasin Total Crop Acreage	**515,986**	**515,986**	**515,931**	**515,883**	**515,849**	**515,821**	**515,796**	**515,779**	**515,768**	**515,759**	**515,751**	**515,747**	**515,741**	496,788

1. Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year

Table D2-3
Historical Kings River Diversions

Tulare Lake Subbasin Hydrologic Model
Kings County, California

	GSA	Mid-Kings River					South Fork Kings						Southwest Kings									
	Agency	Peoples Ditch Company	Last Chance Water Ditch Company				Stratford Irrigation District	Empire West Side Irrigation District			Lemoore Canal & Irrigation Company					Dudley Ridge Water District-Monthly Diversions Assumed							
Kings River Water Years	Diversion	***Peoples Canal- MKRGSA Total***	***Last Chance Canal- MKRGSA Total***	***Lakeside IWD***	Imported Water	Mid Kings	Stratford Canal	Empire West Side ID total from SWP	Empire West Side Canal	Westlake Canal	Lemoore Canal	Imported Water	South Fork Kings River	***Blakeley Canal-Kings River & Lateral A***	TLBWSD Lateral C, T203	**Dudley Ridge State Turnout (DR-1), T201**	**Dudley Ridge State Turnout (DR-1B), T202**	**Dudley Ridge State Turnout (DR-1A), T204**	**Dudley Ridge State Turnout (DR-2), T205**	**Dudley Ridge State Turnout (Paramount), T207**	**Dudley Ridge State Turnout (DR-3), T208**	**Imported Water, Angiola/Green Valley Well Fields, City of Lemoore and Westlands RD 761**	Southwest Kings
		(AF/Y)	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**	**(AF/Y)**
71%	**1966**	**107,763**	**50,356**	-	-	158,119	2,158	**-**	4,770	3,604	96,079	-	106,612	**20,559**	-	-	-	-	-	-	-	-	20,559
197%	**1967**	**136,889**	**78,468**	-	-	215,358	3,947	**-**	9,622	5,861	109,323	-	128,753	**29,187**	-	-	-	-	-	-	-	-	29,187
49%	**1968**	**75,809**	**31,878**	-	-	107,688	3,540	**1,780**	13,636	12,718	91,478	-	123,153	**19,692**	0	**3,312**	**949**	**2,372**	**11,388**	**9**	**5,694**	-	43,416
256%	**1969**	**107,636**	**61,339**	-	-	168,975	1,139	**50**	2,878	6,056	87,537	-	97,659	**534**	0	**3,942**	**1,130**	**2,824**	**13,554**	**11**	**6,777**	-	28,771
78%	**1970**	**76,723**	**38,772**	-	-	115,495	1,884	**3,548**	5,359	7,305	93,441	-	111,538	**0**	0	**5,077**	**1,455**	**3,637**	**17,456**	**15**	**8,728**	-	36,366
69%	**1971**	**86,815**	**35,321**	-	-	122,137	4,376	**5,391**	4,665	10,280	96,498	-	121,210	**10,521**	0	**5,158**	**1,478**	**3,695**	**17,735**	**15**	**8,867**	-	47,469
50%	**1972**	**51,631**	**38,190**	-	-	89,820	4,062	**5,216**	6,188	5,133	80,465	-	101,065	**20,920**	0	**5,333**	**1,528**	**3,820**	**18,335**	**15**	**9,168**	-	59,119
125%	**1973**	**139,667**	**62,672**	-	-	202,339	4,411	**5,233**	5,964	6,543	86,382	-	108,534	**22,249**	0	**4,429**	**1,269**	**3,172**	**15,228**	**13**	**7,614**	-	53,973
122%	**1974**	**137,406**	**68,454**	-	-	205,860	4,082	**4,085**	9,291	10,508	102,115	-	130,081	**37,966**	0	**8,390**	**2,404**	**6,010**	**28,849**	**24**	**14,425**	-	98,069
92%	**1975**	**109,458**	**43,937**	-	-	153,395	4,570	**5,803**	8,763	10,939	104,388	-	134,463	**36,603**	0	**10,191**	**2,920**	**7,300**	**35,040**	**29**	**17,520**	-	109,602
32%	**1976**	**37,828**	**2,255**	-	-	40,083	4,284	**5,811**	5,915	5,004	70,925	-	91,940	**22,247**	0	**7,770**	**2,226**	**5,566**	**26,716**	**22**	**13,358**	-	77,906
23%	**1977**	**43,393**	**9,542**	-	-	52,935	2,203	**2,120**	1,598	557	42,067	-	48,545	**8,903**	0	**3,633**	**1,041**	**2,603**	**12,493**	**10**	**6,246**	-	34,930
201%	**1978**	**125,769**	**71,577**	-	-	197,346	2,859	**409**	10,627	9,312	80,567	-	103,774	**26,094**	0	**7,455**	**2,136**	**5,340**	**25,632**	**21**	**12,816**	-	79,494
101%	**1979**	**125,680**	**64,463**	-	-	190,143	6,434	**1,565**	15,449	9,523	107,578	-	140,549	**52,496**	0	**9,685**	**2,775**	**6,938**	**33,302**	**28**	**16,651**	-	121,876
178%	**1980**	**101,388**	**64,365**	-	-	165,753	3,981	**805**	16,100	11,566	103,714	-	136,165	**53,639**	0	**10,061**	**2,883**	**7,207**	**34,594**	**29**	**17,297**	-	125,710
61%	**1981**	**89,091**	**47,482**	-	-	136,572	4,435	**7,966**	7,841	9,437	89,111	-	118,790	**42,806**	0	**9,213**	**2,640**	**6,599**	**31,677**	**26**	**15,839**	-	108,800
181%	**1982**	**127,200**	**65,413**	-	-	192,613	4,479	**4,379**	9,396	20,983	100,153	-	139,389	**41,213**	0	**6,968**	**1,997**	**4,992**	**23,960**	**20**	**11,980**	-	91,130
261%	**1983**	**60,994**	**48,013**	-	-	109,007	3,808	**0**	6,097	10,389	58,631	-	78,926	**22,250**	0	**7,026**	**2,013**	**5,033**	**24,157**	**20**	**12,078**	-	72,577
115%	**1984**	**97,831**	**53,649**	-	-	151,480	2,533	**0**	2,801	3,800	99,362	-	108,496	**10,003**	0	**8,116**	**2,326**	**5,814**	**27,907**	**23**	**13,954**	-	68,144
73%	**1985**	**105,362**	**39,583**	-	-	144,944	4,869	**4,677**	5,209	6,827	103,148	-	124,731	**34,288**	0	**7,791**	**2,232**	**5,581**	**26,788**	**22**	**13,394**	-	90,096
190%	**1986**	**111,962**	**62,457**	-	-	174,419	7,329	**2,070**	7,345	16,723	87,761	-	121,227	**27,361**	0	**6,427**	**1,841**	**4,604**	**22,098**	**18**	**11,049**	-	73,398
45%	**1987**	**70,406**	**24,792**	-	-	95,198	5,177	**3,961**	4,959	10,982	90,541	-	115,620	**28,582**	0	**5,816**	**1,666**	**4,166**	**19,996**	**17**	**9,998**	-	70,242
48%	**1988**	**60,312**	**21,844**	-	-	82,156	3,953	**3,128**	4,457	2,949	76,554	-	91,041	**21,261**	0	**6,030**	**1,728**	**4,319**	**20,733**	**17**	**10,367**	-	64,456
53%	**1989**	**60,579**	**19,935**	-	-	80,514	0	**2,700**	0	-	56,519	-	59,219	**13,458**	0	**7,168**	**2,054**	**5,134**	**24,645**	**21**	**12,323**	-	64,802
40%	**1990**	**53,292**	**9,909**	-	-	63,201	0	**2,979**	0	-	34,465	-	37,444	**6,485**	0	**4,606**	**1,320**	**3,299**	**15,836**	**13**	**7,918**	14,540	54,016
63%	**1991**	**45,654**	**18,622**	-	-	64,276	1,760	**199**	1,006	964	31,492	-	35,420	**5,941**	0	**1,670**	**479**	**1,196**	**5,743**	**5**	**2,871**	8,181	26,085
41%	**1992**	**49,394**	**9,361**	-	-	58,755	1,759	**1,219**	0	0	37,968	-	40,945	**6,003**	0	**1,696**	**486**	**1,215**	**5,831**	**5**	**2,915**	6,095	24,245
149%	**1993**	**147,363**	**53,498**	-	-	200,860	5,070	**2,467**	4,314	8,612	91,166	-	111,629	**30,546**	0	**2,917**	**836**	**2,090**	**10,031**	**8**	**5,016**	6,480	57,925
50%	**1994**	**69,510**	**30,738**	-	-	100,248	2,997	**1,499**	3,808	6,811	76,550	-	91,666	**26,295**	0	**3,834**	**1,099**	**2,747**	**13,184**	**11**	**6,592**	11,642	65,404
202%	**1995**	**143,785**	**102,300**	-	-	246,085	6,123	**1,468**	6,419	1,410	85,049	-	100,469	**34,039**	0	**5,715**	**1,637**	**4,094**	**19,650**	**16**	**9,825**	8,131	83,107
122%	**1996**	**166,765**	**95,338**	-	-	262,103	6,774	**1,681**	5,576	5,778	105,398	-	125,206	**41,813**	0	**6,886**	**1,973**	**4,933**	**23,677**	**20**	**11,839**	14,505	105,645
155%	**1997**	**133,158**	**85,505**	**20,657**	-	239,321	7,460	**0**	8,239	2,079	89,117	-	106,896	**25,259**	0	**7,895**	**2,262**	**5,655**	**27,146**	**23**	**13,573**	11,319	93,132
181%	**1998**	**141,107**	**77,863**	**29,871**	-	248,841	5,578	**488**	4,596	8,447	75,590	-	94,698	**17,157**	3,528	**6,955**	**1,993**	**4,982**	**23,916**	**20**	**11,958**	11,348	81,857
74%	**1999**	**101,773**	**62,938**	**12,119**	-	176,830	4,971	**2,858**	6,135	3,624	95,504	-	113,092	**25,132**	0	**7,958**	**2,280**	**5,701**	**27,363**	**23**	**13,681**	10,280	92,418
90%	**2000**	**108,835**	**82,526**	**13,181**	-	204,541	4,598	**1,619**	2,184	4,566	99,074	-	112,041	**21,426**	0	**7,397**	**2,119**	**5,299**	**25,433**	**21**	**12,717**	10,299	84,711
59%	**2001**	**73,419**	**31,031**	**7,017**	-	111,467	4,959	**1,674**	1,993	2,680	58,979	-	70,285	**11,377**	0	**6,030**	**1,728**	**4,319**	**20,732**	**17**	**10,366**	10,306	64,875
67%	**2002**	**99,376**	**52,020**	**5,354**	-	156,751	4,104	**1,265**	1,364	2,202	74,196	-	83,131	**13,083**	0	**6,930**	**1,986**	**4,964**	**23,828**	**20**	**11,914**	10,291	73,016
83%	**2003**	**104,545**	**54,735**	**13,325**	-	172,605	4,356	**1,292**	752	3,362	63,511	-	73,273	**8,256**	0	**6,657**	**1,907**	**4,768**	**22,888**	**19**	**11,444**	10,359	66,299
61%	**2004**	**79,743**	**27,306**	**5,667**	-	112,717	2,019	**3,206**	1,650	1,480	58,257	-	66,611	**12,382**	0	**6,383**	**1,829**	**4,572**	**21,946**	**18**	**10,973**	10,072	68,176
148%	**2005**	**131,193**	**54,799**	**24,547**	-	210,539	5,619	**3,451**	2,664	1,946	98,279	-	111,958	**24,480**	0	**7,366**	**2,111**	**5,276**	**25,327**	**21**	**12,663**	11,115	88,360
172%	**2006**	**129,571**	**65,459**	**24,718**	-	219,748	6,065	**2,954**	5,417	2,368	96,857	-	113,661	**34,147**	0	**7,766**	**2,225**	**5,563**	**26,702**	**22**	**13,351**	11,115	100,891
40%	**2007**	**84,144**	**20,918**	**3,312**	-	108,374	4,836	**1,876**	3,810	4,727	70,288	-	85,536	**25,308**	0	**6,090**	**1,745**	**4,363**	**20,940**	**17**	**10,470**	9,975	78,909
72%	**2008**	**81,364**	**29,000**	**6,764**	-	117,128	2,037	**852**	1,470	1,081	59,988	-	65,428	**10,209**	0	**5,292**	**1,516**	**3,791**	**18,195**	**15**	**9,097**	10,016	58,131
79%	**2009**	**85,743**	**30,617**	**5,829**	-	122,189	2,047	**148**	1,811	1,771	49,297	-	55,074	**7,997**	0	**3,982**	**1,141**	**2,852**	**13,691**	**11**	**6,846**	12,178	48,699
121%	**2010**	**113,146**	**42,817**	**16,103**	-	172,066	4,318	**2,545**	3,644	2,900	90,694	-	104,101	**17,655**	0	**4,144**	**1,187**	**2,969**	**14,249**	**12**	**7,125**	42,300	89,641
180%	**2011**	**163,801**	**79,589**	**23,764**	-	267,154	4,979	**1,364**	4,625	4,947	109,605	-	125,519	**43,781**	0	**3,373**	**966**	**2,416**	**11,597**	**10**	**5,799**	34,012	101,953
49%	**2012**	**80,025**	**30,309**	**4,595**	-	114,929	4,203	**1,151**	4,594	2,289	71,207	-	83,443	**22,689**	0	**2,775**	**795**	**1,988**	**9,543**	**8**	**4,771**	51,435	94,006
41%	**2013**	**49,246**	**12,881**	**110**	-	62,236	0	**536**	0	0	43,206	-	43,741	**3,284**	0	**3,591**	**1,029**	**2,572**	**12,346**	**10**	**6,173**	19,602	48,606
32%	**2014**	**27,801**	**8,824**	**0**	-	36,626	0	**158**	0	0	17,905	-	18,062	**567**	0	**2,136**	**612**	**1,530**	**7,345**	**6**	**3,672**	23,852	39,720
21%	**2015**	**12,430**	**-**	**0**	-	12,430	0	**326**	0	0	14,759	-	15,085	**184**	0	**3,271**	**937**	**2,343**	**11,247**	**9**	**5,623**	31,718	55,333
75%	**2016**	**67,310**	**20,567**	**2,986**	-	90,863	0	-	0	0	42,532	-	42,532	**-**	-	-	-	-	-	-	-	34,248	34,248
204%	**2017**	**-**	**-**		-	-	-	-	-	-	-	-	-	**-**	-	-	-	-	-	-	-	-	-
	Annual Averages	93,943	44,985	4,312		143,240	3,669	2,156	4,804	5,315	77,554		93,499	20,737	68	5,535	1,586	3,965	19,033	16	9,516	8,734	69,598

Table D2-3
Historical Kings River Diversions

Tulare Lake Subbasin Hydrologic Model
Kings County, California

	GSA	El Rico												Tri-County										
	Agency																							
Kings River Water Years	Diversion	Empire Weir No. 2 (over #2 weir to river extension, River Water) Modified Total-(Empire Weir No. 2 minus Tri County Kings River Water)	TLBWSD Lateral B, T206 (State Water)-Modified Total-(SWP Total for Lateral B minus Tri County Entitlement)	Lakelands Canal-Total	Tulare Lake Canal	Melga Canal-Diversion of Peoples Canal, El Rico GSA Total	Kern River	Deer Creek-30% of Deer Creek Total	Tule River-El Rico	Kaweah River	Loan Oak/New Deal- Diversion of Last Chance, El RicoGSA Total	Imported Water	El Rico	Poso Creek	TLBWSD Lateral A, T200 (State Water)-Assumed Full Entitlement-25% to Lateral A	TLBWSD Lateral B, T206 (State Water)-Assumed Full Entitlement-75% to Lateral B	Tule River-Tri County	Deer Creek-70% of Deer Creek Total	White River	Kings River-Tri County	Other Water	Imported Water	Tr-County	Annual Totals
		(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)	(AF/Y)
71%	1966	2,404	-	14,225	17,831	71,842	-	-	-	-	21,581	-	127,884	-	-	-	-	-	-	-	-	-	0	413,173
197%	1967	82,883	-	71,671	42,476	91,260	-	-	-	-	33,629	-	321,919	-	-	-	-	-	-	-	-	-	0	695,217
49%	1968	4,673	10,256	17,218	49,218	50,540	-	-	-	-	13,662	-	151,775	-	923	2,768	-	-	-	-	-	-	3,690	429,722
256%	1969	196,219	2,893	40,568	0	71,757	-	-	-	-	26,288	-	339,477	-	260	781	-	-	-	-	-	-	1,041	635,924
78%	1970	0	0	52,483	0	51,149	-	-	-	-	16,617	-	120,248	-	0	0	-	-	-	-	-	-	0	383,648
69%	1971	0	47,329	28,610	490	57,877	-	-	-	-	15,138	-	178,091	-	4,257	12,771	-	-	-	-	-	-	17,028	485,935
50%	1972	1,099	103,195	0	7,305	34,420	-	-	-	-	16,367	-	224,849	-	9,282	27,846	-	-	-	-	-	-	37,128	511,981
125%	1973	530	45,583	19,101	31,948	93,111	-	-	-	-	26,860	-	244,723	-	4,100	12,300	-	-	-	-	-	-	16,400	625,968
122%	1974	14,906	56,123	55,482	28,336	91,604	-	0	-	-	29,337	-	309,845	0	5,157	15,472	1,402	0	0	0	0	-	22,032	765,886
92%	1975	11,905	89,737	41,833	53,125	72,972	-	0	-	-	18,830	-	342,042	0	7,224	21,671	224	0	0	2,642	0	-	31,760	771,261
32%	1976	0	47,863	3,493	45,170	25,219	-	0	-	-	967	-	151,071	0	3,541	10,624	0	0	0	9,154	0	-	23,320	384,320
23%	1977	1,732	21,197	0	4,003	28,929	-	0	-	-	4,090	-	71,762	0	635	1,905	0	0	0	950	0	-	3,490	211,662
201%	1978	33,029	3,073	31,904	49,511	83,846	-	3,000	-	-	30,676	-	237,179	1,500	624	1,873	2,476	7,000	1,000	11,956	0	-	26,430	644,222
101%	1979	2,523	97,690	34,336	32,856	83,787	-	0	-	-	27,627	-	334,337	0	4,271	12,814	185	0	0	6,575	0	-	23,846	810,750
178%	1980	41,353	34,131	37,277	29,258	67,592	-	1,800	-	-	27,585	-	259,729	900	3,163	9,488	2,611	4,200	600	2,819	0	-	23,780	711,136
61%	1981	8,761	140,237	9,180	19,710	59,394	-	0	742	78,485	20,349	-	415,677	0	5,033	15,099	223	0	0	8,983	0	-	29,338	809,178
181%	1982	45,602	36,788	54,659	77,268	84,800	-	5,660	63,476	171,808	28,034	-	589,793	2,830	2,598	7,793	3,090	13,207	1,887	12,547	0	-	43,951	1,056,876
261%	1983	238,616	522	21,919	1,333	40,663	-	12,150	193,800	114,301	20,577	-	644,159	6,075	0	0	340	28,350	4,050	0	0	-	38,815	943,484
115%	1984	17,704	1,917	42,516	0	65,220	-	19,804	17,566	120,846	22,992	-	309,830	9,902	303	909	0	46,210	6,601	0	0	-	63,925	701,875
73%	1985	16,118	84,042	20,108	29,821	70,241	-	0	367	73,859	16,964	-	361,048	0	5,881	17,644	826	0	0	1,586	0	-	25,937	746,756
190%	1986	28,395	41,528	50,896	51,205	74,641	-	5,144	43,384	71,918	26,767	-	417,043	2,572	1,269	3,806	1,701	12,004	1,715	11,054	0	-	34,121	820,207
45%	1987	18,250	60,441	27,104	57,023	46,938	-	0	0	44,445	10,625	-	299,874	0	3,517	10,550	0	0	0	9,366	0	-	23,432	604,366
48%	1988	8,209	40,544	18,863	17,816	40,208	-	0	0	25,873	9,362	-	184,264	0	2,207	6,622	0	0	0	984	0	-	9,814	431,730
53%	1989	0	75,859	7,458	0	40,386	-	0	0	24,550	8,544	-	200,939	0	4,605	13,814	150	0	0	0	1,580	-	20,149	425,623
40%	1990	0	37,168	15,114	0	35,528	-	0	0	39,853	4,247	-	153,181	0	1,810	5,430	0	0	0	0	4,556	-	11,796	319,638
63%	1991	344	2,855	6,143	2,870	30,436	-	0	0	28,897	7,981	-	81,060	0	16	49	604	0	0	1,604	0	-	2,274	209,115
41%	1992	0	35,181	0	0	32,930	-	279	0	23,442	4,012	-	115,532	140	1,156	3,469	0	652	93	0	0	-	5,510	244,987
149%	1993	25,174	58,745	66,990	44,555	68,050	-	101	0	108,379	22,928	-	426,703	50	565	1,694	1,155	235	34	6,919	2,575	-	13,226	810,344
50%	1994	15,625	28,204	0	49,718	38,072	-	0	0	28,376	-	-	175,829	0	990	2,970	0	0	0	6,098	0	-	10,058	443,205
202%	1995	51,722	59,720	52,969	48,240	75,670	-	2,285	13,777	149,232	-	-	487,891	1,142	3,032	9,095	6,040	5,331	762	4,902	0	-	30,303	947,854
122%	1996	33,027	107,966	61,767	36,006	81,522	-	1,847	236	139,238	-	-	521,635	924	3,055	9,165	1,913	4,311	616	2,219	0	-	22,202	1,036,790
155%	1997	19,089	2,107	32,557	25,047	65,232	-	9,220	40,122	66,638	-	-	265,690	4,610	1,895	5,684	1,701	21,513	3,073	4,729	0	-	43,206	748,244
181%	1998	4,514	17,487	32,918	16,707	75,570	-	5,590	26,731	58,340	-	-	243,601	2,795	1,057	3,171	2,083	13,042	1,863	50	0	-	24,061	693,058
74%	1999	4,359	140,451	8,184	13,492	49,810	-	0	2,235	51,184	-	-	329,217	0	95	286	274	0	0	167	0	-	822	712,379
90%	2000	16,796	86,346	35,062	33,304	56,416	-	871	2,900	48,050	-	-	319,674	435	3,935	11,804	1,166	2,032	290	0	0	-	19,663	740,630
59%	2001	21,146	39,067	2,122	38,045	38,433	-	0	8	20,131	-	-	180,610	0	1,027	3,082	0	0	0	3,044	3,000	-	10,154	437,390
67%	2002	14,150	33,324	46,842	7,942	45,043	-	0	490	73,770	-	-	242,267	0	2,004	6,011	124	0	0	0	190	-	8,329	563,493
83%	2003	13,153	44,894	36,750	45,168	48,228	-	0	1,748	49,413	-	-	254,241	0	2,152	6,455	790	0	0	6,652	160	-	16,209	582,626
61%	2004	17,145	42,460	40,917	16,768	40,719	-	0	1,106	59,030	-	-	241,003	0	265	795	559	0	0	0	5,293	-	6,912	495,419
148%	2005	73,872	75,546	42,290	64,243	67,430	-	1,767	2,372	86,750	-	-	442,024	884	116	347	1,680	4,123	589	10,632	1,235	-	19,605	872,486
172%	2006	70,800	52,463	80,614	74,920	69,623	-	2,392	17,135	171,601	-	-	561,992	1,196	126	378	795	5,581	797	14,253	0	-	23,126	1,019,418
40%	2007	21,586	39,927	17,889	31,676	46,218	-	0	153	39,474	-	-	217,420	0	50	149	0	0	0	18,083	63	-	18,345	508,584
72%	2008	9,553	11,833	8,051	5,282	41,851	-	0	158	37,662	-	-	123,545	0	156	468	828	0	0	4,756	0	-	6,208	370,440
79%	2009	855	13,750	22,036	99	43,482	-	0	1,383	62,389	-	-	152,859	0	7	21	0	0	0	0	0	-	28	378,849
121%	2010	34,789	32,026	38,210	37,297	55,771	-	0	5,059	102,754	-	-	315,091	0	2	7	1,676	0	0	10,587	282	-	12,555	693,453
180%	2011	89,121	25,964	88,052	78,409	83,250	-	0	11,316	140,553	-	-	530,567	0	68	205	-	0	0	0	-	-	273	1,025,466
49%	2012	24,964	43,921	3,483	15,977	39,616	-	0	200	60,683	-	-	205,755	0	57	170	-	0	0	0	-	-	227	498,360
41%	2013	0	13,062	58,140	0	27,281	-	-	-	-	-	-	109,253	0	58	174	-	0	0	0	-	-	232	264,069
32%	2014	0	3,681	41,472	0	12,461	-	-	-	-	-	-	59,473	0	38	115	-	0	0	0	-	-	154	154,035
21%	2015	0	0	21,076	0	2,493	-	-	-	-	-	-	24,175	0	45	0	-	0	0	0	-	-	45	107,068
75%	2016	0	-	32,114	0	27,677	-	-	-	-	-	-	59,791	0			-	0	0	0	-	-	0	227,433
204%	2017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Annual Averages	26,210	40,175	31,229	26,107	54,847	0	1,383	8,586	45,614	10,052		268,189	705	1,816	5,446	666	3,227	470	3,333	364		16,175	590,701

Table D2-3
Historical Kings River Diversions

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Notes:
1. Values highlighted have been modified.
2. Values with "0" indicate no surface water delivery to the best of our knowledge.
3. Values with "-" have no verified data.
4. Total flow from Peoples Canal is split 60% to Mid-Kings, 40% to Melga.
5. Last Chance Diversion is split 50% between Mid-Kings and El Rico.
6. Blakeley has added State Water from Lateral A for Southwest.
7. Total flow from Deer Creek split 30% to El Rico, 70% to Tri-County.
8. Tule River for El Rico includes the total of Elk Bayou and TID Spill.
9. SWP from TLBWSD Split Through out Tri-County and Southwest Kings.
10. Kings River water in Tri-County was subtracted from the total in Empire Weir No. 2. 1976 and 2010 are 0 for Empire Weir No. 2 because of negative values.
11. Lakeside is a portion of Kaweah River, Reduced Total Kaweah River between Mid-Kings and El Rico.
12. Additional Tule River flow data added for Tri-County.
13. Empire Westside Irrigation District total from SWP reduce annual totals by 10%.
14. Dudley Ridge Water District reduce annual totals by 10%.
15. Lateral A (T200) & Lateral B (T206) reduce annual totals by 18% for El Rico & Tri-County.
16. Modifications to Peoples Canal and Last Chance as a result of discussions with Mid-Kings River GSA on 2/14/19.

Key
Wet Year
Dry Year
Average Precipitation
GSA Annual Totals
Kings River Watershed Total

Average Annual
690,714
494,326
649,938

Reduction in Entitlement	
Empire West Side ID Total from SWP	10%
Dudley Ridge State Turnouts	10%
Lateral A & B for El Rico & Tri County	18%

Table D2-4
Annual Specified Well Field Pumping[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Date	El Rico GSA Well Field (AF/Y)	Creighton Ranch Well Field (AF/Y)	Corcoran ID Well Field (AF/Y)	Angiola Well Field (AF/Y)	Westlands Well Field (AF/Y)	Municipal Well Fields (AF/Y)	Apex Ranch Well Field (AF/Y)
1990	70,716	27,222	87,977	34,500	67,131	9,370	--
1991	57,509	38,484	84,438	23,396	98,656	9,109	--
1992	80,012	27,255	72,348	33,494	98,344	9,666	--
1993	11,395	4,035	14,248	5,956	44,056	10,208	--
1994	48,043	17,986	78,297	16,389	72,674	10,928	--
1995	2,897	905	7,145	-	27,589	10,775	--
1996	-	-	20,261	-	28,516	12,719	--
1997	-	-	15,586	-	27,000	12,775	--
1998	-	-	2,484	-	20,988	11,555	--
1999	-	-	33,406	-	37,185	13,087	--
2000	14,910	2,849	40,672	6,784	43,392	13,421	--
2001	89,799	41,120	64,353	23,244	65,947	13,895	--
2002	68,933	35,843	64,736	26,537	66,530	26,701	--
2003	32,420	10,856	62,246	22,429	40,841	19,349	526
2004	82,875	47,511	74,007	26,805	42,115	18,777	912
2005	-	468	20,138	662	14,744	16,536	--
2006	-	72	14,034	141	16,526	15,822	6,939
2007	69,863	40,266	85,434	32,894	40,373	17,221	6,319
2008	92,269	52,980	79,362	32,502	63,519	18,432	5,435
2009	78,097	45,292	81,493	37,798	69,904	16,354	7,677
2010	36,129	17,740	29,669	22,568	34,895	15,271	6,345
2011	606	314	7,328	11,336	15,509	17,042	--
2012	95,154	52,325	70,008	19,388	55,298	17,467	9,044
2013	100,275	66,005	78,175	30,528	70,940	18,411	4,970
2014	108,976	68,726	69,880	27,695	94,077	16,930	298
2015	116,254	61,050	67,982	30,220	90,723	16,146	--
2016	126,886	53,113	67,982	29,047	93,853	14,555	--
1990-2016 Average	**51,260**	**26,386**	**51,618**	**18,308**	**53,382**	**14,908**	**4,847**
1998-2010 Average	**43,484**	**22,692**	**50,156**	**17,874**	**42,843**	**16,648**	**4,879**
Well Count	**99**	**52**	**98**	**51**	**150**	**30**	**5**

1. GSA = Groundwater Sustainability Agency, ID = Irrigation District, and AF/Y = acre-feet per year.

Table D2-5

Reference Crop Evapotranspiration Values[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Crop Evapotranspiration	**January (inches)**	**February (inches)**	**March (inches)**	**April (inches)**	**May (inches)**	**June (inches)**	**July (inches)**	**August (inches)**	**September (inches)**	**October (inches)**	**November (inches)**	**December (inches)**
Reference ETo	0.82	2.22	4.5	6.73	8.52	8.23	8.34	7.62	5.8	4.2	1.28	0.84
Fallow Land	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Almonds	0.83	0.85	2.71	3.91	6.75	6.39	6.58	6.08	3.92	2.25	0.75	0.83
Pistachio	0.83	0.66	1.92	1.13	2.77	5.91	8.17	7.65	5.26	2.99	0.81	0.83
Grain and Grain Hay	0.89	2.09	4.67	6.86	3.84	0.14	0.20	0.09	0.08	0.38	0.84	0.89
Cotton	0.88	0.64	1.88	0.75	1.62	4.68	8.17	7.70	5.35	1.52	0.78	0.87
Corn and Grain Sorghum	0.88	0.64	2.89	1.16	2.83	7.00	8.06	5.12	0.38	0.38	0.78	0.87
Misc. field crops	0.88	0.64	2.89	1.16	2.77	7.32	7.56	3.03	0.08	0.38	0.78	0.87
Alfalfa Hay and Clover	0.88	2.12	4.31	5.78	7.25	7.02	7.01	6.34	4.80	2.01	1.33	0.91
Pasture and Misc. Grasses	0.89	1.64	3.37	5.17	7.83	7.64	7.74	7.00	5.32	3.25	1.18	0.87
Small Vegetables	0.88	1.29	4.07	1.25	0.02	0.11	0.18	1.08	1.54	1.84	1.61	0.90
Potatoes, Sugar beets, Turnip etc.	0.88	0.92	3.13	6.72	8.84	8.58	7.58	0.18	0.08	0.37	0.77	0.86
Onions and Garlic	0.88	1.88	4.10	5.48	4.80	0.56	0.18	0.08	0.08	0.37	1.34	0.88
Citrus (no ground cover)	0.83	1.98	3.96	4.69	5.54	5.76	5.72	5.24	3.91	3.14	1.47	0.86
Tomatoes and Peppers	0.88	0.63	2.57	0.70	4.39	8.12	7.42	0.78	0.08	0.37	0.77	0.86
Wine Grapes with 80% canopy	0.84	0.66	2.17	1.42	4.18	6.06	6.00	4.82	2.74	0.40	0.75	0.84
Dairy Single Crop	1.03	1.94	3.48	4.67	4.50	6.71	7.72	6.32	3.91	2.27	1.24	1.14
Carrot Single Crop	1.02	1.60	3.14	5.95	4.79	5.75	6.16	4.36	3.70	2.85	1.77	1.19
Carrot Double Cropping	0.54	1.40	2.93	4.41	5.84	3.59	2.71	3.53	3.12	2.60	1.41	1.12
Dairy Double Cropping	0.59	1.59	3.26	4.65	3.57	5.27	7.87	6.81	3.71	0.77	0.59	0.67
Urban, Commercial	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban, Industrial	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Riparian	0.00	0.01	3.49	6.13	8.33	8.23	8.34	7.62	5.74	3.91	1.02	0.10
Open Water	0.82	2.22	4.50	6.73	8.52	8.23	8.34	7.62	5.80	4.20	1.58	0.84
Average All Crops	0.85	1.29	3.19	3.66	4.56	5.37	5.84	4.23	2.67	1.56	1.05	0.90

Table D2-5

Reference Crop Evapotranspiration Values[1]

Crop Evapotranspiration	January (ft/d)	February (ft/d)	March (ft/d)	April (ft/d)	May (ft/d)	June (ft/d)	July (ft/d)	August (ft/d)	September (ft/d)	October (ft/d)	November (ft/d)	December (ft/d)
Reference ETo	0.00220	0.00661	0.01210	0.01869	0.02290	0.02286	0.02242	0.02048	0.01611	0.01129	0.00356	0.00226
Fallow Land	0	0	0	0	0	0	0	0	0	0	0	0
Almonds	0.00223	0.00253	0.00728	0.01086	0.01815	0.01775	0.01769	0.01634	0.01089	0.00605	0.00208	0.00223
Pistachio	0.00223	0.00196	0.00516	0.00314	0.00745	0.01642	0.02196	0.02056	0.01461	0.00804	0.00225	0.00223
Grain and Grain Hay	0.00239	0.00622	0.01255	0.01906	0.01032	0.00039	0.00054	0.00024	0.00022	0.00102	0.00233	0.00239
Cotton	0.00237	0.00190	0.00505	0.00208	0.00435	0.01300	0.02196	0.02070	0.01486	0.00409	0.00217	0.00234
Corn and Grain Sorghum	0.00237	0.00190	0.00777	0.00322	0.00761	0.01944	0.02167	0.01376	0.00106	0.00102	0.00217	0.00234
Misc. field crops	0.00237	0.00190	0.00777	0.00322	0.00745	0.02033	0.02032	0.00815	0.00022	0.00102	0.00217	0.00234
Alfalfa Hay and Clover	0.00237	0.00631	0.01159	0.01606	0.01949	0.01950	0.01884	0.01704	0.01333	0.00540	0.00369	0.00245
Pasture and Misc. Grasses	0.00239	0.00488	0.00906	0.01436	0.02105	0.02122	0.02081	0.01882	0.01478	0.00874	0.00328	0.00234
Small Vegetables	0.00237	0.00384	0.01094	0.00347	0.00005	0.00031	0.00048	0.00290	0.00428	0.00495	0.00447	0.00242
Potatoes, Sugar beets, Turnip etc.	0.00237	0.00274	0.00841	0.01867	0.02376	0.02383	0.02038	0.00048	0.00022	0.00099	0.00214	0.00231
Onions and Garlic	0.00237	0.00560	0.01102	0.01522	0.01290	0.00156	0.00048	0.00022	0.00022	0.00099	0.00372	0.00237
Citrus (no ground cover)	0.00223	0.00589	0.01065	0.01303	0.01489	0.01600	0.01538	0.01409	0.01086	0.00844	0.00408	0.00231
Tomatoes and Peppers	0.00237	0.00188	0.00691	0.00194	0.01180	0.02256	0.01995	0.00210	0.00022	0.00099	0.00214	0.00231
Wine Grapes with 80% canopy	0.00226	0.00196	0.00583	0.00394	0.01124	0.01683	0.01613	0.01296	0.00761	0.00108	0.00208	0.00226
Dairy Single Crop	0.00276	0.00578	0.00936	0.01296	0.01211	0.01863	0.02076	0.01698	0.01085	0.00611	0.00344	0.00305
Carrot Single Crop	0.00274	0.00476	0.00844	0.01652	0.01288	0.01598	0.01657	0.01173	0.01027	0.00765	0.00490	0.00320
Carrot Double Cropping	0.00144	0.00416	0.00788	0.01226	0.01570	0.00998	0.00729	0.00950	0.00867	0.00700	0.00393	0.00301
Dairy Double Cropping	0.00158	0.00474	0.00877	0.01291	0.00958	0.01463	0.02115	0.01831	0.01029	0.00207	0.00165	0.00180
Urban, Commercial	0	0	0	0	0	0	0	0	0	0	0	0
Urban, Industrial	0	0	0	0	0	0	0	0	0	0	0	0
Riparian	0.00000	0.00004	0.00938	0.01703	0.02240	0.02286	0.02242	0.02048	0.01595	0.01052	0.00284	0.00026
Open Water	0.00220	0.00661	0.01210	0.01869	0.02290	0.02286	0.02242	0.02048	0.01611	0.01129	0.00439	0.00226
Average All Crops	0.00229	0.00383	0.00858	0.01016	0.01227	0.01491	0.01569	0.01138	0.00742	0.00420	0.00293	0.00243

1. Grass reference ETo based on typical year, CIMIS Zone 16 monthly evapotranspiration. Irrigation Training and Research Center, California Polytechnic State University, San Luis Obispo.
   ft/d = feet per day.

Table D2-6
Historical Evapotranspiration Demand

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Tulare Lake Subbasin[1]	1990-1995 (AF/Y)	1996-1998 (AF/Y)	1999-2006 (AF/Y)	2007 (AF/Y)	2008 (AF/Y)	2009 (AF/Y)	2010 (AF/Y)	2011 (AF/Y)	2012 (AF/Y)	2013 (AF/Y)	2014 (AF/Y)	2015 (AF/Y)	2016 (AF/Y)	Average (AF/Y)
Alfalfa Hay and Clover	172,519	135,032	225,167	300,041	333,752	296,086	288,555	160,621	174,457	204,219	148,325	122,839	100,395	**190,580**
Almonds (Adolescent)			8,113			11,218	19,864	8,127	10,631	18,529	16,937	15,155	13,714	**6,332**
Almonds (Mature)	26,791	18,278	15,869	47,030	43,122	35,832	30,537	36,976	39,450	41,720	46,956	54,869	55,084	**28,083**
Almonds (Young)		2,287	6,480	12,062	26,125	15,445	17,964	13,431	14,580	18,458	17,621	15,779	20,206	**8,292**
Berries	47								2	6		1		**11**
Carrot Single Crop								37	16	41	7	6	56	**6**
Citrus (no ground cover)			91		42	46	14	405	99	335	300	74	32	**74**
Corn and Grain Sorghum	36,877	100,450	75,793	101,418	82,027	89,467	59,478	87,236	75,344	71,190	58,462	48,619	44,935	**65,605**
Cotton	463,179	525,386	362,232	320,870	258,511	212,071	287,383	308,970	260,527	261,476	185,559	130,368	215,815	**345,645**
Dairy Single Crop*	14,290	15,268	16,421											**9,129**
Fallow Land*														**-**
Forest*														**-**
Grain and Grain Hay	50,167	84,811	110,025	33,572	48,563	47,755	45,271	13,518	17,369	19,505	21,282	36,934	33,228	**60,837**
Melons	413	92	468				21	3	16	10	1,182	27	128	**275**
Misc. field crops	40,450	30,296	121,265		5			1			4			**43,795**
Onions and Garlic	807	846	1,359			12	2,417	731	538	167	893	266	1,146	**854**
Open Water*														**-**
Pasture and Misc. Grasses	10,799	21,726	24,256	218,974	191,082	289,198	229,306	63,417	57,751	66,333	144,942	68,014	59,370	**62,524**
Pistachio (Adolescent)								213	315	559	1,290	4,713	5,704	**474**
Pistachio (Mature)	15,229	12,354	12,341	17,831	5,680	2,825	1,236	1,283	1,237	1,135	1,075	1,412	1,374	**9,256**
Pistachio (Young)		394	2,265	1,091	1,370	2,454	2,395	3,729	5,770	7,498	8,281	8,231	9,024	**2,477**
Pomegranates (Adolescent)											5	23	41	**3**
Pomegranates (Young)				11	303	99	52	901	210	376	537	567	746	**141**
Potatoes, Sugar beets, Turnip etc.	18,604	4	676	19		10		29		127		7	7	**4,317**
Riparian*														**-**
Small Vegetables	2,835	1,147	8,009	33	3	20	340	227	212	390	264	126	317	**2,905**
Stone Fruit (Adolescent)			4,238			28	138	232	291	171	106	414	425	**1,166**
Stone Fruit (Mature)	25,350	17,875	13,818	4,560	1,886	584	64	11	80	141	79	95	136	**11,485**
Stone Fruit (Young)		1,310	3,001	466	1,234	1,217	1,879	1,010	547	1,250	1,186	913	667	**1,308**
Tomatoes and Peppers	12,971	3,747	33,791	261	5	246	26	47,851	52,725	15,847	26,555	42,793	52,168	**20,892**
Urban, Industrial*														**-**
Wine Grapes with 80% canopy	7,586	8,301	14,872	14,203	8,893	5,692	6,980	13,625	23,455	11,832	16,450	11,874	27,920	**11,683**
Winter Wheat*														**-**
Tulare Lake Subbasin Irrigated ET Demand	**884,626**	**964,336**	**1,044,130**	**1,072,442**	**1,002,603**	**1,010,305**	**993,918**	**762,584**	**735,624**	**741,315**	**698,299**	**564,117**	**642,636**	**879,019**
Tulare Lake Subbasin GSA Total ET Demand	**898,916**	**979,604**	**1,060,551**	**1,072,442**	**1,002,603**	**1,010,305**	**993,918**	**762,584**	**735,624**	**741,315**	**698,299**	**564,117**	**642,636**	**888,148**

1. Fields with an Asterisk (*) are not Irrigated; Annual Total is by Calendar Year. AF/Y = acre-feet per year, GSA = Groundwater Sustainability Agency, and ET = evapotranspiration.

Table D2-7

Historical Farm Demand[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Date	Other SB (AF/Y)	TLSB (AF/Y)	Westside (AF/Y)	Kings (AF/Y)	Kaweah (AF/Y)	Tule (AF/Y)	Kern (AF/Y)	Mid-Kings (AF/Y)	El Rico (AF/Y)	South Fork (AF/Y)	Southwest (AF/Y)	TCWA (AF/Y)
Jan-90	1,728,732	1,065,856	379,829	425,121	552,538	256,615	114,629	325,993	417,055	166,690	114,789	41,329
Jan-91	1,614,099	994,832	358,828	401,725	514,334	233,176	106,035	306,828	388,094	155,314	107,036	37,561
Jan-92	1,628,359	1,012,909	343,450	406,535	528,115	241,481	108,779	313,628	395,489	156,526	108,443	38,824
Jan-93	1,625,686	1,008,709	347,335	404,875	524,762	240,425	108,288	310,417	394,078	156,684	108,853	38,677
Jan-94	1,667,754	1,047,937	339,746	419,143	544,830	251,521	112,514	321,367	409,642	163,677	112,809	40,442
Jan-95	1,518,505	973,503	292,869	389,226	502,007	229,979	104,424	298,503	382,014	151,236	104,578	37,172
Jan-96	1,576,024	1,067,962	313,585	344,546	482,623	304,804	130,465	274,763	432,798	171,197	134,163	55,041
Jan-97	1,680,694	1,123,726	337,872	377,306	511,503	317,630	136,383	296,047	449,362	180,958	139,428	57,931
Jan-98	1,549,840	1,059,009	286,711	361,492	480,381	294,124	127,132	282,666	424,886	167,423	132,138	51,896
Jan-99	1,691,385	1,232,448	339,665	407,814	535,160	327,150	81,596	286,433	535,576	191,560	148,842	70,039
Jan-00	1,445,415	1,127,412	284,814	349,602	457,426	279,949	73,623	251,153	506,236	164,195	141,354	64,475
Jan-01	1,448,592	1,111,506	309,426	344,390	447,420	273,032	74,325	252,107	492,321	161,311	143,460	62,308
Jan-02	1,541,594	1,201,455	318,210	370,000	480,162	290,750	82,471	275,691	524,619	174,107	159,485	67,554
Jan-03	1,555,120	1,198,411	341,139	366,586	474,349	288,517	84,529	276,879	519,352	171,951	163,815	66,414
Jan-04	1,505,353	1,162,011	319,587	357,269	463,075	281,525	83,897	267,176	504,557	165,885	160,028	64,366
Jan-05	1,470,433	1,155,548	293,659	353,639	461,355	278,436	83,344	266,036	503,020	165,545	157,409	63,538
Jan-06	1,423,773	1,129,741	281,543	345,256	445,626	268,596	82,751	260,555	488,753	162,180	156,955	61,299
Jan-07	1,645,495	1,183,096	324,200	294,958	447,694	338,016	240,627	248,586	542,967	168,715	157,357	65,471
Jan-08	1,618,955	1,083,093	307,929	286,930	474,164	335,571	214,361	252,038	499,213	157,222	99,089	75,531
Jan-09	1,579,778	1,091,697	349,701	288,327	381,416	286,941	273,394	222,909	473,147	141,969	186,010	67,662
Jan-10	1,563,995	1,016,725	297,419	297,831	370,133	326,713	271,898	197,569	442,224	138,271	178,015	60,646
Jan-11	1,145,135	791,090	287,744	234,224	382,183	166,368	74,617	190,992	384,027	114,892	65,595	35,584
Jan-12	1,254,900	776,133	330,525	245,767	397,981	200,454	80,173	191,423	373,845	122,949	65,986	21,930
Jan-13	1,322,113	826,405	371,025	237,221	406,748	194,551	112,569	199,812	420,487	105,696	73,137	27,273
Jan-14	1,422,271	757,265	413,917	266,385	385,588	218,818	137,564	199,827	289,182	112,733	97,591	57,932
Jan-15	1,335,608	624,647	428,797	253,146	362,160	194,523	96,982	196,099	250,843	101,691	46,314	29,700
Jan-16	1,285,028	677,936	417,581	260,622	348,283	168,493	90,048	188,850	320,298	97,905	47,386	23,497
1990-2016 Average	**1,512,764**	**1,018,558**	**333,967**	**336,664**	**457,853**	**262,524**	**121,756**	**257,568**	**435,707**	**151,425**	**122,595**	**51,263**
1998-2010 Average	**1,541,517**	**1,134,781**	**311,846**	**340,315**	**455,259**	**297,640**	**136,457**	**256,907**	**496,682**	**163,872**	**152,612**	**64,707**

1. SB = subbasin, TLSB = Tulare Lake Subbasin, TCWA = Tri-County Water Agency, AF/Y = acre-feet per year.

Table D4-1
Tulare Lake Subbasin Hydrologic Model Stress Periods

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Date	Stress Period	Days
Jan-90	1	31
Feb-90	2	28
Mar-90	3	31
Apr-90	4	30
May-90	5	31
Jun-90	6	30
Jul-90	7	31
Aug-90	8	31
Sep-90	9	30
Oct-90	10	31
Nov-90	11	30
Dec-90	12	31
Jan-91	13	31
Feb-91	14	28
Mar-91	15	31
Apr-91	16	30
May-91	17	31
Jun-91	18	30
Jul-91	19	31
Aug-91	20	31
Sep-91	21	30
Oct-91	22	31
Nov-91	23	30
Dec-91	24	31
Jan-92	25	31
Feb-92	26	29
Mar-92	27	31
Apr-92	28	30
May-92	29	31
Jun-92	30	30
Jul-92	31	31
Aug-92	32	31
Sep-92	33	30
Oct-92	34	31
Nov-92	35	30
Dec-92	36	31
Jan-93	37	31
Feb-93	38	28
Mar-93	39	31
Apr-93	40	30
May-93	41	31
Jun-93	42	30
Jul-93	43	31
Aug-93	44	31
Sep-93	45	30
Oct-93	46	31
Nov-93	47	30
Dec-93	48	31
Jan-94	49	31
Feb-94	50	28
Mar-94	51	31
Apr-94	52	30
May-94	53	31
Jun-94	54	30
Jul-94	55	31
Aug-94	56	31
Sep-94	57	30
Oct-94	58	31
Nov-94	59	30
Dec-94	60	31
Jan-95	61	31
Feb-95	62	28
Mar-95	63	31
Apr-95	64	30
May-95	65	31
Jun-95	66	30
Jul-95	67	31
Aug-95	68	31
Sep-95	69	30
Oct-95	70	31
Nov-95	71	30
Dec-95	72	31
Jan-96	73	31
Feb-96	74	29
Mar-96	75	31
Apr-96	76	30

Table D4-1

Tulare Lake Subbasin Hydrologic Model Stress Periods

Date	Stress Period	Days	Date	Stress Period	Days
May-96	77	31	Oct-99	118	31
Jun-96	78	30	Nov-99	119	30
Jul-96	79	31	Dec-99	120	31
Aug-96	80	31	Jan-00	121	31
Sep-96	81	30	Feb-00	122	29
Oct-96	82	31	Mar-00	123	31
Nov-96	83	30	Apr-00	124	30
Dec-96	84	31	May-00	125	31
Jan-97	85	31	Jun-00	126	30
Feb-97	86	28	Jul-00	127	31
Mar-97	87	31	Aug-00	128	31
Apr-97	88	30	Sep-00	129	30
May-97	89	31	Oct-00	130	31
Jun-97	90	30	Nov-00	131	30
Jul-97	91	31	Dec-00	132	31
Aug-97	92	31	Jan-01	133	31
Sep-97	93	30	Feb-01	134	28
Oct-97	94	31	Mar-01	135	31
Nov-97	95	30	Apr-01	136	30
Dec-97	96	31	May-01	137	31
Jan-98	97	31	Jun-01	138	30
Feb-98	98	28	Jul-01	139	31
Mar-98	99	31	Aug-01	140	31
Apr-98	100	30	Sep-01	141	30
May-98	101	31	Oct-01	142	31
Jun-98	102	30	Nov-01	143	30
Jul-98	103	31	Dec-01	144	31
Aug-98	104	31	Jan-02	145	31
Sep-98	105	30	Feb-02	146	28
Oct-98	106	31	Mar-02	147	31
Nov-98	107	30	Apr-02	148	30
Dec-98	108	31	May-02	149	31
Jan-99	109	31	Jun-02	150	30
Feb-99	110	28	Jul-02	151	31
Mar-99	111	31	Aug-02	152	31
Apr-99	112	30	Sep-02	153	30
May-99	113	31	Oct-02	154	31
Jun-99	114	30	Nov-02	155	30
Jul-99	115	31	Dec-02	156	31
Aug-99	116	31	Jan-03	157	31
Sep-99	117	30	Feb-03	158	28

Table D4-1
Tulare Lake Subbasin Hydrologic Model Stress Periods

Date	Stress Period	Days	Date	Stress Period	Days
Mar-03	159	31	Aug-06	200	31
Apr-03	160	30	Sep-06	201	30
May-03	161	31	Oct-06	202	31
Jun-03	162	30	Nov-06	203	30
Jul-03	163	31	Dec-06	204	31
Aug-03	164	31	Jan-07	205	31
Sep-03	165	30	Feb-07	206	28
Oct-03	166	31	Mar-07	207	31
Nov-03	167	30	Apr-07	208	30
Dec-03	168	31	May-07	209	31
Jan-04	169	31	Jun-07	210	30
Feb-04	170	29	Jul-07	211	31
Mar-04	171	31	Aug-07	212	31
Apr-04	172	30	Sep-07	213	30
May-04	173	31	Oct-07	214	31
Jun-04	174	30	Nov-07	215	30
Jul-04	175	31	Dec-07	216	31
Aug-04	176	31	Jan-08	217	31
Sep-04	177	30	Feb-08	218	29
Oct-04	178	31	Mar-08	219	31
Nov-04	179	30	Apr-08	220	30
Dec-04	180	31	May-08	221	31
Jan-05	181	31	Jun-08	222	30
Feb-05	182	28	Jul-08	223	31
Mar-05	183	31	Aug-08	224	31
Apr-05	184	30	Sep-08	225	30
May-05	185	31	Oct-08	226	31
Jun-05	186	30	Nov-08	227	30
Jul-05	187	31	Dec-08	228	31
Aug-05	188	31	Jan-09	229	31
Sep-05	189	30	Feb-09	230	28
Oct-05	190	31	Mar-09	231	31
Nov-05	191	30	Apr-09	232	30
Dec-05	192	31	May-09	233	31
Jan-06	193	31	Jun-09	234	30
Feb-06	194	28	Jul-09	235	31
Mar-06	195	31	Aug-09	236	31
Apr-06	196	30	Sep-09	237	30
May-06	197	31	Oct-09	238	31
Jun-06	198	30	Nov-09	239	30
Jul-06	199	31	Dec-09	240	31

Table D4-1
Tulare Lake Subbasin Hydrologic Model Stress Periods

Date	Stress Period	Days	Date	Stress Period	Days
Jan-10	241	31	Jul-13	283	31
Feb-10	242	28	Aug-13	284	31
Mar-10	243	31	Sep-13	285	30
Apr-10	244	30	Oct-13	286	31
May-10	245	31	Nov-13	287	30
Jun-10	246	30	Dec-13	288	31
Jul-10	247	31	Jan-14	289	31
Aug-10	248	31	Feb-14	290	28
Sep-10	249	30	Mar-14	291	31
Oct-10	250	31	Apr-14	292	30
Nov-10	251	30	May-14	293	31
Dec-10	252	31	Jun-14	294	30
Jan-11	253	31	Jul-14	295	31
Feb-11	254	28	Aug-14	296	31
Mar-11	255	31	Sep-14	297	30
Apr-11	256	30	Oct-14	298	31
May-11	257	31	Nov-14	299	30
Jun-11	258	30	Dec-14	300	31
Jul-11	259	31	Jan-15	301	31
Aug-11	260	31	Feb-15	302	28
Sep-11	261	30	Mar-15	303	31
Oct-11	262	31	Apr-15	304	30
Nov-11	263	30	May-15	305	31
Dec-11	264	31	Jun-15	306	30
Jan-12	265	31	Jul-15	307	31
Feb-12	266	29	Aug-15	308	31
Mar-12	267	31	Sep-15	309	30
Apr-12	268	30	Oct-15	310	31
May-12	269	31	Nov-15	311	30
Jun-12	270	30	Dec-15	312	31
Jul-12	271	31	Jan-16	313	31
Aug-12	272	31	Feb-16	314	29
Sep-12	273	30	Mar-16	315	31
Oct-12	274	31	Apr-16	316	30
Nov-12	275	30	May-16	317	31
Dec-12	276	31	Jun-16	318	30
Jan-13	277	31	Jul-16	319	31
Feb-13	278	28	Aug-16	320	31
Mar-13	279	31	Sep-16	321	30
Apr-13	280	30	Oct-16	322	61
May-13	281	31	Nov-16	323	30
Jun-13	282	30	Dec-16	324	31

Table D5-1
Tulare Lake Subbasin Historical and Current Water Balance[1]

Tulare Lake Subbasin Hydrologic Model
Kings County, California

Land Surface Water Budget													
			Inflows						Outflows				Net
Year	Kings River Flows	Year Type	Effective Precipitation (AF)	Applied Surface Water (AF)	Applied Pond Water (AF)	Imported Groundwater (AF)	Applied Groundwater (AF)	Total Inflows (AF)	Drain Outflow (AF)	Farm Demand Evapotranspiration (AF)	Deep Percolation (AF)	Total Outflows (AF)	Inflow-Outflow (AF)
1990	40%	D	19,958	319,870	10,310	48,885	609,474	1,008,496	0	1,065,856	132,933	1,198,789	-190,293
1991	63%	D	78,722	209,568	3,793	52,225	568,130	912,439	0	994,832	125,674	1,120,507	-208,068
1992	41%	D	64,818	245,345	8,619	46,926	587,328	953,036	0	1,012,909	126,365	1,139,274	-186,238
1993	149%	W	67,191	811,312	31,153	7,533	238,616	1,155,805	0	1,008,709	124,472	1,133,181	22,624
1994	50%	D	34,514	443,731	4,237	27,612	481,028	991,122	26	1,047,937	129,432	1,177,394	-186,272
1995	202%	W	95,479	948,773	42,079	905	177,847	1,265,083	82	973,503	116,897	1,090,481	174,601
1996	122%	N	100,745	1,038,046	26,566	0	182,868	1,348,225	251	1,067,962	127,604	1,195,817	152,408
1997	155%	W	58,885	749,117	54,380	0	265,952	1,128,333	1,392	1,123,726	143,342	1,268,459	-140,126
1998	181%	W	116,167	693,908	49,104	0	237,530	1,096,709	1,870	1,059,009	128,533	1,189,412	-92,703
1999	74%	D	34,039	713,206	39,371	0	325,154	1,111,771	7,376	1,232,448	151,647	1,391,471	-279,701
2000	90%	N	70,413	741,494	35,618	6,833	247,306	1,101,664	17,343	1,127,412	95,624	1,240,379	-138,714
2001	59%	D	94,963	437,871	8,911	54,771	453,432	1,049,949	13,351	1,111,506	90,933	1,215,791	-165,841
2002	67%	D	26,034	564,134	21,817	51,428	408,568	1,071,981	10,253	1,201,455	85,417	1,297,125	-225,143
2003	83%	N	40,108	583,124	4,687	24,029	366,253	1,018,201	8,170	1,198,411	95,332	1,301,914	-283,713
2004	61%	D	74,858	495,764	25,863	63,254	475,486	1,135,226	20,849	1,162,011	86,876	1,269,736	-134,510
2005	148%	W	80,390	873,425	36,085	857	200,953	1,191,709	5,413	1,155,548	101,553	1,262,513	-70,804
2006	172%	W	104,703	1,020,922	37,530	154	189,607	1,352,916	9,651	1,129,741	108,496	1,247,887	105,029
2007	40%	D	14,800	508,886	4,613	60,608	456,931	1,045,839	14,999	1,183,096	97,935	1,296,030	-250,191
2008	72%	D	35,836	371,231	9,331	72,842	497,113	986,354	13,795	1,083,093	89,622	1,186,511	-200,157
2009	79%	N	32,367	379,590	16,632	68,391	440,286	937,266	4,295	1,091,697	94,173	1,190,165	-252,899
2010	121%	N	88,203	694,592	51,406	31,531	234,505	1,100,238	2,440	1,016,725	78,915	1,098,080	2,158
2011	180%	W	52,937	1,026,568	21,035	7,241	60,638	1,168,420	4,486	791,090	83,959	879,535	288,885
2012	49%	D	45,317	498,937	20,785	64,173	339,834	969,046	3,226	776,133	62,058	841,417	127,629
2013	41%	D	2,800	264,515	1,725	84,661	437,315	791,017	8,381	826,405	65,687	900,473	-109,456
2014	32%	D	30,586	154,346	0	85,650	491,323	761,906	3,579	757,265	62,755	823,599	-61,693
2015	21%	D	15,085	107,212	0	79,517	508,193	710,008	829	624,647	49,756	675,231	34,777
2016	75%	D	41,890	227,755	0	70,864	413,868	754,377	2,497	677,936	53,544	733,977	20,400
1990-2016 Avg	**91%**	**--**	**56,363**	**560,120**	**20,950**	**37,440**	**366,501**	**1,041,375**	**5,724**	**1,018,558**	**100,353**	**1,124,635**	**-83,260**
1998-2010 Avg	**96%**	**--**	**62,529**	**621,396**	**26,228**	**33,438**	**348,702**	**1,092,294**	**9,985**	**1,134,781**	**100,389**	**1,245,155**	**-152,861**

Subsurface Water Budget																	
			Inflows							Outflows					Annual Change in Storage		
			Deep Percolation				Interbasin Inflow			Groundwater Pumping		Interbasin Outflow					
Year	Kings River Flows	Year Type	Precipitation Infiltration (AF)	Applied Water Infiltration (AF)	Stream Leakage (AF)	Intentional Recharge (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Total Inflows (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Total Outflows (AF)	Upper Aquifer (AF)	Lower Aquifer (AF)	Total Aquifer (AF)
1990	40%	D	17,012	132,933	222,466	1,021	60,944	120,265	554,640	363,970	254,873	52,493	58,787	730,124	-392,438	206,512	-185,926
1991	63%	D	10,310	125,674	149,106	0	59,832	104,657	449,578	351,785	225,455	44,466	68,123	689,829	-379,415	154,951	-224,464
1992	41%	D	13,215	126,365	122,515	0	58,304	102,535	422,934	345,307	251,686	43,733	75,762	716,488	-379,874	89,485	-290,389
1993	149%	W	43,499	124,472	178,243	61	51,892	77,023	475,190	239,755	9,069	42,526	80,157	371,507	-117,785	275,064	157,279
1994	50%	D	20,701	129,432	121,447	23,540	52,755	83,154	431,028	310,055	181,901	44,438	80,974	617,368	-255,820	87,113	-168,707
1995	202%	W	58,569	116,897	160,315	60,372	45,868	68,012	510,032	205,637	17,015	50,708	79,891	353,250	-23,977	255,398	231,421
1996	122%	N	78,864	127,604	161,750	32,081	42,064	60,065	502,429	184,321	11,265	47,154	88,966	331,705	-4,023	190,504	186,481
1997	155%	W	65,946	143,342	153,373	42,787	40,618	63,597	509,662	204,969	73,758	50,417	89,192	418,336	-15,247	116,032	100,786
1998	181%	W	75,095	128,533	152,395	61,425	38,754	67,063	523,264	191,289	57,797	55,626	78,577	383,288	17,175	136,362	153,536
1999	74%	D	47,885	151,647	180,710	0	41,389	79,296	500,928	227,049	111,192	47,970	93,144	479,355	-71,374	71,897	522
2000	90%	N	51,238	95,624	159,781	23,540	41,391	75,001	446,574	201,799	58,927	44,741	85,312	390,779	-76,900	120,539	43,638
2001	59%	D	26,775	90,933	124,376	0	44,167	84,217	370,468	264,888	202,438	45,556	85,202	598,085	-222,719	-20,340	-243,059
2002	67%	D	41,347	85,417	164,069	0	46,006	76,591	413,429	272,312	162,957	45,147	97,839	578,256	-174,685	-3,708	-178,393
2003	83%	N	36,128	95,332	174,955	23,540	45,798	78,735	454,487	255,270	130,332	46,552	94,198	526,352	-133,547	32,464	-101,083
2004	61%	D	40,008	86,876	148,458	10,700	46,099	79,299	411,440	279,593	214,670	46,854	90,221	631,339	-181,729	-49,393	-231,122
2005	148%	W	64,268	101,553	185,872	58,945	41,121	60,617	512,376	194,492	22,996	48,908	89,165	355,562	516	120,500	121,017
2006	172%	W	57,791	108,496	169,501	170,266	37,534	56,625	600,213	174,179	31,250	56,025	86,840	348,293	117,742	102,907	220,649
2007	40%	D	23,538	97,935	174,019	0	42,192	67,360	405,044	264,654	209,499	52,530	90,375	617,057	-177,972	-70,518	-248,490
2008	72%	D	26,373	89,622	137,369	0	43,266	76,606	373,236	283,431	232,114	49,766	93,253	658,564	-210,701	-85,575	-296,277
2009	79%	N	29,563	94,173	167,126	10,700	43,877	74,501	419,939	268,843	187,798	49,818	92,397	598,856	-170,773	-42,237	-213,010
2010	121%	N	67,953	78,915	145,364	23,540	37,974	63,446	417,193	187,770	62,006	47,711	91,016	388,504	-56,332	69,461	13,129
2011	180%	W	88,853	83,959	180,036	180,066	32,182	51,038	616,133	126,313	48,633	58,840	85,781	319,567	197,345	163,884	361,228
2012	49%	D	46,276	62,058	126,057	10,700	34,819	64,180	344,090	205,013	152,288	52,627	89,367	499,295	-137,135	-32,812	-169,947
2013	41%	D	23,005	65,687	123,434	0	38,673	66,410	317,209	252,639	203,087	50,934	92,285	598,945	-222,003	-83,604	-305,607
2014	32%	D	20,546	62,755	92,469	23,320	41,277	69,232	309,598	276,394	231,859	51,497	100,472	660,223	-247,305	-113,047	-360,352
2015	21%	D	25,814	49,756	74,156	23,540	41,875	72,128	287,269	283,699	240,639	50,653	90,840	665,831	-286,779	-105,501	-392,279
2016	75%	D	26,426	53,544	32,070	42,659	36,829	65,273	256,801	248,557	179,866	60,070	100,280	588,773	-234,011	-60,314	-294,325
1990-2016 Avg	**91%**	**--**	**41,740**	**100,353**	**147,460**	**30,474**	**43,981**	**74,331**	**438,340**	**246,814**	**139,458**	**49,547**	**86,978**	**522,797**	**-142,214**	**56,519**	**-85,694**
1998-2010 Avg	**96%**	**--**	**45,228**	**100,389**	**160,307**	**29,435**	**42,274**	**72,258**	**449,892**	**235,813**	**129,537**	**49,016**	**89,811**	**504,176**	**-103,177**	**29,412**	**-73,765**

1. AF = acre-feet, D = dry, W = wet, and N = normal.