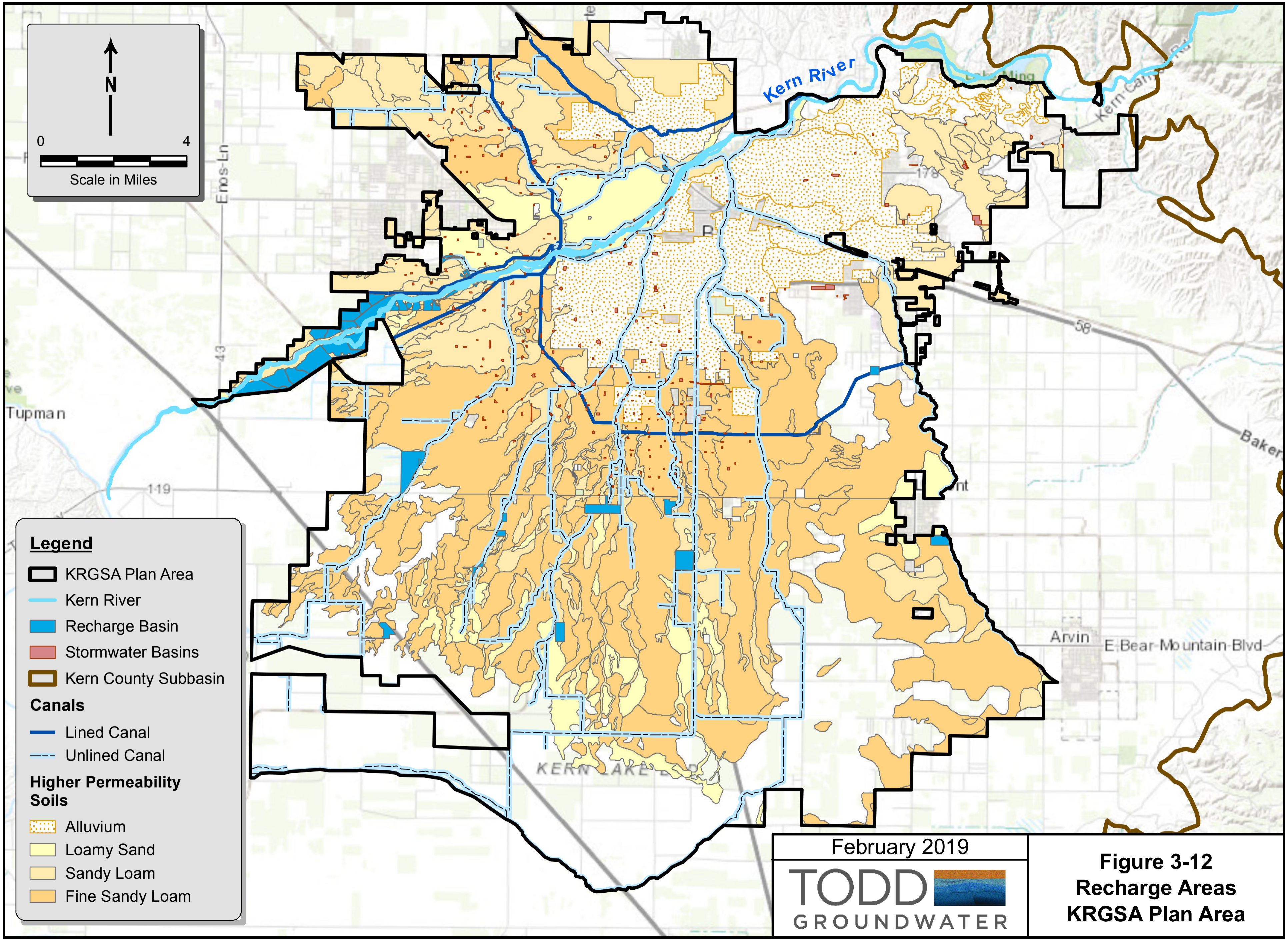


February 2019

TODD GROUNDWATER

Figure 3-12
Recharge Areas
KRGSA Plan Area

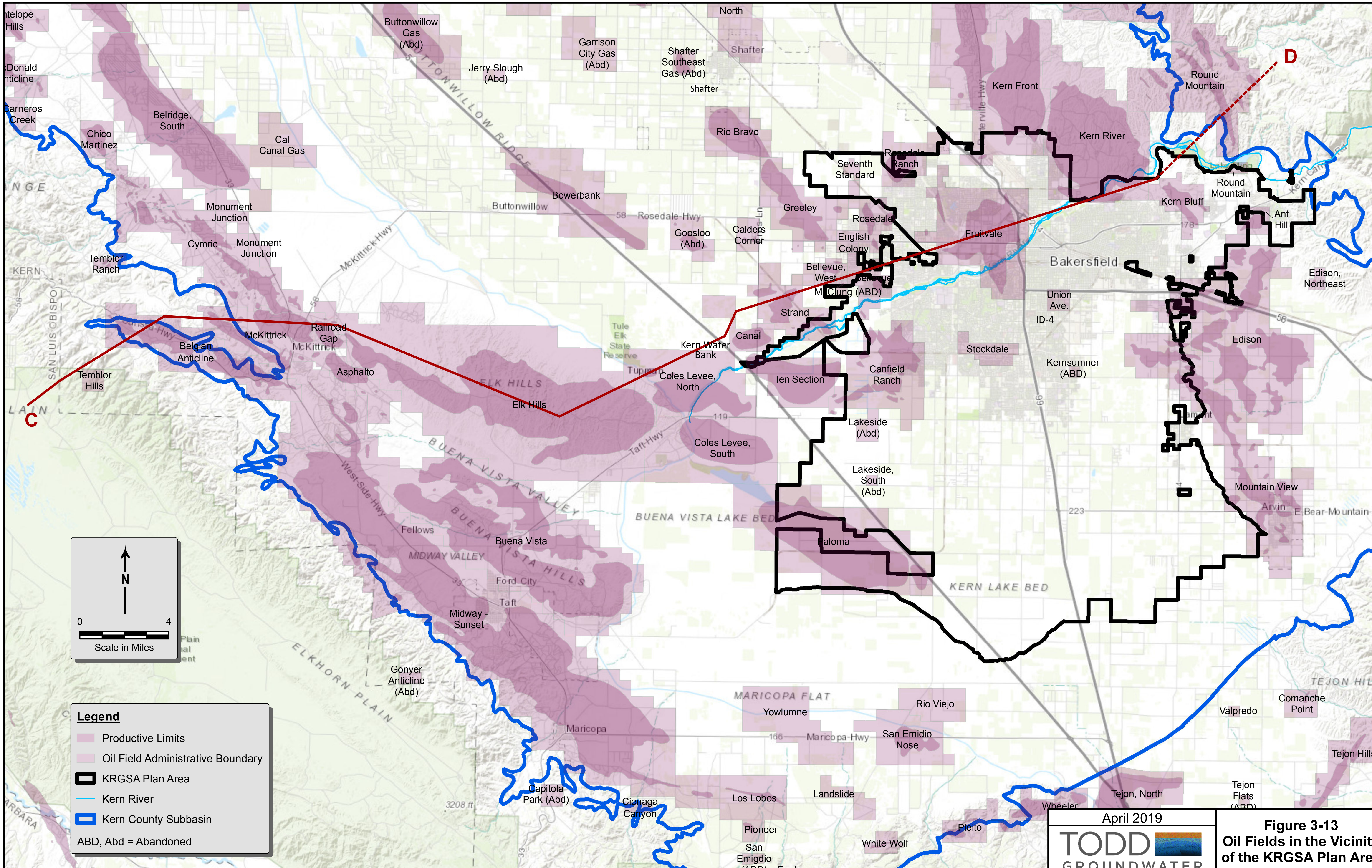
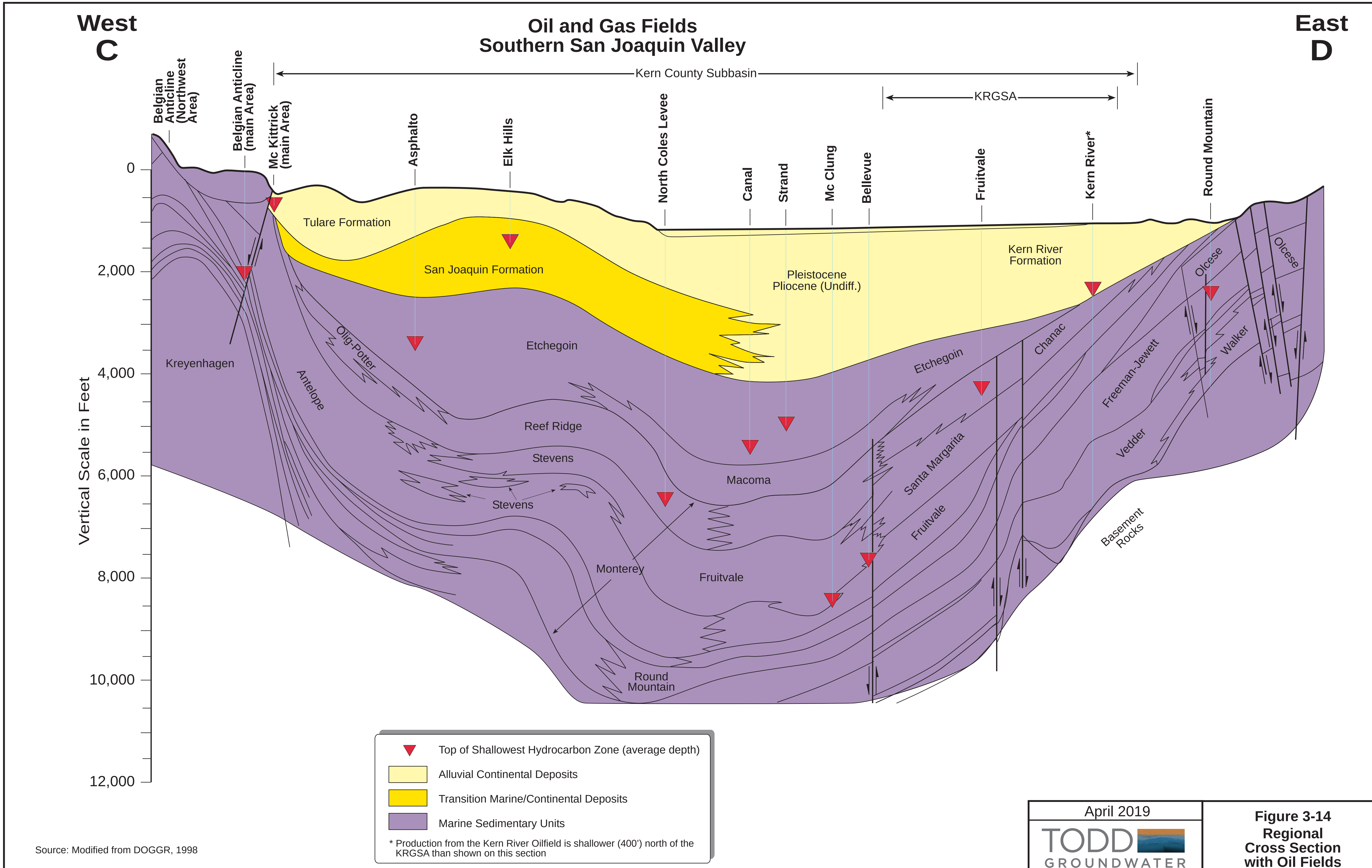


Figure 3-13 Oil Fields in the Vicinity of the KRGSA Plan Area

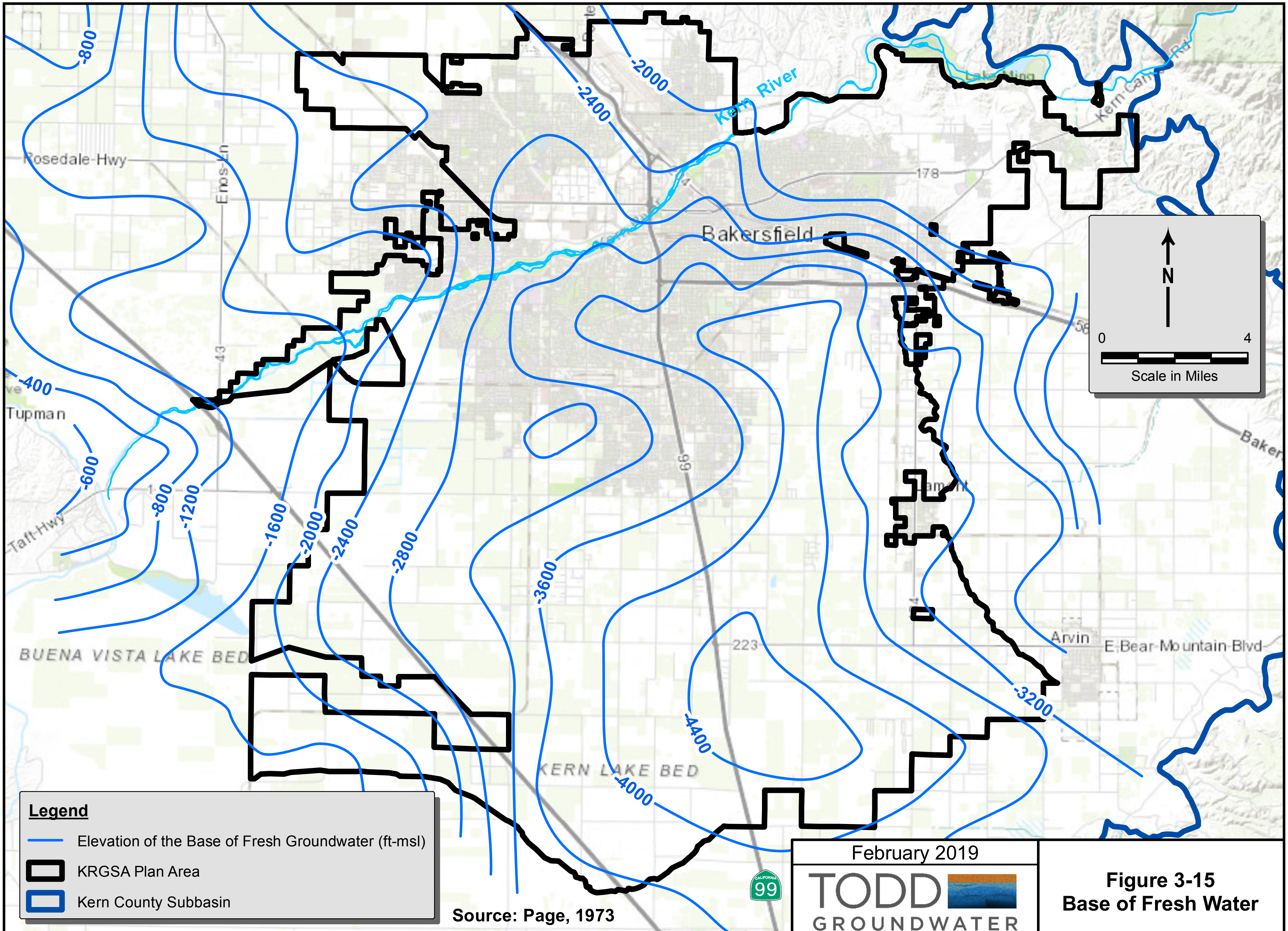


Source: Modified from DOGGR, 1998

April 2019

TODD GROUNDWATER

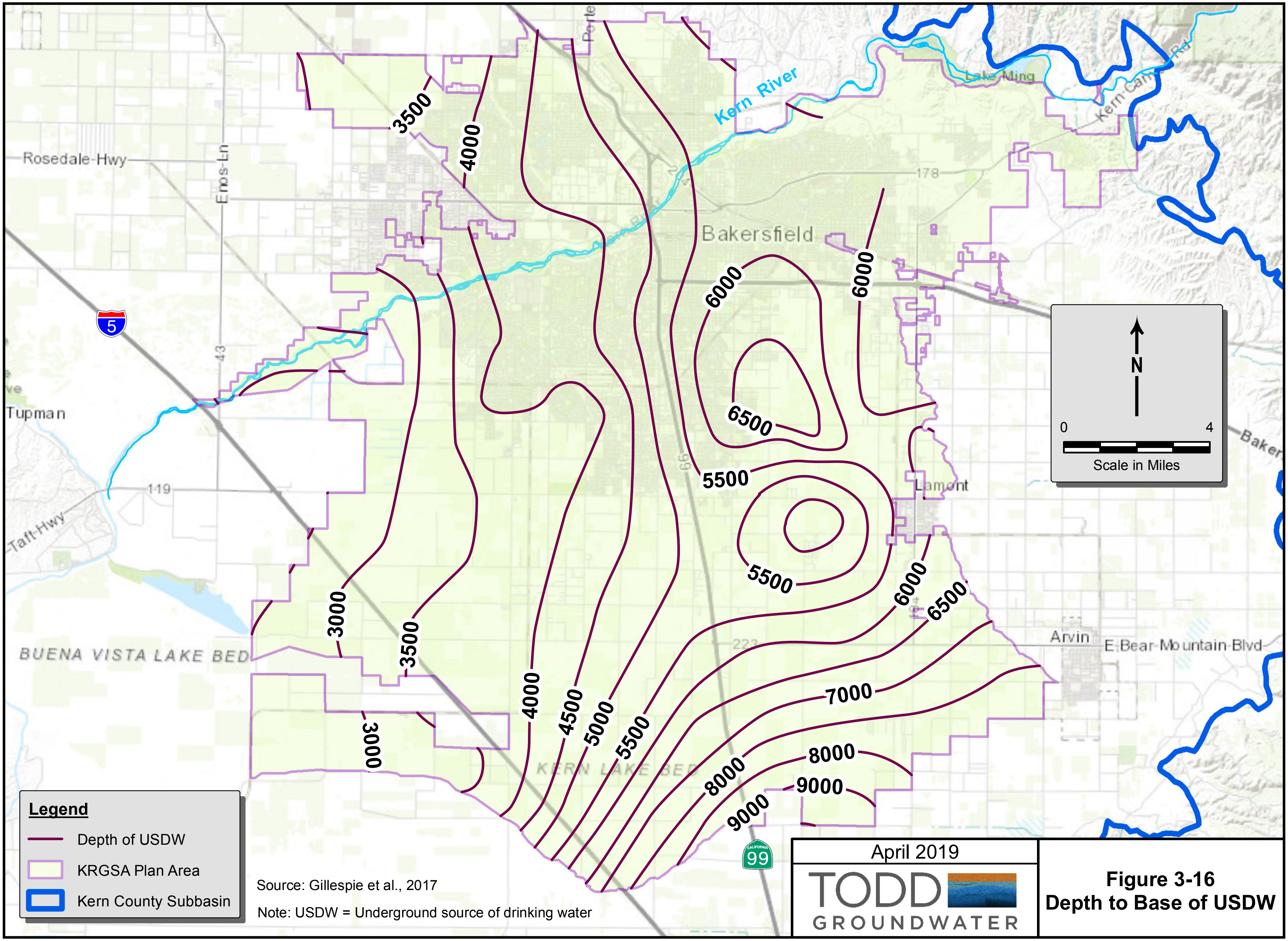
Figure 3-14
Regional Cross Section with Oil Fields



February 2019

TODD GROUNDWATER

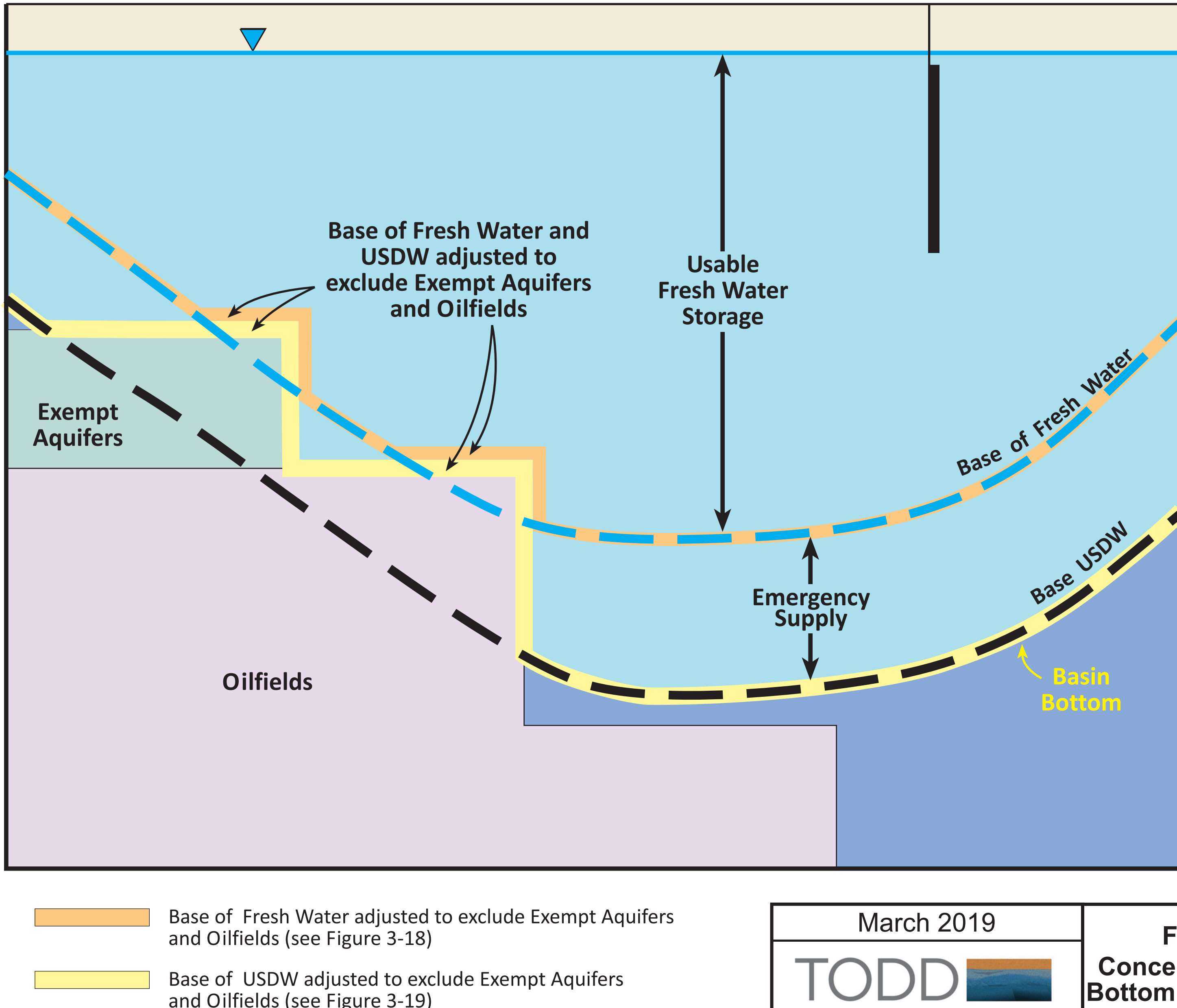
Figure 3-15
Base of Fresh Water



April 2019

TODD GROUNDWATER

Figure 3-16
Depth to Base of USDW



March 2019

TODD GROUNDWATER

Figure 3-17
Conceptual Approach Bottom of the Subbasin in the Plan Area

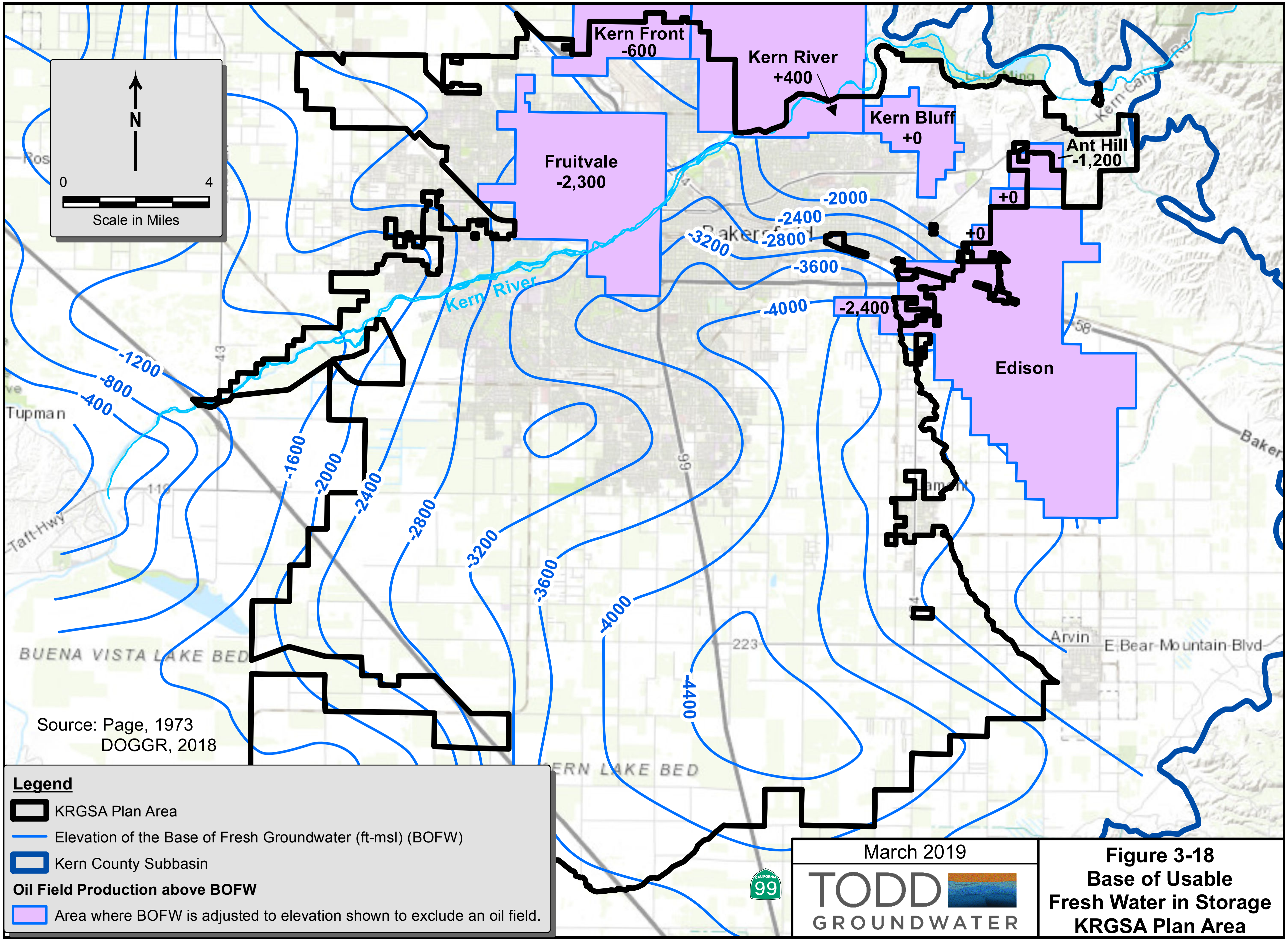


Figure 3-18
Base of Usable Fresh Water in Storage
KRGSA Plan Area

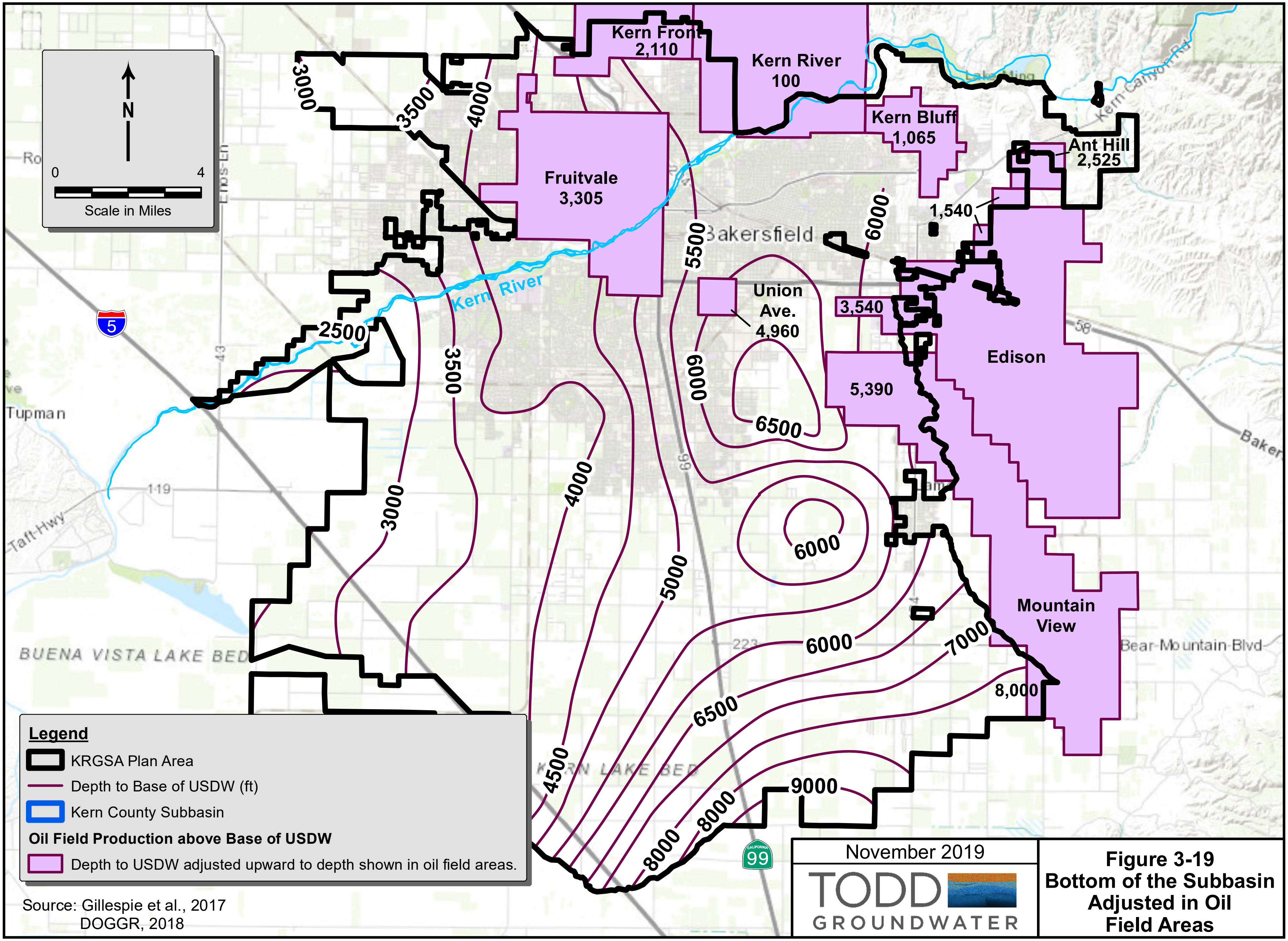
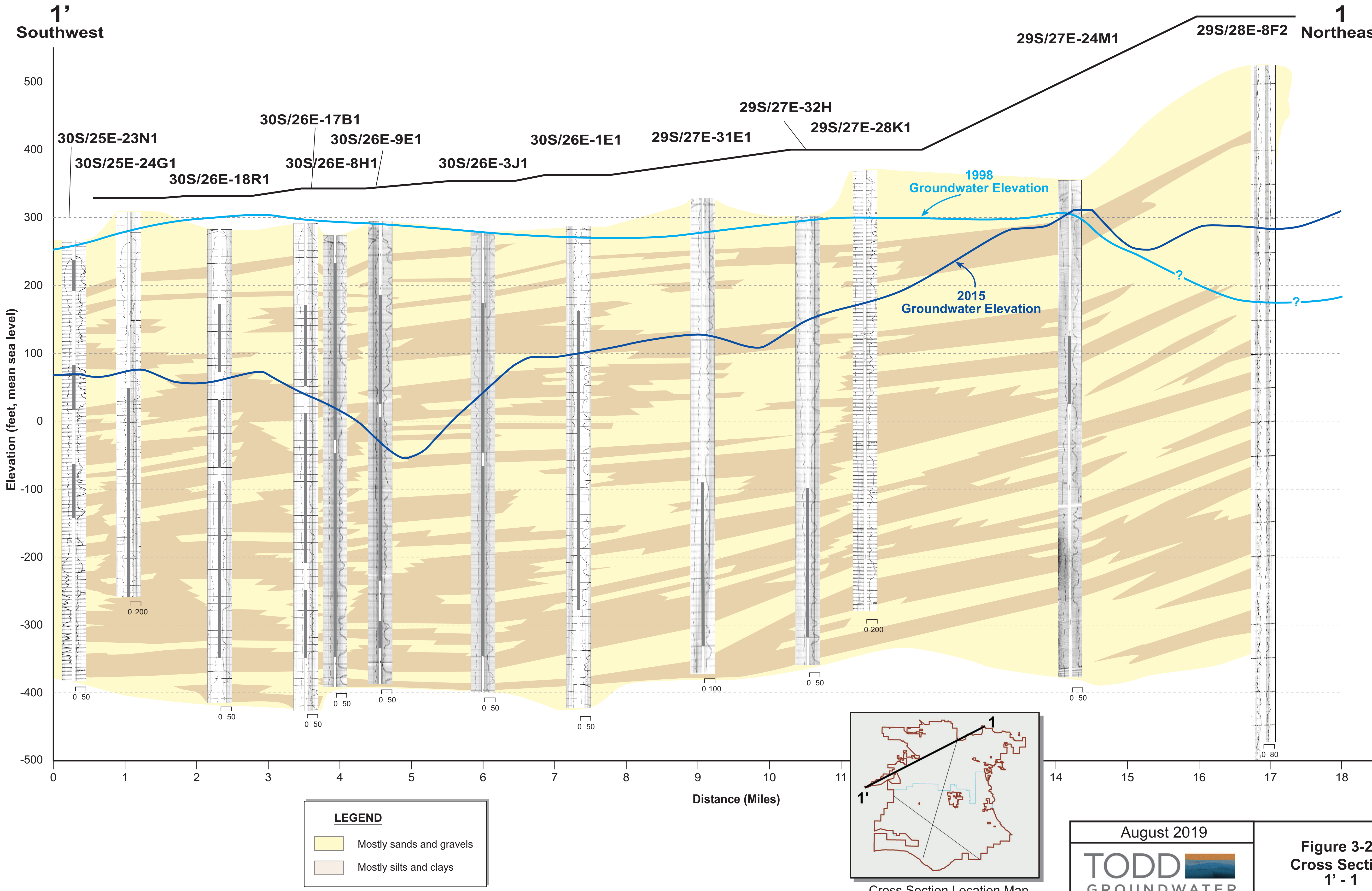


Figure 3-19
Bottom of the Subbasin Adjusted in Oil Field Areas



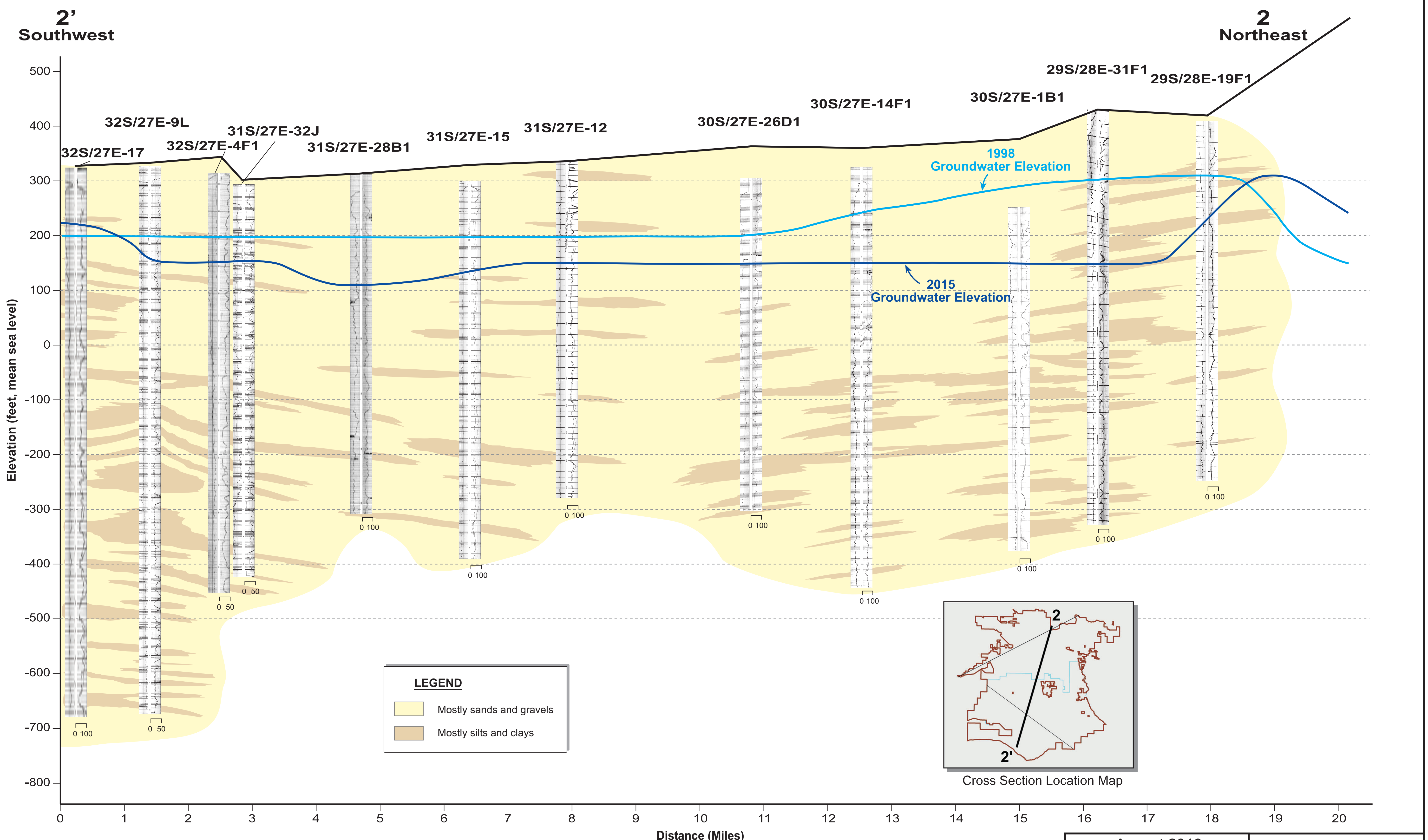
LEGEND

- Mostly sands and gravels
- Mostly silts and clays

August 2019

TODD GROUNDWATER

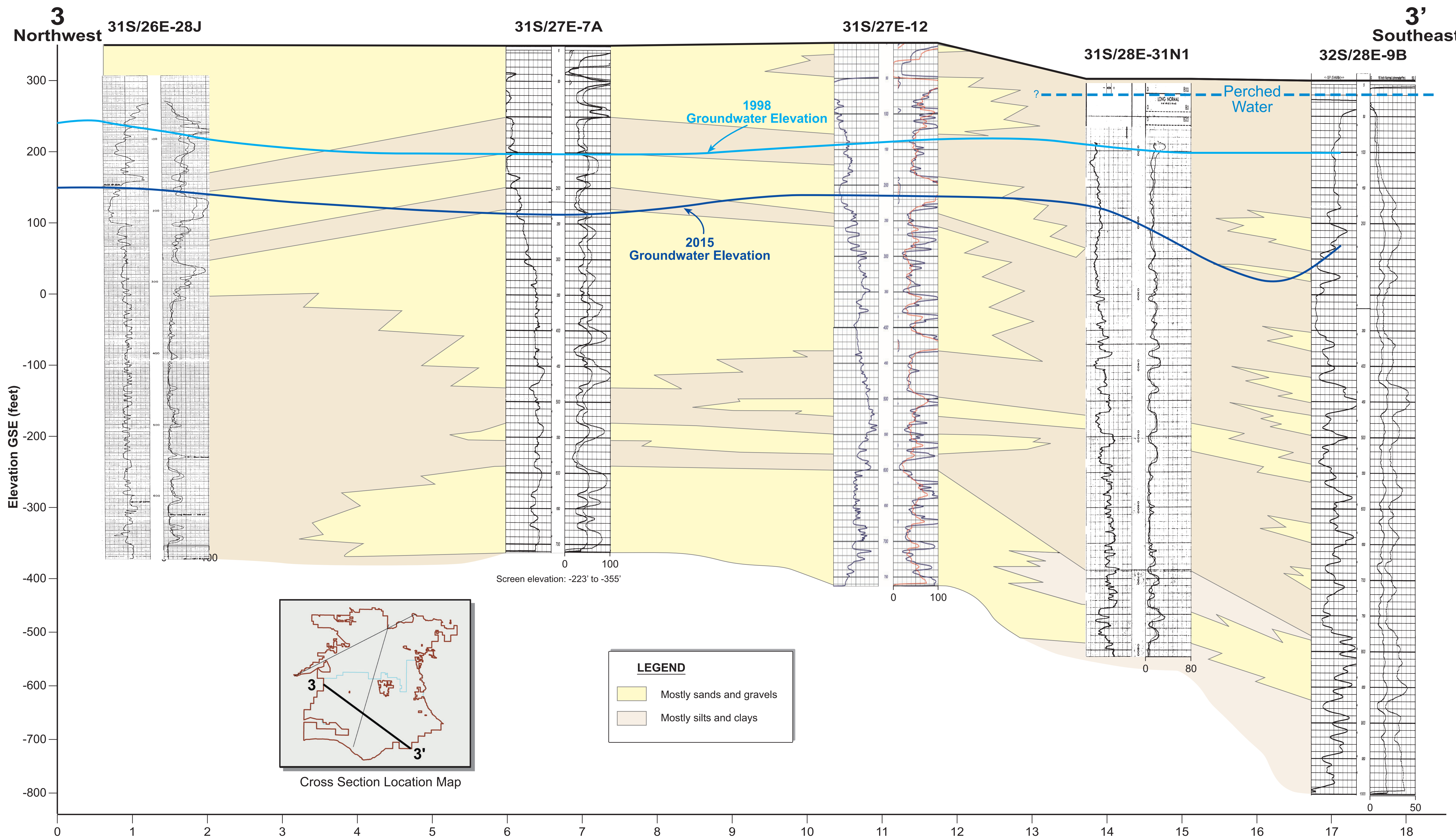
Figure 3-20
Cross Section
1’ - 1



August 2019

TODD GROUNDWATER

Figure 3-21
Cross Section 2' - 2



April 2019

TODD GROUNDWATER

Figure 3-22
Cross Section
3 - 3'

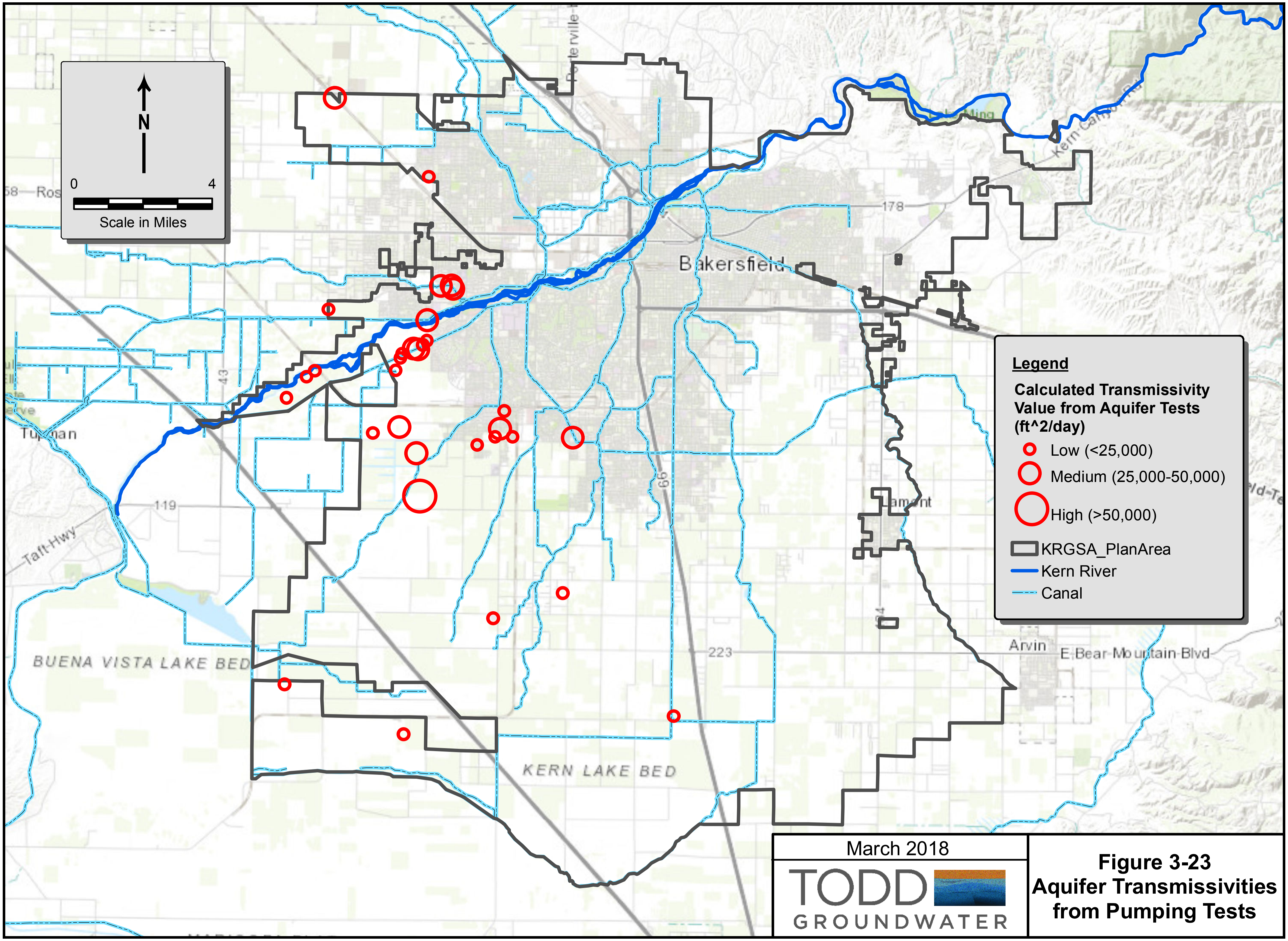
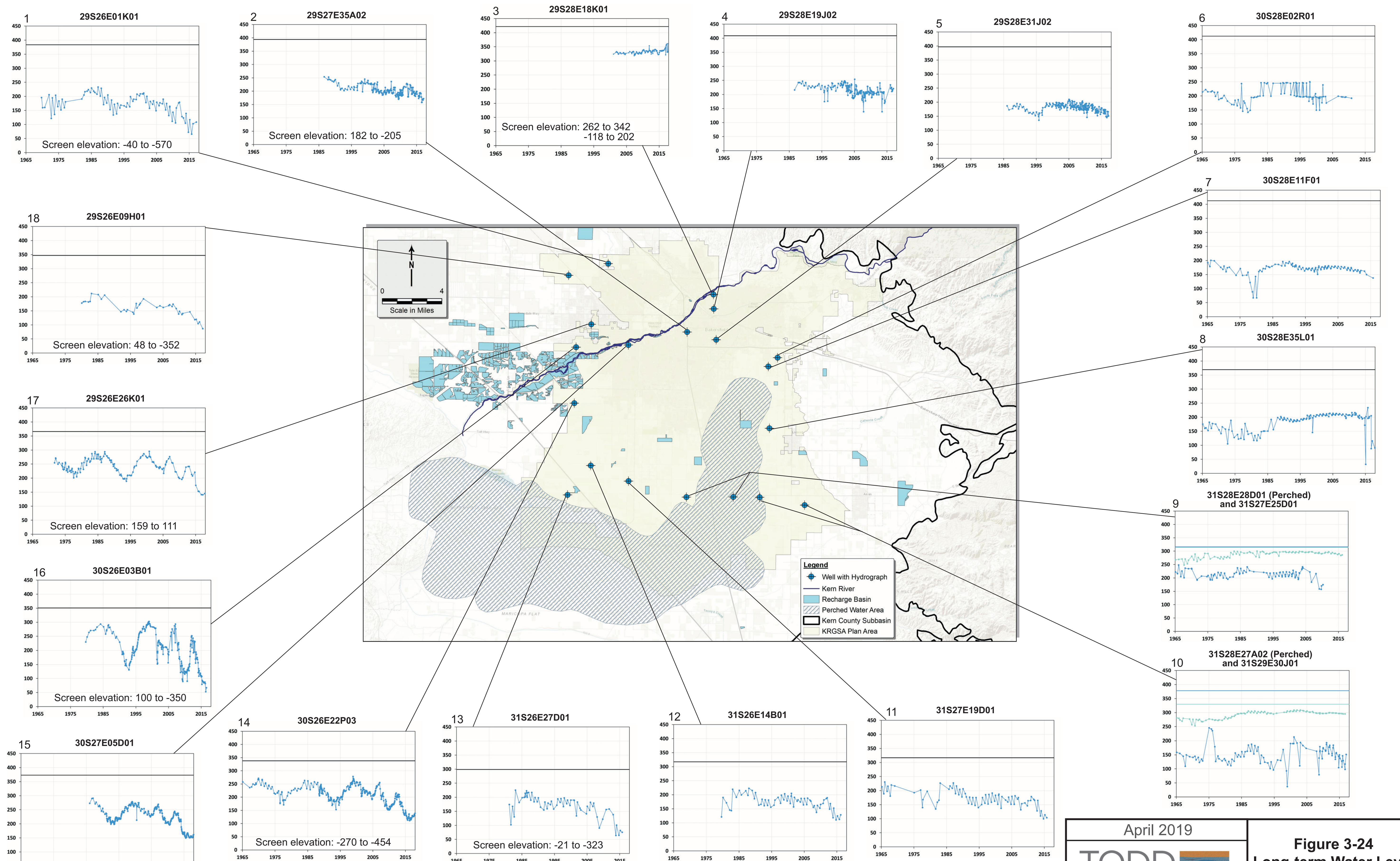


Figure 3-23
Aquifer Transmissivities from Pumping Tests



Notes: 1. Vertical axis shows groundwater elevation in feet msl. Horizontal axis shows calendar years 1965 - 2017.
2. Bold horizontal lines represent ground surface elevation.

April 2019

TODD GROUNDWATER

Figure 3-24
Long-term Water Level Hydrographs

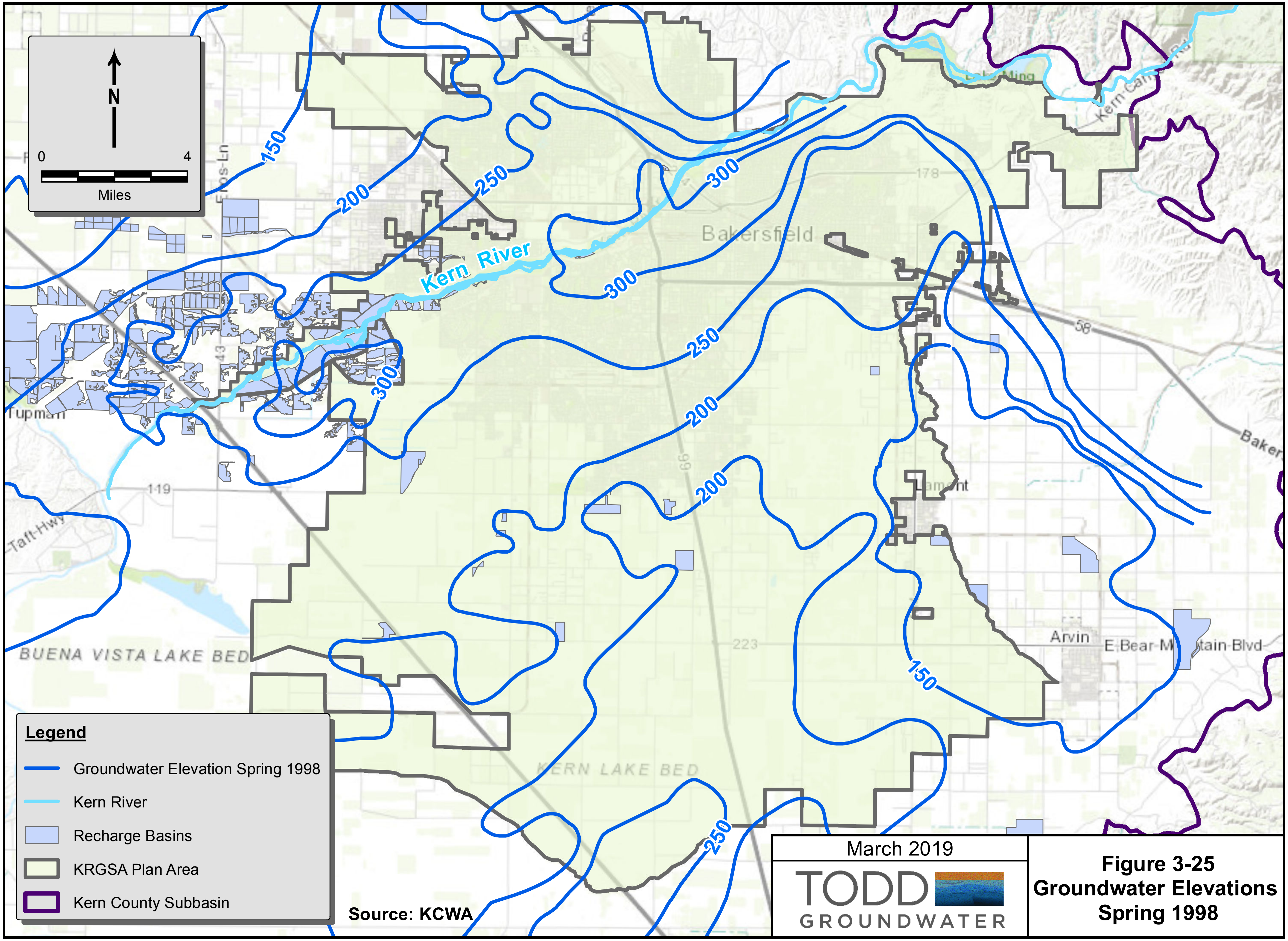
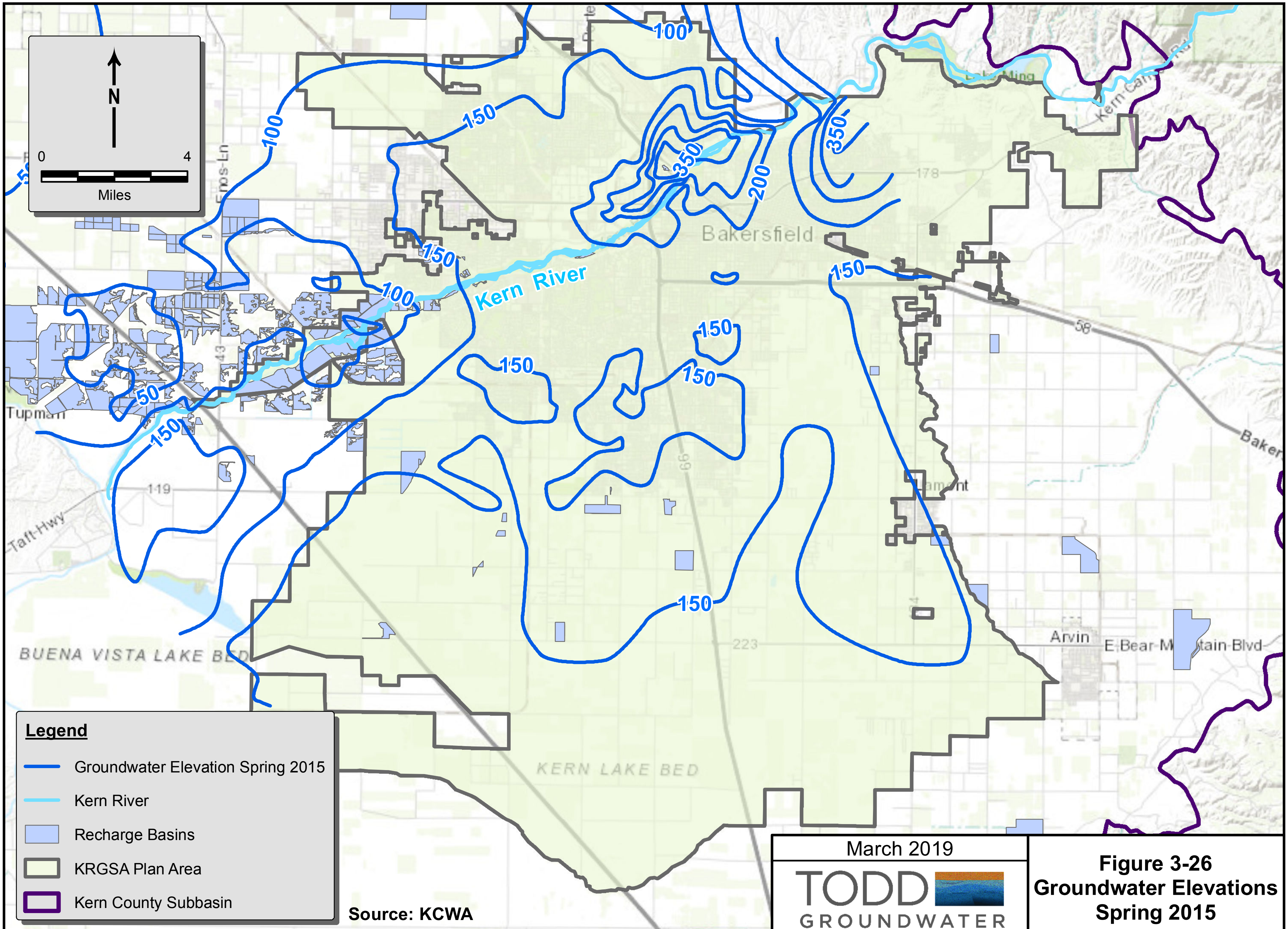


Figure 3-25
Groundwater Elevations
Spring 1998

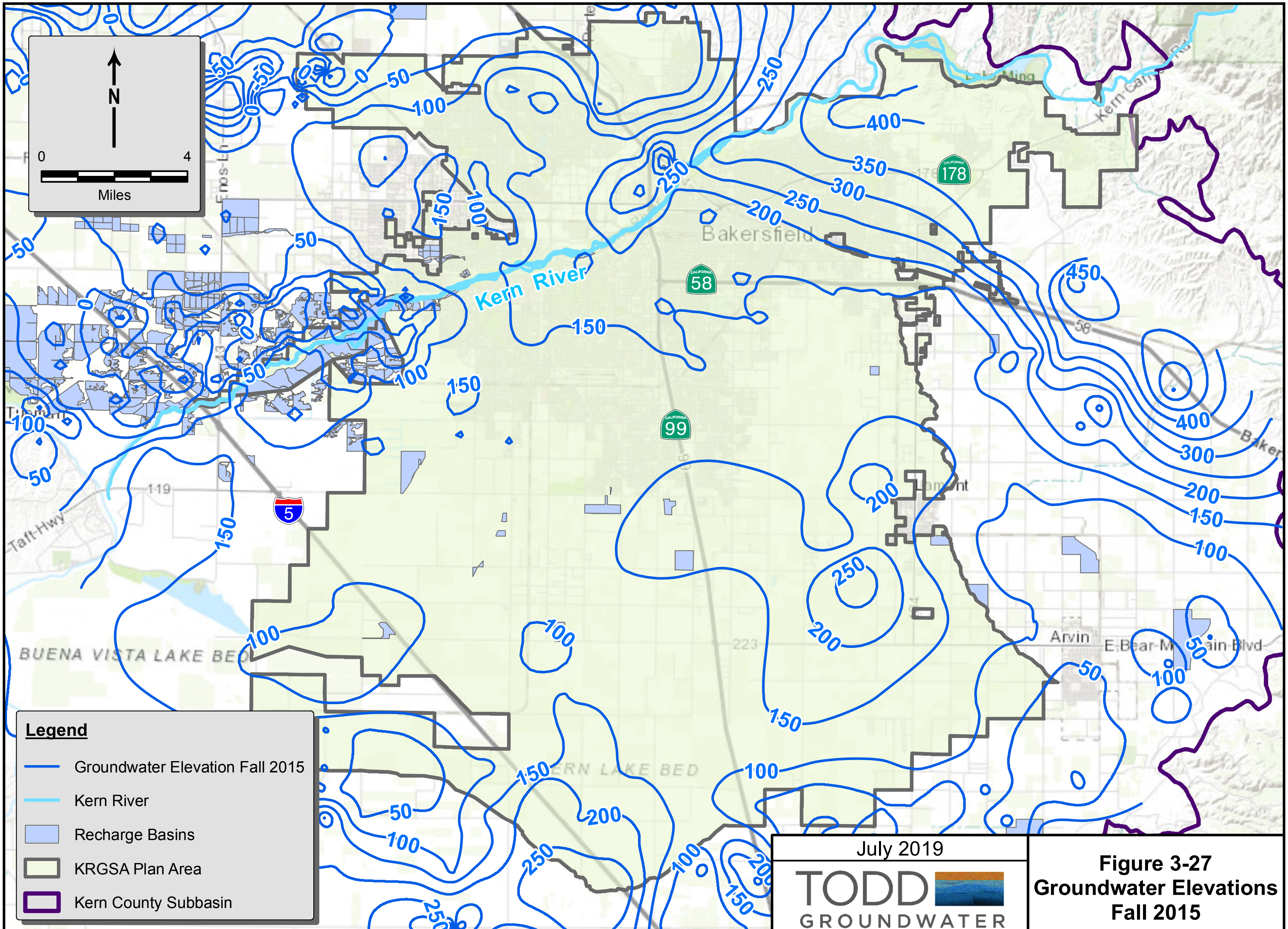


Source: KCWA

March 2019

TODD GROUNDWATER

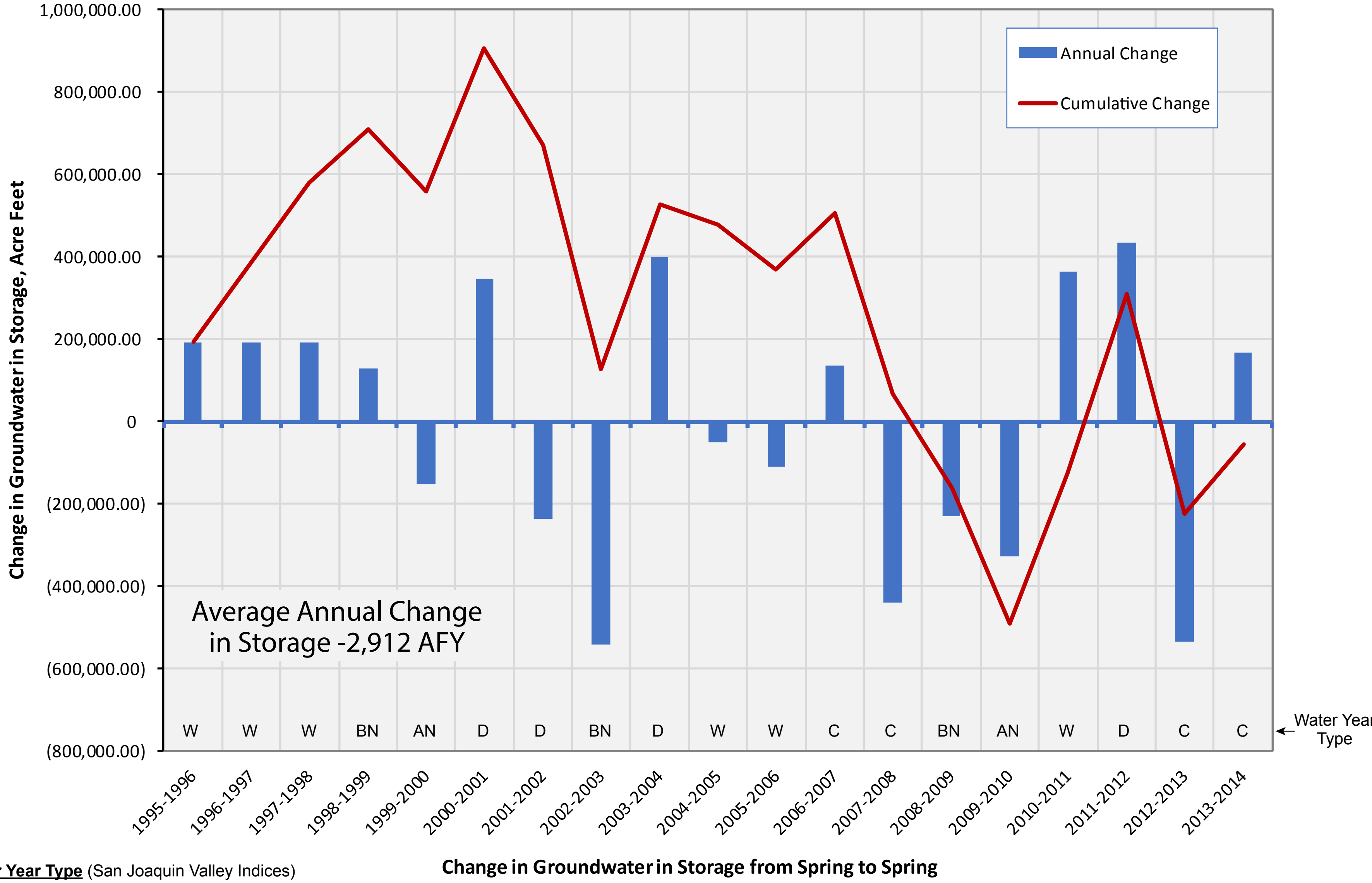
Figure 3-26
Groundwater Elevations
Spring 2015



July 2019

TODD GROUNDWATER

Figure 3-27
Groundwater Elevations
Fall 2015



Water Year Type (San Joaquin Valley Indices)

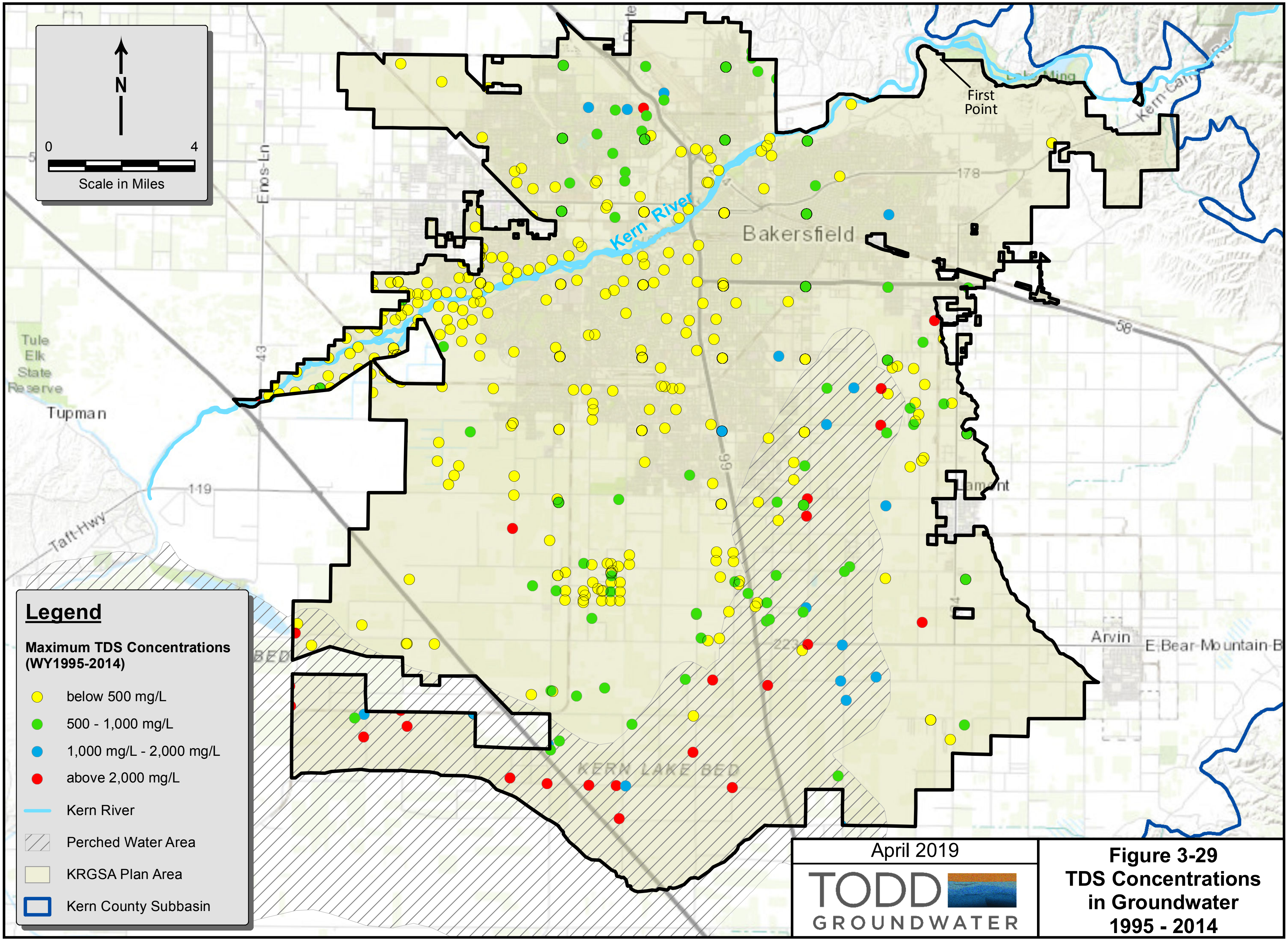
W - Wet
AN - Above Normal
BN - Below Normal
D - Dry
C - Critical

Analysis is based on annual Spring groundwater elevation contour maps by KCWA, 1995-2014 (missing 1996 and 1997).

March 2019

TODD GROUNDWATER

Figure 3-28
Change in Groundwater in Storage
KRGSA Plan Area



April 2019

TODD GROUNDWATER

Figure 3-29
TDS Concentrations in Groundwater
1995 - 2014

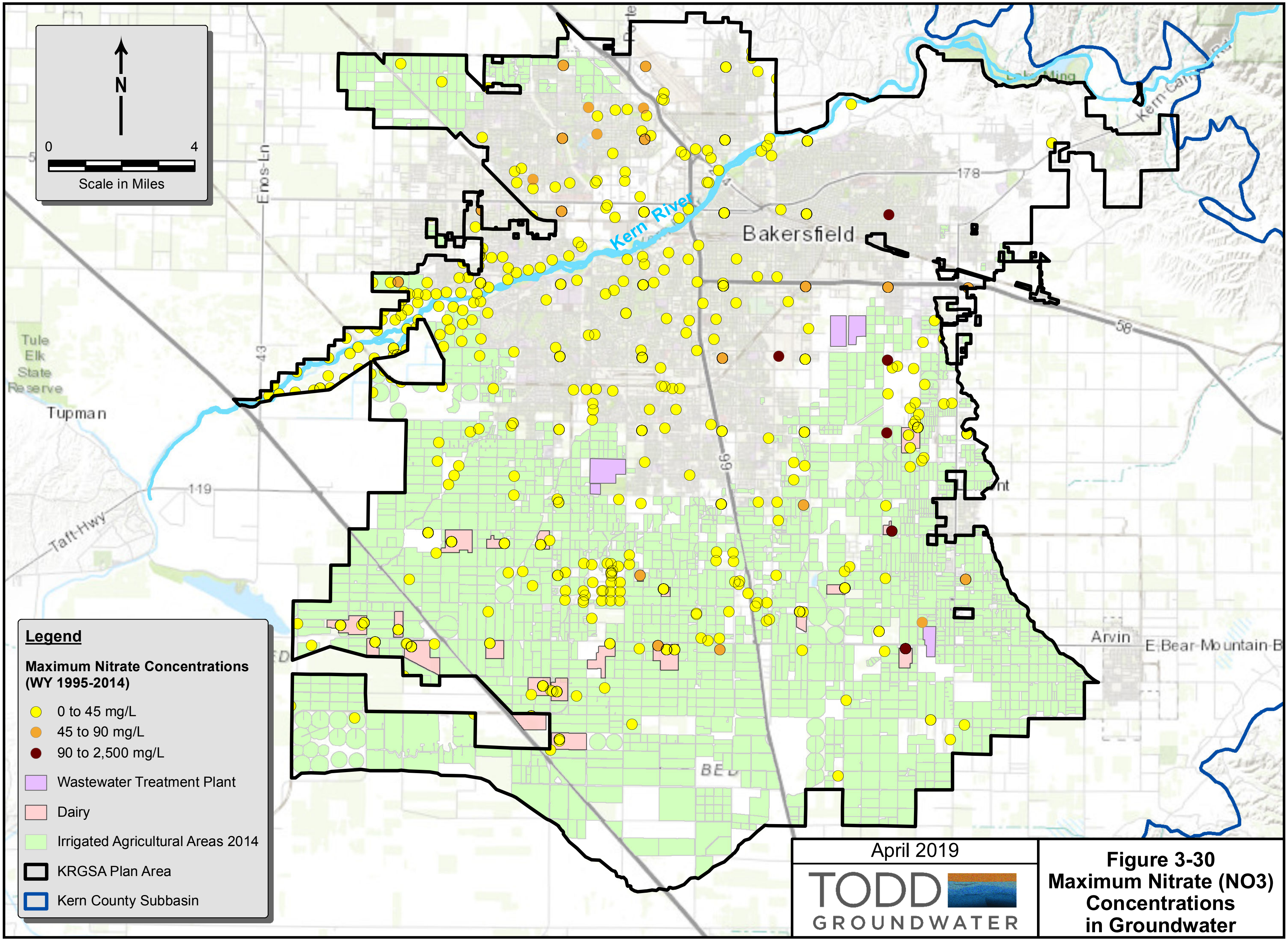
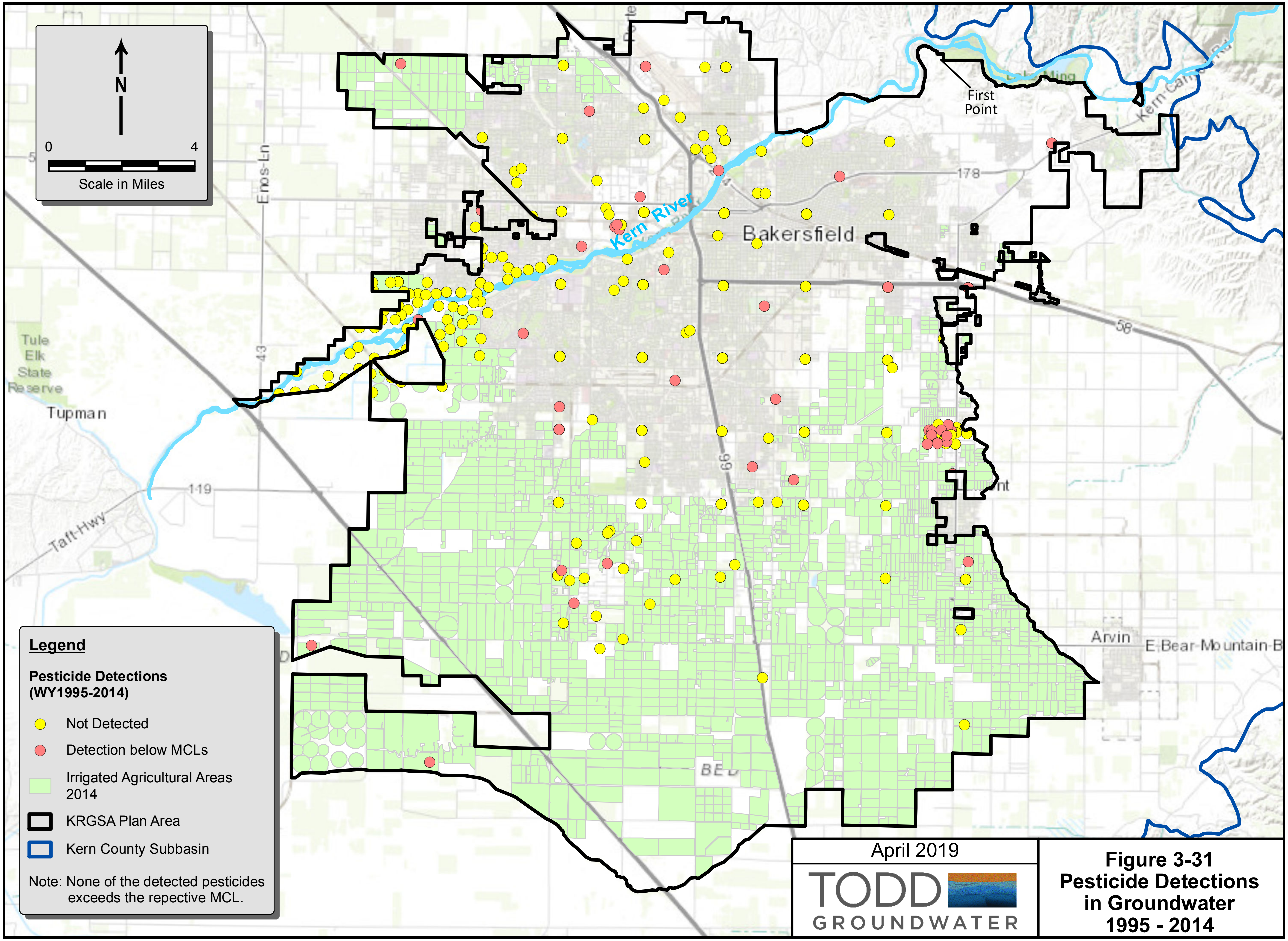


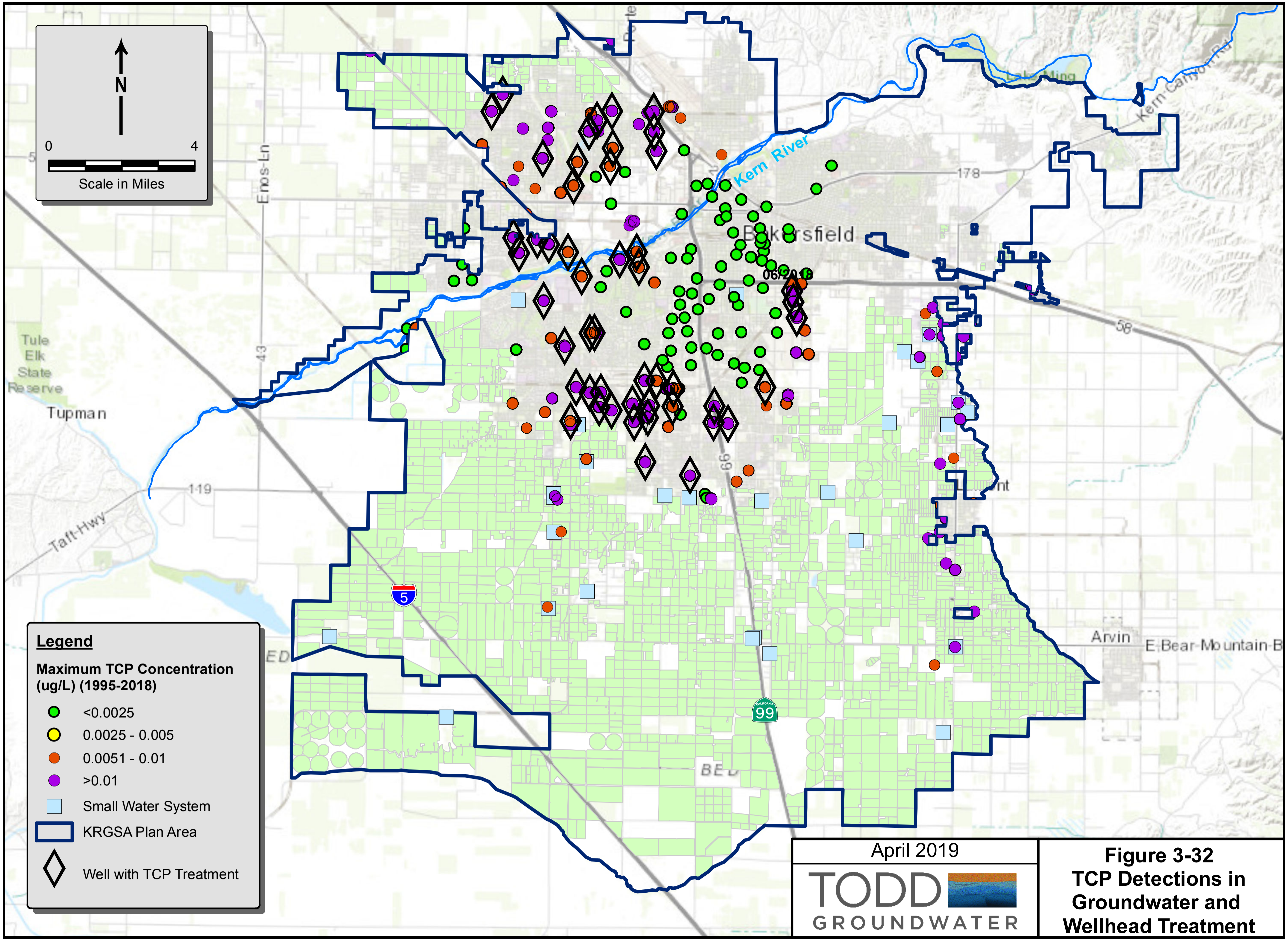
Figure 3-30
Maximum Nitrate (NO3) Concentrations in Groundwater



April 2019

TODD GROUNDWATER

Figure 3-31
Pesticide Detections in Groundwater 1995 - 2014



April 2019

TODD GROUNDWATER

Figure 3-32
TCP Detections in Groundwater and Wellhead Treatment

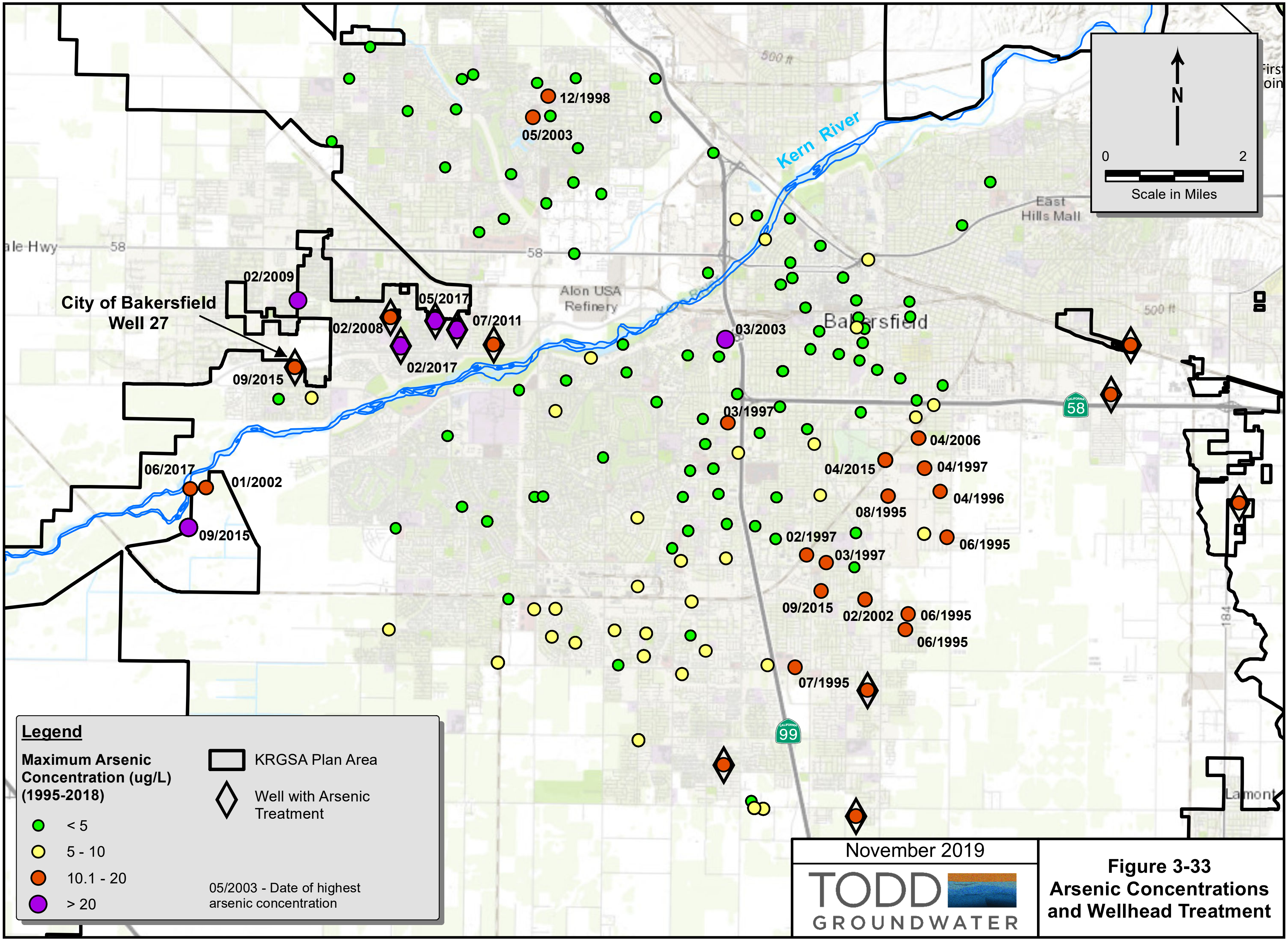
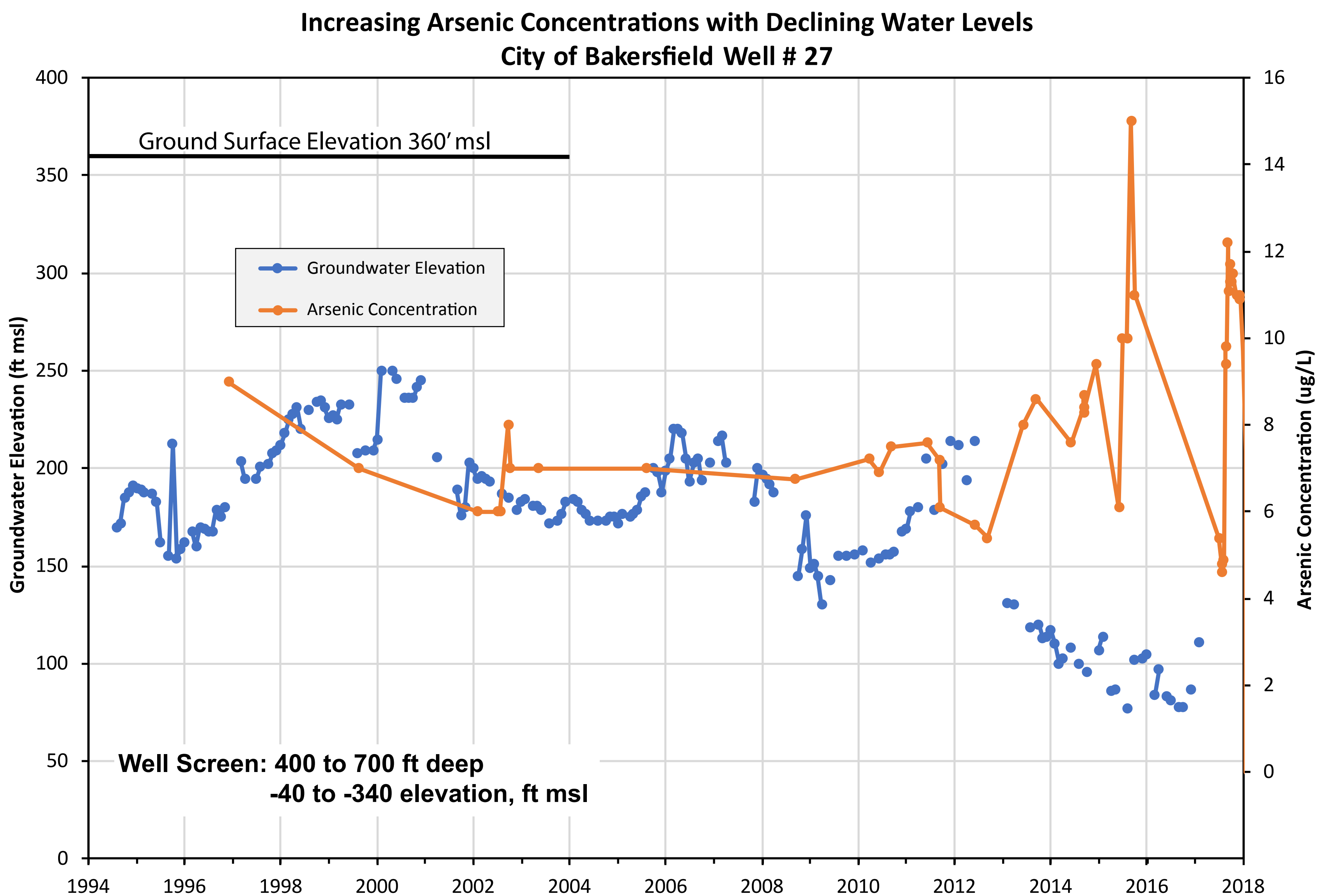


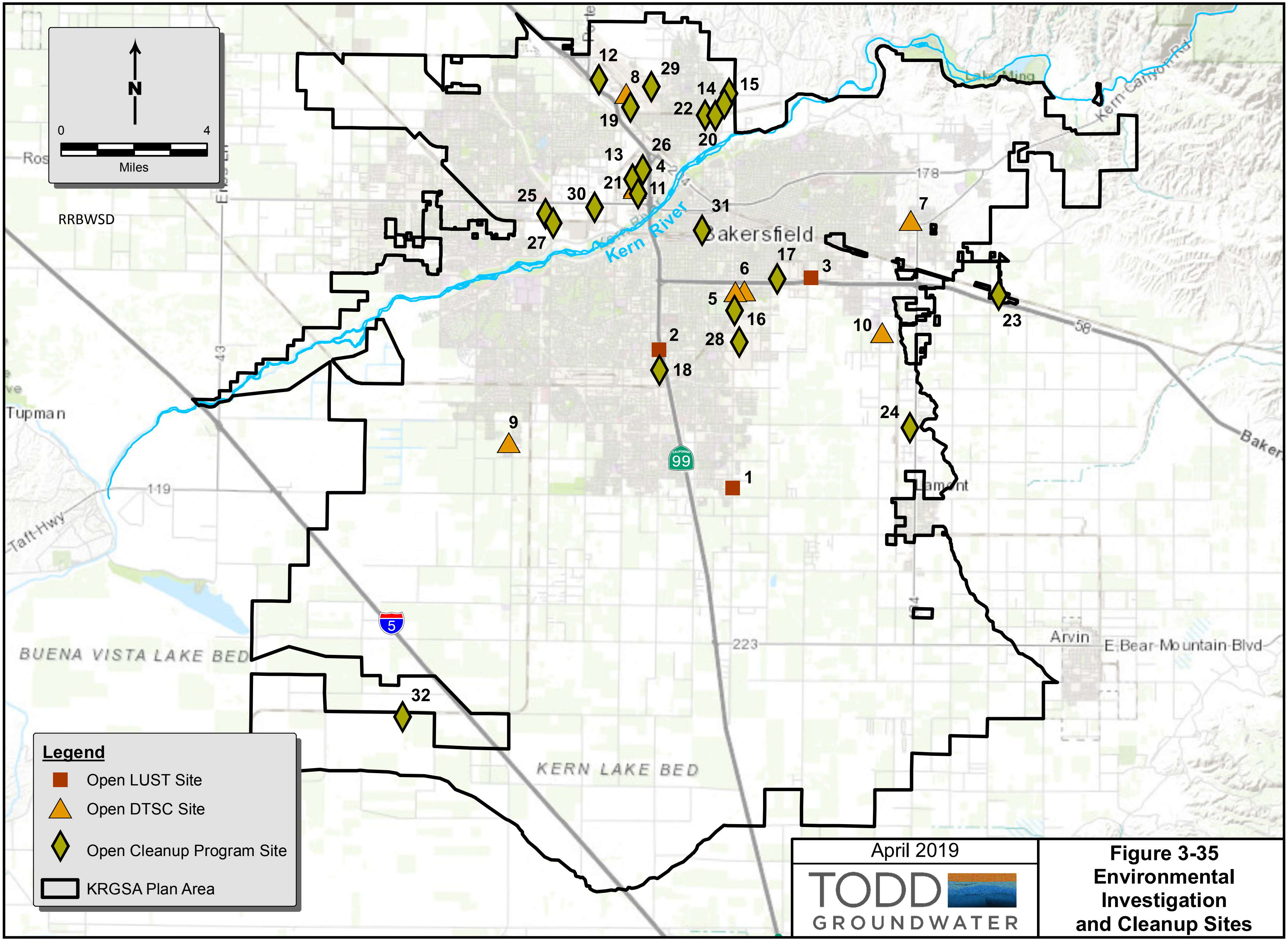
Figure 3-33 Arsenic Concentrations and Wellhead Treatment



April 2019

TODD GROUNDWATER

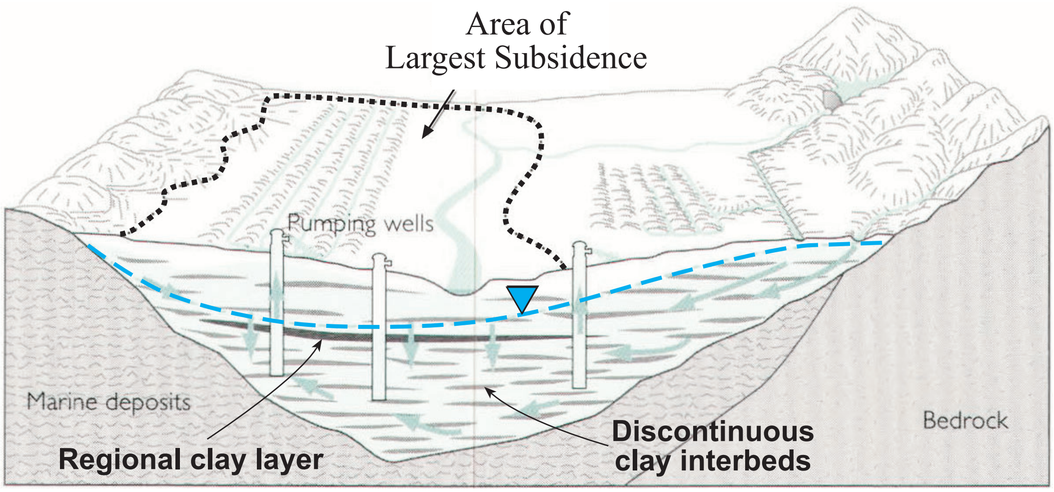
Figure 3-34
Arsenic Concentrations and Groundwater Elevations



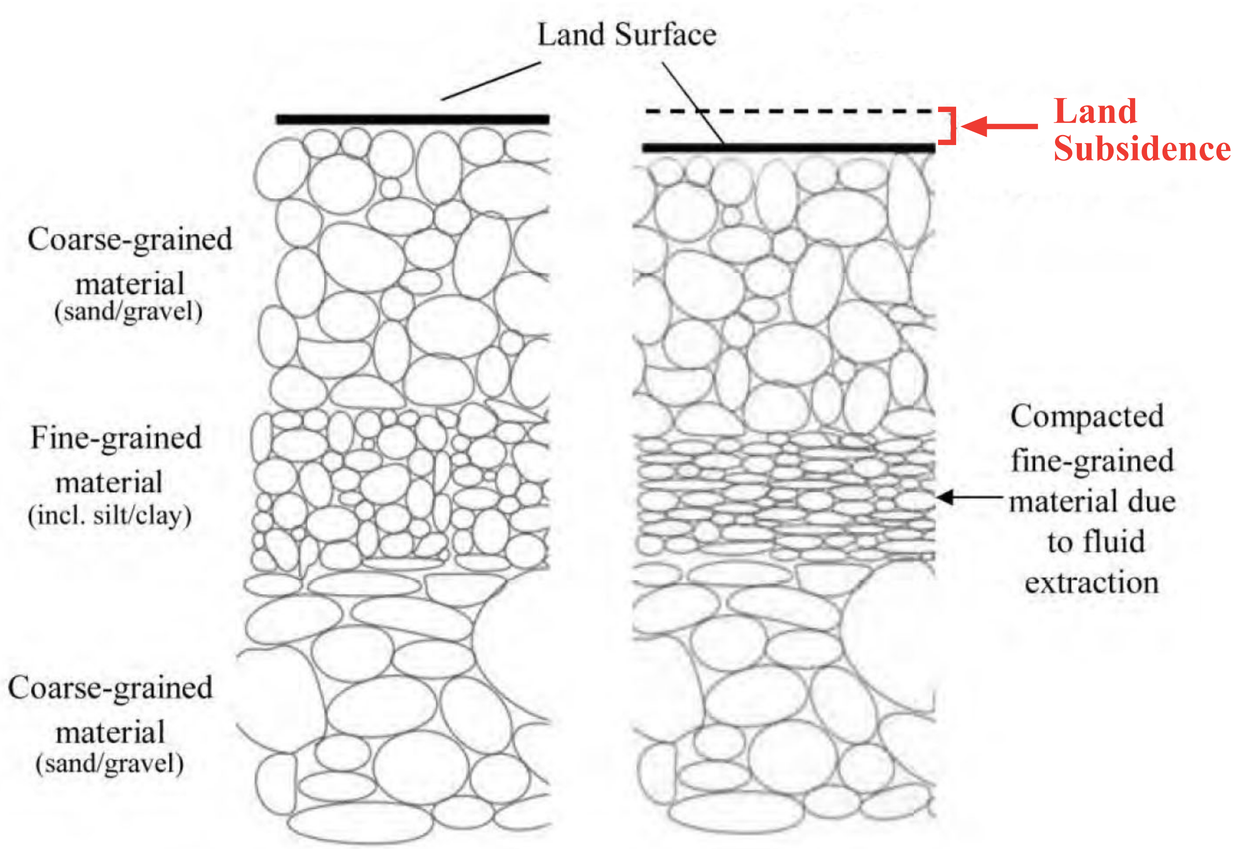
April 2019

TODD GROUNDWATER

Figure 3-35
Environmental Investigation and Cleanup Sites



Source: Galloway et al., 1999.

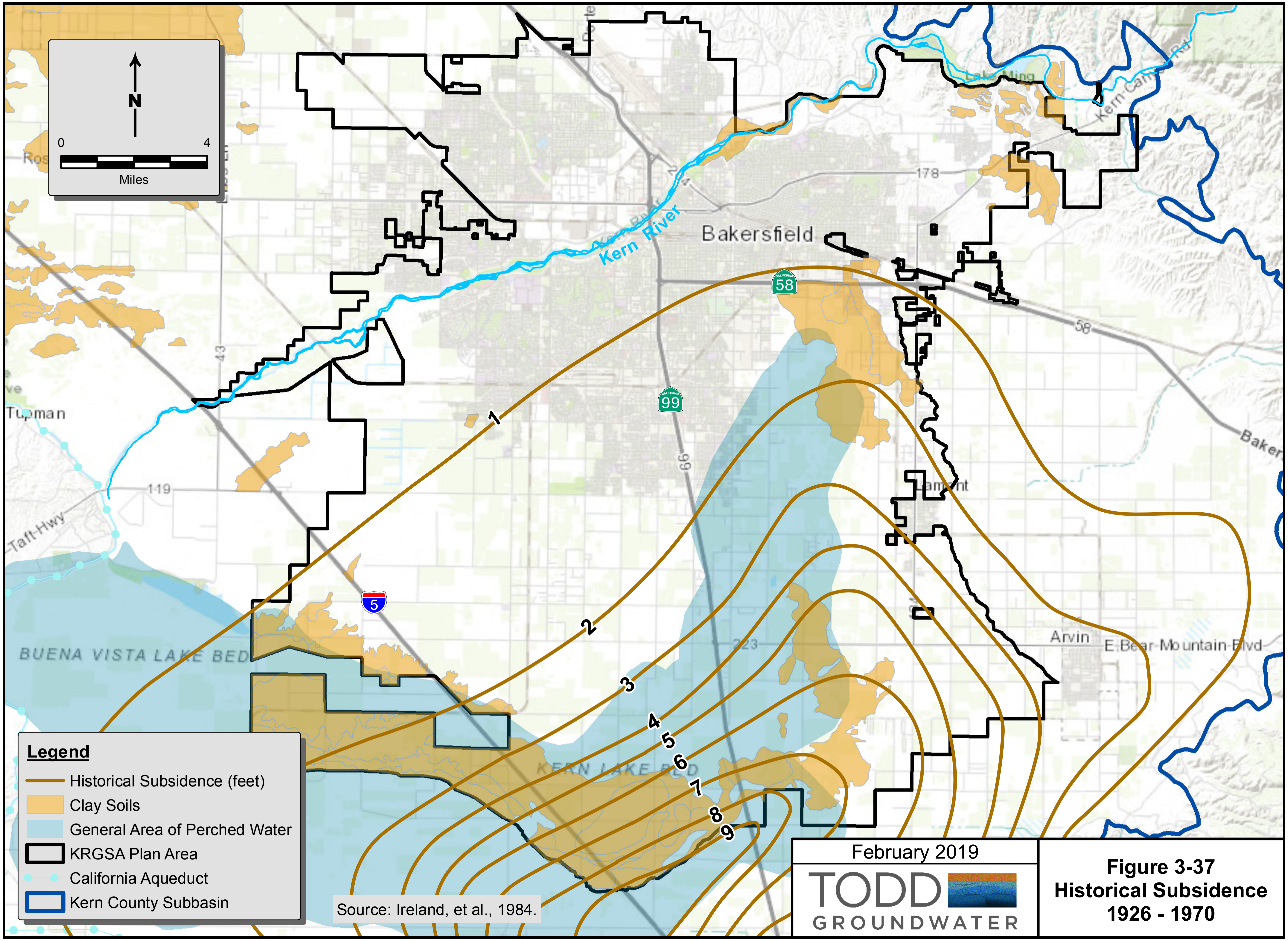


After LSCE et al., 2014.

March 2019

TODD GROUNDWATER

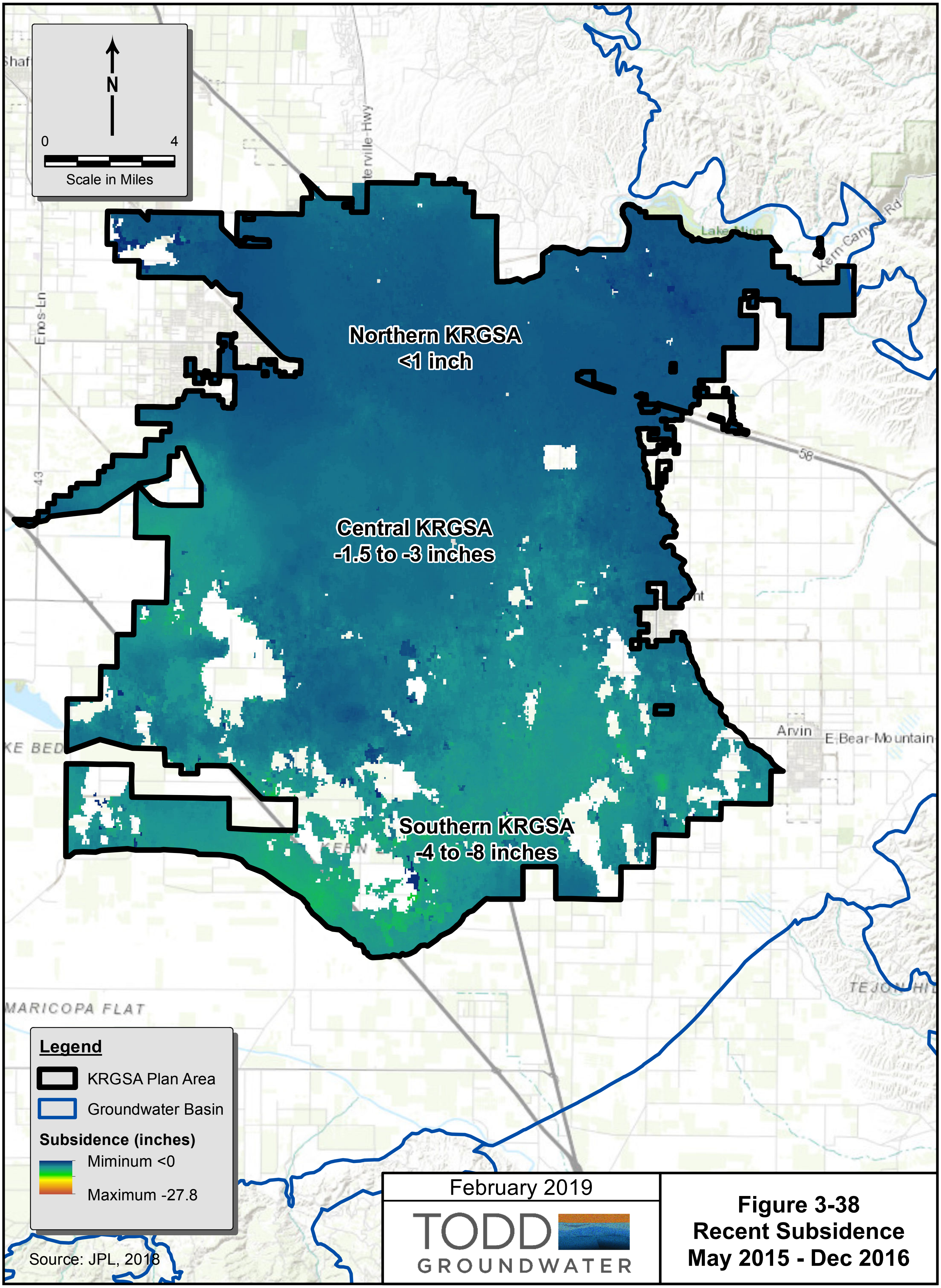
Figure 3-36
Concepts of Land Subsidence



February 2019

TODD GROUNDWATER

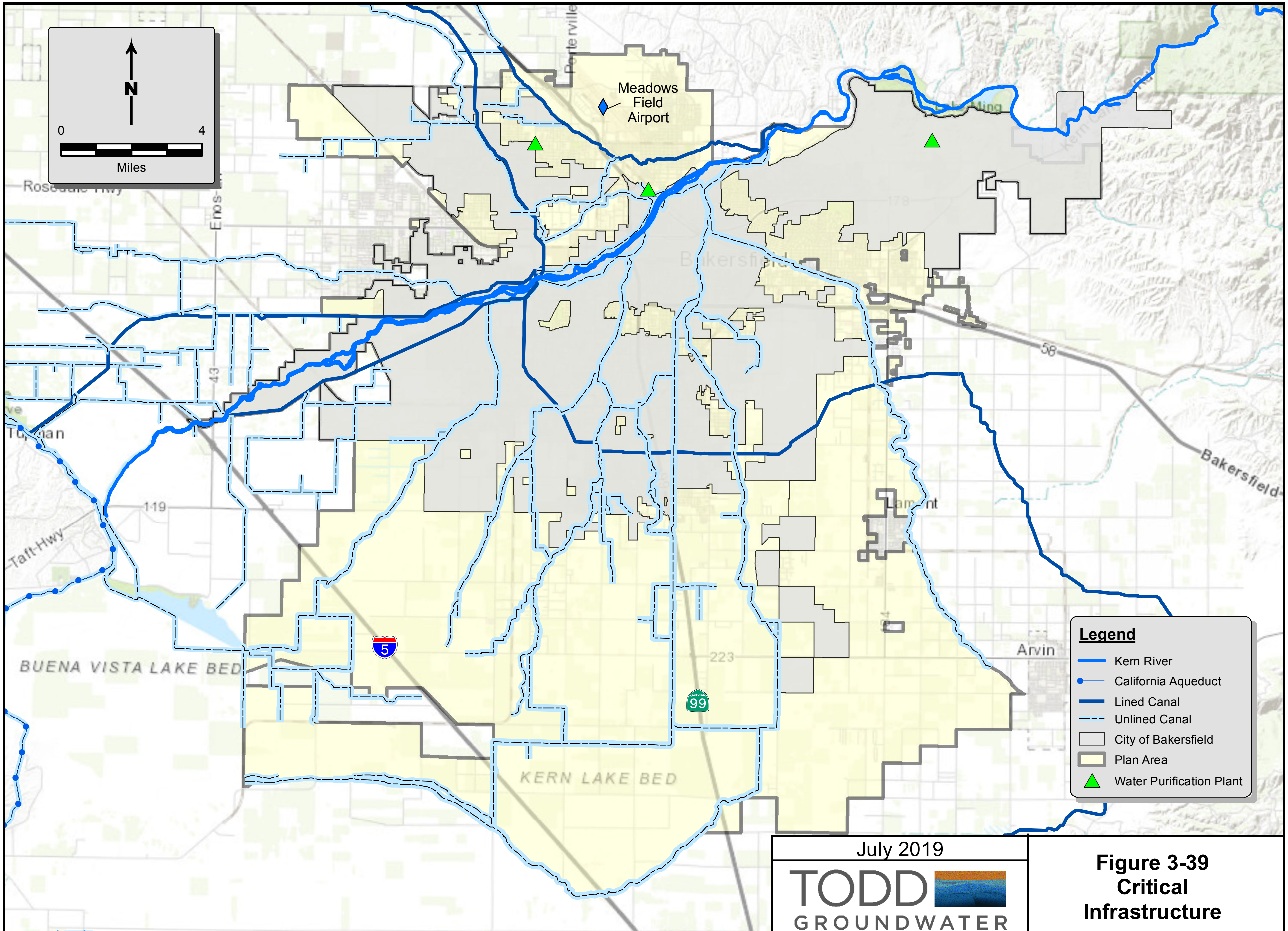
Figure 3-37
Historical Subsidence
1926 - 1970



February 2019

TODD GROUNDWATER

Figure 3-38
Recent Subsidence
May 2015 - Dec 2016



July 2019

TODD GROUNDWATER

Figure 3-39
Critical Infrastructure

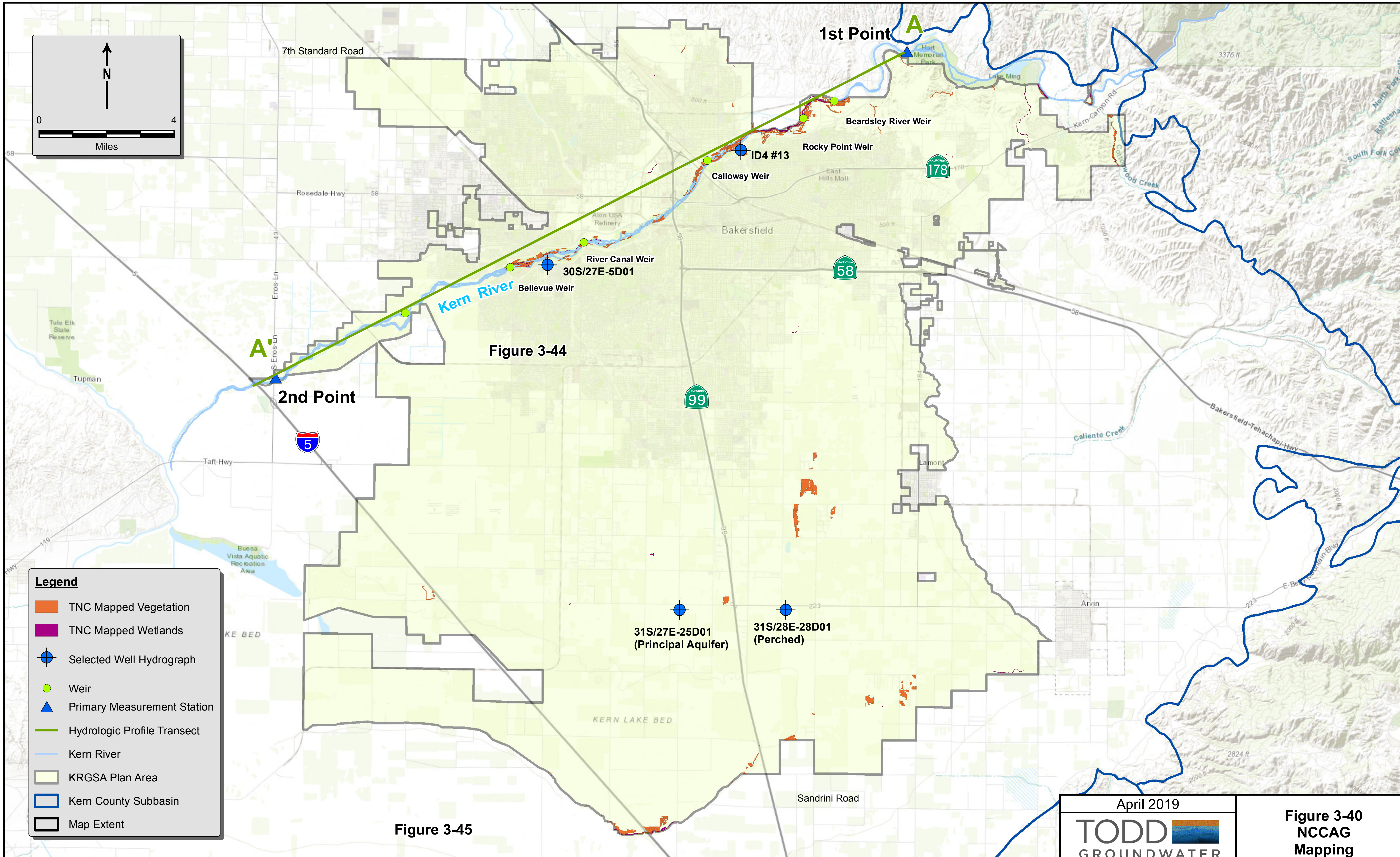
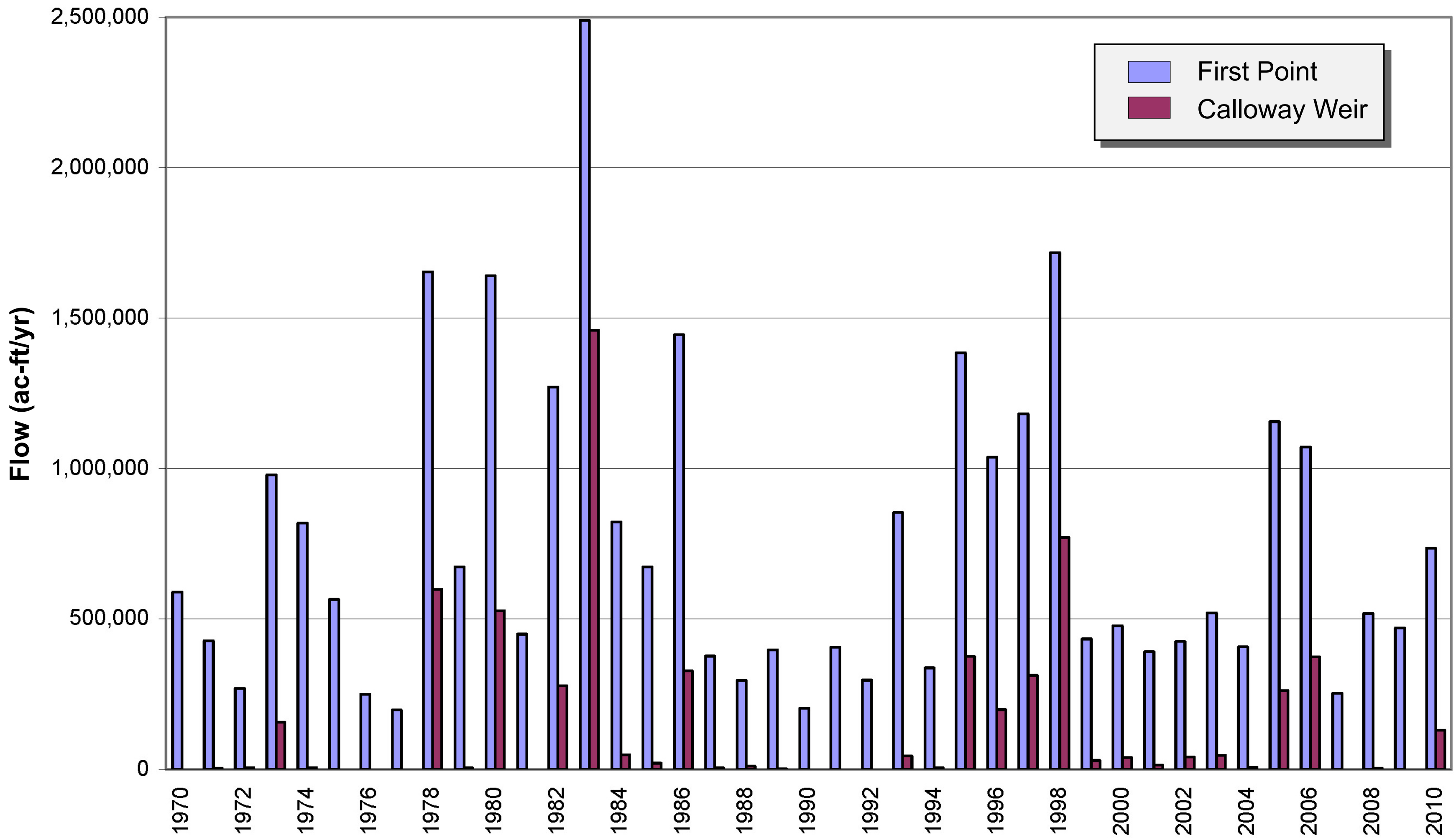


Figure 3-40
NCCAG Mapping

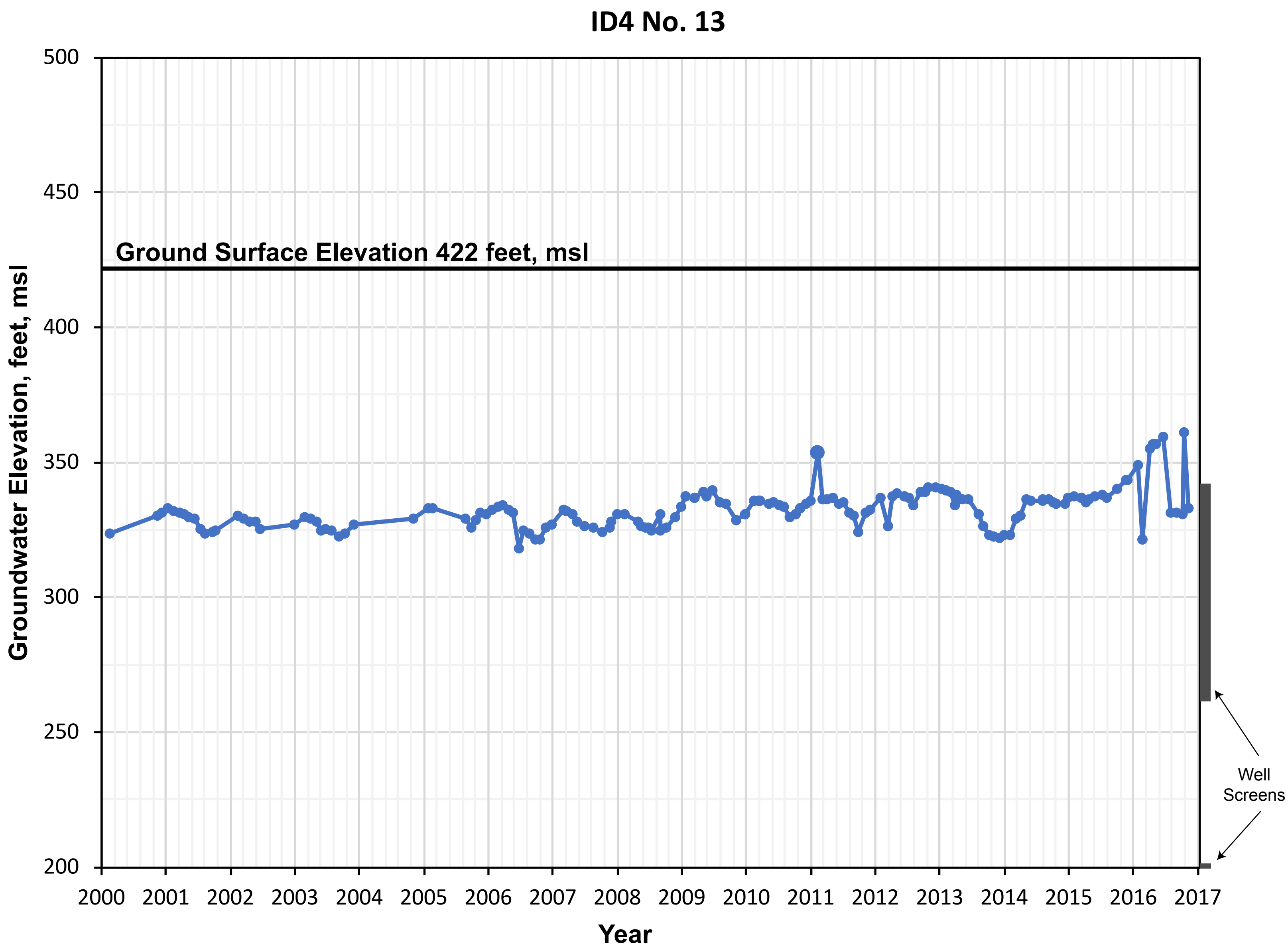


Source: DBS&A, 2012.

April 2019

TODD GROUNDWATER

Figure 3-41
Annual Flow at
First Point and Callloway Weir
1970 - 2010

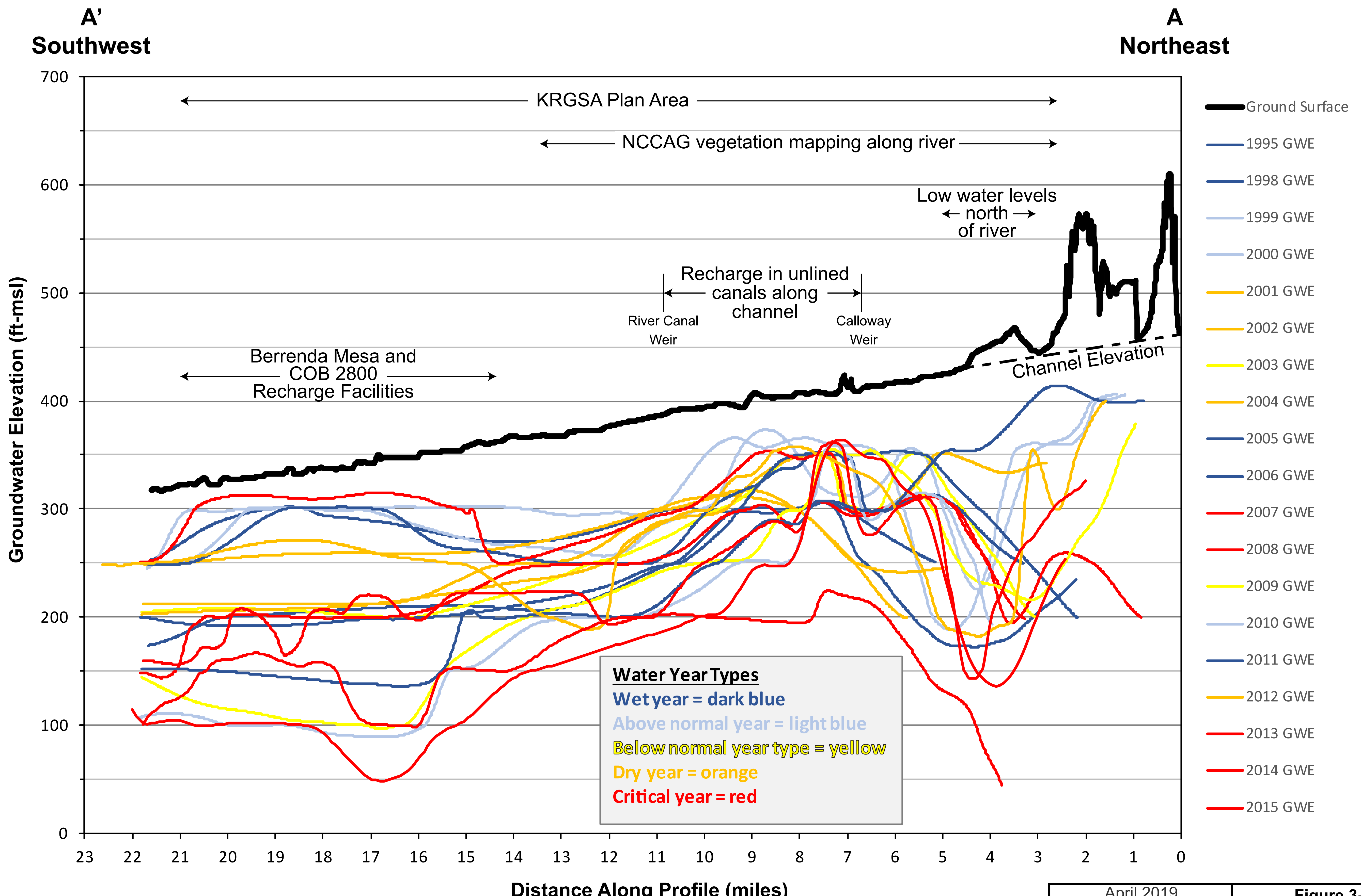


Screen Elevation: 262 to 342
-118 to 202

April 2019

TODD GROUNDWATER

Figure 3-42
Water Levels at the Calloway Pool



April 2019

TODD GROUNDWATER

Figure 3-43
Hydrologic Profiles Along Kern River 1995 - 2015

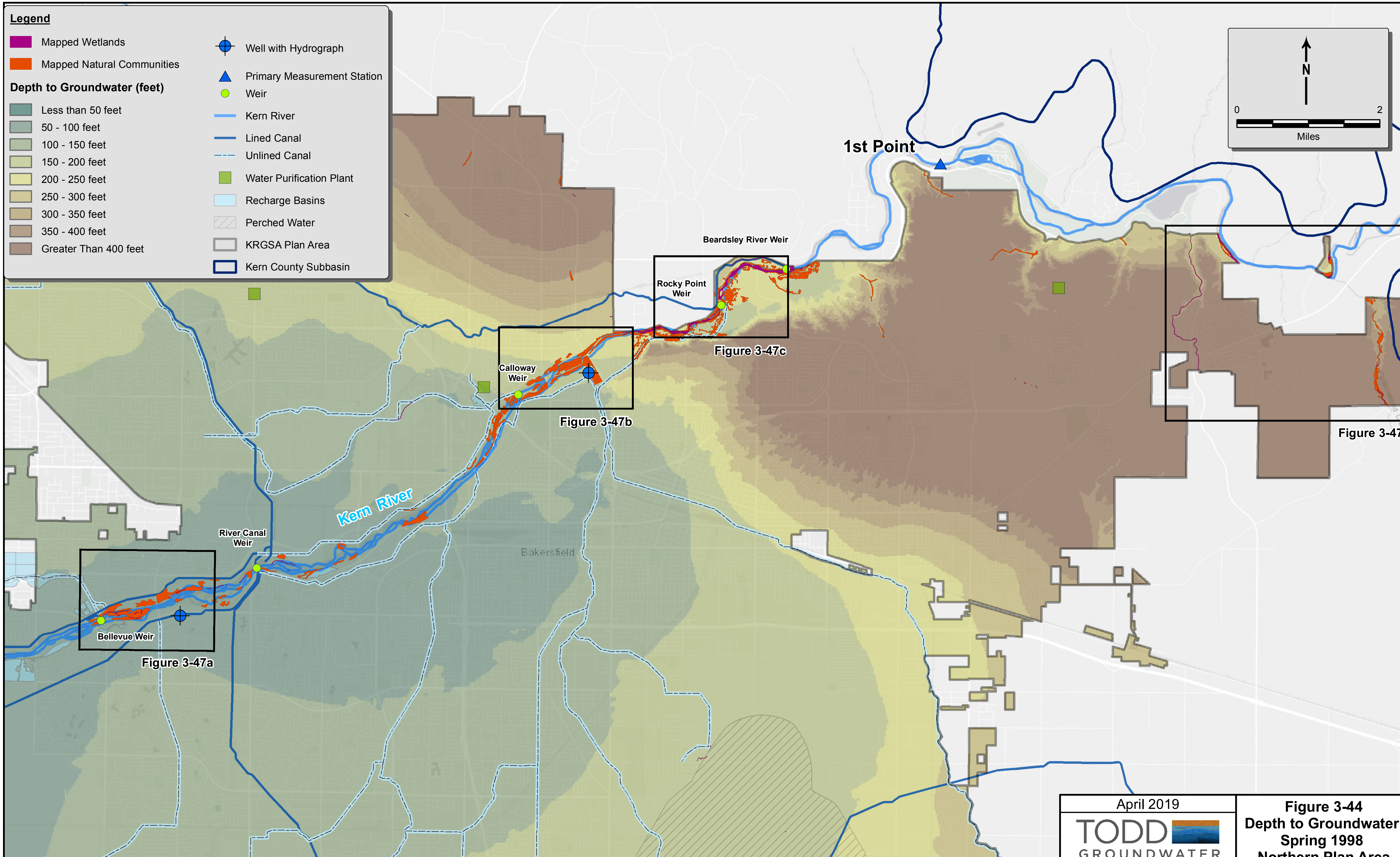


Figure 3-44
Depth to Groundwater
Spring 1998
Northern Plan Area

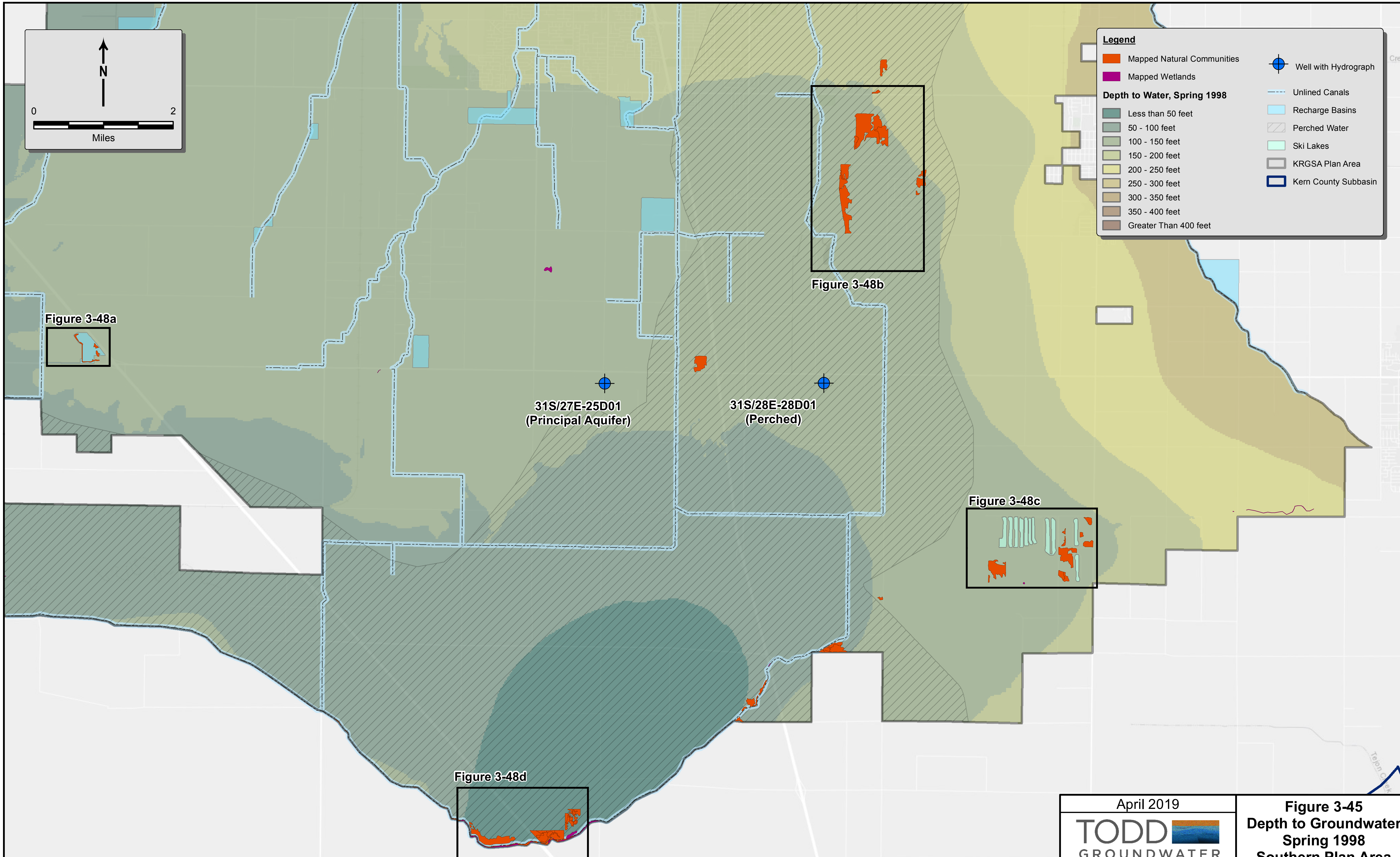
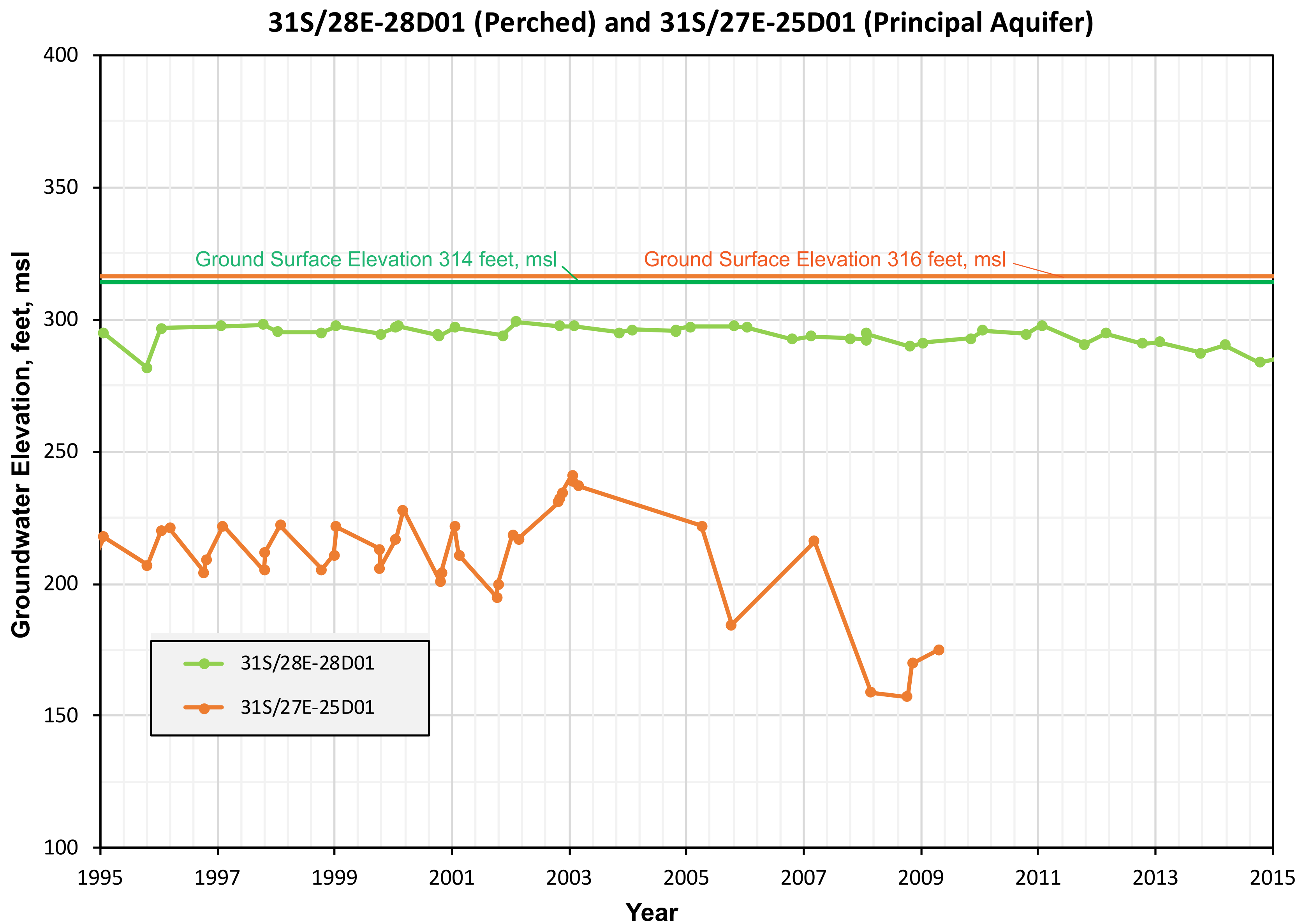


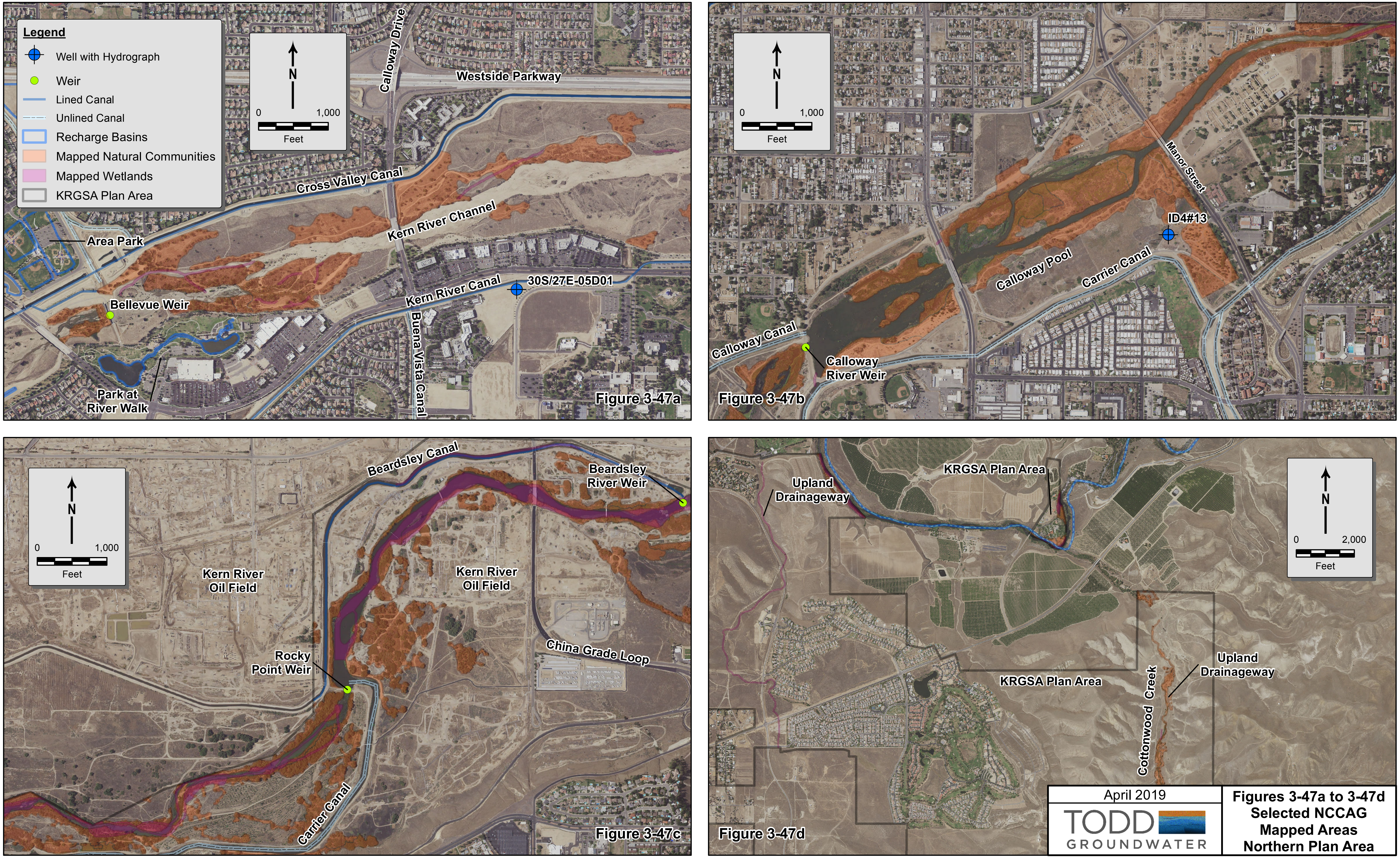
Figure 3-45
Depth to Groundwater
Spring 1998
Southern Plan Area



April 2019

TODD GROUNDWATER

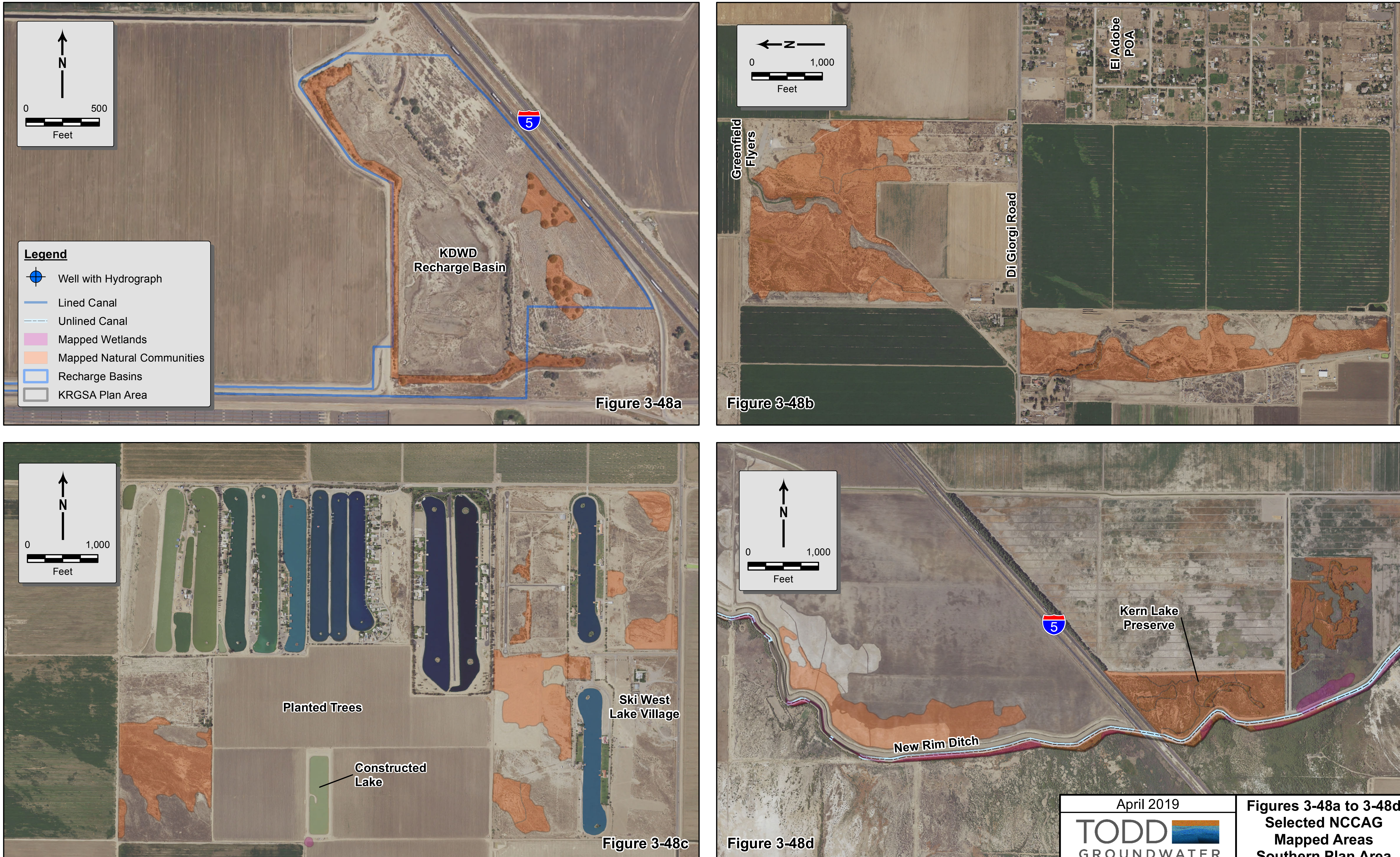
Figure 3-46
Perched Water
Southern Plan Area



April 2019

TODD GROUNDWATER

Figures 3-47a to 3-47d Selected NCCAG Mapped Areas Northern Plan Area



Figures 3-48a to 3-48d
Selected NCCAG
Mapped Areas
Southern Plan Area

4 WATER BUDGETS

Surface and groundwater budgets have been developed for the KRGSA Plan Area to quantify historical changes in the amount of groundwater in storage and to identify the amount of sustainable groundwater available for future use. In particular, reductions of groundwater in storage are estimated to assess the potential for undesirable results.

The water budget analysis presented herein allows the response of the physical groundwater system to be correlated to current and historical groundwater use. This analysis also provides the foundation for identifying potential future deficits of groundwater based on future projections of surface water supplies and demands. A primary objective of the groundwater budget analysis is to quantify historical, current, and projected groundwater deficits so that management actions can be identified to mitigate undesirable results attributable to potential groundwater deficits.

The groundwater budgets for the KRGSA Plan Area quantify inflows and outflows to the groundwater system and illustrate how these flows change over time. The annual difference between inflows and outflows represents the annual change of groundwater in storage beneath the Plan Area[29]. The analysis considers average historical conditions, current conditions, and future projections of these flows, incorporating GSP requirements and DWR guidance. Although the water budget balance is focused on the groundwater system, surface water supplies are also tabulated for the analysis.

4.1 WATER BUDGET APPROACH

The KRGSA Plan Area contains the largest urban area (Metropolitan Bakersfield) within the Subbasin, almost 15 percent of the Subbasin total irrigated agricultural acres, a major supplier of imported water, the largest natural water supply in the Subbasin (Kern River), and several of the large groundwater banking projects on the Kern Fan. KRGSA member agencies cooperatively manage a broad portfolio of water sources including imported water (SWP and CVP), Kern River water, stormwater, recycled water, and groundwater for beneficial use.

The approach to a water budget analysis for this large, multi-faceted area begins with an understanding of the local management operations that either recharge (inflow) or extract (outflow) groundwater in the KRGSA Plan Area. These and other inflows and outflows to the groundwater system were tabulated monthly to create a hydrologic inventory over the 20-year historical Study Period WY 1994 through WY 2014 and the one-year current Study Period WY 2015. These data were also used to support integrated surface water-groundwater modeling of historical, current, and future projected groundwater budgets.

[29] Multiple methods of analyzing the groundwater budget are employed in this analysis. One method conservatively excludes subsurface flows for planning purposes; this is more relevant to local deficits in supplies compared to demands than to physical changes of groundwater in storage.

4.1.1 Methods of Analysis

These and other data were used to analyze the KRGSA GSP water budgets. The approach to this analysis incorporates three independent methods to compare and corroborate water budget results, as summarized below.

1. ***Checkbook groundwater budgets*** were prepared to provide a detailed accounting of inflows and outflows for historical and current study periods. These data also support the development and analysis of projected future water budgets and are used to identify potential future deficits in sustainable groundwater supply. For planning purposes, this analysis does not consider subsurface flows and allows groundwater managers to focus on the inventory of water supplies that they each control and manage.
2. ***C2VSimFG-Kern model water budgets*** were developed using the DWR regional C2VSim model, which has been revised with Subbasin-specific water budget data to represent a local Subbasin model. Data from the checkbook method described above was used as input for model revisions and analysis of the KRGSA Plan Area. This analysis provided estimates of subsurface flows, which had not been included in the Checkbook method. Water budgets were analyzed on both a Subbasin-wide and Plan Area basis for historical and current study periods and over a 50-year planning horizon, which included climate change analyses for 2030 and 2070 climate change conditions, as required by GSP regulations. The Subbasin modeling was supported by all GSAs in the Subbasin for a coordinated and consistent analysis, which incorporated the same data and methodologies.
3. ***Electronic subtraction of annual groundwater elevation contour maps*** was conducted for the KRGSA Plan Area to provide an independent check of the changes in groundwater in storage over the historical and current study periods. Maps prepared in spring of each year by KCWA were used in the analysis to provide a consistent approach and incorporate similar data sets from year to year over the KRGSA Plan Area. This method allows for documentation of overdraft, if any, on an annual basis for a 20-year period as required by the GSP regulations for a critically over-drafted Subbasin. This analysis of change in groundwater in storage was described previously in **Section 3.3.3**, illustrated on **Figure 3-28**, and is referenced, but not repeated in this section on water budgets.

4.1.2 Water Budget Study Periods and Analysis Considerations

As discussed in **Section 3.1**, the historical Study Period (WY 1995 – WY 2014) was selected based on average hydrologic conditions (precipitation and Kern River flows), 20 years of satellite image-based evapotranspiration (ET) data, at least 10 years of coverage (as required by the regulations), overlap with the time period of the C2VSimFG-Kern model, and other criteria (see **Section 3.1**). WY 2015 was selected as the Study Period for current conditions as it represents the most recent available year in the C2VSimFG-Kern numerical model and immediately follows the historical Study Period.

As discussed previously (**Section 3.1**), it is recognized that the historical and current study periods end in the drought of record when then-current water levels were at or near historic lows. Ending a study period in the drought of record will almost always result in a cumulative decline of groundwater in storage from the beginning to the end of the period. However, such a cumulative decline does not necessarily indicate overdraft conditions. Regardless of when a study period begins or ends, the sustainable yield is more closely represented by average annual conditions rather than any one year or years that are analyzed sequentially and cumulatively. The annual, cumulative, and annual average change in groundwater in storage are all presented for the historical Study Period, with a focus on the average annual change in groundwater in storage for the sustainability analysis.

The initial development of the checkbook water budget focused on changes to the physical groundwater system within Plan Area boundaries to better link water budgets to local water levels. A complicating factor to that approach involved operations by both KRGSA and non-KRGSA agencies that recharge and recover groundwater inside the Plan Area for use outside the Plan Area. Although these actions affect the physical groundwater system in the Plan Area, not all inflows and outflows are available for local Plan Area use. Similarly, KRGSA member agencies also take advantage of groundwater banking opportunities adjacent to but outside the KRGSA for future use within the Plan Area. To make the water budgets more reflective of the Plan Area agencies' water portfolio, the checkbook water budget was adjusted to remove water attributable to others and to include outside water attributable to KRGSA. This alternative checkbook water budget is presented with other water budgets in this section.

It is recognized that the checkbook water budget approach does not account for subsurface flows into and out of the KRGSA Plan Area. KRGSA Plan managers, coordinating with KGA GSA managers, generally agreed that reliance on subsurface inflows by others – especially when it occurs from groundwater banking projects operated for the benefit of others – would not adequately reflect which areas were sustainable on their own. KGA, KRGSA, and other GSA managers have noted that the checkbook approach would be more suitable for local sustainability planning purposes.

Notwithstanding the need for the checkbook water budget approach, it is recognized that subsurface flows occur almost everywhere across the complex KRGSA Plan Area perimeter; furthermore, these flows are dynamic and change significantly over space and time. A more sophisticated method than the analytical checkbook approach is needed to quantify these flows. As such, the local C2VSimFG-Kern model is used to estimate these subsurface flows over time. Water Budgets, including subsurface flows, have been developed for the KRGSA Plan Area using the C2VSimFG-Kern model and are described in this section. A technical report describing model documentation, revisions, application, and the basin-wide water budget analysis is being incorporated into all GSPs for the Kern County Subbasin; that report is incorporated by reference herein as **Attachment 1**.

Types and sources of data used to develop the checkbook water budgets and also to provide input for the C2VSimFG-Kern local model are described in the sections below. The data descriptions are followed by an analysis of changes in groundwater in storage for historical and current Study Periods using the checkbook method and C2VSimFG-Kern model. Finally, future projected water budgets over a 50-year period are summarized including a projected baseline and projected conditions of climate change for 2030 and 2070 scenarios.

4.2 Inflows for Historical and Current Groundwater Budget

Surface inflows to KRGSA Plan Area groundwater occur primarily from conjunctive management of Kern River water, imported water (primarily SWP water), stormwater, and recycled water. Managed recharge in the River channel, unlined canals, and banking recharge facilities account for about two thirds of average groundwater inflows using the checkbook method. Additional recharge occurs over a broader area and includes deep percolation from precipitation, stormwater conservation, infiltration from irrigation with recycled water and wastewater percolation and return flows from agricultural and municipal uses. As explained above, subsurface inflows are quantified separately using the groundwater model and discussed in **Section 4.4**.

Annual average inflows of the checkbook method are summarized in **Table 4-1** for the historical Study Period (WY 1995 – 2014) and the current Study Period (WY 2015). As shown, average annual inflows to the groundwater system (excluding subsurface inflows) total 319,893 AFY. During the historical Study Period, inflows ranged from about 153,000 AFY in 2014 up to about 558,000 AFY in 2011. As shown in **Table 4-1**, inflows for the drought year of 2015 total 163,104 AFY, only about one-half of the average annual inflow.

Table 4-1: Groundwater Inflows, KRGSA Plan Area – Checkbook Method

Inflow Component	Historical Study Period (WY 1995 – 2014) Average Annual Inflows, AFY	Current Study Period (WY 2015) Annual Inflows AFY
Kern River Channel Recharge	69,779	8,447
Unlined Canal Recharge	77,820	60,145
Municipal Return Flows	9,949	8,773
Applied Irrigation Infiltration	33,133	31,151
Agricultural Return Flows	34,162	26,207
Deep Percolation of Precipitation	4,243	4,434
Stormwater Conservation	20,786	17,827
Wastewater Percolation	4,142	4,600
Groundwater Banking	65,879	1,520
TOTAL INFLOWS	**319,893**	**163,104**

Information on data and methodology used to estimate each inflow component is described in the following sections.

4.2.1 Kern River Channel and Canal Operational Recharge

The Kern River channel and local unlined canals are used for both conveyance and recharge of surface water resources in the KRGSA Plan Area including Kern River water, imported water, and stormwater runoff diverted to the channel and canals. The City of Bakersfield operates the River channel and has agreements with other agencies for banking directly in the permeable sands of the unlined channel, including through conveyance of water to more formal banking areas. Unlined canals are also maintained and used for recharge and are purposefully kept unlined to allow recharge to occur over a broad area of the KRGSA. During the non-irrigation season, River water is often released into canals for recharge only, which serves to supplement recharge basins and banking projects. This strategy has been implemented by KRGSA agencies and is a key component of the KDWD Water Allocation Plan (WAP), adopted in 2018 (KDWD, 2011), along with City polices and projects (**Sections 7.1.1** and **7.1.2**). The Kern River channel and unlined canals in the KRGSA Plan Area are shown on **Figures 3-11** and **3-12**.

As discussed previously, flows are measured along the River channel, at diversion points, and along canals. Seepage losses in the channel and canals are calculated and recorded monthly in each Kern River Annual Hydrographic Report. Additional daily documentation is used by the City of Bakersfield to provide historical monthly flows attributable to each agency using the channel for conveyance and recharge. For this project, flow data from the City were summed and compared to measured monthly and annual totals in the Annual Hydrographic Reports to avoid double counting.

During the historical and current Study Periods, the City, ID4, KDWD, KCWA and other agencies recorded operational losses in the Kern River channel involving regulated flows between First Point and Second Point. Measured losses were corrected for water use by riparian vegetation along the River channel to estimate groundwater recharge. Riparian water use amounts for various hydrologic conditions (wet, dry, and average years) were derived from a separate study by Daniel B. Stephens and Associates (DBS&A, 2012) for defined reaches along the Kern River. These factors were used to estimate a percentage of total flow per reach consumed by riparian vegetation ET and were applied based on water year type to the measured flow of each reach.

As shown on **Table 4-1** above, the annual average recharge in the Kern River channel for the KRGSA is estimated at 69,779 AFY for historical conditions. About 86 percent of this recharge was attributable to KRGSA member agencies, mostly to ID4 and the City. An additional 12 percent was recharged in the channel by KCWA and the remaining 2 percent represented conveyance recharge by other agencies. This total does not include recharge in the banking projects located along the River channel, such as the COB 2800 recharge facilities or Berrenda Mesa, which are evaluated separately in **Section 4.2.7**.

Some of the recharge associated with the channel involves imported water. For example, KCWA may use the River channel to recharge and store excess imported water outside of designated banking projects. Recharge in the Kern River channel by ID4 represents both local storage of imported water and conveyance of Kern River water to the Henry C. Garnett Water Purification Plant (HCG WPP) through exchanges with Kern River interests. Monthly recharge in the Calloway Pool and along the Calloway

Canal attributable to ID4 exchange water is summarized separately in the Kern River Annual Hydrographic Reports beginning in 1997. For 1995 and 1996, recharge attributable to ID4 was estimated from the Calloway Operations Report in the hydrographic reports.

Data on operational recharge along unlined canals were obtained from the Kern River Annual Hydrographic Reports, the annual Report of Water Conditions (ROWC) developed by ID4, and supplemental sources provided by KDWD, the City, and ID4. Canal recharge occurring in the KRGSA Plan Area was estimated monthly for the Calloway Canal (portions in the KRGSA only), Carrier Canal, Kern Island Canal, Eastside Canal, Stine Canal, Famers Canal, Buena Vista Canal, and unlined portion of the Cross Valley Canal (CVC). As shown on **Table 4-1** above, the annual average recharge along unlined canals in the KRGSA Plan Area is estimated at 77,820 AFY.

4.2.2 Municipal Return Flows

A portion of municipal water applied as urban irrigation (e.g., lawns, parks, urban landscaping) and for other outdoor purposes infiltrates below the root zone and results in groundwater recharge; because most of this water is sourced from the groundwater system, this recharge component is referred to as municipal return flows. Although some portion of this water represents deep percolation of irrigation sourced from either imported or local surface water, all municipal uses resulting in recharge are included in municipal return flows to simplify the calculations.

The percent of municipal water used outdoors, average ET rates, and the resulting return flows were estimated on a monthly basis over the historical and current study periods. Consistent with information from the Bakersfield area, 50 to 70 percent of municipal supply is assumed to be used outdoors for some purpose. Further, it is assumed that 12 to 16.8 percent of the outdoor use (or 6 to 8.4 percent of total applied irrigation depending on the month) recharges the aquifer as return flow. Municipal return flows were estimated for the City and Cal Water Service Areas as well as the smaller water systems including ENCSD, OMWC/NORMWD, Vaughn MWC (portions in the KRGSA Plan Area), Greenfield CWD, and portions of Lamont PUD. Additional return flows from other smaller water systems, MWCs, and private pumpers in the ID4 service area (except for agricultural pumping which is considered separately) were also included in this water budget category based on pumping estimates reported to ID4. Total municipal return flows are estimated at 9,949 AFY on an average annual basis (see **Table 4-1** above).

4.2.3 Applied Surface Water Infiltration and Agricultural Return Flows

Both applied surface water infiltration and agricultural return flows refer to the portion of agricultural irrigation that is applied in excess of the evapotranspiration (ET) of the crop (overapplication) and subsequently percolates to the groundwater system. Applied irrigation infiltration occurs with overapplication of local surface or imported water (primarily the Kern River or SWP water); agricultural return flow refers to overapplication of groundwater. Although these two inflow components result from the same process in the same area, they are calculated separately because the deep percolation of local surface or imported water represents a new water source to the groundwater system.

Overapplication of groundwater simply returns some component of groundwater back to the groundwater system.

The amount of irrigation that is applied in excess of the crop ET is related to both the irrigation method and the permeability of the soils. This overapplication is also referred to as irrigation efficiency. An irrigation efficiency of 80 percent indicates that an extra 20 percent is applied above the crop ET to ensure that crop ET is satisfied. For the purposes of this checkbook water budget, these inflow components also incorporate any natural precipitation in the agricultural irrigation areas that percolates to groundwater.

The ET crop demand in agricultural areas was estimated based on monthly satellite imagery processed with METRIC, a procedure developed at the University of Idaho and applied by the Irrigation Training and Research Center (ITRC) of California Polytechnic State University (Cal Poly) (Burt, 2016). METRIC ET data were developed for the entire Kern County Subbasin from 1993 through 2016 (Howes, 2018) and have been incorporated into the C2VSimFG-Kern local surface water-groundwater model. For the checkbook method, average ET data were analyzed for the KRGSA independent of the local model.

Parcels with an ET of more than 20 inches per year were assumed to be irrigated lands and incorporated into the analysis. Areas near the City of Bakersfield were reviewed to remove any large parcels irrigated by municipal sources (cemeteries, golf courses, parks, etc.) and already incorporated in municipal return flows.

Parcel ET values for agricultural irrigated lands were summed monthly for the KRGSA Plan Area and an irrigation efficiency of 80 percent was applied to develop agricultural irrigation infiltration/agricultural return flows. As such, these inflow components are estimated at approximately 20 percent of the METRIC crop demand. Although actual irrigation efficiencies are unknown and expected to vary throughout the KRGSA Plan Area and over time, an average irrigation efficiency of 80 percent was determined to be sufficient for the checkbook water budget. Previous analyses by KDWD suggest average efficiencies of about 80 percent for the southern Plan Area where most of the irrigated agriculture occurs (see **Figure 2-9** for irrigated agriculture in the Plan Area).

It is recognized that return flows do not recharge groundwater immediately upon application of irrigation and require variable transport times through the unsaturated zone based on sediment permeability and depth to groundwater. For simplification, no transport time is assumed for the checkbook water budget and the infiltration/return flows are assumed to recharge groundwater within the same month as the associated crop ET.

This approach resulted in an estimate of 33,133 AFY of applied local surface water/imported water providing groundwater recharge on an average annual basis (**Table 4-1** above). The analysis of agricultural return flows indicates about 34,162 AFY of applied groundwater returning to the groundwater system (**Table 4-1**).

4.2.4 Recharge from Rainfall (Non-agricultural areas)

Deep percolation of precipitation on undeveloped, non-irrigated lands was estimated at eight percent of monthly precipitation. These undeveloped areas were identified using monthly METRIC satellite imagery and included natural areas with a total ET of less than 20 inches per year. Deep percolation on these areas is estimated at about 4,243 AFY on an average annual basis (**Table 4-1**). Percolation of precipitation in irrigated agricultural areas is included in agricultural return flows discussed above. Precipitation in the urban areas is incorporated into the estimates of stormwater runoff and conservation described below.

4.2.5 Stormwater Conservation

The City of Bakersfield and Kern County operate a storm drainage system that serves urbanized areas of the City and County enclosed within or surrounding the City limits. The system includes open storm drain channels, closed pipes, and stormwater basins (referred to in local stormwater plans as sumps). This storm drainage system serves an area designated as the Bakersfield Urbanized Area (which also includes some undeveloped lands) and is operated under a RWQCB Waste Discharge permit (December 2013).

The Bakersfield Urbanized Area covers about 88,576 acres and includes 322 stormwater basins (RWQCB, 2013). The stormwater basins are dispersed throughout the area and collectively cover approximately 534 acres. Locations of the larger stormwater basins are shown on **Figure 3-12**. Stormwater runoff from this area is conveyed either to the stormwater basins, to the East Side, Carrier, Stine, or Kern Island canals, or to the Kern River channel (RWQCB, 2013). Stormwater flows into the canals either directly or indirectly via detention basins/outfalls. KDWD works cooperatively with the City and County to direct local stormwater to nearby unlined canals to maximize recharge.

As indicated in the RWQCB Permit (2013), approximately 80 percent of the Bakersfield Urbanized Area discharges stormwater runoff to the stormwater basins. The remaining 20 percent of the area drains to the Kern River or nearby canals. The City has estimated that approximately 90 percent of the average annual stormwater runoff is retained in these stormwater basins for groundwater recharge (Carollo, 2015). The remaining 10 percent is discharged directly to a receiving water (Kern River and/or groundwater) or is detained in a basin and then discharged (RWQCB, 2013). These unlined stormwater basins are generally located on highly permeable soils and are maintained to function as recharge basins.

These conditions predict that approximately 72 percent of the runoff from the Bakersfield Urbanized Area would infiltrate to groundwater. Once in a stormwater basin, any standing stormwater would be subject to some evaporation, but given the nature of the soils, the maintenance of the basins, and the assumption that stormwater is generated during relatively low ET conditions, evaporation is assumed to be small. Accordingly, this methodology assumes that 72 percent of the Bakersfield Urbanized Area runoff is available for groundwater recharge (i.e., 80% of runoff to stormwater basins x 90% retained for recharge = 72% of the runoff is recharged).

To estimate the amount of stormwater runoff, it was assumed that about 50 percent of the area connected to the storm water system is impervious and that all of the rainfall on this impervious area runs off into the storm water system. The remaining rainfall either infiltrates or is lost to evapotranspiration or evaporation. To estimate monthly recharge from the stormwater basins, monthly rainfall measured at the Bakersfield Airport station (#040442) was multiplied by the percentage of rainfall on the Bakersfield Urbanized Area that is estimated to runoff to the basins and recharge (i.e., 72 percent x 50 percent).

Applying this methodology results in about 16,514 AFY of stormwater runoff being recharged in stormwater basins on an average annual basis. With 20 percent of the stormwater runoff being directed to the River and canals, an additional 4,272 AFY is estimated to be conserved in the River and unlined canals. These two components indicate a total of 20,786 AFY of stormwater from the urbanized areas is being recharged in the KRGSA Plan Area on an average annual basis (see **Table 4-1** above).

4.2.6 Wastewater Discharge

Discharge operations and WWTP activities within the KRGSA Plan Area were reviewed for potential re-use and/or inflows pertinent to the groundwater budget. Multiple wastewater treatment plants (WWTP) are located in the KRGSA, two of which are owned and operated by the City (see information in **Section 2.4.4** and **Table 2-1**). Effluent from the Kern Sanitation Authority and North of the River Sanitary District is recycled for crop irrigation in portions inside and outside of the KRGSA; these flows already are accounted as recharge from surface water application for irrigation as described in **Section 4.2.3** and are not double-counted here. Wastewater collected by CSA-71 is conveyed to other WWTPs for treatment. Wastewater infiltration from individual septic systems occurs in the Plan Area; amounts are unknown but are likely to be negligible compared to the other water balance components and have not been estimated.

The water budget focuses on the two city-owned wastewater treatment plants – Wastewater Treatment Plant No. 2 (WWTP No. 2) and Wastewater Treatment Plant No. 3 (WWTP No. 3) – which generally serve areas east of Highway 99 and west of Highway 99, respectively (City of Bakersfield, 2018). Until 2017, all wastewater flows from East Niles CSD were also treated at WWTP No. 2; up to about 10 percent of these flows are now diverted to Kern Sanitation Authority (KSA) with the remainder continuing to be treated at WWTP No. 2. Monitoring of WWTP discharges and quality is regulated by the Central Valley Water Board.

4.2.6.1 City of Bakersfield WWTP No. 2

WWTP No. 2 has a design capacity of 25 million gallons per day (mgd) with a current average daily flow of 13.7 mgd (City of Bakersfield, 2018). Secondary effluent is discharged to nine plant reservoirs for subsequent irrigation of about 447 acres of City-owned fields leased for agricultural use. The leased lands are located south of the WWTP and extend into KDWD. For the water budget, wastewater effluent from WWTP No. 2 already is accounted as an additional surface water source for irrigation, consistent with the methodology described in **Section 4.2.3** above. The plant reservoirs are lined and are not associated with groundwater recharge.

4.2.6.2 City of Bakersfield WWTP No. 3

WWTP No. 3 provides primary, secondary, and tertiary treatment. The plant has a design capacity of 32 mgd and a current average daily flow of 17.3 mgd (City of Bakersfield, 2018). Beginning in 2010, tertiary effluent has been used for landscape irrigation at the plant and at the adjacent State Farm Sports Village, a local soccer and football complex. Secondary treated, denitrified effluent is discharged to four onsite ponds for groundwater recharge. In addition, the City exports recycled water to agricultural lands outside its service area for irrigation. The irrigated lands, referred to as Green Acres Farm, are owned and operated by the City of Los Angeles, and are located partially inside and partially outside the KRGSA Plan Area. When irrigation demands are low in the winter, the recycled water is discharged into the four onsite ponds for storage and percolation.

The City provided monthly effluent flow data for 2000 through 2016. Annual effluent flows for 1986 through 1999 were estimated using population growth trends and a typical per capita effluent flow rate. The estimated annual flows were divided evenly over each 12-month period.

For 1989 through 2016, a portion of the effluent discharged between February and September was provided directly to Green Acres Farm for irrigation. From October through January, effluent was stored first in onsite ponds (up to a percolation rate of 900 AF/month) and then provided to Green Acres Farm. For the water budget, irrigation was prorated to reflect the approximately 28 percent of the farm that lies within the KRGSA Plan Area and this prorated portion was accounted in the applied surface water infiltration component described in **Section 4.2.3**. Pond recharge was calculated on a monthly basis less a six percent evaporation loss to determine remaining wastewater provided to the farm.

In sum, effluent used for surface water irrigation is already accounted in the applied surface water infiltration component described in **Section 4.2.3**. The remaining water budget component is the amount of recharge occurring in the unlined recharge ponds at WWTP No. 3. An analysis of the total effluent data indicates an annual average recharge of approximately 4,142 AFY in the ponds (**Table 4-1**).

4.2.7 Additional Managed Recharge and Groundwater Banking Projects

As discussed throughout this GSP, managed recharge and conjunctive use represent core operations of the KRGSA member agencies. In addition to the ongoing recharge associated with the Kern River channel and canals, more formal groundwater banking projects occur throughout the KRGSA Plan Area.

Over the last four decades, the City of Bakersfield has operated its COB 2800 Recharge facility along a 5.5 mile reach of the Kern River above Second Point (see **Figure 3-11**). The facility has 13 recharge basins with a total capacity of more than 150,000 AFY. Over the 20-year historical Study Period, recharge in this facility alone has averaged 37,606 AFY. The City, ID4, and KCWA have all banked water in the 2800 Recharge facility during the 20-year Study Period.

An additional groundwater banking project, Berrenda Mesa, lies just upstream of the 2800 Facility (see **Figure 3-11**) and consists of six recharge basins. Managed by KCWA, pursuant to an agreement with Berrenda Mesa Water District, the recharge project provides storage and recovery of primarily imported water for use by participants in the northwestern Subbasin outside the KRGSA Plan Area. Over the historical Study Period, water was recharged in Berrenda Mesa 13 of 20 years; recharge events have ranged up to about 29,000 AFY with a 20-year annual average of 9,221 AFY. Nearby Wilson Ditch, located just upstream of Berrenda Mesa, is located in a wide portion of the Kern River channel and used to convey water to these two banking projects. The sandy River bottom along the Wilson Ditch provides for excellent recharge and this area is considered part of the KRGSA banking facilities.

In addition to the managed recharge along the Kern River Channel, the City also operates smaller recharge facilities, generally consisting of lakes in City parks, for groundwater banking and other purposes. Three small lakes south of the River along the Kern River Parkway and Truxtun Avenue, referred to as Truxtun Lakes, are used by both the City and ID4 for groundwater recharge and operational purposes. During the 20-year historical Study Period, the lakes were used to recharge up to about 6,000 AFY (1998), with additional capacity added since that time. Small recreational lakes are also used by the City and ID4 for recharge at Aera Park (Rio Vista Lake) and The Park at River Walk, both located along Stockdale Highway, north and south of the River, respectively. Collectively these lakes are capable of recharging up to about 1,000 AFY. The City also operates the Kern River Canal and Irrigation (KRC&I) canal for recharge of about 1,500 AFY in areas north of the Kern River.

In the southern KRGSA Plan Area, KDWD operates groundwater banking facilities for banking partners including Metropolitan Water District of Southern California (Metropolitan) and San Bernardino Valley Municipal Water District (Valley). KDWD facilities include more than 1,000 acres of recharge basins throughout and adjacent to the KDWD service area. The Metropolitan banking agreement allows the agencies to store up to 50,000 AFY beneath KDWD with a maximum storage amount of 250,000 AF. The Valley agreement allows for a one-time delivery of 30,000 AF with a maximum recovery of 5,000 AFY (about 11,300 AF remaining in the account). An 11 percent conveyance loss is retained by KDWD in both agreements. Since the program began in 2003, KDWD has stored approximately 160,000 AF for banking partners.

The City, ID4 and KCWA provided groundwater banking data for use in the checkbook water budget. Banking of Kern River water by the City and ID4 were also available in the Kern River Hydrographic Reports. KDWD provided monthly data on the banking operations in the southern KRGSA Plan Area. Additional small amounts of recharge by Kern Sanitation Agency, Rosedale Ranch and others are also grouped into this inflow component. Those data were provided by the individual agencies. Additional duplicate sources were checked to avoid double counting of the large amounts of recharged water including the River channel (**Section 4.2.1**), canals (**Section 4.2.1**), and groundwater banking facilities.

As shown on **Table 4-1** above, groundwater banking recharge results in about 65,879 AFY on an annual average basis. During the Study Period, recharge associated with the groundwater banking facilities ranged up to about 200,000 AFY. The additional banking capacity that has been added to the KRGSA in recent years would allow for much more water to be banked during future wet years.

4.3 OUTFLOWS FOR HISTORICAL AND CURRENT GROUNDWATER BUDGET

Outflows from the groundwater system beneath the KRGSA Plan Area include groundwater pumping and subsurface outflows. Consistent with the checkbook water budget method, subsurface outflows are not quantified and not discussed in this section. Rather, subsurface flows are estimated with the C2VSimFG-Kern numerical model and provided in **Section 4.4**. Outflows quantified in this section include pumping for municipal, agricultural, banking recovery, industrial/domestic, and other water supply purposes.

Average annual outflows for KRGSA Plan Area using the checkbook method are summarized in in **Table 4-2** for the historical Study Period (WY 1995 – 2014) and current conditions (represented by 2015). As shown in the table, the average annual outflows (pumping) for the KRGSA Plan Area checkbook total about 321,871 AFY. Outflows during the critically dry year of 2015 total 401,177 AFY - about 25 percent higher than the average – reflecting an overall increase in agricultural and recovery pumping to supplement a decrease in surface water supplies.

Agricultural pumping is estimated at 175,668 AFY and represents about 55 percent of the total groundwater production. Municipal pumping of about 109,966 AFY is about 34 percent of the total. An additional 8 percent of pumping is conducted to recover banked groundwater. Remaining outflows include pumping from small water systems and private industrial and domestic wells (**Table 4-2**).

Table 4-2: Groundwater Outflows, KRGSA Plan Area – Checkbook Method

Outflow Component	Average Outflows, AFY (WY 1995 – 2014)	Annual Outflows AFY (WY 2015)
Agricultural Pumping	175,668	196,859
Municipal Pumping	109,966	96,390
Small Water Systems/Private Pumping	9,038	7,201
Banking Recovery Pumping	27,199	100,727
TOTAL AVERAGE OUTFLOWS	**321,871**	**401,177**

Data and methodologies for estimating the pumping components listed above are described in the following sections.

4.3.1 Agricultural Groundwater Pumping

This outflow component includes pumping for irrigation of agricultural crops in the KRGSA Plan Area and totals 175,668 AFY on an average annual basis (**Table 4-2**). Agricultural crop lands for the KRGSA Plan

Area in 2016 are shown on **Figure 2-9**. Although groundwater pumping for agricultural irrigation occurs throughout the KRGSA Plan Area, about 87 percent occurs in the KDWD Service Area; the remaining 13 percent occurs mostly in the northwestern Plan Area (e.g., in Rosedale Ranch ID) but also occurs on smaller isolated parcels in Greenfield CWD, Lamont PUD, and other areas. In general, these smaller irrigated areas have declined over the historical Study Period. For example, during the first 10 years of the historical Study Period (WY 1995 – 2004), agricultural pumping in the KRGSA Plan Area outside of KDWD averaged about 26,000 AFY, with several years exceeding 30,000 AFY. Since 2009, annual average pumping for non-KDWD areas has decreased to about 16,000 AFY (data through 2016).

Pumping for agricultural irrigation was estimated by first calculating the total crop demand for irrigated acres in the Plan Area. Crop demand (ET) was estimated analytically from the monthly METRIC data from satellite imagery provided by the ITRC, Cal Poly (see **Section 4.2.3**). A total ET threshold of more than 20 inches per year was used to differentiate parcels with agricultural irrigation from parcels of native vegetation.

The total crop ET demand was corrected using an irrigation efficiency of 80 percent to estimate the total applied irrigation water needed to satisfy the crop demand (i.e., the volume of water applied in excess of the crop ET; see discussion on irrigation efficiency in **Section 4.2.3** above). This correction increased the total crop demand value by 20%, resulting in an applied water demand of 120% of the analytically-derived crop ET.

Precipitation was used to first satisfy the applied water demand if rainfall occurred in sufficient amounts during the irrigation season. For the purposes of the water budget, precipitation that satisfied a portion of the applied water demand is referred to as effective precipitation. It was recognized that daily precipitation and evaporation needed to be considered to make sure that the precipitation event was sufficient to be effective. A separate evaluation of precipitation and evaporation over the Study Period determined that about 20 percent of the monthly precipitation occurred in small rainfall events that would not likely contribute to crop demand. Therefore, 80 percent of the monthly precipitation data was compared to each month of the crop applied water demand.

Surface water used for agricultural irrigation was then subtracted from the remaining applied water demand. In addition to precipitation, surface water sources used to offset the total applied water in the KRGSA Plan Area include Kern River water, imported water, and recycled water (from the City, LPUD, dairies, and others). Almost all Kern River water and imported water (SWP water) delivered for agricultural irrigation was used in KDWD. Wastewater/recycled water was available for irrigation both inside and outside KDWD.

Dairy wastewater is an additional source of water reused for agricultural irrigation in the KRGSA Plan Area. For the checkbook water budget calculation, the pumping and irrigation application by dairies was included in the agricultural private pumping calculation so that all of the METRIC calculations could be conducted collectively. A separate estimation of consumptive use by dairies was calculated and included in the outflow component for private industrial pumping. This consumptive use calculation is explained in **Section 4.3.3**.

With the subtraction of surface water deliveries, all remaining monthly applied water demands were assumed to be satisfied through groundwater pumping for agricultural irrigation. KDWD pumping for in-district use was tabulated separately and included in the groundwater banking recovery pumping (**Section 4.3.4**). After adjusting applied water for surface water deliveries and KDWD pumping, the remaining applied water demand is assumed to be satisfied by private agricultural pumping. Although estimated separately, KDWD pumping was a relatively small amount and is combined with the private agricultural pumping to total 175,668 AFY on an average annual basis.

4.3.2 Municipal Groundwater Pumping

For the purposes of the checkbook water budget, this outflow category includes pumping for Metropolitan Bakersfield by Cal Water and the City, along with five relatively large purveyors in the Plan Area including ENCSD, NORMWD/OMWC, Vaughn Water Company, Greenfield CWD, and Lamont PUD. Service areas for these purveyors within the KRGSA Plan Area[30] are shown on **Figure 2-4**. For these systems, metered pumping records were provided from each purveyor for at least a portion of the historical and current study periods. Collectively, this municipal groundwater pumping totals 109,966 AFY on an average annual basis (**Table 4-2**).

Pumping at smaller water systems throughout the KRGSA Plan Area was estimated based on either pumping records (for systems in ID4 service area) or population. Data for these smaller water systems are excluded from municipal pumping and tabulated separately as discussed in **Section 4.3.3**. The arbitrary division between pumping by municipalities and pumping by smaller public or private water systems was based more on the type of available data rather than a strict definition of municipal or non-municipal pumping.

In addition to groundwater, municipal water supplies also include local surface water and imported water sources. Data presented herein refers only to groundwater pumping and does not include all of the urban demand in the KRGSA Plan Area.

4.3.2.1 California Water Service Company (Cal Water)

Cal Water is the largest municipal water supplier in Bakersfield. Their system serves a large portion of the City and segments of unincorporated lands adjacent to the City encompassing about 49 square miles and a population of about 225,000 (see **Figure 2-4**). Groundwater has historically supplied up to 80 percent of the Cal Water demands with about 20 percent supplied by Kern River and imported SWP water. In 2011, Cal Water operated about 115 active wells with a design capacity of 142,000 AFY.

[30] Some purveyors overlap only portions of the KRGSA Plan Area with service areas both inside and outside of the KRGSA (see **Figure 2-4**). Only pumping from wells inside the KRGSA Plan Area are included in this groundwater budget.

Cal Water provided monthly production by well for 2000 through 2016 in electronic format. Data from 1994 through 1999 were provided as handwritten monthly well production sheets, which were hand-entered into the KRGSA database. During the historical Study Period, Cal Water pumped 57,588 AFY on an annual average basis.

4.3.2.2 City of Bakersfield Water System (City Water System)

The City's Water System service area covers about 35 percent of western Bakersfield (about 38 square miles) and provides water to a population of about 118,600 (**Figure 2-4**). Similar to Cal Water, the City relies on a variety of water sources including groundwater, Kern River water, and imported SWP water. By an agreement with the City, Cal Water operates the City's domestic water system, including approximately 50 active groundwater wells and local surface water treatment plants. Metered monthly production data were provided by well from 1994 through 2016 to support this water budget analysis.

City wells located within the COB 2800 Recharge Facility are referred to as the Olcese wells and can be pumped by the City for municipal supply and/or recovery of banked groundwater. These wells are also available for pumping by KCWA for banking recovery. For this water budget, production from Olcese Wells No. 1 and 2 is included in the City totals as municipal pumping. In order to prevent double counting of shared facilities and provide a more accurate use of production wells, a separate water budget pumping category has been designated specifically for recovery of banked groundwater. This recovery pumping category, described in **Section 4.3.4**, includes production from the Olcese Wells No. 3 through No. 8, which are typically pumped for groundwater recovery. Recovery pumping also includes pumping of any Olcese wells by KCWA.

Over the historical Study Period, municipal pumping from City wells averaged 34,085 AFY (including production from Olcese No. 1 and No. 2 wells as discussed above).

4.3.2.3 East Niles Community Services District (ENCSD)

ENCSD is a member agency of the KRGSA covering about 6,202 acres in the northeastern Plan Area and serving a population of about 35,364 (see **Figures 1-2** and **2-4**). (MKN, 2016). The District provided monthly pumping data for its seven groundwater wells from 2000 through 2017. Pumping from 1995 to 1999 was estimated based on an approximate 4 percent decrease in 2000 monthly pumping. Over the historical Study Period, ENCSD has pumped about 4,081 AFY on an average annual basis.

4.3.2.4 North of the River Municipal Water District (NORMWD) / Oildale Mutual Water Company (OMWC)

NORMWD and OMWC are located on the north-central boundary of the KRGSA Plan Area. The two entities previously operated separately but they merged operations in 2013. Collectively, they serve a population of about 32,000 from about 14 wells with a combined service area located both inside and outside KRGSA. Both entities rely on both groundwater and imported SWP water from ID4. Production in the KRGSA Plan Area is reported to ID4 on a semi-annual basis. These amounts were distributed evenly on a monthly basis for the purposes of the water budget. Combined production for NORMWD and OMWC of about 1,000 AFY has been estimated on an average annual basis for the KRGSA Plan Area.

4.3.2.5 Vaughn Water Company (Vaughn WC)

Vaugh Water Company covers about 17,280 acres located both inside and outside of the KRGSA Plan Area. Vaugh WC is reliant solely on groundwater and participates in local recharge projects through property taxes and pumping fees to ID4 (Dee Jaspar, 2016c). Vaughn WC provided monthly pumping data by well from 1995 through 2017. Only wells located in the KRGSA Plan Area (about 10 wells) were used for this water budget category. The annual average pumping for these wells during the historical Study Period was about 6,721 AFY.

4.3.2.6 Greenfield County Water District (Greenfield CWD)

Greenfield CWD supplies groundwater to a population of about 8,500 from five wells. In support of the GSP, Greenfield CWD provided monthly pumping data for 2005 through 2011 and 2015 through 2017. Annual pumping totals were provided for 2003 and 2004. Annual water use data were available for 1998 through 2001 in annual Water Supply Reports prepared by KCWA (KCWA 2002; 2003; 2005; 2008). Available data were used to develop estimates for the incomplete data sets. For 1995 through 1997, pumping was estimated based on observed pumping increases over time. Annual pumping in 2002 was estimated to be the mid-point between 2001 and 2003 data; pumping for 2012-2014 was estimated by averaging the monthly data for 2011 and 2015. Monthly pumping averages from 2005 through 2010 were used to distribute the annual 1995 through 2004 pumping on a monthly basis. Based on this analysis, the average annual pumping total for Greenfield CWD during the historical Study Period was about 1,810 AFY.

4.3.2.7 Lamont Public Utilities District (Lamont PUD)

Lamont PUD is located along the east-central KRGSA Plan Area boundary and provides water and sewer services to the communities of Lamont and Weedpatch. Its service area consists of about 2,000 acres, most of which (about two-thirds) is included inside KRGSA Plan Area. The district relies solely on groundwater for its water supply and operates about nine wells within the KRGSA Plan Area. Lamont PUD provided monthly pumping data by well from 2000 through 2017 in support of this GSP. Monthly pumping data from 2001 were extrapolated to fill in missing data for 1995 to 1999. Based on the information provided, the average annual pumping for Lamont PUD during the historical Study Period was about 4,804 AFY in the KRGSA Plan Area.

4.3.3 Small Water Systems and Additional Private Groundwater Pumping

Additional pumping occurs in the KRGSA Plan Area that is not accounted for in other water budget pumping components discussed above. This pumping is associated with the smaller Community Water Systems and mutual water companies, and private wells used for industrial or domestic purposes. As indicated in **Table 4-2**, this additional groundwater pumping is estimated at 9,038 AFY on an average annual basis. Estimates have been developed separately in the northern (7,558 AFY) and southern KRGSA Plan Area (1,480 AFY) based on data types and availability, as summarized below.

4.3.3.1 Additional Pumping in the Northern KRGSA Plan Area

Groundwater pumping in the ID4 Service Area is reported to ID4 and compiled on semi-annual basis. As shown on **Figure 2-4**, ID4 covers most of the northern Plan Area and provides the best available data for pumping by public water systems, mutual water companies, and private well owners for agricultural, industrial, and domestic supply. Metered pumping data for the larger purveyors in the ID4 service area were obtained from each agency and tabulated separately including the City of Bakersfield, Cal Water, ENCSD, NORMWD/OMWC, and Vaughn WC (**Section 4.3.2** above). Remaining pumping data as reported to ID4 were reviewed, divided into monthly data, and incorporated into the water budget. Due to the large number of well owners and the relatively small amount of pumping per party, data are combined and categorized collectively in this water budget as small water systems and private industrial and domestic pumping for the northern KRGSA Plan Area.

4.3.3.2 Additional Pumping in Southern KRGSA Plan Area

As shown on **Figure 2-24**, there are about 26 small water systems in the southern KRGSA Plan Area and also multiple systems along the eastern boundary. These systems are outside the area where pumping is reported to ID4 (as described above), and production data are generally unavailable. However, the data reported to ID4 provided a methodology for estimating this unreported pumping in the southern KRGSA Plan Area.

Water use totals reported to ID4 for the northern small water systems were divided by reported population for each system's service area to estimate a water demand per capita for small water systems in the KRGSA. This estimate, 0.2442 AFY per capita, was applied to the populations associated with the 26 water systems within the KDWD service area as obtained from the SWRCB. Greenfield CWD and Lamont PUD were excluded from this analysis because these water systems provided more accurate metered pumping data by well to support the water budget (see **Section 4.3.2.4** above).

4.3.3.3 Dairies Consumptive Use

About 25 dairies are located in the southern KRGSA Plan Area (in KDWD service area), all of which are assumed to rely on groundwater for water supply. Known historical dairies are included in the confined animal category shown on **Figure 2-7**; more accurate locations of dairies in the KRGSA Plan Area were provided by KDWD and are shown on **Figure 2-9**. These dairies are regulated by the Central Valley RWQCB and have developed water management plans that provide for re-use and recharge of dairy wastewater. In the Plan Area, re-use typically includes irrigation of nearby agricultural fields. Pumping estimates for agricultural irrigation and irrigation return flows are already accounted for in the water budget based on METRIC ET data and estimated pumping of irrigated lands. However, there is some additional consumption of groundwater associated with dairy water management, primarily associated with watering and cooling the cows, evaporation, and subsequent export of water in the milk products.

To estimate this consumptive use, local dairy practices and published information were reviewed. A 2013 study in the western U.S. conducted by researchers at the University of Arizona and Kansas State University provided a scientific analysis of dairy water budgets (Harner, et al., 2013). Although it is recognized that there is a wide variety of information on how much water is used per dairy cow and that each dairy may be different in how water is applied and managed, the 2013 study provides recent data developed in a western U.S. study for use on an average basis. That study suggests that approximately 71 gallons/day/cow (0.08 AFY) is needed for drinking, cooling, and milking the herd. Herd size was compiled for the 25 dairies in the KRGSA Plan Area to assess the amount of groundwater that is likely required; for the KRGSA dairies, herd size averaged about 2,800 cows. Because most of this water is re-used and included in other water budget components (i.e., re-use for irrigation described above), consumptive use was estimated. Using reasonable assumptions for the amount of water in milk products to be sold, a consumptive use of about 10.2 percent of the total groundwater pumped is estimated. This calculation resulted in a combined total of 581.65 AFY for all 25 dairies in the Plan Area (average about 23 AFY/dairy); this consumptive use is included in the Smaller Water Systems and Additional Private Pumping outflow component.

4.3.3.4 Ski Lakes

The southeastern KRGSA Plan Area contains man-made lakes, constructed as a private recreational water skiing resort. The general location of the largest lake area is shown by the Ski West Village Water System on **Figure 2-4**. A more detailed view of the constructed lakes is shown on the aerial photograph on **Figure 3-48c** (with a location map provided on **Figure 3-45**). The lakes extend up to about one-half mile long, 300 feet wide, and 5 feet deep. The water surface of the combined lakes covers about 11.5 acres. Lakes are replenished with groundwater from a private well system for each lake.

Although domestic water use for the Ski West Village Water System is already incorporated into the water budget based on population, groundwater pumping to keep the lakes filled is not included. Leakage beneath the lakes is estimated to be minimal, given that they have been sited on clay soils and in the area where perched water has been observed. Therefore, the estimated evaporation from the lake surface is considered a reasonable estimate for the groundwater pumping to maintain the lakes.

Historical aerial imagery (Google Earth) dating back to at least 1992 indicates that approximately 9 to 12 lakes have been filled at any given time. CIMIS evapotranspiration data (Arvin-Edison Station) was collected and converted to evaporation from open water surfaces using a lake evaporation factor of 1.1 inches of evaporation for every inch of reference ET (University of California, Davis, 1982). Based on the surface area and monthly reference evaporation, the evaporative loss of the lakes (and therefore the groundwater replenishment) is calculated to range from 54 AFY to 68 AFY. Given the small amount of this pumping compared to other outflow components, the extra groundwater pumping associated with lake filling is combined with groundwater pumping estimates from the small water systems.

4.3.4 Groundwater Pumping for Banking Project Recovery

Managed aquifer recharge in the KRGSA as described in **Section 4.2**[31] above is recovered either from dedicated recovery wells or from production wells for municipal or agricultural supply. Most of the recovery occurs from the latter because most of the managed recharge in the KRGSA is conducted to benefit water levels and water supply wells. Recognizing that recovery pumping for water supply is already incorporated into the water supply pumping categories above, recovery pumping tabulated for this category involves only pumping of dedicated recovery wells. Monthly pumping data were provided for all recovery wells by each agency that owns and/or uses the wells. As shown on **Table 4-2**, recovery pumping has averaged about 27,199 AFY over the historical 20-year Study Period. Recovery pumping during the drought year of 2015 was about 100,727 AFY, more than three times the average (**Table 4-2**).

For the COB 2800 Recharge facility, the City, KCWA, and ID4 all share the City's facility recovery wells (also referred to as the Olcese wells). These wells function as both municipal wells and banking recovery wells. To avoid double counting, production from Olcese 1 and 2 is included in municipal pumping (**Section 4.3.2.2** above) and production from Olcese 3 through 8 is included in this water budget category, consistent with the primary use of each well.

ID4 operates 18 recovery wells, 7 of which are shared with RRBWSD for the Joint Use Groundwater Recovery Project. The remaining 11 wells are used to recover ID4 recharge/banking in the COB 2800 recharge facility, along the unlined portion of the CVC, and other in-district recharge conducted by ID4.

KCWA is active in the KRGSA, sharing recharge facilities and groundwater banking recovery wells with KRGSA member agencies through agreements. Because of the close proximity of multiple Kern Fan groundwater banking facilities (i.e., COB 2800, Berrenda Mesa, Pioneer Project), recharge and recovery for the same project may occur both inside and outside of the KRGSA. For example, fourteen wells are used to recover water recharged on behalf of Berrenda Mesa groundwater banking project for project participants (outside of the KRGSA). Of the 14 wells, only 9 are located inside KRGSA boundaries.

Because the first approximation of the water budget is to define inflows and outflows from the physical groundwater system, only recovery occurring within the KRGSA boundaries is included in this section. As discussed previously, the checkbook water budget is further modified in subsequent sections of this GSP to facilitate KRGSA planning for sustainable management using only its own water supplies.

In the southern KRGSA, KDWD recovers water for the Metropolitan and SBVMWD banking program from 18 district wells. KDWD pumping for in-district use is also included in this water budget category.

As mentioned previously, recovery pumping occurs primarily in dry years to supplement decreases in surface water supplies. Accordingly, the amount varies widely from year to year from 0 AFY to more

[31] Although all inflow categories in **Section 4.2** involve some management of groundwater recharge, the two primary categories applicable to this discussion include *Kern River Channel and Canal Operational Recharge* (**Section 4.2.1**) and *Additional Managed Recharge and Groundwater Banking Projects* (**Section 4.2.7**).

than 100,000 AFY. No recovery pumping occurred during 8 years of the 20-year historical Study Period. Further, more than one-third of all of the water recovered during the 20-year Study Period (about 189,000 AF) was produced during the last 2 years (2013 – 2014) of the period, commensurate with the recent drought. The drought continued through WY 2015 with recovery pumping totaling about 100,727 AFY, the second highest annual total in more than 20 years of KRGSA banking (**Table 4-2**).

4.4 CHANGE IN GROUNDWATER IN STORAGE - CHECKBOOK METHOD

The inflows and outflows listed in **Tables 4-1** and **4-2**, respectively, and described above are used to estimate the change in groundwater in storage for the KRGSA Plan Area as summarized below:

Inflows – Outflows = Change in Groundwater in Storage

This simple equation provides a first approximation of the change in groundwater in storage over time based solely on recharge and extraction in the Plan Area. Because the checkbook method does not incorporate subsurface flows, it allows GSA managers to link surface supplies directly to demand. Subsurface flows are incorporated into the water budget in subsequent analyses.

4.4.1 Annual Inflows, Outflows, and Change in Groundwater in Storage – Checkbook Method

Monthly inflow (recharge) and outflow (pumping) data were compiled by water year to develop the change in groundwater in storage over the historical Study Period WY 1995 – WY 2014 and the current Study Period WY 2015. Annual inflows, outflows, and changes in groundwater in storage for the 20-year historical Study Period are presented in **Table 4-3** and displayed graphically on **Figure 4-1**. The two columns on the far right side of the table summarize the cumulative and average annual amounts for each component and the overall change in groundwater in storage.

As shown in **Table 4-3** and **Figure 4-1**, inflows and outflows vary significantly from year to year during the historical Study Period. Inflows range from 153,128 AFY in the critically dry year of 2014 to more than 550,000 AFY in the wet year of 2011. Outflows (pumping) are highest in 2014 when surface supplies are scarce, and groundwater is needed to fulfill more of that year's demand. Similarly, outflows (pumping) are smallest in 2011, when surface supplies were more plentiful (as evidenced by significant increases in recharge). Using the Kern River annual index as an indication of the changes in surface water supplies, the indices for 2011 and 2014 were 201 percent and 24 percent of the long-term average flow, respectively.

WY 2011 and WY 2014 also represent the largest gain (395,347 AFY) and loss (-328,106 AFY), respectively, of groundwater in storage (see bottom row in **Table 4-3**). Over the 20-year period, a cumulative net loss of approximately -39,570 AF is indicated. The average annual change in groundwater in storage is approximately -1,978 AFY on an average annual basis (**Table 4-3**). These data suggest a relatively small amount of overdraft for the groundwater system beneath the KRGSA Plan Area, representing less than one percent of the average annual inflows or outflows.

Table 4-3: Historical Groundwater Budget, KRGSA Plan Area

All values presented in acre-feet; Years are Water Years.

Groundwater Budget Component	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Cumulative	Average Annual
Inflows																					Inflows	
Kern Channel Recharge	87,965	96,671	85,684	85,199	77,064	79,546	25,899	48,425	84,473	77,891	140,139	101,716	32,858	17,210	19,536	81,921	155,341	58,570	24,465	14,999	1,395,572	69,779
Canal Operational Recharge	100,022	104,016	114,105	93,284	96,061	79,700	61,328	71,299	70,656	63,787	91,316	92,961	52,340	54,328	47,130	88,703	114,336	68,504	45,425	47,091	1,556,392	77,820
Municipal Return Flows	9,110	10,041	9,523	7,953	10,094	9,847	10,011	10,252	9,874	9,853	8,799	8,894	10,457	10,796	9,858	9,567	10,273	12,204	10,519	11,065	198,989	9,949
Applied Water Infiltration (Agriculture)	37,218	41,754	42,389	30,511	34,506	36,421	27,665	29,085	31,768	33,288	41,328	42,515	27,742	35,004	30,799	34,760	34,439	31,493	20,891	19,087	662,665	33,133
Agriculture Pumping Return Flows	32,183	37,420	30,278	24,668	28,672	30,085	38,669	43,501	33,954	48,197	33,376	17,936	52,932	42,445	39,169	15,756	7,190	32,098	50,950	43,766	683,245	34,162
Precipitation Percolation	4,309	3,913	4,780	6,999	4,931	4,147	4,186	3,428	3,689	3,810	4,425	5,691	3,070	3,353	3,649	6,182	5,681	2,532	2,462	3,630	84,866	4,243
Stormwater Conservation	34,083	21,975	21,574	50,138	22,510	16,958	19,466	11,840	20,135	15,185	31,073	22,610	10,670	7,526	16,590	23,714	34,551	16,556	10,469	8,094	415,718	20,786
Wastewater Percolation	3,578	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,470	3,600	3,600	3,600	3,600	8,506	7,528	5,726	3,632	82,841	4,142
GW Banking Recharge	162,607	124,060	87,624	141,045	49,511	48,200	10,260	8,125	7,621	20,623	169,255	115,334	31,387	2,032	3,058	31,264	187,670	92,135	23,994	1,764	1,317,570	65,879
TOTAL INFLOWS	**471,074**	**443,450**	**399,556**	**443,397**	**326,948**	**308,504**	**201,085**	**229,556**	**265,770**	**276,235**	**523,310**	**411,127**	**225,057**	**176,293**	**173,389**	**295,467**	**557,988**	**321,621**	**194,903**	**153,128**	**6,397,859**	**319,893**
Outflows																					**Outflows**	
Agricultural Pumping	(165,633)	(192,328)	(154,647)	(126,458)	(146,404)	(154,191)	(197,215)	(221,238)	(173,255)	(245,680)	(170,955)	(104,774)	(268,938)	(215,766)	(198,745)	(95,887)	(39,773)	(162,330)	(257,739)	(221,399)	(3,513,353)	(175,668)
Municipal Pumping	(94,400)	(109,169)	(107,031)	(91,572)	(108,133)	(105,563)	(110,093)	(114,274)	(110,698)	(111,213)	(104,060)	(106,528)	(117,330)	(120,460)	(109,263)	(104,628)	(115,232)	(130,838)	(109,043)	(119,794)	(2,199,321)	(109,966)
Small Water System/Private Pumping	(12,861)	(12,029)	(1,913)	(8,611)	(11,820)	(11,485)	(11,728)	(10,902)	(9,292)	(8,696)	(5,012)	(8,150)	(9,821)	(9,867)	(8,303)	(7,958)	(7,636)	(7,645)	(7,776)	(9,259)	(180,765)	(9,038)
Banking Recovery	-	-	-	-	-	-	(52,034)	(15,820)	(19,190)	(10,632)	(8,845)	-	(51,583)	(73,466)	(72,150)	(31,055)	-	(19,949)	(58,484)	(130,782)	(543,990)	(27,199)
TOTAL OUTFLOWS	**(272,894)**	**(313,526)**	**(263,591)**	**(226,640)**	**(266,356)**	**(271,238)**	**(371,069)**	**(362,233)**	**(312,435)**	**(376,221)**	**(288,872)**	**(219,452)**	**(447,673)**	**(419,559)**	**(388,461)**	**(239,528)**	**(162,641)**	**(320,762)**	**(433,042)**	**(481,234)**	**(6,437,429)**	**(321,871)**
Change in Groundwater in Storage																					**Totals**	
INFLOWS minus OUTFLOWS	**198,180**	**129,923**	**135,965**	**216,757**	**60,592**	**37,265**	**(169,984)**	**(132,678)**	**(46,665)**	**(99,985)**	**234,438**	**191,675**	**(222,616)**	**(243,266)**	**(215,072)**	**55,939**	**395,347**	**859**	**(238,139)**	**(328,106)**	**(39,570)**	**(1,978)**

A similar presentation of inflows, outflows, and change in groundwater in storage is provided in **Table 4-4** and **Figure 4-2** for the current Study Period, represented by WY 2015. The critically dry year of 2015 is associated with decreased recharge and relatively high levels of pumping, resulting in a negative change in groundwater in storage of -238,072 AFY. This loss of groundwater in storage over a one-year period is consistent with the lack of surface water supplies in a dry year and cannot be used solely as an indication of long-term overdraft conditions.

Table 4-4: Current Groundwater Budget, Checkbook Method, KRGSA Plan Area

Groundwater Budget Component	WY 2015 AFY
INFLOWS	
Kern Channel Recharge	8,447
Canal Operational Recharge	60,145
Municipal Return Flows	8,773
Applied Water Infiltration (Ag)	31,151
Agricultural Pumping Return Flows	26,207
Precipitation Percolation	4,434
Stormwater Conservation	17,827
Wastewater Percolation	4,600
GW Banking Recharge	1,520
Total Inflows	163,104
OUTFLOWS	
Agricultural Pumping (METRIC)	(196,859)
Municipal Pumping	(96,390)
Small Water System/Private Pumping	(7,201)
Banking Recovery	(100,727)
Total Outflows	(401,177)
Change in GW in Storage	
Inflows minus Outflows	(238,072)

The annual changes in groundwater in storage discussed above and summarized in **Tables 4-3** and **4-4** are shown graphically on **Figure 4-3** for the historical and current study periods. **Figure 4-3** more clearly illustrates the annual gains and losses of groundwater in storage through drought and wet cycles over the study periods.

Figure 4-3 also includes the cumulative change in groundwater in storage over time. The cumulative curve (in orange) illustrates the -39,570 AF cumulative decline by 2014 at the end of the historical Study Period (see also last row, right side of **Table 4-3**). The curve continues to decline in 2015 to -277,642 AFY as the -238,072 AFY change in groundwater in storage from the current Study Period (**Table 4-4**) is added to the cumulative value from the historical Study Period.

The overall trend of the cumulative curve compares reasonably well with the cumulative curve derived from the change in groundwater in storage analysis using water level contour maps as shown on **Figure 3-28** and discussed in **Section 3.3.3**. Although these represent two independent methods of analyzing the groundwater budget, both methods provide overall consistent results over the average hydrologic conditions of the historical Study Period. For example, the average annual change in groundwater in storage from the checkbook method is -1,978 AFY compared to -2,912 AFY from the water level contour map method as shown on **Figures 4-3** and **3-28**, respectively. The cumulative loss of groundwater in storage of -39,570 AF from the checkbook method also compares reasonably well with -55,325 as estimated from the water level contour map analysis.

The cumulative loss of groundwater in storage is due, in part, to the timing of the study periods, which begin during normal to wet periods and end in the drought of record. The average annual change in groundwater in storage of -1,978 AFY is a better indicator for evaluating overdraft and sustainability for average hydrologic conditions (**Figure 4-3**).

4.4.2 Adjustments for Groundwater Banking Obligations and Water Attributable to Others

The water budget analysis using the checkbook method described above incorporated all of the physical recharge (inflows) and pumping (outflows) for the Plan Area to account for all KRGSA groundwater-related activities and to better link aquifer response to ongoing management. This approach did not consider ownership of the water or management activities for and by others within the KRGSA Plan Area. For example, groundwater banking occurs within the Plan Area for ultimate export out of the Plan Area. Examples of these banking obligations include the Berrenda Mesa project, KDWD-Metropolitan banking project, and recharge operations along the Kern River channel, unlined canals, and in the COB 2800 recharge facility by KCWA and other parties outside of the KRGSA. This recharge also included operational loss along the Carrier and Calloway canals as others have conveyed water attributable to them across the KRGSA Plan Area.

KRGSA Plan Managers determined that the checkbook method required adjustment for water that had been recharged in the KRGSA Plan Area but was attributable to others. Accordingly, recharge by/for others was removed from the checkbook water budget along with any associated recovery pumping. Additionally, water banked outside of the KRGSA Plan Area for use within the Plan Area was added back to the checkbook budget. These adjustments facilitated improved accounting of KRGSA water supplies.

Adjustments for the groundwater banking obligations and water attributable to others are summarized in **Table 4-5**. Recharge for and by others has been removed from the Inflows; banking recovery pumping for and by others has been removed from the Outflows (**Table 4-5**). Banking balances outside of the KRGSA have been added to the checkbook.

Table 4-5: Historical and Current Checkbook Water Budget Adjusted for Banking Obligations and Water Attributable to Non-KRGSA Entities

All values presented in acre-feet; Years are Water Years.

Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	1995 - 2014 Cummlative	Average Annual	2015
Inflows																					Historical		Current
Kern Channel Recharge	62,877	62,315	72,537	78,731	75,838	73,555	25,760	45,312	75,050	50,595	105,701	95,115	32,550	17,120	19,536	81,921	134,871	51,476	24,447	14,999	1,200,307	60,015	8,447
Canal Operational Recharge	72,644	80,334	105,264	75,595	65,756	71,209	59,853	66,285	69,849	62,798	68,057	67,391	52,334	54,770	47,645	69,549	72,167	62,414	45,383	46,751	1,316,048	57,683	37,782
Municipal Return Flows	9,110	10,041	9,523	7,953	10,094	9,847	10,011	10,252	9,874	9,853	8,799	8,894	10,457	10,796	9,858	9,567	10,273	12,204	10,519	11,065	198,989	8,737	8,773
Applied Water Infiltration (Ag)	37,218	41,754	42,389	30,511	34,506	36,421	27,665	29,085	31,768	33,288	41,328	42,515	27,742	35,004	30,799	34,760	34,439	31,493	20,891	19,087	662,665	36,151	31,151
Ag Pumping Return Flows	32,183	37,420	30,278	24,668	28,672	30,085	38,669	43,501	33,954	48,197	33,376	17,936	52,932	42,445	39,169	15,756	7,190	32,098	50,950	43,766	683,245	21,671	26,207
Precipitation Percolation	4,309	3,913	4,780	6,999	4,931	4,147	4,186	3,428	3,689	3,810	4,425	5,691	3,070	3,353	3,649	6,182	5,681	2,532	2,462	3,630	84,866	6,712	4,434
Stormwater Conservation	34,083	21,975	21,574	50,138	22,510	16,958	19,466	11,840	20,135	15,185	31,073	22,610	10,670	7,526	16,590	23,714	34,551	16,556	10,469	8,094	415,718	18,162	17,827
WW Percolation	3,578	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,600	3,470	3,600	3,600	3,600	3,600	8,506	7,528	5,726	3,632	82,841	5,213	4,600
GW Banking Recharge	97,667	89,897	62,595	79,404	25,048	12,722	7,721	6,645	8,606	9,280	43,454	34,943	3,102	2,077	3,058	31,264	127,987	68,043	18,244	1,764	733,522	4,420	1,520
Input Total	**353,669**	**351,249**	**352,538**	**357,599**	**270,954**	**258,544**	**196,932**	**219,949**	**256,525**	**236,607**	**339,812**	**298,565**	**196,458**	**176,690**	**173,904**	**276,313**	**435,666**	**284,345**	**189,093**	**152,788**	**5,378,201**	**268,910**	**140,741**
Outflows																							
Agricultural Pumping (METRIC)	(165,633)	(192,328)	(154,647)	(126,458)	(146,404)	(154,191)	(197,215)	(221,238)	(173,255)	(245,680)	(170,955)	(104,774)	(268,938)	(215,766)	(198,745)	(95,887)	(39,773)	(162,330)	(257,739)	(221,399)	(3,513,353)	(175,668)	(196,859)
Municipal Pumping	(94,400)	(109,169)	(107,031)	(91,572)	(108,133)	(105,563)	(110,093)	(114,274)	(110,698)	(111,213)	(104,060)	(106,528)	(117,330)	(120,460)	(109,263)	(104,628)	(115,232)	(130,838)	(109,043)	(119,794)	(2,199,321)	(109,966)	(96,390)
Small Water System/Private Pumping	(12,861)	(12,029)	(1,913)	(8,611)	(11,820)	(11,485)	(11,728)	(10,902)	(9,292)	(8,696)	(5,012)	(8,150)	(9,821)	(9,867)	(8,303)	(7,958)	(7,636)	(7,645)	(7,776)	(9,259)	(180,765)	(9,038)	(7,201)
Banking Recovery	-	-	-	-	-	-	(4,350)	(4,464)	(10,073)	(5,956)	(2,137)	-	(13,020)	(23,817)	(21,041)	(5,327)	-	(4,833)	(33,848)	(83,891)	(212,757)	(10,638)	(61,929)
TOTAL OUTFLOWS	**(272,894)**	**(313,526)**	**(263,591)**	**(226,640)**	**(266,356)**	**(271,238)**	**(323,385)**	**(350,877)**	**(303,318)**	**(371,545)**	**(282,164)**	**(219,452)**	**(409,110)**	**(369,910)**	**(337,352)**	**(213,800)**	**(162,641)**	**(305,646)**	**(408,406)**	**(434,343)**	**(6,106,196)**	**(305,310)**	**(362,379)**
Change in Groundwater in Storage																							
INFLOWS MINUS OUTFLOWS	80,775	37,723	88,947	130,959	4,597	(12,694)	(126,453)	(130,929)	(46,793)	(134,937)	57,648	79,114	(212,652)	(193,220)	(163,448)	62,513	273,025	(21,301)	(219,313)	(281,555)	(727,995)	(36,400)	(221,637)

Banking Adjustments*

	1995 - 2014 Cummlative	Average Annual	2015
Banking balances in KDWD for Others (Metropolitan, SBVWD):	-155,782		-123,806
Banking balances by KCWA for KDWD in KRGSA:	2,877		2,995
Banking balance by KCWA for ID4 in KRGSA:	37,662		29,288
Banking balances outside KRGSA for KDWD (Pioneer, KWB):	70,194		70,244
Banking balances outside KRGSA for ID4 (Pioneer, KWB):	189,981		172,146
TOTAL BANKING ADJUSTMENTS	144,932		150,867
Adjusted Change in Groundwater in Storage	-583,063	(29,153)	(70,770)

1. Inflows and outflows above have been adjusted to remove recharge and recovery operations in KRGSA for and by others

2. Adjustments made in this section account for banking balances to be exported from (subtract) or imported to (add) the KRGSA Plan Area

A comparison of the adjusted checkbook to the initial checkbook indicates a greater annual decline in groundwater in storage from -1,978 (**Table 4-3**) to -36,400 AFY (**Table 4-5**). The annual change for the 2015 Study Period indicates a slight gain of groundwater in storage from -238,072 AFY in **Table 4-4** to -221,637 AFY in **Table 4-5** because of the removal of recovery pumping delivered outside of the KRGSA.

Additional adjustments are made to the checkbook to incorporate other banking obligations as well as banking balances outside of the KRGSA attributable to KRGSA agencies. For KDWD, the banking balance owed to out-of-basin banking partners is subtracted from the cumulative change in storage for the historical Study Period and also for the current Study Period. By making these one-time adjustments using the then-current banking balance, the annual amounts dedicated to the KRGSA as "leave-behind" are already in the checkbook. The remaining banking adjustments are additive and account for water banked outside of the KRGSA for Plan Area use. For example, ID4 routinely banks excess SWP water in the Kern Water Bank or Pioneer Project (and other areas) for dry-year storage if needed at the Henry C. Garnett Treatment Plant. Banking balances for KRGSA agencies were provided by KCWA.

The results of the adjusted checkbook water budget indicate a deficit of about -29,153 AFY on an average annual basis for the KRGSA Plan Area and a deficit of about -70,770 AFY for the current WY 2015 (**Table 4-5**).

4.5 C2VSimFG-Kern Model Water Budget Analysis

The primary goal of the C2VSim-Kern local model is to analyze historical, current, and projected water budgets for the entire Kern County Subbasin. Development of the Subbasin model is described in more detail in **Attachment 1**. In brief, the water budget data in the DWR regional C2VSim-FG model were revised with local water budget data provided by water and irrigation districts, municipalities, and GSAs in the Subbasin. To facilitate review of the revised input data in the model, the modeling team produced numerous local water budgets for distinct zones within the Subbasin, typically on a District- or GSA-basis, using the Z-Budget tool in the model (described in **Attachment 1**).

As part of this data-checking process, two separate zone budgets were developed for the KRGSA Plan Area, including the southern Plan Area generally aligning with the KDWD boundaries and the northern KRGSA Plan Area approximately aligned with the City/ID4 outer boundaries. These two zone budgets do not align perfectly with the KRGSA Plan Area boundaries due to model cell configuration and some simplifying assumptions required for analyzing urban demand in the Subbasin-wide model. However, overall area differences are relatively small and do not adversely impact the analysis. Model water budget areas are overlain on the KRGSA boundaries on **Figure 4-4a** and **4-4b**.

4.5.1 Application of the C2VSimFG-Kern Model to the KRGSA Plan Area

In general, input data for the C2VSimFG-Kern Model were revised for the KRGSA Plan Area based on the historical and current inflows and outflows described above in **Sections 4.3** and **4.4**, respectively. Because the model simulates the physical groundwater system, data from the initial checkbook method (see **Section 4.4.1**) were used instead of the adjusted checkbook method (see **Section 4.4.2**). Specifically, all recharge in the Plan Area was included in the model, even the managed recharge that was conducted by or on behalf of non-KRGSA agencies. Any recovery pumping that occurred in the KRGSA Plan Area for or by others was also included in the model. The recovered water was either routed to other Subbasin areas by the model or removed from the model to account for export out of the Subbasin. By representing all flows associated with the physical groundwater system, the model develops results that are more directly comparable to changes in groundwater in storage estimated by both the checkbook and the water level contour map methods. Collectively, these three methods serve as independent checks for estimating changes in groundwater in storage for the KRGSA Plan Area.

Although the C2VSimFG-Kern numerical model was based on the inflows and outflows from the checkbook method, the model analysis differs significantly from the checkbook analysis. Some of the more significant differences are summarized below:

- The model estimates urban pumping by populations and per capita water use rather than the metered pumping by well used by the checkbook method. The per capita water use was modified within reasonable and documented ranges to better match metered pumping data, as needed.
- Urban pumping from adjacent areas (e.g., pumping in RRBWSD by Vaughn Water Company) was combined with municipal pumping in the northern KRGSA Plan Area to facilitate model setup for estimating urban demand throughout continuously developed urban lands.
- The Independent Demand Calculator (IDC) module of the model was used to conduct a soil moisture balance in the unsaturated zone, providing estimates of deep percolation of precipitation and applied water return flows based on current monthly surface water deliveries, soil properties, and antecedent soil moisture conditions. The checkbook method employed simplified assumptions for these estimates, using a percentage of rainfall for deep percolation and an average overall agricultural efficiency of 80 percent to estimate return flows (20 percent of applied water).
- The model calculated effective precipitation and agricultural pumping based on METRIC ET crop demand and the estimated mix of crop types by model cell. The checkbook method calculated the METRIC ET for the Plan Area independent of crop type and used an analytical approach for developing monthly estimates of effective precipitation and agricultural pumping.
- The model simulated the Kern River as an active stream with channel seepage calculated directly by the model independent of measurements at stream gages or weirs. Stream gage and weir data were used to check and adjust model seepage estimates, as needed.

These differences highlight many of the model features being used to simulate various water budget components directly rather than "hard-wiring" the model with historical measured data (metered pumping, for example). By allowing the model to generate these components independently, the C2VSimFG-Kern model is preserved as a planning and management tool capable of predicting water budget components for future simulations.

Finally, as mentioned previously, the model water budget areas for the KRGSA Plan Area are based on boundaries of model cells, which do not precisely align with the Plan Area boundaries (**Figure 4-4**). Accordingly, the water budgets either include areas outside of the Plan Area or omit some areas within the Plan Area; these small differences in area prevent a direct comparison of some model water budget metrics to similar metrics in the checkbook. Notwithstanding these limitations, the model serves to corroborate the changes of groundwater in storage from the other methods and links aquifer response to historical and current groundwater management activities in the Plan Area.

4.5.2 Model Results for the KRGSA Plan Area

The results of the groundwater budget from the C2VSimFG-Kern model are presented for the northern and southern portions of the KRGSA Plan Area in **Tables 4-6** and **4-7**, respectively. Each table provides a summary of the groundwater budget for both historical (WY 1995 – WY 2014) and current (WY 2015) study periods. Results for the historical Study Period are also presented graphically on **Figure 4-5a**. and **4-5b.** for the northern and southern KRGSA Plan Area, respectively.

Although model input files are based on detailed checkbook data, the model output is organized a bit differently. Annual inflows (positive numbers) and outflows (negative numbers) are presented in **Tables 4-6** and **4-7** below and illustrated on **Figure 4-5**. Inflows associated with the deep percolation of precipitation and applied water (including surface water infiltration and pumping return flows) are combined in the second column of each table (orange on **Figure 4-5**). Inflows associated with managed recharge and operational recharge in unlined canals are combined in column 3 of each table (purple on **Figure 4-5**). Recharge in the River channel is presented separately in column 4 because the model calculates this separately based on River flows (light blue on **Figure 4-5**). Groundwater pumping, presented in column 5 of each table (dark blue on **Figure 4-5**), represents the largest outflow and combines data from all pumpers including municipal, industrial, agricultural, small water systems, and domestic/other private pumping occurring in the northern (**Tables 4-6**) and southern Plan Area (**Table 4-7**).

Subsurface inflows (positive numbers) and outflows (negative numbers) are shown in column 6 of each table and represent the net subsurface flow for each water year. Net annual subsurface flows are shown in yellow on **Figure 4-5** and vary from net inflows to net outflows based on then current water level conditions. Subsurface flows from the model (unavailable for the checkbook) account for the dynamic conditions around the complex KRGSA Plan Area boundary over time. Some subsurface flow originates from the adjacent bedrock of the Sierra Nevada foothills along the Plan Area perimeter where the model water budget area abuts the Subbasin boundary in the northeast (see **Figure 4-4a**). These basin inflows are presented in column 7 on **Table 4-6** and shown by the thin red bar as an inflow in **Figure 4-5a**. This inflow does not occur in the southern KRGSA Plan Area as indicated by the 0s in column 7 of **Table 4-7**.

Table 4-6: Historical and Current Groundwater Budget from C2VSimFG-Kern Model Northern KRGSA Plan Area

(1) Water Year	(2) Deep Percolation (precipitation, applied water return flows)	(3) Managed Recharge and Canal Operational Recharge	(4) River Channel Recharge	(5) Groundwater Pumping	(6) Net Subsurface Flows	(7) Basin Inflow	(8) Change in Groundwater in Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
HISTORICAL STUDY PERIOD WY 1995 - WY 2014							
1995	88,051	183,107	86,672	-142,689	-14,016	195	201,321
1996	79,906	125,137	12,391	-153,176	27,440	196	91,895
1997	68,113	88,080	45,404	-156,476	16,739	195	62,056
1998	97,059	168,050	15,365	-147,154	18,338	197	151,855
1999	65,509	74,945	9,912	-145,513	24,019	199	29,071
2000	38,448	61,711	46,793	-149,991	-7,631	198	-10,473
2001	32,278	28,643	33,692	-205,909	-23,853	198	-134,951
2002	27,912	21,836	39,828	-174,248	-13,502	197	-97,977
2003	32,736	25,492	68,331	-166,873	-3,701	196	-43,818
2004	31,274	31,306	49,961	-182,544	-4,300	196	-74,107
2005	83,027	200,919	88,207	-136,920	-3,125	196	232,304
2006	90,903	164,011	4,609	-131,961	23,480	196	151,238
2007	39,119	50,394	2,106	-210,177	-26,580	195	-144,942
2008	27,293	14,443	30,553	-233,663	-41,981	194	-203,161
2009	25,136	25,980	34,340	-220,742	-24,198	194	-159,289
2010	38,965	62,484	76,765	-163,908	-10,278	193	4,220
2011	100,336	199,248	122,441	-134,712	28,486	195	315,994
2012	54,370	68,659	34,604	-169,938	-6,880	196	-18,990
2013	36,097	20,510	28,207	-189,200	-35,813	195	-140,005
2014	24,212	12,072	24,233	-237,293	-39,068	194	-215,651
Total	**1,080,744**	**1,627,029**	**854,413**	**-3,453,088**	**-116,424**	**3,914**	**-3,413**
Average	**54,037**	**81,351**	**42,721**	**-172,654**	**-5,821**	**196**	**-171**
CURRENT STUDY PERIOD WY 2015							
2015	**21,186**	**20,608**	**17,169**	**-221,748**	**-30,709**	**193**	**-193,301**

Finally, column 8 of **Tables 4-6** and **4-7** presents the annual change in groundwater in storage for the northern and southern Plan Area, respectively. The average annual inflows, outflows, and change in groundwater in storage for the historical Study Period are shown at the bottom of each table above the Current Study Period. An annual tabulation of inflows and outflows is presented on **Figure 4-5** for the northern (**Figure 4-5a**) and southern (**Figure 4-5b**) Plan Area.

As indicated in **Table 4-6** and shown on **Figure 4-5a**, the average annual change in groundwater in storage is about -171 AFY for the northern KRGSA Plan Area. This change is relatively small and, given the magnitude of the inflows and outflows, is within the margin of error of flow measurements. As indicated in **Table 4-7** and shown on **Figure 4-5b**, the average annual change in groundwater in storage is about 4,226 AFY for the southern Plan Area. When these estimates are combined, the C2VSimFG-Kern model indicates that the change in groundwater in storage for the entire KRGSA Plan Area is about 4,055 AFY on an average annual basis.

Table 4-7: Historical and Current Groundwater Budget from C2VSimFG-Kern Model Southern KRGSA Plan Area

(1) Water Year	(2) Deep Percolation (precipitation, applied water return flows)	(3) Managed Recharge and Canal Operational Recharge	(4) River Channel Recharge	(5) Groundwater Pumping	(6) Net Subsurface Flows	(7) Basin Inflow	(8) Change in Groundwater in Storage
Units	**Acre-ft**	**Acre-ft**	**Acre-ft**	**Acre-ft**	**Acre-ft**	**Acre-ft**	**Acre-ft**
HISTORICAL STUDY PERIOD WY 1995 - WY 2014							
1995	100,173	60,330	3,799	-90,415	-16,821	0	57,066
1996	106,571	65,704	0	-135,400	-5,466	0	31,409
1997	103,925	70,665	121	-132,462	2,607	0	44,856
1998	127,735	63,157	5,152	-104,747	15,968	0	107,266
1999	104,118	53,227	0	-150,039	28,278	0	35,584
2000	87,397	56,971	0	-165,322	28,622	0	7,668
2001	79,301	46,696	0	-188,998	34,251	0	-28,750
2002	58,867	47,836	0	-211,118	29,157	0	-75,257
2003	63,392	65,042	452	-144,702	17,429	0	1,612
2004	75,702	54,373	0	-201,175	15,866	0	-55,234
2005	103,497	68,705	3,717	-109,726	8,332	0	74,525
2006	96,209	57,588	513	-143,503	19,181	0	29,989
2007	65,234	41,606	0	-219,142	31,546	0	-80,755
2008	50,194	43,547	0	-194,060	23,030	0	-77,290
2009	47,026	36,554	0	-207,959	10,861	0	-113,518
2010	75,414	75,325	2,040	-116,260	-5,879	0	30,641
2011	208,665	142,454	5,170	-90,215	-24,486	0	241,588
2012	135,260	112,351	0	-103,737	-14,852	0	129,021
2013	114,803	52,249	0	-261,221	-2,382	0	-96,551
2014	36,592	39,505	0	-257,385	1,947	0	-179,341
Total	**1,840,075**	**1,253,886**	**20,964**	**-3,227,585**	**197,190**	**0**	**84,530**
Average	**92,004**	**62,694**	**1,048**	**-161,379**	**9,859**	**0**	**4,226**
CURRENT STUDY PERIOD WY 2015							
2015	**34,712**	**33,554**	**0**	**-253,654**	**-3,570**	**0**	**-188,958**

4.5.3 Historical and Current Subsurface Flows

The C2VSimFG-Kern model provides the best available estimates of subsurface groundwater flows into and out of the KRGSA Plan Area. The model accounts for monthly dynamic conditions governing subsurface inflows and outflows over the entire historical and current study periods. Because these data are not included in the checkbook method, details of the subsurface flows are presented here.

For the northern Plan Area, an average annual net subsurface outflow of -5,821 AFY is estimated by the model (Column 6, **Table 4-6**). A detailed examination of these subsurface flows on an average annual basis indicates a net inflow of groundwater from the east-northeast and a net outflow of groundwater to the north, west, and south (**Table 4-8**). The predominance of a net outflow of groundwater from the northern Plan Area is consistent with historical groundwater elevations along the Kern River, which are generally higher than surrounding areas, especially in downgradient areas to the north. The amount of groundwater outflow to the west is the net result of both inflows and outflows associated with recharge and recovery events at the large Kern Fan banking projects. The outflow of groundwater beneath the northern KRGSA Plan Area to the south (-5,073 AFY) serves as an inflow to the southern KRGSA Plan Area from the north (5,073AFY) (**Tables 4-8** and **4-9**).

Table 4-8: Net Subsurface Flows In/Out of Northern KRGSA Plan Area

Net Subsurface Flows	Average Annual Flow (AFY)	Adjacent Agency Areas
Inflow from East	12,660	AEWSD, Olcese WD, other eastern lands
Outflow to North	-10,413	NKWSD, Cawelo WD, other northern lands
Outflow to West	-2,995	RRBWSD, Pioneer, Kern Water Bank
Outflow to South	-5,073	Southern KRGSA Plan Area
Net Total Subsurface Flows:	-5,821	

Table 4-9: Net Subsurface Flows In/Out of Southern KRGSA Plan Area

Net Subsurface Flows	Average Annual Flow (AFY)	Adjacent Agency Areas
Inflow from North	5,073	Northern KRGSA Plan Area
Inflow from West	13,272	Kern Water Bank, Henry Miller WD, BVWSD-Maples, other western lands
Inflow from East	1,989	Arvin-Edison WSD
Outflow to South	-10,475	Wheeler Ridge-Maricopa WSD
Net Total Subsurface Flows:	9,859	

For the southern KRGSA Plan Area, the model indicates an overall net inflow of 9,859 AFY on an average annual basis. Subsurface inflows occur from the northern KRGSA Plan Area, the east, and also from the west where water levels are relatively high near the Kern Fan banking projects (**Table 4-9**). The model suggests a net outflow to the south, although perched water conditions are not well-simulated in this area; accordingly, the model may be overestimating flow through the clay deposits beneath the Kern lakebed.

Combining the northern and southern net subsurface flows, an average annual inflow of approximately 4,038 AFY is estimated for the KRGSA Plan Area. As with all subsurface flows discussed herein, the flows vary substantially on a monthly basis and are typically associated with both inflows and outflows over time. Net subsurface flows are expected to diverge from these estimates as water level conditions change in the Subbasin over time in response to GSP implementation by the KRGSA and other GSAs.

4.5.4 Estimated Sustainable Yield

The detailed water budget, developed using three independent methods of analysis, indicates that, in general, the KRGSA has experienced only relatively small changes in groundwater in storage on an average annual basis over the 20-year Study Period. **Table 4-10** presents a summary of these groundwater in storage changes.

Table 4-10: Method Comparison, Annual Change in Groundwater in Storage, KRGSA Plan Area

Water Budget Method	Change in Groundwater in Storage (AFY)[1]	Comments
Checkbook	-1,978 AFY	Tabulates recharge and pumping for the physical groundwater system beneath the KRGSA (**Table 4-3**, **Figure 4-1**)
C2VSimFG-Kern Model	4,055 AFY	Simulated inflows and outflows including subsurface flows (**Tables 4-6** and **4-7**, **Figure 4-5**)
Groundwater Elevation Contour Maps	-2,912 AFY	Subtraction of spring groundwater elevation contour maps (**Figure 3-28**)
Adjusted Checkbook	-29,153 AFY	Removes recharge and pumping attributable to non-KRGSA parties. Adds banking outside of KRGSA attributable to KRGSA agencies (**Table 4-5**)

[1]Average Annual Change over Historical Study Period (WY 1995 – WY 2014) for the KRGSA Plan Area

Table 4-10 shows that the first three methods of analysis, while different in many aspects, provide similar average annual changes in groundwater in storage over a 20-year period, ranging between -2,912 AFY and 4,055 AFY. Given the magnitude of inflows and outflows, which average more than 300,000 AFY (**Tables 4-1** and **4-2**), the results for the first three methods are within about one percent of the estimated flows. Collectively, these results indicate that there has not been a significant and unreasonable reduction in groundwater in storage historically beneath the KRGSA. Any small deficits (indicated by negative numbers) for the first three methods could be readily eliminated with minor management actions, thereby establishing a sustainable water budget.

This sustainable water budget for the KRGSA physical groundwater system suggests that groundwater outflows could be sustained at historical averages without significant overdraft and thus represents an initial estimate of a sustainable yield for groundwater beneath the KRGSA Plan Area[32]. This is considered only an initial estimate, in part, because the SGMA definition of sustainable yield is broader than just a sustainable water budget. Specifically, SGMA defines sustainable yield as follows:

> "…the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result (§10721(w))."

As indicated above, the sustainable yield is linked directly to the analysis of undesirable results, which includes a comprehensive analysis of sustainability indicators other than the reduction of groundwater in storage. Undesirable results are analyzed in **Section 5** of this GSP. Accepting this qualification for the purposes of an initial estimate only, the average annual sustainable yield is approximately 321,871 AFY and assumes average annual groundwater inflows of about 319,893 AFY as itemized on **Table 4-1**. The sustainable yield also assumes that the average annual surface water supplies available for the historical Study Period remain available to meet demands (presented in **Section 4.6**).

The adjusted checkbook method (row 4 on **Table 4-10**) indicates a more significant decline in groundwater in storage than the water budget analysis of the physical groundwater system provided above. As discussed in **Section 4.4.2**, a change in groundwater in storage of about -29,153 AFY is being considered by KRGSA Plan Managers for planning purposes (**Table 4-10**). As discussed previously, this method removes recharge and pumping attributable to others outside of the KRGSA (e.g., banking projects within the KRGSA such as Berrenda Mesa or banking by outside parties in the COB 2800 facility). Even though this decline may be offset, in part, by subsurface flows and/or maintenance of positive banking balances, the KRGSA Plan Managers have decided to address this deficit in the GSP for future sustainable groundwater management. Using these adjustments for the checkbook method, the sustainable yield of the KRGSA Plan Area would be reduced to about 290,740 AFY, assuming historical adjusted inflows presented in **Table 4-10**.

The initial sustainable yield estimates discussed above of about 290,000 AFY to 320,000 AFY are considered sufficiently accurate for planning purposes. However, this GSP recognizes that the actual sustainable yield of a groundwater basin is not a fixed number; rather, the sustainable yield will change based on changes in water supplies and demands for the future. Future projected demands are expected to increase while future projected supplies may be adversely impacted due to climate change and other factors. Therefore, the GSP is being developed to eliminate this and future projected deficits, as reasonable. The projected water budgets are described in more detail in the following sections.

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[32] It is recognized that a simple comparison of inflows and outflows may not equate to a sustainable yield if the inflows cannot be adequately captured (Bredehoft,2002). However, results of the change in storage analysis using the groundwater elevation contour maps and the numerical groundwater modeling both corroborate the checkbook method and support the use of this water budget analysis for planning purposes.

4.5.5 Native Safe Yield Estimates for the Kern County Subbasin

The Kern County Subbasin GSAs have been coordinating on a Subbasin-wide checkbook-type water budget analysis (Subbasin Checkbook) for planning purposes. Specifically, the Subbasin Checkbook has been developed to ensure that GSAs are not double-counting water supplies and to estimate a consistent range for a native safe yield in the Subbasin. Ranges of values were developed and selected primarily for application to non-managed lands in the Subbasin.

In developing estimates, the Subbasin GSAs considered results from the C2VSim-FG Kern model and other local information. Recognizing the uncertainty associated with spatial variation and other factors affecting the analysis, a range of numbers was developed and evaluated. After discussions with the Kern Subbasin Policy Committee, it was determined that a preliminary estimate of 0.15 AF/acre represented a reasonable approach for a native safe yield to be applied to currently-undeveloped Subbasin lands. For lands that are currently irrigated, an estimate of 0.2 AF/acre was selected for the amount of effective precipitation that would satisfy a portion of the crop ET. Therefore, for currently irrigated lands, the Subbasin-wide estimates indicate a safe yield of 0.35 AF/acre (0.15 AF/acre plus 0.2 AF/acre). This range of 0.15 AF/acre to 0.35 AF/acre will continue to be evaluated and revised, as needed.

4.6 Surface Water Supplies

KRGSA agencies have a long history of conjunctive use in the Plan Area. Local surface water sources (primarily the Kern River) and imported water sources (mostly SWP) are managed for direct use and groundwater recharge. These actions serve to decrease reliance on groundwater and to replenish it for times when surface water supplies are limited. In this manner surface water and groundwater are managed conjunctively to optimize water supply for beneficial uses in the KRGSA Plan Area.

Almost all surface supplies available to the KRGSA are managed by the City of Bakersfield, ID4, and KDWD. The surface water supplies used in the KRGSA Plan Area by these agencies over the historical and current study periods are shown graphically on **Figure 4-6**; average annual supplies from the historical Study Period are summarized in **Table 4-11**.

Table 4-11: Historical Average Annual Surface Water Use, KRGSA Plan Area, WY 1995 – 2014

Agency	Average Annual Surface Water Use WY 1995 – WY 2014	Sources
City of Bakersfield	59,770 AFY	Kern River
Improvement District No. 4	74,035 AFY	SWP, Kern River (right or exchange), CVP by exchange
Kern Delta Water District	192,517 AFY	Kern River (right or exchange), SWP, CVP
East Niles CSD	1,464 AFY	CVP from AEWSD; average deliveries 1996-2003
TOTAL	327,786 AFY	

Note: Does not include surface supplies banked outside KRGSA for future use in the KRGSA, which represents significant quantities that vary over time and can be extracted as a reserve supply, when needed.

During this period, additional surface water supplies were available for use but were not always optimized for a variety of reasons. Some water was available during wet years prior to the completion of current recharge facilities. During wet periods, some agencies within the KRGSA did not use their full SWP allocation because water levels were high and groundwater pumping was determined to be less expensive. For the City, a portion of its Kern River supplies was obligated to long-term contracts that have since expired. For KDWD, its Water Allocation Plan (WAP), which resulted in more effective use of its Kern River entitlement, had not yet been adopted. A primary goal of this GSP is optimize surface water supplies available to the KRGSA Plan Area to eliminate undesirable results and promote sustainable groundwater management for the future.

4.6.1 Current Surface Water Supplies

Descriptions of the various surface water supplies managed by the KRGSA are summarized in **Section 2.4.5** for KRGSA Water Purveyors and are not repeated here. Surface water supplies to be optimized in this GSP are listed in **Table 4-12**. Average supplies are based on either current availability or actual historical availability over hydrologic conditions (WY 1995 – WY 2014), as applicable. Using guidance from DWR and data from the ID4 UWMP, available SWP supplies have been reduced from actual historical use to current availability. In addition, DWR has provided guidance for further reductions to SWP supplies for the purposes of Climate Change planning. These reductions are not included below but are incorporated as 2030 and 2070 Climate Change baselines in the projected future water budget analysis using the C2VSimFG-Kern local model and discussed in subsequent sections.

Table 4-12: Total Surface Water Supplies Managed by the KRGSA

Agency	Average Annual Surface Water Supplies	Description
City of Bakersfield	163,139 AFY[1]	Kern River entitlement (incl. KRC&I and South Fork)[1]
	29,171	Recycled water and stormwater conservation
Kern Delta Water District	201,943 AFY	Kern River entitlement[2]
	15,765 AFY	SWP, Table A SWP Allocation – Current Conditions[3]
	1,257 AFY	11% "leave behind" from Groundwater Banking Program
Improvement District No. 4	51,281 AFY	SWP Table A Allocation – Current Conditions[3]
	1,432 AFY	SWP Article 21 Allocation – Current Conditions[3]
	9,000 AFY	Kern River, Lower River Water Right (KCWA)[4]
		Additional miscellaneous surface supplies not quantified[5]
		Not all water budget components included in table[6]
TOTAL	437,780 AFY	

[1] Pre-1914 water rights, average annual conditions; see **Section 2.4.5.** Total amount includes current obligations to others.
[2] Pre-1914 water rights; KDWD average annual entitlement adjusted for Court-imposed restrictions, Todd Engineers, 2011.
[3] Availability of SWP supplies based on Table A and Article 21 allocations and current DWR operations imposed on average hydrologic conditions; annual amounts provided by DWR.

[4] KCWA water rights on the Lower Kern River below 2nd Point; the first 40,000 AFY is provided to ID4, when excess River water is available – typically in wet years only. Based on the 20-year average hydrologic study period, an average annual 9,000 AFY is estimated for the ID4 Lower River right.
[5] KDWD has rights on the Lower River but water is available only in very wet years and in relatively small quantities; supply not quantified for purposes of this table. In addition, both the City and KDWD have used Kern River water released by other water rights holders. Over the historical Study Period, the City used an average of 20,000 AFY of released water. Because the future amount of release water is uncertain for projected River flows, it is acknowledged as an additional supply but not quantified for purposes of this table.
[6] Return flows from pumping, effective precipitation, and other water budget components are not included in **Table 4-12.**

As noted above, **Table 4-12** is not meant to be a full accounting of water budget components. Although groundwater contributes to surface supplies when extracted, the purpose of **Table 4-12** is to capture the primary surface water supplies available to use conjunctively with groundwater.

In addition, **Table 4-12** lists most but not all surface water supplies that have been available to the KRGSA from year to year. For example, the table does not include historical banking balances for water currently banked outside of the KRGSA for use by KRGSA agencies, even though significant amounts of banked water are available for recovery as needed and represent an important water supply. Previously banked water is viewed as a reserve source of water and, similar to surface water stored in Isabella Reservoir, provides a buffer for periods of limited supplies. Any excess water associated with the current supplies in **Table 4-12** will also be available for banking and recovery for future use. Finally, each of the KRGSA agencies listed above have coordinated the use of available supplies among Subbasin entities and obtained additional water through purchases, exchanges, or releases of supply to others.

4.6.2 Surface Water Storage in Lake Isabella

Isabella Dam and Reservoir were completed in 1953 to control the unregulated flows of the Kern River. Although built primarily for flood control, the reservoir facilitates delivery of regulated flows for water supply and also provides surface water storage. The reservoir was designed to hold 570,000 AF of water, but since 2006 the capacity has been operated at about 340,860 AF (about 60 percent of capacity) due to issues concerning seepage, earthquakes, and floods. The US Army Corps of Engineers (USACE) initiated the Isabella Dam Safety Modification project in 2012 to address these and other concerns. The project involves both design improvements to the existing dams and relocation of U.S. Forest service buildings in the excavation footprint. The ongoing project is expected to be completed in 2022 (USACE, 2012).

The reservoir has a minimum pool volume of 30,000 AF; the remaining storage capacity in the reservoir is reserved for downstream water rights holders to conserve water and is referred to as the conservation storage space. As explained previously, the USACE releases water from the dam as requested by the City on behalf of the Kern River Watermaster as long as the integrity of the dam is not jeopardized. Hydroelectric power generators have diversion rights that are also considered in the timing and amounts of releases from the dam.

KRGSA agencies have various rights associated with storing water in Lake Isabella. The City can use up to 34% of the total conservation storage space in the reservoir. KDWD is also allowed to store water within and as a part of the City's 34% conservation space with storage rights varying from month to month based on a rule curve (c). KDWD can store a maximum of 44,000 AFY in Lake Isabella with a maximum carryover amount of 7,000 AFY (KDWD, 2015). The Kern County Water Agency also has the right to store water in Lake Isabella during years when Kern River flows are approximately 125% of the long-term average or greater. As mentioned previously, KCWA has Kern River rights for the Lower River and allocates a portion of this to ID4.

The ability to store water in Lake Isabella for subsequent use and the ability to carry-over storage to the following year are important water management tools for securing long-term sustainability in the KRGSA Plan Area. Primary sustainability benefits of conserving water in Lake Isabella are summarized below:

- Regulates the timing of surface water deliveries to better match demands by storing winter and spring runoff for use in the summer. This practice provides water managers with more flexibility to satisfy demands while also optimizing groundwater recharge.
- Allows Carry-Over of stored water from one year to the next, which can be especially valuable when the following year is dry. Reliance on the stored water in dry years allows groundwater pumping to be reduced when water levels are likely declining, while still meeting water demands.
- Optimizes capture and management of runoff for beneficial use when climate change results in less snowpack and earlier snow melt runoff.

4.7 Projected Water Budgets

Although the historical water budgets provide useful water budget deficits representing average hydrologic conditions, changes in projected water supplies are anticipated to impact future water budgets. To better understand potential future deficits, the C2VSimFG-Kern local model was modified to simulate baseline and GSP conditions over a 50-year Planning and Implementation horizon incorporating 50 years of hydrologic data in the Subbasin. Model set-up and baseline development is described in **Attachment 1** and summarized below with an emphasis on conditions in the KRGSA.

4.7.1 Baseline Development

The 50-year planning and implementation horizon begins in WY 2021 after GSP submittal and review and extends through WY 2070. This 50-year sequence was developed using actual hydrologic data and water management practices documented in the 20-year historical Study Period WY 1995 – WY 2014, which represents average hydrologic conditions. These years were re-combined/repeated into a 50-year sequence, which also represented average hydrologic conditions in terms of average precipitation and the long-term mean flow on the Kern River. In addition, the intervening years between the last year of water budget data (Current Condition Study Period of WY 2015) and the beginning of GSP implementation (2021) had to be "bridged" to represent WY 2016 through 2020.

The sequence of the 20 years from the historical Study Period was re-ordered slightly to prevent the sequence from ending in the drought of record and to equal 50 years of average hydrologic data. The model set-up of the 50-year sequence based on historical data is summarized in **Table 4-13**.

Table 4-13: C2VSimFG-Kern Model Set-Up for the Planning and Implementation Horizon

Planning and Implementation Horizon (Water Year)	Based on Historical Study Period (Water Year)
2021 - 2032	2003 - 2014
2033 - 2052	1995 - 2014
2053 - 2070	1995 - 2012

Using this sequencing, three separate 50-year baselines were developed as described below.

1. **Baseline Conditions**: represented by current land use and projected water supply and demand. For current land use, conditions from WY 2013 were selected. Land use for the more recent years of WY 2014 and 2015 contained abnormal conditions associated with the drought of record including agricultural land fallowing and mandatory conservation measures. As such, these recent years would likely under-estimate projected future demands. Increases in urban demand for the KRGSA were simulated using projections of population and per capita water use from local KRGSA UWMPs including the City of Bakersfield, Cal Water, NORMWD/OMWC, Vaughn WC, Lamont PUD, and ENCSD. Using data from the UWMPs and County population projections, an area-weighted average population growth rate of 1.17 percent annually through 2040 and a 0.8 percent increase for subsequent years was incorporated into the model. Using targets of per capita water use from the UWMPs, a weighted average of 248 gallons per capita per day (gpcd) was developed and applied over the entire Planning and Implementation horizon. Reductions in SWP availability provided by KCWA/DWR for ID4 and KDWD were incorporated into the analysis.

2. **2030 Climate Change Conditions**: represented by reductions in water supply and increases in water demand using DWR climate change factors and guidance. For the KRGSA, further reductions in SWP water availability provided by KCWA/DWR (2070 climate change tables) for ID4 and KDWD were incorporated. Increases in urban demand were estimated using the same methodology as applied in baseline conditions (see description above). Agricultural demand was increased by an average of about four percent based on decreases in effective precipitation and higher estimates of potential ET as provided by DWR. DWR climate change guidance also includes a change in the timing of Kern River flows, with more winter/early spring flows and less summer flows. However, the total volume of the Kern River does not change.

3. **2070 Climate Change Conditions:** represented by further reductions to the 2030 Climate Change conditions for water supply and additional increases in water demand using DWR climate change factors and guidance. For the KRGSA, reductions in SWP amounts for ID4 and

KDWD were incorporated from KCWA/DWR 2070 SWP availability data as summarized and distributed by KGA (Erlwine, 2019). Increases in urban demand were estimated using the same methodology as applied in baseline conditions. Increases in agricultural demand of approximately seven percent were based on DWR guidance for 2070 conditions of precipitation and potential ET.

4.7.2 Projected Water Budget Deficits

Based on the increases in demand and decreases in water supplies, additional water budget deficits are projected for future conditions. The primary changes to the checkbook water budget are summarized in **Table 4-14** for planning purposes. A more detailed assessment of projected water budgets has been developed for both the Subbasin and the KRGSA using the C2VSimFG-Kern local model. These Subbasin-wide analyses are described in **Attachment 1** and summarized for the KRGSA in **Section 4.7.3**.

Table 4-14: Projected Water Budget Components and Potential Deficits (Checkbook Method)

Water Budget Component	Historical Average Annual Amounts (AFY)	Baseline Conditions (AFY)	2030 Climate Change Conditions (AFY)	2070 Climate Change Conditions (AFY)
SWP[1] – ID4	74,035	52,758	51,182	48,759
SWP - KDWD	18,655	15,765	15,294	14,537
TOTAL SWP	92,690	68,523	66,476	63,296
Net decrease in SWP from historical:		**24,167**	**26,214**	**29,394**
Agriculture Demand	261,019	261,019	271,460	281,460
Urban Demand[2]	167,970	182,290	178,115	254,117
TOTAL DEMAND	428,989	443,309	449,575	535,577
Net increase in demand from historical:		**14,320**	**20,586**	**106,588**
Potential Future Water Budget Deficits[3]:		-38,487	-46,800	-135,982
Deficit from Historical Water Budget[4]:		-29,153	-29,153	-29,153
Combined Future Water Budget Deficits:		**-67,640**	**-75,953**	**-165,135**

[1] *Table A Allocation and Article 21 water*

[2] *Baseline Conditions urban demand from WY 2013. Urban demand for 2030 based on area-weighted population growth (average 1.1% annually) and per capita water demand estimates from UWMPs (average 248 gpcd). Population growth rates for the County (0.8% annually) used for years 2040 through 2070.*

[3] *Sum of net decrease in SWP and net increase in demand from data in upper table.*

[4] *Remaining average annual deficits from adjusted checkbook method of the historical water budget; see **Table 4-5**.*

As shown in **Table 4-14**, SWP water availability is projected to decline under baseline and both climate change conditions. Agricultural demand increases under climate change conditions as a result of higher potential evaporation and lower precipitation (i.e., hotter and drier conditions). Urban demand is projected to increase based on an increase in population and changes in per capita water demand, as documented in the individual UWMPs of the primary water purveyors. A decline in urban demand from baseline to 2030 conditions is due to a decrease in per capita water demand for future conditions as indicated in the UWMPs. Collectively, these projected supplies indicate potential water budget deficits of -38,487 AFY (Baseline), -46,800 AFY (2030 Climate Change), and -135,982 AFY (2070 Climate Change).

The methodology used to develop the projected increases in demand is conservative in that current land use is unchanged. The increases in urban demand listed in **Table 4-14** are controlled by population growth projections for the future. A portion of the City's growth could convert agricultural lands to urban use, resulting in a double-counting of demands in **Table 4-14**. Based on recent trends of urbanization, conversion of about 10,000 acres of agricultural lands (about 10 percent of total agriculture in the KRGSA) to urban use is estimated to occur over the planning horizon, providing an agricultural demand reduction. To account for this land use conversion in the projected water budgets, a decrease in agricultural demand of about 27,000 AFY (i.e., 2.7 AF/acre) is included as a project in this GSP (see **Section 7.1.4**). Accordingly, no changes for this demand reduction are made for purposes of the climate change baseline analyses.

Also, as shown on **Table 4-14**, previously-identified checkbook deficits from the historical water budget are added to the future projected water budgets. Specifically, a deficit of about -29,153 AFY was estimated for an adjusted checkbook analysis that removed banking, recharge, and other activities in the KRGSA Plan Area that were attributable to others from the historical water budget (see **Section 4.4.2** and **Table 4-5**). This historical water budget deficit is added to the projected baseline deficits (38,487 AFY) and the 2030 and 2070 Climate Change deficits (-46,800 AFY and -135,982 AFY in **Table 4-14)**, resulting in combined potential future water budget deficits of -67,640, -75,953 AFY and -165,135 AFY for the three baseline conditions. Again, these deficit estimates are computed on a checkbook basis and do not account for subsurface flows or banking in the KRGSA conducted by others. Nonetheless, they represent maximum estimated future deficits for planning purposes.

Kern River supply is not included in **Table 4-14** because it is not associated with a significant future deficit. Although there are projected changes in the monthly timing and flows for the Kern River under both 2030 and 2070 Climate Change conditions, the total average annual flows in the River are not expected to decline significantly. Specifically, GEI consultants analyzed projected future changes in the monthly unregulated River flows at First Point to assist with setting up the climate change analysis in the C2VSimFG-Kern model. GEI used DWR monthly and annual runoff change factors for the contributing watersheds and re-calculated local runoff. These estimates predict a significant decrease in summer flows between April and September and a corresponding projected increase in flows from October through March. However, overall projected changes in the total annual flow volumes are less than one percent (99.6 percent for 2030 condition and 99.4 percent for 2070 conditions). Further, the change in timing of flows can be managed by KRGSA diverters for optimal Kern River use.

The potential decreases in supply and increases in demand in **Table 4-14** are used to develop appropriate projects and management actions that target a sustainable water budget. Projects and management actions are described in **Section 7** of this GSP.

The potential deficits projected in **Table 4-14** for the 2030 Climate Change conditions occur only 10 years after GSP implementation in 2020 and are within the window for achieving sustainability. Accordingly, those conditions are the focus of the priority GSP projects. It is recognized that the 2070 Climate Change conditions are less certain, given the long-term 50-year implementation and planning horizon. As part of the GSP, future Annual Reports and five-year GSP evaluations will be used to update these potential projected deficits when more detailed information from the KRGSA water budgets will be available. During those re-evaluations, the GSP will be adapted as needed to maintain sustainable groundwater management.

4.7.3 Projected Water Budget Results for the KRGSA Plan Area

Projected water budgets were analyzed based on the conditions described above for baseline, 2030 Climate Change, and 2070 Climate Change scenarios. Based on the checkbook estimate of water budget deficits described above, three GSP water supply projects and one demand reduction project were developed to erase those deficits. Those four projects – the KDWD Water Allocation Plan, the City Kern River Conjunctive Use Optimization, the City Expansion of Recycled Water Use and Urbanization of Agricultural Lands – are all scheduled to begin implementation in Phase One (by 2025) with benefits realized by 2030; projects are described in more detail in **Sections 7.1.1**, **7.1.2**, **7.1.3**, and 7.1.4, respectively. As documented in **Section 7.1**, these four projects are sufficient to eliminate potential future deficits for both baseline and the 2030 Climate Change scenarios using the checkbook water budget methodology. Projects were demonstrated to meet all estimated future deficits when analyzed with the C2vSimFG-Kern model, as described in the sections below.

4.7.3.1 Projected Water Budget Change in Groundwater in Storage

Model input files were developed for the Phase One GSP projects affecting water supply or demand and simulated with the C2VSimFG-Kern model for each of the three baseline/climate change scenarios. Model results demonstrate the ability for GSP projects to offset deficits, avoid future overdraft conditions, and prevent undesirable results. In total, six model simulations were developed, one for each of the three baselines/climate change scenarios with and without projects. Model results over the Planning Horizon WY2041 through WY2070 are summarized in **Table 4-15**; annual model results are presented in **Appendix H** for the entire 50-year Implementation and Planning horizon. Model results in **Appendix H** include three simulations that impose GSP projects on each of the three baseline conditions. The change in groundwater in storage for each of the three simulations in **Appendix H** are summarized in the second column of **Table 4-15**.

Table 4-15: Future Projected Water Budget Model Results

Water Budget Scenario	Change in Groundwater in Storage*	Adjustments for Model Limitations		Adjusted Change in Groundwater in Storage
		Excess Kern River Outflow from Model	Banking Obligations for Export from Subbasin**	
AFY	AFY	AFY	AFY	AFY
Baseline	-13,395	0	-6,714	-20,109
Baseline with Projects	47,404	12,629	-6,714	53,319
2030 Climate Change	-16,309	4,680	-6,548	-18,177
2030 with Projects	45,183	21,476	-6,548	60,111
2070 Climate Change	-33,421	9,371	-6,217	-30,267
2070 with Projects	29,111	27,854	-6,217	50,748

**Model results with projects demonstrate sustainability over the Planning Horizon WY2041 through WY2070.*
*** Only water banked for export from the Subbasin is included in this adjustment to preserve the overall Subbasin water budget simulated in the model. As explained in **Section 4.4.2**, additional banking obligations, as well as credits, are applicable for adjustments in the KRGSA using the checkbook method.*

The change in groundwater in storage for each model run in the second column of **Table 4-15**, requires adjustments due to model limitations. Specifically, the model is not optimized to simulate Kern River management and cannot account for all of the recharge from the Kern River; that is, the model indicates baseflow beneath the western banking projects (west of the KRGSA) where no baseflow occurs. This excess Kern River outflow from the model requires manual adjustment for the amount of recharge that is not captured by the model; those amounts are tabulated and summarized in the third column of **Table 4-15**.

An additional adjustment is made in the fourth column of **Table 4-15** involving a correction for the banking obligations in the KRGSA that are dedicated for subsequent export out of the Subbasin. Such obligations will add to water budget deficits when exported. This adjustment has to be made outside of the model to preserve the physical inflows and outflows to the groundwater system. By adjusting for only the banked water that will be exported from the Subbasin, the overall Subbasin water budget is preserved. (As indicated by the footnote below **Table 4-15**, this banking adjustment does not account for all of the banking complexities within the KRGSA; these are discussed in more detail below).

The resulting adjusted change in groundwater in storage is provided in the last column of **Table 4-15**. Adjusted model results are shown graphically on **Figure 4-7** for the 70-year implementation and planning horizon. Changes of groundwater in storage are illustrated on a cumulative basis for the six model runs summarized on **Table 4-15** (note that the units on **Figure 4-7** are in thousands of AF). Results in **Table 4-15** and **Figure 4-7** demonstrate the ability of the GSP projects to achieve sustainability within the KRGSA during the implementation period and to maintain sustainability throughout the planning horizon.

As shown in **Table 4-15**, the baseline/climate change deficits indicated from the modeling (i.e., -20,109 AFY, -18,177 AFY, and -30,267 AFY) are smaller than estimated previously in **Table 4-14** by the checkbook method. This is due to the differences between a numerical model method (**Table 4-15**) and a checkbook method (**Table 4-14**). First, subsurface flows occur dynamically in the groundwater model and are not included in the checkbook approach. Second, banking recharge conducted within the KRGSA by others is included in the model but not in the checkbook. This is appropriate because the model represents the physical groundwater system, yet this inclusion of others' banked water in the checkbook could over-estimate water available to the KRGSA.

Notwithstanding these subsurface flows and banking complications, GSP projects clearly provide sufficient increased water supply and decreased demand to eliminate both checkbook and adjusted model deficits and fully mitigate potential future overdraft. Volumes of water associated with Phase One GSP projects to address deficits from baseline and 2030 climate change conditions are summarized on **Table 7-1** and documented in **Sections 7.1.1**, **7.1.2, 73.1.3**, and **7.1.4**.

4.7.3.2 Future Projected Model Hydrographs

Model results also indicate that GSP projects are sufficient to eliminate undesirable results during the implementation period and avoid them throughout the planning horizon. This was tested by the model using preliminary representative monitoring well locations as shown on **Figure 4-8**. Initial sustainable management criteria (including minimum thresholds and measurable objectives[33]) were selected for these wells (as described in **Section 5**). As described in more detail in **Attachment 1**, the model was set up to simulate water level response to GSP projects at these wells and predict whether levels could be maintained above the selected minimum thresholds[34]. These hydrographs were constructed using the principle of superposition and began with observed water levels in Spring 2015.

Eight model hydrographs were selected to illustrate how water levels are predicted to respond to GSP projects; four hydrographs were selected in the northern KRGSA Plan Area and four in the southern KRGSA Plan area as highlighted on **Figure 4-8**. Remaining superposition hydrographs for the GSP monitoring wells on **Figure 4-8** are included with more detailed model results in **Appendix H**.

Hydrographs from the northern and southern Plan Area are presented on **Figures 4-9** and **4-10**, respectively. Dark blue and black lines are used for the three baseline scenarios without projects (i.e., Baseline and the 2030 and 2070 Climate Change scenarios); magenta (solid and dashed) and yellow lines represent the three baseline scenarios with Projects. The initial minimum threshold is shown as a red line and labeled on each hydrograph; the measurable objective is shown in green.

Hydrographs from the northern Plan Area on **Figure 4-9** includes a northern well in agricultural areas (**Figure 4-9a**), two wells near the municipal wellfields of north-central Plan Area (**Figures 4-9b** and **4-9d**),

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[33] These thresholds are defined and discussed in detail in **Section 5**.

[34] Some minimum thresholds have been adjusted slightly since modeling was completed but adjustments are not sufficient to change the conclusions of the model results.

and a well in the banking area (**Figure 4-9c**) (see locations on **Figure 4-8**). With the exception of the banking area hydrograph (**Figure 4-9c**), all hydrographs show the overall declining trend in the baseline/climate change scenarios and an overall positive trend when the GSP projects are simulated. The banking area hydrograph doesn't illustrate these trends because of the banking operations whereby recharge occurs in wet years followed by pumping of an equal or lesser amount in dry years. Given this operation, local KRGSA banking projects do not contribute to overdraft. Although water levels fluctuate more significantly in response to these operations, model results indicate that water levels can be maintained above the minimum threshold to avoid undesirable results. In the southern KRGSA Plan Area, four wells (**Figures 4-10a** through **4-10d**) also illustrate the declining trends of the projected baselines and the rising water levels associated with GSP projects.

Collectively, these model scenarios indicate that the KRGSA projects described in **Section 7** are sufficient to address future water budget deficits and to meet GSP minimum thresholds as described in **Section 5**.

4.8 DATA AND KNOWLEDGE GAPS FOR THE WATER BUDGET ANALYSIS

As described above, surface water and groundwater components of the water budget analysis represent measured, estimated, and/or inferred amounts of water, each associated with an increasing level of uncertainty. Some uncertainty associated with missing or incomplete historical data cannot be addressed simply due to an absence of information; however, these missing data may not represent significant levels of "uncertainty" or a "data gap" as defined by SGMA. Both of these terms are defined in the regulations as representing significant unknowns that would affect the ability to assess whether a basin is being sustainably managed. For the water budget, the data gap analysis focuses on the larger water budget components that would likely affect the efficacy of Plan implementation or the ability to assess future sustainable management.

Surface water inflows represent mostly measured and well-documented values including Kern River flow, diversions, and deliveries, importation of SWP water, and wastewater deliveries. Groundwater banking amounts are also based on measured deliveries.

Municipal pumping, including several small water systems, is also measured via well meters. Although some estimates were required to fill incomplete historical data, these estimates are considered reasonable because they are based on other relatively accurate datasets such as population, water demands, and metered data covering similar time intervals. Pumping totals within the ID4 service area represent both metered and estimated data but are reported and recorded semi-annually by a public agency; accordingly, these data are considered reasonably accurate for the purposes of the water budget. The largest pumpers in ID4 have metered data, as do some smaller industrial pumpers and other water users. Most of the private and domestic pumping in the northern Plan Area is estimated, however, amounts are relatively small and would not significantly affect the water budget analysis.

Evaporative loss along the River is estimated based on measured reference evapotranspiration and observed vegetative conditions and considered sufficient for the water budget purposes. Estimates of stormwater conservation are based on previous studies and are regulated by the Central Valley Water Board through a stormwater permit. Estimates of municipal return flows are less certain, but the amounts are relatively small and based on established methods of estimation of indoor and outdoor water use for the region.

The most significant data gaps for the water budget analysis involve agricultural pumping and associated return flows. Private agricultural pumping is inferred based on estimated crop ET, surface water deliveries, and effective precipitation. Although the METRIC ET dataset provides a reasonable estimate for the cumulative agricultural pumping in the Plan Area on an historical basis, pumping details are unknown for any specific location or for future cropping patterns across the large agricultural areas. Private agricultural wells are located throughout the southern Plan Area (**Figure 2-14**), but there is no information on which wells are pumping when and how much. Well completion reports are a source of general information on pumping depths within the Principal Aquifer but are difficult to match to each active agricultural well identified by KDWD staff.

Because METRIC ET data are available for the historical Study Period, estimates are considered sufficient for the historical water budgets. However, future pumping will require either ongoing ET analysis or an alternative method to estimate pumping. In addition, the ability of rainfall to satisfy ET is also uncertain due to the difficulty of applying daily (or hourly) rainfall intensity and duration to then-current crop needs. This uncertainty in effective precipitation contributes to the uncertainty of how much water needs to be pumped to satisfy the total crop demand.

Even if ET and effective precipitation are better known, return flows associated with agricultural pumping are unknown and are qualitatively based on past KDWD analyses and general soil and irrigation assumptions. In the absence of actual values, an irrigation efficiency of 80 percent was applied evenly throughout the KRGSA Plan Area. However, the perched water conditions in the southern Plan Area clearly represent an area where return flows are expected to be much lower than in other parts of the KRGSA; any over-irrigation in these areas could be lost to evaporation. Even outside of the perched water zone, infiltration rates are expected to vary, and the amount of deep percolation is not well-quantified.

Finally, subsurface flows around the Plan Area perimeter are associated with significant uncertainty. Depending on Kern River flows, the activities at nearby Kern Fan banking projects, and other factors, these flows are highly dynamic and change seasonally and with wet/drought cycles. The C2VSimFG-Kern model is the best available tool for analysis of subsurface flows, but this component of the water budget will be more difficult to manage in the future. As GSP implementation projects occur at various times and rates in areas surrounding the KRGSA Plan Area, the ability to store and capture recharged water will depend on local hydraulic gradients, which are affected by water levels outside of the Plan Area and the resultant subsurface flows.

A summary of these data gaps, including the impact on groundwater management and potential management actions to address the issue are shown on **Table 4-16**.

Table 4-16: Data Gaps / Knowledge Gaps for the Water Budget Analysis

Issue	Area	Groundwater Management	Actions to Address
Agricultural Pumping	KRGSA Plan Area	Future pumping as crop ET changes over time.	Consider well metering. Consider use of METRIC or other ET estimating methods in future.
Agricultural Return Flows and Deep Percolation of Precipitation	KRGSA Plan Area	Affects the amount, timing, and location of groundwater recharge.	Consider well metering. Continue to monitor and analyze perched water conditions in the southern Plan Area. Document irrigation methods, as needed. Incorporate local infiltration rates into the water budget analysis.
Subsurface Flows	KRGSA Plan Area	Potential to affect the ability to meet Minimum Thresholds and understand water level changes.	Coordinate with adjacent areas and GSAs to manage water levels across district/GSA boundaries. Continue to document recharge/banking in the KRGSA by others.

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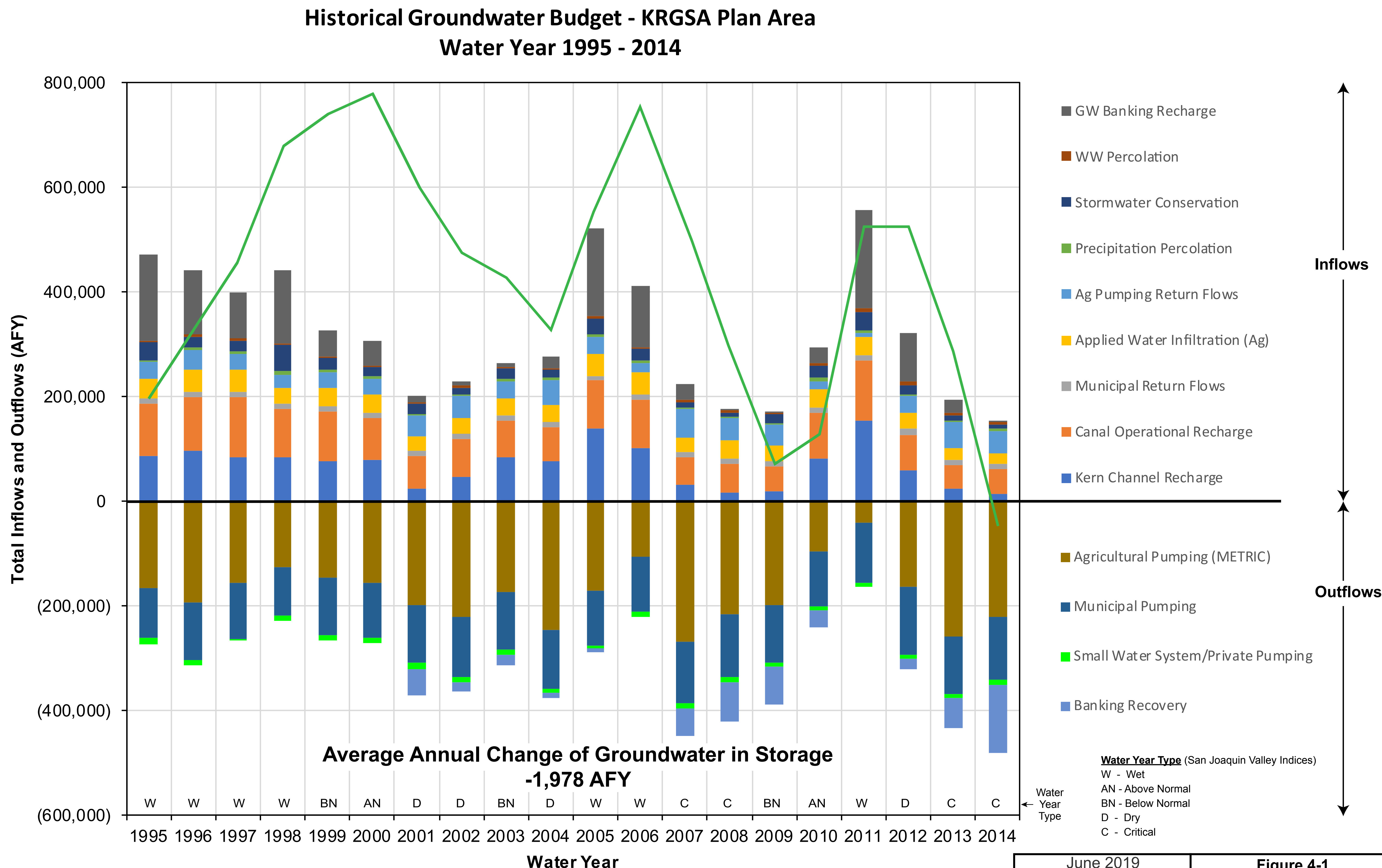
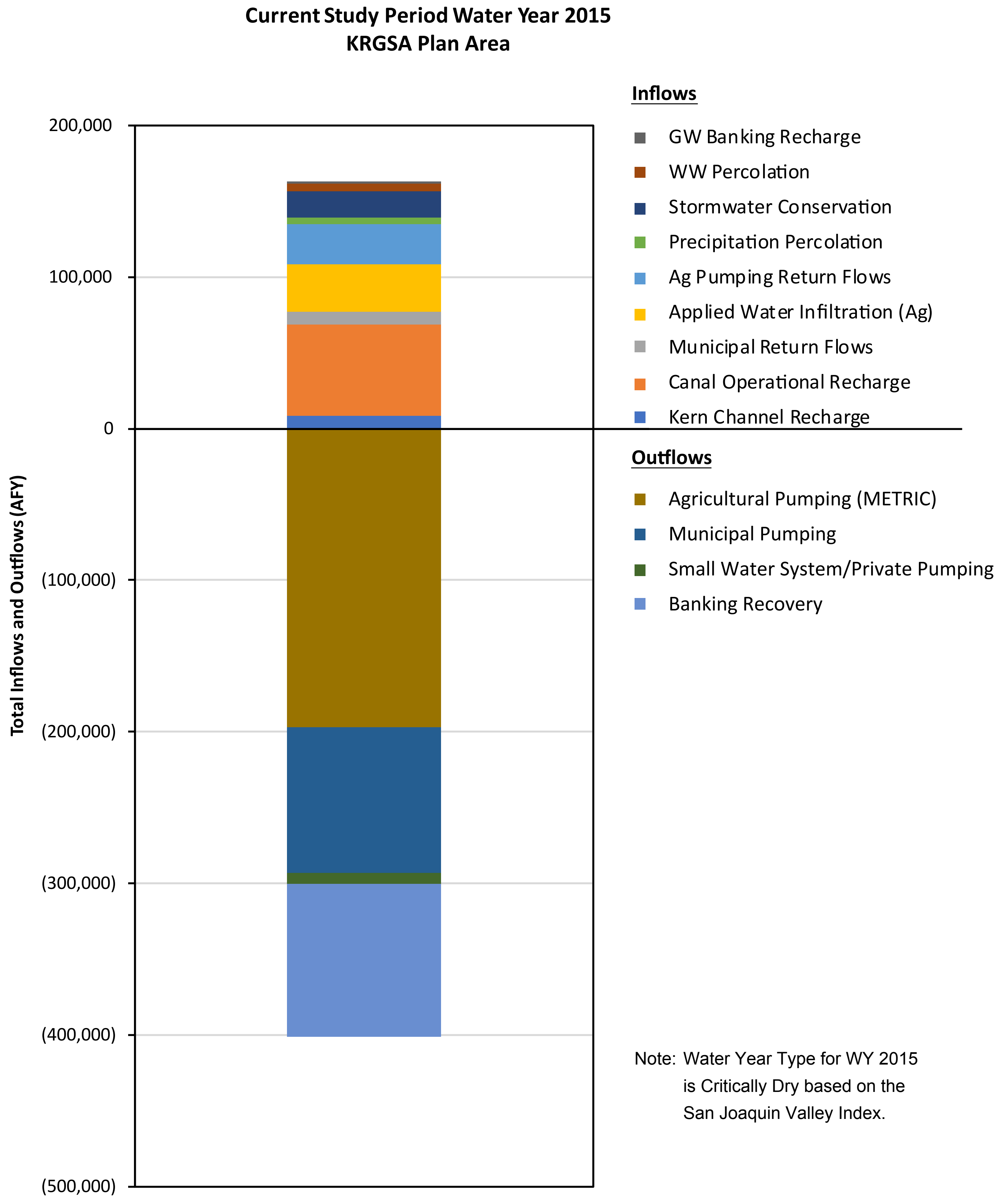


June 2019

TODD GROUNDWATER

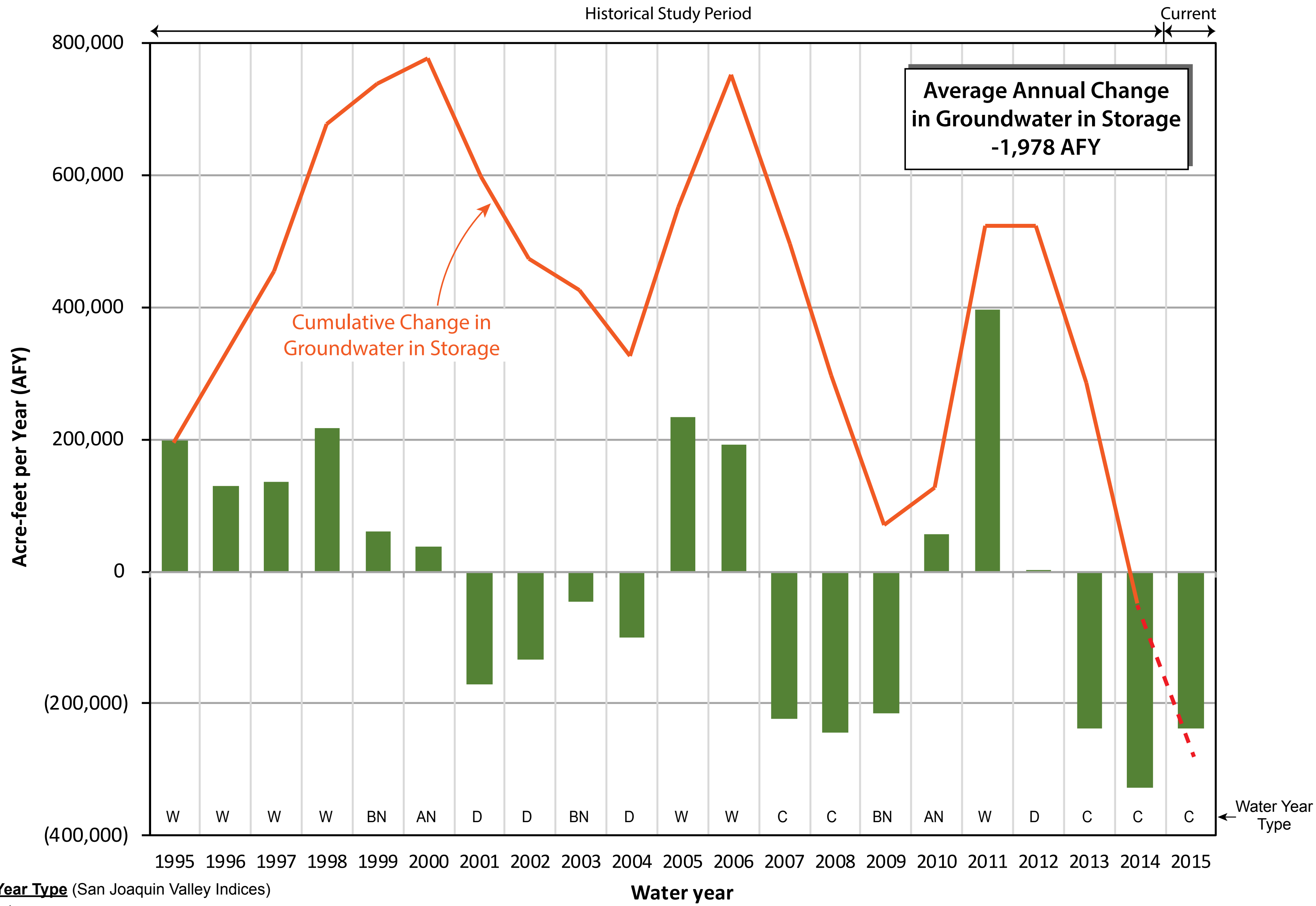
Figure 4-1
Historical Groundwater Budget Checkbook Method



June 2019

TODD GROUNDWATER

Figure 4-2
Groundwater Budget
Current Study Period
Checkbook Method

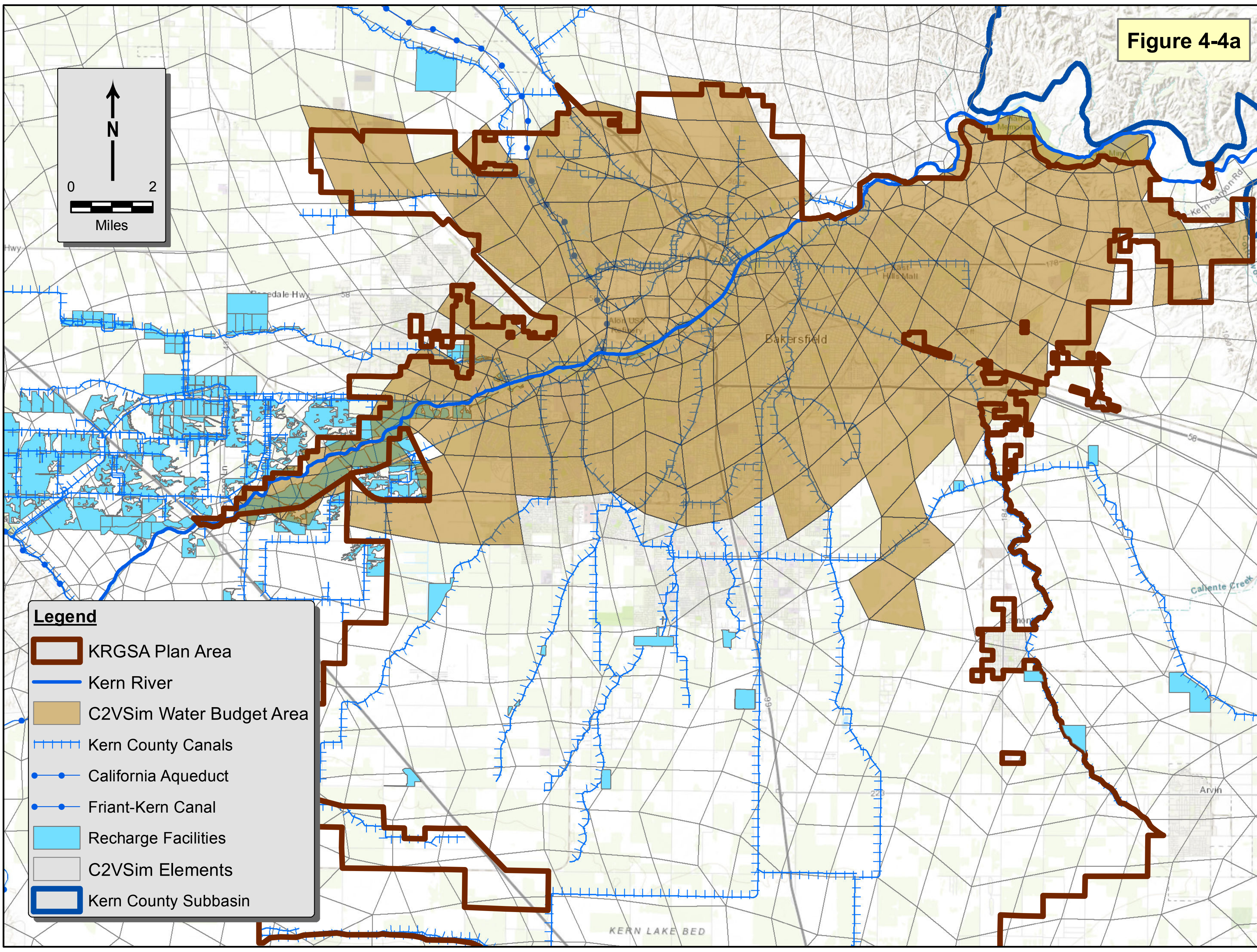


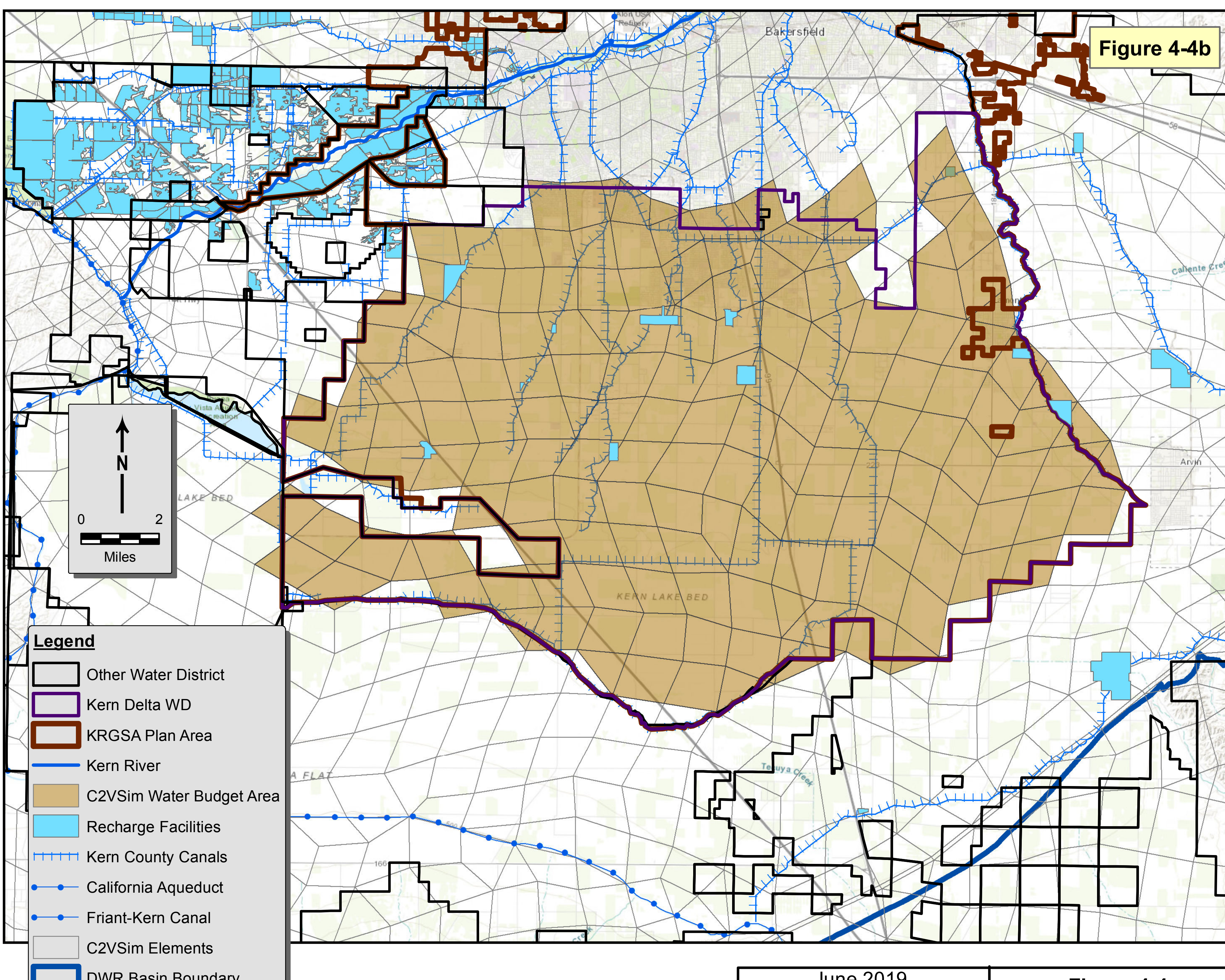
Water Year Type (San Joaquin Valley Indices)
W - Wet
AN - Above Normal
BN - Below Normal
D - Dry
C - Critical

June 2019

TODD GROUNDWATER

Figure 4-3
Changes in Groundwater in Storage Checkbook Method





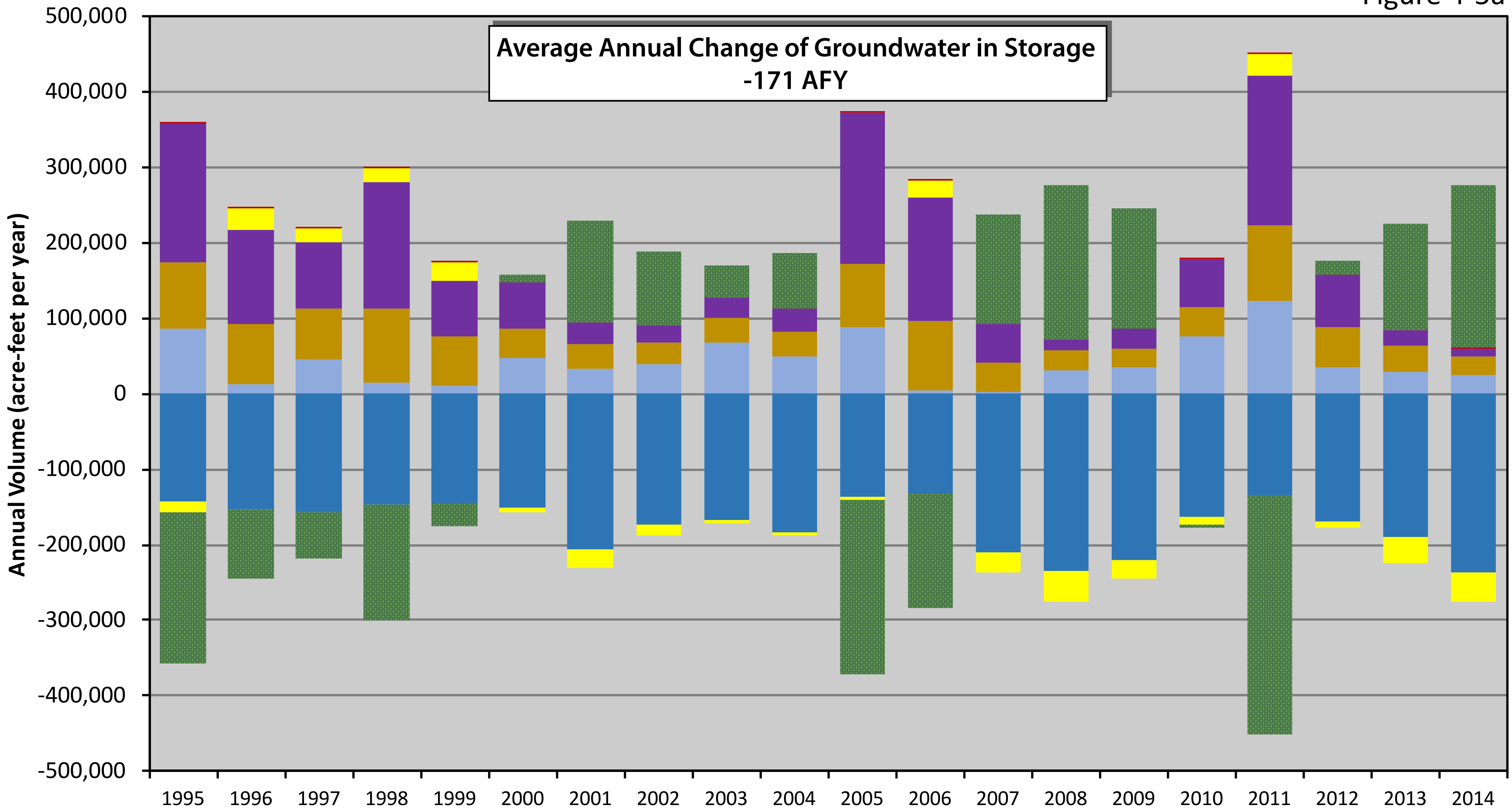
June 2019

TODD GROUNDWATER

Figure 4-4
C2VSimFG-Kern Model Water Budget Areas KRGSA Plan Area

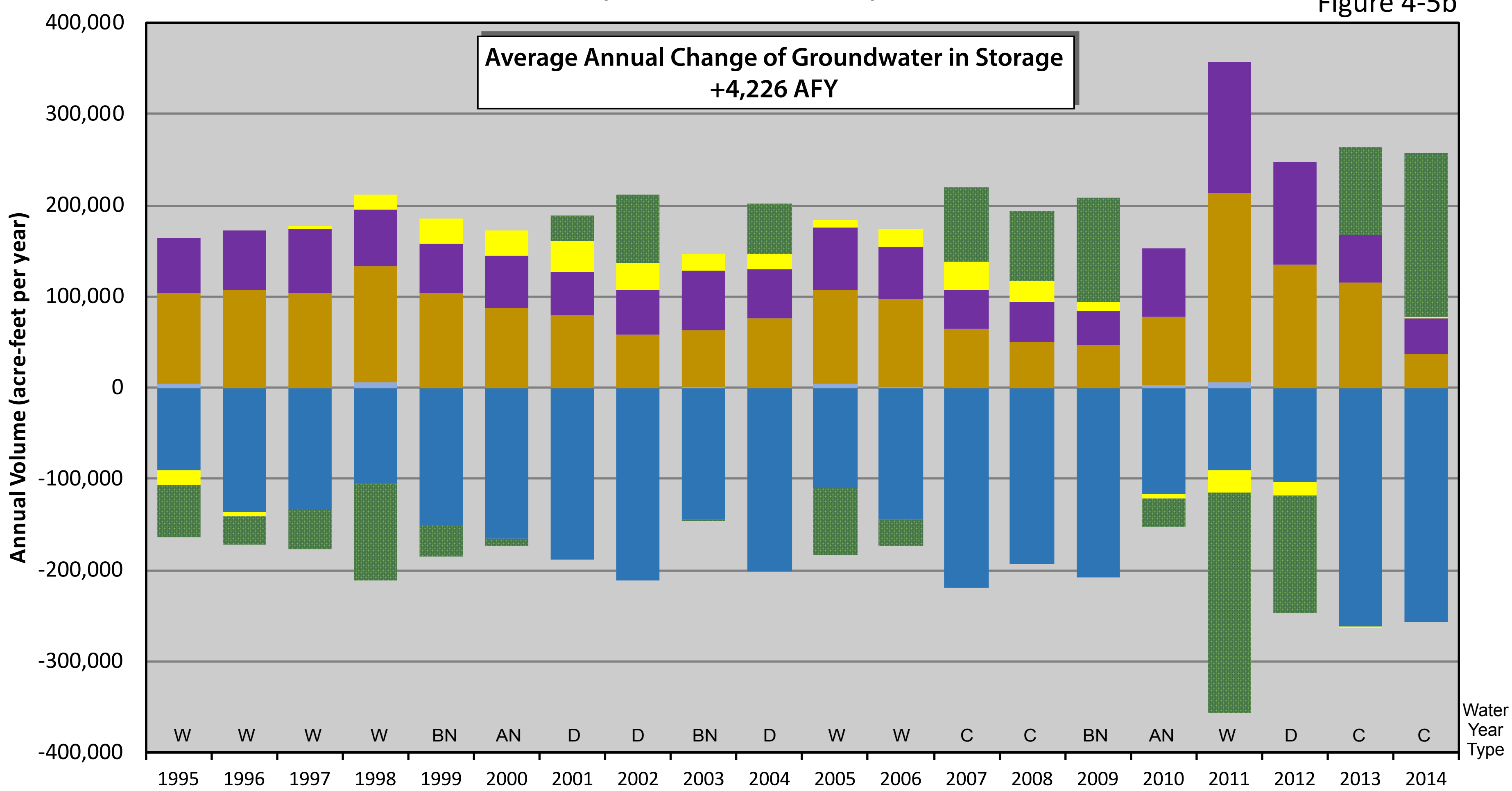
Historical Groundwater Budget for Northern KRGSA Plan Area
(WY 1995 - WY 2014)

Figure 4-5a



Historical Groundwater Budget for Southern KRGSA Plan Area
(WY 1995 - WY 2014)

Figure 4-5b



- River Channel Recharge
- Percolation of Precipitation, Return Flows, and Applied SW Infiltration
- Groundwater Pumping
- Managed Recharge; Canal Operational Recharge
- Net Subsurface Flows
- Basin Inflow
- Change in Groundwater in Storage

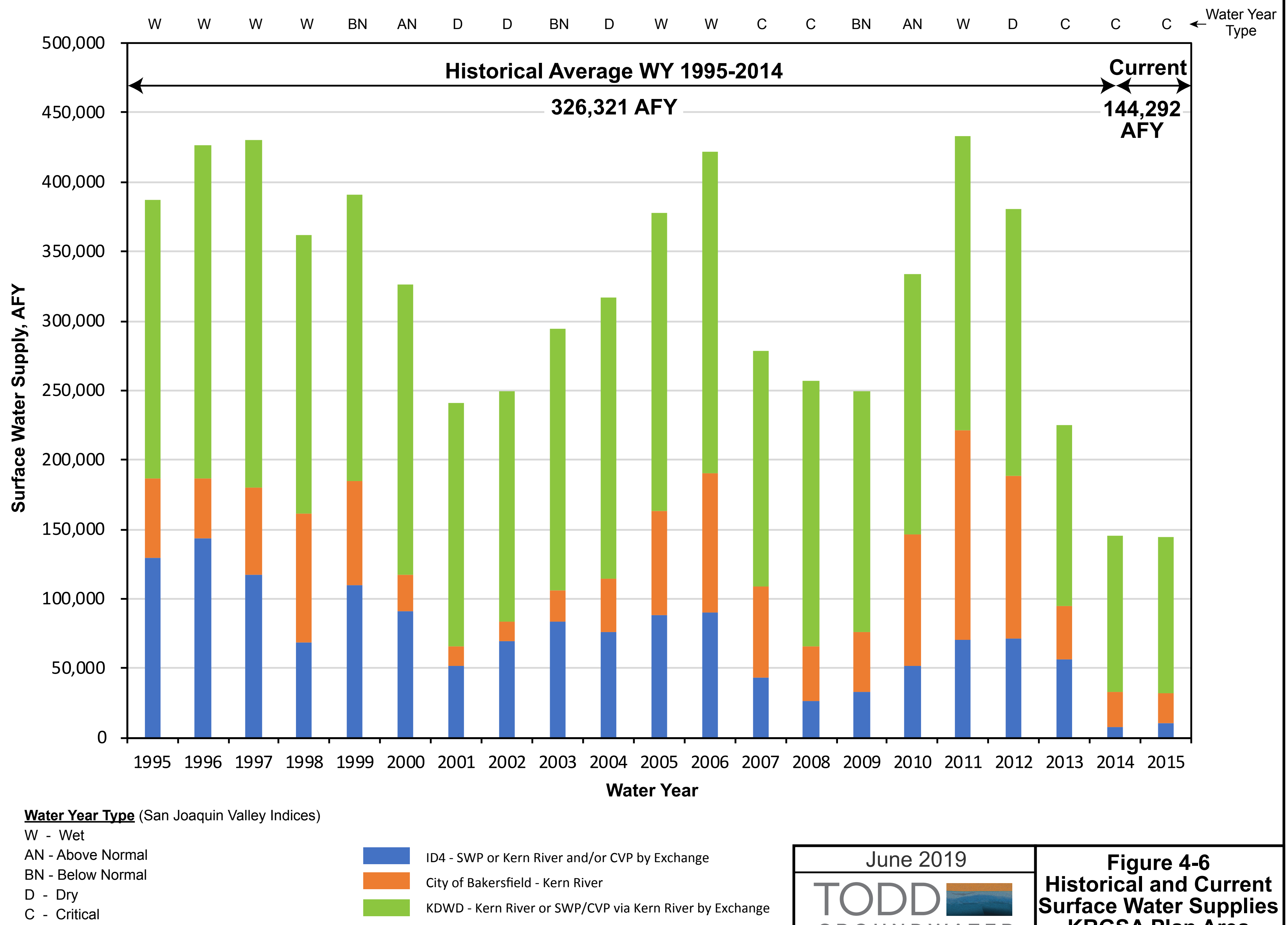
Water Year Type (San Joaquin Valley Indices)

W - Wet
AN - Above Normal
BN - Below Normal
D - Dry
C - Critical

June 2019

TODD GROUNDWATER

Figure 4-5
Historical Groundwater Budget
C2VSimFG - Kern Model
KRGSA Plan Area

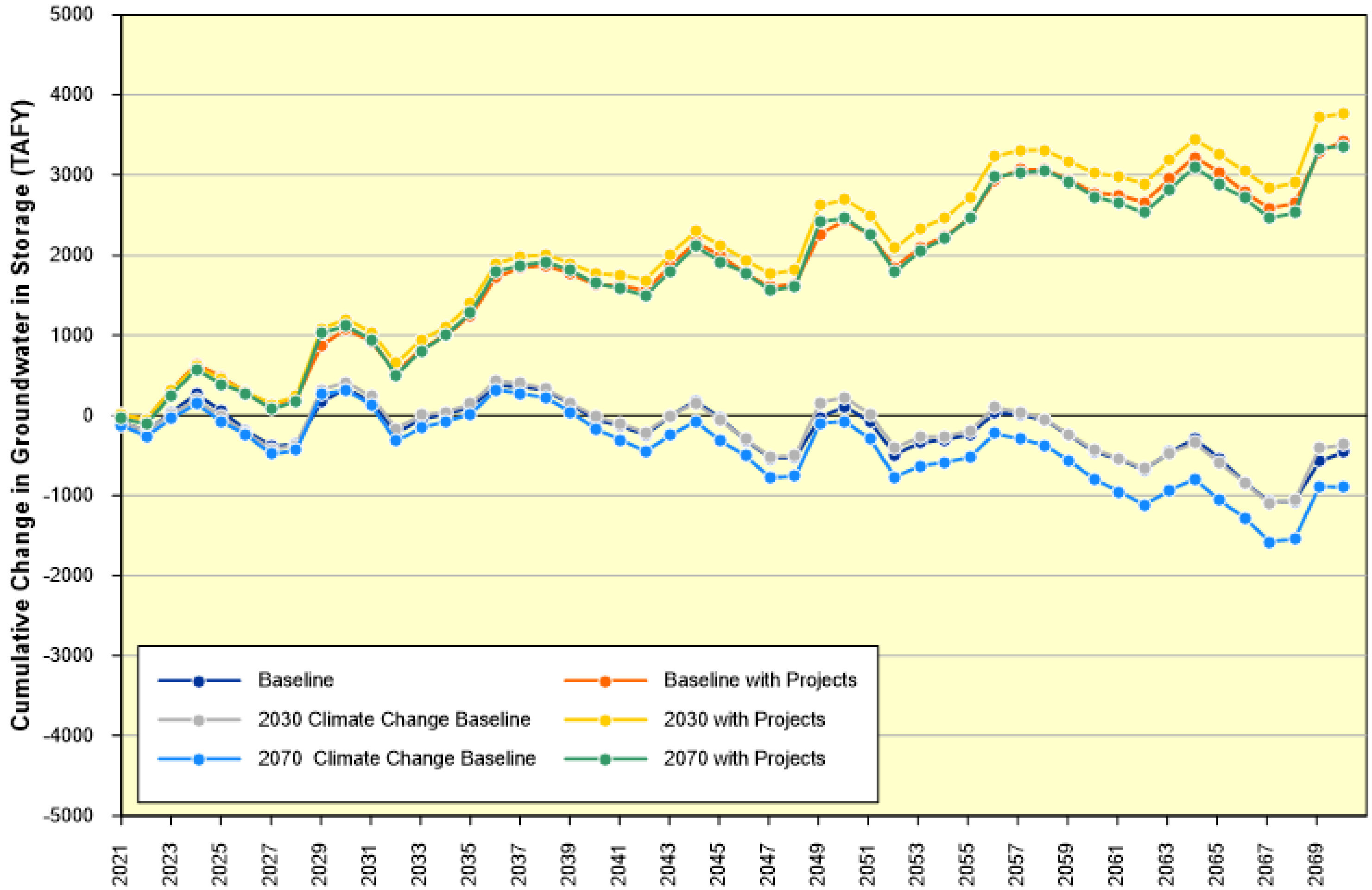


June 2019

TODD GROUNDWATER

Figure 4-6
Historical and Current Surface Water Supplies
KRGSA Plan Area

Future Projected Water Budget - Change in Groundwater in Storage
Baseline and Project Scenarios for the KRGSA Plan Area



Future Projected Water Budget as simulated with C2VSimFG-Kern model and adjusted for excess model outflow and banking obligations for Subbasin export.

November 2019

TODD GROUNDWATER

Figure 4-7
Future Projected Change in Groundwater in Storage

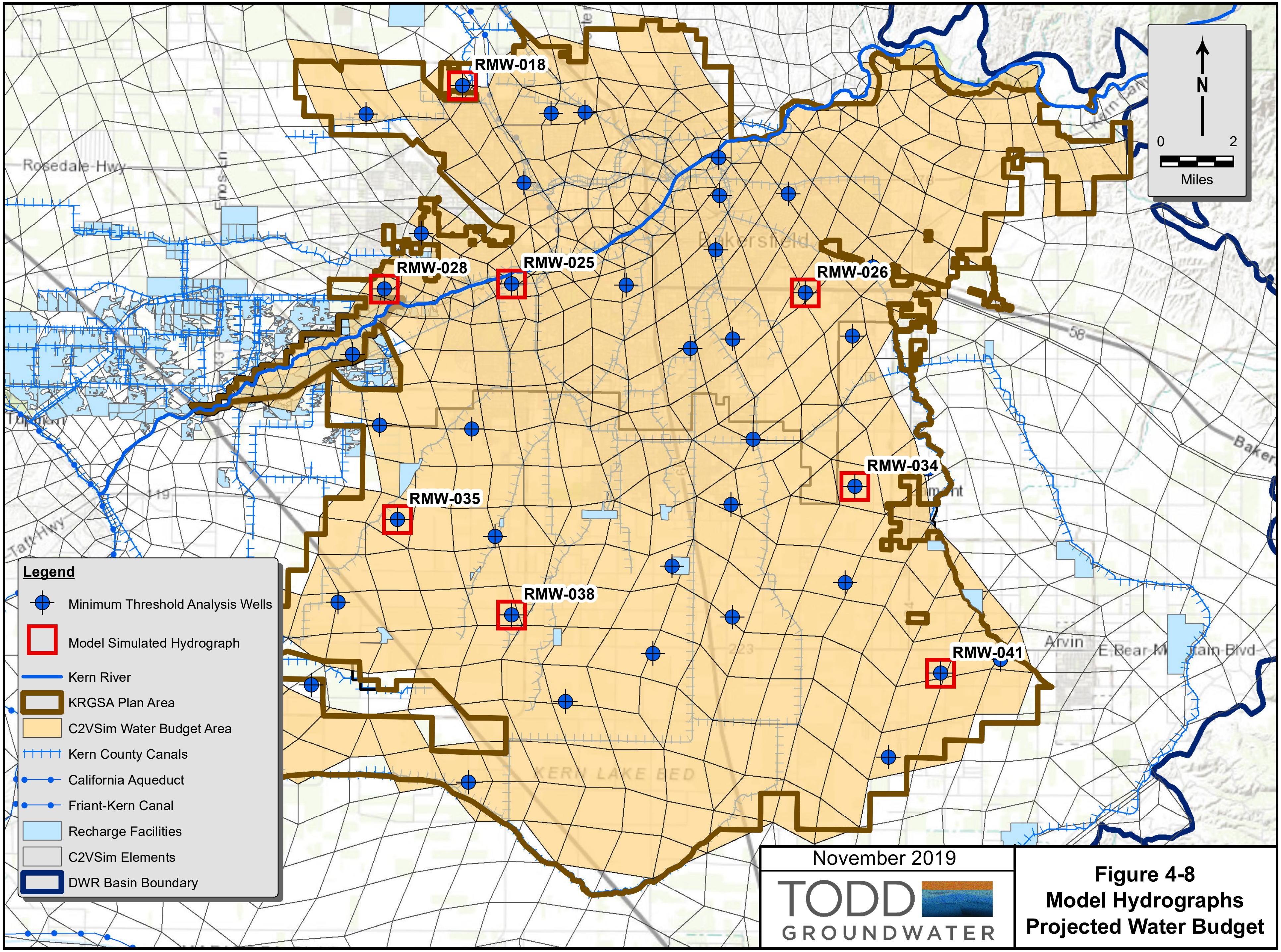
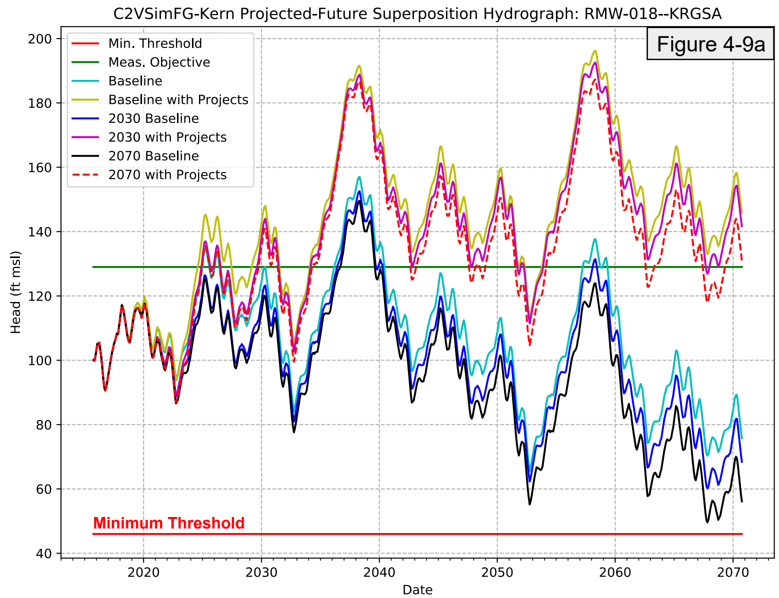
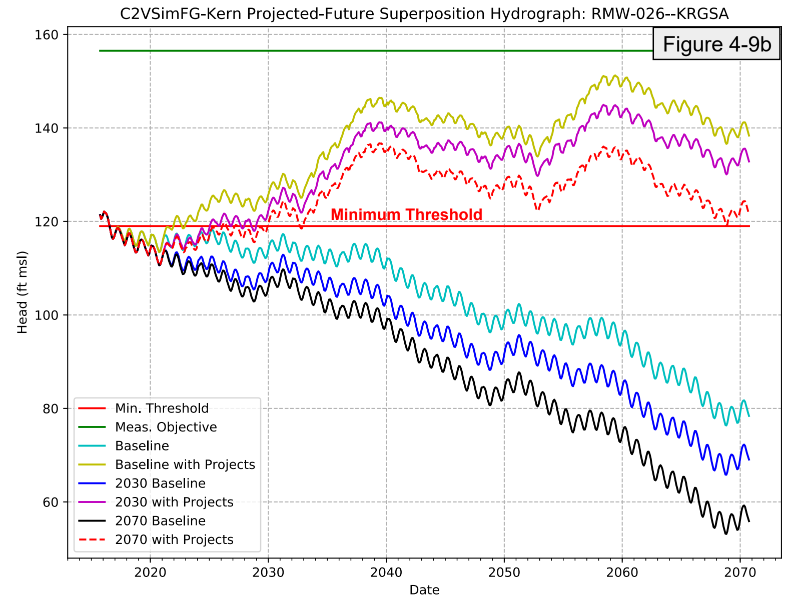
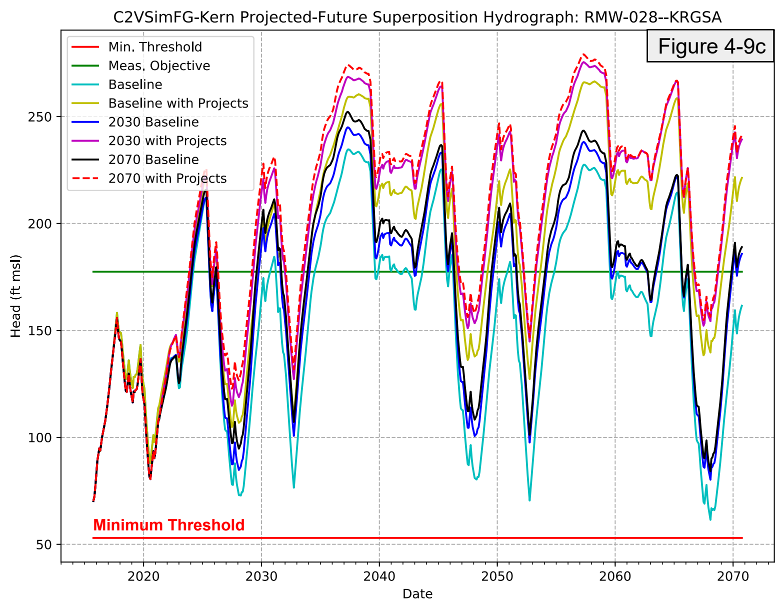
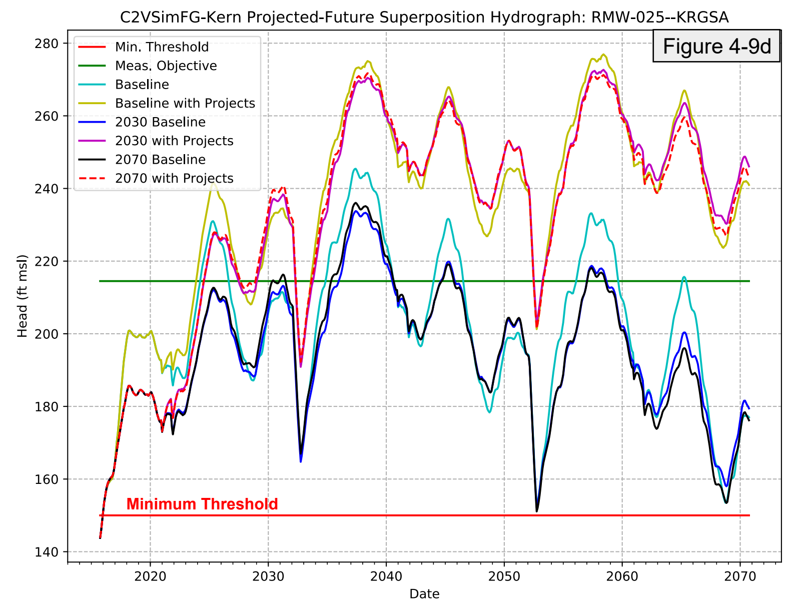


Figure 4-8
Model Hydrographs
Projected Water Budget





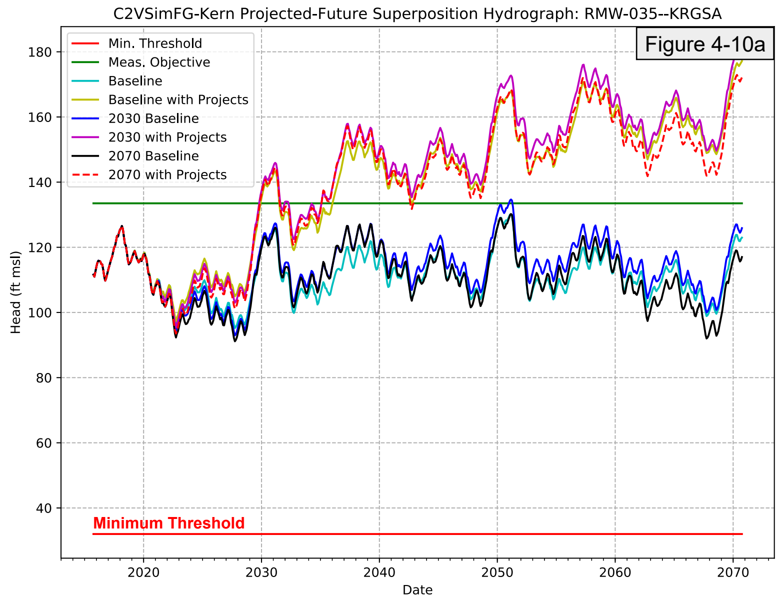


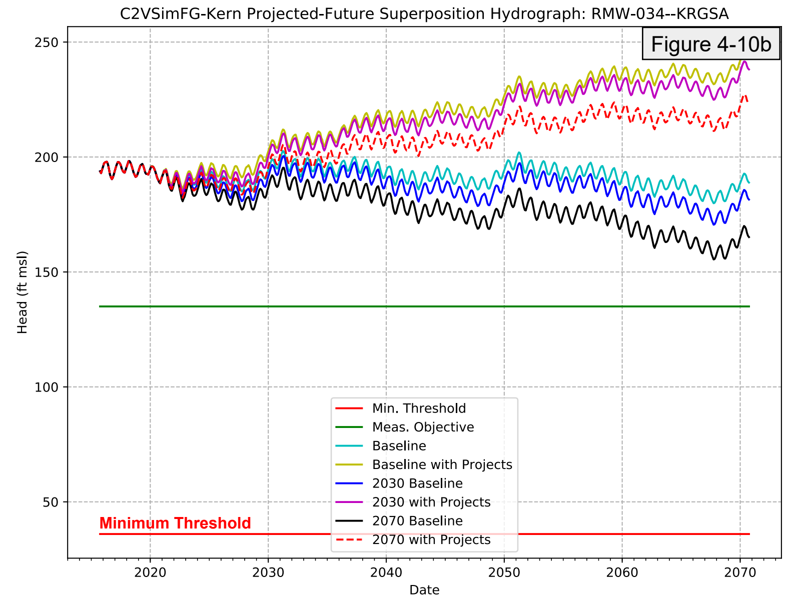


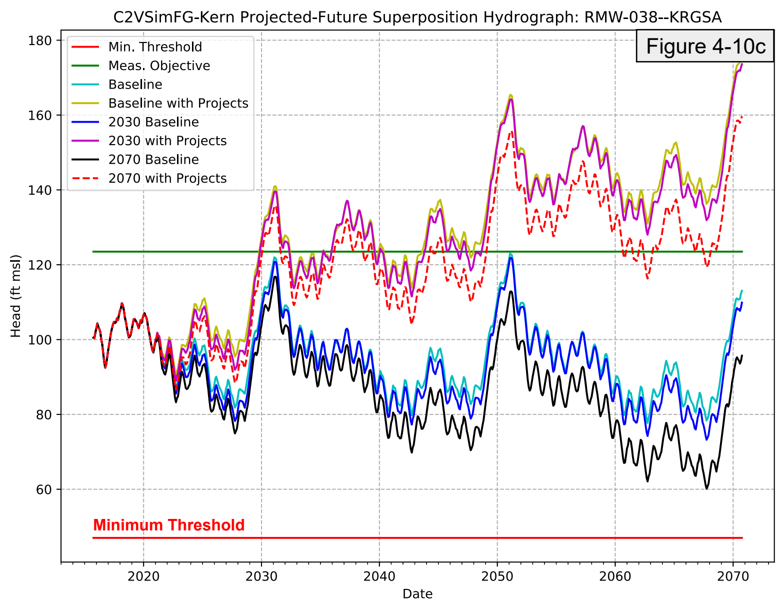
November 2019

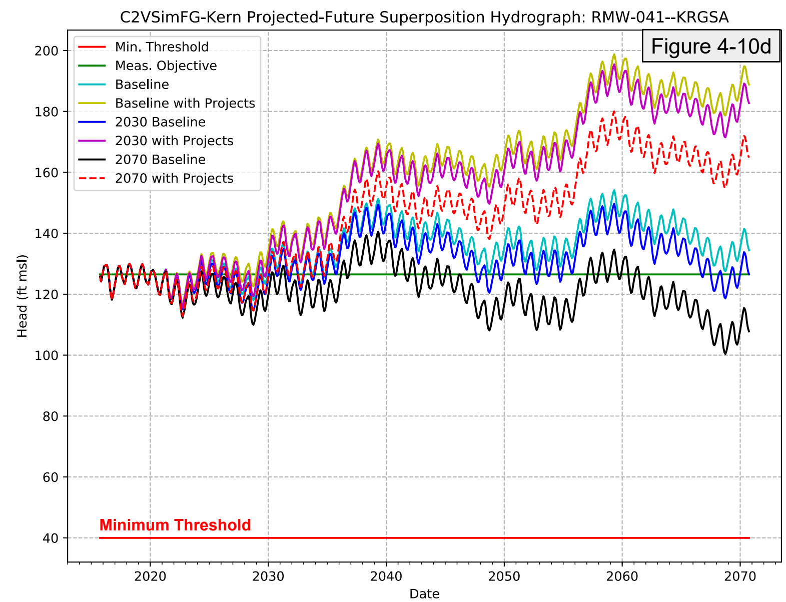
TODD GROUNDWATER

Figure 4-9
Projected Water Levels
Northern Plan Area









November 2019

TODD GROUNDWATER

Figure 4-10
Projected Water Levels
Southern Plan Area

5 SUSTAINABLE MANAGEMENT CRITERIA

GSP regulations provide a framework of sustainable management criteria, which allow the GSAs to define, quantitatively measure, and track ongoing sustainable management. These criteria include the following terms, along with a summary[35] of how each is used in this GSP:

- Undesirable Result – significant and unreasonable conditions for any of the six sustainability indicators
- Minimum Threshold (MT[36]) – numeric value used to define undesirable results for each sustainability indicator
- Measurable Objective (MO[24]) – specific, quantifiable goals to track the performance of sustainable management
- Interim Milestone – target value representing measurable groundwater conditions, in increments of five years, as set by the GSAs as part of the GSP.

Collectively, these terms provide the framework on which to:

- define sustainable management for the KRGSA Plan Area
- provide guidelines for favorable groundwater conditions
- identify unfavorable groundwater conditions and associated warning signs
- select and evaluate appropriate management projects and actions
- monitor progress on achieving the sustainability goal.

Development of the sustainable management criteria is based on the analysis of SGMA-defined sustainability indicators, such as declining water levels or degraded water quality. Although the concept of a sustainability indicator is simple, and achievement of sustainability is highly beneficial, evaluating these indicators over the 1.8 million acres of the Kern County Subbasin is complex. Moreover, the groundwater system is highly dynamic, given extensive groundwater banking, managed recharge and diversions, water exchanges and purchases, and a complex system of water rights. Further, the inflows and outflows to and from the KRGSA groundwater system are relatively large, occur at irregular intervals, and are not all attributable to KRGSA actions.

In such an environment, actual measured water levels along with trends and fluctuations are responding to a variety of inputs and actions, some of which are beyond the control of the KRGSA Plan Managers. A simple assessment of water levels without consideration of ongoing conjunctive management can produce misleading results. Yet, groundwater levels are foundational and provide the best available data

[35] Sustainable management criteria are more fully defined in §351 of the GSP regulations.

[36] Because of the frequency of use, and to facilitate review of the text, the terms "minimum threshold" and "measurable objective" are abbreviated as "MT" and "MO", respectively, throughout remaining sections of the GSP. However, the terms are provided in full, un-abbreviated form where helpful for context and clarity or when contained in a direct quotation.

with which to monitor groundwater conditions and to document the performance of management actions. However, KRGSA water levels require analysis within the context of the ongoing dynamic groundwater system and the management actions that control them. Annual reporting and five-year updates to the GSP will be used to track both water levels selected as MTs and MOs and analyze them in the context of the overall water budget and management activities.

5.1 SUSTAINABILITY GOAL

The Sustainability Goal of the KRGSA GSP is to manage groundwater sustainably in the KRGSA Plan Area to:

- Support current and future beneficial uses of groundwater including municipal, agricultural, industrial, public supply, domestic, and environmental
- Optimize conjunctive use of surface water, imported water, and groundwater
- Avoid or eliminate undesirable results throughout the planning and implementation horizon
- Evaluate GSP performance through ongoing monitoring and reporting of groundwater conditions.

This sustainability goal is based on the information in the Plan Area (**Section 2**), Basin Setting (**Section 3**), and Water Budget (**Section 4**) sections of this GSP that:

- Identify the types and quantities of groundwater reliance and use across the KRGSA Plan Area including an estimate of more than 1,200 active water supply wells
- Document the thick and permeable aquifer system, especially in the northern, central, and western KRGSA Plan Area where more than 1,000 feet of primarily sand and gravel are highly conducive to large quantities of recharge
- Identify and quantify surface water supplies including local Kern River water, imported SWP water, recycled water, and stormwater
- Describe the ongoing water management actions and banking operations, which have optimized conjunctive management of local and imported surface water supplies, thereby increasing the reliability of water supply in the KRGSA Plan Area
- Recognize the potential for additional enhanced recharge, expanded groundwater banking opportunities, and improved water treatment facilities to better manage a projected deficit in imported supplies and to balance that deficit against the projected increase in KRGSA water demands.

The KRGSA coordinated with other GSAs in the Subbasin in 2018 to develop a consistent Subbasin-wide sustainability goal to ensure that all GSAs are striving towards common goals. This Subbasin goal was revised slightly during the Amended KRGSA GSP process to re-enforce the commitment to protection of beneficial use of groundwater for drinking water supply. The components of the Subbasin Sustainability Goal were also re-ordered for emphasis. The revised, coordinated sustainability goal of the Kern County Subbasin for the Amended KRGSA GSP is to:

- Collectively bring the Subbasin into sustainability and to maintain sustainability over the implementation and planning horizon and beyond
- Achieve sustainable groundwater management in the Kern County Subbasin through the implementation of projects and management actions at the member agency level of each GSA
- Maintain its groundwater use within the sustainable yield of the basin as demonstrated by monitoring and reporting of groundwater conditions
- Operate within the established sustainable management criteria, which are based on the collective technical information presented in the GSPs in the Subbasin
- Protect beneficial uses for municipal and domestic drinking water supply wells.

The KRGSA incorporates the revised Subbasin sustainability goal into this GSP; sustainability goals of both the KRGSA and the Kern County Subbasin will be achieved through coordinated implementation of projects and programs to increase recharge, reduce reliance on the groundwater basin, and better manage high river flows and excess imported water opportunities for a more sustainable future. As described in subsequent sections, two large conjunctive use projects are included in this GSP that are ready for implementation in Year One of the 20-year timeline for achieving sustainability. This will allow early monitoring of GSP project performance and time for project adjustments, as needed. Further, these projects involve continuation and expansion of similar ongoing management actions that already have a proven track record for successful conjunctive management.

The GSP includes improvements to monitoring networks for ongoing tracking of management performance. Direct monitoring of groundwater will be supplemented by ongoing tracking of checkbook water budget components to better understand measured data within the context of conjunctive management. To ensure that the entire Subbasin will be operated within its sustainable yield by 2040, the KRGSA will do its part through active monitoring and adaptive management to better match the groundwater response to specific management actions.

5.2 Sustainable Management Areas

GSP regulations allow GSAs to define management areas for the purposes of assigning "different MTs, MOs, monitoring, or projects and management actions based on difference in water use sector, water source type, geology, aquifer characteristics or other factors" (351(r)). Three Management Areas (MAs) have been delineated within the KRGSA to accommodate the need for different sustainable management criteria, to facilitate management actions, and to align management responsibilities with agency jurisdictional boundaries. These three MAs are shown on **Figure 5-1** and designated as follows:

- Urban Management Area (Urban MA)
- Agricultural Management Area (Agricultural MA)
- Banking Management Area (Banking MA).

As indicated by the designations, the KRGSA MAs are generally delineated by the primary land use for each area, which governs how most of the water used in the MA is delivered and managed. It is acknowledged that there is overlapping land use throughout each of the three KRGSA MAs and MA boundaries are not perfectly aligned with either land use or agency jurisdictional boundaries. Nonetheless, MAs provide a useful delineation for primary differences in sustainable management criteria.

The approximate size of each of the KRGSA MAs along with primary responsible agencies are summarized in **Table 5-1**. Due to substantial overlap in jurisdictional boundaries of KRGSA agencies, and also the overlap of MAs within each agency's service area, each MA will require coordinated management among several agencies/entities in the KRGSA. Jurisdictional boundaries of the three largest agencies in the KRGSA, the City, ID4, and KDWD, are shown with the MA boundaries on **Figure 5-2**.

Because KRGSA MAs were defined prior to GSP implementation, the original boundaries in the 2020 KRGSA GSP were considered preliminary. Specifically, revised MA boundaries, along with the KRGSA boundaries, were adjusted in 2021 to better align with certain jurisdictional boundaries, adjacent GSPs, and parcels of common ownership along GSA boundaries. Most of these revisions were envisioned in the 2020 GSP but were not yet final at the time of GSP submittal (see **Appendix K).** The KRGSA and MA boundary revisions have been finalized in coordination with boundaries of adjacent GSAs and add about 1,699 acres to the original KRGSA (less than one percent of the total Plan Area).

As explained in **Section 1.6.3**, these revised boundaries are incorporated into this Amended KRGSA GSP and the approximate size of the MAs and KRGSA listed in **Table 5-1** below reflect these changes.

Table 5-1: KRGSA Management Areas

KRGSA Management Area	Approximate Size (acres)	Responsible Agencies	Coordinating Agency/Entity
KRGSA Urban MA	93,350	City of Bakersfield, ID4	KDWD, ENCSD, Vaughn WC, NORMWD, Cal Water
KRGSA Agricultural MA	134,104	KDWD, Greenfield CWD GSA	Lamont PUD, City of Bakersfield
KRGSA Banking MA	5,045	KCWA/ID4, City of Bakersfield	Banking participants
TOTAL KRGSA Plan Area Acres	232,499		

5.2.1 KRGSA Urban Management Area

The KRGSA Urban MA was created to allow groundwater management to focus on urban supplies; it contains most of the municipal wells in the KRGSA Plan Area. As shown by the agency boundaries that are added to the MAs on **Figure 5-2**, the Urban MA includes almost all of the ID4 service area and most of the City of Bakersfield. A portion of the southern KRGSA Urban MA also extends into the KDWD service area, where KDWD coordinates with the City to ensure that newly-developed urban lands have a water supply. Importantly, the Urban MA includes more than 162 municipal wells owned by the City and

Cal Water. It also includes additional public water supply wells owned and operated by ENCSD, NORMWD/OMWC, Vaughn Water Company (portions in KRGSA only), and other smaller water systems.

Municipal wells in the KRGSA Urban MA are shown on **Figure 5-3** for reference. **Figure 5-3** highlights a variety of data and analyses that are considered in the KRGSA sustainability criteria analysis, as described in subsequent sections below.

Although most of the KRGSA Urban MA is characterized by urban development or undeveloped lands, there are pockets of irrigated agriculture in the Urban MA. The largest of these is located in the northwest corner of the Urban MA and covers a portion of Rosedale Ranch ID (as indicated by crops in the northwestern KRGSA Plan Area – see **Figure 2-9**). Because its location is not adjacent to other KRGSA agricultural lands and because Rosedale Ranch ID has coordinated with both North Kern WSD and the City on past water supplies, its inclusion in the Urban MA seems reasonable. However, there may need to be special consideration for sustainable management criteria in this area.

5.2.2 KRGSA Agricultural Management Area

The KRGSA Agricultural MA was created to allow KDWD to continue to manage the complex Kern River water rights, SWP rights, and extensive infrastructure associated with almost all of the irrigated acres in the KRGSA Plan Area. The Agricultural MA is defined by the primary areas of mostly contiguous irrigated acres and includes almost all of the KDWD service area (**Figure 5-2**). The MA extends northward to include agricultural lands outside of KDWD in the east-central and west-central KRGSA Plan Area (**Figure 5-2**). These agricultural lands in the KRGSA Agricultural MA are encompassed by the City limits; lands in the east-central KRGSA (outside of KDWD) are also encompassed by the ID4 service area (**Figure 5-2**). As discussed above, the agricultural areas of Rosedale Ranch ID in the northwestern KRGSA Plan Area are included in the Urban MA.

The mostly urbanized area of the community of Greenfield is included in the Agricultural MA because of the close relationship between Greenfield CWD GSA and KDWD (**Figure 5-2**). Specifically, KDWD recharges water locally to maintain water levels at the Greenfield CWD municipal wells. Because the GSA is adjacent to the Urban MA, sustainable management criteria will consider conditions in both the Urban and Agricultural MAs.

The KRGSA Agricultural MA is also created to better manage areas more susceptible to land subsidence and perched water conditions (see **Section 3.3.5** and **Figures 3-37** and **3-38)**. The southern and eastern rim of the KRGSA Agricultural MA (see **Figure 5-3**) are the only KRGSA areas where significant rates of subsidence have been documented; this area warrants delineation because subsidence can be a primary driver of sustainable management criteria.

5.2.3 KRGSA Banking Management Area

The KRGSA Banking MA was created to acknowledge the specialized groundwater banking activities that occur in the western KRGSA Plan Area and along the Kern River channel (**Figure 5-1**). Although the

KRGSA Banking MA is relatively small in size, its location adjacent to other major groundwater banking projects provides for consistent management across these west-central KRGSA Plan Area boundaries. As discussed in other sections of this GSP, these lands are managed primarily for recharge and recovery operations and have water levels fluctuations that are more similar to adjacent groundwater banking projects outside of the KRGSA (i.e., Pioneer Project and Kern Water Bank) than other KRGSA areas. The groundwater banking projects outside the KRGSA but adjacent to the Banking MA are indicated by the blue recharge basins on **Figure 5-3**.

The KRGSA Banking MA covers the two largest groundwater banking projects in the western KRGSA – COB 2800 Recharge Facility and Berrenda Mesa Project – along with downstream portions of the Kern River that are primarily used for recharge and recovery (**Figure 5-1**). City facilities used for recharge including ponds at Aera Park, Park at Riverwalk, and Truxtun Lakes are covered by the Banking MA. Most of the banking recovery wells, shown on **Figure 5-3** as yellow triangles, are included in the Banking MA. ID4 recovery wells located along banking areas of the River channel are also included.

The groundwater banking project in KDWD is not included in the KRGSA Banking MA. As indicated on **Figure 5-3**, recharge basins and recovery wells in KDWD occur throughout the Agricultural MA and are dispersed among agricultural lands. In addition, these recharge and recovery facilities are managed separately by KDWD and are not shared among multiple agencies as are many of the banking facilities in the Banking MA. Accordingly, assignment of different sustainable management criteria may be appropriate for the KDWD banking areas.

Although additional upstream portions of the Kern River channel are also managed for groundwater replenishment and banking, the channel is also flanked by numerous municipal wells owned by the City and Cal Water. These wells have different considerations with respect to sustainable management criteria. Accordingly, the Banking MA does not extend upstream along the entire Kern River recharge area. MA designations do not preclude consideration of the recharge/banking operations occurring upstream including those in the unlined portion of the Cross Valley Canal, Calloway Pool, and other important areas of managed recharge.

The KRGSA Banking MA also includes areas of undeveloped land surrounding other banking projects, including land north of the Pioneer Project. This land may be targeted for development in the near future and could be reassigned to the Urban MA, if needed. Similarly, land use changes south of the Pioneer Project may require reassignment from the Urban MA to the Banking MA. Recently, water banking has been expanded into this area.

5.2.4 Management Areas and Sustainable Management Criteria

The Hydrogeologic Conceptual Model, groundwater conditions, and water budget analyses as presented in **Sections 3** and **4** cover all of these MAs and are not repeated here. Those analyses form the foundation for establishing sustainable management criteria in each MA. The analyses also summarize conditions within each MA that require special considerations for sustainable management criteria. Monitoring networks for each MA are discussed in **Section 6**.

Sustainable management criteria will be considered on an MA-basis, KRGSA-basis, and in coordination with adjacent GSAs to ensure that sustainable management criteria will not create undesirable results in adjacent MAs or GSAs. Agencies within the KRGSA have been coordinating groundwater management activities for decades (examples in **Section 2.5** and throughout the GSP). KRGSA Plan Managers are well-equipped for close cooperation to achieve the KRGSA sustainability goal in each MA and across the entire Plan Area.

5.3 APPROACH TO UNDESIRABLE RESULTS AND A MANAGEMENT AREA EXCEEDANCE

For this Amended KRGSA GSP, the approach to undesirable results in the Subbasin has been further clarified in response to the DWR Determination Letter (DWR, 2022). Specifically, GSAs in the Subbasin have now developed consistent definitions and terminology for avoiding undesirable results at both the Subbasin level and the local Management Area level. These definitions, along with examples, are provided in Appendix 3 of the First Amended Kern County Subbasin Coordination Agreement (2022).

During development of the 2020 GSPs, Subbasin GSAs coordinated on sustainable management criteria and defined consistent undesirable results for the entire Subbasin as required by GSP regulations. Those definitions of undesirable results were approved by all Subbasin GSAs and were included in the 2020 Coordination Agreement (as well as in the 2020 KRGSA GSP).

The Subbasin definitions provided a flexible construct that allowed each GSA to further define local conditions that could potentially lead to significant and unreasonable impacts in each separate Management Area. In the original KRGSA GSP, these conditions were also referred to as "undesirable results" within the undesirable results framework defined for the larger Subbasin. As noted in the DWR Determination Letter, it was confusing to refer to both the Subbasin definition and the local KRGSA GSP conditions as undesirable results. Accordingly, the local undesirable results (on a KRGSA Management Area level) are now referred to as a "Management Area Exceedance" rather than "undesirable results."

Even though undesirable results are referred to locally in this Amended KRGSA GSP, the quantitative criteria used to "trigger" the Subbasin-wide undesirable results and the Management Area exceedances are different. These triggers are the criteria that allow these two concepts to function together.

The use of the phrase "undesirable results" for a MA has been generally replaced with "local adverse impacts" to avoid confusion between Subbasin-wide and local undesirable results. Where appropriate, those impacts on a MA basis are referred to as a Management Area exceedance. However, not all instances of "undesirable results" that refer to local MA impacts have been removed from the Amended KRGSA GSP text. In many cases, the phrase is useful to evaluate local conditions that may contribute to Subbasin-wide undesirable results. In addition, the phrase is unmodified when describing local conditions that control potential impacts on beneficial uses and users (which refers to the Subbasin definition.

The approach to definition of a Management Area exceedance in the KRGSA Plan Area relies on analysis of the six sustainability indicators as defined by SGMA:

- Chronic lowering of water levels
- Reduction of groundwater in storage
- Seawater intrusion
- Degradation of water quality
- Land subsidence that substantially interferes with surface land uses
- Depletions of interconnected surface water that adversely impact beneficial use of surface water.

GSP regulations state that if any of these indicators are causing significant and unreasonable effects in the Subbasin, then that indicator is defined as an undesirable result for the Subbasin. For the Amended KRGSA GSP, if sustainability indicators are causing significant and unreasonable effects in any of the three MAs in the KRGSA Plan Area, then that condition is defined by criteria (triggers) as a Management Area exceedance. As noted in the Sustainability Goal for the KRGSA GSP, sustainable management is meant to eliminate and avoid any Management Area exceedance in the Plan Area over the planning and implementation horizon.

Each of these indicators is examined with respect to conditions within the KRGSA Plan Area based primarily on the data and analysis described in **Section 2** (Plan Area), **Section 3** (Basin Setting), and **Section 4** (Water Budgets). The approach for the analysis of each of the sustainability indicators is summarized as follows:

- Describe each indicator and summarize the potential causes of undesirable results as defined in the Subbasin and clarified for local KRGSA GSP conditions. This step also describes adverse impacts to beneficial uses and users of groundwater.
- State the coordinated definition of undesirable results for the Kern County Subbasin.
- Clarify local conditions that would result in a Management Area exceedance for the KRGSA Plan Area, which could, in turn, contribute to or cause Subbasin-wide undesirable results.
- Determine if local conditions have indicated "local undesirable results" historically or if they are occurring as of the SGMA baseline of January 2015.
- Predict whether conditions for local undesirable results have the potential to occur in the future.
- Propose an appropriate minimum threshold (MT) and measurable objective (MO) as targets for elimination and future avoidance of local adverse impacts.
- Develop quantitative triggers to determine when and where exceedances of a MT would constitute a Management Area exceedance for the KRGSA Plan Area.

5.3.1 Approach for Minimum Thresholds (MT)

MTs are evaluated and selected based on either the occurrence of local adverse impacts (historically or currently) or the potential for those conditions to occur in the future. In some cases, previous conditions – for some municipal wells, for example – have been partially mitigated through well modification, wellhead treatment, well replacement, and other actions. For these areas, MTs are established to avoid future local conditions that could contribute to Subbasin-wide undesirable results in recognition of these previous actions in place. These previous actions allow for either a lower MT or the ability to tolerate the threshold longer than would have been acceptable prior to the actions.

As part of the MT selection process, the criteria for triggering a Management Area exceedance have also been developed. These criteria recognize that a Management Area exceedance is not necessarily triggered by one MT exceedance in one well during one monitoring event.

Water level monitoring is the foundation of determining a Management Area exceedance for the KRGSA Plan Area. As explained in the remainder of this section, water levels are a good proxy for identifying undesirable results for all sustainability indicators relevant to the KRGSA GSP.

5.3.2 Approach for Measurable Objectives (MO)

Water levels are less reliable for establishment of MOs in the KRGSA. BMPs and guidance documents provide a simplistic condition where water levels would be expected to rise substantially in response to sustainable management actions. For these conditions, a MO associated with a water level higher than current conditions would be appropriate. However, for the KRGSA, it is more important to manage water levels locally and offset future deficits rather than to have water levels rise overall. As explained in the following sections, a Management Area exceedance in the KRGSA is closely related to the water budget and localized conditions that would define a Management Area exceedance.

Specifically, the change in groundwater in storage based on water level contour maps, modeling, and the physical checkbook water budget suggested that the KRGSA was operating within a sustainable yield (see **Section 4.5.4** and **Table 4-10**). However, resulting water levels were influenced by groundwater banking activities inside the KRGSA for and by others. KRGSA Plan Managers decided to adjust the checkbook water budget to only include banking related to KRGSA agencies for use inside the KRGSA. Accordingly, a water budget deficit of about 29,153 AFY was estimated.

To eliminate this deficit, a GSP project is proposed for implementation in Year One of the implementation period that will provide additional supply to the large Agricultural MA (WAP, see **Section 7.1.1**). Recognizing that this added water supply will be delivered for the benefit of landowners over about 90,000 acres, the associated rise in water levels as a result of the project is less than a foot per year. Groundwater modeling associated with the SEIR for this project indicated an overall water level rise of only about three to six feet over a 50-year period (ESA, 2017). Given the wide fluctuations in water levels over much of the KRGSA Plan Area, this small change will not be sufficiently detectable for use as a reliable MO.

While the projected water budget modeling in **Section 4.7.3** indicates that water levels will rise substantially, that simulation represented the physical groundwater system and, again, did not account for in-KRGSA banking attributable to others. When projected changes in supply and demand are evaluated on a checkbook method, projected future deficits associated with climate change and urban growth are larger than indicated in the modeling. Therefore, management projects are providing the ability for water levels to remain within the historical range.

Given these complexities, a simplistic approach to a Measurable Objective is incorporated into this GSP. Recognizing the need to maintain water levels within a reasonable operational range similar to an historical range, the midpoint of an operational range is selected as a guide for a MO as explained in the following sections.

5.3.3 Summary of Sustainable Management Criteria

To facilitate review of the analysis of each sustainability indicator and how the criteria are proposed in various subareas of each MA, the MT for each sustainability indicator is summarized in **Table 5-2**. The analysis leading to the selection of the MTs shown on **Table 5-2** is providing in the following sections, organized by each of the sustainability indicators.

As part of the Amended KRGSA GSP, **Table 5-2** has been simplified for use throughout the remaining sections of Chapter 5. The upper table (**5-2a**) summarizes the MTs for each MA along with groundwater management conditions that were considered in the MT selection. The lower table (**5-2b**) summarizes the criteria that are used to trigger a Management Area exceedance. **Table 5-2** is referenced in the discussions of sustainability indicators and explained in more detail in **Section 5.10**.

Table 5-2a: Minimum Thresholds for Sustainability Indicators in the KRGSA Management Areas **Amended June 2022**

KRGSA Management Area (MA)	MA Subarea and Considerations for Management		Sustainability Indicator and Minimum Threshold (MT)			
			Chronic Lowering of Water Levels	Reduction of Groundwater in Storage	Degraded Water Quality	Land Subsidence
KRGSA Urban MA	Central/South	Municipal wellfields	Historic Low WL	Historic Low WL	Historic Low WL	Historic Low WL
	Northeast	ENCSD wellfield	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL
	Northwest corner	Transition to agricultural lands	20' below Historic Low WL	20' below Historic Low WL	20' below Historic Low WL	20' below Historic Low WL
KRGSA Agricultural MA	Along southern Urban MA	Transition with municipal wells	Historic Low WL	50' below Historic Low WL	Historic Low WL	Historic Low WL
	North-Central	Greenfield CWD wells	Historic Low WL	50' below Historic Low WL	Historic Low WL	Historic Low WL
	West and Northwest	Agricultural and recovery wells	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL
	Southeast	Subsidence potential	50' below Historic Low WL	50' below Historic Low WL	50' below Historic Low WL	20' below Historic Low WL
	East	Transition to small system wells	Historic Low WL	50' below Historic Low WL	Historic Low WL	Historic Low WL
KRGSA Banking MA	Kern River Channel	ID4/KCWA/City recovery activities	20' below Historic Low WL	Not applicable	20' below Historic Low WL	20' below Historic Low WL
	Berrenda Mesa	KCWA operational area	Historic Low WL	Not applicable	Historic Low WL	Historic Low WL
	COB 2800 Facility	City of Bakersfield municipal wells	Historic Low WL	Not applicable	Historic Low WL	Historic Low WL

Historic low water level (WL) is the lowest level observed in an area during the recent drought of 2013-2016.
Measurable Objective (MO) for each sustainability indicator is the average of the MT and the historical high groundwater elevation during the historical Study Period.
Highlighted green cell indicates the controlling sustainability indicator(s) for that area in each MA.
MTs are set in each Representative Monitoring Well (RMW) as documented in Chapter 6 and shown in Appendix J.

Table 5-2b: Triggers for Management Area Exceedances in the KRGSA Plan Area

KRGSA Management Area (MA)	Management Area Exceedances for Controlling Sustainability Indicators		
	Controlling Indicators	Percent of RMWs Exceeding MTs	Duration of MT Exceedance
KRGSA Urban MA	Water Levels and Water Quality	Any one RMW	>3 Consecutive Months
KRGSA Agricultural MA	Water Levels, Water Quality, and Subsidence	40% of RMWs	4 Consecutive Semi-Annual Monitoring Events (2 Consecutive Years)
KRGSA Banking MA	Water Levels and Water Quality	Any one RMW	>3 Consecutive Months

5.4 CHRONIC LOWERING OF WATER LEVELS

SGMA defines an undesirable result from chronic lowering of water levels as "indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon" (§10721(x)(1)). The definition considers the duration of water level declines, as well as the result (i.e., depletion of supply). The definition also allows water levels to decline under certain conditions: "Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reduction in groundwater levels or storage during a period of drought are offset by increasing groundwater levels or storage during other periods" (§10721(x)(1)).

As described in **Section 3.3.2.2**, water level declines within the KRGSA have occurred primarily during drought cycles, which are also associated with low flows on the Kern River, less precipitation, and decreases in imported water supplies. This decrease in surface water supply is typically coupled with an increase in groundwater pumping. Collectively, these changes also result in decreases in recharge from banking activities, surface water conveyance, and surface water infiltration associated with irrigation and other outdoor water use. In addition, these drought periods are typically associated with increased recovery pumping at groundwater banking projects, which can result in significant local declines. Hydrographs on **Figure 3-24** also demonstrate the ability for water levels in the KRGSA to recover following drought conditions (e.g., the water level rise in the late 1990s following drought in the early 1990s). Although the hydrographs in **Figure 3-24** end in the drought of record (2015-2016), water levels have since risen in response to recent wet conditions in 2017 and 2019.

The impacts of groundwater level declines are fundamental to most of the remaining sustainability indicators. As indicated in the quote above, SGMA links chronic lowering of water levels to a reduction of groundwater in storage – a separate sustainability indicator. Chronic lowering of water levels is also closely related to inelastic land subsidence, interconnected surface water, seawater intrusion, and degraded water quality (e.g., where constituents of concern occur in depth-specific portions of the aquifer). Local conditions that could lead to a Management Area exceedance and contribute to undesirable results for the other sustainability indicators are discussed separately in each associated section below. This section examines the potential for water levels to impact the ability of wells to access groundwater for beneficial uses.

5.4.1 Potential Causes of Undesirable Results from Water Levels

Chronic lowering of water levels can adversely impact pumping wells and, in some cases, prevent practical or economical access to groundwater supply. With more than 1,200 active wells estimated in the KRGSA Plan Area, these impacts can be widespread and represent a significant economic impact on KRGSA groundwater users.

As water levels decline, well owners face an increase in energy costs due to the extra distance that the well pump must lift the water from the aquifer to the ground surface. Well capacity can also decline and may not produce sufficient water to meet the beneficial use. If water levels decline below the pump intake, the well will no longer produce. In this case, the pump must be lowered to depths sufficient to accommodate pumping water levels, sometimes at considerable cost. For some wells, this modification may not be feasible, and the well may need to be replaced.

If water levels fall below the tops of screens, water will cascade downward to the pumping water level, entraining air during the fall. This can cause cavitation at the pump as the mixture of air and water passes the pump impellor, resulting in vibration, potential pump damage, and a reduction in well efficiency. The introduction of oxygen can also create an environment for naturally-occurring iron bacteria to proliferate, potentially leading to biofouling and clogging. Well rehabilitation may be able to address some of the damage, but long-term well operation with water levels below the top of screens can ultimately result in inefficient wells, higher operating costs, increases in corrosion, and shorter well life.

If water levels continue to decline, the well may become dry and lose its ability to produce groundwater. Dry wells will occur first in the shallowest wells, such as is more common for a domestic well. If the dry well is the sole source of water for the well owner, drilling a deeper replacement well may be the only option for water supply – an option that may not be economically viable for the water user.

5.4.2 Subbasin Definition of Undesirable Results from Water Levels

In coordination with other GSAs in the Subbasin, the KGA developed a Subbasin-wide definition of an undesirable result for each sustainability indicator (December 14, 2018). KRGSA Plan Managers participated in development of the definitions, which were reviewed and approved by the KRGSA Board for Subbasin-wide coordination on January 10, 2019. The undesirable result for chronic lowering of water levels in the Subbasin is defined as:

> The point at which significant and unreasonable impacts over the planning and implementation horizon, as determined by depth/elevation of water, affect the reasonable and beneficial use of, and access to, groundwater by overlying users.
>
> This is determined when the minimum threshold for groundwater levels is exceeded in at least three (3) adjacent management areas which represent at least 15% of the sub-basin or greater than 30% of the Sub-Basin (as measured by each Management Area). Minimum thresholds shall be set by each of the management areas through their respective Groundwater Sustainability Plans.

The second paragraph of the Subbasin definition above meets the GSP requirement to include quantitative criteria that defines “when and where” groundwater conditions cause undesirable results (§354.26(b)(2)). Regulations require “the combination of MT exceedances that cause significant and unreasonable effects in the basin.” As stated above, undesirable results occur when MTs are “exceeded in at least three (3) adjacent management areas, which represent at least 15% of the Subbasin or greater than 30% of the Subbasin (as measured by each Management Area).”

The exceedance of MTs "as measured by each Management Area" refers to local conditions within each MA in the Subbasin, including the three MAs in the KRGSA GSP. Additional criteria are developed for each MA to determine a *Management Area exceedance*. This Management Area exceedance is the local equivalent to undesirable results, which are defined at a Subbasin level. Criteria that define when and where groundwater conditions cause this local Management Area exceedance are referred to as "triggers" by Subbasin GSPs and in this Amended KRGSA GSP.

5.4.3 KRGSA GSP Considerations for Management Area Exceedances from Lowering of Water Levels

The KRGSA GSP adopts the Subbasin definition of undesirable results for the water level sustainability indicator as provided above and provides further clarification for conditions in the KRGSA Plan Area as follows:

> "The point at which significant and unreasonable impacts over the planning and implementation horizon, as determined by depth/elevation of water, affect the reasonable and beneficial use of, and access to, groundwater by overlying users." *These impacts are focused on groundwater wells and balance the need for higher water levels in some wells with the need to lower water levels in other wells, primarily to support recovery of banked surface water during multi-year droughts*.

Specifically, this sustainability indicator includes the transitioning of MTs across the KRGSA Plan Area to balance water level objectives for multiple types of groundwater wells. This balance provides operational flexibility to support the KRGSA Sustainability Goal, which includes optimization of conjunctive use (**Section 5.1**). The KRGSA GSP also recognizes that adverse well impacts may be mitigated if a well can be reasonably modified to accommodate anticipated water level declines, if pumping can be readily re-distributed, or if alternative water supplies are available. If impacts to water supply wells cannot be mitigated, pumping of groundwater recovery wells may require re-distribution, reduced rates, and/or temporary cessation.

For this Amended KRGSA GSP, these shared well responsibilities are reinforced, and an updated analysis of potential impacts to domestic wells has been incorporated into the Amended KRGSA GSP as **Section 5.4.4.4** below. The analysis recognizes that SGMA does not require protection of all shallow wells. As indicated in **Section 2.4.6.2**, most domestic wells in the Plan Area were drilled more than 40 years ago and may fail for multiple reasons not related to water level declines. Researchers at University of California, Davis (UC Davis) have estimated the life span of domestic wells in the Central Valley at 28 to 31 years. Age, pump placement, well design, construction materials, maintenance, storage, and use – among other factors – all affect the viability of a domestic well.

Nonetheless, the GSAs intend to manage groundwater to support all beneficial uses and to avoid actions that could cause widespread impacts to drinking water supply. Accordingly, an expanded management action (**Section 7.2.9**) has been incorporated into the Amended KRGSA GSP to track, analyze, and, to the extent reasonable, adjust groundwater management activities to support groundwater supply for domestic wells.

5.4.4 Sustainable Management Criteria for Water Levels in the Plan Area

The Subbasin-wide definition for an undesirable result due to water levels is tested against conditions in each KRGSA MA to determine whether such impacts are occurring locally as of the SGMA baseline January 2015 or if the sustainability indicator has the potential for future impacts. This analysis is used, in turn, to select appropriate MTs and MOs and triggers for a potential Management Area exceedance for the water level sustainability indicator in each MA. As explained previously, a Management Area exceedance can contribute to undesirable results as defined in the Subbasin.

5.4.4.1 KRGSA Urban Management Area

The recent drought of record produced historic lows in groundwater levels across the KRGSA Urban MA in 2015-2016 (**Section 3.3.2.5** and **Figure 3-27**), providing a test period for potential adverse impacts at existing groundwater supply wells. In particular, the City and Cal Water, who collectively own more than 160 municipal supply wells identified significant issues during this time, as discussed in **Section 3.3.2.5**. Wells were affected across Metropolitan Bakersfield with declining capacity, well inefficiency, water levels falling below pump intakes, degraded water quality[37], and both pumping and static water levels falling below the top of well screens (i.e., cascading water).

To estimate the extent of Urban MA wells affected from declining water levels, average depth to water during Fall 2015 (see **Figure 3-27**) was plotted on a one-square-mile grid across the KRGSA Plan Area and compared to well screens in the large municipal wellfields. The average depth to water is shown by the color-ramp on **Figure 5-4**; the large municipal well fields are also shown on the map. On a system-wide basis, tops of well screens average about 290 feet deep.

As shown on **Figure 5-4**, the shallowest groundwater in the Urban MA (northern Plan Area) generally occurs beneath the River with deeper groundwater transitioning away from the River. An area of relatively deep groundwater (greater than 200 feet deep) and relatively shallow well screens occurs in the municipal wellfields south of the River (**Figure 5-4**). Wells where aquifer water levels fell below the top of screens (i.e., cascading water) are indicated by the triangles on **Figure 5-4**, generally consistent with the lower water levels. This analysis indicated that about 42 municipal wells, representing about one-quarter of the larger-capacity municipal wells in the KRGSA Plan Area, were affected by water levels falling below the top of well screens, creating well issues primarily in the central KRGSA Urban MA. Additional wells encountered this problem on a more intermittent basis, depending on the then-current pumping rates.

These conditions required operational changes and significant capital expenditures by the City and Cal Water to re-distribute pumping, lower pumps, remove impacted wells from service, secure

[37] Water quality impacts are addressed separately in **Section 5.7.4.1**.

supplemental supplies, and otherwise manage wellfield operations to meet water demands through the drought. Inefficient wells were no longer operating within the range of well pump performance, incurring un-due wear on pumps and potential damage to well equipment. Pumping rates were decreased in City wells equipped with variable drive motors for partial mitigation of pumping water levels below the top of screen; however, this resulted in a system-wide decrease in capacity. SWP water (including banked water) provided a buffer during this period, but these supplies are subject to future curtailment (see **Section 4.7.2**).

Although the City and Cal Water were able to actively manage wells and secure supplemental supplies to meet demands during 2015 and 2016, numerous challenges remain with the municipal well system. Only when water levels began to rise did the ongoing well problems subside. Lowered pumps in some wells reduce the risk of future adverse impacts in some wells, but the potential for cascading water remains. Because most of the municipal wells are similarly constructed, any future declines below the historic low water level will place more wells at risk. Widespread deepening of municipal wells is not an option due to water quality issues (discussed in **Section 3.3.4.6** summarized in the subsequent **Section 5.7.4.1**).

Minimum Thresholds, Management Area Exceedance, and Measurable Objectives for Municipal Wellfields

Given the economic impact, large number of municipal wells, and future risk to additional wells, the City has determined that the historic low water levels during Fall 2015 represent an undesirable result for the chronic lowering of water levels in the KRGSA Urban MA **(Table 5-2a)**. Accordingly, the minimum threshold (MT) selected for these wells is the historical low water level as measured in representative GSP monitoring wells (see **Section 6**). As discussed in more detail in **Section 6**, monitoring wells located within and adjacent to the large municipal wellfields are targeted for GSP monitoring.

Recognizing that these conditions could be managed in a relatively small number of wells for a relatively short period of time, the definition for a Management Area exceedance incorporates this flexibility. For the KRGSA Urban MA, a Management Area exceedance is defined as occurring when a representative monitoring well in the Urban MA falls below the MT for more than three consecutive months (**Table 5-2b**).

Short-term operational measures, such as turning on resting wells, operating some wells outside of the normal capacity range for short periods, and other measures, allow water levels to be temporarily lowered below historic lows. With the modifications made to wells during the previous drought, such as lowering of pumps, these measures will provide some operational flexibility to well owners. It is recognized that municipal wells made it through the recent drought with aquifer levels at the historic low for much longer time periods. Although the pumping and static water level records are not continuous, some wells appear to have operated in a range of lowered pumping water levels for numerous consecutive months over a two-year period. During this period of operational challenges, all urban demands were met. With GSP implementation beginning in Year One, water levels can be more locally managed to provide this operational flexibility.

To better track the performance of representative monitoring wells with respect to the MT, a measurable objective (MO) is selected for representative monitoring locations within the KRGSA Urban MA. Because the KRGSA Urban MA managers wish to operate within a reasonable range of water levels above the MT, the MO is defined as the average of the high water level of the historical Study Period (typically 1998) and the MT in each GSP monitoring well. It should be noted that the MO is defined here as the midpoint of an operable range. It is not in itself the objective (i.e., desirable or optimal) water level, but along with the high-water mark and the MT, provides a useful guideline for fluctuating groundwater levels. In addition, given that the range of KRGSA water levels represent an average water level associated with a sustainable water budget (see **Section 4.5.4** and **Table 4-10**), the MO also provides an average target water level that indicates ongoing sustainable management.

While maintaining water levels above the MT in representative monitoring wells is anticipated to result in improved wellfield operation in the KRGSA Urban MA, the exact water level that will prevent adverse impacts cannot currently be quantified with certainty. Rather the MT, MO, triggers for a Management Area exceedance, and representative monitoring points will require ongoing testing and potential future adjustment.

Minimum Thresholds, Management Area Exceedance, and Measurable Objectives in Northeast ENCSD Wellfield

ENCSD is leading a GSP project to consolidate up to six small water systems into its current system for improvement of water quality to Disadvantaged Communities inside and outside of the KRGSA (**Section 7.1.5**). With the additional pumping that will occur in the ENCSD localized area, ENCSD would like an increase in the operational range of water levels near its current wellfield. As such, ENCSD has requested a MT of 50 feet below the historic low water level in its service area. This request is reasonable in that the MT is not expected to negatively impact other MTs in the Urban MA or cause local adverse impacts for chronic lowering of water levels. Accordingly, an MT of 50 feet below the historic low is assigned for the ENCSD area as monitored by an ENCSD inactive well adjacent to its wellfield (**Table 5-2a**). The MO is assigned as the average between the historic high water level observed during the historical Study Period and the MT. As previously stated, a Management Area exceedance is defined as occurring when a representative monitoring well in the KRGSA Urban MA fall below the MT for more than three consecutive months (**Table 5-2b**).

Minimum Thresholds, Management Area Exceedance, and Measurable Objectives in Northwest Agricultural Wells

It is recognized that areas outside of the large municipal wellfields (including agricultural areas in the northwest Urban MA, the Banking MA to the west and the Agricultural MA to the south) may not have similar adverse impacts for water levels below historic lows due to differing well designs, concentrated pumping primarily during the irrigation season, a lower sensitivity to well inefficiency, the absence of adjacent municipal wellfields, and other factors. Accordingly, water levels in these areas could decline below the historic lows without the same local adverse impacts as in the municipal wellfields. To accommodate differing beneficial uses and well operational requirements, MTs are transitioned slightly downward moving away from the municipal wellfields toward the northwestern agricultural area in the Urban MA as described below.

In the northwestern corner of the KRGSA Urban MA, the MT is lowered 20 feet below the historic water level lows in those areas to allow some operational flexibility for groundwater users in the RRID agricultural area **(Table 5-2)**. As indicated on **Figure 5-4**, the northwestern corner of the KRGSA Plan Area contains some of the deepest water levels in the Plan Area and management actions may not benefit these areas immediately. Further, this area is subject to subsurface flows toward significantly lower water levels in the north. The MO is defined as the average of the selected MT and the highest groundwater level observed during the historical Study Period, consistent with the methodology for the MO in the remaining Urban MA. As previously stated, a Management Area exceedance is defined as occurring when water levels in a representative monitoring well in the KRGSA Urban MA fall below the MT for more than three consecutive months (**Table 5-2b**).

Representative monitoring wells are selected for various areas of the KRGSA Urban MA to track water levels and the assigned MTs and MOs during the GSP implementation and planning horizon. The GSP monitoring well network used to track the selected numerical values of MTs and MOs as discussed herein is described in **Section 6**.

5.4.4.2 KRGSA Agricultural Management Area

Similar to the KRGSA Urban MA, the KRGSA Agricultural MA has competing objectives with respect to the selection of MTs and MOs to avoid local adverse impacts. In particular, municipal wells owned by Greenfield CWD, Lamont PUD (see **Appendix K**) and others occur inside the KRGSA Agricultural MA in the central Plan Area (**Figure 5-3**) and may have different objectives from local agricultural pumping wells or banking recovery wells. As described below, different MTs and MOs are selected for certain areas across the KRGSA Agricultural MA to meet varying objectives.

Minimum Thresholds and Measurable Objectives in Wells along the southern Urban MA Boundary

Well problems similar to those identified for the KRGSA Urban MA have been documented in a Greenfield CWD well located in the north-central KRGSA Agricultural MA (see Greenfield CWD service area on **Figure 5-2**). When water levels declined during the drought, the pumping water level in the Panama Well fell below the relatively shallow well screen (top of screen 180 feet deep) resulting in a need to cut the pumping rate (QK, 2016). This well was recently replaced to maintain the existing capacity of the Greenfield CWD well systems (QK, 2016). Two replacement wells have been drilled, both with deeper screens (top of screens at about 420 feet deep) to accommodate lower water levels and also to decrease concentrations of TCP, which are generally higher in shallow groundwater (see **Section 3.3.4.6** on TCP and **Figure 3-32**).

Although installation of treatment and the two replacement wells provide improved resiliency to the Greenfield CWD wellfield, maintenance of higher water levels would be protective of the older system wells. Because the historic low water level is the MT selected for municipal wells in the adjacent KRGSA Urban MA, this MT is maintained for the Greenfield CWD representative monitoring well **(Table 5-2)**.

This MT is also selected for areas where municipal wells are located adjacent to the southern Urban MA boundary or just across the boundary in the Agricultural MA **(Table 5-2)**. Consistent with the methodology for the Urban MA, the MO is defined as the average of the MT and the historic high water level during the historical Study Period (typically 1998).

Minimum Thresholds and Measurable Objectives for Small Water Systems in the Eastern Agricultural MA

With the addition of Lamont PUD in the KRGSA Plan Area (see **Appendix K**), sustainable management criteria were reviewed to ensure that small water system wells were evaluated appropriately. In particular, Lamont PUD and Fuller Acres Mutual Water Company (see **Figure 2-4**) attended community workshops in Lamont and requested that MTs and MOs in the eastern Agricultural MA be consistent with those assigned to Greenfield CWD. Although the well construction for both of these smaller water systems indicated that current MTs below the historic low water level could be sustained, KRGSA Plan Managers determined that higher MTs and MOs in the vicinity of these small water systems were more appropriate. Therefore, the MT was selected at the historic low water level for two GSP monitoring wells adjacent to and north of Lamont PUD and the MO was defined as the average of the MT and the high water level during the historical Study Period. This revision resulted in consistent sustainable management criteria in all of the GSP monitoring wells north of Lamont PUD in the Agricultural MA.

Minimum Thresholds and Measurable Objectives in the Remaining Areas of the KRGSA Agricultural MA

In general, well problems have not been documented in remaining areas of the KRGSA Agricultural MA. DWR completion reports identify some shallow water supply wells throughout the MA, but it is unknown whether shallow wells are active. Although matching well construction to specific private wells in the Agricultural MA has been difficult, most wells in the southern Plan Area appear to be sufficiently deep to accommodate the historic lows of 2015; in addition, DWR completion reports indicate that well depths have been increasing over time.[38] In addition, recent questionnaires and surveys of well owners did not identify any dry well issues in the KRGSA Agricultural MA in addition to water system wells along the southern MA boundary as described above.

An absence of documented well issues associated with declining water levels may be due to a shallower water table in the southern Plan Area than in the northern Plan Area (**Figure 5-4**[39]). Conditions contributing to shallower groundwater include lower surface elevations, widespread recharge along unlined canals, and deliveries of surface water for irrigation. An absence of well problems may also be attributable to deeper agricultural and banking recovery wells, deeper well pumps, or other factors. Based on available information, local adverse impacts associated with water levels are not occurring in

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[38] A management action to better document domestic well owners and well construction throughout the Plan Area is included in **Section 7.2.9** to address the uncertainty in well analyses (see discussion on domestic wells in **Section 2.4.6** and an updated impacts analysis in **Section 5.4.4.4**).

[39] Although perched water has been identified in the KRGSA Agricultural MA, groundwater depths on **Figure 5-4** are associated with the Principal Aquifer.

the KRGSA Agricultural MA. However, because water level declines have the potential to cause local adverse impacts in the future, MTs and MOs are selected for the Agricultural MA.

KDWD operates large-capacity banking recovery wells in the north-central and northwestern Agricultural MA (and also in the southern Urban MA); banking recovery wells owned by KDWD, and others are shown by the yellow triangles on **Figure 5-3**. In order to continue to maintain a mutually-beneficial groundwater banking program in KDWD, MTs need to be lower than in municipal wellfields to accommodate large-scale recovery of banked water during a multi-year drought. KDWD banking wells within the Urban MA are already being constrained by the MT set at historic low water levels. Setting a MT too high in the Agricultural MA could prevent beneficial use of the recovery wells, especially during the GSP implementation period; preventing the beneficial uses of recovery wells is an undesirable result, especially when considering the importance of conjunctive use to the KRGSA GSP in achieving the sustainability goal.

In addition, more than 640 active agricultural wells have been identified in the KRGSA. These wells provide landowners critical supplemental supply for irrigation and other agricultural needs. Landowners require flexibility to lower water levels during multi-year droughts in order to meet demands. As a large contributor to the economic vitality of Metropolitan Bakersfield, access to groundwater supply is an important beneficial use for the entire KRGSA and Kern County Subbasin.

Finally, both small water systems and domestic wells occur throughout the KRGSA Agricultural Area. Although well problems with historic low water levels have not been documented, such problems could be occurring with stakeholders that have not yet engaged with the GSP process. To account for this uncertainty, a management action has been included in this Plan to provide for improved identification and documentation of wells throughout the KRGSA Agricultural MA to adapt future sustainable management criteria to consider all wells and landowners (see **Section 7.2.9**).

To balance the competing objectives of the recovery, agricultural, and drinking water supply wells in the Agricultural MA, KRGSA Plan Managers will need to cooperate on wellfield operation. Because some KDWD recovery wells are several miles south of the Urban MA, those wells could be used for recovery (including potential water exchanges) when adjacent Urban MA water levels are close to the MTs. Recovery wells within the Urban MA could be used for recovery when water levels are sufficiently high. It is noted that the management projects included in this GSP are anticipated to result in higher water levels than recorded during the recent drought, providing some assurance that multiple objectives can be accomplished (see projected water budget results in **Section 4.7.3** and descriptions of management projects in **Section 7.1**).

In the absence of any identified well problems – and recognizing the need for recovery and agricultural wells to meet beneficial uses – there is no indication that lower local water levels would trigger local adverse impacts for this sustainability indicator[40] in the KRGSA Agricultural MA (except in areas of

[40] These MTs are adjusted for the subsidence sustainability indicator as explained in **Section 5.8**.

drinking water wells as described above). Given that water levels declined about 40 to 50 feet during the previous drought of record (see **Section 3.3.2.2**), a MT of 50 feet below the historic low is selected as the MT for representative monitoring points away from the urban wells on the KRGSA Urban MA/Agricultural MA boundary **(Table 5-2)**. This would allow for the southern recovery wells and agricultural wells in the KRGSA Agricultural MA to accommodate a multi-year drought cycle slightly longer than encountered in 2013 - 2016. This MT is selected to preserve the beneficial use of the KDWD banking recovery wells and agricultural wells yet recognizes the close proximity of municipal wells that require a higher MT. Because the MT suggests an operational range between high groundwater levels of the historical Study Period and the new MT, the selected MO is defined as the average of the high water level and the MT, the same method used for the MO in the Urban MA.

Management Area Exceedance in the KRGSA Agricultural MA

Because local water levels may fall lower than MTs during short periods of agricultural and recovery pumping without impact to long-term water levels, the definition of a Management Area exceedance for water levels incorporates the potential of a multi-year drought during the GSP implementation period. To allow operational flexibility for implementing the GSP in drought conditions, a Management Area exceedance will be triggered when levels in 40 percent or more of the representative monitoring wells in the Agricultural MA remain below the MT over a period of two years. These criteria for numbers of wells and duration below the MT avoid regional declines over a long-term period and require recovery relatively quickly, even in drought conditions. These criteria were also coordinated with adjacent water districts and are consistent with the definitions of a Management Area exceedance in adjacent GSPs for the AEWSD and Wheeler Ridge-Maricopa Water Storage District (WRMWSD). As indicated in revised Appendix 3 of the First Amended Kern County Subbasin Coordination Agreement, most Subbasin GSAs have also adopted these triggers.

Coordination within the KRGSA Agricultural MA and with the KRGSA Urban MA

As the primary GSP manager of the KRGSA Agricultural MA, KDWD will coordinate water level management with the primary GSP managers (City of Bakersfield and ID4) and municipal well owners in the KRGSA Urban MA, as described above. In addition, KDWD and Greenfield CWD will continue their ongoing coordination activities including maintenance of water levels through local recharge in canals. Finally, KDWD will begin coordination with other small water systems in the KRGSA Agricultural MA to better understand local system needs. As a primary KRGSA Plan Manager for the Urban MA with respect to municipal wells, the City will want to coordinate with the recovery operations, as well as agricultural well operators in the KRGSA Agricultural MA.

5.4.4.3 KRGSA Banking Management Area

The KRGSA Banking MA contains both dedicated recovery wells and municipal wells (which also recover banked water). The locations of recovery wells are represented by the yellow triangles on **Figure 5-3**; the two municipal wells are shown by the three purple dots in the western banking MA. The selection of MTs and MOs in the KRGSA Banking MA considers the beneficial use of both well types and balances the needs of both.

Recovery Well Considerations
ID4 banks imported water in the Kern River channel for subsequent recovery in its recovery wells to provide a critical water source for the Henry C. Garnett WPP during times of limited imported water. These wells are the eastern-most recovery wells shown on **Figure 5-3** (yellow triangles in east Banking MA). Further to the west, banking in the Berrenda Mesa project provides a critical water source to project participants within the Subbasin who require water in areas of limited to no groundwater supply (due to water quality).

Recovery wells operated by KCWA and others both inside and outside the Banking MA affect water levels throughout the western KRGSA Plan Area due to the close proximity of recovery wells and relatively large pumping volumes. The adjacent Pioneer Project has set a MT equivalent to more than 50 feet below historic low water levels in some wells to accommodate the need for extensive recovery pumping during multi-year droughts. For the Banking MA, a local adverse impact could result if pumping wells were prohibited from lowering water levels sufficiently to recover critical banked water supplies during a multi-year drought. This could occur if the water level MT is set too high in the Banking MA or too low in adjacent banking areas outside of the KRGSA.

Municipal Well Considerations
While a high MT may negatively impact recovery wells, a low MT would present a challenge for sustainable management at the three municipal wells located within the Banking MA (and perhaps other nearby municipal wells in the Urban MA). Specifically, City municipal wells – Olcese No. 1, No. 2, and No.3 – are located at the COB 2800 banking facility and pump banked water directly into the City water distribution system. These wells have relatively shallow screens (about 200 feet deep), and Olcese No. 1 experienced cascading water during the recent drought (as well as water quality problems mentioned in **Section 5.6.4.1**). These conditions can cause local adverse impacts in the Urban MA.

With the implementation of the City's management project to optimize conjunctive use of Kern River water, described in **Section 7.1.2**, water levels should be able to be maintained at higher levels locally than in the past. Increased recharge of surface water will provide flexibility to raise water levels at different locations to meet differing objectives. The project also provides more surface water for direct use, allowing wellfields to pump at lower capacities and prevent excessive drawdown in sensitive areas. This would provide a buffer for the recovery wells during future droughts. Additional recharge in the COB 2800 facility near the Olcese municipal wells could mitigate water levels declines that could lead to potential local adverse impacts to wells.

MT, Management Area Exceedance, and MO Selection for the Banking MA
With a successful City optimization project summarized above, water levels could be managed to accomplish multiple objectives in the Banking MA including focused mitigation for problems at the Olcese wells and perhaps allowing more drawdown to occur for relatively short periods at recovery wells.

Accordingly, a MT up to 20 feet below the historic water level low is selected for the ID4 recovery wells in the Kern River Channel of the eastern Banking MA **(Table 5-2)**. To protect the Olcese municipal wells, a higher MT equal to the historical low is selected for the remainder of the Banking MA including Berrenda Mesa and the COB 2800 facility **(Table 5-2)**. Although these areas are in close proximity, a difference of 20 feet between monitoring wells may be feasible, especially if recovery pumping and municipal pumping is managed and coordinated for water level maintenance. Consistent with the methodology for this sustainability indicator in other MAs, the MO for the Banking MA is defined as the average of the high-water level during the historical Study Period and the MT.

It is recognized that the City may be able to mitigate levels in municipal wells through focused recharge in the COB 2800 facility or make other short-term operational changes to manage municipal wells in the Banking MA. Further, it is recognized that recovery wells need as much operational flexibility as possible to allow critical water supplies to be recovered. To incorporate these factors, a Management Area exceedance for the KRGSA Banking MA is refined as follows:

> A Management Area exceedance for the water level sustainability indicator in the Banking MA occurs when levels in representative monitoring wells are below the MT for a period of more than three consecutive months.

As described in **Section 5.4.4.1** above, municipal well operators should be able to implement short-term operational measures to manage wellfields for several months without incurring local adverse impacts. Measures will be more effective with the implementation of the GSP project, which will provide Cal Water and the City with an increased ability to manage water levels locally. Short-term lower water levels in the Banking MA are not expected to affect municipal wells outside of the City service area due to the distance between recovery wells and other municipal wells. This three-month duration allows for recovery wells to operate during critical periods but also requires cessation of pumping or mitigation to allow water levels to rebound. Balancing water levels to achieve multiple objectives will require close coordination among KRGSA Plan Managers and the willingness to re-distribute recovery pumping and/or municipal pumping as needed to avoid local adverse impacts as provided in the KRGSA Sustainability Goal. These management actions are captured in the GSP as described in **Section 7.2.1**.

5.4.4.4 Amended Impacts Analysis for Domestic Wells in the Plan Area

At the time of the 2020 GSP analysis, the GSAs were unaware of any domestic wells in the Plan Area that had been dewatered due to groundwater level declines. An analysis by the Leadership Counsel of Justice and Accountability[41] suggested the potential for seven domestic wells to be impacted if water levels declined to the MTs; however, those wells were all located in the central portion of the northern Plan Area, south of the Kern River and within existing municipal water service areas of the Urban MA. In that area, MTs were set at historic low water levels and those domestic wells would have already been impacted before GSA management of MTs began. Also, given the locations in an existing municipal water service area, it was unlikely that those domestic wells – even if active – provided the sole water

[41] Comment letter to Kern River GSA from Leadership Counsel for Justice & Accountability, Kern River GSP Comments, October 21, 2019, in KRGSA GSP, Appendix F.

supply available for residents. Nonetheless, the 2020 KRGSA GSP recognized the potential for unknown impacts to domestic wells and planned to address the issue through a management action.

As described in **Section 2.4.6.2**, the updated DWR WCR database was obtained and reviewed for this 2022 Amended KRGSA GSP. This database included significantly more domestic well information than was available for the original GSP analysis in 2020. In addition, information associated with local dry domestic wells is now available on a DWR Household Water Shortage website[42]. This website incorporates a dry well reporting system allowing domestic well owners to report problems and connect to state and local resources for assistance. Collectively, the updated DWR WCR and dry well datasets are used to evaluate potential impacts of MTs on domestic wells for the Amended KRGSA GSP.

Comparison of MTs and Domestic Wells

As shown on **Table 5-2** and explained throughout subsequent sections of **Chapter 5** of this Amended KRGSA GSP, the MTs considered local beneficial uses of groundwater across each Management Area for each sustainability indicator. In general, the MT selection started with the historic low water level that had occurred during the drought of record (WY 2013 – WY 2016). Most of the final MTs remained at that level. In some areas, such as the western Agricultural MA, MTs were adjusted up to 50 feet lower based on larger water level fluctuations in close proximity to groundwater banking areas; adjustments were less in the primary area of historical land subsidence. The historic low water level MTs were not adjusted over most of the disadvantaged communities (DACs) in the eastern KRGSA to be more protective of local drinking water supplies (**Figure 2-16**). Although the depth of some MTs varied based on the sustainability indicator, the shallow-most MT represents the controlling elevation at each monitoring site for tracking MT compliance and avoidance of local significant and unreasonable impacts from any of the applicable sustainability indicators.

The shallow-most MT elevations were contoured to develop a surface representative of water levels at MTs across the entire Plan Area. That surface was electronically converted to depth below ground surface (bgs) using GIS spatial analyst and a digital elevation model (DEM) of ground surface elevations. Wells that would have failed previously at the observed historical low levels prior to GSP management were not included in the analysis. This is consistent with SWRCB and UC Davis methodologies used to analyze MT impacts to domestic wells in the Central Valley (SWRCB, 2021; Bostic, et al., 2020).

The MT contours and GIS raster of the MT surface are shown on **Figure 5-5**. A color ramp is applied to the raster to highlight areas where the depths to MTs are relatively shallow (blue-green-yellow) or relatively deep (dark yellow-brown-gray). The shallowest portions of the MT surface occur in the northern Plan Area along and downgradient of the Kern River for the protection of municipal wellfields. Another area of shallow MTs occurs on the ancient Kern Lake Bed to avoid exacerbation of historical land subsidence from compaction of lakebed clays. The area in the northeast is shown as gray on **Figure 5-5** to remove areas of closely-spaced depth contours from the figure, which were produced by the higher topographic elevations and hilly terrain of the foothills. This area was included in the electronic

[42] https://mydrywell.water.ca.gov/report/

impacts analysis, but the MT contours have been removed from the color ramp to highlight areas where domestic wells are more likely to be impacted. No impacted domestic wells were identified in the northeastern gray area of **Figure 5-5**. F

The MT surface was compared to the completed well depths for domestic wells in the DWR WCR database (897 wells of the total 1,071 wells had well depths). Of these wells, approximately 37 domestic wells – if they are still active – are expected to be dry if water levels declined to MT levels across the entire Plan Area. These potentially vulnerable wells are shown on **Figure 5-5** and represent about three percent (3%) of all domestic wells drilled since 1950 in the KRGSA Plan Area. All but two of these wells are less than 300 feet deep with an average completed depth of 255 feet.

All 37 wells were drilled at least 29 years ago, and 28 wells (75%) were drilled more than 50 years ago (i.e., before May 1972). The viability and status of these wells are unknown; many of these older wells have likely been replaced with additional wells or other water supplies. According to a recent study by researchers at the University of California, Davis (UC Davis), the average life cycle for a domestic well in the Central Valley is estimated at 28 to 31 years (Gailey, et al., 2019). When additional UC Davis researchers conducted a San Joaquin Valley-wide analysis of dry domestic wells at MTs reported in the 2020 GSPs, the analysis excluded wells drilled more than 29 years ago (Bostic, et al., 2020). If wells older than 29 years had been excluded from the KRGSA amended domestic well impact analysis described above, no domestic wells would have been predicted dry at MT levels in the KRGSA Plan Area.

In addition, as noted on **Figure 5-5**, seven of the 37 potentially-impacted wells appear to be located within a municipal water service area in the Urban MA (California Water Service Company, City of Bakersfield, Vaugh Water Company, or East Niles Community Services District). Service areas of active purveyors in the Plan Area are shown on **Figure 2-4**. All of these wells are relatively old wells with six of the seven wells drilled in the 1960s. These wells may have been drilled prior to the expansion of municipal services that occurred with increasing urbanization in the northern Plan Area over time. Regardless, it appears that these residences now have another potential source of water supply other than a vulnerable domestic well. A management action has been added to the Amended KRGSA GSP to better track and identify active domestic wells and potential impacts in the Plan Area (**Section 7.2.9**)

This well impacts analysis under MT conditions has also been expanded to include an analysis of impacts for the triggers selected in the KRGSA for Management Area exceedances. That additional analysis is described in **Section 5.10.2** to cover all of the sustainability indicators.

Comparisons of MTs and Small Water System Wells

The updated impacts analysis was also expanded to include public water supply wells, including small water system wells. The same methodology described above for the domestic well analysis was applied to the public water supply wells, but no additional well impacts were identified.

Reported Dry or Failed Domestic Wells

Well failures in four domestic wells in the Plan Area have been reported on the DWR Household Water Shortage website (problems initiating in 2016). Locations of the four failed wells are shown in yellow on a map of the KRGSA MAs on **Figure 5-6**, along with the 37 potential vulnerable domestic wells identified in the MT impacts analysis (shown in red). As indicated on the map, two wells are located in the south and eastern portions of the Urban MA, including one well on the eastern “peninsula” of land in the Urban MA. One well is located along the northeastern boundary of the Agricultural MA, and one is located in the central Agricultural MA east of Highway 99.

According to the DWR website, problems with the failed wells began in the three northern-most wells in 2016 and 2019, prior to the adoption of the 2020 GSP (**Figure 5-6**). Two of these three wells were reported to be dry and no longer producing water. Well depths were not available for those wells, and it is not known whether the wells were completely dewatered to the completed total depth or if water levels simply dropped below the well pump. The well in the northeastern Agricultural MA was reported to be pumping sand and muddy water. These conditions could indicate a failed well casing and it is not known if the well was actually determined to be dry.

The failed well in the central Agricultural MA was recently reported dry in 2022 (**Figure 5-6**). That well was apparently shared among five parties. Well owners are hauling water on a short-term basis while finding a driller to repair or replace the well. As with the other dry wells, it is not known if the well has been completely dewatered or if water levels have only dropped below the well pump. Local monitoring wells indicate that water levels have not fallen below historic low levels in this area.

Notwithstanding the relatively shallow MTs selected over the Plan Area, the information from the DWR website and the impacts analysis indicates that some domestic wells may be impacted if water levels decline to MTs throughout the Plan Area. Given the large number of data gaps associated with impacts to domestic wells, a management action has been developed to identify active domestic wells, track potential impacts, and adjust groundwater management of water levels as needed. This amended management action is described in **Section 7.2.9**.

5.5 REDUCTION OF GROUNDWATER IN STORAGE

GSP regulations require that the groundwater storage sustainability indicator consider a total volume of groundwater that can be withdrawn from the Subbasin without causing undesirable results (§354.28(c)(2)), a concept consistent with the SGMA definition of sustainable yield (see **Section 4.5.4**). The indicator involves a potential depletion of groundwater supply, or overdraft. Overdraft refers to conditions when the average annual amount of groundwater outflow (e.g., groundwater extraction) exceeds the long-term average groundwater inflow. Because avoidance of overdraft is fundamental to sustainable management, this sustainability indicator focuses on water budget results and the potential for overdraft.

SGMA links overdraft conditions to both the water level sustainability indicator and the groundwater storage sustainability indicator as evidenced by portions of the California Water Code (§10721) as reproduced below. This Water Code section specifically addresses the reduction of groundwater that occurs during drought and relates overdraft to storage.

> Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reduction in groundwater levels *or* storage during a period of drought are offset by increasing groundwater levels *or storage* during other periods" (§10721(x)(1)) (*emphasis added*).

As indicated by the text above, overdraft and sustainable yield are related to the amount of recharge/replenishment that can be accomplished during non-drought conditions to balance any declines in water levels and storage during drought. As indicated in the Subbasin definition of undesirable results related to chronic lowering of water levels, that indicator focuses on potential impacts to wells and the ability to support beneficial uses. This sustainability indicator for groundwater in storage allows a focus on the depletion of supply and overdraft conditions.

5.5.1 Potential Causes of Undesirable Results for Reduction of Groundwater in Storage

In general, overdraft conditions occur when average annual inflows into the groundwater system are significantly less than average annual outflows, causing a continual depletion of groundwater supplies over time. Overdraft conditions result from a wide variety of groundwater mismanagement (or an absence of management) involving either a net increase in outflows or a net decrease in inflows, or both. Such activities may include over-pumping, changes in land use (e.g., paving recharge areas or other reduction in reduce surface infiltration), reduction in surface water (reducing recharge), or an absence of other water supplies to meet demands.

GSP regulations (§354.44(b)(2)) require that if the water budget analyses identify conditions of overdraft, the imbalance must be mitigated through projects, management actions, and/or demand reduction. For relatively thin aquifer systems or systems with deep confined groundwater that cannot be readily replenished at the surface, a depletion in supply may be more difficult to mitigate.

Conditions of critical overdraft also have the potential to cause a chronic lowering of water levels, inelastic land subsidence, and/or reduction of surface water supply (as a reduction in baseflow to streams or an increase in induced surface water recharge). This close linkage to other sustainability indicators highlights the potential for a reduction in groundwater in storage to cause adverse impacts within the Plan Area.

5.5.2 Subbasin Definition of Undesirable Results for Reduction of Groundwater in Storage

In coordination with other GSAs in the Subbasin, the KGA developed a Subbasin-wide definition of an undesirable result for each sustainability indicator (December 14, 2018). KRGSA Plan Managers participated in the development of the definitions, which were reviewed and approved by the KRGSA

Board for Subbasin-wide coordination on January 10, 2019. This Subbasin-wide definition of Undesirable Results for the Groundwater Storage sustainability indicator is as follows:

> The point at which significant and unreasonable impacts, as determined by the amount of groundwater in the basin, affect the reasonable and beneficial use of, and access to, groundwater by overlying users over an extended drought period. (10-years)
>
> This is determined when the volume of storage (above the groundwater level minimum thresholds) is depleted to an elevation lower than the groundwater level minimum threshold in at least three (3) adjacent management areas that represent at least 15% of the subbasin or greater than 30% of the subbasin (as measured by the acreage of each Management Area).
>
> Minimum thresholds shall be set by each of the management areas through their respective Groundwater Sustainability Plans.

5.5.3 KRGSA GSP Considerations for Reduction of Groundwater in Storage

In the KRGSA, the Principal Aquifer contains a thick column of fresh water extending several thousand feet deep. The total amount of groundwater in storage beneath the KRGSA likely exceeds 20,000,000 AF above the base of fresh water (see **Section 3.2.5.4**, last paragraph), not including deeper groundwater available for emergency supply. Although access to the entire water column is not readily available with existing wells, the risk of depleting a significant quantity of groundwater supply is small. The sustainable average annual groundwater withdrawals are about 290,000 to 320,000 AFY (see **Section 4.5.4**), equivalent to less than two percent of the total supply. Even when withdrawals increased to about 400,000 AFY during the drought of record (**Table 4-4**) when water levels reached historic lows, the total associated change in groundwater in storage was estimated at 238,072 AF, about two percent of the total amount of groundwater in storage.

However, a more important assessment of undesirable results for the KRGSA is the potential for overdraft conditions, which would also result in a chronic lowering of water levels. As shown in **Table 4-10** and discussed in **Section 4.5.4**, three independent methods of analysis indicate collectively that there has not been a significant and unreasonable reduction in groundwater in storage over the average conditions of the historical Study Period. This conclusion suggests that there were no undesirable results occurring in the physical groundwater system as of the SGMA baseline of January 2015 for this sustainability indicator.

However, when adjusted for banking obligations outside of the KRGSA and recharge inside of the KRGSA attributable to others, the change in storage increases to about -29,153 AFY (**Table 4-10**), suggesting that overdraft conditions should be considered for planning purposes. In addition, future increases in demand and projected decreases in supply have the potential to exacerbate overdraft conditions in the future. Importantly, water levels may not reflect overdraft conditions when they occur due to the extensive recharge and groundwater banking operations inside and adjacent to the KRGSA by non-KRGSA entities.

Based on these considerations, the KRGSA GSP intends to develop sustainable management criteria that represent the KRGSA GSP water budget with the purpose of avoiding overdraft as follows:

> The KRGSA intends to avoid significant and unreasonable amounts of overdraft, which will be analyzed by the KRGSA adjusted checkbook water budget analysis, based on average hydrologic conditions.

As indicated in **Section 5.5.2** above, the Subbasin has defined the MT for this sustainability indicator to be the same MT as defined for the chronic lowering of water levels sustainability indicator. Given the close linkage of water levels and storage, using the same MTs for both indicators provides a practical limit for operating levels and storage beneath the KRGSA. In addition, the high groundwater level from 1998, used in the development of the MO for water levels (see **Section 5.4.4**) provides a reasonable upper limit for this range. The amount of storage represented by this operational range is estimated at about 1,500,000 AFY[43].

5.5.4 Sustainable Management Criteria for Groundwater in Storage in the KRGSA Plan Area

The MTs and MOs selected for the water level sustainability indicator provide numerical values for this groundwater storage indicator. The combination of these two closely-linked sustainability indicators creates an operational range of water levels and storage for each MA. However, the Banking MA is not subject to a reduction of groundwater in storage because of the operation of groundwater banks on the Kern River Fan. For each banking project, recharge occurs before recovery and recovery does not exceed recharge. Accordingly, the MT and MO for water levels are not applicable to the Banking MA, as stated below. The MTs and MOs for chronic lowering of water levels for the Urban and Agricultural MAs are re-stated below for completeness. The triggers for a Management Area exceedance developed for the chronic lowering of water levels is also applied to the Urban and Agricultural MAs.

In addition to the quantitative MTs and MOs selected for this indicator, the KRGSA Plan Managers will continue to update the KRGSA checkbook water budget as an additional mitigation against future overdraft conditions. While not quantified as an MT, the maintenance of the KRGSA checkbook water budget analysis – with low to no change in groundwater in storage over average hydrologic conditions – provides additional confirmation of sustainable management to supplement water level monitoring.

5.5.4.1 KRGSA Urban Management Area

The MT for the reduction of groundwater in storage sustainability indicator in the KRGSA Urban MA is selected as the historic low water level except in the northwestern corner where the MT is lowered 20 feet below the historic water level lows to allow operational flexibility for groundwater users in the RRID area **(Table 5-2)**. In addition, the MT in ENCSD in the northeast is lowered 50 feet to provide operational

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[43] Based on an average water level change of about 70 feet across most of the KRGSA Plan Area from 1998 to 2015 and using a 10 percent specific yield.

flexibility for the increased pumping associated with the water system consolidation project identified in **Section 7.1.5**. The MO is defined as the average of the high groundwater level from 1998 and the MT.

5.5.4.2 KRGSA Agricultural Management Area

The MT for the KRGSA Agricultural MA is defined as 50 feet below the historic low water level for this sustainability indicator to accommodate a multi-year drought cycle slightly longer than encountered in 2013 – 2016 **(Table 5-2).** The assumption here is that the water budgets would be adjusted to account for average conditions, even if an extended drought occurs, as is planned for the 2030 and 2070 climate change scenarios presented in **Section 4.7.3**. The MO is defined as the average of the high groundwater level (typically 1998) and the MT.

5.5.4.3 KRGSA Banking Management Area

The KRGSA Banking MA is not subject to a reduction of groundwater in storage. Banking projects are operated such that recharge occurs before recovery, and recovery pumping does not exceed the quantity of banked water. It is recognized that recovery pumping can lower water levels to depths below what would have occurred in the absence of banking because banked water can migrate away from the capture zone of the recovery wells. However, this occurrence would already be incorporated into the analysis for the sustainability indicator associated with chronic lowering of water levels. Therefore, no additional MT or MO is selected for this sustainability indicator in this MA.

5.6 Seawater Intrusion

The KRGSA is more than 50 miles from the closest shoreline and separated from the Pacific Ocean by the bedrock units of the Coast Ranges. Accordingly, seawater intrusion is not occurring, not expected to occur in the future, and is not an applicable sustainability indicator for the KRGSA Plan Area or the Subbasin. As allowed in the GSP regulations (§354.28(e)), no sustainable management criteria are defined for this indicator and seawater intrusion is not considered further in this GSP.

5.7 Degraded Water Quality

Unlike the other sustainability indicators, water quality is already regulated through numerous programs by a variety of federal, state, and local agencies. GSAs do not have the mandate or authority to duplicate these programs. Further, the GSAs are not required to correct for historical issues, naturally-occurring degradation, or degradation caused by others. Nonetheless, to support sustainable groundwater supplies for all beneficial uses, this GSP recognizes and states the intention to cooperate with the regulatory programs in the KRGSA for the management and prevention of degraded groundwater quality. The GSP proposes coordination with these programs through data sharing and analyses. In addition, local management actions are proposed that support compliance with water quality programs (described in **Sections 7.1** and **7.2**). GSP Projects and management actions also support the improvement of groundwater quality and assist with the prevention of future contamination (**Sections 7.1** and **7.2**).

GSAs intend to avoid management actions that would contribute to water quality degradation or unnecessarily spread groundwater contamination through pumping or other means. Therefore, the definition of undesirable results for the Subbasin and selection of MTs considers groundwater quality related to water levels or other attributes that could potentially be affected by management actions.

5.7.1 Potential Causes of Undesirable Results for Water Quality

Degraded water quality can impair water supply, impact human health and the environment, and create the need for alternative water sources. Accordingly, degraded water quality has the potential to affect beneficial uses of groundwater including drinking water, agricultural or industrial supply, and environmental uses. Impacts to drinking water supply wells can cause expensive response actions including contaminant investigations, well modifications, increased sampling and monitoring, increased treatment costs, loss of wells, and/or a loss of water supply. Impacts to agricultural supply can cause poor yields, loss of crops, changes in irrigation methods/sources, impacts to property values, and other economic effects. Impacts to industrial supply can cause product damage, inadequate process water, increased treatment costs, degraded wastewater, and other problems. Discharge of degraded groundwater can cause harm to surface water, wetlands, and other habitats/ecosystems.

Both naturally-occurring and human-related (anthropogenic) constituents of concern have been identified in the KRGSA. Naturally-occurring constituents can be difficult to predict and control. Anthropogenic impacts can create plumes that migrate and spread contaminants downgradient (horizontally and vertically). Non-point sources can create widespread impacts that can be difficult to contain and manage. Impacts associated with releases of constituents at the surface may remain undetected for years or decades before migration through the vadose zone allows detection in underlying groundwater. Degraded water quality can be spread or exacerbated by pumping wells.

5.7.2 Subbasin Definition of Undesirable Results for Water Quality

In coordination with other GSAs in the Subbasin, the KGA developed a Subbasin-wide definition of an undesirable result for each sustainability indicator (December 14, 2018). KRGSA Plan Managers participated in the development of the definitions, which were reviewed and approved by the KRGSA Board for Subbasin-wide coordination on January 10, 2019. The definition of Undesirable Results for the Degraded Water Quality Trends sustainability indicator is as follows:

> The point at which significant and unreasonable impacts over the planning and implementation horizon, as caused by water management actions, that affect the reasonable and beneficial use of, and access to, groundwater by overlying users.
>
> This is determined when the minimum threshold for a groundwater quality constituent of concern is exceeded in at least three (3) adjacent management areas that represent at least 15% of the subbasin or greater than 30% of the designated monitoring points within the basin. Minimum thresholds shall be set by each of the management areas through their respective Groundwater Sustainability Plans.

5.7.3 KRGSA GSP Considerations for Avoiding Degradation of Water Quality

The Subbasin definition of an undesirable result focuses on impacts *caused by management actions*. Consistent with this definition, the primary concern of this GSP is to ensure that management actions proposed by the KRGSA Plan Area agencies do not cause local adverse impacts for water quality. Such actions could potentially involve:

- operation of groundwater levels that increase concentrations of contaminants in wells such that the beneficial use of groundwater is impacted,
- recharge of surface water supplies that could impact water quality, or
- pumping wells that are likely to spread or exacerbate contaminant plumes.

The potential for the second and third bullets to cause local adverse impacts is unlikely under current conditions in the KRGSA. Surface water quality of the Kern River is acceptable for all beneficial uses and supplies high quality drinking water to the KRGSA. Therefore, the extensive managed recharge operations using Kern River water is likely to improve groundwater quality rather than degrade it. Imported water that is banked for subsequent recovery is also considered high quality water and would not contribute to water quality degradation.

With regards to the potential to spread contaminant plumes, no distinct plumes have been identified in the KRGSA Plan Area. Pumping centers have been established for decades and wells are routinely monitored for groundwater quality. It is recognized that there are some areas of unknown impacts from anthropogenic sources (see **Section 3.3.4.6** and **Table 3-4**). Accordingly, the KRGSA will continue to monitor groundwater and work with the Central Valley Water Board to identify key contaminant sites (see **Section 7.2**).

As described in **Section 3.3.4.6**, the primary constituents of concern for the KRGSA Plan Area drinking water are arsenic and TCP. Because TCP is primarily related to legacy application of fumigants in agricultural areas, it would have been applied at the surface and likely occurs at highest concentrations in shallow portions of the Principal Aquifer. However, this relationship was difficult to evaluate with current data and requires additional analysis. Further, elevated concentrations of TCP are currently being managed through wellhead treatment facilities installed on more than 55 wells with additional lawsuits pending to fund treatment on other impacted wells.

A correlation between water levels and arsenic has been interpreted for some KRGSA wells and could be affected by management actions. As shown by the graph on **Figure 3-34**, arsenic concentrations increase in some wells when water levels decline. If arsenic is associated with the deeper aquifer zones, then contributions from those zones could be higher when water levels are low. If water levels are allowed to decline significantly below historic lows, arsenic concentrations could exceed the MCL in wells with current low concentrations. Although wellhead treatment has been installed on eleven of the more vulnerable wells identified to date (**Figure 3-33**), tens of additional municipal wells have detected arsenic near or above the MCL and are at risk of increasing arsenic concentrations over time. An undesirable result could be triggered if arsenic concentrations rose in untreated wells such that wells could not be used to meet the beneficial use of drinking water supply.

5.7.4 Sustainable Management Criteria for Water Quality in the KRGSA Plan Area

This definition for an undesirable result due to degraded water quality is tested against conditions in each KRGSA MA to determine whether local adverse impacts are occurring as of the SGMA baseline of January 2015 or if the sustainability indicator has the potential for future impacts. This analysis is used, in turn, to select appropriate MTs for the water quality sustainability indicator in each MA.

GSP regulations state that the minimum threshold for degraded water quality be based on "the number of supply wells, a volume of water, or a location of an isocontour that exceeds concentrations of constituents determined by the agency to be of concern for the basin" (§354.28(4)). The number of supply wells are considered in the minimum threshold, but volumes of water or the position of an isocontour is not applicable to naturally-occurring arsenic that creates impacts across the Plan Area. Such impacts vary based on well construction, well capacity, and depth and thickness of the arsenic-bearing strata.

Regulations also state that "…the Agency shall consider local, state, and federal water quality standards applicable to the basin." (§354.28(4)). The water quality standard for arsenic is considered in the minimum threshold but is not a reliable target. First, arsenic concentrations in some wells peak to levels above the MCL without a steady increase in concentration over time. Further, some wells have detected arsenic at levels close to the MCL for long periods without further increases. Impacts appear to be more closely related to water levels than to predictable trends in water quality. Although the arsenic MCL is the underlying basis for potential adverse impacts, controlling water levels is considered the most manageable method for avoiding these impacts as explained in more detail below.

5.7.4.1 KRGSA Urban Management Area

In the KRGSA Urban MA, elevated arsenic concentrations above the MCL have been detected in at least 20 municipal wells that do not have wellhead treatment; many other nearby wells are vulnerable to arsenic concentrations. During the drought of 2015-2016, concentrations rose in certain wells, but concentrations were managed with blending and with re-distribution of pumping.

Although these are not ideal management conditions, the costs of lost wells and additional treatment facilities were minimized. Wells were modified and are now better-positioned to manage drought conditions. Nonetheless, the historic lows caused multiple well and management problems that could be avoided by maintaining water levels above the critical levels reached in the recent drought. This goal is consistent with the City's intention to provide high quality water to urban residents at the lowest possible price. High water levels would also protect wells operated by smaller water systems without resources for well modifications or wellhead treatment.

It is recognized that the actual water level needed to avoid adverse impacts may vary from well to well and require adjustment over time. However, because the historic low created management problems for KRGSA municipal wells, the historic low level is selected as the MT for this sustainability indicator as monitored in representative monitoring wells. To monitor ongoing performance for operating above the MT, an MO is defined as the average of the MT and the high water level in the representative monitoring well during the historical Study Period (average hydrologic conditions). This is the same MT and MO as selected for the water level sustainability indicator, conveniently facilitating GSP monitoring and management.

KRGSA Plan Managers considered the potential for setting water levels higher than the historic low to create more certainty for avoiding adverse impacts. However, managers recognized that water levels adjacent to the KRGSA may take more time to stabilize as GSP projects are brought online during the GSP Implementation period; therefore, higher water levels will not likely be achievable until GSP implementation is underway. Also, as discussed previously (**Section 5.4.4**), banking recovery wells – some of which are adjacent to municipal wells – may need the operational flexibility to lower water levels locally during critical periods of drought.

Accordingly, the MT is maintained at the historic low for this water quality indicator for most of the Urban MA and will be tested during the GSP Implementation period for control of arsenic levels **(Table 5-2)**. As described in **Section 4.7.3**, a proposed KRGSA GSP management project is expected to maintain higher water levels in the KRGSA Urban MA. Fortunately, the KRGSA Urban MA can implement its GSP project (Kern River Conjunctive Use Optimization project) early in the implementation phase and begin maintenance of water levels directly for the benefit of drinking water supply (see **Section 7.1.2**). Consistent with other sustainability indicator MOs, an MO is defined for the water quality indicator as the average of the high groundwater level during the historical Study Period (typically 1998) and the MT.

Similar to the water level sustainability indicator, the MT in the eastern portion of the Urban MA is adjusted to 50 feet below the historic low water level to accommodate increased local pumping associated with the ENCSD water system consolidation project (see **Section 7.1.5**). As discussed in more detail in **Section 7.1.5**, this project is being implemented to improve drinking water quality for small water systems serving portions of the KRGSA DACs. The ENCSD wells either already contain or have plans to install arsenic treatment facilities; accordingly, arsenic concentrations are already being managed locally. ENCSD has requested the operational flexibility that may be needed during drought to provide sufficient quantities of groundwater to its expanded service area. This localized adjustment is not expected to negatively impact large municipal wellfields to the west.

The MT for the northwest corner of the Urban MA is also lowered to allow for the transition to agricultural wells both inside and north of the Urban MA. Consistent with the water level sustainability indicator, the MT is defined as 20 feet below the historic low water level and the MO is the average of the high groundwater level and the MT **(Table 5-2)**. The triggers for a Management Area exceedance developed for the chronic lowering of water levels are also protective of water quality in drinking water wells. Specifically, MT exceedances are limited to a three month interval before action is required. Accordingly, these criteria are maintained of the water quality sustainability indicator.

5.7.4.2 KRGSA Agricultural Management Area

Arsenic has been identified as a constituent of concern in the north-central KRGSA Agricultural MA where Greenfield CWD (**Figure 5-2**) has installed wellhead treatment facilities for elevated arsenic levels at two of its wells (see **Section 3.3.4.6** and **Figure 3-33**). Greenfield CWD has recently completed two deep replacement wells and can now accommodate slightly deeper water levels on a system-wide basis. Also, the replacement wells were constructed to minimize arsenic concentrations after water testing identified the highest arsenic-bearing zones (QK, 2016). Accordingly, the water quality is currently being managed and local adverse impacts have been mitigated. However, to protect Greenfield CWD and other water supply wells along the urban fringe and avoid adverse impacts in the future, KRGSA Plan Managers have selected the historic low as the MT in Greenfield CWD, areas to the north of Lamont PUD (transition to small water systems), and along the southern boundary of the Urban MA, consistent with the adjacent municipal wellfields to the north **(Table 5-2)**. The MO is defined as the average of the MT and the high groundwater level during average historical conditions.

However, conditions throughout the remaining KRGSA Agricultural MA have not experienced arsenic issues similar to those in the north. In addition, arsenic is not a constituent of concern for agricultural operations (**Section 3.3.4**). Lowering water levels in areas away from the Urban MA would not be expected to exacerbate arsenic concentrations in municipal wells to the north. Accordingly, a lower MT of 50 feet below the historic low water level is selected for the remaining Agricultural MA with an MO defined as the average of the high groundwater level during the historical Study Period (typically 1998) and the MT **(Table 5-2)**. With fewer drinking water wells and higher MTs in DACs, the triggers for a Management Area exceedance in the Agricultural MA appear to be sufficiently protective of significant degradation of water quality. The impact of these triggers on local domestic wells is further evaluated in **Section 5.10.2**.

5.7.4.3 KRGSA Banking Management Area

Arsenic has been detected at concentrations above the MCL in the three municipal wells located in the KRGSA Banking MA (City wells in the COB 2800 Recharge facility); as seen in other municipal wells, arsenic concentrations increased in proportion to water level declines during the recent drought. In addition, wells in the adjacent Pioneer banking project have also detected arsenic concentrations at depth. Those offsite wells are managing arsenic levels through blending and other actions and have set MTs below the historic low water level at monitoring wells adjacent to the KRGSA Banking MA. Although it may be difficult to maintain water levels in the KRGSA Banking MA significantly higher than in those adjacent areas, a planned GSP project involves less pumping and more recharge in the KRGSA Urban and Banking MAs (**Section 7.1.2**). In addition, the City and the Pioneer Project have a Joint Operating Agreement on shared facilities and infrastructure and includes mitigation steps for minimizing impacts on the respective operations.

Therefore, to protect the municipal wells in the banking MA, the MT is defined as the historic low water level in the COB 2800 facility and adjacent Berrenda Mesa banking project **(Table 5-2)**. The MT is lowered 20 feet for ID4 recovery wells in the eastern Banking MA **(Table 5-2)**. In that area, wellhead treatment has been installed on local municipal wells, allowing better management of arsenic concentrations (**Figure 5-3**). For all subareas of the Banking MA, the MO is defined as the average of the high groundwater level over the historical Study Period (typically 1998 levels) and the MT. Proposed criteria that would trigger a Management Area exceedance are the same as those in the adjacent Urban MA (i.e., MT exceedances for more than three consecutive months, see **Table 5-2b**).

5.8 LAND SUBSIDENCE AFFECTING BENEFICIAL USE

Historical land subsidence has been documented in the KRGSA Plan Area and is likely being exacerbated by water levels lowered during the recent drought. As water levels decline in the subsurface, dewatering and compaction of aquifer materials, predominantly fine-grained materials such as clay, can cause the overlying ground surface to subside (see analysis in **Section 3.3.5**). Historical and current land subsidence in the KRGSA Plan Area is illustrated on **Figures 3-37** and **3-8**, respectively. **Figure 5-3** outlines the general area of the largest historical subsidence, which occurs primarily in the southern and southeastern portions of the Agricultural MA.

5.8.1 Potential Causes of Undesirable Results for Land Subsidence

Inelastic compaction is initiated when the magnitude of the greatest pressure that has acted on the clay layer since its deposition, or pre-consolidation stress, is exceeded. With respect to the effects of groundwater pumping, the pre-consolidation stress is exceeded when groundwater levels in the aquifer reach a new historically low water level. The volumetric compaction of the clay layers in the subsurface is transmitted to the land surface where it is manifested as land subsidence.

Land subsidence can impact land use and damage critical infrastructure. Adverse impacts would be more pronounced if subsidence occurred unevenly through the area (referred to as differential subsidence). The following potential impacts have been associated with land subsidence due to groundwater withdrawals (modified from LSCE, et al., 2014):

- Damage to infrastructure including foundations, roads, bridges, or pipelines
- Loss of conveyance in canals, streams, or channels
- Diminished effectiveness of levees
- Collapsed or damaged water well casings
- Land fissures.

Undesirable results for land subsidence would clearly include loss of capacity in major water conveyance infrastructure such as the Friant-Kern Canal or California Aqueduct. Subsidence damage along the Friant-Kern Canal has resulted in loss of capacity and the need for expensive repairs. The Friant-Kern Canal terminates at the Kern River in the northern KRGSA, where little to no land subsidence has been documented. The California Aqueduct is more than four miles from the closest portion of the KRGSA and current levels of subsidence in the KRGSA are unlikely to affect it.

However, KRGSA Plan Managers rely on the conveyance capacity of the Aqueduct and are interested in the mitigation of any undesirable results with respect to land subsidence along the aqueduct caused by others. Accordingly, the KRGSA is cooperating with Subbasin-wide efforts for investigating and managing inelastic land subsidence impacts on regional critical infrastructure[44]. The California Aqueduct and the Friant-Kern Canal have been defined as regional critical infrastructure and will be managed cooperatively by all of the GSAs in the Subbasin as explained in more detail in **Sections 5.8.2** below and **Section 6.2.6.4**.

For the KRGSA, undesirable results (as defined for the Subbasin – see **Section 5.8.2** below) could also occur if the functionality of critical infrastructure identified in **Section 3.3.5.3** was impacted. In brief, KRGSA Plan Managers rely on numerous canals and pipelines for water conveyance and management (**Figure 3-39**). Major roadways such as I-5 and Highway 99 traverse across the KRGSA Plan Area. The City of Bakersfield contains a myriad of critical infrastructure including municipal wells, water and other utility pipelines, roads, buildings, associated appurtenances and numerous other facilities that may be at risk if inelastic subsidence occurred in the city. The three water treatment facilities in the Bakersfield area are also specifically recognized as critical infrastructure. Other critical infrastructure exists outside of the City limits and/or away from urban centers including the Bakersfield Meadows Field Airport, industrial pipelines/conduits, and other features.

Damage to any of the critical infrastructure could result in expensive repairs, loss of capacity, interruption of utility service, loss of damage to transportation corridors, impacts to the economy, and, in the event of catastrophic damage, possible risks to human health and the environment.

5.8.2 Subbasin Definition of Undesirable Results for Land Subsidence

In coordination with other GSAs in the Subbasin, the KGA developed a Subbasin-wide definition of an undesirable result for each sustainability indicator (December 14, 2018). KRGSA Plan Managers participated in the development of the definitions, which were reviewed and approved by the KRGSA Board for Subbasin-wide coordination on January 10, 2019. The definition of Undesirable Results for the Land Subsidence Trends sustainability indicator is as follows:

> The point at which significant and unreasonable impacts, as determined by a subsidence rate and extent in the basin, that affects the surface land uses or critical infrastructure.
>
> This is determined when subsidence results in significant and unreasonable impacts to critical infrastructure as indicated by monitoring points established by a basin wide coordinated GSP subsidence monitoring plan.

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[44] As indicated in the First Amended Kern County Subbasin Coordination Agreement, Appendix 3, the Subbasin has coordinated on a Subbasin-wide approach to land subsidence and has developed consistent terminology for use in the GSPs. See Section 5.8.2 for definitions of regional critical infrastructure relating to inelastic land subsidence.

In response to the DWR Determination Letter in January 2022, the Kern County Subbasin GSPs have further coordinated on analyzing and establishing regional critical infrastructure of Subbasin-wide importance and developing preliminary sustainable management criteria for these structures. Specifically, DWR concluded in the January Determination Letter that the Subbasin "lacks a coordinated Subbasin-wide management approach for subsidence…" To address this deficiency, the Subbasin has developed definitions for critical infrastructure to differentiate between *local* critical infrastructure in a Management Area and *regional* critical infrastructure of Subbasin-wide importance. The revised coordinated definitions are provided in the Appendix 3 of the First Amended Kern County Subbasin Coordination Agreement and are reproduced, with minor clarifications to a Management Area, below.

> *Regional Critical Infrastructure* is defined as infrastructure located within the Subbasin that serves multiple areas of the Subbasin and whose loss of significant functionality due to inelastic subsidence, if caused by SGMA related Subbasin groundwater extractions, would have significant impacts to beneficial users. The Subbasin has collectively determined that the only infrastructure that meets the definition for Regional Critical Infrastructure are the California Aqueduct and the Friant-Kern Canal.
>
> *Management Area Critical Infrastructure* is defined as infrastructure located within a particular Subbasin Management Area whose loss of significant functionality due to inelastic subsidence, if caused by SGMA related Subbasin groundwater extractions, would have significant impacts to beneficial users within that Subbasin Management Area. Each Subbasin Management Area, including the three Management Areas in the KRGSA Plan Area, has identified their respective Management Area Critical Infrastructure in the individual GSPs including this Amended KRGSA GSP.
>
> As mentioned previously, the Subbasin GSAs have also coordinated on interim sustainable management criteria for impacts to regional critical infrastructure due to inelastic land subsidence if caused by Subbasin groundwater extraction. Those details are provided in the revised Appendix 3 of the First Amended Kern County Subbasin Coordination Agreement, submitted separately on the SGMA Portal.

5.8.3 KRGSA GSP Considerations for Land Subsidence

The KRGSA GSP adopts the Subbasin definition by reference and provides further clarification for the KRGSA Plan Area as follows:

The impacts from land subsidence are determined to be significant and unreasonable if Subbasin groundwater extractions in the KRGSA Plan Area cause inelastic land subsidence that impacts the functionality of surface land use or critical infrastructure in a KRGSA Management Area. For the KRGSA, Management Area critical infrastructure is identified in **Section 3.3.5.3**.

5.8.4 Sustainable Management Criteria for Subsidence in the KRGSA Plan Area

The Subbasin definition for an undesirable result due to inelastic land subsidence is tested against conditions in each KRGSA MA to determine whether local adverse impacts are occurring as of the SGMA baseline January 2015 or if the sustainability indicator has the potential for future impacts. This analysis is used, in turn, to select appropriate MTs for the water level sustainability indicator in each MA.

5.8.4.1 KRGSA Urban Management Area

The aquifer system in the KRGSA Urban MA is likely less susceptible to land subsidence from groundwater withdrawal than other areas in the KRGSA. First, the aquifer system is composed of predominantly coarse-grain sediments with no evidence of confining layers in the zones of municipal pumping (i.e., about 700 feet deep, see **Figure 3-20**). Although clay content increases somewhat to the west, the large quantities of recharge in the western banking projects demonstrate the highly permeable shallow subsurface. Historical subsidence data do not indicate significant subsidence rates in this area and recent data from the NPL suggest that subsidence over most of the Urban MA is minimal. Given the absence of significant land subsidence and no reports of damage to critical infrastructure, undesirable results do not appear to be occurring in the Urban MA as of January 2015.

Nonetheless, the Urban MA contains the most critical infrastructure subject to damage if significant amounts of inelastic differential subsidence occurred in the future. Therefore, MTs and MOs consider subsidence potential and also recognize that the MTs for the other sustainability indicators are set at the historic low water level for most of the MA (see **Sections 5.4.4** and **5.7.4**). If water levels are maintained at or near the historic low water level, the potential for exacerbating future subsidence from groundwater extractions would be mitigated and additional analysis would be unnecessary. In this manner, water levels can be used as a proxy for sustainable management criteria for inelastic land subsidence. Accordingly, the MT of the historic low water level is adopted for the land subsidence indicator **(Table 5-2).** The MO is selected as the average of the high groundwater level during the historical Study Period and the MT. If KRGSA Plan Managers decide to modify the MT for the water level and water quality sustainability indicators in the future, then selection of sustainable management criteria for land subsidence should be re-visited. The criteria for a Management Area exceedance for chronic lowering of water levels in the Urban MA are also used for this indicator.

The agricultural lands in the northwest corner of the Plan Area have not experienced significant rates of subsidence based on historical investigations and current JPL analysis (see **Figure 3-38**). There is no indication that undesirable results are occurring or have the potential to occur in this area. However, given that previous MT and MO definitions for other indicators are set at or near the historic low water levels, potential future impacts would already be mitigated without further analysis. Accordingly, previous MT, triggers for a Management Area exceedance, and MO designations are adopted for this sustainability indicator, setting the MT at the historic low water level and the MO at the average of the high groundwater level and the MT **(Table 5-2)**.

Because subsidence monitoring has not occurred in the Urban MA, the KRGSA will supplement the groundwater level monitoring program with a preliminary monitoring program that incorporates the DWR SGMA portal where updated InSAR data will be posted. These data will be used for screening on an annual basis to determine if negative vertical displacement is indicated in new areas of the Urban MA. Data will be provided in the Annual Report; if significant subsidence rates of more than 1 inch per year are indicated by the tool over a two-year period, additional monitoring of subsidence may be added to the GSP monitoring network such as GPS benchmarks.

5.8.4.2 KRGSA Agricultural Management Area

Northwest and North-Central KRGSA Agricultural MA

Significant amounts of historical land subsidence have not been associated with the northwestern KRGSA Agricultural MA (see discussion in **Section 3.3.5** and **Figure 3-37**). Current analyses from JPL indicate some subsidence associated with the recent drought ranging from about one to three inches (see **Figure 3-38**). Yet there has been no evidence of damage to any infrastructure to date. KDWD has not observed land subsidence along its extensive network of unlined canals or around other infrastructure even though they have field staff continually monitoring and managing the canals. KDWD landowners have not reported any damage to well casings or other local infrastructure. Therefore, undesirable results do not appear to be occurring in this area of the KRGSA Agricultural MA as of January 2015. Although there is a potential for future subsidence in this area based on the JPL analysis, rates and extents are not known. Recent rates over a 10-year period (from 2000 to 2020) have been estimated at 0.95 inches per year in the area of the largest subsidence rates (**Section 3.3.5.2**).

The water level MT, set at 50 feet below the historic low water level in the northwest Agricultural MA, would allow for additional subsidence to occur, but the rate is expected to be less than in southern, more clay-rich areas of the Agricultural MA. In order to maintain the operational flexibility needed for agricultural and banking recover wells in this area, especially until the GSP projects have been fully implemented, the water level MT, triggers for a Management Area exceedance, and MO are also selected for the land subsidence indicator in the northwest Agricultural MA.

Similar to the northwest, historical subsidence in the north-central Agricultural MA has not been a significant issue in the KRGSA Agricultural MA. As in other areas, the sustainable management criteria for lowering of groundwater levels would protect against exacerbating inelastic land subsidence from groundwater extractions in the future; as such, those criteria are selected as a proxy for managing inelastic land subsidence in this area. Specifically, the MT is selected to be the historic low water level that occurred during the 2012-2016 drought and the MO is defined as the average of the high groundwater levels during the historical Study Period and the MT (**Table 5-2a**). The criteria to trigger a Management Area exceedance developed for the chronic lowering of groundwater levels are also selected for this area (**Table 5-2b**). This selection is further bolstered by conjunctive use recharge projects to be implemented in the GSP (**Section 7**) and a multi-faceted monitoring network (**Section 6.2.6**) to further investigate subsidence potential in this area.

Southern and Eastern Agricultural MA

Historical subsidence between one and nine feet has been documented in the south and southeast, occurring over a period of about 1926 to 1970 with most of the subsidence occurring in the 1950s and 1960s (see **Section 3.3.5.1** and **Figure 3-37**). More recent vertical displacement measurements have been taken at two high-accuracy GPS stations in the southeastern portion of the KRGSA Plan Area. These data cover a recent 10-year period up to the submittal of the 2020 KRGSA GSP (2000 to 2020) and represent the best available data for a current rate of subsidence, which has averaged about 0.95 inches per year (see **Section 3.3.5.2**). As in other areas of the KRGSA, no damage to critical infrastructure has been identified and undesirable results do not appear to be occurring as of January 2015. This may be the result of large-scale agricultural development, undeveloped land, and the absence of widespread critical infrastructure such that no impact from subsidence is observed.

It is not surprising to see additional subsidence triggered during this recent drought, although much of this ongoing subsidence is likely due to the slow compaction of the thick clay sequences in the area, which may have been triggered by historical water levels as well. Nonetheless, historical and current rates of subsidence, along with the presence of thick clay deposits indicate that future potential subsidence is a risk. The water level MT assigned for this area of 50 feet below historic low water levels seems excessive, given the historical and current indications of subsidence. Because these rates of subsidence are not currently evident, local subsidence requires future ground-truthing and maintenance of water levels near historic lows to mitigate the subsidence potential.

However, to provide a transition from the MT in the northwest Agricultural MA and the MT assignments in adjacent WRMWSD and AEWSD, an allowance of 20 feet below the historic low water level is selected as the MT in the southern and eastern Agricultural MA **(Table 5-2)**. Given that water levels declined an average of about 10 feet per year during the recent drought, this would allow about two additional years of subsidence at current rates, which have been estimated at local GSP stations to be about 0.95 inches per year. Therefore, the MT would allow for about two inches of subsidence beyond what has already been triggered from historical conditions, a small percentage of the total historical subsidence estimated to date. As indicated in **Section 3.3.5.2**, recent studies have predicted that subsidence would be expected to continue even if water levels did not continue to decline based on the expected slow rate of compaction of subsurface clay layers such as those that occur in the area of historical subsidence (Lees, et al., 2022). Further, land subsidence in this area has been indicated to show rebound during wet years and with additional recharge from infiltration with surface water irrigation (Lees, et al., 2022; Vasco, 2022).

This MT also provides a means of transitioning from the higher MT set along the boundary between the Agricultural MA and the Urban MA in the eastern Plan Area. Although a MT set below the historic low water level will allow some additional subsidence to occur during the early portions of the GSP implementation period, management projects are expected to allow future maintenance of water levels above historic low levels (see **Section 4.7.3** and **Section 7.1**).

To provide additional protection to this area during GSP implementation, the KRGSA will supplement water level monitoring with additional evaluations of subsidence. As indicated in the subsidence monitoring discussion in **Section 6**, KDWD will use the InSAR data portal being developed by DWR to monitor subsidence rates across this area. KDWD field staff will continue to examine canals and roadways in the area to identify field evidence. In addition, data from three existing GPS monitoring stations will be obtained, reviewed and documented in Annual Reports (**Section 6.2.3**). Finally, the KRGSA is cooperating with KGA and the other GSAs in a Subbasin-wide subsidence monitoring program for shared interests in critical infrastructure in the Subbasin (documented in **Section 5.8.4.4** below).

In consideration of the above discussion, an MT of 20 feet below the historic low water level is selected for the southern and southeastern KRGSA Agricultural MA **(Table 5-2)**. The MO is defined as the average of the high groundwater elevation during the historical Study Period (typically from Spring 1998) and the MT.

In the eastern Agricultural MA, the MTs for water levels are already set at historic lows due to the number of drinking water wells in areas of DACs. These MTs would be protective of triggering additional land subsidence in this area and are appropriate proxies for inelastic land subsidence.

Consistent with the criteria defined in WRMWSD and AEWSD, an undesirable result is triggered if levels in 40 percent of the representative monitoring wells remain below the MT for two consecutive years or if material damage to critical infrastructure from land subsidence is observed (**Table 5-2b**). This provides management flexibility during a future multi-year drought before GSP projects are fully implemented.

5.8.4.3 KRGSA Banking Management Area

Similar to the Urban MA, the KRGSA Banking MA is less likely to be susceptible to significant land subsidence under current operations. No historical subsidence has been documented in the Banking MA. Subsidence monitoring by others at the banking projects, including the Kern Water Bank, have not documented any inelastic land subsidence. No infrastructure damage relating to land subsidence has been documented in the Banking MA and undesirable results as of January 2015 do not appear to be occurring. The potential for future damage to critical infrastructure in this area also seems unlikely. Wells at the adjacent Pioneer banking project observed water levels close to -50 feet msl with no subsidence indicated, about 35 feet below the historic water level low in the KRGSA. Pioneer has selected an MT of 50 feet below that level for sustainable management criteria in the Pioneer Project.

The MT selected for other sustainability indicators maintain water levels at or near the historic low level and would be the controlling indicator for GSP compliance. Nonetheless, with no historical subsidence indicated at adjacent banking programs when water levels declined below those observed in the KRGSA, an MT of 50 feet below the historic low water level in the KRGSA is not likely to trigger significant levels of subsidence and is selected for the Banking MA including Berrenda Mesa, the COB 2800 facility, and the ID4 recovery wells along the Kern River channel **(Table 5-2)**. As in the Urban MA, water level monitoring will occur in the Banking MA and document the maintenance of water levels. As with the other KRGSA MAs, the water level sustainable management criteria will serve as a good proxy for land subsidence monitoring in the KRGSA Banking MA.

5.8.4.4 Coordinated Subbasin Monitoring for Land Subsidence

Because of the mutual interest in protecting regional critical infrastructure from adverse impacts from land subsidence, the KRGSA is cooperating with the other GSAs in the Subbasin for coordinated sustainable management criteria and a land subsidence monitoring program focused on the California Aqueduct and Friant-Kern Canal. As explained previously, these two structures of Subbasin-wide importance have been identified as regional critical infrastructure by the Subbasin GSAs. This program would supplement monitoring of land subsidence and MTs and MOs in the KRGSA Agricultural and Urban MAs as described above and provide additional protection for the shared critical infrastructure across the Subbasin (see also **Section 6.2.3**).

The Subbasin-coordinated sustainable management criteria and monitoring program for regional critical infrastructure is provided in the First Amended Kern County Subbasin Coordination Agreement, Appendix 3. This agreement is being submitted separately on the SGMA Portal.

5.9 DEPLETION OF INTERCONNECTED SURFACE WATER

An analysis of interconnected surface water and GDEs, as described in **Section 3.3.6**, did not identify applicable areas of interconnected surface water/GDEs in the KRGSA Plan Area. Given the depth to water beneath the NCCAG areas, and ongoing management activities along the Kern River channel and local unlined canals, interconnected surface water is not likely to be present or to occur in the near future. An analysis by KGA confirmed the assessment that interconnected surface water was not likely present in the Subbasin; accordingly, a Subbasin-wide definition of undesirable results was not developed for this sustainability indicator. Given the results of the analysis in the KRGSA GSP, no sustainability criteria are defined including undesirable results, or a MT or MO.

Although it does not appear that there are current environmental users of groundwater in the KRGSA as defined by SGMA, the Sustainability Goal of the KRGSA GSP strives to protect any future or un-identified environmental users of groundwater. This GSP involves projects that raise or maintain water levels near the historic low level observed during the 2015-2016 drought, which would protect any un-identified GDEs. The GSP monitoring network will document the ongoing water level conditions beneath the Plan Area. Additional monitoring has been added along the Kern River to track any future changes in interconnected surface water, including wells 30S/27E-05D01 and ID4#13 as shown on **Figures 3-47a** and **3-47b**, respectively.

5.10 AMENDED INFORMATION IN RESPONSE TO DWR DETERMINATION LETTER

This new **Section 5.10** is being incorporated into the Amended KRGSA GSP in response to a Corrective Action that is applicable to all Kern County Subbasin GSPs as provided in the DWR Determination Letter (see page 35 of 40, Deficiency 2, DWR, 2022). Specifically, the DWR letter states *the GSPs must* *demonstrate the relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the GSA has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators*.

DWR also expressed concerns regarding the fragmented manner in which Management Area exceedances and undesirable results were triggered across the Subbasin (Deficiency 1, DWR, 2020). To better coordinate on this issue, the GSAs have agreed to consistent terminology and similar triggers for most management areas in the Subbasin. Specifically, the Subbasin-wide definition of undesirable results is retained in the First Amended Kern County Subbasin Coordination Agreement and is triggered by local Management Area exceedances (which involves criteria based on local conditions in each Management Area). Separate criteria are developed to trigger local Management Area exceedances, although the Subbasins have now better coordinated on the local triggers (revised Appendix 3, First Amended Kern County Subbasin Coordination Agreement). Management Area exceedances for the KRGSA Plan Area are discussed and analyzed further in this new **Section 5.10** of the Amended KRGSA GSP.

The selection and rationale of sustainable management criteria, including MTs, are discussed separately for each applicable sustainability indicator in **Sections 5.1** through **5.9** above. Those discussions reference **Table 5-2**, which documents the selection of MTs including management considerations and adjustments based on local conditions within each Management Area. **Table 5-2a** summarizes the MTs, and **Table 5-2b** summarizes how the MTs are applied to trigger a Management Area exceedance. Those two components of **Table 5-2** (i.e., 5-2a and 5-2b) are summarized in **Sections 5.10.1** and **5.10.2** below in response to the deficiencies noted above in the DWR Determination Letter.

5.10.1 Relationship between Minimum Thresholds for Each Sustainability Indicator

For the selection of MTs, the KRGSA GSP begins with the historic low water levels that had been observed throughout the Plan Area during the 2013-2016 drought. Those levels were chosen initially to be protective of wellfields and water quality in the Urban MA. The initial MTs were then adjusted downward for certain sustainability indicators in some local areas to balance competing objectives for various beneficial users of groundwater across the Plan Area.

Most downward adjustments were made in consideration of the following objectives for groundwater management and use (see **Table 5-2a**):

- allow larger groundwater level fluctuations in areas of concentrated pumping for recovery of banked water (Banking MA and west/northwest Agricultural MA)
- allow increases in local pumping to support ongoing consolidation of numerous small water systems into one local wellfield (ENCSD consolidation of six small water systems, northeast Urban MA)
- accommodate the need for increased groundwater reliance during drought when surface water supplies are less available (Agricultural MA, entire Plan Area)

- transition to lower water levels in areas adjacent to the KRGSA Plan Area (all KRGSA boundaries).

These downward adjustments were balanced with the need for maintaining higher water levels in certain areas in consideration of the following objectives for groundwater management and use (see **Table 5-2a**):

- avoid exacerbation of historical rates of inelastic land subsidence to protect critical infrastructure (southern, southeastern, and eastern Agricultural MA)
- manage water levels in areas of DACs to protect against widespread impacts to domestic and small water systems wells (east Agricultural MA and northeast Plan Area, see **Figure 2-16**)
- protect large municipal wellfields (e.g., more than 150 municipal wells) from widespread well operation and water quality problems (Urban MA).

To the extent practical, MTs were initially based on the considerations of each single sustainability indicator separately. Then, in recognition of the interrelationship of one indicator on another, the shallow-most MT was selected for compliance in each Representative Monitoring Well (RMW). In that manner, there is complete coordination among all sustainability indicators and the most protective groundwater conditions at each MT are maintained to avoid significant and unreasonable adverse impacts across the entire KRGSA Plan Area. An additional advantage to this approach is that groundwater management is simplified by managing to the single most protective MT in each well and to one set of criteria that triggers a Management Area exceedance in each KRGSA MA.

As an additional protective measure, two management actions were developed to offset any potential significant and unreasonable impacts associated with the final MTs, including an Action Plan for addressing any MT exceedance (**Section 7.2.1**) and a management action to document, track, and assess potential impacts to domestic wells and small water systems, and to adjust management actions for the protection against widespread impacts (**Section 7.2.9**).

5.10.2 Triggers for Management Area Exceedances in the Amended KRGSA GSP Plan Area

The triggers for a Management Area exceedance in the Plan Area have been coordinated among all GSP Management Areas in the Subbasin. In general, this Amended KRGSA GSP did not change its criteria for triggers from the 2020 KRGSA GSP as other GSPs adopted triggers already being used for the KRGSA Agricultural MA. Criteria for triggering a Management Area exceedance is summarized on **Table 5-2b**. These criteria are developed in response to GSP regulations as a part of the definition for undesirable results (§354.26(b)(2)). For the Kern County Subbasin, triggers for a local Management Area exceedance considers local conditions that may affect the Subbasin-wide definition of undesirable results as provided in the First Amended Kern County Subbasin Coordination Agreement.

The presentation of criteria that trigger a Management Area exceedance has been simplified in amended **Table 5-2b** to provide consistent triggers across each Management Area. This organization better clarifies how MT exceedances in KRGSA Management Areas will be tracked and managed over time. Triggers for Management Area exceedances are discussed and analyzed further for each KRGSA Management Area in the following sections.

5.10.2.1 Urban and Banking MAs

As indicated in **Table 5-2b**, an MT exceedance in any RMW lasting more than three consecutive months triggers a Management Area exceedance for the Urban and Banking MAs. As discussed in **Section 5.4.4.1** and **5.4.4.3**, these short-term exceedances, coupled with the MTs assigned at or close to the historic low water level (2013-2016 drought) are highly protective of beneficial users of groundwater. As required by the Action Plan in **Section 7.2.1**, even a one-time exceedance will be investigated. For example, when MT exceedances occurred in one Urban MA RMW, the City coordinated directly with nearby well owners to mitigate the exceedances within a few months; no local adverse impacts were identified.

Because RMWs with short-term exceedances are required to recover in a matter of months, no significant reduction of groundwater in storage would occur. Further, City wells have demonstrated that depth-related water quality impacts improve when water levels recover; as such, no long-term impacts to water quality are expected with these triggers. With regards to land subsidence, no impacts to critical infrastructure have been noted, and recent InSAR data indicate zero to positive vertical displacement over almost all of the Urban MA (i.e., no inelastic land subsidence). Accordingly, no adverse impacts are expected from the short-term MT exceedances in the Urban and Banking MAs for any of the applicable sustainability indicators.

5.10.2.2 Agricultural MA

In the Agricultural MA, a Management Area exceedance is triggered when 40 percent of the RMWs exceed the MTs for four consecutive semi-annual monitoring events (2 years). Other GSPs in the Subbasin have also adopted these criteria for their Management Areas. With 20 RMWs in the current KRGSA GSP monitoring network, eight wells would be allowed to decline during this period.

The longer duration and larger number of wells associated with the triggers allow flexibility during drought conditions when an increased reliance on groundwater is expected in accordance with the Sustainability Goal of optimizing conjunctive use. Criteria also balance the need for pumping during drought to recover previously banked groundwater during wet periods. Because RMWs are required to recover after the two-year period, long-term water level declines across the Plan Area can be avoided, even in the midst of a multi-year drought.

With regards to the sustainability indicators, a two-year decline below MTs is not anticipated to result in significant impacts to reduction of groundwater in storage or inelastic land subsidence. Because water levels will be managed for recovery, no significant loss of groundwater in storage would occur. The highest rate of recent subsidence over generally average to dry conditions in the southern Agricultural MA was up to about one inch per year – with some recovery during seasonal fluctuations. The additional two inches – if managed such that the exceedances do not continually occur – is not expected to impact local critical infrastructure (which has experienced no known adverse impacts from subsidence to date –

even during the two most recent and extreme drought periods. Impacts to water quality are not expected to worsen such that water quality is degraded over the short time interval.

However, it is recognized that additional impacts to domestic wells could occur if water levels decline significantly during the period of MT exceedances. Impacts to a large number of wells over a two year period could result in a significant loss of drinking water supply wells. As presented in **Section 5.4.4.4,** a total of about 37 domestic wells in the DWR WCR database (about three percent of KRGSA domestic wells) were indicated by the analysis to become dry if water levels declined to MTs over the entire Plan Area (recognizing the limitations of the analysis including unknown well status, inexact well locations, and indications that almost all of the wells were near the end of their expected life span – see **Section 5.4.4.4**). Of the 37 domestic wells, 30 were in the Agricultural MA (F**igure 5-5**). To determine how many additional domestic wells might be at risk during these short-term MT exceedances associated with the Agricultural MA triggers for a Management Area exceedance, additional analyses were conducted.

Three scenarios were analyzed for the Agricultural MA triggers involving the eight eastern-most RMWs (40%), the eight western-most RMWs (40%), and the eight RMWs in the central Agricultural MA (40%), respectively, with some overlap in RMWs among the scenarios. Water level declines were estimated at 10 feet per year (20 feet over the two-year period) as a worst-case decline that mirrored some of the largest annual declines recorded in the KRGSA during the recent drought (see discussion of historical groundwater level declines in **Section 3.3.2** of this KRGSA GSP).

The same methodology used for the domestic and small water system well impacts analysis (see **Section 5.4.4.4**) was used for the analysis of the triggers. The analysis of the scenarios indicated that between 3 and 11 additional domestic wells were predicted to be dry – assuming those wells are still active and at locations close to those estimated in the DWR database. The additional potentially-impacted wells were generally older wells, similar to the 37 wells estimated to be vulnerable to MT levels. For example, only two of the wells impacted by the triggers were drilled within the last 30 years and only three were drilled in the last 50 years. Given that the life span for domestic wells in the Central Valley has been estimated to be about 30 years (Gailey, et al., 2019), these wells may be already targeted for replacement or are no longer active as a drinking water supply.

To improve management of impacts to domestic wells, the Amended KRGSA GSP includes a management action to document active wells, track potential impacts, provide resources and technical assistance as practical, and adjust management actions as needed to avoid significant and unreasonable impacts to local beneficial users (see **Section 7.2.9**).

5.11 Sustainable Management Criteria and Adaptive Management

The MTs for the applicable sustainability indicators described above are summarized in **Table 5-2a**. **Table 5-2b** provides addition criteria for defining undesirable results including consideration of the number of wells and duration that the MT is exceeded. Generalized subareas described within each of the MAs are included on the table along with considerations for the MT selection. As shown in **Table 5-**

2, historic low water levels encountered during the drought of 2013-2016 are used as the basis for each MT associated with every applicable sustainability indicator. For each indicator, the historic low water level is either used directly as the MT or adjusted based on the analysis discussed above.

Although each MT is slightly different for the subareas within each MA, the shallowest MT will be the controlling MT for GSP compliance. The controlling sustainability indicator for each subarea in the MA is highlighted in green in **Table 5-2**. For subareas that include or are adjacent to municipal wells that are already experiencing undesirable results related to both chronic lowering of water levels and degraded water quality, both indicators are highlighted.

The subareas will be monitored with representative monitoring wells as described in **Section 6**. Monitoring wells will be selected based on location and water level record. Wells with long records and frequent measurements are prioritized to allow historical context for local water levels. An example hydrograph on **Figure 5-7** illustrates how the sustainability criteria are being applied. As shown on the hydrograph and summarized in **Table 5-2**, the historic low water level is the basis for the MTs and is adjusted, as needed, based on the analysis of the sustainability indicator discussed above. The MO is the average between the high-water level mark and the MT (**Figure 5-7**). The high and low water level provide a reasonable operational range of water levels in the KRGSA Plan Area. Importantly, as mentioned in **Section 5.2.4**, this MO also reflects a water level range associated with a sustainable yield in the KRGSA (see also **Section 4.5.4**). This method of monitoring sustainability illustrates the reliance on groundwater levels and the importance of selecting representative monitoring wells, discussed in **Section 6**.

The use of water levels as a proxy for all of the applicable sustainability indicators is allowed by the regulations, provided the justification and basis for doing so is technically defensible. As explained for each indicator above, water levels are directly linked to how the indicator is being applied in this GSP. The actual water level for each MT may require future adjustment, however, once the aquifer response to management actions is more accurately measured.

As mentioned previously, this selection of water level MTs and MOs represents the first attempt to quantify sustainable management criteria for the KRGSA Plan Area. Management of water levels and water budgets have not previously been linked to groundwater usage on a real-time basis, and operation of the groundwater resource at this level of detail contains inherent uncertainty. Groundwater management within these constraints may not prevent all undesirable results or allow sufficient operational flexibility to optimize groundwater resources.

Accordingly, the selected MTs and MOs in **Table 5-2** and management actions will require adaptation. Modification of management criteria as well as improvements in management are expected to be identified as KRGSA Plan Managers cooperate and coordinate in meeting the GSP sustainability goal. This concept of adaptive management will be continually evaluated during the implementation horizon to achieve sustainability by 2040 while also providing for beneficial uses of groundwater.

5.12 INTERIM MILESTONES

As the GSP in being implemented between 2020 and 2040, results of the management actions and GSP performance are tracked, in part, by interim milestones established by the GSAs. GSP regulations define interim milestone as follows:

> "Interim milestone" refers to a target value representing measurable groundwater conditions, in increments of five years, set by an Agency as part of a Plan. (§351(q)).

The selection of interim milestones considers the time period required to implement the primary management projects and the potential for observed changes in the groundwater system as a result of these actions. Numerous future factors will affect performance with respect to the interim milestones and achievement of sustainability criteria most notably the timing and duration of the next multi-year drought. Nonetheless, the GSP Annual and Five-Year Assessment Reports can refer to interim milestones in evaluating GSP progress.

Water levels fell to historic lows during the recent drought and are now recovering from those low levels. As water levels rise closer to the average during the implementation period, the MO will be achieved. The MO, as defined in this GSP, represents the average water level within the operational range of the groundwater beneath the KRGSA. To reach the MO target, interim milestones are defined between the historic low water level and the MO. Regulations require that the milestones be developed in five-year increments over the 20-year GSP implementation period (2020 to 2040), resulting in four increments. Accordingly, three increments are developed evenly between the MT and the MO, with the MO established at the end of the fourth period. This method is summarized in **Table 5-3.**

Table 5-3: Methodology for Interim Milestones

GSP Implementation Period	Interim Milestone Groundwater Elevation (ft msl)	Method Example: IF MT = 100 ft msl AND MO = 200 ft msl
Begin Implementation	Minimum Threshold (MT)	100 ft msl
Year 5	((MO-MT) x 0.25) + MT	125 ft msl
Year 10	((MO-MT) x 0.5) + MT	150 ft msl
Year 15	((MO-MT) x 0.75) + MT	175 ft msl
Year 20 Achieve Sustainability	Measurable Objective (MO)	200 ft msl

In addition to water levels, the ongoing analysis of water budgets in the KRGSA Plan Area will also serve as interim milestones. Increments of additional inflows to groundwater will be used to measure progress toward meeting the KRGSA sustainability goal. Monitoring of water budget components are documented in **Section 6**.

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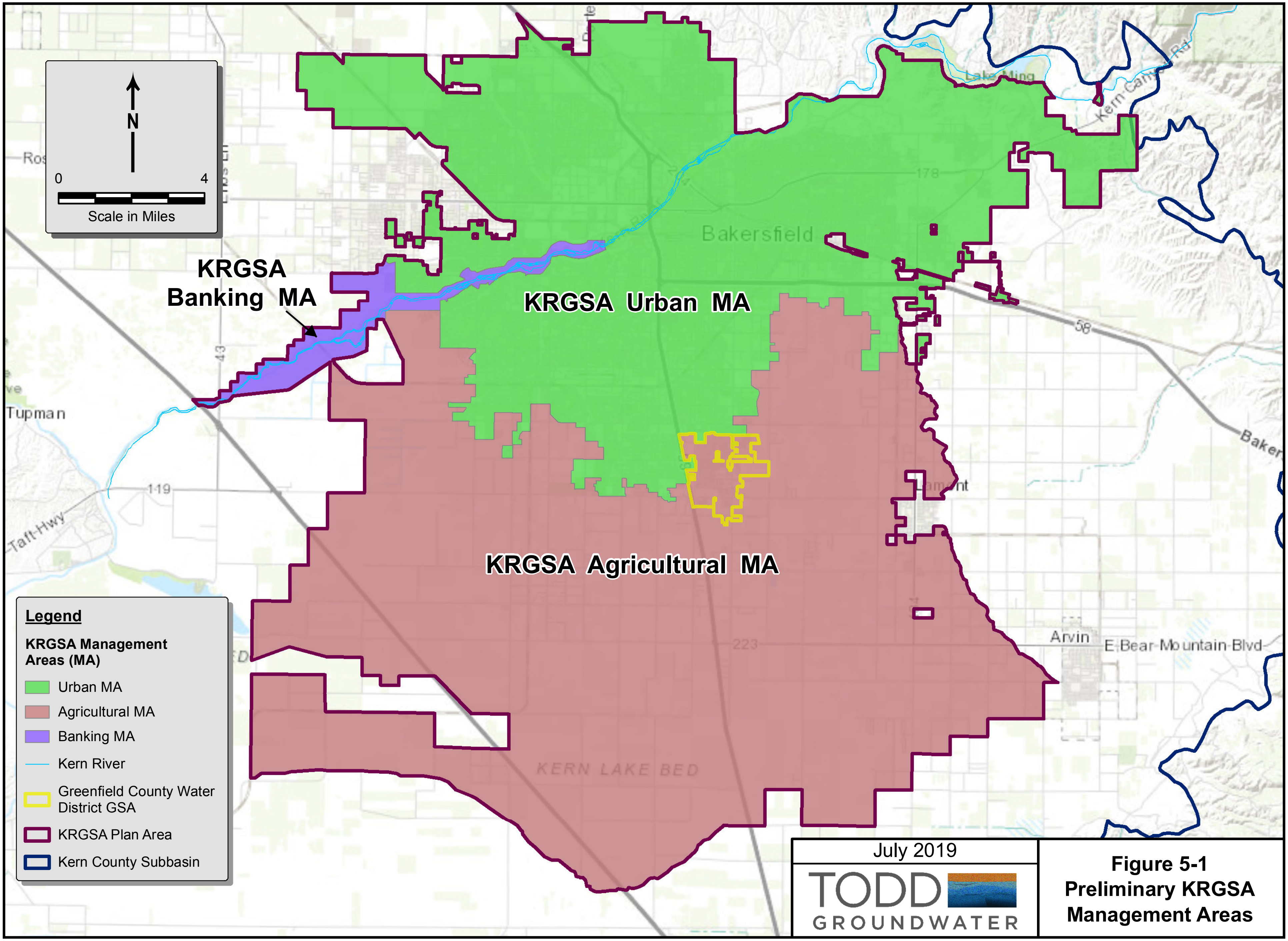


July 2019

TODD GROUNDWATER

Figure 5-1
Preliminary KRGSA Management Areas

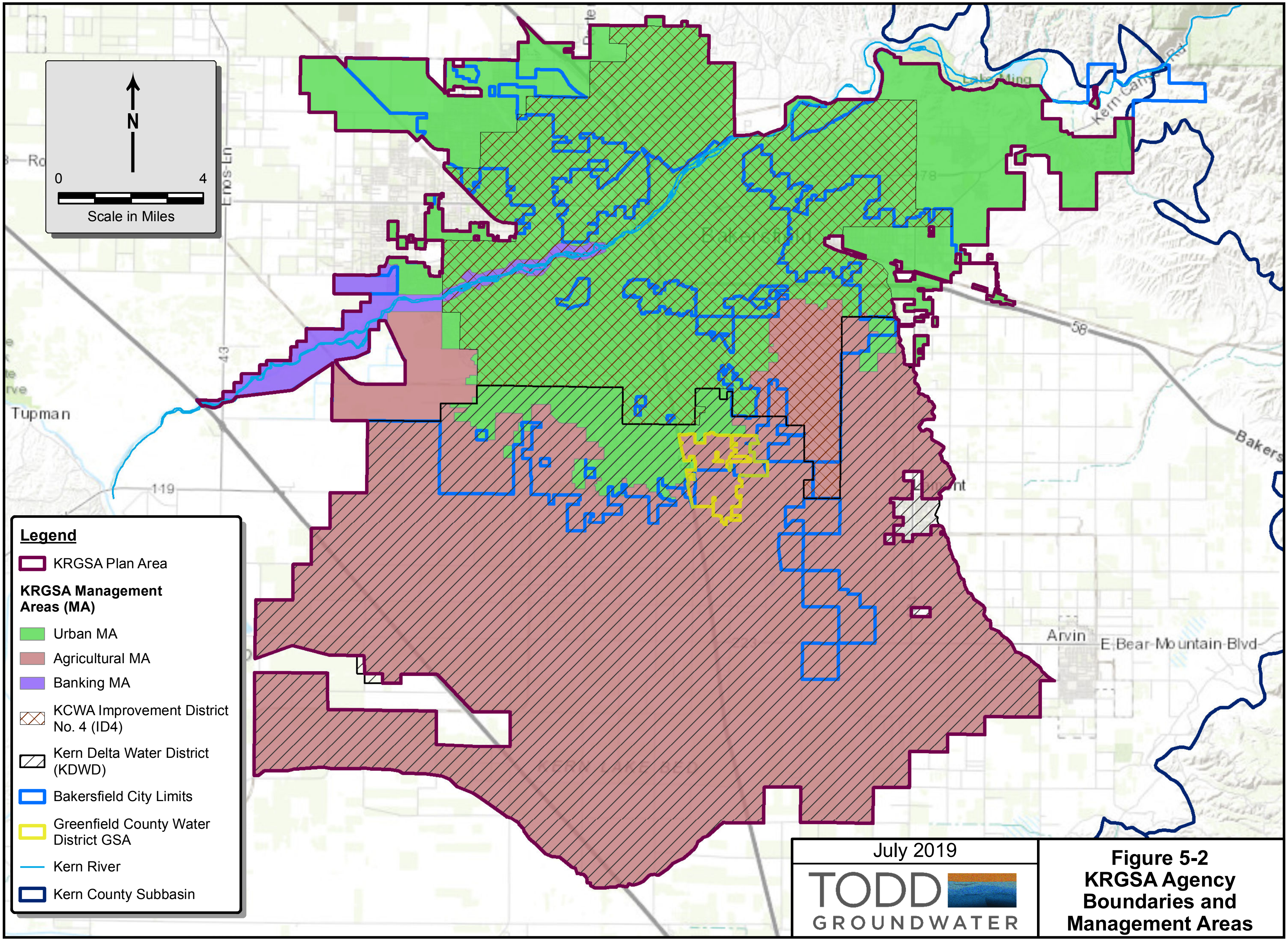


Figure 5-2
KRGSA Agency Boundaries and Management Areas

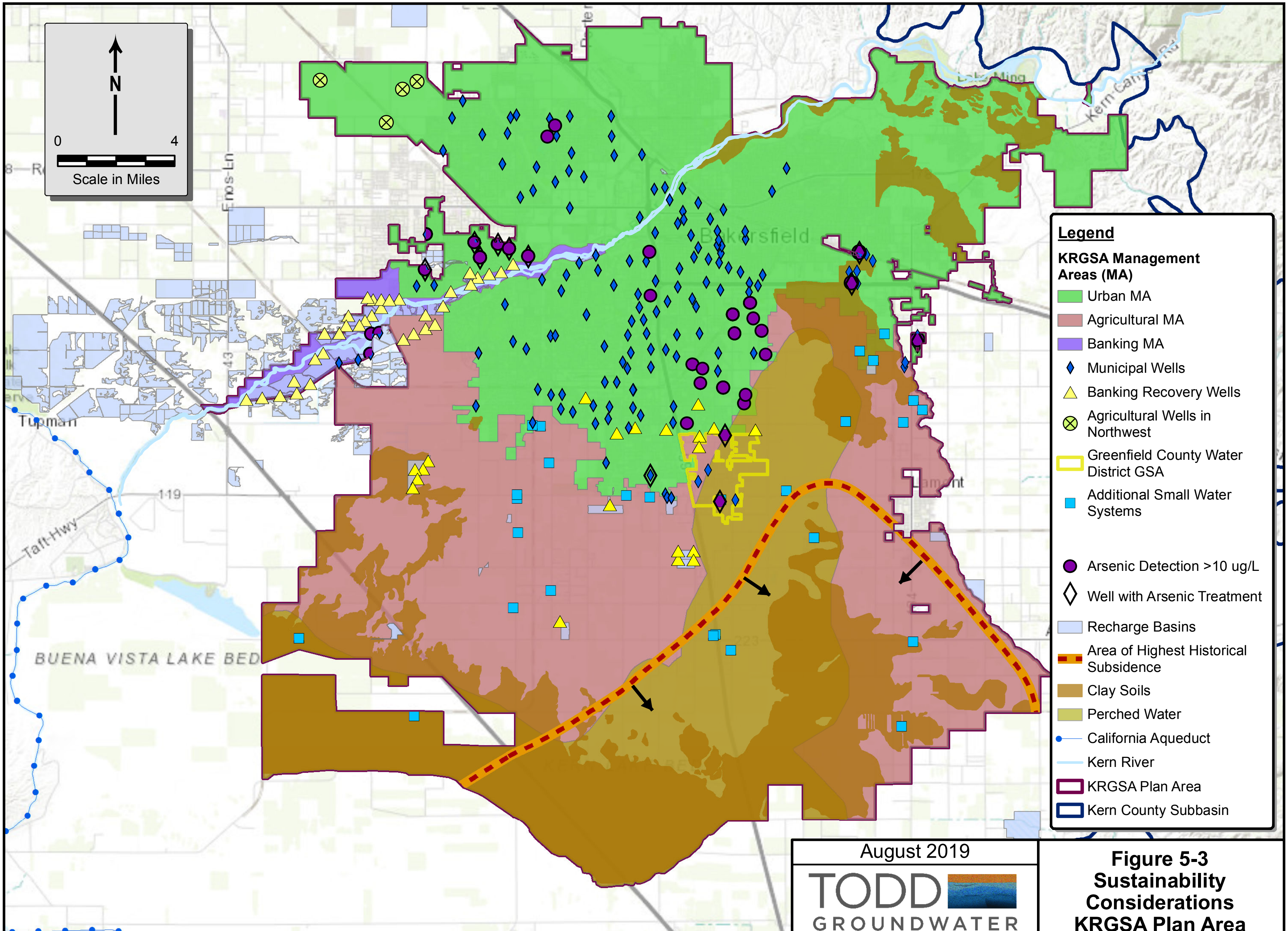


Figure 5-3
Sustainability Considerations
KRGSA Plan Area

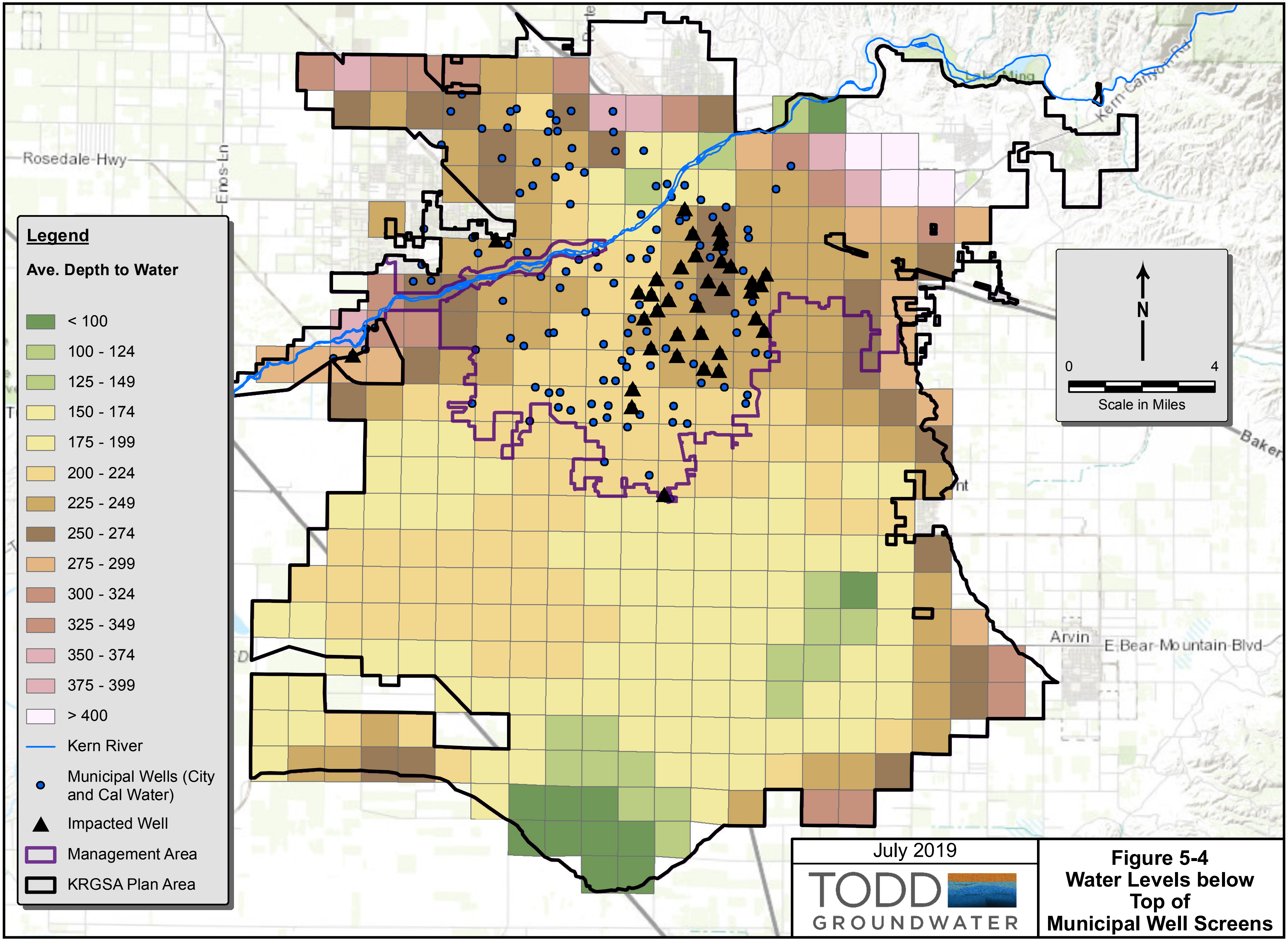
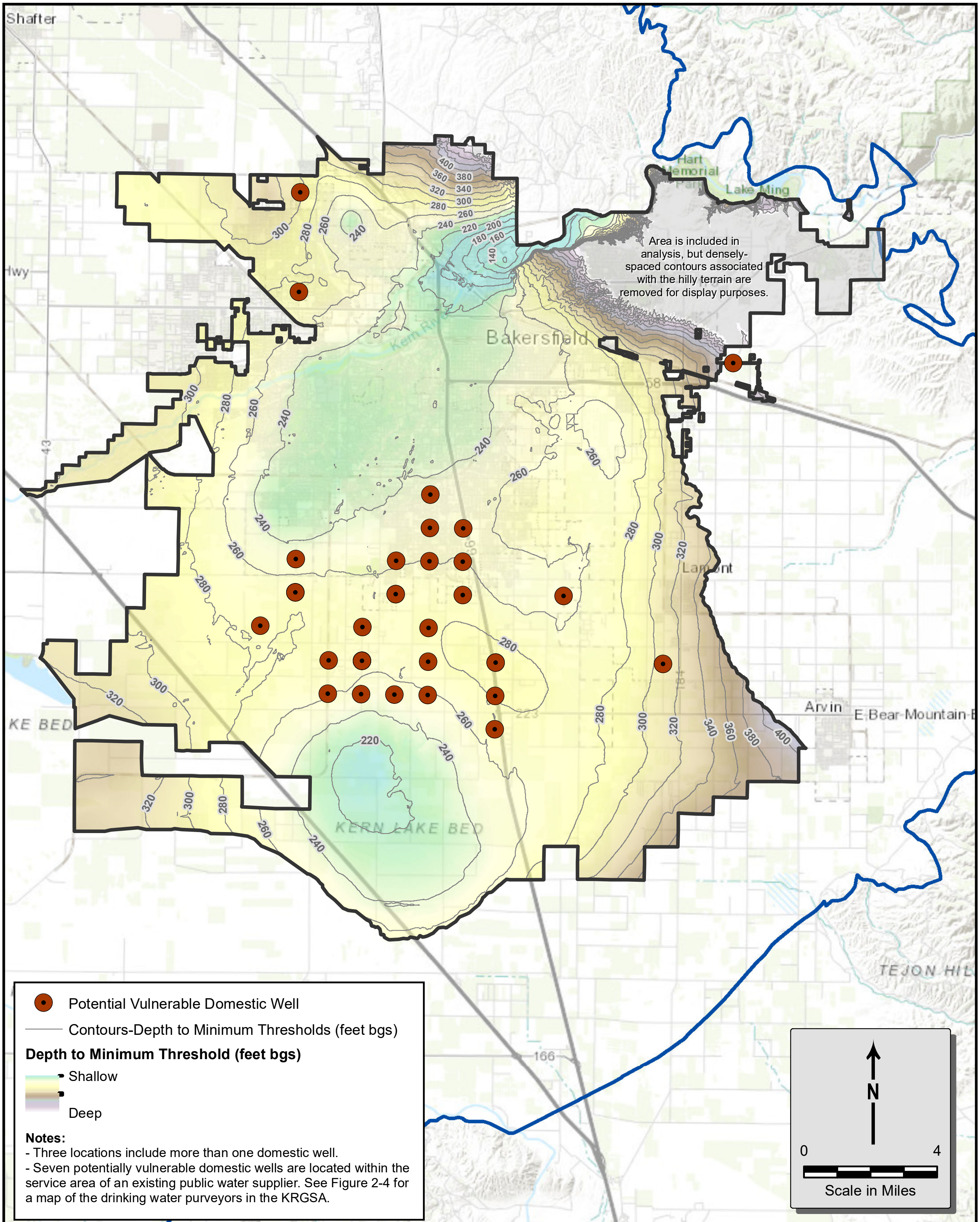


**Figure 5-4
Water Levels below
Top of
Municipal Well Screens**



Notes:

- Three locations include more than one domestic well.
- Seven potentially vulnerable domestic wells are located within the service area of an existing public water supplier. See Figure 2-4 for a map of the drinking water purveyors in the KRGSA.

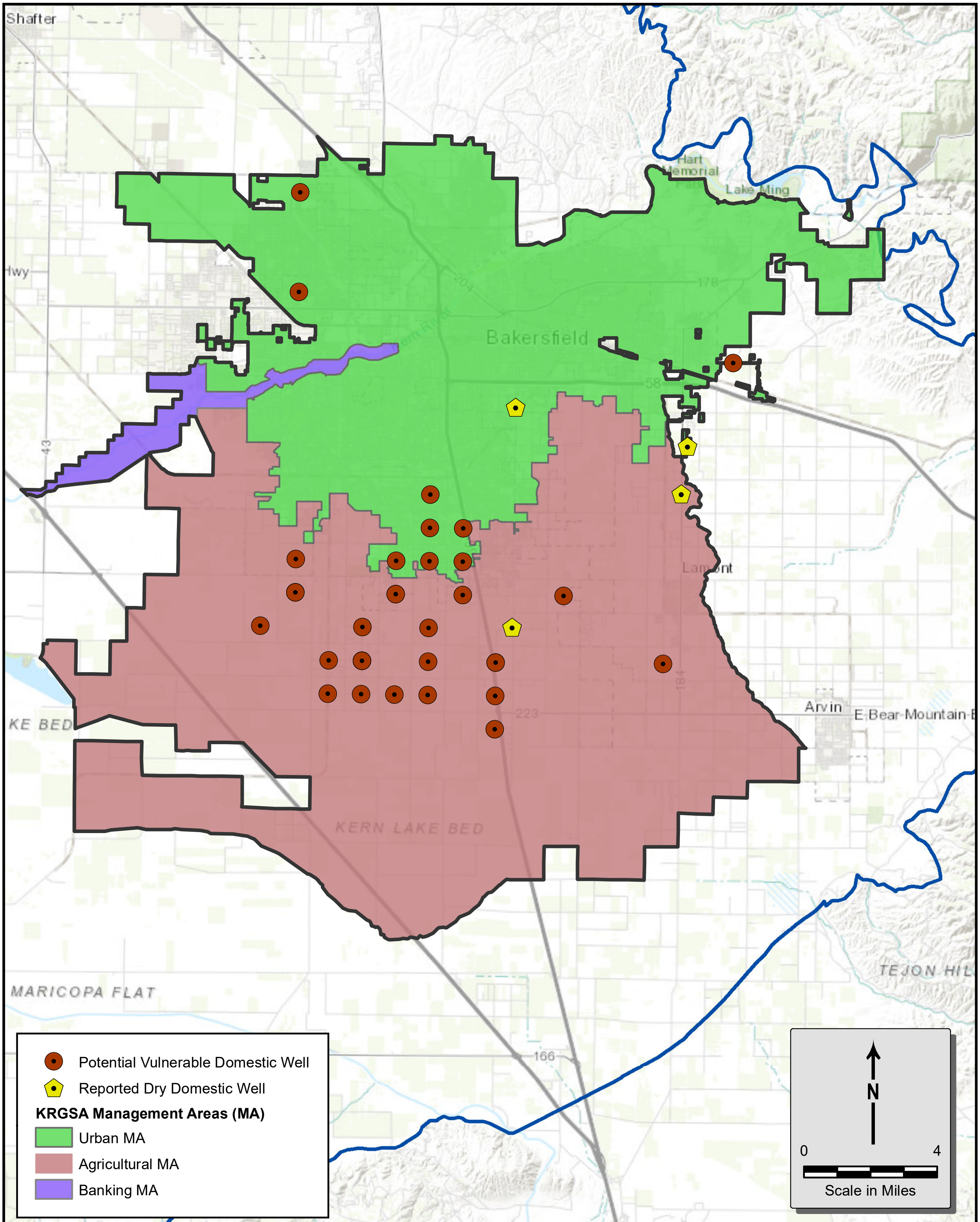
Amended KRGSA GSP Plan Area

Kern County Subbasin

May 2022

TODD GROUNDWATER

Figure 5-5
Domestic Well Impacts Analysis

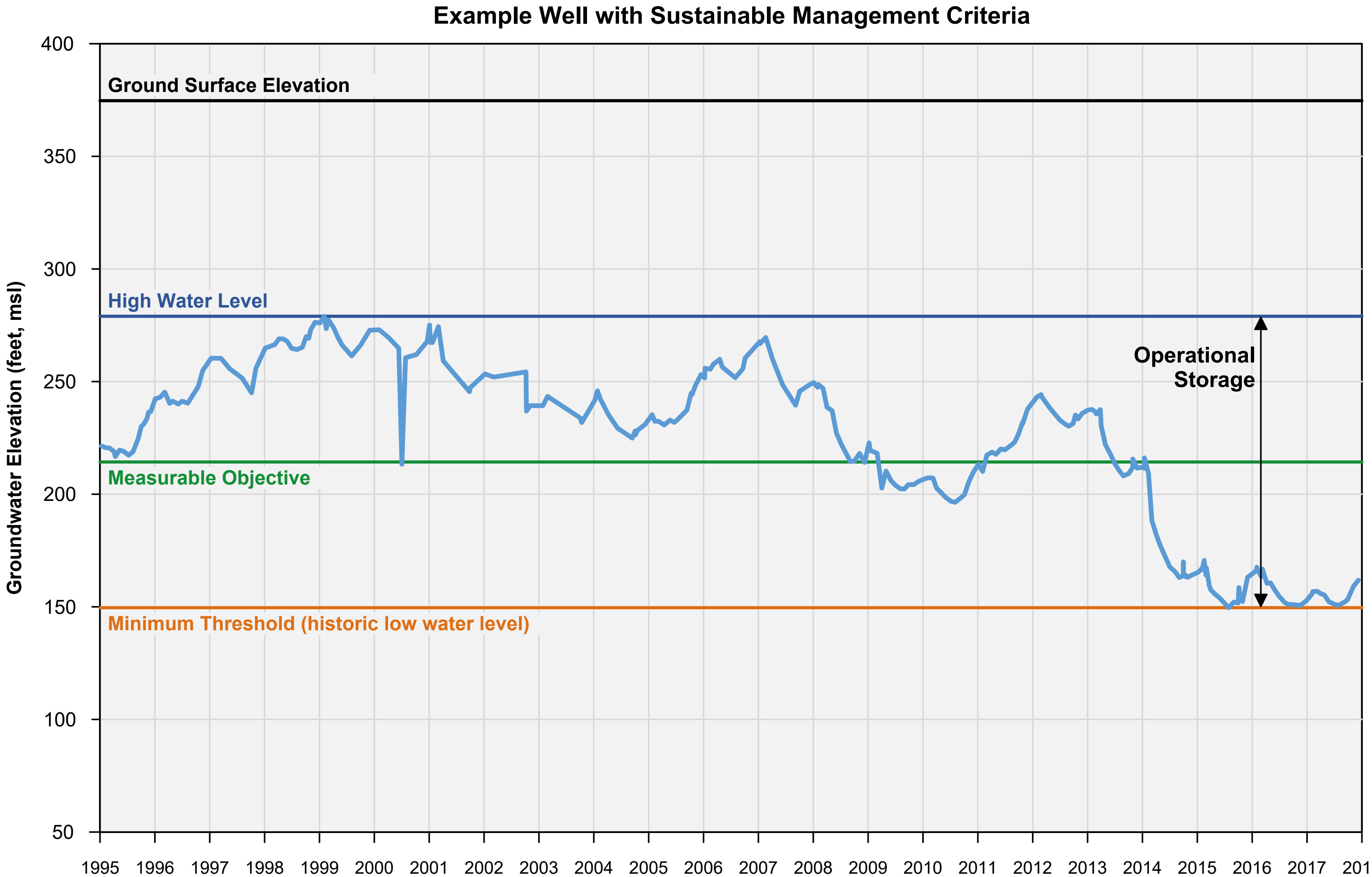


Amended KRGSA GSP Plan Area
Kern County Subbasin

May 2022

TODD GROUNDWATER

Figure 5-6
Dry Domestic Wells and Potential Future Impacts



July 2019

TODD GROUNDWATER

Figure 5-7
Example Sustainable Management Criteria

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6 GSP MONITORING NETWORK

Numerous existing monitoring programs have been developed in the KRGSA Plan Area for a variety of monitoring objectives. This GSP takes advantage of existing monitoring networks to provide a relatively long-term and continuous record of measurements from each monitoring station. In that manner, changes to the groundwater system can be evaluated within the context of historical information to provide a more informed dataset on which to make management decisions. Existing monitoring programs are summarized in **Section 2.5.1**; some components of these efforts are adopted into this GSP as dual-purpose programs to optimize data collection efforts. A brief summary of key programs relevant to the GSP monitoring network is provided herein for context.

Monitoring networks were established to address each of the sustainability indicators relevant to the KRGSA Plan Area. As described in **Section 5**, water levels serve as a reasonable proxy for each of the indicators being evaluated. Water level monitoring is supplemented with other methods where needed; for example, land subsidence monitoring incorporates a coordinated Subbasin-wide monitoring program and includes tracking of InSAR data (being published periodically by DWR) in more susceptible areas of the KRGSA Plan Area.

The preliminary GSP monitoring network for the KRGSA Plan Area is shown on **Figure 6-1**. This map contains 39 representative monitoring wells (RMWs) across the Plan Area, including 38 KRGSA wells and 1 Greenfield CWD well. This initial GSP monitoring network will be improved over time to comply with GSP regulations on data and standards (§352.4). Many wells in the current program are production wells and will require shutting off pumps for an adequate time to measure representative monitoring levels. In addition, detailed construction data are not available for about one-half of the wells, although water level records for all wells indicate extractions from the Principal Aquifer. Finally, program wells are available for monitoring currently, but access agreements are not yet in place. Nonetheless, efforts are underway to fill monitoring network deficiencies. Management actions have been developed for network improvements over the first five years of GSP implementation as described in **Section 7.2.8.**

In addition to the monitoring well network improvements, two other management actions provide improvements for monitoring key components of the KRGSA water budget:

- Implement Well Metering Program in the Agricultural MA (see **Section 7.2.3**)
- Implement Groundwater Extraction Reporting Program (see **Section 7.2.3**)

6.1 MONITORING OBJECTIVES

The KRGSA GSP monitoring network is designed to support the KRGSA GSP Sustainability Goal. The primary objectives of the network are to detect indications of undesirable results as defined in **Section 5** and to monitor the effectiveness of Plan implementation as described in **Section 7**. As provided in GSP regulations, the monitoring network, when implemented, shall accomplish the following:

(1) Demonstrate progress toward achieving MOs.
(2) Monitor impacts to the beneficial uses or users of groundwater.
(3) Monitor changes in groundwater conditions relative to MOs and MTs.
(4) Quantify annual changes in water budget components. (§354.34)

These are also considered monitoring objectives of the KRGSA GSP monitoring network; additional objectives are listed below:

- Provide sufficient information to determine if MTs are being exceeded.
- Demonstrate progress toward interim milestones and MOs.
- Provide adequate spatial distribution and appropriate well construction to monitor groundwater conditions in the KRGSA Principal Aquifer.
- Record accurate water levels (within 0.1 feet) to evaluate sustainable management criteria.
- Document performance of GSP projects and management actions.
- Ensure that management actions do not cause undesirable results.

In addition to these attributes, wells must be accessible, functional, and practical, and have reasonable structural integrity for monitoring with typical water level monitoring equipment.

6.2 MONITORING NETWORK

The GSP monitoring network is presented on **Figure 6-1** and includes wells where water level monitoring will be conducted. These spatially-distributed wells represent 39 monitoring locations across the three KRGSA MAs including the Urban MA (17 wells), Agricultural MA (20 wells), and Banking MA (2 wells) as summarized in **Table 6-1**. Wells are identified on **Table 6-1** by both State Well Number – as shown on **Figure 6-1** – and by the Representative Monitoring Well (RMW) No. assigned by the KGA. The RMW No. facilitates identification of the KRGSA wells on the Subbasin-wide GSP monitoring network map in the KGA GSP. The well locations were based on sustainability indicators (see **Figure 5-3**) that are explained throughout **Section 5** (in particular **5.4**, **5.7** and **5.8**) and include the following considerations:

- Municipal wells requiring maintenance of water levels for efficient well operations and water quality compliance.
- Agricultural areas requiring flexibility to draw down water levels during the irrigation season.
- Banking areas, which need operational flexibility to recover relatively large quantities of groundwater during drought to provide a critical water supply when other sources are limited.
- Areas of potential land subsidence, primarily located in the southeastern Agricultural MA, where historical and recent subsidence has been indicated.
- Transition areas between MAs and along the boundaries of the KRGSA to avoid unreasonable hydraulic gradients.

As explained in **Section 5**, undesirable results for each of the sustainability indicators are evaluated by MTs set at various water levels, generally based around adjustments to the historic low water level in 2015-2016. The sustainability indicator requiring the shallow-most MT will control the allowable water level at each well. This simplifies the monitoring program yet allows for evaluation of all sustainability indicators to occur. The MT, MO, and controlling sustainability indicator for the GSP monitoring network wells are summarized in **Table 6-1**. The MT and MO for each well are shown spatially on **Figures 6-2** and **6-3,** respectively.

Table 6-1: KRGSA GSP Monitoring Well Network with Sustainable Management Criteria

GSP RMW State Well Number	RMW No.	Management Area	Other Monitoring Program	Historic High Water Level (ft, msl)	Historic Low Water Level (ft, msl)	Adjustment to Historic Low for MT (ft, msl)	Minimum Threshold (ft, msl)	Measurable Objective (ft, msl)	Controlling Sustainability Indicator
29S/26E-01K01	RMW-018	Urban	DWR/KCWA	212	66	-20	46	129	Water Levels
29S/26E-09H01	RMW-017	Urban	DWR/KCWA	193	87	-20	67	130	Water Levels
29S/26E-26K01	RMW-022	Urban	DWR/KCWA	296	141	0	141	219	Water Quality
29S/27E-08H53	RMW-019	Urban	KFMC/CASGEM	287	205	-20	185	236	Water Levels
29S/27E-09H	RMW-209	Urban	CWS Water Levels	261	158	0	158	210	Water Levels and Quality
29S/27E-20F01	RMW-201	Urban	City DDW	214	112	0	112	163	Water Levels and Quality
29S/28E-18K01	RMW-020	Urban	CASGEM	361	322	-20	302	332	Water Levels
29S/28E-19J02	RMW-021	Urban	CWS Water Levels	254	169	0	169	212	Water Levels and Quality
29S/28E-21G	RMW-210	Urban	CWS Water Levels	282	192	0	192	237	Water Levels and Quality
29S/28E/31B	RMW-211	Urban	CWS Water Levels	255	168	0	168	212	Water Levels and Quality
29S/28E/35H	RMW-212	Urban	ENCSD Wtr Levels	188	165	-50	115	152	Water Levels
30S/26E-03B01	RMW-028	Banking	KFMC	302	53	0	53	178	Water Levels and Quality
30S/26E-16B02	RMW-029	Banking	City Piezometers	317	39	0	39	178	Water Levels and Quality
30S/26E-22P03	RMW-031	Agricultural	KFMC	279	111	-50	61	170	Water Levels
30S/26E-25A02	RMW-032	Urban	KFMC	236	128	0	128	182	Water Levels and Quality
30S/27E/02D	RMW-213	Urban	CWS Water Levels	238	152	0	152	195	Water Levels and Quality
30S/27E-05D01	RMW-025	Urban/Banking	KFMC/CASGEM	279	150	0	150	215	Water Levels and Quality
30S/27E/12J	RMW-214	Urban	CWS Water Levels	239	147	0	147	193	Water Levels and Quality
30S/28E-03D01	RMW-026	Urban	CASGEM	194	119	0	119	157	Water Levels and Quality
30S/28E/08E	RMW-215	Urban	CWS Water Levels	192	132	0	132	162	Water Levels and Quality
30S/28E-11F01	RMW-030	Agricultural	KDWD Monthly	181	125	0	125	153	Water Levels and Quality
30S/28E-29B02	RMW-216	Agricultural	KDWD Monthly	213	84	0	84	149	Water Levels and Quality
30S/28E-35L01	RMW-034	Agricultural	KDWD Monthly	234	86	0	86	160	Water Levels and Quality
30S/29E-31C	RMW-217	Agricultural	CASGEM	183	76	0	76	130	Water Levels and Quality
31S/26E-03J01	RMW-035	Agricultural	KDWD Monthly	235	82	-50	32	134	Water Levels
31S/26E-16P01	RMW-037	Agricultural	KDWD Monthly	202	59	-50	9	106	Water Levels
31S/26E-32B	RMW-042	Agricultural	KDWD Monthly	191	5	-50	-45	73	Water Levels
31S/27E-07B	RMW-195	Agricultural	CASGEM	197	104	-50	54	126	Water Levels
31S/27E-12Q	RMW-196	Agricultural	CASGEM/ILRP	233	97	-50	47	140	Water Levels
31S/27E-19D01	RMW-038	Agricultural	KCWA/DWR	200	97	-50	47	124	Water Levels
31S/27E-25D01	RMW-040	Agricultural	KCWA/DWR	241	114	-50	64	153	Water Levels
31S/27E-33K	RMW-218	Agricultural	KDWD StToll	218	151	-50	101	160	Water Levels
31S/28E-05D2	RMW-202	Agricultural	Greenfield CWD	181	103	0	103	142	Water Levels and Quality
31S/28E-14D	RMW-219	Agricultural	KDWD Monthly	176	104	-20	84	130	Subsidence
31S/28E-20D	RMW-192	Agricultural	CASGEM	264	79	-50	29	147	Water Levels
31S/29E-28C	RMW-193	Agricultural	CASGEM	185	55	-50	5	95	Water Levels
31S/29E-30J01	RMW-041	Agricultural	DWR/KCWA	213	60	-20	40	127	Subsidence
32S/27E-07N	RMW-200	Agricultural	KDWD Monthly	170	58	-20	38	104	Subsidence
32S/28E-01P	RMW-197	Agricultural	KDWD Monthly	161	26	-20	6	84	Subsidence

KFMC - Kern Fan Monitoring Committee, CASGEM - California Statewide Groundwater Elevation Monitoring, City DDW - Division of Drinking Water water quality monitoring, KCWA/ID4 - Various KCWA and ID4 monitoring prgrams for evlauation of local groundwater conditions, KCWA/DWR - wells included in the Water Data Library and KCWA databases, Inactive CWS - Cal Water Inactive municipal well; Inactive ENCSD - ENCSD inactive municipal well; KDWD Monthly - depth to water measurements for water level maintenance in its service area, KDWD StToll - water level monitoring for calculation of assessments.

As discussed in **Sections 5.3** through **5.8**, the MO is a representative midpoint of the estimated operational range for each well (average of the historic water level high during the study period and the MT). Assuming the KRGSA is relatively close to a sustainable water budget (discussed in **Section 4.5.4**), this operational range is reasonable for future management. The MO for each monitoring well is provided on **Figure 6-3**. Also as explained in **Section 5**, the MT is adjusted downward in some areas for more flexible operation and to provide a buffer for another multi-year drought during the implementation period before all additional water supply projects are fully online.

As discussed in **Section 5-10** and illustrated by an example in **Figure 5-7**, hydrographs for the GSP monitoring wells have been used to determine the MT and MO. This analysis follows the approach to these criteria described in **Section 5.3** and the analyses of sustainability indicators (**Sections 5.4**, **5.5**, **5.7**, and **5.8**). The hydrographs are provided in **Appendix J**.

As indicated on **Figure 6-1**, portions of the southern and northeastern Urban MA and the southern Agricultural MA could benefit from additional monitoring sites. As indicated by a Phase One management action (**Section 7.2.8**), improvements to the KRGSA GSP monitoring program will be developed over time. The entire program will be re-evaluated in the first Five-Year Report. The basis for the monitoring program, its ability to monitor each sustainability indicator, and additional monitoring networks are described below.

6.2.1 Site Selection and Representative Wells

Because of the primary reliance on water level monitoring, the GSP network was based first on availability of recent/current monitoring data. These data made it possible to determine the representativeness of the well and to conduct a qualitative evaluation of the water level data. Wells that were already being monitored as part of an ongoing monitoring program are prioritized based on the sustainability considerations discussed above and well records. **Table 6-1** identifies the GSP monitoring wells by monitoring program as described below.

6.2.1.1 Kern Fan Monitoring Committee (KFMC) Program Wells

Wells included in the current Kern Fan Monitoring Committee (KFMC) program were identified as a first priority for inclusion in the KRGSA GSP monitoring network. Wells in this program selected for the GSP monitoring network are shown in **Table 6-1**.

These wells are located over a broad area of the Urban MA, the Banking MA, and the western Agricultural MA and provide maximum benefits for GSP monitoring. First, the purpose of these wells is to monitor groundwater conditions on the Kern Fan both adjacent to and surrounding the multiple groundwater banking projects, a purpose also applicable to this GSP monitoring network. For example, one KFMC monitoring well (30S/27E-05D01) installed on the California State University Bakersfield campus, is important for monitoring local banking activities on the Kern River and the aquifer response in local municipal wells in the KRGSA Plan Area. Second, the program has been developed based on agency agreements including a KFMC MOU executed in the mid-1990s; accordingly, these wells have been part of a coordinated and widely-used monitoring program for more than 20 years.

Importantly, these wells have been determined by the KFMC to be representative of groundwater conditions in the region and have been successful at tracking the aquifer response to groundwater recharge and recovery along the Kern River channel and in the Banking MA. Finally, water levels from this monitoring program are used by KCWA and others to develop water level contour maps, water quality information, and hydrographs that allow tracking of water level trends and fluctuations over time. This use demonstrates the ability of these wells to adequately represent groundwater conditions in the Urban MA and western Agricultural MA.

These KFMC wells provide the following attributes to the GSP monitoring network:

- Long established records of high-quality data.
- Data from numerous multi-depth monitoring wells for vertical gradients.
- Vetted by numerous agencies over time.
- High frequency of monitoring; many wells have monthly records.
- Publicly-available data for transparency and wide-spread use.
- Higher likelihood of obtaining access for GSP monitoring.

6.2.1.2 KCWA/ID4 Monitoring Program

In addition to the KFMC program, KCWA/ID4 conducts monitoring in numerous wells and piezometers throughout the ID4 service area to evaluate a variety of local groundwater conditions throughout the Urban MA. In particular, ID4 has drilled and monitored a well adjacent to the Calloway Pool (29S/28E-18K01 – also part of the KFMC) that provides a monthly record of water levels adjacent to the Kern River near one of the primary diversion points on the River. This well, along with others, is also included in the DWR CASGEM program, described below. KCWA/ID4 ownership of key wells in this program facilitate long-term access for the KRGSA GSP monitoring network.

The program also includes compilation of data from additional wells in the Urban MA that are monitored by others. Municipal wells included in this program are being prioritized for inclusion in the GSP monitoring network because of the relatively long-term data record for these wells. In general, wells in this program have the same attributes as the KFMC wells. Inclusion of some private wells will require additional communication to develop access agreements.

6.2.1.3 Inactive Municipal Wells and Nearby Monitoring Wells

As mentioned in the above paragraphs, municipal well owners in the KRGSA are cooperating in the monitoring program by allowing the GSP monitoring network to include inactive municipal wells or other monitoring wells in the Urban MA.

For example, the City has identified both an inactive production well and multi-depth piezometers for inclusion in the program. These wells, 29S/27E-20F01and 30S/26E-16B01/B02, are strategically located in the middle of the City wellfield in the Urban MA and adjacent to the municipal wells in the Banking MA, respectively. Cal Water is allowing six inactive municipal wells to be incorporated into the Urban MA GSP monitoring network (abbreviated *CWS Water Levels* in **Table 6-1**). KRGSA member agency ENCSD has also identified an inactive well (29S/28E/35H) for GSP water level monitoring in the eastern portion of the Urban MA (**Table 6-1 and Figure 6-1**).

Greenfield CWD has dedicated one of its inactive municipal wells to GSP monitoring in the Agricultural MA (adjacent to the Urban MA). As documented in its MOU with the KRGSA (**Appendix C**), Greenfield CWD is responsible for independent implementation of the GSP in its service area and will conduct its own water level monitoring program; data will be provided to the KRGSA Plan Managers for annual reporting. The Greenfield CWD well has been reviewed for the capability to monitor for sustainable management criteria, and monitoring protocols included in this document are also applicable to the Greenfield CWD well (31S/28E-5D2 on **Figure 6-1** and in **Table 6-1**).

6.2.1.4 CASGEM Program – KCWA/ID4 and KDWD

Since its inception, two KRGSA member agencies, ID4 and KDWD, have participated in the State CASGEM program for monitoring of water levels in the KRGSA. Incorporation of these wells into the GSP monitoring program provides many of the same attributes as wells from other monitoring programs including existing approved protocols, relatively long water level records, ability to access the well for reporting purposes, and the use of publicly-available data. CASGEM wells included in the GSP monitoring networks are identified in **Table 6-1**.

6.2.1.5 KDWD Monitoring Programs

KDWD monitors local agricultural and district-owned wells for a variety of objectives including tracking depth to water for water level maintenance, calculation of assessments on SWP water supplies, CASGEM compliance, and provision of data for KCWA or DWR monitoring programs. Most of the wells currently included in the GSP monitoring network in KDWD are included in one of these programs with CASGEM and KCWA monitoring programs identified as priorities. Except for KDWD-owned wells, all of the wells in the monitoring network are privately-owned with limited construction data and less-complete water level records compared to other wells. Nonetheless, they provide spatial distribution and the ability to increase monitoring in areas of potential land subsidence. Improvements to the monitoring network are identified for these wells (see **Section 7.2.8**).

6.2.2 Monitoring Frequency

At a minimum, water levels will be measured in all wells on a semi-annual basis in Spring and Fall to capture seasonal high and low levels. This program will allow for the generation of water table/potentiometric surface maps of the Principal Aquifer on an annual basis. In general, the semi-annual water level measurements are also useful for examining the drawdown from irrigation pumping and the ability of the aquifer to recover each Spring. Due to the large number of wells requiring coordination in the Subbasin, the KGA has suggested coordinated time frames for water level measurements as follows:

- January 15th to March 30th
- September 15th to November 15th.

Although a semi-annual program is appropriate for the Agricultural MA, monthly water level measurements will be needed for some wells in the Urban MA to detect potential undesirable results sufficiently early to manage the wellfield accordingly. **Table 6-2** documents the monitoring frequency for tracking the sustainable management criteria.

Table 6-2: Monitoring Frequency of Wells in the KRGSA GSP Network

GSP RMW State Well Number	RMW No.	Controlling Sustainability Indicator	Monitoring Frequency
29S/26E-01K01	RMW-018	Water Levels	Semi-annually
29S/26E-09H01	RMW-017	Water Levels	Semi-annually
29S/26E-26K01	RMW-022	Water Quality	Monthly
29S/27E-08H53	RMW-019	Water Levels	Semi-annually
29S/27E-09H	RMW-209	Water Levels and Quality	Monthly
29S/27E-20F01	RMW-201	Water Levels and Quality	Monthly
29S/28E-18K01	RMW-020	Water Levels	Semi-annually
29S/28E-19J02	RMW-021	Water Levels and Quality	Monthly
29S/28E-21G	RMW-210	Water Levels and Quality	Monthly
29S/28E/31B	RMW-211	Water Levels and Quality	Monthly
29S/28E/35H	RMW-212	Water Levels	Semi-annually
30S/26E-03B01	RMW-028	Water Levels and Quality	Monthly
30S/26E-16B02	RMW-029	Water Levels and Quality	Monthly
30S/26E-22P03	RMW-031	Water Levels	Semi-annually
30S/26E-25A02	RMW-032	Water Levels and Quality	Monthly
30S/27E/02D	RMW-213	Water Levels and Quality	Monthly
30S/27E-05D01	RMW-025	Water Levels and Quality	Monthly
30S/27E/12J	RMW-214	Water Levels and Quality	Monthly
30S/28E-03D01	RMW-026	Water Levels and Quality	Monthly
30S/28E/08E	RMW-215	Water Levels and Quality	Monthly
30S/28E-11F01	RMW-030	Water Levels and Quality	Monthly
30S/28E-29B02	RMW-216	Water Levels and Quality	Monthly
30S/28E-35L01	RMW-034	Water Levels and Quality	Monthly
30S/29E-31C	RMW-217	Water Levels and Quality	Monthly
31S/26E-03J01	RMW-035	Water Levels	Semi-annually
31S/26E-16P01	RMW-037	Water Levels	Semi-annually
31S/26E-32B	RMW-042	Water Levels	Semi-annually
31S/27E-07B	RMW-195	Water Levels	Semi-annually
31S/27E-12Q	RMW-196	Water Levels	Semi-annually
31S/27E-19D01	RMW-038	Water Levels	Semi-annually
31S/27E-25D01	RMW-040	Water Levels	Semi-annually
31S/27E-33K	RMW-218	Water Levels	Semi-annually
31S/28E-05D2	RMW-202	Water Levels and Quality	Monthly
31S/28E-14D	RMW-219	Subsidence	Semi-annually
31S/28E-20D	RMW-192	Water Levels	Semi-annually
31S/29E-28C	RMW-193	Water Levels	Semi-annually
31S/29E-30J01	RMW-041	Subsidence	Semi-annually
32S/27E-07N	RMW-200	Subsidence	Semi-annually
32S/28E-01P	RMW-197	Subsidence	Semi-annually

In addition, the DWR's BMPs on groundwater monitoring protocols note that GSAs should obtain and document a long-term access agreement that allows access on a year-round basis for increased monitoring frequency, as needed. Access agreements will be developed in the first five years of GSP implementation as described in **Section 7.2.8**.

6.2.3 Well Construction Data

Well construction data are shown for the GSP monitoring network wells, as available. Well records are being researched for missing data. In the future, other wells may be considered for inclusion in the program or as a substitute for wells with missing information. A management action to fill key data gaps in the monitoring well network is included in **Section 7.2.8**.

Table 6-3: GSP Monitoring Network Construction Data

GSP RMW State Well Number	RMW No.	Ground Surface Elevation (ft, msl)	Well Depth (ft, bgs)	Top of Perforated Interval (ft, bgs)	Bottom of Perforated Interval (ft, bgs)	Well Use
29S/26E-01K01	RMW-018	383.73	950	420	950	Irrigation
29S/26E-09H01	RMW-017	344	700	300	700	Irrigation
29S/26E-26K01	RMW-022	365	500	200	500	Domestic
29S/27E-08H53	RMW-019	404.5	300	N/A	N/A	Domestic
29S/27E-09H	RMW-209	428	600	N/A	N/A	Inactive
29S/27E-20F01	RMW-201	393	710	375	675	Inactive
29S/28E-18K01	RMW-020	421.9	540	220	540	Monitoring
29S/28E-19J02	RMW-021	409	600	N/A	N/A	Inactive
29S/28E-21G	RMW-210	552	612	N/A	N/A	Inactive
29S/28E/31B	RMW-211	402	600	N/A	N/A	Inactive
29S/28E/35H02	RMW-212	423	1250	600	N/A	Inactive
30S/26E-03B01	RMW-028	351	700	250	700	Monitoring
30S/26E-16B02	RMW-029	346	390	300	390	Monitoring
30S/26E-22P03	RMW-031	338.5	794	330	120	Monitoring
30S/26E-25A02	RMW-032	348	690	290-390	590-690	Monitoring
30S/27E/02D	RMW-213	388	600	N/A	N/A	Inactive
30S/27E-05D01	RMW-025	374.7	516	85	504	Monitoring
30S/27E/12J	RMW-214	381	600	N/A	N/A	Inactive
30S/28E-03D01	RMW-026	381	804	300	805	Irrigation
30S/28E/08E	RMW-215	383	730	N/A	N/A	Inactive
30S/28E-11F01	RMW-030	387	600	306	600	Inactive
30S/28E-29B02	RMW-216	362	720	300	710	Recovery/inactive
30S/28E-35L01	RMW-034	367	N/A	N/A	N/A	Inactive
30S/29E-31C	RMW-217	400	N/A	N/A	N/A	Production
31S/26E-03J01	RMW-035	327.14	N/A	N/A	N/A	Irrigation
31S/26E-16P01	RMW-037	302	700	250	700	Irrigation
31S/26E-32B	RMW-042	290	N/A	N/A	N/A	Irrigation
31S/27E-07B	RMW-195	330	630	156	630	Irrigation
31S/27E-12Q	RMW-196	330	710	200	697	Irrigation
31S/27E-19D01	RMW-038	316.85	N/A	N/A	N/A	Irrigation
31S/27E-25D01	RMW-040	314	N/A	N/A	N/A	Irrigation
31S/27E-33K	RMW-218	303	N/A	N/A	N/A	Irrigation
31S/28E-05D2	RMW-202	348	420	180	420	Inactive
31S/28E-14D	RMW-219	360	N/A	N/A	N/A	Irrigation
31S/28E-20D	RMW-192	322.38	200	100	200	Irrigation
31S/29E-28C	RMW-193	406.43	630	350	630	Irrigation
31S/29E-30J01	RMW-041	376.00	N/A	N/A	N/A	Inactive
32S/27E-07N	RMW-200	292.52	N/A	N/A	N/A	Irrigation
32S/28E-01P	RMW-197	343.62	N/A	N/A	N/A	Irrigation

6.2.4 Groundwater Level Monitoring Protocols

In the KRGSA, groundwater levels are currently monitored by municipal well owners including Cal Water (for the City of Bakersfield), KCWA/ID4, Greenfield CWD, ENCSD, KDWD, and others. These agencies employ a variety of methods and equipment for water level monitoring including electric sounders, acoustic sounders, and transducers. Cal Water and KCWA/ID4 generally follow procedures developed by USGS (Cunningham and Schalk, 2011), as reproduced in **Appendix I**.

The KRGSA has coordinated with other GSAs for establishment of Subbasin-wide water level monitoring protocols. These Subbasin protocols are reproduced below and are adopted for this GSP to the extent applicable to each GSP monitoring network well.

- Groundwater level data shall be sufficient to produce seasonal maps of potentiometric surfaces or water table surfaces throughout the basin that clearly identify changes in groundwater flow direction and gradient.
- Use the Well Data form provided (example form provided in KGA Umbrella document).
- Groundwater level data shall be collected from each principal aquifer in the basin.
- Collection of data between the approved time frames only:
- January 15th to March 30th
- September 15th to November 15th
- If attempts have been made and a measurement cannot be collected from a representative monitoring well during the approved timeframe, one of the following is to occur:
    - A measurement from a nearby well with similar water level trends can be used as a proxy.
    - If no substitute well is available, the static water level can be estimated based on trending for Spring and Fall levels from the previous four or more bi-annual measurements; estimates are used for purposes of comparing to the established thresholds for each Management Area only.
    - If the water level is estimated, the entry must be flagged with a DWR No Measurement Code using the DWR pull-down menu options and described in the Water Level Measurements Comments field as "Estimated groundwater level based on trending for Spring or Fall levels from the previous four or more bi-annual measurements."

- If an existing representative monitoring well cannot be measured during two bi-annual timeframes, a plan to replace or repair the well in the monitoring network shall be made prior to the subsequent monitoring period or annual report, whichever occurs first.
- A weighted water level meter or other CASGEM approved measuring device will be used to measure the depth to groundwater.
- Depth to groundwater must be measured relative to an established Reference Point on the well casing. If no mark or reference point is apparent, the person performing the

measurement should measure the depth to groundwater from the north side of the top of the well casing.

- The elevation of the Reference Point of the well must be referenced to the North American Vertical Datum of 1988. The accuracy of the reference point should be consistent with CASGEM established guidelines.
- Each well's Reference Point will be cataloged to ensure identical procedures are followed for subsequent measurements.
- The data collector should remove the appropriate cap, lid or plug that covers the monitoring access point listening for pressure release. If a release is observed, the measurement should follow a period of time to allow the water level to equilibrate.
- Depth to groundwater must be measured to the accuracy associated with the approved monitoring method or device.
- The water level meter shall be decontaminated after measuring each well.
- The data collector shall calculate the groundwater elevation as:
- GWE = RPE – DTW
- GWE = Groundwater Elevation
- RPE = Reference Point Elevation
- DTW = Depth to Water.
- The data collector must ensure that all measurements are consistent units of feet, tenths of feet or hundredths of feet. Measurements and Reference Point Elevations should not be recorded in feet and inches.

The KRGSA will continue to work with the KGA and other GSAs in the Subbasin to revise data collection protocols for a coordinated monitoring network, as needed. Monitoring protocols shall be reviewed at least every five years as part of the Five-Year Plan Update evaluation.

6.2.5 Groundwater Quality Monitoring

Given that water level monitoring is providing a proxy for the groundwater quality sustainability indicator, no new groundwater quality monitoring is being proposed for the GSP monitoring network at this time. Rather, the KRGSA GSP intends to compile and incorporate water quality sampling data from others to take advantage of multiple ongoing, regulated groundwater quality monitoring programs. For example, the KRGSA contains more than 200 municipal and small water system wells that are sampled periodically for compliance with drinking water quality regulations. These data are concentrated in the Urban MA where undesirable results with respect to degraded water quality have occurred, but also provide significant data in the Agricultural MA. Ongoing water quality sampling also occurs in the Banking MA as part of the Kern Fan Monitoring Committee programs and other regulations.

Data will be used for ongoing tracking and characterization of groundwater quality in the KRGSA. No MTs or MOs are being applied to the characterization. However, if the characterization warrants consideration regarding the future potential for degraded water quality resulting from management actions, additional MTs and MOs may be assigned.

The current water quality monitoring programs are conducted with approved protocols and QA/QC measures and involve wells determined to be representative monitoring sites to meet the water quality objectives associated with each program. As such, these programs collectively represent the best data available for analyzing water quality conditions across the KRGSA Plan Area. The primary water quality monitoring programs in the KRGSA, summarized briefly below, provide access to sufficient, high-quality data for ongoing assessments of changes in groundwater quality.

6.2.5.1 Municipal Well Title 22 Compliance Monitoring

In compliance with SWRCB drinking water programs, municipal wells and small water systems are routinely monitored for a wide variety of water quality constituents in accordance with permits for provision of drinking water. For example, in 2018 about 120 wells were part of the groundwater quality sampling program in the large municipal wellfield of the Urban MA. The City of Bakersfield KRGSA Plan Manager is also the City Water Resources Manager with access to all sampling and analyses associated with the municipal well water quality programs.

Groundwater quality data are also available in the Agricultural MA as part of these drinking water programs. Small water systems and community water systems routinely sample groundwater quality in compliance with the SWRCB drinking water programs. Most of these data sets can be accessed from the online water quality data portal GeoTracker, maintained by the SWRCB.

Selected wells from these drinking water programs will be used to track groundwater quality for GSP evaluations and reporting. During the first five years of implementation, annual data from these programs will be compiled and assessed to select key wells and constituents for targeted future monitoring. A re-assessment of groundwater quality across the KRGSA Plan Area will be presented in the Five-Year Report (2025) and used to prioritize data from these water quality programs for incorporations into the KRGSA GSP monitoring network.

6.2.5.2 Irrigated Lands Regulatory Program (ILRP)

Groundwater quality is also being sampled in compliance with the State Water Board's Long-Term Irrigated Land's Regulatory Program" (ILRP). This program provides for waste discharge requirements from irrigated lands through surface water and groundwater monitoring. Owners or operators of irrigated lands may comply with the program either as individuals or through coalition groups. In the KRGSA area, the Kern River Watershed Coalition Authority was formed to combine resources in order to monitor, review, analyze, and reduce the cost of compliance in the Kern River sub-watershed.

The latest monitoring plan is detailed in the KRWCA's Groundwater Trend Monitoring Work Plan – Phase II Monitoring Network Addendum 2.0. There are four secondary wells (not yet being monitored) and five supplementary wells (monitored by local public water systems and reported to KRWCA) located in the KRGSA including several wells owned by KDWD. Selected wells in the ILRP monitoring program will be analyzed annually for nitrate concentrations; TDS will be analyzed on a five-year interval. Wells in the KRGSA area began the monitoring program in 2019. In addition, the ILRP provides best-management practices (BMPs) for control of nitrate and TDS including BMPs for fertilizer application to control and manage nitrogen.

As this program is implemented across the KRGSA, KDWD will provide local analyses. Additional sampling results will be downloaded from GeoTracker and incorporated into the ongoing tracking of groundwater conditions.

6.2.5.3 Water Quality Monitoring at Regulated Sites

As described in **Section 3.3.4.6**, numerous sites associated with regulated environmental investigations and clean-up programs have been identified in the KRGSA Plan Area (see **Table 3-4**). Some of these sites are associated with groundwater monitoring that may provide useful information for the GSP implementation. In particular, sites located near municipal wellfields would allow for potential impacts to water supply to be tracked and evaluated. Data from these programs are available on GeoTracker and will be downloaded and reviewed for possible inclusion in the ongoing water quality analysis.

6.2.5.4 SWP Water Quality Monitoring

ID4 conducts Title 22 and constituents of concern analyses of source water, treated water and groundwater wells as part of the monitoring program for the Henry C. Garnett Water Purification Plant. When groundwater provides the influent water supply, samples are analyzed weekly for arsenic, conductivity, and nitrate. Monthly monitoring includes 1,2-dibomomethand (EDB), DBCP, VOCs and gross alpha. Source water data have been summarized in the ID4 Report of Water Conditions (KCWA, 2019).

6.2.5.5 Kern River Water Quality Monitoring

The City of Bakersfield monitors Kern River water quality at various locations along the Carrier and River Canals. Some data are compiled and included in the annual Hydrographic Reports developed for the Kern River. Additional monitoring occurs in compliance with the City and County Stormwater Permit, which includes a monitoring and reporting program approved by the Central Valley Water Board. The objectives of the monitoring are to assess the chemical, physical, and biological impacts of urban runoff on receiving waters, including the Kern River. River water quality is monitored at Rocky Point Weir and the Calloway Headgate (locations on **Figure 2-1**). The City is responsible for this monitoring and will incorporate the data into the GSP analysis of surface water quality.

6.2.6 Inelastic Land Subsidence Monitoring

Although no undesirable results with respect to land subsidence have been identified in the KRGSA, a multi-faceted approach for land subsidence monitoring has been developed for the GSP monitoring network. Water level monitoring described in GSP sections above will provide the initial evaluation of the potential for undesirable results and focus on areas of historical and current land subsidence in the southern and eastern KRGSA Plan Area. Because minimum thresholds associated with water levels and water quality maintain water levels at or above historic low levels, the potential for land subsidence for almost all of the KRGSA Urban MA is mitigated. The KRGSA Banking MA is also mitigated due to minimum thresholds associated with the water quality sustainability indicator.

For the Agricultural MA, historical subsidence has been identified in previous investigations as explained in **Section 3.3.5**. With the potential for undesirable results higher in the southern and eastern Agricultural MA, minimum thresholds have been set at or within 20 feet of historic low water levels. These protective levels are supplemented with selected monitoring from local GPS stations and also using the InSAR data being published by DWR on a web portal. Finally, the land subsidence monitoring program will include participation in the Subbasin-wide monitoring program. This four-pronged approach to land subsidence monitoring is summarized below.

6.2.6.1 Water Level Monitoring for Land Subsidence

Minimum thresholds included on **Figure 6-2** will be evaluated at each of the GSP monitoring network wells controlled by land subsidence on a semi-annual basis (see **Table 6-2**). These data will be supplemented with the three additional subsidence monitoring activities below.

6.2.6.2 GPS Station Monitoring for Land Subsidence

Three GPS control stations, which collect high-precision geodetic data useful for land subsidence monitoring, are in the KRGSA Plan Area as shown by the red dots on **Figure 6-4**. Two of the monitoring points (ARM1 and ARM2), located south of Bakersfield, are part of the California Spatial Reference Center (CSRC) monitoring (SOPAC/CSRC, 2019). The third monitoring site (BFLD), located north of Bakersfield and north the Kern River, is part of the California Real Time Network (CRTN). The CSRC and CRTN operate under the Scripps Orbit and Permanent Array Center (SOPAC). Data are collected at a rate of one sample per second by Southern California Integrated GPS Network (SCIGN) for ARM1 and ARM 2 and by UC Berkeley/Caltrans for BFLD (SOPAC/CSRC, 2019). ARM1 and ARM2 are part of the California Spatial Reference System (CSRS) established July 2, 2017 as the official geodetic datum in California (SOPAC/CSRC, 2019). BFLD is one of 48 continuous Global Navigation Satellite Systems (GNSS) stations operated by SOPAC (SOPAC/CSRC, 2019).

Data from the stations will be downloaded annually each Spring for the GSP Annual Report. Protective water levels are already established for the MTs and no additional MTs are assigned to the GPS data at this time. GPS data will be reviewed in the Five-Year evaluation of the GSP, which will allow for revisions to the land subsidence MTs at that time, if needed.

6.2.6.3 InSar Monitoring for Land Subsidence

To supplement the GPS data described above, the KRGSA will also monitor subsidence through the DWR SGMA web portal, which will publish ongoing InSAR data from NASA/JPL for GSA use. Recent InSAR data available from May 2015 through December 2016 (recent drought) is shown on **Figure 6-4**. (These data are the same data presented on **Figure 3-38** with an adjusted color ramp to highlight local KRGSA data rather than the regional dataset).

It is our understanding that DWR will post these data on a one-mile grid for easy viewing and download. Data will be accessed through the DWR website for each mile-section selected for review. For the preliminary program, the KRGSA has selected 12 square mile sections for semi-annual (Spring and Fall) downloading and comparison to the water level and GPS data. The 12 one-mile sections for monitoring are indicated by an "X" on **Figure 6-4.**

No additional MTs are associated with the InSar data. Rather, these data will be included in Annual Reports and discussed in the Five-Year evaluation of the GSP. Collectively, the subsidence monitoring data will be assessed for additional MT assignments, as needed.

6.2.6.4 Coordinated Subsidence Monitoring in the Subbasin

In response to the DWR Determination Letter (DWR, 2022), the Kern County Subbasin GSAs have coordinated on establishing regional critical infrastructure of Subbasin-wide importance to target future land subsidence monitoring efforts. Specifically, the Subbasin GSAs have identified the California Aqueduct and the Friant-Kern Canal for additional investigation and monitoring. More information on the definitions and selection of regional critical infrastructure is provided in revised Appendix 3 of the First Amended Kern County Subbasin Coordination Agreement and summarized in **Sections 3.3.5.3** and **5.8.2** of this Amended KRGSA GSP.

A Subbasin-coordinated land subsidence monitoring program that prioritized areas of interest along this regional critical infrastructure was developed for the 2020 Kern County Subbasin GSPs but has not been fully implemented. That program will be re-initiated and modified based on existing Subbasin cooperation with agencies responsible for infrastructure operation. Specifically, the Subbasin GSAs are working directly with DWR staff from the California Aqueduct Subsidence Program (CASP) on current monitoring data and upcoming monitoring improvements. In addition, Subbasin GSAs are coordinating monitoring efforts on the Friant Kern Canal with the Friant Water Authority (FWA) through Subbasin GSA member agencies that are also member agencies of the FWA.

Proposed Subbasin monitoring plans for regional critical infrastructure are multi-faceted and make the best use of available data. Monitoring sites include those monitored by CASP, regional InSAR data, and existing local subsidence stations monitored by others (e.g., NOAA and SOPAC). In addition, Subbasin GSAs recently received grant funding for installation of an extensometer to supplement current monitoring programs. Finally, the Subbasin is committed to ongoing investigations for an improved understanding of subsidence mechanisms along the regional critical infrastructure including an upcoming Basin Study that incorporates subsidence modeling.

These monitoring strategies are presented in the First Amended Kern County Subbasin Coordination Agreement, being submitted separately on the SGMA portal. The KRGSA has participated in these Subbasin-coordinated efforts and intends to continue participation in the regional subsidence monitoring program as well as the KRGSA Plan Area subsidence monitoring network as described in **Sections 6.2.6.1** through **6.2.6.3** above.

6.3 Annual Reporting and Five-Year Evaluation

Annual reporting will be coordinated at the Subbasin level but will provide separate analyses on compliance and implementation with the KRGSA GSP. Results for GSP monitoring will be summarized in each annual report with an emphasis on compliance with minimum thresholds for each sustainability indicator. Progress toward maintaining measurable objectives will also be presented. Spring and Fall measurements will be taken to capture the estimated high and the low water level of each water year. For the Kern County Subbasin, these measurements are typically collected in March and October to bracket the irrigation season. The timing of Spring and Fall water level measurements will be coordinated on a Subbasin-wide basis in accordance with the Subbasin monitoring protocols in **Section 6.2.4**. Water level measurements will be used to develop Subbasin-wide water level contour maps for Spring and Fall time periods. The monitoring program will be re-evaluated every five years.

6.4 Quality Assurance/Quality Control Program

Protocols for quality assurance/quality control will be conducted at various levels for the KRGSA GPS monitoring program. Typically, these include written procedures for equipment use, transport, and calibration; full recordation of well details; and accurate water level measurements, verified and checked by field and office personnel.

Field equipment must be properly maintained and calibrated for accurate water level measurements. Any calibration documentation will include the equipment type, make/model, and serial number. Written procedures will be used for each type of equipment used in the water level monitoring program.

KCWA has developed specific protocols for calibration of well sounders used to monitor water levels. Those calibration protocols are adopted for this GSP monitoring network for KCWA-monitored wells. Additional details for QA/QC of the water level monitoring program are provided in **Appendix I**.

6.5 Data Management System

Water levels will be input and maintained in a KRGSA Data Management System (DMS) for ease and use and reference by KRGSA Plan Managers. The Subbasin is exploring options for a Subbasin-wide DMS to allow access and use by all Subbasin GSAs. Accordingly, the separate DMS for the KRGSA data will likely consist of basic electronic formats in common software programs such as Microsoft Excel or Access that provide compatibility and ease of uploading into a Subbasin-wide DMS when developed.

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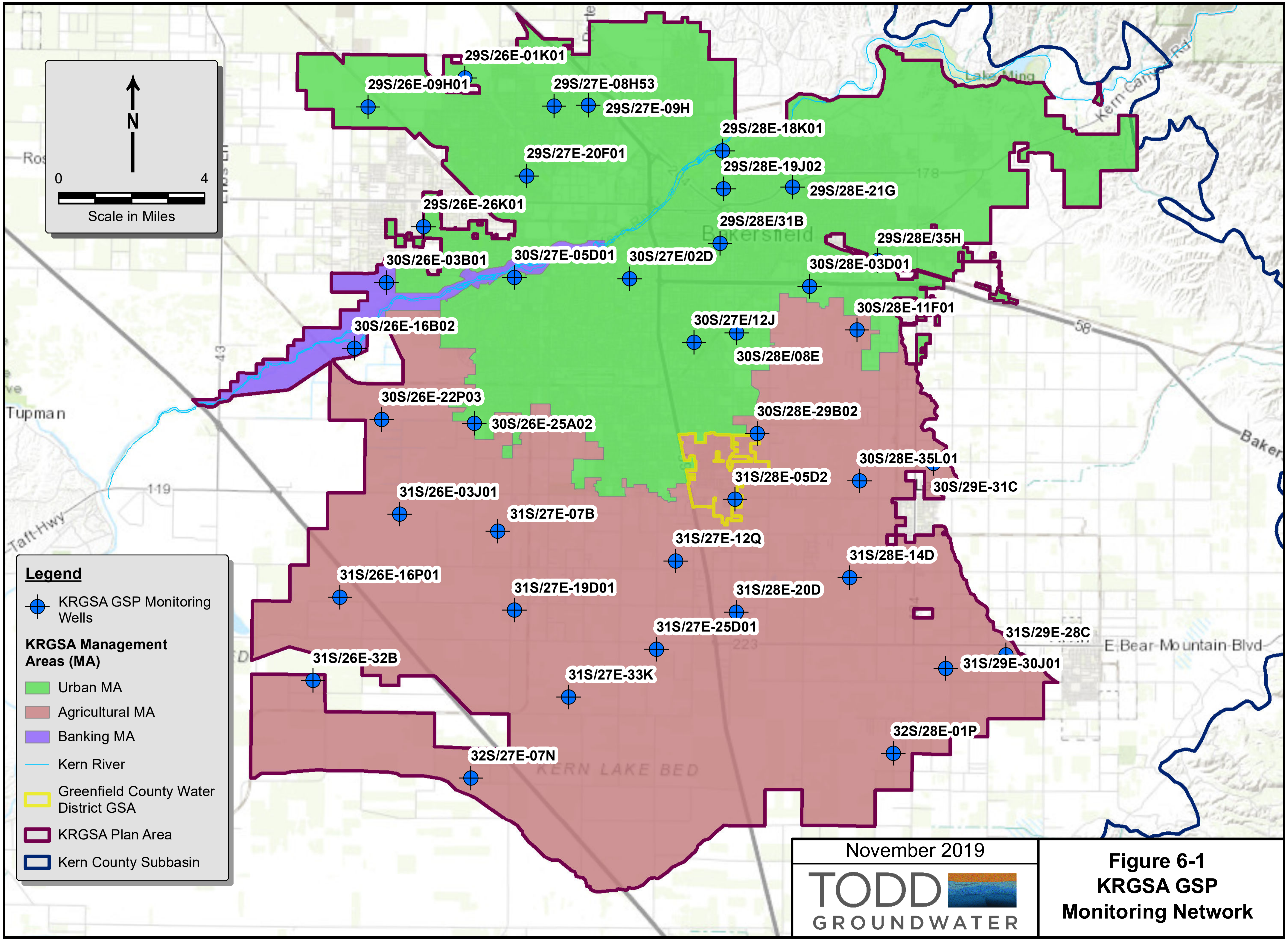


Figure 6-1
KRGSA GSP
Monitoring Network

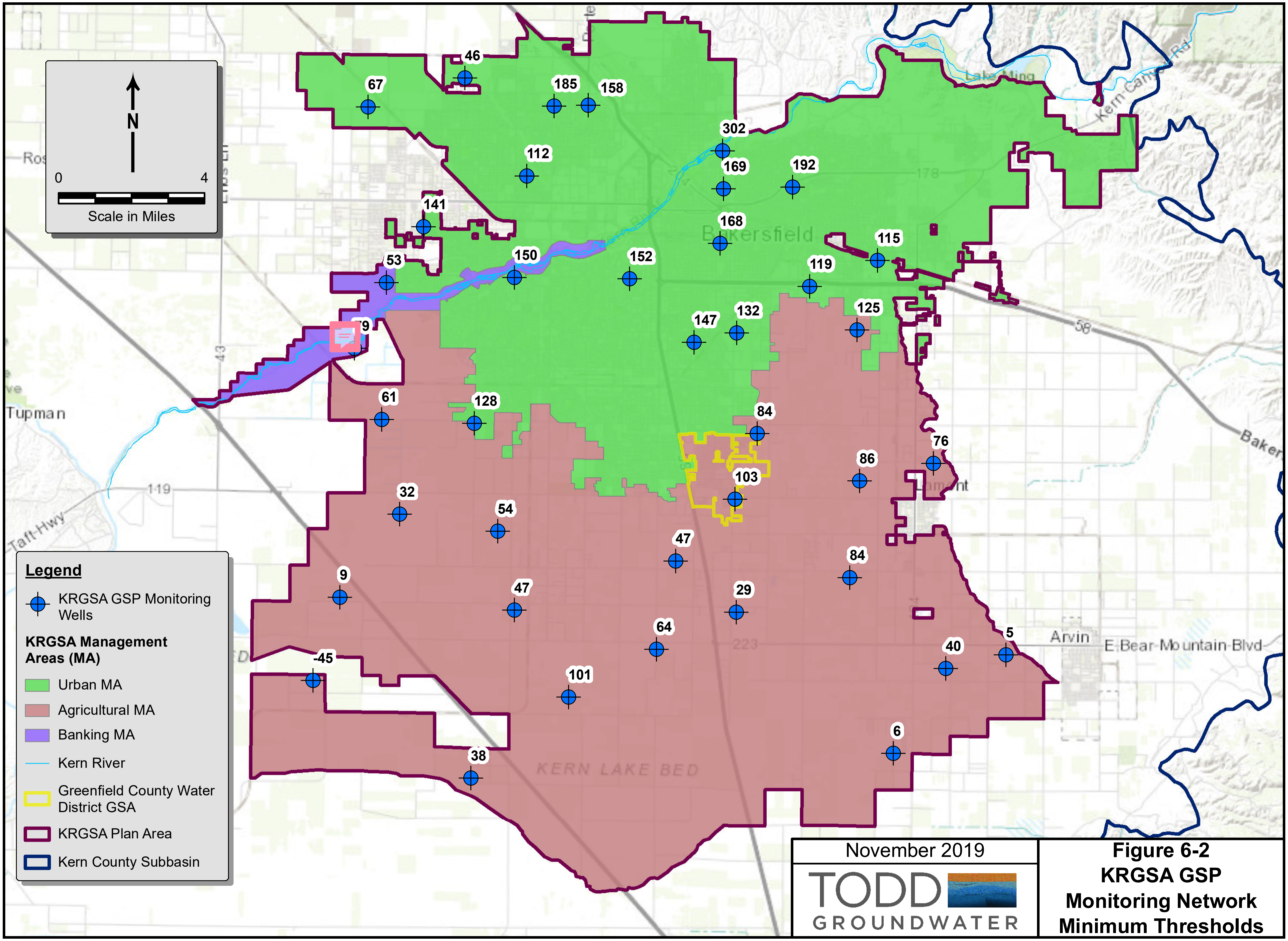
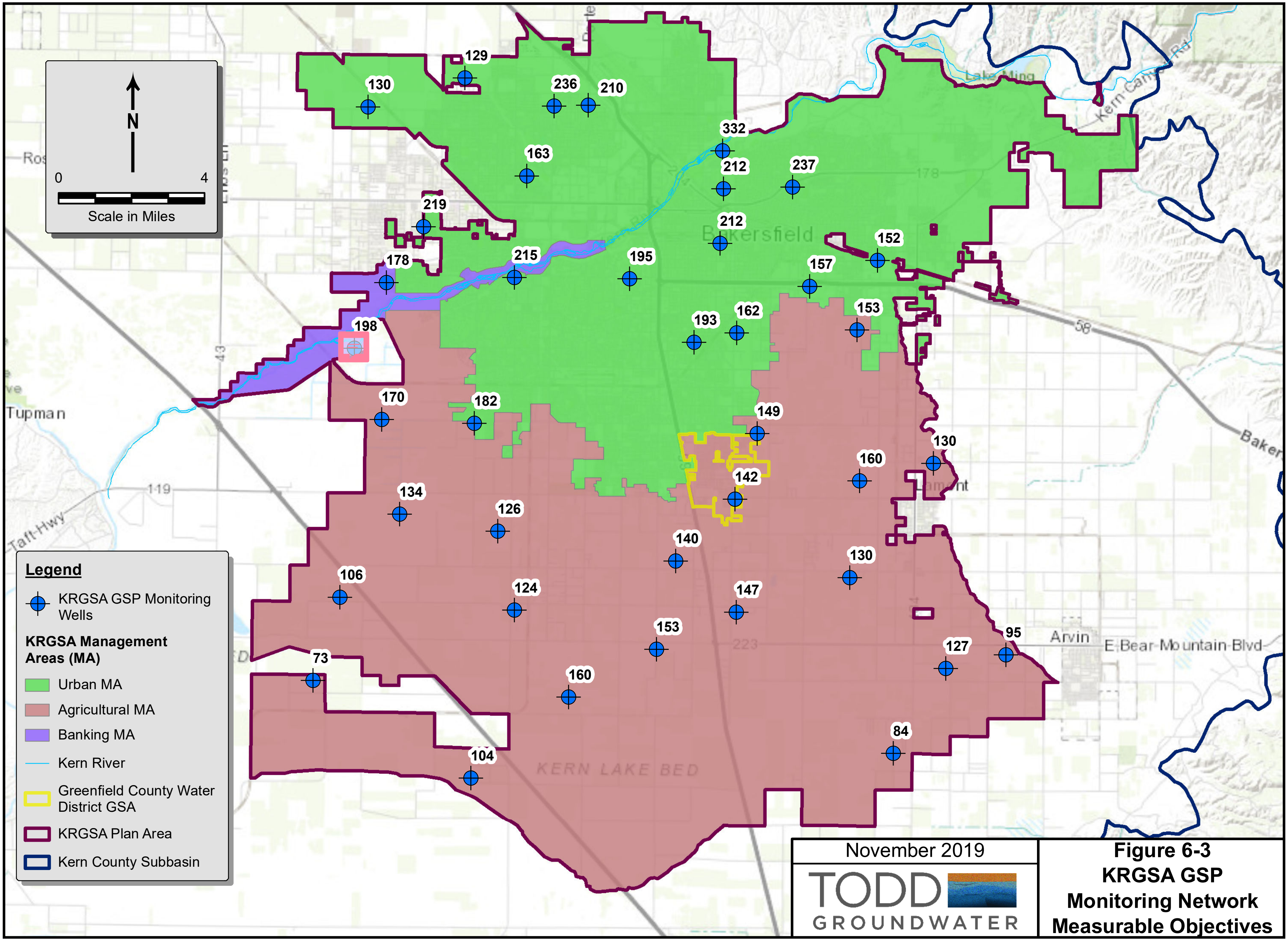


Figure 6-2
KRGSA GSP
Monitoring Network
Minimum Thresholds



November 2019

TODD GROUNDWATER

Figure 6-3
KRGSA GSP
Monitoring Network
Measurable Objectives

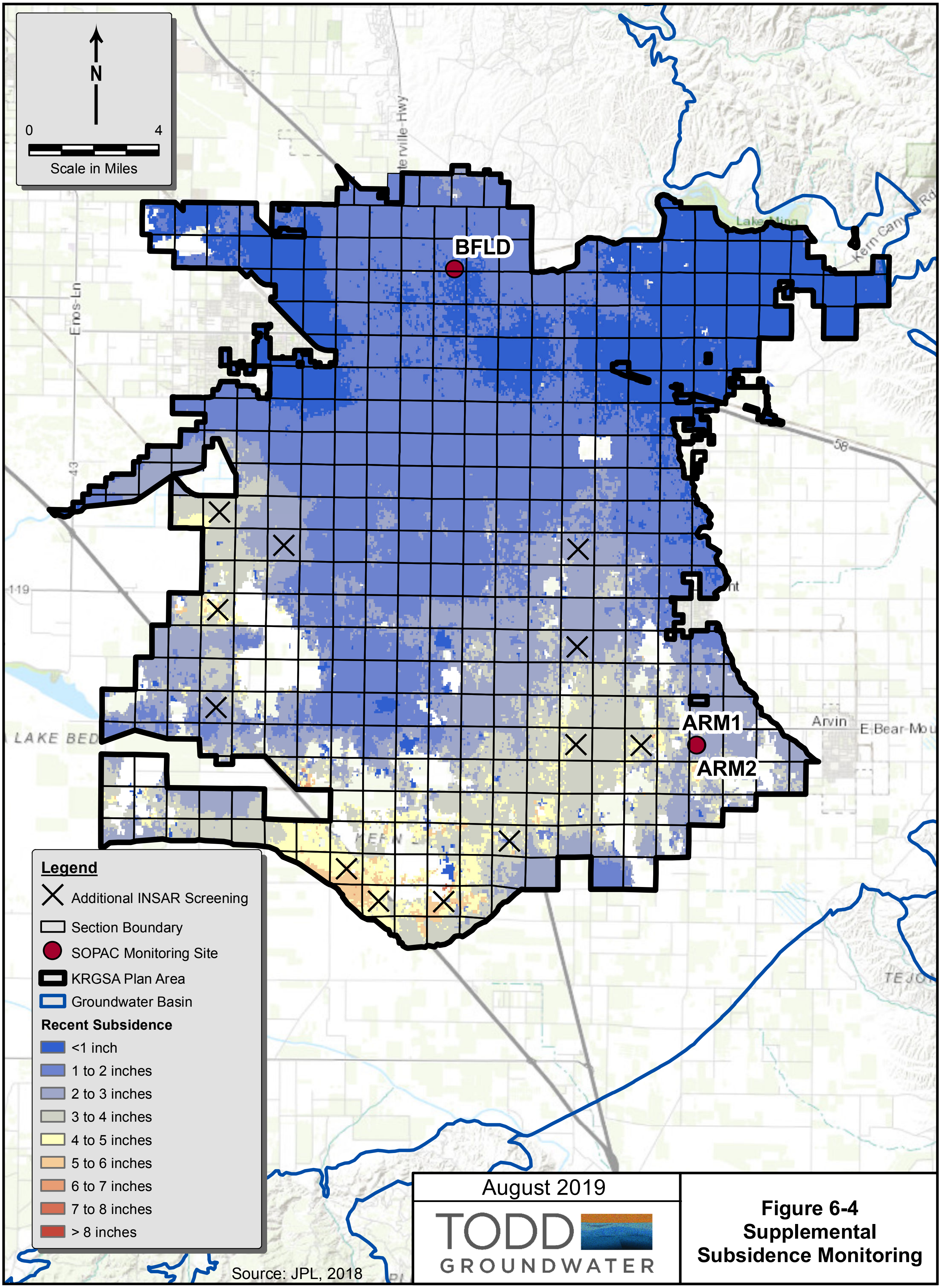


Figure 6-4
Supplemental Subsidence Monitoring

7 PROJECTS AND MANAGEMENT ACTIONS TO ACHIEVE SUSTAINABILITY GOAL

Multiple projects and management actions have been identified for planning and implementation to support the KRGSA sustainability goal. In particular, the projects and actions center around conjunctive use, a cornerstone of the sustainability goal of the KRGSA. The projects and actions also have been defined in the context of the sustainability goal of the Kern County Subbasin, which is to:

- Achieve sustainable groundwater management in the Kern County Subbasin through the implementation of projects and management actions at the member agency level of each GSA
- Maintain its groundwater use within the sustainable yield of the basin through as demonstrated by monitoring and reporting groundwater conditions
- Operate within the established sustainable management criteria, which are established based on the collective technical information presented in the GSPs in the Subbasin.
- Collectively bring the Subbasin into sustainability and to maintain sustainability over the implementation and planning horizon.

Projects involve substantial efforts that provide either an increase in water supply or a reduction in demand for the KRGSA. *Actions* provide a framework for groundwater management including establishing GSP policies and filling data gaps.

Projects and actions are categorized as Phase One or Phase Two, depending on the timing and circumstances of implementation. Phase One projects and actions will begin implementation during the first five years of the GSP. Some Phase One project benefits should be evident by the five-year update of this GSP, scheduled for 2025. Implementation of some project elements will extend into the second or third five-year periods (to 2035). Phase Two projects and actions involve additional activities that could be considered, as needed, for future sustainable management. These projects and actions will begin implementation after the 2030 five-year update, as needed. Additional project and actions may be identified at that time as needed to achieve the KRGSA and Subbasin sustainability goals.

7.1 PHASE ONE PROJECTS

The KRGSA already has under its control sufficient Kern River and imported SWP water to achieve sustainability under a variety of future demand scenarios. By using all of its Kern River entitlement (less obligations) conjunctively with imported water and recycled water supplies, the KRGSA intends to implement six Phase One projects that collectively provide:

- Increases in recharge and banking to offset potential future deficits and avoid overdraft
- Decreases in municipal and agricultural pumping
- Optimal conjunctive management of surface water and groundwater resources
- Improvements in drinking water quality for disadvantaged communities
- Mitigation for the potential of land subsidence in disadvantaged communities.

Three water supply projects have been identified to meet potential future deficits in the historical and projected water budgets, thereby reducing the potential for future overdraft conditions while providing adequate supply to support projected demands. One project provides for demand reduction with increased urbanization of former agricultural lands. Two water quality projects provide improvements to drinking water quality for disadvantaged communities (DACs) in the KRGSA.

A summary of the six water supply projects is provided in **Table 7-1** and described in the following sections.

Table 7-1: Phase One Project Summary for KRGSA GSP

Project	Description	New KRGSA Water Supply
Water Allocation Plan	KDWD plans to use its full Kern River entitlement as prioritized in its Water Allocation Plan (WAP) for the Agricultural MA. The WAP total average supply has been corrected for planned sales to NKWSD.	20,797 AFY
Kern River Optimized Conjunctive Use	The City plans to use its full Kern River entitlement, less current obligations, to mitigate undesirable results for water levels and water quality in the Urban MA.	89,619 AFY
Expand Recycled Water Use in the KRGSA	The City will increase recycled water use inside of the KRGSA from its WWTP No. 3 in 2026 when a contract for use outside of the KRGSA expires (about 72% is currently used outside of the KRGSA).	11,556 to 13,407 AFY
Conversion of Agricultural Lands to Urban Use	Approximately 10,000 acres of current KRGSA agricultural lands is expected to be urbanized; this future urban demand is already included in the projected water budget, so 100% of this agricultural water use represents a demand reduction.	27,000 AFY
ENCSD North Weedpatch Highway Water System Consolidation	Up to six small water systems in the northeast KRGSA will be consolidated into the ENCSD system for benefits to drinking water quality, including to disadvantaged communities (DACs).	No new supply; improved water quality to DACs
Possible Water Exchange	KRGSA member agencies can perform exchanges of surface water and groundwater for benefits to water quality, including to DACs	No new supply; improved water quality to DACs

As indicated in **Table 7-1**, Phase One projects provide about 148,972 AFY to 150,823 AFY of additional water supply to the KRGSA. As discussed in **Section 4.7.2** and summarized in **Table 4-14**, projected future deficits could range between -67,640 AFY (Baseline Conditions) and -165,135 AFY (2070 Climate

Change Conditions) using a conservative checkbook method approach. Accordingly, projects on **Table 7-1** have been selected to address deficits in this estimated range. At this time, Phase One projects fully address projected deficits for both baseline and 2030 climate change conditions. In addition, projects are within about 15,000 AFY of the projected 2070 deficits. Phase Two projects provide additional measures in the event that the more severe climate change conditions of the 2070 scenario are realized.

Each of these six projects will begin implementation during the first five years of the GSP. However, several projects will require adjustment and possible re-direction over time to optimize project performance and avoid undesirable results. Incorporating this concept of adaptive management will be key to achieving the KRGSA sustainability goal.

7.1.1 Water Allocation Plan (WAP) – Kern Delta Water District

For more than 130 years, canal systems on the Kern River have delivered a cost-effective, high quality water supply to support the agricultural economy in the KRGSA Plan Area. These systems were first developed as separate canal companies, each with its own Kern River water right and defined service area; separate canal companies were later consolidated. Until recently, KDWD had managed water supply according to each canal's separately-defined water right, which resulted in increased reliance on groundwater for some portions of KDWD. In 2011, KDWD developed its Water Allocation Plan (WAP) to optimize its Kern River entitlement,[45] increasing overall supply across the Agricultural MA. Project implementation was delayed due to litigation regarding compliance with the California Environmental Quality Act (CEQA). In 2018, the litigation was resolved, a Supplemental Environmental Impact Report (SEIR) was certified (ESA, 2017), and the WAP was adopted by the KDWD Board (Resolution 2018-03).

The WAP (Todd Engineers, 2011) consists of a series of prioritized management actions to allow KDWD to use its full Preserved Entitlement of 201,943 AFY from the Kern River to meet both agricultural and municipal demands in its service area. By revising internal operations for full use of the Preserved Entitlement, the WAP provides a supplemental supply of about 33,048[46] AFY on average to offset groundwater demands for both agricultural and municipal beneficial uses. The additional supply will be delivered directly to meet irrigation demands. Recharge will occur in unlined conveyance canals and will also be focused locally to benefit water levels and water quality near municipal wells, including the disadvantaged communities of Greenfield and Lamont (**Figure 2-16**). This beneficial recharge is documented as a specific management action in the WAP.

To estimate an average amount for this new supply to the KRGSA in **Table 7-1**, the historical Study Period (WY 1994 – WY 2015) is used to estimate the increase in supply if the WAP had been in place during that time period. During this time period, the average annual supply associated with the WAP

[45] Pre-1914 water right as modified by recent court decisions; also referred to as the *Preserved Entitlement*.

[46] As explained in the SEIR (ESA, 2017), the average of 33,048 AFY from the WAP was developed from a strict accounting of unused water from 1997 through 2007, representing average hydrologic conditions on the Kern River. As noted in the SEIR, the average varies slightly depending on the time period selected for average hydrologic conditions.

was 30,472 AFY. In a 2017 Settlement Agreement with NKWSD, KDWD committed a certain portion of the WAP water for sale to NKWSD, with an approximate total of 9,675 AFY occurring for conditions during the historical Study Period. Accordingly, a new supply of 20,797 AFY is provided in **Table 7-1**.

GSP regulations require the inclusion of specific details associated with projects and management actions in the GSP (§354.44). These requirements are also listed in the GSP Preparation Checklist develop by DWR for GSP submittal (**Appendix E**). These required items have been categorized into project benefits and the project implementation process, as described below.

7.1.1.1 Project Benefits

Specific benefits of the WAP are summarized below:

- Provides an additional 33,048 AFY[31] to the Agricultural MA to reduce groundwater demands
- Maintains water levels through both increased recharge and decreased groundwater pumping to support measurable objectives for all of the sustainability indicators applicable to the KRGSA
- Provides operational flexibility through the network of conveyance canals and recharge basins to focus recharge and manage water levels for subsidence and municipal well water quality in the Agricultural MA (see **Sections 5.7.4** and **5.8.4**)
- Mitigates overdraft conditions as estimated by the adjusted checkbook water budget method described in **Section 4.4.2**. Sufficient to meet the estimate of 29,000 AFY of overdraft discussed in **Section 4.5.4** and shown in **Table 4-10**)
- Addresses numerous GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP, most notably the replenishment of groundwater extractions, activities for implementing conjunctive use or underground storage, and measures addressing groundwater recharge, in-lieu use, diversions to storage, and conveyance projects.

7.1.1.2 Implementation Process:

The WAP was approved and adopted in 2018, and implementation has already begun. Public notice, permitting, regulatory, and procedural requirements were addressed through applicable provisions of the California Water Code (WC 35525 et seq.), the CEQA process, and the certified KDWD SEIR (ESA, 2017). Legal authority is provided through the California Water Code, various contractual agreements, and court decrees, decisions, and judgments. No additional legal authority is required for implementation. Costs have already been accounted for in KDWD operational budgets; no added costs are anticipated for full implementation. The implementation process will occur over time to optimize operations for the additional water supply in KDWD; as such, the project is expected to be fully implemented over the next five years. However, operations will be adapted on an ongoing basis to best support the sustainability goal while meeting beneficial uses of the water supply.

7.1.2 Kern River Conjunctive Use Optimization – City of Bakersfield

In order to increase flows in the Kern River channel to support municipal wellfields and other beneficial uses, and to avoid undesirable results, the City intends to optimize conjunctive use of its full entitlement of Kern River water that is now available due to the expiration of the “basic term” of City contracts with several parties outside of the KRGSA. Specifically, the City executed three long-term contracts for sale of certain amounts of Kern River water after its acquisition of the Kern River water right in 1976. At that time, funds were needed for infrastructure improvements relating to the City’s River management responsibilities. The initial 35-year basic term of the contracts expired in 2012, making about 70,000 AFY of Kern River water available to the City to supplement current supplies. It is recognized that the City may still have an obligation to supply some amount of water to certain parties under the “Extension Term” of the agreements, limited to years when there are substantial surface water supplies available to the City, and only after the City’s needs and demands have been satisfied.

In addition to the expired contract water, other discretionary historical diversions by the City were tabulated to better identify additional amounts of water that might be available to meet future urban demand increases. The tabulation of historical discretionary diversions and expired contract water resulted in an average amount of about 89,619 AFY (**Table 7-1**), indicating a significant additional future water supply for the KRGSA. This water is supplemental to the average amount of 59,770 AFY used by the City during the historical Study Period (**Table 4-11**). The total amount of 149,389 AFY accounts for the City’s full Kern River entitlement less future obligations and represents the City’s Kern River surface water supply to serve beneficial uses in the KRGSA and to avoid undesirable results (see **Section 5.4.4**). Accordingly, the net new supply of 89,619 AFY (**Table 7-1**), is incorporated as a Phase One project in the projected future water budgets. This project alone is sufficient to mitigate future water budget deficits estimated for baseline (-67,640 AFY) and 2030 Climate Change (-75,953 AFY) conditions (see **Table 4-14**).

The City has developed priority uses for allocating the GSP project water. The first will be to meet municipal demands by conveyance of water to the three water treatment plants in the KRGSA. Additional water will be targeted for recharge in the Kern River channel below the Calloway weir where the channel is dry most of the time. For planning purposes, three segments of the channel are prioritized for recharge, but locations and amounts will vary depending on available water, other obligations, and activities by others in the River. Finally, water will continue to be recharged in the COB 2800 facility, which has excess capacity in most years. As such, recharge of GSP project water would occur in addition to routine ongoing banking in the COB 2800 facility by the City. Priorities for use of GSP project water are summarized in **Table 7-2** below along with maximum monthly amounts.

Table 7-2: Kern River Conjunctive Use Optimization Project

Priority	Location	Maximum Monthly Amounts
1	Henry C. Garnett Water Purification Plant (WPP)	Up to 542 AF/month
2	Cal Water North East Treatment Plant (WTP)	Up to 5,604 AF/month
3	Cal Water North West Treatment Plant (WTP)	Up to 747 AF/month
4	Kern River Channel (below Calloway Weir)	Up to 12,000 AF/month
5	Kern River Channel (below the River Canal)	Up to 2,000 AF/month
6	Kern River Channel (below Rocky Point)	Up to 2,800 AF/month
7	COB 2800 Facility	Up to 20,000 AF/month

As indicated in **Table 7-2**, the City recognizes the potential for water budget deficits related to decreases in SWP supply, especially when considering the DWR climate change factors applied to Table A allocations. Therefore, the City has determined that the first priority for this GSP project will involve deliveries of Kern River water to the Henry C. Garnett Water Purification Plant operated by ID4 and the Northeast and Northwest water treatment plants operated by Cal Water. Treated surface water will be limited by plant capacity and demand; as such, plant deliveries will vary over time. In its UWMP, Cal Water documents plans for future expansion of its Northeast WTP that increase capacity to 43 MGD by 2030 (Cal Water, 2016a). Build-out for the plant is 60 MGD, with a peaking capacity of 69 MGD (Cal Water, 2016a). Although the final expansion is not currently scheduled before 2035, plans are in place for implementing the expansion earlier, as needed, depending on growth and urban demand.

7.1.2.1 Project Benefits

Project benefits of the Kern River Conjunctive Use Optimization Project are summarized as follows:

- Additional banking of water in the Kern River channel will benefit water levels in municipal wellfields and assist in meeting measurable objectives for chronic lowering of water levels, degraded water quality, and mitigation of potential future land subsidence.
- Aquifer replenishment raises water levels locally in the Urban MA for all beneficial uses and avoidance of undesirable results.
- Municipal wellfields will have excess capacity allowing a reduction in groundwater pumping of certain wells at certain times. This will provide operational flexibility for managing local water levels to avoid undesirable results.
- The Project provides sufficient water to meet the checkbook deficits estimated for the 2070 climate change scenario in **Table 4-14**. When combined with other projects, the amount fully mitigates the potential for future overdraft conditions, based on projected demands.
- The Project addresses numerous GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP, most notably the replenishment of groundwater extractions, activities for implementing conjunctive use or underground storage, and measures addressing groundwater recharge, in-lieu use, diversions to storage, and conveyance projects.
- Use of the River channel as a primary groundwater recharge source restores more natural hydrologic functions of recharge beneath the River.

7.1.2.2 Implementation Process:

The City intends to implement this project incrementally over time and to continue project adaptation to changing conditions, adjusting the direct use of the additional Kern River water based on plant capacity and demand. Increased recharge associated with the project will be implemented in Year 1 (2020). Depending on the availability of Kern River water, the project will begin by testing the recharge capacity and aquifer response in certain areas of the channel to better develop management strategies for avoiding undesirable results. In particular, the location and amount of groundwater level increases will be evaluated over time, based on an analysis of scenarios involving resting wells and channel recharge.

Implementation of the project can begin without impediments because the GSP project water supply is part of the City's Kern River entitlement based on its pre-1914 appropriative rights. This provides the City with the legal authority to use the water for multiple reasonable beneficial uses. The City developed an EIR to describe how current water supplies and potential additional water supplies would be incorporated into a new proposed program referred to as the Kern River Flow and Municipal Water Program; that program involved a potential new supply and associated rights on the Kern River, which is on hold pending the outcome of a SWRCB application. However, this GSP project includes only the current Kern River entitlement that belongs to the City and remains available to the City. Additionally, the use of the water is not subject to new permits or regulatory requirements beyond current obligations regarding Kern River management and use.

Public notice of the City's intent to increase conjunctive use in the Kern River was provided during the CEQA process for numerous projects, including, but not limited to, the EIR for the Kern River Parkway project, the EIR for the 2800 Acres project, the EIR for the Kern River Flow and Municipal Water Program, and in a number of City planning and policy documents including the land use planning efforts described above and documented in **Sections 2.6.1** and **2.6.2** of this GSP (although this GSP does not involve all water sources included in those projects and documents). Additional public notice will be accomplished through the GSP outreach process, which includes public hearings and an open house occurring over the next several months.

Because this project simply increases the volume of water retained in the KRGSA, the City will manage a similar total of water that is managed now but will be directing it to increased recharge and/or water purification facilities. Accordingly, project costs are anticipated to be managed within the City's current operational budget for Kern River management. If additional facilities for recharge are required, those costs will be developed as a new KRGSA GSP project.

The timing for full implementation of this project is related, in part, to the planned expansion of the North East treatment plant (and other treatment plants), which in turn is tied closely to growth and future demands. Expansion of the Northeast WTP to 43 MGD is scheduled to occur by 2030 and full buildout will likely occur in the GSP Planning horizon. Scheduling of project details will be developed for the five-year update to the GSP, based on then-current projections.

Two additional treatment plants – Southwest Bakersfield WTP and Rosedale Ranch/Seventh Standard Corridor WTP – are also proposed to increase capacity for direct deliveries of Kern River water (Cal Water, 2016a). These plants are on hold due to economic conditions, but ultimately would serve to decrease reliance on groundwater.

7.1.3 Expand Recycled Water Use in the KRGSA Plan Area

For more than 30 years, the City of Bakersfield has been providing treated wastewater from its WWTP No. 3 to a 4,700-acre farm for irrigation, known as Green Acres. The farm is owned by the City of Los Angeles and located on the western edge of the KRGSA with most of the land outside of the KRGSA boundary (about 72 percent). Currently the City provides an average of about 18,000 AFY to Green Acres in accordance with its contract.

On July 17, 2019, the Bakersfield City Council voted not to renew the contract when it expires in 2026. This action allows all of the recycled water to be used in the KRGSA as needed. The City is currently exploring options for use including replacement of potable water for irrigation or for groundwater recharge. Although the water will not be available until after 2026, planning has begun for identification of needs in the Plan Area.

The average amount of water provided to Green Acres during the historical Study Period of WY 1995 – 2015 was about 11,321 AFY, but this average has increased over time with increasing inflows to WWTP No. 3. In addition, current amounts are expected to increase over time with population growth in the City. For analysis in the C2VSim-FG Kern local model, wastewater flows from WWTP No. 3 were increased proportional to the increase in urban water demand over time with a similar proportional increase in available recycled water. As a simplifying and conservative assumption, the amount of new water supply was limited to the percent of supply that had been used outside of the KRGSA (72 percent of the total amount). This calculation indicates a new average annual water supply to the KRGSA of about 11,556 to 13,407 AFY for the 20-year implementation period and the entire 50-year planning horizon, respectively.

Benefits and Implementation: This project will increase the availability of recycled water in the KRGSA for beneficial use. This water supply will support measurable objectives for all sustainability indicators with a net positive impact on the KRGSA Plan Area water budget to mitigate the potential for future overdraft. If used to replace potable water, the net benefit would be even greater by preserving a high-quality potable supply for other beneficial uses. This project supports a key GSP element by providing measures to address water recycling, as listed in Water Code §10727.4 and re-stated in **Section 2.6.6** (see item (h)). Depending on the selected water use, this project supports additional GSP elements including replenishment of groundwater extractions, opportunities for conjunctive use or underground storage.

The City owns the wastewater and no additional legal authority is needed to retain the water for local use. A permitting and regulatory process may be required depending on the type of use. At this time, the project is simply to retain the recycled water for use within the KRGSA; implementation will occur with the expiration of the contract in 2026. A more defined project and other implementation considerations will be developed between 2020 and 2026; updated project components will be provided in annual reports as they are developed. Costs have not yet been estimated for this project. The public was notified of this project at the City Council meeting on July 17, 2019. Numerous newspaper articles documented the discussion and vote of the City Council (Bakersfield Californian, 2019). Additional public notice will be provided through the public review period of this GSP. Additional public outreach will occur as specific uses are identified for the increase in available recycled water.

7.1.4 Land Use Conversion - Urbanization of Agricultural Lands

As indicated by the increase in urban demand over time (**Table 4-14**), growth in Metropolitan Bakersfield is anticipated. According to the UWMPs in the northern Plan Area, urbanization is expected to occur through increased density in urban lands, expansion onto undeveloped lands, and conversion of agricultural lands. Although the exact location of urban growth has not been defined specifically, much of the growth has been expanding to the south into the central and southern Plan Area, as indicated by the delineation of the KRGSA Urban MA (see **Figure 5-1**). Much of this land is either currently or historically used for irrigated agriculture and some of that land will likely be converted within the 20-year GSP implementation phase.

For the purposes of this project, it is assumed that about 10,000 acres of agricultural lands in the KRGSA Plan Area (about 10 percent of the total agricultural lands) will be urbanized. Most of this area is located in the Agricultural MA, but agricultural lands also occur in the Urban MA. Although the acreage and locations are uncertain, the City indicates that this is a reasonable assumption based on current urbanization areas. Project acreage would already be embedded in the analysis of future urban demand in the projected water budget, which is based simply on population growth. Accordingly, the total agricultural demand for the project acreage is decreased to prevent double counting of water use on these 10,000 acres. Using the average crop ET demand in the southern KRGSA Plan Area of 2.7 AF/acre, approximately 27,000 AFY is eliminated from the agricultural demand, representing an overall net demand reduction in the KRGSA as a result of this project.

Project benefits of this urbanization of former agricultural lands are summarized as follows:

- Decreases overall water demand, which supports measurable objectives of all sustainability indicators applicable to the KRGSA including chronic lowering of water levels, reduction of groundwater in storage, degraded water quality, and the potential for land subsidence
- Mitigates potential for future overdraft conditions by decreasing demand; this allows for surface water to meet a larger portion of the demand, thereby reducing groundwater pumping
- Allows for decreased pumping in areas of potential land subsidence
- Addresses several GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP, most notably processes to review land use plans and efforts to coordinate with land use planning agencies and measures addressing in-lieu use.

7.1.4.1 Implementation Process:

There are no impediments to implementation of this project. Although the GSA does not specifically control the location of future growth, the City will assist in tracking and coordinating the conversion of agricultural lands through time as opportunities arise. Given previous patterns of growth and projections of population increase, this project is expected to be fully implemented within the 20-year GSP implementation period. Legal authority, permitting, and regulations for locations of population growth within the City limits reside with the land use planning, water resources, and other City departments and with the City Council. Outside city limits, land use planning resides with Kern County. Funding is not needed for implementation of this project.

Water use for urbanization of agricultural lands in KDWD is covered under an agreement between KDWD and the City of Bakersfield. That agreement obligates KDWD to make water available for those newly-urbanized lands, provided that those lands have been served historically by the water rights obtained by KDWD. Some of the recently urbanized lands in KDWD were not historically served by KDWD water rights and, as such, are not currently served by KDWD. KDWD has the responsibility to support the new urban demand at a rate of about 1.0 – 1.5 AF/acre. This agreement will provide sufficient water to serve urban demand and will prevent the need for additional groundwater pumping to support new growth in this area.

7.1.5 ENCSD North Weedpatch Highway Water System Consolidation Project

Six small water systems in the vicinity of Highway 184 (Weedpatch Highway) and Muller Road have had to cope with water quality issues including elevated nitrate, TCP, and arsenic concentrations detected in water supply wells. These disadvantaged communities (DACs) have limited resources and provide drinking water supply to more than 1,400 persons along the eastern KRGSA boundary. Three of these systems are located within the KRGSA Plan Area as noted below; the remaining three are just outside the KRGSA Plan Area in AEWSD.

- Oasis Property Owners Association (Oasis POA) – in KRGSA
- East Wilson Road Water Company (East Wilson Rd) – in KRGSA
- Wilson Road Water Community (Wilson Road WC) – east of KRGSA
- San Joaquin Estates Mutual Water Company (SJE MWC) – east of KRGSA
- Del Oro Water Company Country Estates District (Del Oro WC) – east of KRGSA
- Victory Mutual Water Company (Victory MWC) – in KRGSA.

Service areas of these small water systems are adjacent to, and in some areas surrounded by, the ENCSD service area (see **Figure 2-4**). In response to water quality violations, the SWRCB DDW ordered corrective actions to meet drinking water standards. Consolidation with ENCSD was evaluated as a possible corrective action for each of the water systems. ENCSD prepared an initial Engineering Report in 2016 evaluating the consolidation of four of the water systems (AECOM, 2019, see Attachment T-1). At the request of the SWRCB-DDW, an amendment to the Engineering Report was prepared in April 2019 to add Del Oro WC and Victory MWC to the consolidation evaluation (AECOM, 2019).

The project includes new water distribution systems, a new well (1,400 gpm capacity) with arsenic treatment, a storage tank, hydropneumatics tank, and a booster pump station. If TCP is detected in the new well, the grant will also fund a TCP treatment system. All wells with water quality violations will be properly abandoned according to Kern County Environmental Health regulations. Grant funding through the Drinking Water State Revolving Fund (DWRSF) program has been secured for construction costs. The small water systems have also received assistance from Self-Help Enterprises, a community development organization that assists rural communities identify clean drinking water sources in eight counties of the San Joaquin Valley.

Although this consolidation project was conceived prior to the preparation of this GSP, ENCSD is documenting this project in the GSP as a member agency in the KRGSA.

7.1.5.1 Project Benefits

Project benefits of the North Weedpatch Consolidation Project are summarized as follows:

- Supports measurable objectives for degraded water quality by managing local arsenic concentrations with construction of an arsenic wellhead treatment facility, thereby avoiding an undesirable result
- Controls projected urban demand through conservation efforts implemented by ENCSD
- Abandons wells with poor water quality
- Provides DACs with a reliable, clean drinking water supply
- Supports numerous GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP, including wellhead protection areas (for the new project well), migration of contaminated groundwater (elevated nitrate from a nearby septic system as suggested in one DDW Water Quality Violation Order), adherence to well abandonment and well construction policies, measures addressing groundwater contamination, and efficient water management practices.

7.1.5.2 Implementation Process:

Numerous activities are required prior to project construction. ENCSD has adopted standards and policies that control this annexation process and requires legal Consolidation Agreements with the water systems for adherence to ENCSD requirements. Annexation proceedings will be completed through the Local Agency Formation Commission (LAFCO); approval is anticipated. CEQA compliance will include preparation of a CEQA Plus mitigated Negative Declaration, with a Notice of Determination filed with Kern County and the State Clearinghouse. ENCSD will need to acquire about 1.5 acres of undeveloped land from the Fairfax School District for the new well site. Construction design documents are approximately 90 percent complete (Ruiz, personal communication, 7/31/2019).

The project is scheduled for implementation once all of the agreements and CEQA compliance have been completed. To date, ENCSD has signed agreements to annex and consolidate service areas into ENCSD for SJE MWC, Oasis POA, and Wilson Road WC. Once annexed, ENCSD will have the legal authority to serve water throughout its expanded service area. Construction permits, including well drilling, are required for the project. The ENCSD permit with DDW for the provision of drinking water will be amended to include system improvements.

Construction of the consolidation project is being funded by a DWRSF grant. Funding includes new infrastructure, including pipelines, pump station, storage, and a new well. Costs for an arsenic treatment facility and TCP treatment, if needed, are included in the grant. Project costs are estimated at approximately $20 million. More detailed costs, including O&M are provided in the Engineering reports (AECOM, 2019).

The Project schedule is summarized below and expected to take approximately 62 months.

- Project design and CEQA Plus Document – 6 months
- DWRSF construction application process – 24 months
- Annexation proceedings, property acquisition, permitting and well drilling – 8 months
- Well equipping, booster pump station, treatment processes, facilities construction – 24 months.

Once permitted, ENCSD will have the authority to deliver drinking water to all customers and no additional legal authority is needed for project implementation. Public notice will occur through the CEQA process as well as in planned public hearings on this GSP. As mentioned previously, project design activities are proceeding, and agreements have been executed with three of the six systems (as of July 31, 2019).

7.1.6 Possible Water Exchange for Improved Drinking Water Quality in Disadvantaged Communities

The GSA recognizes the challenges of the DACs within the KRGSA to obtain sufficient high-quality drinking water with limited resources. Given the large infrastructure network in the KRGSA, the potential for numerous exchanges of various source waters provides management flexibility for controlling water levels, water quality, and avoiding undesirable results.

One possible exchange is envisioned between ENCSD, which serves water to DACs, and KDWD, who operates the Eastside Canal located through the ENCSD service area. In the event that ENCSD has an immediate need to mitigate elevated nitrate concentrations, KDWD could deliver Kern River water to the ID4 treatment plant on behalf of ENCSD. Then ENCSD could provide groundwater with elevated nitrate or arsenic into the Eastside Canal, where it would be blended and provided for agricultural irrigation (recognizing that nitrate and arsenic are not constituents of concern for agricultural use).

A similar exchange to assist DACs in Oildale MWC could be developed. For this exchange, surface water would be provided for treatment from an additional agency who could receive returned groundwater from Oildale MWC in the Beardsley Canal.

7.1.6.1 Project Benefits

Project benefits of water exchanges to improve drinking water quality for DACs are summarized as follows:

- Support measurable objectives for degraded water quality.
- Assists with improvement of water quality to DACs within the KRGSA and supports the KRGSA sustainability goal to meet municipal demands.
- Supports GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP measures addressing groundwater contamination and efficient water management practices.

7.1.6.2 Implementation Process:

For implementation of this type of project, KRGSA Plan Managers would need to coordinate and consider institutional, legal, or permitting barriers prior to the exchange. For these types of exchanges, additional agreements may be required. For example, ID4 cannot deliver treated surface water from its purification plant outside of ID4 boundaries without amending or developing new contracts. Public notice will be accomplished as part of the public review of this GSP. Implementation of this type of water exchange is considered discretionary and will be considered and implemented only on an as-needed basis. Nonetheless, it remains a viable option for assisting DACs with a high-quality drinking water supply.

7.2 PHASE ONE MANAGEMENT ACTIONS

Phase One *management actions* differ from Phase One *projects* in that they typically do not represent new water supply or reductions in demand. Rather, these actions provide a framework for overall groundwater management including establishing GSP policies and filling data gaps. Ten management actions have been identified for implementation in Phase One.

As provided by SGMA and re-sated in the MOU forming the GSA, the KRGSA may perform the following functions:

1. Adopt standards for measuring and reporting water use.
2. Develop and implement policies designed to reduce or eliminate overdraft within the boundaries of the GSA.
3. Develop and implement conservation best management practices.
4. Develop and implement metering, monitoring, and reporting related to groundwater pumping.

The management actions included in this section rely on SGMA authority and no additional legal authority is required. In addition, the MOU states that the City and ID4 are jointly responsible for GSP implementation in the City limits and ID4 boundaries. KDWD is responsible for GSP implementation in its boundaries. In addition, Greenfield CWD is responsible for GSP implementation in its service area as per the MOU executed with the KRGSA (**Appendix C**). Unless explicitly stated, these responsibilities are assumed for the Phase One management actions.

Unless stated otherwise, all costs associated with these management actions are assumed to be a part of the administrative costs of the KRGSA. Cost sharing among the agencies will continue in the same manner used for GSP development. During the first five years, KRGSA Plan Managers may decide to develop a different cost sharing structure for certain actions below.

7.2.1 Implement Action Plan if Water Levels Fall Below Minimum Thresholds

As described in **Section 5**, managing water levels at or above minimum thresholds is the selected strategy for ongoing avoidance of undesirable results throughout the KRGSA. While it is recognized that water levels may fall below minimum thresholds for relatively short periods of time without triggering undesirable results, such an occurrence is used to trigger a series of actions to better understand the nature and extent of the failure to meet thresholds.

The three KRGSA Plan Managers, representing the City, ID4, and KDWD, are the responsible parties for monitoring conditions and complying with GSP requirements within their respective service areas. Further, ID4 and the City will share and coordinate responsibility for additional agencies and entities within the Urban and Banking MAs. KDWD is responsible for coordinating with additional agencies and entities in the Agricultural MA. Greenfield CWD is responsible for GSP implementation within its service area (see MOU in **Appendix C**).

A five-step action plan for addressing exceedance of GSP thresholds, including KRGSA Plan Manager coordination, is outlined below.

1. Identify the Well(s) and Investigate the Area: This initial step will assist in determining if the issue is associated with one well or is systemic to an area. Various conditions surrounding the compliance well will be considered. For example: Are water levels declining in nearby wells? If so, how large of an area is affected? Is the area close to new or increasing groundwater extraction? Is the problem related to area-wide drought conditions? Has local demand increased? If increased demand during drought is responsible for the exceedance, then is a sustainable water budget being adhered to in the KRGSA?

2. Coordinate with KRGSA Plan Managers: The conditions associated with the low water levels in one MA may be the result of operations in an adjacent MA or by another KRGSA agency. In addition, an activity in an adjacent MA may have the ability to assist or correct the problem. For example, minimum thresholds have been set differently in adjacent areas to balance various management objectives; this occurs in the portions of the Banking MA that are surrounded by the Urban MA and also along the shared boundary of the Urban and Agricultural MAs. This balance will require close coordination among KRGSA Plan Managers and the willingness to modify operations as needed to avoid undesirable results as provided in the KRGSA Sustainability Goal. The KRGSA Plan Managers are already actively engaged in cooperative management and are committed to frequent communication and coordination for collective GSP compliance.

3. Select Appropriate Management Actions or Projects for Mitigation: The widespread network of canals and other infrastructure in the KRGSA, as well as access to a variety of water sources, provides significant flexibility for the movement of water and active management of water levels throughout the Plan Area. Large wellfields, canals, pipelines, three surface water purification plants, and access to the Kern River, imported water, and recycled water all contribute to management opportunities for minimum threshold mitigation. Various strategies can be employed to manage water levels in local areas. Possible actions to consider include water sales or exchanges such that wells may be temporarily turned off, re-distribution of pumping, or increased recharge in certain areas. Long-term capital improvements, such as wellhead treatment or well modifications, may also be identified for

implementation. If the actions or projects selected for mitigation are not currently included in the GSP, such actions will be incorporated into the Plan during the next Five-Year Plan Update.

4. Consider Institutional Changes for Future Mitigation: Inability to meet minimum thresholds may require institutional solutions. KRGSA Plan Managers may consider the need to develop programs to curtail pumping or allocate groundwater.

5. Consider the Need for Improved Monitoring: The conditions associated with the low water levels may require increased monitoring frequency or locations. The GSP monitoring program is already subject to improvements as part of an additional management action in this GSP.

Benefits and Implementation: These actions support all measurable objectives applicable to the KRGSA through active management of the sustainability indicators and avoidance of undesirable results. KRGSA Plan Managers have the responsibility to manage groundwater sustainably and no additional legal authority, permits, or regulatory process is needed for these actions. GSA managerial costs for implementation of the GSP are being determined and will be funded similar to the cost-sharing structure used in GSP development. Additional public notice will be provided through the public review period of this GSP.

7.2.2 Optimize Conjunctive Use in the KRGSA

With this GSP, the KRGSA formalizes its current policy to make best use of the diverse portfolio of water supplies available to KRGSA agencies through conjunctive management. As documented throughout this GSP and emphasized in the KRGSA Sustainability Goal, managing surface water and groundwater conjunctively has been the foundation of water management in the KRGSA. Surface water sources available to the KRGSA will be prioritized for use when available, retaining the shared groundwater resources for periods when surface water is scarce. This balance of water use and higher reliance of groundwater during drought provides for increased reliability, higher groundwater levels to avoid undesirable results, and preservation of groundwater resources for other supplies are less available. Conjunctive management also encourages recharge of any excess surface water for storage and subsequent recovery to assist with drought management. These actions include a continued policy of increasing recharge for both replenishment and storage for subsequent recovery and use. This KRGSA policy supports the ongoing recharge operations in formal banking projects inside the KRGSA (e.g., COB 2800 Recharge Facilities), Kern River channel, and unlined channels and canals. The policy supports continued use of Kern River and SWP supplies within the KRGSA Plan Area, to the extent feasible.

7.2.3 Establish Well Metering Policy in the KRGSA

This action establishes a KRGSA policy to have all extraction wells in the Plan Area metered except for de minimis production (<2AFY) as defined by SGMA. This policy will assist with monitoring groundwater extractions for ongoing water budget analyses and compliance with SGMA reporting requirements. Well metering is already in place for most municipal wells in the Urban MA, including those owned or operated by the City, Cal Water, Greenfield CWD, ENCSD, Lamont PUD, and others. In addition, recovery wells for groundwater banking projects in the Banking MA and elsewhere in the KRGSA are also already metered. The City will implement well metering requirements for additional un-metered wells within the Urban MA while coordinating with ID4 and KDWD where service areas overlap.

ID4 conducts a groundwater extraction reporting program within its service area (Urban MA and portions of the Banking MA) but does not currently require meters for private wells. Rather, the measurement or estimation method used to report production is required on the reporting forms. As a member agency of the KRGSA, ID4 is currently exploring options for a well meter program that is consistent with its enabling act. Wells associated with de minimis production as defined under SGMA (i.e., less than 2 AFY) will not be included in any future metering program.

In accordance with the KRGSA policy to require well metering, KDWD is planning to require agricultural wells to install meters within the KDWD boundaries. Initially, all new wells will require a well meter to measure production while details of meter installation on existing wells are developed. KDWD is exploring options for providing financial assistance to well owners for installation of meters on existing wells. The well meter installation program will be phased in over the first five years of the GSP with functional compliance expected by 2025.

To facilitate implementation of the KRGSA well metering program, the KRGSA Managers intend to inform all new well applicants of this requirement. This action is coordinated with Kern County Environmental Health, who notifies the KRGSA Managers of any County well permit request in the KRGSA Plan Area.

<u>Benefits and Implementation</u>: This action will allow improved accounting of groundwater production throughout the KRGSA including in the large Agricultural MA where most wells are currently not metered. Previous estimates of pumping relied on crop ET estimates and the uncertainty associated with effective precipitation and irrigation return flows. Because groundwater extractions are the largest groundwater outflow component of the water budget analysis, metered extractions will improve the accuracy of monitoring groundwater in storage to avoid overdraft conditions and associated undesirable results.

Several GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP relate to groundwater extractions and are supported by this management action. KDWD has the authority under SGMA to develop well metering requirements and does not need additional legal authority. No permits or regulatory requirements are applicable. Public notice will be provided through the public review period of this GSP.

7.2.4 Implement Groundwater Extraction Reporting Program

As required by SGMA, the KRGSA will begin reporting extractions to DWR on an annual basis. In order to improve the accuracy of its reporting and to support the ongoing water budget analysis, KRGSA Plan Managers will implement a program for all well owners to report groundwater production to the GSA. Private domestic wells supporting only residential use in a single-family household using 2 AFY or less may be determined to be de minimis and exempt from the reporting program at the discretion of the KRGSA Plan Managers.

For each reporting program, pumpers will be required to provide total production on a WY basis and list the amount associated with each beneficial use along with the method used to determine the amount of production. Categories of use and methods will be coordinated with the GSP annual reporting requirements by DWR.

This program will begin implementation in Year One and proceed in a phased approach over the first five years as program details are more clearly defined. Coordination of the program and shared responsibility is summarized below.

7.2.4.1 Urban MA:

ID4 already manages a successful well reporting and assessment program within its service area, which covers most of the Urban MA. All agency and private well owners are required to provide semi-annual reporting to ID4 for groundwater production. Well owners are also required to provide the measurement method for the reported production and estimate its accuracy. Currently production is reported on a semi-annual basis for each calendar year, which will be converted to Water Year for the purposes of reporting.

A similar program for well reporting outside of ID4 in the City limits will be implemented by the City. The City may coordinate with the ID4 program to establish similar reporting procedures for areas outside of ID4 boundaries.

7.2.4.2 Agricultural MA:

With its well metering program described above, KDWD will also establish a production reporting program to provide accurate groundwater extraction data to the GSA for the GSP Annual Report. Until meters are in place, production may be estimated on electrical records or using established crop ET values from the METRIC ET analysis that supported the historical Study Period. The program will require groundwater production by well including total production and the level of accuracy associated with the method.

KDWD will also compile production from its metered wells, which are used as recovery wells for its banking program. Production will be tabulated by use (i.e., recovery pumping or in-district use).

7.2.4.3 Banking MA:

ID4 will be the responsible GSP Plan Manager for reporting and accounting of recovery pumping from groundwater banking activities within the KRGSA, given its close connections with KCWA staff who currently manage much of the local banking operations. Recovery pumping by and for the benefit of ID4 both inside and outside of the KRGSA will be tabulated. Other banking production will be focused on pumping inside the KRGSA including for the Berrenda Mesa and Pioneer Project. Production reporting will be coordinated with the City for the COB 2800 Facility. KDWD will be responsible for reporting pumping from its metered district-owned wells inside the Agricultural MA as provided above.

7.2.4.4 Benefits and Implementation

This action will directly support the water budget analysis, which is used to ensure that the KRGSA is operating within its sustainable yield. A more reliable water budget, in turn, will support the measurable objective for reduction of groundwater in storage. The action also allows for the KRGSA to supply accurate information to DWR as required by SGMA. GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP that relate to groundwater extractions are supported by this management action.

SGMA also provides the legal authority – and mandate – to the GSA for groundwater extraction reporting, and no additional legal authority is required. No permits or additional regulatory actions are needed. Public notice will be provided through the public review period of this GSP.

7.2.5 Support California Delta Conveyance Project to Preserve Imported Water Supplies

In its UWMP, ID4 emphasizes the need for state-wide support in improving the availability and reliability of SWP supplies. On April 29, 2019, Governor Newsom announced that his administration will develop a water resiliency portfolio (Portfolio) intended to address a range of water-related challenges facing the state. The Portfolio will address unsafe drinking water, major flood risks, severely depleted groundwater aquifers, communities with uncertain water supplies and native fish populations. The governor issued an executive order to implement the Portfolio that includes "current planning to modernize conveyance through the Bay Delta with a new single tunnel project." ID4 continues to monitor and support the Delta Conveyance Project for the reliable delivery of SWP water supplies that are critical to sustainable management in the KRGSA. As described throughout this GSP, SWP water provides both drinking water supply and water for groundwater banking and recovery when needed.

Benefits and Implementation: This management action supports more reliable delivery of SWP supplies to the KRGSA. Imported surface water supplies provide the opportunity for conjunctive use, replacing groundwater supplies when available and supplementing native groundwater resources during drought with recovery of banked water. As noted above, optimization of conjunctive use is a policy of the KRGSA and a cornerstone of the KRGSA sustainability goal. This management action supports surface water supplies for more sustainable groundwater use, and as such, supports measurable objectives for all sustainability indicators including protection against potential future overdraft. As with other actions in this GSP, this action supports numerous GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6**, especially those elements relating to conjunctive use or underground storage, and in-lieu use.

This action involves *support* of the Delta Conveyance Project and does not, by itself, require additional legal authority, permitting, a regulatory process, or CEQA compliance. ID4 support of the project has been discussed at Urban Bakersfield Advisory Committee and KCWA Board meetings and will continue to be disseminated through the public review period of this GSP.

7.2.6 Incorporate Climate Change Adaptation Strategies

As noted in its 2015 UWMP (P&P, 2016), ID4 has identified strategies that can be adapted to fit within ID4 operations to address potential uncertainties associated with the reliability of imported water supplies. In brief, climate change may result in reduced surface water that will be even more unpredictable on a year-to-year basis. As listed in the UWMP, ID4 has identified the following measures for consideration:

- Work with retail purveyors to identify impacts of demand management measures to improve the accuracy of overall ID4 future demands. New developments are incorporating the latest water conversation features and policies that may alter the current ID4 demand projections.
- Continue groundwater banking activities to the extent practicable to increase reliability of supplies during dry-year conditions.
- Explore options to capture excess runoff in off-stream recharge facilities to conserve additional water for beneficial use that might otherwise be lost from local supplies.

Benefits and Implementation: These strategies will provide a framework for development of more detailed management actions in the first five years of the GSP. More accurate demand estimates will support measurable objectives for reduction of groundwater in storage and improve overall planning in the KRGSA. Historical, current, and future groundwater banking in the KRGSA supports all of the measurable objectives by improving conjunctive use of imported water and decreasing reliance on groundwater. Capture of excess runoff has the same contributions to the sustainability indicators as other recharge projects. These planning actions support numerous GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP, most notably those relating to conjunctive use and recharge.

ID4 has the legal authority to conduct these actions and no additional legal authority is required. Permits considerations and close coordination with the City's Stormwater Management Plan will be incorporated into the planning process. Public notice will be first accomplished through the outreach process during the public review of the draft GSP.

7.2.7 Support Sustainable Groundwater Supplies for KRGSA Disadvantaged Communities

The three founding KRGSA member agencies have established lines of communication and coordination with other agencies in the GSP Plan Area, many of whom provide water to DACs in the KRGSA Plan Area. In this manner, representation of these communities is considered in KRGSA actions and policies.

In addition, KRGSA will support Plan Area DACs in securing technical, managerial, and financial assistance through partnerships with local organizations such as the California Rural Water Association, as needed. Such agencies offer programs, including the Specialized Utilities Services Program, which could provide ongoing assistance to DACs in the KRGSA Plan Area. These programs, in conjunction with state and local grant funding, can support abandonment of poor-quality wells and/or installation of replacement wells to improve drinking water supply.

As evidenced by the details of the ENCSD Consolidation project discussed above, water quality problems in DAC areas often resolve around an impacted well. The first response often is to drill a replacement well, but typically the poor water quality is less of a well problem and more of an aquifer problem. KRGSA Plan Managers may have specialized knowledge about water quality in certain areas of the GSA and can advise applicants of new wells on known issues and provide names of knowledgeable drillers or other professionals who can assist with certain water quality problems.

In addition, a well with poor water quality requires proper abandonment to avoid spreading contaminants through the water column. Kern County currently notifies KRGSA Plan Managers when well drilling or abandonment applications are filed in the KRGSA Plan Area. This provides KRGSA Plan Managers with the opportunity to notify well owners about GSP management actions and to better understand potential local issues with respect to water quality in the area. The KRGSA will continue to coordinate with Kern County on the well permitting process to assist new well applicants in their service area, as needed, and to ensure proper abandonment of wells, especially those with poor water quality.

<u>Benefits and Implementation</u>: This action supports the measurable objectives associated with degraded water quality and promotes sustainable management throughout the KRGSA in support of the Sustainability Goal. The action supports several GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP including maintaining relationships with regulators (including Kern County Environmental Health), supporting proper well abandonment, and minimizing migration of contaminated groundwater. No new legal authority or permitting is associated with this action. Costs are administrative and consistent with other managerial activities of the KRGSA Plan Managers. Additional public notice of these actions will be provided through the public review period of this GSP.

7.2.8 Improve Groundwater Monitoring in the KRGSA Plan Area

It is the policy of the KRGSA to monitor groundwater for GSP compliance and to provide the understanding necessary for sustainable groundwater management. The preliminary monitoring network described in **Section 6** of this GSP provides a technically-credible program for establishment and monitoring of sustainable management criteria and providing data for ongoing groundwater evaluation. Nonetheless, significant improvements for this monitoring network are envisioned. This management action provides a series for first steps for improving the KRGSA GSP monitoring network, all of which will be implemented in the Phase One Management Actions.

7.2.8.1 Improve Documentation of Well Construction in the KRGSA Plan Area

As discussed in **Section 6**, there are significant challenges in identifying wells appropriate for the GSP monitoring network, namely those that are inactive wells (i.e., non-pumping wells) with known construction and a reasonable record of water level data. Two areas where data require organization include much of the Agricultural MA and the northeastern KRGSA.

Drilling new wells is an option but installation of a reasonable number of wells across the area will take time and financial resources and may be unnecessary given the large number of wells that are routinely monitored. A systematic compilation of monitored wells and incorporation of those data into a data management system would be beneficial for selection of potential wells for the GSP monitoring network. A large water level database has been assembled for the GSP, but identifying which monitoring wells have reliable access, long water level records, known construction data, and locations in key areas to support selection of sustainable management criteria has been difficult. Further, it is important that wells are not pumping and not adjacent to large production wells that would locally skew water level readings. Reliance on water levels is key to avoiding undesirable results.

In the Agricultural MA, KDWD has retained staff for managing the current monitoring program for annual reporting of depth to water and meeting other program requirements such as CASGEM. However, the GSP network would benefit from a more complete database of water level records and research on construction information. It is also important to begin to better understand the relationship in the Principal Aquifer to the perched water observed throughout the southern and eastern Agricultural MA.

To the extent possible, the GSP monitoring network will continue to identify and enlist monitoring wells installed or developed for other objectives. Working with data and information from the Central Valley Water Board on local monitoring well installation may provide some synergies with wells being installed by others.

If these efforts are insufficient to improve the GSP monitoring network such that minimum thresholds monitoring can be better evaluated throughout the KRGSA, key locations of potential new monitoring wells will be identified. Even if new wells are eventually required, the action of processing and documenting wells and well owners in the KRGSA will ultimately benefit ongoing GSP management.

<u>Benefits and Implementation</u>: This action should result in a better understanding of wells and water levels being recorded in the KRGSA. This knowledge fills a data gap and provides a useful link between water level monitoring and a better understanding of aquifer response. Because monitoring improvements supports improved understanding of the groundwater system, measurable objectives for all sustainability indicators are supported. The action supports several GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP including maintaining relationships with regulators and improvements to monitoring.

No legal authority is required to conduct work under this management action. No permitting or regulatory requirements are involved prior to drilling new monitoring wells. A more robust DMS in the KRGSA would also support Subbasin-wide evaluations of water level data. Public notice will be provided through the public review period of this GSP and will improve cooperation of well owners to assist with this action.

7.2.8.2 Coordinate Water Quality Analysis through Existing Monitoring Programs

Numerous regulatory and monitoring programs are generating water quality data for wells in the Principal Aquifer in the KRGSA Plan Area. This management action involves the KRGSA Plan Managers to compile and review water quality from multiple programs for a more comprehensive understanding of water quality conditions in the KRGSA Plan Area. Results of this action will support coordinated management of water quality across the KRGSA, provide efficiencies such that duplicative water quality monitoring is not conducted, and ensure that management actions do not degrade groundwater quality.

Primary water quality monitoring programs that provide useful data to this management action are acknowledged below:

- Nitrate and TDS monitoring as part of the Irrigated Lands Regulatory Program (ILRP) through the Kern River Watershed Coalition Authority
- Contaminant monitoring as part of the cleanup and environmental sites investigations regulated by the Central Valley Water Board
- Municipal Well water quality sampling and analysis as part of Title 22 and permit requirements from the SWRCB-DDW
- Small community water systems monitoring for water quality in compliance with DDW requirements
- Ongoing monitoring efforts by the USGS as part of the continuation of the GAMA program.

Individual member agencies are engaged in several of these programs, but no current efforts exist to compile data for a more comprehensive understanding of groundwater conditions. Collectively, these programs provide powerful data to support sustainable groundwater management.

KRGSA Plan Managers will decide the best manner in which to compile data into a database and where such a database will reside. There is the potential to coordinate with other GSAs for database structure and compatibility for a Subbasin-wide DMS. The SWRCB has developed its Geotracker online database where much of the state's water quality data are assembled. This management action does not intend to duplicate these efforts. Rather development of a focused KRGSA-specific database is envisioned to meet local objectives relating to SGMA.

<u>Benefits and Implementation</u>: This management action supports measurable objectives relating to degraded water quality and provides information on the potential for migration of plumes. Other benefits include development of a local water quality database to support future actions and evaluations. This action also directly addresses data gaps for groundwater quality recognized in **Section 3.4**. Several GSP elements described in Water Code §10727.4 and listed in **Section 2.6.6** of this GSP are supported by this management action, most notably efforts to develop relationships with state and federal regulatory agencies maintaining relationships with regulators and improvements to monitoring.

No impediments to this management action are identified and the actions can be implemented beginning in 2020. No legal authority beyond GSA mandates is needed for implementation of this management action. No permitting, regulatory requirements, or CEQA review are applicable. Public notice of this action will be provided through the public review process associated of this GSP.

7.2.8.3 Secure Inactive Wells/Dedicated Monitoring Wells

A substantial level of effort has been made to identify dedicated monitoring wells for the KRGSA network including previously-active production wells that are not now in use. However, some active production wells remain in the current KRGSA GSP monitoring program. These wells have been incorporated into this initial GSP network to take advantage of relatively long water level records and the best available historical datasets.

It is recognized that water level measurements in production wells could be influenced by pumping if wells are not shut down for a sufficient amount of time prior to monitoring. Use of these wells may result in lower water level measurements than actually exist in the aquifer and could indicate an exceedance of sustainable management criteria when none has occurred. While not technically optimal, lower water levels measurements are considered conservative and protective of undesirable results; as such, the program is determined to be sufficient for the first few years of implementation. During this time, monitoring will occur when wells have been inactive for a reasonable amount of time (determined on a well-by-well basis). Over the next five years, these wells will be replaced by dedicated monitoring wells, which may consist of inactive wells that are determined to be sufficient for incorporation into the KRGSA monitoring network.

7.2.8.4 Obtain Access Agreements for GSP Monitoring Network Wells

Although the current GSP monitoring network contains wells that have been monitored for decades to support complementary programs such as the Kern Fan Monitoring Committee and CASGEM, most network wells are not owned by the KRGSA member agencies and access agreements for GSP monitoring are not yet in place. As documented in the Subbasin-wide monitoring protocols (**Section 6.2.4**), over the first five years of implementation, access agreements will be negotiated with network wells that demonstrate technical ability to monitor sustainable management criteria as developed in this GSP.

7.2.9 Avoid Widespread Impacts to Domestic and Small Water System Wells in the Plan Area

This management action has been developed in response to a request for clarification in the DWR Determination Letter (DWR, January 28, 2022, page 32 of 40). In that request, DWR referenced a management action *related to identification of well users, including domestic users and small water systems, in the agricultural subareas of the Agricultural Management Area* (DWR, 2022, p. 32 of 40). Details of that management action were fragmented among several management actions, and the issue was not fully addressed in the original 2020 KRGSA GSP. For the Amended KRGSA GSP, this new management action has been developed to provide clarity and more focused information on the issue of potential impacts to domestic and small water system wells. The new management action is based on an updated analysis of potential impacts to domestic and small water system wells throughout the entire Plan Area (see **Sections 2.4.6.2** and **5.4.4.4**).

As stated in **Section 5.4.2**, the KRGSA intends to manage groundwater to support all beneficial uses. This includes management that protects against significant and unreasonable impacts to drinking water as accessed by domestic and small water system wells in the Plan Area. In order to support this goal, this management action takes important steps to better identify, track, and manage potential impacts to active drinking water wells. Specific components of the management action include documenting active domestic and small water system wells, tracking the potential for impacts to these wells, investigating local impacts, and adjusting groundwater management activities to address potentially impacted areas. These components are described in more detail below.

7.2.9.1 Document Active Domestic and Small Water System Wells

As described in **Section 5.4.4.4**, widespread impacts to domestic wells or small water system wells have not been identified in the KRGSA Plan Area. However, there are significant data gaps associated with these wells, including numbers and locations of active wells that are currently supplying drinking water. As described in **Section 2.4.6.2**, there are approximately 1,071 domestic wells that have been drilled in the Plan Area dating back to at least the 1950s according to a recently updated DWR WCR database. The analysis in **Section 5.4.4.4** considers the database to represent the best available data for all potential domestic wells in the Plan Area. Yet, it is not known which of these wells are currently active.

Within the ID4 service area, all active wells are registered, including domestic wells with a de minimis amount of annual production (two acre feet per year or less as defined by SGMA) (see **Section 2.4.6.1**). As part of this management action, those data will be reviewed for identification and information on active domestic and small water system wells. Data gaps associated with these data will be identified and addressed over time. This dataset covers a substantial portion of the Urban MA and smaller portions of the Agricultural MA. As such, use of this dataset represents a significant step for identifying a large number of active Plan Area wells. For the remaining areas of the Urban MA, City managers will assist with various methods to identify and tabulate remaining active domestic and small water system wells over time. Urban MA domestic wells are also protected by the MTs, set at or near historic low water levels and conservative triggers for a Management Area exceedance (**Section 5.10.2.1**).

For the Agricultural MA, KDWD has already begun the process of identifying and surveying active domestic well locations. A similar process conducted for agricultural wells as part of the 2020 GSP identified more than 600 active agricultural wells in KDWD, some of which may also provide domestic water supply (see **Section 2.4.6.1**). To the extent practical, KDWD is expanding its GPS well surveying program to include active domestic wells throughout the KDWD service area of the Agricultural MA.

In addition, the KRGSA managers are coordinating with Kern County to develop a systematic review process for all new well permit applications in the KRGSA. This process will be used to identify well permit applications for new domestic and small water system wells throughout the Plan Area to keep the dataset current going forward.

7.2.9.2 Track the Potential for Impacts to Active Domestic and Small Water System Wells

The primary method for tracking potential impacts to domestic and small water system wells is the ongoing monitoring of RMWs for compliance with sustainable management criteria. As indicated in **Section 5.4.4.4**, MTs appear to be protective of about 97 percent of all domestic wells that have been drilled in the Plan Area (as indicated by DWR well completion reports database). When any MT exceedance occurs in any RMW, the KRGSA managers implement their Action Plan for investigating groundwater conditions in that area (see **Section 7.2.1**).

Because sustainable management criteria allow for some exceedances of MTs over a brief period of time, a small number of additional domestic wells could potentially be impacted (see **Section 5.10.2.2**). Accordingly, the KRGSA intends to take additional steps for tracking potential impacts. Such steps include the periodic monitoring of the DWR Website for Household Water Supply Shortages where wells owners can self-report failed domestic wells. Data from that website has been reviewed for reported impacts in the KRGSA Plan Area as described in **Section 5.4.4.4**.

In addition, DWR has recently developed online tools for tracking potential impacts to domestic wells before they occur. Specifically, DWR has added a *Dry Domestic Well Susceptibility* tool to its *California Groundwater Live* website (https://sgma.water.ca.gov/CalGWLive/). This tool, combined with the domestic well analysis in **Section 5.4.4.4**, can serve as an early warning tool of potentially impacted areas of domestic wells.

As the first responder during drought conditions, the Kern County Office of Emergency Services provides local resources that may be helpful for domestic well owners. Accordingly, this office may have the first contact with an impacted well owner in the KRGSA Plan Area. The KRGSA managers will coordinate with the County to track when and where well impacts in the Plan Area are reported.

Most KRGSA member agencies are public drinking water suppliers including the City, ID4, NORMWD/OMWC, and ENCSD. In addition to KRGSA, the Greenfield CWD GSA is also a drinking water supplier in the Plan Area. These agency relationships provide good coordination in the Plan Area between local water purveyors and KRGSA. These purveyors have knowledge of local groundwater conditions and may be contacted by impacted well owners or local water haulers for supplemental water supply.

In addition to the agency coordination described above, KRGSA will continue outreach to domestic and small water system well owners in the Plan Area to better understand when and where local well impacts are occurring.

7.2.9.3 Investigate Issues and Assist Active Domestic and Small Water System Wells

After an impact to a domestic or small drinking water well has been identified, KRGSA will assess local conditions in the impacted area. In cooperation with purveyors, regulating agencies, and impacted well owners, KRGSA will compile information on where and how impacts are likely occurring. Management activities will be reviewed to determine if adjustments are needed. Specifically, KRGSA will identify what actions might be helpful to protect against worsening conditions and avoiding impacts to additional wells (see **Section 7.2.9.4** below).

Once impacts have been assessed, the KRGSA can offer additional contacts for resources and technical assistance, if appropriate. KRGSA, in cooperation with local purveyors, may be able to identify potential short-term assistance with water hauling from a Plan Area purveyor. As described below, several existing non-governmental organizations (NGOs) provide local assistance for impacts to rural and/or low-income impacted well owners.

In particular, Self-Help Enterprises (SHE) has state funding to provide emergency assistance for owners of failed domestic wells, including technical and financial assistance for numerous programs in Kern County involving testing, short-term emergency water supplies (e.g., bottled water or hauled water), and long-term assistance. SHE has been helpful in assisting impacted well owners, including at least one in the Plan Area, and has also assisted KRGSA with outreach meetings on the development of the 2020 GSP. Many of these programs are overseen by the California Regional Water Boards and are funded through the State's Division of Financial Assistance Statewide and Regional SAFER[47] programs. According to the recent updated SAFER Programs status (June 2022), more than $50 million remain in the SHE funding programs involving Kern County[48].

KRGSA can also coordinate with local purveyors and non-governmental organizations (NGOs) on the possibility of long-term assistance regarding local hookups to other water systems or small water system consolidations. As reported in the 3rd Annual GSP Report for the Kern County Subbasin, several water system consolidations are currently underway in the KRGSA Plan Area. One such project was incorporated into the 2020 GSP projects list. Specifically, ENCSD is working to consolidate up to six small water systems into its service area to improve local groundwater quality and reliability in nearby DACs (see **Section 7.1.5**). Lamont PUD is also working with DDW on the consolidation of El Adobe POA into the Lamont service area. Finally, the City is consolidating two small water systems in underrepresented communities (South Kern Mutual Water Company and Old River Mutual Water Company) into its service area for improvements to drinking water quality.

The Rural Community Assistance Corporation (RCAC) is an additional resource for drinking water impacts. RCAC is a 501(c)(3) nonprofit organization that serves rural communities through training, technical and financial assistance, and advocacy. Their sustainable rural water programs target small, low-income communities to assist with compliance of state and federal regulations. They are also the recipient of SAFER program funding for assistance on drinking water wells, especially for DACs. The City has developed relationships with RCAC over the years and can assist RCAC coordination as needed.

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[47] Safe and Affordable Funding for Equity and Resilience (SAFER) programs were designed to ensure Californians who lack safe, adequate, and affordable drinking water receive it as quickly as possible, and that the water systems serving them establish sustainable solutions. These programs support California's Human Right to Water law.

[48] Additional funds are available in Statewide SAFER programs, as well as SAFER programs with other funding recipients such as the Community Water Center (CWC) and California Rural Water Association (CRWA).

Additional potential assistance measures are provided in a related but separate management action to support sustainable groundwater supplies for DACs (**Section 7.2.7**). That management action identifies possible coordination with the California Rural Water Association for assistance with an impacted drinking water supply.

As part of its outreach efforts, the KRGSA is posting a list of resources for owners of failed domestic wells on its website. The posted list includes those Resources identified by DWR on its Household Water Supply Shortage website and provide any additional local resources for the KRGSA Plan Area. In addition, the KRGSA website includes a link to resources on the County's website, which includes a list of well drillers in Kern County and other County information on domestic wells.

7.2.9.4 Adjust KRGSA Management Activities, if Needed

Depending on the nature and extent of domestic and/or small water system impacts, KRGSA may identify management activities that could improve local conditions. Most of these measures are captured in a related but separate management action (see **Section 7.2.1**). In brief, the existing infrastructure of canals, wellfields, and surface water purification plants in the Plan Area provides significant flexibility to move water for improvement of local conditions. When combined with the numerous water sources that include the Kern River, imported water supplies, and recycled water, KRGSA has numerous possibilities for offsetting local impacts to wells.

If water levels are declining locally, KRGSA can work with local agencies to consider re-distribution of pumping, decreased pumping rates, or modification of pumping schedules. Domestic and small water system well owners may also benefit from local storage tanks to allow for pumping to storage when other production wells are offline. With numerous unlined canals and recharge basins, there is the potential to convey excess water for enhanced recharge to support water levels in certain areas, as needed. For example, KDWD began conveyance of irrigation water along the unlined Eastside Canal early in 2022 to support declining water levels being observed in some of the RMWs.

Long-term capital improvements, such as wellhead treatment or municipal well modifications, may also support this management action. A Phase Two GSP Project – discussed in a subsequent section below – describes equipping some municipal wells with variable drive pumps to allow more flexibility for pumping rate adjustments (see **Section 7.3.3**).

If local agricultural wells are impacting nearby domestic or small water system wells, there is also the potential to provide irrigation surface water to support in lieu pumping during certain time periods. A variety of water exchanges, re-operations, and other management activities are possible and can be developed as part of this management action over time.

7.2.9.5 Update Management Action

This management action is based on the best information available for domestic well and small water system well impacts in the Plan Area as documented by the impacts analysis in **Section 5.4.4.4**. Initial components of this management action will provide better locations and depths of potentially impacted wells and improve the predictions of potential future impacts. As more information is available, the activities associated with this management action may need to be revised. Accordingly, this management action will be re-assessed at the five-year GSP update (2025).

As indicated in **Sections 7.2.9.2** and **7.2.9.3** above, DWR and the SWRCB have developed numerous programs, datasets, and tools, along with technical and financial resources to assist with tracking and mitigating drinking water well impacts in the context of a GSP. Data and information from these additional resources will inform this management action going forward. In addition, it is our understanding that DWR is developing additional guidance with respect to impacts to drinking water supply wells, including domestic wells; that guidance may be available in Fall 2022. If appropriate, this management action may be revised in consideration of that guidance or other new information relevant to SGMA compliance.

7.2.9.6 Benefits and Implementation

This management action supports the sustainability goal by providing additional protection and assistance for beneficial uses of groundwater from domestic and small water system wells. This, in turn informs the sustainable management criteria, including measurable objectives (MOs), for all sustainability indicators, but in particular chronic lowering of water levels and water quality.

The management action is already being implemented with the ongoing field reconnaissance for locating active domestic wells. As a first step, the identification of active wells supports all remaining components of the management action including how groundwater management activities could be revised to protect against future impacts, if appropriate.

This management action is included in Phase One of the Amended KRGSA GSP management actions and will be implemented immediately. The management action will be maintained by the KRGSA managers as an ongoing program throughout the implementation horizon. The timing is shown on the implementation schedule in **Table 8-1** (**Section 8.1.1**), which has been amended to include this management action. The benefits of the program include improved protection of domestic and small water system wells to support beneficial uses of groundwater; the success of the management action will be demonstrated by the small number – or absence – of impacts to domestic or small water system wells from groundwater level declines from groundwater extractions throughout the Plan Area.

As stated in **Section 7.2.9.5** above, this management action was developed based on the best available information and will be revised through the collection of improved information. The management action accounts for uncertainty by requiring steps to better understand well impacts as they arise and adjust groundwater management activities accordingly. These steps are ongoing while KRGSA managers work to better predict future impacts.

This management action does not require permits or other regulatory processes for implementation, and no additional legal authority is required. KRGSA does not need to rely on water outside of the current water supplies in the Plan Area to accomplish this management action. However, it is the intent of KRGSA to coordinate with member agencies and local purveyors in the Plan Area, and others, as needed, to accomplish the objectives of the management action.

The cost of this management action will be shared initially among the KRGSA agencies through their normal operating funds. As with other GSP programs, agencies also commit significant levels of in-kind resources to GSP activities. For example, KDWD is committing staff time to perform field reconnaissance and GPS surveying of active domestic wells in the southern Agricultural MA. In addition, all of the KRGSA member agencies, Greenfield CWD GSA, and other entities coordinate on groundwater monitoring to track compliance with MTs and assist with identification of potential well impacts in the Plan Area. The well impacts program, along with other activities in this Amended KRGSA GSP, will be part of the ongoing GSP Implementation budget (see **Section 1.3.3**). Grant funding may also be considered in the future, if available.

This Amended KRGSA GSP and management action has been discussed with the KRGSA Board of Directors and stakeholders in public meetings including a public hearing held July 7, 2022. The management action – as part of the Amended KRGSA GSP – was adopted by the KRGSA Board of Directors immediately after the close of the public hearing. As described above, this Amended KRGSA GSP and resources for impacted drinking water well owners have been posted on the KRGSA website and will be maintained for future use.

7.2.10 Incorporate a Policy of Adaptive Management in the KRGSA GSP Process

This management action is included to state the KRGSA policy and intent to continue to monitor and evaluate groundwater conditions in response to management actions and adapt those actions to meet the sustainability goal of avoiding undesirable results. Specifically, this policy of adaptive management will allow for future adjustments to sustainable management criteria and undesirable results as GSP projects and management actions are implemented. Although minimum thresholds may be exceeded during the Implementation Period, the Projects associated with this plan – when fully implemented – are expected to provide an immediate and detectable response in the local groundwater system.

KRGSA Plan Managers also recognize the need for flexibility in the GSP. Numerous minimum thresholds and other sustainability criteria were selected in the absence of undesirable results; several were selected at conservative levels to ensure that the future potential of undesirable results can be mitigated. Actual MTs may be lower (or higher) than those selected. These will be re-evaluated for each five-year update of the GSP. Ongoing analysis will be summarized in each annual report.

Benefits and Implementation: This management action supports measurable objectives for all sustainability indicators in that managers are committed to meaningful, ongoing evaluation of sustainable management criteria, including the commitment to groundwater monitoring. The concept of adaptive management provides assurances to stakeholders that future groundwater management will not be constrained by current levels of uncertainty and estimates. Rather, management and sustainable management criteria will be adapted over time as more data are available for informed management