Kaweah Basin Water Quality Association

Groundwater Quality Assessment Report

Tulare County, California • February 2015

Prepared for:

Kaweah Basin Water Quality Association

Prepared by:

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Provost & Pritchard Consulting Group
An Employee Owned Company

KAWEAH BASIN WATER QUALITY ASSOCIATION

Groundwater Quality Assessment Report

Tulare County, California
February 7, 2015

Prepared for:
Kaweah Basin Water Quality Association
Post Office Box 2840 • Visalia, California 93279

Prepared by:
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Visalia, California

CERTIFICATIONS

This Groundwater Quality Assessment Report is signed by the following certified professionals:

Provost & Pritchard Consulting Group

PROJECT TEAM

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Abbreviations

AGR .... agricultural supply

APN .... Assessor's Parcel Number

Basin Plan .... Tulare Lake Basin Plan

CASGEM .... California Statewide Groundwater Elevation Monitoring

CDPH .... California Department of Public Health

CDPs .... Census Designated Places

CVHM .... Central Valley Hydrologic Model

CV-SALTS .... Central Valley Salinity Alternatives for Long-Term Sustainability

DAC .... Disadvantaged Community

Dairy GO .... Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies

DBCP 1,2-dibromo-3-chloropropane

DDW .... SWRCB Division of Drinking Water

DEM .... Digital Elevation Model

DPR .... California Department of Pesticide Regulation

DWR .... California Department of Water Resources

EC .... electric conductivity

EDF .... Electronic Data File

EDT .... Electronic Data Transfer

ET .... evapotranspiration

FMMP .... Farmland Mapping and Monitoring Program

GAMA .... Groundwater Ambient Monitoring and Assessment

General Order .... Waste Discharge Requirements Order No. R5-2013-0120

GIS .... Geographic Information Systems

HVA .... high vulnerability area

ILRP .... Irrigated Lands Regulatory Program

IND .... industrial supply

IPM .... Integrated Pest Management

KBWQA .... Kaweah Basin Water Quality Association

KCWD .... Kings County Water District

KDWCD .... Kaweah Delta Water Conservation District

Ksat .... saturated hydraulic conductivity

KSJRA .... Kaweah and St. John's Rivers Association

LUST .... Leaking Underground Storage Tank

MCL .... maximum contaminant levels

MG/L .... milligrams per liter

MPEP .... Management Practices Evaluation Program

MRP .... Monitoring and Reporting Program

MSL .... mean sea level

MUN .... municipal and domestic supply

NAIP .... National Agriculture Imagery Program

NDVI .... Normalized Difference Vegetation Index

NHD .... National Hydrography Dataset

NO_3 .... nitrate

NO^3-N .... nitrate as nitrogen

NOA .... Notice of Applicability

NRCS .... Natural Resources Conservation Service

PAM .... polyacrylamide

PRO .... industrial process supply

REC-1 .... water contact recreation

REC-2 .... non-contact water recreation

RWQCB .... Central Valley Regional Water Quality Control Board

SAR .... sodium adsorption ratio

SCID .... Stone Corral Irrigation District

SSJVWQC .... Southern San Joaquin Valley Water Quality Coalition

SWRCB .... California State Water Resources Control Board

TDS .... total dissolved solids

TID .... Tulare Irrigation District

UCD .... University of California, Davis

USDA .... United States Department of Agriculture

USEPA .... United States Environmental Protection Agency

USGS .... United States Geological Service

VK .... vertical conductivity

WDR .... Waste Discharge Requirements

WRI.. Water Resources Investigation for the KDWCD
WWTF...wastewater treatment facility

Executive Summary

This Groundwater Quality Assessment Report (**GAR**) has been prepared for the Kaweah Basin Water Quality Association (**KBWQA**) to fulfill the requirements of the Central Valley Regional Water Quality Control Board (**RWQCB**) adopted Waste Discharge Requirements (**WDRs**) on September 19, 2013 for Growers within the Tulare Lake Basin Area that are a member of a Third-Party Group, Order No. R5-2013-0120 (**General Order**).

Kaweah Basin Water Quality Association

The KBWQA was formed in October 2013 with the purpose of implementing the General Order Irrigated Lands Regulatory Program (**ILRP**) for its grower members. Within the KBWQA, there are approximately 356,000 total acres in the Primary valley floor and 602,000 total acres in the Supplemental foothill and mountain areas (**Figure 1-1**, **Figure 1-2**). Of these areas, approximately 163,000 and 4,000 acres, respectively, are enrolled as grower members in compliance with the ILRP as of October 2014.

GAR Timeline

The KBWQA was authorized by the RWQCB as the third-party group to represent growers within its service area by the Notice of Applicability (**NOA**) received from the RWQCB on February 7, 2014. This approval started a timeline of various requirements outlined in the WDRs. This includes the submittal of a proposed outline for the GAR that describes the data sources and references that will be considered in developing the GAR. The GAR outline was submitted on May 6, 2014. The GAR is due one calendar year after approval of the NOA, which for the KBWQA is February 7, 2015.

GAR Overview

This GAR has been prepared in accordance with the requirements provided in the WDRs and with the outline previously submitted. Some minor modifications to the submitted outline have occurred where data availability and reader comprehension improvements were warranted.

Publically available data was researched and collected during the preparation of this GAR. This information was gathered and combined to provide a scientifically based vulnerability analysis and subsequent prioritization for the study area. Ground-truthing was performed in instances where data was insufficient to make a determination.

Summary of Findings

Geology and Soils

Information obtained from reports prepared for irrigation and water districts in the area, Central Valley Hydrologic Model (**CVHM**) well log texture data, and Natural Resources Conservation Service (**NRCS**) soils reports were summarized for the preparation of this GAR.

The Kaweah Delta Water Conservation District (**KDWCD**) covers approximately 71 percent of the Primary KBWQA area. A report prepared by Fugro West, Inc. indicates that most of the fresh groundwater pumped within the KDWCD is from unconsolidated deposits of Pliocene, Pleistocene, and Recent Age. Consolidated marine rocks of Pliocene age and older which contain brackish or salty water constitute the effective base of fresh water (or permeable sediments).

Geologic units that affect the occurrence and movement of groundwater in the KDWCD are generally classified and described as follows:

a. Basement Rocks of pre-Tertiary age consisting of non-water-bearing granitic and metamorphic rocks. In the subsurface, they slope steeply westward from the Sierra Nevada beneath the deposits of Cretaceous age and younger rocks that compose the valley fill.

b. Marine Rock of Tertiary age consisting of non-water-bearing marine sediments including the San Joaquin Formation which overlap the basement complex and underlie the unconsolidated deposits.

c. Unconsolidated Deposits of older and younger alluvium consisting of non-marine, water-bearing material comprised of the Tulare Formation and equivalent units which thicken from zero along the western front of the Sierra Nevada to a maximum of about 10,000 feet at the west boundary of the KDWCD.

d. Alluvial Deposits consisting of coarse-grained, water-bearing alluvial fan and stream deposits including older oxidized and reduced units, and younger alluvium which underlie the older alluvium. The 200 to 500 feet thick oxidized deposits are red, yellow, and brown, consist of gravel, sand, silt and clay, and generally have well-developed soil profiles. Reduced deposits which extend to about 3,000 feet below land surface are blue, green, or gray, calcareous, and generally are finer grained than oxidized deposits, and commonly have a higher organic content than the oxidized deposits.

e. Lacustrine and Marsh Deposits consisting of fine-grained sediments representing a lake and marsh phase of equivalent continental and alluvial fan deposition. Only the "E" Clay (or Corcoran Clay member) of the Tulare Formation, one of the laterally continuous clay zones in the southern San Joaquin Valley, is found within the KDWCD, extending from Tulare Lake Bed to U.S. Highway 99 with vertical bifurcation near Goshen. It is about 140 feet thick near Corcoran and the average thickness is about 75 feet.

Soils developed on younger alluvium show little or no profile development and are generally free of underlying clay subsoil or hardpan. Very coarse soils can be found beneath the channels of the Kaweah, Tule and Kings Rivers, with fine-grained deposits occurring in the channel of Cross Creek.

In the eastern portion of the KDWCD the Rocky Hill fault disrupts pre-Eocene deposits and may locally penetrate older alluvial deposits, potentially restricting the hydrologic connection of aquifers.

A thickening section of unconsolidated deposits is indicated moving west across the KDWCD with modest warping of the Tulare Formation's surface, suggesting regional folding during and after deposition, but having little effect on the patterns of groundwater flow within or at the perimeter boundaries of the KDWCD.

Other local irrigation districts include Alta, Stone Corral, Ivanhoe, Exeter and Lindmore. These districts surround the KDWCD along the north and east borders. Most of the districts are sloped ranging from 1 to 30 percent and have some form of shallow hardpan. Adobe clay is commonly found on the smooth valley plain near the foothills with coarser materials along current or old streambeds.

CVHM Well Log Texture

Maps prepared from the available extent of the CVHM percent coarse material data based on the upper 200 feet of well logs in the Primary KBWQA area were reviewed. The maps were based on 50-foot increments and are included in as **Figure 2-3**, **Figure 2-4**, **Figure 2-5**, and **Figure 2-6**. For location references, see **Figure 1-1**.

Coarse grain materials are indicated at the 0 to 50 foot interval at the mouth of the Kaweah River outlet and at a couple of other points along the current St. Johns and Kaweah River footprints; development with increasing depth of a coarse material paleo-channel near the mouth of the current Yokohl Creek; and general coarsening with depth towards the west.

Fine grain materials are indicated at all intervals at the Twin Buttes area to the northeast and the Exeter, Cairns Corner, Tulare, and Lindsay areas to the south and southeast.

The interval with the overall coarsest material is the 50 to 100 foot depth. The finest material in the western area occurs in the shallowest 0 to 50 foot interval with the eastern areas generally consistently of fine materials at all depths unless located at the Kaweah River or Yokohl Creek mouths.

Supplemental Area Regional Geologic Setting

The Sierra Nevada Mountain range, partially located within the KBWQA Supplemental area, is the result of initial and continued uplifting of the Pacific and North American tectonic plates. As illustrated in **Figure 2-2**, the area is predominately plutonic rocks of the Mesozoic era, interspersed with outcrops of mixed rocks of pre-Cambrian to Mesozoic era. Portions of the Sequoia and Kings Canyon National Parks are located in the uppermost elevations of the area.

Lake Kaweah is centrally located near the western border. Small areas of Quaternary alluvium are located up- and down-stream of the lake, with larger areas along the foothill borders.

Soil Surveys and Soil Surface Characterization

Soil information for the Primary study area is well documented. However, information for the Supplemental area is limited, with the eastern portion of the area unmapped in soil surveys.

The predominant soil texture in the Primary KBWQA area is loam at approximately 52 percent. Sandier soils are found near streams and channels. In general, the areas to the east are more subject to hardpan with coarser soils along the riverbeds atop the alluvial fan and clay deposits off to either side of the fan.

Soils in the Supplemental area are generally coarser than the soils found in the Primary study area. The majority of the soils are sandy loam and coarse sandy loam. Rock outcroppings are also found in this area with most of the areas lying near the eastern border of the available information.

Areas of higher permeability are located within the study area near ancient and modern stream channels, consistent with the CVHM well log texture analysis (**Figure 2-9**). Areas of higher runoff potential are located predominantly in the northeastern area and along the eastern border.

There are limited soils within the KBWQA range with high electrolytic conductivity and/or sodium absorption ratio (**SAR**) located primarily along the central north and central south borders of the area. These soils are located coincident to highly alkaline soils and mostly coincident to silty clay textures in the same areas (**Figure 2-10**).

Soils within the KBWQA range from extremely acidic to moderately alkaline with the majority of the soil being slightly alkaline in the Primary area and acidic in the Supplemental study area. In general soils become more acidic in the eastern portion of the study area, near the base of the Sierras (**Figure 2-11**).

The steepest portion of the KBWQA is in the Supplemental area, generally with slopes between 20 and 50 percent. The land surface becomes more level as the foothills transition to the valley floor with the Primary area having little slope and topography.

Land Use

Numerous information sources were investigated for the land use section of this GAR. The most useful information found for the KWBQA area was obtained from the Tulare County Agriculture Commissioner, USDA and DWR. In general, there is very limited irrigated agriculture in the Supplemental Area. Along the eastern border of the Primary Area, crops grown are generally citrus and other permanent crops. West of this area, crops are generally field crops including alfalfa. This area is also dominated by dairies that are covered under the Waste Discharge Requirements General Order for Existing Milk Cow Dairies (Order No. R5-2007-0035).

The majority of the irrigated acreage within both the Primary and Supplemental study areas is planted in citrus crops. The second highest acreage crops are forage crops.

Groundwater Hydrology

Recent depth to groundwater was determined based on a combination of KDWCD and California Statewide Groundwater Elevation Monitoring (**CASGEM)** information. In general, the depth-to-water is shallowest in the northeast and southeast with an overwhelmingly southwest regional direction of flow. A groundwater ridge occurs along the Kaweah River footprint with troughs on either side. The deepest groundwater is found in the eastern area between the cities of Exeter and Lindsay. The affects of pumping are apparent in groundwater contours. The Supplemental area has limited data available, but it can be assumed that, other than within fractured bedrock, groundwater will generally follow the topography.

The Terminus Dam was constructed in 1962, which coincides with a regional drop in groundwater levels of 40 feet or more. Recent high water years can be noted in the mid- to late-1980s with water levels generally not reaching those elevations in the years following. The State of California is currently in a drought state of emergency and the Central Valley, in particular, is in a severe overdraft condition, as is apparent in the hydrographs for the valley floor wells. Groundwater levels have generally been in decline since 1999 with a recent decline of up to 100 feet in some wells since approximately 2008.

Recharge areas within the Primary valley floor area were identified and mapped using a combination of publicly available resources. To determine relative recharge rates, identified recharge areas were layered over CVHM vertical conductivity (**VK**) layers of varying thicknesses (**Figure 4-7**). The fastest VK values are included in the areas near the mouths of the Kaweah River and the current Yokohl Creek and extending northwestward. The slowest VK values include the areas to the north and south of the two alluvial fans (Kaweah and Yokohl creek locations) and the better part of the south-central and southeast areas.

The most significant recharge area is at and near the mouth of the Kaweah River due to the shallowest groundwater at less than 50 feet and the upgradient position to the majority of the KBWQA area. The second most significant recharge area is the northwest-southeast trending belt of relatively high VK values and multiple surface waterways and impoundments. Depth-to-water in this area ranges from 50 to 150 feet and less of the KBWQA area is downgradient.

Groundwater Quality Data and Interpretation

Water quality data was gathered from the State Water Resources Control Board's GeoTracker and Groundwater Ambient Monitoring and Assessment Program (**GAMA**), which provided the most comprehensive dataset of water quality information, RWQCB dairy management group, University of California, Davis (**UCD**), Department of Pesticide Regulation (**DPR**), Tulare County and local entities.

Nitrates appear to be the primary water quality issue within the KBWQA area. For wells with detections that remain below the MCL, an analysis was performed to determine if there was a statistically significant increasing trend within a well dataset. MCL exceedances and statistically significant increasing trend are illustrated in **Figure 5-1**.

Nitrate exceedances are located almost entirely within the Primary KBWQA area. The main locations without nitrate exceedances are located along the Kaweah River footprint and to the southeast of the City of Visalia. The limited set of statistically up-trending wells are scattered throughout the area and mostly coincide with CVHM sections already noted to be in exceedances for nitrates. Limited nitrate exceedances are located within the Supplemental KBWQA area.

Only those pesticides with designated MCLs were assessed. Detected pesticide MCL exceedances are illustrated in **Figure 5-2**. Pesticide exceedances are primarily grouped in the southeast area with noted blocks within the City of Visalia and within and south of the City of Tulare.

Existing Groundwater Monitoring Programs

As illustrated in **Figure 6-1** and **Figure 6-2**, existing state and local groundwater quality and groundwater elevation monitoring programs include:

- California Department of Water Resources (**DWR**) with approximately 965 wells within the Primary boundary and 24 wells within the Supplemental boundary for groundwater elevation data from 1945 to 1991;
- CASGEM with 117 wells with active groundwater level monitoring that lie within the KBWQA Primary boundaries and 0 within the Supplemental boundary;
- DPR with 138 wells with active groundwater quality monitoring within the KBWQA Primary boundaries and 16 within the Supplemental boundary;
- California Division of Drinking Water (**DDW**) with 67wells with active groundwater quality monitoring within the KBWQA Primary area and 25 within the Supplemental area;
- KDWCD and Tulare Irrigation District who are CASGEM members; and

- RWQCB-supervised programs with shallower monitoring well networks such as 12 active leaking underground storage tank (**LUST**) cleanup sites, four county landfills, two municipal wastewater treatment facilities, three food processing sites, and 18 dairy sites.

Wells identified as part of the DWR, CASGEM, DPR, or DDW systems are generally presumed to be supply wells of unspecified well type. Both the deeper and RWQCB-supervised well networks are potentially suitable for future trend monitoring pending available well construction data, accurate well location data, and the ability to differentiate constituent provenance. The shallow well network will not be sufficient to monitor the entire area, but with the impacts to the deeper groundwater, a deeper well network may be more appropriate. Complete feasibility will be assessed within the Trend Monitoring Workplan.

Vulnerability Assessment

As defined in the WDRs, a groundwater high vulnerability area (**HVA**) is:

1. Where known groundwater quality impacts exist for which irrigated agricultural operations are a potential contributor or where conditions make groundwater more vulnerable to impacts from irrigated agricultural activities; or
2. Areas that meet any of the following requirements for the preparation of a Groundwater Quality Management Plan:
    a. There is a confirmed exceedance (considering applicable averaging periods) of a water quality objective or applicable water quality trigger limit in a groundwater well and irrigated agriculture may cause or contribute to the exceedance;
    b. The Basin Plan requires development of a groundwater quality management plan for a constituent or constituents discharged by irrigated agriculture; or
    c. The Executive Officer determines that irrigated agriculture may be causing or contributing to a trend of degradation of groundwater that may threaten applicable Basin Plan beneficial uses.

HVAs are identified and prioritized by inputting a combination of weighted critical, secondary, and contributing parameters into an additive and overlay system constructed using geographic information system (**GIS**) that assigned point values based on parameter sub-categories. The critical factors that are considered are in agreement with item 2) a. as defined in the WDRs and listed above. HVA data gaps for cropped or potentially cropped areas are assessed using secondary factors in agreement with item 1) above.

To define the locations of the HVAs, the relative vulnerability of groundwater to the potential impacts from irrigated or potentially agricultural land is assessed based on the following critical criteria:

- Recent groundwater detections within the last 10 years of water quality indicating a condition of pollution defined as MCL exceedances in nitrates or pesticides;
- Longer-term groundwater detections of water quality indicating a condition of active degradation defined as statistically significant up-trending nitrate detections; and
- Impacted areas upgradient of a Disadvantaged Community (**DAC**) or small water system that is reliant on groundwater.

Cropped or potentially cropped areas are classified as located within a HVA if at least 50 percent of the parcel was within designated CVHM grid cells identified as containing adverse water quality conditions. Specifics on the designated buffer zones are detailed in **Section 5.4**. Attributes of each well were assigned to the entire individual 1-mile CVHM grid cell.

Spatial gaps are then assessed for exclusion from the HVAs based on the following criteria:

- Groundwater quality testing over the most recent 10 year time frame indicating a lack of groundwater impacts from nitrate or pesticides;
- Endangered species critical habitat;
- Residential or industrial; and
- Other incompatible land use areas such as gravel mining, landfills, wetlands, and water storage or waterways.

If not excluded from the HVA due to the above criteria, the remaining cropped or potentially cropped areas in both the Primary and Supplemental areas are assessed for inclusion in or exclusion from the HVAs using factors in agreement with Item 1) as defined in the WDRs and listed on the previous page. Ground-truthing was performed in the Primary area by a professional geologist and an agricultural specialist in instances where data was insufficient to make a determination. Once the final HVAs were identified, grower member parcels enrolled as of October 2014 located within the HVA are prioritized based on point values assigned within the GIS additive and overlay system. **Table 7-1** provides a summary of the factors used for prioritization.

The assessment criteria results after resolving the data gaps are illustrated in **Figure 7-1**. The final Designated HVAs encompassing all the cropped or potentially cropped Primary and Supplemental areas are illustrated in **Figure 7-2** . A map showing the locations of current grower members as of October 2014 with applied HVA designation is included as **Figure 7-3** with prioritization assessment results within the entire KBWQA boundary illustrated in **Figure 7-5**. A fairly clear picture emerges of high priority areas in the area near the mouth of the Kaweah River, areas near DACs and other small water systems, and areas of coarse soil or recharge over coarse soil.

The HVA areas are then divided into three acreage-equal tiers of grower members enrolled as of October 2014 resulting in **Figure 7-6**. The red parcels with point scores ranging from 175 to 495 are the Tier 1 priority areas which will be the first areas required to comply with the WDRs. The orange Tier 2 parcel point scores range from 140 to 174 while the yellow Tier 3 parcel point scores range from 0 to 139.

1 Introduction

1.1 Kaweah Basin Water Quality Association Organization Background

The Kaweah and St. John's Rivers Association (**KSJRA**) was formed in 2002 as a sub-watershed of the Southern San Joaquin Valley Water Quality Coalition (**SSJVWQC**) to address surface water quality issues within the Kaweah sub-basin. The SSJVWQC addresses water quality issues common to the sub-watersheds in the Tulare Lake Basin Area.

The Central Valley Regional Water Quality Control Board (**RWQCB**) adopted Waste Discharge Requirements (**WDRs**) for Growers within the Tulare Lake Basin Area that are a member of a Third-Party Group, Order No. R5-2013-0120 (**General Order**) on September 19, 2013. The Kaweah Basin Water Quality Association (**KBWQA**) was formed in October 2013 as a California non-profit mutual benefit corporation as the successor organization to the KSJRA, with the purpose of implementing the General Order Irrigated Lands Regulatory Program (**ILRP**) for its grower members. The KBWQA was authorized by the RWQCB as the third-party group to represent growers within its service area by the Notice of Applicability (**NOA**) received from the RWQCB on February 7, 2014.

Within the KBWQA, there are approximately 356,000 total acres in the Primary valley floor and 602,000 total acres in the Supplemental foothill and mountain areas, (**Figure 1-1**, **Figure 1-2**). Of these areas, approximately 163,000 and 4,000 acres, respectively, are enrolled as grower members in compliance with the ILRP as of October 2014 (**Figure 1-3**).

1.2 Purpose and Contents of Groundwater Quality Assessment Report

The KBWQA has prepared this Groundwater Quality Assessment Report (**GAR**) in accordance with the guidelines associated with the Monitoring and Reporting Program (**MRP**) of the General Order. Specific guidelines, as applicable to this GAR, are referenced where appropriate.

The purpose of the GAR is to provide the technical basis informing the scope and level of effort for implementation of the General Order's groundwater monitoring and implementation provisions. The main elements addressed in this GAR are provided below.

1.2.1 Report Objectives

- Provide an assessment of all available, applicable and relevant data and information to determine the high and low vulnerability areas where discharges from irrigated lands may result in groundwater quality degradation;
- Establish priorities for implementation of monitoring and studies within high vulnerability areas (**HVA**);
- Provide a basis for establishing workplans to assess groundwater quality trends;

- Provide a basis for establishing workplans and priorities to evaluate the effectiveness of agricultural management practices to protect groundwater quality; and
- Provide a basis for establishing groundwater quality management plans in high vulnerability areas and priorities for implementation of those plans.

1.2.2 GAR Components

- Detailed land use information with an emphasis on land uses associated with irrigated agricultural land;
- Information regarding depth to groundwater;
- Identification of areas contributing to recharge of urban and rural communities where groundwater serves as a source of supply;
- Soil survey information;
- Shallow groundwater constituent concentrations that could impact beneficial uses or cause degradation; and,
- Information on existing groundwater data collection and analysis efforts relevant to the General Order.

1.2.3 GAR Data Review and Analysis

- Determine where known groundwater quality impacts exist for which irrigated agricultural operations are a potential contributor or where conditions make groundwater more vulnerable to impacts from irrigated agricultural activities;
- Determine the merit and feasibility of incorporating existing groundwater data collection efforts and their corresponding monitoring well systems for obtaining appropriate groundwater quality information to achieve the objectives of groundwater monitoring under the General Order;
- Prepare a ranking of high vulnerability areas to provide a basis for prioritization of workplan activities; and,
- Discuss pertinent geologic and hydrogeological information for the Kaweah basin.

1.2.4 Groundwater Vulnerability Designation

- Designate high/low vulnerability areas for groundwater in consideration of high and low vulnerability as defined in Attachment E of the General Order.

1.2.5 Prioritization of High Vulnerability Groundwater Areas

Prioritize areas designated as high vulnerability to comply with the requirements of the General Order considering the following:

- Identify exceedances of water quality objectives for which irrigated agriculture waste discharge are a contributing source;

- Proximity of the high vulnerability area to areas contributing to recharge to urban and rural communities where groundwater serves as a significant source;
- Existing field or operational practices identified with irrigated agriculture waste discharge are a contributing source;
- The largest acreage commodity types comprising up to at least 80 percent of the irrigated agricultural acreage in the high vulnerability areas and the irrigation and fertilization practices employed by these commodities;
- Legacy conditions of the groundwater; and,
- Identify constituents of concern.

1.3 Additional Information Considered in Designating and Prioritizing Vulnerability Areas for Groundwater

1.3.1 Dairies

According to RWQCB data, as of 2012 there were approximately 71,000 acres of dairy associated land (dairy facility and manure land application areas) located within the Primary KBWQA area. Dairies are regulated under the RWQCB Order R5-2013-0122 Reissued Waste Discharge Requirements General Order for Existing Milk Cow Dairies (**Dairy GO**). For the purposes of this GAR, dairy properties and potential associated impacts are noted and discussed, with all properties subject to inclusion in the vulnerability areas. Water quality data for the dairies was obtained from the RWQCB. This data covers the 2007 to 2012 time period.

1.3.2 Undefined Properties

Based on the most recent California Department of Water Resources (**DWR**) land use data from 2007, there is approximately 11.6 percent and 0.2 percent of undefined irrigated acreage within the Primary and Supplemental KBWQA areas, respectively. These undefined properties were checked against both the Dairy GO and the ILRP membership list and have not been identified as belonging to either order. For the purposes of this GAR, if the parcels are irrigated, growing a commercial crop, and not identified under the Dairy GO, then they are considered to be farmland under this GAR analysis, regardless of ILRP membership status.

1.3.3 Disadvantaged Communities and Small Water Systems

The KBWQA recognizes the impact that poor water quality may have on local disadvantaged communities (**DACs**) and small water systems that are reliant on groundwater. Multiple data sources were reviewed to identify these systems and their locations. Based on the sources listed below, 59 systems were identified with 34 of those found to be reliant on groundwater with 22 located within the Primary KBWQA area and 11 located within the Supplemental area:

a. DWR geospatial database (**GIS**) data from census data for DACs, 2010;

b. State Water Resources Control Board Division of Drinking Water (**DDW**, formerly CDPH), web-based coordinate table for water system locations, 2014 (note that most data is still listed as coming from CDPH);

c. Mr. Mike Hickey, Tulare County Resource Management Agency, water supplier database, 2014;

d. Mr. Kris Sisk, RWQCB dairy management group, dairy assessor's parcel number (**APN**) list and water quality records, 2007 to 2012;

e. County of Tulare (**Tulare County**) – *Disadvantaged Community Water Study of the Tulare Lake Basin*, Table 3.8, August 2014; and

f. State Water Resource Control Board (**SWRCB**) Report to the Legislature, *Communities that Rely on a Contaminated Groundwater Source for Drinking Water*, Table 8.1, January 2013.

Figure 1-4 illustrates the locations of the systems with a complete list included as **Table 1-1**. Examples of the water system types include:

a. DACs - cities or Census Designated Places (**CDPs**) as classified by the DWR;

b. Small DACs – DACs as classified by DWR that fall within census tracts or block groups. These were further determined to be DACs in the Tulare County Tulare Lake Basin study; and

c. DDW systems - includes every domestic water supply that serves more than one house.

Groundwater quality impacts to the DACs and small water systems, as a result of agricultural activity, will be evaluated as part of this study.

1.3.4 Previous Designations

Finally, high vulnerability lands identified by the State Water Board as Hydrogeologically Vulnerable Areas and California Department of Pesticide Regulation groundwater protection areas are considered in designating and prioritizing vulnerability areas for groundwater.

1.4 Kaweah Basin Water Quality Association Area

The KBWQA covers the watershed from the Sierra Nevada Mountains to the valley floor in northern Tulare County within the Tulare Lake Basin. The KBWQA is comprised of the valley floor area as its Primary Area which contains the majority of the irrigated agricultural activity, while the foothill and mountain regions are considered as the Supplemental Area due to significantly reduced irrigated agricultural activity.

The northern boundary roughly follows the Kaweah Delta Water Conservation District (**KDWCD**) northern border, but has been extended further north to include Stone Corral Irrigation District (**SCID**) and portions of Cottonwood Creek. The western boundary generally follows the Kings County Water District (**KCWD**) and Tulare Irrigation District (**TID**) borders. The southern boundary generally follows the KDWCD southern border, but approximately follows the Avenue 212 alignment as it heads towards the foothills. In total, the KBWQA's service area approximately encompasses 958,000 acres.

1.4.1 Kaweah Sub-basin

The Kaweah sub-basin is located on the east side of the south-central portion of the San Joaquin Valley within the Tulare Lake Basin (**Figure 1-5**). The San Joaquin Valley, which is the southerly part of the great Central Valley of California, extends about 250 miles from the Sacramento-San Joaquin Delta area at the north end to the Tehachapi Mountains at the south end. In the vicinity of the KBWQA, the Valley is approximately 65 miles wide. The Valley is bordered on the east by the Sierra Nevada Mountains which range in elevation from about 1,000 feet or less to more than 14,000 feet above sea level. The Coast Range, which borders the Valley on the west, rises to about 6,000 feet above sea level. The southern end of the San Joaquin Valley, also known as the Tulare Lake Basin, is a closed feature separated from the Sacramento-San Joaquin Bay-Delta system and without external surface drainage.

The Tulare Lake Basin as referenced by the General Order is bounded by the crest of the Sierra Nevada Mountain Range to the east, the San Joaquin River to the north, the Westlands Water Quality Coalition and the crest of the Southern Coast Ranges to the west, and the crest of the San Emigdio and Tehachapi Mountains to the south. Tributary streams drain to depressions, the largest of which is the Tulare Lake bed located to the west of the KBWQA boundary. The Kings, Kaweah, and Tule Rivers and, on occasion, the Kern River, discharge into the Tulare drainage basin including the beds of the former Tulare, Buena Vista, and Kern Lakes at times when flows exceed the capacity of foothill reservoirs and of the irrigation diversion systems.

The Kaweah sub-basin lies between the Kings Groundwater sub-basin on the north and west, the Tule Groundwater sub-basin on the south, and crystalline bedrock of the Sierra Nevada foothills on the east. The sub-basin generally comprises lands in the Kaweah Delta Water Conservation District and is the approximate extent of the Primary KBWQA area. The sub-basin's watershed is to the east and is the approximate extent of the Supplemental KBWQA area. Major rivers and streams in the sub-basin include the Kaweah and St. Johns Rivers (**Figure 1-6**). The Kaweah River is the primary source of recharge to the area.

1.4.2 Kaweah River Watershed

The Kaweah River watershed area is approximately 630 square miles above the foothill line in Tulare County. The Terminus Reservoir on Lake Kaweah, located about 20 miles east of the City of Visalia, collects the majority of the tributary drainage area of about 560 square miles and produces about 95 percent of the total runoff of the watershed.

In general, the east side of the San Joaquin Valley constitutes a broad plain formed by large coalescing alluvial fans of streams draining the western slope of the Sierra Nevada. In the Kaweah area, the Kaweah River alluvial fan or delta is separated from the large Kings River fan on the north by Cross Creek. To the south, Elk Bayou separates the Kaweah River fan from the Tule River fan. Cottonwood Creek, an intermediate stream between Kings and Kaweah Rivers, discharges onto the interfan area of these two systems.

The Kaweah River fan is the most important fan complex in the Kaweah watershed and is characterized by a surface of low topographic relief, with variations rarely exceeding 10 feet except in stream channels. Elevations vary from about 500 feet above sea level near the easterly boundary to about 200 feet at the westerly boundary. These lands generally slope in a southwesterly direction at about 10 feet per mile, with the slope lessening as the westerly boundary is approached. In the easterly part of the area, surface soils are sandy and permeable, generally grading to finer materials to the west. The Kaweah River fan is characterized by a network of natural channels of the Kaweah River and its distributaries as well as numerous canals constructed for irrigation purposes.

1.5 Climate

The climate in the Primary KBWQA area can be defined as near desert, based on the amount of rainfall it receives. Desert regions are defined as receiving less than 10 inches of rainfall annually. The long-term average rainfall in the KBWQA is just above that limit at 10.26 inches, based on historical statistics for the City of Visalia. Nearly 80 percent of the rainfall occurs between November and March, when most crops are not being irrigated. Rainfall in summer months, when irrigation is at its highest, is basically negligible. A summary of the temperature and precipitation for the Primary area is provided in **Table 1-2**.

Storm intensities are generally insufficient to induce large runoff, except from impervious surfaces such as roads and parking lots typical of urban infrastructure. On the Valley floor, average monthly rainfall during the wettest month of the year is only 1.94 inches, or an average of just over 0.06 inches per day. While rainfall intensities can vary, it is clear that generally, rainfall on the valley floor does not generate sufficient runoff volumes to be of concern.

Temperature in the Primary area can be classified as hot summer months with mild to cool winter months. Irrigation is at its peak during the summer months when temperatures can easily surpass 100°F during the day and crop evapotranspiration is at its highest. Winter months are generally fairly mild, but temperatures can drop below freezing during nights, which can become problematic for citrus growers in the KBWQA.

The climate in the Supplemental area can be divided into the foothill and mountain areas. Foothill temperatures near Three Rivers tend to be somewhat cooler than the valley floor with a yearly average precipitation of 21.71 inches. The higher elevation mountain areas near Lodgepole in the Sequoia National Forest are typically the coolest in the region with normal winter lows down to 16°F and summer highs up to 73°F. The mountain area yearly precipitation averages 44.53 inches with the highest average precipitation occurring in January. Much of the winter precipitation occurs in the form of snow, due to below freezing temperatures. This precipitation remains frozen until temperatures increase causing the snow to melt, increasing flows in rivers and streams in the spring and early summer. A summary of the temperature and precipitation for the Supplemental area is provided in **Table 1-3**.

1.6 Tulare Lake Basin Plan

The RWQCB's Tulare Lake Basin Plan (**Basin Plan**) identifies the beneficial uses of the Kaweah Basin in 1993 as municipal and domestic supply (**MUN**), agricultural supply (**AGR**), industrial service supply (**IND**), industrial process supply (**PRO**), water contact recreation (body contact with water) (**REC-1**), and non-contact water recreation (no body contact with water) (**REC-2**). Exceptions to the beneficial use designations that would be considered by the RWQCB are delineated within the Basin Plan.

The Basin Plan identifies the greatest long-term problem facing the Basin as the increase in salinity in groundwater. Because of the closed nature of the Tulare Lake Basin, there is little subsurface outflow.

Thus salts accumulate within the Basin due to the importation and evaporative use of water. A large portion of this increase is due to the intensive use of soil and water resources by irrigated agriculture.

The Basin Plan recognizes that degradation is unavoidable without a plan for removing salts. For the Kaweah River hydrographic unit, the maximum average annual increase in salinity measured as electrical conductivity (**EC**) shall not exceed three micromhos per centimeter (**µmhos/cm**) as specified in Table III-4 of the Basin Plan. Further, the average annual increase in EC will be determined from monitoring data by calculation of a cumulative average annual increase over a 5-year period.

On June 6, 2014, the RWQCB adopted Resolution No. 5-2014-0074, Amendments to the Water Quality Control Plan for the Sacramento River and San Joaquin River Basins and the Water Quality Control Plan for the Tulare Lake Basin to Add Policies for Variances from Surface Water Quality Standards for Point Source Dischargers, Variance Program for Salinity, and Exception from Implementation of Water Quality Objectives for Salinity. The Resolution must pass SWRQB Office of Administrative Law and United States Environmental Protection Agency (**USEPA**) review.

The proposed amendments apply to the time period during which the comprehensive Salt and Nutrient Management Plans for the Central Valley are under development. Under the proposed amendments, in part, certain qualified dischargers may apply for a variance from salinity water quality standards for groundwater. Variances would be for one of the following applicable constituents EC, total dissolved solids (**TDS**), chloride, sulfate, or sodium. Variances would be reviewed by the RWQCB every three to five years depending on the applicant, and will not be renewed after June 30, 2019.

Table 1-1. DACs and Small Water Systems Reliant on Groundwater

DACs and Small Water Systems Reliant on Groundwater						
System Name	**System ID**	**Water Source**	**Community Type**	**Ownership**	**Population (Est.)**	**Connections (Est.)**
Primary KBWQA Area						
Bedel Mutual Water Company	5400816	GW	non-DAC	Private	155	66
California Water Service - Tulco Water Company	5410041	100% GW	DAC	Private	565	108
City of Exeter	5410003	GW	DAC	PWS	10,665	3,176
City of Farmersville	5410004	GW	DAC	PWS	10,971	2,403
City of Tulare Water Service Area	5410015	GW	DAC	PWS	60,289	17,086
City of Woodlake	5410020	GW	DAC	PWS	7,300	1,903
Goshen Community Water System	DAC – see note below.					
Ivanhoe Public Utility District	5410019	100% GW	DAC	Public	4,474	1,174
Lemon Cove Water Company	5400616	100% GW	DAC	Public	150	50
Linnell Farm Labor Center	5400631	100% GW	SDAC	Private	896	190
Matheny Tract/Pratt Water Company	5410015	100% GW	SDAC	Private	1,980	325
Mountain View Mobile Home Park	5400819	100% GW	DAC	Private	44	24
Oak Ranch Community Water System	5410046	GW	non-DAC	Private	675	270
Patterson Tract Community Services District	5402038	100% GW	DAC	Private	550	114
Soults Mutual Water Company	5400805	100% GW	DAC	Private	100	36
Sunrise Mutual Water Company	5400881	100% GW	DAC	Private	140	39
The Lakes	5400880	GW	non-DAC	Private	160	70
Tooleville Water Company	5400567	100% GW	SDAC	Private	350	77
Tract 92 Community Services District	5400903	100% GW	SDAC	Private	500	91
West Goshen Mutual Water Company	5400957	100% GW	DAC	Private	200	69
Westlake Village Mobile Home Park	5400966	GW	non-DAC	Private	350	139
Yokohl Mutual Water Company	5400647	GW, SW	non-DAC	Private	75	32

GW – groundwater
SW – surface water
PWS – public water system

Table 1.1 (Continued) – DACs and Small Water Systems Reliant on Groundwater

DACs and Small Water Systems Reliant on Groundwater						
System Name	**System Name**	**System Name**	**System Name**	**System Name**	**System Name**	**System Name**
Secondary KBWQA Area						
Badger Hill Estates	5400710	GW		Private	300	77
Deer Meadow Mutual Water Company	5401026	GW, SW		Private	75	22
Hartland	5403135	GW	SDAC		36	20
Improvement District #1	5400968	GW,SW		Public	200	77
Lower Springs Water Company	5403001	GW			50	3
River Retreat Mutual Water Company	5400556	GW		Private	25	9
Sierra Glen Mobile Home Park	5400551	GW	DAC		22	14
Sierra King Homeowners Association	5400940	GW		Private	120	40
Silver City Water Company	5401071	GW, SW			128	48
South Kaweah Mutual Water Company	5400754	GW		Private	300	105
Trailer Isle Park	5400629	GW		Private	150	57

GW – groundwater
SW – surface water
PWS – public water system

Notes:

Matheny Tract: Due to nitrate issues within the existing groundwater supply for the Pratt Mutual Water Company (Matheny Tract) located southwest of the City of Tulare, Pratt MWC has been in talks with the City to connect to their municipal water system. As of this report, Pratt is still on their old water system but this could change at any time.

Goshen Community Water System: Goshen CWS is listed as a designated census place per DWR however they source their water from the City of Visalia. Since Goshen is not incorporated and not within Visalia city limits it has not been included in the DAC assessment.

Table 1-2. Primary Area Temperature and Precipitation Summary

Primary Area Temperature and Precipitation Summary			
Visalia, California			
Month	Maximum Temperature	Minimum Temperature	Precipitation (in)
January	55.1	38.6	2.01
February	61.7	42.2	1.95
March	67.7	46.0	1.81
April	73.8	49.5	1.02
May	81.9	55.7	0.38
June	89.3	61.6	0.13
July	94.2	66.3	0.01
August	93.1	64.8	0.01
September	87.7	60.0	0.14
October	77.9	52.5	0.55
November	62.8	42.5	1.15
December	55.1	38.2	1.79
Annual Average/Total:	**75.03**	**51.5**	**11.0**

Table 1-3. Supplemental Area Temperature and Precipitation Summary

Supplemental Area Temperature and Precipitation Summary				
Ash Mountain, California				
Month	**Maximum Temperature**	**Minimum Temperature**	**Precipitation (in.)**	**Snowfall (in.)**
January	57.5	36.1	4.75	1.1
February	61	39.0	4.70	0.5
March	64.5	41.6	4.30	0.4
April	70.5	45.7	2.62	0.2
May	79.8	52.4	1.04	0
June	89.6	60.3	0.32	0
July	98.1	67.8	0.08	0
August	96.9	66.9	0.07	0
September	91.1	61.0	0.39	0
October	80.2	52.3	1.10	0
November	67.1	42.7	2.69	0.2
December	58.6	37.1	4.13	0.1
Annual Average/Total:	**76.2**	**50.2**	**26.2**	**2.50**

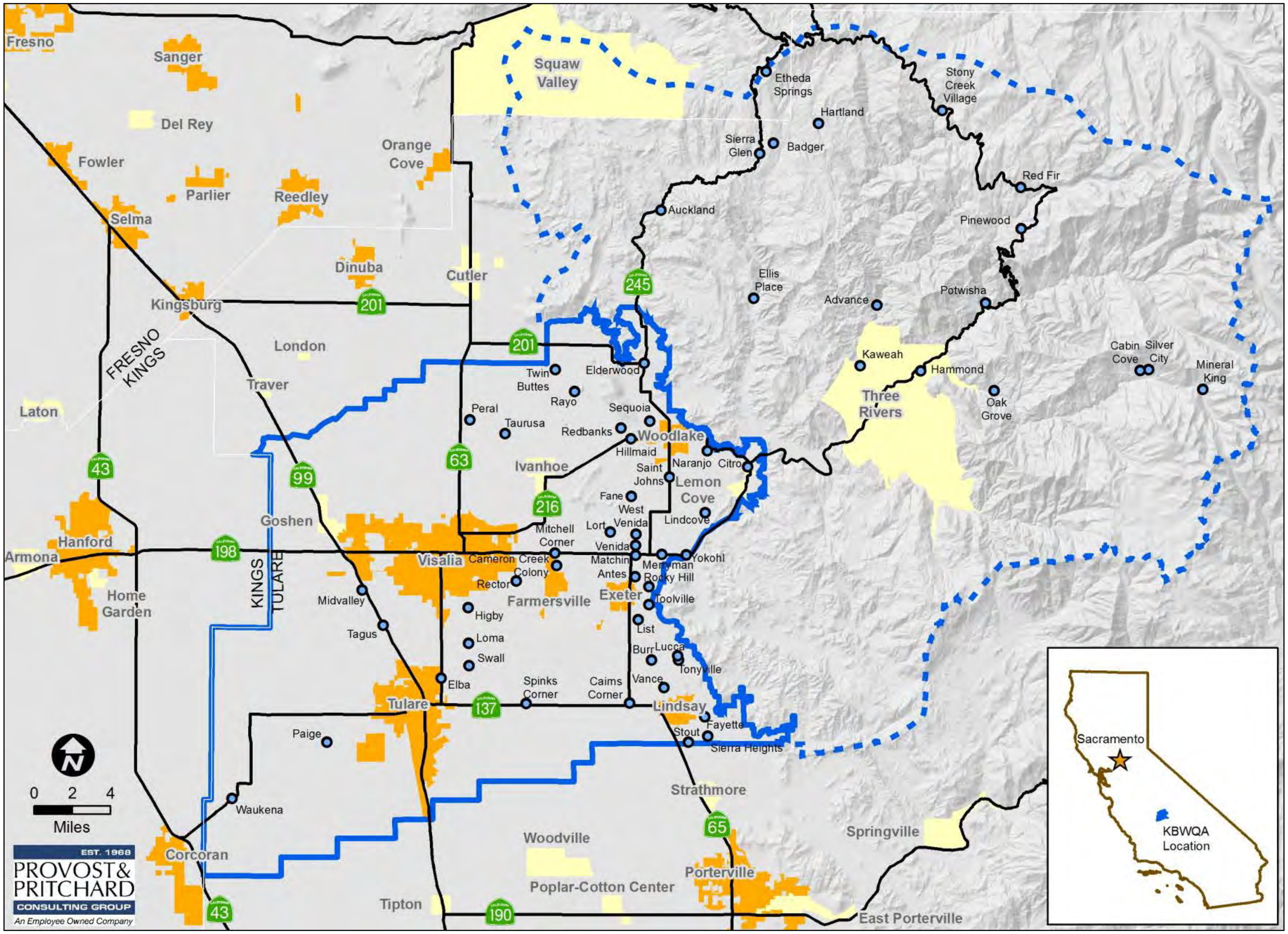

Figure 1-1. Vicinity Map

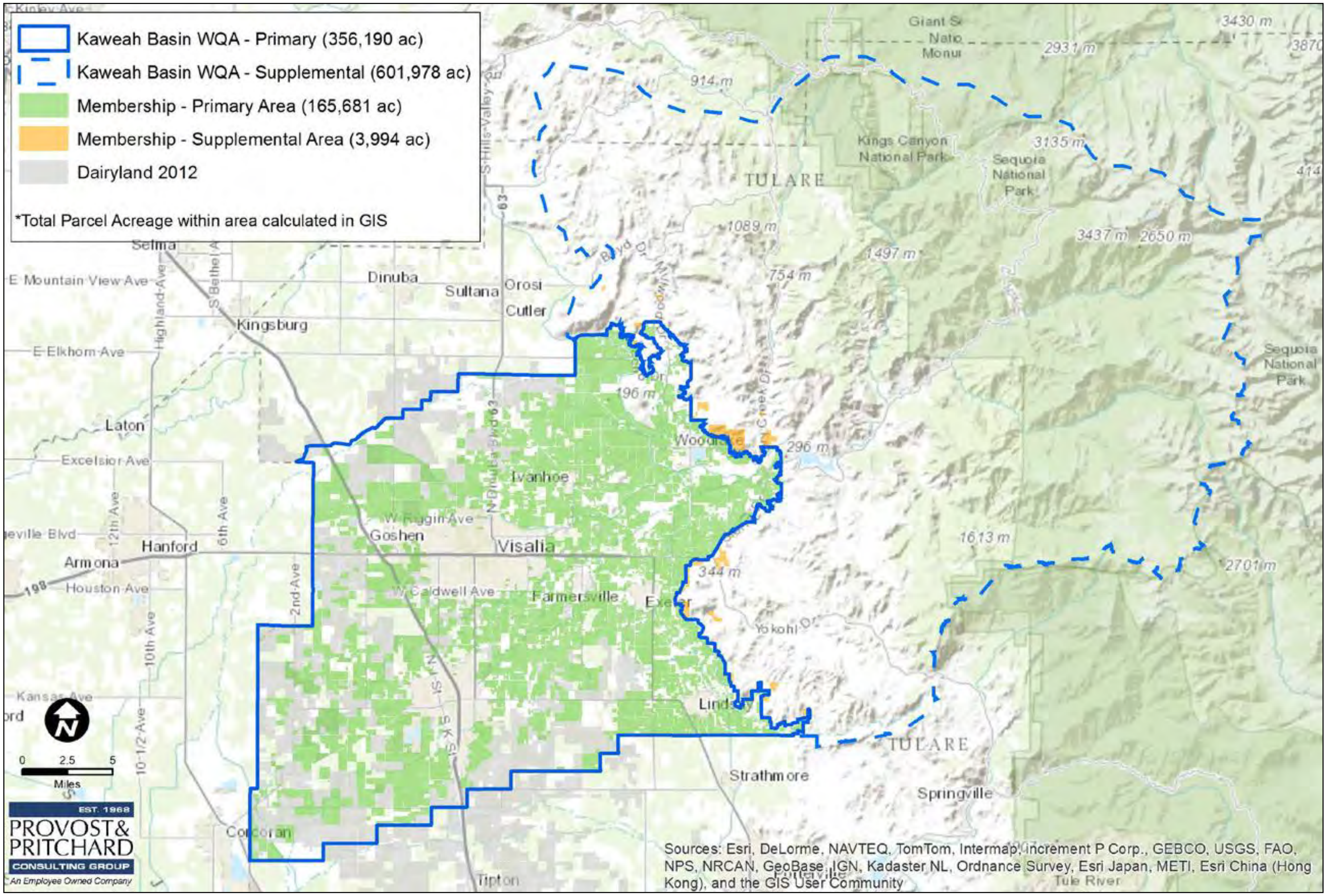

Figure 1-2. KBWQA Boundary Map

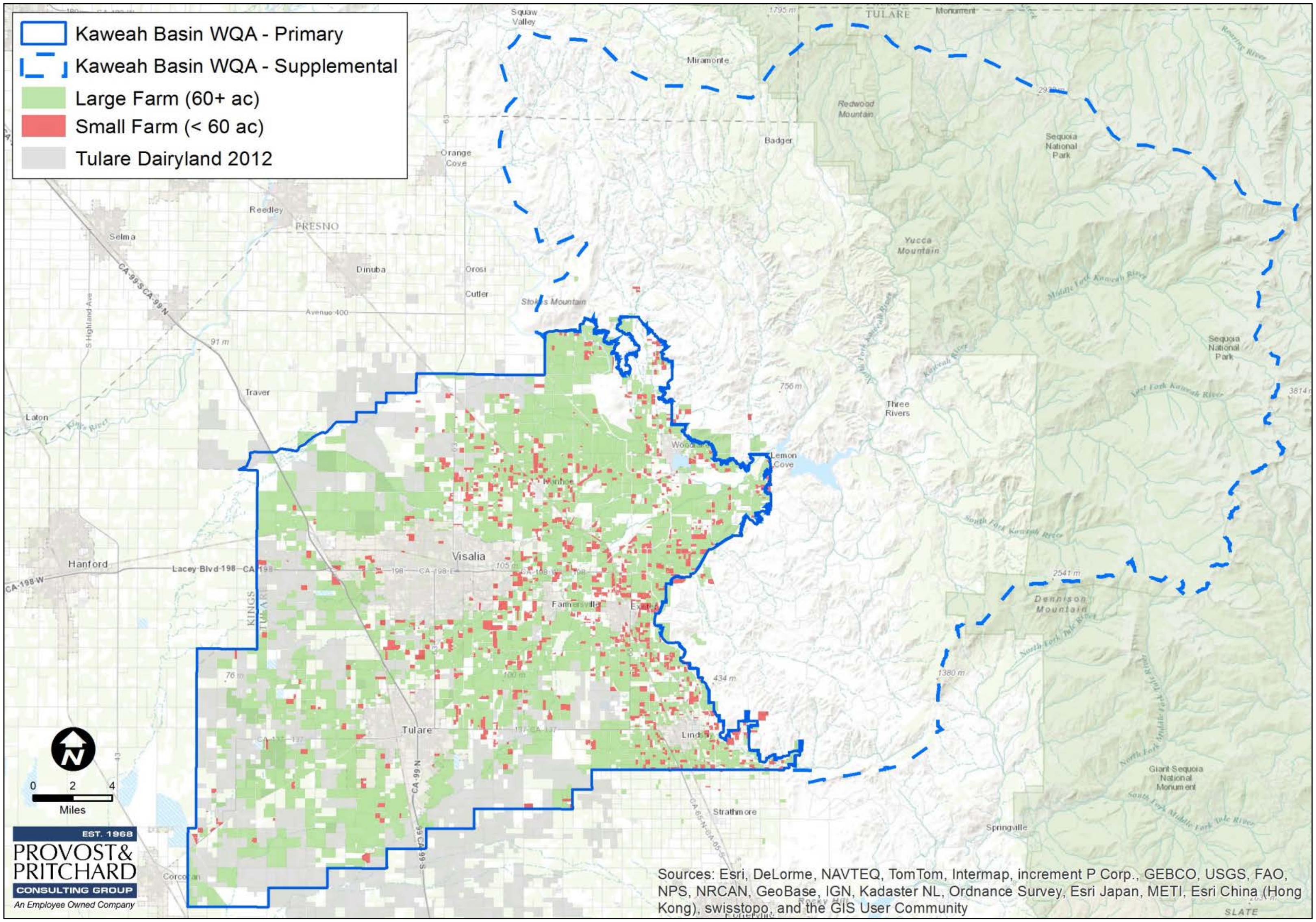

Figure 1-3. KBWQA Irrigated Lands Membership by Farm Size as of October 2014

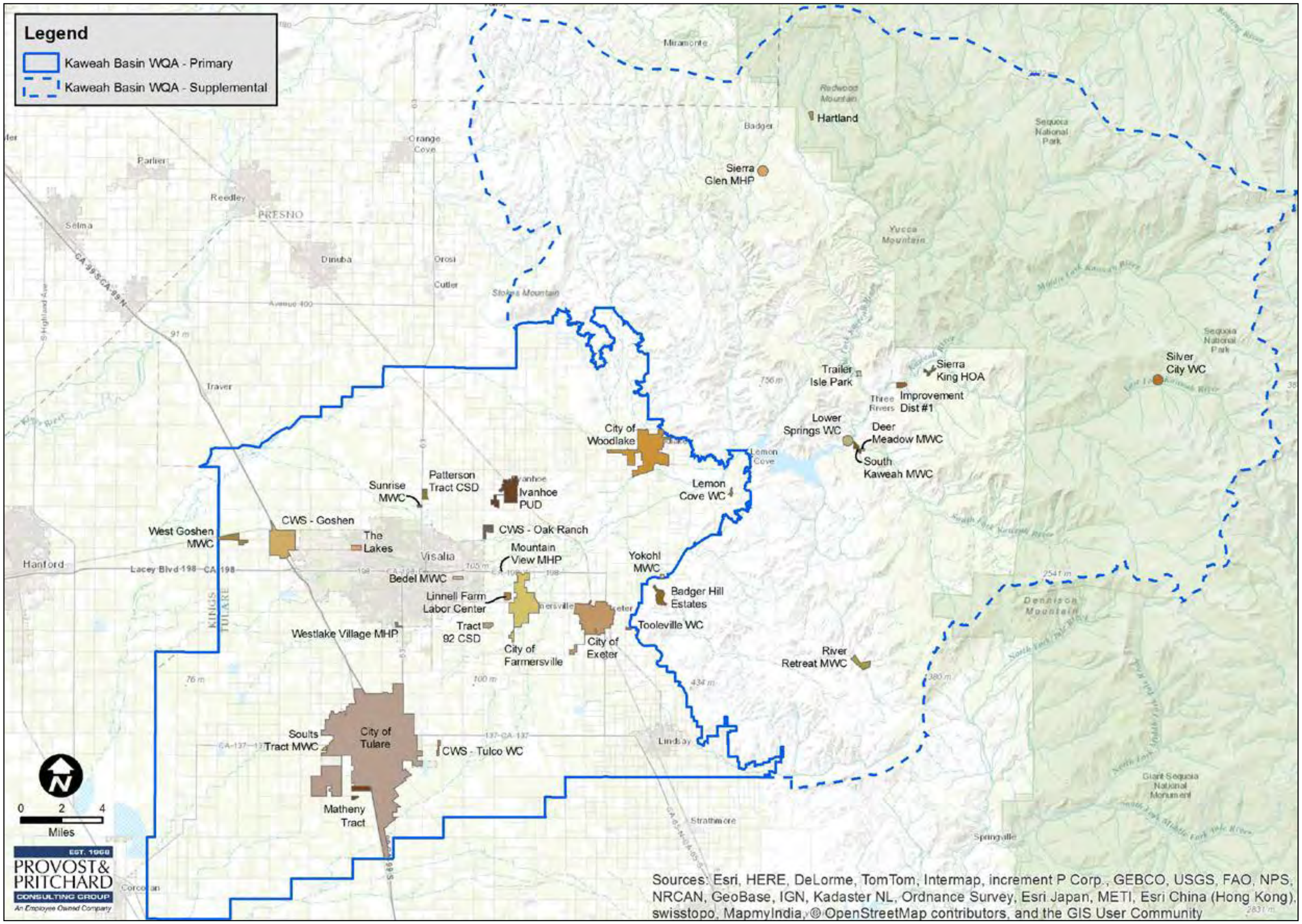

Figure 1-4. DACs and Small Water Systems Reliant on Groundwater

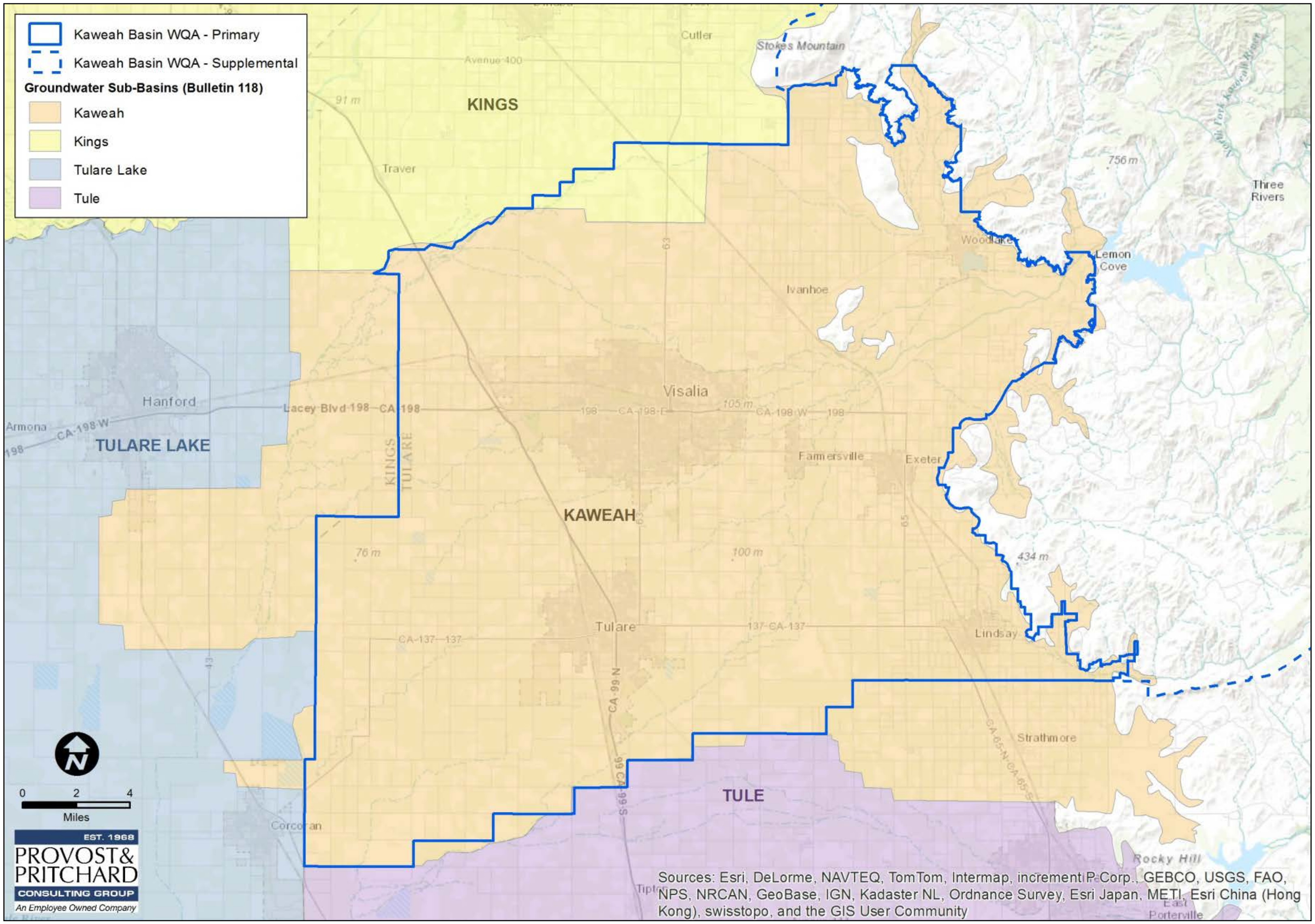

Figure 1-5. Groundwater Basins

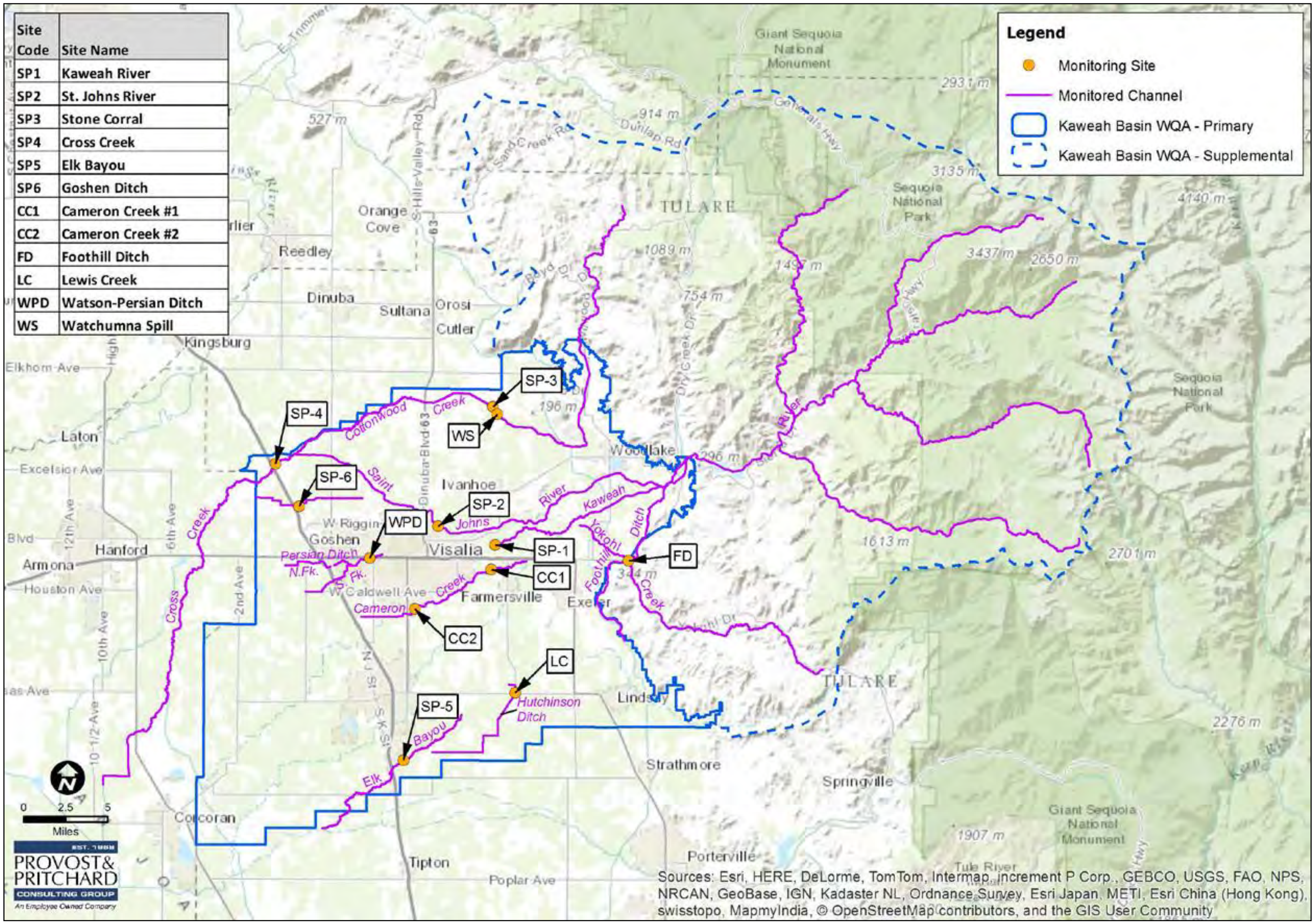

Figure 1-6. Major Hydrology

2 Geology and Soils

2.1 Potential Sources of Information

2.1.1 Geologic and Hydrogeologic Data from Published Reports

A comprehensive geologic and hydrogeologic chapter for the Primary area was prepared as part of the *Water Resources Investigation of the Kaweah Delta Water Conservation District* (**WRI**) prepared by Fugro West, Inc. and dated December 2003, revised July 2007. Since the KDWCD is the predominant district within the KBWQA area, the Fugro information has been reproduced with original references as part of the Regional Geologic Setting section of this GAR.

2.1.2 Local Irrigation and Water Districts

Other nearby districts include Alta, Stone Corral, and Ivanhoe Irrigation Districts to the northeast of KDWCD, as well as Exeter and Lindmore Irrigation Districts and the Lewis Creek Water District to the southeast. Information from these districts was researched and incorporated herein, as applicable.

2.1.3 USGS Central Valley Hydrologic Model

Developed by the United States Geological Survey (**USGS**), the Central Valley Hydrologic Model (**CVHM**) is a detailed three dimensional computer model that simulates how water moves through the Central Valley hydrologic system. The model was developed to provide a method for water managers to develop management strategies based on how surface and groundwater move throughout the region. The model does not include the Supplemental area.

GIS information was combined with a texture model of deeper soil profiles developed from information from well driller's logs and the hydrologic modeling software MODFLOW which simulates natural and human-induced water flows.

The CVHM utilizes information from the Natural Resources Conservation Service (**NRCS**) soil survey for the surface soil profile used in the model. Therefore, information regarding surface soil characteristics from this source will be a duplicate of the data obtained from the NRCS. The hydraulic conductivity and soil type of soils deeper than the soils information provided in the NRCS was compiled in the CVHM based on well drillers logs. A discussion of the CVHM's upper 200 feet of coarse grain texture percentage is included in this section.

2.1.4 DWR Bulletin 118

DWR Bulletin 118 is a comprehensive groundwater report prepared for the State and for groundwater basins within the State. The Bulletin 118 was updated for the State in 2003 with previous updates performed in 1952, 1975, and 1980. A series of region specific bulletins were also written, but the KBWQA area is not included in any of these regional bulletins. Bulletin 118 geologic information was found to be redundant to the detailed irrigation district reports, accordingly, was not specifically utilized within this section.

2.1.5 Natural Resources Conservation Service

The primary source of soil information is from the NRCS which provides surface soil data and mapping for 95 percent of the United States. NRCS soil survey data is typically used for general farm information, local and wider area planning activities and has been incorporated, as applicable. NRCS data does not cover the entire the Supplemental area.

2.1.6 USGS Digital Elevation Model

The USGS digital elevation model (**DEM**) provides information on the terrain and slope of the land surface. The USGS created and maintains the National Elevation Dataset for use by scientists and engineers. The data is updated when more current or accurate information becomes available. DEM data was incorporated, as applicable.

2.2 Regional Geologic Setting

2.2.1 Kaweah Delta Water Conservation District

The KDWCD covers approximately 254,000 of the Primary 356,000 KBWQA area acres (71 percent) (**Figure 2-1**). The Fugro report describes the District in great detail from near the mouth of the Kaweah River extending to the aerial extent of its alluvial fan. This section is heavily excerpted from that report. An overview geology map is included as **Figure 2-2.** Please see the Fugro report for more detailed mapping and cross sections.

The rocks that crop out in the KDWCD include a basement complex of pre-Tertiary age consisting of consolidated metamorphic and igneous rocks, and unconsolidated deposits of Pliocene, Pleistocene, and Recent Age, all of which contain fresh water. Consolidated marine rocks of Pliocene age and older do not crop out in this area but are penetrated by wells in the subsurface. Because the water from those wells generally is brackish or salty, the marine rocks are not considered as part of the fresh-water reservoir and constitute the effective base of fresh water (or permeable sediments). Most of the groundwater pumped within the KDWCD is from the unconsolidated deposits and they have therefore been studied in greater detail (Croft, 1968) with reference to their water-bearing properties.

Geologic units that affect the occurrence and movement of groundwater in the KDWCD are generally classified and described as follows:

a. Basement Rocks: Non-water-bearing granitic and metamorphic rocks.

b. Marine Rocks: Non-water-bearing marine sediments including the San Joaquin Formation.

c. Unconsolidated Deposits: Non-marine, water-bearing material comprised of the Tulare Formation and equivalent units.

d. Alluvial Deposits: Coarse-grained, water-bearing alluvial fan and stream deposits including older oxidized and reduced units, and younger alluvium.

e. Lacustrine and Marsh Deposits: Fine-grained sediments representing a lake and marsh phase of equivalent continental and alluvial fan deposition.

The basement complex of pre-Tertiary age consists of metamorphic and igneous rocks. They underlie the Sierra Nevada and occur as resistant inliers in the alluvium and as linear ridges in the foothills east of the KDWCD. In the subsurface, they slope steeply westward from the Sierra Nevada beneath the deposits of Cretaceous age and younger rocks that compose the valley fill. There are escarpments that are interpreted as buried fault scarps associated with the Rocky Hill fault. West of the escarpments, the slope of the basement complex steepens. In the Tulare Lake area, an oil-test well failed to penetrate the basement complex at 14,642 feet below sea level (Smith, 1964).

The basement complex is at shallow depths in the Lindsay, Strathmore, and Ivanhoe areas and in the intermontane valleys where it is penetrated by many water wells. Near Farmersville and Exeter, the basement complex forms a broad, gently westward-sloping shelf overlain by 100 to 1,000 feet of unconsolidated deposits. In T17S/R24E (near Ivanhoe), the basement complex drops abruptly to about 2,000 feet below land surface, presumably due to faulting.

Along the east border of the San Joaquin Valley, Tertiary rocks, mainly of marine origin, overlap the basement complex and underlie the unconsolidated deposits. Croft (1968) suggests this unit may locally include beds of continental origin in the upper part. In the KDWCD, the marine rocks do not crop out. The Tertiary marine rocks have locally been penetrated by oil- and gas-test wells in the east part of the KDWCD, and range in age from Eocene to late Pliocene and consist of consolidated to semi-consolidated sandstone, siltstone, and shale. They have traditionally been locally divided into several formations by geologists (Park and Weddle, 1959), but as they generally contain brackish and saline connate or dilute connate water unsuitable for most uses, they are treated here as one unit.

The unconsolidated deposits described in this report are equivalent to those that have been described in previous reports and are divided into several geologic units. In the Kettleman Hills, west of the KDWCD, Woodring et al. (1940) divided the unconsolidated deposits into the Tulare Formation and into older and younger alluvium. The Tulare Formation in the Kettleman Hills overlies the upper Mya zone (Woodring et al., 1940, p. 13), a fossil horizon at the top of the San Joaquin Formation. The Mya zone is reported in well logs beneath Tulare Lake Bed and is a prominent marker bed outside of the KDWCD that separates the marine rocks (described above) from overlying continental deposits. The base of the unconsolidated deposits is projected by electric log correlation from the upper Mya zone beneath Tulare Lake Bed, eastward to the top of marine rocks. The unconsolidated deposits of this report are equivalent to the continental deposits from the Sierra Nevada of Klausing and Lohman (1964) and to the unconsolidated deposits as used by Hilton et al. (1963).

The unconsolidated deposits thicken from zero along the western front of the Sierra Nevada to a maximum of about 10,000 feet at the west boundary of the KDWCD. The unconsolidated deposits in the KDWCD are divided into three stratigraphic units: continental deposits, older alluvium, and younger alluvium. In the subsurface, the younger alluvium interfingers and/or grades laterally into the floodbasin deposits and into alluvium, undifferentiated. The older alluvium and continental deposits interfinger and/or grade laterally into the lacustrine and marsh deposits or into alluvium. In the subsurface, the older alluvium and continental deposits are also further subdivided into oxidized and reduced deposits on the basis of environment of deposition.

Unconsolidated deposits, which locally crop out east of the KDWCD and extend beneath the valley floor, were eroded from the adjacent mountains, then transported by streams and mudflows, and deposited in lakes, bogs, swamps, or on alluvial fans. The lithologic and waterbearing characteristics of the deposits are dependent upon several controlling factors, which include 1) environment of deposition, 2) the type of rock in the source area, and 3) competence (or energy) of the streams.

According to Davis et al. (1957), oxidized deposits generally represent subaerial deposition, and reduced deposits generally represent subaqueous deposition. Oxidized deposits are red, yellow, and brown, consist of gravel, sand, silt and clay, and generally have well-developed soil profiles. Reduced deposits are blue, green, or gray, calcareous, and generally are finer grained than oxidized deposits, and commonly have a higher organic content than the oxidized deposits. In some cases, the separation between the oxidized and reduced deposits can be identified on well logs based on lithologic color. Such delineation can of course be highly subjective. The coarsest grained reduced deposits were laid down in a flood plain or deltaic environment bordering lakes and swamps. Because of a high water-table in the east side of the KDWCD, the sediments have not been exposed to subaerial weathering agents. The finest grained reduced deposits were mapped as flood basin, lacustrine, and marsh deposits.

The oxidized deposits underlie the older and younger alluvium and throughout most of the KDWCD, the oxidized deposits are 200 to 500 feet thick. The oxidized deposits consist mainly of deeply weathered, reddish brown, calcareous sandy silt and clay and can, in most well completion reports, be readily identified when present. Beds of coarse sand and gravel are rare, but where present, they commonly contain significant silt and clay. The highly oxidized character of the deposits is the result of deep and prolonged weathering. Many of the easily weathered minerals presumably have altered to clay and, as such, are poorly permeable.

The lacustrine and marsh deposits of Pliocene and Pleistocene age consist of bluegreen or gray gypsiferous silt, clay, and fine sand that underlie the flood-basin deposits and conformably overlie the marine rocks of late Pliocene age. In the subsurface beneath parts of Tulare Lake Bed, these beds extend to about 3,000 feet below land surface. Where the equivalent beds crop out in the Kettleman Hills on the west side of the valley, they were named the Tulare Formation by Anderson (1905, p. 181). The lacustrine beds and fossils of the Tulare Formation were mapped and described in detail by Woodring et al. (1940, p. 13-26) who considered the top of the Tulare Formation to be the uppermost deformed bed. Therefore, by this definition, all the deformed unconsolidated deposits would form the Tulare Formation.

In the subsurface around the margins of the Tulare Lake Bed, the lacustrine and marsh deposits form several clay zones that interfinger with more permeable beds of the continental deposits, alluvium, undifferentiated, and older alluvium. Because of contained fossils and stratigraphic relations to adjacent deposits, these clays are considered to be principally of lacustrine origin. Clay zones are generally indicated by characteristic curves on electric logs and thereby facilitate some areal correlations between adjacent logs as shown in hydrogeologic cross sections. Although as many as six laterally continuous clay zones have locally been defined in the southern San Joaquin Valley, only the most prominent of these clay zones known as the "E" Clay (or Corcoran Clay member) of the Tulare Formation is found within the KDWCD , pinching out just east of the U.S. Highway 99 corridor. Clay deposits are nearly impermeable and yield little water to wells and that which is obtained is generally of poor chemical quality.

The E Clay is one of the largest confining bodies in the area and underlies about 1,000 square miles west of U.S. Highway 99. The beds were deposited in a lake that occupied the San Joaquin Valley trough and which varied from 10 to 40 miles in width and was more than 200 miles in length (Davis et al., 1957). The first wide-scale correlation of the Corcoran Clay was made by Frink and Kues (1954).

The E Clay extends from Tulare Lake Bed to U.S. Highway 99 and is vertically bifurcated near Goshen. It is about 140 feet thick near Corcoran and the average thickness is about 75 feet. The deposits near Corcoran are probably the thickest section in the San Joaquin Valley.

As previously mentioned, the reduced older alluvium is a moderately permeable arkosic deposit that is not exposed in the KDWCD. It overlies the continental deposits, interfingers with lacustrine and marsh deposits beneath Tulare Lake Bed, and interfingers with alluvium, undifferentiated, north of Tulare Lake Bed. Around the margin of Tulare Lake Bed, the reduced older alluvium interfingers with lacustrine deposits.

The reduced older alluvium consists mainly of fine to coarse sand, silty sand, and clay that were probably deposited in a flood plain or deltaic environment. Gravel that occurs in the oxidized older alluvium is generally absent. The deposits are sporadically cemented with calcium carbonate, according to logs of core holes made by geologists of the Bureau of Reclamation. Those descriptions imply, however, that the calcium carbonate is probably less abundant than in the underlying reduced continental deposits.

The oxidized older alluvium unconformably overlies the continental deposits. The beds consist of fine to very coarse sand, gravel, silt and clay derived for the most part from granitic rocks of the Sierra Nevada. Beneath the channels of the Kaweah, Tule and Kings Rivers, electric logs indicate that the beds are very coarse. In the interfan areas, metamorphic rocks and older sedimentary units locally contributed to the deposits and, in those areas, the beds are probably not as coarse as the beds beneath the Kaweah, Tule, and Kings Rivers. Fine-grained deposits occur in the channel of Cross Creek.

East of U.S. Highway 99, the contact of the older alluvium with the underlying oxidized continental deposits is well defined in electric logs. The older alluvium thickens irregularly from east to west, and probably has filled gorges cut by the ancient Tule River in the underlying oxidized continental deposits near Porterville. The base of the deposits occurs 195 feet below land surface near Exeter, and declines to 430 feet below land surface near Visalia and Goshen. In the log of 18S/23E-12H1, the base of the older alluvium occurs about 200 feet beneath the E Clay.

Younger alluvium consists of gravelly sand, silty sand, silt, and clay deposited along stream channels and laterally away from the channels in the westerly portion of the KDWCD. Younger alluvium is relatively thin locally, reaching a maximum depth below ground surface of perhaps 100 feet. Except in the extreme easterly portion of the KDWCD, it is generally above the water table and does not constitute a major water-bearing unit.

Soils developed on younger alluvium show little or no profile development and are generally free of underlying clay subsoil or hardpan. Because percolation rates through the younger alluvium are moderate to high, this deposit serves as a permeable conveyance system for recharge to underlying water-bearing materials.

The structural geology of the KDWCD is relatively simple. In the eastern portion of the KDWCD the Rocky Hill fault disrupts pre-Eocene deposits and may locally penetrate older alluvial deposits. The linearity of the ridges in this area defines the fault line. Croft (1968) suggests that the Rocky Hill fault does not offset younger alluvium based on water level data. Nonetheless, the hydrologic connection of aquifers (oxidized alluvial deposits) may be restricted.

A thickening section of unconsolidated deposits is indicated moving west across the KDWCD. The surface of the Tulare Formation is described by Woodring et al. (1940) as being modestly warped, suggesting regional folding during and after deposition. For the most part, such warping has little affect on the patterns of groundwater flow within the KDWCD (i.e., across the hydrologic unit boundaries) or at the perimeter boundaries.

2.2.2 Other Irrigation and Water Districts

Basic topography and soils of the irrigation and water districts located to the northeast and southeast of the KDWCD area are noted below.

2.2.2.1 Alta Irrigation District

The Alta Irrigation District is part of the valley floor and is a nearly flat northwest to southeast trending alluvial plain. Alluvial sediments are a heterogeneous mix of clay, silt, sand and gravel bounded on the east by Sierra Nevada granitic rocks. The soils are complex with the unconsolidated alluvial fans made up of varied textured material. The upper soils vary from heavy clays near the base of the Sierras to relatively coarse sand to the west along the Kings River. Much of the area is underlain by hardpan that restricts the vertical percolation of water. There are isolated coarse grained materials with high percolation rates typically found where old streambeds historically meandered throughout the area.

2.2.2.2 Stone Corral Irrigation District

The Stone Corral Irrigation District slopes generally to the southwest, varying from 30 percent on the steepest northeastern slopes, to less than 1 percent along the western border. The District is situated on the ridge between the Kaweah and Kings River alluvial fans with elevations ranging from 500 feet above sea level in the northeast portion to 345 feet in the southwestern quarter. The District area consists chiefly of rolling terrace land with hardpan soils and uniformly sloping lands with adobe clay soils.

2.2.2.3 Ivanhoe Irrigation District

Ivanhoe Irrigation District is located generally between the St. Johns River on the south and Cottonwood Creek on the north. Those two streams flow generally to the southwest and northwest, respectively, from the foothills of the Sierra Nevada Mountains. Two prominent features in the area are Twin Buttes on the north boundary of the District and Venice Hills on the south boundary. Cottonwood Creek flows north of Twin Buttes and the St. Johns River flows south of Venice Hills. The Kaweah River, of which the St. Johns River is a distributary, flows to the southwest on the south side of the St. Johns River. The elevation of the District lands varies from about 430 feet above sea level on the east side, to about 350 feet above sea level on the west side of the District. The peak of the Venice Hills is 85 feet and the peaks of Twin Buttes are 584 feet and 651 feet above sea level. The extent of the District is about 6 miles east and west and about 4 miles north and south. The lands of the District slope about 13 feet per mile to the west.

About 90 percent of the District is situated on an old alluvial plain, lying between the St. Johns River and Cottonwood Creek. The plain is characterized by gently rolling terrain and strongly developed soils, underlain by hardpan at depths ranging from 18 to 30 inches. The remainder of the District consists of small areas of foothill lands, recent stream deposits adjoining Cottonwood Creek and adobe clay soils on the smooth valley plain near the foothills.

2.2.2.4 Exeter Irrigation District

Elevation within Exeter Irrigation District ranges from about 630 feet along the northeastern boundaries to 340 feet in the southwest, with approximately 98 percent of the District below elevation 460. That portion of the District north of State Highway 198 has a northwesterly slope of approximately 17 feet per mile, while that portion of the District south of State Highway 198 has a southwesterly slope of about 16 feet per mile.

The Friant-Kern Canal, traversing basically in a north-south direction, lies within or is the District's eastern boundary for approximately eight miles. The District lies within the Yokohl Creek portion of the Kaweah River Alluvial Fan. Yokohl Creek is an intermittent stream which traverses through the northern portion of the District in a northwesterly direction for approximately two miles. The predominant soils within the Exeter area are of the San Joaquin or Exeter series with significant, however, lesser areas of the Porterville series, all of which are largely situated on hardpan soils.

2.2.2.5 Lindmore Irrigation District

The Lindmore Irrigation District lies at the base of the western foothills of the Sierra Nevada, on the east side of the San Joaquin Valley. It extends from two miles north of Lindsay southward roughly 1½ miles south of Strathmore, a distance of about nine miles. The District's greatest width east and west is about 10 miles. The topography of lands within the District varies in elevation from 375 feet along the northeastern boundary to 500 feet along the southeastern boundary. The ground surface slopes to the west at about 15 feet per mile. The southeastern portion lying east of the railroad and above the Friant-Kern canal, extends back into the foothills where the topography is rougher, with slopes varying from 20 to 100 feet per mile. Surface drainage is provided by natural slope of the land and is accumulated in small intermittent streams. Hardpans are common throughout the northern areas, at depths of 3 to 4 feet, and less common in the southern end of the District.

2.2.3 CVHM Well Log Texture

Maps prepared from the CVHM percent coarse material data based on the upper 200 feet of well logs in the Primary KBWQA area were reviewed. The maps were based on 50-foot increments and are included in as **Figure 2-3**, **Figure 2-4**, **Figure 2-5**, and **Figure 2-6**. For location references, see **Figure 1-1**.

The 0 to 50 foot interval indicates that the coarsest materials are identified to the east at the mouth of the Kaweah River outlet and at a couple of other points along the current St. Johns and Kaweah River footprints. The finest materials are identified at the Twin Buttes area to the northeast and the Exeter, Cairns Corner, and Lindsay area to the southeast. The remaining westerly areas are a checkerboard of moderately fine to moderately coarse materials. In general, the area north of Visalia and westward near Waukena tend towards coarse materials with the area in between tending towards finer materials.

The 50 to 100 foot interval indicates a larger fine material area near Twin Buttes and a much reduced area near Lindsay. The development of a coarse grain area near the mouth of the current Yokohl Creek is becoming apparent with a fading of the coarse material at the Kaweah mouth. The remaining areas to the west remain a checkerboard but with fewer fine and more coarse materials.

The 100 to 150 foot interval illustrates a more defined coarse material channel from the Yokohl Creek mouth trending northwestward. The finest material is again prevalent beneath the Twin Buttes area and much expanded westward in the Lindsay area to the eastern side of Tulare and the southern side of Visalia. The area near Waukena continues to coarsen with depth.

The 150 to 200 foot interval illustrates an expanded coarse area near Waukena which now covers most of the extreme southwest section of the KBWQA. The other notable coarse area is between Ivanhoe and Mitchell Corner where the Kaweah River appears to quit flowing. Fine materials remain in the Twin Buttes and Tulare/Lindsay areas.

The interval with the overall coarsest material is the 50 to 100 foot depth. The finest material in the western area occurs in the shallowest 0 to 50 foot interval with the eastern areas generally consistently of fine materials at all depths unless located at the Kaweah River or Yokohl Creek mouths.

2.2.4 Supplemental Area Regional Geologic Setting

The Sierra Nevada Mountain range, partially located within the KBWQA Supplemental area, is the result of initial and continued uplifting of the Pacific and North American tectonic plates. As illustrated in **Figure 2-2**, the area is predominately plutonic rocks of the Mesozoic era, interspersed with outcrops of mixed rocks of pre-Cambrian to Mesozoic era. Portions of the Sequoia and Kings Canyon National Parks are located in the uppermost elevations of the area.

Lake Kaweah is centrally located near the western border. Small areas of Quaternary alluvium are located up- and down-stream of the lake, with larger areas along the foothill borders.

2.3 Soil Surveys and Soil Surface Characterization

NRCS soil scientists observe many variables to characterize a soil profile. These include the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. A soil profile extends from the surface down into the unconsolidated material in which the soil forms. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Commonly, individual soils on a landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, soil scientists note soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in a survey area and determining their properties, the soil scientists assign the soils to taxonomic classes (units).

A taxonomic class is a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile.

Information regarding soils in the study area is most complete for the Primary area. Soil survey information for the Supplemental area is incomplete. The information that is available for this area is summarized in this report.

2.3.1 Soil and Soil Surface Characteristics

Due to the differences in their formation and topography, the soils in the Primary and Supplemental areas display different characteristics. Soils in the Primary area are generally finer while the Supplemental area soils are sandier with sporadic rock outcroppings as illustrated in **Figure 2-7**. These textures can be further defined by soil type as detailed in **Figure 2-8**.

The predominant soil texture in the Primary KBWQA area is loam at approximately 52 percent. Fine sandy loam (22 percent) and sandy loam (13 percent) located near streams and channels make up another 35 percent. The remaining 13 percent includes more course grained soils, and finer grained materials located along the eastern, north central, and south central boundaries. In general, the areas to the east are more subject to hardpan with coarser soils along the riverbeds atop the alluvial fan and clay deposits off to either side of the fan.

The portion of the Supplemental area with soil information available is mostly comprised of sandy loam (40 percent), coarse sandy loam (23 percent), loam (13 percent) and rock outcrop (8 percent). Soils that are more course are found along the primary river and stream pathways. The number of rock outcroppings increases to the east of the area with information available.

2.3.1.1 Permeability & Runoff Potential

The term permeability, as used in soil surveys, indicates saturated hydraulic conductivity (**Ksat**). Saturated hydraulic conductivity refers to the ability of a soil to transmit water or air and estimates the rate of water movement, in micrometers per second, when the soil is saturated. The higher the permeability, the faster water will move through the material and the lower the runoff potential. Therefore, the runoff potential and the hydraulic conductivity of the soil have an inverse relationship. The runoff potential of the soils within the study area were mapped using this NRCS soil data and are illustrated in **Figure 2-9**.

The highest runoff potential areas are generally located in the transition area between the Primary and Supplemental study areas. The valley floor is mostly composed of soils with moderately low runoff potential. The Supplemental area is generally comprised of moderately high runoff potential soils.

2.3.1.2 Chemistry including Salinity, Sodium Adsorption Ratio, and pH

The NRCS developed estimates of soil chemistry are measured or inferred based on field observations and on test data for these and similar soils.

Soil salinity is expressed by electrolytic conductivity which is a measure of the concentration of water-soluble salts in soils. High concentrations of neutral salts, such as sodium chloride and sodium sulfate, may interfere with the absorption of water by plants because the osmotic pressure in the soil solution is nearly as high as or higher than that in the plant cells. Salts may also interfere with the exchange capacity of nutrient ions, resulting in nutritional deficiencies in plants. In addition to laboratory testing, field estimates are made from observations of visible salts throughout the horizon matrix, on the soil surface, or some combination of the three; from plant productivity; from the presence of native plant indicator species; and from field salinity meters. Bare spots, salt-tolerant plants, and uneven crop growth are used as indicators of salinity. When combined with laboratory results these observations help to estimate the amount of salts.

Sodium adsorption ratio (**SAR**) is a measure of the amount of sodium relative to calcium and magnesium in the water extracted from a saturated soil paste. Soils that have SAR values of 13 or more may have an increased dispersion of organic matter and clay particles, reduced saturated hydraulic conductivity and aeration, and a general degradation of soil structure.

There are limited soils within the Primary KBWQA range with high electrolytic conductivity and/or SAR located primarily along the central north and central south borders of the area. These soils are located coincident to highly alkaline soils and mostly coincident to silty clay textures in the same areas (**Figure 2-10**). There are no salt affected soils located in the Supplemental area.

Soil pH is a measure of the concentration of hydrogen ions present in the soil. A pH of 7 is considered neutral. Soils having a pH greater than 7 are considered alkaline while soils with a pH less than 7 are considered acidic. Soil pH can affect the ability to grow crops. Although crops vary in their preferred soil pH range, most crops grow best in neutral and in slightly acidic soils. Highly alkaline soils can affect crop yield and plant growth.

Soils within the Primary area range from extremely acidic to moderately alkaline with the majority of the soil being slightly alkaline. In general soils become more acidic in the eastern portion of the study area, near the base of the Sierras (**Figure 2-11**). Soils in the Supplemental area are more acidic than the soils in the Primary area. The soils in this area range generally range from a pH of 5.9 to 6.5.

2.3.1.3 Surface Slope

Slope information was obtained from the NRCS soil survey for the Primary and portions of the Supplemental areas (**Figure 2-12**). In general, the steepest portion of the KBWQA is in the Supplemental area. The land surface becomes more level as the foothills transition to the valley floor with the Primary area having little slope and topography.

The Supplemental area has a portion of area along the eastern boundary that is not covered by a soil survey. However, the majority of the area does have slope information available. The slopes in the Supplemental area are generally between 20 and 50 percent, with some areas of lesser slopes in the northern portion and along streams and rivers.

The Primary area shows a transition from the mountains and foothills to the valley floor. The area along the eastern boundary of the Primary study area is steeper than the remainder with slopes of 40 percent. The steeper slopes transition to the generally flat valley floor area with slopes of 2 to 4 percent.

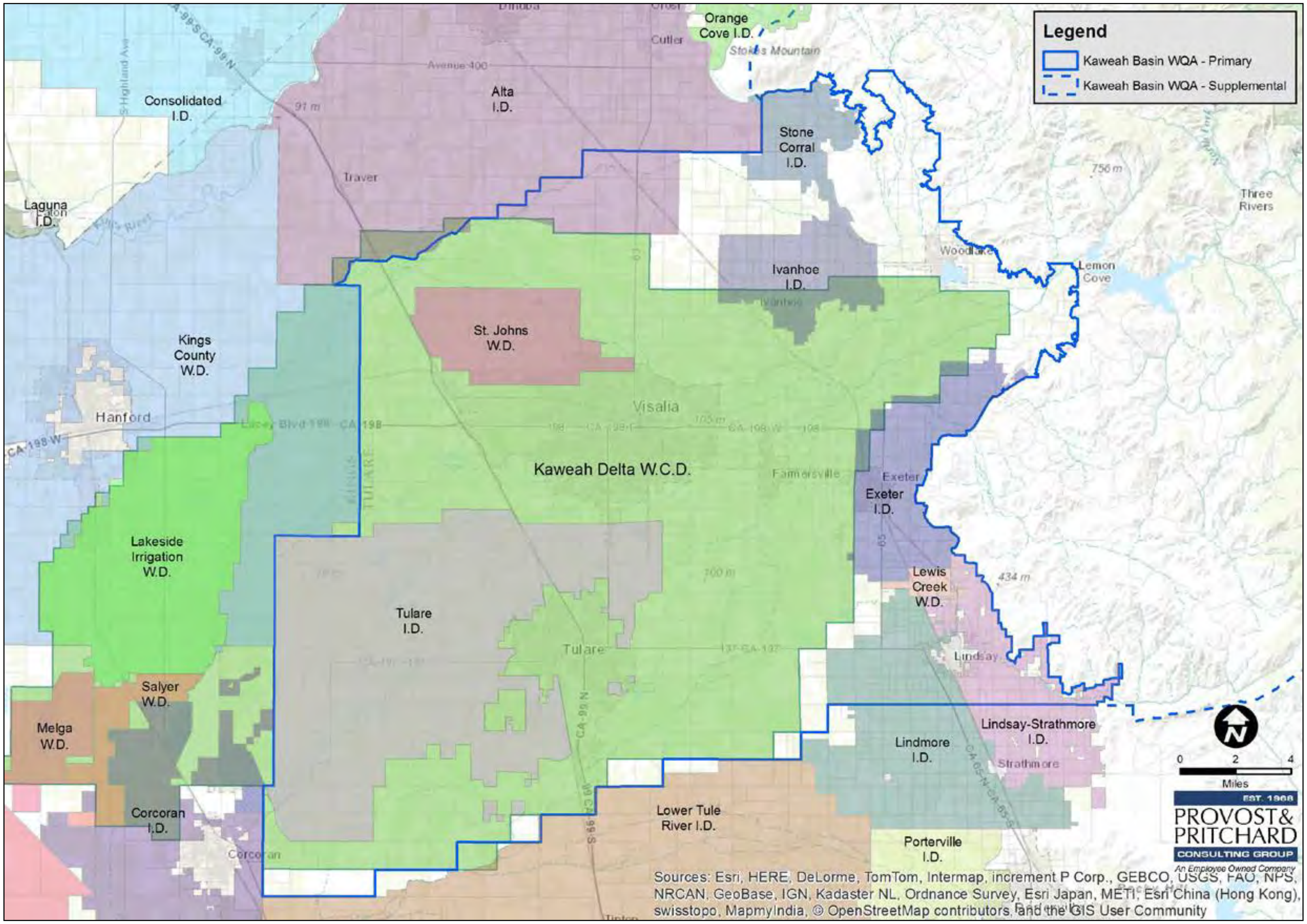

Figure 2-1. Irrigation Districts

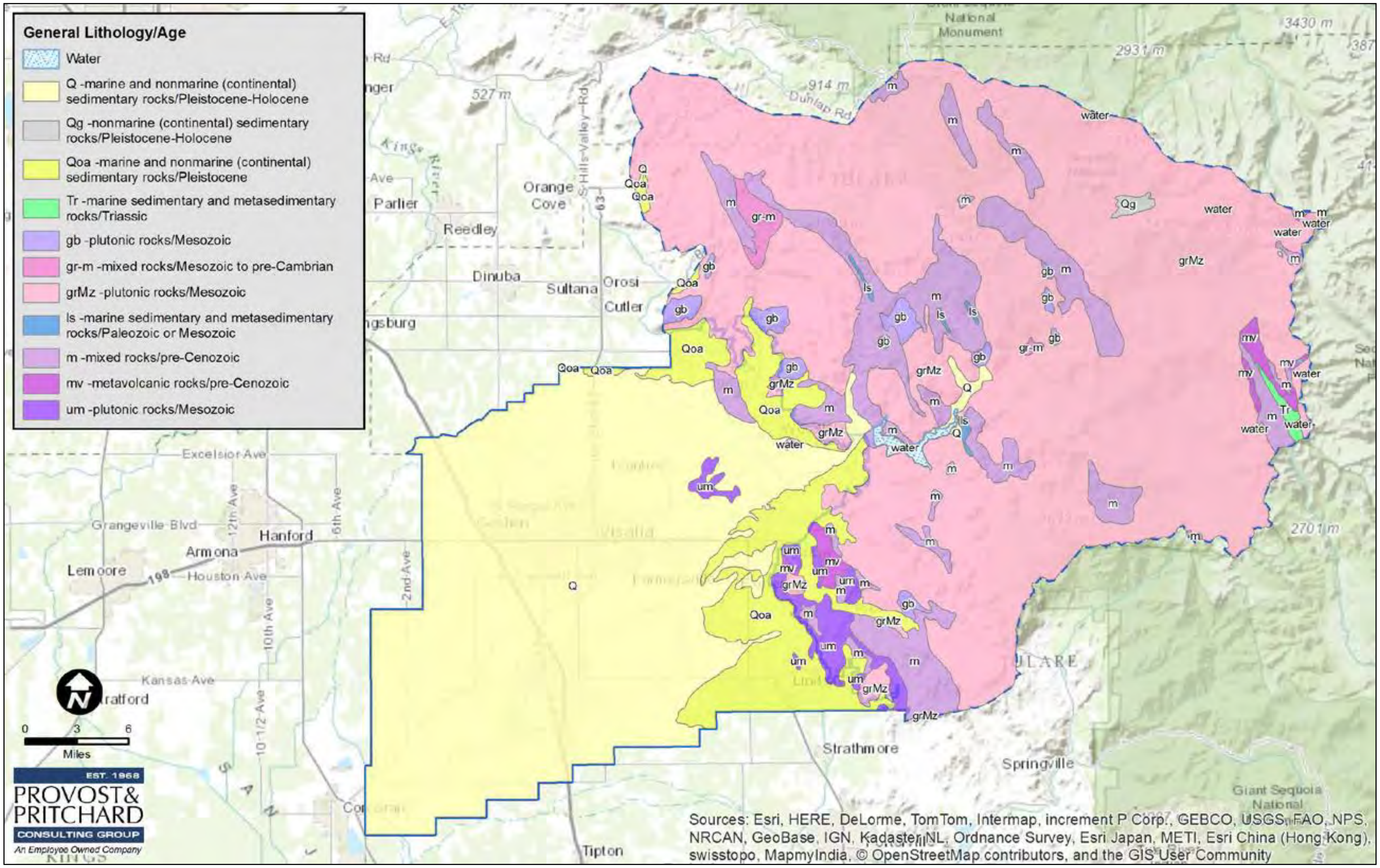

Figure 2-2. Geology Map

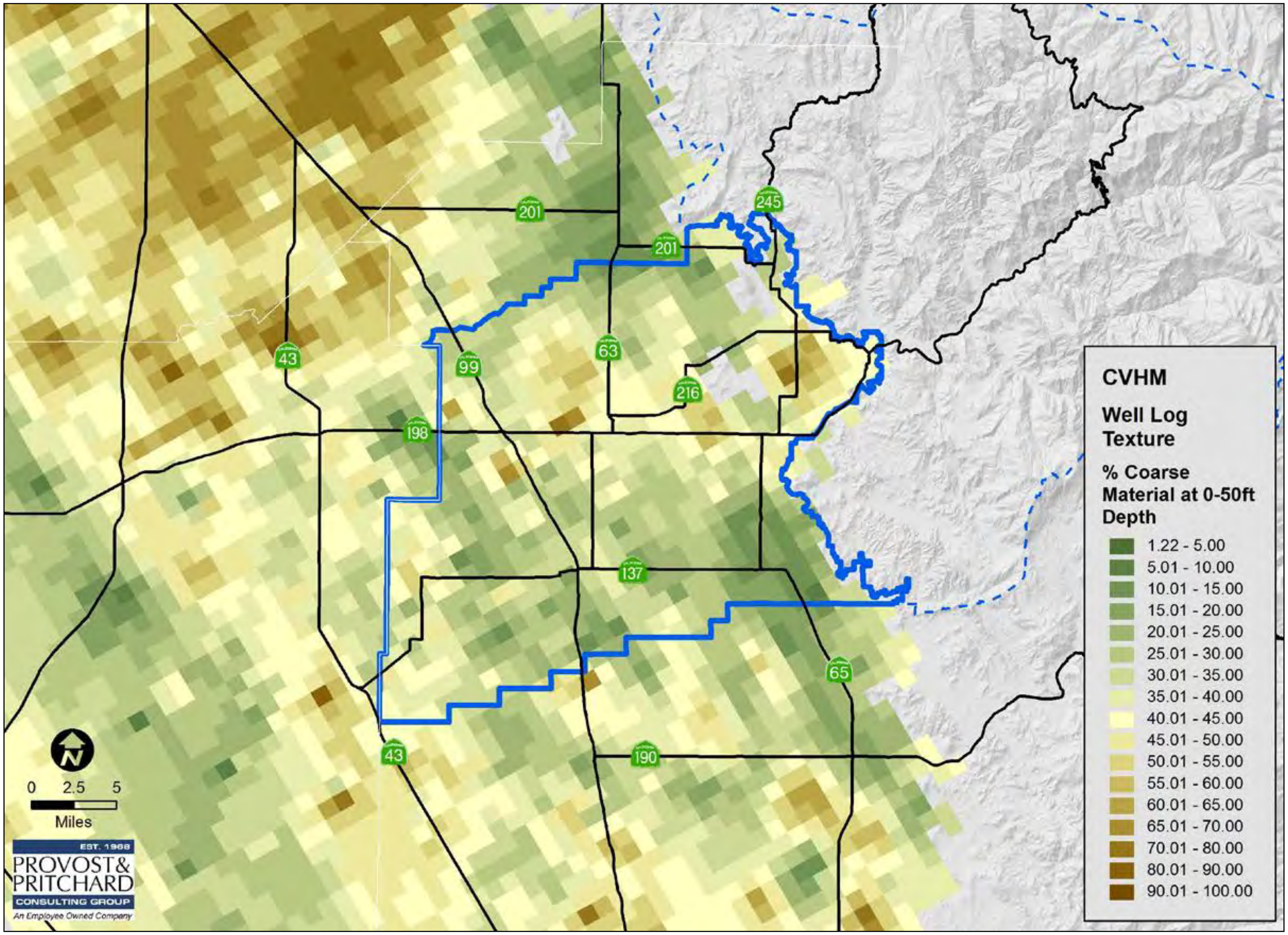

Figure 2-3. CVHM Well Log Texture at Depth 0-50 feet

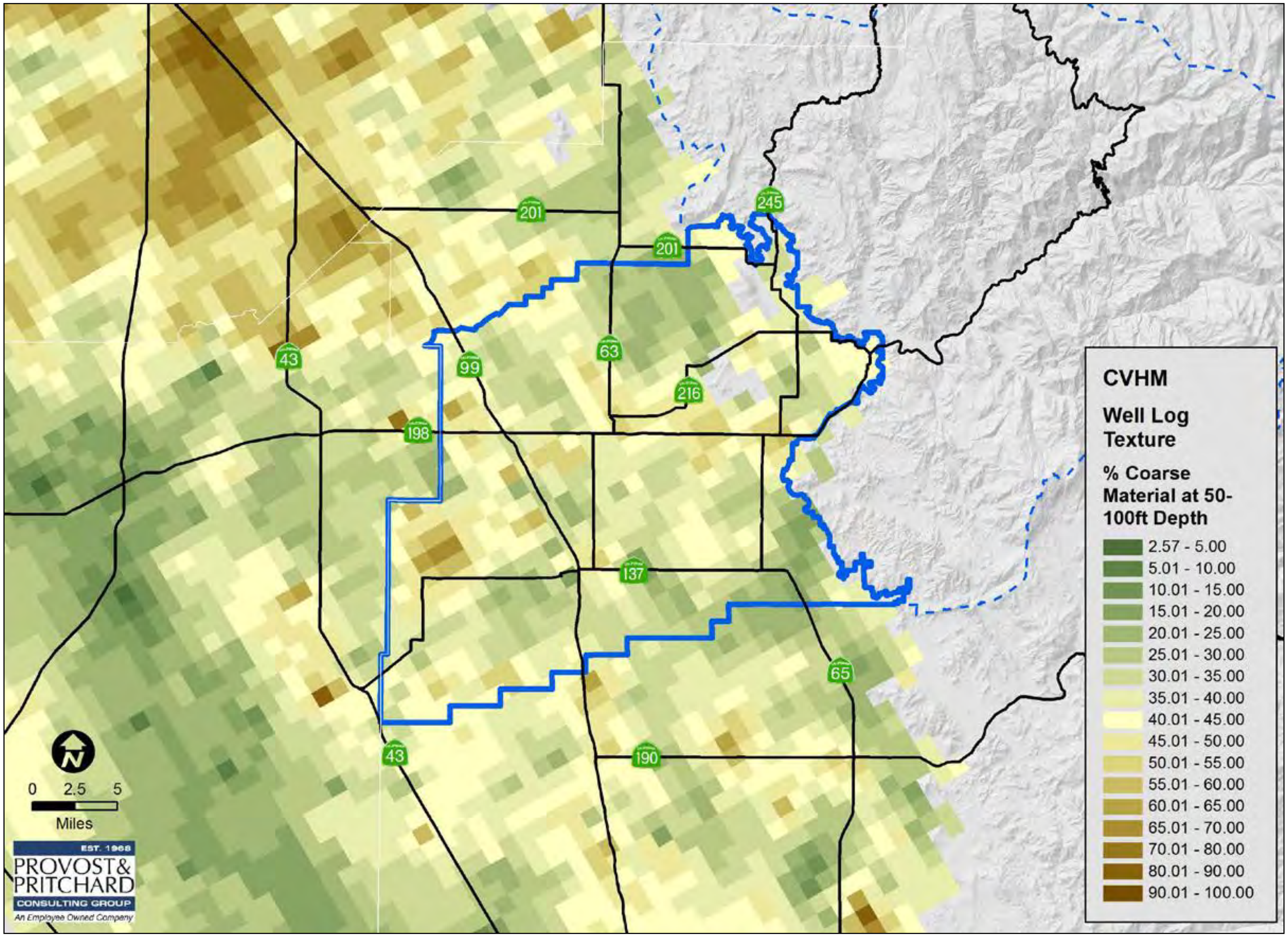

Figure 2-4. CVHM Well Log Texture at Depth 50-100 feet

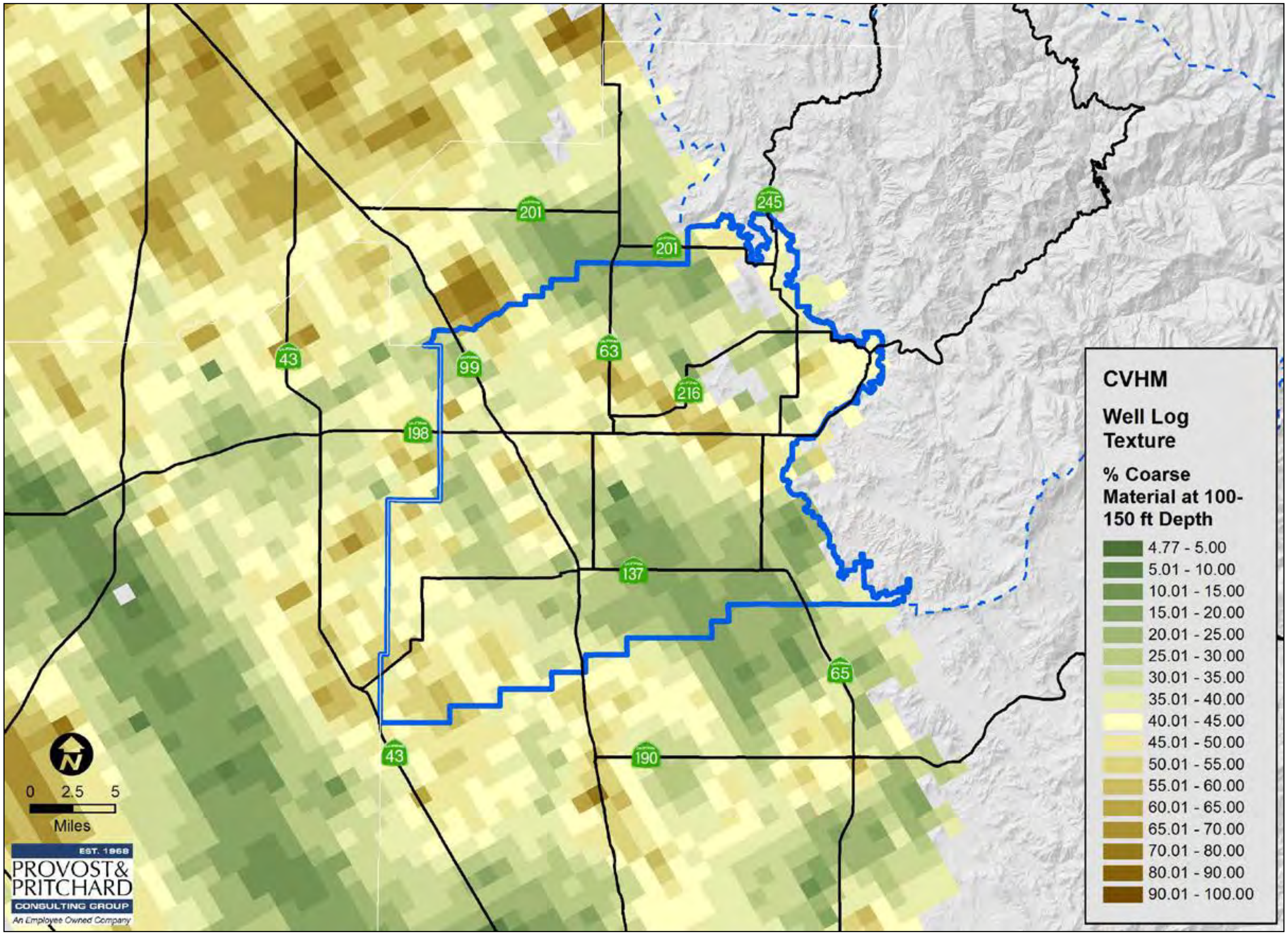

Figure 2-5. CVHM Well Log Texture at Depth 100-150 feet

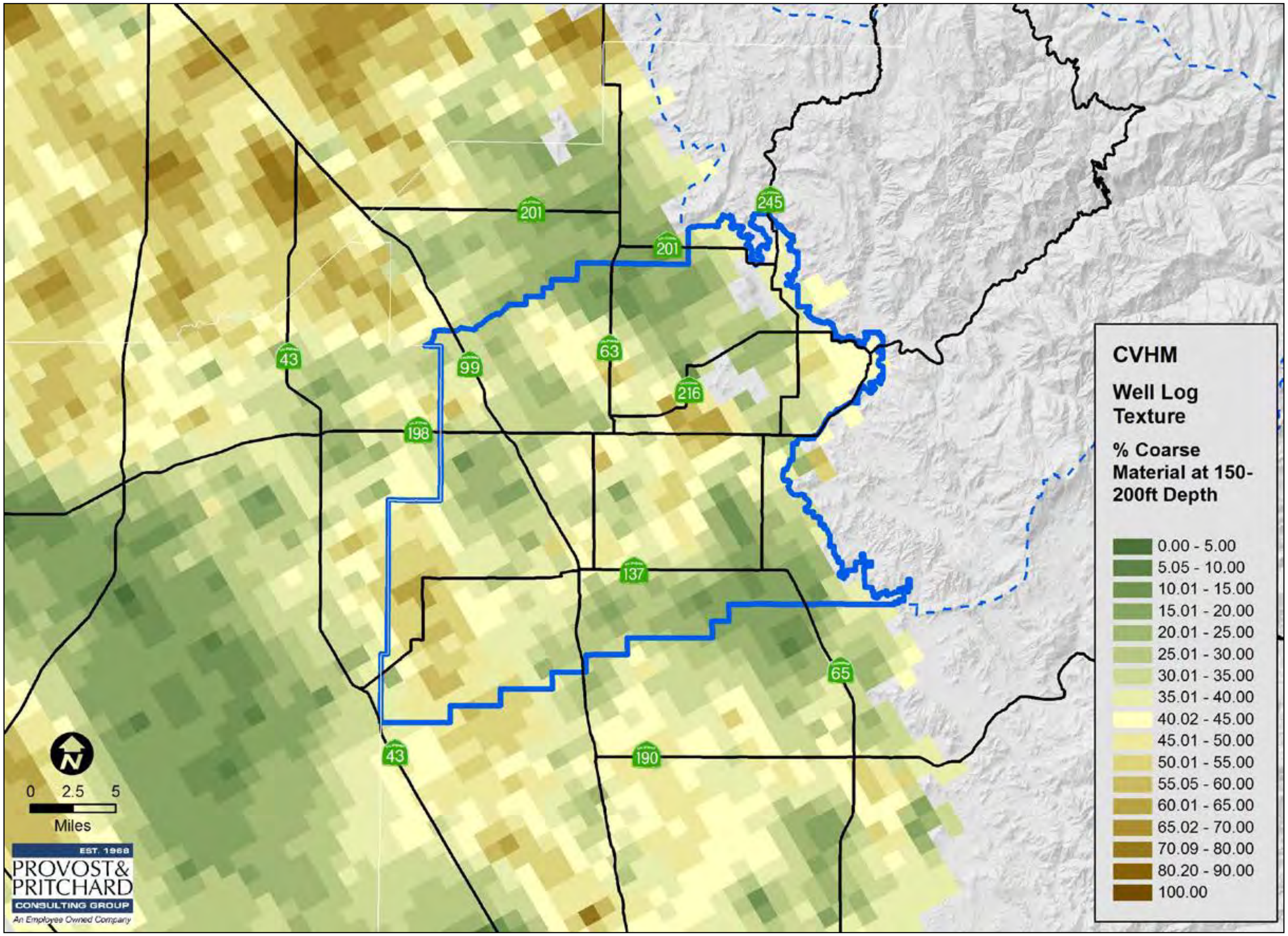

Figure 2-6. CVHM Well Log Texture at Depth 150-200 feet

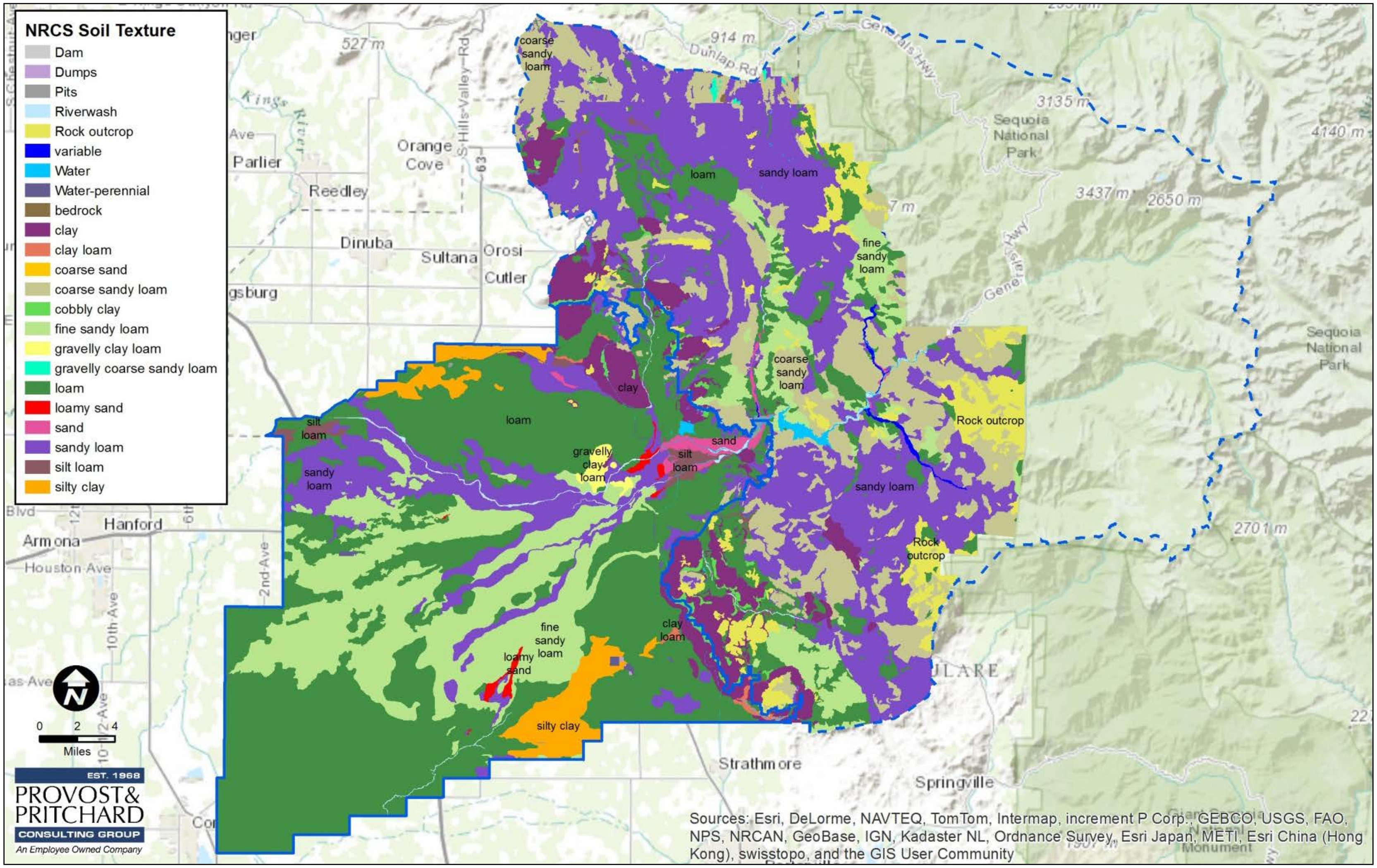

Figure 2-7. Soil Texture

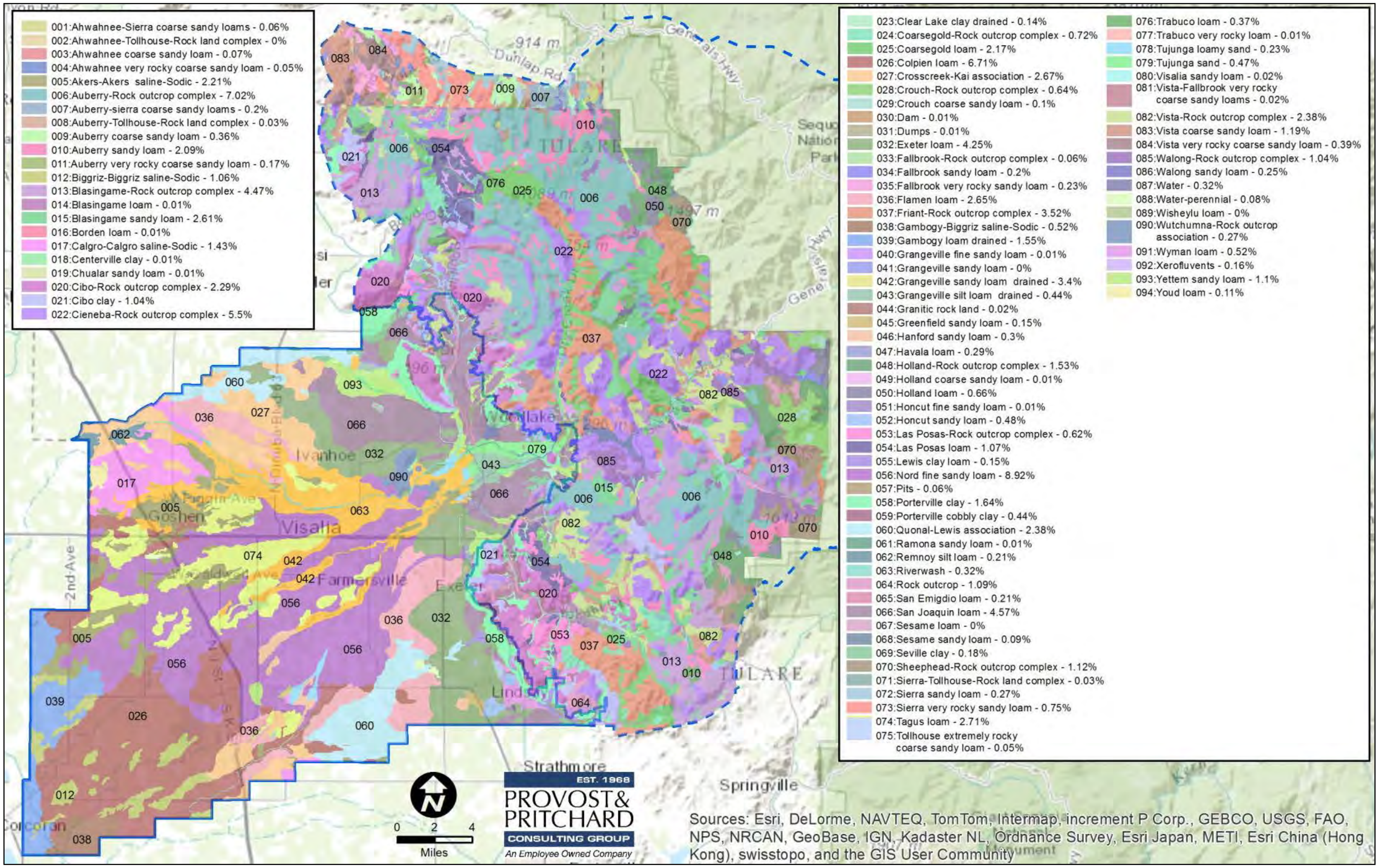

Figure 2-8. Soil Type

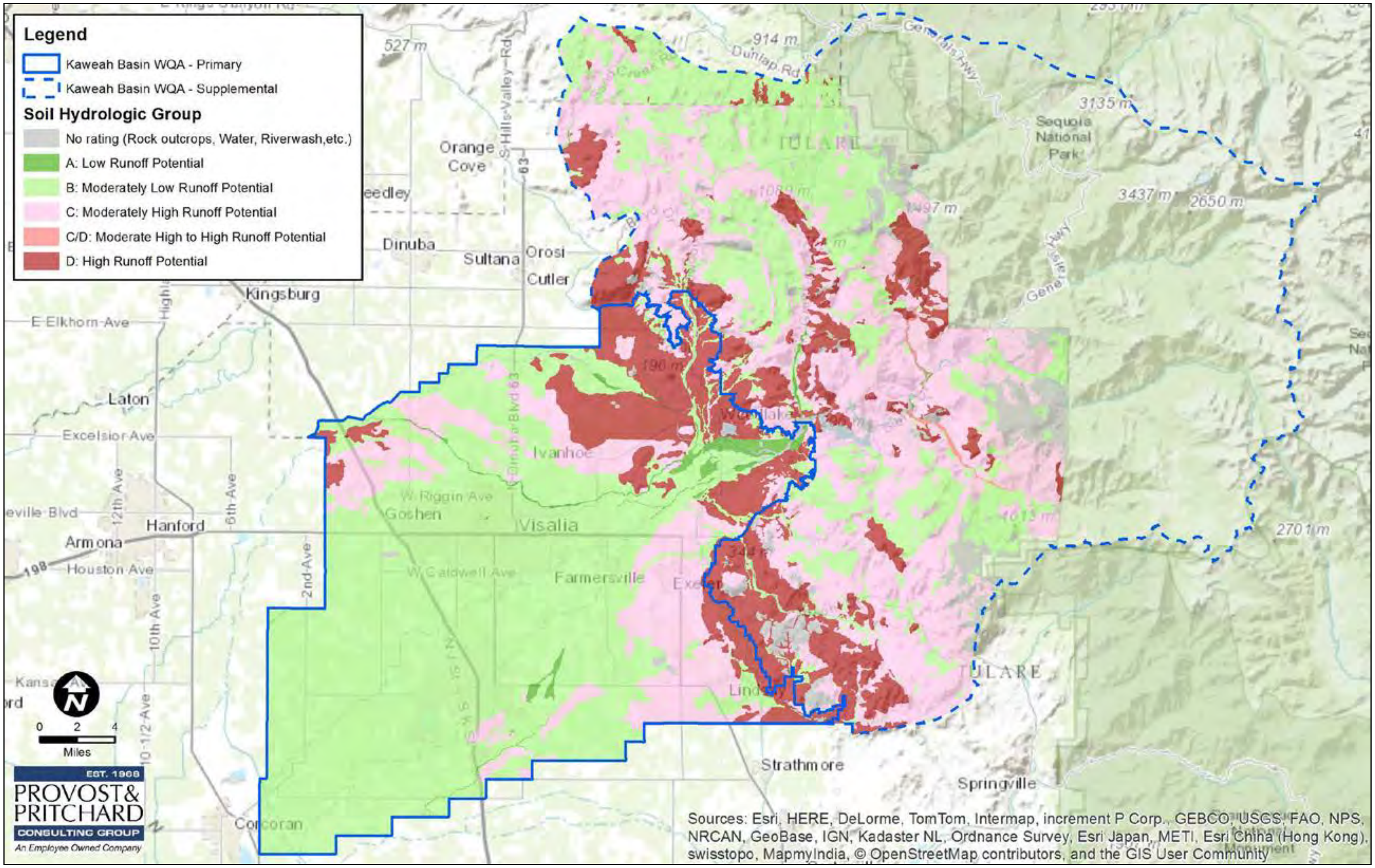

Figure 2-9. Runoff Potential

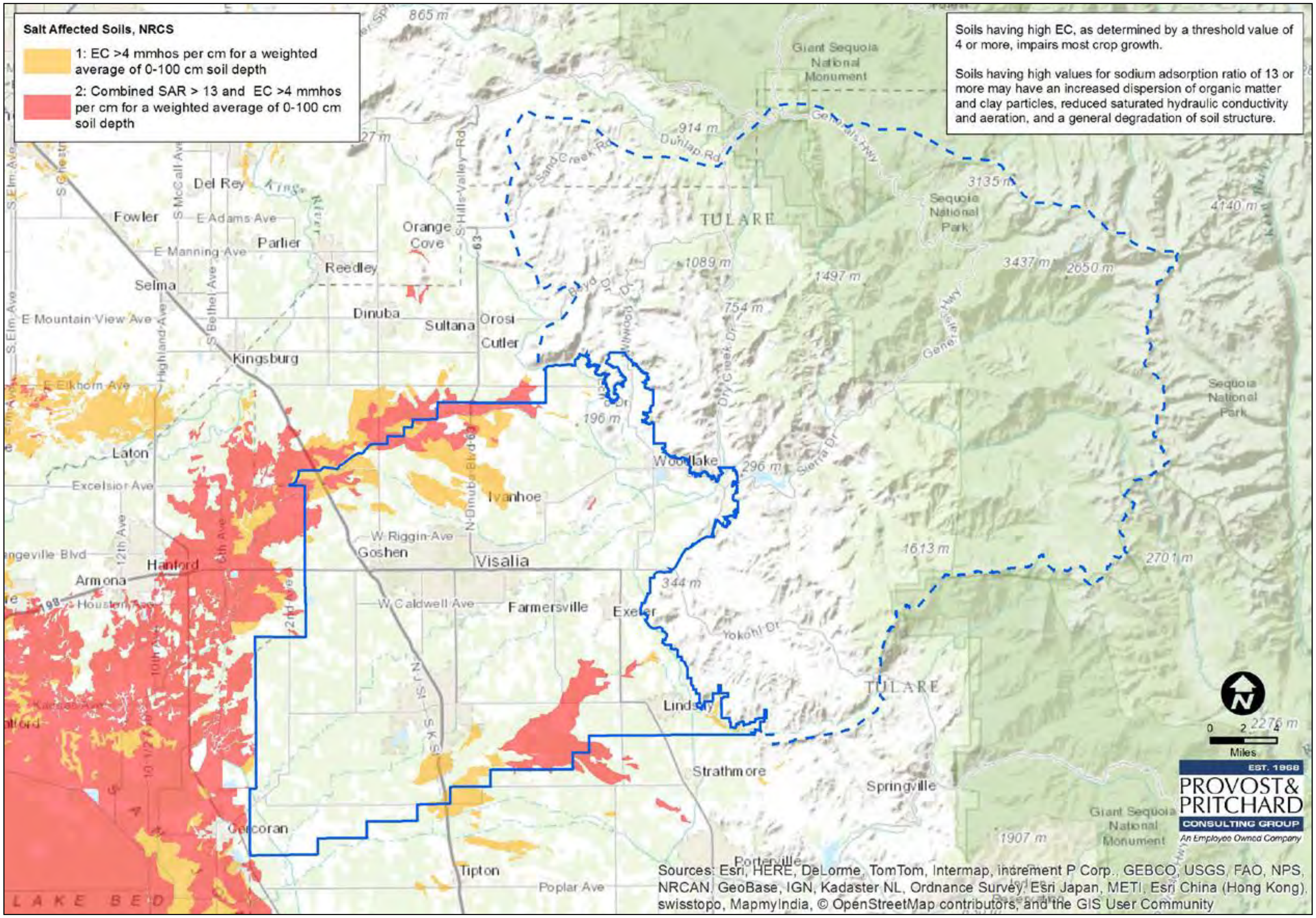

Figure 2-10. Soil Salinity

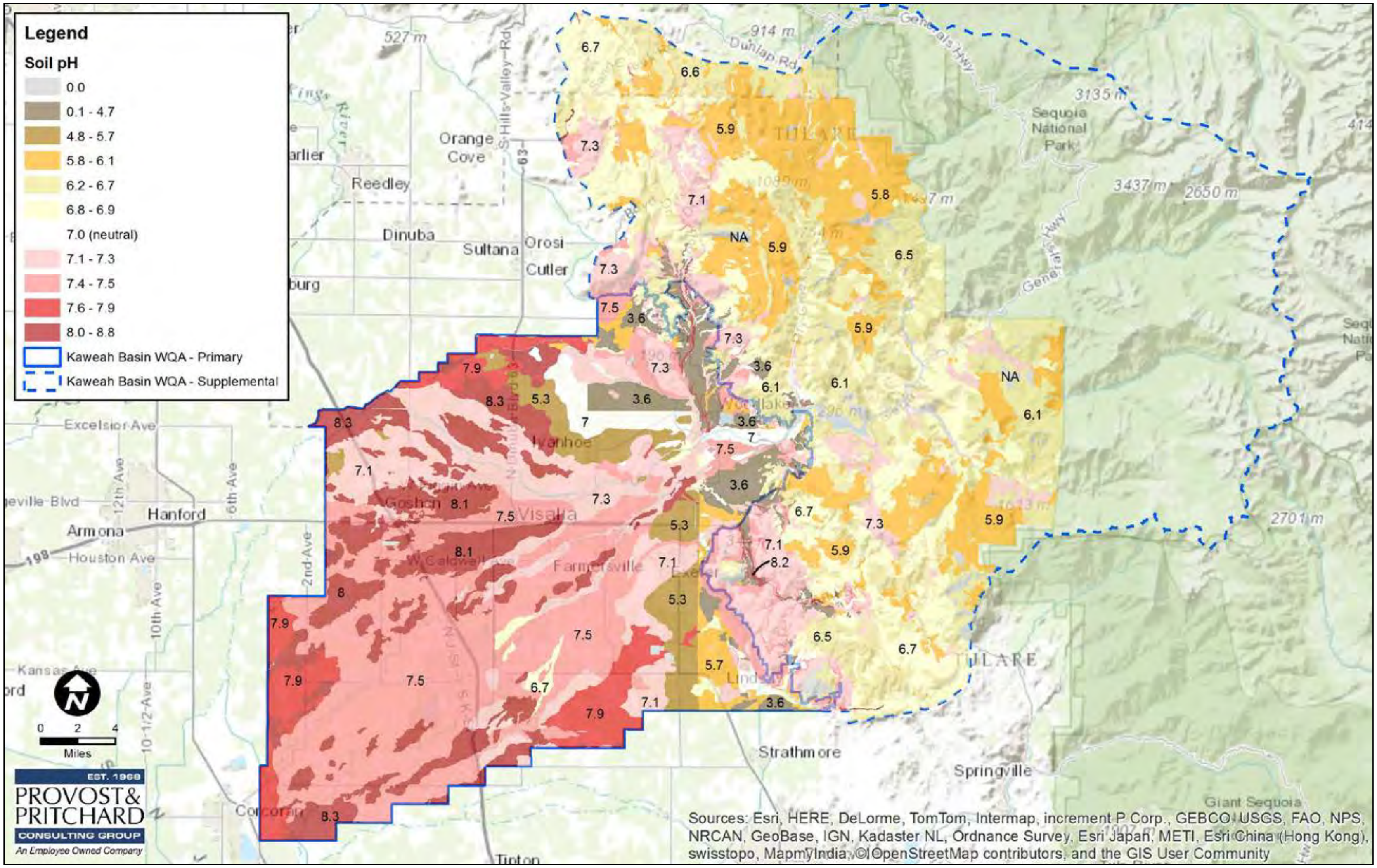

Figure 2-11. Soil pH

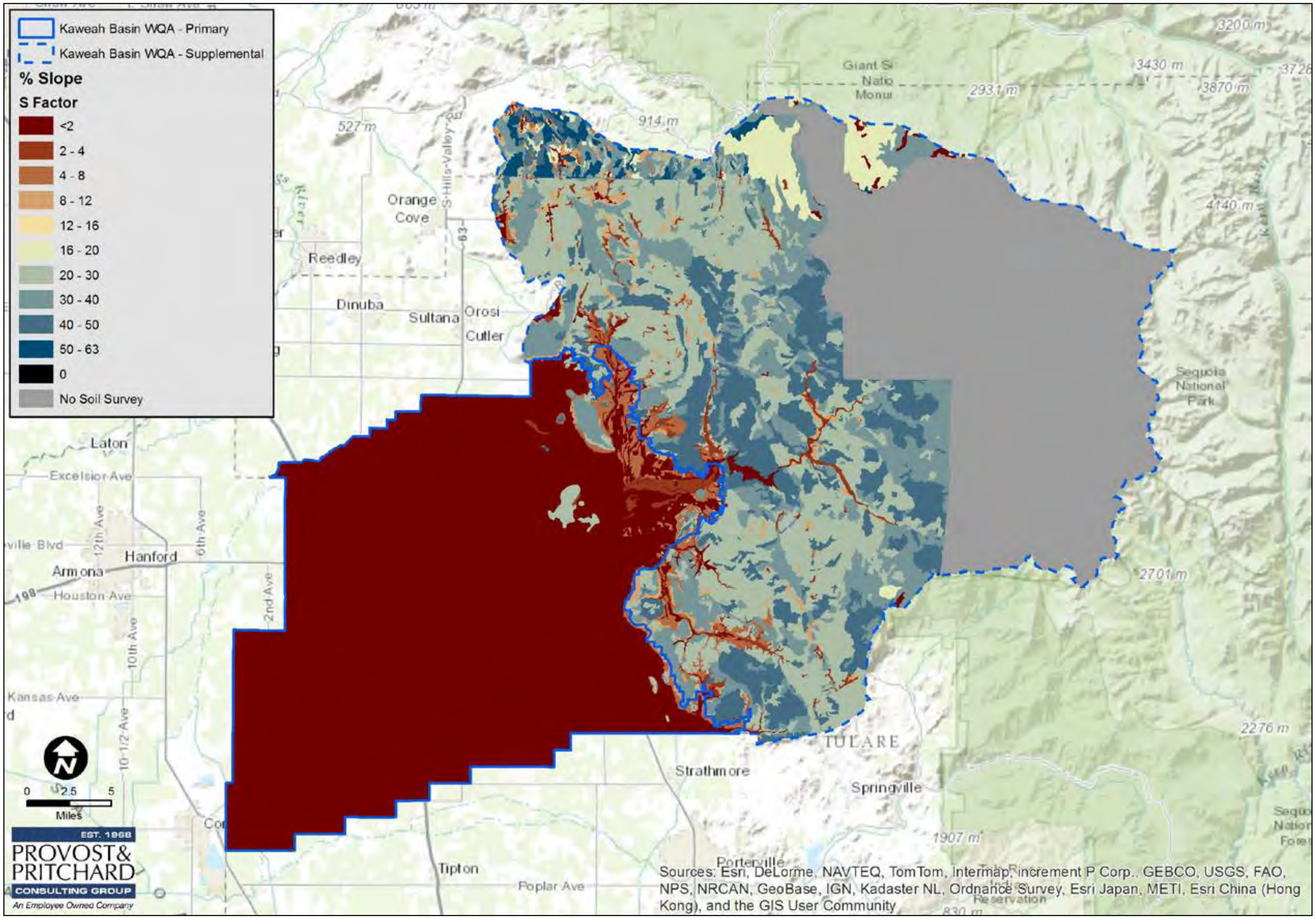

Figure 2-12. Slope

3 Land Use

3.1 Potential Sources of Information

A survey of available land use data was performed to determine sources, quality, and availability of information. The sources were compared to determine the accuracy and relevancy of the information. To be appropriate for this study, the data needed to provide sufficient information to determine the predominant crops for the KBWQA area, utilizing the most recent information.

3.1.1 Existing Data of KBWQA Land Cover

The KDWCD prepared Time Series Evapotranspiration and Applied Water Estimates from Remote Sensing (Davids Engineering, 2013). This report utilized a combination of normalized difference vegetation index (**NDVI**) and DWR crop surveys to determine the water demands for the KDWCD area.

Although this report had assigned crop designations to area, the report did not provide enough information to include in this report. Information from the report did not cover the entire KBWQA area. Additionally, the crops were grouped into five crop groups: deciduous, field and truck, pasture, subtropical and vineyards. Therefore this report was not used to determine land use information within the KBWQA boundaries.

Other potential sources of land use information are grower surveys. KBWQA is not expected to receive completed grower surveys from the members until after this GAR has been prepared and submitted, so this information source is not available at this time. Further updates to the GAR may be able to use information from this source.

3.1.2 DWR

DWR land use data is compiled and available for some years for land within the KBWQA boundary. Recent DWR land use information is available for 1993, 2000 and 2007. DWR data provides information for over 70 crop types and associated irrigation method. DWR obtains the cropping information from a combination of aerial photos and satellite imagery. Department staff also visits and visually confirm 95 percent of the fields to verify the crop is correct. Because of the multiple sources and visual confirmation, this information is the most accurate information available.

A crop map created from the 2007 DWR survey information for the KBWQA area is provided as **Figure 3-1**.

3.1.3 CVHM

The CVHM was developed by USGS to provide a hydrologic model of California's central valley. The model provides water managers a model to demonstrate how water moves through the aquifer system. The model provides a method of predicting water supply scenarios and can be used to investigate the effects of water management and land use scenarios for the region.

The CVHM utilized land use information from other government sources including the following:

- California GAP Analysis – Information from the 1990's that is used to assess natural/wild lands/habitat conservation in comparison with protection status. Generally considered a course data set, USGS converted it to one square mile grid cells.
- CA DWR Land Survey – DWR land use data has already been discussed. USGS resampled the data to one square mile grid cells making a coarse-grained dataset. For instance, if you had a 20 acre orchard and 620 acres of cotton in a section, the orchard would disappear in their version of the dataset.
- Central Valley Historical Vegetation Mapping Project – Doesn't detail land use types for developed land and focused on historical, not current conditions. Resampled to grid of one square mile cells. Based on early GIS mapping of the 1970s and 1980s at a scale of 1:250,000 and 1:100,000 has much less detail (and current relevancy) than current land use surveys such as DWR, FMMP, CropScape and County Agricultural Commissioner. Resampled to grid of one square mile cells.
- Landsat satellite data from 1992, making it out of date. Also large areas including one or more states were processed at once with very little ground-truthing making it less accurate than other sources that have utilized ground-truthing/ground surveying. Resampled to grid of one square mile cells.

In general, although the CVHM is a useful tool for modeling various land use and water availability scenarios, the land use information contained in the CVHM utilizes information is available from other sources for use in this study. Furthermore, since the land use information was resampled to one square mile sensitivity to aid in simplifying the hydrologic model, the land use information is not as relevant as information obtained from other sources.

3.1.4 USDA

USDA produces cropping maps based on satellite imagery on an annual basis. The California Cropland Data Layer is developed using satellite imagery and sensor data that identifies the unique aspects or signatures for crop types. This process identifies the crop type of land use with a spatial resolution of 56 meters, or 0.77 acres. A portion of digital analysis is verified through ground-truthing. This data source provides more recent land use information, but the data lacks the quality control found in the DWR data.

3.1.5 County Agricultural Department

The Tulare County Agricultural Commission has the most recent crop information for the KBWQA Primary area. A crop map based on 2013 data is provided as **Figure 3-2.**

The Tulare County Agricultural Commissioner also produces an annual summary of agricultural activities for the County. The 2013 Tulare County Agricultural Crop and Livestock Report provides information on the acreages of crops grown and revenue produced. **Table 3-1** provides a summary of the top agricultural crops based on revenue for the County.

3.1.6 Impact of Dairy Facilities on Land Use

A significant portion of the land within the Primary area is permitted as dairies that are covered under the Dairy GO and are not included as members in the coalition. Acreage within the study area that is covered by the Dairy GO is more than 71,000 acres, approximately 7 percent of the total land area within the study boundary area. Cropland associated with these dairy areas has been included in land use information provided in this chapter.

3.2 Land Cover

Irrigated agriculture and dairies are the primary land use within the KBWQA Primary area. Citrus crops dominate land use in the eastern portion. The center of the Primary area has deciduous fruit and nut crops as the primary crops with urban areas also located in the vicinity. In the western half of the study area, dairy land dominates the land use with forage crops dominating the types of crops grown.

3.3 Predominant Commodity Representing the Top 80% of Irrigated Agricultural Crops

Table 3-2 summarizes crops by acreage and percentage for the KBWQA Primary and Supplemental areas based on the most current DWR information (2007).

Citrus, alfalfa, hay and forage, fruit and nuts, stone fruit, and vegetables make up 85 percent of the crops grown within the KBWQA Primary area. Citrus is the primary crop grown within the Supplemental area. Most crops in this area are located adjacent to the border between the two areas.

3.4 Irrigation Practices Generally Associated with Predominant Commodities

The DWR land use surveys also provide irrigation methods for some years. Irrigation methods were recorded for 1999 and 2007. In 2007, the primary irrigation methods were border strip irrigation (38.9 percent), micro sprinkler (32.2 percent) and furrow irrigation (22.0 percent) (Figure 3-3).

Surface water deliveries typically occur March through September or October, depending upon crop demand and surface water availability. In some years, an irrigation or water district may not receive any surface water due to the hydrologic conditions of the source supply. Regardless of the water year, surface water supplies are limited so growers try to closely match crop needs when irrigating a field, reducing the likelihood of significant discharges.

Irrigation practices are increasing in efficiency, as the cost of pumping water and the reduction in available surface supplies impact growers' production. Many permanent crops have converted to drip or microsprinkler irrigation systems and application rates are being more closely matched to a crop's water usage, reducing the amount of water that can potentially be lost to runoff or below the root zone as deep percolation. However, this efficiency comes at risk with soil salinity concentrations increasing as less water is applied to leach these salts below the root zone.

Improvements to water application practices have not only benefited production but have also led to the reduction of field runoff that could potentially discharge pesticides and other pollutants. These improved systems for water control and efficient water application include: regulation and measuring devices, check structures, turnouts, and control gates and valves. Benefits of these improvements in water application can potentially allow for:

a. Reduction in volume of water applied to refill the crop root zone.

b. Change in the amount, rate, or timing of water being applied to the crop that leads to improved efficiency and no loss of crop production.

c. Reduction of erosion caused by irrigation.

d. Increased distribution uniformity of applied water.

e. Changes in flow rates to compensate for changes in intake rates.

f. Installation of one or more structural components that improve irrigation efficiency.

The addition of irrigation water additives may have the potential for reducing pesticides in the tail water by increasing infiltration during irrigation events, which also reduces erosion, and reduces the amount of pesticides that adhere to particulates by promoting the aggregation of dispersed soil colloids. These water additives are primarily added to irrigation water for erosion control and/or improved water infiltration. Examples of additives include polyacrylamide (**PAM**), gypsum, and humic acid.

In the KBWQA Primary area, topography of irrigated lands is generally flat to gently sloping, so furrow and surface irrigation is still practiced in various areas. A large majority of surface irrigated fields are now laser leveled providing improved distribution uniformity and reducing runoff. Many growers rely on pumped groundwater, and because of significantly increased energy costs for pumping (e.g. time of use and demand charges for electricity), they are not running their irrigation pumps any longer than necessary to properly irrigate their lands.

Some growers have extensive tail water recovery systems, where they collect, store, and transport irrigation tail water for reuse back into their irrigation distribution system. These systems are suitable for use on sloping lands with surface irrigation systems or for use in areas where there is recoverable irrigation runoff flow or where such flows can be expected under the management practices used. Many growers have switched to tail water systems since monitoring went into place under the previous Conditional Waiver.

In addition to irrigating for crop cultivation, during cold weather conditions farmers will often use irrigation systems to provide frost control for crops. This primarily occurs on permanent crops, particularly citrus. Wet soil conditions increase the air temperature near the ground surface and help to prevent the trees from freezing. Water is primarily applied through surface water applications; however, sprinklers can also be sued. The climate in the valley is generally above freezing. Periods of frost will occur at times during the winter months and are usually associated with clear skies and do not occur during rainfall events when additional surface runoff could occur.

3.5 General Fertilization Methods and Soil Amendments Associated with Predominant Commodities

The addition of irrigation water additives may have the potential for reducing pesticides in the tail water by increasing infiltration during irrigation events, which also reduces erosion, and reduces the amount of pesticides that adhere to particulates by promoting the aggregation of dispersed soil colloids. These water additives are primarily added to irrigation water for erosion control and/or improved water infiltration. Examples of additives include PAM, gypsum, and humic acid.

3.6 General Nitrogen Application and Removal Rates Associated with Predominant Commodities

Fertilizer applications are also becoming more efficient. Soil nutrient levels are typically tested during the winter months. Plant tissues are sampled for nutrient levels frequently during the growing season, and many plant nutrients are direct injected into micro irrigation systems or applied as a foliar spray. Some fertilizers are applied as banded applications within orchards, and are quickly incorporated by a following irrigation. Others are direct injected into planting beds for quick uptake by the soon to be planted crops.

Greater knowledge and education on the amount, type of, and application timing of fertilizers has occurred by crop, from the University of California Ag Extension Service. For example, excess applications of nitrogen on stone fruit can lead to increased brown rot and excess nitrogen can also cause some crops to grow more vegetation but reduce fruit set. This knowledge has helped to improve timing and reduce fertilizer applications on some crops.

Fertilizer use data for Tulare County is summarized in **Figure 3-4**. This figure provides estimates of the applied synthetic fertilizer and livestock manure for the years from 1987 to 2006. This data is compiled from several sources and are based on county fertilizer sales. They indicate that total fertilizer sales for Tulare County generally increased during this period of record.

Fertilizer rates typically applied to the crops grown in the study area from 2005 are summarized in **Table 3-3**. This data is calculated from a simple average of expert recommendations (UC Davis) and grower accounts, which the authors call the “representative rate”. Due to a lack of data, some crops are not available from this study.

3.7 Pesticide Usage

Integrated pest management (**IPM**) has been gaining traction within the KBWQA as a means of controlling costs. IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, use of predatory insects (e.g. ladybugs for aphids), use of softer selective pesticides, mating disruption pheromones, and use of disease resistant varieties. Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment. The advent of “softer” materials (more pest specific, less broad spectrum) has further reduced both the frequency and volume of material applications, as now only the target pest is eliminated when a predetermined economic threshold is reached.

Management methods vary, and can be a combination of one or more aspects including biological control, cultural practices, pheromone disruption, pesticide treatment, etc. Biological control includes the use of natural enemies that attack pests. Use of such biological control agents, however, may not be enough to suppress pest populations to prevent them from reaching damaging levels. Cultural practices include field level practices that can affect the intensity of pest infestation. This includes practices such as orchard sanitation or proper pruning and painting of exposed wood to prevent sunburn as well as reduce tree susceptibility to wood-boring insects. Proper irrigation and fertilization may also help reduce certain pests.

Spray control practices have improved with many growers. Many growers have the applications performed by a customer applicator and these operations recognize the benefits of higher efficiency spray equipment, as they are paid by the acres sprayed, not by the time it takes to do the work. Efficient spray equipment means that individual fields can be covered quicker, and more acres can be done per working day. With the use of target sensor recognition applicators, chemical costs are reduced due to only mixing what is needed to spray the crop, not the open spaces between the plants (net vs. gross acres). Orchards and row crops both benefit from such equipment.

In general, less pesticide is applied on the hay and forage crops than on the citrus and other permanent crops. As such, the amount of pesticide use in the eastern portion of the Primary study area is generally higher than pesticide usage in the western portion of the study area (**Figure 3-5**). There is minimal pesticide usage in the Supplemental area.

3.8 Known Tile Drain Distribution

Tile drain systems are installed in areas where farmlands have naturally poor drainage. Based on NRCS soil data, the majority of the soils within the KBWQA are loam, sandy loam, and fine sandy loam. A very small amount of the area is noted as silty clay or clay, and very little of that area contains KBWQA membership lands.

Based on DWR San Joaquin Valley Agricultural Drainage maps, only one tile drain system was identified and it is located within the Stone Corral ID near the foothills along the central eastern edge of the KBWQA.

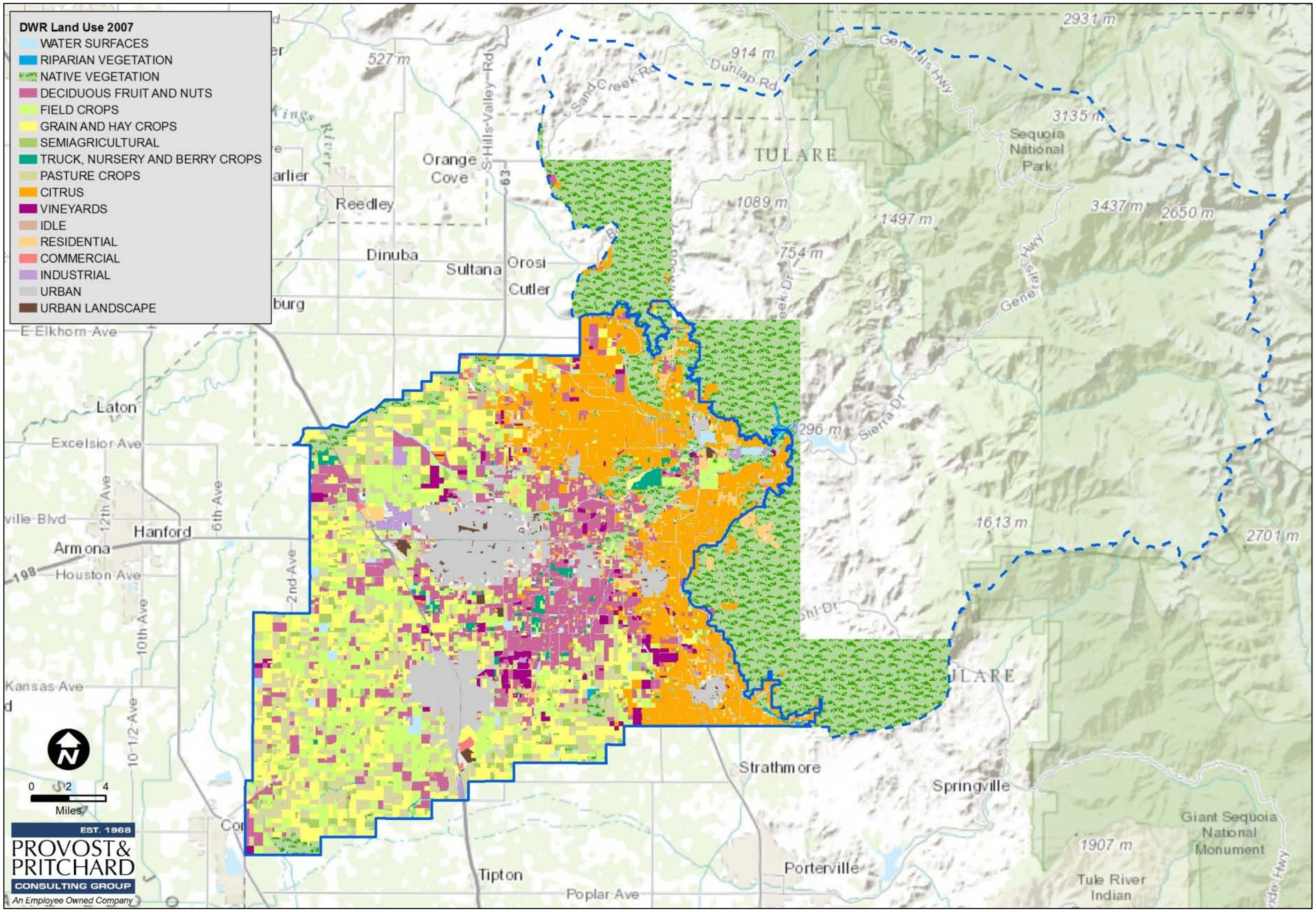

Figure 3-1. DWR Land Use 2007

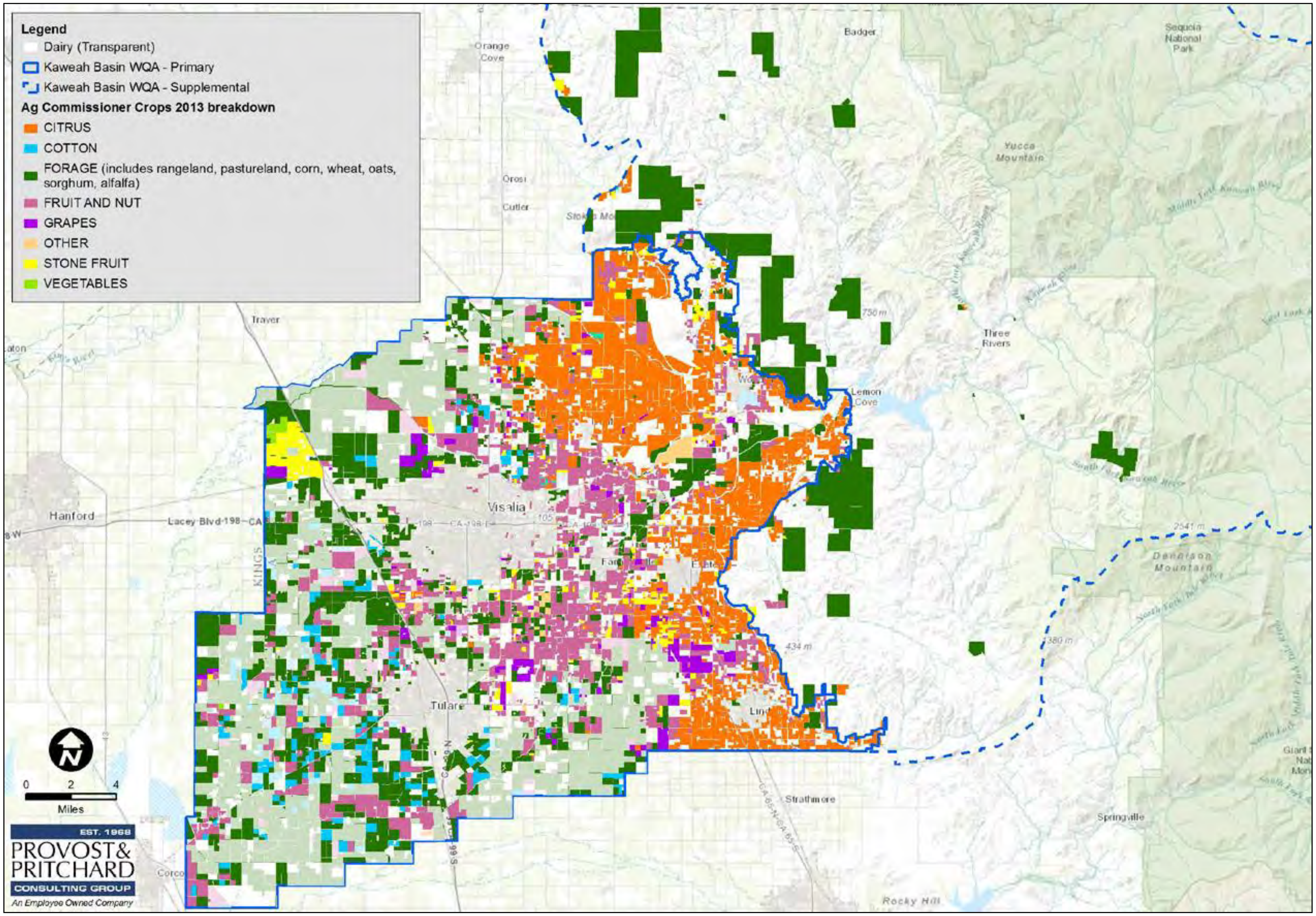

Figure 3-2. Agriculture Commission Crops 2013

Table 3-1. 2013 Tulare County Agricultural Revenue

2013 Tulare County Agricultural Revenue		
Ranking	**Commodity**	**Total Value**
1	Milk	$2,083,354,000
2	Grapes	$984,879,000
3	Oranges	$854,693,000
4	Cattle & Calves	$687,960,000
5	Pistachio Nuts	$271,206,000
6	Walnuts	$262,094,000
7	Almonds – Meat & Hulls	$256,516,000
8	Corn – Grain & Silage	$256,218,000
9	Nectarines	$234,900,000
10	Alfalfa – Hay & Silage	$175,598,000

Table 3-2. Crops by Acreage

2013 Crops by Acreage				
Crop	KBWQA Primary Area		KBWQA Supplemental Area	
	Acres	Percent of Cropped Area	Acres	Percent of Cropped Area
Oranges	51,543	21%	1,442	1%
Grain & Hay	49,954	20%	0	0%
Alfalfa & Alfalfa Mixtures	36,563	15%	0	0%
Walnuts	23,852	10%	0	0%
Corn	23,833	10%	0	0%
Cotton	14,200	6%	0	0%
Plums	8,603	3%	248	0%
Vineyard	7,168	3%	16	0%
Pistachios	7,012	3%	7	0%
Olives	6,544	3%	593	0%
Other Crops	16,535	7%	330	0%

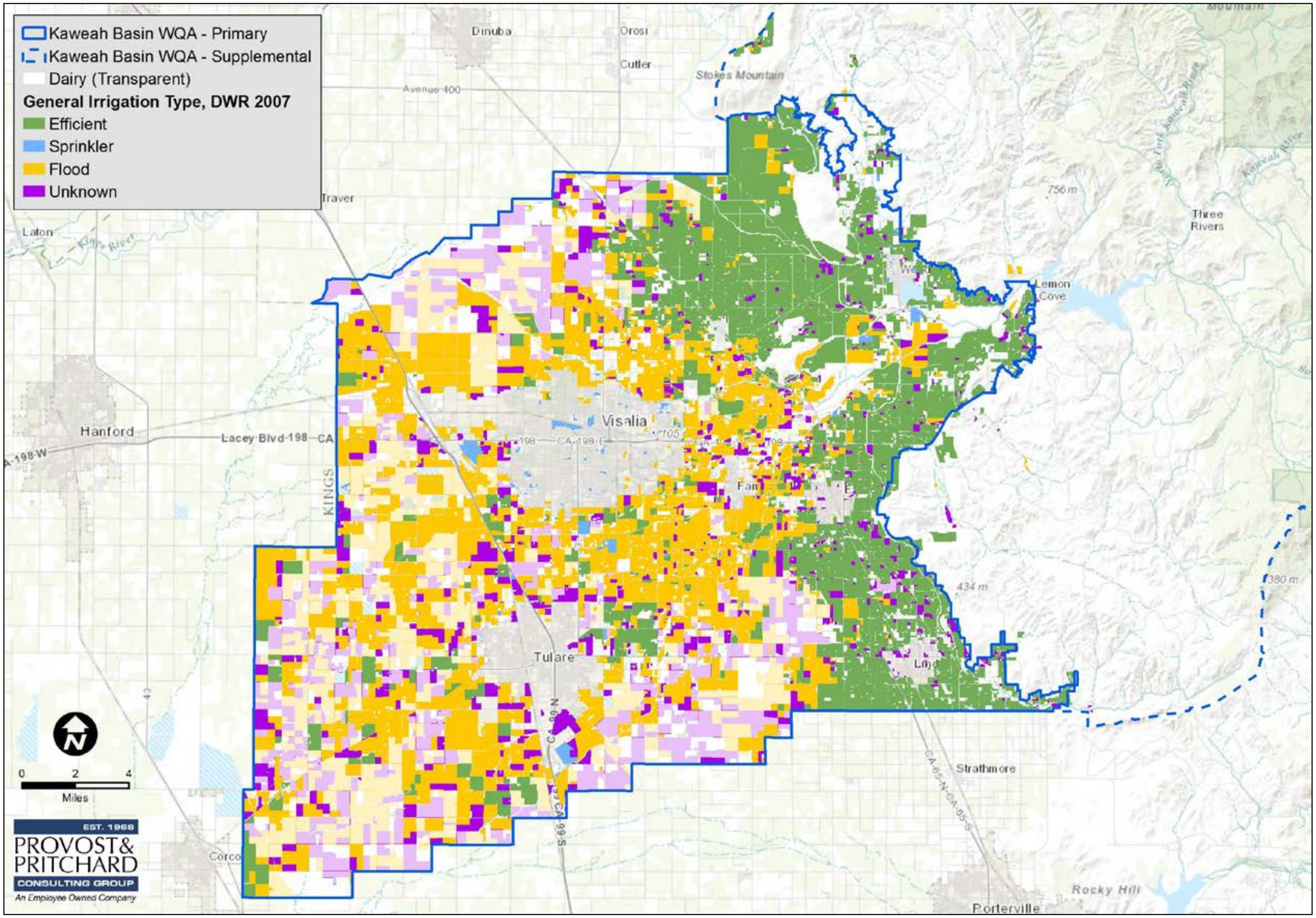

Figure 3-3. Irrigation Methods

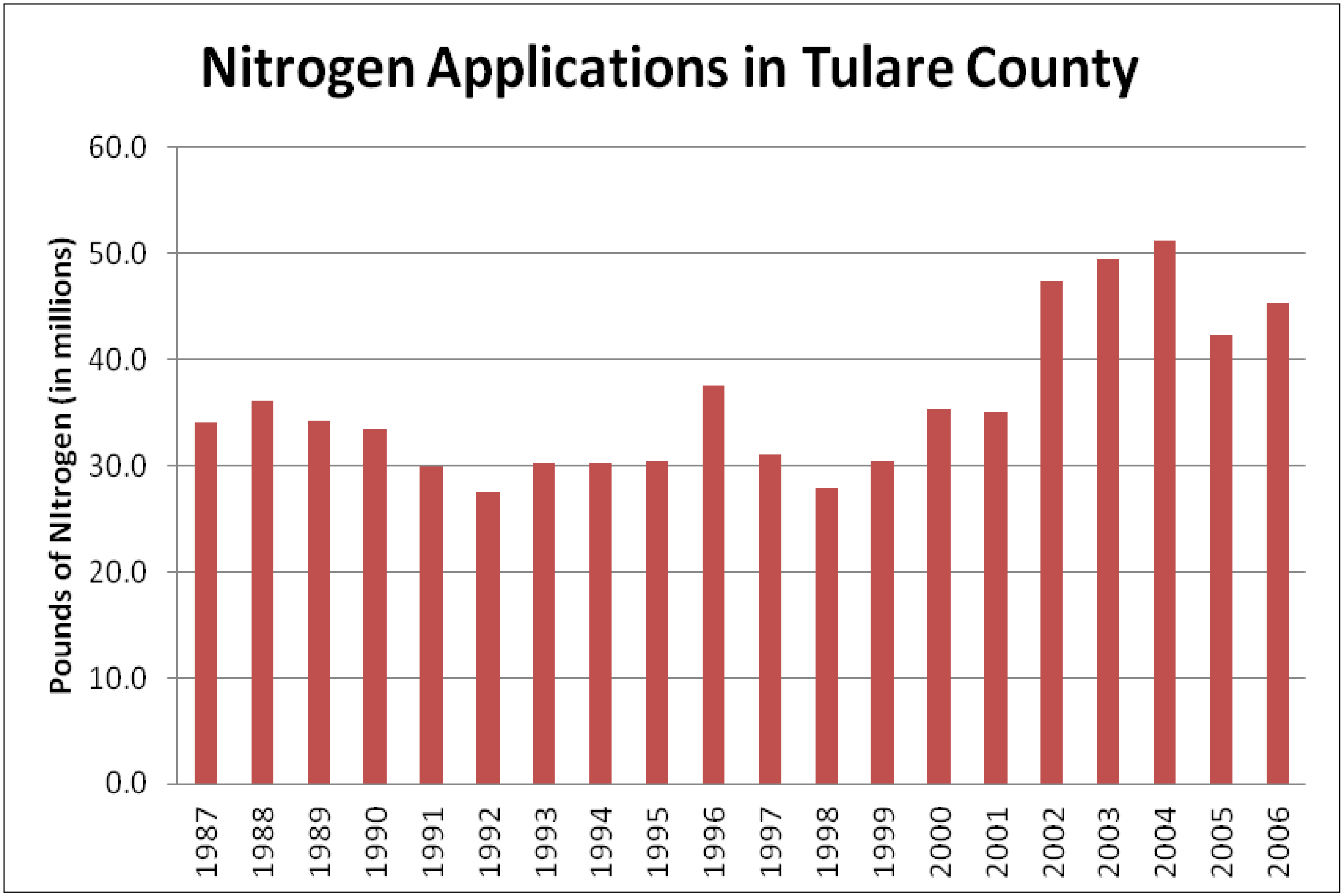

Figure 3-4. Nitrogen Applications in Tulare County

Source: Gronberg and Spahr, 2012

Table 3-3. Typical Fertilizer Rates

Source: Rosenstock et al. 2013

2012 Tulare County Agricultural Revenue				
Crop	**Primary KBWQA (acres)**	**Secondary KBWQA (acres)**	**Nitrogen Application Rate (lbs/acre)**	**Comments**
Oranges	51,251	1,442	95	
Walnuts	22,642	0.4	138	
Alfalfa and Alfalfa Mixtures	20,036	0	Not Available	
Grain And Hay	18,582	0	177	Wheat
Corn	17,682	0	213	Sweet
Cotton	11,327	0	174	
Plums	8,348	247	117	Average of Dried and Fresh
Vineyard	6,979	16	38	Average of Wine, Table and Raisin

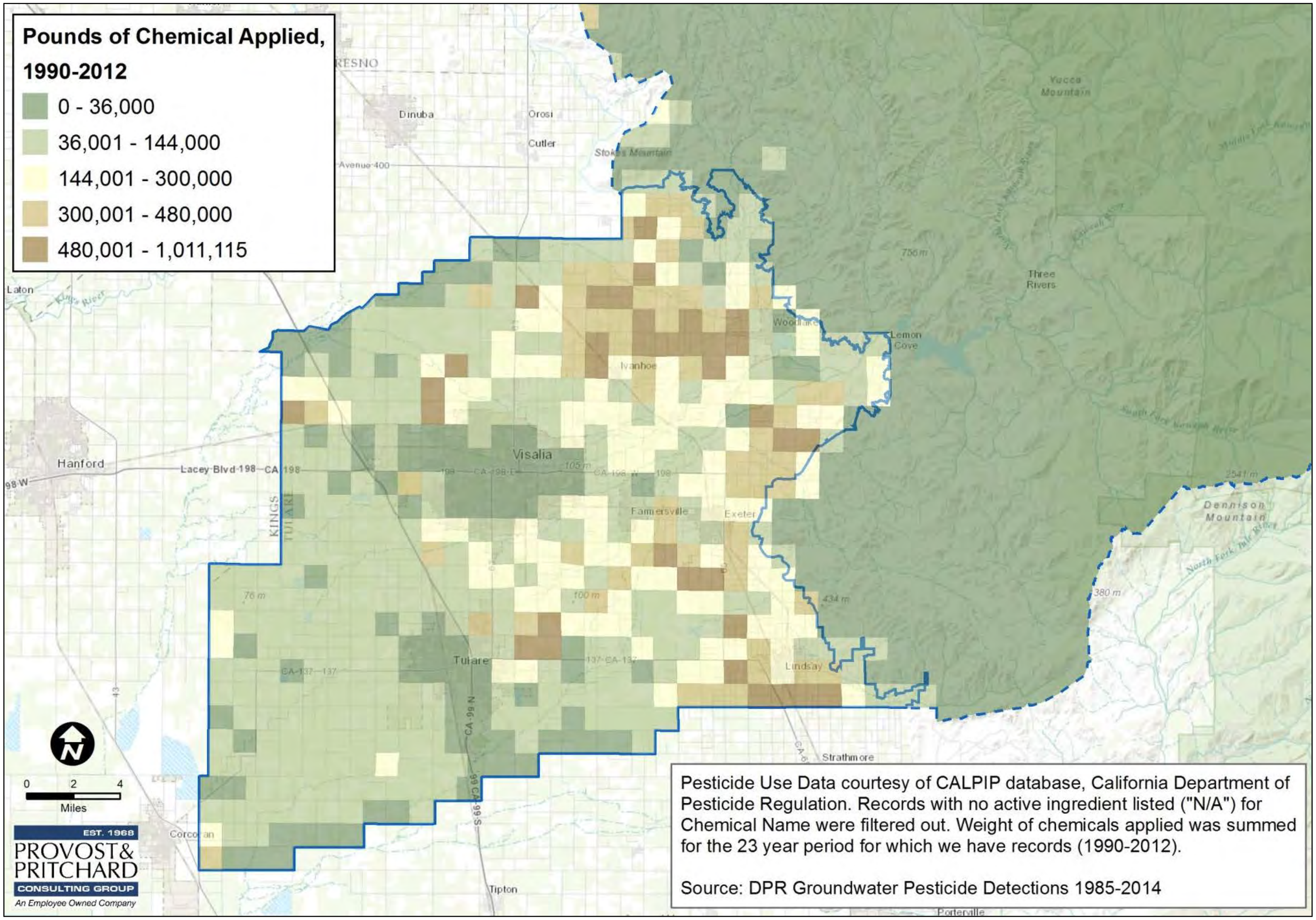

Figure 3-5. Pesticide Usage

4 Groundwater Hydrology

4.1 Potential Sources of Information

Water level information was gathered from the DWR California Statewide Groundwater Elevation Monitoring (**CASGEM**) database and from KDWCD. For the KBWQA area, the CASGEM database includes records from the following:

- Alta Irrigation District
- Bureau of Reclamation
- DWR
- Exeter Irrigation District
- Ivanhoe Irrigation District
- KDWCD
- Kings County Water District
- Kings River Conservation District
- Lewis Creek Water District
- Lindmore Irrigation District
- Lindsey-Strathmore Irrigation District
- Orange Cove Irrigation District
- Stone Corral Irrigation District
- Tulare Irrigation District

Of the 989 CASGEM system wells with available data for the KBWQA area, 965 are located in the 356,000 acre Primary area and 24 in the 602,000 acre Supplemental area. Due to the limited data set for the Supplemental area, depth-to-water and elevation contour maps were only prepared for the Primary area.

An extensive well log research and comparison was not performed; however, reasonable assumptions and extrapolations were used for map preparations. The largest percentage of area was evaluated using vetted KDWCD data. Only 31 CASGEM wells (including a few outside the Primary/Supplemental areas) were used to prepare the depth-to-water and elevation contour maps. Many of the CASGEM wells either didn't have recent data or the same well or area was already represented in the KDWCD data. Therefore, the most complete currently available data sets were for Fall 2013 and Spring 2014.

An effort was made to map the shallow groundwater zones but 90 percent of the CASGEM and all of the KDWCD data did not indicate well type. The minor percentage of known well type is not enough to generate meaningful contour maps. It is presumed that most of the data is from production wells of some type.

The Corcoran clay is present beneath the western portion of the Primary area at depths of approximately 200 feet beneath the City of Visalia, deepening westward to approximately 550 feet beneath the City of Corcoran. Without well type delineation or well construction information, it cannot be ascertained which well measurements represent confined groundwater conditions. It is possible that the 'pocked' appearance in the western portion of the groundwater maps presented herein is due to using measurements from both confined and unconfined groundwater conditions, and also possibly due to pumping activities. While the presence of the clay and the unknown well information complicates obtaining more precise conditions, the maps are still useful for general regional scale groundwater flow direction and gradients.

Other sources were researched for groundwater and surface water recharge information. Details are listed below.

4.1.1 USGS

CVHM does not have a water surface elevation or depth-to-water grid per Claudia Faunt, USGS, nor are there USGS wells noted as included in the CASGEM database. In the CVHM model, the water surface elevation is generated dynamically during simulation runs based on other input parameters. CVHM vertical conductivity (**VK**) was utilized in **Section 4.5**.

The USGS National Hydrography Dataset (**NHD**) for Waterbodies was utilized in Section 4.5 for the recharge assessment. The dataset includes vector data for all rivers and other natural water bodies as would be seen on a USGS topographic map. The dataset provides good cover and was used as a visual reference to confirm the NAIP information below.

4.1.2 NAIP

The most recent 2012 USDA National Agriculture Imagery Program (**NAIP**) imagery was utilized as part of the recharge assessment in Section 4.5. The data is collected every two years during the growing season and has a one meter resolution.

4.1.3 Google/Bing Maps

Google/Bing Maps were also used to visually double-check the NHD and NAIP information.

4.1.4 SWRCB GeoTracker

The SWRCB GeoTracker database does not include an extractable aggregated water level data set.

4.1.5 Local Entities

Since the KDWCD is the predominant district within the KBWQA area, the comprehensive Fugro WRI report was also utilized for this section. Basin information was utilized from both the KDWCD and TID for **Section 4.5**.

4.2 Depth to Groundwater

Recent depth to groundwater was determined based on a combination of KDWCD and CASGEM information. Map observations are noted below.

4.2.1 Primary Valley Floor Area

There are 965 wells within the 356,000 acre Primary area with available data from CASGEM. These wells were compared to and supplemented by the KDWCD data set.

4.2.1.1 Fall 2013 depth to groundwater contours

Depth-to-water is shallowest to the northeast and southeast with typical levels ranging from approximately 16 to 45 feet (**Figure 4-1**). A groundwater ridge occurs along the Kaweah River footprint with troughs apparent to either side. The deepest groundwater in the eastern area is approximately 127 feet located between the cities of Exeter and Lindsay.

The topography to the east is the steepest in the Primary area. Combined with the Kaweah River ridge, steep declines in groundwater levels can be noted within the eastern regions. Topography through the central and western portions is relatively flat with groundwater levels exhibiting an apparent greater reaction to pumping activities.

The deepest groundwater is located in the western portions typically ranging from approximately 140 to 180 feet with a maximum of 188 feet. The western portions are pock-marked with seemingly anomalous groundwater depths but these points only serve as evidence of the pumping effects.

4.2.1.2 Spring 2014 depth to groundwater contours

Depth-to-water is again shallowest to the northeast and southeast with levels ranging from approximately 13 to 34 feet (**Figure 4-2**). These levels are slightly shallower than in the previous fall. The groundwater ridge and side troughs are again apparent along the Kaweah River footprint. The deepest groundwater in the eastern area is approximately 113 feet located between the cities of Exeter and Lindsay, 14 feet shallower than in Fall 2013.

The deepest groundwater is located in the western portions typically ranging from approximately 130 to 170 feet, approximately 10 feet shallower than in Fall 2014. Pumping effects are still apparent in the region.

4.2.2 Supplemental Foothill and Mountain Area

For the Supplemental area it can be reasonably presumed that, other than within fractured bedrock, groundwater will generally follow the topography. With limited cropped acreage located within the Supplemental area, the lack of data is not considered to be a major issue.

4.3 Groundwater Level Trends

Hydrographs were prepared for 17 selected wells within the KBWQA Primary area. The wells were selected based on length of data set to include up to the last five years, and to provide general coverage within the region (Figure 4-3). Some datasets go back as far as the 1920s with the majority of them starting regular data collection in the mid-1950s (Figure 4-4).

The Terminus Dam was constructed in 1962, which coincides with a drop in groundwater levels of 40 feet or more. Wells located in the higher elevations tend to have smaller fluctuations and less severe declines than those located on the valley floor. Recent high water years can be noted in the mid- to late-1980s with water levels generally not reaching those elevations in the years following. The State of California is currently in a drought state of emergency and the Central Valley, in particular, is in a severe overdraft condition. Groundwater levels have generally been in decline since 1999 with a recent decline of up to 100 feet in some wells since approximately 2008.

4.4 Groundwater Flow Directions

The datasets which were used for depth-to-water maps were also utilized to assist with current flow direction assessment. Per the Fugro report, the principle direction of groundwater flow within the KDWCD is to the southwest parallel to the major axis of the District. Based on the maps prepared for this GAR, multiple micro-gradients also exist which are likely due to pumping activities. Additional observations are noted below.

4.4.1 Fall 2013 Groundwater Contours

In agreement with the Fugro report, the regional direction of groundwater flow in the Primary area is to the southwest. The most consistent flow directions are in the east with the steepest gradients influenced by topography and the Kaweah River system. The most inconsistent flow directions are in the flatter western portions and appear to be heavily influenced by groundwater pumping (Figure 4-5).

4.4.2 Spring 2014 Groundwater Contours

There is very little difference in general groundwater flow direction between the two seasonal periods. The main difference is that in the spring, the groundwater appears to “fall off a ridge” along a northwest-southeast trending line which bisects approximately through the middle of the area. In the Fall, the flow direction in this central region is less linear.

With the limited differences between the two seasons, it is clear that groundwater flow from the east is overwhelmingly to the southwest. The central and western portions undergo much more variable flow directions on a small scale, but are again overwhelmingly to the southwest on a regional scale (Figure 4-6).

4.5 Recharge Areas

4.5.1 Sources of Recharge

Recharge areas within the Primary valley floor area were identified using a combination of publicly available resources. The most recent 2012 USDA NAIP imagery, KDWCD facility waterways and recharge basins, TID basins, USGS NHD Waterbodies (ponds etc.), and Google/Bing Maps were reviewed and compared to visually identify the rivers, streams, creeks, canals, ponds and basins that were the most likely to have recharge. Only waterways that were clearly a natural channel or retained some natural attributes were included. These channels were identified by increased sinuosity, riparian vegetation, wider profiles, or connection to recharge ponds. Basins identified by TID or KDWCD were confirmed in at least one aerial photo. Tiny, straight, clean channels with smooth regular edges and no connections to recharge ponds and apparent dairy lagoons or ponds that would likely be lined (small artificial lakes surrounded by houses) were not included.

4.5.2 Relative Recharge Rates

As a generalized method of determining relative recharge rates, the above identified recharge areas were layered over CVHM VK layers of varying thicknesses within the Primary area (**Figure 4-7**). The layers were dynamically utilized based on the depth of the layers and the depth-to-water. The legend illustrates color coded borders for each cell which indicate the depth to the bottom of the lowest layer used. For instance, Layer 1 has a relatively uniform depth of 50 feet (indicated by the green border), so recharge areas where Spring 2014 depth-to-water is 50 or less are underlain by Layer 1 and the VK value was only attributable from the one layer. Numbers within the cells denote the number of layers that were averaged to get the final VK. CVHM data is not available for the Supplemental area.

The fastest VK values are included in the areas near the mouths of the Kaweah River and the current Yokohl Creek and extending northwestward. These coarse grain areas were previously discussed in Section 2.2.3 CVHM Well Log Texture. Depth-to-water in these areas ranges from approximately 50 to 150 feet.

The slowest VK values include the areas to the north and south of the two alluvial fans (Kaweah and Yokohl creek locations) and the better part of the south-central and southeast areas. Depth-to-water in these areas ranges from less than 50 to more than 150 feet.

Areas to the far west are more mid-range with depth-to-water levels at 100 to 150 feet and above.

4.5.3 Identification of Significant Recharge Areas Upgradient of Urban Areas

The most significant recharge area is at and near the mouth of the Kaweah River. This area contains the shallowest groundwater at less than 50 feet and is upgradient of the majority of the KBWQA area. Although there are a limited number of membership growers in the area which is steadily recharged by the good quality Kaweah River water, virtually all of the KBWQA area is downgradient. Water quality in this important area will be assessed in **Section 5**.

The second most significant recharge area is the northwest-southeast trending belt of relatively high VK values and multiple surface waterways and impoundments. Depth-to-water in this area ranges from 50 to 150 feet. This belt includes the Cities of Exeter, Farmersville, and Visalia and is upgradient of Goshen, the City of Tulare, and multiple DACs and small water systems reliant on groundwater. Although this belt is larger and literally bisects the region, a smaller portion of the KBWQA area is downgradient making this area of secondary significance. Water quality in this area will also be assessed in **Section 5**.

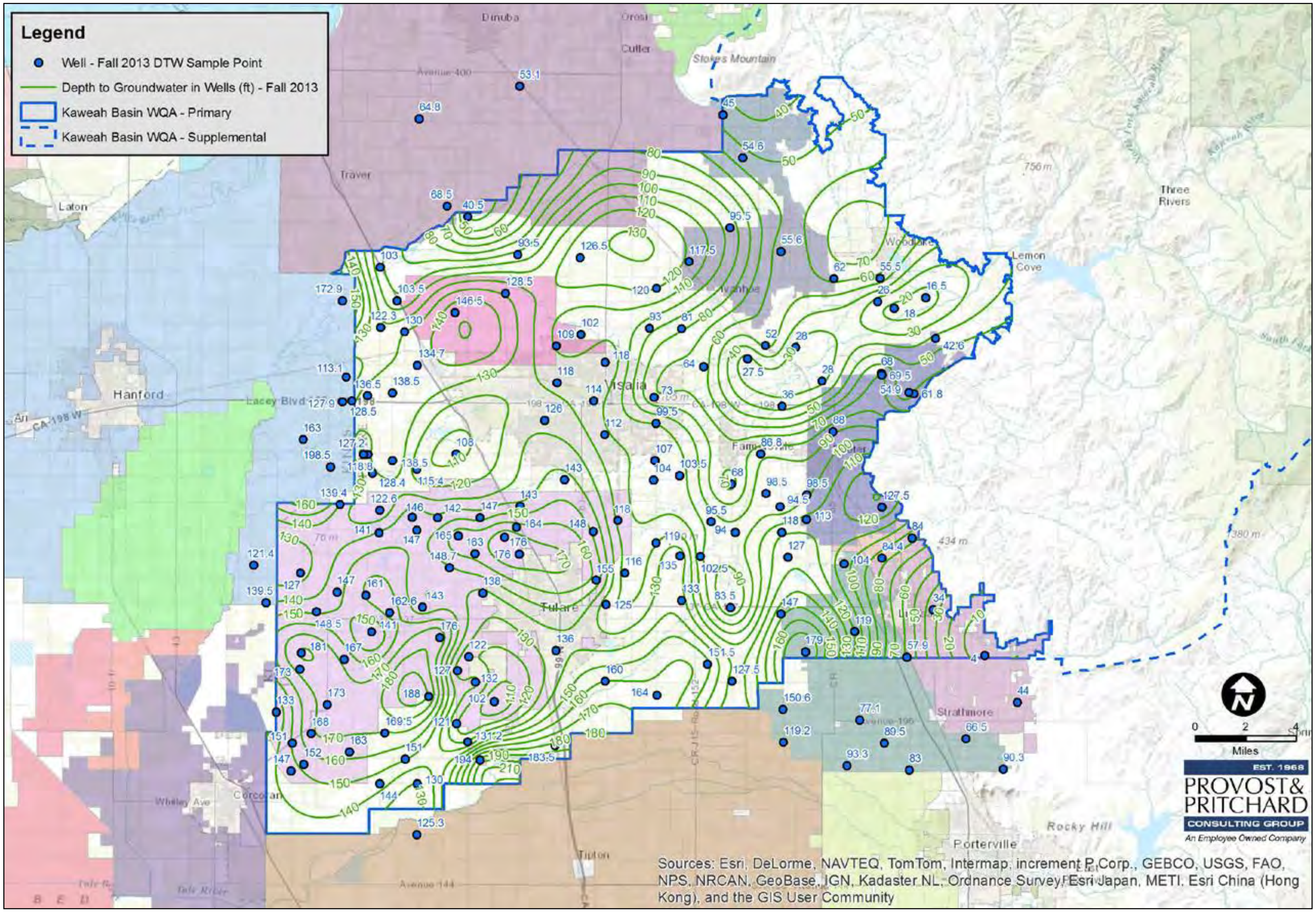

Figure 4-1. Fall 2013 Depth to Water

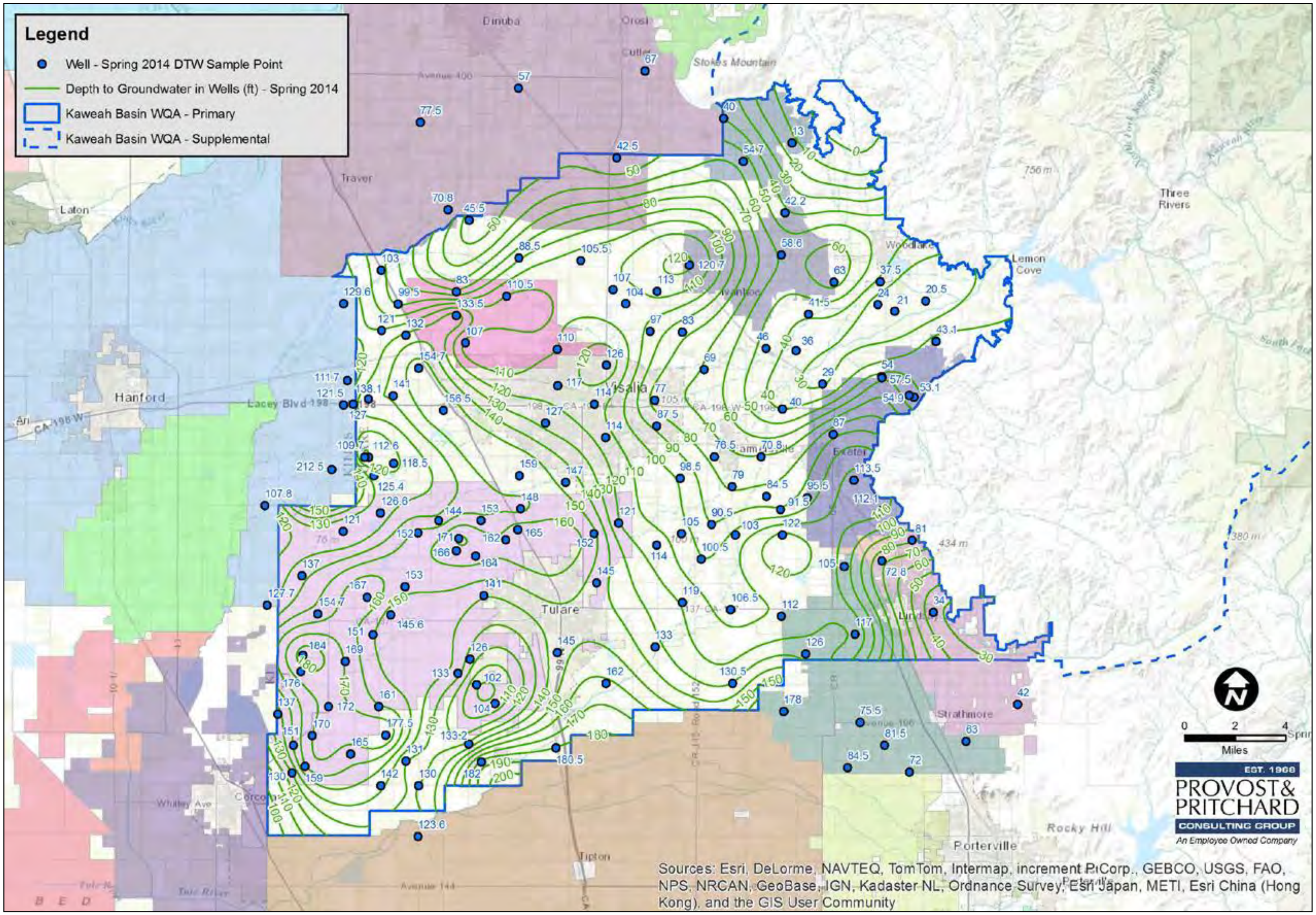

Figure 4-2. Spring 2014 Depth to Water

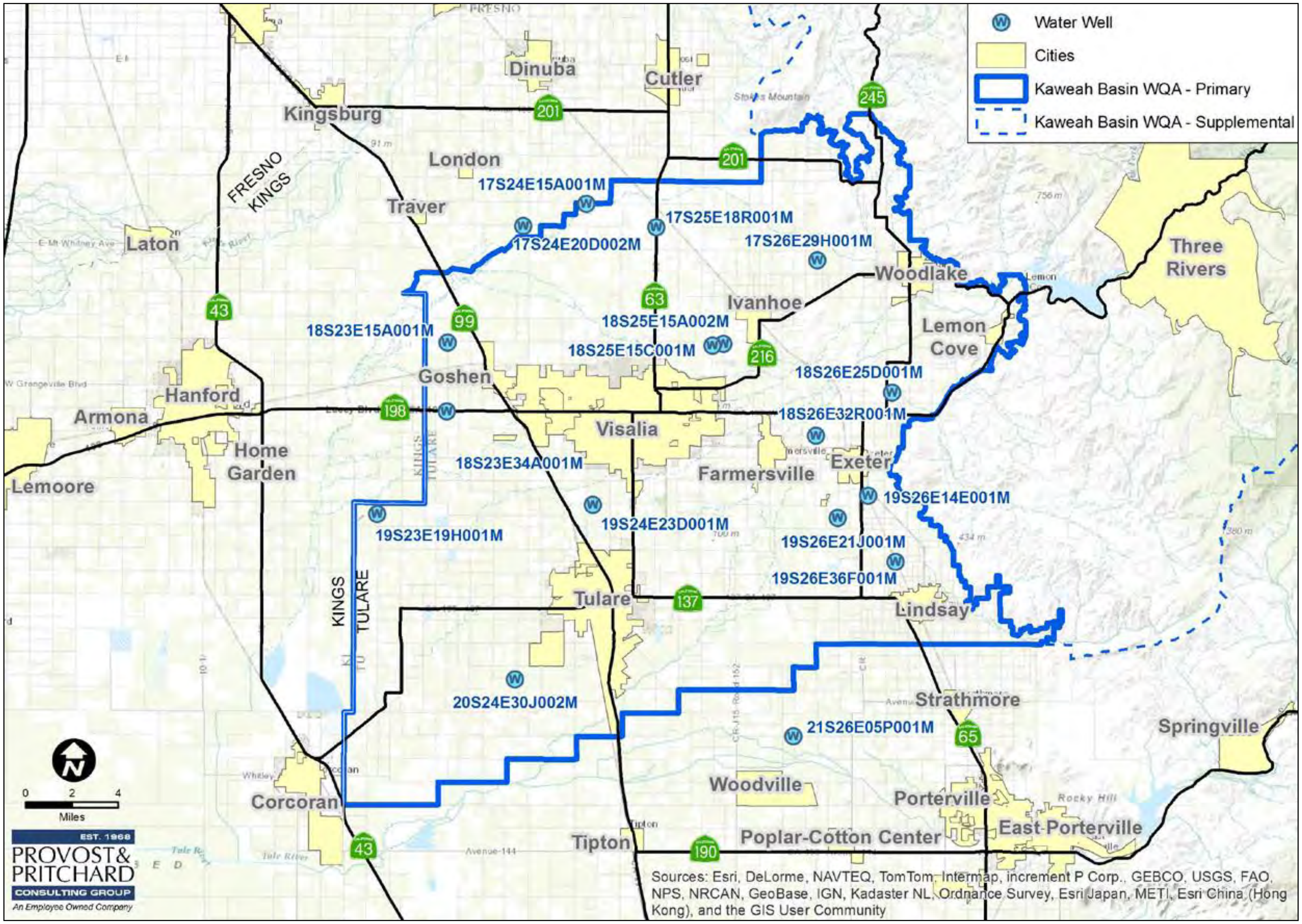

Figure 4-3. Selected Hydrographs Well Locations

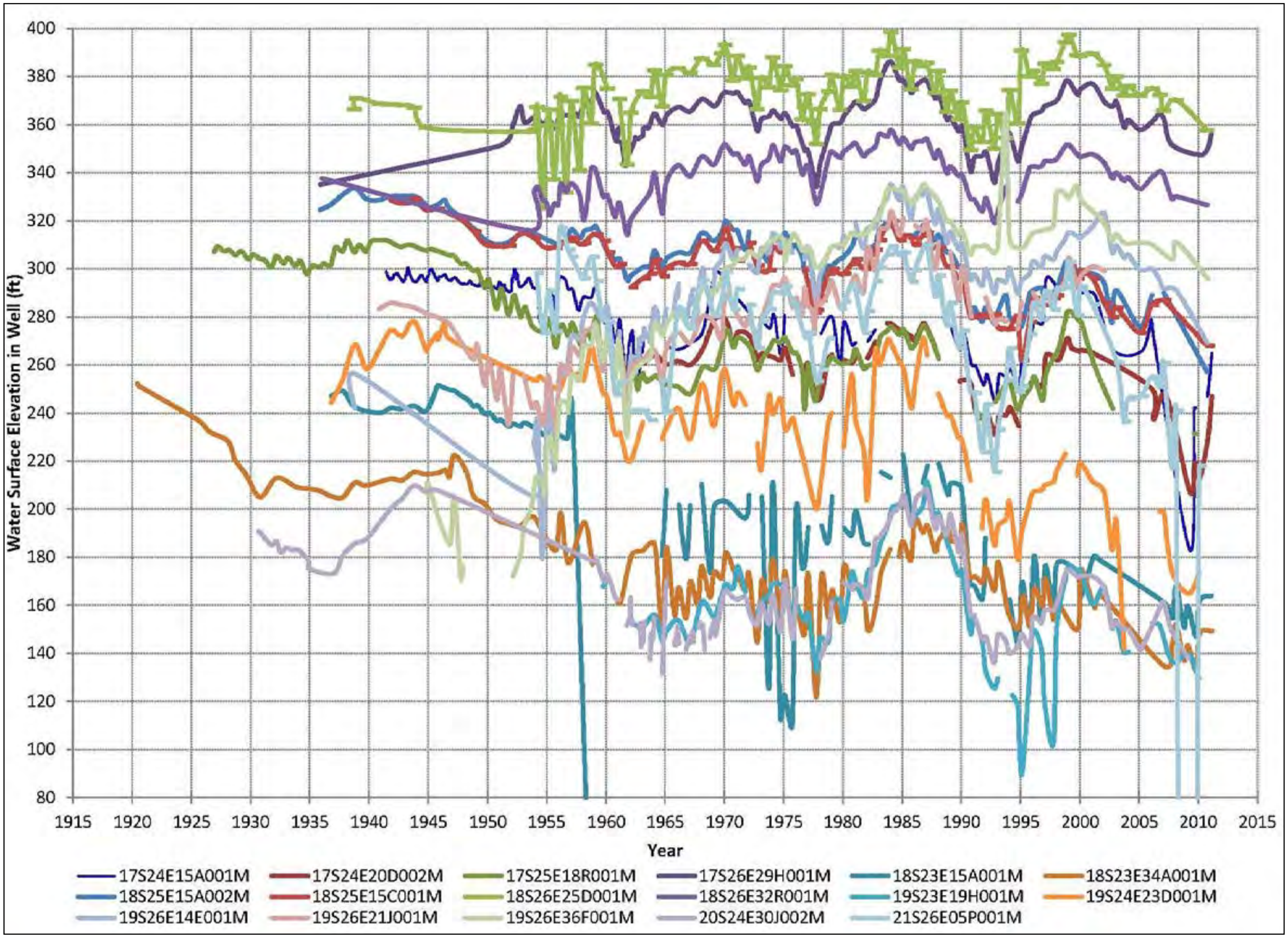

Figure 4-4. Selected Hydrographs

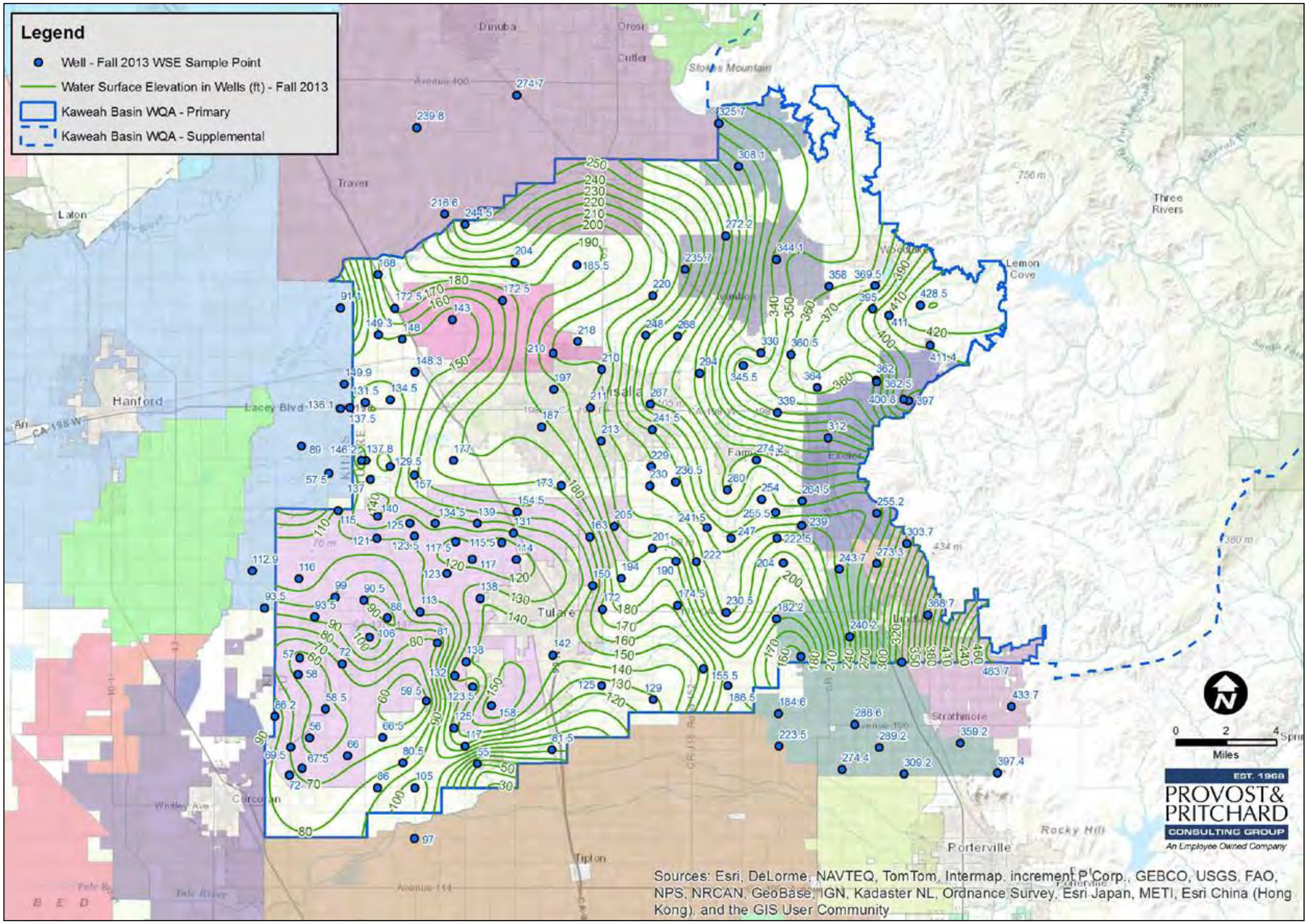

Figure 4-5. Fall 2013 Water Surface Elevation

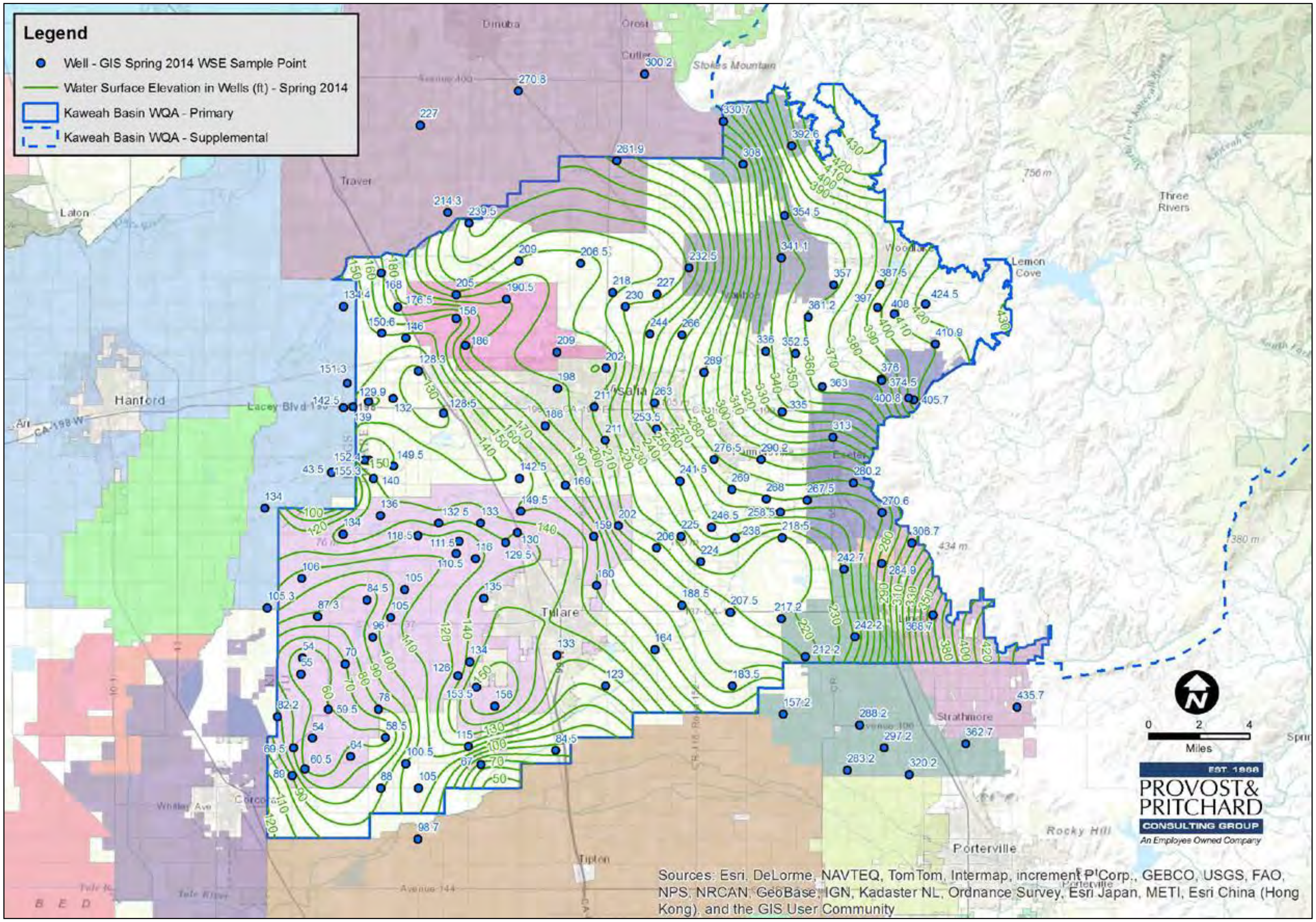

Figure 4-6. Spring 2014 Water Surface Elevation

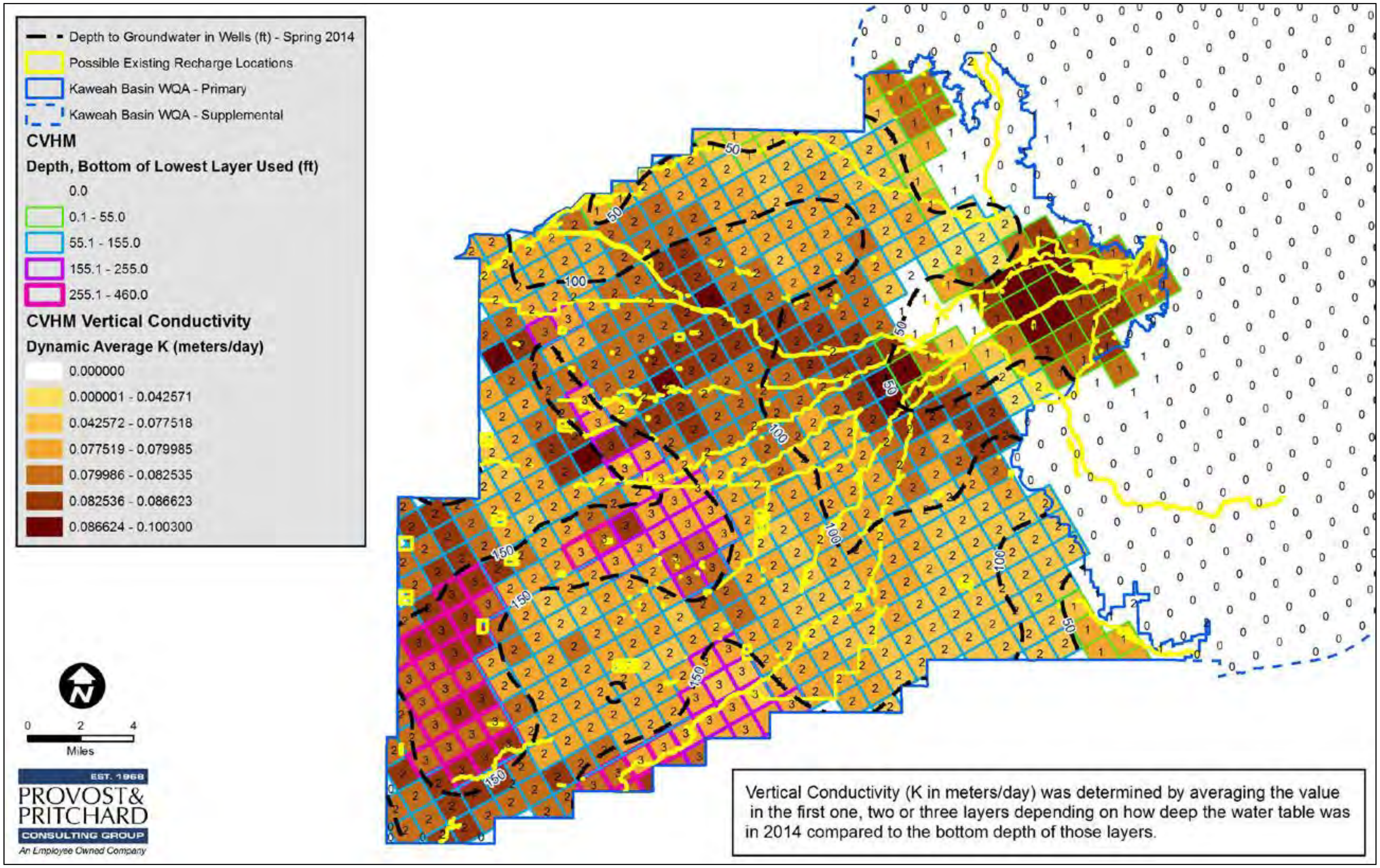

Figure 4-7. Vertical Conductivity and Potential Recharge Areas

5 Groundwater Quality Data and Interpretation

5.1 Potential Sources of Information

Water quality data was gathered from a large variety of public sources as detailed below. Again, an extensive well log research and comparison was not performed; however, reasonable assumptions and extrapolations were used for map preparations.

5.1.1 Geotracker/GAMA

The State Water Resources Control Board's GeoTracker and Groundwater Ambient Monitoring & Assessment Program (**GAMA**) provided the most comprehensive dataset of water quality information. For the KBWQA area, the GAMA database includes records from the following:

- DDW
- Department of Pesticide Regulation (**DPR**)
- GAMA
- USGS
- CalWater
- Electronic Data File (**EDF**)

Of the 950 GAMA system wells with available data for the KBWQA area, 819 are located in the 356,000 acre primary area and 131 in the 602,000 acre Supplemental area. It can be presumed that the largest percentage of data is from supply wells.

5.1.2 RWQCB

Mr. Kris Sisk, RWQCB dairy management group, provided dairy water quality records for the time period of 2007 to 2012. The dataset included records for 1,888 wells in the Primary area with no wells in the Supplemental area therefore the need to include the Supplemental area in the water quality assessment due to these nitrate detections was eliminated. It can be presumed that the largest percentage of data is from supply wells; however, this dataset likely has more monitoring wells than the GAMA dataset.

5.1.3 University of California, Davis (UCD)

Water quality records compiled for the UCD 2012 Harter study *Addressing Nitrate in California's Drinking Water* were utilized from both the published document and as made available by the RWQCB. Once the study was complete, the data was compiled by UCD with data from GAMA and other sources and given to the RWQCB to release as a separate product on GAMA's website. While the UCD dataset has additional wells that aren't in the GAMA dataset, and there is an undisclosed overlap, the GAMA dataset has the most recent records because the UCD study used data through 2010.

There are records for 2,638 wells in the Primary area with 137 wells in the Supplemental area. It can be presumed that the largest percentage of data is from supply wells.

5.1.4 DPR

Water quality data was downloaded from the DPR database which included records for 746 wells within the Primary area and 39 wells within the Supplemental area. DPR collects data that is separate from what they report to GAMA so the separate download was required. It can be presumed that the largest percentage of data is from supply wells.

The DPR database is not meant for research into point source issues since if a release is known as a contamination point source up-front the data is not entered in the database. Regardless, because there were noted pesticide detections in the Supplemental area, additional DPR research included reviewing known point source contamination records for that area. There were 11 records describing three wells distributed across two neighboring sections. The two noted sections were not located in a probable downgradient direction from ILRP membership growers, therefore eliminating the need to include the Supplemental area in the water quality assessment due to pesticide detections.

5.1.5 Tulare County

Tulare County was contacted for information which was incorporated as appropriate. Data collected by both the Resource Management Agency and the Health and Human Services Agency was supplied. Specific nitrate and 1,2-dibromo-3-chloropropane (**DBCP**) GIS layers (as created by the County) were added to the water quality maps.

5.1.6 Local Entities

The KDWCD provided a limited dataset of water quality information which was incorporated as appropriate. The dataset did not add significantly to the extensive dataset from the above sources.

5.2 Water Quality Thresholds

As defined in the WDRs, a water quality exceedance is a reading using a field instrument or detection by a California state-certified analytical laboratory where the detected result indicates an impact to the beneficial use of the receiving water when compared to a water quality objective for the parameter or constituent.

For the purposes of this GAR, an exceedance has been defined as the above-described detected result at a value at or above the California Primary Maximum Contaminant Levels (**MCL**), as codified in Title 22 California Code of Regulations and as listed in the Table 5 – Basin Plan Numeric Water Quality Objectives for the Tulare Lake Basin Area, Attachment B, Pg 30 of the ILRP WDRs and included here as **Table 5-1**.

5.3 Constituent Focus: Nitrate, DPR-Monitored Pesticides, and Salinity

In consideration of the constituents that would indicate impacts to groundwater from ILRP membership growers, nitrate, salinity, and pesticides were selected as the focus for the groundwater quality assessment. While these three parameters are commonly used to identify areas that may have been impacted by irrigated agriculture, higher nitrates and salinity in groundwater may also be present from natural sources.

5.3.1 Nitrate

Nitrate (**NO_3**) is a naturally occurring form of nitrogen that can be sourced from the atmosphere or decomposing organic matter. Naturally occurring nitrate concentrations are generally less than 10 milligrams per liter (**mg/L**) nitrate as nitrate and generally do not exceed 20 mg/L in groundwater (Todd 1980 and Hounslow 1995). Nitrate can also be found in groundwater as a result of, including but not limited to, excess application of nitrogen fertilizers in irrigated agricultural and landscaped areas, runoff from feedlots or dairies, or from wastewater percolation.

There are two MCLs for nitrate in drinking water based on reporting type; 10 mg/L for nitrate as nitrogen (**NO^3-N**) and 45 mg/L for NO^3 (CCR 2014). The MCL for nitrate as nitrogen is based on an approximate relationship whereby 10 mg/L nitrate as nitrogen is equivalent to 45 mg/L nitrate as NO_3. This equivalency relationship is not absolute, so evaluation of nitrate as nitrate is preferred. In addition, a preponderance of available data was reported as NO^3, so for this GAR, the 45 mg/L nitrate as nitrate MCL has been used as the basis for identifying areas of existing nitrate impacted groundwater.

5.3.2 Pesticides

Pesticides are chemicals used to control bacteria, fungi, weeds, insects, and other vectors in agriculture and generally do not occur naturally in the environment. Sources of pesticides in the environment include applications to agricultural and lawn and garden areas, golf courses, and roadside weed control. Some of these chemical compounds are readily soluble in water, but highly sorptive to soil, and historically degrade very slowly tending to persist in soils for many years. Some pesticide chemicals have low chemical stability and rapidly decay in the environment (Chapman and Kimstach 1992). Concentrations in most water bodies are rather low, generally ranging from 10^{-5} to 10^{-3} mg/L (Chapman and Kimstach 1992 and Montgomery 1993). There are at least 146 individual chemical compounds that indicate pesticides in water quality samples. A list of pesticides considered for this assessment from the GAMA data and from the DPR data are presented as **Table 5-2** and **Table 5-3**, respectively.

5.3.3 Salinity

Salinity can be measured as EC in µmhos/cm or TDS in mg/L with respective lower level secondary MCLs of 900 µmhos/cm and 500 mg/L. Both constituents are commonly analyzed during initial groundwater quality assessments and routine water quality sampling events and can be made up of numerous individual constituents, and both can be used as general indicators of salinity.

Salinity in water supplies can originate from natural sources, sewage, runoff and deep percolation from urban and agricultural areas, industrial wastewater, and oilfield produced water. Complex hydrogeologic processes often dissolve, transport, dilute, concentrate, and/or precipitate salts. Variations in surface water availability affect recharge with higher quality surface water and subsequent salt dilution of salts.

Once maps were prepared for the three constituents of focus, it was determined that mapped EC/TDS exceedances were redundant to the nitrate/pesticide issues and not necessarily indicative of potential groundwater impacts due to irrigated agriculture within the KBWQA area. Discussions that follow will concentrate on nitrate and pesticides water quality concerns.

5.4 Groundwater Quality and Trends

An effort was made to determine which data was collected from the shallow groundwater zones but most data does not indicate well type. The minor percentage of known well type is not enough to generate meaningful maps. It is presumed that most of the data is from production wells of some type.

In map preparations for groundwater quality, it is clear that well locations for water quality data are also not precise. Mapping buffers based on well location inaccuracies are created as follows:

- 100 foot radius for data from the Tulare County dataset, UCD, and GAMA data not derived from DDW;
- 1 mile section squares for DPR data; and
- 2 mile squares for DDW data derived from the GAMA database.

Once the buffers are set, the GIS layer is underlain by the CVHM 1-mile grid. Where a buffer lies within a CVHM grid cell, the cell is considered to be within the sphere of influence of that groundwater quality detection. With this approach, the extent of groundwater quality exceedances and up-trending impacts are considered to be conservative and err on the side of groundwater quality protection.

Recent test results within the last 10 years for the constituents of focus were each mapped in this manner. It was subsequently determined that mapped EC/TDS exceedances were redundant to the nitrate/pesticide issues and not necessarily indicative of potential groundwater impacts due to irrigated agriculture within the KBWQA area. Accordingly, discussions that follow will concentrate on nitrate and pesticide groundwater quality concerns.

5.4.1 Nitrate Concentrations

Nitrates appear to be the primary groundwater quality issue within the KBWQA area. MCL exceedances are illustrated as red-hashed squares in **Figure 5-1** Nitrate Exceedances and Up-Trending. For wells with detections that remain below the MCL, an analysis was performed to determine if there was a statistically significant increasing trend within a well dataset. Wells identified with a statistically significant increasing trend appear as blue-filled red-hashed squares in the same figure. The remaining cells are either of known good groundwater quality or did not have available groundwater quality data. These areas are rectified during the HVA analysis and detailed in **Section 7.1**.

To calculate statistically significant up-trends in the water quality data, a Theil-Sen analysis was performed using the USEPA ProUCL software program which has a 95 percent confidence interval. The Theil-Sen analysis does not require normally-distributed data, can deal with some non-detect data points and is a recommended method of determining if statistically significant trends are found in the dataset. To ensure that all of the available nitrogen concentration data was captured and not duplicated, the UCD dataset was used for the calculations. This dataset included the wells from the GAMA data in addition to other wells not provided in the GAMA system. Because both the GAMA and UCD dataset did not provide exact well locations and used different well naming conventions, it was impossible to correlate the two datasets. While the data ends in 2010, the length of the dataset is sufficient for the calculations.

To be of sufficient quantity for analysis, only wells with at least eight detections within the monitoring record period were used. The datasets were entered in the ProUCL software program and tested for trends using the Theil-Sen slope calculations.

5.4.1.1 Primary Valley Floor Area

Nitrate exceedances are located almost entirely within the Primary area. The main locations without nitrate exceedances are located along the Kaweah River footprint, and to the southeast of the City of Visalia. The limited set of statistically up-trending wells are scattered throughout the area and mostly coincide with CVHM sections already noted to be in exceedances for nitrates.

5.4.1.2 Supplemental Foothill and Mountain Area

Limited nitrate exceedances are located within the Supplemental area, mostly along the border to the Primary area, and near Three Rivers. The Three Rivers exceedances do not correlate with membership grower properties.

5.4.2 Pesticide Detections

Only those pesticides with designated MCLs were assessed. Listed pesticides can be reviewed from **Table 5-2** and **Table 5-3**. Detected pesticide MCL exceedances based on the most recent 10 years of data are illustrated in **Figure 5-2** as red-hashed squares. The occurrences of pesticide exceedance are much reduced from the nitrate occurrences and provide few new water quality impacted areas.

In addition, while ample nitrate datasets per well were available from a variety of sources, pesticide datasets with enough data points were not available.

5.4.2.1 Primary Valley Floor Area

Pesticide exceedances are primarily grouped in the southeast area with noted blocks within the City of Visalia and within and south of the City of Tulare. As noted above, statistically significant up-trending analysis for pesticides was not performed.

5.4.2.2 Supplemental Foothill and Mountain Area

There are no pesticide detections associated with irrigated agriculture within the Supplemental area.

5.5 Legacy and Naturally Occurring Constituents

There are multiple anecdotal accountings of naturally occurring or heritage nitrates along the eastern boundary of the valley floor area and in formerly swampy areas. Research for this GAR has not, as yet, uncovered any definitive studies for legacy or naturally occurring constituents. A 2011 study titled *California GAMA Domestic Wells: Nitrate and Water Isotopic Data for Tulare County* by Lawrence Livermore National Laboratory found that…

> *In general, foothill wells have low nitrate concentrations, while valley wells have moderate to high nitrate concentrations. Nitrate concentrations in the most polluted wells are sufficiently high to preclude a significant contribution from soil or atmospheric sources. Such sources cannot be precluded in wells with nitrate concentrations below the regulatory drinking water limit, however the data set*

> *does not include enough samples near typical background concentration levels to assess the isotopic characteristics of natural nitrate sources in this area.*

The findings indicated that there were potentially one or two areas that may have naturally occurring nitrates but results are not conclusive.

Table 5-1. Basin Plan Numeric Water Quality Objectives for the Tulare Lake Basin Area

Basin Plan Numeric Water Quality Objectives for the Tulare Lake Basin Area													
						Numeric Threshold Protects Designated Beneficial Use(s) in the Water Body:							
						Groundwater (b)			Inland Surface Waters				
Constituent/Parameter (Synonym)	Basin Plan Water Quality Objective	Source of Numeric Threshold *(footnotes in parentheses are at bottom of table)*	Numeric Threshold (a)	Units	G = Groundwater IS = Inland Surface Water	MUN-MCL	MUN-Toxicity	AGR	MUN-MCL	MUN-Toxicity	Aquatic Life & Consump	AGR	CAS Number
Boron, total	Chemical Constituents	Basin Plan, discharge limitation (A)	1,000	µg/L	IS							X	7440-42-8
Coliform, fecal	Bacteria	Basin Plan (c) (d)	200/100	MPN/mL	IS				X				
		Basin Plan (c) (e)	400/100	MPN/mL	IS				X				
Coliform, total	Bacteria	Basin Plan	2.2/100	MPN/mL	G	X							
Conductivity at 25 C	Salinity	Basin Plan. Kings River, Reach I, Above Kirch Flat	100	µmhos/cm	IS								
		Basin Plan. Kings River, Reach II, Kirch Flat to Pine Flat Dam	100(f)	µmhos/cm	IS								
		Basin Plan. Kings River, Reach III, Pine Flat Dam to Friant-Kern	100	µmhos/cm	IS								
		Basin Plan. Kings River, Reach IV, Friant-Kern to Peoples Weir	200	µmhos/cm	IS								
		Basin Plan. Kings River, Reach V, Peoples Weir to Island Weir	300(g)	µmhos/cm	IS								
		Basin Plan. Kings River, Reach VI, Island Weir to Stinson Weir (North Fork) and Empire Weir #2 (South Fork)	300(g)	µmhos/cm	IS								
		Basin Plan. Kaweah River, Reach I, Above Lake Kaweah	175	µmhos/cm	IS								
		Basin Plan. Kaweah River, Reach II, Lake Kaweah	175(h)	µmhos/cm	IS								
		Basin Plan. Kaweah River, Reach III, Below Lake Kaweah	(i)	µmhos/cm	IS								
		Basin Plan. Tule River, Reach I, Above Lake Success	450	µmhos/cm	IS								
		Basin Plan. Tule River, Reach II, Lake Success	450	µmhos/cm	IS								
		Basin Plan. Tule River, Reach III, Below Lake Success	(i)	µmhos/cm	IS								
		Basin Plan. Kern River, Reach I, Above Lake Isabella	200	µmhos/cm	IS								
		Basin Plan. Kern River, Reach II, Lake Isabella	300	µmhos/cm	IS								
		Basin Plan. Kern River, Reach III, Lake Isabella to Southern California Edison Powerhouse (KR-1)	300	µmhos/cm	IS								
		Basin Plan. Kern River, Reach IV, KR-1 to Bakersfield	300	µmhos/cm	IS								
		Basin Plan. Kern River, Reach V, Below Bakersfield	(i)	µmhos/cm	IS								
(Electrical conductivity)		California Secondary MCL	900-1600	µmhos/cm	G & IS	X	X		X	X			
Copper	Chemical Constituents	California Secondary MCL (total copper)	1,000	µg/L	G & IS	X			X	X			7440-50-8
	Toxicity	California Toxics Rule (USEPA), (j) (dissolved copper)	variable	µg/L	IS						X		
Dissolved Oxygen, minimum	Oxygen Dissolved	Basin Plan. Kings River, Reach I, Above Kirch Flat	9.0	mg/L	IS						X		7782-44-7
		Basin Plan. Kings River, Reach II, Kirch Flat to Pine Flat Dam	9.0	mg/L	IS						X		
		Basin Plan. Kings River, Reach III, Pine Flat Dam to Friant-Kern	9.0	mg/L	IS						X		
		Basin Plan. Kings River, Reach IV, Friant-Kern to Peoples Weir	7.0	mg/L	IS						X		

Basin Plan Numeric Water Quality Objectives for the Tulare Lake Basin Area													
Constituent/Parameter (Synonym)	Basin Plan Water Quality Objective	Source of Numeric Threshold *(footnotes in parentheses are at bottom of table)*	Numeric Threshold (a)	Units	G = Groundwater IS = Inland Surface Water	Numeric Threshold Protects Designated Beneficial Use(s) in the Water Body:							CAS Number
						Groundwater (b)			Inland Surface Waters				
						MUN-MCL	MUN-Toxicity	AGR	MUN-MCL	MUN-Toxicity	Aquatic Life & Consump	AGR	
		Basin Plan. Kings River, Reach V, Peoples Weir to Island Weir	7.0	mg/L	IS						X		
		Basin Plan. Kaweah River, Lake Kaweah	7.0	mg/L	IS						X		
		Basin Plan. Tule River, Lake Success	7.0	mg/L	IS						X		
		Basin Plan. Kern River, Reach I, Above Lake Isabella	8.0	mg/L	IS						X		
		Basin Plan. Kern River, Reach III, Lake Isabella to Southern California	8.0	mg/L	IS						X		
		Edison Powerhouse (KR-1) Basin Plan. Waters designated WARM	5.0	mg/L	IS						X		
		Basin Plan. Waters designated COLD and/or SPWN	7.0	mg/L	IS						X		
Lead	Chemical Constituents	California Primary MCL (total lead)	15	µg/L	G & IS	X			X				7439-92-1
	Toxicity	California Toxics Rule (USEPA) (j) (dissolved lead)	variable	µg/L	IS						X		
Molybdenum, total	Chemical Constituents	Basin Plan. Kings River, Peoples Weir to Stinson Weir (B)	(B)	µg/L	IS							X	7439-98-7
		Basin Plan. Kings River, Peoples Weir to Empire Weir #2	(B)	µg/L	IS							X	
Nitrate (as nitrogen)	Chemical Constituents	California Primary MCL	10	mg/L	G & IS	X	X		X	X			14797-55-8
Nitrite (as nitrogen)	Chemical Constituents	California Primary MCL	1	mg/L	G & IS	X	X		X	X			14797-65-0
Nitrate+Nitrite (as nitrogen)	Chemical Constituents	California Primary MCL	10	mg/L	G & IS	X	X		X	X			
pH — minimum	pH	Basin Plan	6.5	units	G & IS	X	X		X	X			
pH — maximum	pH	Basin Plan	8.3	units	G & IS	X	X		X	X			
Selenium, total	Chemical Constituents Toxicity	California Primary MCL National Toxics Rule (USEPA), 4-day mean	50 5	µg/L	G & IS IS	X			X		X		
Simazine	Chemical Constituents	California Primary MCL	4	µg/L	G & IS	X	X		X	X			122-34-9
Temperature	Temperature	Basin Plan (k)	variable		IS								
Total Dissolved Solids (TDS)	Chemical Constituents	California Secondary MCL, recommended level	500 — 1,000	mg/L	G & IS	X	X		X	X			
Turbidity		Turbidity Where natural turbidity is between 0 and 5 NTUs, increases shall not exceed 1 NTU.	variable; 1-6	NTU	IS								
		Turbidity Where natural turbidity is between 5 and 50 NTUs, increases shall not exceed 20%.	variable; 6 - 60	NTU	IS								
		Where natural turbidity is between 50 and 100 NTUs, increases shall not exceed 10 NTUs.	variable; 60-110	NTU	IS								
		Where natural turbidity is greater than 100 NTUs, increases shall not exceed 10%.	variable	NTU	IS								
Zinc	Chemical Constituents Toxicity	California Secondary MCL (total zinc) California Toxics Rule (USEPA) (j) (dissolved zinc)	5,000 variable	µg/L	G & IS IS	X			X		X		7440-66-6

Table 5-1 Notes	
a	Numeric thresholds are maximum levels unless noted otherwise.
b	For groundwater the following beneficial uses have been identified and occur throughout the Tulare Lake Basin: MUN, AGR, IND, PRO, REC-1, and WLD. To protect these beneficial uses, numeric and narrative thresholds not listed in this table may be applicable.
c	Applies in waters designated for contact recreation (REC-1).
d	Geometric mean of the fecal coliform concentration based on a minimum of not less than five samples for any 30-day period shall not exceed this number.
e	No more than ten percent of the total number of samples taken during any 30-day period shall exceed this number.
f	Maxium-10-year average — 50 pmhos/cm
g	During the period of irrigation deliveries. Providing, further, that for 10 percent of the time (period of low flow) the following shall apply to the following reaches of the Kings River:
	Reach V 400 pmhos/cm
	Reach VI 600 pmhos/cm
h	Maximum 10-year average — 100 pmhos/cm.
i	During the irrigation season releases should meet the levels shown in the preceding reach. At other times the channel will be dry or controlled by storm flows.
j	These numeric thresholds are hardness dependent. As hardness increases, water quality objectives generally increase.
k	The natural receiving water temperature shall not be altered unless it can be demonstrated to the satisfaction of the Water Board that such alteration does not adversely affect beneficial uses. However, at no time shall the temperature of WARM and COLD waters be increased more than 5 degrees F above natural receiving water temperature.
A	Agricultural drainage may be discharged to surface waters provided it does not exceed 1,000 pmhos/cm EC, 175 mg/l chloride, nor 1 mg/l boron
B	A numeric limit is not prescribed in the Basin Plan. For these reaches of the Kings River agricultural drainage should be reduced using, at minimum, the management practices provided on page IV-3 of the Basin Plan.
Abbreviations	
CAS	Chemical Abstracts Service Registry Number
fw	freshwater
MCL	maximum contaminant limit
MUN	municipal and domestic supply
Beneficial Uses	
AGR — Agricultural water uses, including irrigation supply and stock watering	
Aquatic Life & Consump — Aquatic life and consumption of aquatic resources	
MUN-MCL — Municipal or domestic supply with default selection of drinking water MCL when available	
MUN-Toxicity — Municipal or domestic supply with consideration of human toxicity thresholds that are more stringent than drinking water MCLs	
AGR — Agricultural water uses, including irrigation supply and stock watering	

Table 5-2. List of Pesticides from GAMA Data

List of Pesticides from GAMA Data			
Pesticide	**Chemical Name**	**MCL**	**Units**
PCA	1,1,2,2 Tetrachloroethane (PCA)	1	µg/L
TCA112	1,1,2-Trichloroethane	5	µg/L
EDB	1,2 Dibromoethane (EDB)	0.05	µg/L
DCBZ12	1,2 Dichlorobenzene (1,2-DCB)	600	µg/L
DCA12	1,2 Dichloroethane (1,2 DCA)	0.5	µg/L
TCB124	1,2,4- Trichlorobenzene (1,2,4 TCB)	5	µg/L
DBCP	1,2-Dibromo-3-chloropropane (DBCP)	0.2	µg/L
DCP13	1,3 Dichloropropene	0.5	µg/L
DCBZ14	1,4-Dichlorobenzene (p-DCB)	5	µg/L
TCDD2378	2,3,7,8-Tetrachlorodibenzodioxin (Dioxin)	0.00003	µg/L
SILVEX	2,4,5-TP (Silvex)	50	µg/L
24D	2,4-Dichlorophenoxyacetic acid (2,4 D)	70	µg/L
ALACL	Alachlor	2	µg/L
ATRAZINE	Atrazine	1	µg/L
BTZ	Bentazon	18	µg/L
CRBFN	Carbofuran	18	µg/L
CHLORDANE	Chlordane	0.1	µg/L
DALAPON	Dalapon	200	µg/L
DINOSEB	Dinoseb	7	µg/L
ENDOTHAL	Endothall	100	µg/L
ENDRIN	Endrin	2	µg/L
GLYP	Glyphosate (Round-up)	700	µg/L
HEPTACHLOR	Heptachlor	0.01	µg/L
HEPT-EPOX	Heptachlor Epoxide	0.01	µg/L
HCLBZ	Hexachlorobenzene (HCB)	1	µg/L
BHCGAMMA	Lindane (Gamma-BHC)	0.2	µg/L
MTXYCL	Methoxychlor	30	µg/L
MOLINATE	Molinate	20	µg/L
OXAMYL	Oxamyl	50	µg/L
PICLORAM	Picloram	0.5	mg/L
SIMAZINE	Simazine	4	µg/L
TOXAP	Toxaphene	3	µg/L
XYLENES	Xylenes (total)	1750	µg/L

Table 5-3. List of Pesticides from DPR Data

List of Pesticides from DPR Data		
Pesticide	**Chemical Name**	**CA MCL**
TCB124	1,2,4-Trichlorobenzene	5
DCPA12	1,2-Dichloropropane (Propylene Dichloride)	5
ALACHLOR	Alachlor	2
ATRAZINE	Atrazine	1
BENTAZON	Bentazon, Sodium Salt	18
DBCP	Dbcp	0.2
EDIBROMIDE	Ethylene Dibromide	0.05
METHYLENEC	Methylene Chloride	5
PICLORAM	Picloram	500
SIMAZINE	Simazine	4
XYLENE	Xylene	1750

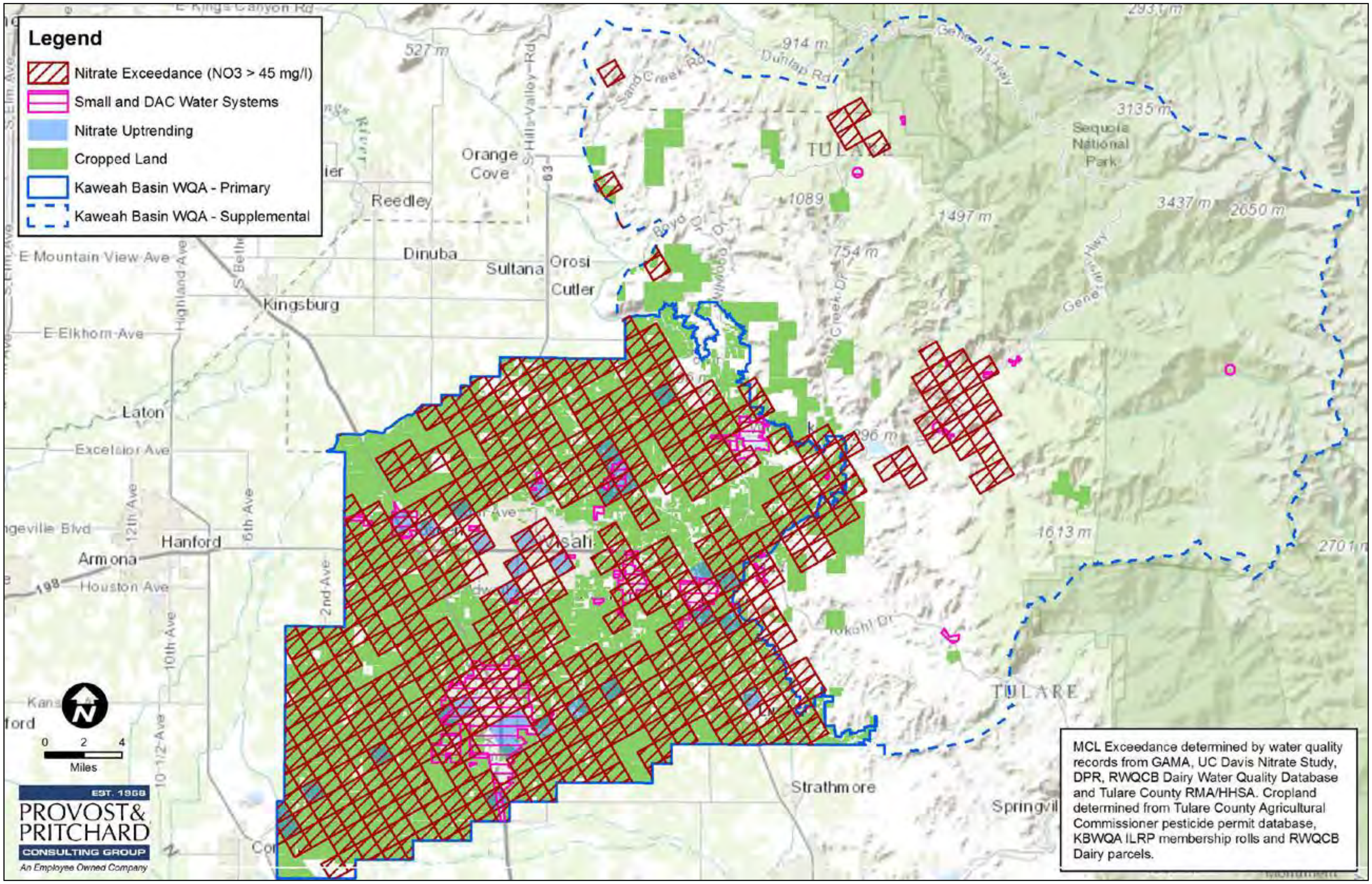

Figure 5-1. Nitrate Exceedance and Uptrending

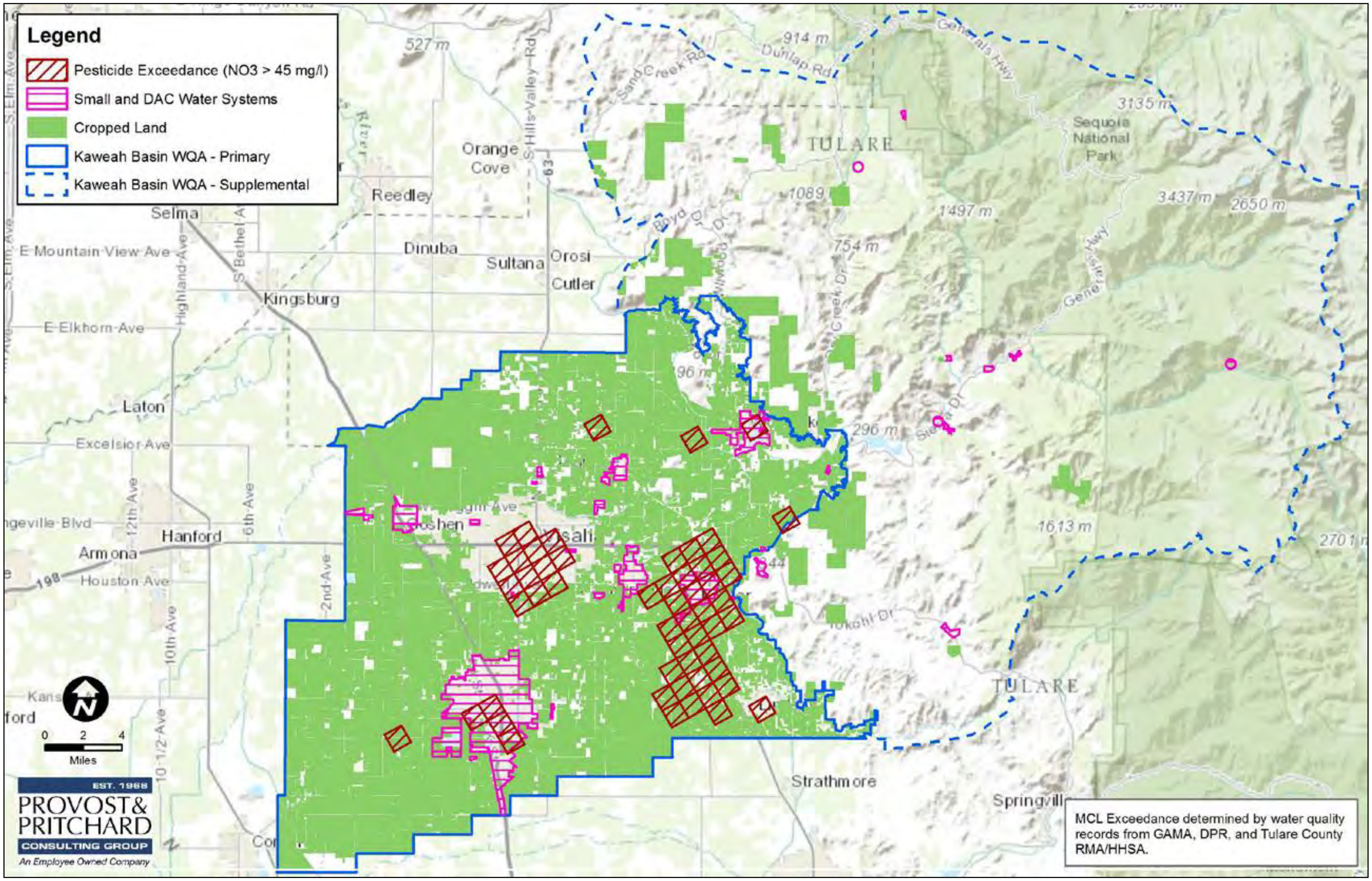

Figure 5-2. Pesticide Exceedance

6 Existing Groundwater Monitoring Programs

6.1 Potential Sources of Information

There are many entities that historically and currently conduct groundwater monitoring in the KBWQA area. This monitoring includes groundwater quality and groundwater elevation data collection. The wells included in these monitoring programs are spread throughout the entire KBWQA area. However, there is a significantly higher density of wells and data collection focused in the Primary area as compared to the Supplemental area.

The ILRP General Order specifies that within one year after approval of the GAR, the KBWQA shall develop a Management Practices Evaluation Program (**MPEP**) Workplan. If a group effort is undertaken, the workplan is due two years after GAR approval. The workplan must include a scientifically sound approach to evaluate the effect of management practices on groundwater quality. The proposed approach may include groundwater monitoring, modeling, vadose zone sampling, and/or other scientifically sound and technically justifiable methods for meeting the objectives of the MPEP. Any groundwater quality monitoring that is part of the MPEP workplan must be of first encountered groundwater. Thus, the MPEP may be limited with regards to the kinds of existing groundwater monitoring programs that can be incorporated as part of the workplan.

The ILRP General Order further specifies that within one year from the approval of the GAR, KBWQA shall develop a workplan for conducting trend monitoring that meets the objectives and minimum requirements of the MRP. The objectives for the trend monitoring program are to determine current water quality conditions of groundwater relevant to irrigated agriculture and develop long-term water quality information that can be used to evaluate the regional effect of irrigated agriculture and its practices.

The design and implementation of the trend monitoring program will include a groundwater monitoring network workplan that will address:

- Groundwater quality in high and low vulnerability portions of the KBWQA area;
- The potential suitability of existing monitoring programs and networks; and
- The rationale for the distribution of the trend monitoring wells.

There is very little available information relating to well construction associated with the existing monitoring programs described in this section. As a result, the workplan for the KBWQA trend monitoring program and MPEP may include further evaluation of these monitoring programs to identify appropriate wells.

6.2 Summary of Existing Groundwater Monitoring Programs

Existing state and local groundwater quality and groundwater elevation monitoring programs are summarized in this section to provide a preliminary assessment as a basis for the future KBWQA trend monitoring program and MPEP.

6.2.1 DWR/CASGEM

DWR manages the water resources of California in cooperation with other agencies. DWR monitors groundwater elevations and quality throughout the state. Water quality samples are collected directly from selected monitoring wells by DWR and combined with data from other State agencies, along with county and local agency data, in a comprehensive database. The DWR monitoring program covers the entire state, including both the Primary and Supplemental areas of the KBWQA. The DWR has monitoring records for approximately 965 wells within the Primary boundary and 24 wells within the Supplemental boundary for groundwater elevation data, all of which are likely to be deeper than the monitoring wells required by the existing RWQCB-supervised programs.

The DWR has, historically, collected groundwater quality data from wells within the KBWQA, but is not doing so currently. Within the CASGEM database, there are approximately 1200 wells within Tulare County, which have historical groundwater quality records dating as far back as 1945. However, there are no records of groundwater quality sampling being completed within the KBWQA since 1991. It is anticipated that many of these historical groundwater quality records may be useful for the assessment of long-term trends. The wells utilized within the DWR monitoring program will likely have limited construction information available and are likely to be deeper than the monitoring wells required by the existing RWQCB-supervised programs.

The CASGEM program tracks seasonal and long-term trends in groundwater elevations across all groundwater basins within the State. This program is a collaboration between local monitoring entities and DWR to collect groundwater elevation data. The CASGEM program was initiated by State legislation in 2009 that amended the California Water Code to include a mandate for monitoring groundwater elevations in designated groundwater basins.

The CASGEM program relies on established local long-term groundwater monitoring and management programs, with DWR acting in a coordination and database maintenance role. This program functions independently from the DWR monitoring program described above. Monitoring and reporting for CASGEM began in 2011. Currently there are 117 wells with active monitoring associated with the CASGEM that lie within the KBWQA Primary boundaries which are likely to be somewhat deeper than the monitoring wells required by the existing RWQCB-supervised programs. There are no active CASGEM wells located in the Supplemental area.

DWR well locations are illustrated in **Figure 6-1**. The CASGEM wells are dedicated to an ongoing monitoring program, while monitoring of the voluntary wells is at the discretion of other entities such as water districts.

6.2.2 DPR

The DPR Environmental Monitoring Program evaluates and samples wells for pesticides to determine if they may contaminate groundwater, identifies areas sensitive to pesticide contamination, and develops mitigation measures to prevent impacts. The DPR samples and analyzes a limited number of wells for pesticides but also uses groundwater quality data gathered from the DDW. There are 138 DPR-monitored wells in the KBWQA Primary area with 16 in the Supplemental area. Of the wells which were sampled, 66 wells had detectable levels of pesticides or pesticide degradates. In 2012, there were analyses for a total of 16 pesticide chemicals. Construction information for the wells sampled by the DPR may be extremely limited due to the present privacy policies the DPR holds with regard to the location and ownership of each well that is used for monitoring. DPR associated wells are likely to be somewhat deeper than the monitoring wells required by the existing RWQCB-supervised programs. DPR well locations are illustrated in **Figure 6-1**.

6.2.3 DDW

Public community water systems are required to report water quality parameters to the DDW on a triennial or more frequent schedule, pending location of the system and specific circumstances that may require more frequent testing and reporting. An exceedance in an MCL generally increases the frequency in monitoring for that analyte for that water source. All laboratory analytical data is electronically submitted (**EDT**) to the DDW. This data collection responsibility of the DDW extends to all public community water systems in the state. The monitoring frequency varies by water system and well as a function of past detections and nearby sources of potential contamination. The water quality constituents that are monitored in these wells also vary as a function of potential sources of contamination and past detections. TDS, nitrate, and other nitrogen species are generally required for all public community water supply wells. Some of these wells are also monitored for pesticides, but these monitoring requirements are less frequent. Construction information associated with these wells is not generally available but these wells are likely to be deeper than the monitoring wells required by the existing RWQCB-supervised programs. There are 67 DDW monitored wells in the KBWQA Primary area with 25 in the Supplemental area. DDW well locations are illustrated in **Figure 6-1**.

DDW has stated that water quality analysis results would be available when requested from the DDW district office. Although the amount of water quality analysis data will be significant, generally, depth-to-water is not included in the required data reporting.

6.2.4 Local Groundwater Management Plans

KDWCD has a groundwater management plan that covers a large percentage of the KBWQA area. Both KDWCD and Tulare ID are CASGEM members and upload data to the database. As previously noted, 90 percent of the CASGEM database and all of the KDWCD data does not indicate well type but these wells are likely to be deeper than the monitoring wells required by the existing RWQCB-supervised programs. It is presumed that most of the data is from production wells of some type. Well locations are already illustrated as part of the CASGEM well set in **Figure 6-1**.

6.2.5 RWQCB-Supervised Programs

Monitoring systems installed under a variety of RWQCB-supervised programs are likely more suitable for a shallow groundwater monitoring system. These programs include leaking underground storage tank (**LUST**) and other cleanup sites, solid waste and wastewater treatment plant facilities, and food processor and dairy sites. The RWQCB-supervised sites are illustrated in **Figure 6-2** and listed in **Table 6-1**.

6.2.5.1 Clean-up Sites

There are 38 LUST and other cleanup sites with existing monitoring well systems identified in the GAMA database as being located within the KBWQA Primary area. Three sites reside within the Supplemental area. Of these sites, 12 are listed as open cases. These sites may have an increased likelihood of having more current data available. All but one of the sites are cleanup investigations related to hydrocarbon releases; the remaining one was due to 'other solvent or non-petroleum hydrocarbon'. Although the monitoring systems are listed as active, it is likely that some of the monitoring wells will have water depths exceeding their screen intervals due to falling groundwater levels over the years. Additionally, general mineral analysis is not common.

6.2.5.2 Solid Waste and Wastewater Treatment Facilities

Four county landfill sites and two municipal wastewater treatment facilities (**WWTF**) which have existing groundwater monitoring networks were identified on Geotracker as located within the KBWQA Primary boundary, or just outside. Annual and semi-annual reports of water quality analysis and depths to water for the landfill sites are available through direct request from the RWQCB Fresno office or through Geotracker. The monitoring systems for the WWTF are measured quarterly for depth-to-water and sampled for specific conductance, TDS, general minerals, and nitrogen compounds with reports also available through the RWQCB Fresno office.

6.2.5.3 Food Processors

A list of food processing facilities was supplied by Mr. Warren Gross of the RWQCB Fresno office. Three of these facilities have existing groundwater monitoring systems, each with independent requirements for monitoring and for reporting.

6.2.5.4 Dairy

As part of the overall RWQCB dairy monitoring program, existing wells located on dairy properties regulated under the Dairy General Order are required to be monitored. Within the KBWQA, there are 18 dairies which the RWQCB reports as having existing groundwater monitoring systems. Dairies possessing monitoring well systems are required to measure depth-to-water quarterly and to sample for nitrate, ammonia and EC biannually with annual reporting. Construction information for each monitoring well and the annual reports are likely available through file reviews at the RWQCB Fresno office.

The dairy monitoring program also requires water supply well sampling for nitrate, ammonia and EC on an annual basis. This data is also included in the annual reports.

Although a great amount of water quality data may be made available through the existing dairy monitoring well systems, data trends from the surrounding dairy farming practices may be indiscernible from data attributable to the general farming practices within the KBWQA.

6.3 Identify Key Data Gaps for Wells in Existing Monitoring Programs

Wells identified as part of the DWR, CASGEM, DPR, or DDW systems are generally presumed to be supply wells of unspecified well type. These wells were likely installed over decades with well construction data difficult to obtain on many. Access to well completion reports in general for individual wells is restricted to the property owner or to the property owner authorized designee under Section 13752 of the California Water Code. Incomplete information regarding a well's construction may limit the meaningfulness of any data gathered from these wells. Therefore, while these well networks appear to be well suited to provide generalized regional groundwater level, flow direction, and gradient maps, the lack of well construction data makes them not suitable for closer inspection of these criteria.

Well location is also an issue for many of the wells. For instance, the DPR maintains a policy of anonymity and privacy towards the well ownership and well location data within its studies, and the DDW maintains a policy of generalizing the locations of wells operated by public water systems for security reasons. The lack of true well coordinates will impact the accuracy of data gathered and therefore any conclusions made from that data.

Finally, water quality data from these wells currently indicates broad nitrate impacts across the KBWQA area, hindering the ability of these wells to serve as release detection wells. However, water quality trend analysis may still be possible.

The shallow RWQCB-supervised monitoring well networks are better suited to the required monitoring program based on well depth alone. Unfortunately, these networks are not oriented in a spatial pattern (either too clustered or too dispersed) that would provide sufficient data for a regional scale, shallow groundwater assessment of either groundwater levels or quality. The existing RWQCB-supervised networks could be utilized locally for these types of monitoring however differentiating the provenance of select constituents in groundwater samples collected from these wells may prove difficult.

6.4 Preliminary Feasibility Assessment of Existing Monitoring Well Use for Future Trend Monitoring

Both the deeper and RWQCB-supervised well networks are potentially suitable for future trend monitoring pending available well construction data, accurate well location, and the ability to differentiate constituent provenance. The shallow well network will not be sufficient to monitor the entire area, but with the impacts to the deeper groundwater, a deeper well network may be more appropriate. Complete feasibility will be assessed within the Trend Monitoring Workplan.

6.5 Preliminary Information Needs Recommendations for Trend Monitoring Workplan

Accurate well locations and well log availability will be critical to the success of an effective monitoring network, as well as determining a constituent differentiation method for those wells located near known points of impact. A complete list of needs will become apparent when preparing the Trend Monitoring Workplan.

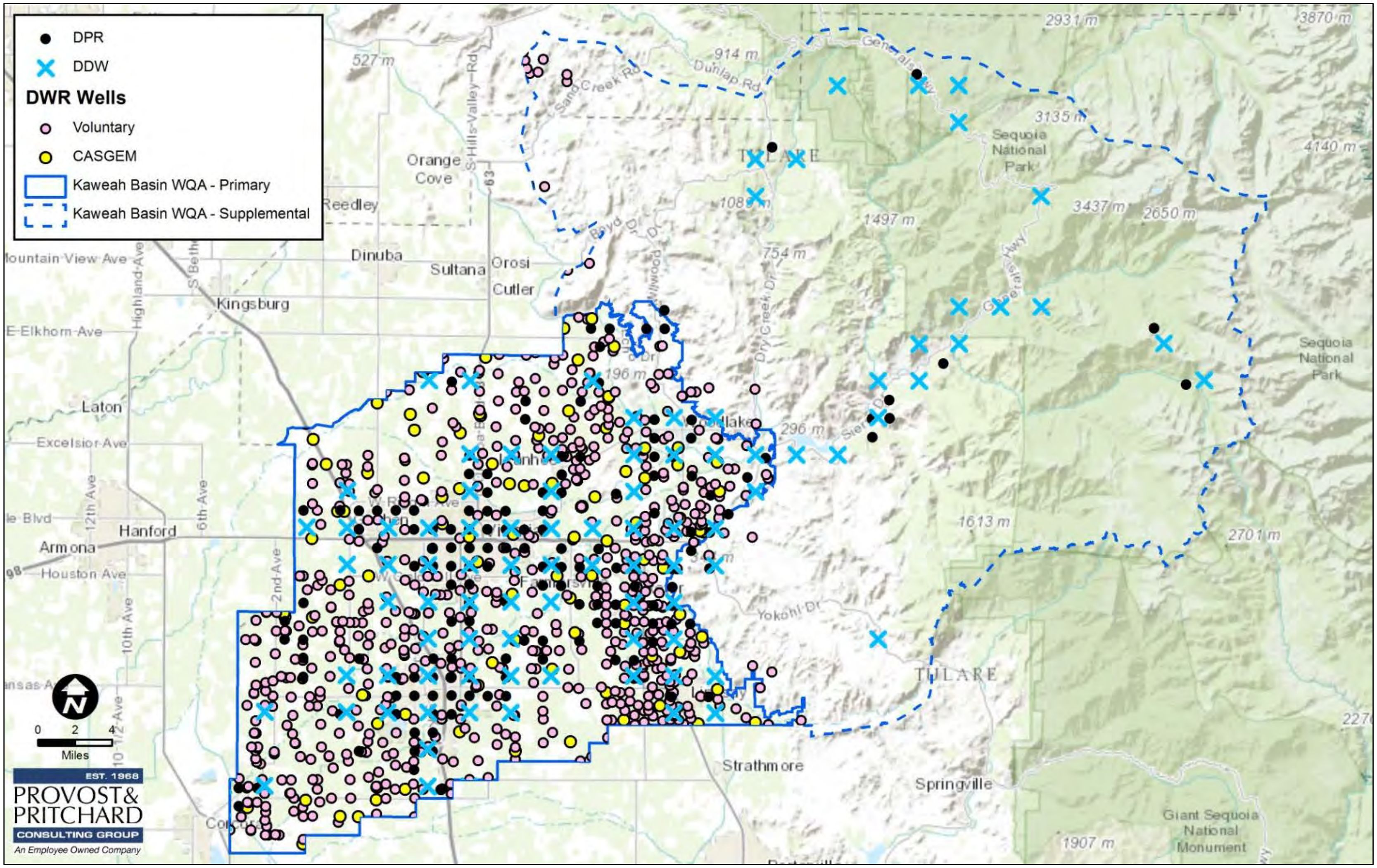

Figure 6-1. Supply Well Location Map

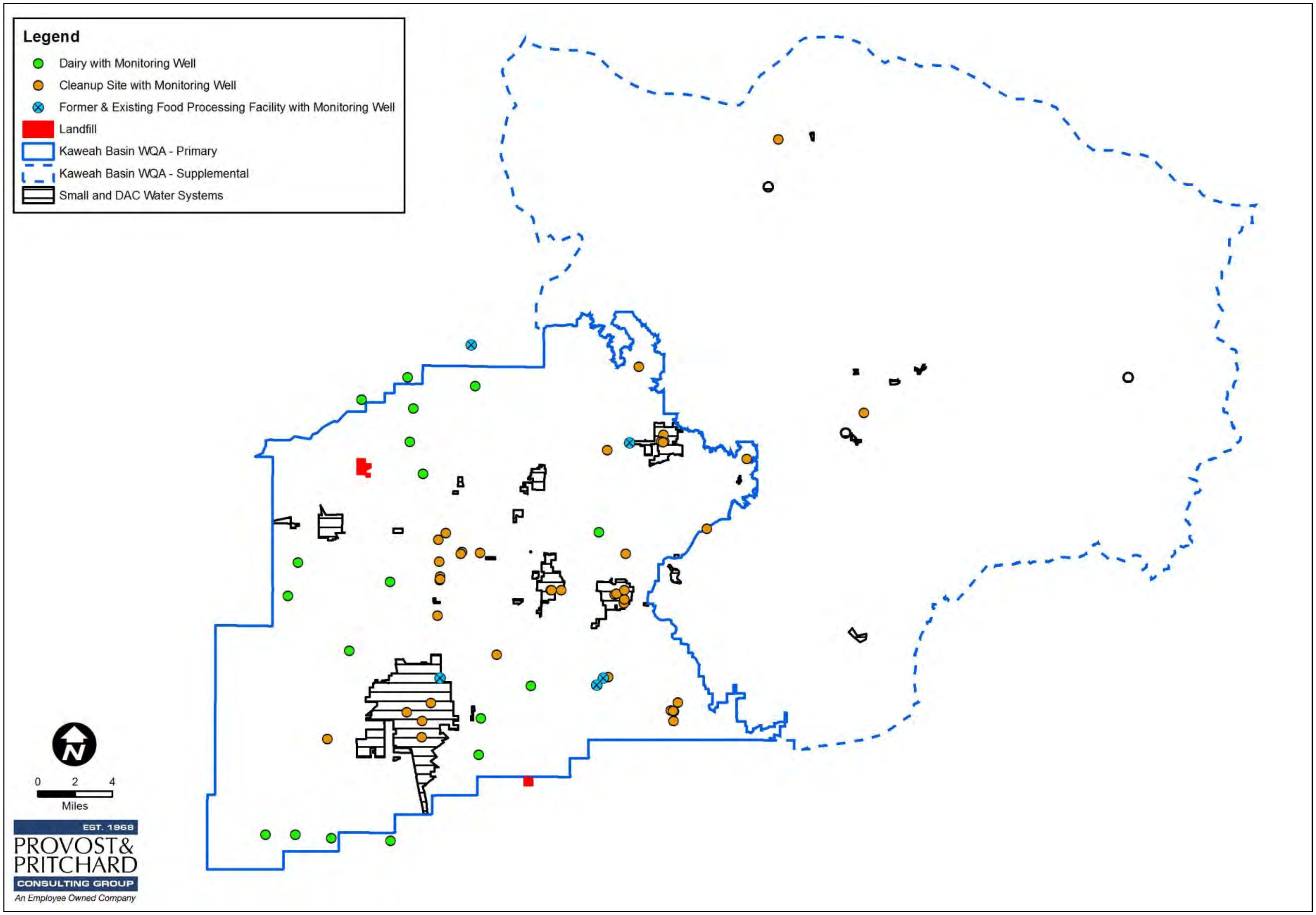

Figure 6-2. RWQCB-Supervised Well Network Location Map

Table 6-1. RWQCB-Supervised Sites with Monitoring Well Networks

RWQCB-Supervised Sites with Monitoring Well Networks				
ID #	**# of MWs**	**Business Name**	**City**	**Case Type**
Open Sites – Primary				
SL205194270	15	Sprague Electric Co. (Former)	Visalia	Cleanup Program Site
T0610700157	12	Elderwood Market	Woodlake	LUST Cleanup Site
T0610700193	12	El Rancho Market	Woodlake	LUST Cleanup Site
T0610700279	28	Jack Griggs Inc.-Bulk Plant	Exeter	LUST Cleanup Site
T0610700290	34	Sub Station	Woodlake	LUST Cleanup Site
T0610700327	20	Valley Convenience Store #9	Exeter	LUST Cleanup Site
T0610700407	12	Villicana's Gasoline Alley	Woodlake	LUST Cleanup Site
T0610700464	6	Banti Market	Tulare	LUST Cleanup Site
T0610779138	3	Caltrans Right-of-Way	Exeter	LUST Cleanup Site
T0610793750	13	Chief Enterprises	Lindsay	LUST Cleanup Site
T10000001159	10	Union Pacific Railroad	Tulare	Cleanup Program Site
L10008919544	52	Visalia Landfill	Visalia	Solid Waste Facility
L10001207790	11	Woodlake Landfill - Closed	Woodlake	Solid Waste Facility
L10001505773	21	Exeter Landfill - Closed	Exeter	Solid Waste Facility
L10001873737	37	Woodville Landfill - just south of boundary	Woodville	Solid Waste Facility
	14	Visalia WWTP	Visalia	Wastewater Treatment Plant
	29	Tulare WWTP	Tulare	Wastewater Treatment Plant
	19	City of Lindsay (Lindsay Brine Ponds East)	Lindsay	Food Processors
	25	Sierra Cattle (Lindsay Brine Ponds West)	Lindsay	Food Processors
	6	The Wine Group	Tulare	Food Processors
	3	Aukeman Dairy	Tulare	Dairy Facility
	3 - 6	De Jong Heifer Feed Lot	Visalia	Dairy Facility
	3 - 6	Dykstra Dairy	Tulare	Dairy Facility
	3 - 6	Edwin Brasil Dairy	Visalia	Dairy Facility
	3 - 6	Elkhorn Dairy	Visalia	Dairy Facility
	3	FM Ranch #4 Dairy	Visalia	Dairy Facility
	3	Friesian Farms	Tulare	Dairy Facility
	3 - 6	Highstreet Dairy	Tulare	Dairy Facility
	3	Holstein Farms	Tulare	Dairy Facility
	3 - 6	Homestead Dairy	Visalia	Dairy Facility
	3 - 6	Hynes Dairy	Tulare	Dairy Facility
	3 - 6	Rancho Sierra Vista	Visalia	Dairy Facility

RWQCB-Supervised Sites with Monitoring Well Networks				
ID #	# of MWs	Business Name	City	Case Type
	3	Mineral King Dairy	Vislia	Dairy Facility
	3 - 6	Moonlight Dairy	Visalia	Dairy Facility
	3 - 6	Shirk Dairy	Visalia	Dairy Facility
	3 - 6	Sierra View Dairy	Tulare	Dairy Facility
	3	Triple H Dairy	Tulare	Dairy Facility
	3 - 6	Vanderham Dairy	Visalia	Dairy Facility
Open Sites – Supplemental				
T0610700237	35	Sequoia Grocery	Exeter	LUST Cleanup Site
Closed Sites – Primary				
T0610700014	15	Time Oil Co./Mooney Mart	Visalia	LUST Cleanup Site
T0610700028	17	Caltrans Lemon Cove	Lemon Cove	LUST Cleanup Site
T0610700035	21	R. E. Havens Lease Property	Lindsay	LUST Cleanup Site
T0610700038	18	Value & Convenience (Exeter Mini Mart)	Exeter	LUST Cleanup Site
T0610700043	12	Sierra Citrus Packing	Lindsay	LUST Cleanup Site
T0610700108	7	City of Lindsay	Lindsay	LUST Cleanup Site
T0610700170	7	Private Residence	Tulare	LUST Cleanup Site
T0610700175	5	Gong's Market	Farmersville	LUST Cleanup Site
T0610700244	4	Souza Property	Tulare	LUST Cleanup Site
T0610700245	6	J. A. Fischer Inc.	Visalia	LUST Cleanup Site
T0610700248	11	Tosco - Facility #4318	Visalia	LUST Cleanup Site
T0610700288	7	Lonestar Canteen	Exeter	LUST Cleanup Site
T0610700331	15	Roche Oil	Tulare	LUST Cleanup Site
T0610700332	8	Felix's Chevron	Woodlake	LUST Cleanup Site
T0610700363	35	Gas Ranch	Woodlake	LUST Cleanup Site
T0610700381	6	Visalia Unified School District	Visalia	LUST Cleanup Site
T0610700399	4	Tosco - Facility #5389	Visalia	LUST Cleanup Site
T0610700402	11	Quality Mart	Lindsay	LUST Cleanup Site
T0610700426	4	Shell Service Station	Visalia	LUST Cleanup Site
T0610700433	13	Tosco - Facility #2177	Visalia	LUST Cleanup Site
T0610700435	8	Double D Mini Mart	Visalia	LUST Cleanup Site
T0610700436	24	Quick Stop Food Market	Woodlake	LUST Cleanup Site
T0610700453	6	C. P. Phelps	Tulare	LUST Cleanup Site
T0610709906	3	Tri Mart Chevron	Exeter	LUST Cleanup Site
T0610741247	3	AA Gas-N-Grub #2	Farmersville	LUST Cleanup Site
T0610752851	12	Shell Service Station	Visalia	LUST Cleanup Site

RWQCB-Supervised Sites with Monitoring Well Networks				
ID #	# of MWs	Business Name	City	Case Type
T0610799010	11	Farmersville Chevron	Farmersville	LUST Cleanup Site
Closed Sites – Supplemental				
T0610700234	3	Private Residence	Three Rivers	LUST Cleanup Site
T0610793753	3	Badger Forest Fire Station	Badger	LUST Cleanup Site

7 Vulnerability Assessment

This section discusses the methods and findings for vulnerability area designations and prioritization within those areas.

7.1 Vulnerability Designation

As defined in the WDRs, a groundwater high vulnerability area is:

1. Where known groundwater quality impacts exist for which irrigated agricultural operations are a potential contributor or where conditions make groundwater more vulnerable to impacts from irrigated agricultural activities; or
2. Areas that meet any of the following requirements for the preparation of a Groundwater Quality Management Plan:
    a. There is a confirmed exceedance (considering applicable averaging periods) of a water quality objective or applicable water quality trigger limit in a groundwater well and irrigated agriculture may cause or contribute to the exceedance;
    b. The Basin Plan requires development of a groundwater quality management plan for a constituent or constituents discharged by irrigated agriculture; or
    c. The Executive Officer determines that irrigated agriculture may be causing or contributing to a trend of degradation of groundwater that may threaten applicable Basin Plan beneficial uses.

7.1.1 High Vulnerability Designation

High vulnerability areas (**HVAs**) are identified and prioritized by inputting a combination of parameters that are in agreement with Item 2)a. as defined in the WDRs and listed above (**Section 7.1**) into an additive and overlay system constructed using geographic information systems (**GIS**) that assigned point values based on parameter sub-categories. These factors are defined as:

- Recent detections within the last 10 years of groundwater quality indicating a condition of pollution defined as MCL exceedances in nitrates or pesticides;
- Longer-term detections of groundwater quality indicating a condition of active degradation defined as statistically significant up-trending nitrate detections; and
- Groundwater impacted areas upgradient of a DAC or small water system that is reliant on groundwater.

Cropped or potentially cropped areas are classified as located within an HVA if at least 50 percent of a parcel is within a designated CVHM grid cell identified as containing adverse water quality conditions. Specifics on the designated buffer zones are detailed in **Section 5.4**. Groundwater quality attributes of each well are assigned to the entire individual 1-mile CVHM grid cell. Additionally, areas within identified groundwater impact cells that are located directly upgradient of a DAC or small water system that is reliant on groundwater are specifically included in the HVA designation.

Spatial gaps are then assessed for exclusion from the HVAs based on the following criteria:

- Groundwater quality testing over the most recent 10 year time frame indicating a lack of groundwater impacts from nitrate or pesticides;
- Endangered species critical habitat;
- Residential or industrial; and
- Other incompatible land use areas such as gravel mining, landfills, wetlands, and water storage or waterways.

If not excluded from the HVA due to the above criteria, the remaining cropped or potentially cropped areas in both the Primary and Supplemental areas are assessed for inclusion in or exclusion from the HVAs using factors in agreement with Item 1. as defined in the WDRs and listed on the previous page (**Section 7.1**). Ground-truthing was performed in the Primary area by a professional geologist and an agricultural specialist in instances where data was insufficient to make a determination.

The assessment criteria results, after resolving the data gaps, are illustrated in **Figure 7-1**. DACs and small water systems that are reliant on groundwater, as listed and discussed in **Section 1.3.3**, are illustrated as black-hashed polygons with cropped or potentially cropped areas underlain as dark gray. Identified CVHM grids cells having nitrate or pesticide water quality exceedances are illustrated as pink areas, uptrending nitrate cells are identified as yellow-hashed, and non-impacted areas identified as green. These are overlain by the groundwater elevation contour lines from spring 2014 (which are reasonably consistent with historical groundwater contour maps). Cropped or potentially cropped areas with nitrate or pesticide groundwater quality impacts (both exceedances and uptrending), that are located within 0.75 miles upgradient of a DAC or small water system that is reliant on groundwater, are included as HVA properties. To augment this designation, these particular HVA properties will additionally be designated as the highest priority. The final Designated High Vulnerability Areas encompassing all the cropped or potentially cropped Primary and Supplemental areas are illustrated in **Figure 7-2**. A map showing the locations of current grower members, as of October 2014, with applied HVA designation is included as **Figure 7-3**.

7.1.2 Comparison of Results with Other Groundwater Vulnerability Assessments for the Area

Both the DPR and the SWRCB previously prepared vulnerability assessments for what is now the KBWQA Primary area with small portions along the western border of the Supplemental area as illustrated in **Figure 7-4**. The DPR Groundwater Protection Area covers areas in the north, east, and south of the KBWQA Primary area; the SWRCB Hydrologic Vulnerable Area covers almost the entire eastern portion of the KBWQA Primary area. The two previous assessments are in general agreement with each other except for the eastern half of the City of Visalia and the surrounding areas. For the most part, the eastside designated HVAs as defined in this GAR are in general agreement with the DPR assessment. The eastside designated HVAs are also in general agreement with the SWRCB assessment with the exception of the low vulnerability areas along the Kaweah River footprint and southeast of the City of Visalia. Neither the DPR nor the SWRCB assessments agree with the extensive HVAs to the west of the City of Visalia and the southwestern portion of the KBWQA area.

7.2 Priority Designation

Within the WDRs, some guidance is provided for prioritizing areas within the HVAs. These guidelines are listed in **Section 1.2.5**.

Prioritization of the land within the high vulnerability zones for this GAR was accomplished for the current grower members located within Primary and Supplemental HVA designated areas as of October 2014 by using a combination of critical, secondary, and contributing parameters. Critical parameters include properties with groundwater quality issues and properties with groundwater quality issues that are upgradient of a DAC or small water system that is reliant on groundwater. Secondary parameters include physical properties of the soil and hydrogeology that are not expected to change significantly in the foreseeable future. Contributing parameters include factors that are generally expected to experience temporal variations. These factors include crop type, irrigation type, and other management decisions. **Table 7-1** provides a summary of the factors used for prioritization.

Although all of the critical, secondary, and contributing parameters add to the priority designations for the area, their relative importance varies. Therefore, the point values assigned to the parameters and associated sub-categories varies. For instance, land located adjacent to a DAC that is reliant on groundwater with nitrate exceedances is more likely to be a higher priority than an area with shallow groundwater and nitrate exceedances that is not located near a DAC. Rationale for the point assignments are discussed below.

7.2.1 Critical Parameters

Critical parameters were the highest weighted category. The categories included with these criteria include groundwater exceedances and uptrends (where available) and if the area is upgradient of a DAC or small water system that is reliant on groundwater. These categories were assigned the highest point value ranging up to a high of 75.

As described in **Section 5**, groundwater quality has been impacted in many areas within the KBWQA. These areas are, by definition, the most vulnerable. Nitrates and pesticides have been identified as the primary constituents of concern. Areas were assessed based on MCL exceedances and data trends where sufficient data was available.

The most vulnerable groundwater is groundwater intended for human consumption, so impacted groundwater in proximity to a DAC or small water system that is reliant on groundwater is also considered a critical component. Areas with groundwater exceedances that are immediately upgradient of a DAC or small water system that is reliant on groundwater received 75 points for the exceedance and an additional 75 points for their proximity to the DAC, resulting in a higher priority value.

7.2.2 Secondary Parameters

Secondary parameters include physical conditions that are unlikely to change within a temporally significant framework. These include NRCS and CVHM hydraulic conductivities, groundwater depth and flow direction, and location proximity to a recharge area. These secondary parameters are the conditions that are beyond the control of the grower, but play a significant part in groundwater vulnerability. The categories have assigned point values ranging from 0 to 50 with the exception of groundwater gradient which ranges from 5 to 25. In some areas, groundwater gradient is the one parameter most likely to significantly change, so it was weighted the least within this group.

7.2.3 Contributing Parameters

Contributing parameters include management practices, farm size, and proximity to other permitted dischargers. Management practice points range from 0 to 25 since these are the most controllable of all the assessed parameters. A grower could then change his/her practices but still be in an area of impacted groundwater so the higher priority designation would be unlikely to change. Proximity to a permitted discharger such as a food processor or landfill ranges from 0 to minus 10 so that a grower with impacted groundwater will get a small credit indicating that the groundwater could be impacted by the other permitted discharger. Finally, farm size points range from 0 to 10 with 10 points being assigned to large farms since their management practices have a wider impact than from a small farm.

7.2.4 Priority Assessment and Findings

Figure 7-5 illustrates the prioritization results within the entire KBWQA boundary. A fairly clear picture emerges of the most vulnerable areas near the mouth of the Kaweah River, areas near DACs and other small water systems that are reliant on groundwater, and areas of coarse soil or recharge over coarse soil.

To provide a delineation of the HVA and a framework for where future activities should be focused, the HVA is then divided into priority tiers. The tiers were determined by splitting the area into three acreage-equal tiers of grower members as of October 2014 resulting in **Figure 7-6**. Tier 1 consists of the highest priority areas. These parcels are shown in red with point scores ranging from 175 to 495. Tier 1 parcels will be the first areas required to comply with the WDRs. The orange Tier 2 parcel point scores range from 140 to 174 while the yellow Tier 3 parcel point scores range from 0 to 139.

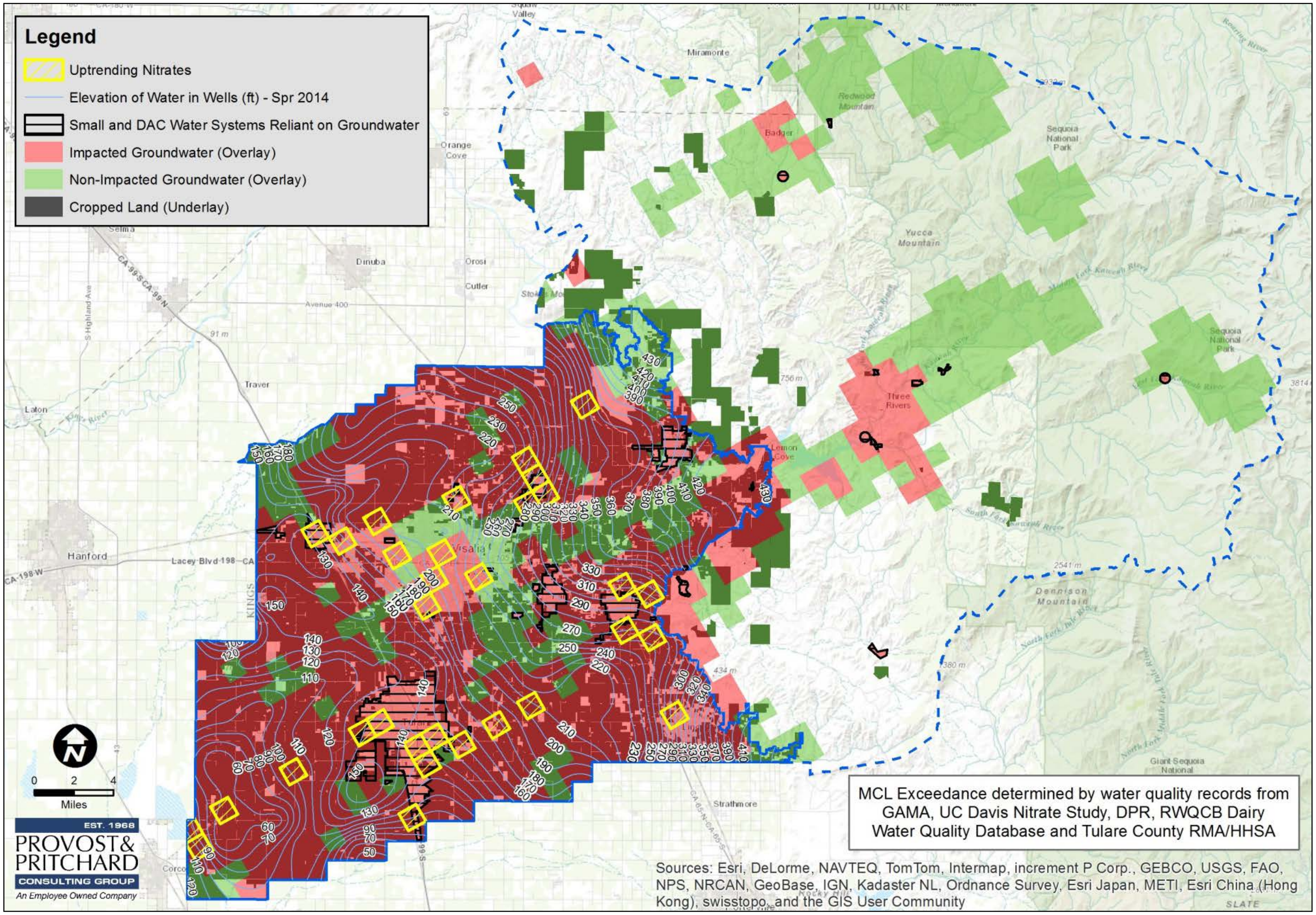

Figure 7-1. High Vulnerability Area Assessment

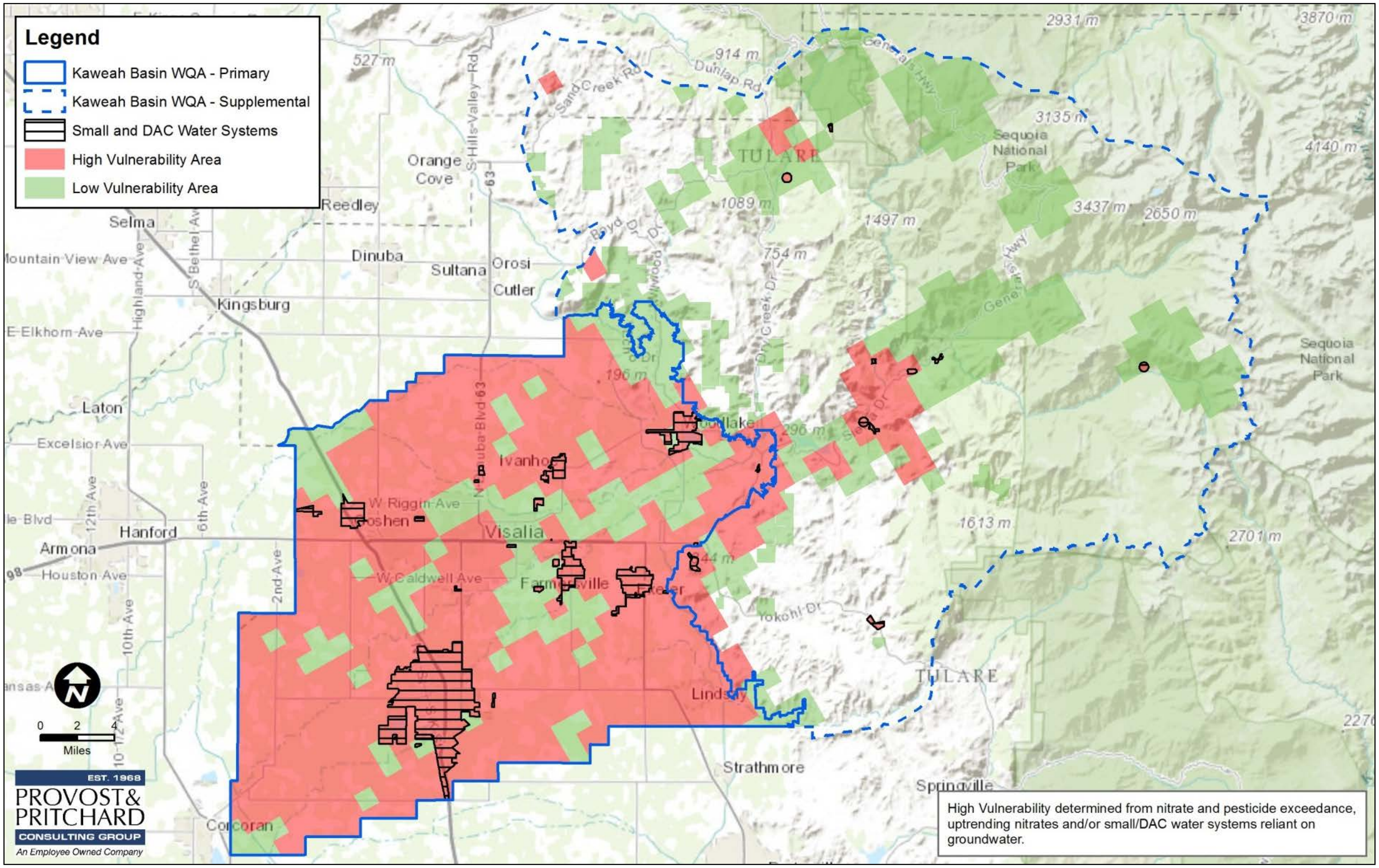

Figure 7-2. Designated High Vulnerability Areas

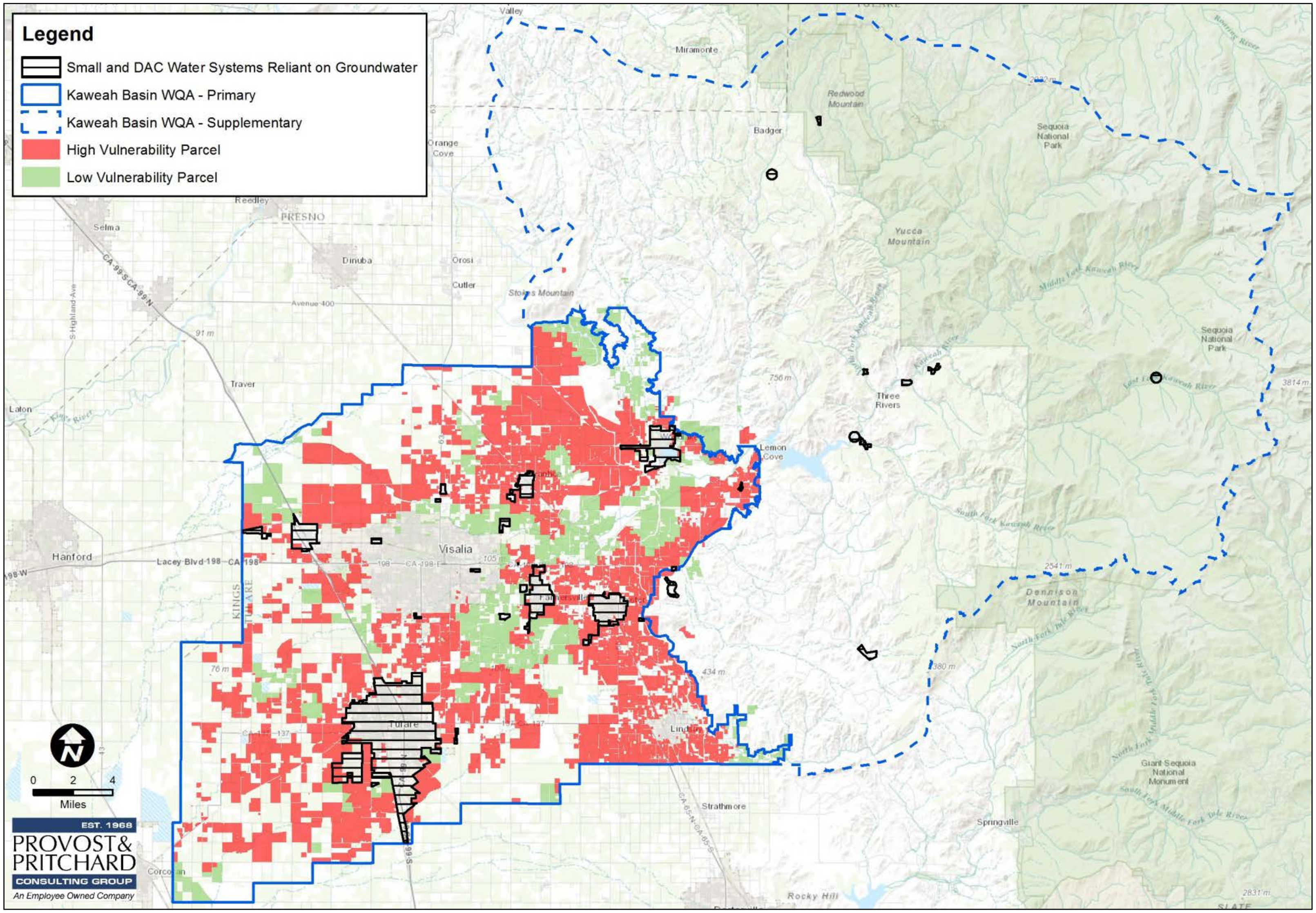

Figure 7-3. High Vulnerability Areas by Grower Membership

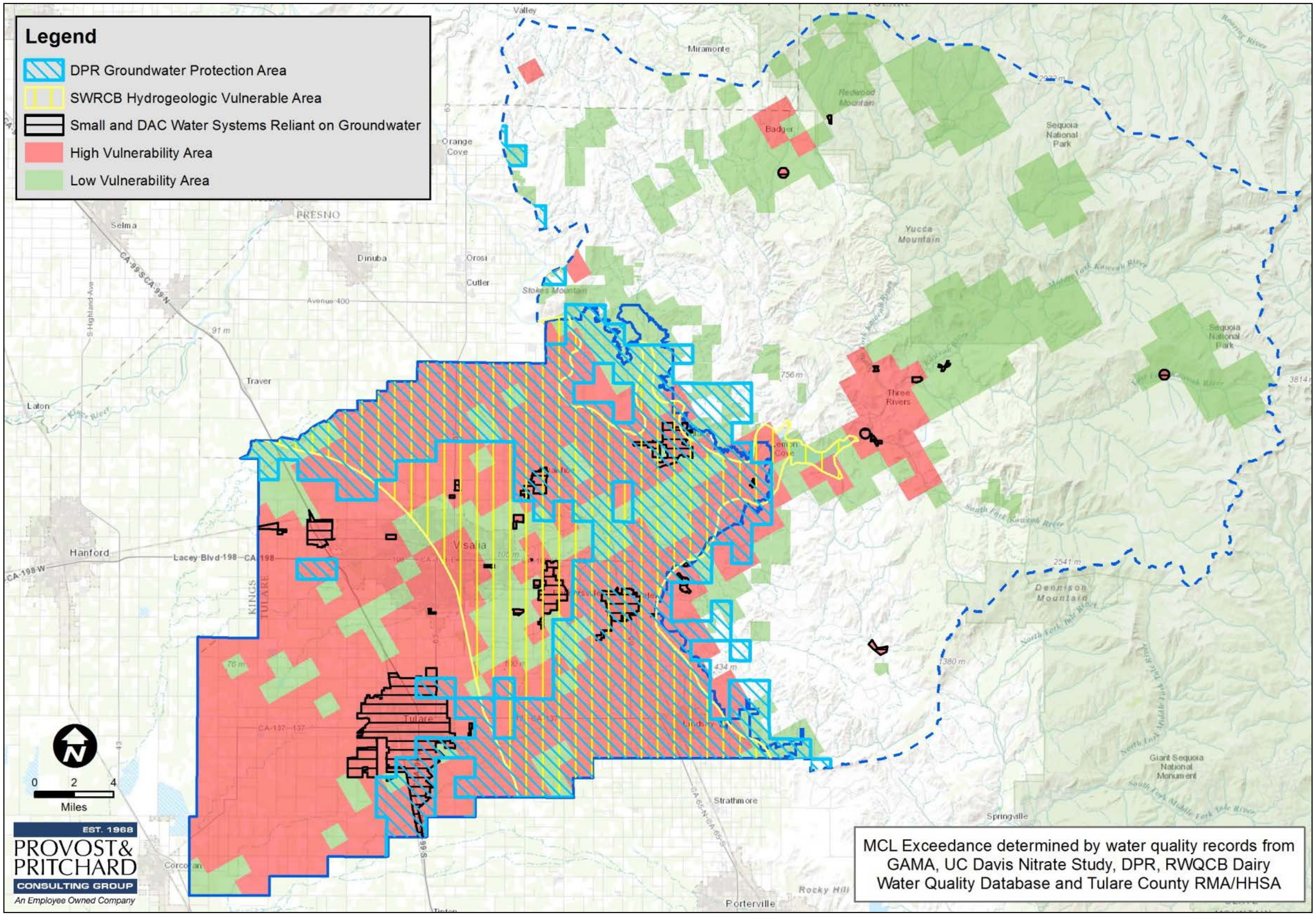

Figure 7-4. Other Groundwater Vulnerability Comparison

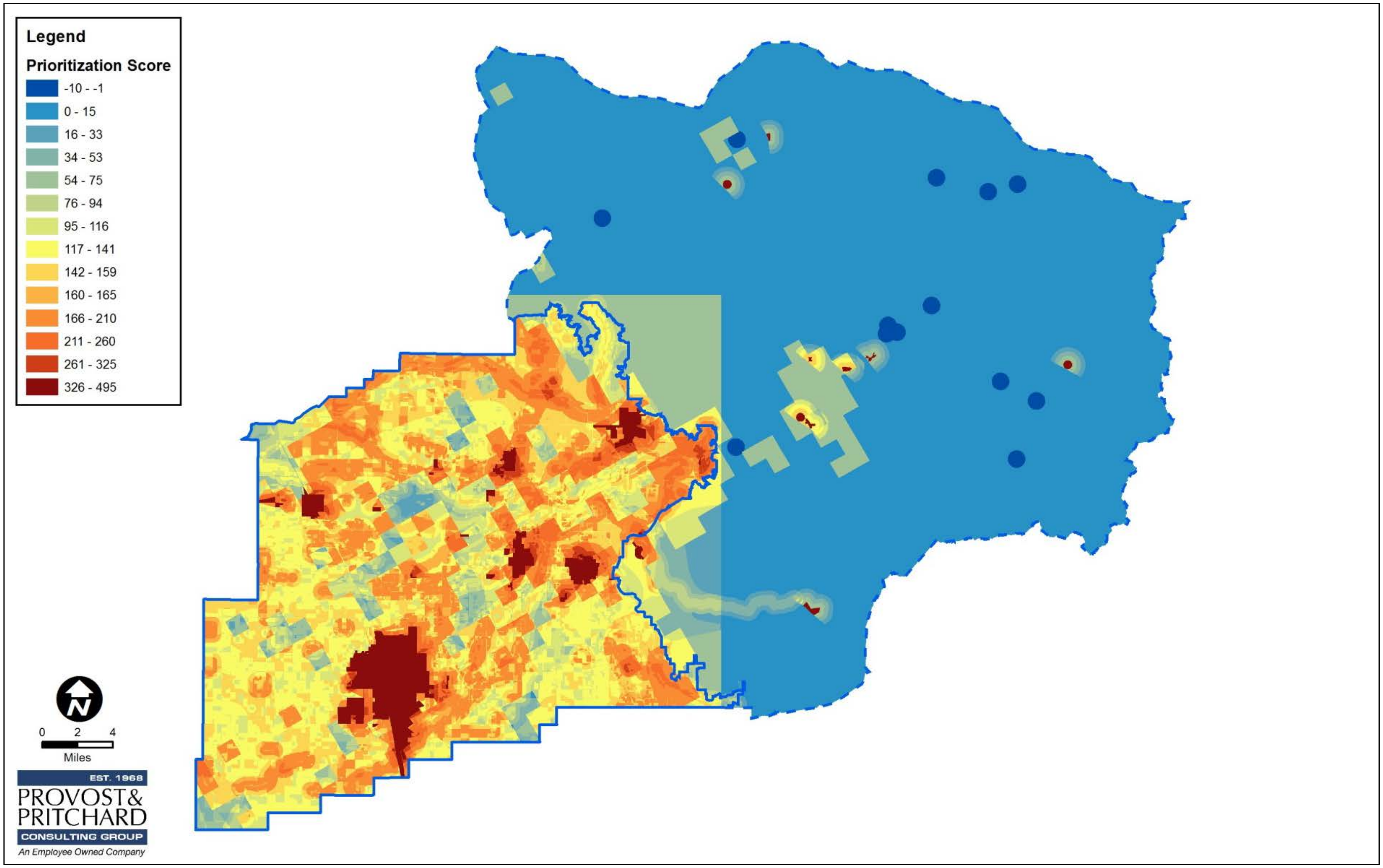

Figure 7-5. Designated Prioritization Areas

Table 7-1. Prioritization Matrix

Prioritization Matrix	
	Score
Critical (Score 0-75)	
Nitrate or Pesticide Water Quality over MCL	75 points
Upgradient of a DAC or Small Water System	0.25 miles away – 75 points 0.5 miles away – 25 points >0.75 miles away – 0 points
Nitrate Water Quality Trends	Upward – 50 points Stable – 0 points Downward – minus 25 points
Secondary (Score 0-50)	
NRCS Hydraulic Conductivity	Sand, Loamy Sand, Riverwash – 50 points Sandy Loam, Gravelly Clay Loam, Fine Sandy Loam, Course Sandy Loam, Loam, Silt Loam – 25 points Clay, Clay Loam, Cobbly Clay, Silty Clay – 10 points
CVHM Vertical Hydraulic Conductivity	75-100% – 50 points 50-75% – 30 points 25-50% – 15 points 0-25% – 0 points
Upgradient of Recharge Area	0.25 miles away – 50 points 0.5 miles away – 25 points >0.75 miles away – 0 points
Depth to Groundwater	<50 feet – 50 points 50-100 feet – 25 points >100 feet – 0 points
Groundwater Gradient	Steep – 25 points Moderate – 15 points Fairly Flat – 5 points
Contributing (Score 0-25)	
Irrigation Method	Flood – 25 points Sprinkler – 15 points Efficient – 0 points
Crop	Onion/Cilantro/Cabbage – 25 points Melons/Tomatoes – 14 points Citrus/Alfalfa/Corn/Stone Fruit/Grain & Hay/Walnuts – 7 points Grapes/Olives/Fallow – 0 points
Proximity to Permitted Discharger	0.25 miles away – minus 10 points 0.5 miles away – minus 5 points >0.75 miles away – 0 points
Farm Size	Large – 10 points Small – 0 points

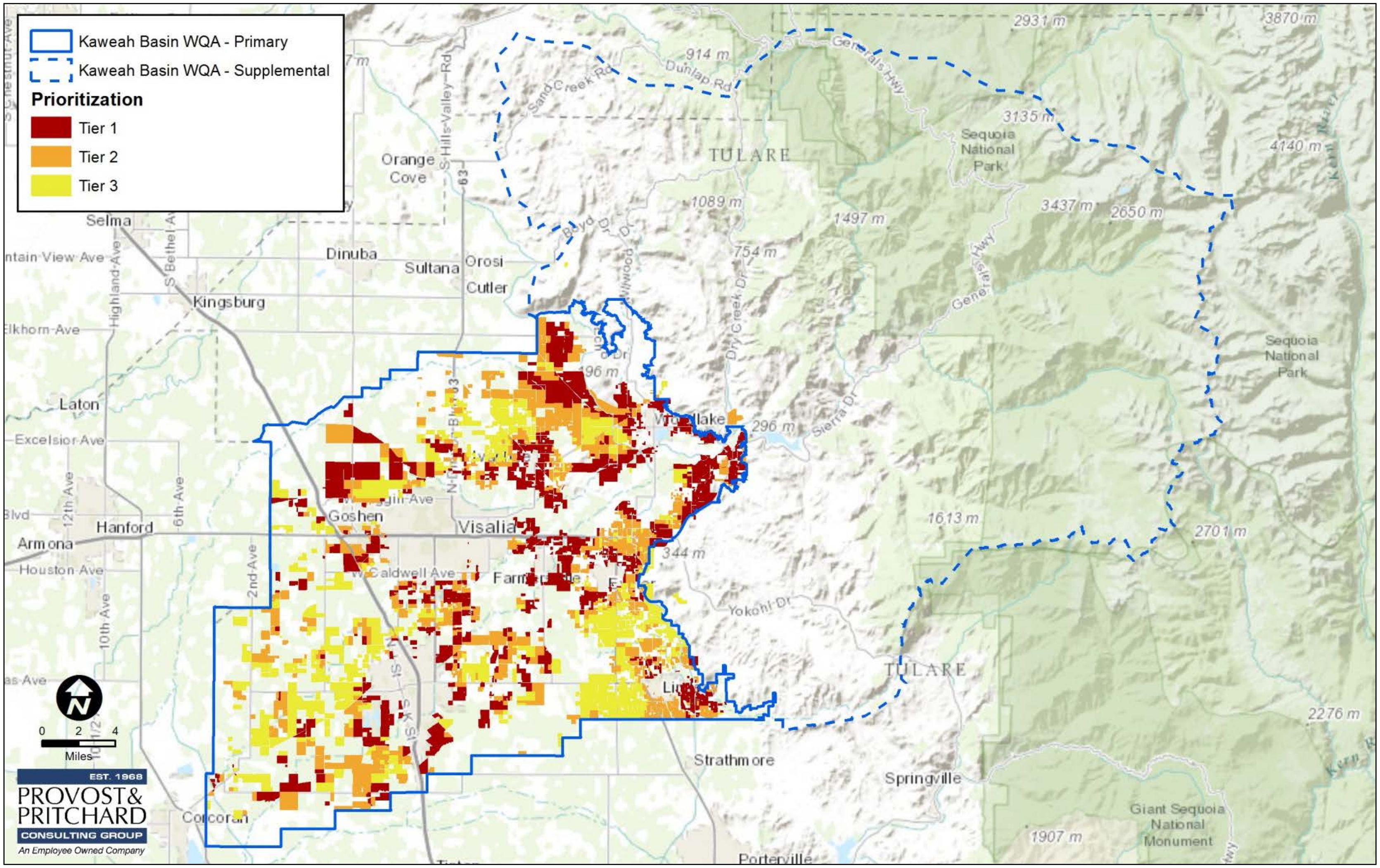

Figure 7-6. Prioritization by Grower Membership

8 Summary and Recommendations

8.1 Summary of GAR Findings

Nitrate emerges as the indicative constituent for the KBWQA area. Based predominately on nitrate exceedances, a majority portion of the Primary KBWQA area is considered to be of high vulnerability, with selected areas in the Supplemental area near Three Rivers and along the border with the Primary area. Selected locations within the Primary area, largely along stream paths, have groundwater quality data indicating that groundwater impacts have not occurred. A limited number of areas did not have available groundwater quality data so are designated as high or low vulnerability based on the geologic and hydrologic conditions, with select ground truthing as needed.

The HVAs are further prioritized using the GIS additive and overlay method and critical, secondary, and contributing parameters as described in Section 7.2. The resultant total acreage of the affected member grower properties are equally divided into three prioritization tiers.

8.2 Recommendations for High Vulnerability Area Designations and Prioritization

The HVA and prioritization of parcels within the HVA provided in this GAR are primarily dependent upon a review of publically available data and will be reanalyzed during future GAR updates. Information obtained from other reports including the Farm Evaluation, Groundwater Quality Trend Monitoring Program, Management Practice Evaluation Program, Farm Evaluations and Nitrogen Management Plans required by the WDRs will aid in providing more accurate, up to date information for the study area. A review of this information will allow the HVA and priorities to be refined and evaluated.

8.3 Recommendations Relating to Data Gaps and Future Development of the Trend Monitoring Program

Data gaps within the Primary KBWQA area were rectified within this GAR to allow for HVA designation. Most of the Supplemental area is unfarmable and is not considered to lack sufficient data for designation.

The largest data set available for trend monitoring contains wells identified as part of the DWR, CASGEM, DPR, or DDW systems which are generally presumed to be supply wells. Due to restricted access, well completion reports may be difficult to obtain. Without reasonably accurate construction information, these well networks may be suited to provide generalized regional groundwater level, flow direction, and gradient maps, but are likely not suitable for closer inspection of these criteria.

Other issues with the currently available deeper well networks include:

- Well locations are typically inaccurate impacting the accuracy of the data gathered and any conclusions made from that data; and
- The groundwater quality data currently indicates broad nitrate impacts hindering the ability of these wells to serve as release detection wells. Water quality trend analysis may still be possible, however.

There are a limited number of shallower RWQCB-supervised monitoring well networks which may be better suited to the required monitoring program based on well depth alone. Unfortunately, these networks are not oriented in a spatial pattern that would provide sufficient data for a regional scale monitoring effort. While the existing RWQCB-supervised networks could be utilized for monitoring locally, differentiating the provenance of select constituents in groundwater samples collected from these wells may prove difficult.

Both the deeper and RWQCB-supervised well networks are potentially suitable for future trend monitoring pending available well construction data and the ability to differentiate provenance. The shallow well network will not be sufficient to monitor the entire area, but with the impacts to the deeper groundwater, a deeper well network may be more appropriate. Complete feasibility will be assessed within the Trend Monitoring Workplan.

Well logs will be critical to the success of an effective monitoring network, as well as determining a constituent differentiation method for those wells located near known points of impact. A complete list of needs will become apparent when preparing the Trend Monitoring Workplan.

8.4 Basin Plan Amendment Workplan (if applicable)

Not applicable.

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