COMPREHENSIVE GROUNDWATER QUALITY MANAGEMENT PLAN

WESTSIDE WATER QUALITY COALITION

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Certification:

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1. INTRODUCTION AND BACKGROUND

This Comprehensive Groundwater Quality Management Plan (CGQMP) has been prepared by the Westside Water Quality Coalition (WWQC) in accordance with the requirements of the Waste Discharge Requirements General Order for Growers within the Tulare Lake Basin Area that are Members of a Third-Party Group, R5-2013-0120 (General Order). Groundwater Quality Management Plans are required for areas designated as high vulnerability areas in the Groundwater Quality Assessment Report (GAR) and for areas of confirmed water quality exceedances. The General Order provides an opportunity to develop a single CGQMP to address the noted exceedances rather than developing separate management plans for each area of concern.

A. Geographic Boundary

The WWQC coverage area is located in the north-westerly most portion of Kern County and the South-westerly most portion of Kings County and encompasses roughly 700,000 acres. The WWQC coverage area includes the communities of Lost Hills and Avenal and the boundaries of the Belridge Water Storage District (BWSD), Berrenda Mesa Water District (BMWD), Lost Hills Water District (LHWD), Devils Den Water District (DDWD) and a portion of Dudley Ridge Water District (DRWD). Major roads include portions of Interstate 5 and State Highways 33, 41, and 46. The WWQC coverage area is shown in **Figure 1.**

The areas to be covered by this CGQMP are all irrigated agriculture in WWQC, under active membership, and in the High Vulnerability Areas (HVA) previously proposed by Central Valley Water Board staff and used by the WWQC for Nitrogen Management Plan purposes. The high vulnerability areas are shown on **Figure 2.**

B. Constituents of Concern

Nitrate and salts and to a lesser extent certain agricultural chemicals, in the groundwater, are the focus of this CGQMP.

<u>Nitrate</u>

Nitrate is a naturally occurring form of nitrogen that can be formed from atmospheric nitrogen or decomposing organic matter. DWR (1970) noted that weathering granite, shales rich in organic matter, underground peat deposits, oilfield brines, and connate waters are considered potential natural sources of nitrate, and mapped the presence of nitrate in Kern County from 1950 to 1969. Nitrate can also be found in groundwater as a result of excess application of nitrogen fertilizers in irrigated agricultural and landscaped areas, percolation from feedlots or dairies, wastewater and food processing waste percolation, and leachate from septic system drain fields (Harter T., et al. 2012).

The Maximum Contaminant Level (MCL) for nitrate as N is 10mg/L or for nitrate (NO3) is 45mg/L. Over the previous 60 years, scattered wells tested in the WWQC area have shown levels of NO3 that have exceeded the MCL. The source of the NO3 contamination has not been definitively determined however, irrigated agriculture has historically been present in the WWQC area and is one potential NO3 source. However, some of the elevated NO3 concentrations in groundwater predated agricultural development or are associated with other non-irrigation sources of NO3. **Figure 3** shows the location of wells (either water supply or monitoring wells) where elevated nitrate concentrations have been detected.

Salts

Groundwater vulnerability is dependent upon its current and potential uses. The Secondary Maximum Contaminant Level (SMCL) for salinity in drinking water is 1,600 µmhos/cm. Groundwater in excess of the SMCL typically has aesthetic effects (taste, odor, color, and/or turbidity) that are usually not palatable for human consumption. Groundwater within the WWQC contains naturally elevated salinity based on groundwater contact with marine sediments containing salts.

Groundwater within the BWSD, BMWD, DDWD and LHWD consistently exceeded the SMCLs for salinity and are not used for domestic or municipal supply, except for one well in BMWD that has an under-sink treatment system (reverse osmosis) for limited domestic use. The principal purveyor of potable water, Lost Hills Utility District, obtains imported groundwater from wells located about 10 miles east of the WWQC for municipal water supply. The groundwater salinity of the unconfined/semi-confined groundwater within these districts is used for stock watering and occasionally for irrigation, after blending with higher quality imported water from the State Water Project (SWP). Confined groundwater is of somewhat lower salinity and is also used occasionally for irrigation, after blending with higher quality SWP water.

Unconfined/semi-confined groundwater within the Pleasant Valley hydrographic unit (Kettleman Plain and Sunflower Valley) is of somewhat lower salinity than within BWSD, BMWD, DDWD and LHWD and is used for irrigation and stock watering. The principal purveyor of potable water, the City of Avenal, obtains imported surface water from the California aqueduct for municipal water supply. Groundwater within the Pleasant Valley hydrographic unit is used for irrigation water supply and stock watering, where the salinity allows, specifically in northern Kettleman Plain and in Sunflower Valley. The exceptions would be based on poor mineral quality groundwater in Avenal Gap, Degany Gap, and Devils Den. **Figure 4** shows the distribution of EC concentrations within the WWQC area.

Ag Chemicals

CDPH (now part of the SWRCB) has required monitoring of pesticide residues in California municipal water supplies for many years. Much of these data are summarized in the SWRCB's GeoTracker GAMA database. During preparation of the WWQC's Groundwater Assessment Reports (GAR), Amec Foster Wheeler found pesticide analytical results for two wells in the Study Area for samples collected in 1987 through 2006. The samples were collected from two wells in southern BWSD (Clean Harbors) and a water system in central LHWD (La Cuesta Verde Ranches). These samples were analyzed for a variety of chlorinated pesticides and volatile organic compounds; none were detected. The Clean Harbors wells are identified on CDPH's DRINC database as "inactive." The database identified the La Cuesta Verde Ranches facility as "NP" or a "non-piped source of water…transported to a facility via a sanitary tanker."

The CDPR has monitored California well water for pesticide residues for more than 25 years. In 1982, CDPR collected water samples from one well in BWSD and one well in LHWD and arranged for selected pesticide analyses (carbofuran, 1,2-dibromochloropropane [DBCP], ethylene dibromide, and simazine); none were detected. The CDPR did not find detected pesticides in these well water samples collected within the WWQC Area.

In 2008, the USGS published the results of a study of *Nitrate and Pesticides in Groundwater in the Eastern San Joaquin Valley* (USGS, 2008b). Although the USGS Study Area did not include the Northern Supplemental Area of the Coalition, it identifies the pesticides most likely to be detected in groundwater. USGS found that the most frequently detected pesticides were atrazine, simazine, diuron, 1,2,3-trichloropropane (TCP), and DBCP. Also in 2008, the USGS published the results of a similar study for the central part of Kern County (not including this Study Area) (USGS, 2008a). For central Kern County, USGS found that the most frequently detected pesticides were atrazine, simazine, 1,2-dichloropropane (DCP).

While preparing the GARs, the GeoTracker GAMA database was searched for analytical data on atrazine, simazine, diuron, TCP, DBCP, and DCP for groundwater within the Study Area. The following table summarizes the results of that review:

Pesticide	Wells with Data	Wells with Detections
Atrazine	31	1 (E)
Simazine	42	1 (E)
Diuron	17	0
TCP	28	0
DBCP	41	0
DCP	25	1

E = estimated value at or below analytical detection level

This review indicated that the available data for the WWQC Study Area did not typically include detections of pesticides commonly detected in groundwater. Two of the reported detections (atrazine and simazine) were at or near the analytical detection level; well below concentrations of potential health concern in drinking water. DCP was detected in one sample at a concentration of 0.3 µg/L, well below the MCL for DCP in drinking water (5.0 µg/L).

DWR's agricultural drainage database, was also reviewed for analytical data on atrazine, simazine, diuron, TCP, DBCP, and DCP in perched groundwater within BWSD and LHWD. DWR sampled one tile drain (LNW5467) in LHWD for pesticides consisting of 12 samples collected between 2006 and 2012. Drainage water samples were not analyzed for TCP, DBCP, or DCP.

Pesticide	LNW5467 Samples	Samples with Detections
Atrazine	12	2
Simazine	12	2
Diuron	12	3

The maximum detected concentrations of atrazine, simazine, and diuron were 0.09, 0.05, and 0.34 µg/L, respectively. These detected concentrations were well below the corresponding MCLs for atrazine and simazine (1.0 and 4.0 µg/L, respectively); an MCL has not been established for diuron. The most recent samples (2011) from LNW5467 did not contain detectable atrazine, simazine, or diuron.

Based on the above data, pesticides were infrequently detected in groundwater samples from wells within the WWQC and the detections were at concentrations well below corresponding MCLs.

C. Objectives

The overall objective of a groundwater quality management plan is to determine whether irrigated agriculture is known to cause or contribute to the degradation of groundwater quality and if so, to reduce impacts to meet groundwater quality receiving limitations. If the impacts of irrigated agriculture on groundwater quality cannot be definitively established, then approved studies or other activities, such as outreach and education, can be implemented to reduce potential impacts from irrigated agricultural in the future. As described in the WWQC GAR, much of the groundwater quality data available in the area is over 50 years old and some pre-date agricultural development. Many of the management practices that will be proposed during the Management Practice Evaluation Program (MPEP) process have already been implemented by growers in the WWQC. Therefore, it is possible that groundwater quality may have improved since those samples were collected.

The WWQC will work cooperatively with Regional Board staff to develop a strategy to investigate the potential sources of NO3 and salts impacts in groundwater and to determine if current irrigated agricultural practices can be eliminated as the source of said impacts in certain HVAs. If these efforts prove inconclusive, then this CGQMP provides a strategy to; (1) evaluate agricultural practices, (2) provide education and outreach programs, (3) solicit feedback from the MPEP process and (4) implement approved management practices that are deemed protective of groundwater quality. Groundwater monitoring will be addressed in the Groundwater Trend Monitoring Program process.

2. PHYSICAL SETTING AND INFORMATION

A. Land Use

Agriculture is the primary land use within the WWQC area with approximately 15% of the area was irrigated agriculture in 2016. Approximately 82% of the area was fallow, rangeland or oil fields, and approximately 3% is used for general commercial purposes. The remaining areas are attributed to residential, roadways, reservoirs, and other miscellaneous non-agricultural uses.

Table 1 provides a comparison of acreage by certain areas within the WWQC.

Table 1

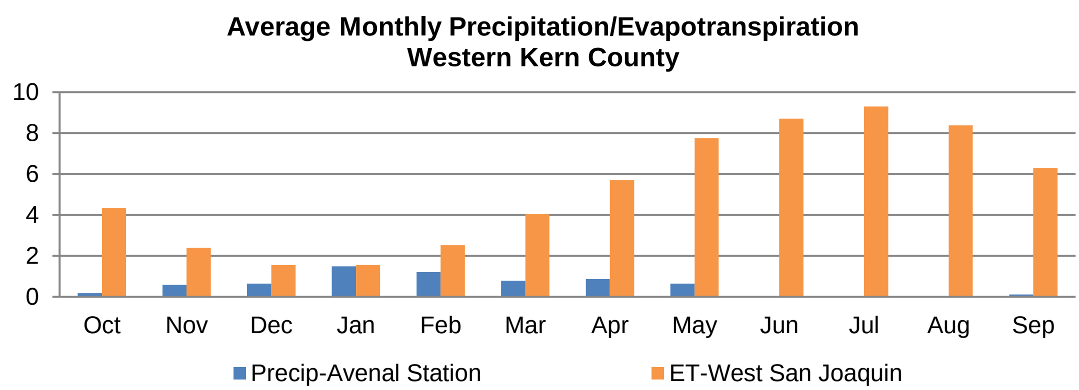
	Total	Irrigated
BWSD	97,396	36,563
BMWD	55,440	21,893
DRWD	17,280	9,891
LHWD	74,357	26,513
WSA	213,499	0
NSA	230,222	5,904
Totals	688,194	100,764
Percentages	100%	15%

Almonds, pistachios, citrus and carrots are the primary crops grown in the WWQC area and comprise 97% of all crops grown in the WWQC area in 2016. Crop acres are shown on **Figure 5.**

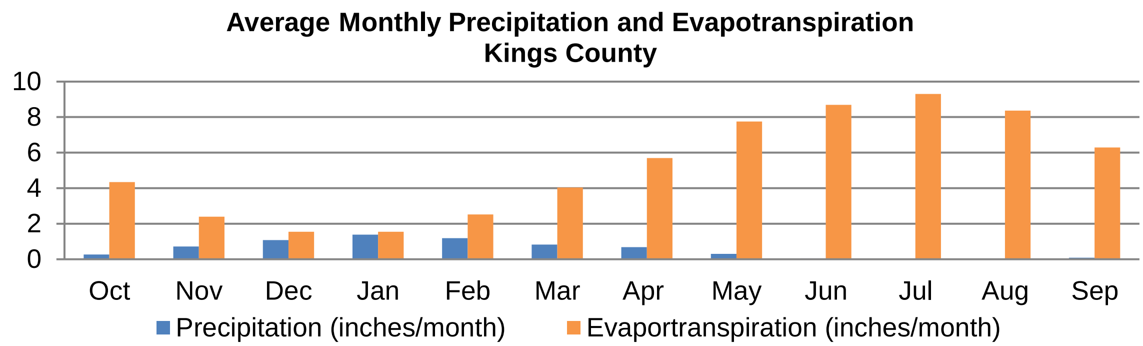
B. Climate

Regional climate can be described as semi-arid with summers that are typically hot and dry with daytime temperatures reaching above 100 degrees Fahrenheit. No significant precipitation occurs during the summer months. The winters are typically cooler with daytime highs in the 60's. Most of the precipitation occurs from November to April with an average annual rainfall of 6 inches. Precipitation amounts increase slightly moving west into the foothills of the Temblor Range.

The monthly average precipitation (Precip in inches per month) and evapotranspiration (ET in inches per month) for the western Kern County area are summarized in the following chart:



The monthly average Precip and ET for the Kings County area are similar, as shown in the following chart:



C. Geology and Soil

The Study Area is within the southwestern portion of the San Joaquin Valley. Regional geology in the southwestern San Joaquin Valley is characterized by a long history of structural deformation associated with tectonic movement along the continental borderland, including the prominent and still active San Andreas Fault. Uplift of the Sierra Nevada east of the valley, later uplift of the Temblor Range on west side, and formation of the deep structural trough beneath the valley floor, have resulted in the accumulation of more than 20,000 feet of marine and terrestrial sediments of Cretaceous to Holocene age throughout the basin (Maher et al., 1975). **Figure 6** shows the localized surface geology for the WWQC area.

Surface soils for the Study Area are described in soil surveys (USDA, 1986 and 1988; NRCS 1986, 1988 and 2014).

For northwestern Kern County (BWSD, BMWD, and LHWD), soils transition from well-drained alluvial fans and plains on the east to somewhat poorly drained basin clays and silt loams on the west. For the western Kings County (DRWD), soils transition from well drained alluvial fans on the west to saline-alkaline basin loams or clay loams on the east. Soils in the Kettleman Plain and Sunflower Valley are described as naturally saline-alkaline, well to excessively drained loamy alluvium derived primarily from sedimentary rock. The distribution of these primary soil series is shown on **Figure 7** with a detailed description provided in **Figure 8**.

D. Hydrogeology

Within the WWQC area, groundwater occurs under perched, unconfined, semi-confined and confined conditions. In eastern LHWD and eastern BWSD, groundwater occurs under all these conditions. Perched groundwater extends from the eastern boundary of the WWQC to the base of the Lost Hills and Belridge anticlines. Unconfined or semi-confined groundwater occurs below the perched groundwater in eastern LHWD and eastern BWSD as well as throughout the remainder of Pleasant Valley hydrographic unit (Kettleman Plain and Sunflower Valley) and western Kern County hydrographic unit (Antelope Plain). Confined groundwater occurs below the E-clay (Corcoran Clay below about 600 feet in depth) in eastern BWSD, eastern LHWD, and DRWD. Neither perched nor confined groundwater is known to occur below Pleasant Valley hydrographic unit (Kettleman Plain and Sunflower Valley) and western Kern County hydrographic unit (Antelope Plain).

Three groundwater sub-basins, as defined in DWR Bulletin 118, underlie the WWQC Study Area (Kern County, Tulare Lake and Pleasant Valley) (**Figure 9**). Generally, groundwater within the WWQC Study Area occurs under perched, unconfined, and confined conditions (USGS 1959, KCWA 1974). A more detailed description of groundwater conditions is provided on a sub-basin level in the following section.

Kern County and Tulare Lake Sub-basins – (DWR 5-22. 14 & .12)

The portion of WWQC that overlies the Kern County and Tulare Lake sub-basins is generally located in western most Kern County and southeastern Kings County in an area known as the Antelope Plain and near the town of Kettleman City, respectively and encompasses the boundaries of the Belridge Water Storage District, Berrenda Mesa Water District, Lost Hills Water District and a portion of the Dudley Ridge Water District (Districts).

Areas of shallow perched groundwater in this portion of the WWQC Study Area appear to correspond to the presence of a shallow clay layer (designated the A-clay) beneath the BWSD, DRWD and LHWD. The perched aquifer consists of Pleistocene-Holocene fluvial and flood basin sediments comprised predominately of silts and clay interbedded with sand layers (Hilton et al., 1963; Croft, 1972). These sediments overlie the A-clay and grade laterally into younger alluvium to the west. The areal extent of perched aquifers appears centered on an axis along the Kern River Flood Channel between Goose Lake and Tulare Lake beds and lie east of the California Aqueduct (DWR, 2008). The lateral extents of the A-clay are poorly constrained.

The A-clay reportedly has been encountered under LHWD at depths of 30 to 60 feet (P&P, 2007). The poor mineral quality of groundwater below the Study Area has been documented in many area groundwater studies conducted by federal, state, and local agencies and has been acknowledged in WDRs issued by the RWQCB for individual facilities in the vicinity of the Study Area. The poor mineral quality of groundwater has also severely limited beneficial uses of groundwater within the Study Area. Because of the poor mineral quality of groundwater within the Study Area, surface water is imported from the SWP into the Districts for AGR uses. As such, there are almost no remaining AGR-Irrigation or MUN uses of groundwater within the Districts. Some IND beneficial uses of water remain (principally water for water/steam flood in oil fields); such IND uses of water are not limited by poor water quality.

Unconfined aquifers exist in alluvial sediments east of the Lost Hills Anticline and below the perched groundwater in the upper Tulare Formation. The unconfined aquifer consists predominately of coarser alluvial sediments flanking the Temblor Range that grade laterally eastward into finer grained fluvial, marsh, deltaic, and lacustrine deposits between Goose Lake and Tulare Lake. In areas where fluvial deposits become highly interbedded and bifurcated, semi-confined groundwater conditions may be encountered in the upper Tulare Formation. The base of the unconfined aquifer is defined by the presence of the Corcoran Clay (E-clay), where it is present. In areas where the E-clay is absent, the unconfined aquifer extends to the top of the marine formations.

The modified E-clay described in Page (1986) forms the major regional aquitard that separates the upper unconfined aquifer from the lower confined aquifer in the southwestern San Joaquin Valley. Within BWSD and LHWD, it has been encountered in wells east of the California Aqueduct (Page, 1986). The E-clay is also known to underlie DRWD and portions of LHWD east of the Lost Hills Anticline, but appears absent west of this structure beneath the Antelope Plain (P&P, 2007) and BMWD. The presence of the E-clay beneath BWSD west of the California Aqueduct is poorly constrained. The depth at which the E-clay is encountered varies due to structural deformation associated with the presence of anticline and syncline structures along the west side of the valley. It is encountered as shallow as 100 feet along the east limb of Lost Hills (P&P, 2007) to as deep as 900 feet near the southwest edge of Tulare Lake bed (Page, 1986). The thickness of the E-clay ranges from 8 feet south of Lost Hills to 205 feet near the southwest edge of the Tulare Lake bed (Page, 1986).

Groundwater below the E-clay is encountered in confined conditions. The Tulare Formation below the E-clay consists of unconsolidated interbedded sand, silt, and clay. The nature of these sediments ranges from coarser alluvial fan deposits near the Temblor Range to fine grained lacustrine, fluvial, and marsh deposits eastward toward the axis of the valley trough (Croft, 1972).

Occurrence of Groundwater in Kern County and Tulare Lake Sub-basins
The DWR indicates that perched groundwater occurs below the eastern Districts (DWR, 2008). Perched water in portions of the BWSD, DRWD, and LHWD ranges in depth from 5 to 20 feet (Appendix C). DWR does not identify perched groundwater in the BMWD, although it may be

present in some areas.

The DWR does not characterize the occurrence of semi-confined or confined groundwater within the Study Area due to lack of current data. However, the Kern County Water Agency (KCWA) indicates the depth to groundwater in the Districts (except BMWD and DRWD) in 2001 was between 50 and 100 feet with a general gradient to the east. KCWA performed a groundwater study between 1970 and 1974 (KCWA, 1974) within the Districts; at that time, groundwater gradients in the unconfined aquifer showed an east-northeast trend, except around the Lost Hills anticline, which appeared to act as a hydraulic barrier. In the immediate vicinity of the anticline, groundwater level data indicate that groundwater flows radially away from the axis of the anticline. (Figure 10)

Pleasant Valley Sub-basin (5-22.10)

The Pleasant Valley sub-basin lies along the west side of the San Joaquin Valley, north of the Kings-Kern County line. It straddles the Fresno-Kings County Line. The sub-basin is surrounded throughout most of its perimeter by Tertiary continental and marine sediments of the Coast Ranges and west flank of the Kettleman Hills. The sub-basin includes the older and younger alluvium of the San Joaquin Valley. The eastern boundary of the sub-basin abuts the Westside and Tulare Lake sub-basins. The southern boundary abuts the Kern County portion of the Tulare Lake sub-basin. These sub-basin boundaries have been derived from both hydrologic and political criteria. The Kings County portion of the Pleasant Valley Sub-basin extending from Avenal to the north to Devils Den in the south and Kettleman Hills on the east to the Kreyenhagen Hills on the west. Internal valleys (the Kettleman Plain and Sunflower Valley) formed of alluvial sediments from these hills and currently include some irrigated agriculture. The principal surface water in the NSA is Avenal Creek, an ephemeral stream bed that occasionally flows from the Kreyenhagen Hills through Sunflower Valley, Dagany Gap, the Kettleman Plain, and Avenal Gap into the Tulare Lake Basin. Groundwater is encountered in two basins with the northern portion of WWQC: the Kettleman Plain and Sunflower Valley. Within the Kettleman Plain, the unconsolidated Tulare Formation and alluvium (older and younger) comprise the primary aquifers. In Sunflower Valley, the alluvium comprises the principal aquifer; the Tulare Formation appears absent.

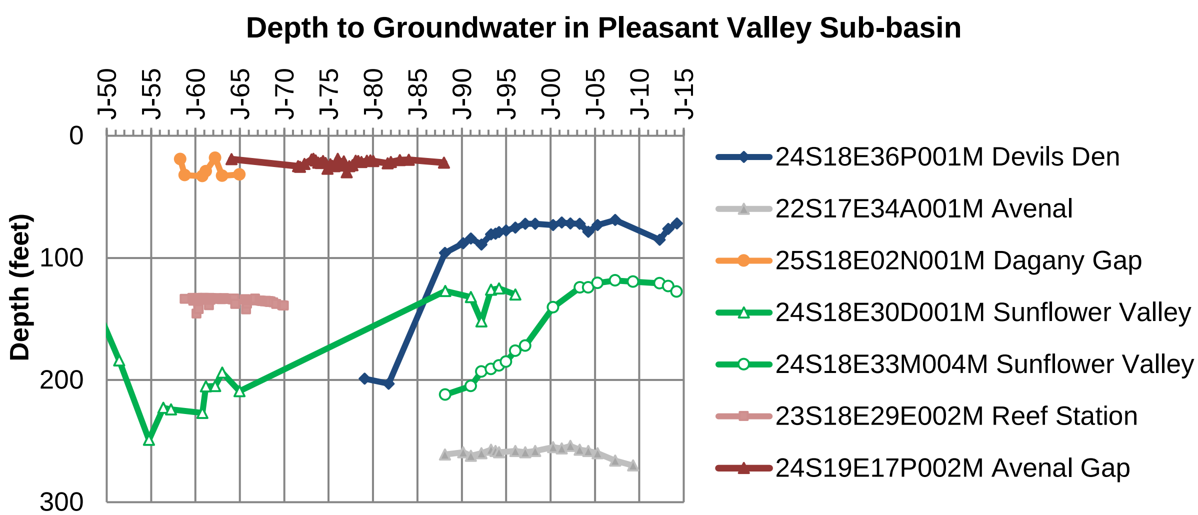
Occurrence of Groundwater - Kettleman Plain
Groundwater occurrence in the Kettleman Plain occurs in aquifers developed in the Tulare Formation and overlying alluvium. These sediments are comprised of mostly silty material containing lenses of poorly sorted sand and gravel (Wood and Davis, 1959). Irrigation wells south and west of Avenal Gap and east of Dagany Gap range in depth between 500 to 1,432 feet (Wood and Davis, 1959). Groundwater yields range from 300 to about 1,400 gallons per minute (gpm) and average about 800 gpm. Specific capacities range from 6 to 21 gpm per foot of drawdown with an average of 14 gpm per foot of drawdown.

Depth to groundwater ranges from 39 to 340 feet bgs. Groundwater flow is generally from north to south and toward Avenal and Dagany Gaps. Historically, groundwater flowed through Avenal and Dagany Gaps but now is generally intersected by irrigation wells (Wood and Davis, 1959).

Occurrence of Groundwater - Sunflower Valley

Groundwater in Sunflower Valley occurs in the alluvium that ranges in thickness from a few feet to about 400 to 500 feet below ground surface (bgs) (Wood and Davis, 1959). The alluvium unconformably overlies marine sedimentary rock of Tertiary age. The alluvium consists of poorly sorted silty material that contains lenses of gravel and clayey gravel (Wood and Davis, 1959) derived from eroded marine sediments. Irrigation wells range in depth from 150 to 625 feet bgs (Wood and Davis, 1959). Historical groundwater yields range between 200 gpm near Dagany Gap to more than 1,000 gpm in the northern irrigated areas (Wood and Davis, 1959). Specific capacities range from 12 to 100 gpm per foot of drawdown with an average of 35 gpm per foot of drawdown. Depth to groundwater ranges from 19 to 257 feet bgs. Groundwater flow is generally from west to east and toward a pumping depression west of Dagany Gap. Historically, groundwater flowed through Avenal and Dagany Gaps but now is generally intersected by irrigation wells (Wood and Davis, 1959). Historically, groundwater encountered a fault barrier upstream of Dagany Gap and rose to the surface a series of low flowing springs known as Alamo Solo springs (Wood and Davis, 1959). The spring ceased flowing shortly after groundwater was pumped for irrigation west of Dagany Gap (Wood and Davis, 1959). Currently, Dagany Gap functions as a groundwater divide and groundwater within Sunflower Valley does not flow further east of the divide (Wood and Davis, 1959).

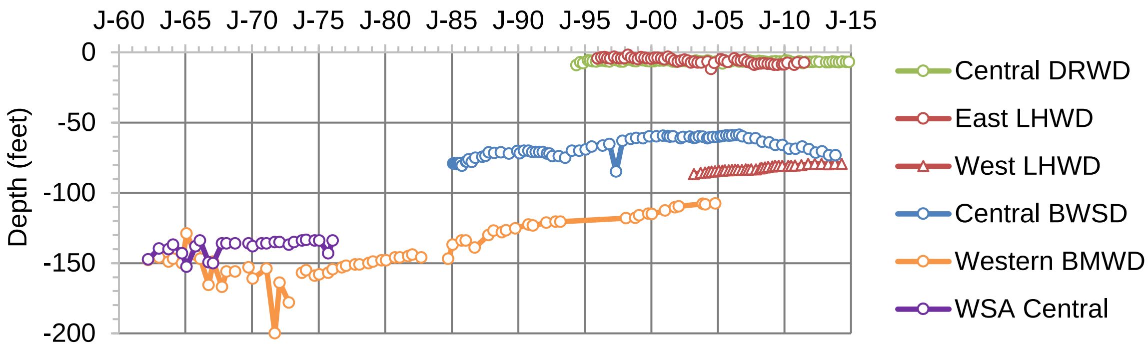
Within the Pleasant Valley Sub-basin, groundwater occurs primarily in the alluvium and in the Tulare Formation. Although there are limited data on groundwater occurrence within the area, it is clear that the depth to groundwater varies spatially and temporally. The following chart compares the depth to groundwater (DWR, 2014) in selected wells within these areas:



The depth to groundwater has varied spatially from about 25 feet below Degany Gap to more than 250 feet below the City of Avenal. Over the past 60 years, the depth to groundwater has decreased from 249 to 119 feet in Sunflower Valley and from 203 to 72 feet in the Devils Den area. Depth to groundwater in the vicinity of Avenal has been relatively constant at about 260 feet. These data indicate that with the exception of Degany Gap, these areas have a substantial unsaturated zone varying from 70 to 250 feet.

The following chart compares the depth to groundwater for selected wells within the Kern County and Tulare Lake sub-basin parts of WWQC:

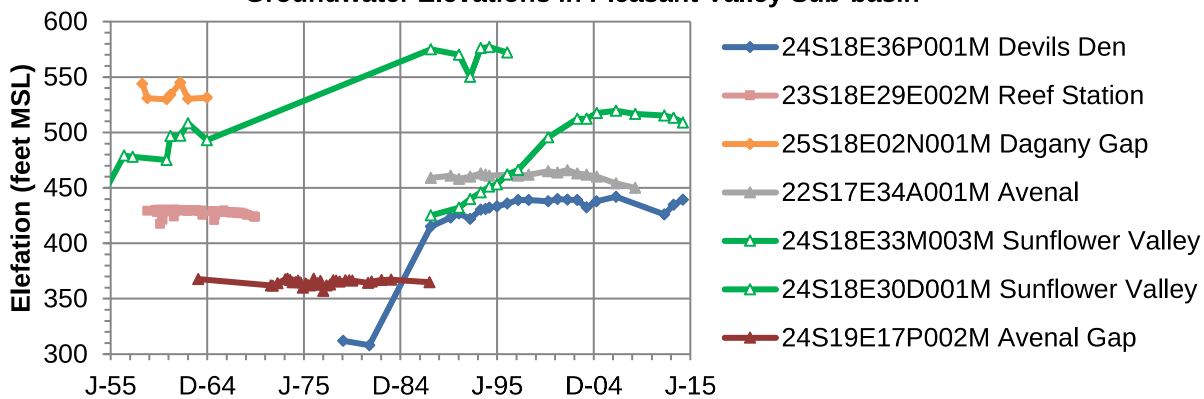
Depth to Groundwater below Kern County and Tulare Lake Sub-basins



Perched groundwater occurs in the central part of DRWD and eastern LHWD between 2 and 12 feet below ground surface. Wells within western LHWD, central BWSD, BMWD and the WSA produce water from the unconfined/semi-confined aquifer. Unconfined/semi-confined groundwater within these wells varies between 59 and 200 feet below ground surface.

During preparation of the WWQC GAR, Amec Foster Wheeler also plotted the calculated groundwater elevations for selected wells to evaluate groundwater gradients. The following chart compares groundwater elevations in wells within the Pleasant Valley sub-basin:

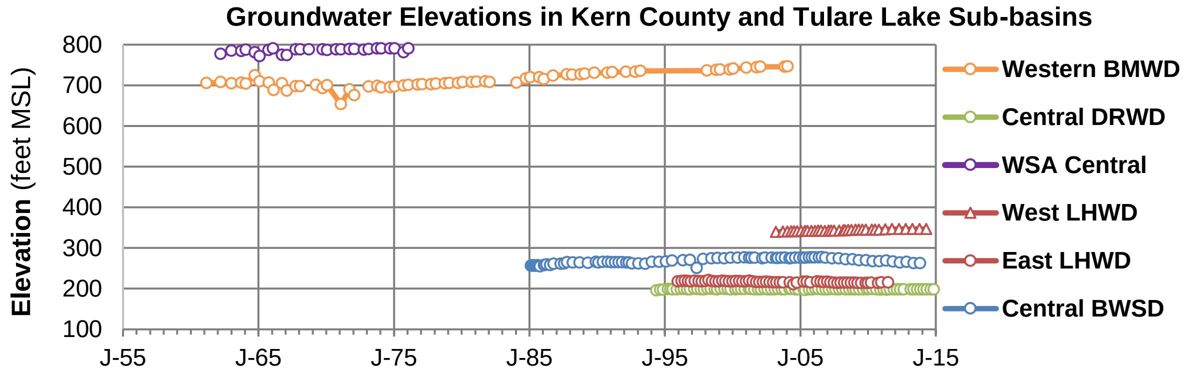
Groundwater Elevations in Pleasant Valley Sub-basin



The above chart shows that groundwater has varied by as much at 140 feet in wells within Devils Den and Sunflower Valley. However, the available data show stable groundwater elevations for the areas of Avenal, Avenal Gap, Dagany Gap, and Reef Station. Based on the above data, the highest groundwater elevations occurred within in Dagany Gap in the 1960s and, more recently, in Sunflower Valley. Groundwater within the Kettleman Plain (Avenal, Reef Station, and Devils Den) is mostly at a consistently lower elevation. Groundwater elevations in Sunflower Valley appeared to drop to or below elevations in the Kettleman Plain during periods of overdraft in Sunflower Valley.

Groundwater flow is relatively complicated in the Pleasant Valley sub-basin. In 1959, the USGS published a study of groundwater conditions in the area and prepared a map of groundwater level contours for fall 1955 (**Figure 10**). This USGS map shows that groundwater within Sunflower Valley flowed west through Dagany Gap into southern Kettleman Plan (DDWD) then north and west through Avenal Gap into the San Joaquin Valley. Groundwater within northern Kettleman Plain flowed southeast and then west through Avenal Gap into the San Joaquin Valley.

The following chart compares groundwater elevations in wells within the Kern County and Tulare Lake sub-basins:



This chart shows that groundwater elevations are highest in wester Kern County sub-basin and lowest in eastern LHWD and central DRWD. Groundwater elevations appear stable over the period of these measurements, suggesting that the limited groundwater extraction has not significantly affected groundwater elevations. These data are also consistent with the reported groundwater gradient from west-southwest to east-northeast within the area (USGS, 1959), as shown in **Figure 10**.

E. Irrigated Agriculture

The water districts in the WWQC areas have maintained crop survey information for 50 years. Cotton was the predominant crop in the early years accounting for about 70,000 acres annually in BWSD, BMWD and LHWD alone. Since the late 1990s cotton and row crop acreage has slowly declined and replaced with permanent crops, mostly almonds, pistachios and citrus. Little to no cotton has been planted in the Westside Districts for nearly 10 years.

In addition to carrots and other row crops, areas of the Kettleman Plain and Sunflower Valley have also been recently planted in permanent crops, mainly pistachios.

The Districts provides irrigation water to farmers by means of a distribution system that includes pipelines and lined canals and reservoirs that delivers water directly to farmer turnouts. With the exception of some areas in the Devil's Den area, all water used for irrigation in the Kettleman Plain and Sunflower Valley is pumped groundwater. Nearly all growers in the WWQC area currently utilize a pressurized irrigation system, typically drip and micro-sprinkler, to irrigate their crops. **Figure 11** provides a distribution of irrigation type in the WWQC area. There are few remaining areas (mainly in the Belridge Water Storage District and the Kettleman Plain) where solid set sprinklers are used on row crops, mainly carrots.

F. Existing Management Practices

Due primarily to the topography (i.e., the need to pump surface water uphill into most of the WWQC coverage area) and the ever increasing cost of water from the State Water Project, the cost to irrigate crops in most areas of the WWQC is relatively expensive.

In addition to high irrigation water cost, nutrient applications in the WWQC are highly managed to improve nutrient uptake and reduce cost. Fertigation is common in drip, micro-sprinkler and solid set sprinkler irrigation systems and is an effective method to deliver nutrients more efficiently. While high efficiency nutrient applications can be achieved using row or flood irrigation methods, they are generally considered less efficient than management practices associated with drip, micro-sprinkler, or solid set sprinklers.

Management practices can vary from grower to grower within a single commodity and can be dependent on a variety of factors including; target yields, individual irrigations systems, soil types, and operational schedules. In general, nutrient management practices are similar for each of the primary crops in the WWQC area and can include soil broadcast, fertigation and foliar applications on post, and pre-harvest application schedules. Further information is necessary to determine the current baseline of management practices and will be obtained from the completed Farm Evaluation forms to be submitted by coalition members.

G. Available Groundwater Data

The analysis of groundwater data for the WWQC area, focused on nitrate, salts and pesticides, was presented in the GARs prepared for the *Westside Districts and Western Supplement Area* and *Northern Supplemental Area*. Groundwater data was obtained from the State Water Resources Control Board's Groundwater Ambient Monitoring and Assessment Program (GAMA). The GAMA database includes data from the California Department of Public Health, California Department of Pesticides Regulation, USGS GAMA Priority Basin, and GAMA Domestic Wells. This, along with additional data sources including, the Kern County Water Agency and the District's groundwater monitoring programs were compiled in a groundwater quality database for the GAR. These groundwater quality monitoring data represent results from 1908 to 2013. Nitrate, salts and pesticides information in the database was used to designate high vulnerability areas and establish the baseline for this CGQMP, Groundwater Quality Trend Monitoring program, and the Management Practices Evaluation Program.

3. MANAGEMENT PLAN STRATEGY

A. Approach

An effective management plan relies on an understanding of the range of agricultural management systems in the WWQC and the factors that influence management choices. Given temporal gaps and the lack of available groundwater quality data (i.e. knowledge gaps) in the WWQC, it is difficult to link past and present management practices of irrigated agriculture to known groundwater quality exceedances, nor does it lend itself to a reliable evaluation of the effectiveness of current management practices to protecting groundwater quality. As such, management plan implementation will focus efforts on irrigation, nutrient, and pesticide management practices through extensive outreach and education for all growers in the WWQC. For example, nitrogen applied/removed (A/R) ratio is one tool that will be used to help growers gauge the impact of agricultural system management decisions on farm and their potential impact on groundwater quality. Additional collaborative research has been proposed through the MPEP process and will be needed to improve available data particularly for estimating nitrogen removed and for identifying appropriate nutrient ratios for a variety of agricultural systems. A secondary focus of the management plan will be to generate an inventory of operating and abandoned water supply wells in the WWQC area and determine their operational status and condition with a focus on well-head protection. Any abandoned well(s) that has not been properly destroyed and/or any operating wells that may lack proper well-head protection will be identified and the owner notified to determine a proper course of action.

B. Prioritization

The GARs prepared for the WWQC prioritized the high vulnerability areas based on an electrical conductivity (EC) threshold of 5000 µmhos/cm which was deemed not appropriate, because it excludes areas with groundwater that contains nitrate concentrations in excess of the maximum contaminant level (MCL). The GARs were conditionally approved provided the Coalition's HVAs include:

- The HVAs previously proposed by Central Valley Water Board staff and used by the Coalition for the Nitrogen Management Plan
- All areas that the Coalition has identified as having nitrate concentrations in groundwater that are 45mg/L or greater, regardless of salinity concentrations in groundwater; and
- All areas that the Coalition has identified as having nitrate concentrations in groundwater that are 22.5 mg/L (with a trend indicating a statistically significant increasing concentration) or greater, regardless of salinity concentrations in groundwater.

Figure 12 shows the HVAs previously proposed by Central Valley Water Board staff along with the WWQC's prioritization of those HVAs using the methodology and rationale described below. As previously mentioned, spatial and temporal gaps, and a general lack of groundwater quality data in the WWQC area make the determination of whether irrigated agriculture is the source of elevated concentrations or exceedances of groundwater quality in certain areas of WWQC problematic and HVA prioritization difficult. However, to comply with the Tulare Lake General Order, the WWQC developed a prioritization framework that considers, (**1**) the proximity of HVA to public and disadvantage community (DAC) groundwater supply wells and (**2**) intrinsic vulnerability relative to hydrogeologic factors (e.g. shallow groundwater (depths of < 20 feet below ground surface (bgs)).

Figure 13 provides a flow-chart of the two prioritization parameters and scenarios for each parameter. Considering that the current HVAs were established using the nitrate concentration thresholds provided in Conditional Approval letter, HVAs, or portions thereof, that meet both criteria **1** and **2** above were considered High priority, those that met only one of the criteria were considered Medium priority and those where neither applied, were considered Low priority. One Disadvantaged Community (Lost Hills) and one community water system (Avenal) are located within the WWQC area, neither of which pump local groundwater, but instead, use imported water to serve their customers. The depth to groundwater in both Lost Hills and Avenal is approximately 200 feet bgs (KCWA 1974 and USGS 1955).

Based on the prioritization criteria described above, neither Lost Hill nor the Avenal area satisfy either prioritization parameter and are therefore included in the Low Priority area along with the others. The shallow groundwater area (i.e., perched water in the LHWD) has EC values ranging from 14,950 to 28,000 µmhos/cm (DWR 2012) and, therefore, has no current beneficial uses and no known future beneficial uses. Additionally, there are no DACs or DAC water supply wells in the area with shallow groundwater. However, since the area does meet one of the prioritization parameters (i.e., shallow groundwater) it is considered Medium priority and is the only such area in the WWQC area.

C. Source Identification Study

It is recognized there are large knowledge gaps in the WWQC area regarding the source of nitrate, salts, and pesticides in groundwater and, therefore, a conclusive determination of nitrate, salts, and pesticide sources may be infeasible or unlikely for most of the HVAs without additional effort. As such, the WWQC will request that the Executive Officer approve a limited Source Identification Plan (SIP) that will focus primarily on nitrate and salts in areas within the WWQC, with known groundwater quality exceedances and with a high probability, based on literature review and available records, that the source of which is not irrigated agriculture. As discussed in the WWQC GAR, salts can come from a variety of sources including; naturally occurring soil salinity, oil field produced water disposal, sewage disposal, gypsum mines, composting operations, tile drainage ponds (LHWD), industrial wastes, landfills and irrigated ag. Sources of nitrate can include; oil field produced water disposal, sewage disposal, composting operations, tile drainage ponds (LHWD), industrial wastes, landfills and irrigated ag. All of these potential sources exist in the WWQC area.

Sources of nitrate and salts identified as non-irrigated agriculture will be documented and reported to the Regional Board. WWQC will work with the Regional Board to determine the next steps to address these specific areas, up to and including eliminating them from the current HVAs, if warranted. The potential source of pesticides in groundwater will be addressed in the Groundwater Quality Trend Monitoring Work Plan.

If irrigated agriculture is determined to be a potential contributor to groundwater nitrate and salts impacts, or if the results of the SIP are found to be inconclusive in that regard, then those areas will remain in the current HVAs. Additionally, the intent of the MPEP is to determine which management practices are protective of the groundwater and any new applicable information generated from the MPEP will be evaluated and provided to the appropriate members.

Figure 14 is a flow diagram presenting the approach to the CGQMP.

D. Actions Taken

Historically, the cost of water in the WWQC area has been relatively high. This has generally driven most growers to employ more efficient methods of irrigation on both permanent and row crops. However, some row crops require row irrigation and as such, it was used occasionally, in the past, by certain growers in the relatively flat areas on certain crops. The steady increase in permanent crop acreage (almonds, pistachios and citrus) and switch to more efficient irrigation methods since the early 1990s has, with the exception of carrots, all but eliminate row crop acreage in the WWQC.

Nearly all growers in the WWQC area currently utilize a pressurized irrigation system, typically drip or micro-sprinkler, and/or solid set sprinklers, to irrigate their crops, as presented in **Figure 11,** and are some of the most efficient in Kern County and the Tulare Lake Basin area. There are currently no crops in the WWQC area irrigated using flood or row irrigation methods.

In addition to high irrigation water cost, nutrient applications in the WWQC are highly managed to improve nutrient uptake and reduce cost. Fertigation is common in drip, micro-sprinkler, and solid set sprinkler irrigation systems and is an effective method to deliver nutrients more efficiently.

While high efficiency nutrient applications can be achieved using row or flood irrigation methods, they are generally considered less efficient than management practices associated with drip, micro-sprinkler, or solid set sprinklers.

Extensive research has been conducted on California agricultural management practices, particularly for irrigation and nutrient management, including publications such as Nitrogen Source Reduction to Protect Groundwater Quality (Dzurella et al., 2012). The WWQC, in coordination with other coalitions, to gather available relevant research, evaluate best practices and attempt to identify data gaps to develop a strategy for implementation of management practices in a variety of scenarios.

E. Outreach and Education

Outreach and Education programs for members with operations in HVAs will focus on providing resources to assist growers to improve irrigation and nutrient practices, where necessary. These programs will be developed based upon the coordinated efforts of the coalitions and focus on practices appropriate for the priority being addressed. Programs will be organized by WWQC and held annually, at a minimum. Programs will enlist the assistance of other appropriate groups such as commodity groups, California Department of Food and Agriculture, University of California Cooperative Extension, and other suitable groups or experts.

Additionally, as information and studies become available from the MPEP, applicable materials will be incorporated into the education and outreach programs or MPEP specific outreach will be provided.

F. Management Practices Identification and Validation

A better understanding of agricultural management practices will be developed from the information provided on Farm Evaluation forms submitted by members. As noted earlier, growers in the WWQC area currently employ high efficiency irrigations systems and management practices but the additional information will help to provide details to further evaluate and refine our understanding of the management methods currently employed.

Evaluation of the management practices and how they may potentially impact groundwater quality is an inherently difficult and problematic effort. Discharge of irrigation water and transport of nitrates to the groundwater can be impacted by many factors including, but not limited to, soil type, depth to groundwater, crop type, and past and current management practices. Large data gaps in understanding nitrate impacts and its interaction with the various crops and conditions along with large variations in the temporal delay between activities at the surface and their direct impacts on the groundwater further exacerbate the problem.

Efforts by the south San Joaquin Valley coalitions in the MPEP implementation should help fill data gaps and assist with the management practices evaluation process. The general objective of the MPEP is to establish the direct relationship between current management practices for various crops and the impact, if any, they have on the groundwater quality. This process is intended to determine which practices are protective of the groundwater quality however, for the reasons stated, this will prove to be a difficult task and applicable studies and information generated by the MPEP may not be available to WWQC for many years. WWQC is currently participating in the group development of the MPEP

with other Tulare Lake Basin coalitions and will endeavor to help develop a program that initially addresses the high priority areas in WWQC. In addition, WWQC will cooperate with other coalitions to conduct a literature review of current knowledge pertaining to efficient irrigation and nutrient management practices. Finally, information gathered during WWQC's Groundwater Quality Trend

Monitoring Program will also provide useful information relative to the effectiveness of current practices to protect groundwater quality. Although the State Board Agricultural Expert Panel and others recognize that trends must be evaluated over multiple years and my not be representative of current practices.

G. <u>Identification of Administration and Duties</u>

The WWQC Irrigated Lands Regulatory Program coordinator is Greg Hammett and will be responsible for administering the CGQMP. The WWQC Board of Directors have assigned this duty to Mr. Hammett and authorized him to delegate general tasks as necessary and require him to obtain Board approval for consultants and partnerships. See **Figure 15** for organization chart.

4. IMPLEMENTATION STRATEGY

Figure 12 presents the two (Medium and Low) priority areas within the WWQC's current HVAs. There are no High Priority areas identified in the WWQC area based on the prioritization methodology described in Section 3.B (Prioritization) of this CGQMP. Through partnerships with other coalitions, the WWQC will compile existing relevant management practices information for crops specific to the HVA, facilitate training programs and provide appropriate outreach and educational materials to those growers in identified priority areas. Implementation will focus initially on current management practices in the Medium Priority Areas and the different commodities within those areas. Almonds and pistachios are the primary crops within the Medium Priority areas and therefore will be the initial focus of the CGQMP efforts. Members with operations in these areas will be required to attend a minimum of one outreach and education workshop per year.

A. Implementation Schedule

Implementation of the management practices and strategies described in this CGQMP have been underway in the WWQC area for decades. Initial efforts such as outreach and literature review have already begun and will continue after this CGQMP is approved. Work related to the SIP, will begin immediately upon approval by the Executive Officer. Information compiled from the Farm Evaluation forms is also critical to the CGQMP implementation and the determination of potential sources. Additional field surveys and other efforts may also be needed and will require a significant amount of time to complete. Information from Farm Evaluations will require 3 months or more to compile and a report prepared. The SIP could require up to a year to complete depending upon the level of effort needed. Once completed, outreach and education programs can be better defined.

The MPEP effort by the south valley coalitions will commence and continue to evolve over the next several years, therefore evaluation of existing management practices could potentially require several years to complete after initial implementation of the CGQMP. As MPEP information becomes available it will be incorporated into the process as appropriate.

B. Partners and Participating Members

WWQC will draw on many different resources to develop effective outreach and education programs. The programs will be organized by WWQC and enlist the assistance of various groups such as commodity groups, California Department of Food and Agriculture, University of California

Cooperative Extension, other coalitions and other appropriate groups and industry experts. Members in the high vulnerability areas will be required to attend a minimum of one outreach and education program and will be provided with additional information on available resources. Members will be required to evaluate the information provided and report to the WWQC plans to incorporate or the implementation of new management practices.

5. MONITORING METHODS

Again, evaluation of management practices and their potential impact to groundwater quality is problematic and a difficult effort. Discharge of irrigation water and transport of nitrates to the groundwater can be impacted by many different factors as identified previously. According to published reports, depth to groundwater in the WWQC area is approximately 5 to 20 feet in shallow perched zones (intrinsic vulnerability) and 200 to 300 feet below ground surface in others. The GAR roughly estimates the transportation of nitrates from the root zone to the groundwater can be over 20 to 30 years. The General Order requires groundwater quality trend monitoring however, the current or future agricultural activities cannot be evaluated based on available groundwater quality data that is both spatially and temporally lacking. WWQC will develop a groundwater quality trend monitoring plan with the understanding that a monitoring plan is a long-term effort taking into consideration the activities occurring over decades or more. Results from the SIP, if approved, will also lend valuable information to help fill data gaps.

WWQC will review and evaluate other potential methods to monitor the effectiveness of the outreach and education programs and applicable MPEP studies and information.

A. Data Evaluation

Data will be collected per an approved GQTMP and analyzed for long-term nitrate, salt and Ag-Chemical impacts. The temporal delay of potential water quality impacts from surface activities prevents any direct evaluation of current or newly employed management practices and any evaluations will have to be based on representative studies or information provided by the outreach and education programs, the MPEP and SIP (if approved).

B. Reporting

The status and progress of the CGQMP, along with data and information collected, will be reported to the Regional Board as required and submitted May 1 of each year.

6. REFERENCES

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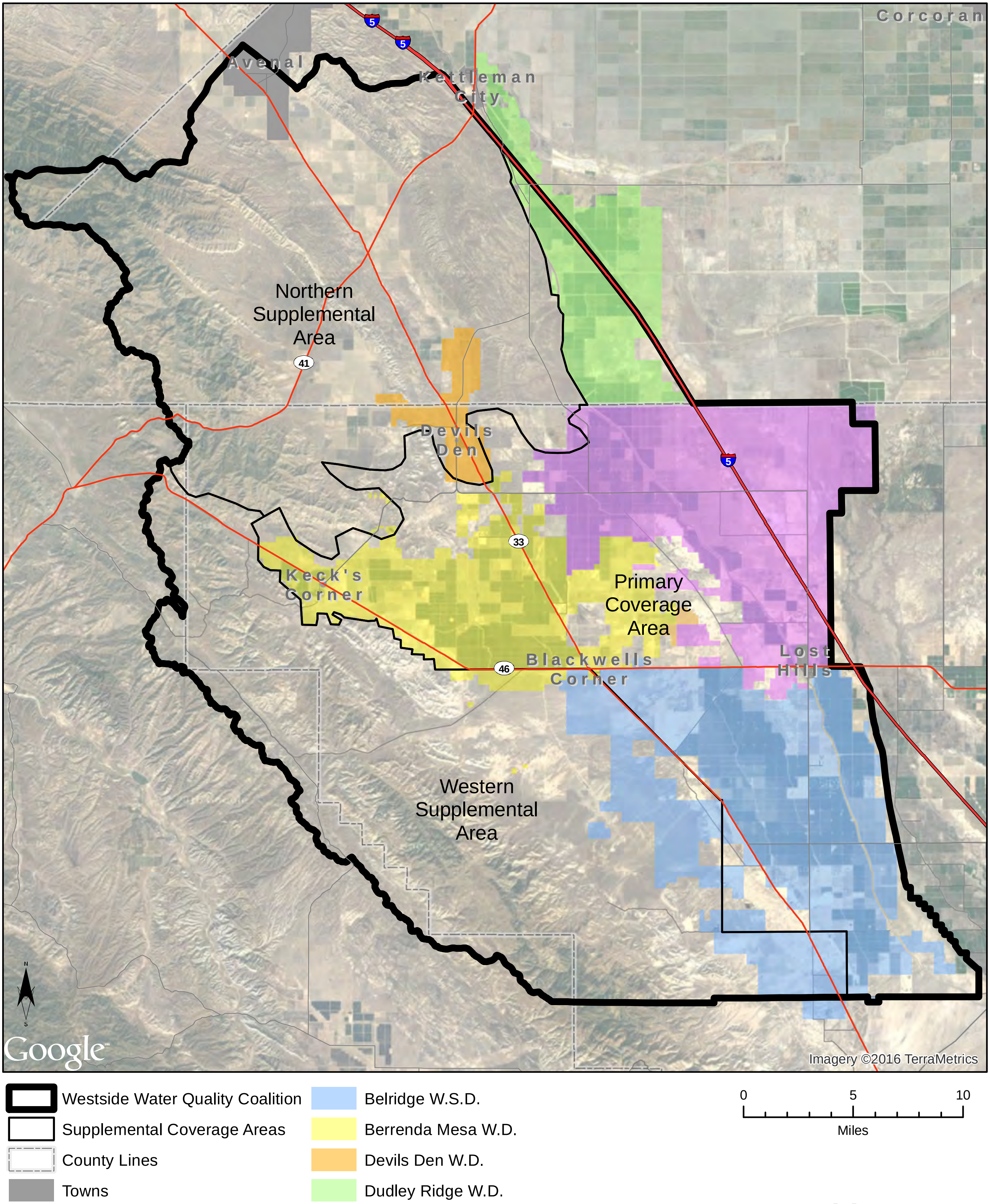

Westside Water Quality Coalition

Figure 1

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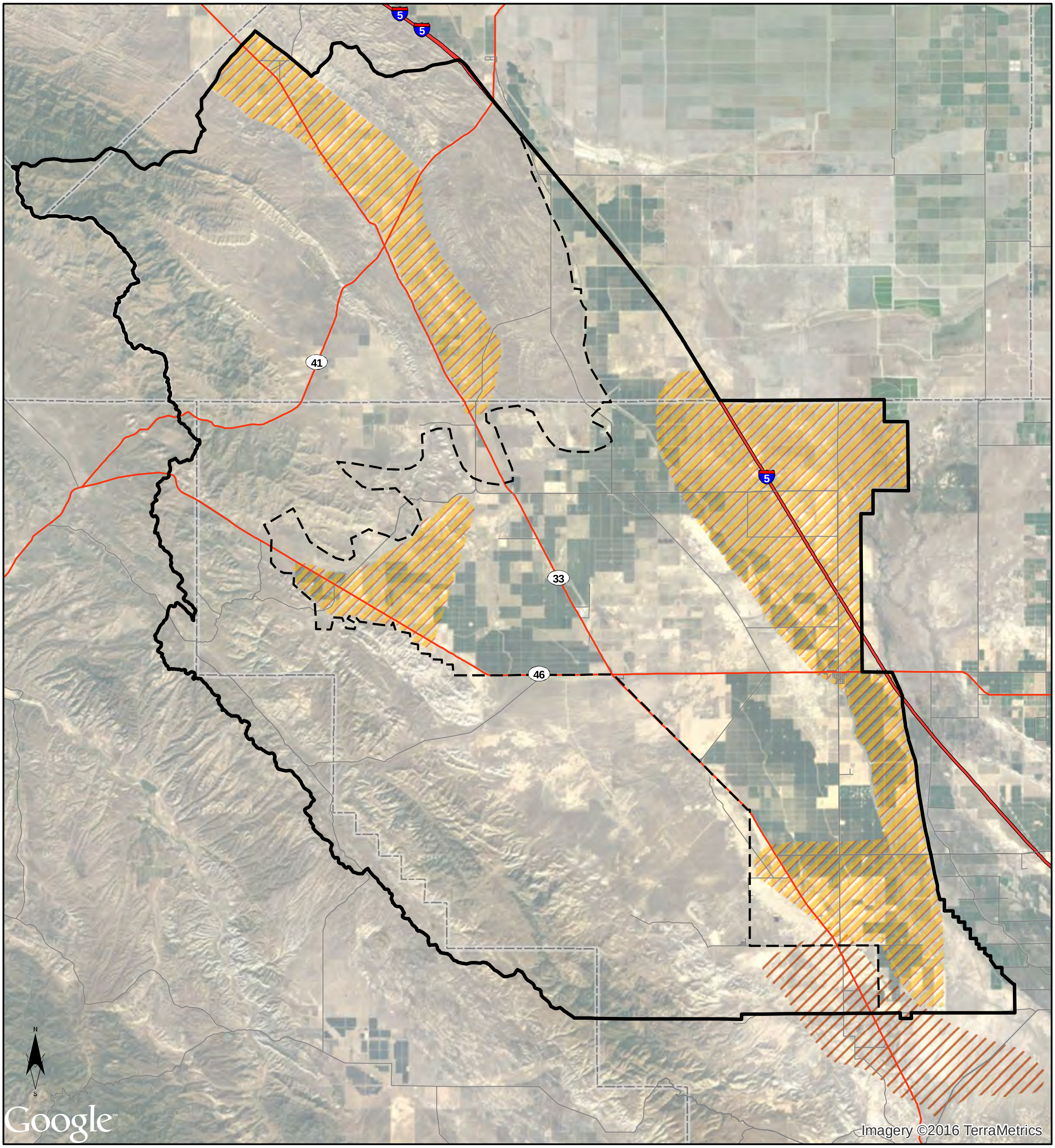

Westside Water Quality Coalition

Westside Water Quality Coalition - Primary Coverage Area

County Lines

High Vulnerability Areas used for NMP Compliance

RWQCR High Vulnerability Area

0 5 10

Miles

Westside Water Quality Coalition High Vulnerability Areas (HVAs)

Figure 2

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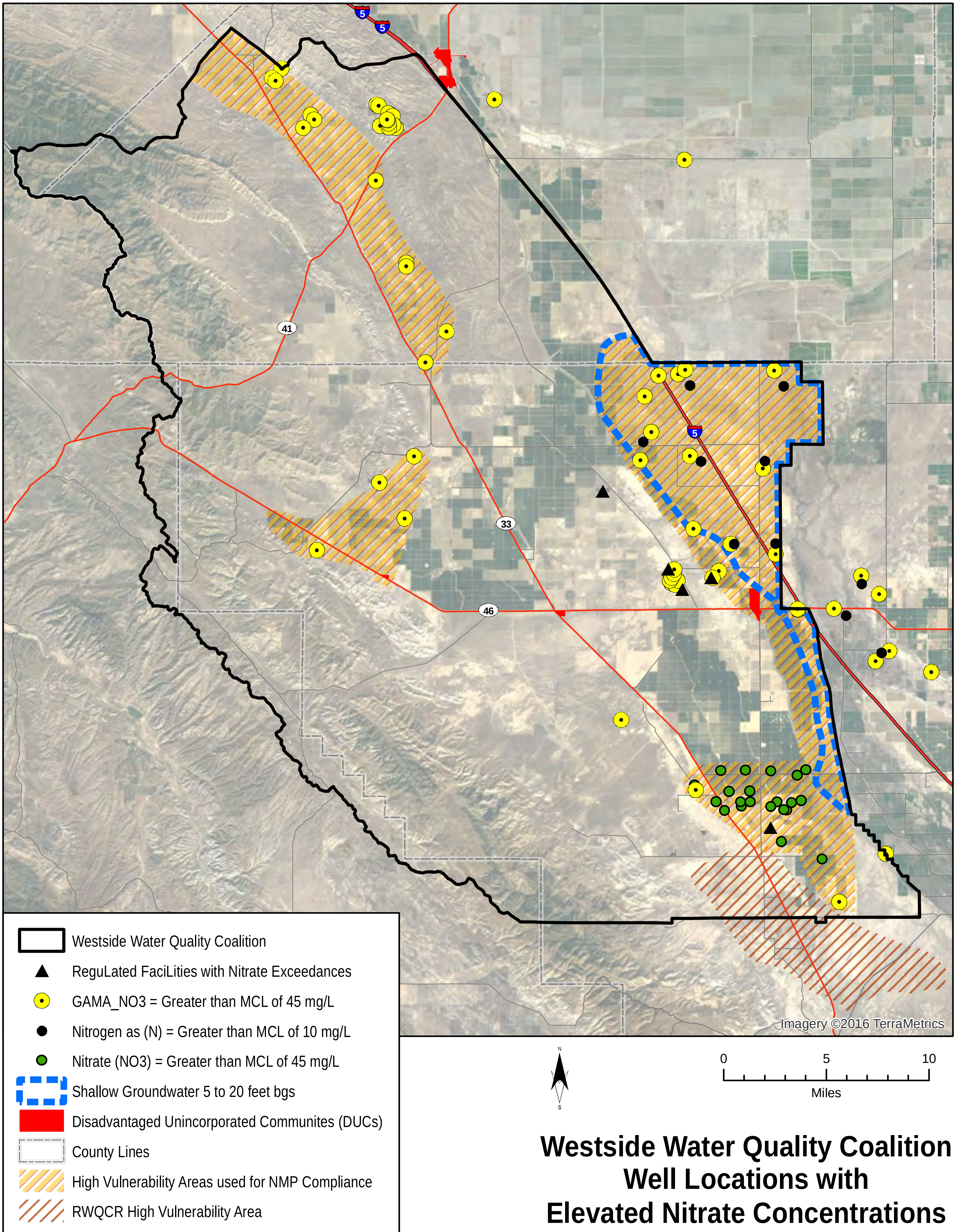

Westside Water Quality Coalition
Well Locations with
Elevated Nitrate Concentrations
Figure 3

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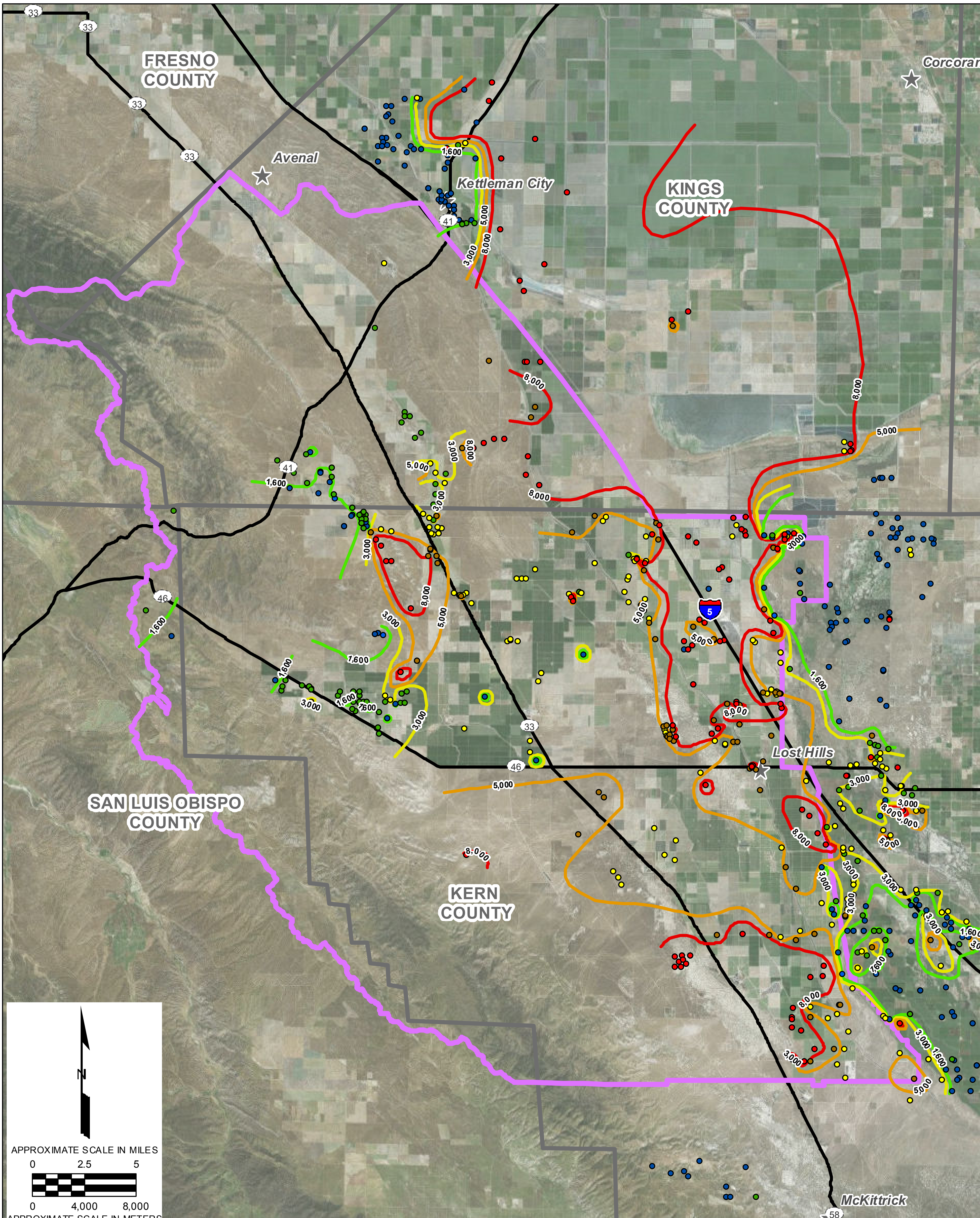


Explanation

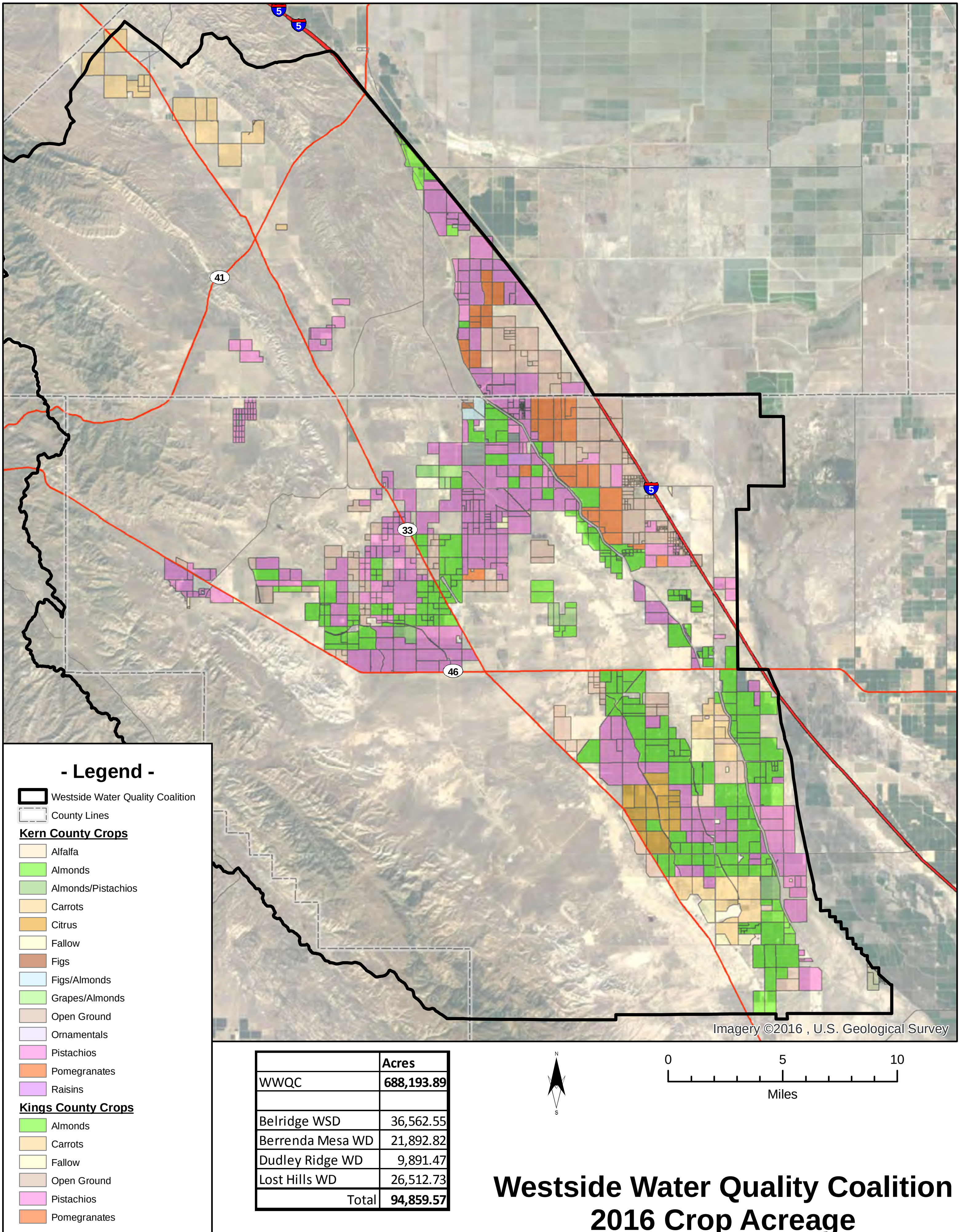
- ★ Major community location
- County boundary
- Major roads
- WWQC jurisdiction boundary

Electric Conductivity Data (Umhos/cm)

- 0 to 1,600 umhos/cm = MUN, AGR-Irrigation, AGR-Poultry, and AGR-Livestock
- 1,601 to 3,000 umhos/cm = AGR-Irrigation, AGR-Poultry, and AGR-Livestock
- 3,001 to 5,000 umhos/cm = AGR-poultry and AGR-Livestock
- 5,001 to 8,000 umhos/cm = AGR-livestock
- >8,000 umhos/cm = no MUN or AGR beneficial use
- 1,600 umhos/cm contour
- 3,000 umhos/cm contour
- 5,000 umhos/cm contour
- 8,000 umhos/cm contour

Basemap modified from ESRI online shared content, aerial imagery web mapping services.

ELECTRICAL CONDUCTANCE IN GROUNDWATER Westside Water Quality Coalition Kern and Kings Counties, California		amec foster wheeler
Date: 09/13/2016	Project No.: FR1216043A	Figure
Submitted By: TS	Drawn By: JC	4



	Acres
WWQC	**688,193.89**
Belridge WSD	36,562.55
Berrenda Mesa WD	21,892.82
Dudley Ridge WD	9,891.47
Lost Hills WD	26,512.73
Total	**94,859.57**

Westside Water Quality Coalition
2016 Crop Acreage

Figure 5

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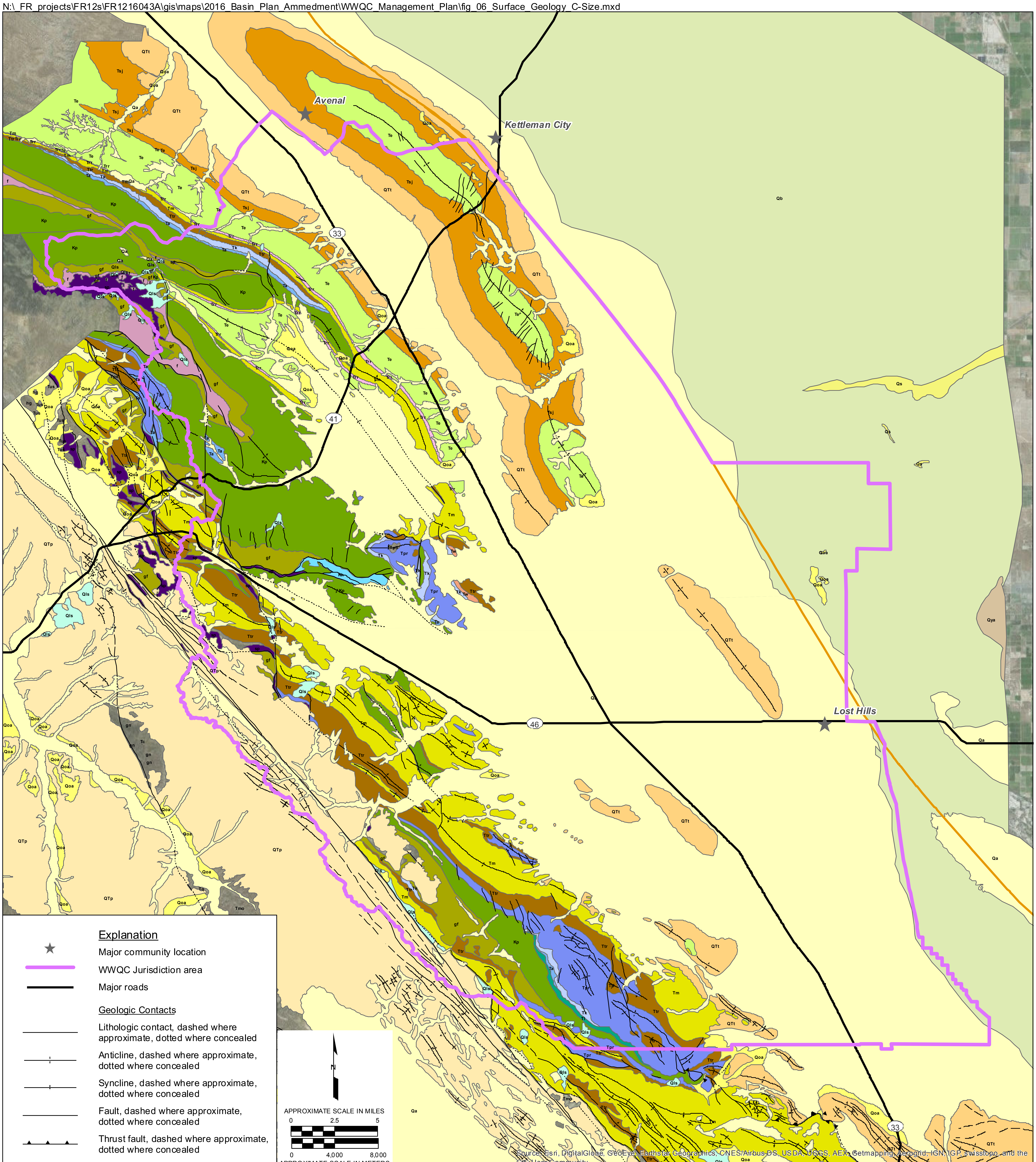

Lithology

Symbol	Description
Qa / Qb / Qs	Qa = Alluvium, QB = Basin fluvial, lucustrian, and marshland Deposits, Qs = Stream deposits: (Pleistocene to Holocene)
Qoa	Older Alluvium: (Pleistocene)
	UNCONFORMITY
QTp / QTt	Tulare Formation (QTt) and Paso Robles Formation (QTp): (Pliocene to Pleistocene)
	UNCONFORMITY
Tsj	San Joaquin Formation: (Pliocene)
Te	Etchegoin Formation: (Pliocene)
	LOCAL UNCONFORMITIES
Trr	Reef Ridge Shale: (Miocene)
Tm	Monterey Shale: (Miocene)
Ttr	Temblor Formation: (Oligocene to Miocene)
	UNCONFORMITY
Tpr	Kreyenhagen Shale (Tk) and Point of Rocks Sandstone (Tpr): (Eocene)
Ta	Avenal Sandstone: (Eocene)
Tl	Lodo Formation: (Paleocene to Eocene)
	UNCONFORMITY
Kp	Panoche Formation (Kp) clay shale and claystone (Kps) sandstone and clay shale (Kpg) conglomerage (Upper Cretaceous)
gf	Gravelly Flat Formation: (Upper Jurassic(?) and Lower Cretaceous)
	UNCONFORMITY
sp	Panoche Formation (Kp) clay shale and claystone (Kps) sandstone and clay shale (Kpg) conglomerage (Upper Cretaceous)
f	Gravelly Flat Formation: (Upper Jurassic(?) and Lower Cretaceous)

Basemap modified from USGS Open-File Report 99-14, Sheet 1, Digital Database, 1999.

SURFACE GEOLOGY
FOR WWQC
Westside Water Quality Coalition
Kern and Kings Counties, California

amec foster wheeler

Date: 09/13/2016	Project No.: FR1216043A	Figure
Submitted By: TS	Drawn By: JAC	6

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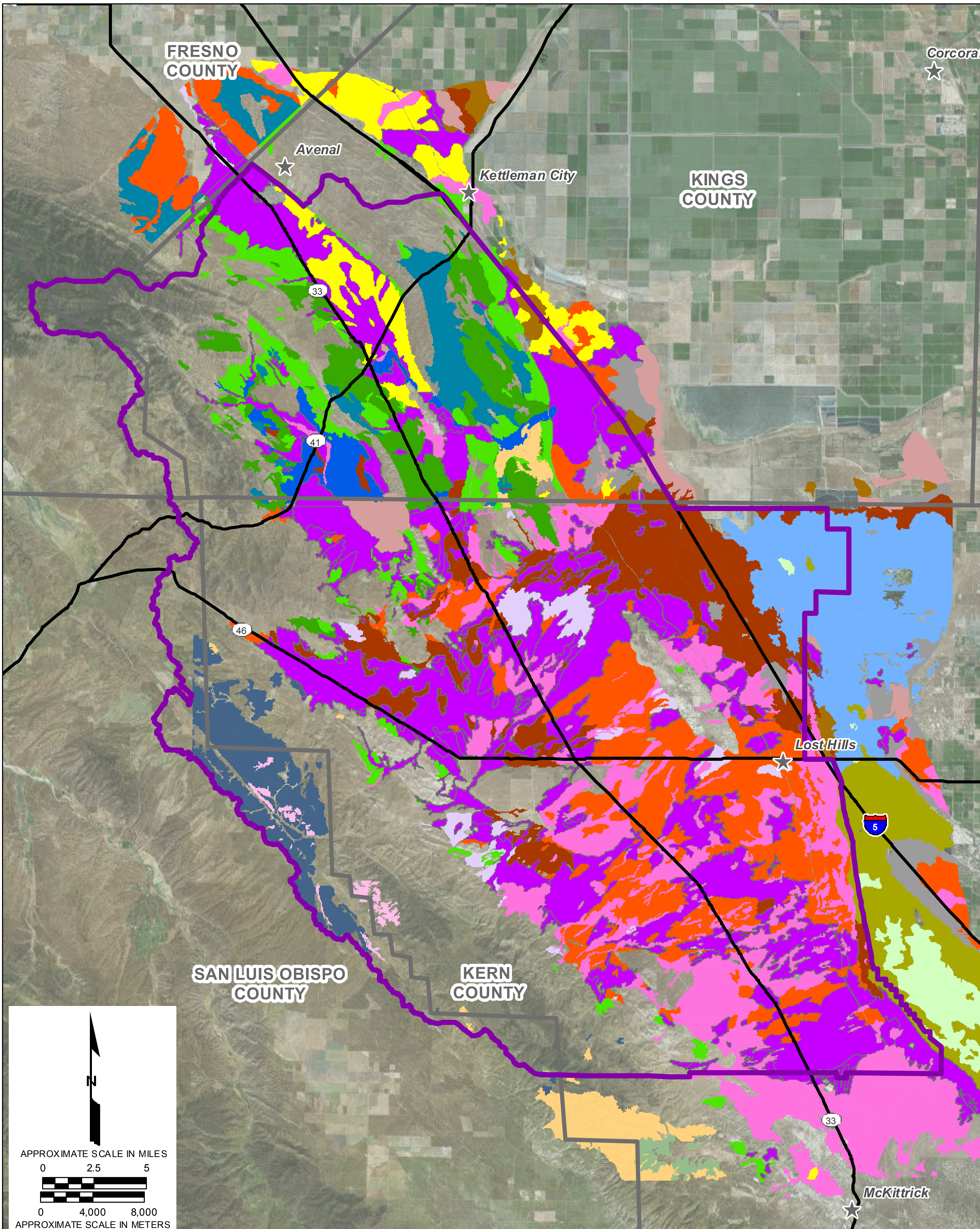

Explanation

- ★ Major community location
- County boundary
- Major roads
- WWQC jurisdiction boundary

Soil Series

- Amramburu
- Avenal Loam
- Balcom
- Buttonwillow
- Delgado
- Garces
- Ketteman
- Kimberlina
- Lethent
- Lokern
- Mercy
- Milham
- Naciemento
- Nahrub
- Panoche
- Reward
- Twisselman
- Wasco
- Westhaven
- Yribarren

Basemap modified from ESRI online shared content, aerial imagery web mapping services.

SOIL TEXTURE MAP
FOR WWQC
Westside Water Quality Coalition
Kern and Kings Counties, California

amec foster wheeler

Date: 09/13/2016	Project No.: FR1216043A	Figure
Submitted By: TS	Drawn By: JC	7

Figure 8

Surface Soils

Soil Survey of Kern County Northwestern Part (NRCS, 1988)

Near-surface soils within the Kern County part of the Study Area include the following soil series:

Series	pH (s.u.)	Salinity (mmhos/cm)	Limitations
Buttonwillow	7.9-8.4	<4	Drainage, Salinity
Kimberlina	6.6-8.4	<2-8	Fertility, Alkalinity
Lethent	>7.8-9.0	4-16	Saline-Alkali
Lokern	6.6-9.0	<2-16	Saline-Alkali, Drainage
Milham	7.4-8.4	<2-<8	Fertility
Nahrub	>7.4->7.8	4-16	Saline-Alkali, Drainage
Panoche	7.4-8.4	<2-16	Saline-Alkali, Drainage
Twisselman	7.9-9.0	<2->16	Saline-Alkali, Drainage
Yribarren	7.9-8.4	<2-<8	Saline-Alkali

Soil Survey of Kings County (NRCS, 1986).

Near-surface soils within the Kings County part of the Study Area (DRWD) include the following soil series:

Series	pH (s.u.)	Salinity (mmhos/cm)	Limitations
Garces	6.6-9.0	2-8	Saline-Alkali
Lethent	<7.8-9.0	4-16	Saline-Alkali
Panoche	7.4-8.4	<2-16	Saline-Alkali, Drainage
Wasco	6.1-8.4	<2	None
Westhaven	7.4-9.0	<2-8	Saline-Alkali

These data show that most of soil series within the Study Area are naturally saline-alkaline and those conditions limit the range of crops that can be grown productivity.

Near-surface soils within the Kings County part of the Study Area (DRWD) include the following soil series:

Series	pH (s.u.)	Salinity (mmhos/cm)	Limitations
Amramburu	6.6-8.4	0-2	Slope-Erosion
Balcom	7.9-8.4	0-2	Slope-Erosion
Naciemento	7.9-8.4	0-2	Slope-Erosion
Reward	7.9-8.4	0-2	Slope-Erosion
Temblor	7.9-8.4	0-2	Slope-Erosion

These soils are typically shallow and steep and contain rock fragments that limit their utility for irrigated agriculture. The distribution of these primary soil series are shown on Figure 2.

The National Resource Conservation Service (NRCS) web soil survey (NRCS, 2014).

Kettleman Plain, NRCS indicates the following soil series:

Soil Name	pH (s.u.)	Salinity
Panoche loam	20,107.9	31.3%
Delgado sandy loam	6.1to 8.4	14.4%
Wasco sandy loam	8,122.6	12.7%
Kettleman loam	7,618.5	11.9%
Mercey-Delgado-Kettleman	5,276.1	8.2%
Mercey loam	4,918.2	7.7%
Others (11)	8,868.0	13.8%

Delgado, Panoche, and Wasco series soils predominate within the Kettleman Plain. These series have low salinity (<2,000 micromhos per centimeter [µmhos/cm]) and neutral to slight alkalinity (6.1 to 8.4 pH). Following are excerpts from NRCS descriptions for these series:

> The Delgado series are shallow, somewhat excessively drained soils on hills, foothills and uplands. Depth to a lithic contact (bedrock) is 7 to 20 inches. These soils formed in material weathered from hard sandstones and shales. Somewhat excessively drained; medium to very high runoff;

moderately rapid permeability. This soil is used for livestock grazing during the late winter and spring. Natural vegetation is annual grasses, forbs and species of saltbush (Atriplex).

The Panoche series consists of very deep, well drained soils on alluvial fans and flood plains. These soils formed in loamy calcareous alluvium from sedimentary rock. Used for irrigated crops such as alfalfa, almonds, barley, cotton, sugar beets and sorghum. Dryland areas are used as range following seasonal rains. A few areas are used for dryland grain, but are seldom successful.

The Wasco series consists of very deep, well drained soils on recent alluvial fans and flood plains. These soils formed in mixed alluvium derived mainly from igneous and/or sedimentary rock sources. Used for growing field, forage and row crops.

Sunflower Valley, the NRCS indicates the following soil series:

Soil Name	**Acres in NSR**	**Percent of NSR**
Panoche clay loam	11,746	32.5%
Avenal loam	6,391	17.7%
Delgado sandy loam	3,917	10.9%
Kettleman loam	3,910	10.8%
Lethent clay loam	3,536	9.8%
Others (14)	6,592	18.3%

Avenal, Delgado, and Panoche series soils series predominate within Sunflower Valley. These series have neutral to slight alkalinity (6.6 to 9.0 pH) and low salinity (<2,000 µmhos/cm), except that Avenal series soil's salinity is less well defined (<8,000 µmhos/cm). Following are excerpts from NRCS's narrative descriptions of these soil series:

The Avenal series consists of deep, well drained soils that formed in calcareous alluvium from sedimentary rocks. Avenal soils occur on alluvial fans and have slopes of 0 to 5 percent. Permeability is moderately slow. Well drained; medium runoff; moderately slow permeability. The soils are used mostly for range.

The Delgado series are shallow, somewhat excessively drained soils on hills, foothills and uplands. Depth to a lithic contact (bedrock) is 7 to 20 inches. These soils formed in material weathered from hard sandstones and shales. Somewhat excessively drained; medium to very high runoff; moderately rapid permeability. This soil is used for livestock grazing during the late winter and spring. Natural vegetation is annual grasses, forbs and species of saltbush (Atriplex).

The Panoche series consists of very deep, well drained soils on alluvial fans and flood plains. These soils formed in loamy calcareous alluvium from sedimentary rock. Used for irrigated crops such as alfalfa, almonds, barley, cotton, sugar beets and sorghum. Dryland areas are used as range following seasonal rains. A few areas are used for dryland grain, but are seldom successful.

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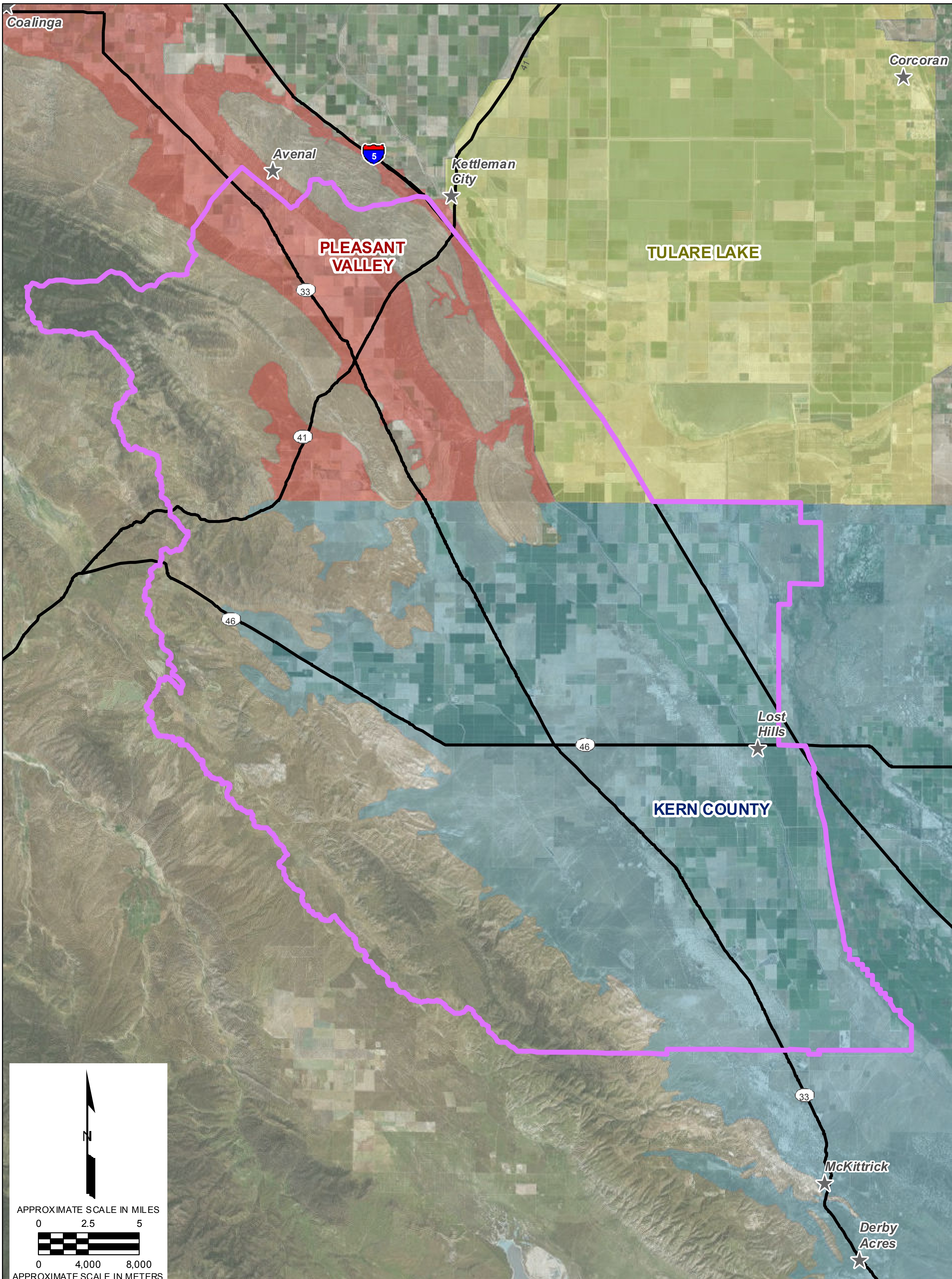

Explanation

★ US Census Populated Places

Westside Water Quality Coalition Jurisdiction

Hydrogeologic Sub-Basins

- Kern County
- Pleasant Valley
- Tulare Lake

Basemap modified from ESRI online shared content, aerial imagery web mapping services.

HYDROGEOLOGIC BASINS WITHIN WWQC
Westside Water Quality Coalition
Kern and Kings Counties, California

amec foster wheeler

Date: 09/13/2016	Project No.: FR1216043A	Figure
Submitted By: GLK	Drawn By: JAC	9

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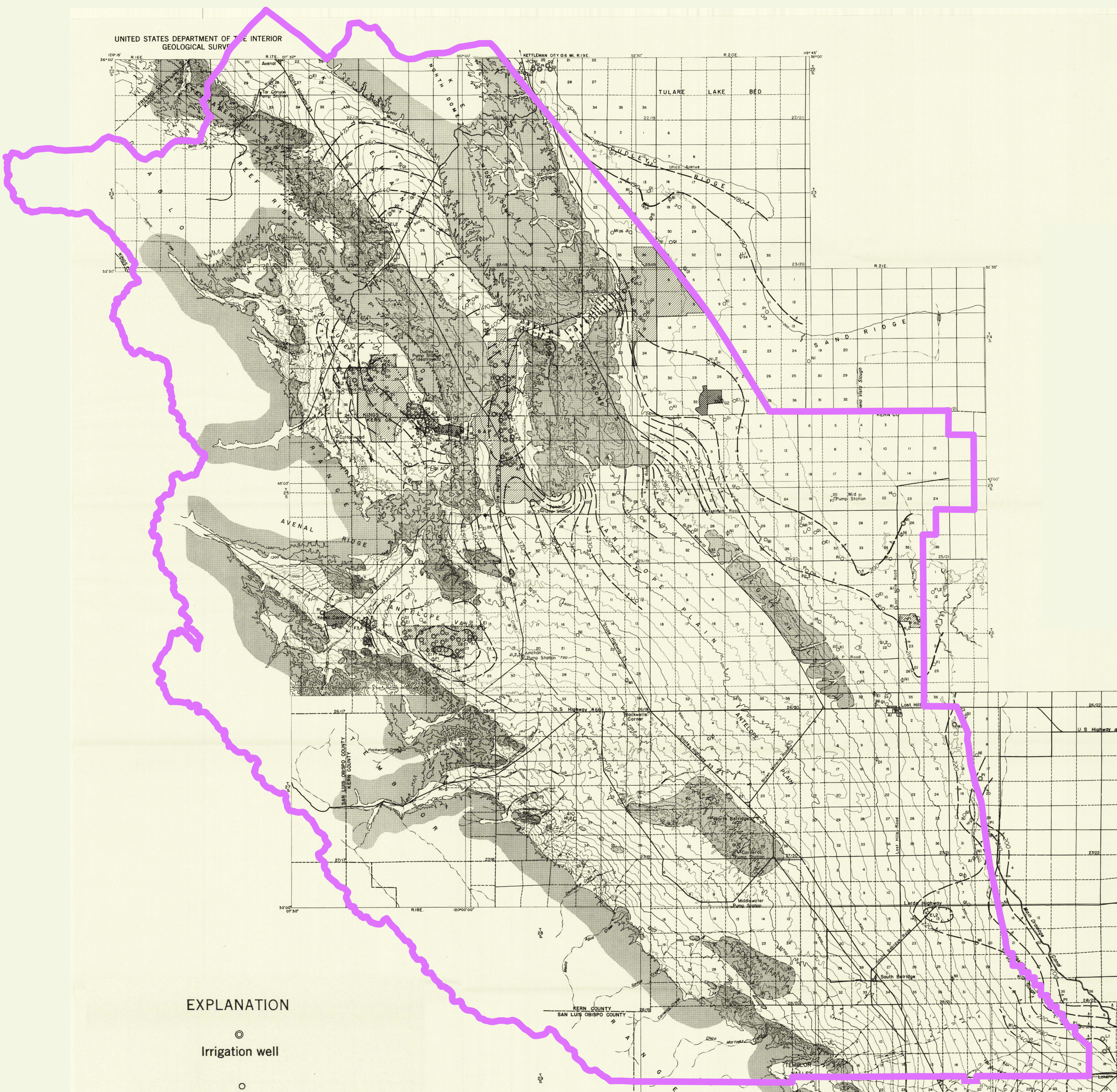


EXPLANATION

Irrigation well

Domestic, stock, industrial, or unused well

Destroyed well

Spring

Water-level contour
Arrow indicates direction of ground-water movement. Contour interval 10 and 50 feet. Datum is mean sea level

Boundary between alluvium and older rocks

Ground-water barrier

Area irrigated in 1955

Area formerly irrigated but not under irrigation in 1955

1 0 1 2 3 4 5 Miles

Contour interval 25 feet

Datum is mean sea level

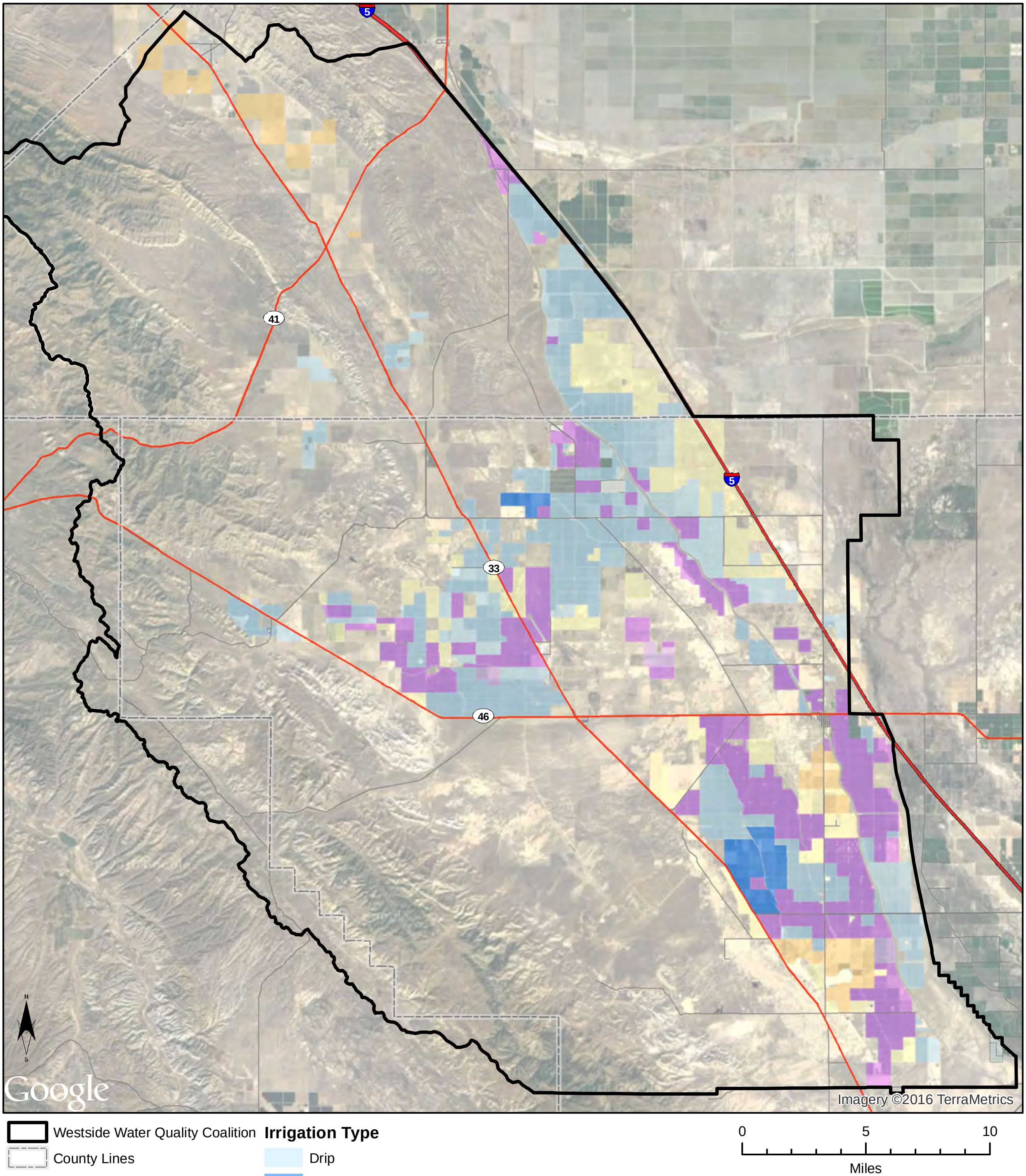
Westside Water Quality Coalition Jurisdiction

Map of Avenal-McKittrick Area, California, Showing Location of Wells, Springs, Irrigated Areas and Water-Level Contours for the Autumn of 1955 (adapted from USGS Water-Supply Paper 1457, Plate 3)

LINES OF EQUAL ELEVATION OF GROUNDWATER 1955
Westside Water Quality Coalition
Kern and Kings counties, California

amec foster wheeler

Date: 09/08/2016	Project No.: FR1216043A	Figure
Submitted By: TS	Drawn By: JC	10



Westside Water Quality Coalition 2016 Irrigation Type

Figure 11

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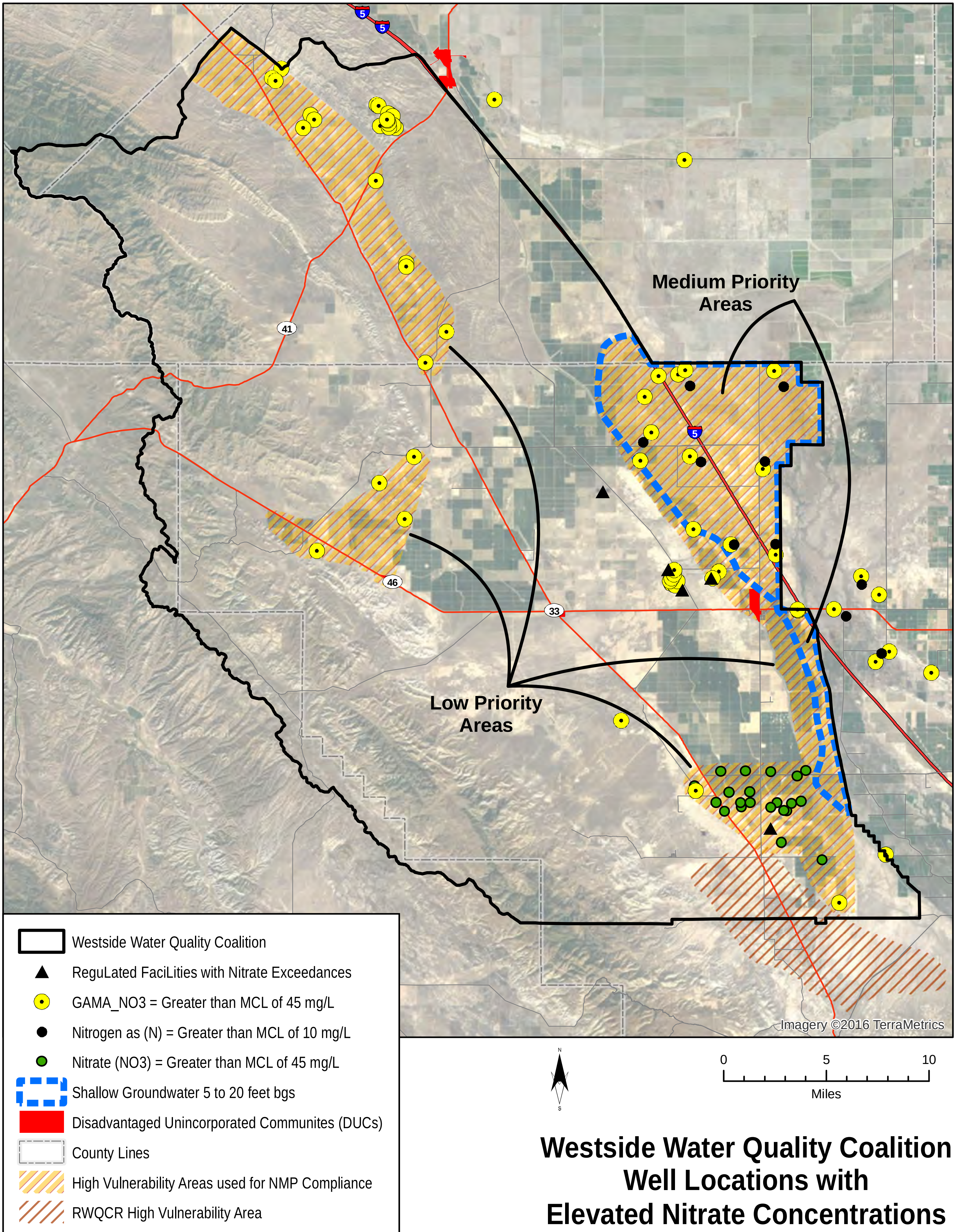

Westside Water Quality Coalition Well Locations with Elevated Nitrate Concentrations

Figure 12

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Figure 13 – Prioritization of WWQC – HVA's

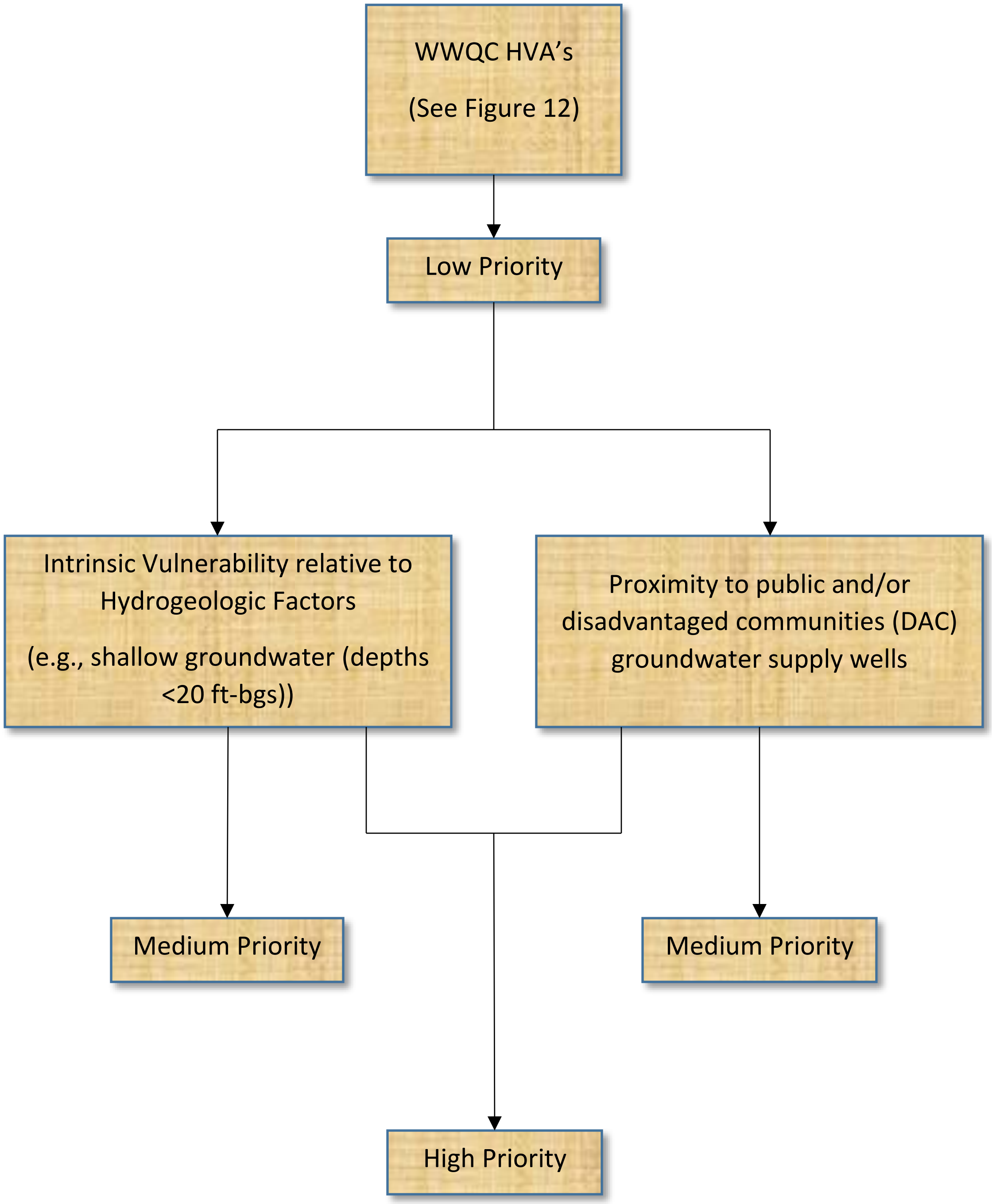

Figure 14 - CGQMP Approach Flow Diagram

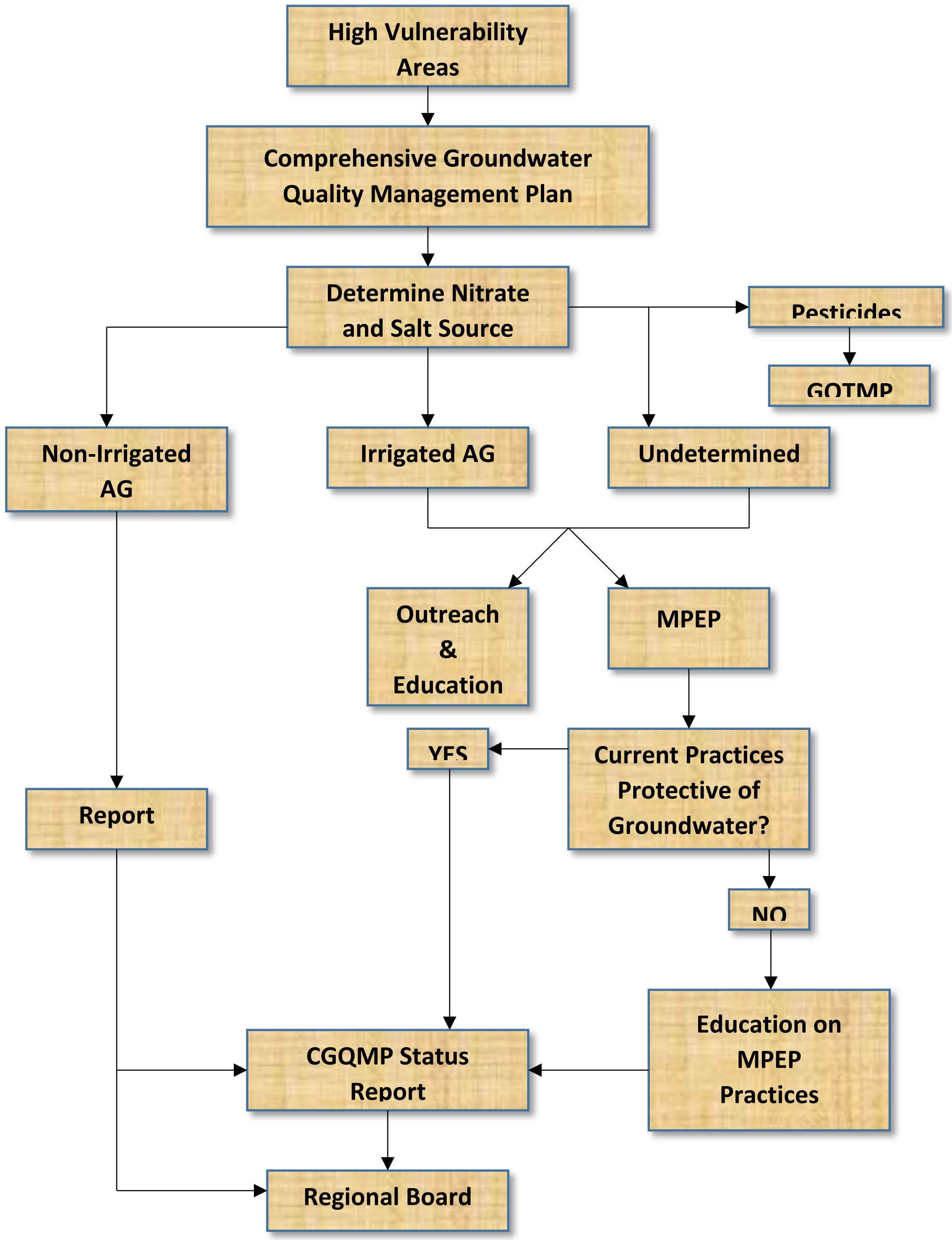

Figure 15 – Organizational Chart

WESTSIDE WATER QUALITY COALITION (WWQC)
Organizational Chart
(CGQMP Administration)