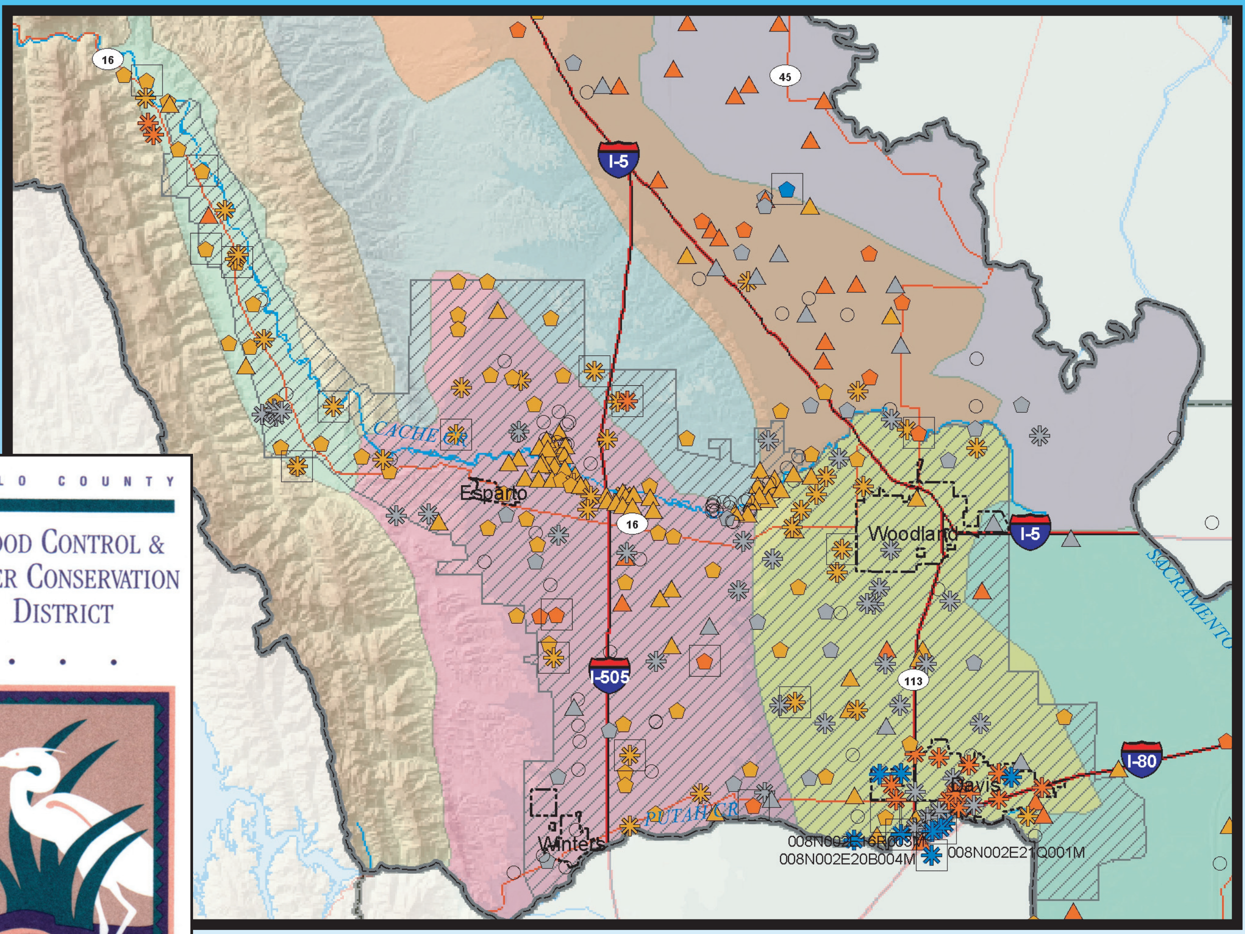
Groundwater Monitoring Program, Data Management System, and Update of Groundwater Conditions in the Yolo County Area

AB 303 Groundwater Management Assistance Act Program



YOLO COUNTY
FLOOD CONTROL & WATER CONSERVATION DISTRICT

prepared for
Yolo County Flood Control & Water Conservation District

July, 2004

prepared by

LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

in association with
Wood Rodgers, Inc.

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The material and data in this report were prepared under the supervision and direction of the undersigned.

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List of Selected Abbreviations

Cal/EPA	California Environmental Protection Agency
DHS	California Department of Health Services
District	Yolo County Flood Control & Water Conservation District
DPR	California Department of Pesticide Regulation
DWR	California Department of Water Resources
EC	Specific conductance
Els	E lower sands
Elus	E lower upper sand
Eus	E upper sands
GIS	Geographic information system
gpm	Gallons per minute
GPS	Global positioning system
IRWMP	*Yolo County Integrated Regional Water Management Plan*
LSCE	Luhdorff and Scalmanini, Consulting Engineers
MCL	Maximum contaminant level
MSL	Mean sea level
MTBE	Methyl *tert*-butyl ether
mybp	Million years before present
PCE	Tetrachloroethene
Plan	*Yolo County Flood Control & Water Conservation District Water Management Plan*
QA/QC	Quality assurance and quality control
SAR	Sodium adsorption ratio
SWN	State well number
TCE	Trichloroethene
TDS	Total dissolved solids
UCD	University of California, Davis
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
VOCs	Volatile organic compounds
WDIS	Water data information system
WDL	Water data library
WRA	Yolo County Water Resources Association
WRID	Water resources information database
YCEHD	Yolo County Environmental Health Department

EXECUTIVE SUMMARY

Groundwater is one of Yolo County's most important natural resources, and it is the source of water for all municipal and domestic uses in Yolo County except for the City of West Sacramento, which has a surface water supply from the Sacramento River. Collectively, the Yolo County Flood Control & Water Conservation District (District) and numerous other entities, including municipalities, reclamation districts, commercial and industrial operations, the agricultural community and the public, are stewards for the water resources available to Yolo County. The Yolo County community actively supports and invests in water to sustain agricultural productivity. Concurrently, municipal stakeholders are actively engaged in assessing the potential for the development of additional water supplies, both groundwater and surface water of good quality, to meet future urban water demands. This interest has prompted expanded exploration and evaluation of the aquifer system underlying the County and the investigation of conjunctive use opportunities. A *Water Management Plan* (Borcalli, 2000) (Plan) prepared for the District identifies interrelated Plan elements, including public outreach, workshops for agricultural water users, water resources monitoring, cooperation with other entities and specific water resources projects, that describe specific actions to accomplish effective water resources management. Essential prerequisites for effective water resources management are groundwater and surface water monitoring. Groundwater and surface water data, and continued analysis of those data, enable water resources managers to make informed decisions and to determine appropriate actions to design, implement, and monitor the effectiveness of groundwater management programs.

AB 303 PROJECT

Although the need for a formal Yolo County region-wide comprehensive groundwater quality monitoring program had been recognized for many years, no such program had been implemented prior to the District's AB 303 Project described herein. Through the District's leadership, and continued interests in coordinated and cooperative water resources management, the District conveyed its interest in administering the proposed AB 303 Project to other local agencies and received their written support for the project. In 2002, the California Department of Water Resources (DWR) awarded AB 303 grant funds to the District to implement this project that enables ongoing coordinated water resources data collection and evaluation that will yield long-term benefits to the County. The District was established as the lead agency for implementing this groundwater quality monitoring program and establishing an overall water resources information database for area-wide groundwater data. In Fall 2003, Luhdorff and Scalmanini, Consulting Engineers (LSCE) was authorized to proceed with the technical project work, and Fran Borcalli of Wood Rodgers, Inc. managed the overall program. An AB 303 Committee was established at the project outset, and meetings were held during the project to describe project activities and invite input from committee members.

Project Area

The AB 303 Project area includes the south to southwest portions of the Sacramento Valley Groundwater Basin that underlie the Cache and Putah Creeks Alluvial Plain. The AB 303 Project area includes all of Yolo County.

Project Analysis Units – Subbasins

This report utilized a subdivision of the Yolo County groundwater-bearing area into seven informal hydrologic units, or subbasins, based on geologic, aquifer, and topographic characteristics. A related water resources investigation in Yolo County is presently underway by DWR and others. Specifically, the *Yolo County Integrated Regional Water Management Plan* (DWR, 2004) (IRWMP) is in preparation and includes work by DWR to define subbasin areas. Prior investigations have delineated somewhat different subbasin areas than those shown in this AB 303 report and the IRWMP. However, as a result of this AB 303 Project and concurrent IRWMP subbasin area definition efforts, and mutual interests by DWR and AB 303 program participants in establishing consistent hydrologic units, increased coordination among state and local investigators has been facilitated through this AB 303 Project. Technical exchanges initiated during the AB 303 draft report review resulted in mutually agreeable first steps that advance unification of the Yolo County hydrologic units. Additional steps remain to accomplish the objective of establishing consistent units for purposes of the ongoing countywide monitoring program (and also independent entity programs) and data analyses and applications using the Yolo County Water Resources Information Database (WRID). It is anticipated that as actions occur to continue the countywide program, an addendum to this report will describe a consistent set of the hydrologic units/subbasins proposed for water resources data collection and analyses.

Zones within the Aquifer System

For purposes of this study, zones within the aquifer system were designated as shallow, intermediate, and deep as an initial step toward refining the method of analyzing historical and future groundwater level and quality data. The zone designations are based on a rough correlation to the geologic units and on water well completion depths, and all occur within the upper Tehama Formation and alluvium. The shallow zone extends to about 220 feet and consists of Pleistocene-Holocene alluvium (where present) to depths of 100 to150 feet, and also the underlying upper Tehama Formation. Most domestic wells are perforated in this zone, and many irrigation wells draw from it as well. The intermediate zone extends from about 220 to 600 feet below ground surface and encompasses only the uppermost Tehama Formation. Most irrigation wells and many public supply wells are completed in this aquifer. The deep zone extends from 600 to about 1,500 feet and consists of the deeper upper Tehama Formation. Only a few wells are perforated in this unit and include those located in the City of Davis and at the University of California, Davis (UCD). The deeper (below –1,500 feet elevation) lower Tehama Formation is not utilized by water wells in Yolo County. As described in the project recommendations, additional aquifer characterization is needed, particularly for the upper aquifer system (to a depth of about 600 feet in the central part of the County). As the aquifer system and depositional and hydraulic features of the system are better understood, then the countywide database can be correspondingly updated and database tools and applications further refined.

Purpose And Objectives

The purpose of this AB 303 Project was to develop and implement an ongoing groundwater monitoring program for the Yolo County area and to promote coordinated and effective water resources management and dissemination of information on water resources management (especially groundwater conditions). There is currently a network of wells that is monitored for groundwater levels by the District, DWR, federal agencies, municipalities, UCD, and others. Prior investigations of area groundwater quality have occurred, including investigations documented in the reports *Chemical Quality of Groundwater in Yolo and Solano Counties, California* (Evenson, 1985) and *Investigation of Groundwater Resources* (Scott and Scalmanini, 1975). However, these efforts were not part of a continuing groundwater quality monitoring program. At the outset of the project, groundwater quality monitoring (with the exception of point source investigations) was understood to be limited to the requirements for community water supplies. Previously, the Yolo County Water Resources Association (WRA) with assistance from LSCE, compiled a *Data & Information Directory for Water Resources of Yolo County* (WRA, 1998). This Directory was prepared to gain a better understanding of the data being collected, additional data that would be desirable (especially groundwater quality data), and the tasks necessary to move toward development of a centralized data repository, i.e., the WRID. This AB 303 Project updates and refines what is known about groundwater quality in the County and establishes an ongoing groundwater monitoring network and program.

The District's broad goals for the AB 303 Project included gathering available water-related data from collaborating entities in the County, cross-correlating ancillary data (e.g., well construction information and subsurface hydrogeologic features) to enhance the value of basic data, evaluating historical water level and water quality data to assess area groundwater conditions, and developing a centralized WRID that provides the data necessary to effectively manage area water resources and enables long-term protection of the basin.

The AB 303 Project objectives included:

- Reviewing the existing groundwater level monitoring network, "qualifying" the wells such that the collected data are representative of aquifers of interest, modifying the wells included in the water level monitoring network as appropriate, and identifying wells to include in a groundwater quality monitoring network.

- Collecting available historical monitoring data (including water level records and selected groundwater quality records, surface water deliveries and pumpage). Data collection for purposes of the AB 303 Project focused on overall groundwater quality conditions, i.e., point source data for local contamination investigations were generally not a focus of this project. However, efforts were made to map known sources or potential sources of contamination based on readily accessible state and local agency records.

- Performing a critical review and evaluation of selected available data (particularly groundwater data) to determine the adequacy and accuracy of the data for desired assessments of groundwater conditions. Data gaps would be identified and recommendations provided for the ongoing monitoring program to facilitate effective interpretation and understanding of groundwater conditions.

- Developing a groundwater level and quality monitoring program (parameters, monitoring frequency, data management, and evaluation) that provides the data needed to describe current groundwater conditions, including an assessment of conditions observed in response to water management activities conducted by the District and others.

- Developing and implementing a water resources information database for ongoing, centralized storage of water resources data that would be annually updated with data from cooperating entities, exchanged with area cooperators, state and federal agencies, and (with appropriate security tiers) accessible to the public.

- Implementing a baseline groundwater quality sampling program; this program includes testing of network wells for a variety of chemical parameters to establish baseline groundwater quality conditions and evaluate the occurrence of constituents of interest to program collaborators.

- Providing a comprehensive report (the report herein) that includes the results of the baseline sampling effort and an evaluation of the historical and current groundwater level and quality data. Complementary reporting objectives included development of report templates and graphical queries that would be suitable for ongoing annual reports and/or future comprehensive reports.

Scope

The AB 303 Project consisted of three phases.

- **Phase 1** included: 1) collection and evaluation of groundwater level and quality data and well data; 2) review of existing hydrogeologic data and preparation of a physical hydrogeologic description (subbasins) of the project area; and 3) preparation of groundwater monitoring objectives and a recommended groundwater level and quality monitoring network and program.

- **Phase 2** included development of an organized area-wide effort to establish a centralized repository (the WRID) for recording and archiving historical groundwater quality data and developing procedures for analyzing data on a programmatic basis with the ultimate goal of performing analyses that ensure protection of the County’s groundwater resources.

- **Phase 3** included preparation of the comprehensive report herein that expands on the existing knowledge of area-wide groundwater conditions; provides an update on groundwater conditions; and establishes the framework for future reporting of groundwater conditions. As a significant product of this AB 303 Project, the groundwater quality conditions in the County (including the results of the baseline water quality sampling event) are described and illustrated by subbasin. Queries have been developed for this and future evaluations that illustrate the spatial distribution of selected water quality parameters by concentration ranges in specific zones. Indicator wells have been selected as available for some subbasins to show trends for selected constituents.

FINDINGS AND RECOMMENDATIONS

This AB 303 Project accomplished its main purpose – development and implementation of an ongoing groundwater monitoring program for Yolo County that provides a framework to facilitate coordinated and effective integrated water resources management. This project also resulted in important benefits, including:

- Formalized a countywide groundwater quality monitoring program (232 wells) and groundwater level monitoring program (410 wells); 558 wells comprise the total network with some wells serving dual monitoring purposes.
- Created a centralized data repository (WRID).
- Developed a better understanding of the physical water resources system.
- Identified data gaps.
- Updated subbasin delineations.
- Established baseline zone-specific groundwater quality conditions from which future changes could be compared.
- Assessed groundwater quality trends.
- Established an expanded groundwater level monitoring network in the Capay Valley area to refine the understanding of groundwater conditions, especially surface/water groundwater interrelationships.
- Project facilitates increased coordination among program participants.
- Created foundation for programs that enhance integrated water resources management and planning.
- Project complements planned statewide groundwater quality monitoring program.
- Project builds framework for public outreach and programs that enhance understanding of water resources.

Tasks performed during this AB 303 Project led to a broader awareness of the water resources data currently available and how those data could be used to assess current groundwater conditions. These insights resulted in the identification of additional data needs and in recommendations to facilitate integrated regional water management and planning for sustainable supplies that support urban, agricultural, environmental, and other beneficial uses. Highlights of the findings and recommendations include:

I. General Findings and Recommendations

Findings

- Groundwater resources are an important source of supply for private domestic, municipal, commercial, and agricultural purposes.

- Community water systems currently have acceptable quality; however, trends show nitrate and specific conductance (EC) are increasing in some locations, especially in the shallow zone.
- No pesticides or volatile organic compounds were detected in the wells sampled during the March 2004 baseline sampling program.
- Long-term systematic monitoring and data evaluation are needed in conjunction with the baseline monitoring to identify future trends and changes. A comprehensive understanding of groundwater quality will provide the additional tools needed to develop a sustainable management approach.

Recommendations

- Expand the countywide database through interagency cooperation.
- Improve zone/aquifer-specific monitoring.
- Use the centralized water resources database (WRID) and associated tools to regularly evaluate countywide data, promote and coordinate effective water resources management, and disseminate information to broaden community awareness of water resources conditions.

II. Hydrogeologic Setting

Findings

- The uppermost 500 feet of nonmarine deposits are not well understood.
- Different subbasin boundaries and subbasin names have been used in Yolo County.

Recommendations

- Define the extent and thickness of the units in the upper aquifer system.
- Coordinate with DWR to finalize subbasin boundaries and establish consistent units for future data collection and water resources analyses.

III. Water Resources Information Database

a. Data Collection and Security

Findings

- Water quality information is more extensive than anticipated at the project outset.
- DWR has conducted groundwater quality monitoring in Yolo County for nearly 30 years.
- Pumpage amounts from private domestic and irrigation wells are largely unknown (although pumpage has been estimated for purposes of earlier investigations).
- Data security is a large issue since September 11, 2001.

Recommendations

- Data received for inclusion in the database should be provided in a uniform format that is compatible with the database.
- Additional available data are known to exist (e.g., hard copy data for small community systems); these data should be added to the database.

- Expand the database with other water-related information (e.g., very little pumpage data are available thus far; expand groundwater use information with land-use based estimates or other methods).
- Data security needs to be further addressed.

b. Database Construction

Findings

- Monitoring data are available for over 4,000 wells in Yolo County and surrounding areas.
- Well logs were provided electronically by DWR for over 7,300 wells in Yolo County for the years prior to 2000.
- Different naming conventions are used by different agencies for the same analyte; this causes difficulty in evaluating the constituent (e.g., nitrate).

Recommendations

- Scan remaining drillers' reports for Yolo County (from about 2000 to present) to complete the DWR electronic log file.
- Standardize analyte names to simplify data entry and evaluation.
- Establish an interagency users' group to exchange ideas on applications and facilitate use of database tools.

IV. Monitoring Network

a. Groundwater Level Monitoring

Findings

- 90 of the 410 groundwater level monitoring wells lack construction information.
- Monthly monitoring locations are limited.
- Capay Valley residents expressed concerns about groundwater levels.

Recommendations

- Replace and/or eliminate monitoring wells where no construction information is available or wells are completed in more than one zone (i.e., implement phased approach to network improvements to enhance data value).
- Increase the spatial/vertical distribution of monthly groundwater level measurements.
- Increase the spatial distribution of semi-annual level measurements through the addition of water level measurements obtained from the new District groundwater quality monitoring network.
- Implement expanded Capay Valley groundwater level monitoring program.

b. Groundwater Quality Monitoring Network

Findings

- About 90 of the 232 groundwater quality monitoring wells lack construction information (similar to level network finding).

- Nearly 50% of the 144 well owners contacted for the March 2004 baseline sampling event gave permission for testing; some owners are concerned about "enforcement action" if results are above the Maximum Contaminant Level (MCL).

Recommendations

- Implement ongoing District groundwater quality monitoring program that includes a network of qualified wells.
- Replace monitoring wells completed in more than one aquifer with wells completed in a single zone (phased approach to network improvement as feasible; many wells would not be "replaced" as much of the data is derived from community water supply wells).

c. <u>Surface Water Monitoring</u>

Findings

- Surface water monitoring data should be incorporated in the regional database.

Recommendations

- Expand input of surface water data gathered and entered into database.

V. Groundwater Conditions

Findings

- Groundwater levels indicate current conditions are stable in all zones.
- Previous investigations use an aggregate of groundwater level data to prepare groundwater elevation contour maps; significant differences in groundwater elevations were observed between zones and/or aquifers at some locations.
- Trend of increasing EC and nitrates, especially in the shallow zone.
- Average boron concentrations are highest in Capay Valley. Average boron concentrations in the shallow zone in the Lower Cache-Putah Subbasin are elevated relative to the Western Yolo Subbasin. Historical records indicate that boron concentrations in the shallow and intermediate zones for the most part appear stable.

Recommendations

- Coordinate with other program participants on additional monitoring needs to address data gaps and special water quality issues; monitoring needs for the Lower Cache-Putah Subbasin, which has the highest population density and municipal supply requirements, should have a high priority.
- Prioritize and conduct studies to understand the distribution of naturally occurring constituents and human-influenced constituents in groundwater, particularly in specific zones and/or aquifers.
- Coordinate with the Yolo County Environmental Health Department (YCEHD) to assess the number of private wells used for domestic supply and steps needed to better understand water quality concerns.

VI. Ongoing Monitoring Program

Findings

- District is well suited to facilitate program continuation.
- Interagency coordination is critical to continuation of the monitoring program and the WRID.

Recommendations

- Establish program administration and mechanisms for ongoing monitoring program coordination and WRID oversight and management.
- Identify locations for construction of dedicated monitoring wells for water level and quality monitoring; coordinate efforts being conducted for water supply investigation work (municipal and other).
- Replace wells in the monitoring network that have no well construction information to improve understanding of zone/aquifer-specific conditions (implement phased network improvements).
- Annually update regional database, assess network and findings, and make changes to program as needed.
- Communicate program results to cooperating entities.
- Coordinate the AB 303 WRID with other County Geographic Information System (GIS) applications.
- Provide public access to program information via the District's website.

PROGRAM CONTINUATION

The AB 303 Project has resulted in a monitoring program and WRID that hold long-term benefits for the County; however, this can occur only if steps are taken to establish the operation of the ongoing program. The District's interests in promoting and implementing activities that sustain the County's water resources make the District a well-suited agency for providing ongoing administration of the monitoring and WRID programs established through the AB 303 Project. For the program to be successful requires coordination with other cooperating entities, including members of the AB 303 Committee, and also continued cooperation of landowner participants who have authorized use of their wells for the water level and now also water quality monitoring programs.

Ongoing Program – Next Steps

- Identify active collaborators (including local, federal, state agency representatives) and interested stakeholders for implementing the program.
- Agree on lead agency to administer the ongoing monitoring program and WRID.
- Coordinate with DWR to finalize subbasin boundaries and establish consistent units for future data collection and water resources analyses.
- Lead agency to establish program coordinator.
- Arrange meeting of collaborators to:

  - Establish short and long-term monitoring objectives/issues of interest;
  - Coordinate efforts among collaborators (chemical analyses to address issues of concern, analytical methods, reporting formats, quality assurance/quality control (QA/QC) data entry processes, formats for data transfer [from labs and also entities]);
  - Discuss evolution of the database (additions, ongoing data updates, and database applications);
  - Discuss data evaluation objectives and approaches for reporting results and water resources conditions and recommendations;
  - Discuss additional data types needed (e.g., groundwater extraction, land use, other);
  - Discuss AB 303 report recommendations and identify priorities for implementing;
  - Establish users' group (e.g., collaborating entity representatives applying WRID);
  - Discuss data security issues; and
  - Discuss mechanisms to facilitate public outreach.
- Annually update the regional database (e.g., groundwater levels and quality and other water-related data), assess network and findings, and make changes to the program where necessary.
- Coordinate with County GIS program.
- Seek funding to support program continuation, including WRID system management, data evaluation, and implementation of priority recommendations.

1.0 INTRODUCTION

Groundwater is one of Yolo County's most important natural resources, and it is the source of water for all municipal and domestic uses in Yolo County except for the City of West Sacramento, which has a surface water supply from the Sacramento River. Collectively, the Yolo County Flood Control & Water Conservation District (District) and numerous other entities, including municipalities, reclamation districts, commercial and industrial operations, the agricultural community and the public, are stewards for the water resources available to Yolo County. The Yolo County community actively supports and invests in water to sustain agricultural productivity. Concurrently, municipal stakeholders are actively engaged in assessing the potential for the development of additional water supplies, both groundwater and surface water of good quality, to meet future urban water demands. This interest has prompted expanded exploration and evaluation of the aquifer system underlying the County and the investigation of conjunctive use opportunities. A *Water Management Plan* (Borcalli, 2000) (Plan) prepared for the District identifies interrelated Plan elements, including public outreach, workshops for agricultural water users, water resources monitoring, cooperation with other entities and specific water resources projects, that describe specific actions to accomplish effective water resources management. Essential prerequisites for effective water resources management are groundwater and surface water monitoring. Groundwater and surface water data, and continued analysis of those data, enable water resources managers to make informed decisions and to determine appropriate actions to design, implement, and monitor the effectiveness of groundwater management programs.

Although the need for a formal Yolo County region-wide comprehensive groundwater quality monitoring program had been recognized for many years, no such program had been implemented prior to the District's AB 303 Project described herein. Through the District's leadership, and continued interests in coordinated and cooperative water resources management, the District conveyed its interest in administering the proposed AB 303 Project to other local agencies and received their written support for the project. In 2002, the California Department of Water Resources (DWR) awarded AB 303 grant funds to the District to implement this project that enables ongoing coordinated water resources data collection and evaluation that will yield long-term benefits to the County. The District was established as the lead agency for implementing this groundwater quality monitoring program and establishing an overall water resources information database for area-wide groundwater data. In Fall 2003, Luhdorff and Scalmanini, Consulting Engineers (LSCE) was authorized to proceed with the technical project work, and Fran Borcalli of Wood Rodgers, Inc. managed the overall program. An AB 303 Committee was established at the project outset, and meetings were held during the project to describe project activities and invite input from committee members.

1.1 BACKGROUND

The California Legislature formed the District in 1951 to control, manage, and distribute water resources for beneficial use within the District's boundaries. The District's mission as set forth in its water management plan is:

> "To plan, develop, and manage the conjunctive use of its surface and groundwater resources to provide a safe and reliable water supply, at a reasonable cost, to sustain the socioeconomic and environmental well-being of Yolo County."

The District has acquired water rights and manages extensive facilities, while developing plans to obtain supplemental water supplies to meet future needs within the District. The County of Yolo, in adopting the *Yolo County Water Plan – 1984* (Borcalli et al., 1984) and the *Yolo County Water Plan Update – 1992* (Borcalli, 1992), recognized the District's role in helping to provide water supplies for current and future needs within the County. To further its mission, the District prepared the *Water Management Plan* (Borcalli, 2000) to: 1) provide information about the District's water rights, facilities, and distribution system, 2) provide information about the District's historic management activities in the conjunctive use of surface water and groundwater supplies, and 3) set forth actions for the District to plan for the management of its existing water supplies and develop supplemental supplies to meet beneficial needs within the District.

The District's Plan does not extend beyond the existing boundaries of the District because the District's authority to implement the Plan outside its boundaries is limited. The District Act authorizes the District to enter into contracts, joint powers agreements, and other cooperative arrangements with the County, cities, other public agencies, and water companies. Therefore, part of the Plan is to investigate cooperative arrangements with other public agencies within Yolo County regarding implementation of the District's Plan. As an illustration of its desire to achieve cooperative efforts, the District, in preparing the Plan, received guidance from a Scoping Committee comprised of stakeholders representing urban and agricultural interests within and outside the District.

The following findings were summarized in the Plan (Borcalli, 2000):

- The District wishes to implement a program to provide the basic data and information required to adequately monitor and manage water resources within and available to the District.
- The District's long-term perspective is important to ensuring the integrity of the available water supplies over the long term.
- The District's surface water monitoring program needs to be expanded to document the water use efficiency of its "system."
- The District's program for monitoring groundwater levels should be enhanced to facilitate understanding of the basin under a variety of hydrologic conditions.

- The availability of data to document groundwater quality is inadequate.
- The District's proposed projects will, if implemented, enhance the utilization of water from the Cache Creek system.
- The District should determine whether or not opportunities exist for delivering water supplies for agricultural use in the Dunnigan Hills.

From these findings, and a review of the District's activities, a 12-element Action Program was developed to summarize the District's plan for improving the management of its water resources. The 12 elements, each of which is a stand alone task, include:

Action A. Public Relations Program
Action B. Agricultural Water Users Workshops
Action C. Land Use/Water Use Surveillance
Action D. Surface Water Monitoring
Action E. Groundwater Monitoring
Action F. Cache Creek Recharge/Recovery Project
Action G. Sacramento River Water Diversion Project
Action H. District-Woodland In-Lieu Recharge Project
Action I. District-Yolo-Zamora In-Lieu Recharge Project
Action J. Dunnigan Hills Water Needs/Options
Action K. Drought Management Preparedness
Action L. Water Management Report

Actions A – E and L necessitate two essential components to achieve an effective groundwater management program – collaboration among local agencies and implementation of a coordinated monitoring program that develops, maintains, and effectively utilizes groundwater and surface water data. Steps to further local agency collaboration were demonstrated during preparation of the Plan. Actions A, B, and L detail the cooperative activities that will lead to regular dissemination of area water resources information (to the public as well as collaborators), better coordination among the agencies, and more effective management of the local resource. Actions C – E describe monitoring program needs for the purposes of: 1) continually assessing the quality and quantity of the water resources in the basin, 2) carefully planning and implementing programs to protect the long-term sustainability of the resource, and 3) assessing the beneficial effects of implemented water resources management programs. Other Action items listed above are included in the Plan as Recharge Projects and Management Programs that are directed toward benefits achieved by optimum resource management. While these projects are future objectives of the Plan, this AB 303 Project focused on the implementation of relevant aspects of Actions A – E and L with particular emphasis on Actions E and L.

1.2 AB 303 PROJECT PURPOSE

The purpose of this AB 303 Project was to develop and implement an ongoing groundwater monitoring program for the Yolo County area and to promote coordinated and effective water resources management and dissemination of information about water resources management (especially groundwater conditions). There is currently a network of wells that is monitored for groundwater levels by the District, DWR, federal agencies, municipalities, the University of California, Davis (UCD), and others. Prior investigations of area groundwater quality have occurred, including investigations documented in the reports *Chemical Quality of Groundwater in Yolo and Solano Counties, California* (Evenson, 1985) and *Investigation of Groundwater Resources* (Scott and Scalmanini, 1975). However, these efforts were not part of a continuing groundwater quality monitoring program. At the outset of the project, groundwater quality monitoring (with the exception of point source investigations) was understood to be limited to the requirements for community water supplies. Previously, the Yolo County Water Resources Association (WRA) with assistance from LSCE compiled a *Data & Information Directory for Water Resources of Yolo County* (WRA, 1998). This Directory was prepared to gain a better understanding of the data being collected, additional data that would be desirable (especially groundwater quality data), and the tasks necessary to move toward development of a centralized data repository or data management system. This AB 303 Project updates and refines what is known about groundwater quality in the County and establishes an ongoing groundwater monitoring network and program.

1.3 PROJECT AREA

The AB 303 Project area includes the south to southwest portions of the Sacramento Valley Groundwater Basin that underlie the Cache and Putah Creeks Alluvial Plain. The AB 303 Project area includes all of Yolo County (Figure 1.1). As further described in Chapter 2 "Geology and Water Resources of Yolo County," this report proposes a subdivision of the Yolo County groundwater bearing area into seven informal subbasins based on geologic, aquifer, and topographic characteristics. Yolo County groundwater quality conditions are described later in this report and are illustrated in relation to the subbasins and also by concentration ranges of specific constituents by aquifer.

The District overlies a significant area in the center of the County. Generally, three subbasins occupy the District area, including the Lower Cache-Putah and Western Yolo Subbasins and the Capay Valley Subbasin. Historical data largely occur within the District area, although groundwater level monitoring data exist for all subbasins. The highest population density and urban water use occurs within the District area; thus, the groundwater quality data evaluations in Chapter 5 "Groundwater Conditions" emphasize results for these three subbasins.

1.4 AB 303 PROJECT GOALS AND OBJECTIVES

The District's broad goals for the AB 303 Project included gathering available water-related data from collaborating entities in the County, cross-correlating ancillary data (e.g., well construction information and subsurface hydrogeologic features) to enhance the value of basic data, evaluating historical water level and water quality data to assess area groundwater conditions, and developing a centralized water resources information database

(WRID) that provides the data necessary to effectively manage area water resources and enables long-term protection of the basin.

The AB 303 Project objectives included:

- Reviewing the existing groundwater level monitoring network, "qualifying" the wells such that the collected data are representative of aquifers of interest, modifying the wells included in the water level monitoring network as appropriate, and identifying wells to include in a groundwater quality monitoring network.

- Collecting available historical monitoring data (including water level records and selected groundwater quality records, surface water deliveries and pumpage). Data collection for purposes of the AB 303 Project focused on overall groundwater quality conditions, i.e., point source data for local contamination investigations were generally not a focus of this project. However, efforts were made to map known sources or potential sources of contamination based on readily accessible state and local agency records.

- Performing a critical review and evaluation of selected available data (particularly groundwater data) to determine adequacy and accuracy of the data for desired assessments of groundwater conditions. Data gaps would be identified and recommendations provided for the ongoing monitoring program to facilitate effective interpretation and understanding of groundwater conditions.

- Developing a groundwater level and quality monitoring program (parameters, monitoring frequency, data management, and evaluation) that provides the data needed to describe current groundwater conditions, including an assessment of conditions observed in response to water management activities conducted by the District and others.

- Developing and implementing a WRID for ongoing, centralized storage of water resources data that would be annually updated with data from cooperating entities, exchanged with area cooperators, state and federal agencies, and (with appropriate security tiers) accessible to the public.

- Implementing a baseline groundwater quality sampling program; this program includes testing of network wells for a variety of chemical parameters to establish baseline groundwater quality conditions and evaluate the occurrence of constituents of interest to program collaborators.

- Providing a comprehensive report (the report herein) that includes the results of the baseline sampling effort and an evaluation of the historical and current groundwater level and quality data. Complementary reporting objectives included development of report templates and graphical queries that would be suitable for ongoing annual reports and/or future comprehensive reports.

1.5 PROJECT PARTICIPANTS

With the completion of the District's *Water Management Plan* (Borcalli, 2000), and the continued recognition of the need for groundwater monitoring, the District responded with a commitment to proceed with such a program. Because of the importance of coordinating this effort with other area agencies, the District expanded one of the activities in its Plan (Action E. Groundwater Monitoring) to an area extending beyond the District boundary, conveyed this interest to collaborators, and confirmed the support of collaborators in proceeding with the proposed AB 303 Project. The District was established as the lead agency for implementing the groundwater monitoring program and establishing the overall WRID for area-wide groundwater data.

At the outset of the AB 303 Project, further efforts were made by the District to invite participation in the project. Some of the AB 303 program participants are also shown on Figure 1.1. In addition, a list of interested persons and entities was maintained and used for regular project communications. An AB 303 Committee was established and meetings were held during the project to describe project activities and invite input from committee members.

Full implementation of the monitoring and interpretation required significant effort, and the planned coordination with multiple collaborators required additional time. Since a key desired result of the project was an improved understanding of groundwater resources in the area (especially quality), the District has invested additional financial resources needed to fulfill the project objectives.

1.6 PROJECT SCOPE

The AB 303 Project scope was organized in three phases with a number of specific tasks described within those phases to incrementally accomplish all the project objectives. The three phases included:

1.6.1 Phase 1 – Data Collection, Evaluation, and Recommended Groundwater Monitoring Program

Phase 1 was comprised of three tasks: 1) collection and evaluation of groundwater level and quality data and well data; 2) review of existing hydrogeologic data and preparation of a detailed physical hydrogeologic description of the project area and groundwater monitoring objectives; and 3) preparation of a recommended groundwater level and quality monitoring network and program.

1.6.2 Phase 2 – Water Resources Information Database

Although, there is an ongoing gathering, review, and dissemination of water level data through the efforts of DWR, there had not prior to this AB 303 Project been an organized area-wide effort to establish a centralized repository for historical groundwater quality data. Also lacking prior to this AB 303 Project was an ongoing program to regionally analyze water level and water quality data with the ultimate goal being the protection of groundwater resources.

The District and entities comprising the AB 303 Committee each collect their own data. Before this AB 303 Project, there was no established mechanism or recommendations to ensure consistency in the manner in which those data were gathered by the collaborating agencies prior to reporting the data to DWR. A goal for the continuation of the AB 303 program is for the District as program administrator to, for example, evaluate the consistency with which reference point elevations have been designated and how "static" versus "pumping" levels have been defined. The District would also upon receipt of data from collaborating entities conduct data qualification prior to transferring data to DWR.

As part of Phase 1, the work included gathering existing monitoring data and evaluating and qualifying those data for the purpose of recommending a monitoring program. In addition, current water quality data were collected as part of the baseline water quality sampling event. As part of this project, monitoring objectives are described, existing data have been inventoried, agency monitoring frequency are summarized, and recommendations are provided to ensure consistency of data collection efforts and data validity. Phase 2 consisted of two tasks: 1) database system design and 2) database system implementation.

1.6.3 Phase 3 – Report of Baseline Groundwater Quality Conditions and Updated Area Groundwater Conditions

Phase 3 of the AB 303 Project is a comprehensive report that expands on the existing knowledge of area-wide groundwater conditions; provides an update on groundwater conditions; establishes the framework for the reporting of water levels and water quality; and integrates groundwater management objectives with the groundwater monitoring program. Earlier geologic and water resources investigations are briefly summarized in the report and are integrated with the more recent efforts conducted to explore subsurface conditions in the County. This report further expands on the current physical understanding of the geologic units and zone system, including relationships to surface features (outcrop/recharge locations and surface water connections) and distinguishing subsurface depositional features. The occurrence and movement of groundwater beneath Yolo County and adjoining areas are described and illustrated with long-term hydrographs and groundwater elevation contours. As a significant product of this AB 303 Project, the groundwater quality conditions in the County (including the results of the baseline water quality sampling event) are described and illustrated by subbasin. Queries that illustrate the spatial distribution of selected water quality parameters by concentration ranges in specific zones have been developed for this and future evaluations. Indicator wells have been selected as available for some subbasins to show trends of selected constituents

1.7 REPORT ORGANIZATION

This report describes the work conducted in Phases 1 and 2 of the project and includes the results of the baseline sampling effort and an update on area groundwater conditions. The report is organized as follows:

- **Geology and Water Resources of Yolo County**

- **Water Resources Information Database**
  - Data collection and security
  - Database construction

- **Groundwater Monitoring Network**
  - Well qualification
  - Groundwater level monitoring network
  - Groundwater quality monitoring network
  - Baseline groundwater quality sampling program
  - Ongoing program

- **Groundwater Conditions**
  - Groundwater levels
  - Groundwater quality
  - Future groundwater level and quality data

- **Ongoing Monitoring Program**
  - Ongoing Program Objectives
  - Program administration
  - Groundwater monitoring program

- **Findings and Recommendations**

2.0 GEOLOGY AND WATER RESOURCES OF YOLO COUNTY

The main groundwater basin area of Yolo County occurs on the southwestern side of the Sacramento Valley, a portion of the larger Central or Great Valley geologic province of California (Figure 2.1). The southern Sacramento Valley has been a tectonically subsiding sedimentary basin with accumulating nonmarine, continental deposits since middle Tertiary time (Miocene, 24 million years before present, mybp). Within these nonmarine sedimentary deposits, fresh groundwater extends to an elevation of –3,000 feet (Figure 2.2).

The following regional geologic setting is adapted largely from Harwood and Helley (1987), Page (1986), and Hackel (1966). The Sacramento Valley Basin (DWR, 1978) is bound to the west by the uplifted, mountainous Coast Range geologic province composed of strongly deformed, earlier Tertiary (pre-24 mybp) and Mesozoic (pre-63 mybp) marine sedimentary rocks. These marine rocks extend beneath the Sacramento Valley eastward to pinch out and overlap onto the granitic and metamorphic rocks of the Sierra Nevada geologic province. The thick (over 15,000 feet) marine rocks beneath the western Sacramento Valley have been extensively explored for natural gas resources. These explorations have identified four early Tertiary submarine canyons, which were carved into the older marine deposits, and in filled with marine shales by early Miocene time. The Markley Gorge is one of these submarine canyons found beneath eastern Yolo County near the Sacramento River. The earlier Tertiary and Mesozoic marine rocks beneath the Sacramento Valley are non-freshwater bearing as they contain saline water from their original marine deposition, and are well-consolidated (sandstone, shales, etc.).

In the southern Sacramento Valley, by the late-middle Miocene, nonmarine sedimentary deposition began capping the underlying older marine deposits. The nonmarine deposition continued through the end of the Tertiary (Pliocene 5.3 to 1.5 mybp), and through the Quaternary [Pleistocene (1.5 to 0.01 mybp) and Holocene (post-0.01 mybp)] to present. The nonmarine deposits contain fresh groundwater and represent the groundwater basin beneath Yolo County. West of the Sacramento River, these nonmarine deposits have been termed the Tehama Formation of late Tertiary (largely Pliocene) to early Quaternary age (early Pleistocene), overlain by Pleistocene Red Bluff Formation, and Pleistocene-Holocene alluvium. The complexity of these nonmarine deposits will be described in a later section.

Tehama Formation deposition ended in the early Pleistocene by the deposition of a thin, wide-spread pediment sand and gravel bed known as the Red Bluff formation. The age of the Red Bluff is constrained by underlying and overlying aged-dated volcanic beds to between 1.09 mybp and 0.45 mybp (Harwood and Helley, 1987). Exposures of the Red Bluff around and on top of Tehama Formation on the Dunnigan Hills and Plainfield Ridge, has been used to define the Pleistocene to present structural Dunnigan Hills domain. The domain consists of: the reverse Zamora fault on the northeast edge of the Hills which offsets Tehama, Red Bluff, and alluvium; the doubly-plunging Dunnigan Hills anticline; and the southeast plunging Madison syncline. South of the Dunnigan Hills, subsurface expression of the syncline and anticline in the Tehama Formation is difficult to discern due to lack of correlatable stratigraphic units and lower density of well control information.

2.1 PREVIOUS STUDIES

Groundwater resources in Yolo County have been investigated by numerous studies over the last century; the most significant or relevant reports are reviewed here. An early reconnaissance report of the Sacramento Valley groundwater resources was presented by Bryan (1923). The California Division of Water Resources (1955) encompassed most of the groundwater areas of Yolo County, curiously titled “The Putah Creek Cone Investigation.” This report presented shallow cross-sections along and across Putah Creek and preliminary deep cross-sections from a concurrent U.S. Geological Survey (USGS) investigation.

The USGS published their detailed study of southern Yolo and parts of Solano County with the finalized deep cross-sections as Thomasson Jr., Olmsted, and LeRoux (1960). A regional study of the entire Sacramento Valley soon followed (Olmsted and Davis, 1961). Scott and Scalmanini (1975) presented a study of Yolo County groundwater resources. A DWR report (1978) covered the evaluation of the groundwater resources of the Sacramento Valley.

The USGS published a series of reports on the entire Central Valley in their regional-aquifer system investigations (Bertoldi et al., 1991). Hull (1984) and Bertoldi et al. (1991) covered the geochemistry of groundwater in the Sacramento Valley. Page (1986) summarized the geology of the entire Central Valley with an extensive list of references.

The most widely available geologic maps covering the Yolo County area is from California Division of Mines and Geology (Wagner et al., 1981; Wagner et al., 1982). The most detailed surficial geologic mapping of groundwater basins was summarized in Helley and Harwood (1985) from previous mapping by themselves and others. Detailed soil mapping of Yolo County by the U.S. Soil Conservation Service was published in 1972.

A report by the State of California (1987) as a proposal for siting the Super Conductor Super Collider provides a 360-degree cross-section extending to about 200 feet deep at about a ten-mile radius centered on the City of Davis.

Hubbard (1989) presented an evaluation of the youngest alluvial deposits across the Yolo County area with an interpretive map of the top of the underlying Tehama Formation (Figure 2.3). Graham (1997) presented a hydrological and geological study of the alluvial aquifer in the Davis area.

West Yost and Associates (1991 and 1992) presented the results of a groundwater investigation of eastern Yolo County. LSCE (2003) presented a conceptualization of the deep freshwater stratigraphy around Davis.

Additional references on Yolo County containing shallow hydrogeologic information are a result of aggregate resources evaluations along Cache Creek. Some of these reports include Wahler et al. (1982); Woodward-Clyde Consultants (1976); and Dames and Moore (1990). Numerous additional references for individual aggregate resources sites exist.

2.2 GROUNDWATER BEARING UNITS

For this report, the fresh groundwater bearing geologic units have been divided into three units: the lower nonmarine deposits; the upper nonmarine deposits; and the overlying alluvium (Figures 2.4 and 2.5; detailed views of these cross-sections are provided in Appendix A). These units were identified using the physical characteristics as contained on geophysical-electrical logs from natural gas test holes and selected deep water wells. Stratigraphic correlations and interpretations are based on previous and ongoing work by LSCE (2003; 2004 in preparation). These studies included review of hundreds of geophysical-electrical logs and stratigraphic correlations on numerous work cross-sections oriented east-west at one to two miles separation. Selected cross-sections developed in these studies are presented and simplified in this report. The following geologic discussion and interpretations are based largely on the results of these LSCE studies.

2.2.1 Lower Nonmarine Deposits

In the center of the basin, the deposits from the base of freshwater (about –3,000 feet elevation) to about –1,500 feet elevation are designated the lower nonmarine deposits. The unit consists of pre-Piocene nonmarine deposits overlain by the lower Tehama Formation, but this contact cannot be identified in the subsurface and therefore will not be distinguished in the following discussion. The lower nonmarine unit is subdivided into fluvial sand sequences: A, B, and C sands. Lateral equivalents to these sequences are deposits of alluvial fan to plain deposits, which rise toward the east (A, B, C East; see Figures 2.4 and 2.5). To the west, at least partially equivalent deposits appear to be alluvial fan to plain deposits from a western source. Below the A sand on the west half of the basin occurs a thick (400 feet) to thin, brackish to saline sandy bed (Z sand) which overlies the distinctly marine deposits and the Markley Gorge Fill. While this unit is below the base of freshwater, it appears to mark the transition to nonmarine deposition in this portion of the valley. These marginal marine Z sand deposits are tentatively correlated to the Miocene Valley Springs Formation exposed in southeastern Sacramento County. This is based on their stratigraphic position above the Markley Gorge Fill (Hackel, 1966), and the eastward thickening nature of these sands (Figure 2.5 and Appendix A).

The A and B sand intervals on the east are believed to be equivalent to the Late Miocene-Pliocene Mehrten Formation. The central A and B sand sequences are believed to be fluvial or stream deposits, while the western A and B equivalents may represent older, possibly unexposed, Pliocene lower Tehama Formation. The eastern C interval may represent the Pliocene Laguna Formation. The C sand sequence in the center may be a fluvial equivalent, and the western C interval may represent alluvial plain deposits of the Tehama Formation.

The lower nonmarine deposits have not been utilized for water supply in Yolo County; these occur below the depths of the deepest production wells. The Mehrten and Laguna Formations are significant water-producing zones in eastern Sacramento County. Because these deposits are not utilized in Yolo County, these units were not studied in detail for this report.

2.2.2 Upper Nonmarine Deposits

The upper nonmarine deposits overlies the lower nonmarine deposits in the center of the basin from –1,500 feet elevation to depths of 100 to 200 feet. These deposits have been subdivided into fluvial sand sequences termed: the E lower sands; the E lower-upper sands; D sands; F sands; and E upper sands (Figure 2.4 and 2.5). The western lateral equivalents to these units appear to be alluvial plain to fan deposits of the Pliocene to early Pleistocene upper Tehama Formation. To the east, the equivalent alluvial plain to tributary fluvial deposits are probably Pliocene upper Laguna Formation to Pleistocene lower River Bank Formation. The uppermost 500 feet of the upper nonmarine deposits have not been as extensively studied for this report as they occur above the geophysical logs of the testholes constructed for natural gas exploration. Detailed evaluation of the uppermost section requires in-depth review of the thousands of water well logs in Yolo County.

The E lower sands (Els) sequence consists of six to seven major sand beds associated with a fluvial system interbedded in adjacent floodplain and flood basin deposits of silts and clays. The sand beds appear to extend as linear bands south toward Davis with each bed tending to thin and split into multiple beds, which may pinch out. The uppermost sand bed appears to extend through western Davis and may represent the lowest beds of the deep zone (600 to 1,500 feet deep) in City of Davis and UCD production wells. The character of these sand beds suggests a change from a northern fluvial environment into a lower-energy distributary delta or possibly a lake margin depositional environment. This pattern persists in all of the upper nonmarine sand sequence with the exception of the E upper sands.

The E lower upper sand (Elus) sequence extends southward in a similar manner, but occurs further eastward beneath the eastern margin of Davis. A higher concentration of Elus beds occurs below the Yolo flood bypass near Davis, but it is missing near Woodland. It may also represent an eastern-sourced tributary fluvial system. Some secondary Elus may extend into north central Davis, possibly interfingered with D sands. The character of the Elus suggests that they extend somewhat further south before entering a lower-energy depositional environment than the Els.

The D sands sequence appears to be partially contemporaneous with the Elus, but it occurs as a narrow band of sands which extends from Davis northwestward to near Woodland Watts Airport. The D sands appear to thin southward across western Davis, and they appear to represent the upper sands of the deep zone in the deep western wells of the City of Davis and UCD. The character and extent of the D sands suggests a western-sourced, tributary fluvial system.

To the west of Davis, UCD Well 7A is constructed in the F sands sequence. This unit appears similar to the D sand as being from a western-sourced, tributary fluvial system. The northern extent of the F sand is less constrained due to lack of deep well control. The F sands appear to extend southward into the Dixon area before thinning and possibly pinching out.

The E upper sands (Eus) appear as a sequence of thick-bedded fluvial channel and floodplain sands, which extend southeastward from Woodland to east of Davis. The Eus appear to remain fluvial in nature further south past Davis, possibly indicating a southward migration or removal of the lower-energy environment indicated by previous deposits. From the sand bed concentration increase southward, there may be an eastern-sourced, tributary fluvial contribution.

The lateral equivalents to the central upper nonmarine deposits are less constrained. West of Davis, an E/D sequence of thin sand beds of an alluvial plain origin appears to extend from the Coast Range. Further north, sand-bed poor alluvial plains seem to be dominant where well control and stratigraphic correlation are poor. This pattern may reflect a lack of large western tributary sediment sources to the north, or possible structural fault or uplift relationships not discernable from the stratigraphic record. East of the Sacramento River, stratigraphic relationships were not examined due to lack of deep testhole control. Detailed regional study of Sacramento County would be needed to further study this area, and such an evaluation may be constrained by limited deep well control, which only exists in eastern Sacramento County from water wells.

As mentioned above, the uppermost 500 to 600 feet of the upper nonmarine deposits were not examined in detail for this study. From previous studies, it appears the deposits are poorly stratified silts and clay beds interbedded with thin to locally thick sand beds of alluvial plain to fluvial channel origin. Detailed evaluation of water well drillers’ reports is necessary to assess the complexity of these deposits.

2.2.3 Alluvium

The uppermost nonmarine deposits are termed the Pleistocene-Holocene alluvium and are 100 to 200 feet thick. Separation of the alluvium from the underlying deposits is difficult because of their similar appearance and lack of distinctive marker characteristics. The alluvium is considered to be correlative to the Pleistocene Red Bluff, Riverbank and Modesto formations, and younger Holocene alluvium deposits identified by surficial geologic mapping (Helley and Harwood, 1985).

For this report, Hubbard’s (1989) top of Tehama Formation map is used to represent the bottom of alluvium (Figure 2.3). The alluvium appears to be a complexly stratified sequence of unconsolidated, interbedded sands and gravels with fine-grained silts and clay beds. Coarser-grained deposits of sand and gravel appear to occur adjacent to major stream channels like Cache and Putah Creeks. Thinner sand beds occur as alluvium plain and distributary channels across the alluvial plain areas of the west. To the east, more fine-grained, floodplain and floodbasin deposits occur, with thin floodplain sands and thicker stream channel deposits toward the Sacramento River.

The State of California (1987) presented a 360-degree cross-section for the proposed Super Collider around the City of Davis, which provided a detailed depiction of the upper 200 feet of the subsurface. A review of this cross-section shows the complex character of the alluvial deposits and the lack of correlation even between closely spaced well logs. A detailed review of water well drillers' reports may prove difficult for purposes of evaluating the complexity of the alluvial deposits.

2.3 VERTICAL ZONE CHARACTERISTICS

For this study, vertical zones within the upper Tehama Formation and alluvium were designated shallow, intermediate, and deep. The zones do not represent laterally extending aquifers but are strictly depth based for purposes of studying subsurface data. These designations are based on a rough correlation to the geologic units and on water well completion depths (Figures 2.4 and 2.5). The shallow zone extends to about 220 feet and consists of Pleistocene-Holocene alluvium (where present) to depths of 100 to 150 feet, and also the underlying upper Tehama Formation. Most domestic wells are perforated in this zone, and many irrigation wells draw from it as well. The intermediate zone extends from about 220 to 600 feet below ground surface and encompasses only the uppermost Tehama Formation. Most irrigation wells and many public supply wells are completed in this zone. The deep zone extends from 600 to about 1,500 feet and consists of the deeper upper Tehama Formation. Only a few wells are perforated in this unit and include those located in the City of Davis and at UCD. The deeper (below –1,500 feet elevation) lower Tehama Formation is not utilized by water wells in Yolo County.

2.3.1 Shallow Zone

The shallow zone extends from the surface to a depth of about 220 feet and consists predominantly of alluvium but also includes the upper portion of the Tehama Formation. The deposits consist of thick sand and gravel deposits within a mile or two of the major sediment sources of Cache and Putah Creeks. The coarse beds appear to thin away from the present stream channels with thinner distributary channel and sheetflood sand deposits occurring under the more distal alluvial plains. Well yields can be relatively high where thick channel deposits are encountered with yields of several hundred to 1,500 gallons per minute (gpm). Specific capacities range up to 100 gpm per foot of drawdown or greater in this setting. More modest production (e.g., up to 500 gpm yields) likely results from wells constructed in thin sands that are more distant from stream channels and have lower specific capacities. Wells completed in even just a few thin sand beds produce sufficient quantities for domestic use.

Recharge to the shallow zone occurs from infiltration from the incised major streams of Cache and Putah Creeks and associated distributary sloughs on the alluvial plains. Recharge from the Sacramento River probably occurs in the eastern part of the county. Additional recharge occurs by deep percolation of precipitation and irrigation waters. Aquifer sand bodies are probably at least weakly connected to sand bodies surrounding the major streams. The shallow zone is probably unconfined, although local confinement in thin sands may occur where overlain by a thick flood clay sequence.

2.3.2 Intermediate Zone

The intermediate zone extends from depths of about 220 to 600 feet and occurs exclusively within the upper Tehama Formation. These deposits are believed to be largely alluvial plains with distributary channel and sheetflood sands interbedded in silts and clays. These deposits are believed to be slightly more consolidated than the shallow zone, although the coarser beds may remain loose. The western alluvial plains appear to be slightly more deficient in thicker sand beds, possibly due to lower deposition rates or sediment bypass to further east. The eastern alluvial plains appear to have somewhat higher, thick sand content, although correlation of beds appears poor. Sand beds are believed to be tributary alluvial plain deposits, fluvial floodplain sands and secondary channel sands from the ancestral Sacramento River system.

Well yields appear to be high for eastern areas with ranges of 500 to 1,000 gpm where thick sands are encountered. Wells yields in the western alluvial plain area appear to be lower and range from about 100 to 500 gpm where thick sands are encountered. In this area, a higher percentage of test holes may not encounter sufficient sand to provide desired production well yields. Specific capacities for wells completed in the intermediate zone are comparatively lower than those for the shallow zone. Intermediate zone wells in the western alluvial plain likely have poor to low yields due to lack of sand beds. Eastern alluvial plain wells may be more productive; however, thick sand beds are less prevalent in the intermediate zone than the shallow zone.

Recharge to the intermediate zone occurs generally through leakage from overlying shallow zone and recharge to outcrop areas. Recharge of the eastern Eus may occur indirectly from the Sacramento River alluvium aquifers. Western alluvial plain aquifers may be recharged by surface exposures along the Coast Range and the interconnection between the intermediate zone and the overlying shallow alluvium along Putah and Cache Creeks. The intermediate zone may be unconfined, although local confinement occurs due to thick overlying clay.

2.3.3 Deep Zone

The deep zone extends from depths of about 600 to 1,500 feet and encompasses the deeper upper Tehama Formation (Els, Elus, D sands, and F sands). These sands sequences are believed to be of central fluvial origin in eastern Yolo County, with the D and F sands being of tributary fluvial plain origin. Further west, the E/D sands are believed to be of alluvial plain/fan origin, but these are not present further to the north. Western alluvial plain deep sands appear to be lacking north of Davis, except for the F sand; however, there is less well control in this area. E/D sand deposits are believed to be weakly consolidated, although the sand beds may remain loose. The eastern alluvial plain appears to show the E sand sequences, but the sand must be closely examined to determine its location and nature. The sands appear to be more widespread in the south near Davis, and more restricted near Woodland. As discussed above, nearly all of the sand sequences tend to show a southward thinning and splitting pattern and form linear, elongate bands where the sand bed concentration is highest.

Well yields appear to be high in the eastern area where thick or numerous sand beds or sand sequences are encountered. Well yields of 1,000 to 3,000 gpm are not uncommon. However, if sand sequences with low sand content are encountered, supply wells may not be feasible. Well yields in the western alluvial plain are largely unknown. Elsewhere in the area sand bed content appears to be low, especially to the north. It appears that the western part of Yolo County is a poor area for deep zone targets, except for the F and D sand sequences, and possibly marginal to the Tehama Formation outcrop area. Specific capacities for deep zone wells completed in thick sand sequences appear to be about 20 to 30 gpm/foot.

Recharge to the deep zone beneath the eastern alluvial plain is believed to be from leakage from overlying aquifers, probably sourced from Sacramento River and Cache Creek to the north. The western alluvial plain deep zone is probably recharged from the overlying units and Tehama Formation outcrops to the west, especially those units associated with Cache and Putah Creeks. The deep zone is a confined system due to the presence of extensive overlying clay units and its overall depth.

2.4 GROUNDWATER SUBBASINS

The groundwater bearing deposits in Yolo County are contained in the Sacramento Valley Basin (DWR, 1978). This report utilizes a subdivision of the Yolo County groundwater-bearing area into seven informal hydrologic units, or subbasins, based on geologic, aquifer, and topographic characteristics (Figure 2.6). A related water resources investigation in Yolo County is presently underway by DWR and others. Specifically, the *Yolo County Integrated Regional Water Management Plan* (DWR, 2004) is in preparation and includes work by DWR to define subbasin areas. Prior investigations have delineated somewhat different subbasin areas than those shown in this AB 303 report and the IRWMP. However, as a result of this AB 303 Project and concurrent IRWMP subbasin area definition efforts, and mutual interests by DWR and AB 303 program participants in establishing consistent hydrologic units/subbasins, increased coordination among state and local investigators has been facilitated through this AB 303 Project. Technical exchanges initiated during the AB 303 draft report review resulted in mutually agreeable first steps that advance unification of the Yolo County hydrologic units.

For purposes of this AB 303 report, seven subbasins are described below and shown on Figure 2.6, including:

- Dunnigan Hills Subbasin
- Buckeye/Zamora Subbasin
- Capay Vally Subbasin
- Western Yolo Subbasin
- Lower Cache-Putah Subbasin
- Northern Sacramento River Subbasin
- Southern Sacramento River Subbasin

In coordination with DWR, and the work it is concurrently conducting in Yolo County, several steps occurred to develop consistent subbasin nomenclature. The Westeran Yolo Subbasin referenced in this report is described as including two subunts in the IRWMP. These subunits include the Hungry Hollow unit located north of Cache Creek and the Upper Cache-Putah Subbasin located south of Cache Creek. Simlarly, this report refers to the Buckeye/Zamora subbasin located north of Cache Creek and east of the Dunnigan Hills. This subbasin nomenclature is an interim step toward recognizing two separate units; the northern unit constitutes a separate subbasin (the Buckeye Creek Subbasin) and the southern unit (the Zamora subunit) becomes the northern part of what in the future is planned to be referred to as the Eastern Yolo Subbasin. Thus, the Eastern Yolo Subbasin is comprised of the Zamora subunit and the Lower Cache-Putah Subbasin (subunit).

Additional steps remain to define consistent subbasin and subunit boundaries for purposes of the ongoing countywide monitoring program (and also independent entity programs) and data analyses and applications using the WRID. One of these steps includes mapping that shows the subbasin boundaries coordinated with DWR. While most of the boundaries shown in Figure 2.6 are similar to those in the IRWMP, there are some slight differences. It is anticipated that as actions occur to continue the countywide program, an addendum to this report will describe a consistent set of the hydrologic units/subbasins proposed for water resources data collection and analyses.

2.4.1 Dunnigan Hills Subbasin

To the northwest, the Dunnigan Hills represent a low hilly area of uplifted Tehama Formation or nonmarine deposits with a thickness of up to 2,000 feet. These deposits appear to contain fresh groundwater, but previous reports indicate that aquifer material may be largely lacking. Little groundwater development appears to have occurred in the hills, and the area may be important only as a recharge area to the rest of the basin. Little study of this area was made for this report, other than literature review.

2.4.2 Buckeye/Zamora Subbasin

To the northeast, the Buckeye/Zamora Subbasin underlies the Valley floor east of the Dunnigan Hills. Little review of this area was made for this report except from previous literature. The area is considered to be underlain by alluvium and nonmarine deposits similar to those seen further south. Future detailed hydrogeologic study may be considered as a potential objective to better define the aquifer system in the Yolo County area.

2.4.3 Capay Valley Subbasin

The Capay Valley Subbasin is a small, structurally controlled valley of Cache Creek bound by faulted marine deposits to the east in the Capay Hills and the Coast Range to the west. Alluvium and the Tehama Formation are present in the valley floor with a thickness up to 1,000 feet. The valley appears to be connected to the larger groundwater basin through downstream alluvium and the underlying Tehama Formation along Cache Creek. The northern end of the valley is separated by a topographic divide of the Tehama Formation, although some groundwater connection may be possible north to Colusa County. No detailed study of the Capay Valley was made for this report, although it is recommended that the geologic and stratigraphic relationships of the alluvium and nonmarine deposits are studied at a future date.

2.4.4 Western Yolo Subbasin

The Western Yolo Subbasin is defined on the north and east by the alluvial plains lying west of the roughly north-south line extending from the western edge of the Dunnigan Hills north of Cache Creek, just east of the mapped Tehama Formation exposures near the Woodland-Watts Airport area and Plainfield Ridge and south to Putah Creek. This subbasin is bound on the south by Putah Creek and extends to the western edge of the mapped Tehama Formation in the low hills marginal to the Coast Range. The exposures of the Tehama Formation may be an important source of recharge for the Tehama Formation further east. The gentle alluvial plain area is underlain by thin alluvium overlying the Tehama Formation. These nonmarine deposits appear to be sand poor except in the vicinity of Putah Creek. Deep testhole control is relatively poor in this subbasin, and additional geologic study using water well data may be warranted to examine shallow and intermediate zone stratigraphic relationships.

2.4.5 Lower Cache-Putah Subbasin

The Lower Cache-Putah Subbasin is bound on the west by the semi-arbitrary boundary of the Western Yolo Subbasin, on the north by Cache Creek, on the east by the flood plain deposits and subsurface occurrence of the Eus and on the south by Putah Creek. The area is underlain by alluvium and nonmarine sedimentary deposits and encompasses most of the designated sand sequences (Els, Ds, Elus) of the upper Tehama Formation. The subbasin also encompasses nearly all of the major groundwater pumping for municipal supply (Davis and Woodland). Further hydrogeologic evaluation of this subbasin is important to advance understanding of the aquifer system. The additional information would also in the future facilitate efforts to forecast the effects of future groundwater development and/or variable hydrologic conditions on subbasin conditions.

2.4.6 Northern and Southern Sacramento River Subbasins

These subbasins encompass the eastern part of Yolo County and contain the flood plain/basin and Sacramento River area. The area is underlain by alluvium and nonmarine deposits. While at least some of the sand sequences occur in the subbasin, there is also a component of eastern sourced alluvial plain and/or tributary fluvial deposits in the nonmarine section. In addition, northeast of Woodland, a lower concentration of sand units occurs in the Tehama Formation. A study to examine the stratigraphic and hydrologic relationships between Yolo County and Sacramento County groundwater bearing nonmarine deposits may provide interesting insights into the Sacramento Valley Basin aquifer system.

2.5 SURFACE WATER HYDROLOGY

Surface water supplies in Yolo County include numerous creeks and streams emanating from the Coast Range and foothills and flowing into the County and also the Sacramento River located along the eastern boundary of the County. Significant surface water courses include Cache Creek, Putah Creek, the Sacramento River, and the Colusa Basin Drainage Canal. Precipitation and runoff strongly influence local hydrology. The prior report by Scott and Scalmanini (1975) describes precipitation occurring in cyclonic storm fronts where most of the rainfall occurs during 6 to 12 hour periods. Topographic characteristics result in high percentages of runoff from the mountains and foothills.

Winter rainfall is stored in reservoirs located outside Yolo County and then released during the summer from Lake Berryessa to Putah Creek, and from Clear Lake and the Indian Valley Reservoir to Cache Creek. The Colusa Basin Drainage Canal carries water into the County throughout the year. The Sacramento River experiences high flows in the winter and spring, and diversions for irrigation occur from the River to the Yolo Bypass during the summer. The Scott and Scalmanini (1975) report also provides detailed descriptions of five “runoff basins” that constitute the watersheds associated with the major drainage courses in the County. These include: Colusa Basin, Cache Creek Basin, Willow Slough Basin, Putah Creek Basin, and East Yolo Basin.

The District’s water supply system essentially consists of Clear Lake, Indian Valley Reservoir, Cache Creek, and the groundwater basin within the District. The District manages two small hydroelectric plants, two reservoirs, more than 150 miles of canals and laterals, and three dams including the world’s longest inflatable rubber dam.

Since completion of the Indian Valley Reservoir in 1975, the District’s water resources became less vulnerable to the dry years that periodically limit water supplies in Yolo County. The dam and reservoir are located on the North Fork of Cache Creek approximately 54 miles from the Capay Diversion Dam. This six-mile long, one-mile wide reservoir provides long-term irrigation storage and mitigates the potential for flash flooding in Cache Creek. As described in the District’s *Water Management Plan* (Borcalli, 2000), the District manages releases from this reservoir in part to augment releases from Clear

Lake. Water supplies from this reservoir are used to meet current year demand; the facility is not operated to maximize carryover storage. The facility includes a hydroelectric plant that produces energy as water is diverted through an outlet.

The District's operational strategy (Borcalli, 2000) maximizes storage in the groundwater basin. The conjunctive water management benefits associated with the Indian Valley Reservoir and other District operations are directly evident in long-term hydrographs for representative wells that show recovered groundwater levels after the reservoir came online in 1977 to 1978.

3.0 WATER RESOURCES INFORMATION DATABASE

3.1 DATA COLLECTION AND SECURITY

A significant component of the AB 303 Project was the compilation of data from different agencies into a comprehensive water resources information database. As a first step in this effort, surface water, groundwater, and well records within Yolo County were requested from agencies that collect and maintain these data. Table 3.1 lists the types of data requested from the agencies along with possible sources of these data. Electronic records were the preferred format; however, hard-copy records were accepted if that was the only form available. It was assumed that historical data provided by agency participants were already reviewed for quality assurance and quality control (QA/AC). No additional QA/QC of historical data was conducted.

Table 3.2 lists the agencies contacted and data provided along with the number of wells or sites, period of record, comments regarding how data were handled, and recommendations for future actions. Generally, well construction, well location, groundwater levels, and groundwater quality information were entered into the database. Surface water flow and quality data and groundwater data from potentially contaminated sites (landfill, wastewater treatment plants and underground storage tank cleanup sites) were collected if possible. Historical surface water flow from USGS for ten sites in Yolo County is included in the database as well as limited surface water quality from DWR. However, surface water data is not evaluated for this project. Key sources of data received for development of the WRID are described below.

3.1.1 California Department of Health Services

Water quality information for public water systems is maintained in a database at the California Department of Health Services (DHS), Drinking Water Program. DHS regulates all large public water systems (>199 connections) (pers. comm., Brian Kinney, District 9, Sacramento, DHS, December, 2003). The water analysis data transfer from water systems to DHS became automated on January 1, 2002, (pers. comm., Dawn Leigenger, DHS, December, 2003) when water quality laboratories were required to submit electronic data directly to DHS. Prior to January 1, 2002, the data was hand-keyed into the DHS database twice and then compared for accuracy, so these values are considered to be very reliable. Although small public water systems (serving five to 199 connections) are regulated by Yolo County Environmental Health Department (YCEHD), water quality information for these systems is also stored in the DHS database.

3.1.2 California Department of Pesticide Regulation, Ground Water Protection Program

The California Department of Pesticide Regulation (DPR) is a division of the California Environmental Protection Agency (Cal/EPA) and has both groundwater and surface water protection programs. The groundwater protection program purpose is to "prevent pesticide pollution of groundwater aquifers that may be used to supply drinking water." DPR is required to establish a Groundwater Protection List of pesticides that may pollute groundwater, monitor for these constituents, and maintain a database of the results. They have established a list of seven pesticides that have been found in groundwater (6800a) and also a list of pesticides that have a potential for being detected in groundwater (6800b). The 6800b list is constantly changing as pesticides change and the properties of the chemicals used in the pesticides are better understood. The program is described on the DPR web site: www.cdpr.ca.gov. The majority of data is collected by DHS, however, all government agencies that sample wells for pesticides are required to submit their sampling results to DPR.

3.1.3 California Department of Water Resources

DWR maintains a variety of databases that contain hydrologic data for the State of California. The Water Data Library (WDL) consists of water level measurements (1929 to present) and water quality (1998 to present). Water quality data in this database have been QA/QC'd. For this project, well construction information was provided for 862 wells in the water level monitoring program with measurements prior to 1992. The Water Data Information System (WDIS) contains water quality data for 1939 to 1990. The WDIS water quality data has no quality control or analytical method information. Water quality data for Yolo County for 1990 to 1998 were provided in hard copy and entered into the project database. Over 7,300 scanned well logs for wells drilled prior to 2000 were provided on a CD. Additional drillers' logs were copied at the DWR office for wells in Yolo County; these logs were predominantly for wells constructed after 1999. In addition, well construction information for 2,505 wells in Yolo County was provided by Ann Roth from DWR (pers. comm., December, 2003) in a database called Welma.

DWR has an ongoing water quality monitoring program in Yolo County that began in the late 1960's and continues to the present. This water quality network currently consists of about 20 domestic wells. All analyses are processed at a DWR laboratory. Prior to 2000, the samples from the DWR well networks were analyzed every other year for a partial analysis and every ten years for a complete analysis. Starting in 2000, full analyses were performed every other year due to reduced laboratory costs. Half of the 23 wells are sampled every year.

3.1.4 Yolo County Environmental Health Department

Yolo County Environmental Health Department (YCEHD) regulates public water systems with fewer than 200 service connections, such as small communities, restaurants, and gas stations. The nearly 100 public water wells range from 100 to 400 feet deep and are generally tested annually for nitrates (YCEHD) and every three years for general minerals (well owner). Groundwater quality results are reported to DHS for inclusion into their database.

3.1.5 Confidentiality and Data Security

During the project, unanticipated data confidentiality and security issues arose that were much more involved than considered when the initial project proposal was prepared in May 2001. Various agencies were contacted about furnishing data that they manage. During this inquiry, responses were received, particularly from State agencies (including DWR) that expressed concern about providing the data for this project. The data issues range from location information (DHS, DWR, and DPR), construction information (by DWR, this was anticipated), existing water quality information (DWR expressed concern that it did not want data that it has collected as part of the Yolo County program distributed in a manner that might jeopardize the continuation of its program), and general concerns expressed by AB 303 Committee members and others about issues associated with positive findings, particularly if there are findings of synthetic organic chemicals, high nitrates, or pesticides.

In light of the above issues, and particularly in response to concern about enforcement actions that might be taken by a state agency in the event of a positive finding, phone contacts were initiated with state agencies regarding notification of positive findings (e.g., detections of pesticides, volatile organic chemicals, etc.). The state agencies verbally communicated that they do not implement regulatory action for detections occurring on private property (unless it is associated with business activity). Related to these communications, a follow-up letter was prepared to confirm the information that was communicated during these calls. [Notably, although not indicated during conversations occurring with the state agency personnel, it was confirmed that the State Water Resources Control Board may be prompted to investigate to some degree if they are concerned that some neighboring activity is the source of the detections.] Letters to confirm the telephone conversations, and responses by the agencies to these letters, are included in Appendix B.

For purposes of this report, confidentiality regarding well location, well construction details and water quality data were each addressed. Well locations are kept confidential in this report by not listing well identifications, owner names, or addresses. Well locations are represented on maps using large symbols without local roads as a reference. Well construction information is discussed and displayed only generally by assigning a well to an aquifer/zone based on well construction information; individual well construction information is not revealed. Water quality information is only generally linked to a specific well except where a state well number (SWN) is used in a few cases to link map information to graphed information. Further security consideration as part of future program efforts are discussed in parts of Chapters 6 and 7.

3.2 DATABASE CONSTRUCTION

The Yolo County WRID structure has been developed to incorporate existing and new data about groundwater and surface water resources within Yolo County. The data incorporated in the WRID will be used on an ongoing basis by collaborating agencies to evaluate water supply conditions within the County.

In order to best meet these needs, the database was designed using Microsoft Access 2000. The Access software is widely available and user-friendly compared to other database software. These attributes facilitate use of the database by the different collaborating agencies. Access has the capacity (two GB per file) to store historical and future data, and the structure can be transitioned to larger-scale database software if this becomes necessary. As with other database software, Access is capable of importing data from and exporting data to other systems; data can also be exported for use in many other commercially available analytical software.

The database structure was designed to maximize the utility of the data, and it is similar to the standard structure used by the USGS and DWR. All of the data entered into the database identifies the data source. The bulk of the data is for wells located throughout Yolo County. Each well is uniquely identified by a SWN, or, in the case of some recent DHS records that did not identify the SWN, by Source Number. In the case that more than one agency maintains data for a well, the agencies sometimes refer to the same well by different names. Each of these well names is entered into the database along with the unique SWN for the well. In this way, records from the different agencies can be entered by the well name used by that agency (which streamlines data entry), but it can also be combined to form a complete dataset for each well by SWN. Appendix C provides format guidelines for data to be entered into the WRID.

An index has been established that lists all township/range combinations within the study area. By using this index, queries of data can be limited to wells located within the study area boundaries.

Table 3.3 lists the types of information (tables) included in the database, the number of entries in each table and the information included for each entry (where available). For example, the well construction table contains 4,863 records with the following information: construction date, well depth, borehole depth, seal depth, and diameter. Perforation information has been entered, and for the wells considered for the monitoring network, zones have been assigned to each perforated interval. Many wells in the database have perforations in more than one zone. Location information consists of: latitude, longitude, horizontal datum, reference point elevation, and vertical datum.

Water level data are entered by well name and include measurement date, reference point elevation, depth to water, and any comments included in the original data. All water levels are assumed to be static unless otherwise specified.

Water quality data are also entered by well name and include measurement date and time, analyte, result, and units. When available, the method for the analysis has also been included. Non-detect results are identified as "–9999" and include the detection limit when available. For historic records of non-detects without a detection limit, a result of "0" has been entered.

Within the database, each water quality analysis has only one name. This is necessary so that all of the results for a particular analysis can be considered together. For example, an unfiltered nitrate analysis is always entered as "Nitrate, unfiltered." However, different agencies often report such analyses using slight variations of the same name, for example "Total Nitrate." The database would not recognize these as the same analysis. Indices can be created to transform between the naming conventions and, thus, simplify the entry of water quality data for different agencies. Alternatively, agencies could be provided with a list of standard analyte names and instructed to provide data using these conventions (Table 6.2). Appendix C includes a table of analytes currently in the database and procedures for providing information for an analyte not listed in this table.

Quality control of the database has been mainly in two forms: graphing of water quality and water level data and spot-checking of data used for further analysis. Graphs have been prepared for all wells with more than 50 water level records and also for all wells with more than several water quality records for the key constituents considered in this report (specific conductance (EC), nitrate, and boron). These graphs have been grouped by SWN; they have also been evaluated in terms of similarity in trend with nearby wells and for outliers within the well record. During further analysis of the data, described elsewhere in this report, spot-checking against agency-provided data was performed whenever questions arose about particular data. Well location, construction, water quality, and water level data are flagged within the database to identify the confidence in the data. When new records are entered, they are flagged by default as "Not QA/QC'd." As these new records are evaluated, the flag can be updated to either "Questionable" or "Not Questionable."

The graphing described above has been done within the AB 303 Project database, in the form of standard queries and reports that produce small graphs (nine per page) suitable for general evaluation of the data. Additional queries and reports within the database have been used to prepare all of the figures in this report, either directly within the database, or by linking with other analytical software. Exporting data for a particular analytical application is generally (and most easily) done by preparing a query that returns the desired data, and then either exporting the data or copying and pasting into spreadsheet software such as Microsoft Excel.

Analysis using ESRI ArcGIS software (used to prepare the map figures in this report) is done using ArcGIS 8.3, which links directly to Microsoft Access and pulls data from tables or queries. The data displayed and analyzed using ArcGIS are updated whenever data within the Access database are updated. This is ideal since the database tools available within Access, at this point, are more functional and user-friendly than those available within ArcGIS. Access is also more widely available and used by more agencies than ArcGIS.

In general, tools within the database (queries and reports) are best developed as needed. Basic queries that are already set up in the database provide a template that can be modified by intermediate Access users to meet more specific requirements. As the uses of the database change, the database should be evaluated to determine if the basic tools within it are still meeting users' needs. As use of the database expands, more tools can be created to simplify new tasks. The database structure has sufficient flexibility that it should be able to be expanded to meet future requirements without much difficulty. As these new requirements arise, the District and other collaborating agencies can develop new tools. Such tools could also be shared among users. To the extent practical, the District should consider establishing a users' group for the database to address these sorts of questions and problems on a collaborative basis as they arise.

4.0 GROUNDWATER MONITORING NETWORK

There is currently a network of wells that is monitored for groundwater levels by the District, DWR, federal agencies, municipalities, UCD, and others (Figure 4.1). Prior investigations of area groundwater quality have occurred; however, these efforts were not part of a continuing groundwater quality monitoring program. A primary objective of this AB 303 Project has been to develop a coordinated groundwater monitoring program, including groundwater levels, water quality constituents and other parameters as further described below, that improves the understanding and thus management of groundwater underlying Yolo County.

At the outset of the AB 303 Project, the District invited others in addition to those that were part of the DWR grant fund application effort to participate in the project. The AB 303 Committee was established and meetings were held during the project to describe project activities and invite input from committee members. During the October 2003 AB 303 Committee meeting, the groundwater quality monitoring program and network design were described to Committee members and input was sought on groundwater quality issues of interest. During this meeting groundwater quality "focus" issues were discussed, including:

a. Urban areas (volatile organic compounds [VOCs], general minerals, nitrate, trace metals [e.g., arsenic, selenium, hexavalent chromium]);
b. Agricultural (general minerals, nitrate, trace metals [including boron], pesticides);
c. Commercial (general minerals, nitrate, VOCs, trace metals) [Large commercial areas of interest as compared to very local site investigations];
d. Areas of interest for future water resources management activities, e.g., future managed recharge programs; and
e. Regional water quality characterization of aquifer system, development of expanded baseline information and network to assess future trends.

As further described below, feedback from AB 303 Committee members and others was used to guide the development of the baseline sampling program.

This Chapter describes the well qualification process and the groundwater level and groundwater quality monitoring that has been conducted by various entities in Yolo County since 2000. This Chapter also describes how, collectively, these independent networks and programs can be coordinated to constitute an ongoing groundwater level and quality monitoring program.

4.1 WELL QUALIFICATION

One of the key objectives of the AB 303 Project was to review all wells included in the monitoring network and "qualify" them such that the collected data are representative of specific vertical zones in order to better address specific groundwater quantity or quality issues. To accomplish this objective, all wells with relatively recent monitoring data (as collected by independent entities during January 2000 to March 2004) were reviewed to determine whether well construction information was available for these wells. Note, the monitoring network referred to herein describes monitoring conducted by program participants and does not include monitoring wells incorporated in point source contamination investigations. It was learned during the well qualification task that well construction information had not been previously correlated or otherwise documented for the District's long-time water level monitoring network, nor had there been a correlation made for most other wells that were included in the "monitoring well" category. As a result, more than 7,325 well logs were obtained from DWR (electronically scanned files) to connect all known records to the wells being monitored. Ultimately, the well qualification task attempted to identify and then correlate well construction information for 558 wells. Following the work conducted to link the wells already being monitored to construction data, a zone(s) of completion was assigned to these wells. A designation method was applied to indicate the level of information available (or not available) for the monitored wells that included:

- Well log (complete log located),
- DWR perforation interval (completion interval included in electronic data received from DWR),
- DWR depth (well depth included in electronic data received from DWR), and
- No well construction information (no type of construction information could be identified for the well).

Tables 4.1 and 4.2 summarize the results of the well qualification task by subbasin and by zone. A total of 410 wells are in the groundwater level monitoring network, including:

- 166 wells completed in the shallow zone,
- 63 wells completed in the intermediate zone,
- 19 wells completed in the deep zone,
- 72 wells completed in multiple zones, and
- 90 wells of unknown completion.

A total of 232 wells are in the groundwater quality monitoring network, including:

- 57 wells completed in the shallow zone,
- 33 wells completed in the intermediate zone,
- 10 wells completed in the deep zone,

- 43 wells completed in multiple zones, and
- 89 wells of unknown completion.

As noted above, the total number of all monitored wells is 558 because there is some overlap between those monitored for levels and quality. The locations of wells monitored for groundwater levels and/or quality during the period January 2000 to March 2004 is shown by entity on Figure 4.2. Due to the well qualification process, it is clear that many of these wells have no known construction information. An important outcome of the well qualification effort includes the development of a better understanding of which zones and subbasins have comparatively better spatial and vertical monitoring coverage. There are spatial monitoring biases since a large source of the water quality data is from DHS; correspondingly, there is a higher density of monitoring data in the larger municipal areas.

As described in Chapter 3, the essential well log data and zones of completion for wells monitored in the County have been incorporated in the database. This information is also used in many of the data evaluations conducted for this project, including zone-specific queries that have been designed and used to illustrate current groundwater conditions.

4.2 GROUNDWATER LEVEL MONITORING NETWORK

The network of groundwater level monitoring wells in Yolo County has been reviewed and inventoried. The existing network includes wells monitored by the District; the U.S. Bureau of Reclamation (USBR); DWR; USGS; cities of Davis, Winters, and Woodland; UCD; Reclamation District 108; gravel mining companies; and the Rumsey Band of Wintun Indians (Figure 4.3). Table 4.3 summarizes the entities conducting groundwater level monitoring, the number of wells monitored, and the monitoring frequency.

The coverage available with the existing groundwater monitoring network was reviewed and modifications are recommended due to that evaluation. During AB 303 Committee meetings, concerns were expressed about groundwater conditions in Capay Valley. As described below, the network has been expanded in this area to establish a more comprehensive understanding of stream-aquifer relationships and groundwater conditions in this subbasin. Additionally, the spatial and vertical coverage of wells with monthly monitoring is currently limited, so recommendations are provided in Chapter 6 for expanded monitoring of either currently monitored wells and/or inclusion of additional wells in the network (Figure 4.4).

4.2.1 Capay Valley Groundwater Level Monitoring

Due to interest expressed by a number of participants of the AB 303 Committee, the groundwater level monitoring network in the Capay Valley was expanded to develop a more comprehensive understanding of existing groundwater conditions and also to provide a baseline to identify future changes in conditions. Specifically, as part of this task, 12 new wells were identified to complement the existing water level monitoring network of 16 wells north of the town of Capay. The existing and new wells, along with five wells monitored on behalf of the Rumsey Band of Wintun Indians, comprise the expanded network. Monthly monitoring is recommended for this network of 33 wells. Once a historical record is established, decreased monitoring of some wells may be appropriate.

Expanding the Groundwater Level Monitoring Network in the Capay Valley

The tasks performed to expand the network are summarized below:

Task 1: Hydrogeologic references were reviewed to identify individual zones to target for the expanded well network, and candidate monitoring wells were located on an area map.

Task 2: Well drillers' reports from DWR were reviewed and 51 wells were selected to achieve geographical representation of the Capay Valley while reflecting depth intervals representative of shallow (young alluvium) and deeper zones (presumably Tehama Formation). Preference was given to wells with single perforated intervals. Other well selection criteria employed were the quality of the well location description and completeness of drillers' reports.

Task 3: Using plat maps from the County Assessors' office, landowner names and addresses were retrieved for 51 wells. A letter was prepared and sent, by the District, to the well owners that describes the District's AB 303 program and seeks the owners' permission to retrieve water level measurements in their wells.

Task 4: Communications with property owners were conducted via phone, fax, and email to discuss the program purpose, discuss owner interest in participating in the program and owner authorization for monitoring, and arrange a field visit.

Task 5: Three rounds of field inspections were conducted in April and May 2004 to determine the wells' suitability for monitoring. Wells were digitally photographed and details (including well location, construction, and accessibility) were recorded to update the District's water level network records.

Task 6: A letter was prepared and sent to all landowners/parties initially contacted to inform them whether their well was selected for inclusion in the water level monitoring network. For those owners whose wells were included in the network, the ongoing water level monitoring program was briefly described in the letter and they were informed of notifications they will receive about the monitoring activities, and the information they will receive in return (e.g., a hydrograph) from the District.

Only a few owners of the initially selected 51 wells responded positively to the request for permission to monitor their well. The lack of response constrained the availability of wells with known construction details. Following initial attempts to garner program interest, two Valley residents assisted with communications about participation in the program, and this resulted in some additional positive responses from well owners that were not part of the initial selection. Due to the overall lack of response, geographical preferences for well location were affected; also, well construction information for most of these wells was not available.

Recommended Network Expansion

In addition to the 16 wells that have been monitored on a semi-annual schedule in the past, 12 new wells were selected for incorporation in the monthly water level monitoring network (Figure 4.5). The depths and perforated intervals of most wells in the expanded network are known, however, for four wells only the depth is known. Conversely, for ten of the 16 existing network wells, only depths are known but not their perforated intervals; and for two wells no construction information is available. Lack of knowledge regarding the exact position of the perforated interval in ten of these wells is less critical to the collection of meaningful data due to their relatively shallow depths (18 to 80 feet). However, four wells are significantly deeper (130 to 175 feet). These wells are also located near the area of anticipated increase in demand on groundwater resources. Video logging of these wells, and the two wells with no construction information, is recommended as feasible. Other recommendations include additional efforts to add three wells that were part of the initial candidate monitoring well list.

4.3 GROUNDWATER QUALITY MONITORING NETWORK

At the outset of the AB 303 Project, groundwater quality monitoring was understood to be limited to the requirements for community water supplies. Previously, the WRA with assistance from LSCE, compiled a *Data & Information Directory for Water Resources of Yolo County* (1998). This Directory was prepared to gain a better understanding of the data being collected, additional data that would be desirable (especially groundwater quality data), and the tasks necessary to move toward development of a centralized data repository or WRID.

As part of the AB 303 Project, the network of groundwater quality monitoring wells in Yolo County have been reviewed and inventoried. The existing network includes wells monitored by the District DWR; small water systems; municipalities; UCD; gravel mining companies; and the Rumsey Band of Wintun Indians (Figure 4.6). Table 4.4 summarizes the entities conducting groundwater quality monitoring, the number of wells monitored, the monitoring frequency, and the constituents monitored. Also included on Table 4.4 is the new groundwater quality monitoring program established for the District as part of the AB 303 Project.

The coverage available with the existing groundwater quality monitoring network was reviewed, and that review helped guide the development of the new District groundwater quality monitoring program. Additionally, the spatial and vertical coverage of wells was evaluated during the assessment of current County groundwater quality conditions, and data gaps have been identified. Recommendations are provided in this report for expanded monitoring using existing qualified wells and/or new wells depending on the results of efforts to coordinate and prioritize ongoing monitoring program interests.

4.3.1 Baseline Groundwater Quality Sampling Program

As an initial step to develop a groundwater quality monitoring program, candidate wells for the baseline sampling program were selected based on well locations and well completion relative to regional water quality issues of interest. Historical groundwater quality data were also evaluated, analytes monitored and trends of selected constituents in existing wells (particularly the DWR program wells), to identify the locations where sampling of "infill" wells would provide the greatest benefit. Existing private domestic wells of known completion were one category of candidate groundwater quality monitoring wells of particular interest due to the typically shallower completion of those wells. Shallow domestic wells were targeted for their potential for pesticide and nitrate exposure that would act as an early warning prior to these constituents migrating to lower zones.

4.3.2 Identifying Wells for Inclusion in the Baseline Monitoring Network

In coordination with the District, a letter was prepared and distributed to 143 owners and/or tenants of properties already included in the District-wide water level monitoring program to invite participation in the AB 303 baseline water quality sampling program. Subsequently, follow-up phone calls were made to (or received calls from) the property owners receiving the letter. A very positive response was received to the initial inquiry with at least 69 letter recipients indicating interest in participating (Table 4.5).

Following evaluation of the information received from the letter inquiry, evaluation criteria were established to select the wells determined to be suitable for the baseline monitoring program (Table 4.6). A key factor in the evaluation was well construction information (including at least information on well depth). Factors that would eliminate or reduce interest in including the well in the program were also considered. Following this initial selection process, further arrangements were made with the owners of potential monitoring well candidates for well inspection (check physical location of well and all necessary information related to accessibility, construction, and sampling point). At the time of the well inspection, any additional arrangements needed prior to sampling were identified (e.g., installation of sampling tap, notification/coordination with owner or tenant about actual sampling date, etc.). Following the field inspections, wells to be included in the baseline sampling program were selected. The baseline program included 33 wells, and the owners of these wells were subsequently contacted by phone to confirm that their well had been selected for inclusion in the program.

4.3.3 Baseline Sampling Program

The baseline sampling program was designed to include general mineral constituents and selected inorganic constituents (nitrate, boron, selenium, arsenic, and hexavalent chromium) at the 33 sampling locations (Tables 4.7 and 4.8). Of these 33 locations (Figure 4.7), 12 were selected for additional analyses, including volatile organic analyses and/or pesticide suites. The pesticide suites included EPA Methods 8141 (organophosphate and organonitrogen pesticides), 8081A (organochlorine pesticides), 8151A (phenoxy acid herbicides), 632 (phenyl urea herbicides), 8318 (carbamate pesticides) [Appendix D describes the process used to select the pesticide analytical suites]. Prior to the sampling event, the program was presented at a meeting of the AB 303 Committee on February 25, 2004.

4.3.4 Baseline Sampling Event

During March 2004, the wells selected for the baseline sampling program were sampled using a standard sampling protocol (Appendix E). As part of this process, sampling taps were installed at 29 wells. Initial Global Positioning System (GPS) measurements were made during the baseline sampling program; at a later time, GPS measurements will be re-measured by the District with more sophisticated instrumentation to achieve a greater degree of precision of the location coordinates and the reference elevation for those wells that may also be included in the groundwater level monitoring program. Field notes recorded during the initial well inspection and also during the baseline sampling event include information about the site access, well construction, and owner/tenant contact information. A field book has been assembled for use by the District for continuation of the groundwater quality monitoring program.

Samples collected during the baseline sampling event were submitted to Kiff Analytical Laboratory in Davis, CA (and also to Cal Science, a subcontract laboratory of Kiff) for general minerals, inorganic constituents, and volatiles analyses. Samples for pesticide analyses were submitted to Environmental Micro Analysis, Inc. in Woodland, CA. Sample results were received in both electronic and paper format. The data were reviewed, and the electronic versions facilitated data transfer into the database system.

Two follow-up correspondences were prepared in association with the baseline sampling event. One letter was provided to program participants in April 2004 to thank them for their participation and to transmit copies of the laboratory results and a table summarizing the constituents tested, results received, and information on water quality standards. The other letter was provided to property owners who volunteered to be in the program but whose wells were not selected.

4.4 ONGOING PROGRAM

Based on results of the activities described above, enhanced groundwater level and quality monitoring networks have been formulated. Chapter 6 describes the Ongoing Monitoring Program that formalizes and integrates the already occurring monitoring efforts of the District, collaborators, and the state and federal agencies; it also includes the new District groundwater quality monitoring and recommendations for further monitoring program improvements.

5.0 GROUNDWATER CONDITIONS

Numerous earlier geologic and water resources investigations describe water resources in Yolo County. Notably, as a result of this project, there is now a means to more easily update and expand on the previous observations and analyses and to investigate new issues of interest. This chapter provides an update of groundwater level and groundwater quality conditions. The data incorporated in the WRID, and particularly the qualification of those data, allow refined summaries and illustrations of the groundwater level and quality records.

This chapter describes the occurrence and movement of groundwater beneath Yolo County and adjoining areas. Historical and current groundwater contours are presented, and hydrographs for indicator wells completed in different zones display historical water level trends for different subbasins of the County. Groundwater quality conditions in the County (including the results of the baseline water quality sampling event) are described and illustrated by subbasin. Queries have been developed for this and future evaluations that illustrate the spatial distribution of selected water quality parameters by concentration ranges in specific zones. Indicator wells have been selected as available for some subbasins to show trends of selected constituents. Illustrations of groundwater quality and zone stratigraphic relationships are also discussed. Specifically, this includes an overview of spatial and vertical current constituent concentrations and variances between subbasins in constituent concentrations and concentration trends.

5.1 GROUNDWATER LEVELS

The District monitors groundwater levels through an extensive network of 153 wells throughout Yolo County. As described in Chapter 4, the countywide network includes monitoring conducted by numerous other entities and the total water level network since 1999 includes 410 wells. Figure 4.3 shows groundwater level monitoring locations for wells with a water level measurement from January 2000 through March 2004. The network wells have been qualified as possible by zone of completion and location within a subbasin. Wells comprising the network include: 166 wells completed in the shallow zone, 63 wells completed in the intermediate zone, 19 wells completed in the deep zone, 72 wells completed in multiple zones, and 90 wells with no construction information.

Annually, an Engineer's Report is prepared on behalf of the District to summarize the groundwater situation in the District area. The latest report (Wood Rodgers, Inc., 2003) also describes water management related activities, including surface water monitoring and management projects planned by the District. Other comprehensive reports, including Scott and Scalmanini (1975), have described historical groundwater conditions for the County. The report herein provides an update on conditions with particular focus on use of the network information that has now been qualified through this project to describe groundwater conditions by zone and also subbasin.

5.1.1 Groundwater Hydrographs

Historical water level records for the County were reviewed along with well qualification information to select representative, or indicator wells, for purposes of illustrating groundwater level trends by zone and subbasin. The locations of these indicator wells (and their completion zone) are shown on Figure 4.3. Six indicator wells were selected for the Capay Valley Subbasin due to interests expressed by members of the AB 303 Committee to develop a better understanding of groundwater conditions in the area. The following discussion of hydrographs is organized by zone.

Shallow Zone

Capay Valley Subbasin – The six indicator wells in the Capay Valley area, and completed in the shallow zone, were selected to include wells located at the upper portion of the Valley, along the Valley, and at the lower portion of the Valley. Figure 5.1 displays groundwater elevations for these wells; a long historical record is available that in most cases extends from 1953 to the present. Four of these wells are located nearer Cache Creek, and two wells are located away from it toward the margin of the subbasin. Groundwater elevations in all six indicator wells show generally stable levels. Wells located in close proximity to the creek show a groundwater elevation difference that corresponds with their position along the Creek.

The well showing groundwater elevations with the largest range of groundwater elevations is one of the indicator wells located toward the margin of the subbasin. Factors contributing to elevation differences ranging from about 380 to 410 feet mean sea level (MSL) were not explored for purposes of this investigation; however, the overall trend in elevations at this location appears stable.

Western Yolo and Lower Cache-Putah Subbasins – Five indicator wells were selected to represent shallow zone conditions across the Western Yolo and Lower Cache-Putah Subbasins. Figure 5.2 shows historical groundwater elevations for the period from the early 1950's to present for these five wells. Prior investigations have described the groundwater level decline observed prior to 1975 (Scott and Scalmanini, 1975). Water resources management actions, particularly surface water deliveries from the Indian Valley project to supplement County water resources, reversed this condition. Groundwater level trends since about 1995 show stable conditions in the five shallow zone indicator wells in the Western Yolo and Lower Cache-Putah Subbasins.

Intermediate Zone

Five indicator wells were selected to represent intermediate zone conditions; wells were selected from the Dunnigan Hills and Western Yolo and Buckeye/Zamora Subbasins. Figure 5.3 shows historical groundwater elevations for the period from the early 1950's to the present for these five wells. Unlike the shallow zone, groundwater elevations in the intermediate zone do not display historical (pre-1975) declining trends like those that occurred in the shallow zone. Groundwater elevations in the five indicator wells show stable conditions.

Deep Zone

Historical data for the deep zone are limited; however, six indicator wells were selected, including three wells located near Davis and in the Lower Cache-Putah Subbasin, and three wells located near Knight's Landing (e.g., near the boundary of the Buckeye/Zamora and Northern Sacramento River Subbasins (Figure 4.3)). The historical records for the wells located near Davis in the Lower Cache-Putah Subbasin extend from the 1980's to the present (Figure 5.4). A significant range occurs in the groundwater elevations (approximately 10 to –50 feet MSL); the overall trend in levels, though, is stable for these wells. The historical records for the three Knight's Landing wells extend from the late 1970's to present. Groundwater elevations range from about 0 to 30 feet MSL and show a stable trend.

Interzone Groundwater Elevations

As possible, historical groundwater level data for "paired" wells were evaluated. This entailed identifying wells completed in different zones located in the same general vicinity to assess hydraulic head differences and to compare water level responses in different zones. Figures 5.5 and 5.6 display two paired well sets; one set is located in the Dunnigan Hills area and the other is located near Davis in the Lower Cache-Putah Subbasin.

Groundwater elevations for shallow and intermediate zone wells in the Dunnigan area show significantly different elevations in these zones (Figure 5.5). The groundwater elevation in the shallow zone is about 175 feet MSL and exhibits little seasonal or long-term fluctuation, whereas the intermediate zone elevation is about 124 feet MSL and shows more fluctuation with time. Figure 5.6 shows two shallow zone wells and a deep zone well near Davis. The groundwater elevations in the shallow zone wells range from about 0 to 40 feet MSL. Groundwater elevations in the deep zone well range from about 0 to –50 feet MSL.

5.1.2 Groundwater Contours

Previous investigations have employed the aggregate of groundwater level data to prepare groundwater elevation contour maps. As indicted above, there can be significant differences in groundwater elevations; thus, a preferred approach is to assess the data by zone. An objective of this project included well qualification and using the well qualification process to refine the understanding of the measured data. The largest coverage of qualified data exists for the wells completed in the shallow zone. Therefore, for purposes of this report, contours have been prepared that are specific to the shallow zone. Contours of equal groundwater elevations were prepared for the shallow zone, including contours for Spring 1977, Fall 2003, and Spring 2004 (Figures 5.7, 5.8, and 5.9 respectively). For reference, shallow and intermediate zone completion wells in the groundwater level monitoring network are both shown on these figures. While the data for the intermediate wells has not been used for contouring, the limited distribution of these wells becomes apparent.

The groundwater elevation contours illustrate the typically observed easterly direction of groundwater flow across the Western Yolo and Lower Cache-Putah Subbasins. As also indicated on individual hydrographs, groundwater elevations during 1977 were considerably lower than subsequent years. Groundwater levels and gradients are somewhat similar for the Fall 2003 and Spring 2004 contours and are generally to the east.

5.2 GROUNDWATER QUALITY

This project creates the framework to facilitate future groundwater quality assessments. It helps identify, or confirm, baseline conditions. The abundant historical record for some constituents helps to highlight where important concentration similarities or differences are occurring when different zones and subbasins are compared. Notably, occurrences and trends for commonly measured constituents such as EC or nitrate also lead to the recognition of data gaps, particularly for other constituents that may be of interest but data may be deficient because these constituents are not part of the routine testing conducted by individual entities. Or, some data may exist for compounds such as arsenic; however, historically high detection limits have resulted in data that are now less useful for evaluating the potential impact and issues associated with the required change in the regulated drinking water level, which will be lowered from the current standard of 50 ug/L to at least 10 ug/L.

As described further below, the available data have confirmed previously reported trends. However, the refined approach developed through this project to evaluate the data set establishes the basis for more definitive future assessments of regional groundwater quality. For this project, trends for selected constituents were preliminarily assessed by subbasin and by zone. Future studies will build on and complement this basic framework. Noteworthy AB 303 Project findings show trends for some constituents in certain indicator wells, where at the same well another parameter selected for trend evaluation shows stable concentrations and no evidence of a trend. These differences provide further insights on the human-induced factors responsible for the trends; they also lend insight to natural conditions that govern the occurrence of constituents due to depositional factors or long-term recharge by source waters that contain similar constituents. As the physical conceptual model continues to be refined, particularly for the shallow and intermediate zones, depositional processes and groundwater flow paths will be better understood. Consequently, groundwater quality monitoring results, including the data developed as part of the historical record, will also be better understood. As trends are identified, long-term potential impacts can be assessed. Through proactive identification of such trends and impacts, water resources management actions can be employed to mitigate the potential for adverse impacts and enhance resource sustainability.

Current groundwater quality characteristics for each subbasin are summarized in tables contained in Appendix F. Each subbasin table contains a breakdown by zone (shallow, intermediate, deep) of the number of wells measured for 29 constituents during the period

January 2000 through March 2004. Due to the number of wells completed in multiple zones, this category is also included. There are also numerous other wells included in the overall groundwater quality monitoring network (e.g., the network comprising the monitoring conducted by numerous entities) for which there is no well construction information. As shown in Table 4.2, 89 wells in the regional groundwater quality monitoring network have no construction information. For purposes of the discussions below, attempts have been made to use primarily the qualified data. A few exceptions to this objective occur for figures that present all available historical data. The tables show the number of total measurements made for the 29 constituents, the range of values, and the average value. The constituents include: alkalinity, aluminum (Al), arsenic (As), barium (Ba), boron (B), cadmium (Cd), calcium (Ca), chloride (Cl), chromium (Cr), hexavalent chromium (Cr VI), copper (Cu), fluoride, hardness, iron (Fe), lead (Pb), magnesium (Mg), manganese (Mn), mercury (Hg), nitrate, pH, potassium (K), selenium (Se), silver (Ag), sodium (Na), EC, sulfate, surfactants, total dissolved solids (TDS), and zinc (Zn). Key findings from these tables are highlighted in discussions presented for selected constituents including EC, nitrate, B, As, Cr/Cr VI, Mn, and Se. The results for these constituents are summarized in Table 5.1.

Although this project is largely focused on regional groundwater quality conditions, this section summarizes locations of some of the known and potential point sources that have or could influence groundwater quality conditions. Locations of underground storage tanks and present or former land uses such as landfills and wastewater treatment facilities are shown on Figure 5.10 (the sources of information are noted on this figure). Water quality results were queried from the data for selected organic constituents; tetrachloroethene (PCE), trichloroethene (TCE), and methyl *tert*-butyl ether (MTBE). These data were provided by DHS for community systems and by individual entities. The wells tested for these constituents during the period January 2000 to March 2004 are shown on Figure 5.11. The results for this period showed few positive detections for the above constituents. Low levels of TCE (concentrations ranging from 0.5 to 0.59 ug/L; the maximum contaminant level (MCL) is 5 ug/L) were detected in one well on three occasions during 2001 to 2003. Three low level detections of MTBE (concentrations ranging from 1 to 1.4 ug/L; the primary MCL is 13 ug/L) occurred in three wells not used for water supply. No widespread issues that affect community water supplies due to organic chemical sources are present in Yolo County; there are point source contamination investigations that are being addressed to mitigate potential impacts.

5.2.1 Specific Conductance

Figure 5.12 shows the location of groundwater quality monitoring network wells with EC data for January 2000 to March 2004. EC records during this period are available for 125 “qualified” wells, including 48 in the shallow zone, 32 in the intermediate zone, 9 in the deep zone, and for 36 wells completed in multiple zones (Table 5.1). Figure 5.12 shows the maximum observed EC results at the network wells that are constructed in the shallow, intermediate, and deep zones (e.g., wells completed in multiple zones are not shown on this figure). The approach used to organize the data in the table and on the figure provides insights about the distribution of EC values and also indicates where data are sparse. The subbasins with the largest number of wells measured during the January 2000 to March 2004 period are the Western Yolo Subbasin for the wells completed in the shallow zone (23 wells) and the Lower Cache-Putah Subbasin for the wells completed in the intermediate zone (23 wells) and deep zone (8 wells). The Lower Cache-Putah Subbasin also includes 24 wells with multiple completions; these data are included on the summary table and provide some value for understanding the average groundwater quality produced by these wells that are included in the monitoring network. As noted above, there are many more wells that are monitored by individual entities that have no construction information; thus, the statistics for these wells are not included in the following discussion.

Below, key observations are presented that highlight the information shown for the zones underlying selected subbasins, indications of vertical differences in EC concentrations by zone, and trends for the historical record of selected wells completed in the shallow, intermediate, and deep zones.

Subbasin and Zone Assessments

EC averages in the shallow zone range from about 480 umhos/cm (Buckeye/Zamora Subbasin) to 1,470 umhos/cm (Lower Cache-Putah and Southern Sacramento River Subbasins). EC ranges for wells located in Western Yolo and Lower Cache-Putah Subbasins illustrate a clear increase in EC concentrations from west to east. The western portion of the Western Yolo Subbasin shows wells for the January 2000 to March 2004 period (Figure 5.12) that generally have EC values that are less than 900 umhos/cm, while the wells located to the east have values that range from 900 to 1,600 umhos/cm. This distribution has also been noted in previously published reports, including Graham (1997) and Evenson (1985) in terms of dissolved solids in groundwater. The secondary MCL (recommended value) for EC is 900 umhos/cm, while the upper and short-term MCLs are 1,600 and 2,200 umhos/cm, respectively. Based on average EC values presented for the subbasins and the range of ECs for the shallow zone showing an increase from west to east that exceeds the recommended secondary MCL, this presents a general water quality concern for wells completed in the shallow zone. As discussed further below, other positive influences (e.g., local recharge) result in locally improved water quality conditions.

EC averages in the intermediate zone range from about 470 umhos/cm (Dunnigan Hills and Northern Sacramento River Subbasins) to about 1,200 umhos/cm (Southern Sacramento River Subbasin). The available data for the January 2000 to March 2004 period mostly occur in the Lower Cache-Putah Subbasin; other subbasins have data from only one to three monitored wells. The Lower Cache-Putah Subbasin has an average EC value of about 1,040 umhos/cm, which is lower than that of the shallow zone (1,470 umhos/cm) for this subbasin.

The available data for the deep zone are the most limited with nearly all monitored wells occurring in the Davis area of the Lower Cache-Putah Subbasin. The EC average for these wells is about 600 umhos/cm.

Interzone EC Differences

The most obvious vertical concentration differences are apparent for the shallow, intermediate, and deep zones in the Lower Cache-Putah Subbasin where the average EC values decline with depth from 1,470 to 1,040 to 600 umhos/cm, respectively. Figure 5.13 displays these same vertical concentration relationships for EC and other constituents for the shallow, intermediate, and deep zones for three wells in the Davis area of the Lower Cache-Putah Subbasin.

Notable differences between zones are also present in other subbasins, including Capay Valley and the Southern Sacramento River Subbasin where EC values also decline with depth. The Western Yolo Subbasin shows a reverse condition where the EC value in the shallow zone is lower than that for the intermediate zone. However, the EC range is also significantly greater for the shallow zone in this subbasin, there are significantly more data for the shallow zone, and more data are from shallow wells located along Cache Creek. These many factors indicate recharge likely plays a role in the range of observed water quality and influences the overall average developed for the shallow zone for the Western Yolo Subbasin.

Preliminary Trend Assessment

In the previous investigation of Yolo County groundwater quality by Scott and Scalmanini (1975), groundwater quality for selected constituents was summarized for the Davis, Woodland, and other county areas. TDS concentrations were indicated to be increasing in the Davis area with shallow ground water shown as having a TDS of 500 mg/L in 1931 and increasing to 684 mg/L in 1970. The generally equivalent EC values for these periods would be about 750 and 1,020 umhos/cm. In Woodland, the TDS in the shallow zone in 1950-59 was 480 mg/L and 455 mg/L in 1970, or EC values of about 720 and 630 umhos/cm, respectively. As noted above, the current average value for the shallow zone in the Lower Cache-Putah Subbasin is 1,470 umhos/cm. Similarly, in 1970 the TDS for the intermediate zone in the Davis area was reported (Scott and Scalmanini, 1975) to be 695 mg/L (or about 1,040 uhmos/cm). The average EC for the intermediate zone in the Lower Cache-Putah Subbasin is 1,040 umhos/cm; however, the average for intermediate zone completion wells in the Davis area is about 1,170 umhos/cm (based on the average of maximum observed values during January 2000 to March 2004). An increase in salinity appears evident from the current data; EC values, at least in some areas, are continuing to increase, especially in the shallow zone.

The apparent EC increase is also borne out through long-term EC data plotted for individual wells. Figure 5.14 shows water quality plots for seven indicator wells located in four subbasins. Four of the seven wells display increasing EC values, while EC values are relatively stable for the other three wells. One well, located in the southeastern portion of the Lower Cache-Putah Subbasin, shows a particularly steep increase. The other three wells that exhibit increases display a more gradual increase. Additionally, Figure 5.13 shows a long-historical record for three wells near Davis in the Lower Cache-Putah Subbasin. A pronounced increasing trend in EC is evident for wells completed in the shallow zone from 1969 to 1997 when EC values increased from about 1,100 to 2,100 umhos/cm. Since 1997 concentrations appear to stabilize. The ECs for the well in the intermediate zone suggests stable EC concentrations (of about 700 umhos/cm) from about 1979 to 1999. Since 1999, a slight concentration increase may be occurring. The EC record from 1982 to present for a deep zone well exhibits stable EC values of about 500 umhos/cm.

Figure 5.15 illustrates EC and other constituent plots for six intermediate zone wells in the Lower Cache-Putah Subasin. Two of these wells, located in the southeastern part of Davis (8N/3E-18F2) and near Woodland (9N/2E-5H1), show increasing EC trends. A third Davis area well (8N/2E-8P1), discussed above, possibly shows a recent increasing EC trend. The other three intermediate zone wells show relatively stable EC values.

Specific Conductance Findings

The previous investigation by Scott and Scalmanini (1975) described in detail the inflows and outflows in the Yolo County subbasins as then defined. A very important finding at that time was the lack of subsurface outflow occurring in the Lower Cache-Putah Plain and other subbasins. The Lower Cache-Putah Plain is generally equivalent to the Lower Cache-Putah Subbasin in this report.

Although data are limited, there are a few findings from the evaluation of current and historical data that may be linked to the prior findings and the physical geohydrologic setting. At the time of the Scott and Scalmanini (1975) report, salinity (as TDS) was forecast over a 20-year horizon with two scenarios – with and without supplemental surface water. The projected TDS values were 823 mg/L (shallow zone) and 749 mg/L (intermediate zone) in 1990 with supplemental surface water deliveries. Thus, salinity was projected to increase, and the current data support this projection. The current EC data compared to equivalent EC values for the projected estimates indicate an increase of more than 400 umhos/cm in the shallow zone (e.g., as broadly estimated for the Lower Cache-Putah Subbasin) and an increase of approximately 150 umhos/cm in the intermediate zone in the Davis area over the last 30 years.

The source of salinity is attributable to a variety of land use factors. This project does not attempt to detail these. The continuing increase in salinity emphasizes the larger groundwater quality concern. In addition to source contributions, hydrologic conditions, particularly the lack of outflow, also contribute to the observed salinity increases. As described further below, other constituents, including nitrate, are also showing increasing trends. Although historical groundwater records are limited, and trend analyses to assess zone-specific conditions are constrained, the rate of increase in EC and nitrate in the Lower Cache-Putah Subbasin (on a broad basis) appears to be greater than elsewhere in the County. Such factors as the lack of outflow, level of extraction in the Lower Cache-Putah Subbasin relative to other subbasins (Scott and Scalmanini, 1975), and potential for increased leakage from the shallow zone to the intermediate zone likely contribute to the observed increase and rate of increase in EC values and nitrate concentrations.

The current groundwater quality conditions and evidence of continued degradation pose potential concerns and necessary actions to mitigate concerns. These are further discussed in Chapter 7 on Findings and Recommendations.

5.2.2 Nitrate

Figure 5.16 shows the location of groundwater quality monitoring network wells with nitrate data for January 2000 to March 2004. Nitrate records during this period are available for 139 "qualified" wells, including 56 in the shallow zone, 34 in the intermediate zone, 10 in the deep zone, and 39 wells completed in multiple zones (Table 5.1). Figure 5.16 shows the maximum observed nitrate results at the network wells that are constructed in the shallow, intermediate, and deep zones (e.g., wells completed in multiple zones are not shown on these figures). As discussed above for EC, the approach used to organize the data in the table and on the figure provides insights to the distribution of nitrate values and also indicates where data are sparse. The subbasins with the largest number of wells measured during the January 2000 to March 2004 period are the Western Yolo Subbasin for the wells completed in the shallow zone (23 wells) and the Lower Cache-Putah Subbasin for the wells completed in the intermediate (24 wells) and deep (9 wells) zones. The Lower Cache-Putah Subbasin also includes 24 wells with multiple completions; these data are included on the summary table and provide some value for understanding the average groundwater quality produced by these wells that are included in the monitoring network. As noted above, there are many more wells that are monitored by individual entities that have no construction information; and, the statistics for these wells are not included in the following discussion.

Below, key observations are presented that highlight the information shown for the zones underlying selected subbasins, indications of vertical differences in nitrate concentrations by zone, and trends for the historical record of selected wells completed in the shallow, intermediate, and deep zones.

Subbasin and Zone Assessments

Nitrate averages in the shallow zone range from about 16 mg/L (Buckeye/Zamora Subbasin) to 64 mg/L (Southern Sacramento River Subbasin). Data for nitrate in the Lower Cache-Putah Subbasin are limited; however, similar to EC, nitrate ranges for wells located in Western Yolo and Lower Cache-Putah Subbasins illustrate an increase in nitrate concentrations from west (average value 33 ug/L) to east (average value 44 ug/L). Notably, nitrate detections in wells along Cache Creek in the Western Yolo Subbasin also show higher nitrate concentrations. These elevated levels near the creek are likely due to the fact that these wells are mostly very shallow and completed in surficial materials overlying the shallow zone. Findings elsewhere in the county would likely show similarly elevated values in very shallow (e.g., near water table) monitoring wells. The average nitrate value of 44 mg/L for the shallow zone in the Lower Cache-Putah Subbasin is based on eight qualified wells; however, the distribution of and results for these wells that are very near or exceed the primary MCL, indicates a significant general water quality concern for wells completed in the shallow zone.

The nitrate average in the intermediate zone for the Lower Cache-Putah Subbasin is about 19 mg/L. The available data for the January 2000 to March 2004 period mostly occur in this subbasin; other subbasins have data from only one to four qualified wells. The average nitrate concentration for the intermediate zone in the Lower Cache-Putah Subbasin is less than half the average value of the shallow zone.

The available data for the deep zone are the most limited with nearly all monitored wells occurring in the Davis area of the Lower Cache-Putah Subbasin. The average nitrate concentration for these wells is about 3 mg/L.

Interzone Nitrate Differences

Vertical concentration differences occur between the shallow, intermediate, and deep zones in the Lower Cache-Putah Subbasin where the average nitrate concentrations decline with depth from 44 to 19 to 3 mg/L, respectively. Figure 5.13 displays these same vertical concentration relationships for nitrate for the shallow, intermediate, and deep zones in the Davis area of the Lower Cache-Putah Subbasin. There are also 24 wells located in the Lower Cache-Putah Subbasin that are completed in multiple zones. The range of nitrate concentrations for this group of wells is very large (<0.1 to 105 mg/L). The average value of 27 mg/L, although representing blended extraction from different zones, suggests that the water quality produced by most of these wells is influenced by groundwater from the intermediate zone.

Notable differences between zones are also present in other subbasins, including the Western Yolo Subbasin and the Southern Sacramento River Subbasin where nitrate concentrations also decline with depth.

Preliminary Trend Assessment

In the previous investigation of Yolo County groundwater quality by Scott and Scalmanini (1975), groundwater quality for selected constituents was summarized for the Davis, Woodland, and other county areas. Nitrate concentrations were indicated to be increasing in the Davis area with shallow groundwater shown as having a nitrate concentration of 4 mg/L in 1931 and increasing to 11 mg/L in 1970. In Woodland, the nitrate concentration in the shallow zone in 1950-59 was 2.7 mg/L and 4.5 mg/L in 1970. As noted above, the current average value for the shallow zone in the Lower Cache-Putah Subbasin is 44 mg/L.

There is an apparent increase evident from the current data; nitrate concentrations, at least in some areas, are continuing to increase. The apparent increase is also illustrated through long-term nitrate data plotted for individual wells. Figure 5.14 shows water quality plots for seven indicator wells located in the shallow zone in four subbasins. Six of the seven wells display increasing nitrate concentrations, while nitrate concentrations are relatively stable for only one well (10N/3W-11A1). Additionally, Figure 5.13 shows a long-historical record for three wells near Davis in the Lower Cache-Putah Subbasin. A pronounced increase in nitrate concentrations has occurred during 1969 to present for the well completed in the shallow zone (8N/2E-13H2); nitrate concentrations increased from about 9 to 52 mg/L. The well completed in the intermediate zone shows nitrate concentrations that have a significant increasing trend, particularly since the early to mid-1990's; nitrate concentrations in this well are currently about 28 to 30 mg/L. The nitrate record for the deep zone appears stable with low nitrate concentrations of about 1 to 2 mg/L.

Figure 5.15 illustrates the historical nitrate record in plots for six wells completed in the intermediate zone. Four of these wells, located in the southeastern part of Davis and south of Woodland in the Lower Cache-Putah Subbasin, show increasing nitrate trends. The other two intermediate zone wells, one located near and northwest of Woodland (10N/2E-30C1) and the other located west of Woodland (10N/1E-33J1), show relatively stable nitrate concentrations.

5.2.3 Boron

Figure 5.17 shows the location of groundwater quality monitoring network wells with boron data for January 2000 to March 2004. Boron records during this period are available for 104 "qualified" wells, including 31 in the shallow zone, 32 in the intermediate zone, 8 in the deep zone, and 33 wells completed in multiple zones. Figure 5.17 shows the maximum observed boron results at the network wells that are constructed in the shallow, intermediate, and deep zones (e.g., wells completed in multiple zones are not shown on these figures). The approach used to organize the data in the table and on the figure provides an understanding of the distribution of boron concentrations and also indicates where data are sparse. The subbasins with the largest number of wells measured during the January 2000 to March 2004 period are the Western Yolo Subbasin for the wells completed in the shallow zone (12 wells) and the Lower Cache-Putah Subbasin for the wells completed in the intermediate (23 wells) and deep (8 wells) zones. Unlike monitoring conducted for EC and nitrate for wells completed in the shallow zones adjacent to Cache Creek, boron has not been part of routine monitoring conducted by all AB 303 Program participants; consequently, the number of wells monitored for boron in the shallow zone is less. The Lower Cache-Putah Subbasin also includes 24 wells with multiple completions; these data are included on the summary table and provide some understanding of the average groundwater quality produced by these wells that are included in the monitoring network.

Below, key observations are presented that highlight the information shown for the zones underlying selected subbasins, indications of vertical differences in boron concentrations by zone, and trends for the historical record of selected wells completed in the shallow, intermediate, and deep zones.

Subbasin and Zone Assessments

Boron averages in the shallow zone range from about 660 ug/L (Western Yolo Subbasin) to 2,300 ug/L (Capay Valley Subbasin). The widest range of boron concentrations also occurs in Capay Valley; boron concentrations for seven wells range from 392 to 9,490 ug/L. The second highest average boron concentration is about 1,600 ug/L and occurs in the Lower Cache-Putah Subbasin.

Although boron is an essential element to plants, concentrations greater than 1 mg/L may be toxic to certain plants. Crops are classified according to boron sensitivity, and due to recognition of elevated boron conditions in Yolo County, boron tolerant crops are grown in some areas. Boron classifications include (but are not limited to) such categories as: sensitive (0.5 – 0.75 mg/L for some plants and 0.75 to 1.0 mg/L for other plants), moderately sensitive (1.0 – 2.0 mg/L), moderately tolerant (2.0 – 4.0 mg/L), and tolerant (4.0 – 6.0 mg/L) (Ayers and Westcot, 1985).

Data for the January 2000 to March 2004 period are limited (Table 5.1); however, Figure 5.17 illustrates boron concentration ranges for the shallow zone that resemble the averages summarized in the table with higher concentrations (1.0 to 4.0 mg/L) occurring in Capay Valley, a few wells located south and in the general vicinity of Cache Creek, and wells located in the Lower Cache-Putah Subbasin. As discussed below, historical data have also been evaluated to further assess the distribution of boron in Yolo County.

The average boron concentration in the intermediate zone is about 1,100 ug/L in Lower Cache-Putah Subbasin. The available data for the January 2000 to March 2004 period mostly occur in this subbasin; other subbasins have data from only one to three qualified wells. The average boron concentration in the Lower Cache-Putah Subbasin is lower in the intermediate zone than it is for the shallow zone (i.e., 1,100 ug/L and 1,600 ug/L respectively).

The available data for the deep zone are the most limited with nearly all monitored wells occurring in the Davis area of the Lower Cache-Putah Subbasin. The average boron concentration for these wells is about 730 ug/L.

The occurrence of boron in Yolo County has been previously investigated. Scott and Scalmanini (1975) showed boron concentrations in the County by three categories of boron concentrations. Boron concentrations ranging from 1.0 to 3.0 mg/L were shown along the length of Capay Valley and in a broad plume to the east that extends north and south of Cache Creek. This distribution has also been noted in previously published reports, including Evenson (1985).

Historical boron concentrations were also further evaluated for this AB 303 Project by querying and displaying the maximum-recorded boron concentration for all wells (including wells that have no available construction information) for the period from 1951 to March 2004 (Figure 5.18). Well qualification information, where available, is shown on this figure.

The distribution of boron across the County is similar to that previously shown (Scott and Scalmanini, 1975); however, the boron concentration relationships, or patterns of distribution, are more apparent. Some broadly interpreted boundaries show where boron concentrations generally range from not detected to 500 ug/L in the western portion of the Western Yolo Subbasin to concentrations ranging from 500 to 1,000 ug/L on the eastern side of the Western Yolo Subbasin and southern portion of the Lower Cache-Putah Subbasin. Boron concentrations at the upper reaches and the base of Capay Valley range from 1.0 to 4.0 mg/L. This concentration range extends along Cache Creek and over much of the Lower Cache-Putah Subbasin and also into the northern part of the Buckeye/Zamora Subbasin.

Interzone Boron Differences

Based on average boron concentrations for the Lower Cache-Putah Subbasin, vertical concentration differences are apparent for the shallow, intermediate, and deep zones where average boron concentrations decline with depth from 1,600 to 1,100 to 730 ug/L, respectively. Unlike the concentration decline with depth suggested by these averages, and also the same relationships exhibited for EC and nitrate in Figure 5.13, boron does not follow this pattern for the wells compared in this figure. Boron concentrations are mostly stable in each zone; however, the deep zone, at the well located in the Davis area of the Lower Cache-Putah Subbasin, has the same or higher concentrations than the shallow and intermediate zones. The boron concentrations for the shallow well in this area, while mostly stable through 2000, show a possibly increasing concentration trend to the present.

Notable differences in boron concentrations between zones are also present in other subbasins, including Capay Valley and the Southern Sacramento River Subbasin where boron values also decline with depth. This same pattern was exhibited for EC relationships. Also, similar to the EC finding, the Western Yolo Subbasin shows a reverse condition where the average boron value in the shallow zone is lower than that for the intermediate zone. However, the boron range is also significantly greater for the shallow zone in this subbasin, and there are more data for the shallow zone.

Preliminary Trend Assessment

Figure 5.14 shows water quality graphs for seven indicator wells located in four subbasins. Compared to EC and nitrate trends at these locations, boron concentrations appear to be generally stable. Upon close examination, three of the seven wells display subtle changes that may indicate slightly increasing boron concentrations, or may be small enough as to be within the limits of precision for this analysis. The concentration changes over a period of about 30 years are small and range from about 60 to 280 ug/L depending on the well. The three wells showing possible increases in concentrations are located in different parts of the County, including the Davis area in the Lower Cache-Putah Subbasin (8N/2E-13H2) and the northern (10N/2W-1M2) and central (9N/1W-21E1) parts of the Western Yolo Subbasin.

Figure 5.15 illustrates boron concentrations plotted for six intermediate zone wells. Only one of these wells, the well located south of Woodland in the Lower Cache-Putah Subbasin

(9N/2E-5H1) that has the shortest historical record (from 1997 to present), shows a possible increase in boron concentrations. This well exhibited a high initial boron concentration of about 2,600 ug/L; the apparent concentration increase in recent years to about 3,200 ug/L may be related to the limits of analytical precision for standard boron analyses.

Boron Findings

Although data are limited, there are a few findings from the evaluation of current and historical data that may be linked to the physical geohydrologic setting. The average boron concentrations are highest in Capay Valley, and elevated levels are exhibited along Cache Creek and particularly in the Lower Cache-Putah Subbasin. The average boron concentrations in the shallow zone in the Lower Cache-Putah Subbasin are notably elevated relative to the Western Yolo Subbasin. Average boron concentrations are elevated in the intermediate zone of the Western Yolo Subbasin; however, the Lower Cache-Putah Subbasin values are generally higher. Historical records indicate that boron concentrations in the shallow and intermediate zones are for the most part stable. At a few locations, small changes may be occurring, but the limited data hamper any clear indications of change. It is, however, clear that EC and nitrate trends are much more pronounced than changes that may be occurring related to boron.

The discussion of geologic conditions in a prior chapter describe the shallow zone as consisting primarily of alluvium but also the underlying Tehama Formation. Two major sediment sources are Cache and Putah Creeks; coarse beds appear to thin away from the present stream channels with thinner distributary channel and sheetflood deposits occurring under the more distal alluvial plains. One source of recharge to the shallow zone is from these incised streams and associated distributary sloughs on the alluvial plains. Based on the likely source of boron in surface water, including from the tributary Bear Creek (District 2001-2002 surface water quality monitoring data), and deposits above the head of the Capay Valley area, the distribution of elevated boron concentrations in groundwater near and in the distal plain of Cache Creek, and the lack of significant trends in boron concentrations, the occurrence of boron shows a correlation to depositional factors and also long-term recharge affects associated with Cache Creek. Other depositional factors and complex boron geochemistry may control boron mobility and/or sorption in the subsurface environment.

5.2.4 Arsenic

Arsenic is a trace element that is receiving renewed interest in its occurrence and distribution due to the change in the Federal MCL in 2001 to 10 ug/L, and the required forthcoming change in the State primary MCL from the current standard of 50 ug/L to 10 ug/L, or an even lower standard if so determined by the State. In light of this interest, the data gathered during this AB 303 Project have been preliminarily assessed to evaluate the distribution of arsenic in Yolo County. Data are limited, and correspondingly so are the findings. However, there are some initial findings that indicate additional study of the environmental conditions under which this constituent is most prevalent in a dissolved form would be helpful for future supply development considerations.

Arsenic concentration ranges for the period January 2000 to March 2004 are shown in Table 5.1. Many of the arsenic analyses have been performed with detection limits (e.g., 15 ug/L) that preclude detailed assessment of the data for the occurrence of concentrations of current interest. Discussion of arsenic "averages" is also problematic since the averages shown on the summary table are averages of detected values; therefore, the average is biased by a detection even if most other results are non-detects. For purposes of identifying the relative value of the calculated "averages," the number of detections used in the average calculation is also shown. The data summarized in Table 5.1 indicate that arsenic has generally not been detected in the shallow zone. Most available arsenic data for the intermediate and deep zones (and wells with multiple completions) have been collected from the Lower Cache-Putah Subbasin. Arsenic analytical results for the intermediate zone and multiple-completion wells show arsenic concentrations range from <2 to 6.4 ug/L. Arsenic detections in the deep zone show a slightly different concentration range with a higher upper end member (i.e., 1.6 to 10 ug/L).

Historical arsenic concentrations were also further evaluated for this AB 303 Project by querying and displaying the maximum-recorded arsenic concentration for all wells (including wells that have no available construction information) for the period from 1953 to March 2004 (Figure 5.19). Well qualification information, where available, is shown on this figure. The distribution of arsenic across the County illustrates some possible patterns of distribution. However, non-detect findings need to be cautiously viewed for this preliminary discussion of the occurrence of arsenic as the non-detects displayed may include wells that have a large range of detection limits. Historical arsenic results show mostly non-detect to low concentrations (up to 2.5 ug/L) in groundwater in the Capay Valley and Western Yolo Subbasin. Whereas, overall, the Lower Cache-Putah Subbasin exhibits higher values than shown in the Western Yolo Subbasin. Particularly, arsenic results for the area from approximately Woodland south to Davis exhibit a greater prevalence of values ranging from 2.5 to 5 ug/L. Near Davis, there are more instances of arsenic results that range from >5 to 10 ug/L. Arsenic detections in the northerly portion of the Buckeye/Zamora Subbasin also exhibit slightly higher arsenic concentrations than are apparent in the Western Yolo Subbasin. Arsenic concentrations are still quite low, though, and most range from >2.5 to 5 ug/L. As noted on the figure, well qualification information is very limited.

5.2.5 Chromium/Hexavalent Chromium

Chromium and particularly hexavalent chromium are constituents that are currently being reviewed by DHS for purposes of possible revisions of the total chromium MCL and establishment of a new MCL for hexavalent chromium. The current MCL for total chromium is 50 ug/L. Hexavalent chromium is an emerging contaminant of concern to public water systems that has received recent widespread public attention as public entities began to include the analysis of hexavalent chromium in groundwater supply monitoring programs. Public water districts, consultants, and regulatory agencies have initiated evaluations to determine the source of hexavalent chromium (man-made or natural occurrence) and the extent of the occurrence. Once water supply purveyors began testing for hexavalent chromium, it was recognized that its occurrence is not as rare as previously understood. Locally, the City of Davis has detected chromium/hexavalent chromium, and most likely detections in the municipal water supply are linked to the natural occurrence in Yolo County. Research efforts by investigators at the University of California at Davis (Chung, Buran, and Zasoski, 2001) have related the occurrence of hexavalent chromium to local alluvial deposits through geologic and geochemical processes that are theorized to have resulted in a transformation of naturally present trivalent chromium in serpentine rocks to hexavalent chromium. Other anthropogenic sources of chromium can occur; and these have led to very localized investigations.

Similar to the above-described preliminary evaluation of historic data, the total chromium and hexavalent chromium data gathered during this AB 303 Project have been evaluated in a cursory manner to assess their distribution in Yolo County. Data are limited, and correspondingly so are the findings. However, there are some initial findings that indicate additional study of the environmental conditions under which this constituent is most prevalent in a trivalent and/or hexavalent state would be helpful for future supply development considerations.

Both total chromium and hexavalent chromium concentration ranges for the period January 2000 to March 2004 are shown in Table 5.1. Similar to arsenic, detection limits are highly variable and preclude detailed assessment of the data for the occurrence of concentrations of current interest. For the reasons indicated above, “averages” should be viewed cautiously. The data summarized in Table 5.1 indicate that chromium has been recently detected in the shallow zone at concentrations ranging from non-detect to as high as 190 ug/L. Hexavalent chromium detections generally exhibit lower concentrations, although concentrations in the Lower Cache-Putah Subbasin range from 7.3 to 50 ug/L. Most chromium/hexavalent chromium data for the intermediate and deep zones (and wells with multiple completions) have been collected from the Lower Cache-Putah Subbasin. Analytical results for the intermediate zone and multiple-completion wells show total chromium ranging from <5 to 71 ug/L and hexavalent chromium concentration ranges from <1 to 54 ug/L. Total chromium and hexavalent chromium detections in the deep zone show a slightly lower concentration range (i.e., <1 to 31 and <1 to 24 ug/L, respectively).

Historical total chromium/hexavalent chromium concentrations were also further evaluated for this AB 303 Project by querying and displaying the maximum-recorded concentrations for all wells (including wells that have no available construction information) for the period from 1958 to March 2004 (Figure 5.20). Distinguishing the occurrence of one oxidation state versus the other was not attempted. Well qualification information, where available, is shown on this figure.

The distribution of chromium/hexavalent chromium across the County illustrates some possible patterns of distribution. However, similar to the above discussion of arsenic, non-detect findings need to be cautiously viewed for this preliminary discussion of the occurrence of chromium/hexavalent chromium. Historical results show mostly non-detect to low concentrations (up to 10 ug/L) in groundwater in the Capay Valley and Western Yolo

Subbasin. Whereas, overall, the Lower Cache-Putah Subbasin exhibits higher values than shown in the Western Yolo Subbasin. Particularly, results from approximately the Woodland area south to Davis exhibit a greater prevalence of values ranging from >10 to 50 ug/L. Near Davis, there are more instances of chromium/hexavalent chromium results that range from >25 to 50 ug/L.

5.2.6 Manganese

Manganese is a required nutrient in the human diet. Community water systems are regulated by the State for purposes of addressing aesthetic issues (i.e., discolored water) at a secondary MCL of 0.05 mg/L. DHS has also established an action level of 0.5 mg/L since risk evaluations indicate that at very high levels manganese may pose a health risk (Agency for Toxic Substances and Disease Registry, 2000; U.S. EPA, 1996).

Manganese in community water supplies has most often been a constituent of interest in the eastern Yolo County area around Broderick, Bryte, and West Sacramento. This AB 303 Project includes historical data for this area, but the current manganese data are largely for areas in the central and western part of the County. The manganese data gathered during this AB 303 Project have been preliminarily assessed to evaluate the distribution of this constituent in Yolo County. Manganese data are limited; however, there are some initial findings that highlight locations where it is occurring at concentrations of interest.

Manganese concentration ranges for the period January 2000 to March 2004 are shown in Table 5.1. The range of averages for detected manganese in the shallow zone include about 20 ug/L for the Lower Cache-Putah Subbasin to more than 800 ug/L for the Capay Valley Subbasin (although the latter is based on limited data and a wide range of results). The Western Yolo Subbasin has the highest number of monitored wells during this period, and the average of the detected manganese was about 115 ug/L.

The most data for the intermediate and deep zones (and wells with multiple completions) have been collected from the Lower Cache-Putah Subbasin. Manganese analytical results for the intermediate zone and multiple-completion wells show manganese concentration ranges from <5 to 181 ug/L. The average manganese detected in qualified wells in the intermediate zone is about 40 ug/L, or less than the secondary MCL. The average manganese detected in the deep zone was about 33 ug/L, although the range of detections included a value up to 210 ug/L.

Historical manganese concentrations were also further evaluated for this AB 303 Project by querying and displaying the maximum-recorded manganese concentration for all wells (including wells that have no available construction information) for the period from 1958 to March 2004 (Figure 5.21). Well qualification information, where available, is shown on this figure. The distribution of manganese across the County is scattered with few patterns evident in the distribution of the historical data. Historical manganese results show many non-detect results for groundwater in the Capay Valley and Western Yolo Subbasin. However, in the Western Yolo Subbasin in a pocket near Cache Creek and the central-eastern area of this subbasin, there are detections ranging from >10 to >50 ug/L. The Lower Cache-Putah Subbasin exhibits mostly non-detect results with the exception of the area near Davis where there are many detections >25 ug/L and also >50 ug/L; the higher values appear to be particularly prevalent on the north to eastern side of the Davis area in the intermediate and deep zones. As noted above, manganese is problematic in the eastern County area, and historical detections in this area are mostly >50 ug/L.

5.2.7 Selenium

Selenium is a trace element that is also an essential nutrient. The primary MCL for selenium is 50 ug/L. The data gathered during this AB 303 Project have been preliminarily assessed to evaluate the distribution of selenium in Yolo County. Selenium data are limited; however, there are some initial findings that highlight locations where it is occurring at concentrations of interest.

Selenium concentration ranges for the period January 2000 to March 2004 are shown in Table 5.1. Detection limits vary, and "averages" should be viewed with caution. The data summarized in Table 5.1 indicate that selenium has been detected in the shallow zone at concentrations ranging from <5 to 58 ug/L. Most data for the intermediate and deep zones (and wells with multiple completions) have been collected from the Lower Cache-Putah Subbasin. Selenium analytical results for the intermediate zone and multiple-completion wells show selenium concentration ranges from <1 to 91.3 ug/L. Selenium detections in the deep zone show a much lower concentration range of <0.5 to 4 ug/L.

Historical selenium concentrations were also further evaluated for this AB 303 Project by querying and displaying the maximum-recorded selenium concentration for all wells (including wells that have no available construction information) for the period from 1969 to March 2004 (Figure 5.22). Well qualification information, where available, is shown on this figure. The distribution of selenium across the County illustrates some possible patterns of distribution. However, non-detect findings need to be cautiously viewed for this preliminary discussion of the occurrence of selenium. Historical selenium results show mostly non-detect to low concentrations (up to 10 ug/L) in groundwater in the Capay Valley and Western Yolo Subbasin. On the other hand, selenium concentrations in the Lower Cache-Putah Subbasin, particularly the southern portion of this subbasin, exhibit higher values (10 to >50 ug/L).

5.3 FUTURE GROUNDWATER LEVEL AND QUALITY DATA

As discussed further in the next chapter, ongoing and also additional groundwater level and quality monitoring are recommended to further assess groundwater conditions in the County. Although an extensive network of water level monitoring wells exists, there are data gaps for measurements that allow evaluation of specific zones. Also, the monitoring locations where monthly data are being measured are limited. Additional zone specific monitoring can be better addressed over time through a phased program of replacing wells that have no known construction information with wells of known completion. The long-term historical records for the existing water level monitoring network would be retained. Existing or new monitoring facilities as needed are proposed for monthly water level monitoring; this is further discussed in the next chapter.

With regard to additional groundwater quality monitoring, either existing water supply wells or new dedicated zone-specific monitoring facilities should be included in the network for areas near rural residential developments. Zone-specific data are limited for all zones. Further studies that are directed toward understanding the natural occurrence of trace elements or other issues of interest (e.g., the implications of planned water management programs on water quality) will necessitate identification or construction of wells suitable for the evaluating zone-specific conditions. Priority considerations for additional monitoring should be placed on the subbasins where the highest population density occurs and the most notable water quality trends have been observed based on available data (e.g., Lower Cache-Putah Subbasin). Additional monitoring in other subbasins should also be considered to provide improved understanding of the groundwater quality character and water quality trends in specific aquifers.

6.0 ONGOING MONITORING PROGRAM

The AB 303 Project findings confirm that long-term, systematic monitoring is essential to better understand and forecast water resources availability and implement future water resources management programs. Groundwater and surface water data collected from established networks are necessary to distinguish trends from short-term fluctuations, anticipate unintended consequences of historical land uses, identify emergency issues, and design effective water resource management strategies. This chapter describes recommendations for the District's ongoing administration and evolution of the WRID established through the AB 303 Project. These recommendations provide a basis for collaborating with other entities to develop a county wide/regional groundwater monitoring program that achieves consistency in data gathering, compilation, and evaluation. Also, a groundwater level and quality monitoring program is recommended, including continued monitoring of the newly established District groundwater quality monitoring network. Additionally, an expanded groundwater level monitoring network has been developed for the Capay Valley Subbasin.

As described in this and previous reports, groundwater and surface waters in Yolo County are interrelated. Some surface water data have been incorporated in the WRID as part of this project. However, as recommended in the "Findings and Recommendations," this is an area of the WRID that requires expansion. It is recommended that future monitoring program efforts be directed toward establishing a surface water monitoring network that includes measurements for flow and quality and also identifies surface water sources, allocations, and diversions.

6.1 ONGOING PROGRAM OBJECTIVES

Effective water resources management requires a comprehensive ongoing monitoring program. As recommended above, the monitoring program (including centralized data management) that is ultimately developed for the County will include monitoring to continually assess groundwater and surface water quality and quantity. This AB 303 Project establishes the basis for the ongoing program.

6.1.1 Global Ongoing Program Objectives

- Local agencies, including the District, AB 303 Committee participants, and others will discuss and confirm water resources management and long-term monitoring program objectives; coordinated management and monitoring objectives will consider integrated regional water management and planning for sustainable supplies that support urban, agricultural, environmental, and other beneficial uses.

- Update the WRID annually with data received from federal, state and local participating agencies; the updated WRID would also be annually exchanged with other agencies; maintain coordinated, centralized data system (the WRID) to facilitate identification of sources/sinks, assess trends, conduct long-term forecasts, and evaluate long-term water management strategies.

- Maximize the accuracy and usefulness of data and develop guidelines for data quality assurance and quality control, consistency, and format compatibility.

- Design an agreeable data security structure in coordination with federal, state and local entities such that data as appropriate can be accessible to the public.

- Explore coordinated Geographic Information System (GIS) applications and web-based systems to facilitate access to resources information and increase public awareness.

- Include consideration of recharge area protection and sustainable water resources for multiple beneficial uses in future data evaluations and GIS applications.

- Coordinate Yolo County groundwater quality monitoring program with statewide program interests, including regional studies by the USGS and others to evaluate isotopes/age dating of water supplies and recharge processes.

6.1.2 Specific Ongoing Program Objectives

- Utilize the WRID developed as a product of the AB 303 Project; the District would administer the program and coordinate the efforts of program participants.

- Conduct ongoing groundwater level monitoring with the District's established water level network; the program would be updated as recommended to collect the data that improve water resources management planning and increase the effectiveness of the County's water resources management programs.

- Conduct groundwater quality monitoring program with the newly established network wells; this includes ongoing sampling of the wells identified by the District as part of the baseline sampling program. The District would also receive monitoring results from other program participants and update the WRID.

- Evaluate changes and long-term trends in groundwater levels and quality as part of the ongoing program; ongoing assessments allow better understanding of natural and human factors affecting groundwater quality conditions; regular assessment also aids timely consideration of shifts in factors that influence persistent and mobile chemical sources in the environment.

- Develop additional extraction estimates to improve the understanding of the water budget for the aquifer system underlying Yolo County. This data would be developed by direct measurement or methods used to estimate extraction based on land use or other means.

- Complete a water budget that includes recharge, extraction, and change in storage in the aquifer(s).

- Employ methods to better estimate groundwater basin conditions and assess local current and future water supply availability and reliability; update analyses as additional data become available.

- Refine the countywide monitoring network through elimination and or replacement of wells providing data of questionable value. The AB 303 Project included a well qualification process and identified many wells that are completed in more than one zone. The long-term benefit of monitoring data would likely be improved with zone-specific information; thus, phased replacement of monitoring wells should be considered with wells of questionable value eliminated from the network, and existing wells with suitable known construction or new wells added as needed.

6.2 PROGRAM ADMINISTRATION

The AB 303 Project has resulted in a monitoring program and WRID that hold long-term benefits to the County; however, this can occur only if steps are taken to establish the operation of the ongoing program. The District's interests in promoting and implementing activities that sustain the County's water resources make the District a well-suited agency for providing ongoing administration of the monitoring and WRID programs established through the AB 303 Project. For the program to be successful requires coordination with other cooperating entities, including members of the AB 303 Committee, and also continued cooperation of landowner participants who have authorized use of their wells for the District's water level and quality monitoring programs.

6.2.1 Ongoing Program – Next Steps

- Identify active collaborators (including local, federal, state agency representatives) and interested stakeholders for the ongoing program.
- Agree on lead agency to administer the ongoing monitoring program and WRID.
- Coordinate with DWR to finalize subbasin boundaries and establish consistent units for future data collection and water resources analyses.
- Lead agency to establish program coordinator.
- Arrange meeting of collaborators to:
  - Establish short and long-term monitoring objectives/issues of interest;

  - Coordinate efforts among collaborators (chemical analyses to address issues of concern, analytical methods, reporting formats, QA/QC data entry processes, formats for data transfer [from labs and also entities]);
  - Discuss evolution of the database (additions, ongoing data updates, and database applications);
  - Discuss data evaluation objectives and approach for reporting results and water resources conditions and recommendations;
  - Discuss additional data types needed (e.g., extraction, land use, other);
  - Discuss AB 303 Report recommendations and identify priorities for implementing;
  - Establish users' group (e.g., collaborating entity representatives applying WRID; exchange ideas on applications and WRID tools);
  - Discuss data security issues;
  - Discuss mechanisms to facilitate public outreach.
- Annually update the regional database (e.g., groundwater levels and quality and other water-related data), assess network and findings, and make changes to the program where necessary.
- Coordinate with County GIS program.
- Seek funding to support program continuation, including WRID, data evaluation, and implementation of priority recommendations.

6.3 GROUNDWATER MONITORING PROGRAM

The groundwater monitoring program described below is one component of the ongoing program objectives. The groundwater monitoring program includes the monitoring regularly conducted by other federal, state, and local entities (including municipalities, local aggregate companies, and the Rumsey Band of Wintun Indians) in Yolo County. The data collected by these groups includes various water-related data as described earlier in this report.

This section provides a summary of the countywide groundwater level and quality monitoring programs and recommendations for the program that will be conducted by the District.

6.3.1 Groundwater Level Monitoring Network

The groundwater level monitoring network in Yolo County includes 410 wells that are monitored by the District, DWR, USGS, USBR, municipalities, aggregate companies, the Rumsey Band of Wintun Indians, and UCD (Table 4.3). Well construction information as available was reviewed for these wells. Following that well qualification effort, these network characteristics were identified (Table 4.1):

- 166 wells are completed in the shallow zone,
- 63 wells are completed in the intermediate zone,

- 19 wells are completed in the deep zone,
- 72 wells are completed in multiple zones, and
- 90 wells are of unknown completion.

Of the 410 wells in the network, most wells are monitored semi-annually in the spring and fall; 45 wells are (or are recommended to be) monitored monthly.

During the review of the existing water level monitoring network, water resources issues in the County were considered to determine whether additional monitoring or other actions were needed. As indicated above, monthly water level monitoring is limited and does not currently provide adequate data to evaluate the effects of hydrologic events or stresses on the aquifer system. Thus, additional monthly monitoring is recommended (Figure 6.1 and 6.2).

Another area of consideration during the evaluation of water level monitoring coverage was water use in the Capay Valley Subbasin. Due to interest expressed by a number of participants of the AB 303 Committee, the groundwater level monitoring network in the Capay Valley was expanded to develop a more comprehensive understanding of existing groundwater conditions and also to provide a baseline to identify future changes in conditions. Additional wells for water level monitoring have been identified that will, through the collection of ongoing groundwater level monitoring data and analysis of those data, provide a better understanding of the groundwater conditions and stream-aquifer relations in the Capay Valley.

Previously, the District monitored 16 wells northwest of the town of Capay and the Rumsey Band of Wintun Indians monitored water levels in wells on their property. The expanded network consists of an additional 12 wells in the Capay Valley area for the purpose of providing more comprehensive coverage along the length of the Valley and near and away from Cache Creek. The total number of wells in the water level monitoring network in the Capay Valley Subbasin is now 33; these wells will be monitored monthly, at least until a baseline of water levels is established for this area that more comprehensively captures the response of the aquifer to hydrologic conditions and groundwater extraction from this subbasin (Figure 4.5).

The groundwater level monitoring program is summarized in Tables 4.3 and 6.1 and shown Figures 4.3, 4.4, 4.5, 6.1, and 6.2. Table 6.1 identifies the wells currently in the District groundwater quality program and the recommended monitoring frequency for water level measurements.

Due to the number of wells that are completed in more than one zone, or that have no completion information, well replacement with an existing water supply well of suitable completion in a specific zone (or a new dedicated monitoring well) is recommended. Well replacements should be phased in, and the existing historical record, even from wells of questionable construction, should be preserved in the event that the historical data may provide important links between data gathered under previous hydrological conditions.

6.3.2 Groundwater Quality Network

The groundwater quality monitoring network in Yolo County now includes 232 wells, including wells monitored by the District, DWR (special program), small water systems, municipalities, aggregate companies, the Rumsey Band of Wintun Indians, and UCD (Table 4.4). Well construction information as available was reviewed for these wells. Following that well qualification effort, these network characteristics were identified (Table 4.2):

- 57 wells are completed in the shallow zone,
- 33 wells are completed in the intermediate zone,
- 10 wells are completed in the deep zone,
- 43 wells are completed in multiple zones, and
- 89 wells are of unknown completion.

Of the 232 wells in the groundwater quality network, the larger community systems conduct annual or more frequent monitoring, while the small water systems generally monitor triennially. DWR biennially monitors its network of wells in the County. The aggregate companies and the Rumsey Band of Wintun Indians conduct quarterly monitoring. Prior to this AB 303 Project, the District did not have a groundwater quality monitoring program. As a result of the project, there are now 33 wells that will be monitored by the District.

The groundwater quality monitoring program for entities in addition to the District is summarized in Table 4.4. The recommended ongoing groundwater quality monitoring program for the District wells is summarized in Table 6.1, and Table 6.2 lists the recommended analyte information for all program wells. Figure 4.6 shows the entire groundwater quality monitoring network.

Similar to the well qualification results described above for the water level monitoring wells, well replacement with an existing water supply well of suitable completion in a specific zone (or a new dedicated monitoring well) is recommended. Well replacements should be phased in and the existing historical record, even from wells of questionable construction, should be preserved in the event that the historical data may provide important links between data gathered under previous hydrologic conditions.

Additional groundwater quality monitoring is also recommended to further assess groundwater quality conditions in the County. Specifically, either existing water supply wells or new dedicated zone-specific monitoring facilities should be included in the network for areas near rural residential developments. As described in Chapter 5 on “Groundwater Conditions,” zone-specific data are limited for all zones. Further studies that are directed toward understanding the natural occurrence of trace elements or other issues of interest (e.g., the implications of planned water management programs on water quality) will necessitate identification or construction of wells suitable for evaluating zone-specific conditions. Priority considerations for additional monitoring should be placed on the subbasins where the highest population density occurs and the most notable water quality trends have been observed based on available data (e.g., Lower Cache-Putah Subbasin). Additional monitoring in other subbasins should also be considered to provide improved understanding of the groundwater quality character and water quality trends in specific zones.

District Groundwater Quality Monitoring

The primary purpose of the groundwater quality monitoring program is to:

- Evaluate the baseline groundwater quality in the various subbasins of Yolo County and identify differences in water quality between zones;

- Identify where data gaps occur and provide infill, replacement, and/or project-specific monitoring (e.g., such as for the Cache Creek Recharge and Recovery Project) as needed;

- Detect the occurrence of and factors attributable to natural or "emerging" constituents that are a concern;

- Assess the changes and trends in groundwater quality; and

- Identify the natural and human factors that affect changes in water quality.

Along with the above monitoring objectives, findings about groundwater quality conditions in the County have been used to guide the recommendations presented below for the District's groundwater quality sampling program. These findings include:

- Yolo County has adequate groundwater quality for municipal and agricultural uses; however, there are continued concerns about increasing constituent concentrations, particularly nitrate and salinity in the shallow zone. Boron is also locally prevalent at elevated levels (e.g., >1.0 mg/L); this is a long-recognized issue and has resulted in planting of boron tolerant crops in some areas, particularly the Lower Cache-Putah Subbasin.

- Although prior testing conducted by DPR has occasionally found low levels of pesticides, no pesticides or VOCs were detected in the wells sampled during March 2004 as part of the baseline water quality sampling event.

- The shallow and intermediate zones are an important source of supply for private domestic and irrigation purposes. Municipal supplies have been largely developed from the intermediate zone; however, since 1990, there is increased interest in the exploration and development of the deep zone system.

- Hexavalent chromium is a naturally occurring constituent of concern in Yolo County that currently does not have an MCL. The MCL for total chromium is 50 ug/L. Two wells tested for hexavalent chromium either met or exceeded the MCL for total chromium (50 and 54 ug/L) and many wells tested for hexavalent chromium exceeded the detection limit.

- Arsenic, mercury, and selenium were targeted as possible constituents of concern in Yolo County. Wells tested after 1999 showed a limited number of wells that exceeded the MCL: arsenic (1) and selenium (3).

Recommended District Groundwater Quality Monitoring Program and Frequency

Water quality samples will be collected on an annual basis from the District wells. Table 6.1 shows the recommended constituents and their sampling frequency. Samples will be collected during the spring so that the sampling of these wells can also be coordinated with the District's spring groundwater level monitoring program. Samples from all wells will be analyzed for major cations (Ca, Mg, K, and Na) and major anions (bicarbonate, carbonate, Cl, nitrate, and sulfate), pH, EC, fluoride, TDS, MBAS, nitrite, ion balance, hardness, and selected trace elements (Al, Ag, As, B, Ba, Cd, Cu, Fe, Mn, Pb, Se, Hg, Cr, Cr VI, and Zn) on an annual basis. Table 6.2 lists the recommended analytes, method for analysis, hold time, reporting limit, units, and preservative. Once a historical record for these constituents has been established, e.g., after approximately the first five annual monitoring events, the program would likely be adjusted so some constituents are monitored less frequently. Triennially, additional constituents (volatile organics and selected pesticide suites) will be monitored at selected locations; these locations may also be rotated among the District wells to allow for greater areal coverage. Sample collection and quality control procedures are summarized in Appendix E. As described in Appendix E, field parameters will be measured, including EC, temperature, pH, dissolved oxygen, metals, redox, and turbidity.

As replacement wells or new monitoring wells are added to the groundwater quality monitoring network, it is recommended that the complete constituent list be analyzed, including major cations, anions, metals, and trace elements. Additionally, for shallow completion wells, it is suggested that volatile organics be tested during the initial sampling event. Pesticides may also be tested pending the location of the replacement/new monitoring well.

The groundwater quality monitoring program will be regularly reviewed; and, based on the data gathered from the current sampling year, review of the historical record, water quality trend analyses, and consideration of issues of interest to the District and collaborating entities, the program may be adjusted. After the first five years, program adjustments may also include consideration of a tiered approach to target constituent monitoring, e.g., certain constituents may be of greater interest for tracking on an annual basis in some subbasins and/or specific zones.

Interagency coordination is important for the ongoing program. Specifically, the local participants will benefit from efforts made toward systematic data collection and analyses. Other data logistics that will help facilitate updates to the WRID include using standardized naming conventions for the same analyte and providing results to be included in the WRID in a standardized format compatible with the database.

Estimated Budget for District Groundwater Monitoring Programs

To facilitate planning needs for the ongoing monitoring program, planning level budget estimates have been developed for two components of the program. These include the ongoing District groundwater quality monitoring for the 33-well network and groundwater level monitoring for the Capay Valley Subbasin. A budget estimate also needs to be developed for the ongoing data management system and countywide data evaluation as these activities are not included in the budgets below.

District Groundwater Quality Monitoring Program – The budget estimate for this program is based on sampling, chemical analyses, and providing results to property owners for the Spring 2005 groundwater quality sampling event. The sampling event, as with this study, would be preceded by communications (written and also oral) to property owners about the planned event. The necessary field equipment (such as instruments to perform field measurements such as EC, temperature, pH, dissolved oxygen, redox, and turbidity measurements) included as part of this budget estimate would be purchased for this event and used for future sampling events. Following receipt of sampling results, a letter would be prepared to transmit the sampling results to property owners; this letter would include a tabulation of the laboratory results along with associated regulatory, or action levels if no regulatory standard exists. The estimated budget amounts are: $13,000 labor and associated materials as needed to prepare for, conduct and provide follow-up for the sampling event; $17,000 for chemical analyses as detailed above (includes major cations and anions and selected trace elements); and $3,500 for field instrumentation (this item would be a one-time cost, until replacement is required).

Capay Valley Groundwater Level Monitoring Program – The budget estimate for the expanded Capay Valley monitoring program includes the annual costs to perform monthly water level monitoring at 33 monitoring wells. The District would monitor 28 of these wells, and five wells will continue to be monitored by representatives for the Rumsey Band of Wintun Indians. The budget includes communications as needed with property owners, field measurements, and follow-up communications to property owners. Annually, a letter would be transmitted to individual property owners along with a hydrograph showing monthly water level measurements for that owner’s well. The estimated budget amount to conduct this program for one year beginning in August 2004 is $32,000.

7.0 FINDINGS AND RECOMMENDATIONS

This AB 303 Project accomplished its main purposes: development and implementation of an ongoing groundwater monitoring program for Yolo County that provides a framework to facilitate coordinated and effective integrated water resources management. This project also resulted in important benefits, including:

- **Formalized a countywide groundwater monitoring program.** A formal comprehensive monitoring program has been developed that provides for long-term protection of the County's groundwater resources. At the outset of the AB303 Project, no formal groundwater quality monitoring program existed; however, about 232 wells are now included in the program (the wells include those monitored by the District, DWR (special program), small water systems, municipalities, aggregate companies, and the Rumsey Band of Wintun Indians). About 410 monitoring wells in seven subbasins are included in the groundwater level monitoring network. The total well network for groundwater level and quality monitoring includes 558 wells.

- **Created a centralized data management system (WRID).** Historical water level and water quality data have been gathered for decades; the collection and organization of these data in a centralized repository significantly increases the utility of these existing data. The central repository also improves cost efficiencies for local agencies and facilitates coordinated planning and management efforts.

- **Developed a better understanding of the physical water resources system.** Hydrogeologic and well construction data gathered for this project have resulted in a better understanding of the physical water resources system. Since the response of the physical system is intrinsically linked to natural and human induced stresses imposed on the system (e.g., increases and/or shifts in water use from different zones of the aquifer system, land use and water quality considerations, and effects of climate change on management considerations), analytical and numerical tools employed to forecast the system response to such effects will be more accurate.

- **Updated subbasin delineations.** Prior investigations have delineated somewhat different subbasin areas than those shown in this AB 303 report. As a result of mutual interests by DWR and AB 303 Program participants in establishing consistent hydrologic units/subbasins, increased coordination among state and local investigators has been facilitated through this AB 303 Project. Technical exchanges initiated during the AB 303 draft report review resulted in first steps that advance unification of Yolo County hydrologic units. In coordination with DWR, it is planned that the subbasin boundaries will be finalized to establish consistent units for purposes of the ongoing countywide monitoring program (and also independent entity programs) and data analyses and applications using the WRID.

- **Identified data gaps.** Historical data collected during this project have allowed data gaps to be identified, i.e., there are many areas in the County where further efforts to establish zone-specific monitoring using existing or new monitoring facilities will improve the value of the data being gathered.

- **Assessed zone-specific groundwater quality conditions and trends.** Available historical data allowed limited groundwater quality trend assessments; these demonstrated important trends in the Lower Cache-Putah Subbasin. Critical information gaps inhibit adequate characterization of groundwater quality conditions; additional efforts to increase zone-specific monitoring will allow better understanding of the natural and human factors affecting groundwater quality conditions in other County subbasins.

- **Responded to expanded committee and public concerns.** The District responded to concerns expressed about groundwater conditions in the Capay Valley area and expanded the scope of this AB 303 Project to develop a more extensive groundwater monitoring program.

- **Increased agency coordination.** The development of the formal monitoring program has led to increased coordination among County entities. Continuation of the program will improve agency awareness of local water issues and urban and rural water management needs.

- **Created foundation for programs that enhance integrated water resources management and planning.** Data gathered for this project can be expanded upon to better understand available water resources (e.g., additional information is needed on water withdrawals; and surface water allocations and diversions should be recorded on a continuing basis). Further applications of the WRID will lead to identification and improved understanding of the issues that may affect the quantity/quality of the County's water resources (climate change, human stresses due to withdrawal, or land use).

- **Project complements statewide monitoring program interests.** Regional monitoring and database efforts accomplished through this project provide a means for further coordination with statewide monitoring program interests, including studies by the USGS and others to evaluate region-wide groundwater quality conditions and application of isotope/age dating techniques to assess source waters and recharge processes.

- **Facilitated efforts to increase public outreach.** This AB 303 Project has created a framework for applying the findings and recommendations of the program to the District's continued efforts to increase public outreach. An informed public enables support of planned water resources projects and programs proposed by the District and others.

Tasks performed during this AB 303 Project led to a broader awareness of the water resources data currently available and how those data could be used to assess current groundwater conditions. These insights resulted in the identification of additional data needs and recommended actions to facilitate integrated regional water management and planning for sustainable supplies that support urban, agricultural, environmental, and other beneficial uses. The findings and recommendations include:

7.1 GENERAL FINDINGS AND RECOMMENDATIONS

Findings

1. Groundwater is one of Yolo County's most important natural resources, and it is the source of water for all municipal and domestic uses in Yolo County except for the City of West Sacramento, which has a surface water supply from the Sacramento River.
2. The baseline groundwater quality data, including data gathered from Yolo County entities, state and federal agency monitoring data and the water quality results for private wells, provide a reasonable indication of current groundwater conditions, although data gaps have been identified and program improvements are recommended.
3. Long-term systematic monitoring and data evaluation are needed in conjunction with the baseline monitoring to identify future trends and changes. A comprehensive understanding of groundwater quality will provide the additional tools needed to develop a sustainable water management approach.
4. The shallow and intermediate zones are an important source of supply for private domestic and irrigation purposes. Municipal supplies have been largely developed from the intermediate zone; however, since 1990, there is increased interest in the exploration and development of the deep zone.
5. Groundwater supplied by community systems meets current standards and is of acceptable quality. However, historical records for nitrates and EC indicate increasing concentrations in some locations. Nitrate concentrations in the shallow zone of the Lower Cache-Putah Subbasin are nearing and/or exceeding the nitrate standard that is applied to community systems of 45 mg/L. Since private wells are not subject to this standard, and testing is not required, owners may be unaware of potentially elevated constituent concentrations.
6. No pesticides or VOCs were detected in shallow and intermediate zone wells during the March 2004 baseline water quality sampling event. Low concentrations of a few pesticides have been rarely detected during DPR testing. The baseline results indicate that pesticides do not pose a groundwater quality concern, but early detection monitoring at regularly scheduled intervals would be useful to ensure no impacts are occurring.
7. Boron is also locally prevalent at elevated levels (e.g., >1.0 mg/L). Boron is naturally occurring and preliminary assessment of geohydrologic relationships

indicates that the distribution of boron is related to the depositional and recharge environment of the aquifer system.

8. Sources of known and potential groundwater quality contamination in the County are human-influenced and also naturally occurring (e.g., wastewater treatment facilities [individual and municipal] contribute to salt loading and potentially other contaminants in the subsurface; such trace elements as arsenic, hexavalent chromium, and selenium [with the exception of possible point source contributions] are naturally occurring).

Recommendations

1. Build on efforts begun with this AB 303 program for regional database development and use through interagency cooperation.
2. Coordinate AB 303 monitoring program and database efforts with other County GIS applications.
3. Provide the public with appropriate access to program information and results via the web and other means.
4. Increase interagency coordination for continuation of the countywide monitoring program, including data sharing, dissemination, and annual evaluation of water resources conditions.
5. Identify priorities for improving zone-specific monitoring, including installation of dedicated monitoring facilities.

7.2 HYDROGEOLOGIC SETTING

Findings

1. The uppermost 500 feet of the nonmarine deposits have not been extensively studied; however, a better understanding is needed of the shallow and intermediate zone stratigraphic relationships to identify specific aquifers if possible.
2. Geologic conditions in the Capay Valley have been previously studied; however, additional detail is needed.
3. Yolo County subbasins are defined in DWR Bulletin 118 (2003) and in Scott and Scalmanini (1975) using different boundaries and subbasin names. For purposes of this AB 303 Project, a subdivision of the Yolo County groundwater bearing area is divided into seven informal subbasins based on geologic, aquifer, and topographic characteristics. These proposed subbasin units are slightly different than those previously used. Efforts should be made to use the same subbasin boundaries to allow for consistent references to these units in the future.

Recommendations

1. Extend the work started by Hubbard (1989) to better define the extent and thickness of the units comprising the shallow and intermediate zones in Yolo County. This entails review and use of available geologic information, including drillers' reports and geophysical logs in Yolo County, to refine the stratigraphic relationships for the surficial, shallow, and intermediate zones.
2. Study Capay Valley subsurface geology and stratigraphic relations of the alluvium

and nonmarine deposits.
3. Technical exchanges initiated during the AB303 draft report review resulted in first steps toward unification of the Yolo County hydrologic units. In coordination with DWR, groundwater subbasin boundaries should be finalized based on physical criteria as feasible; Bulletin 118 should be updated accordingly to reflect subbasin boundaries determined with the additional geologic analyses.

7.3 WATER RESOURCES INFORMATION DATABASE

7.3.1 Data Collection and Security

Findings

1. Local, state, and federal agencies (municipalities, the District, DHS, DWR, DPR, USGS, and USBR) collect surface and groundwater information that provide a reasonable basis for assessing groundwater conditions in Yolo County.
2. County, local, and private company data have individual spreadsheet structures. Uniform structures would reduce the time to transform and reformat the data in the future.
3. Not all small public water system data are included in the DHS database. Water quality information for Yolo County is more extensive and has a longer record than expected.
4. During the initial data collection efforts for the AB 303 Project, it was learned that a special groundwater quality monitoring program has been conducted by DWR in Yolo County for nearly 30 years. Nearly 30 wells have some water quality data and about 20 wells have continuous data and these data have been incorporated in the regional database.
5. Pumpage amounts from private domestic and irrigation wells are largely unknown.
6. Data security is a large issue since September 11, 2001. DHS is concerned about keeping public supply well locations confidential. DWR has concerns for varying reasons, including well construction confidentiality requirements and also maintaining confidentiality for information developed through its Yolo County water quality monitoring program.

Recommendations

1. Increase interagency coordination to define roles, share data, and benefit from systematic data collection and analyses.
2. The lead agency for the ongoing monitoring program should continue to collect data from public agencies (DWR, DHS, DPR, USGS, USBR, UCD, and municipalities) and private companies (e.g., aggregate companies and the Rumsey Band of Wintun Indians) on an annual basis.
3. Data received for inclusion in the regional database should be provided in a uniform format that is compatible with the database (Appendix C).
4. Additional available data are known to exist; it is recommended that entities provide these data to complete entry of historical records in the regional database. Add all hardcopy historical water quality and water level measurements from entities as

summarized in Table 3.2.

5. Request from DPR the locations of wells tested for pesticides in Yolo County.
6. Send DWR the information it needs to assign a SWN to network wells that have not yet been assigned a number.
7. Expand the database to complete current information (e.g., pumpage and surface water data) and include additional information that will be used for the construction of a groundwater model (e.g., lithologic information and/or additional aquifer and/or confining unit designations, precipitation, other sources of recharge and discharge). Where production data are not metered, estimate pumpage based on crop, land use or other methods.
8. Create a web-based access to the database for the public with tiered levels of security depending on public agency affiliation.
9. Data security needs to be further addressed to allow the data to be used to protect and manage the resource but also to protect the well owner.

7.3.2 Database Construction

Findings

1. Data are available in the database for over 4,000 wells in Yolo County and surrounding areas.
2. Well logs were provided electronically by DWR for over 7,300 wells in Yolo County for the years prior to about 2000.
3. Different naming conventions by different agencies for the same analyte cause difficulty in evaluating the constituent (e.g., nitrate).
4. AB 303 database use has been set up for basic queries and reports. Additional queries and reports may be of interest to meet users' needs for the ongoing program.

Recommendations

1. Scan remaining drillers' reports for Yolo County (from about 2000 to present) to complete the DWR electronic log file.
2. Standardize analyte names to simplify data entry and evaluation.
3. Establish an interagency users' group consisting of the District and other collaborating agencies to develop new tools for the database and address questions and issues concerning the database.
4. Coordinate in the future with the Yolo County GIS group to explore internet applications and issues.

7.4 MONITORING NETWORK

7.4.1 Groundwater Level Monitoring

Findings

1. Not all groundwater level monitoring wells have construction information. For monitoring wells with known construction information, many are completed in more than one zone.

2. Monitoring locations where water levels are measured more frequently than semi-annually are limited.
3. Water level records for Yolo County include records that begin in 1931 and continue to the present; water level trends illustrate aquifer system response during drought and wet years.
4. Additional groundwater data exist that have not yet been incorporated in the countywide database (see Table 3.2).
5. Although Capay Valley residents expressed concerns about groundwater levels in that area, property owners invited to participate in the expanded water level monitoring program were reluctant to participate.

Recommendations

1. Replace water level monitoring wells that are completed in more than one zone with wells completed in a single zone (a phased approach is recommended for this effort that considers the historical record for existing wells in the network).
2. Continue groundwater level monitoring on at least a semi-annual basis; increase the spatial and vertical distribution of wells for monthly water level measurements to allow more comprehensive evaluation of groundwater conditions and stream-aquifer relationships.
3. Perform GPS survey with higher accuracy instrumentation to establish reference point elevation data. Replace reference point elevation data presently in the database as the new data are acquired.
4. Expand the District's water level monitoring network with two sets of recently constructed multiple-completion monitoring wells, including the monitoring wells at River Garden Farms and Yolo County Airport on Aviation Avenue.

7.4.2 Groundwater Quality Monitoring Network

Findings

1. Well construction information and, therefore, zone designations are not known for about 90 wells in the groundwater quality monitoring network.
2. Many shallow domestic wells are not sealed or have a very shallow seal.
3. Nearly 50% of the 144 well owners contacted for the March 2004 baseline sampling event gave permission for testing; some owners are concerned about "enforcement action" if results are above an MCL.

Recommendations

1. Implement ongoing District groundwater quality monitoring program that includes a network of qualified wells.
2. Use EPA Method 6020 for future arsenic analyses to achieve a lower reporting limit of 0.001 mg/L.
3. Include Yolo County landfill and wastewater treatment facility monitoring wells (cities of Davis, Winters, and Woodland) in the WRID.
4. As feasible, replace monitoring wells that are completed in more than one zone with wells completed in a single zone.

5. Expand the water quality network to the northeast and include the multi-completion monitoring wells in RD 108.

7.4.3 Surface Water Monitoring

Findings

1. Monthly diversion quantities are available; however, additional information such as diversion locations should also be included in the database.
2. Surface water monitoring data should be incorporated in the regional database. USBR and possibly other agencies have surface water information for Yolo County that is incomplete and has not yet been entered into the WRID.

Recommendations

1. Expand input of surface water data gathered and entered into database.
2. Collect GPS coordinates for District diversion and spill locations.

7.5 GROUNDWATER CONDITIONS

Findings

1. Evaluation of groundwater levels indicates current conditions are stable in all zones.
2. Previous investigations use an aggregate of groundwater level data to prepare groundwater elevation contour maps. Significant differences in groundwater elevations were observed between zones and/or aquifers at some locations. A refined understanding of zone-specific responses requires evaluation of the data by zone. The largest coverage of qualified data in Yolo County exists for the wells completed in the shallow zone.
3. Water quality in Yolo County is generally acceptable; although, elevated EC, nitrates, and boron are present in some areas.
4. Yolo County has a trend of increasing EC and nitrates, especially in shallow wells. Current EC data, while limited, indicate a significant increase in EC in the Lower Cache-Putah Subbasin (on the order of more than 400 umhos/cm over a period of 30 years). An increase of approximately 150 umhos/cm is estimated for the intermediate zone in the Davis area over the last 30 years.
5. The average boron concentrations are highest in Capay Valley, and elevated levels are exhibited along Cache Creek and particularly in the Lower Cache-Putah Subbasin. The average boron concentrations in the shallow zone in the Lower Cache-Putah Subbasin are notably elevated relative to the Western Yolo Subbasin. Average boron concentrations are elevated in the intermediate zone of the Western Yolo Subbasin; however, the Lower Cache-Putah Subbasin values are generally higher. Historical records indicate that boron concentrations in the shallow and intermediate zones are for the most part stable. At a few locations, small changes may be occurring, but the limited data hamper any clear indications of change. It is, however, clear that EC and nitrate trends are much more pronounced than changes that may be occurring related to boron.

6. Pesticides and VOCs were not detected during the March 2004 baseline sampling event.
7. Hexavalent chromium is a naturally occurring constituent of concern in Yolo County that currently does not have an MCL. The MCL for total chromium is 50 ug/L. Two wells tested for hexavalent chromium either met or exceeded the MCL for total chromium (50 and 54 ug/L) and many wells tested for hexavalent chromium exceeded the detection limit.
8. Arsenic, mercury, and selenium were targeted as possible constituents of concern in Yolo County. Wells tested after 1999 showed a limited number of wells that exceeded the MCL: arsenic (1), mercury (0), and selenium (3).

Recommendations

1. Additional investigation is recommended to better understand the distribution of naturally occurring constituents (hexavalent chromium, boron, and possibly selenium, manganese, mercury and arsenic) and human-influenced (EC and nitrate) constituents in groundwater.
2. Coordinate with other program participants on additional monitoring needs to fill data gaps and address special water quality issues. One priority for addressing data gaps should be assessing additional monitoring needs in the Lower Cache-Putah Subbasin where the highest population density occurs and municipal supply requirements are the greatest.
3. Coordinate with the YCEHD to assess the number of private wells used for domestic supply and steps needed to better understand water quality concerns.

7.6 ONGOING MONITORING PROGRAM

Findings

1. Baseline groundwater quality conditions have been established from which future changes could be compared.
2. For the 2004-2005 year the District will continue as lead agency for managing the database, preparing an annual update, and transferring the information to DWR.
3. Interagency coordination is critical to continuation of the monitoring program and the WRID.

Recommendations

1. Establish lead agency for ongoing monitoring program coordination and database oversight and management.
2. Annually update the regional database (e.g., groundwater levels and quality and other water-related data), assess network and findings, and make changes to the program where necessary.
3. Discuss with collaborators monitoring parameters of special interest.
5. Monitor water quality according to frequency and parameters listed in Table 4.4; review annually and revise accordingly pending changes to network wells and/or specific program objectives.
6. Identify locations for construction of dedicated monitoring wells for water level and

quality monitoring (e.g., areas served by individual domestic wells for water supply, recharge areas where zone-specific monitoring is lacking, etc.).

7. Replace wells in the monitoring network that have no well construction information (or are perforated in more than one zone) to improve the understanding of zone-specific conditions.
8. Coordinate efforts being conducted for water supply investigation work (e.g., test hole construction) with opportunities for constructing zone-specific dedicated monitoring facilities for countywide water level and/or water quality monitoring.
9. Communicate program results to cooperating entities.
10. Provide program participants in the District water level and/or water quality monitoring program the information for their well on an annual basis (e.g., hydrograph and/or laboratory results).
11. Provide an overview of program objectives, benefits and results to general public via web information.

7.7 OTHER RECOMMENDATIONS

1. Explore need to develop guidelines for testing private wells to evaluate possible water quality issues. Also evaluate need to develop County standards for construction of new domestic wells (i.e., deeper completions, deeper seals, and proper destruction of unused wells).

8.0 REFERENCES

Agency for Toxic Substances and Disease Registry, 2000, Toxicological profile for manganese: Agency for Toxic Substances and Disease Registry, September, 2000.

Ayers, R.S., and Westcot, D.W., 1985, Water quality for agriculture: Food and Agriculture Organization of the United Nations, Rome, 174 p.

Berkstresser, Jr., C.F., 1973, Base of fresh ground water, approximately 3,000 micromhos in the Sacramento Valley and Sacramento – San Joaquin Delta, California: U.S. Geological Survey Water-resources Investigations 40-73.

Bertoldi, G.L., Johnston, R.H., and Evenson, K.D., 1991, Ground water in the Central Valley, California – A summary report: U.S. Geological Survey Professional Paper 1401-A, 44 p.

Borcalli and Associates Consulting Engineers, 1992, Yolo County water plan update, 1992: 59 p.

Borcalli and Associates, Inc., Consulting Engineers, 2000, Yolo County Flood Control & Water Conservation District water management plan: 188p.

Borcalli, Ensign, and Buckley, 1984, Yolo County water plan, 1984: 24 p.

Bryan, K., 1923, Geology and ground-water resources of Sacramento Valley, California: U.S. Geological Survey Water-Supply Paper 495, 285 p.

California, The State of, 1987, A proposal to the U.S. Department of Energy for siting the super conducting super collider in California, Davis site: Vol. 3 Geology and Tunneling, 80 p.

California Department of Water Resources, 1978, Evaluation of ground water resources: Sacramento Valley, Sacramento: The Department and U.S. Geological Survey Bulletin 118-6, 265 p.

California Department of Water Resources, 2003, California's Groundwater: The Department Bulletin 118 - Update 2003, 246 p.

California Department of Water Resources, 2004, Yolo County Integrated Regional Water Management Plan (in preparation).

California Division of Oil and Gas, 1981, California oil and gas fields Northern California, TR-10, Vol. 3.

California Division of Water Resources, 1955, Report to the California State Legislature on Putah Creek Cone Investigation, 211 p.

Chung, J., Burau, R.G., and Zasoski, R.J., 2001, Chromate generation by chromate depleted subsurface materials: Soils and Biogeochemistry Program, Department of Land, Air, and Water Resources, University of California, Davis, 17 p.

Dames and Moore, 1990, Resource report, Cache Creek aggregate resources, program EIR information document: for the County of Yolo, 108 p.

Evenson, K.D., 1985, Chemical quality of ground water in Yolo and Solano Counties, California: U.S. Geological Survey Water-Resources Investigations Report 84-4244, 50 p.

Graham, M. M., 1997, An hydrological, geohydrological, and geochemical study of an alluvial aquifer system in Northern California: M.S. thesis, University of California, Davis, 173 p.

Hackel, O., 1966, Summary of the geology of the Great Valley: in Bailey, E.H. –ed, 1966 Geology of Northern California; CA. Div. Mines and Geology Bulletin 190, p. 217-238.

Harwood, D.S. and Helley, E.J., 1987, Late Cenozoic tectonism of the Sacramento Valley, California: U.S. Geological Survey, Professional Paper 1359, 46 p.

Helley, E.J. and Harwood, D.S., 1985, Geologic map of the Late Cenozoic deposits of the Sacramento Valley and northern Sierra foothills, California: U.S. Geological Survey Miscellaneous Field Studies Map, 1790.

Hubbard, J. A., 1989, Texture distribution of the younger alluvial sediments and parts of the Tehama Formation in portions of Yolo, Solano, Colusa, and Sacramento Counties, California: M.S. thesis, University of California, Davis, 83 p.

Hull, L.C., 1984, Geochemistry of ground water in the Sacramento Valley, California: U.S. Geological Survey Professional Paper 1401-B, 36 p.

Luhdorff and Scalmanini, Consulting Engineers, May 2003, Hydrogeologic conceptualization of the deep aquifer Davis area, California: for University of California, Davis.

Olmsted, F.H., and Davis, G.H., 1961, Geologic features and ground-water storage capacity of the Sacramento Valley, California: U.S. Geological Survey Water-Supply Paper 1497, 241 p.

Page, R.W., 1974, Base and thickness of the Post-Eocene continental deposits in the Sacramento Valley, California: U.S. Geological Survey Water-Resources Investigation 45-73, 16 p.

Page, R.W., 1986, Geology of the fresh ground-water basin of the Central Valley, California, with texture maps and sections: U.S. Geological Survey Professional Paper 1401-C, 54 p.

Scott, V.H., and Scalmanini, J.C., 1975, Investigation of ground-water resources Yolo County, California: Department of Land Air, and Water Resources, Water Science and Engineering Section, University of California, Davis, Water Science and Engineering Papers Number 2006, 140 p.

Thomasson, Jr. H.G., Olmsted, F.H., and LeRoux, E.F., 1960, Geology, water resources and usable ground-water storage capacity of part of Solano County, California: U.S. Geological Survey Water-Supply Paper 1464, 693 p.

U.S. Environmental Projection Agency, 1996, Manganese, integrated risk information system: U.S. Environmental Protection Agency, Reference Dose last updated May 1, 1996.

U.S. Soil Conservation Service, 1972, Soil survey of Yolo County, California.

Wahler Associates, 1982, Geologic report, Cache Creek aggregate resources, Yolo County, California; for Aggregate Resources Advisory Committee, County of Yolo.

Wagner, D.L., Jenning, C.W., Bedrossian T.L., and Bortugno, E.J. Compilers, 1981, Geologic map of the Sacramento quadrangle: California Division Mines and Geology, Regional Geologic Map Series, Map No. 1A.

Wagner, D.L., Bortugno, E.J., and Kelley, F.R., - Compilers, 1982, Geologic map of the Santa Rosa quadrangle: California Division Mines and Geology, Regional Geologic Map Series, Map No. 2A.

Water Resources Association, 1998, Data and information directory for water resources of Yolo County, 12 p.

West Yost and Associates, 1991, Eastern Yolo County well logs.

West Yost and Associates, 1991, Eastern Yolo County well report.

West Yost and Associates, 1991, Ground water investigation Eastern Yolo County, 14 p.

West Yost and Associates, 1992, Eastern Yolo County groundwater investigation summary report, 60 p.

Wood Rodgers, Inc., 2003, YCFCWCD-Annual Engineer's Report-2003; 8 p.

Woodward-Clyde Consultants, 1976, Aggregate extraction in Yolo County a study of impacts and management alternatives: for Aggregate Resources Advisory Committee, County of Yolo Planning Department, 112 p.

Tables

Table 3.1
Data Requested from Entities for Inclusion in Yolo County Water Resources Information Database

Type of Data	Specific Information Sought	Possible Sources
Well Construction/Location	Agency’s Well Name State Well Number Borehole and Well Depth Seal Type and Depth Diameter Perforated Interval Lithology Date Drilled Well Type (e.g., municipal, irrigation, monitoring) Well Coordinates[1] Descriptive Location or Map Reference Point Elevation[2]	DWR Driller’s Report Agency Records Well Driller's Records
Well Capacity/Efficiency	Date Well Name Capacity (gpm) Specific Capacity (gpm/ft)	PG&E Tests Well Testing Records DWR Driller's Report Well Driller's Records Agency Records
Well Production	Period (e.g., month or year) Well Name Production Units (e.g., MG, acre-feet)	Agency Records
Groundwater Levels	Date Well Name Depth to Water (feet) Reference Point Elevation[2] Static or Pumping (comments)	Agency Records DWR USGS USBR PG&E Tests
Surface Water Measurement Locations	Measurement Point Name Surface Water Body Measurement Point Type (e.g., stage, flow) Measurement Point Coordinates[1] Descriptive Location or Map	Agency Records USGS
Surface Water Stage/Flow	Measurement Point Name Date/Time Reference Point Elevation[2] Stage/Flow Units (e.g., cfs, gpm, feet)	Agency Records USGS
Groundwater and Surface Water Quality	Date Well/Measurement Point Name Constituent Units (e.g., mg/L, ug/L) Detection Limit for Reporting Result Lab	Agency Records DWR USGS DHS

[1]For any locations coordinates, the coordinate system, units and datum (e.g., California State Plane, feet, NAD27) were requested.

[2]For any reference point elevations, the datum, (e.g., NGVD 29) was requested.

Table 3.2
Data from Entities

Entity	Type of Data	Format	# of wells	Period of Record	Comments	To do
California Department of Health Services	Water quality	electronic	222	3/84-3/04	Entered into database 29 analytes listed in Appendix E and TCE, PCE and MTBE	Missing water quality data for some small water systems in Yolo County, work with DHS to collect and enter into database
California Department of Pesticide Regulation	Well construction and locations				Not collected. Requires a letter to the District Chief of DPR requesting permission for the data	Write letter to District Chief, DPR requesting well location and construction data
	Groundwater quality-pesticide non detections	electronic	100	6/85-10/02	Not entered, missing well construction and well location	Enter data once receive well construction data. Request new data annually
	Groundwater quality-pesticide detections, Yolo County	electronic	13	1986-2002	Not entered, missing well construction and well location	Enter data once receive well construction data. Request new data annually
	Pesticides applied to Yolo County by day and product	electronic (CD)		2002	Not entered, not in scope of this project	
California Department of Water Resources	Drillers' Reports	electronic image	7325	for Yolo County up to 2000	Separate dataset with its own index	
	Drillers' Reports	paper copies	>100	after 1999		Scan and incorporate into existing index/dataset
	electric-logs for wells	paper			Not collected, hard copy only	Recommend scanning and enter into index/database
	Well location	electronic	871		Entered into database	
	Well construction	electronic	703	1998-2003	Entered into database	
	Water levels	electronic	855	1929-2003	Entered into database	
	Water quality	electronic	537	1998-2003	Entered into database	
	Surface water quality	electronic	12	1930-1991	Entered into database	
California Integrated Waste Management Board	Location map of solid waste facilities in Yolo County	electronic	30		Not entered, not in scope of this project	Download site locations from www.ciwmb.ca.gov/SWIS/ and enter into ArcView to provide a look at potential contaminated sites
California State Regional Water Quality Control Board (RWQCB)	Water quality-landfill	paper	23 sites		Not entered, not in scope of this project. Yolo County has 23 landfills, 2 are active. RWQCB has paper copies for Winters landfill and Spreckels Sugar Factory in Woodland (closed 2-3 years ago)	Collect and enter historical water quality and location data into database. Compare with California Integrated Waste Management Board data
California State Water Resources Control Board	Water quality-UC Davis Landfill	electronic	45	12/93-6/03	Not entered, not in scope of this project	Enter data
	Water quality-Yolo Central Landfill	electronic	30	2/95-8/02	Not entered, not in scope of this project	Enter data
California State Water Resources Control Board-Geotracker	Water quality-site locations	electronic	249		Site locations for contaminated sites in Yolo County entered into ArcView	
	Groundwater quality				Not collected or entered, not within scope of this project	Collect and enter data in future effort
California State Water Resources Control Board-Water Rights Division	Surface water diversion locations-Yolo County				Verbal confirmation that diversion locations are available and also diversion amounts. Not entered, not in scope of this project	Collect and enter data. Request all parties put meters on diversion and spill locations
California Rural Water Users Association	List of 71 small water systems in Yolo County					
City of Davis	Well location maps	electronic				
	Well construction-public supply wells	electronic	23		Entered into database	
	Well construction-other	paper	3		Entered into database (HW, NDM-1,2)	
	Water levels-public supply wells	electronic	18	1981-2004	Entered into database	Request new data annually
	Water levels-rural wells along Putah Creek	electronic	17	4/76-4/03	Entered into database	Request new data annually
	Water quality-public supply wells	electronic	32	3/76-9/03	Entered into database	Request new data annually
	Water quality-wastewater treatment	electronic	6	6/02	Not entered, not within scope of this project	Enter at a later time
	Production	electronic	31	1/52-12/02	Not entered	Enter data and request new data annually
	Water quality and well construction-former landfill		7		Not entered, not within scope of this project	Collect and enter data
	Location of former and current wastewater treatment facilities and former landfill site	electronic	3 sites		Locations entered into ArcView	

Table 3.2
Data from Entities

Entity	Type of Data	Format	# of wells	Period of Record	Comments	To do
City of West Sacramento	Surface water quality-Bryte Bend Water Treatment Plant	electronic		1995-2002	Not entered-surface water	Enter data and request new data annually
	Surface water quality-Raw Sacramento Water	electronic		1991-2003	Not entered-surface water	Enter data and request new data annually
	Surface water quantity				Not collected, not entered	Request surface water diversion quantities and enter into database
	Well construction	paper	4		Collected but not entered. City once had 23 wells but now uses surface water. These 4 wells are waiting to be abandoned, therefore not used in monitoring network	
	Map of well locations	paper				
City of Winters	Well construction-public supply wells	paper	5		Entered locations into ArcView for wells 2,3, and 5	Missing well construction for wells 4 & 6. Collect and enter into database
	Well construction-wastewater treatment plant		5		Verbally confirmed data are available, not in scope of this project	Request data and enter into database
	Well construction-closed landfill		4			Request data and enter into database
	Water levels- public supply and landfill		9		Verbally confirmed data are available but not received or entered	Missing water level information, gather and enter into database
	Water quality-public supply wells	paper	5	various	Not entered in database, paper copies. Compare with DHS data and add what is not already in database	Compare data with what is in DHS database, enter if not included in DHS
	Water quality-wastewater treatment plant		5		Verbal confirmation that 2 wells existed with 3 installed 12/03	Have water quality results sent directly to District for entry into database
	Water quality-landfill closure	paper	1	12/01	Not entered in database, landfill site	Collect all water quality data for 4 landfill wells and enter into database
City of Woodland	Well construction	paper	18		Entered into database	Missing info for 4 wells
	Groundwater levels	electronic	22	1/60-2/99	Entered into database	Missing 3/99 to present. Collect and enter into database
	Groundwater quality	electronic	11	2000-2003	Not compatible format, use DHS data	
	Production				Verbally confirmed data are available, not received	Collect and enter data into database
	Location of former and current wastewater treatment facilities and former landfill site	paper	3 sites		Entered into ArcView	
Colusa County Water District	Surface water quality				Water quality data for the Colusa Canal are available. It was not collected, not in scope for this project	Determine if Colusa Canal water is used in Yolo County, if so request water quality data and enter into database
Colusa Drain Mutual Water Company	Surface water quality and diversion quantity and location				Not collected or entered. Not in scope of work for this project	Collect surface water information at a later date
Dunnigan Water District	Well location map	paper				
	Well construction-private irrigation wells	paper	55		Table of well construction not entered, no water level or water quality data for these wells	
	Water levels	paper	9	1986-2003	Not entered, missing well location and elevation	Locate wells and determine elevation, enter water levels
	Tehama-Colusa Canal diversion location and quantities and spill quantities and locations				Not collected or entered. Not in scope of work for this project	
Esparto Community Services District	Well location map	paper				
	Well construction and e-logs	paper	8		Not entered, missing water quality information (2000-2004) therefore not in water quality network	Missing water quality and water level data. Enter well construction and location if have water quality and /or water level data
	Water levels				Verbal confirmation that a few are available, not received, not entered	Request water level data from District and enter into database
	Water quality			1984-1996	DHS has some water quality	Request water quality data from District for years that are missing from DHS and enter into database
	Production				Verbal confirmation that production is available for one year. Not received	Collect and enter

Table 3.2
Data from Entities

Entity	Type of Data	Format	# of wells	Period of Record	Comments	To do
Granite Construction	Water levels	electronic	6	1/99-10/03	Not entered, missing well construction	Request well construction, enter all data. Request new data annually
	Annual Report with well construction and water quality				Not received	Request report and enter data
Knight's Landing Service District	Well construction	paper	3		Not received. DHS has water quality	Collect well construction. Check that DHS has all water quality that Knight's Landing has in paper copy
	Groundwater levels				Not currently monitored by KLSD	Recommend measurements are taken
Madison Service District	Well construction and well location	paper	2		Expect new well to be constructed 3/04	Collect new well construction information
	Water quality	paper	1	1995	Not entered, paper copies. DHS has water quality data and DWR has well construction	
Reclamation District 108	Well construction and well location	paper	12		Entered wells located in Yolo County	
	Groundwater quality	electronic	3	8/03	Wells 1, 2, difficult format, not entered	Enter data
	Groundwater levels	electronic	25	4/03-11/03	Not entered. Use monthly water levels in DWR database for 12 multiple completion wells	
	Surface water quality		20 drains		Weekly EC readings taken during irrigation season. Not collected as part of this project	Collect and enter data
Reclamation District 737 (River Garden Farms)	Pump test data	electronic	4	5/03-6/03	Not entered. Not in scope of this project	
	Groundwater levels and pumping quantities during water transfer	electronic	4	6/03-10/03	Not entered, water transfer not in scope of this project	Enter at a later date
	Groundwater quality	electronic	1	1987-2003	Not entered, is in DHS database	Check to confirm this information is in DHS database, if not enter into database
	Cross-sections, well logs, and e-logs	paper			Not entered, not area of focus	Enter at a late date
	Surface water-diversion locations	paper			Not entered. Not in scope of this project	Enter at a later date
Reclamation District 900	Surface water-diversions				Agency has diverted water from Sacramento River and spill data (can be calculated using hours pumped) and locations	Collect locations, and amounts of diversions and spills and enter into database
Reclamation District 2068	Surface water diversion locations and quantities				Diverted water is from Solano Irrigation District and the Sacramento River. Not collected or entered. Not in scope of work for this project	Collect and enter surface water data at a later date
	Land use				Crops grown by field for last 40-50 years and water applied to field for last 10 years. Not collected or entered. Not in scope of work for this project	Collect and enter at a later date
	Well construction for new well completed 3/04		1		Proposed nested monitoring well drilled 3/04. Not entered, not available	Collect and enter. Evaluate well for possible inclusion in water quality monitoring network
Rinker Materials	Well construction	electronic	14		Entered into database	Missing well construction for a few irrigation wells, may not be available. Request new data annually
	Water levels	electronic	14	11/73-9/03	Entered data for wells with well construction	Look for additional well construction and enter data for those wells. Request new data annually
	Water quality	electronic	5	4/92-0/03	Entered data for wells with well construction	Look for additional well construction and enter data for those wells. Request new data annually
Rumsey Band of Wintun Indians	Map of well locations	electronic			Locations entered into database	
	Well construction	paper	11		Entered construction into database for 11 wells	Missing construction for 5 wells. Request well log for new public supply well
	Groundwater quality	electronic	6	1/03-1/04	Entered into database	Request from AES on an annual basis
	Groundwater quality-public supply well	electronic	1	2004	Entered into database	Request from AES on an annual basis
	Groundwater levels	electronic	10	2/03-3/04	Entered into database	Request from AES on an annual basis
Solano County, Stream Keeper	Putah Creek-water quality				Not entered, surface water not in scope of this project	Gather surface water quality data and enter into database
Syar Industries	Well construction	paper/ electronic	12		Entered into database	Missing well construction for MW-9 and 10
	Water levels	electronic	13	5/96-10/03	Entered into database	Request new data annually
	Water quality	electronic	11	6/96-10/03	Entered into database	Request new data annually

Table 3.2
Data from Entities

Entity	Type of Data	Format	# of wells	Period of Record	Comments	To do
Teichert Aggregates Esparto Properties	Well construction	paper/ electronic	15		Entered into database	Missing well construction for Muller and Reiff Ag wells, and plant domestic and supply wells
	Water levels	electronic	24	12/89-9/03	Entered into database	Request new data annually
	Water quality	electronic	5	4/92-10/03	Entered into database	Request new data annually
Teichert Aggregates Woodland Properties	Well construction	paper/ electronic	15		Entered into database	Missing well construction for TA-5A, 9A, and 13R
	Water levels	electronic	39	6/86-10/03	Entered into database	Request new data annually
	Water quality	electronic	5	2/02-10/03	Entered into database	Request new data annually
University of California, Davis	Groundwater levels-domestic wells	electronic	6	1981-2002		
	Groundwater levels-utility wells	electronic	6	1992-2002		
	Groundwater levels-irrigation wells	electronic	24	1957-2002	Need to find well construction and check if in DWR database	
	Groundwater quality-irrigation wells	paper	24?	<1990-present	Water has been tested for boron and possibly other constituents. UCD has paper copies only	Collect and enter data into database
	Groundwater quality-hexavalent chromium	paper			Two reports on chromium in shallow groundwater	
	Production-domestic, utility, irrigation	electronic	total annual	1968-2002	Not in scope for this project	Complete and enter data
	Surface water quantity delivered	electronic		1994-2002	Not in scope for this project	
	Surface water quality	electronic			Wastewater treatment plant and stormwater quality data are available but not collected, not in scope of this project	Collect and enter data into database. CRWQCB studied toxicity in Putah Creek watershed (2000) with samples taken upstream and downstream of the wastewater treatment plant. Collect and enter into database
U.S. Bureau of Reclamation (USBR)	Well locations	electronic	317		Well locations received from DWR database, shows owner as USBR	
	Surface water diversion-Sacramento River within Yolo County	electronic		1964-2002	Monthly for 7 contracts in acre-feet. Not entered, not in scope for this project	Need diversion locations available from SWRCB. Request quantities diverted for individual diverters on the Sacramento River who pay by acre
	Surface water diversion-Tehama-Colusa Canal for Dunnigan Water District	electronic		1/81-2/03	Monthly in acre-feet. Not entered, not in scope for this project	
U.S. Environmental Protection Agency	Surface water quality	electronic			Online data (Storet), not in scope for this project	Collect and enter data. Request all parties put meters on diversion and spill locations
U.S. Geological Survey (USGS)	Groundwater well locations	electronic	809		For Yolo County and surrounding area	
	Groundwater level	electronic	2425	1920-2002	For Yolo County and surrounding area	Update with most recent information
	Groundwater quality	electronic	1123	1940-2002	For Yolo County and surrounding area	Update with most recent information
	Surface water-flow	electronic	12 sites	1903-2002	Not entered into database, not in scope for this project	Enter locations in study area and update to most current information
Yolo County Environmental Health Department- small public water systems (5-199 connections)	Water quality				DHS collects this information	
	List of small community wells	paper			Looked for water quality for these wells in the DHS database. Some data are missing	Work with DHS and YCEHD to complete the water quality database for this set of wells
Yolo County Flood Control and Water Conservation District (YCFCWCD)	Surface water-water quality (boron)	electronic	8 sites	1978-2003	Monthly results. Not entered into database, not in scope for this project	Incorporate into database. Missing site locations
	Surface water-water quality	paper		1930-40	Boron and EC values. Not entered, surface water	
	Surface water quality-historical	paper		<1988	Historical data in binder at District, not copied or entered for this project	Review water quality information for suitability for input in database
	Surface water-diversions	electronic	829 sites	2000-2003	Monthly diversion quantities (acre-feet). Not entered into database, not in scope for this project	Missing diversion location and return flow quantities and locations. Use GPS and/or USGS maps to determine diversion and return flow locations
	Surface water-diversions historical	electronic		1988-1999	Old computer files, not entered, not in scope for this project	Collect data and enter into database
	Surface water-diversions historical	paper		<1988	Not entered, not in scope of this project	Collect data and enter into database
	Well construction	paper	1		Entered into database	
	Groundwater levels	electronic	152	2003-2004	Semi annual results. Entered into database	
	Groundwater quality	paper	18	1996	Boron levels in wells and well locations. Not entered, no well construction information	Missing well construction information

Table 3.2
Data from Entities

Entity	Type of Data	Format	# of wells	Period of Record	Comments	To do
Yolo County Integrated Waste	Esparto Corporation Yard-Contaminated site-water quality	electronic	4	1996-2003	Quarterly general minerals and VOCs. Not entering contaminated sites for this project	Enter all data at a later time
	Esparto Corporation Yard-Contaminated site-water levels	electronic	4	1/96-9/03	Quarterly water level measurements. Not entered, missing well construction information	Enter this data. Find well construction info. Enter well location and well construction, water level and water quality information
	Esparto Corporation Yard-well location map	paper			Can use this for well location once have well construction data	
	Esparto Former landfill					Missing location and water level and quality information
	Yolo County Central Landfill (YCCL)-well construction and location	electronic	66		Inorganic and VOCs. Not entered, not using landfill site information for this project	Enter all data into database
	Yolo County Central Landfill (YCCL)-water level data	electronic	66	4/03-10/03	Quarterly water level measurements. Not entered, not using landfill site information for this project	Missing historical water level data. Enter all data and add these wells to the water level monitoring network
	Yolo County Central Landfill (YCCL)-water quality data	electronic	35	2/95-8/03	Inorganic and VOCs. Not entered, not using landfill site information for this project	Enter all data. Helpful if format revised
Yolo County Resource Department	Surface water quality	electronic	4 sites	7/01-6/03	Test 3 times per year. Not entering surface water data for this project	Enter all data. Missing site location coordinates
Yolo County Resource Conservation District	Surface water quality				Doing water quality study on Willows Slough to be completed 9/04. Surface water not in scope of this study	Request data and enter into database
Yolo County-Subsidence information	Subsidence data	pdf	60 stations	1999-2002	Not entered, not in scope of this project	Enter all data
Yolo-Zamora Water District	Well construction information				Not collected. All wells are private in this area	Request well data from well owners in this district and select wells to add to the network
	Land subsidence				Has largest land subsidence in Northern California	Study what would be helpful to know about this situation and add wells to the water level network if needed

Table 3.3
Yolo County Water Resources Information Database Contents

Table Name	Description	No. of Records	Field Names								
Well Information											
Well	Wells in Database	6,535	Well Name	State Well Number	Subbasin	Township Range	Data Source	Owner	Owner Well Name	Well Log (Yes/No)	
Location	Well Locations	10,753	Well Name	Latitude	Longitude	Coordinate Datum	Reference Point Elevation	Reference Point Elevation Datum	Data Source	QA/QC Status	
Construction	Well Construction Information	4,863	Well Name	Construction Date	Well Depth	Hole Depth	Seal Depth	Diameter	Data Source	QA/QC Status	
Perforation	Perforated Intervals	1,370	Well Name	Aquifer Zone	Zone Assignment Method	Top Perforation	Bottom Perforation	QA/QC Status			
Water Quality											
Water Quality	Water Quality for Wells	129,649	Well Name	Sample Date	Analyte	Result	Reporting Limit	Units	Data Source	Method	QA/QC Status
Water Quality Analyte	Water Quality Analytes	605	Analyte	Analyte Abbreviation	Analyte Summary	Analyte Name	Analyte Type	MCL	Units		
Water Quality Network	Water Quality Monitoring Networks	33	Network ID	Network Well Name	Well Name						
Water Level											
Water Level	Water Levels in Wells	117,287	Well Name	Measurement Date	Reference Point Elevation	Depth to Water	Data Source	QA/QC Status			
Surface Water											
Surface Water Sites	Surface Water Sites	10	Site Number	Station Name	Status	Data Source					
Surface Water Location	Location of Surface Water Sites	10	Site Number	Latitude	Longitude	Coordinate Datum	Reference Point Elevation	Reference Point Elevation Datum	Data Source		
Surface Water Flow	Surface Water Flows	134,115	Site Number	Water Flow Date	Water Flow	Data Source					
Surface Water Quality	Surface Water Quality	1,783	Site Number	Sample Date	Analyte	Result	Detection Limit for Reporting	Units	Method		
Other											
Study Area Index	Township Range Sections in Study Area	63	Township Range								

Table 4.1
Wells in the Groundwater Level Monitoring Network by Subbasin with Zone Designation, Yolo County

Subbasin	Zone	Number of wells*	Designation Method: Well Log	Designation Method: DWR perforation interval	Designation Method: DWR depth
Capay Valley	Shallow	26	9	2	15
	Intermediate	3	2	1	
	Deep				
	Multi	4	4		
	No Well Construction Information	6			
	Total	39			
Buckeye/Zamora	Shallow	12	2	6	4
	Intermediate	17		10	7
	Deep	1		1	
	Multi	15	2	7	6
	No Well Construction Information	12			
	Total	57			
Dunnigan Hills	Shallow	6	2	2	2
	Intermediate	1	1		
	Deep				
	Multi				
	No Well Construction Information	4			
	Total	11			
Lower Cache-Putah	Shallow	33	12	14	7
	Intermediate	16	13	3	
	Deep	9	9		
	Multi	30	20	2	8
	No Well Construction Information	13			
	Total	101			
Northern Sacramento River	Shallow				
	Intermediate	16		16	
	Deep	9		6	3
	Multi	2	1		1
	No Well Construction Information	2			
	Total	29			
Southern Sacramento River	Shallow	8		4	4
	Intermediate	4		3	1
	Deep				
	Multi	2		2	
	No Well Construction Information	11			
	Total	25			
Western Yolo	Shallow	81	12	41	28
	Intermediate	6		2	4
	Deep	0			
	Multi	19	9	3	7
	No Well Construction Information	42			
	Total	148			

Monitoring Network Well: A network well is defined as any well that was monitored between January 2000 to March 2004.

* The number of wells includes wells without an XY location, however, the well has a state well number and was assigned a subbasin designation based on this.

Table 4.2
Wells in the Groundwater Quality Monitoring Network by Subbasin with Zone Designation, Yolo County

Subbasin	Zone	Number of wells*	Designation Method: Well Log	Designation Method: DWR perforation interval	Designation Method: DWR depth
Capay Valley	Shallow	13	1	8	4
	Intermediate	1		1	
	Deep				
	Multi				
	No Well Construction Information	2			
	Total	16			
Buckeye/Zamora	Shallow	5	4	1	
	Intermediate				
	Deep				
	Multi	1	1		
	No Well Construction Information	15			
	Total	21			
Dunnigan Hills	Shallow				
	Intermediate	1	1		
	Deep				
	Multi				
	No Well Construction Information	1			
	Total	2			
Lower Cache-Putah	Shallow	8	2	3	3
	Intermediate	24	22	2	
	Deep	9	9		
	Multi	24	20		4
	No Well Construction Information	36			
	Total	101			
Northern Sacramento River	Shallow	1	1		
	Intermediate				
	Deep				
	Multi	1			1
	No Well Construction Information	4			
	Total	6			
Southern Sacramento River	Shallow	7	4		3
	Intermediate	3	1	2	
	Deep	1	1		
	Multi	4	1	1	2
	No Well Construction Information	18			
	Total	33			
Western Yolo	Shallow	23	7	10	6
	Intermediate	4	1	2	1
	Deep				
	Multi	13	8	3	2
	No Well Construction Information	13			
	Total	53			

Monitoring Network Well: A network well is defined as any well that has a specific conductance, nitrate or boron result between January 2000 to March 2004.

* The number of wells includes wells without an XY location, however, the well has a state well number and was assigned a subbasin designation based on this.

Table 4.3
Groundwater Level Monitoring Network Wells* by Entity with Frequency of Measurement, Yolo County

Entity**	Number of wells	Frequency of measurement***
City of Davis-Public Supply Wells	22	varies
City of Woodland	1	varies
District Capay Valley Water Level Monitoring Network Wells	28	monthly
District Water Level Monitoring Network Wells	125	semi-annually
District Water Quality Network Wells With Water Level Measurements	27	annually
DWR	51	varies
Rinker	9	quarterly
Rumsey Band of Wintun Indians	7	varies
Sac County	1	semi-annually
Syar	14	monthly
Teichert-Esparto	19	quarterly
Teichert-Woodland	33	quarterly
UCD	12	varies
USBR	52	varies
USGS	6	varies

* A network well is defined as any well that was monitored from January 2000 to March 2004.

** Some network wells are monitored by more than one entity; wells have been assigned to the primary responsible entity for water level measurements.

*** Frequency varies when the entity monitors certain wells on different schedules (e.g., monthly, bi-monthly, annually, etc.).

Table 4.4
Groundwater Quality Monitoring Network Wells* by Entity with Frequency of Measurement and Constituents Sampled, Yolo County

Entity**	Number of wells	Frequency of measurement	Constituents			
			General Minerals	Inorganics	VOCs	Pesticides
City of Davis	31	annually	31	31	31	
City of West Sacramento	1	annually	1	1	1	
City of Winters	5	triennially	5	5		
City of Woodland	18	annually	18	18	18	
District	33	annually	33	33	12	12
DWR	20	biennially	20	20		
Rinker	4	semi-annually	4	4	4	
Rumsey Band of Wintun Indians	6	quarterly	6	6	6	
Small Water Systems	98	Typ.every 3 yrs	98	98		
Syar	5	semi-annually	4	4	4	
Teichert-Esparto	2	semi-annually	2	2	2	
Teichert-Woodland	2	semi-annually	2	2	2	
UCD	11	annually	11	11		

* Network wells are defined as any well that has a specific conductance, nitrate, or boron result from January 2000 to March 2004.

** Some network wells are monitored by more than one entity; wells have been assigned to the primary responsible entity for water level measurements.

Table 4.5
Response from Letter to Well Owners Currently Participating in the District Water Level Monitoring Program Requesting Permission to Sample for Water Quality

Description	Number	Percentage
No response	67	47%
Responded positively, would like to participate	69	48%
Undecided	3	2%
Does not want to participate	2	1%
Wells not useable for water quality sampling	2	1%
Total letters sent requesting permission to sample	143	100%

Additonal wells not in the District water quality sampling network that are willing to participate (ie., located in areas of interest to the study)	21
District water level network wells willing to participate	69
Total number of well owners willing to participate	90

Table 4.6
Well Selection Process, Baseline Groundwater Quality Sampling Program

Step	Evaluation Process/ Parameters
1	Well currently part of the District water level monitoring network.
2	Well located in an area lacking current water quality information (DWR, municipal and small public water systems).
3	Permission granted (written or verbal) from well owner for groundwater quality sampling.
4	Domestic wells were preferred. Often in a correspondence or conversation the well owner would indicate that the irrigation well was not suitable for collecting a water quality sample (did not have a pump or electricity is only turned on during the irrigation season). The land owner often had a domestic well available near the same site. Domestic wells are preferable to irrigation wells; the perforated zone and well depths are typically shallower; and these wells are frequently pumped therefore samples better represent the shallow zone.
5	Well depth and/or perforation information is available and are preferably in the shallow zone.
6	Well physical components pass field inspection to check for suitability for water sampling.
7	If no wells were available from the District in an area of interest, non-District wells were identified and owners contacted.

Table 4.7
Constituents for Water Quality Analyses Baseline Groundwater Quality Sampling Program

Constituents	EPA Method
General Minerals	
Alkalinity	
Calcium	
Chloride	
Conductivity	
Copper	
Hardness	
Ion Balance	
Iron	
Fluoride	Combination
Magnesium	
Manganese	
MBAS	
pH	
Potassium	
Sodium	
Sulfate	
TDS	
Zinc	
Inorganic Chemicals	
Aluminum	
Arsenic	
Barium	
Cadmium	
Chromium	
Mercury	Combination
Manganese	
Lead	
Selenium	
Silver	
Nitrate	
Nitrite	
Fluoride	
Boron	6010B
Hexavalent Chromium - Low Level (reporting limit = 1.0 ppb)	7196
Volatile Organic Compounds	524.2
Pesticides	
Organophosphate and organonitrogen pesticides (e.g. simazine, atrazine, diazinon)	8141
Organochlorine pesticides (e.g. metalochlor, alachlor)	8081A
Phenoxy acid herbicides (e.g. 2,4-D, Dimethylamine salt)	8151A
phenyl urea herbicides (e.g. Diuron)	632
carbamate pesticides (e.g. carbaryl, methomyl)	8318

Table 4.8
Baseline Groundwater Quality Monitoring Program Wells

Subbasin	Aquifer	Well ID	Constituents		
			General Minerals and Inorganics	VOCs	Pesticides
Capay	shallow	W18F1	yes	yes	yes
	shallow	W18G2	yes		
	shallow	W13E2	yes		
	shallow	W20F1	yes		
	shallow	W35L1	yes		yes
	intermediate	W4Q1	yes	yes	
Lower Cache-Putah	shallow	W5A2	yes	yes	yes
	shallow	W13H2	yes	yes	yes
	shallow	W21E2	yes	yes	
	shallow	W23Q2	yes	yes	yes
	shallow	W24R3	yes	yes	yes
	shallow	W34A1	yes	yes	
	intermediate	W20D3	yes		
	shallow-intermediate	W15N1	yes		yes
	shallow-intermediate	W16A2	yes		
	shallow-intermediate	W22H2	yes	yes	yes
Southern Sacramento River	shallow	W31A2	yes	yes	yes
	intermediate	W11D2	yes	yes	
Western Yolo	shallow	W1M2	yes		
	shallow	W11C2	yes		
	shallow	W17J4	yes		
	shallow	W18N1	yes		
	shallow	W21E1	yes		
	shallow	W31D1	yes		
	shallow	W32E1	yes		
	shallow	W35R1	yes		
	intermediate	W2B1	yes		
	intermediate	W11L2	yes		yes
	shallow-intermediate	W9D1	yes		
	shallow-intermediate	W10N2	yes	yes	yes
	shallow-intermediate	W17E1	yes		yes
	shallow-intermediate	W28R1	yes		
	shallow-intermediate	W33L2	yes		

Table 5.1
Summary of Water Quality Data - January 2000 to March 2004

Analyte and Subbasin	Shallow Zone					Intermediate Zone					Deep Zone					Multiple Zones				
	No. of Wells	No. of Meas.	Range of Values	Ave. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Ave. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Ave. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Ave. Value (Detects)	No. of Detects
Arsenic	**LIMIT:** 10(1)			**UNITS:** ug/L																
Buckeye/Zamora Subbasin	1	7	<2-<5													1	1	<2		
Capay Valley Subbasin	12	15	<15			1	1	<15								1	1	ND		
Lower Cache-Putah Subbasin	6	6	<15			20	56	<2-6.4	4	47	8	27	1.6-10	5	27	24	37	<2-6.1	3	25
Northern Sacramento River Subbasin																1	1	4.2	4	1
Southern Sacramento River Subbasin	1	1	<15			2	5	<2-3	3	2	1	1	5.7	6	1	1	1	6	6	1
Western Yolo Subbasin	19	82	<2-4	4	1	2	2	<15								9	9	<1-<15		
Boron	**LIMIT:** 1000(2)			**UNITS:** ug/L																
Buckeye/Zamora Subbasin	2	3	1300-1500	1367	3															
Capay Valley Subbasin	7	7	392-9490	2305	7	1	1	715	715	1										
Dunnigan Hills Subbasin						1	2	400-1200	800	2										
Lower Cache-Putah Subbasin	6	8	700-3440	1611	8	23	88	500-3200	1101	88	8	40	550-1000	733	40	24	75	600-7420	1575	75
Northern Sacramento River Subbasin						1	2	700	700	2						1	1	6620	6620	1
Southern Sacramento River Subbasin	4	5	140-1500	1064	5	3	7	600-1570	924	7						2	2	1700-1800	1750	2
Western Yolo Subbasin	12	16	<20-2200	663	15	3	4	500-1870	947	4						6	7	100-2550	953	7
Chromium (Hexavalent)	**LIMIT:** N/A			**UNITS:** ug/L																
Buckeye/Zamora Subbasin																				
Capay Valley Subbasin	6	6	<1-3.6	4	1	1	1	3.6	4	1										
Lower Cache-Putah Subbasin	6	6	7.3-50	17	6	21	96	<1-41	20	91	9	19	<1-24	8	16	24	58	<1-54	22	57
Southern Sacramento River Subbasin	3	3	<1			2	6	<1-11	7	5	1	1	ND			1	1	ND		
Western Yolo Subbasin	8	8	<1-13	9	7	2	2	<1								5	5	<1-24	11	4
Chromium (Total)	**LIMIT:** 50(3)			**UNITS:** ug/L																
Buckeye/Zamora Subbasin	1	7	<10-30	24	4											1	1	<10		
Capay Valley Subbasin	12	15	<5-190	82	3	1	1	7.34	7	1						1	1	8.3	8	1
Lower Cache-Putah Subbasin	6	6	<5-46.2	24	5	21	136	<5-59	25	129	9	36	<1-31	11	26	24	64	<5-71	33	62
Northern Sacramento River Subbasin																1	1	<1		
Southern Sacramento River Subbasin	1	1	<5			2	8	<2-17	14	3	1	1	ND			1	1	2	2	1
Western Yolo Subbasin	19	82	<5-31	13	28	2	2	<5								9	9	<5-25	17	8

1. Federal MCL, State to be determined
2. Action Level
3. State Primary MCL
4. Secondary MCL (recommended/upper)
5. Suggested Range

Table 5.1
Summary of Water Quality Data - January 2000 to March 2004

Analyte and Subbasin	Shallow Zone					Intermediate Zone					Deep Zone					Multiple Zones				
	No. of Wells	No. of Meas.	Range of Values	Ave. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Ave. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Ave. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Ave. Value (Detects)	No. of Detects
Manganese	**LIMIT:** 500(2)/50(4)			**UNITS:** ug/L																
Buckeye/Zamora Subbasin	1	7	<10-110	66	6															
Capay Valley Subbasin	6	6	<5-1700	855	2	1	1	21.9	22	1										
Lower Cache-Putah Subbasin	6	6	<5-34.1	21	2	21	84	<5-150	41	13	8	32	<10-210	33	20	24	42	<5-181	134	3
Northern Sacramento River Subbasin																1	1	190	190	1
Southern Sacramento River Subbasin	1	1	162	162	1	2	7	<5-<10			1	1	370	370	1	1	1	70	70	1
Western Yolo Subbasin	19	82	<5-290	116	7	2	2	42.5-120	81	2						9	9	<3-71.6	42	4
Nitrate as NO3	**LIMIT:** 45(3)			**UNITS:** mg/L																
Buckeye/Zamora Subbasin	5	25	<0.1-48	16	20											1	1	11	11	1
Capay Valley Subbasin	13	16	<0.1-39	16	14	1	1	11.96	12	1										
Dunnigan Hills Subbasin						1	2	0.6-13.4	7	2										
Lower Cache-Putah Subbasin	8	18	21.26-66.45	44	18	24	208	<0.1-41	19	204	9	41	<1-12.2	3	24	24	161	<0.1-105	27	159
Northern Sacramento River Subbasin						1	2	0.3-0.4	0	2						1	2	4.3-8.6	6	2
Southern Sacramento River Subbasin	7	14	<0.1-135	64	5	3	31	<0.1-50	34	30	1	1	ND			4	5	<0.1-37	21	4
Western Yolo Subbasin	23	160	<0.1-120	33	147	4	6	<0.1-22	22	2						9	11	<0.1-33.67	10	9
Selenium	**LIMIT:** 50(3)			**UNITS:** ug/L																
Buckeye/Zamora Subbasin	1	7	<5													1	1	<5		
Capay Valley Subbasin	12	15	<15-11	9	2	1	1	<15												
Lower Cache-Putah Subbasin	6	6	<15-57.7	39	2	20	129	<1-62	14	116	9	44	<0.5-4	2	18	24	58	<15-91.3	18	45
Northern Sacramento River Subbasin																1	1	<5		
Southern Sacramento River Subbasin	1	1	<15			2	9	<15-22	15	8	1	1	ND			1	1	ND		
Western Yolo Subbasin	19	82	<5-7.8	7	3	2	2	<15								9	9	<1-<15		
Specific Conductance (EC)	**LIMIT:** 900/1600(4)			**UNITS:** umhos/cm																
Buckeye/Zamora Subbasin	3	10	400-666	479	10															
Capay Valley Subbasin	13	16	330-6100	1223	16	1	1	580	580	1										
Dunnigan Hills Subbasin						1	2	363-590	477	2										
Lower Cache-Putah Subbasin	6	8	860-2000	1469	8	23	87	608-1700	1039	87	8	39	450-940	592	39	24	68	760-2400	1063	68
Northern Sacramento River Subbasin						1	2	470-477	474	2										
Southern Sacramento River Subbasin	3	4	1200-1750	1463	4	3	7	660-1600	1192	7	1	1	1400	1400	1	2	2	680-840	760	2
Western Yolo Subbasin	23	90	292-1100	713	90	3	4	610-900	802	4						10	11	410-920	635	11

1. Federal MCL, State to be determined
2. Action Level
3. State Primary MCL
4. Secondary MCL (recommended/upper)
5. Suggested Range

Table 6.1
Recommended District Ongoing Groundwater Level and Quality Monitoring Program

Subbasin	Aquifer	Well ID	Water Levels	Water Quality Constituents		
				General Minerals and Inorganics	VOCs	Pesticides
Capay	shallow	W18F1	monthly	annually	triennially	triennially
	shallow	W18G2	monthly	annually		
	shallow	W13E2	monthly	annually		
	shallow	W20F1	monthly	annually		
	shallow	W35L1	monthly	annually		triennially
	intermediate	W4Q1	monthly	annually	triennially	
Lower Cache-Putah	shallow	W5A2	semi-annually	annually	triennially	triennially
	shallow	W13H2	monthly	annually	triennially	triennially
	shallow	W21E2	annually	annually	triennially	
	shallow	W23Q2	monthly	annually	triennially	triennially
	shallow	W24R3	annually	annually	triennially	triennially
	shallow	W34A1	annually	annually	triennially	
	intermediate	W20D3	monthly	annually		
	shallow-intermediate	W15N1	annually	annually		triennially
	shallow-intermediate	W16A2	annually	annually		
	shallow-intermediate	W22H2	annually	annually	triennially	triennially
Southern Sacramento River	shallow	W31A2	semi-annually	annually	triennially	triennially
	intermediate	W11D2	monthly	annually	triennially	
Western Yolo	shallow	W1M2	monthly	annually		
	shallow	W11C2	annually	annually		
	shallow	W17J4	monthly	annually		
	shallow	W18N1	annually	annually		
	shallow	W21E1	annually	annually		
	shallow	W31D1	annually	annually		
	shallow	W32E1	annually	annually		
	shallow	W35R1	annually	annually		
	intermediate	W2B1	annually	annually		
	intermediate	W11L2	monthly	annually		triennially
	shallow-intermediate	W9D1	annually	annually		
	shallow-intermediate	W10N2	annually	annually	triennially	triennially
	shallow-intermediate	W17E1	annually	annually		triennially
	shallow-intermediate	W28R1	annually	annually		
	shallow-intermediate	W33L2	annually	annually		

Table 6.2
Recommended Analyte and Method Information

	Analyte or Analysis	Method	Hold Time	Reporting Limit	Units	Preservative
Field Parameters	Specific Conductance (EC)	field meter				
	Temperature	field meter				
	Dissolved Oxygen	field meter				
	pH	field meter				
	Turbidity	field meter				
	Redox	field meter				
General Minerals and Inorganic Chemicals	Specific Conductance (EC)	EPA 120.1	ASAP (24 hrs)	10	umhos/cm	4º C
	pH	EPA 150.1	ASAP (24 hrs)	0.01	pH units	
	Alkalinity (bicarbonate and carbonate)	SM 2320B	14 days	5	mg/L	
	Chloride	EPA 300.0	28 days	100	mg/L	
	Sulfate	EPA 300.0	28 days	100	mg/L	
	Fluoride	EPA 340.2	28 days	0.1	mg/L	
	TDS	EPA 160.1	7 days	1	mg/L	
	MBAS	EPA 425.1	48 hours	0.1	mg/L	
	Nitrate	EPA 300.0		1	mg/L	
	Nitrite	EPA 300.0		0.1	mg/L	
	Ion Balance	calculation	N/A			
	hardness	EPA 130.2	180 days	2	mg/L	
Metals	Al, Ba, Cd, Ca, Cr, Cu, Fe, Pb, Mg, Mn, K, Se, Ag, Na, Zn	EPA 6010B/200.7	180 days	range .00500-1	mg/L	HNO3
	Arsenic	EPA 6020	180 days	0.001	mg/L	
	Hg	EPA 7470A	28 days	0.0005	mg/L	
	Boron	EPA 6010B	180 days	0.02	mg/L	
	Hexavalent Chromium-Low Level	EPA 7199	24 hours	1	ug/L	4º C
Volatile Organics	Volatile Organic Compounds- Full List	524.2	14 days	varies but all <0.5	ug/L	HCl
Pesticides	Organophosphate and organonitrogen pesticides (simazine, atrazine, diazinon)	8141	7 days	varies	ug/L	4º C
	Organochlorine pesticides (metalochlor, alachlor)	8081A	7 days	varies	ug/L	
	Phenoxy acid herbicides (2,4-D, Dimethylamine salt)	8151A	7 days	varies	ug/L	
	phenyl urea herbicides (Diuron)	632	7 days	varies	ug/L	
	carbamate pesticides (carbaryl, methomyl)	8318	7 days	varies	ug/L	

Figures

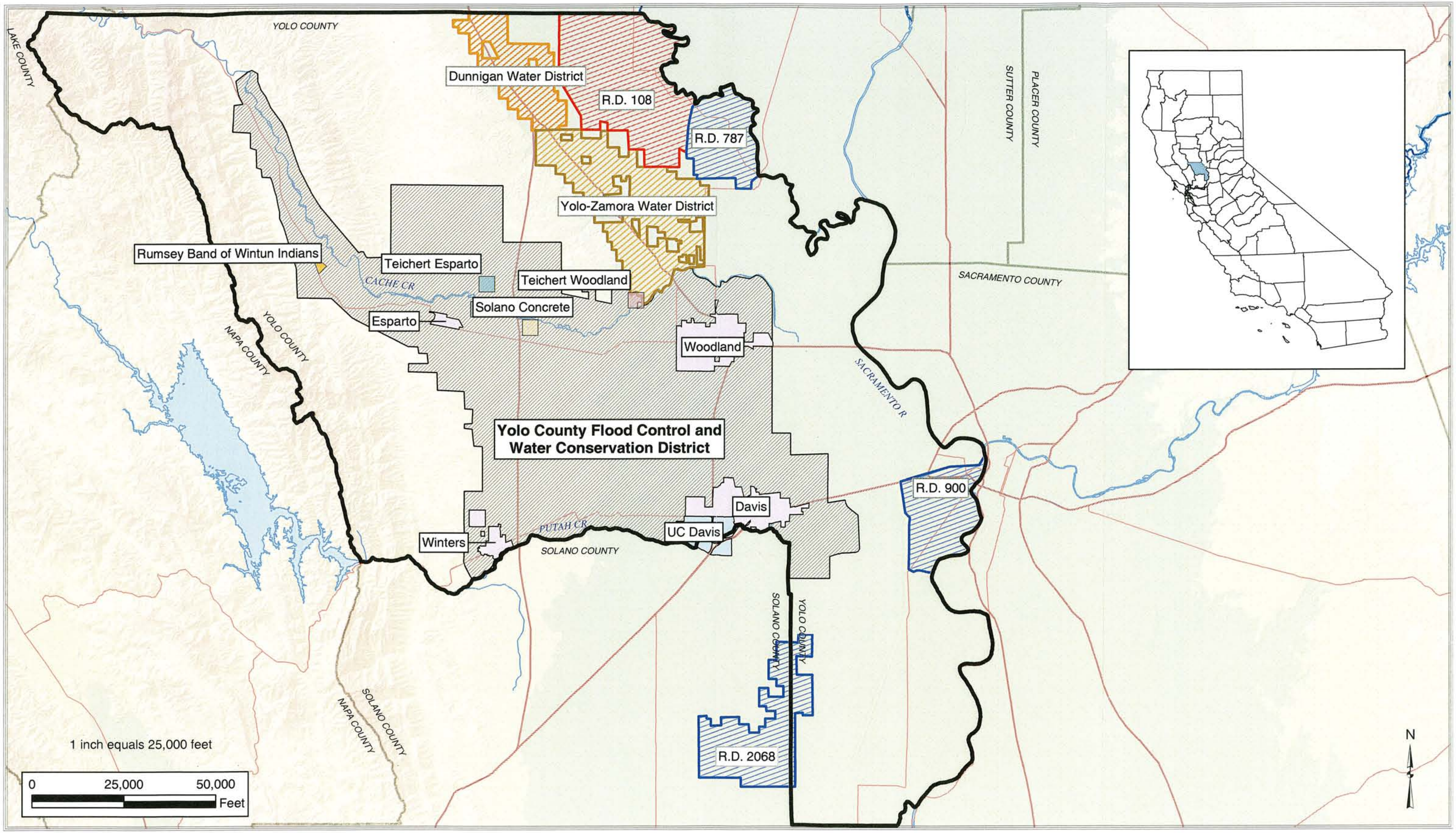

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Figure 1.1
Participating Agencies
AB 303 Project
Yolo County

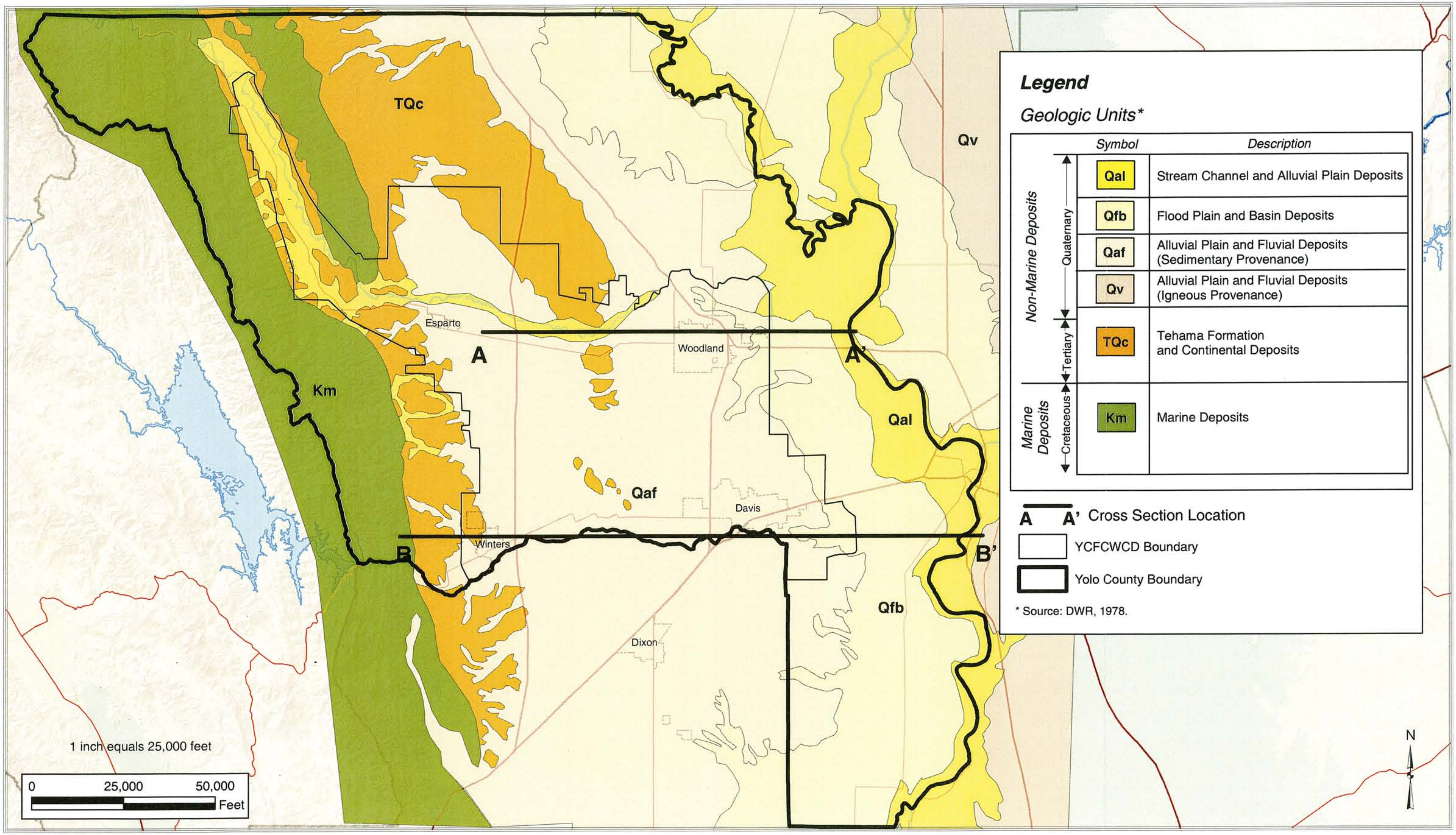

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Figure 2.1
Geologic Map of the Study Area and Cross Section Locations
Yolo County

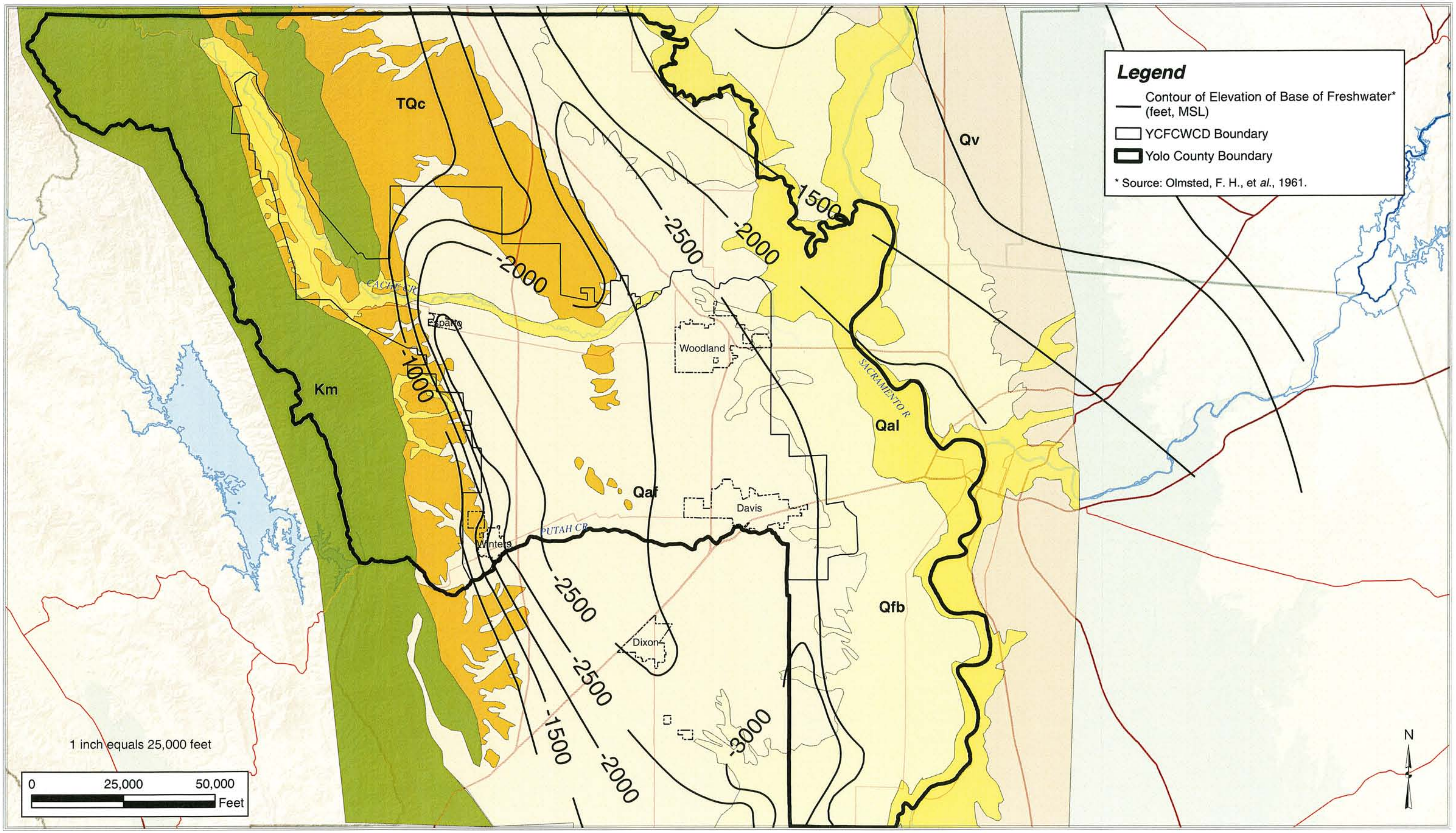

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Figure 2.2
Elevation of Base of Freshwater
Yolo County Area

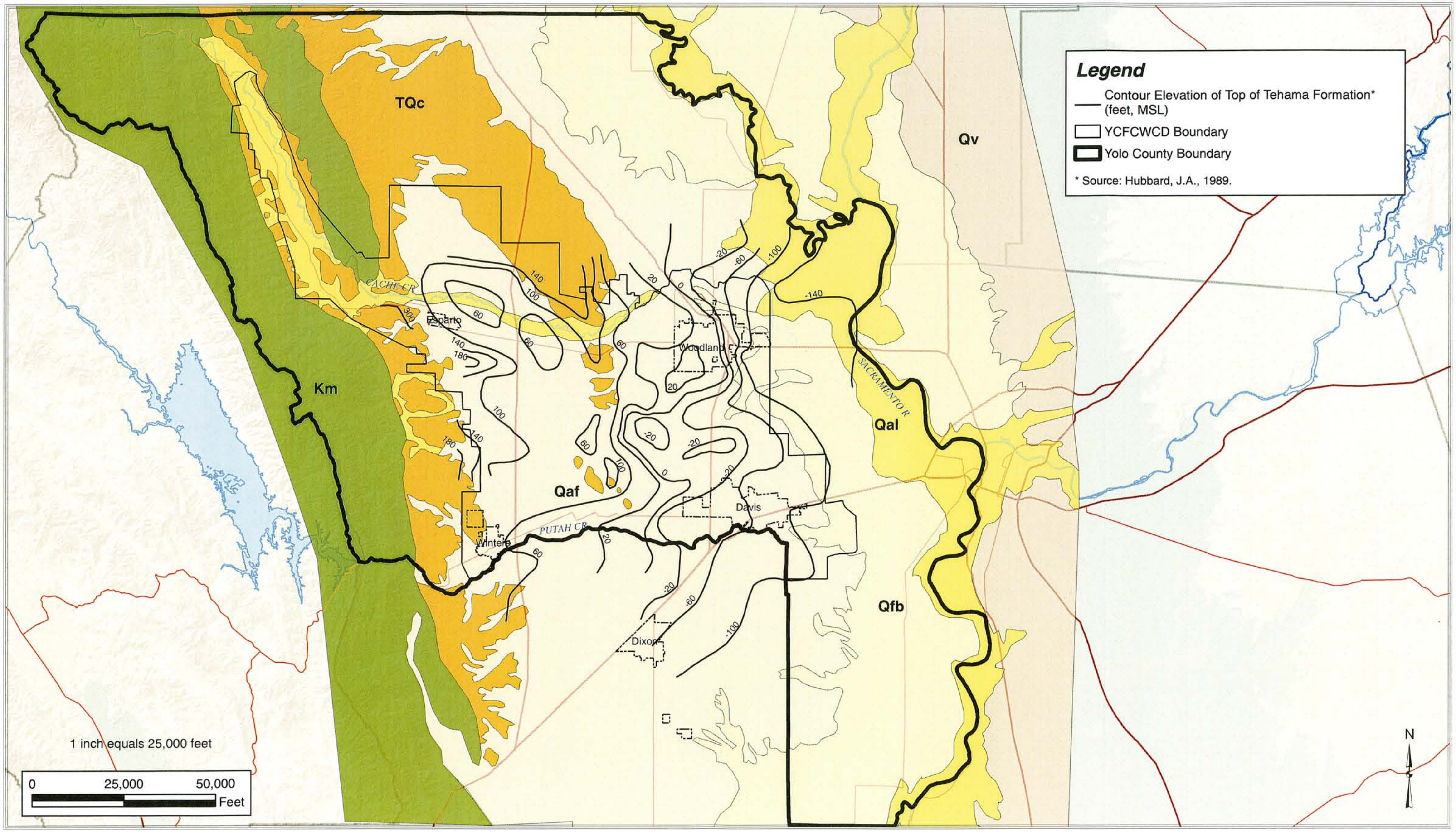

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Figure 2.3
Elevation of Top of Tehama Formation
Yolo County Area

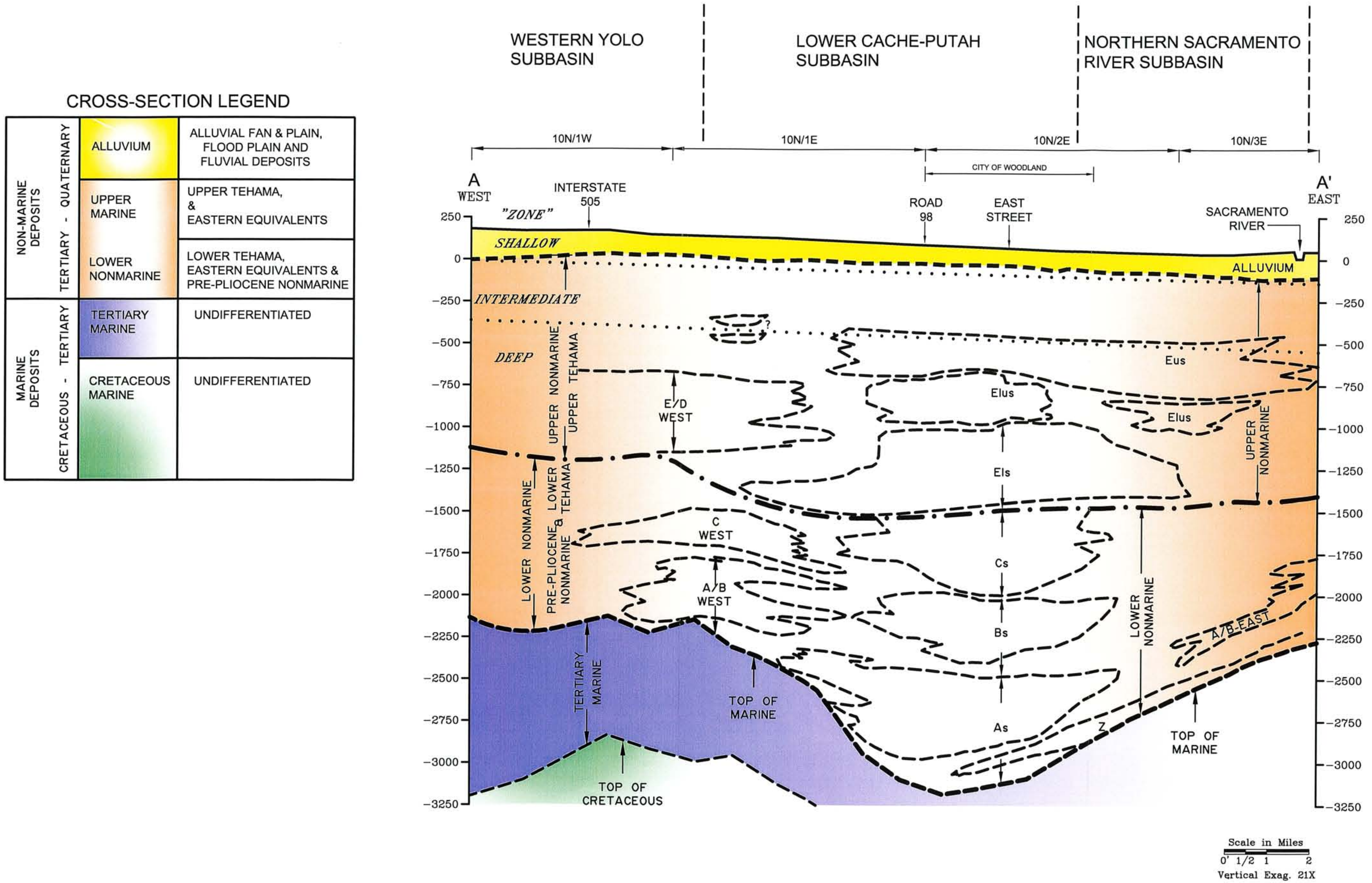

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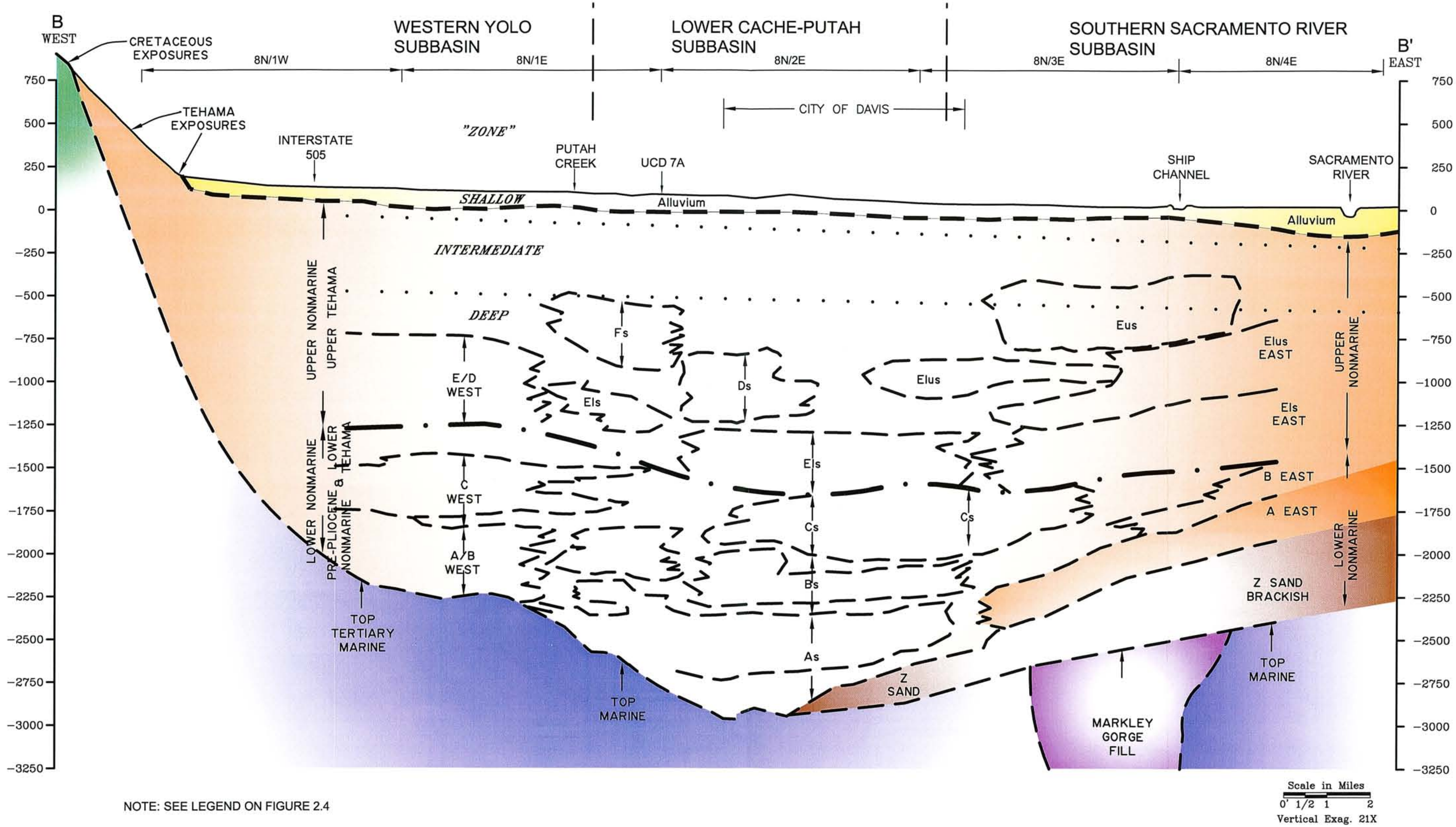
Figure 2.4
Geologic Cross Section A-A'
Yolo County Area



NOTE: SEE LEGEND ON FIGURE 2.4

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Figure 2.5
Geologic Cross Section B-B'
Yolo County Area

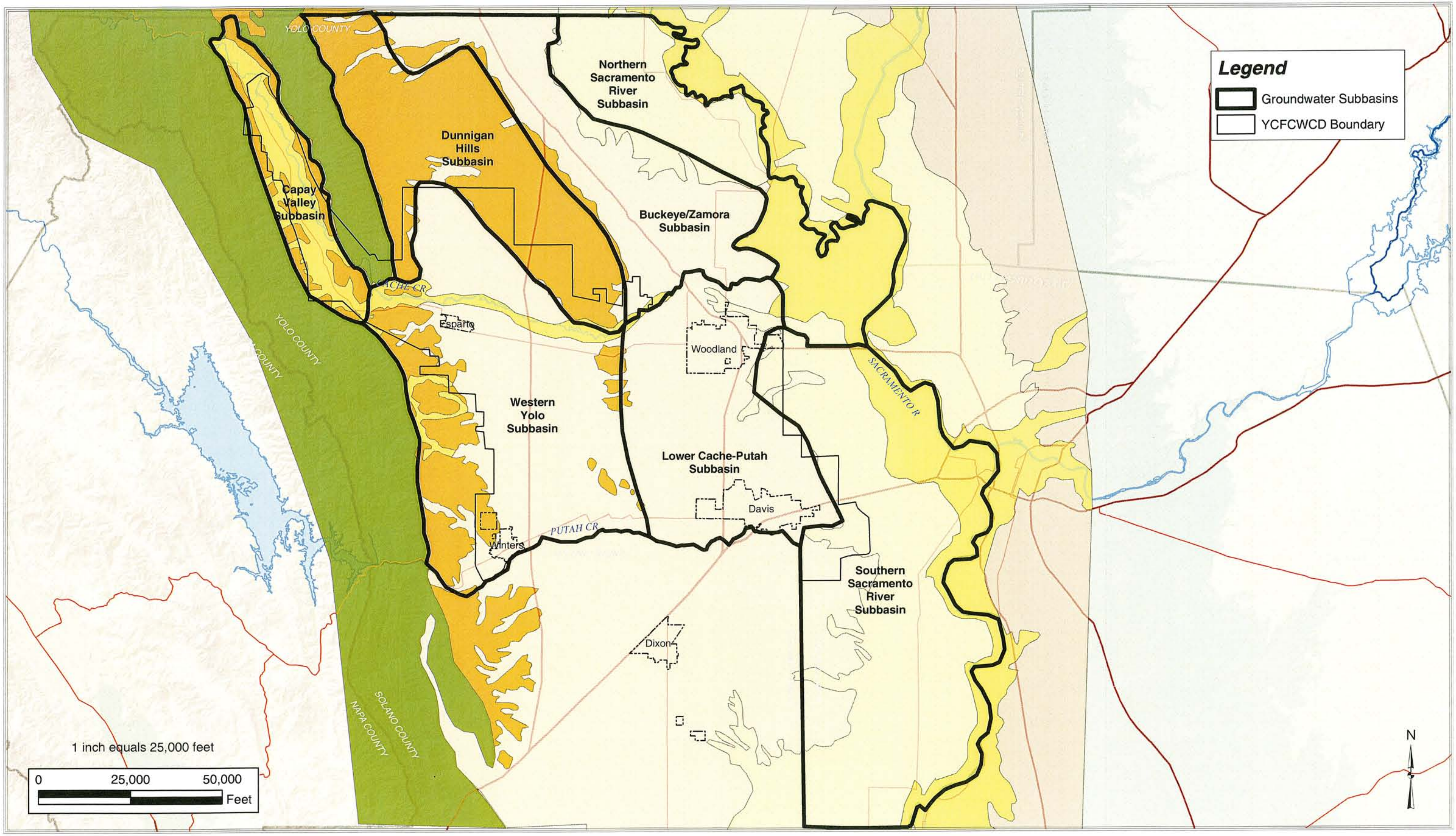

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Figure 2.6
Groundwater Subbasins
Yolo County

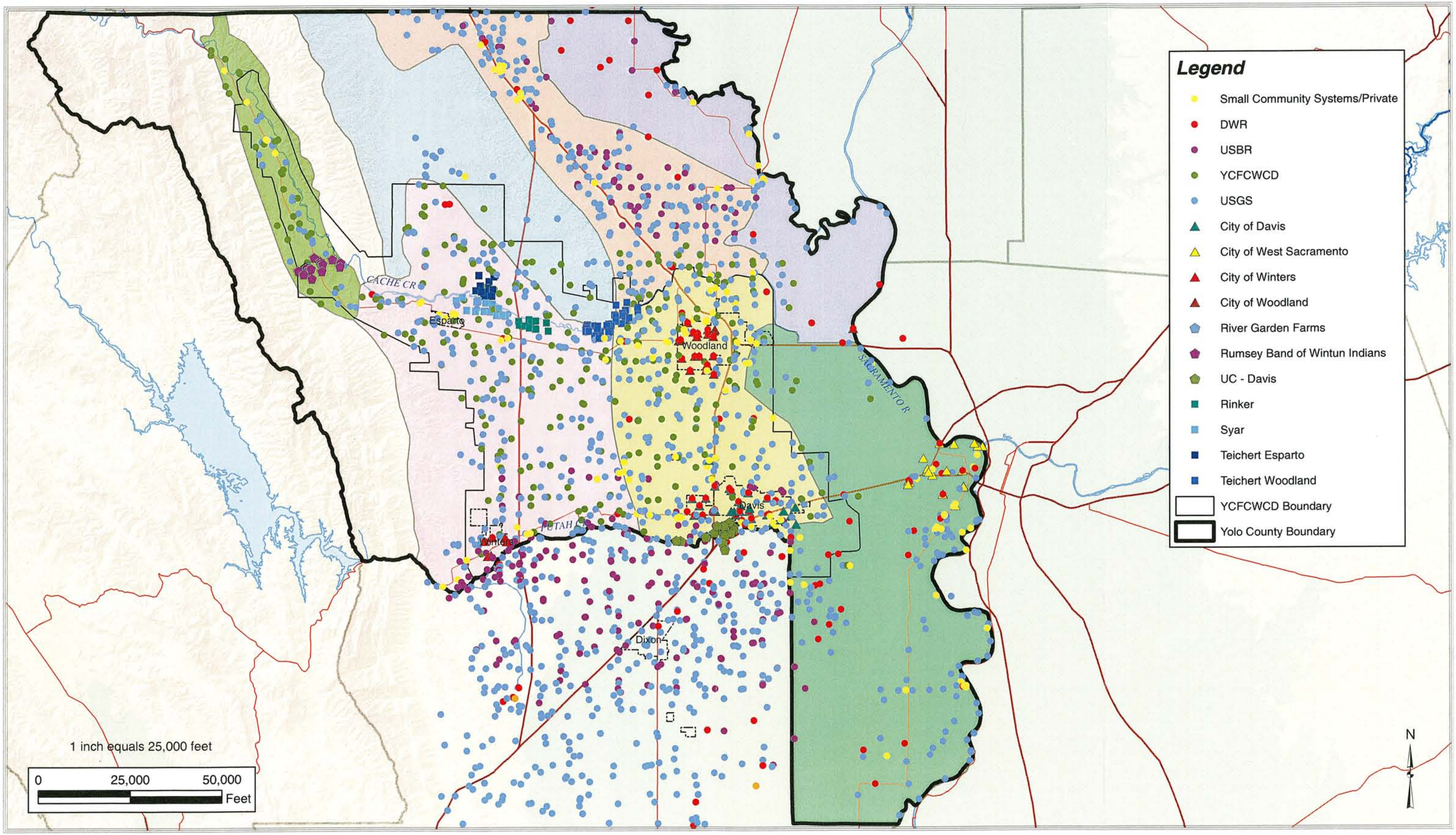

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Figure 4.1
Wells with Information in the Yolo County WRID by Entity

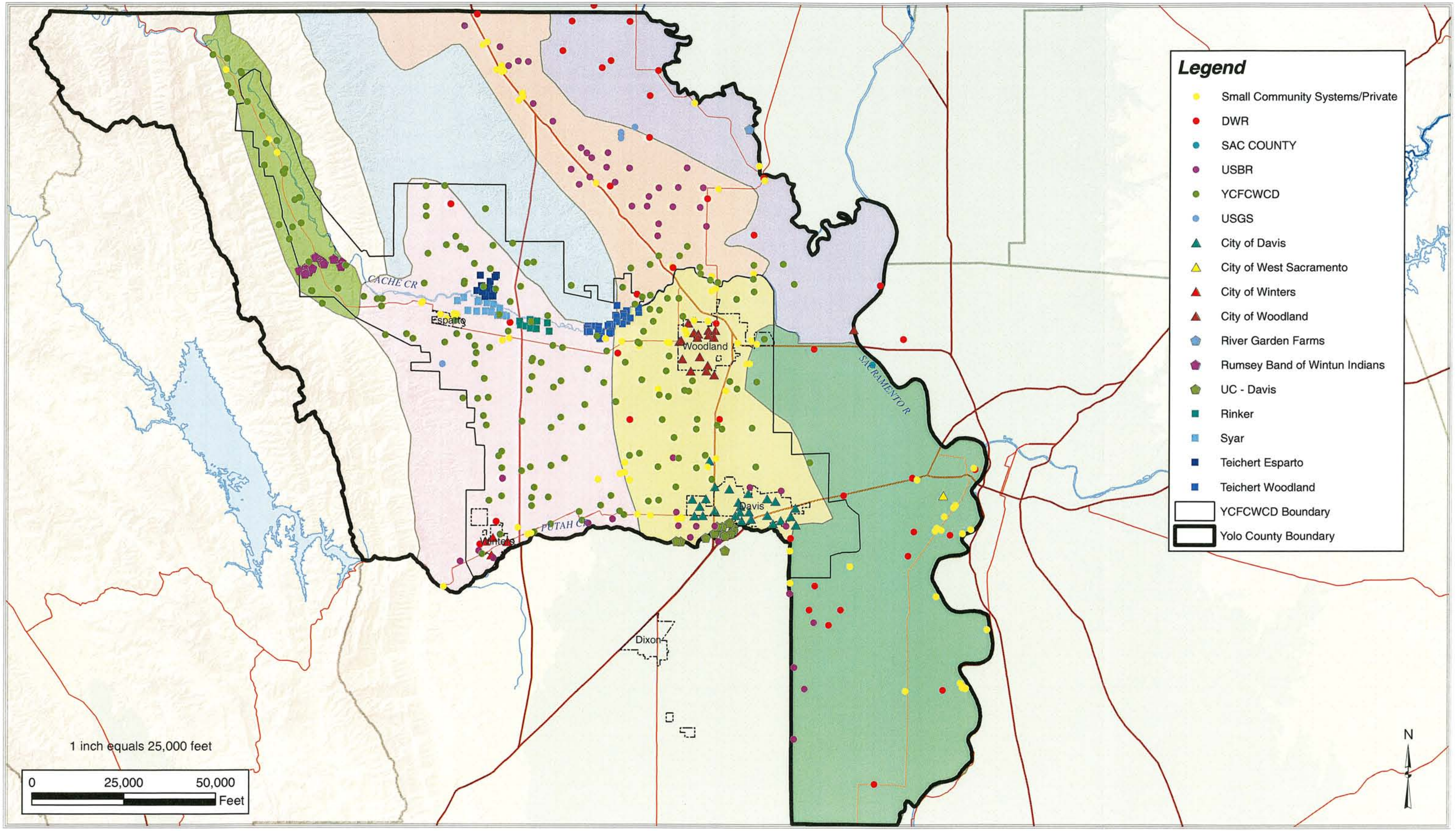

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Figure 4.2
Groundwater Subbasins and Wells by Entity with Water Level or Water Quality Measurement January 2000 to March 2004

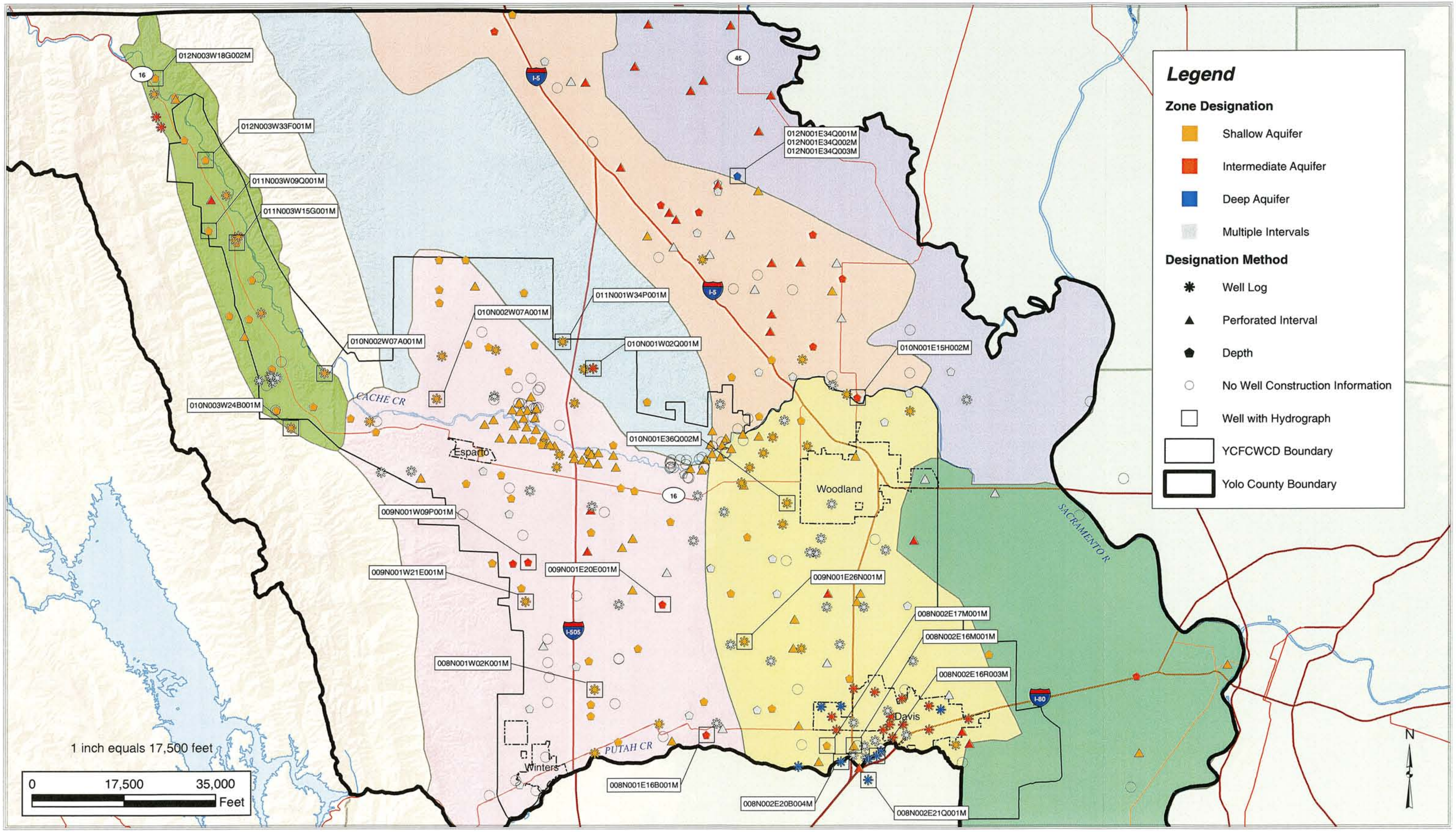

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Figure 4.3
Groundwater Level Monitoring Network Wells with Results
January 2000 to March 2004

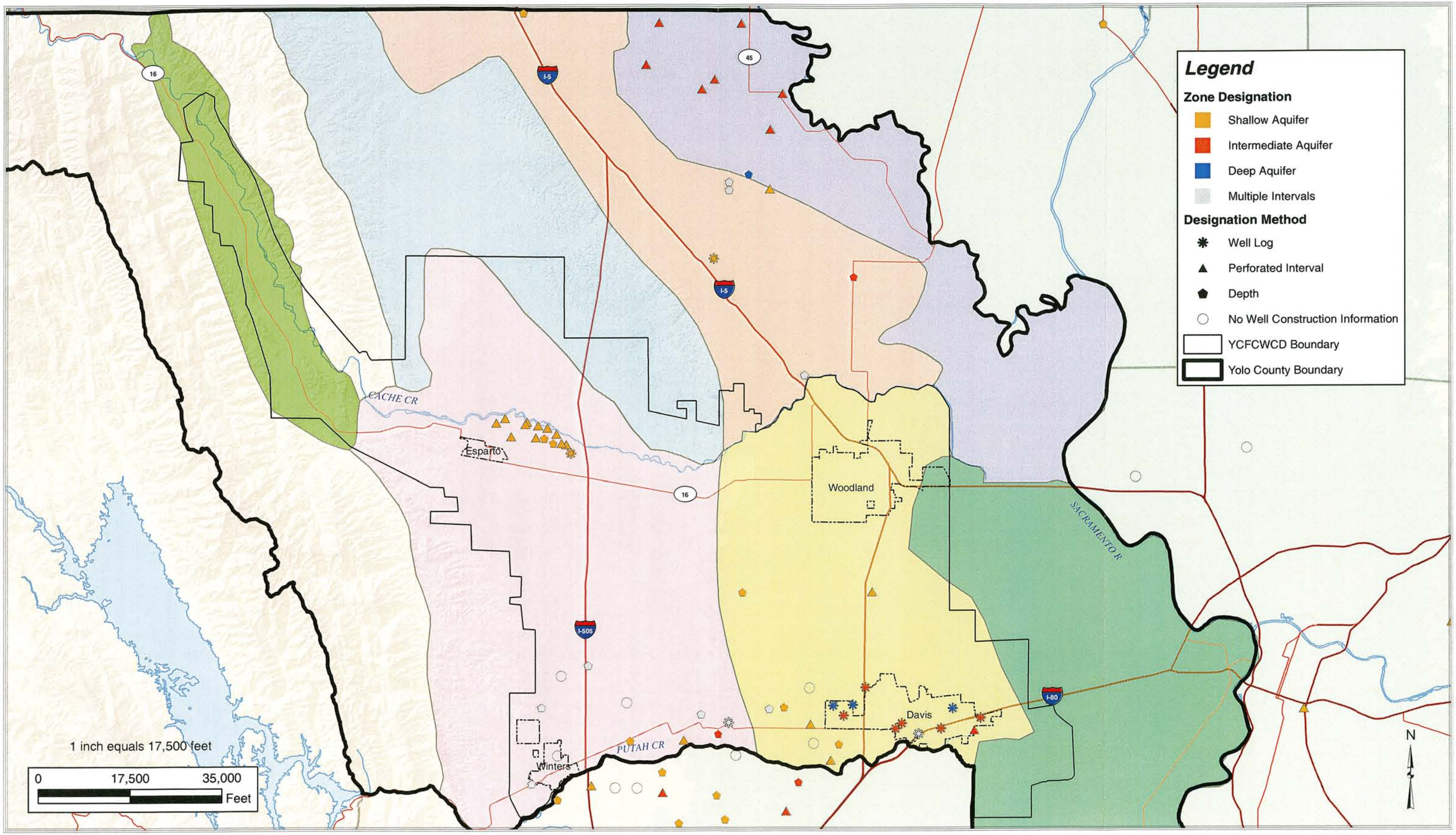

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Figure 4.4
Monthly Groundwater Level Monitoring Network with Results
January 2000 to March 2004

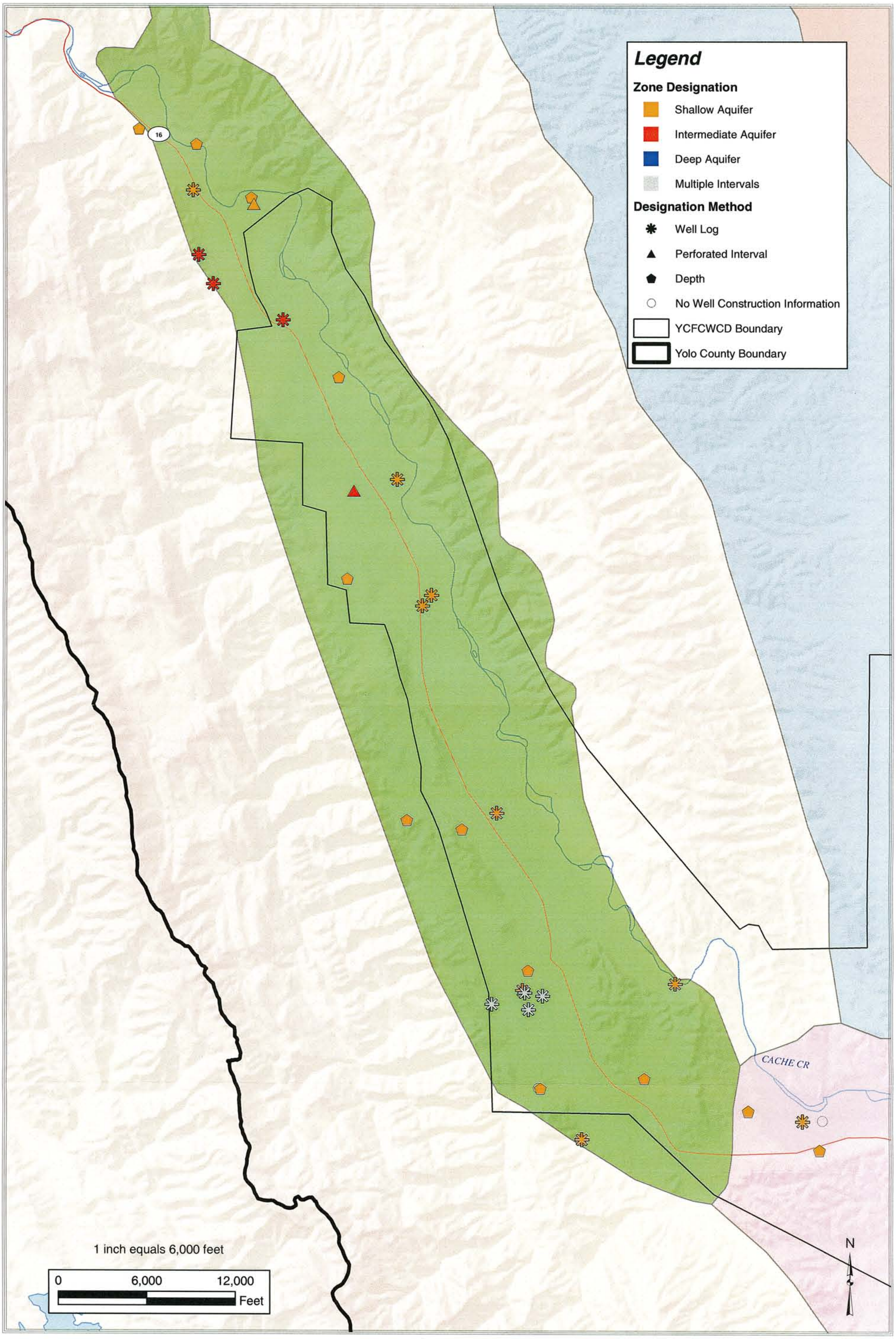

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Figure 4.5
Monthly Groundwater Level Monitoring Network
Capay Valley, Yolo County

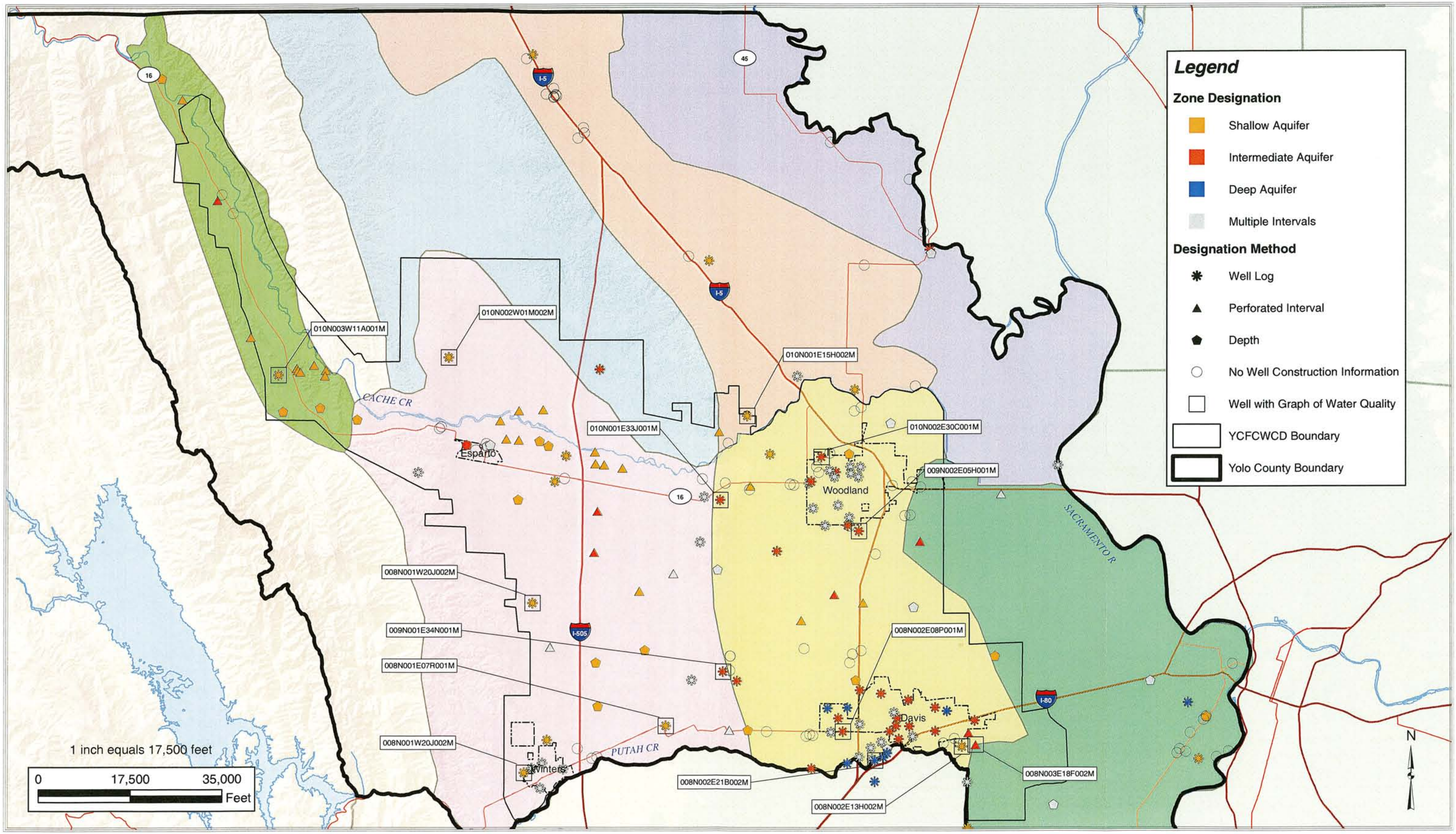

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Figure 4.6
Groundwater Quality Monitoring Network Wells with Measurements for Nitrate, Boron or Specific Conductance January 2000 to March 2004

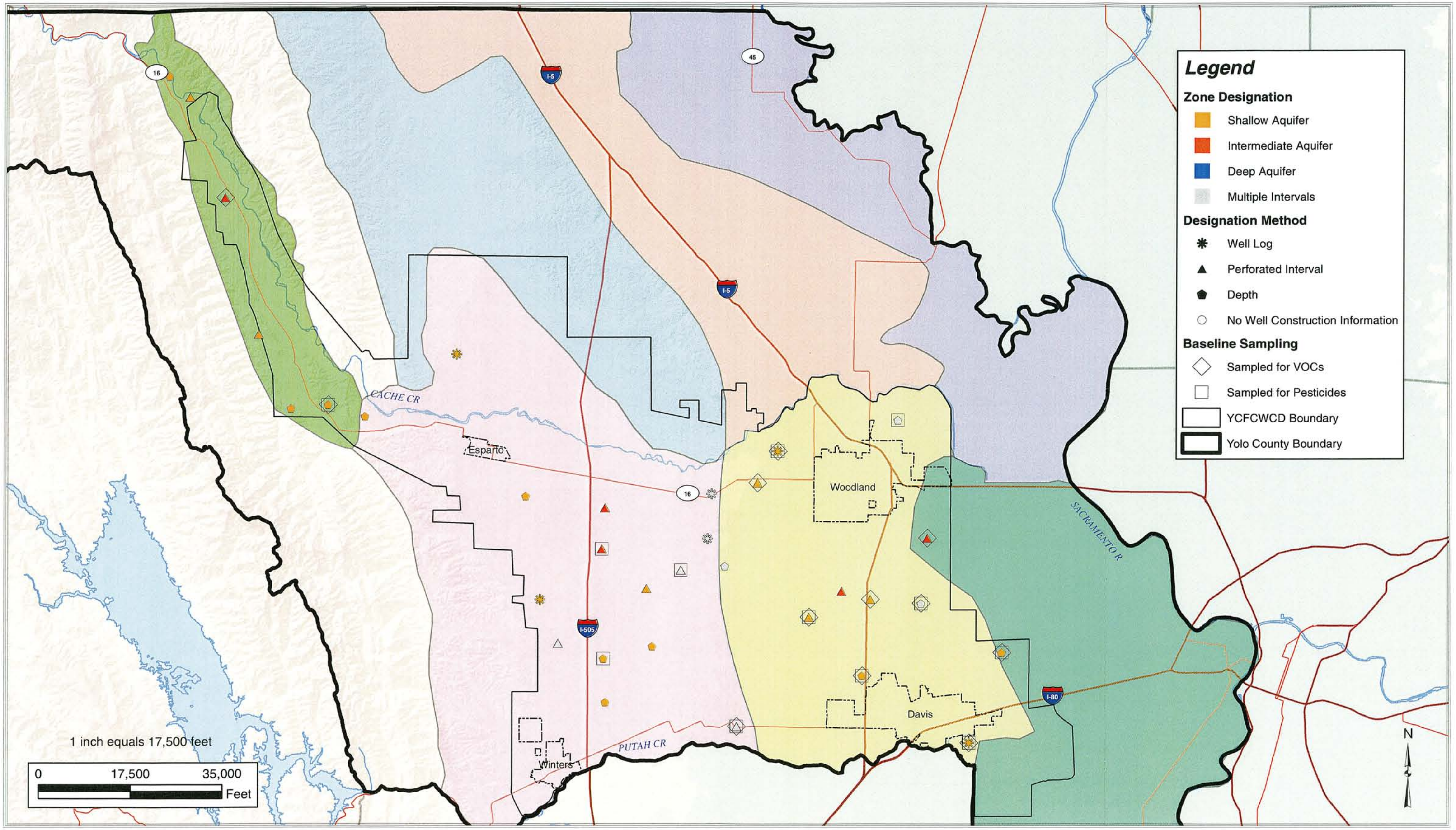

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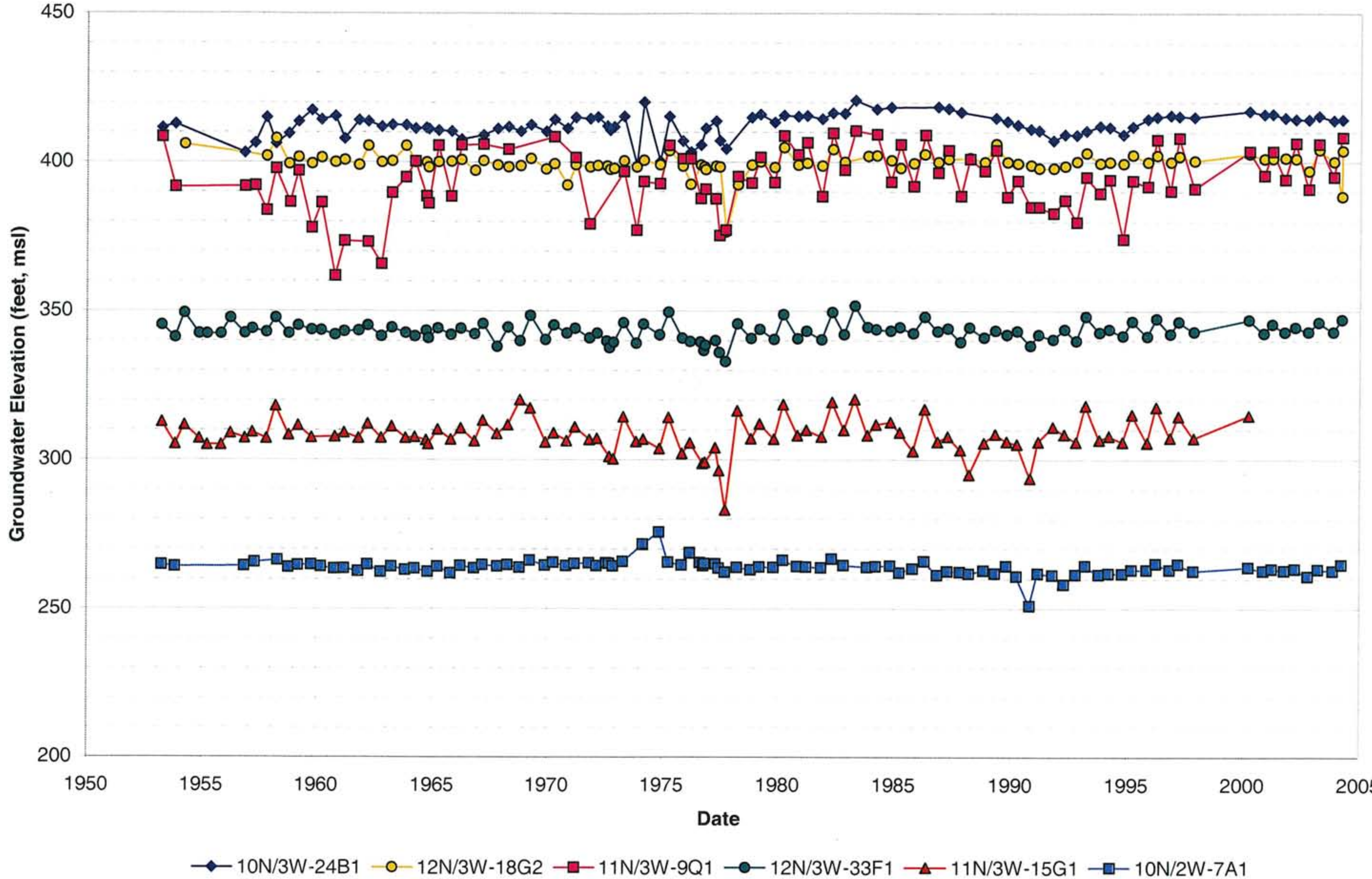
Figure 4.7
Baseline Water Quality Sampling Network Wells
March 2004



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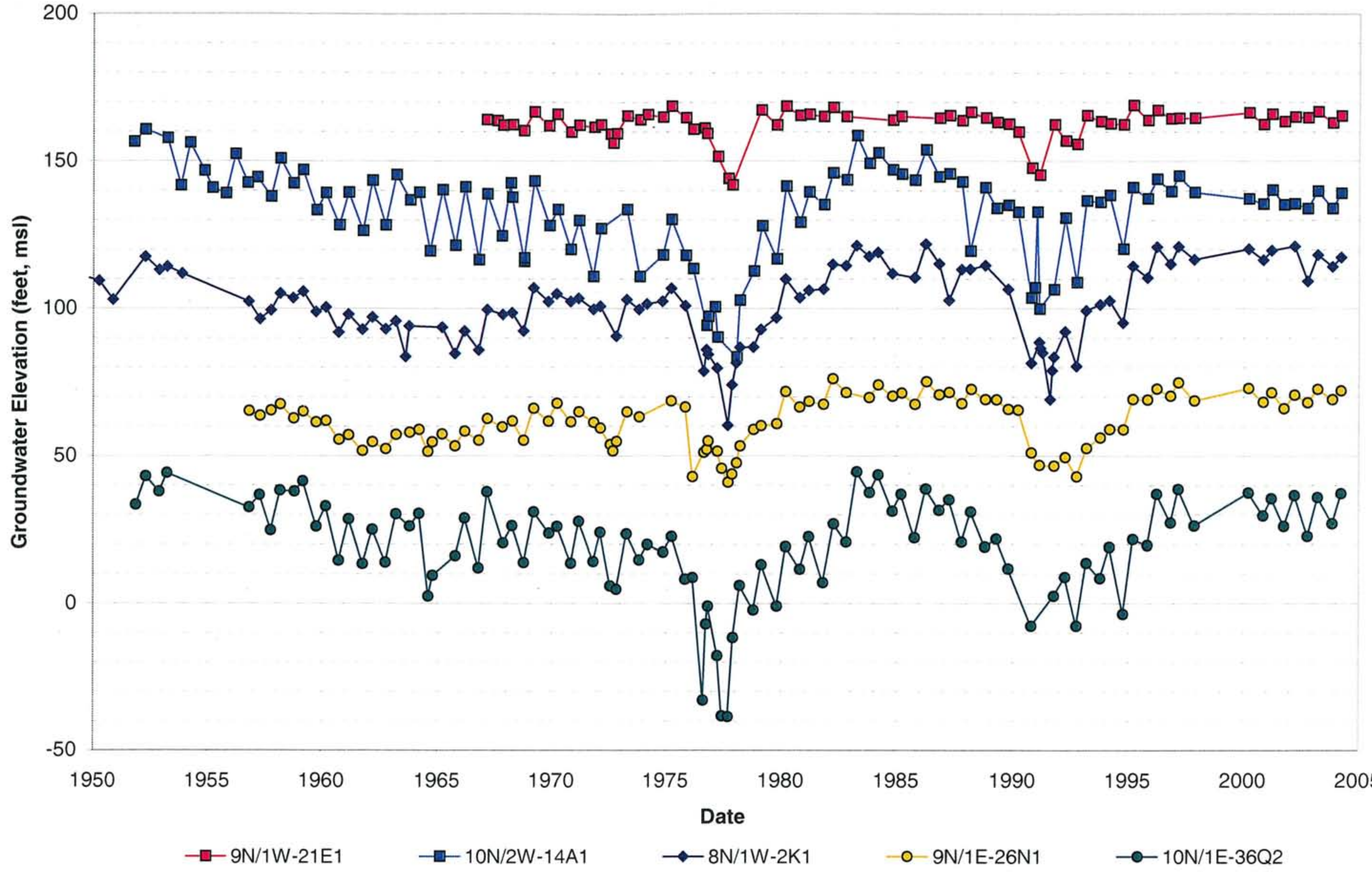
For well locations see Figure 4.6

Figure 5.1
Groundwater Elevations, Shallow Zone
Capay Valley Subbasin, Yolo County



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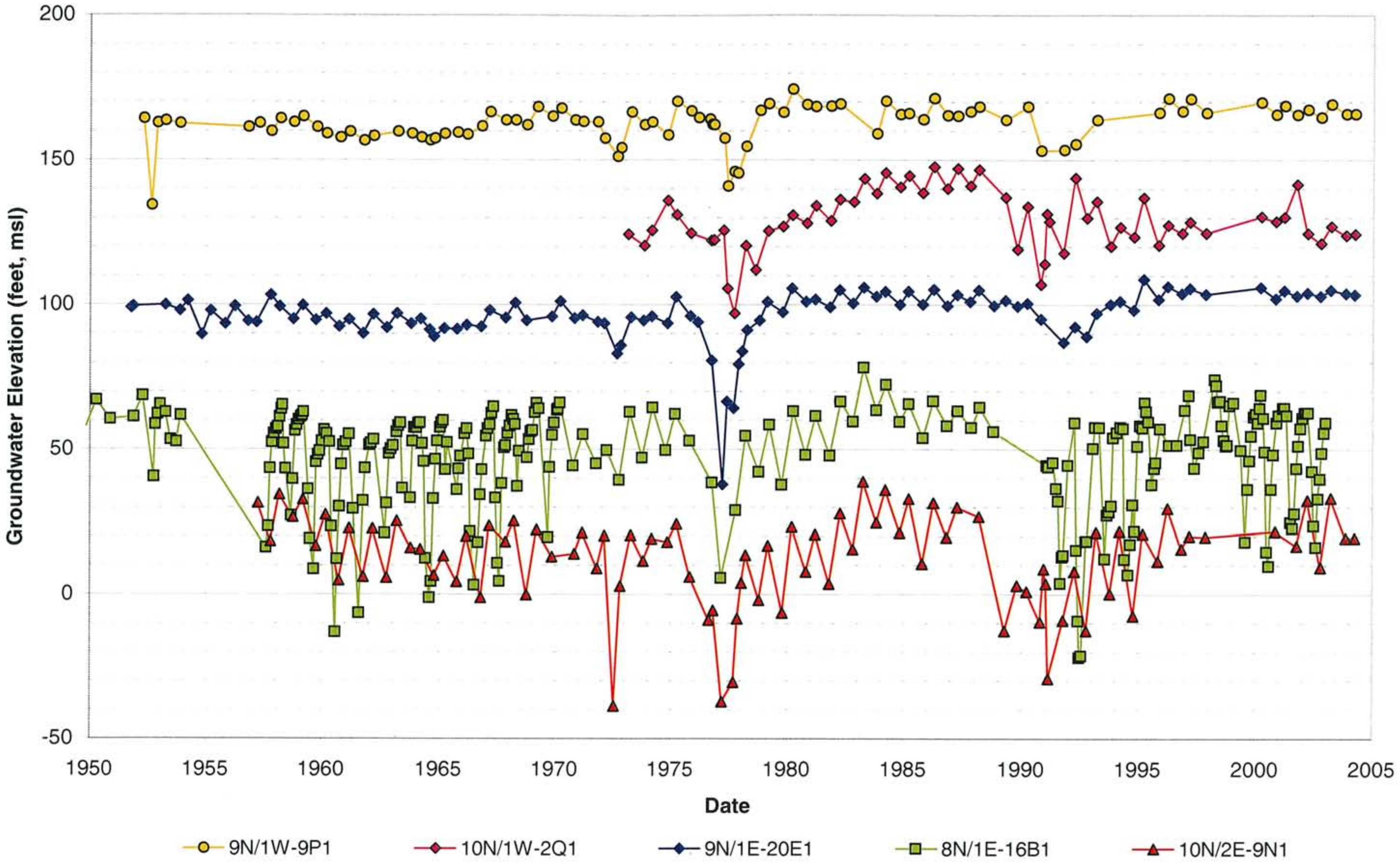
For well locations see Figure 4.3

Figure 5.2
Groundwater Elevations, Shallow Zone
Western Yolo and Lower Cache-Putah Subbasins, Yolo County



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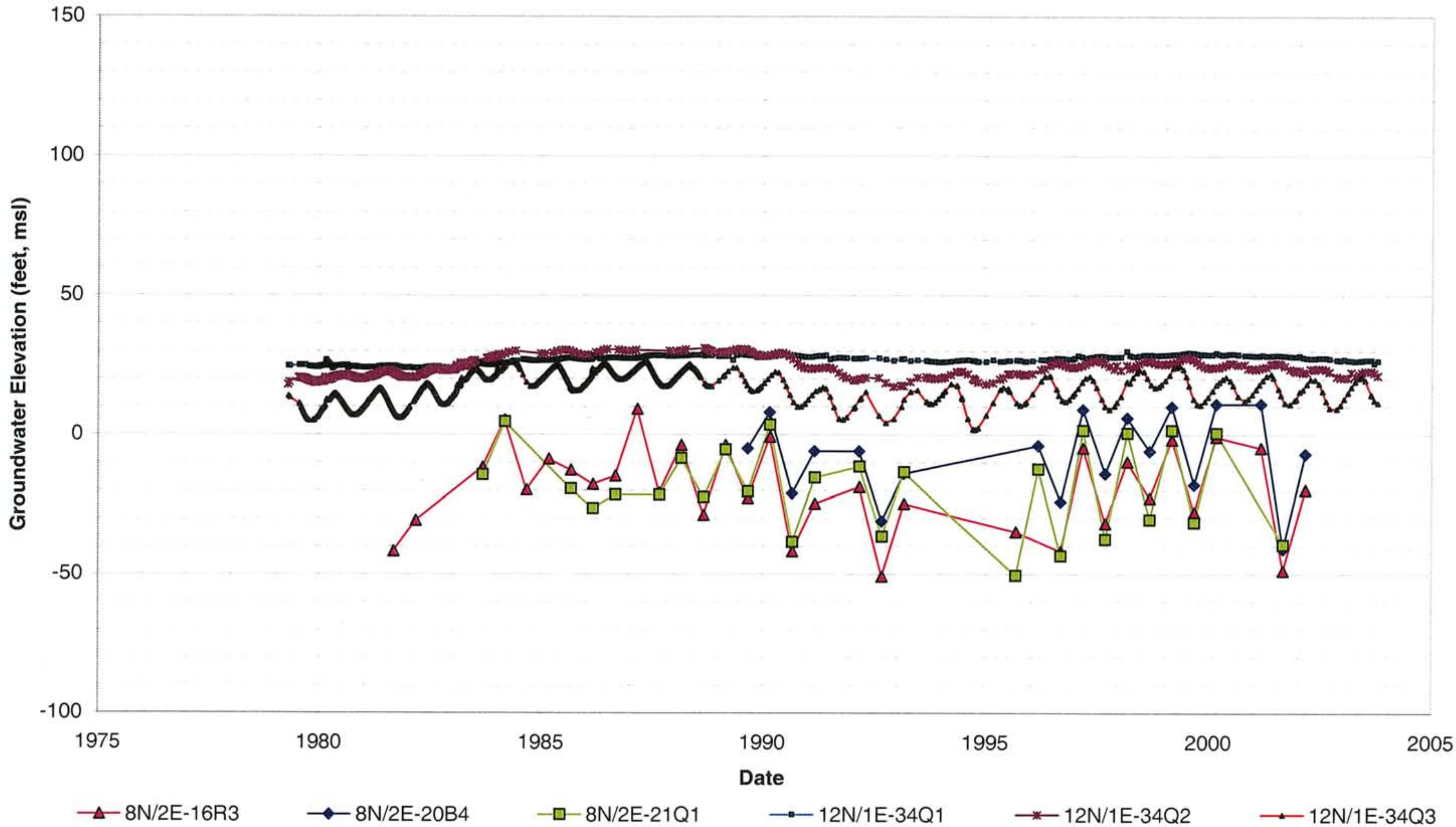
For well locations see Figure 4.3

Figure 5.3
Groundwater Elevations, Intermediate Zone
Central Area, Yolo County



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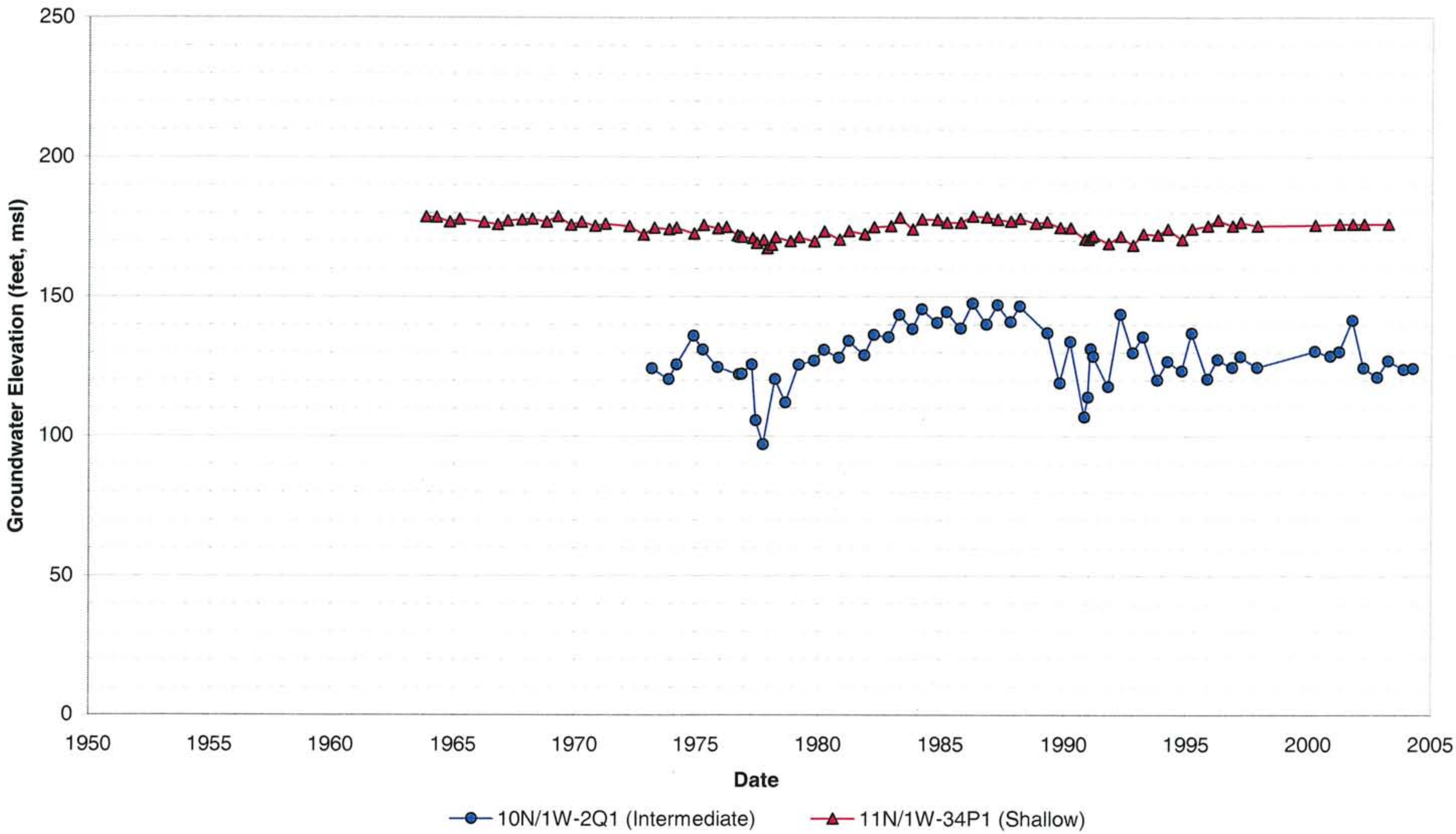
For well locations see Figure 4.3

Figure 5.4
Groundwater Elevations, Deep Zone
Near the City of Davis and Knights Landing, Yolo County



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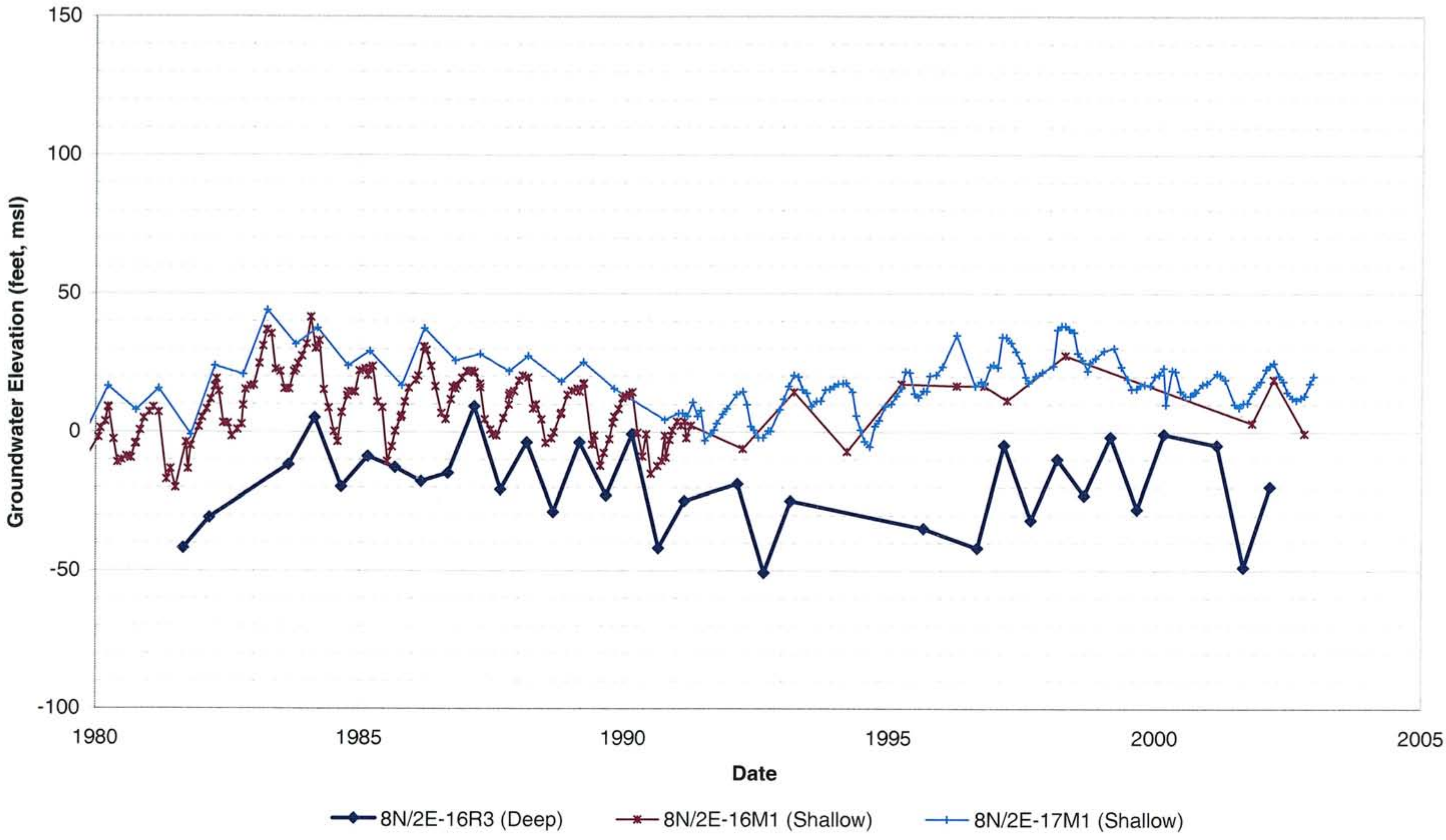
For well locations see Figure 4.3

Figure 5.5
Groundwater Elevations in Paired Wells
Dunnigan Hills, Yolo County



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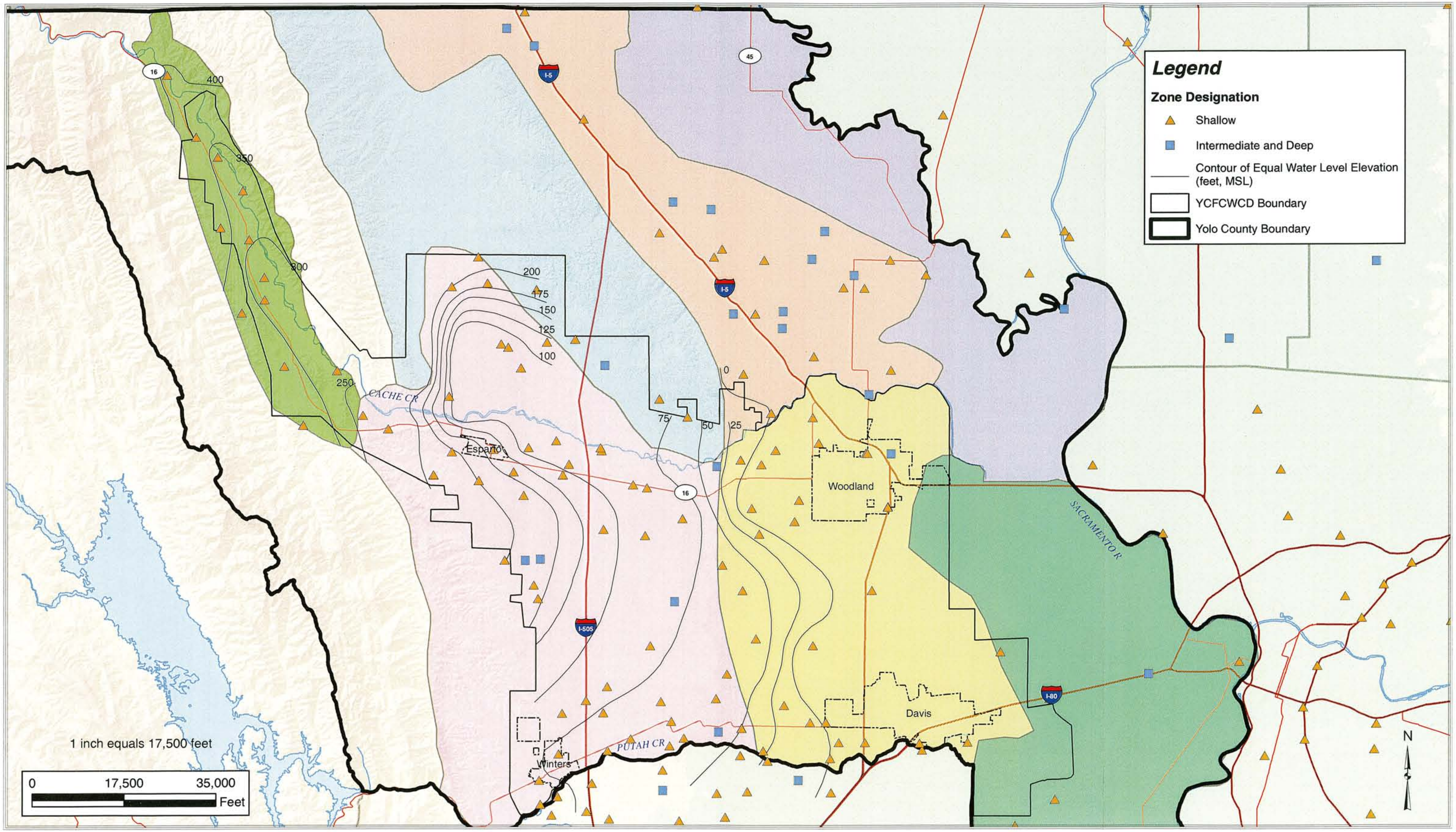
CONSULTING ENGINEERS

For well locations see Figure 4.3

Figure 5.6
Groundwater Elevations in Paired Wells Near the City of Davis, Yolo County



FILE: Y:\Yolo County\Figures\\\Server\Public\Yolo County\Figures\Figure 5.7.mxd DATE: 7/8/2004 8:17:44 PM

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Figure 5.7
Spring 1977 Water Level Contours
Shallow Zone
Yolo County

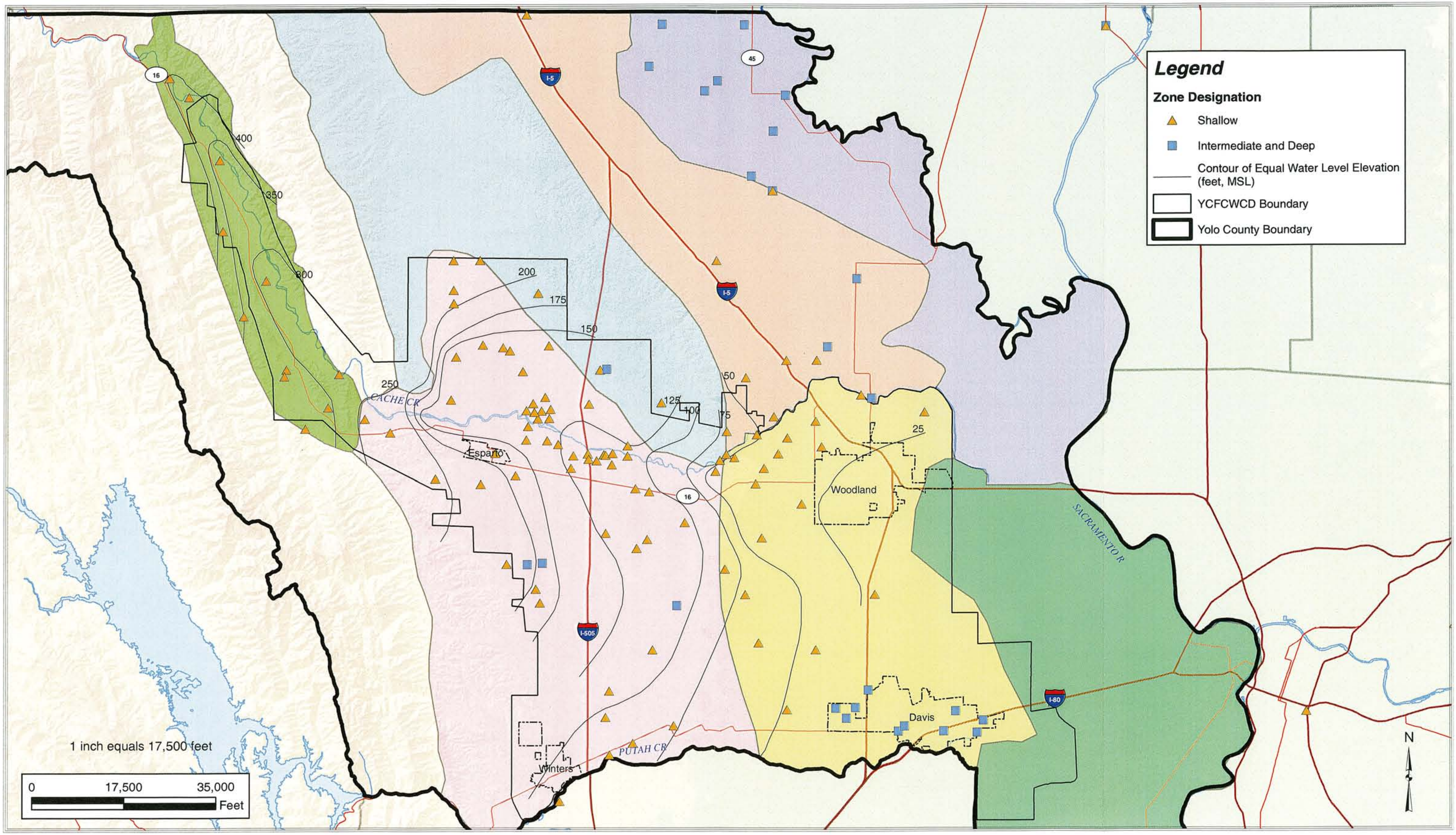

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Figure 5.8
Fall 2003 Water Level Contours
Shallow Zone
Yolo County

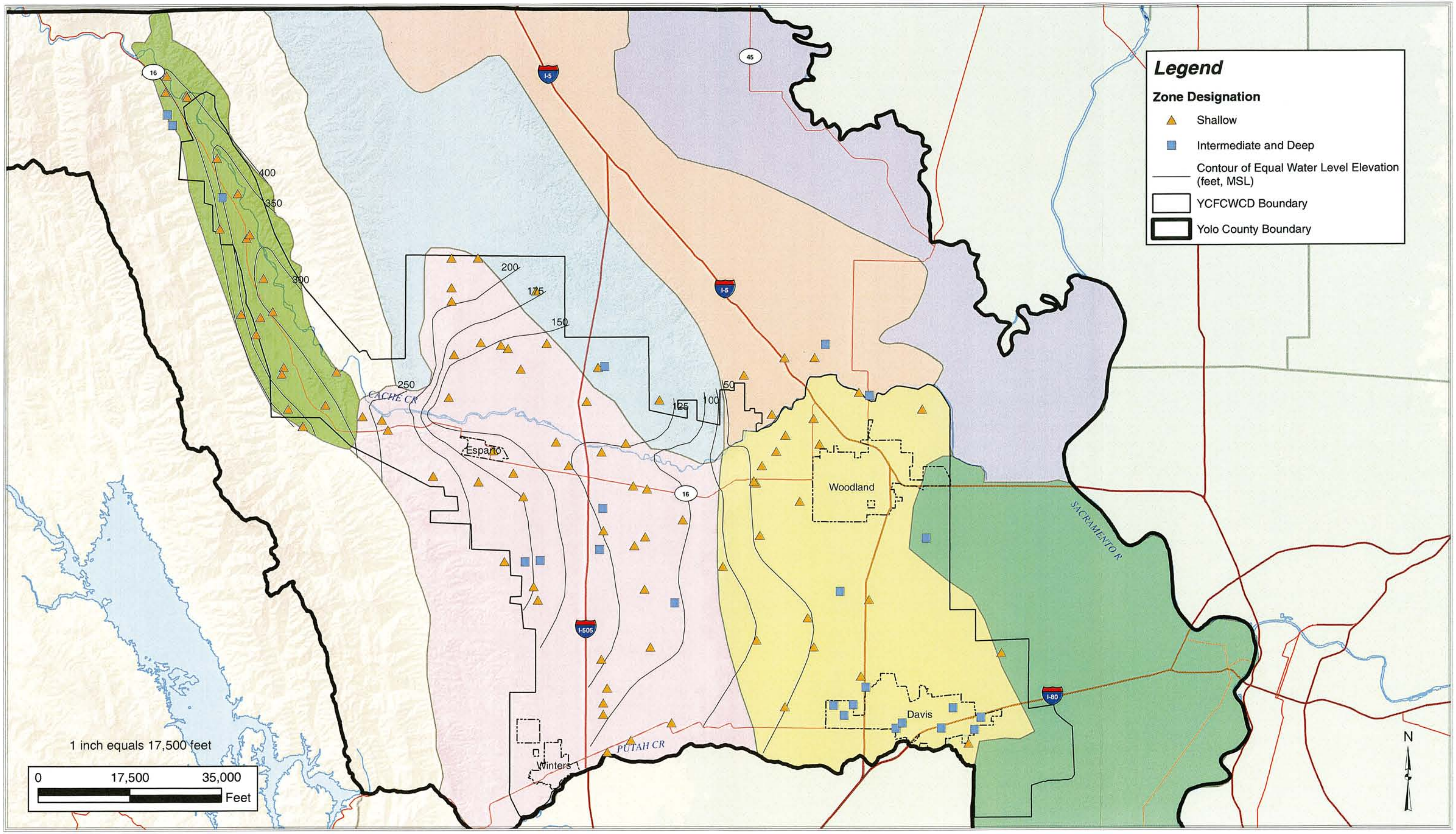

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Figure 5.9
Spring 2004 Water Level Contours
Shallow Zone
Yolo County

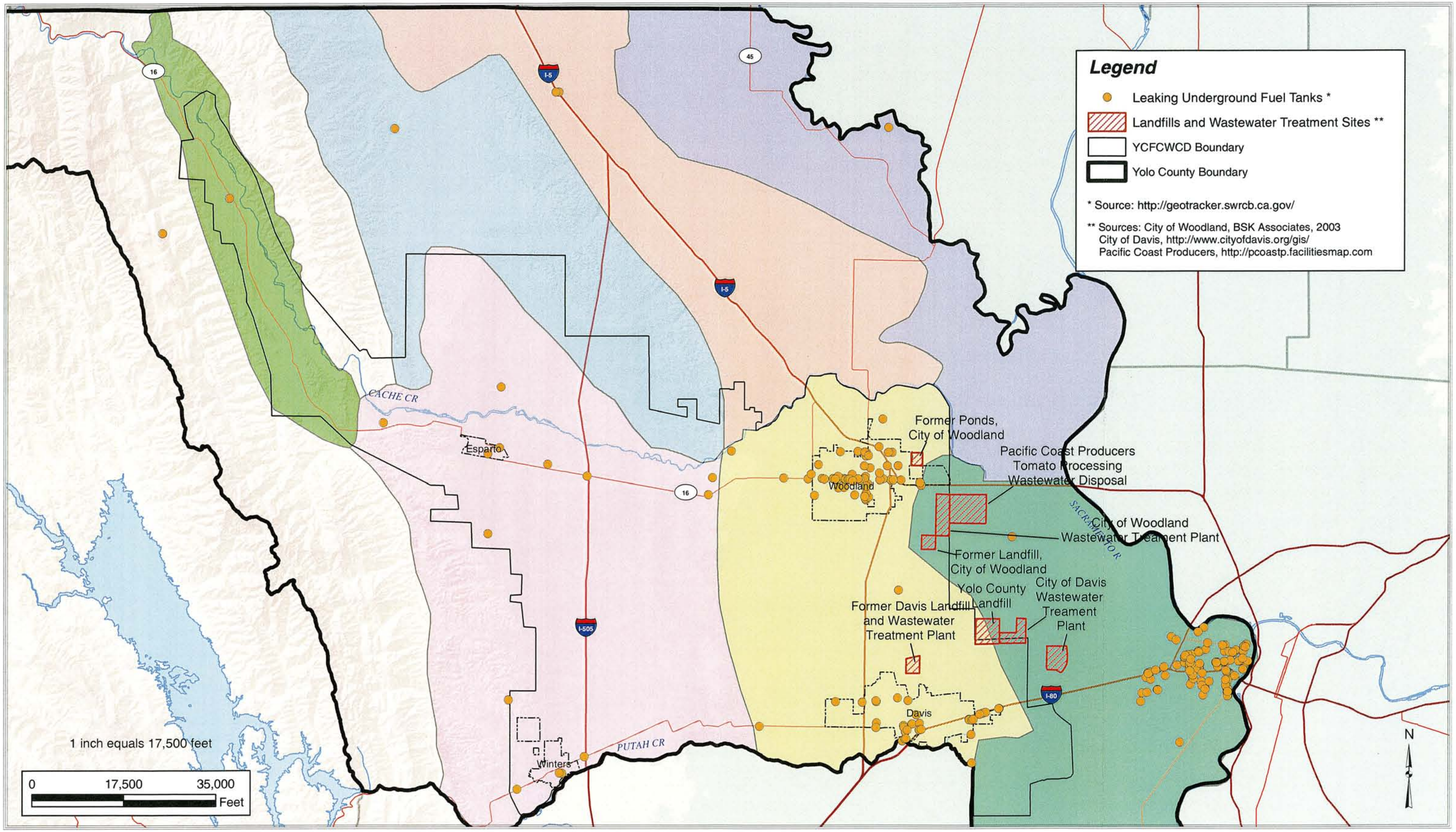

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Figure 5.10
Possible Sources of Contamination
Leaking Underground Fuel Tanks
Landfills and Wastewater Treatment Sites

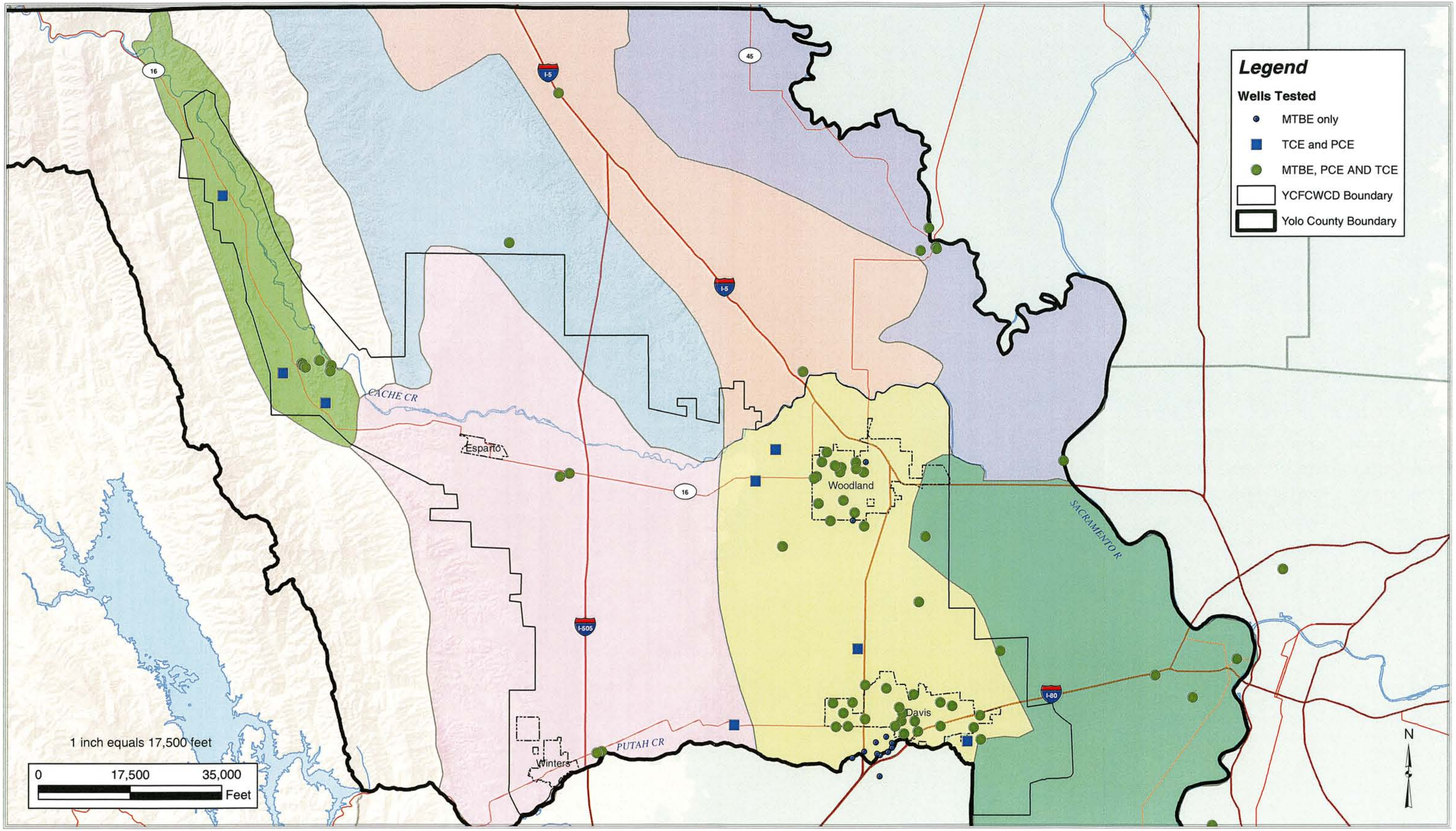

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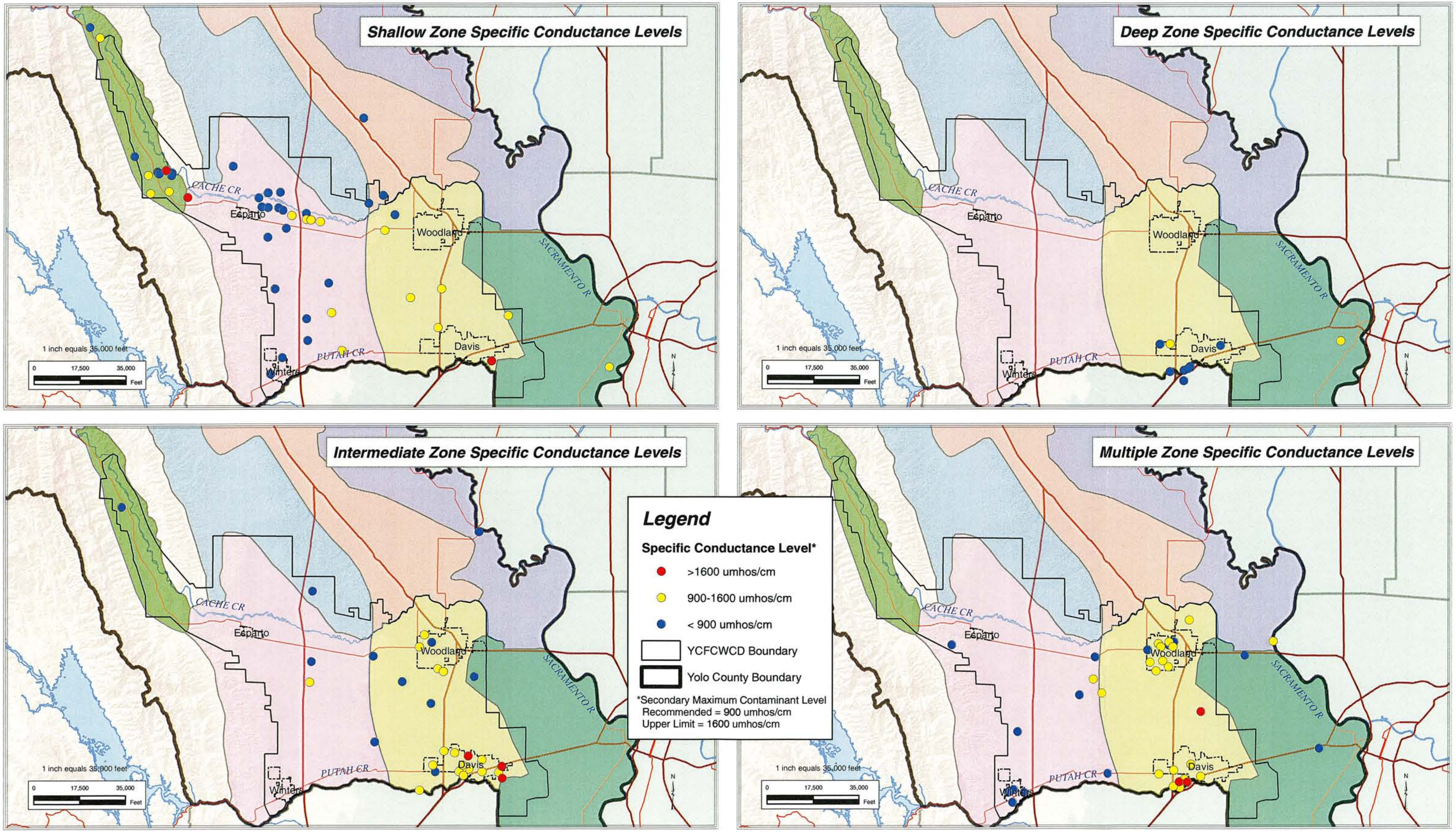
Figure 5.11
Wells Tested for MTBE, PCE or TCE
January 2000 to March 2004



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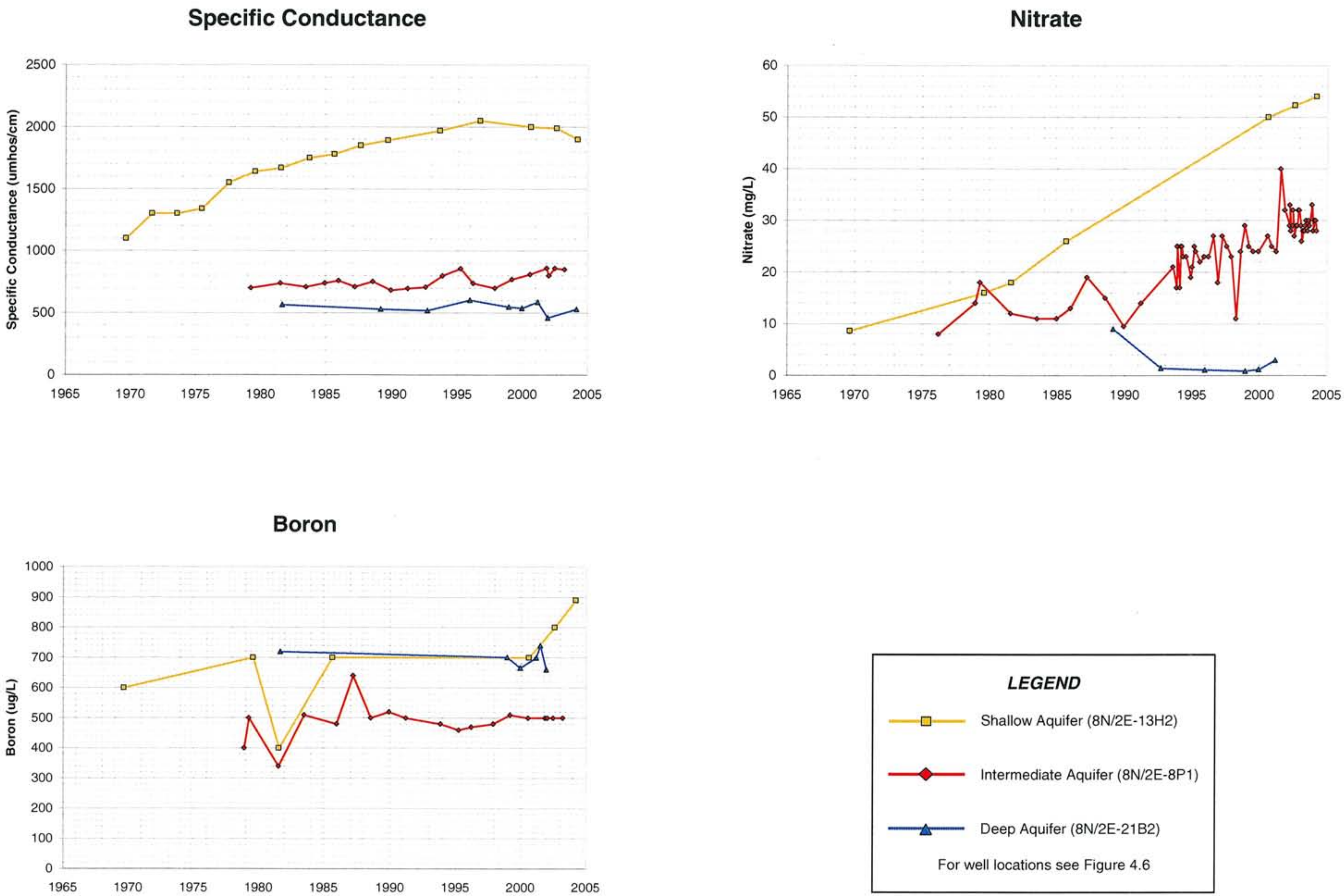
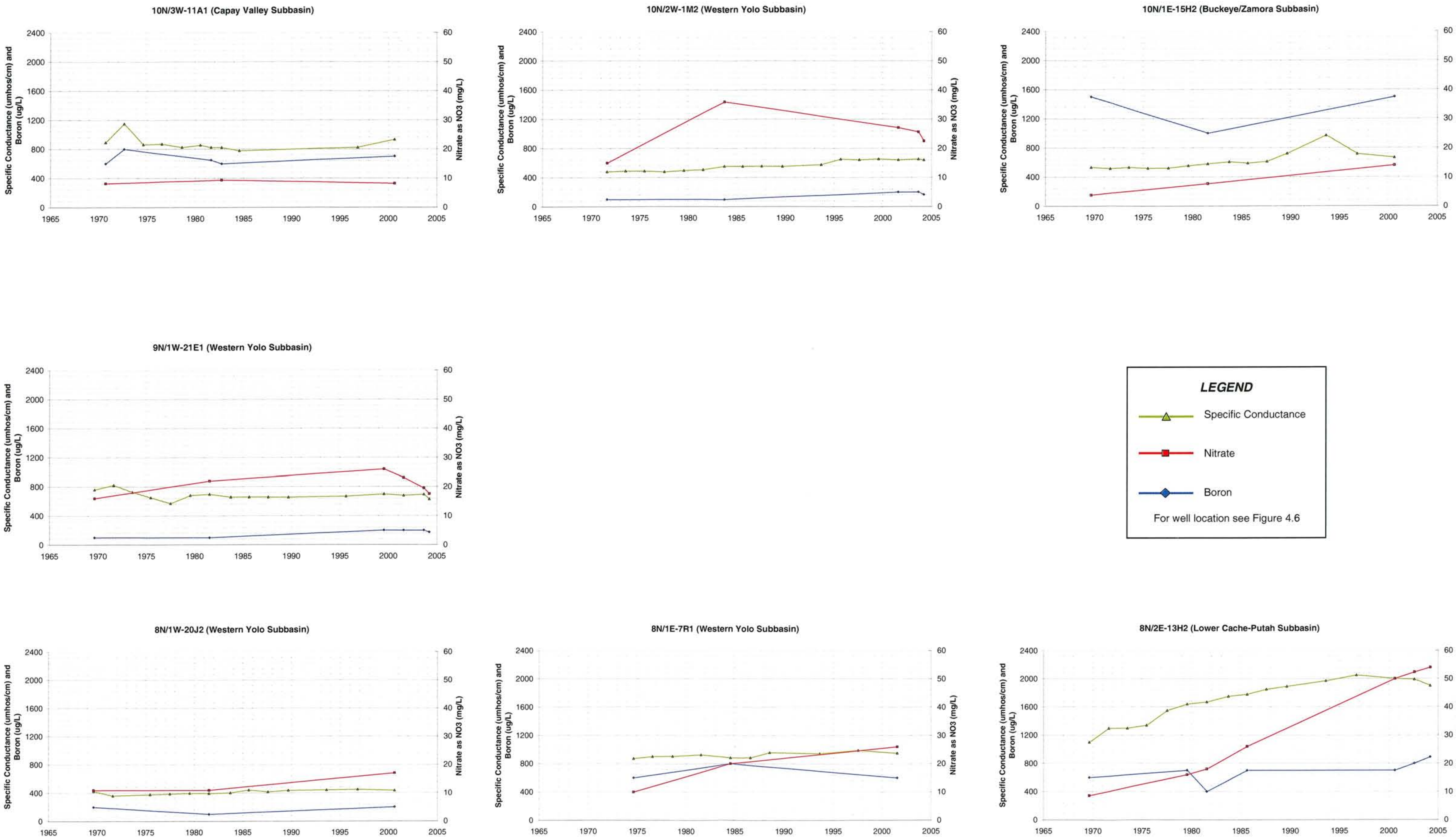
CONSULTING ENGINEERS

Figure 5.12
Maximum Specific Conductance Results for All Zones
January 2000 to March 2004
Yolo County



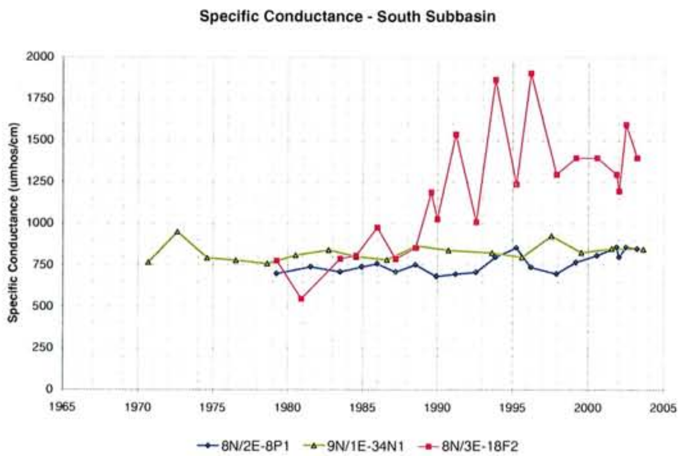
LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

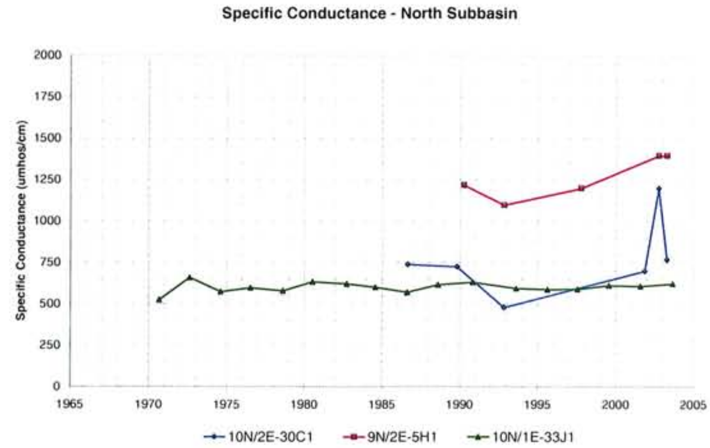
Figure 5.13
Comparison of Water Quality by Aquifer Zone
Davis Area of Lower Cache-Putah Subbasin, Yolo County

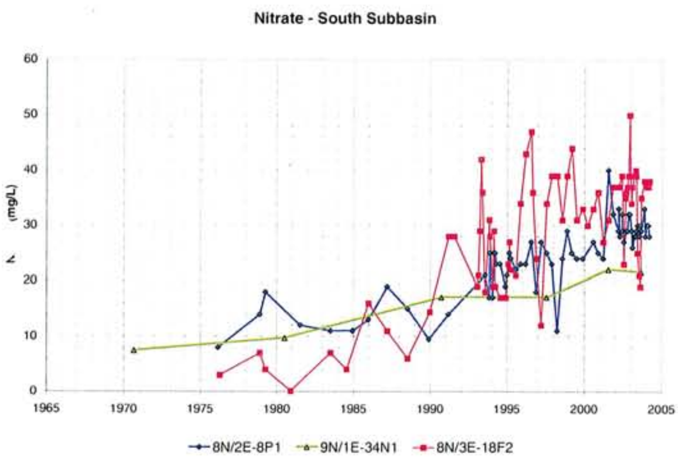


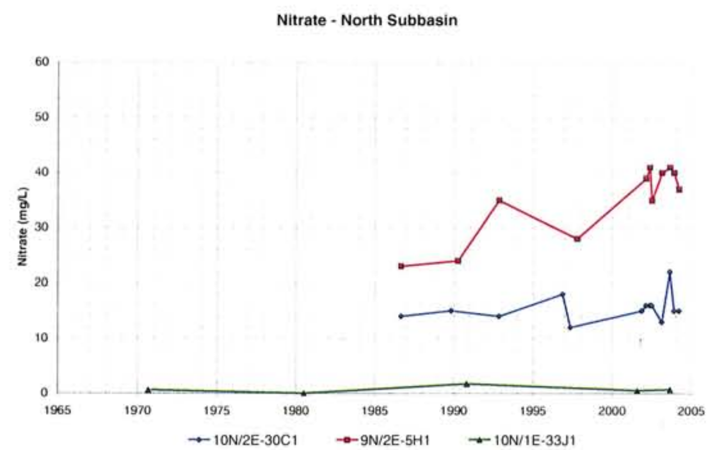
LUHDORFF & SCALMANINI
CONSULTING ENGINEERS

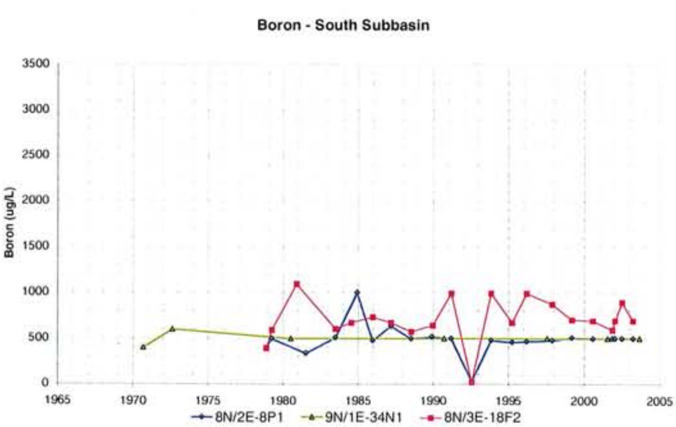
Figure 5.14
Water Quality Trends, Shallow Aquifer Zone
Yolo County











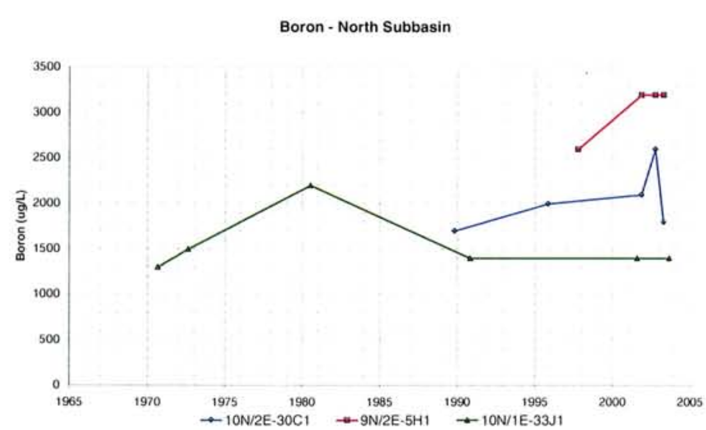


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Figure 5.15
Water Quality Trends, Intermediate Aquifer Zone
Lower Cache-Putah Subbasin, Yolo County

For well location see Figure 4.6

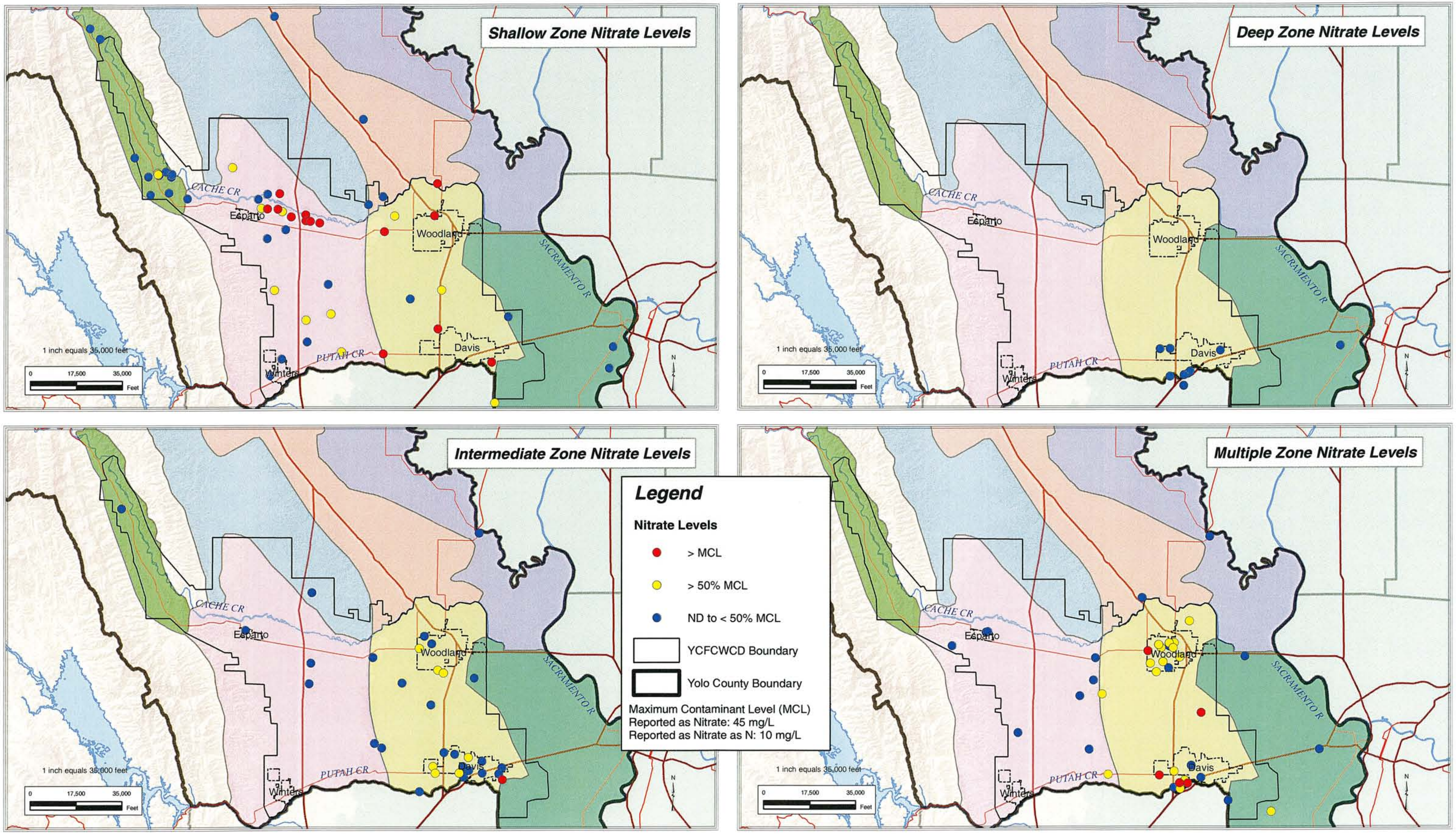

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Figure 5.16
Maximum Nitrate Results for All Zones
January 2000 to March 2004
Yolo County

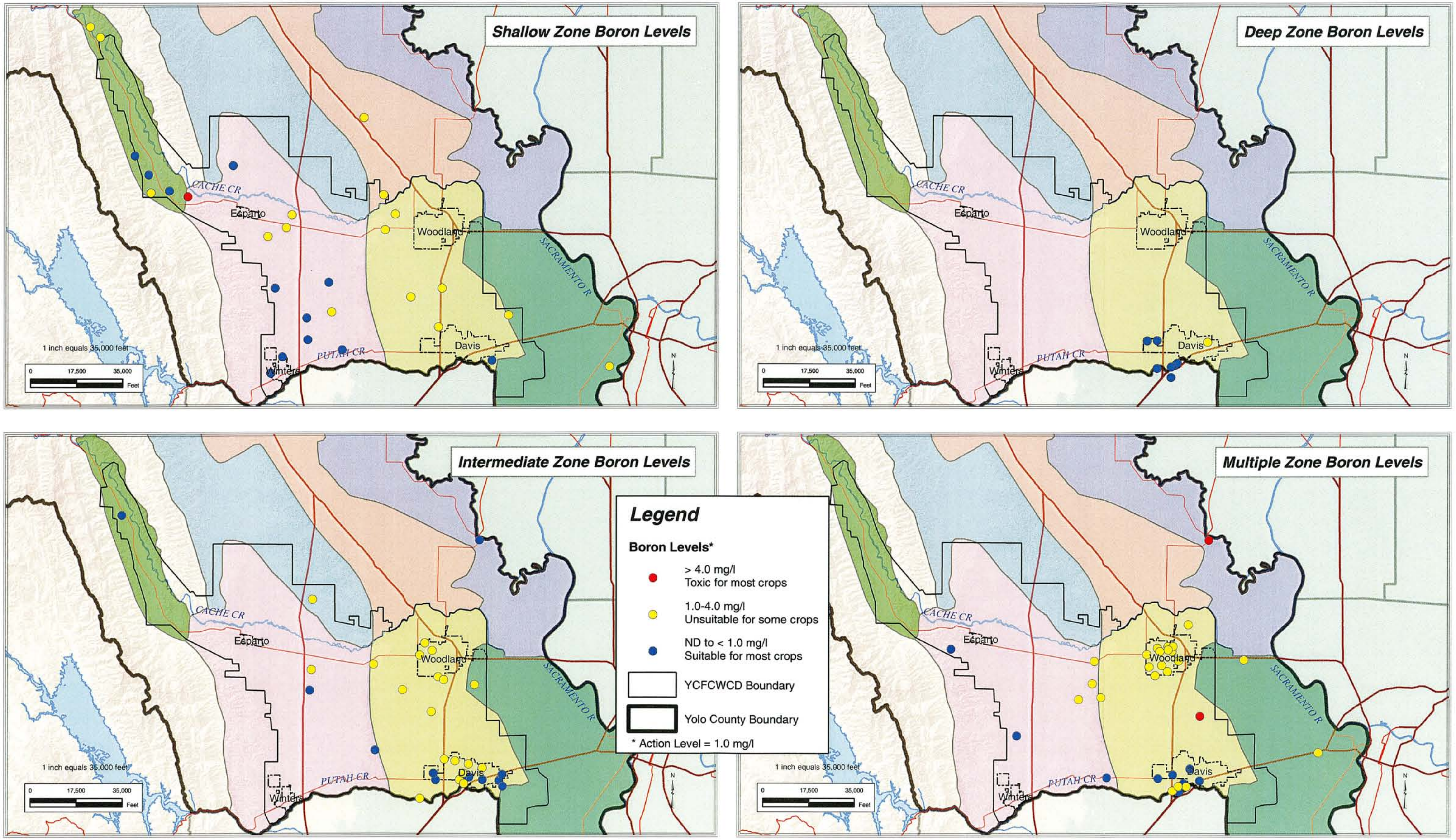

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Figure 5.17
Maximum Boron Results for All Zones
January 2000 to March 2004
Yolo County

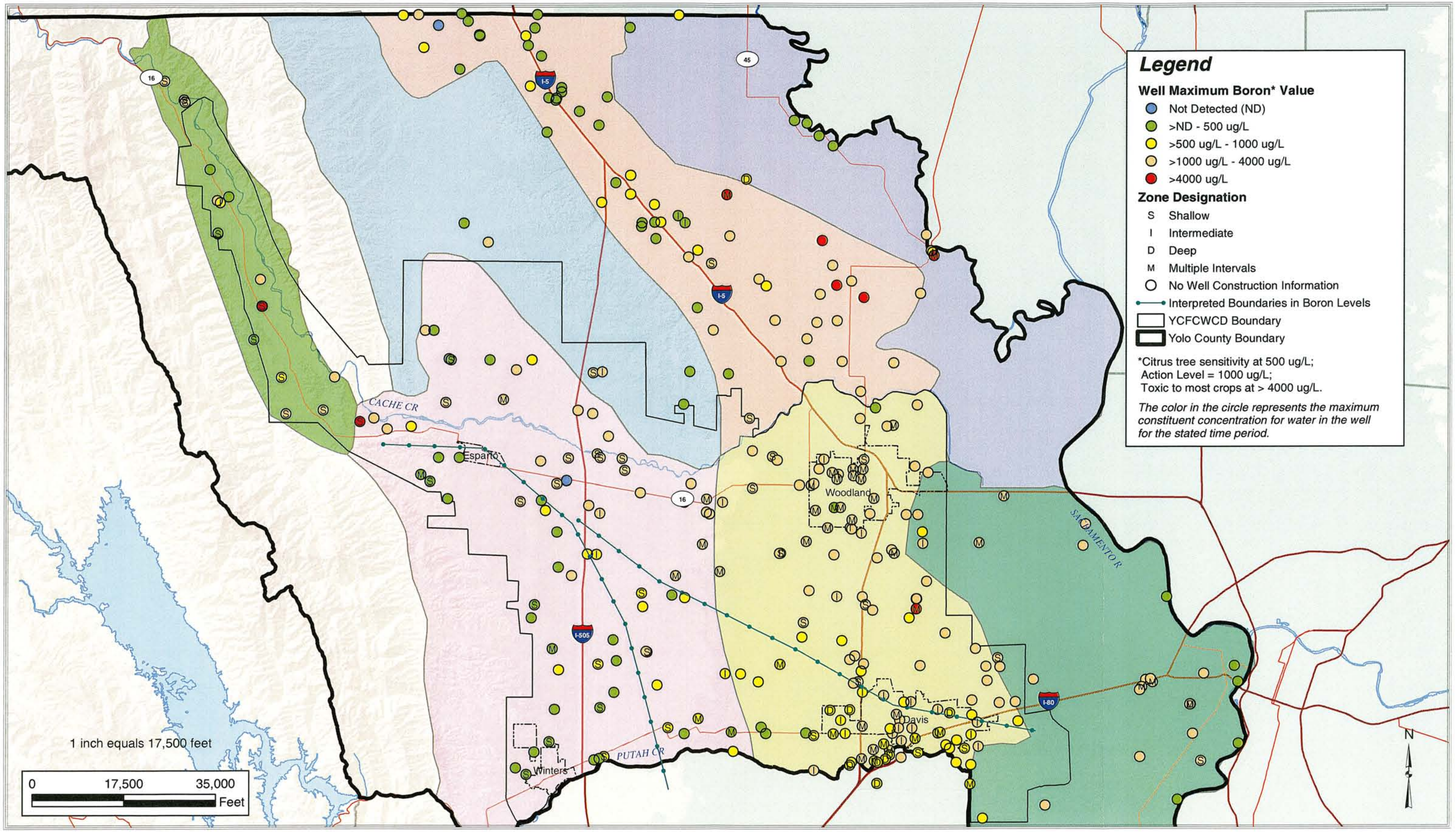

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Figure 5.18
Maximum Boron Value for All Wells
1951 to March 2004
Yolo County

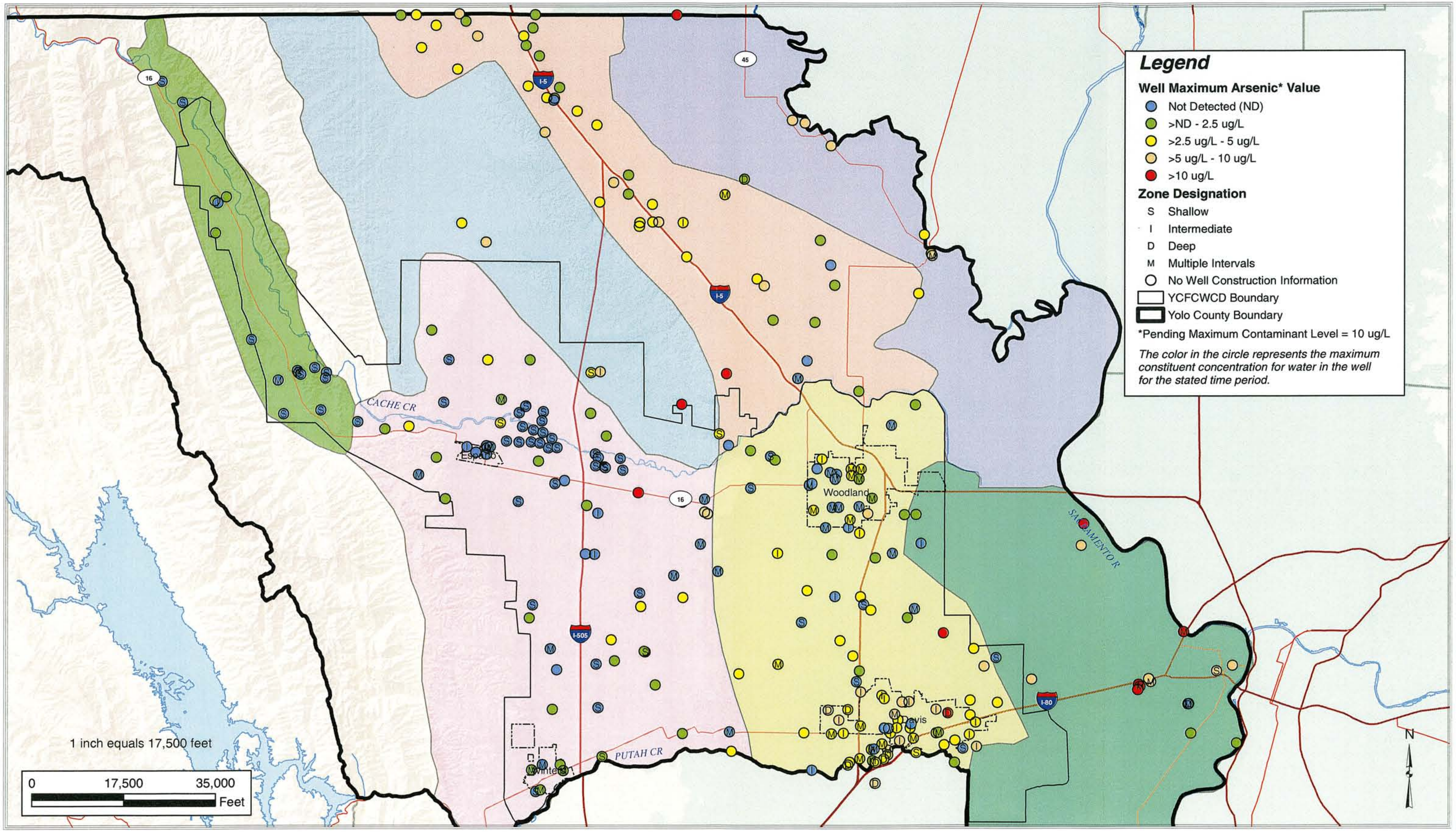

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Figure 5.19
Maximum Arsenic Value for All Wells
1953 to March 2004
Yolo County

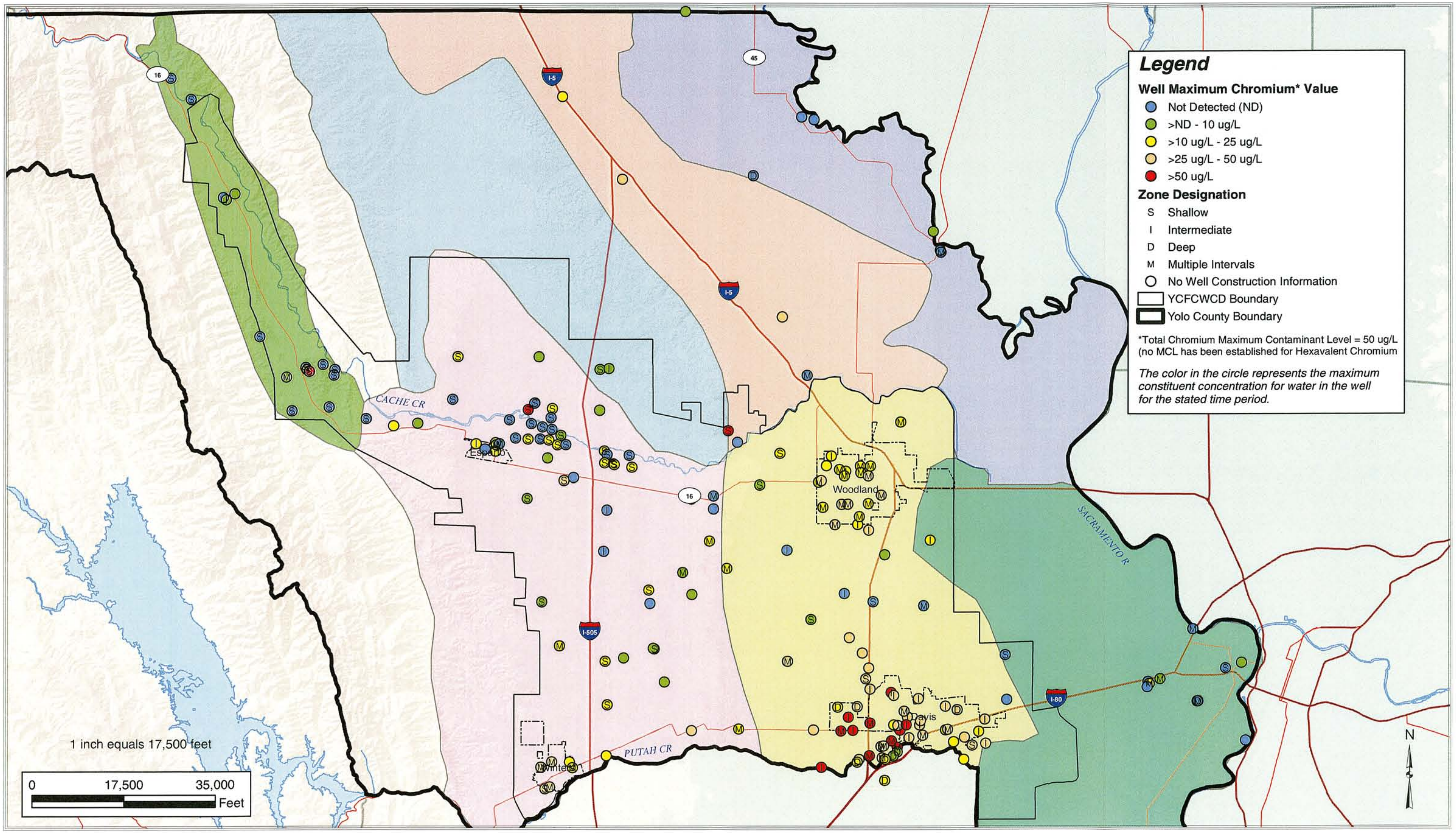

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Figure 5.20
Maximum Chromium Value (Total or Hexavalent) for All Wells
1958 to March 2004
Yolo County

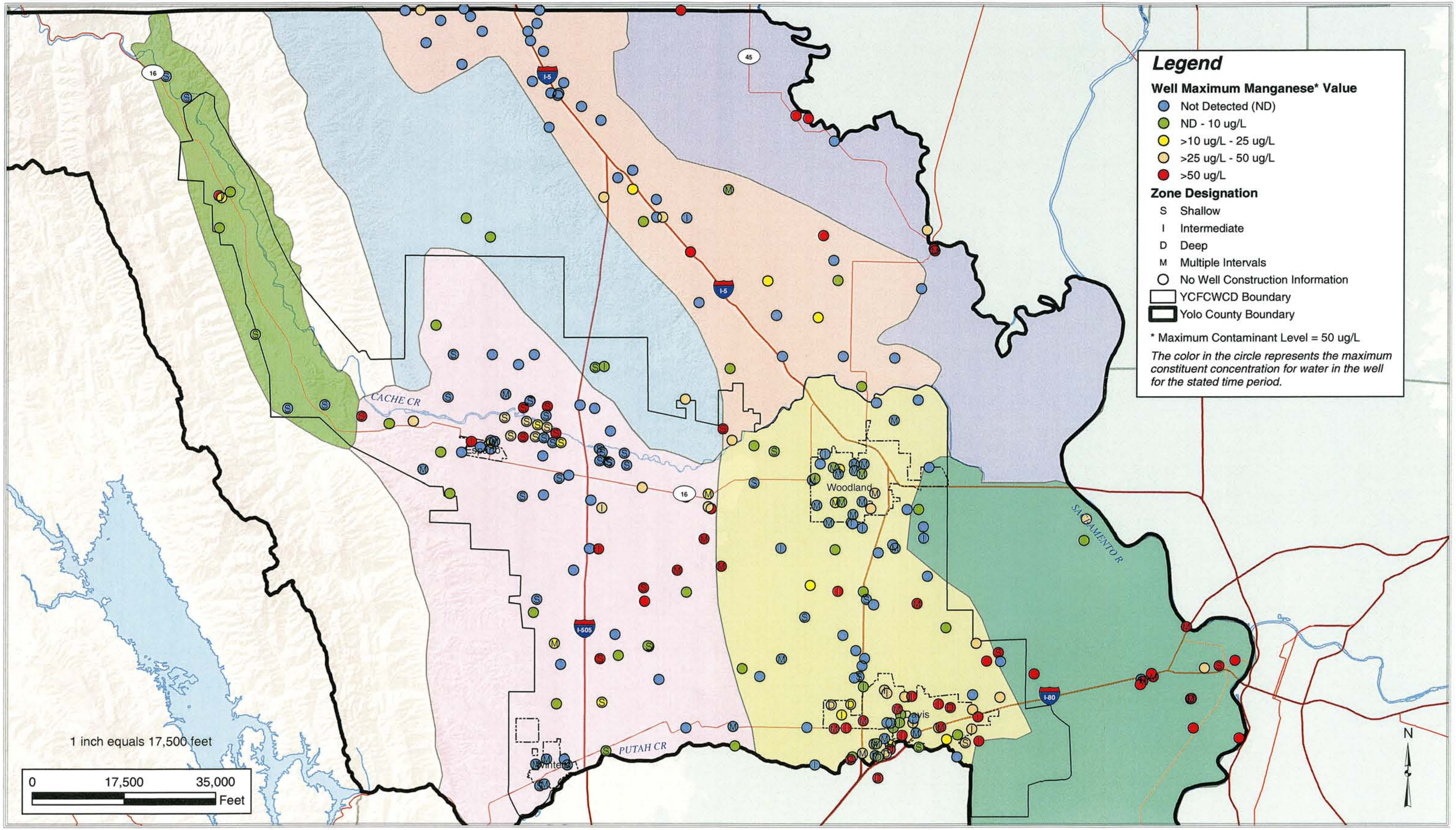

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Figure 5.21
Maximum Manganese Value for All Wells
1958 to March 2004
Yolo County

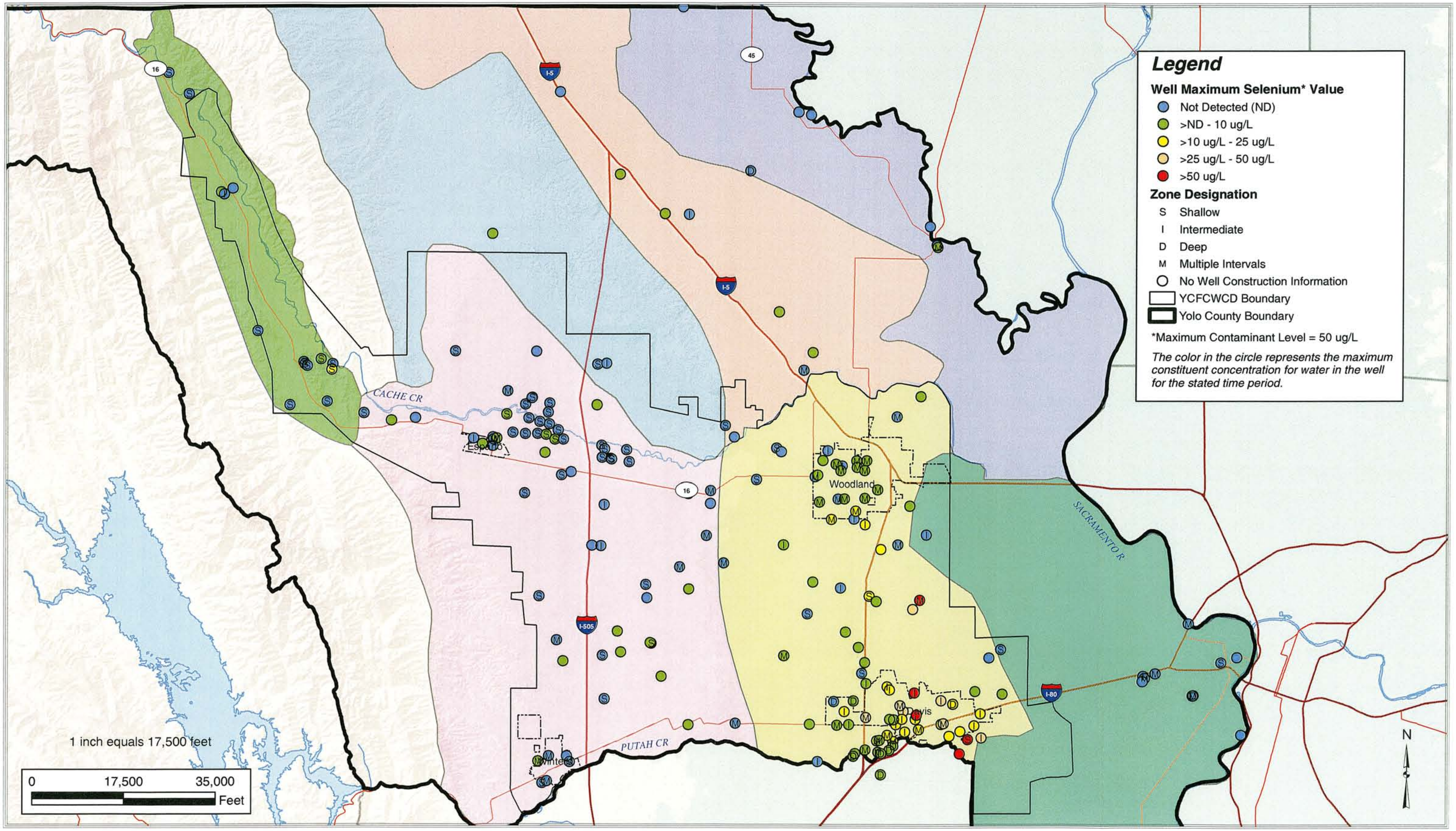

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Figure 5.22
Maximum Selenium Value for All Wells
1969 to March 2004
Yolo County

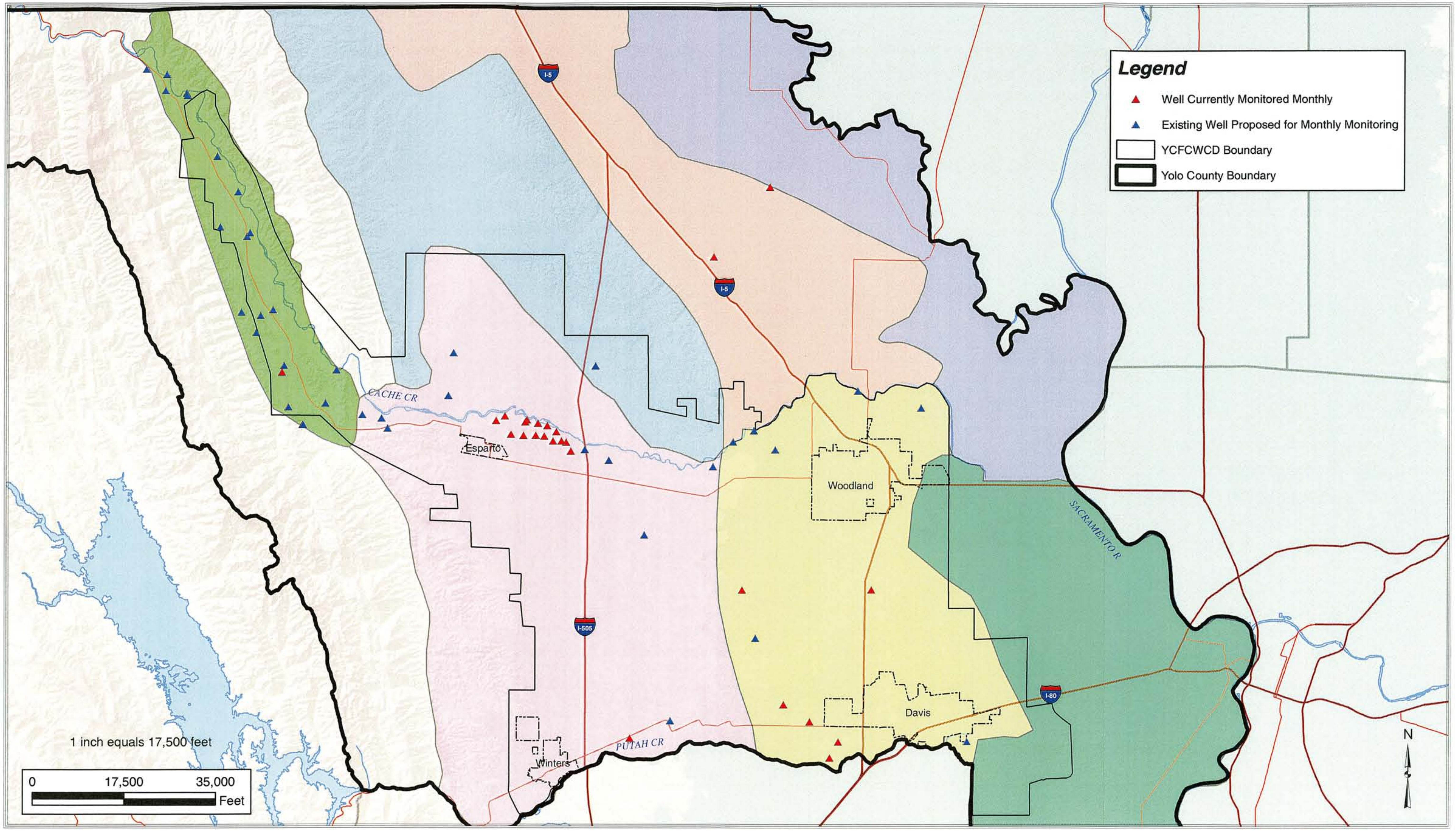

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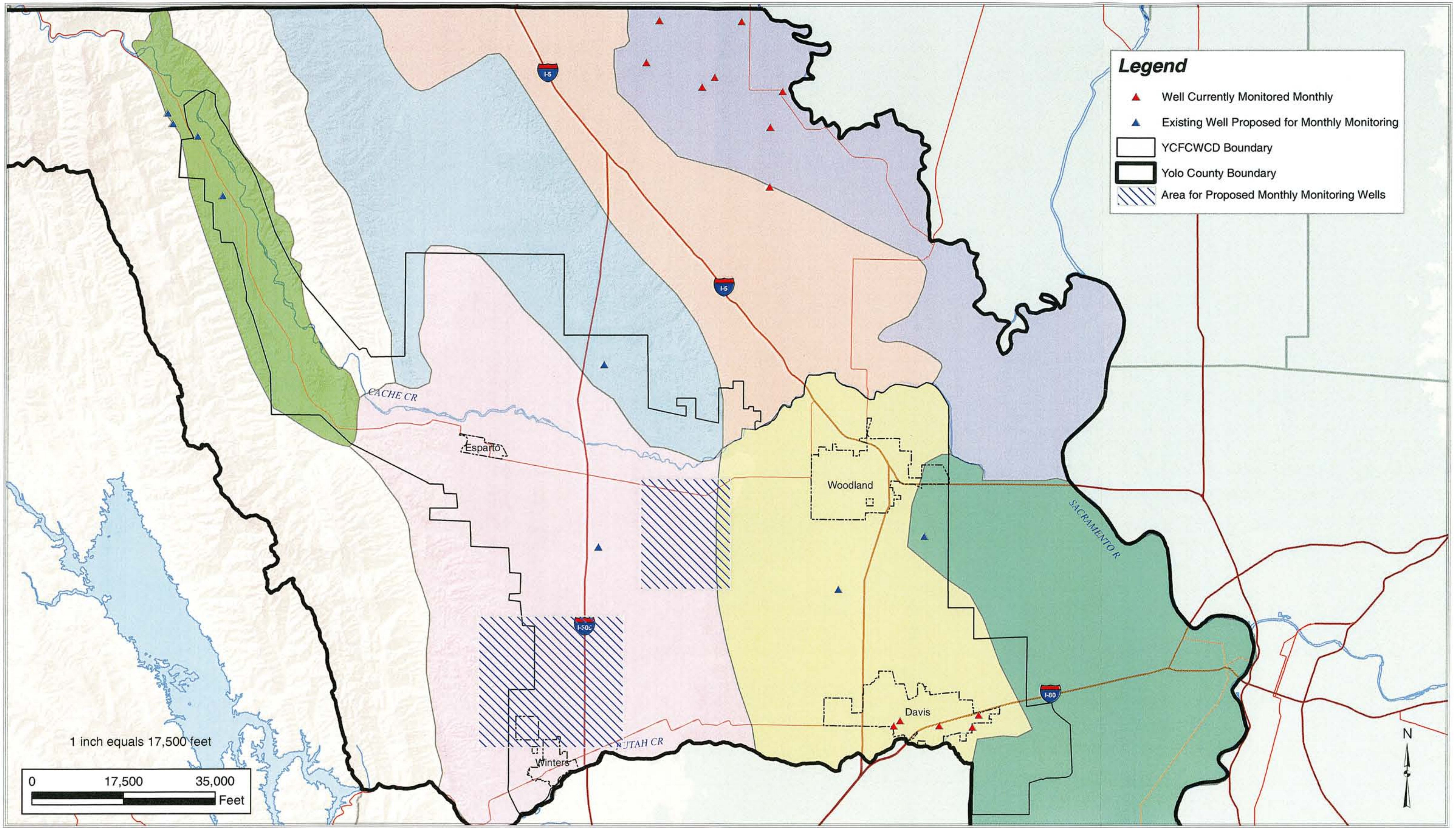
Figure 6.1
Shallow Zone
Monthly Groundwater Monitoring Network
Existing and Proposed Wells



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DATE: 7/9/2004 12:44:29 PM

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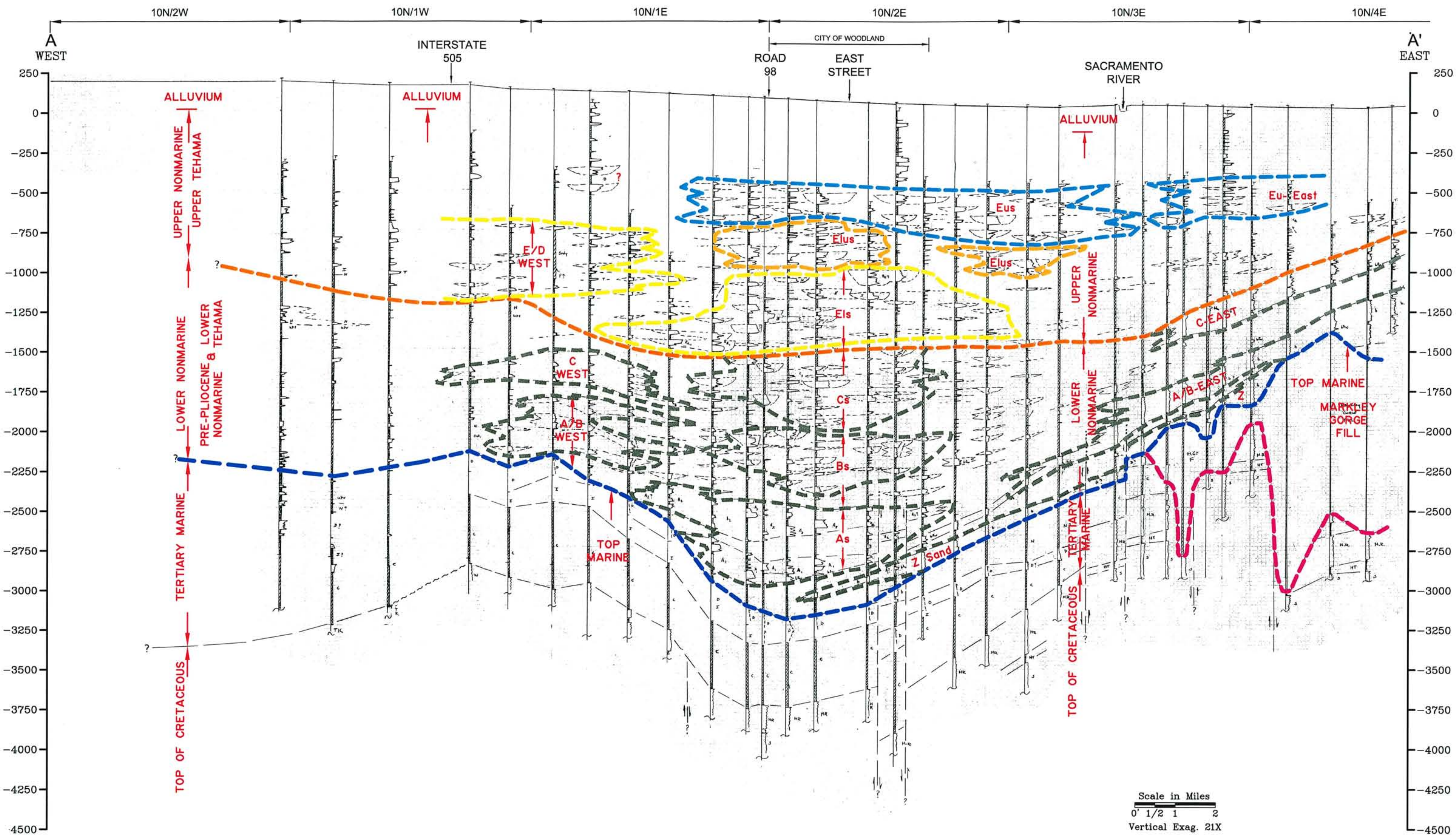
Figure 6.2
Intermediate Zone
Monthly Groundwater Level Monitoring Network
Existing and Proposed Wells

Appendices

Appendix A

Cross-sections A-A’ and B-B’ with Electric Log Information



CAD FILE: G:/Projects/YCFCWCD/03-1-062/Cross Sec/xsection A-A'.DWG CFG FILE: LSCE2500.PCP_MRG DATE: 07-09-04 8:48am

LUHDORFF & SCALMANINI CONSULTING ENGINEERS

Figure A-1
Geologic Cross Section A-A'
Yolo County Area

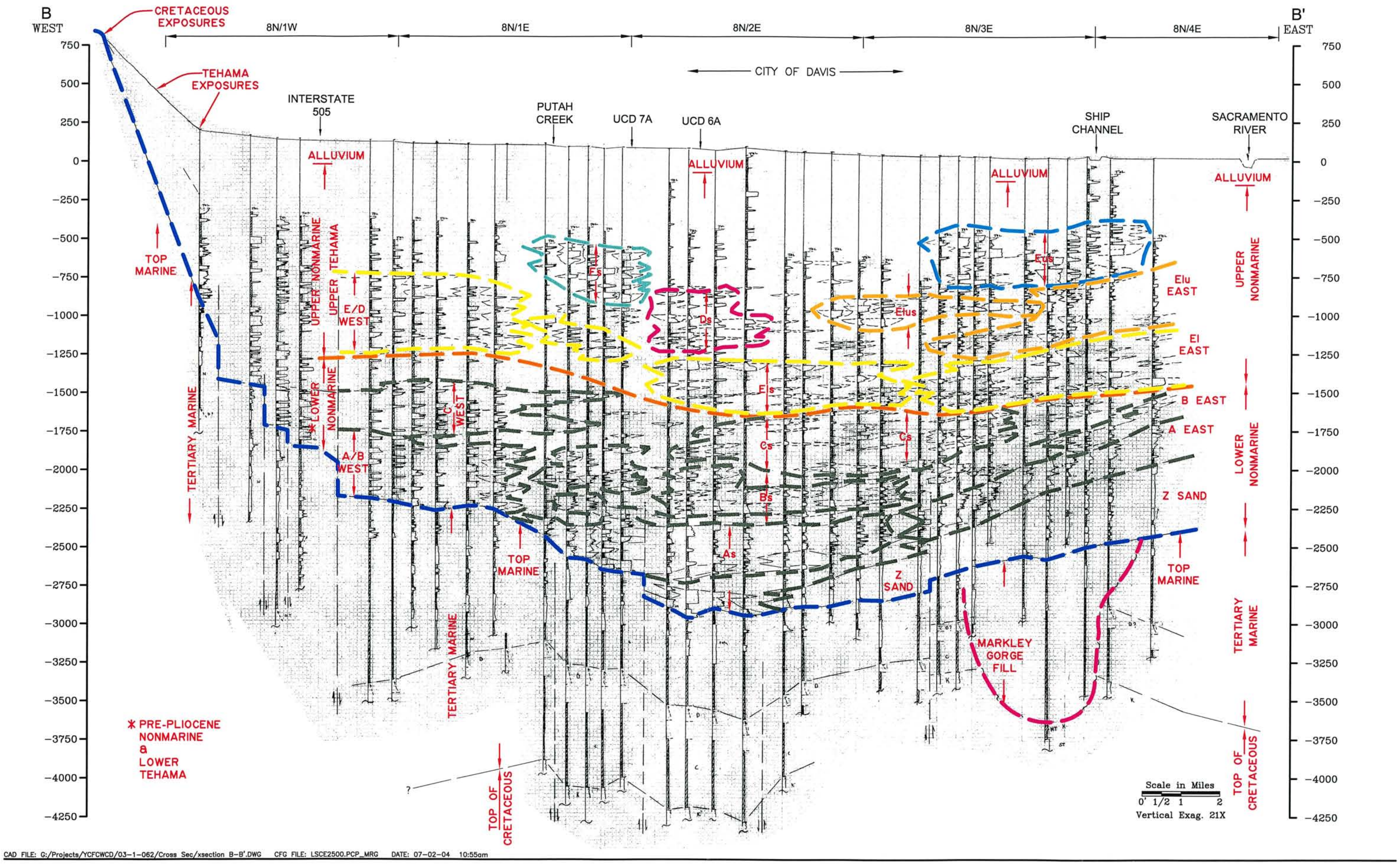


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Figure A-2
Geologic Cross Section B-B'
Yolo County Area

Appendix B

Letters to Agencies Regarding Agency Response to Water Quality Results

April 30, 2004
File No. 03-1-062

Mr. Tom To
Director of Environmental Health
Yolo County Environmental Health Department
10 Cottonwood Street
Woodland, CA 95695

SUBJECT: **CONFIRMATION OF YOLO COUNTY ENVIRONMENTAL HEALTH DEPARTMENT POLICY ON WATER QUALITY RESULTS THAT EXCEED THE MCL IN PRIVATE WELLS**

Dear Mr. To:

This letter is to confirm our conversation from January 13, 2004, regarding Yolo County Environmental Health Department (YCEHD) response to water quality results that exceed the Maximum Contaminant Level (MCL) for samples collected from a private domestic or irrigation well. My notes from this conversation indicate that YCEHD has no authority over private wells and would only offer suggestions to the well owner on how to improve their water quality.

Please reply by email or telephone if you concur or want to add clarification to my understanding of YCEHD's response if results for constituents in a private domestic or irrigation well exceed the MCLs set by the State of California for public water supply wells. This letter, with your approval, will be included, along with letters to other agencies with authority over groundwater quality in Yolo County, in the report for the Yolo County Flood Control and Water Conservation District AB 303 Grant. My inquiry to local and state agencies was prompted by concerns expressed by private well owners when they were approached with a request for permission to sample the water quality in their domestic or irrigation well. Your response will provide these and other private well owners with an understanding of the possible consequences if contaminants are detected in their well.

Your reply by email (dcannon@lsce.com) or telephone (530.661.0109) is requested by June 1, 2004 to allow this letter to be included in the report. We appreciate your consideration of this request. Please call if you have any questions.

Sincerely,

LUHDORFF AND SCALMANINI
CONSULTING ENGINEERS

Debbie Cannon
Senior Hydrogeologist

Debbie Cannon

From: Tom To [mailto:Tom.To@yolocounty.org]
Sent: Thursday, May 06, 2004 1:58 PM
To: dcannon@lsce.com
Subject: MCL in private wells

Debbie,

I received your letter of April 30, 2004 confirming the role of Environmental Health (EH) on private wells that exceed MCL. It is correct that EH does not regulate private wells and only provide recommendation for corrections on MCL matters. However, EH does have a regulatory role on MCL if the private well serves water to the public. The 'public' can be a renter, a business with outside employees or a fountain providing water to the public. Hope this clarification helps.

Tom

April 30, 2004
File No. 03-1-062

Mr. John Troiano
Senior Environmental Research Scientist
Environmental Monitoring Branch
California Department of Pesticide Regulation
P.O. Box 4015
Sacramento, CA 95812

SUBJECT: **CONFIRMATION OF DEPARTMENT OF PESTICIDE REGULATION POLICY ON WATER QUALITY RESULTS THAT EXCEED THE MCL IN PRIVATE WELLS**

Dear Mr. Troiano:

This letter is to confirm our conversation from January 14, 2004, regarding California Department of Pesticide Regulation (DPR) response to water quality results that exceed the Maximum Contaminant Level (MCL) from a private domestic or irrigation well. My notes from this conversation indicate that DPR does not regulate private wells. Action by DPR resulting from a detection of an analyte that exceeded the MCL in a private well would be to add it to a list of wells to be resampled at a time when DPR had a budget to complete this task.

Please reply by email or telephone if you concur or want to add clarification to my understanding of DPR's response if results for constituents in a private domestic or irrigation well exceed the MCLs set by the State of California for public water supply wells. This letter, with your approval, will be included, along with letters to other agencies with authority over groundwater quality in Yolo County, in the report for the Yolo County Flood Control and Water Conservation District AB 303 Grant. My inquiry to local and state agencies was prompted by concerns expressed by private well owners when they were approached with a request for permission to sample the water quality in their domestic or irrigation well. Your response will provide these and other private well owners with an understanding of the possible consequences if contaminants are detected in their well.

Your reply by email (dcannon@lsce.com) or telephone (530.661.0109) is requested by June1, 2004 to allow this letter to be included in the report. We appreciate your consideration of this request. Please call if you have any questions.

Sincerely,

LUHDORFF AND SCALMANINI
CONSULTING ENGINEERS

Debbie Cannon
Senior Hydrogeologist

Debbie Cannon

From: Mark Pepple [mpepple@cdpr.ca.gov]
Sent: Wednesday, May 12, 2004 11:46 AM
To: dcannon@lsce.com
Cc: John Troiano
Subject: Response to April 30 letter to John Troiano

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m_05-4.doc

Ms. Cannon:

John Troiano asked me to respond to your April 30 letter asking what the Department of Pesticide Regulation's (DPR) response is to detections of pesticides in ground water in private domestic or irrigation wells at concentrations that exceed any maximum contaminant levels (MCLs).

Just a reminder that state or federal MCLs have only been established for four of the eight active ingredients that have been found in ground water due to legal agricultural use: aldicarb, atrazine, bentazon, and simazine. No MCLs have been established for bromacil, diuron, norflurazon, and prometon.

MCLs have only been established for the following additional currently registered pesticides: 1,3-D, alachlor, carbofuran, 2,4-D, diquat, endothal, glyphosate, lindane, molinate, oxamyl, and thiobencarb. Of these, only breadown products of alachlor have been found in ground water due to normal use in California.

Attached is how DPR responds, in outline form.

If you have any questions, send me an e-mail or give me a call at (916) 324-4086.

Mark Pepple

How does the Department of Pesticide Regulation (DPR) respond to a reported detection of a pesticide active ingredient at a concentration that exceeds a maximum contaminant level in a private domestic well or irrigation well?

DPR's response depends on the nature of the pesticide detected, the status of the detection, the concentration reported, and the location of the detection.

1. Detections of pesticides that the director has reason to believe meet any of the conditions stated in Food and Agricultural Code section 12825 and that the use or continued use of which constitutes an immediate substantial danger to persons or the environment. The director would immediately suspend the registration pending a hearing on an action to cancel the registration. DPR enters the results in the Well Inventory Database (WID).

For all other detections, DPR responds as follows:

2. Detections of pesticides that are no longer registered for use or of naturally occurring chemicals, such as copper and carbon disulfide.

   a. DPR enters no-longer-registered pesticides in the WID.
   b. DPR reports these detections to the State Water Resources Control Board (SWRCB).

3. Detections of "new" active ingredients " (not yet reviewed under the Pesticide Contamination Prevention Act - PCPA).

   a. DPR enters the results into the WID.
   b. DPR verifies the detection within 30 days, assuming an analytical method is available for the chemical. If not, then an analytical method must be developed. If not verified, no further action is taken. If verified, then:
   c. DPR must determine whether the detection is due to legal agricultural use within 90 days, or the pesticide is cancelled..
      1. DPR conducts well sampling in the section of detection and the three most adjacent sections to determine if a second well is contaminated.
      2. DPR investigates whether the pesticide was legally used in the area and whether there are other sources that could exclusively account for the detection
   d. If use is determined not to be due to legal agricultural use, DPR reports the detection to SWRCB.
   e. If use is determined to be due to legal agricultural use, DPR notifies in writing the well owner, the County Agricultural Commissioner, the county health officer, the county environmental health director, the Office of Drinking Water of the Department of Health Services (DHS), the Pesticide Registration and Evaluation (PREC) subcommittee members (members one each from DPR, SWRCB, and the Office of Environmental Health Hazard Assessment) , the SWRCB memorandum of understanding coordinator, the appropriate regional water quality control board, the reporting agency of the original detection, and the registrant(s) of the pesticide to advise of their opportunity to

request a specified hearing. If a hearing is not requested within 30 days, the pesticide is cancelled.

f. If requested, a hearing of PREC subcommittee must be held within 180 days.

g. The subcommittee must make one of three specified findings and recommendations within 90 days after the hearing, or the pesticide is cancelled.

h. The director must concur with the finding or make a contrary finding within 30 days after the subcommittee findings and recommendations are made, or the pesticide is cancelled..

i. If the director determines the use of the pesticide can be modified so that there is a high probability that pollution will not occur, he/she must adopt modification of use by regulation.

4. Detections of "old" active ingredients (previously reviewed under the PCPA) inside ground water protection areas (GWPAs).

a. DPR enters the results into the WID.

b. DPR verifies the detection. If not verified, no further action is taken. If verified, then:

c. DPR notifies in writing the well owner, the County Agricultural Commissioner, the county health officer, and the county environmental health director.

d. DPR may investigate further to determine the reason for the high levels detected.

e. DPR may consider more stringent restrictions of use or cancellation of use.

5. Detections of "old" active ingredients outside GWPAs

a. DPR enters the results into the WID

b. DPR verifies the detection. If not verified, no further action is taken. If verified, then:

c. DPR notifies in writing the well owner, the County Agricultural Commissioner, the county health officer, and the county environmental health director.

d. DPR determines whether the detection is due to legal agricultural use

1. DPR conducts well sampling in the section of detection and the three most adjacent sections to determine if a second well is contaminated.

2. DPR investigates whether the pesticide was legally used in the area and whether there are other sources that could exclusively account for the detection

e. If use is determined not to be due to legal agricultural use, DPR reports the detection to SWRCB.

f. If use is determined to be due to legal agricultural use, DPR identifies the section where the pesticide was detected as a GWPA in a future rulemaking

April 30, 2004
File No. 03-1-062

Mr. Steven Book
Toxicologist
Division of Drinking Water and Environmental Management
California Department of Health Services
1616 Capitol Avenue, MS 7416
P.O. Box 997413
Sacramento, CA 95899-7413

SUBJECT: **CONFIRMATION OF DEPARTMENT OF HEALTH SERVICES POLICY ON WATER QUALITY RESULTS THAT EXCEED THE MCL IN PRIVATE WELLS**

Dear Mr. Book:

This letter is to confirm our conversation from January 13, 2004, regarding California Department of Health Services, Division of Drinking Water and Environmental Management (DDWEM) response to water quality results that exceed the Maximum Contaminant Level (MCL) from a private domestic or irrigation well. My notes from this conversation indicate that DDWEM does not regulate private wells. Action resulting from widespread detections of analytes that exceed the MCL in private wells would be that water purveyors operating nearby public water supply wells would be required to monitor for the contaminant.

Please reply email or telephone if you concur or want to add clarification to my understanding of DDWEM's response if results for constituents in a private domestic or irrigation well exceed the MCLs set by the State of California for public water supply wells. This letter, with your approval, will be included, along with letters to other agencies with authority over groundwater quality in Yolo County, in the report for the Yolo County Flood Control and Water Conservation District AB 303 Grant. My inquiry to local and state agencies was prompted by concerns expressed by private well owners when they were approached with a request for permission to sample the water quality in their domestic or irrigation well. Your response will provide these and other private well owners with an understanding of the possible consequences if contaminants are detected in their well.

Your reply by email (dcannon@lsce.com) or telephone (530.661.0109) is requested by June 1, 2004 to allow this letter to be included in the report. We appreciate your consideration of this request. Please call if you have any questions.

Sincerely,

LUHDORFF AND SCALMANINI
CONSULTING ENGINEERS

Debbie Cannon
Senior Hydrogeologist

Debbie Cannon

From: Book, Steven (DHS) [sbook@dhs.ca.gov]
Sent: Tuesday, May 18, 2004 10:54 AM
To: dcannon@lsce.com
Subject: contaminants in private wells

To: Debbie Cannon

Your letter of April 30, 2004 (File No. 03-1-062) is correct: DHS regulates public water systems and not private wells.

____
Steven Book, Ph.D.
DHS' Drinking Water Program
email: sbook@dhs.ca.gov
phone: (916) 449-5556
fax: (916) 449-5656
mail: California Department of Health Services/Drinking Water Program /MS 7416/P.O. Box 997413/Sacramento, CA 95899-7413
overnight courier: California Department of Health Services/Drinking Water Program /MS 7416/1616 Capitol Avenue, Suite 74.243/Sacramento, CA 95814

Visit our website at http://www.dhs.ca.gov/ps/ddwem/default.htm

Appendix C

Yolo County Water Resources Information Database
Guidelines for Data Entry

Appendix C
Yolo County Water Resources Information Database
Guidelines for Data Entry

The Yolo County Water Resources Information Database (WRID) stores groundwater and surface water data for locations throughout Yolo County. The database is designed to provide flexibility and simplicity for users, while maximizing the ability to analyze data within the database. This Appendix provides general guidelines for preparing data to be entered into the WRID.

GENERAL GUIDELINES

The goal of the database, as described above, is to maximize the usefulness of the data. In order to accomplish this, certain general guidelines need to be employed:

1. Text entries, such as *Well Name* or water quality *Analyte*, need to be entered consistently with the same spelling, spacing, and punctuation. The database will not recognize, for example, "Chromium, Hexavalent" and "Hexavalent Chromium" as the same *Analyte.* These types of inconsistencies have to be corrected by hand, which is time consuming.

2. Date entries can be in any standard format that includes the month, day, and year of the measurement in that order. Some examples are given below:

Date Formats
1/23/2003
01/23/03
1/23/03
1/23/03 12:00 AM

   For data where the day of the measurement is not available, the measurement should be entered as the first of the month. If a better approximation of the day of the measurement can be made, that approximation should be used. For historic data that is only identified by year, the measurement should be entered as the first of the year. For example:

Date in Record	*Enter As*
March 1980	3/1/1980
March 1980 (middle of month)	3/15/1980
1963	1/1/1963

3. Numeric entries, such as *Depth to Water* and water quality *Results* and *Reporting Limits*, should contain only numeric values. No text, spacing, or punctuation should be included in numeric data. Non-detect values should be entered as "–9999," and the *Reporting Limit* should also be entered. Some water quality examples are given below:

Data in Record	Enter As Result	 Reporting Limit
45	45	
<0.02	–9999	0.02
ND (with no *Reporting Limit*)	–9999	
0 (with no *Reporting Limit*)	0	

WELL AND SURFACE WATER POINT NAMING

Wells within the database are identified by *Well Name* and by *State Well Number*, where available. Different agencies report data for the same well by different *Well Names*, but these data are related in the database by *State Well Number*.

Well Name	*State Well Number*	*Source*
DAVIS_WELL14	008N002EXXX001M	DAVIS
5710001XXX	008N002EXXX001M	DHS
38325912143XXX	008N002EXXX001M	USGS

As illustrated in the table above[1], the City of Davis (DAVIS), DHS, and USGS all have reported data for the City of Davis Well 14; accordingly, the well has three different *Well Names* in the database, all with the same *State Well Number*. When DHS provides water quality data for the well, it uses the *Well Name* "5710001XXX." When the City of Davis provides similar data, it uses the *Well Name* "DAVIS_WELL14."

Surface water measurement locations are identified by *Surface Water Point*. An agency may continue to use its standard naming convention for reporting data, with three requirements:

1. The *Well Name* or *Surface Water Point* should be consistent. All data for a well should be reported using the exact same *Well Name*, including the spacing and punctuation. The database would not recognize "DAVIS_WELL_14" and "DAVIS_WELL14" as the same well. The same is true for *Surface Water Points.*

2. The *Well Name* or *Surface Water Point* should not include spaces. The underscore ("_") character should be used where spacing is desired.

3. Each agency should provide a table with *Well Names* and associated *State Well Numbers* for its wells. For *Surface Water Points*, the agency should provide a table that includes the physical coordinates (latitude and longitude) of the measurement location, as well as a description of the location (i.e., at A Street

[1] Throughout this Appendix, portions of Well Names and State Well Numbers have been replaced with the character "X" to maintain data confidentiality. The full Well Names and State Well Numbers would be entered into the database.

bridge crossing Old Creek). These tables only need to be provided when initially submitting data, and subsequently when new wells or surface water measurement locations are added.

WATER LEVEL DATA (WELLS)

Water level data should be provided in the following format:

Well Name	*Measurement Date*	*Reference Point Elevation (feet, msl)*	*Depth to Water (feet, measured from reference point)*	*Comment*
39113012114XXXX	8/16/1978	1340	110	Pumping???
39113012114XXXX	9/1/1979	1340	22.5	
39113012114XXXX	6/14/1980	1340	10.07	

The *Well Name* should be entered as described above under "Well and Surface Water Point Naming."

The *Measurement Date* is the actual date the measurement is made.

If the *Reference Point Elevation* of the well has been surveyed and is available, it should be entered for each water level measurement. The reference point is the point from which *Depth to Water* is measured. The *Reference Point Elevation* of a well may change if the wellhead is modified, if the well is re-surveyed, or if a different reference point is used.

The *Depth to Water* should be reported in feet below the reference point. This value should be reported in decimal feet; data in feet and inches should be converted to decimal feet for entry into the database. If possible, measurements should be made to the nearest one-hundredth foot; however, all measurements should be reported regardless of precision.

If the measurement is known to be faulty, it should not be reported. However, if the measurement is suspected to be faulty, it should be reported with a *Comment* about the problem, as shown in the first row of the table above. The *Comment* can also be used to make a general remark about the measurement, e.g. "10 AM" or "30 minutes after shutoff," although this is not necessary.

WATER QUALITY DATA (WELLS AND SURFACE WATER)

Water quality data are associated with a specific analyte.

Water quality data should be provided in the following format:

Well Name (or Surface Water Point)	Sample Date	Analyte	Result	Units	Reporting Limit	Method
11N03WXXX001M	3/16/2004	Potassium	1.16	mg/L	0.5	
11N03WXXX001M	3/16/2004	Chloride	37	mg/L	10	EPA 300.0
11N03WXXX001M	3/16/2004	Nitrite as N	–9999	mg/L	0.1	EPA 300.0
11N03WXXX001M	3/16/2004	PH	7.33	pH, lab units		
11N03WXXX001M	3/16/2004	Specific conductance	580	umhos/cm		

The *Well Name* or *Surface Water Point* should be entered as described above under "Well and Surface Water Point Naming."

The *Sample Date* is the actual date the water quality sample was collected (not the analysis date).

The *Analyte* is the constituent being analyzed. At the end of this Appendix is a table listing the *Analytes* in the database. When reporting a result for an *Analyte* listed in the table, the spelling, spacing, and punctuation should be as shown in the table. If the *Analyte* does not appear in the attached table, the *Analyte* should be named consistently throughout the reported data, and when the data are submitted, a note describing the *Analyte* should be included.

The *Result* is the numerical result of the analysis. As described above, if the *Result* is Non-detect, a value of "–9999" should be entered.

The *Units* are the units the analysis was reported in. Where possible, analysis results for each *Analyte* should be reported in the *Units* shown in the attached table of water quality *Analytes*.

Results below the *Reporting Limit* for an analysis are Non-detects. For example, a water quality result of <u><2.0</u> would have a *Reporting Limit* of <u>2.0</u>. The *Reporting Limit* is also known as the Detection Limit for Reporting, or DLR. The *Reporting Limit* should be entered for all Non-detect results; entering the *Reporting Limit* for quantified results is recommended but not required.

The analytical *Method* can be entered where known and available; entering the *Method* is preferred but not required.

All water quality *Results* should be submitted. If the results are known or suspected to be faulty, a *Comment* describing data problems may be submitted.

PUMPAGE DATA (WELLS)

Pumpage data should be provided as total pumpage over a specified period, in the following format:

Well Name	*Interval*	*Start of Interval*	*Total Pumpage*	*Units*
11N03WXXX001M	Year	1/1/1980	900	Acre-feet
11N03WXXX001M	Year	10/1/1985	275.4	MG
11N03WXXX001M	Month	2/1/2004	82.1	Acre-feet
11N03WXXX001M	Month	4/1/2004	96.8	Acre-feet

The *Well Name* should be entered as described above under “Well or Surface Water Point Naming.”

The *Interval* is the period over which pumpage was totaled, for example “Year” or “Month.” Monthly data are preferable where available; however, if monthly data are not available, yearly or other data should be provided.

The *Start of Interval* is the first day of the interval that pumpage is being reported for. The *Start of Interval* should be entered as the first of the month. For example, the record shown in the first row of the table above is total pumpage for 1980. The record shown in the second row of the table is total pumpage for the water year beginning October 1, 1985. The record shown in the third row is total monthly pumpage for February 2004.

The *Total Pumpage* is the total volume pumped during the specified interval. If the *Total Pumpage* for a well over a specified interval is known to be zero, a value of “0” should be entered. If the *Total Pumpage* for a well over a specified period is not known, no data should be entered.

The *Units* are the units the *Total Pumpage* is reported in. If possible, *Total Pumpage* should be reported in Acre-feet; however, other *Units* (e.g. MG or Cubic Feet) may be used.

SURFACE WATER TRANSFER DATA (SURFACE WATER)

Surface water transfer data should be provided as the total volume transferred over a specified period, in the following format:

Surface Water Point	*From*	*To*	*Interval*	*Start of Interval*	*Total Transfer Volume*	*Units*	*Comment*
A001	River D	Canal E	Week	1/1/1980	40	Acre-feet	Approx.
A001	Canal E	River D	Year	10/1/1985	250.4	Acre-feet	
B002	River F	Canal E	Month	4/1/2004	107.8	Acre-feet	

The *Surface Water Point* should be entered as described above under “Well and Surface Water Point Naming.”

The *From* and *To* fields specify the surface water bodies that water was transferred from and to. For example, in the first row of the table above, water was transferred from River D to Canal E.

The *Interval* is the period over which the transfer was totaled, for example “Year” or “Month.” Monthly data are preferable where available; however, if monthly data are not available, yearly or other data should be provided.

The *Start of Interval* is the first day of the interval that the transfer is being reported for. The *Start of Interval* should be entered as the first of the month. For example, the record shown in the first row of the table above is for water transferred during the first week of 1980. The record shown in the second row of the table is for water transferred during the water year beginning October 1, 1985. The record shown in the third row is for water transferred during April 2004.

The *Total Transfer Volume* is the total volume of water transferred during the specified interval. If the *Total Transfer Volume* for a *Surface Water Point* over a specified period is not known, but can be reliably approximated, the approximated value should be entered, and a *Comment* should be made as shown in the first row of the table above.

The *Units* are the units the *Total Transfer Volume* is reported in. If possible, *Total Transfer Volume* should be reported in Acre-feet; however, other *Units* (e.g. MG or Cubic Feet) may be used.

Table C.1
Analytes Included in Yolo County WRID

Analyte	Units
1,1,1,2-Tetrachloroethane	ug/L
1,1,1-Trichloroethane	ug/L
1,1,2,2-Tetrachloroethane	ug/L
1,1,2-Trichloro-1,2,2-trifluoroethane	ug/L
1,1,2-Trichloroethane	ug/L
1,1-Dichloroethane	ug/L
1,1-Dichloroethene	ug/L
1,1-Dichloroethylene	ug/L
1,1-Dichloropropene	ug/L
1,2,3,4-Tetramethylbenzene	ug/L
1,2,3,5-Tetramethylbenzene	ug/L
1,2,3-Trichlorobenzene	ug/L
1,2,3-Trichloropropane	ug/L
1,2,3-Trimethylbenzene	ug/L
1,2,4-Trichlorobenzene	ug/L
1,2,4-Trimethylbenzene	ug/L
1,2-Dibromo-3-chloropropane (DBCP)	ug/L
1,2-Dibromoethane	ug/L
1,2-Dichlorobenzene	ug/L
1,2-Dichloroethane	ug/L
1,2-Dichloropropane	ug/L
1,3,5-Trimethylbenzene	ug/L
1,3-Dichlorobenzene	ug/L
1,3-Dichloropropane	ug/L
1,4-Dichlorobenzene	ug/L
1,4-Dioxane	ug/L
1,4-Naphthoquinone	ug/L
1-Naphthol	ug/L
2-(4-tert-Butylphenoxy)-cyclohexanol	ug/L
2,2-Dichloropropane	ug/L
2,4,5-T	ug/L
2,4,5-TP (Silvex)	ug/L
2,4-D	ug/L
2,4-DB	ug/L
2,5-Dichloroaniline	ug/L
2,6-Diethylaniline	ug/L
2-[(2-Ethyl-6-methylphenyl)-amino]-1-propanol	ug/L
2-Amino-N-isopropylbenzamide	ug/L
2-Chloro-2',6'-diethylacetanilide	ug/L
2-Chloro-4-isopropylamino-6-amino-s-triazine	ug/L
2-Chloro-6-ethylamino-4-amino-s-triazine	ug/L
2-Chloroethyl vinyl ether	ug/L
2-Chlorotoluene	ug/L
2-Ethyl-6-methylaniline	ug/L
2-Ethyltoluene	ug/L
2-Hydroxy-4-isopropylamino-6-ethylamino-s-triazine	ug/L
2-Methyl-4,6-dinitrophenol	ug/L

Analyte	Units
3-(Trifluoromethyl)aniline	ug/L
3,4-Dichloroaniline	ug/L
3,5-Dichloroaniline	ug/L
3-Chloropropene	ug/L
3-Hydroxy carbofuran	ug/L
3-Ketocarbofuran	ug/L
3-OH Carbofuran	ug/L
3-Phenoxybenzyl alcohol	ug/L
4-(Hydroxymethyl) pendimethalin	ug/L
4,4'-Dichlorobenzophenone	ug/L
4-Chloro-2-methylphenol	ug/L
4-Chlorophenyl methyl sulfone	ug/L
4-Chlorotoluene	ug/L
4-Isopropyltoluene	ug/L
Acetamaprid	ug/L
Acetochlor	ug/L
Acetone	ug/L
Acid neutralizing capacity, fixed field	mg/L
Acid neutralizing capacity, fixed lab	mg/L
Acid neutralizing capacity, Gran field	mg/L
Acid neutralizing capacity, incremental field	mg/L
Acifluorfen	ug/L
Acrolein	ug/L
Acrylonitrile	ug/L
Alachlor	ug/L
Aldicarb	ug/L
Aldicarb sulfone	ug/L
Aldicarb sulfoxide	ug/L
Aldrin	ug/L
Alkalinity, Total	mg/L
alpha-Endosulfan	ug/L
alpha-HCH	ug/L
Aluminum	ug/L
Ametryn	ug/L
Ammonia as NH4	mg/L
Antimony	ug/L
Arsenic	ug/L
Atrazine	ug/L
Axiothella	ug/L
Azinphos Methyl	ug/L
Azoxystrobin	ug/L
Barban	ug/L
Barium	ug/L
Barometric Pressure	mm Hg
Bendiocarb	ug/L
Benfluralin	ug/L
Benomyl	ug/L
Bensulfuron	ug/L
Bensulide	ug/L
Bentazon	ug/L

Analyte	Units
Benthiocarb	ug/L
Benzene	ug/L
Benzo(a)pyrene (PAHs)	ug/L
Beryllium	ug/L
beta-Endosulfan	ug/L
BHC	ug/L
Bicarbonate (as CaCO3)	mg/L
Bifenox	ug/L
Bifenthrin	ug/L
Bolstar	ug/L
Boron	ug/L
Bromide	mg/L
Bromobenzene	ug/L
Bromochloromethane	ug/L
Bromocil	ug/L
Bromodichloromethane	ug/L
Bromoethene	ug/L
Bromoform	ug/L
Bromomethane	ug/L
Bromoxynil	ug/L
BTEX	ug/L
Butylate	ug/L
Cadmium	ug/L
Caffeine	ug/L
Calcium	mg/L
Captan	ug/L
Carbaryl	ug/L
Carbofenthion	ug/L
Carbofuran	ug/L
Carbon dioxide	mg/L
Carbon disulfide	ug/L
Carbon tetrachloride	ug/L
Carbonate (as CaCO3)	mg/L
Carbophenothion	ug/L
Chloramben methyl ester	ug/L
Chlorbenzilate	ug/L
Chlordane	ug/L
Chlorfenvinphos	ug/L
Chloride	mg/L
Chlorimuron	ug/L
Chlorobenzene	ug/L
Chlorodiamino-s-triazine	ug/L
Chloroethane	ug/L
Chloroform	ug/L
Chloromethane	ug/L
Chlorothalonil	ug/L
Chlorpropham	ug/L
Chlorpyrifos	ug/L
Chromium, Hexavalent	ug/L
Chromium, Total	ug/L

Analyte	Units
Ciodrin	ug/L
cis-1,2-Dichloroethene	ug/L
cis-1,2-Dichloroethylene	ug/L
cis-1,3-Dichloropropene	ug/L
cis-Permethrin	ug/L
cis-Propiconazole	ug/L
Clopyralid	ug/L
Cobalt	ug/L
Color	
Copper	ug/L
Coumaphos	ug/L
Cyanazine	ug/L
Cyanide	ug/L
Cycloate	ug/L
Cyfluthrin	ug/L
Cyhalothriin	ug/L
Cypermethrin	ug/L
Dacthal	ug/L
Dacthal monoacid	ug/L
Dalapon	ug/L
DCPA	ug/L
Demeton	ug/L
Di(2-ethylhexyl) adipate	ug/L
Di(2-ethylhexyl) phthalate	ug/L
Diazinon	ug/L
Dibrom	ug/L
Dibromochloromethane	ug/L
Dibromomethane	ug/L
Dicamba	ug/L
Dichlobenil	ug/L
Dichlone	ug/L
Dichloran	ug/L
Dichlorodifluoromethane	ug/L
Dichloromethane	ug/L
Dichlorprop	ug/L
Dichlorvos	ug/L
Dicofol	ug/L
Dicrotophos	ug/L
Dieldrin	ug/L
Diethyl ether	ug/L
Diisopropyl ether	ug/L
Dimethoate	ug/L
Dinoseb	ug/L
Dioxin (2,3,7,8-TCDD)	ug/L
Diphenamid	ug/L
Diphenyl Amine	ug/L
Diquat	ug/L
Disulfoton	ug/L
Disulfoton sulfone	ug/L
Disulfoton sulfoxide	ug/L

Analyte	Units
Diuron	ug/L
Dyrene	ug/L
e-Dimethomorph	ug/L
Endosulfan ether	ug/L
Endosulfan sulfate	ug/L
Endosulfan-1	ug/L
Endosulfan-2	ug/L
Endothall	ug/L
Endrin	ug/L
Endrin aldehyde	ug/L
Endrin Ketone	ug/L
Esfenvalerate	ug/L
Ethalfluralin	ug/L
Ethion	ug/L
Ethion monoxon	ug/L
Ethyl methyl ketone	ug/L
Ethoprop	ug/L
Ethyl methacrylate	ug/L
Ethylbenzene	ug/L
Ethylene dibromide	ug/L
Ethyl-t-butyl ether	ug/L
Fenamiphos	ug/L
Fenamiphos sulfone	ug/L
Fenamiphos sulfoxide	ug/L
Fenitrothion	ug/L
Fenthion	ug/L
Fenthion sulfoxide	ug/L
Fenuron	ug/L
Flumetralin	ug/L
Flumetsulam	ug/L
Fluometuron	ug/L
Fluoride	mg/L
Folpet	ug/L
Fonofos	ug/L
Glyphosate	ug/L
Hardness	mg/L
Heptachlor	ug/L
Heptachlor epoxide	ug/L
Hexachlorobenzene	ug/L
Hexachlorobutadiene	ug/L
Hexachlorocyclopentadiene	ug/L
Hexachloroethane	ug/L
Hexazinone	ug/L
Hydroxide (as CaCO3)	mg/L
Imazalil	ug/L
Imazaquin	ug/L
Imazethapyr	ug/L
Imidacloprid	ug/L
Imidan	ug/L
Inuron	ug/L

Analyte	Units
Iodide	mg/L
Iodomethane	ug/L
Iprodione	ug/L
Iron	ug/L
Isobutyl methyl ketone	ug/L
Isofenphos	ug/L
Isopropylbenzene	ug/L
Lead	ug/L
Lindane	ug/L
Linuron	ug/L
Lithium	ug/L
Magnesium	mg/L
Malaoxon	ug/L
Malathion	ug/L
Manganese	ug/L
MCPA	ug/L
MCPB	ug/L
Mercury	ug/L
Metalaxyl	ug/L
Metalochlor	ug/L
Methacrylonitrile	ug/L
Methamidophos	ug/L
Methidathion	ug/L
Methiocarb	ug/L
Methomyl	ug/L
Methoxychlor	ug/L
Methyl acrylate	ug/L
Methyl cis-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane-1-carboxylate	ug/L
Methyl methacrylate	ug/L
Methyl paraoxon	ug/L
Methyl parathion	ug/L
Methyl tert-butyl ether	ug/L
Methyl tert-pentyl ether	ug/L
Methyl trans-3-(2,2-dichlorovinyl)-2,2-dimethylcyclopropane-1-carboxylate	ug/L
Methylene blue active substances	mg/L
Methylene chloride	ug/L
Metribuzin	ug/L
Metsulfuron	ug/L
Mevinphos	ug/L
Molinate	ug/L
Molybdenum	ug/L
Monuron	ug/L
m-Xylene plus p-xylene	ug/L
Myclobutanil	ug/L
N-(4-Chlorophenyl)-N'-methylurea	ug/L
Naled	ug/L
Naphthalene	ug/L
Napropamide	ug/L
n-Butyl methyl ketone	ug/L
n-Butylbenzene	ug/L

Analyte	Units
Neburon	ug/L
Nickel	ug/L
Nicosulfuron	ug/L
Nitrate as NO3	mg/L
Nitrate as N	mg/L
Nitrite as N	mg/L
Nitrite plus nitrate as N	mg/L
Norflurazon	ug/L
n-Propylbenzene	ug/L
o-Dichlorobenzene	ug/L
Odor	
O-Ethyl-O-methyl-S-propylphosphorothioate	ug/L
O-phenyl phenol	ug/L
Orthophosphate	mg/L
Oryzalin	ug/L
Oxadiazon	ug/L
Oxamyl	ug/L
Oxyfluorfen	ug/L
o-Xylene	ug/L
Paraoxon	ug/L
Parathion	ug/L
Parathion, Ethyl	ug/L
Parathion, Methyl	ug/L
Pebulate	ug/L
Pendimethalin	ug/L
Pentachloronitrobenzene	ug/L
Pentachlorophenol	ug/L
Permethrin	ug/L
Perthane	ug/L
pH	pH units
Pheophytin	ug/L
Phorate	ug/L
Phosalone	ug/L
Phosmet	ug/L
Phosphamidon	ug/L
Phosphorus	mg/L
Phostebupirim	ug/L
Picloram	ug/L
Pirimiphos Methyl	ug/L
p-Isopropyltoluene	ug/L
Potassium	mg/L
Profenofos	ug/L
Profluralin	ug/L
Prometon	ug/L
Prometryn	ug/L
Pronamide	ug/L
Propachlor	ug/L
Propanil	ug/L
Propargite	ug/L
Propetamphos	ug/L

Analyte	Units
Propham	ug/L
Propiconazole	ug/L
Propoxur	ug/L
Pymetrazine	ug/L
Radon-222	pCi/L
Ronnel	ug/L
s,s,s-Tributyl Phosphorotrithioate	ug/L
sec-Butylbenzene	ug/L
Selenium	ug/L
Siduron	ug/L
Silica	mg/L
Silicon Dioxide	mg/L
Silver	ug/L
Silvex	ug/L
Simazine	ug/L
Sodium adsorption ratio	
Sodium	mg/L
Specific conductance	umhos/cm
Strontium	ug/L
Styrene	ug/L
Sulfate	mg/L
Sulfide	mg/L
Sulfometuron	ug/L
Sulfotepp	ug/L
Sulprofos	ug/L
Tebuthiuron	ug/L
Tefluthrin	ug/L
Temephos	ug/L
Temperature	C
Terbacil	ug/L
Terbufos	ug/L
Terbuthylazine	ug/L
tert-amyl methyl ether	ug/L
tert-Butanol	ug/L
tert-Butyl ethyl ether	ug/L
tert-Butylbenzene	ug/L
Tetrachloroethene	ug/L
Tetrachloroethylene	ug/L
Tetrachloromethane	ug/L
Tetrachlorovinphos	ug/L
Tetradifon	ug/L
Tetrahydrofuran	ug/L
Thallium	ug/L
Thiabendazole	ug/L
Thiobencarb	ug/L
Thionazin	ug/L
Toluene	ug/L
Total Dissolved Solids	mg/L
Toxaphene	ug/L
trans-1,2-Dichloroethene	ug/L

Analyte	Units
trans-1,2-Dichloroethylene	ug/L
trans-1,3-Dichloropropene	ug/L
trans-1,4-Dichloro-2-butene	ug/L
trans-Propiconazole	ug/L
Triallate	ug/L
Tribenuron	ug/L
Tribromomethane	ug/L
Tribuphos	ug/L
Trichloroethene	ug/L
Trichloroethylene	ug/L
Trichlorofluoromethane	ug/L
Trichloromethane	ug/L
Triclopyr	ug/L
Tridimefon	ug/L
Trifluralin	ug/L
Tritium	pCi/L
Turbidity	NTU
Uranium	ug/L
Vanadium	ug/L
Vegadex	ug/L
Vinclozolin	ug/L
Vinyl acetate	ug/L
Vinyl chloride	ug/L
Xylenes	ug/L
z-Dimethomorph	ug/L
Zinc	ug/L

Appendix D

Selection of Pesticide Analytical Suites

Appendix D
Selection of Pesticide Analytical Suites

Pesticide monitoring, on a limited basis, was included as part of the baseline sampling program. The planned program was preliminarily described during the October 2003 AB 303 Committee meeting (and again during the November 2003 meeting) as one of the activities of interest to better understand whether agrichemicals have influenced groundwater quality conditions in Yolo County. Pesticide sampling was recommended for a representative subset of the baseline sampling network. Specifically, twelve wells located in agricultural areas of the County were selected for pesticide sampling.

Additional data evaluation was necessary to select those pesticides that have had a relatively high usage in the County and that have also been identified by the Department of Pesticide Regulation (DPR) as having the chemical and physical characteristics that result in the potential for persistence in the subsurface and also the potential to leach to groundwater (these pesticides are on DPR's Groundwater Protection List). Although not described in the original scope, in order to conduct this pre-screening assessment, and determine which pesticide analytical methods would be most useful for evaluating regional groundwater quality conditions, pesticide usage data for Yolo County were collected from DPR. The 126 pesticides listed by DPR as having been used in Yolo County between 1990 and 2002 were compared to DPR's Groundwater Protection Lists to prioritize those constituents that may be persistent in groundwater in Yolo County. Through this pre-screening process, the compounds of interest were narrowed; as a result, five analytical methods were recommended.

Table D-1 prioritizes the 126 pesticides recorded by DPR by amount applied to the ground (in pounds) in Yolo County from 1990 to 2002. Also reported is the potential of each chemical to contaminate groundwater as defined by its inclusion on one of three lists: the Groundwater Protection List* 6800a, 6800b, or the DPR Status Report. The Groundwater Protection List (6800a) identifies pesticides that have been detected in groundwater in California. The Groundwater Protection List (6800b) identifies chemicals that have a potential to pollute groundwater based on two criteria: 1) six physiochemical characteristics and 2) an application method that promotes leaching to groundwater. The six physiochemical characteristics include: water solubility, soil adsorption coefficient (Koc), hydrolysis half-life, aerobic and anaerobic soil metabolism half-lives, and field dissipation half-life. The DPR has a third list of chemicals with a potential to pollute groundwater that is based only on favorable physiochemical characteristics; the application method for these chemicals has not been evaluated. These are listed in *2001 Status Report, Pesticide Contamination Prevention Act* (Schuette, 2001, California Department of Pesticide Regulation). Of the 126 chemicals applied in Yolo County between 1990 and 2002, seven are on the Groundwater Protection List 6800a, 58 are on the Groundwater Protection List 6800b, and 61 are listed in the DPR Status Report.

* California Code of Regulations, Title 3. Food and Agriculture Section, Division 6. Pesticides and Pest Control Operations, Chapter 4. Environmental Protection, Subchapter 1. Groundwater, Article 1. Pesticide Contamination Prevention, Section 6800.

DPR continuously updates the list of potential groundwater contaminates; this information should be considered prior to the next groundwater-sampling event when pesticides are tested. Pesticide degradation products may also be a future interest for testing pending detection of pesticides in Yolo County and/or new information developed by DPR.

Table D.1
Chemicals Applied in Yolo County (1990-2002) by Decreasing Total Weight and Potential for Contaminating Groundwater

Chemical Name	Total lbs used in Yolo County, 1990-2002*	EPA Method	Classification	Potential for Contaminating Groundwater
GLYPHOSATE, ISOPROPYLAMINE SALT	1,269,816			c
MOLINATE	567,303	EPA 8141	Organophosphate and organonitrogen pesticides	b
THIOBENCARB	549,156			c
CHLOROTHALONIL	403,987	EPA 8081A	Organochlorine pesticides	b
2,4-D, DIMETHYLAMINE SALT	371,920	EPA 8151A	phenoxy acid herbicides	b
PEBULATE	364,983			b
MCPA, DIMETHYLAMINE SALT	298,142			c
DIURON	292,356	EPA 632	phenyl urea herbicides	a
PROPANIL	288,783			c
NAPROPAMIDE	256,526			b
EPTC	219,891			b
CARBARYL	209,527	EPA 8318	carbamate pesticides	b
PARAQUAT DICHLORIDE	198,236			c
DIAZINON	177,004			b
DIMETHOATE	167,909			b
MALATHION	161,217			c
METHAMIDOPHOS	130,321			c
METHOMYL	118,642			b
HEXAZINONE	96,643			b
METRIBUZIN	85,348			b
AZINPHOS METHYL	80,521			b
ORYZALIN	76,172			b
SIMAZINE	69,247			a
METALOCHLOR	59,480			b
ALACHLOR	59,161			b
METALAXYL	56,393			b
GLYPHOSATE-TRIMESIUM	55,906			c
ALDICARB	55,001			b
CARBOFURAN	54,328			b
4(2,4-DB), DIMETHYLAMINE SALT	53,315			c
DIFENZOQUAT METHYL SULFATE	38,345			c
IPRODIONE	35,491			b
DICAMBA, DIMETHYLAMINE SALT	35,153			c
CYCLOATE	28,359			b
METHIDATHION	28,137			c
TRICLOPYR, TRIETHYLAMINE SALT	27,024			c
FOSETYL-AL	24,093			b
ACROLEIN	23,463			b
SETHOXYDIM	22,790			c
DIETHATYL-ETHYL	20,362			b
NORFLURAZON	16,738			a
FONOFOS	16,224			b

Chemical Name	Total lbs used in Yolo County, 1990-2002*	EPA Method	Classification	Potential for Contaminating Groundwater
MSMA	16,174			c
PHORATE	14,751			b
TRICLOPYR, BUTOXYETHYL ESTER	13,788			c
CYANAZINE	13,696			b
CHLOROPICRIN	13,144			b
DICHLOBENIL	12,989			b
ACEPHATE	12,903			b
DISULFOTON	11,955			b
AZOXYSTROBIN	10,053			c
ATRAZINE	9,926			a
METHYL PARATHION	9,922			c
IMIDACLOPRID	9,035			b
OXYDEMETON-METHYL	8,133			b
2,4-D	8,100			c
THIOPHANATE-METHYL	8,000			c
CYPRODINIL	7,574			c
PARATHION	7,133			b
2,4-D, BUTOXYETHANOL ESTER	7,066			c
DIQUAT DIBROMIDE	7,004			b
TRIADIMEFON	5,701			c
BROMACIL	5,600			a
PIPERONYL BUTOXIDE	5,127			c
ETHOFUMESATE	4,575			b
TRIFLUMIZOLE	4,379			b
TEBUFENOZIDE	3,262			c
DICLORAN	3,260			b
FENAMIPHOS	3,014			b
ENDOTHALL, DIPOTASSIUM SALT	3,013			c
MCPP, POTASSIUM SALT	2,502			c
BENSULIDE	2,454			b
PYRIDATE	1,992			c
PHENMEDIPHAM	1,755			c
FENARIMOL	1,683			c
PROPICONAZOLE	1,515			c
FORMETANATE HYDROCHLORIDE	1,305			c
TEBUCONAZOLE	1,157			c
SULFOMETURON METHYL	1,145			b
PYRAZON	1,108			b
IMAZETHAPYR	1,035			b
MCPP, DIMETHYLAMINE SALT	998			c
PROFENOFOS	998			c
PROPYZAMIDE	972			b
MEPIQUAT CHLORIDE	819			c
LINURON	733			b
NITRAPYRIN	650			b
TEBUTHIURON	624			b
METALDEHYDE	595			b
BUTYLATE	586			b
FENHEXAMID	568			c
CLETHODIM	557			c
RIMSULFURON	507			b
CACODYLIC ACID	457			c
ISOXABEN	386			b
NAPTALAM, SODIUM SALT	365			b

Chemical Name	Total lbs used in Yolo County, 1990-2002*	EPA Method	Classification	Potential for Contaminating Groundwater
HALOSULFURON	311			c
CHLORSULFURON	286			b
VINCLOZOLIN	282			b
FIPRONIL	225			c
PYRITHIOBAC-SODIUM	201			c
BENTAZON, SODIUM SALT	195			a
DITHIOPYR	194			c
FLUAZIFOP-BUTYL	182			c
FENTHION	144			c
KRESOXIM-METHYL	138			c
FLUTOLANIL	130			c
THIAZOPYR	123			c
FENOXYCARB	117			c
NICOSULFURON	111			c
PYMETROZINE	95			c
DODINE	82			c
TRINEXAPAC-ETHYL	79			c
GLUFOSINATE-AMMONIUM	26			c
PROMETON	23			a
ETHOPROP	18			b
DICAMBA	15			c
METHIOCARB	10			b
TRIFLUSULFURON-METHYL	9			c
CYROMAZINE	7			c
PIPERALIN	3			c
DSMA	1			c
METHYL ISOTHIOCYANATE	1			b
METHYL ISOTHIOCYANATE	1			b
SIDURON	0			c
UNICONIZOLE-P	0			c

* Reported by DPR

a - Groundwater Protection List 6800a (chemicals found in groundwater in California)

b - Groundwater Protection List 6800b (chemicals with properties that result in the potential to be persistent in groundwater and also the application procedure that promotes leaching to groundwater)

c - Listed by DPR in the 2002 status report as having chemical properties to be persistent in groundwater but the label has not been reviewed for the application process

Appendix E

Sampling Protocol

Appendix E
Sampling Protocol

PURPOSE

The following protocol for collecting groundwater samples has been established to ensure samples are representative of the particular zone being sampled and that samples from different locations are being collected using the same methods. This document describes procedures for measuring water levels, the well purging method, sample collection, sample handling, and the laboratory analyses. Sampling events conducted in accordance with the following procedures will help to ensure consistent collection of representative samples and will minimize the introduction of sampling factors that can skew laboratory analytical results and also the interpretations of the sampling data. This protocol covers community, domestic, and monitoring wells.

WATER LEVEL MEASUREMENTS

Static water level (SWL) measurements in conjunction with well construction details are used to determine the volume of water in the well (casing volume).

Water levels are to be obtained using a measuring device capable of measuring water levels to the nearest 0.01 foot. Measurements shall be made from a stable, permanent reference point, such as the top of the well casing (TOC) and recorded. If the reference point is not at the level of the ground surface, the distance to ground surface will be measured and noted.

PURGING AND WATER PARAMETER MEASUREMENTS

Prior to sample collection, it is necessary to purge the well of water stored in the casing, this will ensure that samples collected are from the targeted formation. Two different methods, three casing volumes or field parameter stabilization can be used to determine the amount of water required to be purged from the well.

The first method is to calculate the volume of water in the casing and pump three times that volume before sampling.

The second and preferred method involves measuring field parameters of the water until values stabilize. Typically, three indicator parameters are measured: these include specific conductance (EC), pH, and temperature. Stabilization occurs when three consecutive measurements at five-minute increments do not vary by more than five percent for each of the indicators. To measure field parameters, approximately 0.5 liter of discharge water is collected in a beaker to allow for measurement with portable field instrument(s). All instruments used shall be calibrated daily according to manufactures' specifications. All measurements shall be recorded on a field data sheet. Other measurements or observations (turbidity, odor, gas production, volume of water purged, pumping rate) shall also be recorded.

SAMPLE COLLECTION AND HANDLING

Water samples may be collected after purging. Samples are to be collected at low flow rates (<0.10 gpm). Samples may be collected using a portable submersible pump or from dedicated pumping equipment. If a portable pump is used, the pump and associated sample tubing must be either decontaminated or new sampling tubing installed between sampling events. If the well is equipped with dedicated pumping equipment, it may be necessary to install a sample tap to collect samples. The sample tap should be equipped with a valve to control flow. Prior to sample collection, the sample tubing or tap shall be flushed.

Sample container labels and Chain of Custody-Request for Analysis forms shall be filled out completely, specifying the analyses to be performed. Care should be taken during sample collection to ensure that neither the container nor sample becomes contaminated. After collection, samples will be stored in a cooler on ice and delivered to the laboratory as soon as possible.

LABORATORY ANALYSES

The District's groundwater quality monitoring program is summarized in Chapter 6. Table E.1 summarizes the recommended analyses, methods of analysis, typical reporting limits, sampling hold times, and preservatives.

Table E.1
Recommended Analyte and Method Information

	Analyte or Analysis	Method	Hold Time	Reporting Limit	Units	Preservative
Field Parameters	Specific Conductance (EC)	field meter				
	Temperature	field meter				
	Dissolved Oxygen	field meter				
	pH	field meter				
	Turbidity	field meter				
	Redox	field meter				
General Minerals and Inorganic Chemicals	Specific Conductance (EC)	EPA 120.1	ASAP (24 hrs)	10	umhos/cm	4º C
	pH	EPA 150.1	ASAP (24 hrs)	0.01	pH units	
	Alkalinity	SM 2320B	14 days	5	mg/L	
	Chloride	EPA 300.0	28 days	100	mg/L	
	Sulfate	EPA 300.0	28 days	100	mg/L	
	Fluoride	EPA 340.2	28 days	0.1	mg/L	
	TDS	EPA 160.1	7 days	1	mg/L	
	MBAS	EPA 425.1	48 hours	0.1	mg/L	
	Nitrate	EPA 300.0		1	mg/L	
	Nitrite	EPA 300.0		0.1	mg/L	
	Ion Balance	calculation	N/A			
	hardness	EPA 130.2	180 days	2	mg/L	
Metals	Al, Ba, Cd, Ca, Cr, Cu, Fe, Pb, Mg, Mn, K, Se, Ag, Na, Zn	EPA 6010B/200.7	180 days	range .00500-1	mg/L	HNO3
	Arsenic	EPA 6020	180 days	0.001	mg/L	
	Hg	EPA 7470A	28 days	0.0005	mg/L	
	Boron	EPA 6010B	180 days	0.02	mg/L	
	Hexavalent Chromium-Low Level	EPA 7199	24 hours	1	ug/L	4º C
Volatile Organics	Volatile Organic Compounds- Full List	524.2	14 days	varies but all <0.5	ug/L	HCl
Pesticides	Organophosphate and organonitrogen pesticides (simazine, atrazine, diazinon)	8141	7 days	varies	ug/L	4º C
	Organochlorine pesticides (metalochlor, alachlor)	8081A	7 days	varies	ug/L	
	Phenoxy acid herbicides (2,4-D, Dimethylamine salt)	8151A	7 days	varies	ug/L	
	phenyl urea herbicides (Diuron)	632	7 days	varies	ug/L	
	carbamate pesticides (carbaryl, methomyl)	8318	7 days	varies	ug/L	

Appendix F

Summary of Water Quality Data – January 2000 to March 2004
All Subbasins

Appendix F
Summary of Water Quality Data - January 2000 to March 2004
Buckeye/Zamora Subbasin

Analyte	Limit	Units	Shallow Zone					Intermediate Zone					Deep Zone					Multiple Zones				
			No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects
Alkalinity	N/A	mg/L	3	10	180-266	208.9	10															
Aluminum	1000(1)/200(3)	ug/L	1	7	73-1300	674.7	7											1	1	<50		
Arsenic	10(1)	ug/L	1	7	<2-<5													1	1	<2		
Barium	1000(3)	ug/L	1	7	110-150	128.6	7											1	1	110	110.0	1
Boron	1000(2)	ug/L	2	3	1300-1500	1366.7	3															
Cadmium	5(3)	ug/L	1	10	<1-38	34.4	7											1	1	<1		
Calcium	N/A	mg/L	3	10	32-42	35.4	10															
Chloride	250/500(4)	mg/L	3	17	13-37	18.2	17															
Chromium (Hexavalent)	N/A	ug/L																				
Chromium (Total)	50(3)	ug/L	1	7	<10-30	23.5	4											1	1	<10		
Copper	1000(4)	ug/L	1	7	<10-29	29.0	1															
Flouride	2(3)	mg/L	1	7	0.16-0.39	0.2	7											1	1	0.12	0.1	1
Hardness	N/A	mg/L	3	17	140-241	194.6	17															
Iron	300(4)	ug/L	1	7	140-2100	1032.9	7															
Lead	15(2)	ug/L	1	7	<5-22	14.3	3											1	1	<5		
Magnesium	N/A	mg/L	3	17	24-33	26.0	17															
Manganese	500(2)/50(4)	ug/L	1	7	<10-110	65.8	6															
Mercury	2(3)	ug/L	1	7	<0.2-<1													1	1	<1		
Nitrate as NO3	45(3)	mg/L	5	25	<0.1-48	15.9	20											1	1	11	11.0	1
pH	6.5/8.5(5)	pH units	3	10	7.3-8.2	7.7	10															
Potassium	N/A	mg/L	3	10	1-3	1.7	10															
Selenium	50(3)	ug/L	1	7	<5													1	1	<5		
Silver	100(4)	ug/L	1	1	<10													1	1	<10		
Sodium	N/A	mg/L	3	17	29-43	34.6	17															
Specific Conductance (EC)	900/1600(4)	umhos/cm	3	10	400-666	478.9	10															
Sulfate	250/500(4)	mg/L	5	20	5-54	18.6	20															
Surfactants	N/A	mg/L																				
Total Dissolved Solids	500/1000(4)	mg/L	3	17	250-379	283.1	17															
Zinc	5000(4)	ug/L	1	7	<20-32	26.0	2															

1. Federal MCL, State to be determined
2. Action Level
3. State Primary MCL
4. Secondary MCL (recommended/upper)
5. Suggested Range

Appendix F
Summary of Water Quality Data - January 2000 to March 2004
Capay Valley Subbasin

Analyte	Limit	Units	Shallow Zone					Intermediate Zone					Deep Zone					Multiple Zones				
			No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects
Alkalinity	N/A	mg/L	13	16	170-430	294.6	16	1	1	180	180.0	1										
Aluminum	1000(1)/200(3)	ug/L	6	6	<50-105	85.4	2	1	1	65.2	65.2	1										
Arsenic	10(1)	ug/L	12	15	<15			1	1	<15								1	1	ND		
Barium	1000(3)	ug/L	6	6	39-1280	322.5	6	1	1	84.9	84.9	1						1	1	92	92.0	1
Boron	1000(2)	ug/L	7	7	392-9490	2305.0	7	1	1	715	715.0	1										
Cadmium	5(3)	ug/L	12	15	<5			1	1	<5								1	1	ND		
Calcium	N/A	mg/L	13	16	49-170	72.3	16	1	1	44.2	44.2	1										
Chloride	250/500(4)	mg/L	13	16	22-1900	209.7	16	1	1	37	37.0	1										
Chromium (Hexavalent)	N/A	ug/L	6	6	<1-3.6	3.6	1	1	1	3.6	3.6	1										
Chromium (Total)	50(3)	ug/L	12	15	<5-190	82.0	3	1	1	7.34	7.3	1						1	1	8.3	8.3	1
Copper	1000(4)	ug/L	12	15	<5-30	13.8	7	1	1	<5												
Flouride	2(3)	mg/L	12	15	<0.1-0.94	0.5	14	1	1	0.17	0.2	1						1	1	0.18	0.2	1
Hardness	N/A	mg/L	13	16	250-750	328.0	16	1	1	170	170.0	1										
Iron	300(4)	ug/L	6	6	<100-541	370.3	4	1	1	395	395.0	1										
Lead	15(2)	ug/L	12	15	<10-17	12.0	2	1	1	<10												
Magnesium	N/A	mg/L	13	16	20-78	37.3	16	1	1	17.8	17.8	1										
Manganese	500(2)/50(4)	ug/L	6	6	<5-1700	854.6	2	1	1	21.9	21.9	1										
Mercury	2(3)	ug/L	12	15	<0.5-0.6	0.6	1	1	1	<0.5												
Nitrate as NO3	45(3)	mg/L	13	16	<0.1-39	15.9	14	1	1	11.96	12.0	1										
pH	6.5/8.5(5)	pH units	13	16	6.99-7.68	7.4	16	1	1	7.33	7.3	1										
Potassium	N/A	mg/L	13	16	<0.5-9	3.1	14	1	1	1.16	1.2	1										
Selenium	50(3)	ug/L	12	15	<15-11	9.0	2	1	1	<15												
Silver	100(4)	ug/L	12	12	<5			1	1	<5												
Sodium	N/A	mg/L	13	16	18-1270	153.5	16	1	1	53.6	53.6	1										
Specific Conductance (EC)	900/1600(4)	umhos/cm	13	16	330-6100	1223.2	16	1	1	580	580.0	1										
Sulfate	250/500(4)	mg/L	13	16	2.3-470	67.8	16	1	1	47	47.0	1										
Surfactants	N/A	mg/L	12	15	<0.1			1	1	<0.1												
Total Dissolved Solids	500/1000(4)	mg/L	13	16	340-3200	756.4	16	1	1	350	350.0	1										
Zinc	5000(4)	ug/L	12	15	<10-530	115.5	7	1	1	17.7	17.7	1										

1. Federal MCL, State to be determined
2. Action Level
3. State Primary MCL
4. Secondary MCL (recommended/upper)
5. Suggested Range

Appendix F
Summary of Water Quality Data - January 2000 to March 2004
Dunnigan Hills Subbasin

Analyte	Limit	Units	Shallow Zone					Intermediate Zone					Deep Zone					Multiple Zones				
			No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects
Alkalinity	N/A	mg/L						1	2	151-275	213.0	2										
Boron	1000(2)	ug/L						1	2	400-1200	800.0	2										
Calcium	N/A	mg/L						1	2	13-17	15.0	2										
Chloride	250/500(4)	mg/L						1	2	10-13	11.5	2										
Hardness	N/A	mg/L						1	2	78-104	91.0	2										
Magnesium	N/A	mg/L						1	2	11-15	13.0	2										
Nitrate as NO3	45(3)	mg/L						1	2	0.6-13.4	7.0	2										
pH	6.5/8.5(5)	pH units						1	2	7.8-8.3	8.1	2										
Potassium	N/A	mg/L						1	2	0.9-1.2	1.1	2										
Sodium	N/A	mg/L						1	2	38-101	69.5	2										
Specific Conductance (EC)	900/1600(4)	umhos/cm						1	2	363-590	476.5	2										
Sulfate	250/500(4)	mg/L						1	2	12-27	19.5	2										
Total Dissolved Solids	500/1000(4)	mg/L						1	2	213-355	284.0	2										

1. Federal MCL, State to be determined
2. Action Level
3. State Primary MCL
4. Secondary MCL (recommended/upper)
5. Suggested Range

Appendix F
Summary of Water Quality Data - January 2000 to March 2004
Lower Cache-Putah Subbasin

Analyte	Limit	Units	Shallow Zone					Intermediate Zone					Deep Zone					Multiple Zones				
			No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects
Alkalinity	N/A	mg/L	6	8	340-620	500.0	8	21	55	226-810	400.5	55	8	28	170-376	242.7	28	21	32	300-930	477.9	32
Aluminum	1000(1)/200(3)	ug/L	6	6	<50-304	226.5	2	21	85	<50-960	345.9	5	8	35	<50-190	135.0	2	24	44	<50-2300	441.3	6
Arsenic	10(1)	ug/L	6	6	<15			20	56	<2-6.4	4.3	47	8	27	1.6-10	5.0	27	24	37	<2-6.1	3.3	25
Barium	1000(3)	ug/L	6	6	64.2-307	202.2	6	21	58	<10-400	153.9	45	8	30	<50-151	91.0	12	24	36	<10-310	202.6	34
Boron	1000(2)	ug/L	6	8	700-3440	1611.3	8	23	88	500-3200	1101.0	88	8	40	550-1000	732.6	40	24	75	600-7420	1575.4	75
Cadmium	5(3)	ug/L	6	6	<5			20	86	<1-<5			8	35	<1			24	45	<1-<5		
Calcium	N/A	mg/L	6	8	54-104	75.9	8	21	55	19-85	42.7	55	8	28	11-36.9	20.7	28	21	32	34-94	55.4	32
Chloride	250/500(4)	mg/L	6	8	42-180	116.9	8	21	55	<1-190	63.1	53	8	28	13-43	26.0	28	22	33	13-220	68.4	33
Chromium (Hexavalent)	N/A	ug/L	6	6	7.3-50	17.4	6	21	96	<1-41	19.6	91	9	19	<1-24	8.2	16	24	58	<1-54	21.7	57
Chromium (Total)	50(3)	ug/L	6	6	<5-46.2	24.0	5	21	136	<5-59	24.5	129	9	36	<1-31	10.9	26	24	64	<5-71	33.1	62
Copper	1000(4)	ug/L	6	6	<5-128	46.8	3	21	83	<5-490	191.7	8	8	37	<50-430	118.0	5	24	41	<5-130	28.5	9
Flouride	2(3)	mg/L	6	6	<0.1-0.43	0.3	5	20	62	<0.1-0.5	0.3	41	8	30	<0.1-0.2	0.1	10	22	35	<0.1-0.45	0.3	23
Hardness	N/A	mg/L	6	8	350-960	624.8	8	21	55	157-720	421.4	55	8	28	59-322	145.5	28	21	32	350-790	479.2	32
Iron	300(4)	ug/L	6	6	<100-1510	1002.0	2	21	88	<50-1500	370.8	9	8	35	<50-700	257.8	16	24	44	<1-3000	446.2	11
Lead	15(2)	ug/L	6	6	<10			20	86	<5-<10			8	35	<5-8	5.2	2	24	45	<5-1.51	1.5	1
Magnesium	N/A	mg/L	6	8	50.9-183	109.8	8	21	55	26-130	76.6	55	8	28	7.6-55.8	22.8	28	21	32	49-150	81.8	32
Manganese	500(2)/50(4)	ug/L	6	6	<5-34.1	20.7	2	21	84	<5-150	40.9	13	8	32	<10-210	32.7	20	24	42	<5-181	133.7	3
Mercury	2(3)	ug/L	6	6	<0.5			21	87	<0.4-<1			8	36	<0.4-<1			24	45	<0.4-<1		
Nitrate as NO3	45(3)	mg/L	8	18	21.26-66.45	43.5	18	24	208	<0.1-41	19.1	204	9	41	<1-12.2	3.2	24	24	161	<0.1-105	27.0	159
pH	6.5/8.5(5)	pH units	6	8	7.27-8	7.5	8	21	55	7.5-8.3	7.9	55	8	28	7.8-8.4	8.1	28	22	33	7.41-8.29	7.8	33
Potassium	N/A	mg/L	6	8	0.548-3	1.8	8	21	60	<0.5-3	1.7	28	8	29	<2-3	2.1	20	21	33	<0.5-3	1.6	26
Selenium	50(3)	ug/L	6	6	<15-57.7	39.4	2	20	129	<1-62	13.6	116	9	44	<0.5-4	2.0	18	24	58	<15-91.3	17.7	45
Silver	100(4)	ug/L	6	6	<5			21	87	<5-<10			8	36	<10			24	43	<5-<10		
Sodium	N/A	mg/L	6	8	47.6-132	100.3	8	21	55	54-230	87.0	55	8	28	45-100	83.2	28	21	32	53-540	111.5	32
Specific Conductance (EC)	900/1600(4)	umhos/cm	6	8	860-2000	1468.8	8	23	87	608-1700	1038.5	87	8	39	450-940	591.6	39	24	68	760-2400	1063.4	68
Sulfate	250/500(4)	mg/L	7	10	27-300	129.6	10	22	57	26-310	77.3	57	8	28	23-63	41.1	28	22	33	30.8-200	66.4	33
Surfactants	N/A	mg/L	6	6	<0.1			19	85	<0.05-<500			8	36	<0.05-50	50.0	1	17	36	<0.05-0.17	0.2	1
Total Dissolved Solids	500/1000(4)	mg/L	6	8	430-1300	898.8	8	23	78	342-1100	605.6	78	8	28	280-656	365.7	28	24	88	390-1500	600.0	88
Zinc	5000(4)	ug/L	6	6	<10-190	80.2	4	21	85	<10-100	47.7	6	8	36	<50-96	52.8	4	24	42	<10-90	24.7	9

1. Federal MCL, State to be determined
2. Action Level
3. State Primary MCL
4. Secondary MCL (recommended/upper)
5. Suggested Range

Appendix F
Summary of Water Quality Data - January 2000 to March 2004
Northern Sacramento River Subbasin

Analyte	Limit	Units	Shallow Zone					Intermediate Zone					Deep Zone					Multiple Zones				
			No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects
Alkalinity	N/A	mg/L						1	2	213-221	217.0	2						1	1	738	738.0	1
Aluminum	1000(1)/200(3)	ug/L																1	1	90	90.0	1
Arsenic	10(1)	ug/L																1	1	4.2	4.2	1
Barium	1000(3)	ug/L																1	1	260	260.0	1
Boron	1000(2)	ug/L						1	2	700	700.0	2						1	1	6620	6620.0	1
Cadmium	5(3)	ug/L																1	1	<1		
Calcium	N/A	mg/L						1	2	22	22.0	2						1	1	69	69.0	1
Chloride	250/500(4)	mg/L						1	2	20-21	20.5	2						1	1	150	150.0	1
Chromium (Total)	50(3)	ug/L																1	1	<1		
Copper	1000(4)	ug/L																1	1	<50		
Flouride	2(3)	mg/L																1	1	0.23	0.2	1
Hardness	N/A	mg/L						1	2	133-137	135.0	2						1	1	533	533.0	1
Iron	300(4)	ug/L																1	1	<100		
Magnesium	N/A	mg/L						1	2	19-20	19.5	2						1	1	88	88.0	1
Manganese	500(2)/50(4)	ug/L																1	1	190	190.0	1
Mercury	2(3)	ug/L																1	1	<1		
Nitrate as NO3	45(3)	mg/L						1	2	0.3-0.4	0.4	2						1	2	4.3-8.6	6.5	2
pH	6.5/8.5(5)	pH units						1	2	7.3-8.2	7.8	2						1	1	7.8	7.8	1
Potassium	N/A	mg/L						1	2	2.8-2.9	2.9	2										
Selenium	50(3)	ug/L																1	1	<5		
Silver	100(4)	ug/L																1	1	<10		
Sodium	N/A	mg/L						1	2	49-51	50.0	2						1	1	220	220.0	1
Specific Conductance (EC)	900/1600(4)	umhos/cm						1	2	470-477	473.5	2										
Sulfate	250/500(4)	mg/L						1	2	10	10.0	2						1	1	120	120.0	1
Surfactants	N/A	mg/L																1	1	<0.02		
Total Dissolved Solids	500/1000(4)	mg/L						1	2	287-291	289.0	2						1	1	1100	1100.0	1
Zinc	5000(4)	ug/L																1	1	<50		

1. Federal MCL, State to be determined
2. Action Level
3. State Primary MCL
4. Secondary MCL (recommended/upper)
5. Suggested Range

Appendix F
Summary of Water Quality Data - January 2000 to March 2004
Southern Sacramento River Subbasin

Analyte	Limit	Units	Shallow Zone					Intermediate Zone					Deep Zone					Multiple Zones				
			No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects
Alkalinity	N/A	mg/L	3	4	256-747	492.0	4	3	5	205-470	359.0	5	1	1	191	191.0	1	2	2	219-250	234.5	2
Aluminum	1000(1)/200(3)	ug/L	1	1	139	139.0	1	2	7	<50			1	1	ND			1	1	ND		
Arsenic	10(1)	ug/L	1	1	<15			2	5	<2-3	3.0	2	1	1	5.7	5.7	1	1	1	6	6.0	1
Barium	1000(3)	ug/L	1	1	98	98.0	1	2	5	<10-156	105.3	3	1	1	600	600.0	1	1	1	ND		
Boron	1000(2)	ug/L	4	5	140-1500	1064.0	5	3	7	600-1570	924.3	7						2	2	1700-1800	1750.0	2
Cadmium	5(3)	ug/L	1	1	<5			2	7	<1-<5			1	1	ND			1	1	ND		
Calcium	N/A	mg/L	3	4	37-50.8	42.5	4	3	5	13-63	44.5	5	1	1	73	73.0	1	2	2	16-50	33.0	2
Chloride	250/500(4)	mg/L	3	4	57-222	139.8	4	3	5	43-140	103.6	5	1	1	350	350.0	1	2	2	64-111	87.5	2
Chromium (Hexavalent)	N/A	ug/L	3	3	<1			2	6	<1-11	6.6	5	1	1	ND			1	1	ND		
Chromium (Total)	50(3)	ug/L	1	1	<5			2	8	<2-17	14.2	3	1	1	ND			1	1	2	2.0	1
Copper	1000(4)	ug/L	1	1	12.4	12.4	1	2	6	<5-1300	659.1	2	1	1	ND			1	1	ND		
Flouride	2(3)	mg/L	1	1	0.23	0.2	1	2	4	0.15-0.4	0.3	4	1	1	ND			1	1	<0.2		
Hardness	N/A	mg/L	3	4	174-677	515.5	4	3	5	49-610	407.8	5	1	1	277	277.0	1	2	2	61-273	167.0	2
Iron	300(4)	ug/L	1	1	404	404.0	1	2	7	<50-<100			1	1	530	530.0	1	1	1	ND		
Lead	15(2)	ug/L	1	1	<10			2	7	<5-<10			1	1	ND			1	1	ND		
Magnesium	N/A	mg/L	3	4	18-139	97.0	4	3	5	4-110	72.1	5	1	1	23	23.0	1	2	2	5.2-36	20.6	2
Manganese	500(2)/50(4)	ug/L	1	1	162	162.0	1	2	7	<5-<10			1	1	370	370.0	1	1	1	70	70.0	1
Mercury	2(3)	ug/L	1	1	<0.5			2	7	<0.4-<1			1	1	ND			1	1	ND		
Nitrate as NO3	45(3)	mg/L	7	14	<0.1-135	64.2	5	3	31	<0.1-50	33.8	30	1	1	ND			4	5	<0.1-37	20.6	4
pH	6.5/8.5(5)	pH units	3	4	7.56-8.2	7.8	4	3	5	7.76-8.5	8.0	5	1	1	7.8	7.8	1	2	2	8.1-8.3	8.2	2
Potassium	N/A	mg/L	3	4	1-4.5	2.2	4	3	5	<0.5-2.5	2.0	3	1	1	7.2	7.2	1	2	2	2.1-3	2.6	2
Selenium	50(3)	ug/L	1	1	<15			2	9	<15-22	15.3	8	1	1	ND			1	1	ND		
Silver	100(4)	ug/L	1	1	<5			2	7	<5-<10			1	1	ND			1	1	ND		
Sodium	N/A	mg/L	2	3	120-174	144.0	3	3	5	51.1-147	91.0	5	1	1	160	160.0	1	2	2	70-130	100.0	2
Specific Conductance (EC)	900/1600(4)	umhos/cm	3	4	1200-1750	1462.5	4	3	7	660-1600	1192.4	7	1	1	1400	1400.0	1	2	2	680-840	760.0	2
Sulfate	250/500(4)	mg/L	6	7	<1-200	79.6	5	3	5	4-150	80.6	5	1	1	ND			2	2	33-47	40.0	2
Surfactants	N/A	mg/L	1	1	<0.1			2	7	<0.05-<500			1	1	ND			1	1	<0.05		
Total Dissolved Solids	500/1000(4)	mg/L	3	4	671-1052	862.3	4	3	5	380-940	682.2	5	1	1	790	790.0	1	2	2	430-493	461.5	2
Zinc	5000(4)	ug/L	1	1	53	53.0	1	2	6	<10-51	31.1	2	1	1	ND			1	1	ND		

1. Federal MCL, State to be determined
2. Action Level
3. State Primary MCL
4. Secondary MCL (recommended/upper)
5. Suggested Range

Appendix F
Summary of Water Quality Data - January 2000 to March 2004
Western Yolo Subbasin

Analyte	Limit	Units	Shallow Zone					Intermediate Zone					Deep Zone					Multiple Zones				
			No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects	No. of Wells	No. of Meas.	Range of Values	Avg. Value (Detects)	No. of Detects
Alkalinity	N/A	mg/L	23	127	140-400	249.9	127	3	4	270-322	298.5	4						10	11	180-430	272.8	11
Aluminum	1000(1)/200(3)	ug/L	19	82	<0.05-3360	518.6	19	2	2	<50								9	9	<5-703	393.3	2
Arsenic	10(1)	ug/L	19	82	<2-4	4.0	1	2	2	<15								9	9	<1-<15		
Barium	1000(3)	ug/L	19	82	65.4-400	205.2	82	2	2	84.6-122	103.3	2						9	9	<1-229	149.3	8
Boron	1000(2)	ug/L	12	16	<20-2200	663.3	15	3	4	500-1870	946.5	4						6	7	100-2550	952.6	7
Cadmium	5(3)	ug/L	19	126	<1-82	53.6	74	2	2	<5								9	9	<1-<5		
Calcium	N/A	mg/L	18	56	17-75	47.6	56	3	4	10.5-33.1	22.9	4						10	11	22-52	38.2	11
Chloride	250/500(4)	mg/L	23	126	6-160	52.6	126	3	4	9.6-85	55.7	4						10	11	2.3-120	40.5	11
Chromium (Hexavalent)	N/A	ug/L	8	8	<1-13	8.9	7	2	2	<1								5	5	<1-24	11.0	4
Chromium (Total)	50(3)	ug/L	19	82	<5-31	13.0	28	2	2	<5								9	9	<5-25	17.4	8
Copper	1000(4)	ug/L	19	82	<5-110	32.1	6	2	2	<5								9	9	<5-58	22.9	3
Flouride	2(3)	mg/L	19	82	<0.1-0.5	0.2	56	2	2	0.15-0.28	0.2	2						5	5	0.12-0.52	0.2	5
Hardness	N/A	mg/L	23	126	117-460	281.1	126	3	4	54-334	217.8	4						10	11	160-410	272.7	11
Iron	300(4)	ug/L	19	82	<100-6190	1237.5	17	2	2	<100-4070	4070.0	1						9	9	<40-1880	916.7	3
Lead	15(2)	ug/L	19	82	<5-<10			2	2	<10								5	5	<10		
Magnesium	N/A	mg/L	23	130	18-62	37.5	130	3	4	9.69-66	40.3	4						10	11	17-67	42.5	11
Manganese	500(2)/50(4)	ug/L	19	82	<5-290	116.0	7	2	2	42.5-120	81.3	2						9	9	<3-71.6	42.4	4
Mercury	2(3)	ug/L	19	82	<0.2-<1			2	2	<0.5								9	9	<0.2-<0.5		
Nitrate as NO3	45(3)	mg/L	23	160	<0.1-120	33.1	147	4	6	<0.1-22	21.8	2						9	11	<0.1-33.67	10.4	9
pH	6.5/8.5(5)	pH units	23	90	7-8.2	7.7	90	3	4	7.6-8.2	7.9	4						10	11	7.4-8.1	7.8	11
Potassium	N/A	mg/L	23	90	<0.5-3.4	2.4	88	3	4	0.6-1.57	0.9	4						10	11	<0.5-2.17	1.5	6
Selenium	50(3)	ug/L	19	82	<5-7.8	7.1	3	2	2	<15								9	9	<1-<15		
Silver	100(4)	ug/L	10	10	<5-<10			2	2	<5								9	9	<1-<5		
Sodium	N/A	mg/L	23	130	16-105	52.5	130	3	4	55-140	92.0	4						10	11	17-93.7	44.7	11
Specific Conductance (EC)	900/1600(4)	umhos/cm	23	90	292-1100	713.5	90	3	4	610-900	801.8	4						10	11	410-920	634.6	11
Sulfate	250/500(4)	mg/L	23	125	2-120	36.1	125	3	4	37-67	45.8	4						10	11	14-68	39.0	11
Surfactants	N/A	mg/L	8	8	<0.1			2	2	<0.1								9	9	<0.05-<0.1		
Total Dissolved Solids	500/1000(4)	mg/L	23	159	181-690	448.7	159	4	6	350-580	506.3	6						12	13	250-600	419.2	13
Zinc	5000(4)	ug/L	19	82	<10-353	72.4	10	2	2	23-1080	551.5	2						9	9	<10-107	51.6	5

1. Federal MCL, State to be determined
2. Action Level
3. State Primary MCL
4. Secondary MCL (recommended/upper)
5. Suggested Range