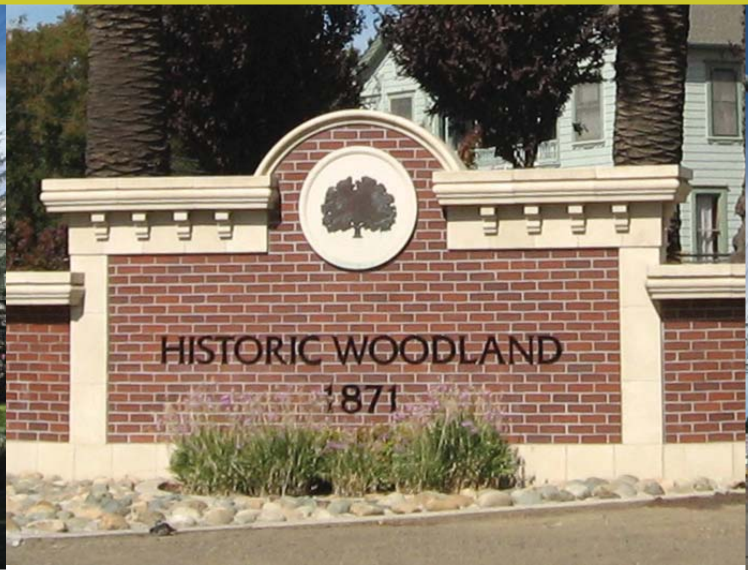
APRIL 2011

City of Woodland

GROUNDWATER MANAGEMENT PLAN

Prepared for
CITY OF WOODLAND

Prepared by
WEST YOST ASSOCIATES



Groundwater Management Plan

Prepared for

City of Woodland

April 15, 2011

WEST YOST
ASSOCIATES
Consulting Engineers

204-00-08-18

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afy	acre-feet per year
ASR	Aquifer Storage Recovery
BMOs	Basin Management Objectives
CEQA	California Environmental Quality Act
CUWA	California Urban Water Agencies
CWC	California Water Code
City	City of Woodland
CORS	Continuously Operating Reference Station
DPH	Department of Public Health
DWR	Department of Water Resources
DWSAP	Drinking Water Source Assessment and Protection Program
DWWSP	Davis-Woodland Water Supply Project
gpm	gallons per minute
GWMP	Groundwater Management Plan
IPCC	Intergovernmental Panel on Climate Change
IRWMP	Integrated Regional Water Management Plan
LSCE	Luhdorff and Scalmanini Consulting Engineers
MCL	Maximum Contaminant Level
msl	mean sea level
my	million years
QA/QC	Quality Assurance and Quality Control
RWMG	Regional Water Management Group
SACOG	Sacramento Area Council of Governments

SBx7-6	Senate Bill 6
SB 1938	Senate Bill No. 1938
SB 7	Senate Bill 7
Sub-basin 5-21.67	Yolo Sub-basin
SWP	State Water Project
SWRCB	State Water Resources Control Board
SWN	state well number
TDS	Total Dissolved Solids
UC Davis	University of California at Davis
UWMP	Urban Water Management Plans
WDCWA	Woodland-Davis Clean Water Agency
WRA	Water Resources Association of Yolo County
WRID	water resource information database
WTP	water treatment plant
YCIGSM	Yolo County Integrated Groundwater Surface Water Model
Yolo County FC&WCD	Yolo County Flood Control and Water Conservation District

The City of Woodland (City) adopted a resolution to prepare this groundwater management plan (GWMP) on June 1, 2010, pursuant to Sections 10750 *et. seq*. of the California Water Code (CWC). The City adopted the GWMP through Ordinance No. 1527 on March 15, 2011. The ordinance became effective 30 days later.

This GWMP was developed in coordination with the other local agencies with adopted plans and other basin stakeholders. This plan will be administered by the City Director of Public Works with consideration of the recommendations of an advisory committee made up of members of the Water Resources Association of Yolo County (WRA) Technical Committee, which includes staff representation from the City of Woodland.

The City intends to work cooperatively with other local agencies to manage water resources in the basin. This GWMP is one of several planning documents that will support the City's efforts. In an effort to better manage groundwater resources, local agencies in the vicinity of the City have adopted and are implementing GWMPs, Urban Water Management Plans (UWMP), and Integrated Regional Water Management Plans (IRWMP). The City is an active agency member of the WRA. The WRA, in cooperation with federal, state, and local agencies, developed an IRWMP intended to identify and describe water supply projects, address flood management, protect water quality, enhance aquatic and riparian habitat, and improve recreational opportunities (WRA, 2007). The writing of the IRWMP led to close collaborative ties between City, County, and State agencies, local water resource agencies, and community organizations. The City is also a member of the Westside Regional Water Management Group (RWMG), which consists of public agencies in Yolo, Solano, Lake, Colusa, and Napa Counties. The Westside RWMG is preparing the Westside IRWMP, which will constitute an integrated Water Management Plan for the Cache and Putah Creek watersheds. The Westside IWRMP is scheduled to be completed in 2016.

Public participation was sought during the development of this plan, and this final version of the GWMP reflects input received from members of the public. Key areas were climate change and plan implementation. Input was sought through the plan's public outreach process. Comments were received in writing, and the City worked with the individual commenters to develop appropriate responses to the comments and revisions to the GWMP. The public comments and City responses are documented in the GWMP.

ES.1 AUTHORITY

The CWC provides the City's authority to adopt this GWMP. The City overlies the Yolo Groundwater Sub-basin and provides water service within its service area. The City is a local agency pursuant to CWC Section 10752 (g). The City is authorized to adopt this GWMP as provided in CWC Section 10753 (a).

ES.2 PURPOSE OF THE GROUNDWATER MANAGEMENT PLAN

The City relies on groundwater to meet the water demands of its customers. The purpose of this GWMP is to:

1. State the City's overall groundwater management goal;
2. Put forth Basin Management Objectives (BMO) applicable to the City service area;
3. Provide a mechanism for the continued collection of baseline groundwater and aquifer information; and
4. Establish management actions, including provisions for updating the plan as conditions change and new information becomes available.

The City is located in the Yolo Sub-basin (Sub-basin 5-21.67) of the Sacramento Valley Groundwater Basin as defined in the California Department of Water Resources (DWR) Bulletin 118 update (DWR, 2003). Figure ES-1 shows the location of the City in relation to the boundaries of other local agencies overlying the groundwater basin. The Yolo Sub-basin is bounded by Cache Creek on the north; the Sacramento River on the east; Putah Creek on the south; and the Coast Range on the west (DWR, 2004). This plan covers the City service area.

ES.3 OVERALL GROUNDWATER MANAGEMENT GOAL

The City's overall groundwater management goal is to work cooperatively with basin stakeholders and the public to maintain a sustainable, reliable, high-quality groundwater supply for beneficial use in the City service area and surrounding areas (Figure ES-2).

ES.4 BASIN MANAGEMENT OBJECTIVES

BMOs were developed to support the City's overall groundwater management goal. BMOs were established to address the following five areas:

- Groundwater quality
- Groundwater elevations
- Inelastic land subsidence
- Adverse impacts to surface water flows and surface water quality due to groundwater pumping
- Adverse impacts to groundwater levels and groundwater quality due to changes in surface water flow or quality

BMO-01 – Protect and maintain groundwater quality within the City service area for the benefit of basin groundwater users. Groundwater within the City's service area is affected by nonpoint sources of nitrate and salts, and localized point sources of anthropogenic contaminants. Naturally occurring contaminants, resulting from dissolution of minerals comprising the aquifer skeleton, also affect groundwater quality. The City's objective is to minimize the impact of these contaminants at the locations of individual municipal wells within its service area, and to support stakeholder efforts to protect beneficial uses in the groundwater sub-basin from adverse impacts to groundwater quality.

The City analyzes groundwater quality samples from its active production wells to comply with applicable standards in Title 22 of the CWC. The Department of Public Health (DPH) Title 22 program specifies the constituents to be tested, the detection limits for these constituents and reporting requirements. Sampling is conducted annually in a subset of the active wells such that each well is sampled on a three-year rotating cycle. Compliance with drinking water standards is a primary objective for the City. The City also uses the groundwater quality results to assess potential impacts to the municipal wastewater treatment plant, which is regulated under a Central Valley Regional Water Quality Control Board Waste Discharge Requirements Order. The primary constituents of concern for the wastewater discharge are selenium, boron and total dissolved solids (TDS). The water quality results will be evaluated on the same annual cycle under which the wells are sampled, such that each well will be evaluated every three years when new sample results are available. Temporal trends in the concentration of each constituent will be evaluated using a three-sample moving average comprised of the three most recent historical sample results for each well. Any increase in the concentration of a constituent of 20 percent or greater relative to the three-sample moving average will trigger evaluation of the need for potential actions, including:

- Consideration of possible agricultural and landscaping best management practices that could help control nitrate, nutrient and salt loading to the groundwater basin
- Additional monitoring, potentially on a more frequent basis
- Operational modifications affecting the pumping schedule and rate
- Well modifications to adjust the depth of pumping or seal zones with inferior water quality
- Well destruction, with possible replacement with a new well
- Replacement with a surface water supply
- Wellhead treatment, if feasible
- Destruction of abandoned wells

BMO-02 – Maintain groundwater elevations that result in a net benefit to basin groundwater users. Groundwater in the Yolo Sub-basin is used for municipal, domestic and agricultural supply. The City recognizes the need to support all of these uses. The City's objective is to work cooperatively with stakeholders to maintain groundwater levels at elevations that economically meet the City's municipal supply needs within its service area, and stakeholder needs for irrigation, domestic and industrial supply in surrounding areas of the sub-basin.

The City measures static water levels in its production wells on a monthly basis and uses the information to assess trends in groundwater levels. Historical data are available from 1976 through the present. This record encompasses significant variations in hydrology, including the 1976-1977, 1988-1992 and 2007-2009 droughts. Reductions in groundwater levels affect well capacity. Typically, the July-August timeframe is the most critical time of year because groundwater levels are near their annual minimum, and demands are near their maximum. Under dry conditions, the July and August groundwater levels could decline to a degree that potentially affects the City's well capacity. The monthly static groundwater levels will be compared to historical results to assess the potential need for management actions. Emphasis will be placed on evaluating April through June static groundwater levels, because groundwater levels typically reach their maximum in April. Significant reductions in April through June static groundwater levels may indicate the need for actions to mitigate reductions in well capacity caused by very low groundwater levels in July and August. Historically low groundwater levels occurred in 1977 and 1991. The lowest recorded measurements for the months of April through June occurred in 1977. The need for potential actions will be considered when April through June groundwater levels decline to levels that are within 25 percent of the April through June 1977 groundwater levels. Potential actions include:

- Outreach to encourage conservation
- Operational modifications to reduce reliance on wells most affected by groundwater level declines
- Construction of additional wells
- Use of surface water supplies

BMO-03 – Minimize the risk of future significant impact due to inelastic land subsidence. Inelastic land subsidence resulting from groundwater withdrawal has had significant consequences in the Yolo Groundwater Sub-basin. The risk of future significant impacts depends on a complex array of variables including: the degree of new groundwater development, especially in areas or at depths not previously exploited; changing land use, which could bring to light an impact that would otherwise go unnoticed; and the mineral composition of the aquifer skeleton, and its consolidation history. The City's objective is to prevent or minimize future impacts that may result from increased rates of inelastic land subsidence in and around its service area by continuing to cooperate with other stakeholders to monitor rates of inelastic land subsidence using the Yolo Subsidence Network.

Rates of inelastic land subsidence are being established by the WRA's Yolo Subsidence Monitoring Project. At present, data are insufficient to establish significance criteria for rates of inelastic land subsidence in the Woodland area. The City will participate in future surveys of the Yolo Subsidence Network and will evaluate the results with other members of the WRA.

BMO-04 – Protect against the risk of impacts to surface water flows and quality caused by groundwater pumping. The City currently does not use surface water, and there are no surface water flows within or adjacent to the City's service area. However, the City recognizes that the importance of protecting against impacts to surface water flows and surface water quality in the watershed. The City's objective is to work with basin stakeholders during integrated regional water management planning efforts to select alternatives that minimize the potential impacts to surface water flows and surface water quality caused by groundwater pumping.

BMO-05 – Protect against the risk of impacts to groundwater levels or groundwater quality caused by changes in surface water flows or surface water quality. Surface water deliveries are an important source of groundwater recharge in the Yolo Groundwater Sub-basin. Modeling studies indicate that, in the Central Valley as a whole, irrigation returns account for about 80 percent of the groundwater recharge on average (Williamson, et. al., 1989). Changes in the quantity of surface water delivered to the basin may affect both groundwater levels and groundwater quality. Changes in the sources of surface water may affect groundwater quality. The City's objective is to work cooperatively with basin stakeholders during integrated regional water management planning efforts to select water supply alternatives that minimize the potential impacts to groundwater flows and groundwater quality caused by changes in surface water flows or surface water quality.

ES.5 GROUNDWATER MANAGEMENT PLAN COMPONENTS

The BMOs are linked to management actions that are planned or triggered to attain the BMOs and overall groundwater management goal (Figure ES-1). Management actions are addressed under the six components of the GWMP:

- Agency Coordination, Stakeholder Involvement and Public Outreach
- Monitoring Program
- Groundwater Sustainability
- Adaptive Management and Mitigation in Response to Climate Change
- Groundwater Protection
- Planning Integration

Each component of the GWMP addresses related groundwater management subject matter and recommended actions. For example, the monitoring program component addresses the related topics of groundwater elevation monitoring; groundwater quality monitoring; land subsidence monitoring; groundwater-surface water interaction monitoring; and data management, quality assurance and quality control. The groundwater protection component addresses well construction and destruction policies, wellhead protection policies, protection of recharge areas, management of sources of groundwater contamination, and control of saline water intrusion.

ES.6 ADVISORY COMMITTEE FORMATION

The Advisory Committee for this GWMP is comprised of the WRA Technical Committee, which includes representation by City of Woodland staff. The City plans to continue to designate City representatives to the WRA Technical Committee and Advisory Committee during implementation of this GWMP.

ES.7 ANNUAL GROUNDWATER MANAGEMENT REPORT

The City plans to annually produce a status report to document the progress of the GWMP implementation throughout the previous year and to review and confirm actions for the next year. The report will include information regarding inelastic land subsidence, when updates are available, groundwater quality, groundwater production, and groundwater levels in relation to the established BMOs. When the Woodland-Davis Clean Water Agency's Davis Woodland Water Supply Project (DWWSP) is implemented, the annual reports will document the effect that the addition of a municipal surface water supply has on the groundwater system through groundwater level, groundwater production, and groundwater quality monitoring.

ES.8 FUTURE GROUNDWATER MANAGEMENT PLAN UPDATES

Periodic GWMP updates will be required as knowledge of the Yolo Sub-basin increases and groundwater management strategies evolve. The City will periodically consider new groundwater management techniques to be incorporated into the GWMP. Over time, BMOs may need to be modified based on changing groundwater conditions, the completion of the DWWSP and the addition of an operable conjunctive use system, or the development of new key groundwater management objectives. If changes must be made, the City will formalize the changes in an updated GWMP. The City plans to update this GWMP every five years on approximately the same update cycle as the City's UWMP.

ES.9 FINANCING

The implementation of this GWMP will be funded by the City. Ongoing coordination activities will be performed by City staff using City funds. Most baseline data collection activities will also be funded by the City. The City plans to provide a proportional share of costs for other regional data collection efforts, such as land subsidence monitoring. State or federal funding may be pursued to support implementation of this GWMP.

N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 1-1 Location Map.mxd 9/20/2010

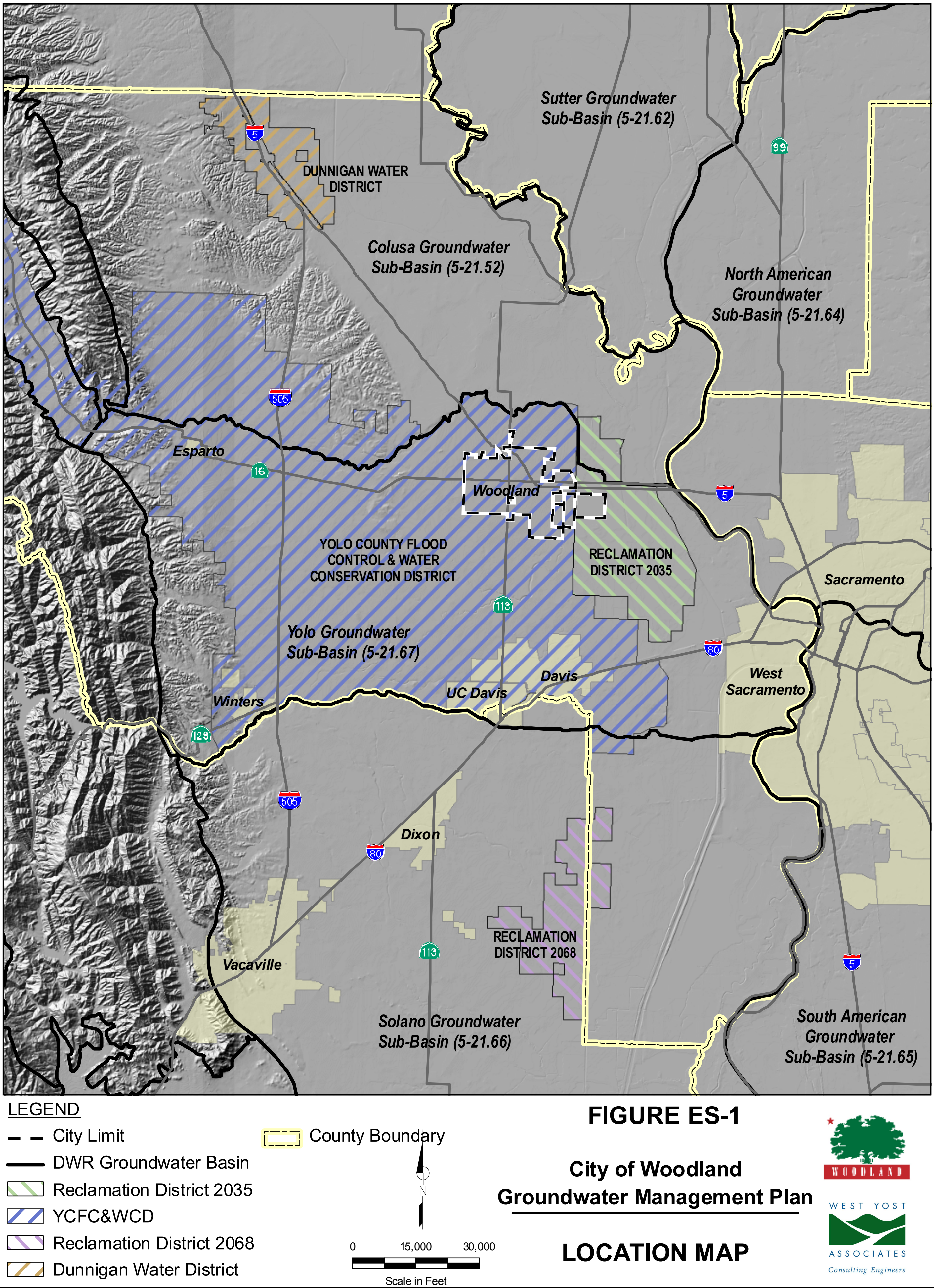

FIGURE ES-1

City of Woodland Groundwater Management Plan

LOCATION MAP

WOODLAND

WEST YOST ASSOCIATES Consulting Engineers

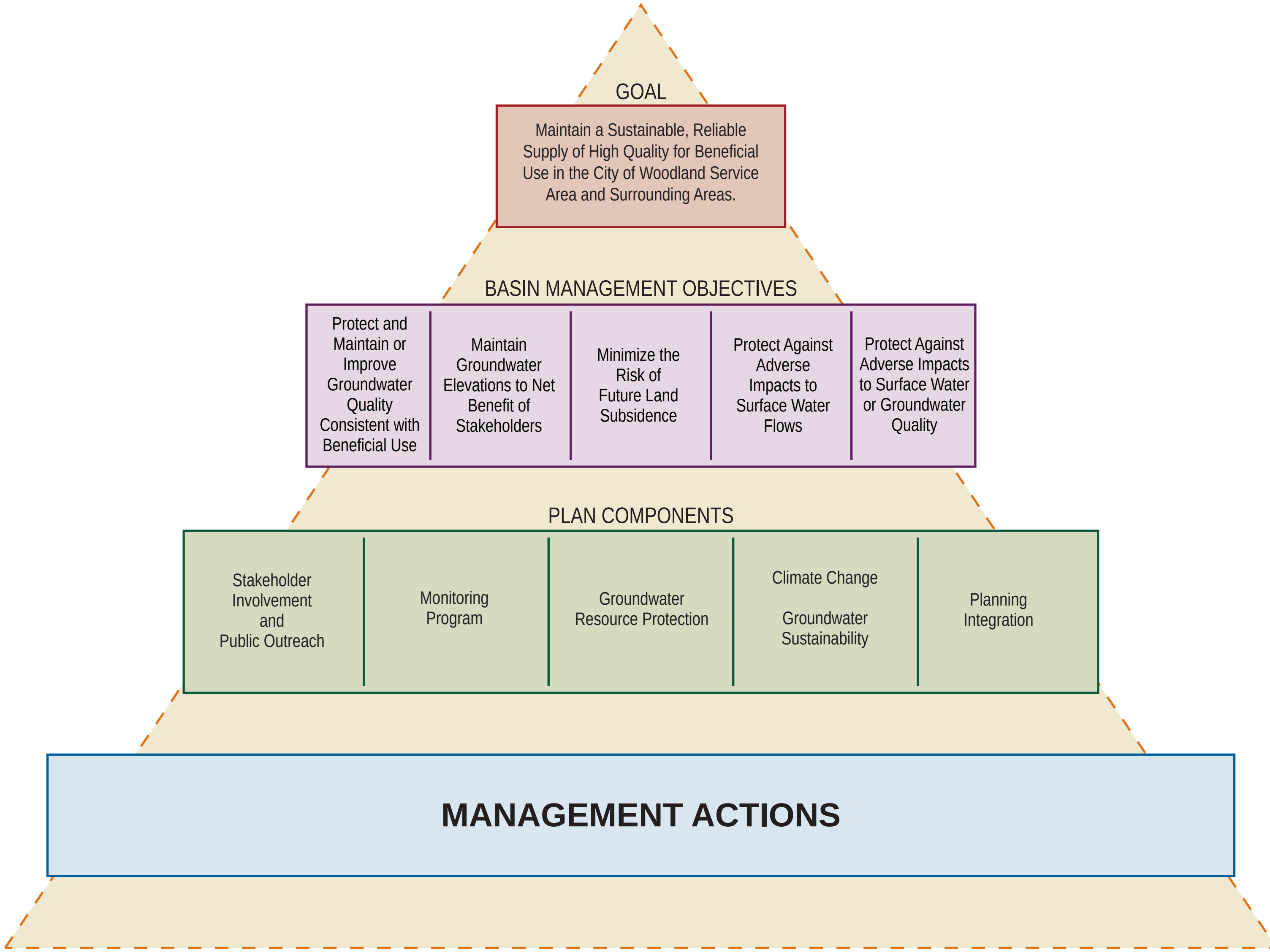

Figure ES-2

City of Woodland
Groundwater Management Plan

GROUNDWATER MANAGEMENT COMPONENTS

WOODLAND

WEST YOST ASSOCIATES
Consulting Engineers

Introduction

The City of Woodland (City) adopted Resolution No. 5099 to prepare this groundwater management plan (GWMP) on June 1, 2010, pursuant to Sections 10750 *et. seq*. of the California Water Code (CWC). The City adopted the GWMP through Ordinance No. 1527 on March 15, 2011. The ordinance became effective 30 days later. Resolution No. 5099, Ordinance No. 1527 and related documentation, including the City's Notice of Exemption from the California Environmental Quality Act (CEQA), are included in Appendix A. Documentation of public and stakeholder involvement during plan development is included in Appendix B.

Effective January 2003, the CWC sections addressing GWMPs were revised as a result of Senate Bill No. 1938 (SB 1938), Machado. The CWC Section 10750 *et. seq*. amendments provide a revised framework for GWMPs with the intent of encouraging local agencies to work cooperatively to manage groundwater.

To be eligible for funding for construction of groundwater projects or groundwater quality projects administered by the DWR, the CWC amendments require local agencies to:

1. Make available to the public a written statement describing the manner in which interested parties may participate in development of a GWMP, which may include appointing an advisory committee. Public notices are provided in Appendix B.
2. Prepare and implement a GWMP that includes BMOs for the groundwater basin that is subject to the plan.
3. Include components relating to the monitoring and management of groundwater levels within the groundwater basin, groundwater quality degradation, inelastic land subsidence, and changes in surface water flow and quality that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin. Consider additional components listed in CWC Section 10753.8 (a) through (l).
4. Prepare a GWMP that involves other agencies and enables the local agency to work cooperatively with other public entities whose service areas or boundaries overly the groundwater basin.
5. Adopt monitoring protocols that are designed to detect changes in groundwater levels, groundwater quality, inelastic subsidence in basins for which subsidence has been identified as a potential problem and flow and quality of surface water that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin. The monitoring protocols should be designed to generate information that promotes efficient and effective groundwater management and supports attainment of the BMOs.
6. Prepare a map that details the areas of the groundwater basin, as defined in DWR Bulletin 118, the area that will be subject to the plan, and the boundaries of the local agencies overlying the basin.

Compliance with these statutes affects the eligibility and award of DWR-administered funding authorized or appropriated after September 1, 2002.

This GWMP was developed in coordination with the other local agencies with adopted plans and other basin stakeholders. This plan will be administered by the City Director of Public Works with consideration of the recommendations of an advisory committee made up of members of the Water Resources Association of Yolo County (WRA) Technical Committee, which includes staff representation from the City of Woodland.

1.1 CITY OF WOODLAND DESCRIPTION AND OVERVIEW

The City is located approximately five miles north of the City of Davis and 10 miles northwest of the City of Sacramento within the Sacramento Valley. The City provides potable water to an area of approximately 9,600 acres, or 14.5 square miles. The City's service area is shown in Figure 1-1.

As shown on Figure 1-1, there are no other major municipal water purveyors within close proximity to the City. The City of Davis and the University of California, Davis are the next closest major water purveyors and are located due south of the City.

The City's existing land uses include rural to medium density residential, agricultural, commercial, professional, industrial, and open space. The City's agricultural setting is largely responsible for the community's distinct identity and plays an important economic role in Woodland. The City's stable residential neighborhoods offer diverse housing stock, mature trees and landscaping, and a sense of personal safety. Woodland neighborhoods are also filled with residents with a high level of community involvement. The City's downtown is an important symbol of the City's history and culture, which includes government buildings, specialty retail, and entertainment opportunities. The City's industrial activities are purposefully separated from residential areas to avoid land use conflicts. Most industrial development is located in the northeastern part of the city, much of it north and east of I-5.

1.2 OVERVIEW OF REGIONAL PLANNING EFFORTS

In an effort to better manage groundwater resources, local agencies in the vicinity of the City have adopted and are implementing GWMPs, Urban Water Management Plans, and an Integrated Regional Water Management Plan (IRWMP). Table 1-1 presents a list of local agencies that have adopted GWMPs.

Most of the City is within the service area of the Yolo County Flood Control and Water Conservation District (Yolo County FC&WCD).

The City is an active agency member of the WRA. The WRA, in cooperation with federal, state, and local agencies, developed an IRWMP intended to identify and describe water supply projects, address flood management, protect water quality, enhance aquatic and riparian habitat, and improve recreational opportunities (WRA, 2007). The writing of the IRWMP led to close collaborative ties between City, County, and State agencies, local water resource agencies, and community organizations.

Table 1-1. Local Agencies with Adopted Groundwater Management Plans		
Agency	Date Adopted	Basin Management Objectives
Reclamation District 2035	April 1995	1. Encourage activities which would maximize the recharge of the basin for beneficial use. 2. Implement a conjunctive use program. 3. Prevent permanent land subsidence. 4. Prevent groundwater quality degradation.
Reclamation District 2068	December 2005	1. Maintain groundwater elevations that result in a net benefit to basin groundwater users. 2. Protect and maintain groundwater quality within the RD 2068 service area for the benefit of basin groundwater users. 3. Minimize the risk of future significant impact due to inelastic subsidence. 4. Plan and implement a conjunctive use program that minimizes short-term decreases in groundwater elevations, maintains groundwater elevations at acceptable levels over the long-term, and minimizes water quality impacts resulting from the use of groundwater to meet some of the demands previously met by surface water.
City of Davis University of California, Davis	May 2006	1. Minimize long-term drawdown of groundwater levels. 2. Protect groundwater quality. 3. Prevent adverse inelastic land subsidence. 4. Minimize changes to surface water flows and quality that directly affect groundwater levels or quality. 5. Minimize effect of groundwater pumping on surface water flows and quality in sensitive areas of Putah Creek. 6. Develop, plan, and implement groundwater replenishment and cooperative management projects. 7. Work collaboratively with and understand the goals and objectives of entities engaged in groundwater management in surrounding areas.
Yolo County Flood Control and Water Conservation District	June 2006	1. Minimize the long-term drawdown of groundwater levels. 2. Protect groundwater quality. 3. Minimize the changes to surface water flows and quality that directly affect groundwater levels or quality. 4. Facilitate groundwater replenishment and cooperative management projects, including subsidence monitoring. 5. Work collaboratively with and understand the goals and objectives of entities engaged in groundwater management in surrounding areas.
Dunnigan Water District	October 2007	1. Maintain groundwater elevations. 2. Prevent degradation of groundwater quality for the benefit of all groundwater users. 3. Protect the area from potential inelastic land surface subsidence.

The City is also a member of the Westside Regional Water Management Group (RWMG), which consists of public agencies in Yolo, Solano, Lake, Colusa, and Napa Counties. The Westside RWMG is preparing the Westside IRWMP, which will constitute an integrated water management plan for the Cache and Putah Creek watersheds. The Westside IWRMP is scheduled to be completed in 2013.

1.3 AUTHORITY

The CWC provides the City's authority to adopt a GWMP. The City overlies the Yolo Groundwater Sub-basin and provides water service within its service area. The City is a local agency pursuant to CWC Section 10752 (g). The City is authorized to adopt this GWMP as provided in CWC Section 10753 (a).

1.4 PURPOSE OF THE GROUNDWATER MANAGEMENT PLAN

The City relies on groundwater to meet the water demands of its customers. The purpose of this GWMP is to:

1. State the City's overall groundwater management goal;
2. Put forth BMO applicable to the City service area;
3. Provide a mechanism for the continued collection of baseline groundwater and aquifer information; and
4. Establish management actions, including provisions for updating the plan as conditions change and new information becomes available.

1.5 ORGANIZATION OF THE GROUNDWATER MANAGEMENT PLAN

This GWMP is organized in five sections. Section 1 provides an introduction to the plan. Section 2 describes the physical setting of the plan area, provides an overview of the City's water supply and demands, and discusses the potential effects of climate change. Section 3 documents the City's overall groundwater management goal, BMOs and components of the plan, including discussion of adaptive management and mitigation strategies responding to climate change. Section 4 discusses implementation of the plan. Section 5 provides a list of references cited in the plan.

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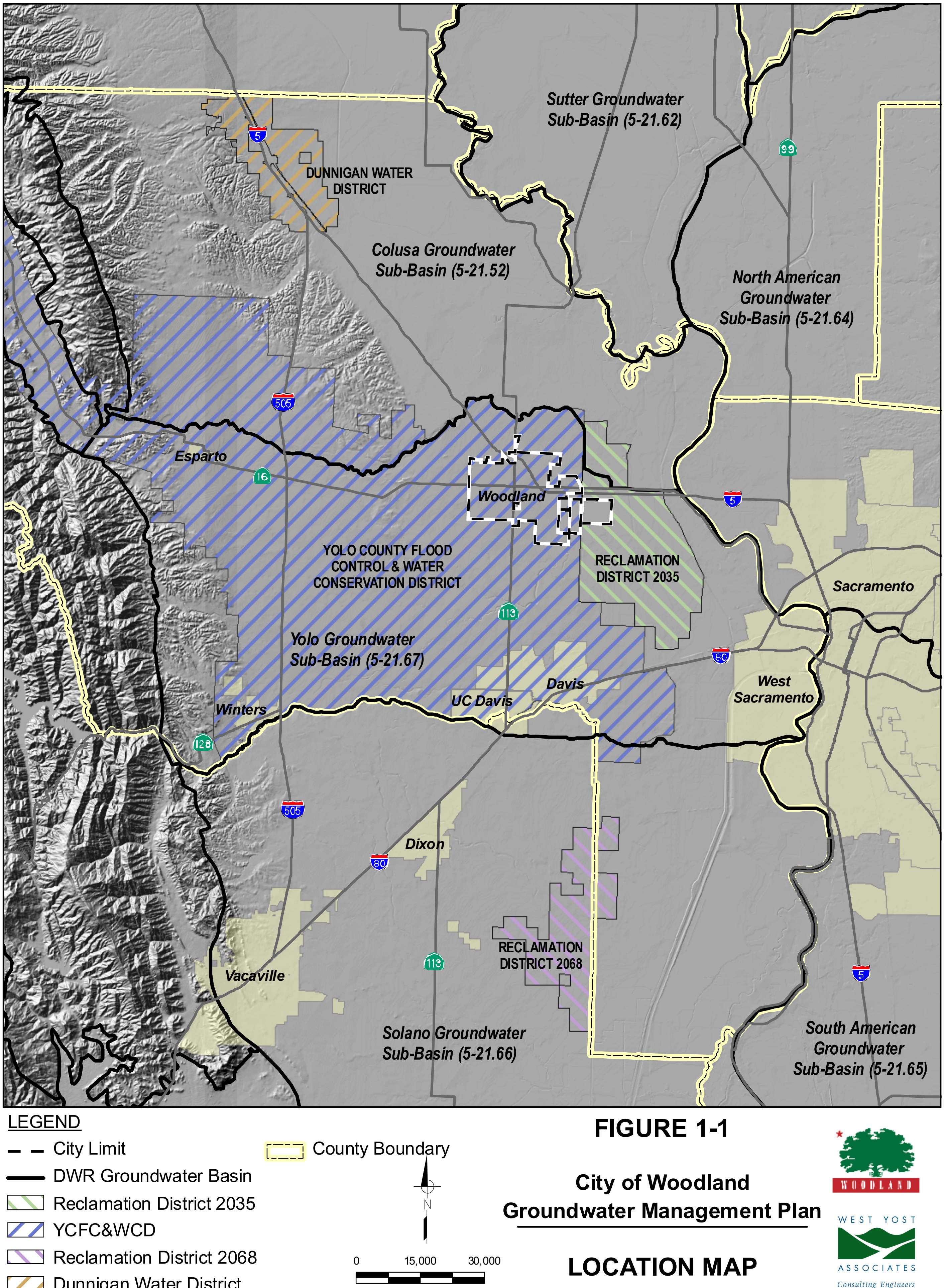


FIGURE 1-1

City of Woodland Groundwater Management Plan

LOCATION MAP

WOODLAND

WEST YOST ASSOCIATES Consulting Engineers

The City is located in the Yolo Sub-basin (Sub-basin 5-21.67) of the Sacramento Valley Groundwater Basin as defined in the California DWR Bulletin 118 update (DWR, 2003). Figure 1-1 shows the location of the City in relation to the boundaries of other local agencies overlying the groundwater basin. The Yolo Sub-basin is bounded by Cache Creek on the north; the Sacramento River on the east; Putah Creek on the south; and the Coast Range on the west (DWR, 2004). This plan covers the City service area.

This section provides a summary description of the basin, describes the City's well infrastructure and water supplies, and identifies known groundwater management issues.

2.1 SUMMARY BASIN DESCRIPTION

2.1.1 Location and Characteristics

This section provides a physical description of the basin.

2.1.1.1 Topography

Land surface elevations, within the Yolo Sub-basin, range from approximately 0 feet along the southeastern edge to approximately 800 feet along the western edge. Except near the western edge of the basin, where land surface elevations increase with proximity to the Coast Range, the topographic relief is low. Land surface elevations within the City service area range from approximately 30 to 80 feet. The Plainfield Ridge, the topographic expression of the Dunnigan Hills anticline, is an area of slightly elevated rolling hills located approximately four miles west of Woodland. The Yolo Basin, the flood basin of the Sacramento River, is located approximately three miles west of Woodland (Figure 1-1).

2.1.1.2 Climate and Precipitation

The Yolo Sub-basin has a Mediterranean climate with cool, wet winters and hot, dry summers. Regionally, temperature and precipitation vary with elevation, with the lower temperatures and higher precipitation occurring at higher elevations. The region is subject to wide variations in annual precipitation, and experiences periodic dry periods. Summers can be hot at times with weekly periods of 100 degree Fahrenheit temperatures, greatly increasing summer irrigation requirements.

Based on the historical data obtained from the Western Regional Climate Center, the City's average monthly temperature ranges from 46 to 76 degrees Fahrenheit, but the extreme low and high daily temperatures have been 15 and 114 degrees Fahrenheit, respectively.

The average annual precipitation varies from 18 inches near the eastern edge of the sub-basin to 24 inches near the western edge (DWR, 2004). Because of the low topographic relief in the eastern part of the sub-basin, including the City, temperature and precipitation do not vary greatly with location.

Figure 2-1 shows the annual precipitation for the Woodland area for the period 1926 through 2007. Table 2-1 summarizes the annual precipitation statistics.

Table 2-1. Summary Statistics for City of Woodland Historical Precipitation, 1926 – 2007[a]

Statistic	Annual Precipitation, inches	Year
Minimum	6.53	1939
Maximum	40.55	1983
Median	17.45	1962
Mean	18.08	1926-2007

[a] Data Source: Western Regional Climate Center (WRCC), Station Woodland WNW, Woodland, California, http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?ca9781.

Multi-year dry periods in the Woodland area include:

- 1927-1930
- 1932-1935
- 1946-1949
- 1956-1957
- 1959-1962
- 1964-1966
- 1971-1972
- 1975-1977
- 1984-1985
- 1988-1992
- 2007-2009

The Woodland area experienced low levels of precipitation in many of the years when multi-year droughts occurred state-wide (DWR, 2000). Figure 2-2 is an exceedance curve for the City precipitation data. The figure shows the frequency at which a given level of annual precipitation was met or exceeded. The curve can be used to gauge how frequently the precipitation recorded in any given year was equaled or exceeded in the past. For example, the minimum historical precipitation of 6.5 inches in 1939 was equaled or exceeded in 100 percent of all years from 1926 to 2007, and the 10.80 inches of precipitation recorded in 2007 was met or exceeded in 90 percent of past years.

2.1.1.3 Surface Water

The major surface water features in the vicinity of the Woodland area form the Yolo Sub-basin's boundaries. These are Cache Creek, Putah Creek, and the Sacramento River and Yolo Bypass on the north, south and east boundaries, respectively (Figure 1-1). Cache Creek is significant because of its proximity to the City.

Cache Creek is separated into the Upper Cache Creek and the Lower Cache Creek. Upper Cache Creek includes the watershed system upstream of the Capay Dam while Lower Cache Creek includes the watershed system downstream of the Capay Dam and upstream of the Cache Creek Settling Basin. Upper Cache Creek drains approximately 1,044 square miles before entering the Sacramento Valley floor near Capay, California. Much of the flow from the watershed passes through Clear Lake on the main fork of Cache Creek, or Indian Valley Reservoir on the north fork of Cache Creek. Lower Cache Creek drains approximately 1,139 square miles and enters the Yolo Bypass through the Cache Creek Settling Basin.

No water is being diverted from the creek for municipal purposes. The Yolo County FC&WCD possesses rights to regulate flow and divert water from the Capay Dam, Clear Lake Dam, and associated irrigation canals for agricultural use. The Indian Valley Reservoir was built by the Yolo County FC&WCD to increase water storage.

Below the Capay Dam, the creek is characterized by a broad, braided channel followed by a narrow, heavily vegetated channel. Near the town of Yolo, California the creek is bounded by levees until it reaches the Cache Creek Settling Basin. The Cache Creek Settling Basin acts as a sediment filter and was specifically designed to preserve the flood capacity of the Yolo Bypass (WRA, 2007).

2.1.2 Hydrogeologic Description

The Sacramento Valley in the vicinity of City Woodland is filled by a thick sequence of marine sedimentary rock of Late Jurassic (159 million years [my] before present) to Eocene (34 my) age, unconformably overlain by a relatively thin sequence of continental sedimentary deposits of Pliocene (5 my) and younger age (Harwood and Helley, 1987).

A generalized geologic cross section for the Sacramento Valley is shown in Figure 2-3.

The older, deeper marine rocks contain saline water. The freshwater aquifers in the vicinity of the City occur in the overlying continental sedimentary deposits. Figure 2-4 is a geologic map encompassing the City and vicinity (CGS, 1981). Figure 2-5 is a geologic column that provides a conceptual overview of the freshwater portion of the aquifer in the Woodland area. A base of freshwater map is shown on Figure 2-6.

Shallow groundwater in the Woodland area occurs under unconfined conditions in the Holocene stream channel deposits, except where these units are overlain by Holocene Basin Deposits, creating confined conditions (DWR, 1978). At greater depths, groundwater occurs under mostly semiconfined to confined conditions in a single heterogeneous aquifer system, composed of predominantly fine-grained sediments enclosing discontinuous lenses of sand and gravel. The aquifer properties, including hydraulic conductivity, vertical leakance and degree of confinement are dependent on the properties of the fine grained units (Williamson, et. al., 1989; Bertoldi, et. al., 1991). The geologic formations comprising the freshwater aquifer are discussed from oldest to youngest in the following sections.

2.1.2.1 Tehama Formation

The Tehama Formation forms the oldest, deepest and thickest part of the freshwater aquifer in the Woodland area (Figure 2-3). The Tehama Formation consists of up to 2,500 feet of moderately compacted silt, clay, and silty fine sand enclosing thin, discontinuous lenses of sand and gravel, silt and gravel deposited in a fluvial (river-borne) environment. In outcrop, the Tehama Formation consists of pale green, gray, and tan sandstone and siltstone with lenses of crossbedded pebble and cobble conglomerates. Based on the mineralogy of surface exposures, the sediments were derived from erosion of the Coast Ranges and Klamath Mountains (Russell, 1931; DWR, 1978, 2004; Helley and Harwood, 1985). The sediments were distributed by ancestral east-flowing Coast Range drainages, and deposited into the Sacramento Valley, which, at that time, was similar but considerably wider than it is today (Olmsted and Davis, 1961). The overall south-flowing drainage of the Sacramento Valley also distributed and reworked these deposits, as evidenced by the crossbedding seen in the coarser layers of the formation and sourcing of some sediments from the north (Olmsted and Davis, 1961). Beneath Yolo County, the formation sediments are finer to the east, possibly indicating eastward transport of sediments to the valley basin (WRA, 2007).

The Tehama Formation is exposed at the land surface over extensive areas on the eastern flank of the Coast Range including the Dunnigan Hills and English Hills. Smaller outcrops are present on the Plainfield Ridge. The Tehama Formation is buried beneath younger sediments in most other areas of the Sacramento Valley (Figure 2-4).

The age of the Tehama Formation is constrained by volcanic rock units, which can be time-correlated with rock units deposited near the base and slightly above the top of the Tehama Formation. The Putah Creek/Nomlaki Tuff, which is located at or near the base of the Tehama Formation has a radiometrically determined age of 3.4 my (Evernden et. al, 1964; Harwood and Helley, 1987). The Putah Creek Tuff is exposed at the land surface in the Capay Hills northwest of the Woodland area (Figure 2-4). Figure 2-5 shows the estimated stratigraphic position of the Putah Creek/Nomlaki Tuff in the subsurface, based on the total thickness of the Tehama Formation. The Tehama Formation is unconformably overlain by a thin gravel pediment known as the Red Bluff Formation (Figures 2-4 and 2-5). The age of the Red Bluff Formation is constrained to be 0.45 to 1.09 my by the radiometrically determined ages of the Rockland ash bed and the Deer Creek basalt, respectively (Harwood, et. al., 1981; Harwood and Helley, 1987).

Based on these constraints, deposition of the Tehama Formation began about 3.4 my and ended about 1.09 my, which is equivalent to a Pliocene to Pleistocene age (Figure 2-5).

The Tehama Formation is the primary water-bearing stratigraphic unit in the area. The permeability of the Tehama Formation is highly variable but generally less than the overlying Quaternary alluvium. Because of the relatively large thickness, wells can yield up to several thousand gallons per minute (gpm) (DWR, 2004). The majority of irrigation and public supply wells in the Woodland area are completed in the Tehama Formation (DWR, 2004).

2.1.2.2 Riverbank and Modesto Formations

The Tehama and Red Bluff Formations are unconformably overlain by the late Pleistocene age Riverbank and Modesto Formations. These formations consist of up to 200 feet of loose to moderately compacted silt, silty clay, sand and gravel deposited in alluvial depositional environments during periods of world-wide glaciation (Lettis, 1988; Weissmann, et. al., 2002; DWR, 2004). In the Woodland area, the Riverbank and Modesto Formation are not directly related to glacial activity but were deposited in response to changes in base level and increased precipitation during the glacial periods. The increased stream gradients and precipitation resulted in greater stream discharge and competency than at the present time. The greater competency of the streams led to scouring of stream channels in pre-existing geologic deposits, followed by transport, deposition and burial of sands and gravels in the channels as the glacial cycles progressed.

Figure 2-4 shows the distribution of the Riverbank and Modesto Formation in the Woodland area. The formations are exposed at the land surface along the channels of Cache and Putah Creeks, and along the fringes of the Dunnigan Hills and Capay Hills, where they form a series of coalescing alluvial fans, emanating from the mouths of the creeks. The Riverbank and Modesto Formations are not differentiated in most areas shown on Figure 2-4. However, the formations typically form terraces along stream channels. The oldest terraces occur furthest from the channel and at the highest elevations. Successively younger terraces are incised into the next oldest deposit and, therefore, occur closer to the stream channel and at lower elevations (Figure 2-4).

The age of the Riverbank Formation ranges from 0.13 to 0.45 my and corresponds to the Illinoisan and older glacial stages. The age of the Modesto Formation ranges from approximately 0.01 to 0.042 my and correlates to the Wisconsin glacial stage. Both formations are Pleistocene age. Age correlative alluvial deposits of the Riverbank and Modesto Formations in most areas south of Putah Creek are mapped as Older Alluvium and alluvium, respectively (CGS, 1981 and 1982).

Wells penetrating the sand and gravel units of the Riverbank and Modesto Formations produce up to about 1,000 gpm (DWR, 2004). The majority of the domestic wells in the Woodland area are completed in the Riverbank and Modesto Formations (DWR, 2004).

2.1.2.3 Holocene Stream Channel and Basin Deposits

Holocene stream channel and basin deposits are the youngest sediments in the region, with ages of 10,000 years or less. The stream channel deposits consist of up to 80-foot sections of unconsolidated clay, silt, sand and gravel reworked from older formations by streams.

Holocene basin deposits are very young near-surface deposits formed during flood events when streams overtopped their natural levees flooding the surrounding area. As the floodwater spread, the current velocity and stream competency decreased, resulting in deposition of silts, clays and fine sands. Flood basin deposits reach thicknesses up to 150 feet and may be interbedded with stream channel deposits (DWR, 2004).

According to DWR (2004), Holocene stream channel deposits form a shallow aquifer of moderate to high permeability, but with limited capacity due to the relatively restricted lateral and vertical extents of the deposits. Some of the shallower domestic wells in the Woodland area may be screened in Holocene stream channel deposits (DWR, 2004). Because of their low permeability, limited extent, and generally poor water quality, Holocene flood basin deposits are typically not used for groundwater production (DWR, 2004). Figure 2-3 shows the distribution of stream channel and basin deposits in the Woodland area.

2.1.2.4 Tectonic Effects

Tectonism related to changing dynamics of the north-northwest trending San Andreas fault plate boundary along the California coast continued to uplift and deform the Coast Ranges after the deposition of the Tehama Formation (Dickenson and Snyder, 1979; Harwood and Helley, 1987). The formation was uplifted and regionally tilted to the east and the western edge of the formation was partially eroded, leaving it exposed on the lower east flank of the Coast Ranges. Stresses related to the San Andreas fault system extended to the western margin of the Sacramento Valley after the initial uplift that tilted the formation eastward. These stresses created a set of broad folds expressed geographically as the Dunnigan Hills (Harwood and Helley, 1987) (Figure 2-4). Other structural features are located in the subsurface.

Figure 2-7, from Harwood and Helley (1987), shows the structural contours in meters delineating the top of the Cretaceous marine sedimentary rocks in the Woodland area. The structural contours were based on the Cretaceous rocks because the resulting surface produces a single structural datum throughout the western Sacramento Valley. This datum reveals the geologic structures – folds and faults – that affect the groundwater basin. The significant structural features in the Woodland area are the Zamora fault, the Dunnigan Hills anticline, and the Zamora syncline. These structural features affect rock units at least as young as the Red Bluff Formation, which indicates that the structural deformation was occurring as recently as 0.45 my – the youngest age of the Red Bluff Formation – and may be continuing at present (Harwood and Helley, 1987).

2.1.2.5 Faults

The Zamora fault is mapped at the land surface along the northeastern flank of the Dunnigan Hills (Figure 2-4, 2-5 and 2-7). The fault has a downward-to-the-east vertical displacement that is reported to offset the Red Bluff Formation by at least 200 feet to more than 720 feet (Bryan, 1923; Harwood and Helley, 1987). The fault may affect groundwater flow by bringing geologic materials with different hydraulic properties into contact across the fault plane or by fracturing the materials, which could either increase or decrease permeability, depending on the degree of fracturing and other geologic processes, such as mineralization, active within the fault zone. The fault might, therefore, act as a boundary or barrier affecting the lateral flow of groundwater between adjacent areas, and might act as a conduit allowing vertical or lateral flow within the fault zone. At present the affects of the fault on groundwater flow are uncertain, but easterly flow of groundwater beneath the Dunnigan Hills appears to be impeded (DWR, 1978).

2.1.2.6 Folds

The Dunnigan Hills are the topographic expression of a doubly plunging anticline, a fold in which the central axis is raised relative to the limbs (Figures 2-4, 2-5 and 2-7). The axis of the Dunnigan Hills anticline is oriented northwest and plunges beneath the land surface on both ends of the structure. To the south-southeast the anticline is subtly expressed as the Plainfield Ridge, the alignment of very low hills that project into the south-central portion of Yolo County along the western margins of Woodland (WRA, 2007).

The Zamora syncline is a similar structural feature, except that the fold axis is lowered relative to the limbs of the fold and is not doubly plunging. The Zamora syncline is located in the subsurface east of the Dunnigan Hills and Zamora fault (Figure 2-7). The axis of the syncline passes beneath the east side of the City. The Zamora syncline has no topographic expression, but the thickness of post-Cretaceous sediments, including the Tehama Formation, is greater along the axis of the syncline than on the limbs (Figure 2-7). This means that the aquifer thickness is greatest along the axis of the syncline.

Folds may also affect groundwater conditions because the folds cause the elevation of geologic units to vary from place to place. This has two effects. First, since the Dunnigan Hills anticline is expressed at the land surface, erosion of the Tehama Formation has exposed older, lower sections of the formation along axis of the fold. Units of equivalent age dip to the east towards the axis of the Zamora syncline and occur at successively greater depths until the axis of the syncline is reached. Thus, the folds may affect recharge characteristics where the Tehama Formation is exposed at the land surface or is in contact with overlying formations that transmit recharging water. Second, the permeability and other material properties of sedimentary rocks, such as the Tehama Formation, are typically anisotropic due to the alignment of mineral grains along bedding planes during deposition of the sediments. This alignment of the mineral grains results in higher permeability along than across bedding plans. Typically, this results in a maximum permeability horizontally and a minimum permeability vertically. Subsequent folding of the bedding planes causes a reorientation of the direction of maximum and minimum permeability, which could tend to affect groundwater directions and rates of flow.

2.1.2.7 Woodland Area Detailed Hydrogeologic Cross-Sections

Geologic cross sections depicting the aquifer system below a depth of about 600 feet were developed for the Woodland area by Luhdorff and Scalmanini Consulting Engineers (LSCE, 2004). These cross sections are based on a detailed evaluation of water well and gas/oil well logs in the City area. Appendix C contains the LSCE (2004) report and cross sections.

The LSCE cross sections depict potable aquifer materials occurring at depths from approximately 600 to 1,500 feet. It should be noted that most of the City's existing production wells are not drilled deeper than approximately 600 feet. However, according to the LSCE (2004) report, the conceptualization for the City area "suggests potential water supply targets and some system attributes," therefore providing "basic input into well development planning."

2.1.2.8 Soils

According to DWR (1978), which summarizes work performed by the United States Geological Survey (Bertoldi, 1974), most soils in the Yolo sub-basin are either 1) "soils containing hardpan or other consolidated horizons that restrict the vertical flow of water, including soils over bedrock", such as in the Dunnigan Hills and other areas in which the Tehama Formation is exposed; or 2) "soils containing clay in sufficient quantities to impede the vertical flow of water" (Figure 2-8). Exceptions to this generalization are the soils in the vicinity of Putah and Cache Creeks, which have "few barriers to the vertical flow of water". Figure 2-9 displays a map of the relative permeability of soils within the Yolo County area. Areas containing soils with few barriers to vertical flow are more likely to be the recharge areas for underlying aquifers.

2.1.2.9 Land Subsidence

Significant land subsidence has been documented in Solano and Yolo Counties over the years. Land subsidence of up to 5.4 feet is documented over the past few decades in a north-south trending zone in the southwestern Sacramento Valley that extends from Zamora to Dixon (Ikehara, 1994). Down-well television surveys have been used to document well casings damaged by land subsidence over this same zone, at the Yolo/Colusa County line, and northward into central Colusa County. Of 81 wells found to be damaged, the substantial damage was in the sections of the well casings penetrating the Tehama Formation. A comparison of damaged and undamaged wells in the main area of subsidence showed similar amounts of compressible sediments and that the damaged wells were those in which the greatest declines in head had occurred after well installation (Borchers, et. al., 1998). Recent studies have verified that subsidence is continuing to occur in the Yolo County portion of this zone (Frame, 2005). Figure 2-10 shows the preliminary results of repeat surveys of the Yolo County Subsidence Monitoring Network conducted in 1999 and 2005. Based on these preliminary results, 3.1 inches of subsidence have occurred at the UC Davis Continuously Operating Reference Station (CORS) (Figure 2-10). This equates to an average rate of subsidence of about 0.5 inches per year at the UC Davis CORS. This rate is significantly higher than the average rate recorded at an extensometer located in the Yolo Bypass approximately 10 miles northeast of Davis. The rate recorded at the Conaway Ranch extensometer is roughly 0.03 inches per year. The significantly higher rates calculated based on the repeat elevation surveys implies that part of the land subsidence is occurring due to compaction of geologic materials at depths greater than the completion depth of the extensometer (roughly 600 feet), and some of the recorded subsidence could be caused by factors other than groundwater withdrawal. Possible mechanisms are withdrawal of gas and saline water from deep gas production zones and natural tectonic subsidence occurring at long-term geologic rates. A copy of the Yolo County Subsidence Monitoring Network 2005 Report is included in Appendix D. The locations of the subsidence benchmarks used in the Yolo County Subsidence Monitoring Network are shown on Figure 2-11 for the City area.

Land subsidence due to groundwater withdrawal is triggered by decreases in pore pressure in a confined aquifer system containing clay layers (typically, montmorillonite clay). The decrease in pore pressure increases the effective stress on the aquifer skeleton. If this effective stress exceeds the maximum stress to which the aquifer skeleton has been subjected in the past, the clay layers will undergo permanent compaction.

Differential land subsidence and associated earth fissuring resulting from groundwater withdrawal have had significant consequences in several California groundwater basins. The risk of significant impacts depends on a complex array of variables including: the degree of new groundwater development, especially in areas or at depths not previously exploited; changing land use, which could bring to light an impact that would otherwise go unnoticed; and the mineral composition and consolidation history of the aquifer skeleton.

Core samples from seven test holes drilled in the southern Sacramento Valley by the U.S. Geological Survey did not contain montmorillonite, the most compressible of common clay minerals (French, et. al., 1982; Borchers, 1998). However, one core sample collected from a test hole drilled near the Colusa Drainage Canal, approximately 10 miles northwest of Woodland at 12N1E34Q1 contained a silty, diatomaceous, kaolinitic clay with a compression index of 1.22 and coefficient of consolidation of 4.98 square feet per year. These values are comparable to samples of diatomaceous clay from the Corcoran Clay of the San Joaquin Valley, and indicate a high susceptibility to compaction (Page, 1998). The core sample was collected at a depth of 534 to 544 feet in the Tehama Formation.

2.1.3 Climate Change

National and international research for the past several decades has indicated a growing concern that our climate is changing, to a large extent due to human activities related to the generation of greenhouse gasses such as carbon dioxide. In the past there has been substantial uncertainty, and some doubt in public discourse and debates. Over the last few years there have been landmark advancements in scientific studies, ultimately leading to major conclusions in the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC).

The IPCC was established to provide the decision-makers and others interested in climate change with an objective source of information about climate change. It was set up by the World Meteorological Organization and the United Nations Environment Programme, and has served since 1988 as a clearinghouse for research and policy discussions related to climate change. The role of the IPCC "…is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation …." Agencies of the United States government have provided major input to both research and discussion, particularly through the U.S. Geological Survey. Science organizations worldwide have been following climate change research, and in 2009 the Academies of Sciences from 13 nations issued a letter calling for urgent and coordinated action to combat climate change (National Academies, 2009).

The IPCC has issued four major "assessments" of the status of climate change research, current levels of understanding, and potential policy implications. The Fourth Assessment Report was released throughout 2007, indicating for the first time clear links between human activities and global warming. The Fifth Assessment Report is scheduled for finalization in 2014. The historical and projected continued warming of the earth has and will continue to cause changes to our climate. While such induced "climate change" has implications to a number of environmental factors, of concern in this discussion is implications to water supply reliability.

The State of California has provided major focus and funding on climate change research and impacts, with particular focus on developing both "adaptation" and "mitigation" strategies. In the context of climate change and its impacts to water resources, "adaptation" is simply the identification and development of strategies to cope with the expected impacts to water supply reliability. "Mitigation" is the identification and development of actions that will reduce the drivers for climate change; for the most part this translates into programs to reduce greenhouse gas emissions and lower the "carbon footprint" of activities associated with water supply and use.

The State's research and continuing recommendations are readily available. The State's Climate Action Team has noted a clear connection between water use and energy consumption, and consequently also with greenhouse gas production (see California Climate Change Portal for the most recent technical and policy information: http://www.climatechange.ca.gov/). The 2005 California Water Plan Update addressed climate change and water in a general way, noting the many potential interconnections as well as the potentially serious impacts of ongoing climate change on water supply reliability. The 2009 Update to the California Water Plan addresses this topic in a more substantive way (http://www.waterplan.water.ca.gov/climate/index.cfm), and includes recommendations and advice on how to incorporate climate change into long-term water resources planning. It is also recommends specific actions in the areas of adaptation and mitigation as discussed above.

DWR maintains an updated web site on climate change and California's water resources (http://www.water.ca.gov/climatechange/). That web site notes, in part: "Climate change is already impacting California's water resources. In the future, warmer temperatures, different patterns of precipitation and runoff, and rising sea levels will profoundly affect the ability to manage water supplies and other natural resources. Adapting California's water management systems to climate change presents one of the most significant challenges for the 21st century". In 2006 DWR published a major report on climate change and California's water resources, Progress on Incorporating Climate Change Into Management of California's Water Resources. This was summarized and updated in a paper published in a special issue of the Journal of Climate Change in 2008 (http://wwwdwr.water.ca.gov/climatechange/docs/CCprogress_mar08.pdf). In 2010, DWR provided another update entitled Climate Change Characterization and Analysis in California Water Resources Planning Studies. This report provides a summary of the climate change characterization approaches and methodologies that have been used in recent planning studies conducted by DWR and its partner agencies. The report is intended for use by DWR to consider how to include climate change analyses in planning studies, with emphasis on the State Water Project (SWP) planning studies.

Collectively this State information provides the most updated information related to potential specific impacts of water supply reliability in California related to impacts of a changing climate.

DWR and others have done studies to model potential future impacts at the regional level on both streamflow and temperature. The focus has been on the Sacramento River system since it is a major source of water for much of California.

The different models are split on whether future annual average runoff will be wetter or drier. Other studies make it clear, however, that we are likely to see more extreme hydrology: more floods and droughts, regardless of the "average" hydrology. However, these same regional models agree that the future will likely be warmer than it is today.

Other potential changes include less snowpack, earlier runoff from snowmelt, more precipitation as rain than snow, changes in the amount and timing of stream flows, changes in water resources system operations, and rising sea levels. In turn, these changes could have serious impacts to water supply reliability, including water quality. DWR has confirmed that some impacts have been underway for many years. For example, the historical Sacramento River snowmelt runoff has been decreasing as a percentage of total annual flows for much of the 20th century. This is an indication of a long-term decrease in snowpack, and perhaps an increase in wintertime flows and floods.

There are few published examples of water supply adaptation and mitigation strategies. In December 2007 the water user organization, California Urban Water Agencies (CUWA), published a summary report of a survey of its 11 large urban water agencies on this topic (CUWA agencies are major urban water utilities throughout the state, and include such agencies as the Metropolitan Water District of Southern California, East Bay Municipal Utility District, and the San Francisco Public Utilities District). This report, "Climate Change and Urban Water Resources, Investing for Reliability", identifies a number of adaptation and mitigation strategies currently being employed to address climate change. Table 2-2 lists some of these strategies. The CUWA report is available on their web site: http://www.cuwa.org/library/ClimateChangeReport12_2007.pdf.

Table 2-2. CUWA Adaptation and Mitigation Examples

Adaptation Examples	Mitigation Examples
Develop groundwater storage	Renewable energy generation
More aggressive conservation	Conserve energy in water facilities
Water transfers	Decrease energy use in fleet, equipment
Optimize local storage	Increase employee incentives for action
Develop regional water projects, partnerships	Develop methane offsets (biogas at wastewater facilities used in place of natural gas or other fuels)
Take leadership role on this issue	Take leadership role on this issue

Despite the high level of attention both in California and internationally, there is very little information developed on the potential impacts of climate change on groundwater. The principal concern is rising sea level and potential salinity intrusion into coastal groundwater aquifers. While this is a concern for coastal areas of California, it is not a concern in the portion of Yolo groundwater subbasin near the City.

While not addressed specifically in IPCC reports, there are potential impacts to groundwater resources that have been discussed over the past few years. These include the following concerns:

1. Decreased reliability of surface water supplies could lead to increased reliance on groundwater, further stressing such supplies.
2. Changes to surface water hydrology – increased winter flood flows, reduced spring and summer snowmelt runoff – could decrease groundwater recharge.
3. Increased landscape and irrigation water demands due to increased temperatures will further increase pressures on groundwater supplies.

2.2 WELL INFRASTRUCTURE, WATER SUPPLIES AND DEMANDS

This section provides a description of the City's existing wells, characteristics of the municipal groundwater supply, land use and water demands in the City, and planned future supplies.

2.2.1 Groundwater Well Infrastructure

The City currently relies on groundwater obtained from 18 of their 20 existing wells for its municipal supply. The locations of the City's production wells are shown on Figure 2-11. Well 9 is currently out of service due to water quality concerns and is not considered reliable. Well 9 is scheduled to be destroyed. Well 10 has recently been rehabilitated and is currently active. However, its reliability is uncertain due to potentially unacceptable nitrate levels. Wells 2, 3, 6b, 7, and 8 have either been destroyed or capped and are no longer operable. One additional well (Well 27) is owned by the County and is located on the County jail property within the City limits. The City has an arrangement with the County to jointly utilize this well on an as-needed basis. The City's service area also contains private wells used for domestic drinking water and industrial supply. Groundwater is used for domestic drinking water and agricultural supply in the surrounding areas of Yolo County.

Seventy percent of the City's existing wells are over 30 years old and will need to be replaced in the near future considering the fact that the useful lifespan of a typical well is between 30 and 50 years. Table 2-3 presents a summary of the existing production well facilities, their status, age, and other key characteristics. Wells 15 and 22 were inactivated in August 2008 due to excessive sand being pumped into the distribution system. Well 15 was redrilled and put back in service in Fall 2010. Well 22 is scheduled to be operable in 2011. Wells 17 and 20 need to be pumped continuously due to an excessive increase in nitrate levels when the pumps are shut down. Figure 2-12 displays the depths, screen intervals, and pump settings for all of the production wells, including those that have been destroyed or are inactive.

Table 2-3. Summary of Production Well Information

Well ID [a]	State Well Number	Current Status	Date Constructed	Depth of Casing, feet	Casing Diameter		Casing Type		Screen Type	Perforation Size	Perforated Zones (Feet, bgs)					Gravel Pack	Sanitary Seal		Well Test Result	Location
					Zone, feet	Diameter	Zone, feet	Casing			100-200	200-300	300-400	400-500	500 +		Zone, feet	Sanitary Seal		
1	66471	Active	Jan-1962	484	0-484	16"	0-484	1/4"	factory punched standard double	1"x1/4"	175-183	231-239	335-351	439-475		3/8"	0-100	cement grout	6020 gpm at 64 ft, 4830 gpm at 60.6 ft, 3375 gpm at 56.6 ft, 2850 gpm at 56 ft	5th Street
2	10N02E29L01M	Destroyed	Apr-1905	211	0-106 106-170 170-211	16" 14" 12"	0-211				142-160 186-208						0-106	concrete seal		Walnut Street
3	*10N02E30K1*	Destroyed	Jul-1943	480	0-480	14"	0-480	3/16"		23/16"x3/16"				420-477			0-80			Sutter Street
4	21611	Active	Jul-1954	484	0-201 201-372 372-484	16" 14" 12'	0-484	1/4" welded	factory	3"x3/16"		274-282	336-361	437-484		pea gravel	90-96	concrete seal	2860 gpm at 90 ft	Beamer Street
5	21633	Active	Jan-1955	452	0-212 212-452	16" 12"	0-452	1/4" welded	factory	3"x3/16"	168-188	205-209		429-448		pea gravel	0-100	cement	2600 gpm at 129 ft	South Land
6b	31438	Destroyed	Jan-1955	490	0-253 253-256 256-490	16" 16"-12" taper 12"	0-490	1/4" butt welded	machine cut at factory	3"x3/16"	176-191	229-253	340-346 362-370 382-394	406-418 436-490		1/2"x3/4"	0-90	concrete		Grand Ave.
6c	38485	Active	Nov-1976	503	0-503	16"	0-503	5/16"	type 304 stainless steel	50 mesh	172-188	226-248		408-418 438-488		31 mix	0-90	cement grout		Grand Ave.
7		Destroyed	Jun-1956	485	0-206 206-209 209-485	16" 16"-12" taper 12"	0-485	1/4"		1"x1/4"		200-206 244-258		438-446 458-482			0-105	cement		Greenfield Village Pump Site
8	35476	Destroyed	Apr-1958	471	0-204 204-207 207-471	16" 16"-14" taper 14"	0-471	1/4" welded	factory punched	1"x1/4"	124-132 171-175			429-465			0-72	cement	2740 gpm at 77 ft	6th Street
9	60236	Inactive	Jun-1960	470	0-470	16"	0-470	1/4" welded	machine cut at factory	3"x1/8"				374-470		1/4"x3/8" pea gravel	0-80	cement grout		Tredway park
10	66684	Active	Apr-1961	504	0-504	16"	0-504	1/4"	factory punched	1"x1/4"	150-160	222-234 280-288		450-496		3/8"	0-138	cement grout	2500 gpm at 63.8 ft, 4150 gpm at 79 ft, 4850 gpm at 82.6 ft	SW Corner of sec. 30
11	15369	Active	Jun-1971	490	+2-287 287-490	16" 12"	+2-490	1/4" welded	johnson well screen	#100 Slot		256-261 275-280		467-482		pea gravel	0-75	cement	2700 gpm at 110.5 ft, 2500 gpm at 107.9 ft, 2000 gpm at 103.4 ft, 1500 gpm at 99.4 ft, 1000 gpm at 95.5 ft	Cottonwood St./Whitehead School
12	56441	Active	Jul-1972	440	0-440	16"	0-440	1/4" welded	johnson screen	#100 Slot	188-198	248-260		406-424		pea gravel	0-100	cement grout		Ventura Industrial Park
13	89182	Active	Mar-1974	482	+1-243 243-482	16" 12.75"	+1-243 243-482	1/4" 5/16" welded	galy johnson well screen galvanized flatwire	#100 Slot	148-158	230-240 291-296		440-470		#21 mesh	0-71	neat cement grout	2900 gpm at 122 ft	Best Park
14	121326	Active	May-1975	436	0-228 228-436	16" 12"	0-436	1/4" welded	UOP Johnson flatwire #304 Stainless Steel "watermark"	#80 Slot		203-219 288-302		396-426		1/4" pea gravel	0-87	cement grout	1505 gpm at 91.7 ft, 1915 gpm at 98.2 ft, 2710 gpm at 106.3 ft, 3500 gpm at 121.8 ft	Freeway Park
15[b]	38492	Destroyed	Nov-1976	543	0-543	16"	0-543	5/16" steel	type 304 stainless steel	50 mesh		214-227 248-262	320-340	402-442	505-528	31 mix	0-81	cement grout		Campbell Park

Table 2-3. Summary of Production Well Information

Well ID [a]	State Well Number	Current Status	Date Constructed	Depth of Casing, feet	Casing Diameter		Casing Type		Screen Type	Perforation Size	Perforated Zones (Feet, bgs)					Gravel Pack	Sanitary Seal		Well Test Result	Location
					Zone, feet	Diameter	Zone, feet	Casing			100-200	200-300	300-400	400-500	500 +		Zone, feet	Sanitary Seal		
15S		Active (2011)	Dec-2009	650	0-650	18"	0-400 400-444 444-502 502-524 524-538 538-552 552-564 564-574 574-608 608-624 624-650	3/8" stainless steel 5/16" stainless steel 3/8" stainless steel 5/16" stainless steel 3/8" stainless steel 5/16" stainless steel 3/8" stainless steel 5/16" stainless steel 3/8" stainless steel 5/16" stainless steel 3/8" stainless steel	Louver	0.045"				400-444	502-524 538-552 564-574 608-624	8x6x12 SRI blend	0-347 460-470 582-591	11 sack sand bentonite bentonite		Campbell Park
16	38486	Active	Nov-1976	490	0-490	16"	0-490	5/16" steel	type 304 stainless steel	50 mesh		250-272 286-304	394-402	422-478		31 mix	0-99	cement	1300 gpm at 154.76 ft, 800 gpm at 124.1 ft, 1800 gpm at 124.1 ft	College St.
17	123418	Active	Mar-1977	513	0-513	16"	0-513	5/16"	johnson screen	30	140-150 174-184			412-442	496-505	21 mix	0-90	cement grout		Borchard
18	10953	Active	Aug-1977	634	+2-634	16"	0-634	5/16" steel	well screen	60 mesh				410-430 490-500	560-576 590-614	6-12 monterey sand	0-75	cement grout		Fairground
19	100076	Active	Apr-1980	470	0-470	16"	0-470	5/16" steel	type 304 stainless steel	.080"			320-340	420-460		31 mix	0-100	cement grout		Sutter Street
20	134765	Active	Jun-1980	490	+3-490	16"	0-490	5/16" steel	johnson screen	80	175-195	230-250		450-470		#31 mesh gravel	0-100	grout		West Court St.
21	134775	Active	Dec-1980	600	+3-600	16"	0-600	5/16" steel	stainless steel johnson screen	80		254-264	352-362	460-500	570-580	3:1	0-107	grout		North Park
22[b]	473587	Destroyed	Jan-1995	522	0-522	17.25" ID	0-522	0.375" steel	0.313" steel	.094"			338-356 386-404	476-512		4x8	0-284	cement	2436 gpm at 47.33 ft	East Gum Ave.
22G		Active (2011)	May-2010	670	0-670	18.75"	0-292 292-318 318-382 382-402 402-472 472-532 532-623 623-653 653-670	3/8" copper bearing 5/16" copper bearing 3/8" copper bearing 5/16" copper bearing 3/8" copper bearing 5/16" copper bearing 3/8" copper bearing 5/16" copper bearing 3/8" copper bearing	Ful Flo	0.045"		292-318	382-402	472-532	623-653	BCJ 6:8:16	0-252	11 sack sand		East Gum Ave.
24	719901	Active	Jan-2005	528	+3-528	18"	+3-260 260-300 300-528	ASTM A-139 grade B steel w/ 0.2% Copper 0.375" Type 304 SS 0.375" Type 304 SS 0.3125"	0.3125" type 304 stainless steel	0.080"			320-345 370-405		498-518	280'-285': 30 mesh 285'-533': SRI 6x12	0-280	12 sack cement		East Gibson Road
26	176973	Active	Jul-1988[b]	575	0-575	16"	0-515	0.375" wall collared	type 304 SS wire wrap	.050" slot			300-340 360-400	475-505		Lonestar #8 Sand Pack	0-125	cement		CR 102 and CR 25

[a] Tabulated information obtained from City records and DWR Drillers Reports.
[b] Wells 15 and 22 were offline as of 2008 due to excessive sand being pumped into the distribution system. Both wells were destroyed and redrilled. Well 15S was completed December 23, 2009 and Well 22G was completed May 26, 2010. The new wells are expected to be online in 2011.
[b] Pumping for the City of Woodland began in 2005.

Wellhead treatment is not currently provided at any of the City's wells. The current pumping capacity of the City's active wells is approximately 28,300 gpm, or 40.7 million gallons per day (mgd) assuming 24 hours of pumping.

The City does not have an existing SCADA system to provide remote operation and monitoring of its facilities. However, the City is installing a SCADA system to monitor all active facilities by the end of 2011.

2.2.2 Groundwater Characteristics

2.2.2.1 Groundwater Elevations and Flow

Generally, groundwater flow is from the margins of the Sacramento Valley toward the Sacramento River and then southward towards the Sacramento-San Joaquin Delta. Groundwater pumping in several areas has created cones of depression that disrupt this pattern. Historically, groundwater elevations in the region have ranged from roughly -20 feet to 50 feet mean sea level (msl). In the vicinity of Woodland, the base of fresh groundwater occurs at a depth of approximately 2,500 feet below msl, implying that the fresh water aquifer is about 2,500 feet thick (DWR, 1978).

Groundwater elevation measurements have been recorded in the Woodland area for over 50 years and are available through the DWR Water Data Library at http://wdl.water.ca.gov. Representative hydrographs for select wells in the Woodland area are shown in Appendix E. The hydrographs show that groundwater elevations generally declined from the 1950s to the 1970s. Groundwater elevations increased thereafter, in response to regional water supply projects implemented by Yolo County FC&WCD.

In addition to changes in groundwater elevations resulting from variation in land and water use practices over time, the hydrographs also show that groundwater elevation have fluctuated in response to changes in precipitation. As noted in Section 2.1.1.2, the area experienced multiple years of below normal precipitation in 1975 through 1977, 1987 through 1991 and more recently in 2007. These periods are apparent in the hydrographs (Appendix E). Groundwater elevations in the falls of 1977 and 1992 dropped significantly in relation to the average measurements. The maximum groundwater elevation measurements were recorded in spring 1983, the same year that the maximum annual precipitation was recorded (Figures 2-1 and 2-2).

Groundwater elevation contour maps depicting the range of groundwater elevations in the Woodland area are shown on Figures 2-13 through 2-16. Near minimum groundwater elevations exemplified by spring 1977 and fall 1977 are shown on Figure 2-13 and 2-14. Figure 2-15 shows the maximum groundwater elevations measured in spring 1983, and Figure 2-16 shows groundwater elevations measured in fall 1983.

2.2.2.2 Groundwater Quality

Groundwater quality varies by well. A summary of recent (i.e. 2006 through 2008) water quality concentrations are provided in Table 2-4. Appendix F contains time series plots for boron, nitrate, selenium, and TDS levels for each of the City's production wells.

Some constituents typically elevated in groundwater include chloride, iron, and manganese. None of the City's wells had detections of iron or manganese in recent years and chloride levels are far below California's Secondary Maximum Contaminant Level (MCL).

Another common groundwater constituent of concern for a drinking water supply, arsenic, was also not detected in most wells. All detections have been below the federal MCL of 10 µg/L. However additional monitoring should be conducted at Well 18, 24, and 26, where arsenic was recently detected above 4 µg/L.

TDS, a parameter with a Secondary MCL of 500 mg/L, was detected above the MCL in nine wells. Even wells that did not exceed the MCL for TDS had elevated concentrations. The TDS concentration in the City's well ranged from 680 mg/L in Well 1 to 330 mg/L in Well 26.

Boron is not a concern for drinking water supplies. However, boron is shown in Table 2-4 because it is a concern in wastewater discharge. The elevated boron levels shown in Table 2-4 show that the boron in the City's wastewater effluent originates in the City's groundwater supply. Boron is detected and elevated in all City wells, but is below the current annual average discharge limitation of 3,100 µg/L. However, the anticipated future long-term waste discharge limit for boron may be lower, based on the 700-µg/L agricultural water quality limit, and the City will need to supplement its groundwater supplies with improved source water from other supplies that have less boron. The City is currently planning on using surface water supply options, which would provide source water with significantly lower boron concentrations.

Metals such as total chromium and selenium were detected at levels well below their MCLs (both 50 µg/L) in all City wells. Total chromium, however, is a potential concern because, if the majority of the total chromium make-up is hexavalent chromium, a carcinogen, then the wells may not meet future water quality limits for this constituent. The City wells have not been tested for hexavalent chromium since 2004. Between 2002 and 2004 the average concentration of hexavalent chromium ranged from 11.2 µg/L in Well 20 to 33 µg/L in Well 22. The maximum concentration of hexavalent chromium in the City wells ranged from 12 µg/L in Well 18 to 35 µg/L in Well 9. Well 9 was inactivated in 2009 due to poor water quality. These elevated concentrations from 2002 through 2004 warrant additional monitoring for hexavalent chromium in the City's wells.

The wells with recent average nitrate concentrations over 30 mg/L are Well 1, 6, 10, 11, 13, 16, and 17. Well 10 was taken out of service in February 2007 due to its high nitrate concentration. After some modifications, Well 10 was placed back in service and is monitored closely for nitrates. Well 6, 11, and 17 have been recommended for replacement due to high nitrate concentrations and structural issues. Well 16 has been recommended for increased water quality monitoring. Despite the elevated nitrate concentrations in Well 1, the well will be operated as normal until its destruction, which is planned in the 2011 to 2012 timeframe.

Table 2-4. Concentrations of Constituents of Concern by Well (2006 - 2008)

	Water Quality Goal[a]	Well Number[b]																			
		1	4	5	6	9[c]	10	11	12	13	14	15	16	17	18	19	20	21	22	24	26
Arsenic, µg/L	10	ND (2)[d]	-[e]	ND (2)	-	-	ND (2)	ND (2)	ND (2)	ND (2)	ND (2)	ND (2)	2.3	-	*5.6*[f]	-	-	ND (2)	-	4.2	*4.6*
Boron, µg/L	3,100[g]	2,000	1,600	2,100	2,300	-	1,900	1,800	1,850	1,850	1,700	*2,150*	1,850	1,700	1,900	2,000	-	2,150	2,250	1,800	1,500
Chloride, mg/L	500	88	-	83	-	-	82	65	*100*	63	75	73	*64*	-	57	-	-	57	-	75	45
Chromium (Total), µg/L	50	*25*	-	27	-	-	21	*22*	15	*21*	13	*20*	*25*	-	10	-	-	13	-	12	ND (10)
Iron, µg/L	300	ND (100)	-	ND (100)	-	-	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	ND (100)	-	ND (100)	-	-	ND (100)	-	ND (100)	ND (100)
Manganese, µg/L	50	ND (20)	-	ND (20)	-	-	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)	ND (20)	-	ND (20)	-	-	ND (20)	-	ND (20)	ND (20)
Nitrate as NO_3, mg/L	45	*31.4*	*18.7*	28.4	**36.1**[h]	-	**40.3**	*31.6*	*23.9*	*33.6*	14.8	*26.7*	*30.9*	32.6	*21.3*	*23.4*	24.3	*23.4*	*26.9*	27.5	6.5
Selenium, µg/L	50[i]	ND (5)	-	5.7	-	-	ND (5)	ND (5)	ND (5)	6.3	ND (5)	4.8	*12*	-	7.5	-	-	2.3	-	23	4.9
TDS, mg/L	500	***680***[j]	-	***563***	-	-	***640***	***550***	***570***	***560***	**450**	***540***	***560***	-	**470**	-	-	**430**	-	***530***	330

[a] California Maximum Contaminant Levels (MCLs) unless otherwise noted. The limit shown for arsenic is the federal MCL.
[b] Concentrations shown are from samples taken in 2006 or later. Where more than one sample was collected between 2006 and 2008, the average concentration is shown.
[c] Wells #9, #10, #15, and #22 are no longer operational. Well #9 was taken out of service in September 2005 due to high nitrate concentration and sand production.
Well #10 was taken out of service in February 2007 due to high nitrate concentration. Well #15 and #22 were taken out of service in 2008 due to sand production.
Wells #15S and #22G are expected to be online by the end of 2010.
[d] Not detected (ND) at the method reporting limit shown in parentheses.
[e] A dash ("-") indicates that no samples were taken for that constituent at that particular well.
[f] Constituent concentrations that are trending upwards and are cause for concern are shown in italics.
[g] There are no state or federal MCLs for boron. However, Central Valley Regional Water Quality Control Board Waste Discharge Requirements Order R5-2009-0010 contains an annual average discharge limitation of 3,100 µg/L. The agricultural water quality limit is 700 µg/L.
[h] Results above 80% of the water quality goal are shown in boldface type.
[i] Central Valley Regional Water Quality Control Board Waste Discharge Requirements Order R5-2009-0010 contains a maximum daily discharge limitation of 9.2 µg/L and an average monthly discharge limitation of 3.2 µg/L.
[j] Results above the water quality goal are shown in italicized boldface type.

Figure 2-17 shows the recent average nitrate concentration for the City wells along with contours, which show the areas of the City that have the most serious nitrate concerns. The highest concentrations of nitrate tend to be found in the southwest area of the City, and the lowest nitrate concentrations tend to be found in the northeast and east areas of the City. If nitrate concentrations continue to rise, many wells may reach the end of their useful life sooner than the 30 to 50 years normally assumed.

2.2.3 Land Use

Figure 2-18 shows the generalized land use for the Yolo County area, which is predominately agricultural. The water supply associated with the land usage is shown on Figure 2-19. The agricultural water use in the vicinity of Woodland is a mixture of groundwater and surface water in the Yolo County FC&WCD service areas west and southwest of Woodland. Water use is predominately surface water in the RD 2035 service area east of Woodland. Groundwater use predominates in the areas outside of the Yolo County FC & WCD and RD 2035 service areas to the west, north and south of Woodland (Figure 2-19).

The City's existing land uses include residential, agricultural, commercial, professional, industrial, and open space. The City's Zoning Map (Figure 2-20) shows the City's future land use plan with the following land use categories:

- Agricultural
- Neighborhood Commercial
- General Commercial
- Service Commercial
- Highway Commercial
- Central Business
- East Street District
- Industrial
- Neighborhood Preservation
- Open Space
- Single Family Residential
- Duplex Residential
- Multiple Family Residential
- Spring Lake Specific Plan

This map, along with the City's Zoning Ordinance provides strict guidelines for what types of land use can occur on specific parcels within the City limits. In general, the planning zones are consistent with current land uses such as commercial, residential, and industrial. As the City grows, the City seeks to preserve Woodland's small-town atmosphere by maintaining the Downtown's central location and accessibility in the larger city. In 2003, the City updated the Downtown Specific Plan to provide additional direction and strategies for the continuing efforts to revitalize Downtown. The City will also encourage the development of residential neighborhoods to reflect a mix of housing types and sizes, similar to the existing city. However, the 2002 General Plan also provides for larger-lot, or executive housing, in planned new development. The City's 2002 General Plan expands the City's northeastern industrial area as the primary location for industrial development but also allows for additional industrial development north of Kentucky Avenue. Where industrial areas are adjacent to residential areas, the General Plan provides for buffering and limits on the types of industrial uses permitted.

2.2.4 Water Demands

2.2.4.1 Historical Water Demands

The City currently provides water service to nearly all residential, commercial, industrial, and institutional facilities within the City's limits. Private wells are used to serve the very few areas within the City limits that are not connected to the City's water system. Table 2-5 presents the historical annual groundwater production for the City. The water demands increased from 13,091 acre-feet in 1995 to a near-maximum of 16,690 acre-feet in 2008. Water demands declined after 2008 and were 13,921 acre-feet in 2010. Per capita demands are expected to decline due to implementation of a metering program and City water conservation efforts.

2.2.4.2 Projected Water Demands

The Sacramento Area Council of Governments (SACOG) recently updated their population projections to the year 2035 based on recent economic and housing trends. A downturn in the economy beginning in late 2007 resulted in slower than previously projected population growth for the Woodland area. Water meters have also been installed, and the State has approved Senate Bill 7 (SB 7), which requires water providers to reduce their per capita water use by 20 percent by the year 2020. In light of these changes, demand projections for the City were updated to reflect the most recent population projections and current information regarding anticipated per capita water use. Table 2-5 summarizes updated population and water demand estimates for the City. Updated assumptions are listed at the bottom of the table. Figure 2-21 is a graph of the historical groundwater production and projected demands listed in Tables 2-5 and 2-6.

2.2.5 Water Supplies

2.2.5.1 Existing Water Supply

The City currently relies exclusively on groundwater to meet the water demands of its customers. However, the City is currently working with the City of Davis and the University of California at Davis (UC Davis) on a joint water supply project that would bring surface water to the City from the Sacramento River. The project is currently in the planning and development phase, as described in Section 2.2.5.

Table 2-5. Historical Annual Groundwater Production

Year[a]	City-Produced Groundwater	
	Acre-feet	Million gallons
1995	13,091	4,266
1996	13,803	4,498
1997	15,346	5,001
1998	13,882	4,523
1999	17,166	5,594
2000	16,832	5,484
2001	17,018	5,545
2002	16,705	5,444
2003	15,917	5,186
2004	16,377	5,336
2005	15,253	4,970
2006	15,879	5,174
2007	16,560	5,396
2008	16,690	5,436
2009	15,330	4,993
2010	13,921	4,535

[a] 1995-1998 data from 2004 Surface Water Supply Project, (LTD Engineering, 2004).
1999-2004 data from the City of Woodland's 2005 Urban Water Management Plan (Kennedy/Jenks Consultants 2005).
2005-2010 data provided by City Public Works Department staff.

Table 2-6. Updated City of Woodland Population and Water Demand Estimates

Year	Estimated Population[(a)]	Average Per Capita Demand[(b)], gpcd	Annual Demand	
			Acre-feet	Million gallons
2015	56,300	260	16,408	5,347
2020	60,471	231	15,658	5,102
2025	64,147	231	16,610	5,412
2030	67,824	231	17,562	5,722
2035	71,500	231	18,514	6,033

Assumptions:

(a) Future population estimates are based on the updated projections developed by Sacramento Area Council of Governments (SACOG). Published projections available from SACOG provide population estimates for the years 2013, 2018, and 2035, a straight-line interpolation was used to determine the population projections for other years.

(b) Estimated per capita water demands in gallons per capita per day (gpcd) reflect the Senate Bill 7 (SB 7) requirement that water providers develop urban water use targets to achieve a statewide 20% reduction in urban water use by the year 2020.

2.2.5.2 Planned Water Supplies

The Woodland-Davis Clean Water Agency (WDCWA) is a joint powers authority including the Cities of Woodland and Davis and the UC Davis. The WDCWA is implementing a regional water supply project, known as the DWWSP, to divert, treat and convey Sacramento River water to their respective service areas. The DWWSP will allow the project partners to reduce their groundwater pumping rates, a shift that will facilitate compliance with existing and anticipated wastewater discharge requirements, ensure compliance with existing and anticipated drinking water standards, and help enable adaptive management in response to climate change. The DWWSP will divert surface water from the Sacramento River using a new water intake/diversion facility. The project will also include untreated and treated-water conveyance pipelines, and a new water treatment plant (WTP). Surface water diverted from the Sacramento River will consist of water appropriated for use by the DWWSP Partners and water purchased from users with senior water rights. Local groundwater will continue to be used but at a substantially reduced rate compared with the current usage. The DWWSP Partners anticipate that surface water deliveries will begin in 2016.

Based on the studies completed to date, the DWWSP Partners could ultimately divert up to approximately 45,000 acre-feet per year (afy) of surface water by the year 2040 to meet most of their municipal and industrial demands.

The DWWSP Partners have applied to the State Water Resources Control Board (SWRCB) for new water-right permits to divert unappropriated water from the Sacramento River. The new water-right permits would contain the SWRCB's Standard Water Right Permit Term 91. Term 91 imposes diversion limitations on certain junior water rights holders, including the DWWSP's new water-right permits, in the Sacramento Valley by prohibiting water diversions when satisfaction of in-basin entitlements require the release of supplemental water by the Central Valley Project or the SWP.

During periods when Term 91 is in effect, the DWWSP may use surface water acquired from one or more Sacramento River water users with senior water rights, or a local conjunctive use project involving Yolo County FC & WCD or RD 2035; or an alternate supply may be developed using Aquifer Storage Recovery (ASR) wells. The ASR wells would be used to store seasonally available treated surface water and to withdraw this water when surface water supplies are limited or unavailable. The volume of supplemental water needed on an annual basis would vary according to water year type (wet, normal, dry), the period during which Term 91 is in effect, and the mix of groundwater to be blended in each Partner's water distribution system.

There are multiple DWWSP objectives. One objective of the DWWSP is to provide a reliable water supply to meet existing and future needs. A second objective is to improve water quality for drinking supply purposes. A third objective is to improve treated wastewater effluent quality discharged by the City and the other DWWSP Partners through 2040.

These objectives have been developed by the City and its DWWSP Partners in response to challenges posed by aging water systems, more stringent drinking water and wastewater discharge standards and regulations, and in response to adopted plans that anticipate increases in water demand through 2040.

2.3 KNOWN GROUNDWATER MANAGEMENT ISSUES

There are three main groundwater management issues regarding the groundwater used by the City. These include: (1) groundwater supply during dry years; (2) groundwater quality; and (3) inelastic land subsidence.

2.3.1 Issue 1: Groundwater Supply during Dry Years

The City currently relies exclusively on groundwater to meet its water demand. Dry conditions during the 2007 to 2009 period led to concerns that groundwater levels could decrease to levels that could adversely affect the City's ability to meet emergency, peak hour or maximum day demand requirements.

Decreasing groundwater elevations associated with multiple years of drought can lead to an increase in system head. Pump capacity decreases as overall head increases; this can lead to an inability to meet emergency, peak hour or maximum day demand requirements.

A preliminary assessment of the potential impact of drought conditions on the City's municipal groundwater pumping capacity is included in Appendix G. The study concluded that lowering of groundwater levels due to dry conditions could affect the City's ability to meet short-term demands given the current level of demand, number of wells and the pump depth settings in the wells.

2.3.2 Issue 2: Groundwater Quality

Constituents of concern found within the City's municipal production wells include TDS, nitrate, boron, selenium, and chromium.

TDS is above the MCL in half of the City's production wells. Most other wells have elevated TDS concentrations.

Multiple City production wells have recent average nitrate concentrations over 30 mg/L. Due to high nitrate concentrations one well has been taken out of service, three wells have been recommended for replacement, and one well has been recommended for increased water quality monitoring. If nitrate concentrations continue to rise, many wells may reach the end of their useful life sooner than the 30 to 50 years normally assumed.

Boron is detected and elevated in all City wells, but is significantly below the potential interim performance-based effluent limit. However, the anticipated future long-term waste discharge limit for boron is 700 µg/L, and the City will need to supplement its groundwater supplies with other supplies that have less boron.

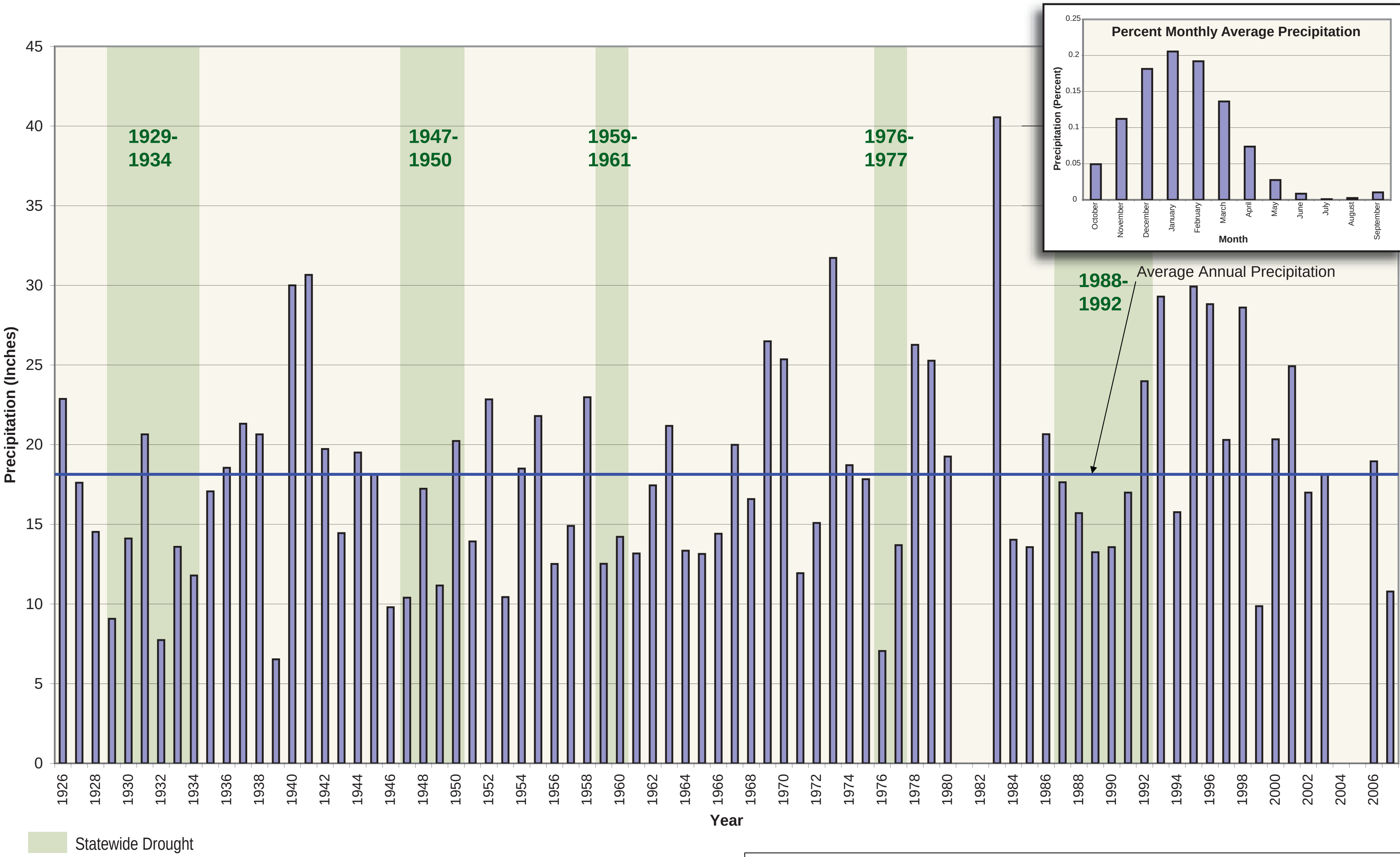
Metals such as total chromium and selenium were detected at concentrations below their MCLs (both 50 µg/L) in all City wells. Total chromium, however, is a potential concern because, if the majority of the total chromium is hexavalent chromium, a carcinogen, then some of the wells may not meet future drinking water standards. City wells have not been tested for hexavalent chromium since 2004 when the average concentration in all City wells, except for Well 26 which has never been tested for hexavalent chromium, exceeded 10 µg/L.

2.3.3 Issue 3: Inelastic Land Subsidence

Differential land subsidence and associated earth fissuring resulting from groundwater withdrawal have had significant consequences in several California groundwater basins, and significant land subsidence has been measured in Yolo County. Based on surveys conducted by the Yolo County Subsidence Monitoring Network, approximately three inches of subsidence have occurred in the City service area from 1999 to 2006.

Significant damage has occurred to municipal well casings in the City and to other wells in Yolo County during past droughts, such as occurred from 1976 to 1977 and 1986 to 1992.

The risk of future significant impacts depends on a complex array of variables including: the degree of new groundwater development, especially in areas or at depths not previously exploited; changing land use, which could bring to light an impact that would otherwise go unnoticed; and the mineral composition and consolidation history of the aquifer skeleton.



Notes:
Data were incomplete for 1981, 1982, 2004 and 2005 and are not graphed. Data for March 1983 missing. Replaced with March 1983 data from Station Davis 2WSW, Davis, CA.

References:
California Data Exchange Center (CDEC) at http://cdec.water.ca.gov, Station Woodland WNW, Woodland, CA.
Governor's Advisory Drought Planning Panel, 2000, Critical Water Shortage Contingency Plan, December 29.

Figure 2-1

City of Woodland
Groundwater Management Plan

HISTORICAL PRECIPITATION,
WOODLAND, CALIFORNIA, 1926-2007

WOODLAND

WEST YOST
ASSOCIATES
Consulting Engineers

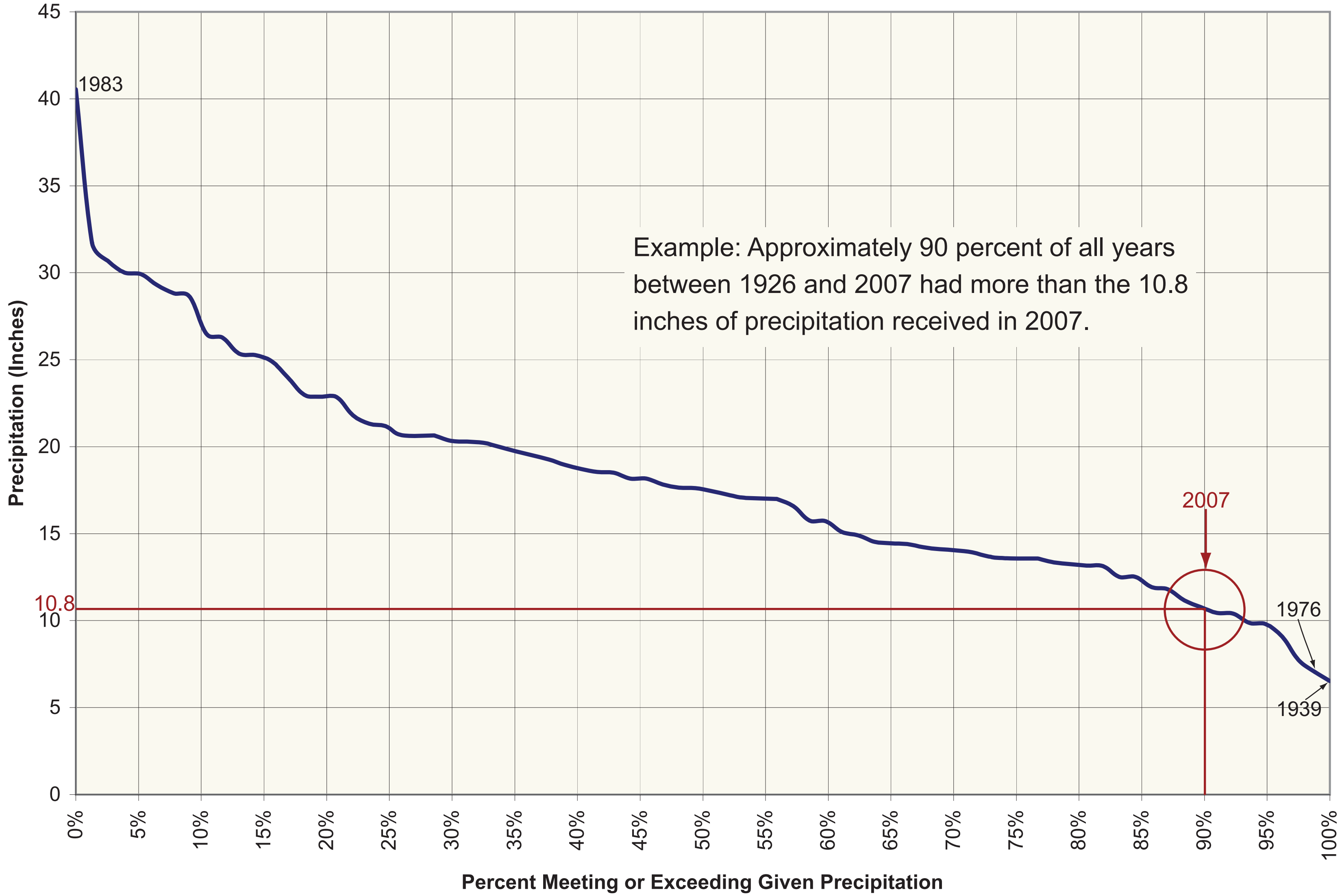


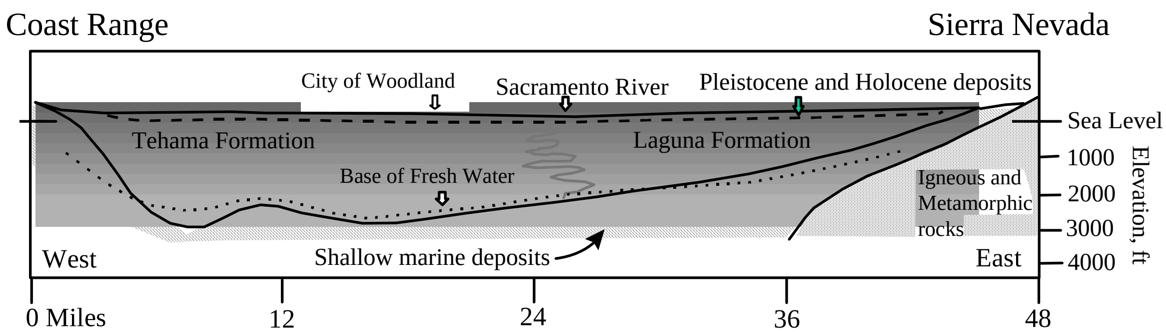
Figure 2-2

City of Woodland
Groundwater Management Plan

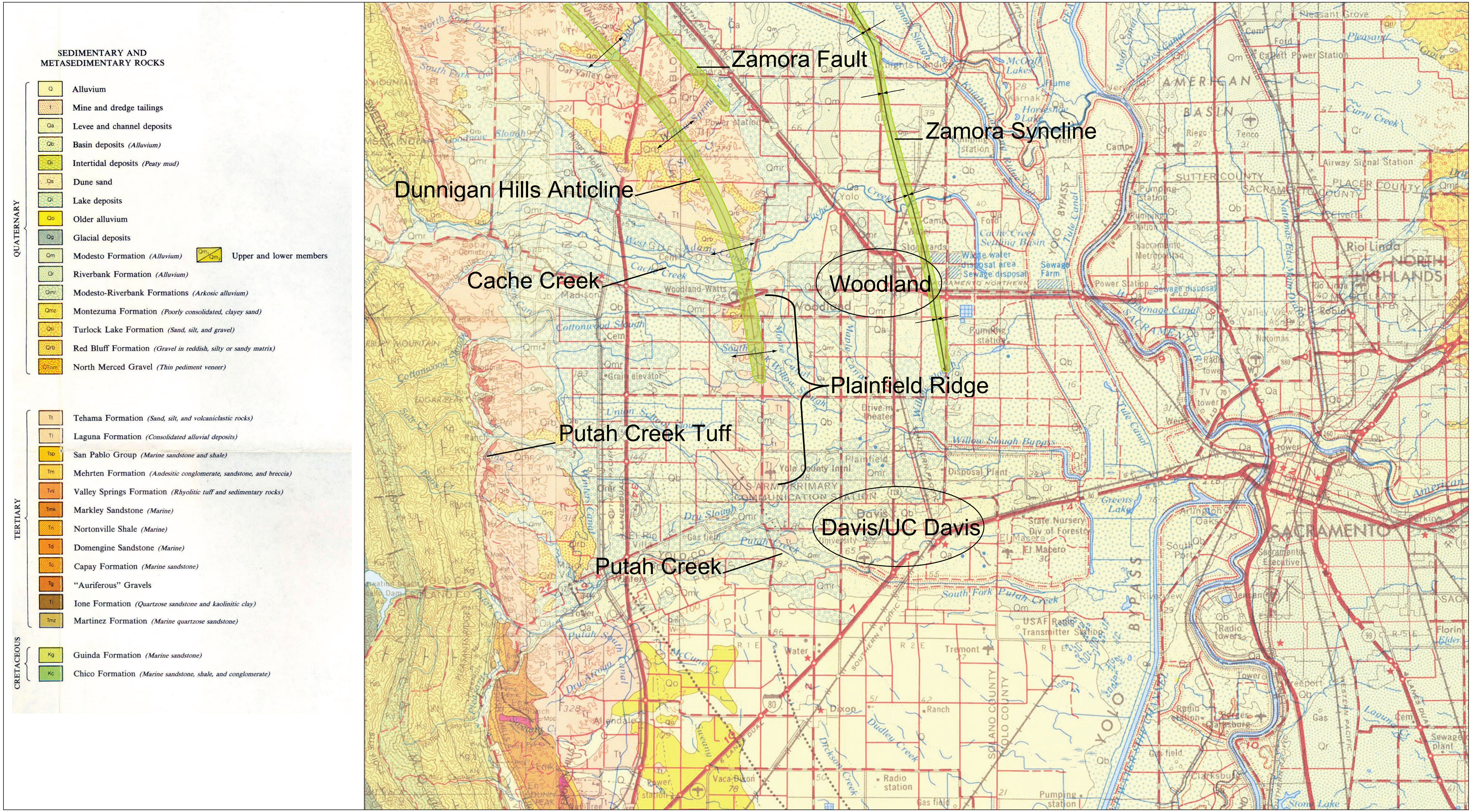
PRECIPITATION EXCEEDANCE CURVE,
WOODLAND, CALIFORNIA, 1926-2007

WOODLAND
WEST YOST ASSOCIATES
Consulting Engineers

Figure 2-3. Generalized Cross Section of the Southern Sacramento Valley



Source: California Department of Water Resources, 1978



References:
California Geological Survey, 1981, Geologic Map of the Sacramento Quadrangle, compiled by D.L. Wagner, C.W. Jennings, T.L. Bedrossian and E.J. Bortugno, 1:250,000, second printing 1987.

California Geological Survey, 1982, Geologic Map of the Santa Rosa Quadrangle, compiled by D.L. Wagner and E.J. Bortugno, 1:250,000, second printing 1999.

Harwood, D.S. and E.J. Helley, 1987, U.S. Geological Survey Professional Paper 1359, Late Cenozoic Tectonism of the Sacramento Valley

N

Not to scale.

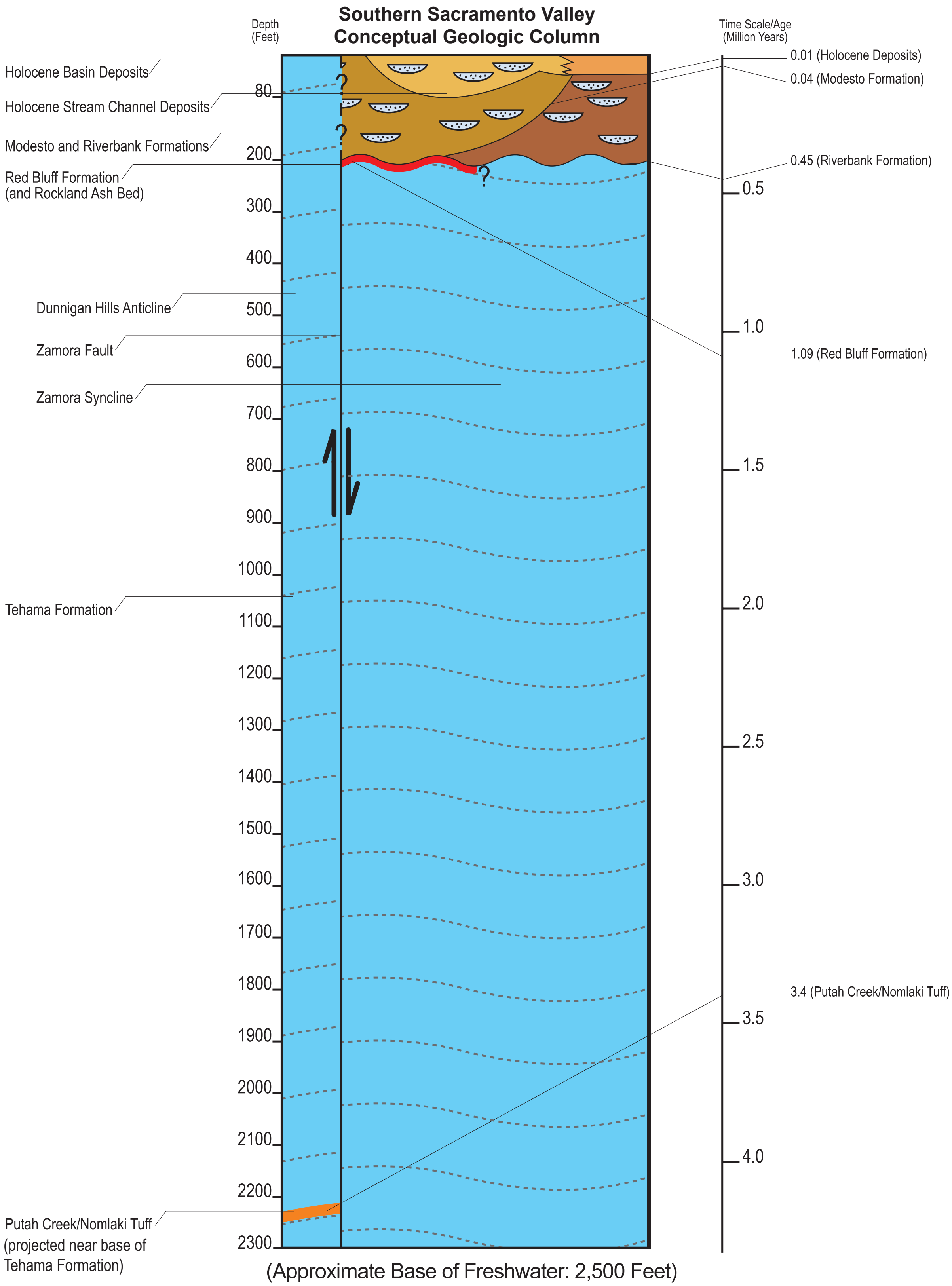
Figure 2-4

City of Woodland Groundwater Management Plan

GEOLOGIC MAP

WOODLAND

WEST YOST ASSOCIATES Consulting Engineers



References:

California Geological Survey, 1981, Geologic Map of the Sacramento Quadrangle, compiled by D.L. Wagner, C.W. Jennings, T.L. Bedrossian and E.J. Bortugno, 1:250,000, second printing 1987.

California Geological Survey, 1982, Geologic Map of the Santa Rosa Quadrangle, compiled by D.L. Wagner and E.J. Bortugno, 1:250,000, second printing 1999.

Harwood, D.S. and E.J. Helley, 1987, U.S. Geological Survey Professional Paper 1359, Late Cenozoic Tectonism of the Sacramento Valley

California Department of Water Resources, 1978, Evaluation of Groundwater Resources: Sacramento Valley, Bulletin 118-6, prepared in cooperation with the U.S. Geological Survey, August.

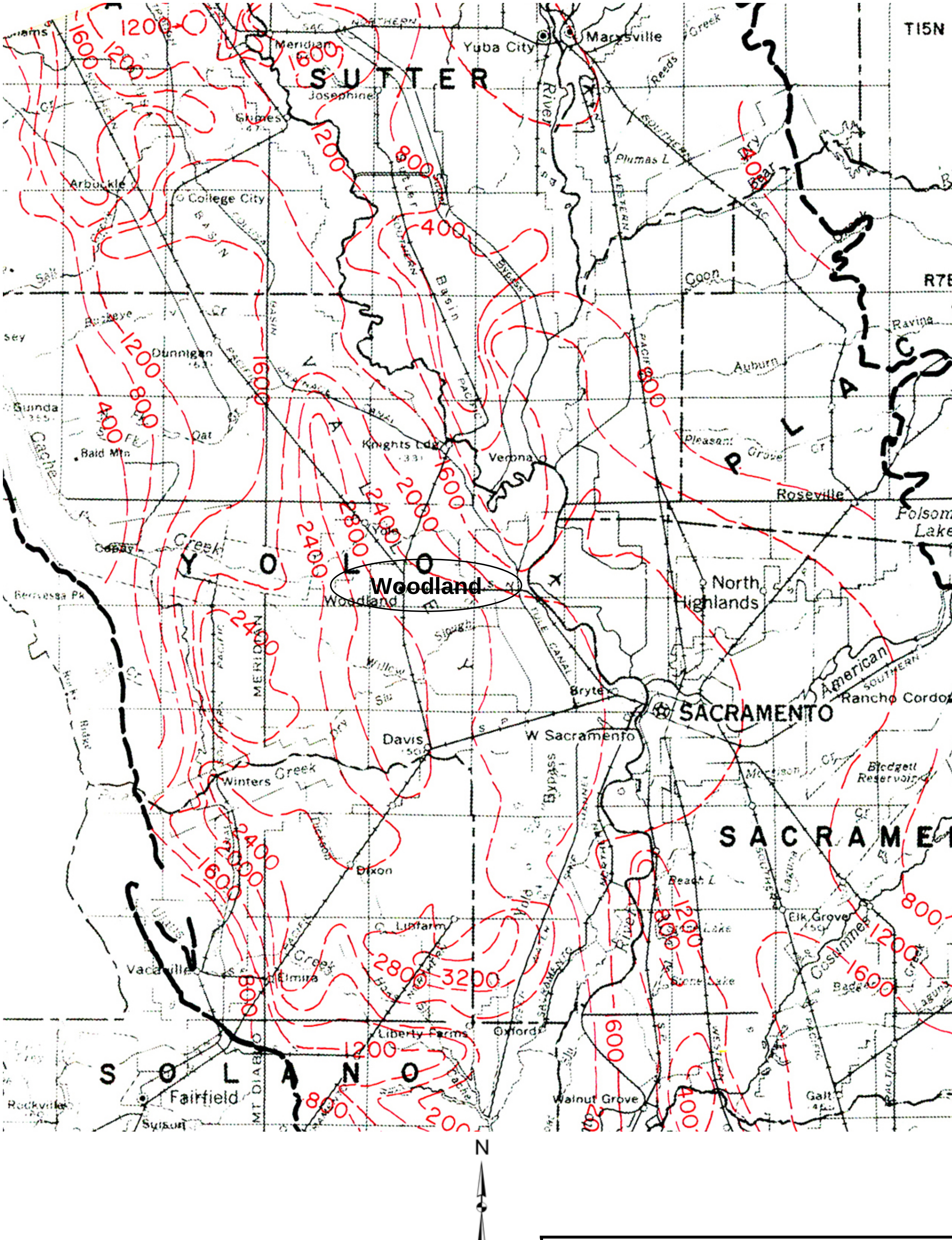
Figure 2-5

City of Woodland
Groundwater Management Plan

SOUTHERN SACRAMENTO VALLEY
CONCEPTUAL GEOLOGIC COLUMN

WOODLAND

WEST YOST ASSOCIATES
Consulting Engineers



Not to Scale

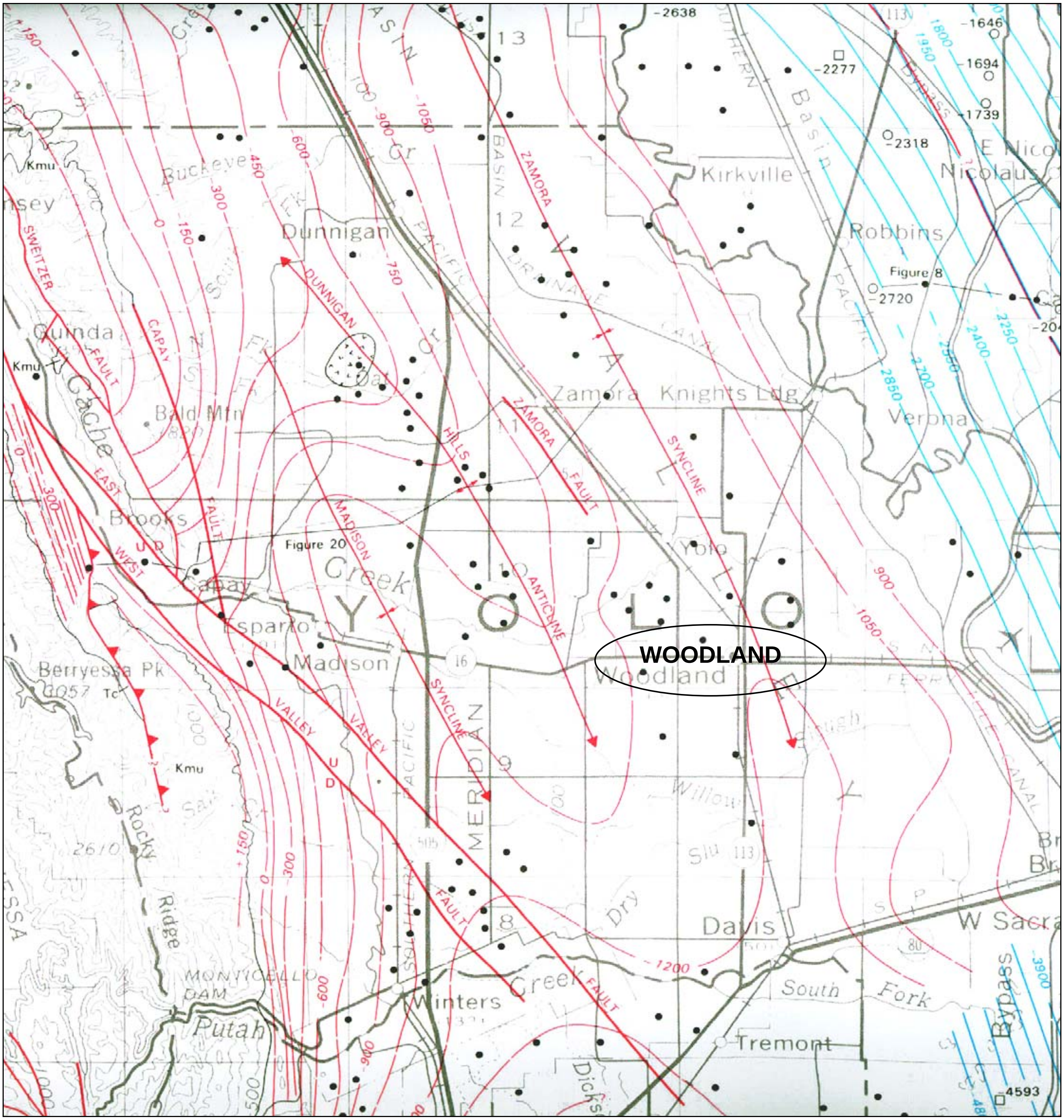
Note: Contours are in feet.

Reference:
California Department of Water Resources, 1978
Evaluation of Groundwater Resources: Sacramento Valley, Bulletin 118-6, prepared in cooperation with the U.S. Geological Survey, August.

Figure 2-6

CITY OF WOODLAND
Groundwater Management Plan

BASE OF FRESH WATER
CONTOUR MAP



N

Not to Scale

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

Figure 2-7
City of Woodland
Groundwater Management Plan

Structural Contour Map

N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 2-8 Soils.mxd 11/9/2010

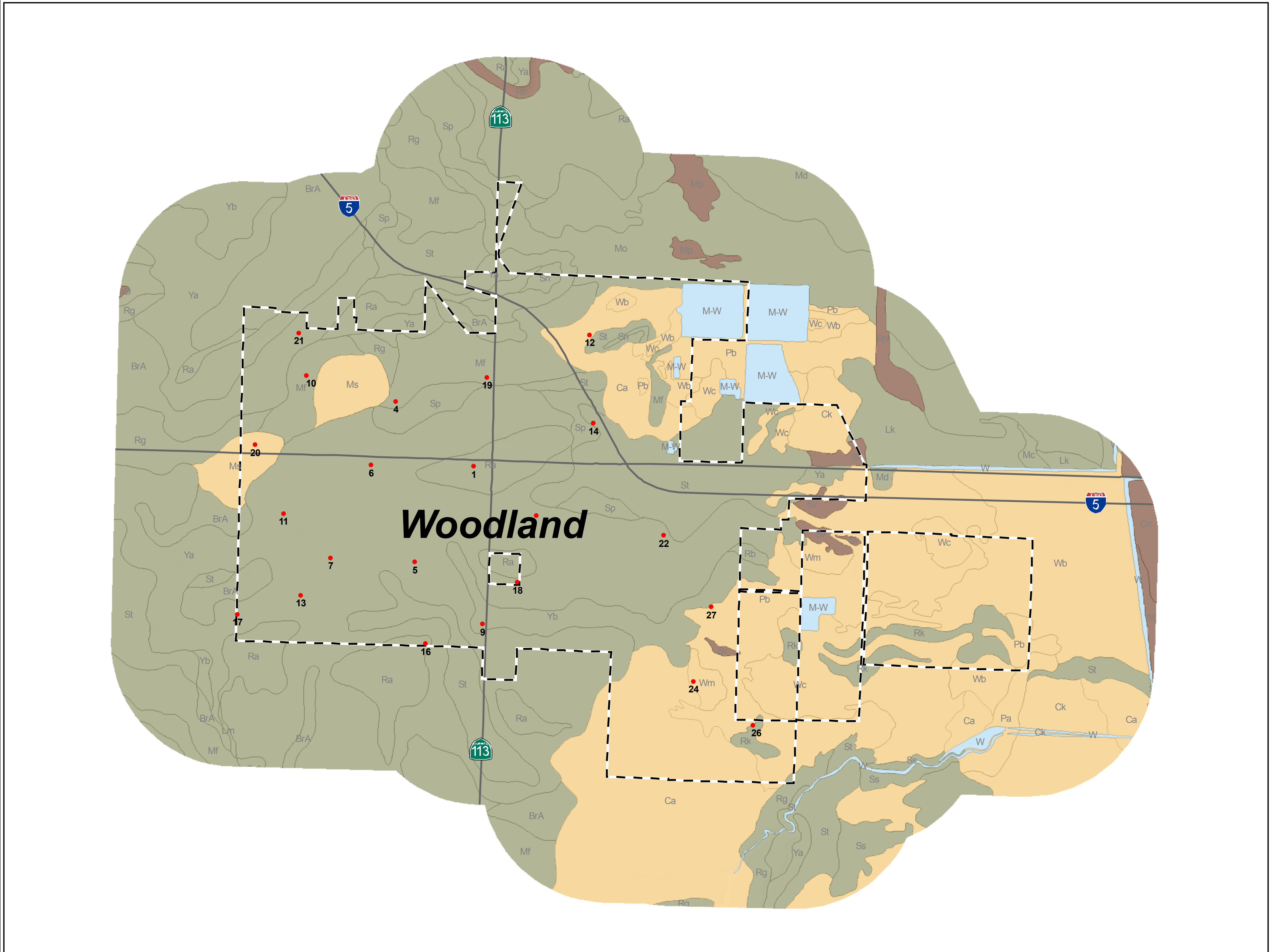


FIGURE 2-8

City of Woodland Groundwater Management Plan

SOIL SERIES MAP

N

0 2,000 4,000

Scale in Feet

Notes

1. Reference: U.S. Department of Agriculture, Natural Resources Conservation Service, 2007, Soil Survey Geographic (SSURGO) database for Yolo County, California: Fort Worth, Texas, U.S. Department of Agriculture, Natural Resources Conservation Service, ca113, http://SoilDataMart.nrcs.usda.gov/

2. Soils within 1 mile of the City's boundary consist of approximately 67% loam, 29% clay and 4% other material.

LEGEND

- City of Woodland Production Well
- City limit
- County Boundary

City of Woodland Soils

(1 mile buffer)

- Clay
- Loam
- Water
- Other
- Ca NRCS Soil Series

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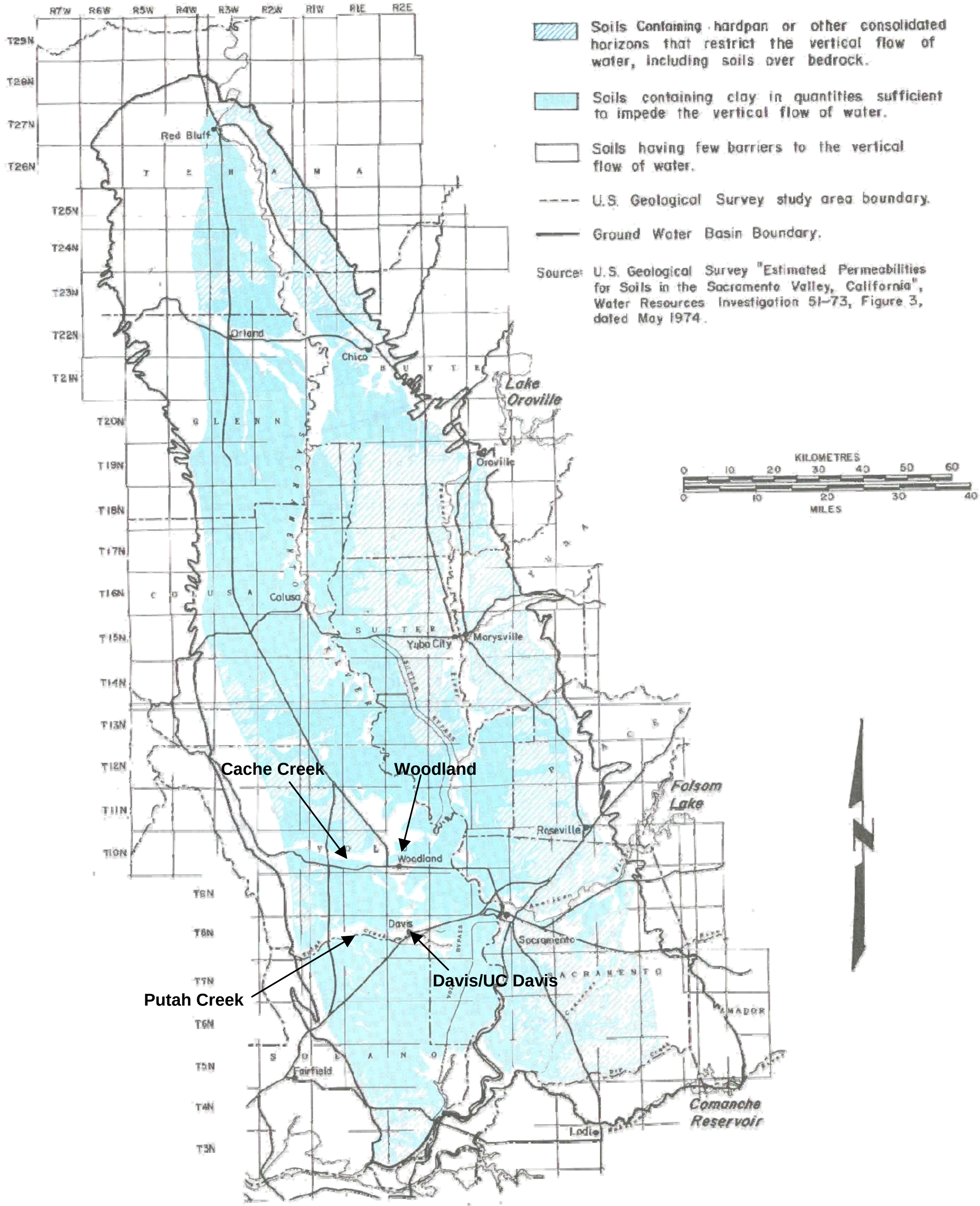

Reference:
California Department of Water Resources Bulletin 118-6, Evaluation of Groundwater Resources: Sacramento Valley, August 1978

Figure 2-9

CITY OF WOODLAND
Groundwater Management Plan

RELATIVE PERMEABILITY OF YOLO COUNTY SOILS

N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 2-10 Subsidence.mxd 2/11/2011

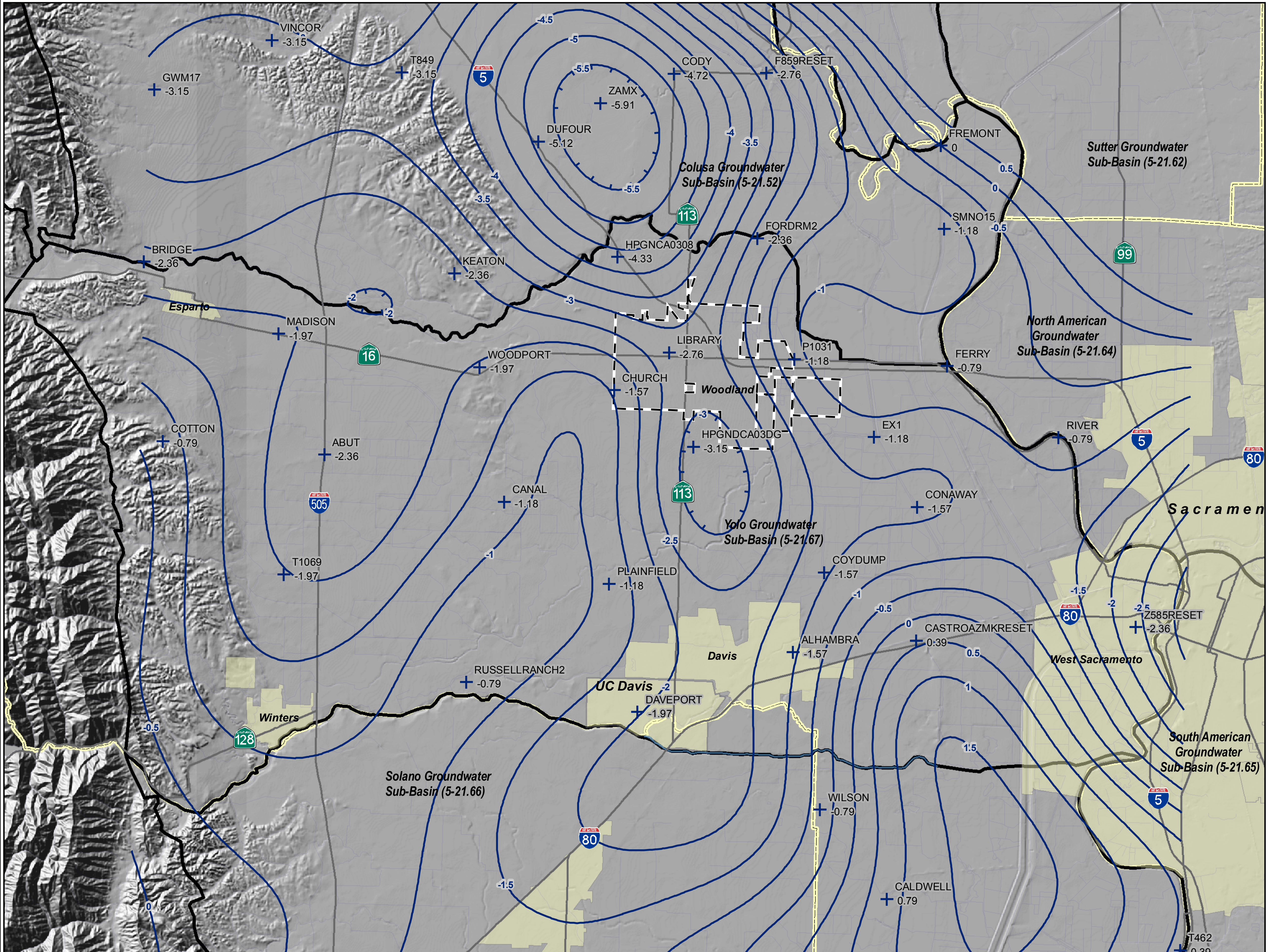

FIGURE 2-10

City of Woodland Groundwater Management Plan

INELASTIC LAND SUBSIDENCE, 1999 - 2005

N

0 7,000 14,000

Scale in Feet

NOTES:
1. Land subsidence data is collected by the Yolo County GPS Subsidence Network.

LEGEND

Subsidence Benchmark ID
1999 - 2005 Land Subsidence (in)
Land Subsidence Contours (in)
City limit
DWR Groundwater Basin
County Boundary

WOODLAND

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N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 2-11 Wells.mxd 2/10/2011

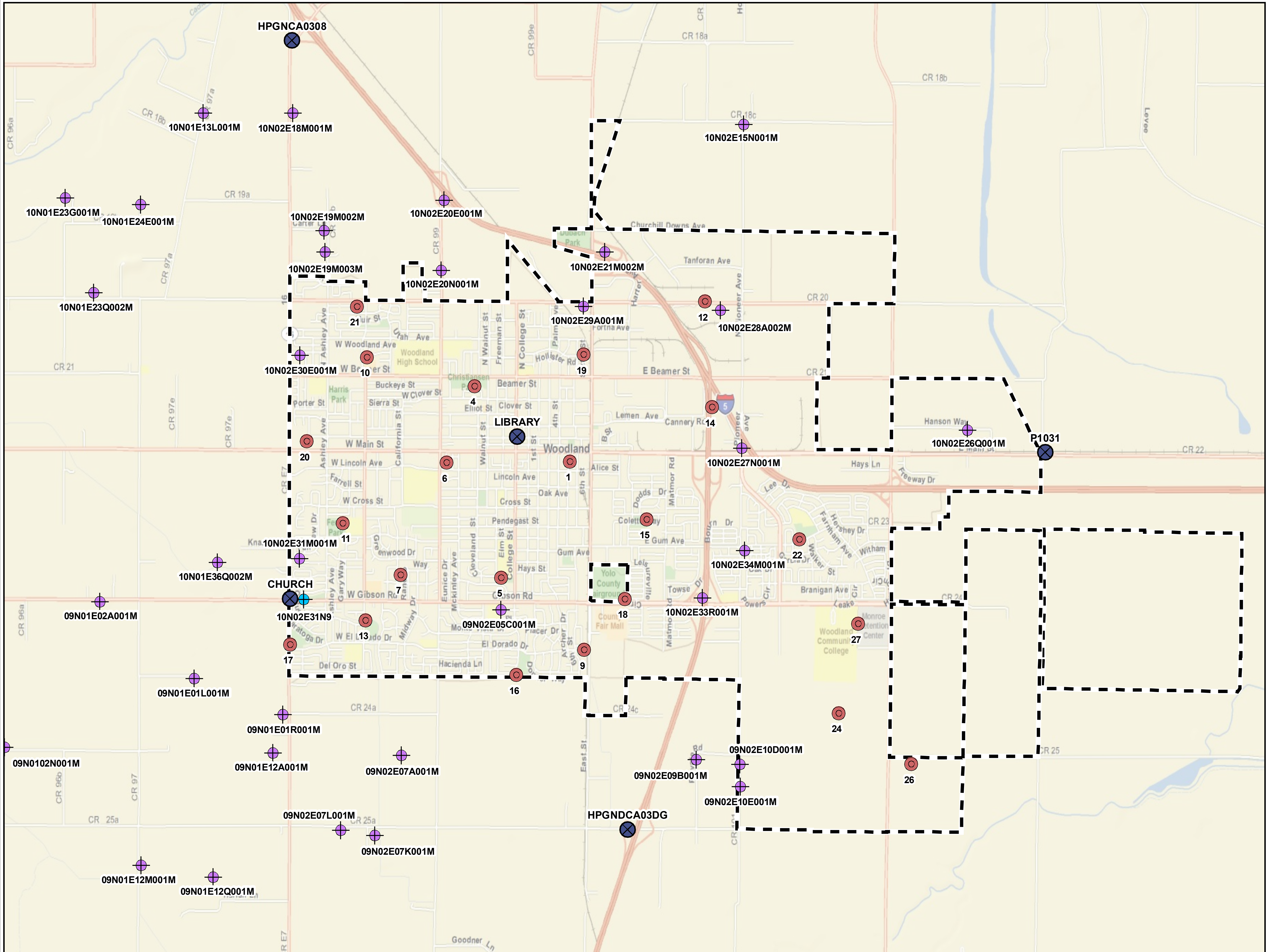

FIGURE 2-11

City of Woodland
Groundwater Management Plan

Monitoring Wells and City of Woodland Production Wells

N

0 1,666.5 3,333

Scale in Feet

NOTE:
1. The City of Woodland's multiple-completion monitoring well consists of two sets of nested wells, MW1 and MW2, situated approximately 20 feet apart.
MW1 contains four nested wells:
MW1A (10N02E31N901M),
MW1B (10N02E31N902M),
MW1C (10N02E31N903M), and
MW1D (10N02E31N904M).
MW2 contains two nested wells:
MW2A (10N02E31N905M) and
MW2B (10N02E31N906M).

LEGEND

- City of Woodland Multiple-Completion Monitoring Well
- DWR Monitoring Well
- Subsidence Benchmarks
- City of Woodland Production Well
- City of Woodland City Limits

WOODLAND

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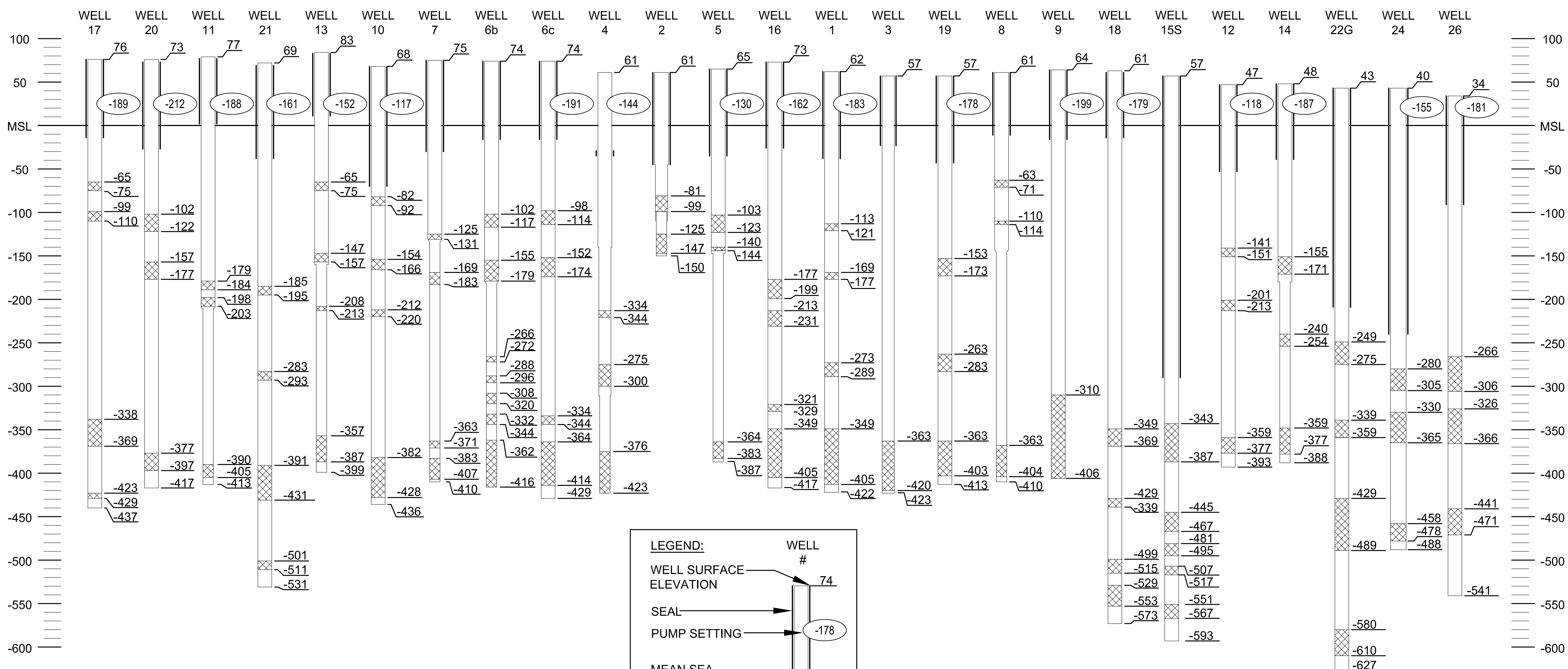

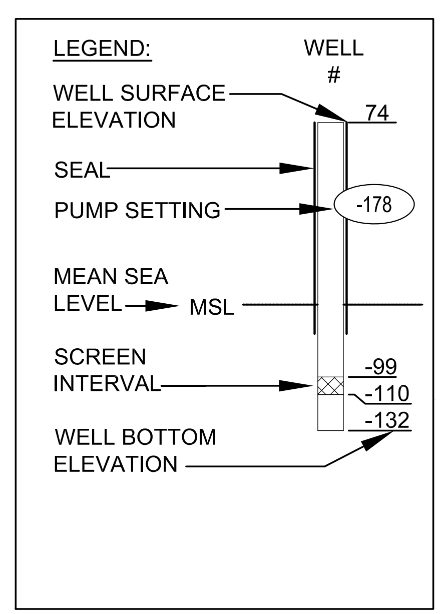

NOTE:
WELLS 2, 3, 6b, 7 AND 8 HAVE BEEN DESTROYED.
WELLS 15 AND 22 WERE OFFLINE AS OF 2008. BOTH WELLS HAVE BEEN DESTROYED AND REDRILLED.
WELL 15S WAS COMPLETED DECEMBER 2009 AND WELL 22G WAS COMPLETED MAY 2010.

Figure 2-12
City of Woodland
Ground Water Management Plan
DEPTH, SCREEN INTERVALS & PUMP SETTINGS FOR PRODUCTION WELLS

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Consulting Engineers

N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\CAD\Figures\Well Details\20400-0818Fig2-12.dwg 2/10/2011 2:05 PM areimer

N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 2-13 Spring 1977.mxd 2/10/2011

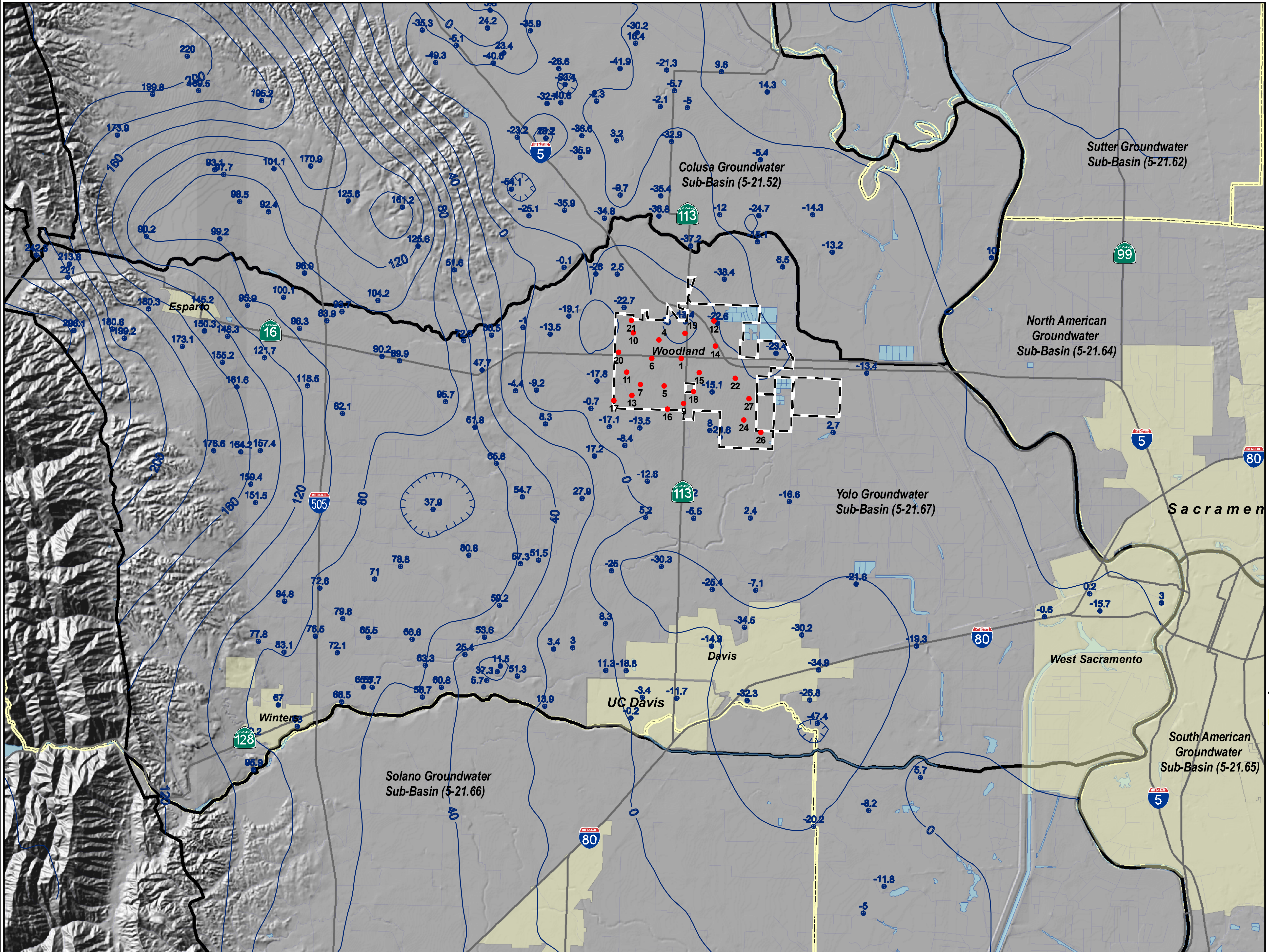

FIGURE 2-13

City of Woodland Groundwater Management Plan

SPRING 1977 GROUNDWATER ELEVATION CONTOURS

N

0 7,000 14,000

Scale in Feet

LEGEND

- City of Woodland Production Well
- DWR Monitoring Well with Groundwater Elevation (feet)
- Groundwater Elevation Contour (20-foot interval)
- City limit
- DWR Groundwater Basin
- County Boundary

WOODLAND

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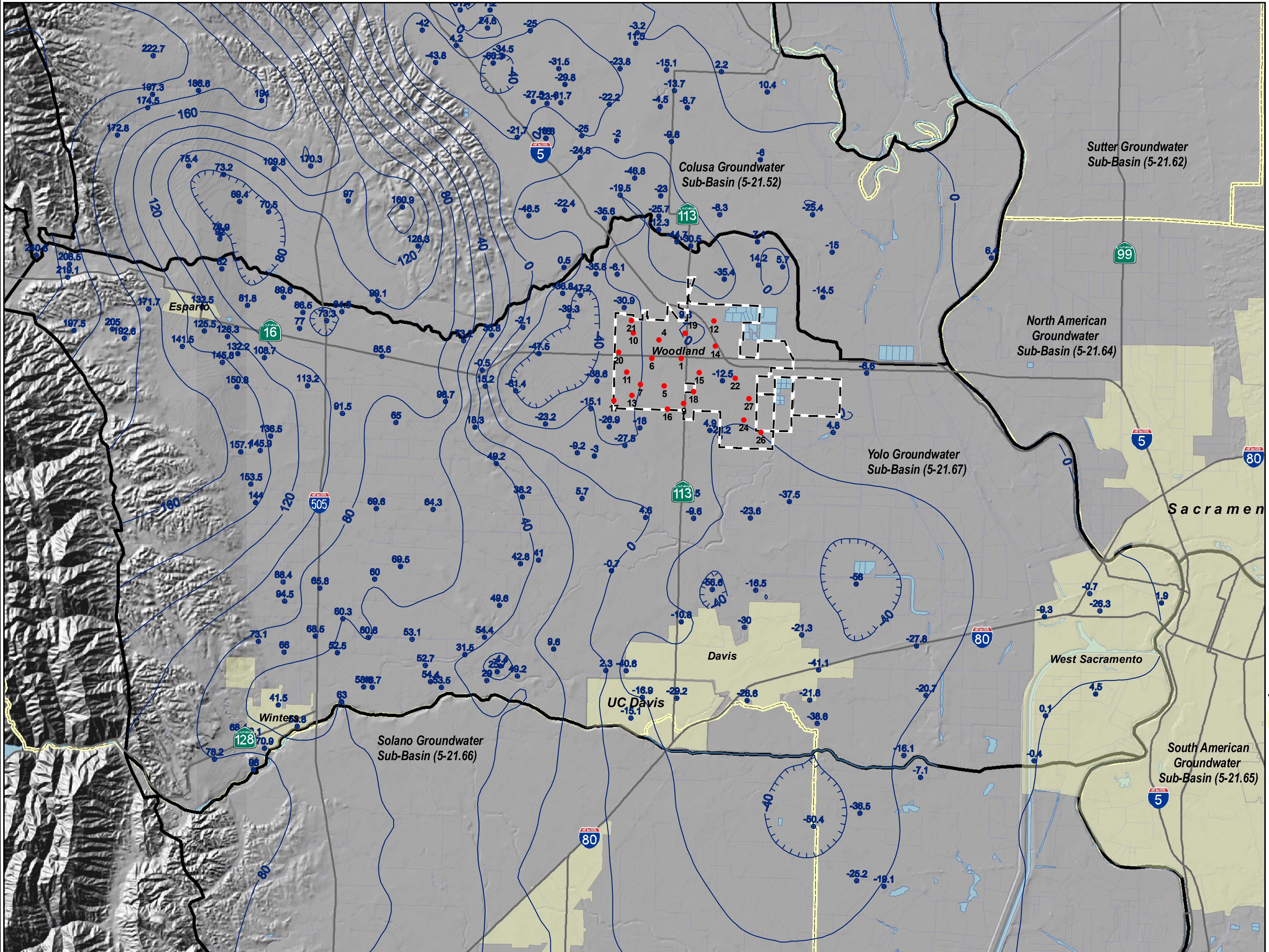

FIGURE 2-14

City of Woodland Groundwater Management Plan

FALL 1977 GROUNDWATER ELEVATION CONTOURS

N

0 7,000 14,000

Scale in Feet

LEGEND

- City of Woodland Production Well
- DWR Monitoring Well with Groundwater Elevation (feet)
- Groundwater Elevation Contour (20-foot interval)
- City limit
- DWR Groundwater Basin
- County Boundary

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N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 2-15 Spring 1983.mxd 2/10/2011

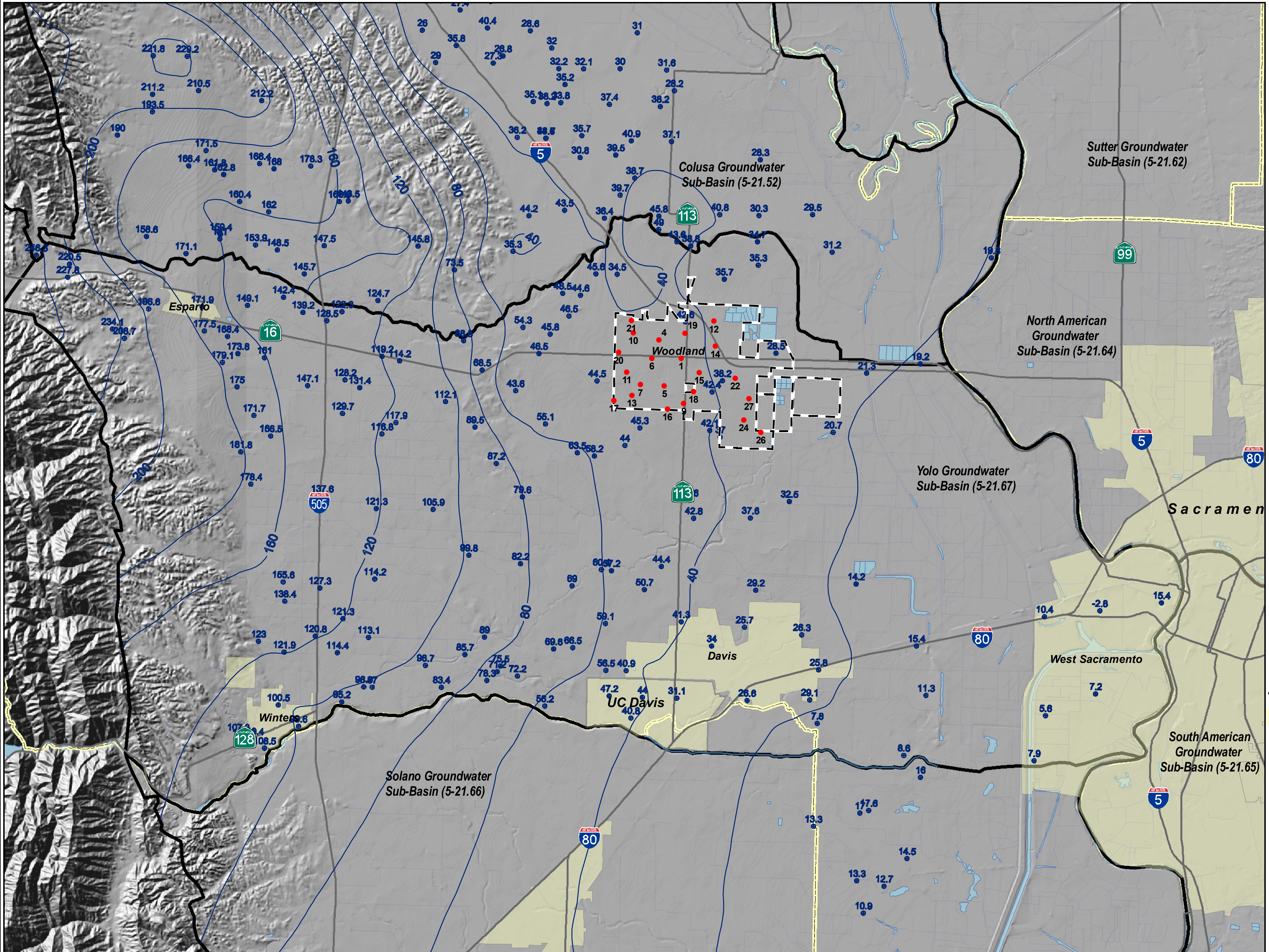

FIGURE 2-15

City of Woodland
Groundwater Management Plan

SPRING 1983 GROUNDWATER ELEVATION CONTOURS

N

0 7,000 14,000

Scale in Feet

LEGEND

- City of Woodland Production Well
- DWR Monitoring Well with Groundwater Elevation (feet)
- Groundwater Elevation Contour (20-foot interval)
- City limit
- DWR Groundwater Basin
- County Boundary

WOODLAND

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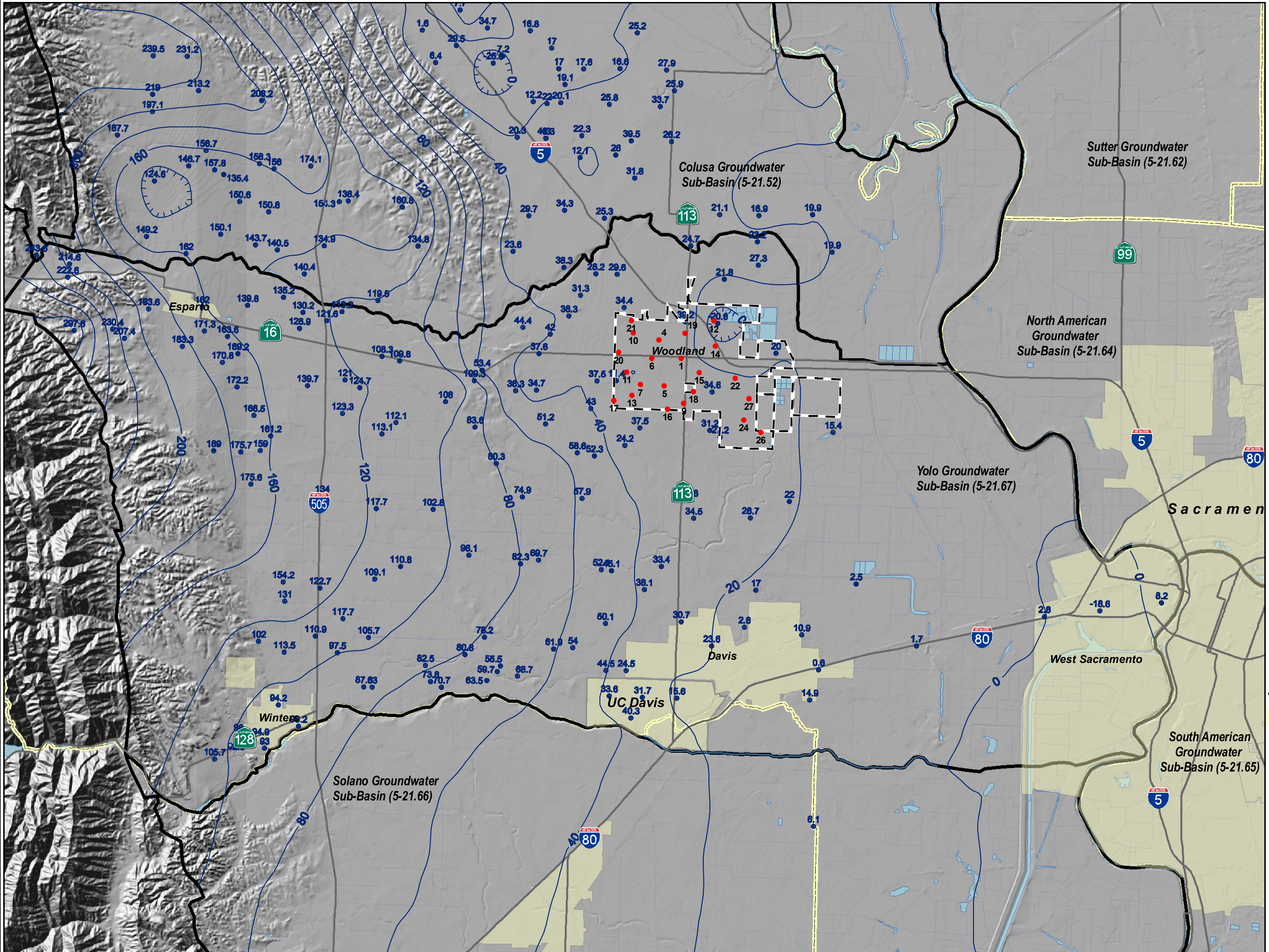
FIGURE 2-16

City of Woodland Groundwater Management Plan

FALL 1983 GROUNDWATER ELEVATION CONTOURS



0 7,000 14,000
Scale in Feet

LEGEND
- City of Woodland Production Well
- DWR Monitoring Well with Groundwater Elevation (feet)
- Groundwater Elevation Contour (20-foot interval)
- City limit
- DWR Groundwater Basin
- County Boundary

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N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 2-17 Nitrate Spatial Trends.mxd 2/10/2011

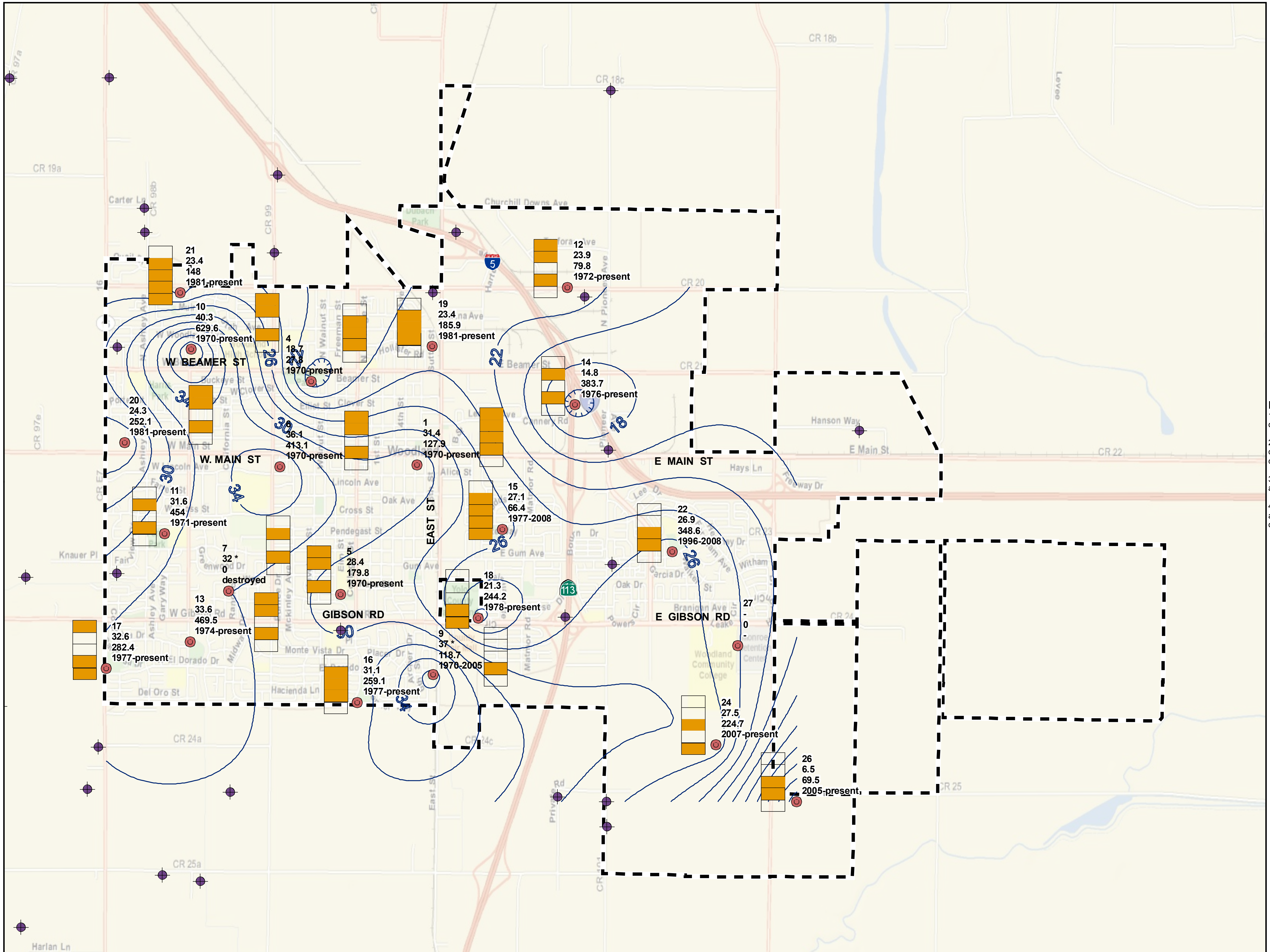

FIGURE 2-17

City of Woodland Groundwater Management Plan

SPATIAL TRENDS IN NITRATE CONCENTRATIONS

N

0 1,500 3,000
Scale in Feet

Notes

1. Nitrate concentration for Well 7 obtained from sample collected on 5/22/2003.

2. Nitrate concentration from Well 9 obtained from sample collected on 9/29/2005. Well 9 was destroyed in 2009 due to poor water quality.

3. Well 15 and Well 22 were offline as of 2008. Replacement wells are expected to be online by the end of 2010.

4. Well 1 is currently scheduled to be replaced by the end of 2011 and will be renamed as Well 28. Well 28 is expected to be operational by spring of 2012.

LEGEND

DWR Monitoring Well

City of Woodland Production Well

16	Well ID
31.1	NO_3 - NO_3 (mg/l, 2006 - 2008 average)
258.1	Avg. Annual Production (mg)
1977-present	Operation Range (Start - End)

Orange shading indicates presence of screen

100' - 200'
200' - 300'
300' - 400'
400' - 500'
500' +

34 Nitrate Contour Line

City Limit

WOODLAND

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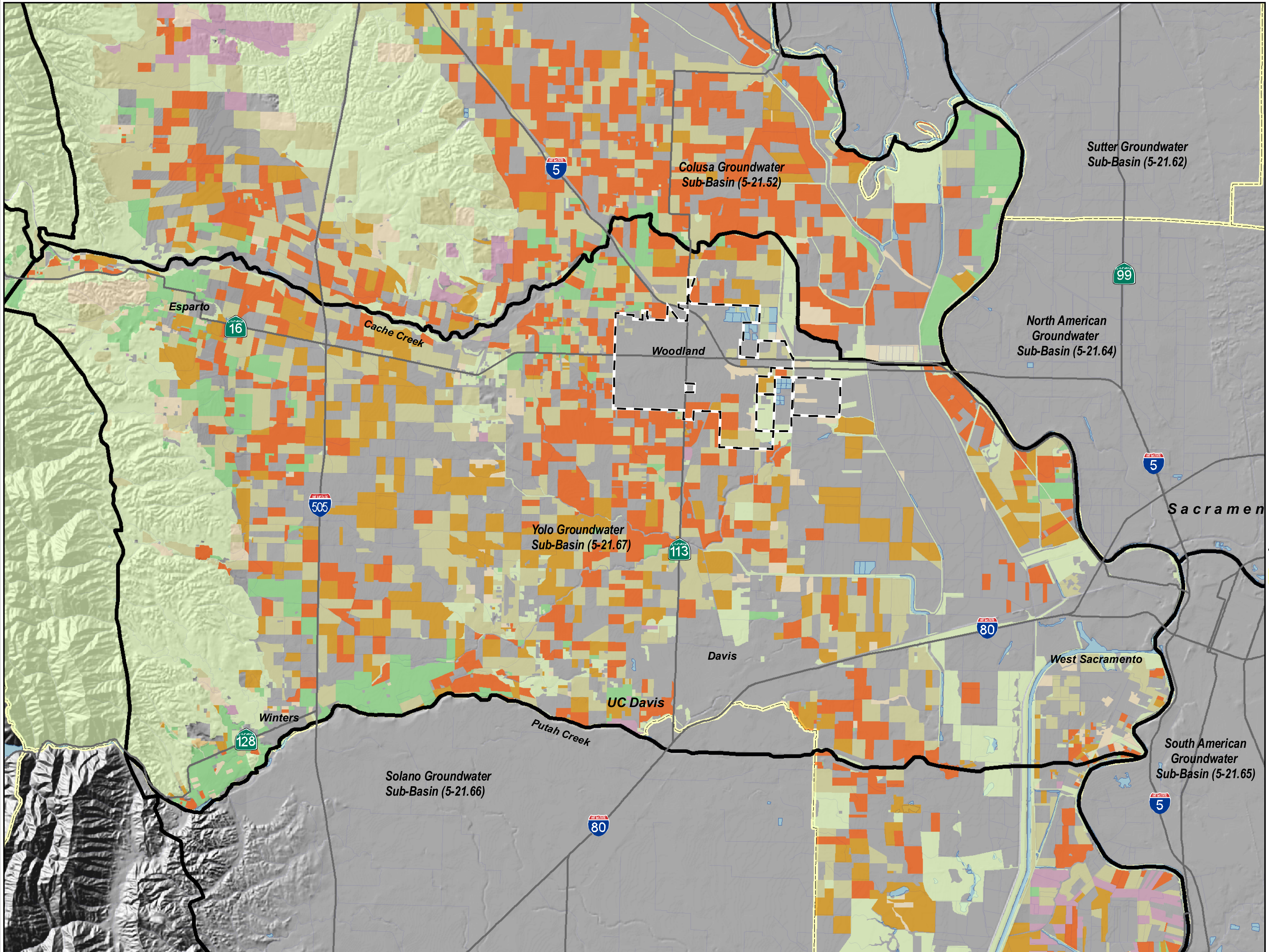
N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 2-18 Land Use.mxd 2/10/2011

FIGURE 2-18

City of Woodland
Groundwater Management Plan

GENERALIZED LAND USE



N

0 7,000 14,000
Scale in Feet

LEGEND

- City limit
- DWR Groundwater Basin
- County Boundary

DWR Land Use Category (1997)

- Subtropical
- Deciduous Fruits and Nuts
- Grain and Hay Crops
- Idle
- Pasture
- Truck and Berry Crops
- Vineyards
- Native Vegetation

WOODLAND

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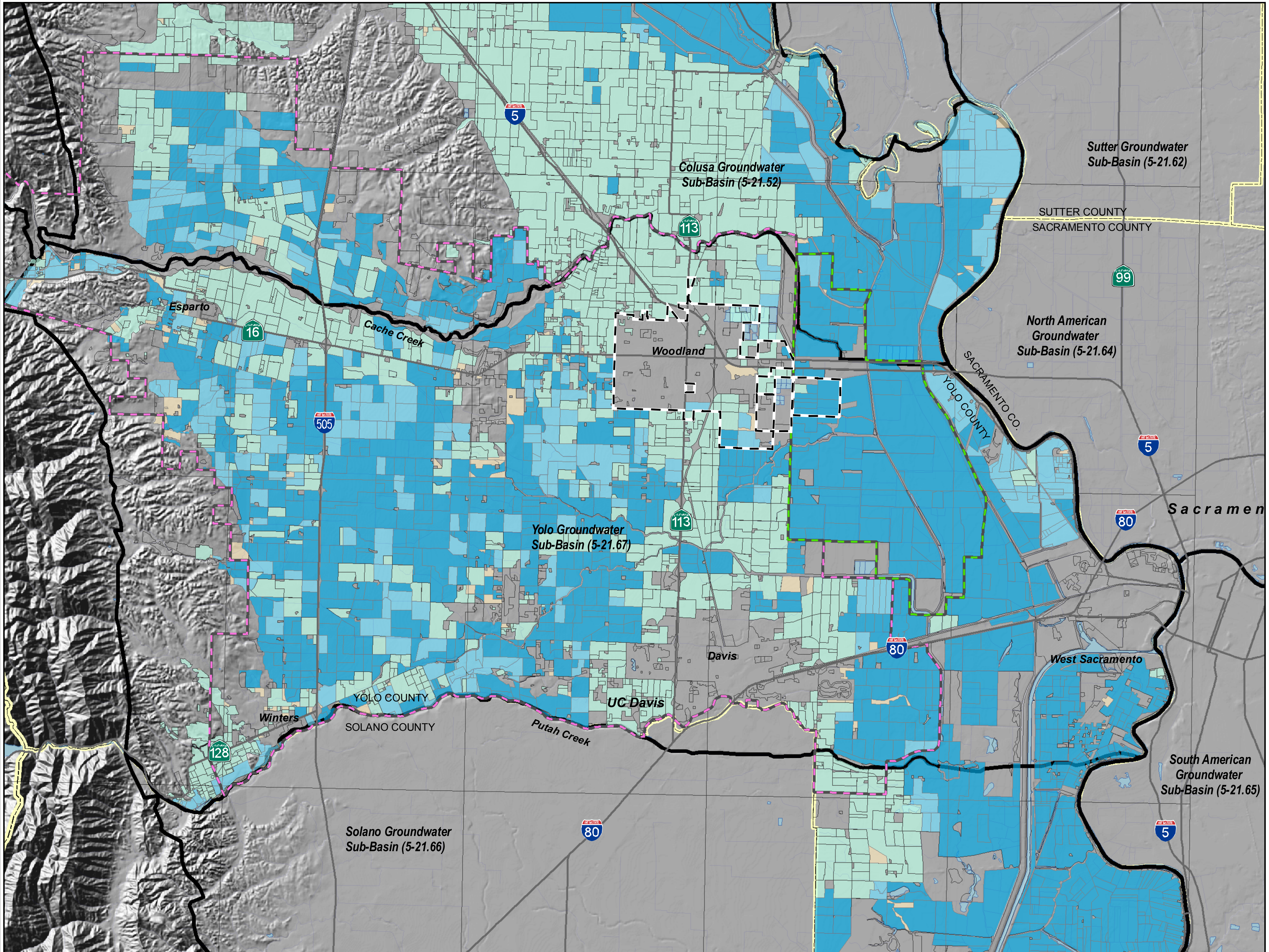
N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 2-19 Water Use.mxd 2/11/2011

FIGURE 2-19

City of Woodland
Groundwater Management Plan

SURFACE WATER AND GROUNDWATER USE



N

0 7,000 14,000

Scale in Feet

LEGEND

- City limit
- DWR Groundwater Basin
- County Boundary
- Reclamation District 2035
- Yolo County FC & WCD

DWR Water Use Category (1997)

- NA
- Surface Water
- Mixed Surface/Ground
- Groundwater
- Unknown

WOODLAND

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N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 2-20 Zoning.mxd 2/11/2011

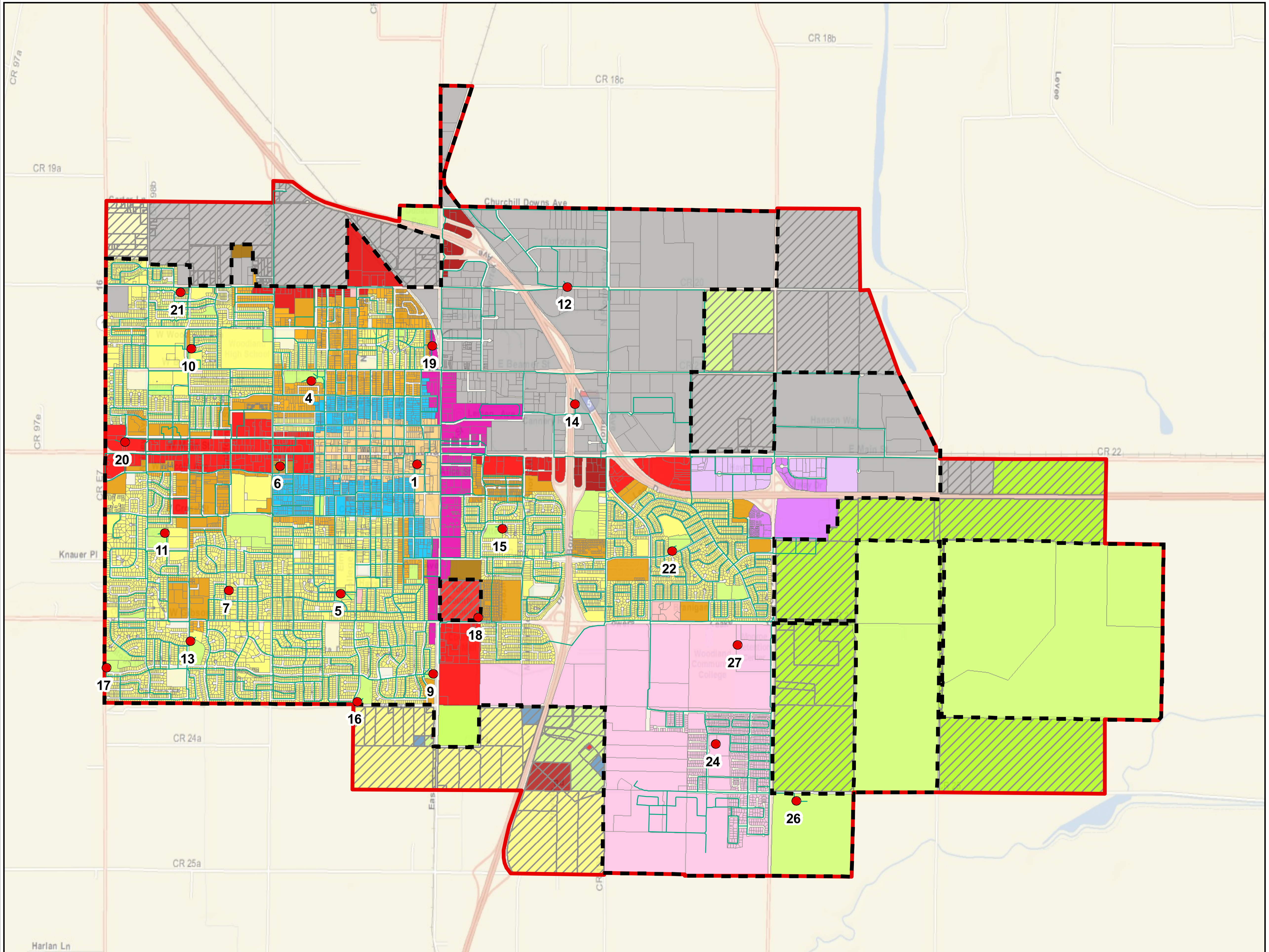

FIGURE 2-20

City of Woodland Groundwater Management Plan

PLANNING ZONE MAP

N

0 1,500 3,000

Scale in Feet

Notes

1. Source of zoning data: City of Woodland, Public Works Department staff, Oct. 2007.

LEGEND

- City of Woodland Production Well
- Water Pipeline
- City Limit
- Planning Area Boundary
- Agricultural Zone
- Neighborhood Commercial Zone
- General Commercial Zone
- Service Commercial Zone
- Highway Commercial Zone
- Central Business District
- Entry Overlay Zone (C-H)
- Entry Overlay Zone (I)
- East Street District
- Industrial Zone
- Neighborhood Preservation Zone
- Open Space Zone
- Open Space Zone (Other)
- Single Family Zone
- Duplex Zone
- Multiple Family Zone
- Spring Lake Specific Plan

WOODLAND

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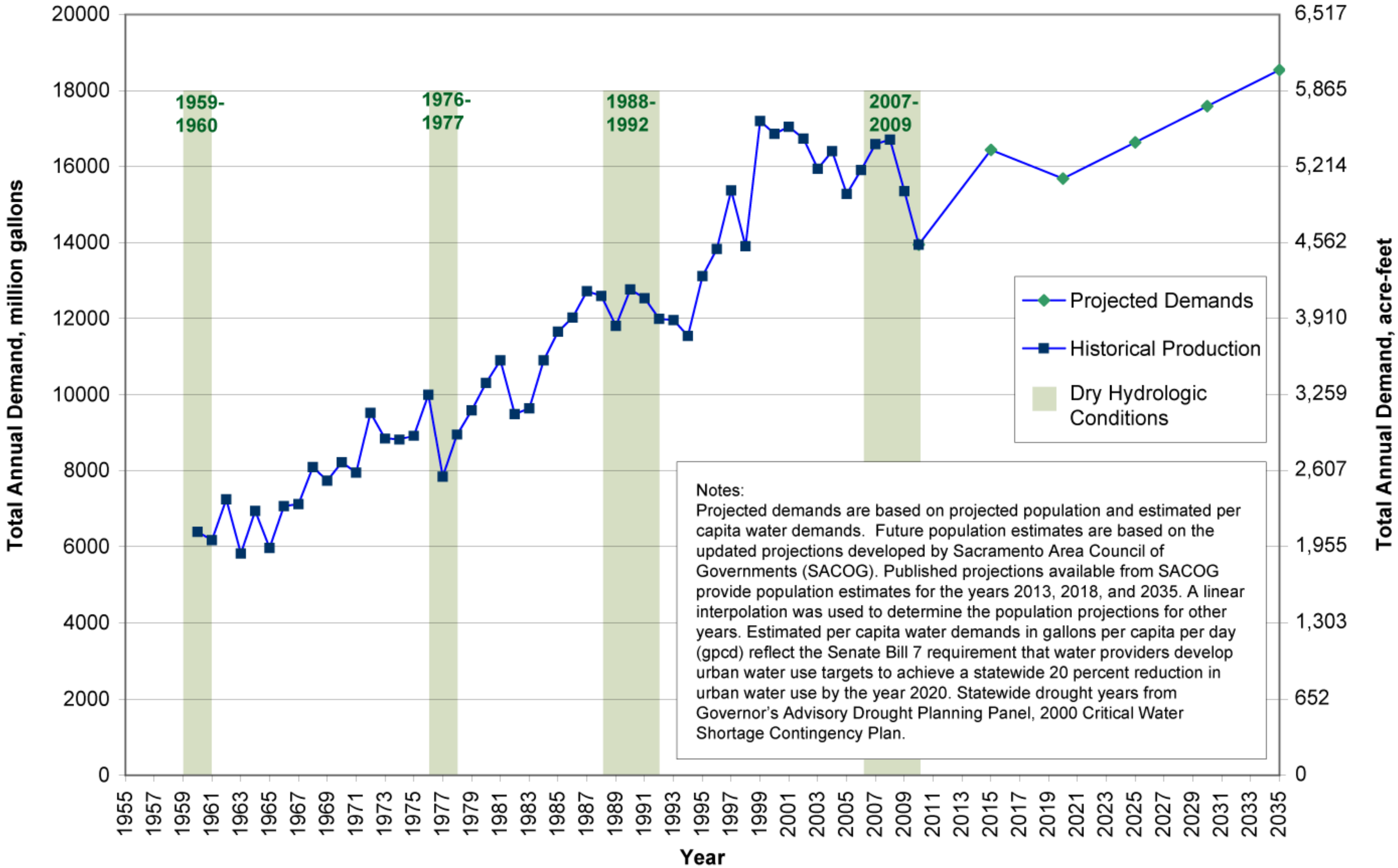

Notes:
Projected demands are based on projected population and estimated per capita water demands. Future population estimates are based on the updated projections developed by Sacramento Area Council of Governments (SACOG). Published projections available from SACOG provide population estimates for the years 2013, 2018, and 2035. A linear interpolation was used to determine the population projections for other years. Estimated per capita water demands in gallons per capita per day (gpcd) reflect the Senate Bill 7 requirement that water providers develop urban water use targets to achieve a statewide 20 percent reduction in urban water use by the year 2020. Statewide drought years from Governor's Advisory Drought Planning Panel, 2000 Critical Water Shortage Contingency Plan.

Figure 2-21

City of Woodland
Groundwater Management Plan

HISTORICAL PRODUCTION AND
PROJECTED ANNUAL WATER DEMANDS

WEST YOST ASSOCIATES
Consulting Engineers

This section describes the City's overall groundwater management goal, BMOs and GWMP components.

3.1 OVERALL GROUNDWATER MANAGEMENT GOAL

The City's overall groundwater management goal is to work cooperatively with basin stakeholders and the public to maintain a sustainable, reliable, high-quality groundwater supply for beneficial use in the City service area and surrounding areas.

3.2 BASIN MANAGEMENT OBJECTIVES

BMOs have been developed to support the City's overall groundwater management goal. BMOs have been established to address the following five areas:

- Groundwater quality
- Groundwater elevations
- Inelastic land subsidence
- Adverse impacts to surface water flows and surface water quality due to groundwater pumping
- Adverse impacts to groundwater levels and groundwater quality due to changes in surface water flow or quality

BMO-01 – Protect and maintain groundwater quality within the City service area for the benefit of basin groundwater users. Groundwater within the City's service area is affected by nonpoint sources of nitrate and salts, and localized point sources of anthropogenic contaminants. Naturally occurring contaminants, resulting from dissolution of minerals comprising the aquifer skeleton, also affect groundwater quality. The City's objective is to minimize the impact of these contaminants at the locations of individual municipal wells within its service area, and to support stakeholder efforts to protect beneficial uses in the groundwater sub-basin from adverse impacts to groundwater quality.

The City analyzes groundwater quality samples from its active production wells to comply with applicable standards in Title 22 of the CWC. The Department of Public Health (DPH) Title 22 program specifies the constituents to be tested, the detection limits for these constituents and reporting requirements. Sampling is conducted annually in a subset of the active wells such that each well is sampled on a three-year rotating cycle. Compliance with drinking water standards is a primary objective for the City. The City also uses the groundwater quality results to assess potential impacts to the municipal wastewater treatment plant, which is regulated under a Central Valley Regional Water Quality Control Board Waste Discharge Requirements Order. The primary constituents of concern for the wastewater discharge are selenium, boron and TDS. The water quality results will be evaluated on the same annual cycle under which the wells are sampled, such that each well will be evaluated every three years when new sample results are available. Temporal trends in the concentration of each constituent will be evaluated using a three-sample moving average comprised of the three most recent historical sample results for each well. Any increase in the concentration of a constituent of 20 percent or greater relative to the three-sample moving average will trigger evaluation of the need for potential actions, including:

- Consideration of possible agricultural and landscaping best management practices that could help control nitrate, nutrient and salt loading to the groundwater basin
- Additional monitoring, potentially on a more frequent basis
- Operational modifications affecting the pumping schedule and rate
- Well modifications to adjust the depth of pumping or seal zones with inferior water quality
- Well destruction, with possible replacement with a new well
- Replacement with a surface water supply
- Wellhead treatment, if feasible
- Destruction of abandoned wells

BMO-02 – Maintain groundwater elevations that result in a net benefit to basin groundwater users. Groundwater in the Yolo Sub-basin is used for municipal, domestic and agricultural supply. The City recognizes the need to support all of these uses. The City's objective is to work cooperatively with stakeholders to maintain groundwater levels at elevations that economically meet the City's municipal supply needs within its service area, and stakeholder needs for irrigation, domestic and industrial supply in surrounding areas of the sub-basin.

The City measures static water levels in its production wells on a monthly basis and uses the information to assess trends in groundwater levels. Historical data are available from 1976 through the present. This record encompasses significant variations in hydrology, including the 1976-1977, 1988-1992 and 2007-2009 droughts. Reductions in groundwater levels affect well capacity. Typically, the July-August timeframe is the most critical time of year because groundwater levels are near their annual minimum, and demands are near their maximum. Under dry conditions, the July and August groundwater levels could decline to a degree that potentially affects the City's well capacity. The monthly static groundwater levels will be compared to historical results to assess the potential need for management actions. Emphasis will be placed on evaluating April through June static groundwater levels, because groundwater levels typically reach their maximum in April. Significant reductions in April through June static groundwater levels may indicate the need for actions to mitigate reductions in well capacity caused by very low groundwater levels in July and August. Historically low groundwater levels occurred in 1977 and 1991. The lowest recorded measurements for the months of April through June occurred in 1977. The need for potential actions will be considered when April through June groundwater levels decline to levels that are within 25 percent of the April through June 1977 groundwater levels. Potential actions include:

- Outreach to encourage conservation
- Operational modifications to reduce reliance on wells most affected by groundwater level declines
- Construction of additional wells
- Use of surface water supplies

BMO-03 – Minimize the risk of future significant impact due to inelastic land subsidence. Inelastic land subsidence resulting from groundwater withdrawal has had significant consequences in the Yolo Groundwater Sub-basin. The risk of future significant impacts depends on a complex array of variables including: the degree of new groundwater development, especially in areas or at depths not previously exploited; changing land use, which could bring to light an impact that would otherwise go unnoticed; and the mineral composition of the aquifer skeleton, and its consolidation history. The City's objective is to prevent or minimize future impacts that may result from increased rates of inelastic land subsidence in and around its service area by continuing to cooperate with other stakeholders to monitor rates of inelastic land subsidence using the Yolo Subsidence Network.

Rates of inelastic land subsidence are being established by the WRA's Yolo Subsidence Monitoring Project. At present, data are insufficient to establish significance criteria for rates of inelastic land subsidence in the Woodland area. The City will participate in future surveys of the Yolo Subsidence Network and will evaluate the results with other members of the WRA.

BMO-04 – Protect against the risk of impacts to surface water flows and quality caused by groundwater pumping. The City currently does not use surface water, and there are no surface water flows within or adjacent to the City's service area. However, the City recognizes that the importance of protecting against impacts to surface water flows and surface water quality in the watershed. The City's objective is to work with basin stakeholders during integrated regional water management planning efforts to select alternatives that minimize the potential impacts to surface water flows and surface water quality caused by groundwater pumping.

BMO-05 – Protect against the risk of impacts to groundwater levels or groundwater quality caused by changes in surface water flows or surface water quality. Surface water deliveries are an important source of groundwater recharge in the Yolo Groundwater Sub-basin. Modeling studies indicate that, in the Central Valley as a whole, irrigation returns account for about 80 percent of the groundwater recharge on average (Williamson, et. al., 1989). Changes in the quantity of surface water delivered to the basin may affect both groundwater levels and groundwater quality. Changes in the sources of surface water may affect groundwater quality. The City's objective is to work cooperatively with basin stakeholders during integrated regional water management planning efforts to select water supply alternatives that minimize the potential impacts to groundwater flows and groundwater quality caused by changes in surface water flows or surface water quality.

These BMOs are linked to management actions that are planned or triggered to attain the BMOs and overall groundwater management goal (Figure 3-1). Management actions are discussed below.

3.3 GROUNDWATER MANAGEMENT PLAN COMPONENTS

The components of this GWMP are organized in six categories:

- Agency Coordination, Stakeholder Involvement and Public Outreach
- Monitoring Program

- Groundwater Sustainability
- Adaptive Management and Mitigation in Response to Climate Change
- Groundwater Protection
- Planning Integration

3.3.1 Agency Coordination, Stakeholder Involvement and Public Outreach

3.3.1.1 Agency Coordination

The City is a member agency of the WRA. WRA was established in 1993 as a "non-profit, mutual benefit corporation and consortium of entities that are authorized to provide a regional forum to coordinate and facilitate solutions to water management issues in Yolo County" (WRA of Yolo County, 2007).

The member agencies include:

- City of Davis
- City of Woodland
- City of West Sacramento
- City of Winters
- University of California, Davis
- Yolo County
- Yolo County Flood Control and Water Conservation District
- Reclamation District 108
- Reclamation District 2035
- Dunnigan Water District
- Colusa County Water District

Groundwater used by the City is obtained from a common groundwater basin that is utilized by local agricultural operations and other domestic, municipal and industrial entities. The City notified the WRA members regarding the preparation of this GWMP and distributed copies of the draft GWMP for their review and comment. Copies of the notices are provided in Appendix B.

Action: The City will continue to be a participating agency member of WRA and will coordinate groundwater management activities through the WRA.

3.3.1.2 Involvement of Other Local Agencies near the Plan Area

The YC FC&WCD is actively collecting and managing groundwater level and quality data in the Yolo Sub-basin. The data collection activities are coordinated with WRA and the City.

The City also has working relationships with the SWRCB, which regulates water rights; the Central Valley Regional Water Quality Control Board, which regulates agricultural runoff, wastewater discharge and other discharges to surface water and groundwater, including ASR; and the California Department of Public Health, which regulates drinking water quality.

Action: The City plans to maintain its existing relationships with state and federal regulatory agencies. The City will continue to coordinate with other local agencies near the plan area using the WRA as the primary mechanism.

3.3.1.3 Public Involvement Process

The City recognizes that groundwater is a limited resource and that coordinated management is critical to ensuring a reliable water source across the region. The principal reasons for encouraging public involvement are to:

- Encourage continued support for implementation of the GWMP
- Ensure that stakeholders and other interested parties understand and have ownership in implementing and supporting the GWMP
- Build on local knowledge and provide review of the GWMP elements
- Help develop consensus among stakeholders and other interested parties
- Help promote awareness of water quality and availability issues, and build support for pollution prevention and conservation activities in the community

The City has and will continue to place a high priority on coordinating groundwater management efforts with stakeholders and the public through the WRA and briefings to the City Council at regularly scheduled, publicly-noticed meetings. Public outreach and notification efforts for this GWMP were initiated in May 2010 when the City published a notice that they were convening a hearing to consider adopting a resolution of intent to prepare a GWMP. Milestone events in the public involvement process for this GWMP were:

- May 18 and 23, 2010. The City published a public notice in advance of a public hearing on whether or not to adopt a resolution of intent to prepare this GWMP.
- June 1, 2010. The City Council held a public hearing on whether or not to adopt a resolution of intent to prepare this GWMP. The resolution of intent was adopted on the same date.
- June 2, 2010. The City issued public notices describing how the public and stakeholders can participate in the GWMP development process.
- October 7, 2010. The City presented the draft GWMP to stakeholders and interested members of the public at a publicly-noticed meeting of the WRA Technical Committee.
- November 18 through December 17, 2010, The draft GWMP was made available for review by the public for a 30-day calendar period. Copies of the draft GWMP were posted on the WRA and City websites, and bound copies of the draft GWMP were made available at the Woodland Branch of the Yolo County Public Library, the City Municipal Services Center and the City Manager's office.

- December 1 and December 8, 2010. The City published a public notice in advance of a public hearing on whether or not to adopt the GWMP.
- January 19 and February 3, 2011. The City republished a public notice in advance of a public hearing on whether or not to adopt the GWMP.
- March 1, 2011. The City Council held an initial public hearing to consider adopting the GWMP.
- March 15, 2011. The City Council held a second public hearing to consider adopting the GWMP. Following the hearing, the City Council adopted the GWMP through Ordinance No. 1527. The ordinance took effect 30 days after its adoption.

Appendix A contains the City resolution to prepare the GWMP, Ordinance No. 1527 adopting the GWMP, and supporting information, including the Notice of Exemption from CEQA.

It is the City's policy to encourage public participation when adopting plans such as this GWMP. Therefore, the City sought public input while developing this GWMP. The draft GWMP was available for public review prior to the scheduled public hearings to consider adoption of the GWMP. During the review period, the draft GWMP was available at the City's offices during normal business hours, posted on the City's web page and WRA's web page, made available for distribution to interested parties and made available at the Yolo County Public Library. Notices for the public hearings were placed in the City newspaper (the Daily Democrat). Appendix B contains the public notices, presentation materials, comments received from members of the public, and letters documenting resolution of the comments.

Action: The City plans to continue the public involvement process through the use of focused public meetings, workshops, and printed media.

3.3.2 Monitoring Program

Senate Bill 6 (SBx7-6) was enacted on November 6, 2009. SBx7-6 revises CWC 10920 et. seq. and establishes a new groundwater monitoring program to more regularly and systematically monitor groundwater in all or parts of groundwater basins throughout the state. Local entities were required to register with the state for groundwater monitoring by January 1, 2011, and begin monitoring by January 1, 2012 to ensure state funding eligibility. The Yolo County FC&WCD will be the monitoring entity for Yolo County, including Woodland. The City will be the designated collecting entity within its service area.

This section describes the six elements of the monitoring program. These include:

- Groundwater Elevation Monitoring
- Groundwater Quality Monitoring
- Land Subsidence Monitoring
- Groundwater-Surface Water Interaction Monitoring

- Data Management
- Data Quality Assurance and Quality Control

Information obtained through the monitoring program will be used to improve understanding of the groundwater basin; update and refine thresholds triggering management actions; and support the BMOs and overall goal. The monitoring program will be reviewed and revised as necessary during periodic plan updates.

3.3.2.1 Groundwater Elevation Monitoring

Groundwater elevations will be monitored on a periodic basis in wells in and near the City service area. The locations of these wells are shown on Figure 3-2. These wells are included in the DWR data collection and data management program implemented by Yolo County FC & WCD and supported by the City. Ten of the wells have been monitored for many years and constitute a significant record of groundwater elevations in the vicinity of the City. Hydrographs for those ten wells are shown in Appendix E. The City also constructed two multiple completion monitoring wells, designated 10N02E31N901M through 10N02E31N906M, near the intersection of Ashley and Gibson Avenues (Figure 3-2). The wells are constructed in June 2008 in two borings separated by a distance of approximately 20 feet and provide groundwater monitoring in six discrete zones ranging from 126 feet to 1,435 feet below and surface.

Figure 3-2 shows the locations of five planned multiple completion monitoring wells within the City service area. The City plans to pursue state funding for construction of these monitoring wells. The locations shown on Figure 3-2 are preliminary and may be revised. When constructed, these wells will be used in conjunction with the City's existing monitoring wells and the other monitoring wells shown on Figure 3-2 to monitor groundwater levels and quality.

Recommended procedures for groundwater level monitoring are included in Appendix H.

Action: The City will continue to review periodic groundwater elevation monitoring through the Yolo County FC & WCD data collection and data management programs at the selected well locations. The City will review the groundwater elevation data annually and during the periodic update of the GWMP.

3.3.2.2 Groundwater Quality Monitoring

Groundwater within the City's service area is affected by non-point sources of nitrate and salts, and localized point sources of anthropogenic contaminants. Naturally occurring contaminants, resulting from dissolution of minerals comprising the aquifer skeleton, also affect groundwater quality.

Water quality samples have been periodically collected from each of the City's production wells. Appendix F contains time plots for boron, nitrate, selenium, and TDS for each of the City's production wells. Continued monitoring of these wells will allow the City to evaluate any changes in groundwater quality around individual municipal wells.

Two new multiple-completion monitoring wells were completed by the City in June 2008 (Figure 3-2). The wells were designed and constructed as part of a project to evaluate the groundwater production potential and groundwater quality in anticipation of the potential constructions of a municipal well at that site. The existing monitoring wells and the planned monitoring wells shown on Figure 3-2 will also enable long-term monitoring of groundwater levels and quality at multiple depths within the aquifer.

Recommended procedures for groundwater quality sampling are included in Appendix I.

Action: The City will continue to review the available water quality data annually and during the periodic update of the GWMP.

3.3.2.3 Land Subsidence Monitoring

Figure 3-2 shows the location of land subsidence benchmarks in and near the City. The benchmarks are part of the Yolo Land Subsidence Network. Repeat surveys of the benchmarks will be conducted periodically to assess changes in land surface elevation that could be attributable to inelastic subsidence. The City will use the results of these surveys to assess baseline subsidence rates using results from the benchmarks. After the DWWSP is implemented, the City will compare the baseline land subsidence rates to rates measured during implementation of the conjunctive use program. The comparison will be performed for the benchmarks shown on Figure 3-2. Appropriate management actions will be based on this comparison.

Action: The City plans to coordinate with other local, state and federal agencies through the WRA to schedule repeat surveys of the networks. The City will endeavor to ensure that the benchmarks shown on Figure 3-2 are included in the repeat surveys. The City will assess the survey results for these benchmarks to establish baseline rates of land subsidence.

3.3.2.4 Groundwater-Surface Water Interaction Monitoring

Surface water is not currently used by the City. Therefore, data collection activities under this monitoring program element will be limited to the baseline data collection activities described under the Groundwater Elevation and Quality Monitoring elements. The City will continue to measure groundwater production volumes.

Action: The City will continue baseline groundwater level and quality monitoring as described in the corresponding monitoring program elements. The City plans to continue to record groundwater production. The City plans to review the data annually and during periodic update of the GWMP. Groundwater quality, production, and elevations will continue to be monitored throughout the implementation and completion of the DWWSP.

3.3.2.5 Data Management, Quality Assurance and Quality Control

Groundwater quality data management for the Yolo Sub-basin is performed by Yolo County FC&WCD. Management of the Yolo Land Subsidence Network and is performed by project staff overseen by the participating agencies. These entities are also responsible for data quality assurance and data quality control.

The Yolo County FC&WCD water resource information database (WRID) contains information including, but not limited to:

- Well construction
- Well location
- Groundwater levels
- Groundwater quality
- Surface water flow
- Surface water quality
- Groundwater data from potentially contaminated sites

The Yolo County WRID was designed to store both historical and future water data. All data entered into the database identifies the data source. Wells are identified by their state well number (SWN) and unique agency well name. If the SWN is not known or provided, then a Source Number is assigned to the well. In some cases, multiple agencies maintain data for a single well, and the agencies may refer to the same well by a different name. Each of the different well names is included separately into the database with the unique SWN. It is possible to combine all data for a given well using the unique SWN, even if the data is spread out amongst different well names.

Two forms of quality control are currently being used for the database: (1) graphing of water quality and water level data; and (2) spot checking of water data. Graphs have been prepared for those wells with 50 or more water levels records and for wells with water quality reports containing key constituents, i.e. specific conductance, nitrate, boron, etc. Guidelines regarding data submission and formatting are included in Appendix J. Instructions for accessing and using the WRID are also included in Appendix J. A recommended groundwater quality assurance quality control plan is included in Appendix K.

Action: The City will communicate with the entities responsible for data management, data quality assurance and data quality control (QA/QC) to assess whether each entity's QA/QC standards are being met. The City, through the Yolo County WRA, will make recommendations to correct deficiencies that may affect data used by the City, and, if deemed necessary, to improve the quality of the data used by the City.

3.3.3 Groundwater Sustainability

This section discusses management actions taken and planned to help ensure groundwater sustainability in the City service area.

3.3.3.1 Conjunctive Use

The City does not use surface water. If surface water could be used to offset the demand for groundwater pumping within the City, particularly during dry and critically dry years, the City's supplies would have better quality, be more diversified, and additional groundwater would be available for other users within the Yolo Sub-basin. The City is a participant in the DWWSP, which would supplement groundwater usage with surface water from the Sacramento River, as discussed in Section 2.2.5.

Action: The City will continue to cooperate with the other members of the DWWSP Partners and work towards the completion of the DWWSP. Monitoring of groundwater quality, groundwater levels, and land subsidence will continue throughout the completion of the DWWSP.

3.3.3.2 Water Recycling

There are currently no water recycling projects in the City. The City is in the early stages of evaluating recycled water use to offset potable water demands. Other potential supplies, including shallow irrigation wells in parks and other public landscape areas, are also being considered for this purpose.

Action: Continue to evaluate alternative supplies that could offset nonpotable demands currently met with drinking water sources.

3.3.3.3 Projects to Increase Potable Yield

The implementation of the DWWSP will increase the supply of surface water available to the City for municipal use. Groundwater production is predicted to decrease with the addition of the surface water. Local groundwater would continue to be used for meeting peak daily demands from May to September and during dry years, but would be used at a substantially reduced rate as compared with the current usage. The DWWSP is discussed in more detail in Section 2.2.5.

One of the City's production wells, Well 10, is currently inactive due to water quality issues. Well 10 is currently under consideration for rehabilitation. If Well 10 is rehabilitated it would be used as a back up municipal well, therefore increasing the City's potential potable yield.

Action: The City will continue to cooperate with the other members of the DWWSP Partners and work towards the completion of the DWWSP. The City will continue to evaluate the need and plan for new wells as needed to meet demands.

3.3.3.4 Water Conservation

Per the City's Water Conservation Regulations Ordinance (see Chapter 23C, Article XI. of the City Code) the City is committed to preserving California's water resources through implementing water conservation measures. Currently the City has a program for low water use plumbing fixture retrofits, which aids water conservation.

The City has also implemented and supported various programs to increase waste reduction, reuse, recycling, and the safe handling of household hazardous wastes. These solid waste management efforts help increase water supply reliability by reducing use and the risk of supply contamination. For example, "grass-cycling" returns moisture to soil and plants, thereby reducing loss of moisture from evaporation. The City also works with Yolo County government and other local communities to provide residents with free household hazardous waste management programs six times annually.

The City is also implementing a water meter program and has installed meters on many customer water connections. May of these customers began receiving sample billings based on their metered consumption in the spring of 2010. The City plans to have virtually all of the water connections in the City metered by the end of 2012. Studies by the California Public Utilities Commission have shown that communities with metered water systems use 7 to 20 percent less water than non-metered areas. Therefore, the City can expect a 7 to 20 percent reduction in water consumption once the City-wide metering is complete.

Action: The City will continue to implement its water meter project. The City will also continue to implement various programs to increase waste reduction, reuse, recycling, and promote the safe handling of household hazardous wastes. The City will continue to monitor and evaluate water usage to ensure that conservation measures are effective and the most representative demand trends are used to project future demands.

3.3.4 Adaptive Management and Mitigation in Response to Climate Change

The City's commitment to the development of diversified water supplies, including both groundwater and surface water sources, will provide opportunities for adaptive management and mitigation in response to climate change. Some of the potential impacts of climate change on water supply are discussed in Section 2.1.3. However, specific impacts to the City's water supplies can not be predicted with certainty. The available data and information on the potential impacts to groundwater are especially limited. The City will use adaptive management and mitigation approaches to address the potential water-supply-related impacts of climate change and the uncertainty associated with these impacts. The groundwater sustainability measures discussed in the previous section, including implementation of the DWWSP, possible development of alternative supplies to meet irrigation demands, and water conservation, will be important tools in both strategies. Potential adaptive management strategies include:

- Development of groundwater recharge, storage and conjunctive use projects
- Water transfers

- Development of regional water projects and partnerships
- Water conservation
- Optimization of local storage

The City's involvement in the DWWSP will enable implementation of several of these strategies, and the City has implemented the others in its service area. Groundwater storage will be increased as a natural consequence of the DWWSP. Average annual groundwater use by the City will decline because of the DWWSP, and this will result in additional groundwater in storage, assuming groundwater use by others does not increase. Through the WDCWA, the City is also evaluating ASR. ASR is the storage of water in the aquifer during times when water is available and recovery of the water from the aquifer when needed at a later time. There is potential to use seasonally available excess capacity in the DWWSP WTP to treat Sacramento River water, which could then be injected through existing or new municipal wells. This water could then be extracted from the same wells during times when surface water is less available to meet municipal demands. A key advantage of this ASR concept, with to respect to climate change, is that it would provide a reliable source of supply to the City without placing additional demands on the overall surface water and groundwater supply of the region. ASR could result in water quality benefits within the portions of the groundwater basin underlying the City, because the quality of the recovered water would be similar to the quality of treated surface water.

Water transfers are also a tool used in the DWWSP. The DWWSP's certified Environmental Impact Report evaluated a range of water transfer alternatives. Because the environmental review of these water transfer alternatives has been completed, they can more easily be considered as part of an adaptive strategy to mitigate future dry conditions.

The City is a member of the WDCWA, the entity implementing the DWWSP, and the WRA. The WDCWA is actively engaged in implementing the DWWSP, and the WRA is an active participant the Westside RWMG. The Westside RWMG represents entities in the Cache Creek and Putah Creek watersheds. The watersheds of these two creeks encompass portions of Yolo, Solano, Lake, Colusa, and Napa Counties. Public agencies in the Westside RWMG coordinate with each other at present, and in the future will cooperate more closely with overlapping and immediately adjacent regions, such as the northern Sacramento Valley. The Westside RWMG was recently awarded a $1 million Prop 84 planning grant for use in preparing the Westside IRWMP. The Westside IRWMP is expected to be completed in 2013.

The City has also embarked on a water conservation program, as described in Section 3.3.3.4. The City's water conservation efforts are expected to result in a 20 percent in reduction in demands by 2020, as mandated by the State in SB7. In addition to the water supply benefits of this conservation program, energy will be conserved, thereby potentially aiding in the control of green house gas emissions.

The City is evaluating measures to optimize storage of potable water, potentially using ASR, as part of its ongoing planning for future capital improvements. The City is coordinating these evaluations with the DWWSP planning efforts through its involvement in the WDCWA.

Action: Continue to review scientific and policy updates related to climate change as they become available through the IPCC, State, CUWA and other climate change authorities. Continue to implement the components of this GWMP. Continue to include adaptive management principals in water supply and infrastructure planning.

3.3.5 Groundwater Protection

This section describes policies and measures planned to help protect groundwater resources within the City service area.

3.3.5.1 Well Construction and Destruction Policies

The need for special well construction and destruction policies has not been identified within the City service area. Therefore, the construction and destruction standards put forth in CWC Section 13700 and detailed in DWR Bulletins 74-81 and 74-90 have been adopted as the applicable standards. These standards are enforced through the well construction and destruction permitting process administrated by the Yolo County Department of Environmental Health.

Action: The City will ensure that any well construction or destruction projects that it undertakes will meet the applicable standards. The City will also include information on these standards in its education and outreach activities to private well owners within the City service area. When reviewing or approving land use plans, the City will endeavor to ensure that project proponents identify and properly destroy abandoned wells within the plan area as a condition of development.

3.3.5.2 Wellhead Protection Policies

To date, there is no formally adopted wellhead protection policy applicable to the City service area, except for the well construction and destruction standards described CWC Section 13700, DWR Bulletins 74-81 and 74-90, and the groundwater portion of the California State Drinking Water Source Assessment and Protection Program (DWSAP). The City understands that point and non-point sources of contamination could jeopardize wells within its service area. The City has identified the following actions for minimizing the potential for impacts to the wells.

Action: The City will endeavor to evaluate the potential for proposed projects in the vicinity of its service area to impact existing private wells and future wells that may be constructed by the City. Any additional wells constructed by the City will be designed to minimize the risk of wellhead contamination and spread of contaminants caused by pumping. The City will continue to coordinate with the Yolo County Planning Department during evaluation of new projects in the vicinity of its service area and the Yolo County Department of Environmental Health for permitting of any wells it may construct.

3.3.5.3 Protection of Recharge Areas

To date, there is no formally adopted recharge area protection policy applicable to the City service area. The City understands that point and non-point sources of contamination could jeopardize recharge areas within its service area. The City has identified the following actions for minimizing the potential for impacts to recharge areas.

Action: Any additional wells constructed by the City will be designed to minimize the risk of adverse impacts to recharge areas caused by pumping. The City will continue to coordinate with the Yolo County Planning Department and the WRA during evaluation of new projects that involve recharge, or that could affect recharge, in the vicinity of its service area, and Yolo County Department of Environmental Health for permitting of any wells it may construct.

3.3.5.4 Management of Sources of Groundwater Contamination

The City understands that point and non-point sources of contamination could jeopardize wells and recharge areas within its service area. The City has identified the following actions for minimizing the potential for impacts to wells and recharge areas.

Action: The City will continue to coordinate with the Yolo County Department of Environmental Health, the Central Valley Regional Water Quality Control Board, and the California Department of Toxic Substances Control for updates on known and suspected point and non-point sources of groundwater contamination.

3.3.5.5 Control of Saline Water Intrusion

The City completed site-specific studies regarding salinity control and appropriate salinity effluent criteria. In May 2005, the City completed the City Salinity Source Control Plan (Larry Walker Associates, 2005), which identified sources of salinity and addressed potential salinity control measures. The study concluded that the primary source of salinity in the City's wastewater was the City's water supply.

Action: The City is implementing the DWWSP, which is scheduled to begin operation in 2016. The DWWSP will result in a significant reduction in the salinity of the City's water supply. The City will continue to evaluate groundwater quality data for evidence of increasing salinity. This review will be performed annually and during the periodic review and update of the GWMP.

3.3.6 Planning Integration

The City is coordinating planning activities with other local agencies in the Yolo Groundwater Sub-basin and has endeavored to integrate this GWMP with other relevant planning activities.

3.3.6.1 Existing Integrated Planning Efforts

3.3.6.1.1 Yolo County IRWMP

WRA adopted its IRWMP in 2007. The IRWMP identifies and prioritizes all water related actions for the Yolo County agencies, including the City. The water management strategies addressed by the IWRMP were organized by WRA into five Water Resource Management Categories, including:

- Water Supply and Drought Preparedness
- Water Quality (Surface Water and Groundwater)
- Flood Management and Storm Drainage
- Aquatic and Riparian Ecosystem Enhancement
- Recreation

This GWMP is integrated with, and supports implementation of, the IRWMP. The City adopted the IRWMP in April 2007, by action of the City Council.

The City is an active member of the WRA and is a participating member of the actions described in the IRWMP.

As discussed in Section 3.3.4, the City is participating in development of the Westside IRWMP, which is a regional planning effort, including public agencies in Yolo, Solano, Lake, Colusa and Napa Counties. The Westside IRWMP is scheduled for completion in 2013.

Action: The City will continue to participate in IRWMP development and implementation activities. The City will implement plan policies, programs, and projects approved by the WRA for which there is funding. If there is no funding, then the City will consider pursuing funding sources for implementation of the plan policies, programs, and projects.

3.3.6.1.2 Yolo County Groundwater Management

The City, along with all other Yolo Sub-basin stakeholders, is a member of the WRA (Section 1.2 and Section 3.3.1). Other members of WRA, including Dunnigan Water District, RD 2035, Yolo County FC&WCD, and the City of Davis, have adopted their own GWMPs. The WRA provides a forum for coordination of groundwater management program activities, including this GWMP. Table 1-1 lists the qualitative BMOs for other local agencies in Yolo County.

Action: The City will coordinate groundwater management efforts with neighboring local agencies and WRA member agencies.

3.3.6.1.3 DWSAP Program

California's DWSAP was prepared by the California DPH in response to the 1996 reauthorization of the federal Safe Drinking Water Act; this included an amendment requiring states to develop a program to assess sources of drinking water and to encourage those states to establish protection programs (DPH, 1999). The drinking water source protection programs entail local, regional, state, and federal agencies cooperating to maintain and protect sources of drinking water. The groundwater portion of the DWSAP serves as the State's wellhead protection program (Bachman, et. al., 2005).

Goals of the DWSAP include:

- Protecting the State's public water systems
- Improving drinking water quality
- Supporting effective water resources management
- Assisting in the refinement of monitoring requirements for drinking water sources
- Informing the public and drinking water system owners/operators of contaminants and activities that may affect drinking water quality
- Encouraging a proactive approach to protecting the State's drinking water sources and enabling protection activities by the public and drinking water system owners/operators
- Focusing cleanup and pollution prevention efforts on the most serious threats to the State's drinking water sources
- Complying with federal regulation for establishing wellhead protection and drinking water source assessment programs
- Assisting in meeting all other regulatory requirements

Action: The City will continue to comply with the drinking water source assessment standards and procedures outlined in the DWSAP. The City will strive to comply with the goals established for the DWSAP.

3.3.6.1.4 City of Woodland Land Use Planning

The City coordinates with the Yolo County Planning Department to review proposed projects that could potentially impact groundwater quality, as described in preceding sections.

Action: The City will consider the components of this GWMP when reviewing proposed projects within the City limits. The City will continue to monitor and provide input to Yolo County land use planning policies and project proposals potentially impacting the City.

3.3.6.1.5 Yolo County Land Use Planning

For the past 50 years, Yolo County has upheld policies that focus on protecting the agricultural and open space resources, commodities and identity; resisting urbanization; and directing growth into existing cities and towns. According to the 2030 Countywide General Plan for Yolo County, in order to ensure sustainable communities, a reliable food supply, and a healthy environment in the future, the County has identified seven land use goals for the County, including:

- Maintain an appropriate range and balance of land uses to maintain the variety of activities necessary for a diverse, healthy, and sustainable society
- Preserve farm land and expand opportunities for related business and infrastructure to ensure a strong local agricultural economy
- Manage growth to preserve and enhance the County's agriculture, environment, rural setting, and small town character
- Ensure inclusion, fair treatment and equitable outcomes in local land use decisions and regulations
- Ensure inclusion, fair treatment and equitable outcomes for the County in land use matters involving other local government entities
- Ensure inclusion, fair treatment and equitable outcomes for the County and its residents in regional land use planning efforts

Action: The City will continue to consider the Yolo County land use planning policies and goals in the implementation of this GWMP.

3.3.6.1.6 Yolo County IGSM

The Yolo County FC&WCD and members of the WRA, in coordination with the DWR, completed the Yolo County Integrated Groundwater Surface Water Model (YCIGSM) in 2006 (WRIME, 2006). The YCIGSM is a hydrologic model that is designed to simulate both groundwater and surface water flow systems.

Some of the key features of the YCIGSM include:

- Groundwater flow simulation
- Surface water flow simulation
- Unsaturated flow simulation
- Soil moisture accounting
- Stream-aquifer interaction
- Crop consumptive use computation

Action: The City, being a member of the WRA, participated in decisions regarding YCISGM model development. The City has selected potential sites for monitoring wells (Figure 3-2) using YCIGSM simulation results as a guide. The City will continue to consider the results obtained from the YCIGSM, or other suitable models, during implementation of this GWMP.

3.3.6.2 Advisory Committee Formation

The following local agencies are actively involved in the management of groundwater in and around the City:

- Yolo County FC&WCD
- City of Davis
- Reclamation District 2035
- WRA
- Yolo County

The City is an active member of the WRA. The Advisory Committee for this GWMP is comprised of the WRA Technical Committee, which includes representation by the City of Woodland staff.

Action: Continue to designate City representatives to the WRA Technical Committee and Advisory Committee during implementation of this GWMP.

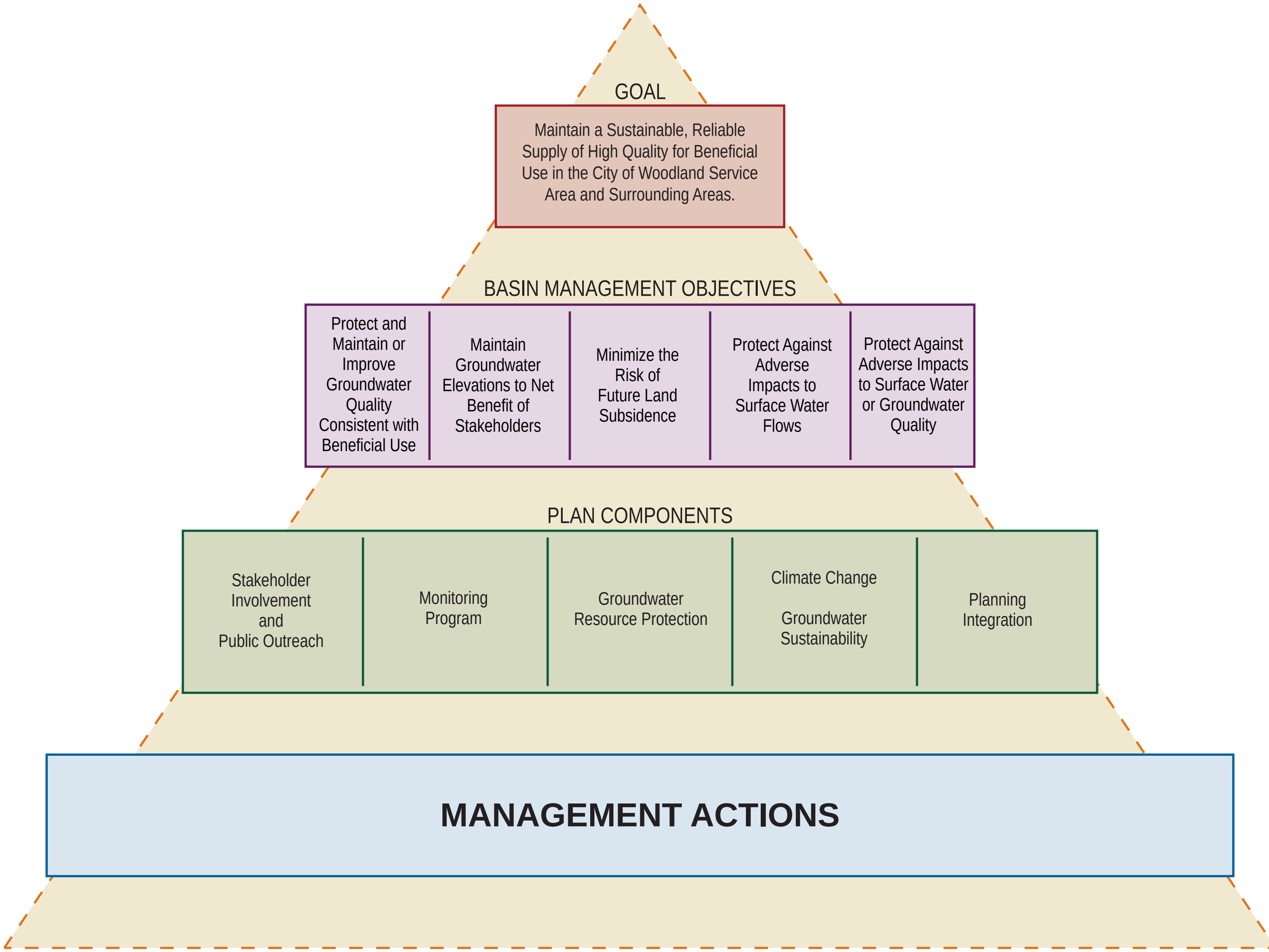

Figure 3-1

City of Woodland
Groundwater Management Plan

GROUNDWATER MANAGEMENT COMPONENTS

WOODLAND

WEST YOST ASSOCIATES
Consulting Engineers

N:\Clients\204 Woodland\00-08-18 Groundwater Mngmnt Plan\GIS\figure 3-2 GW Network.mxd 9/15/2010

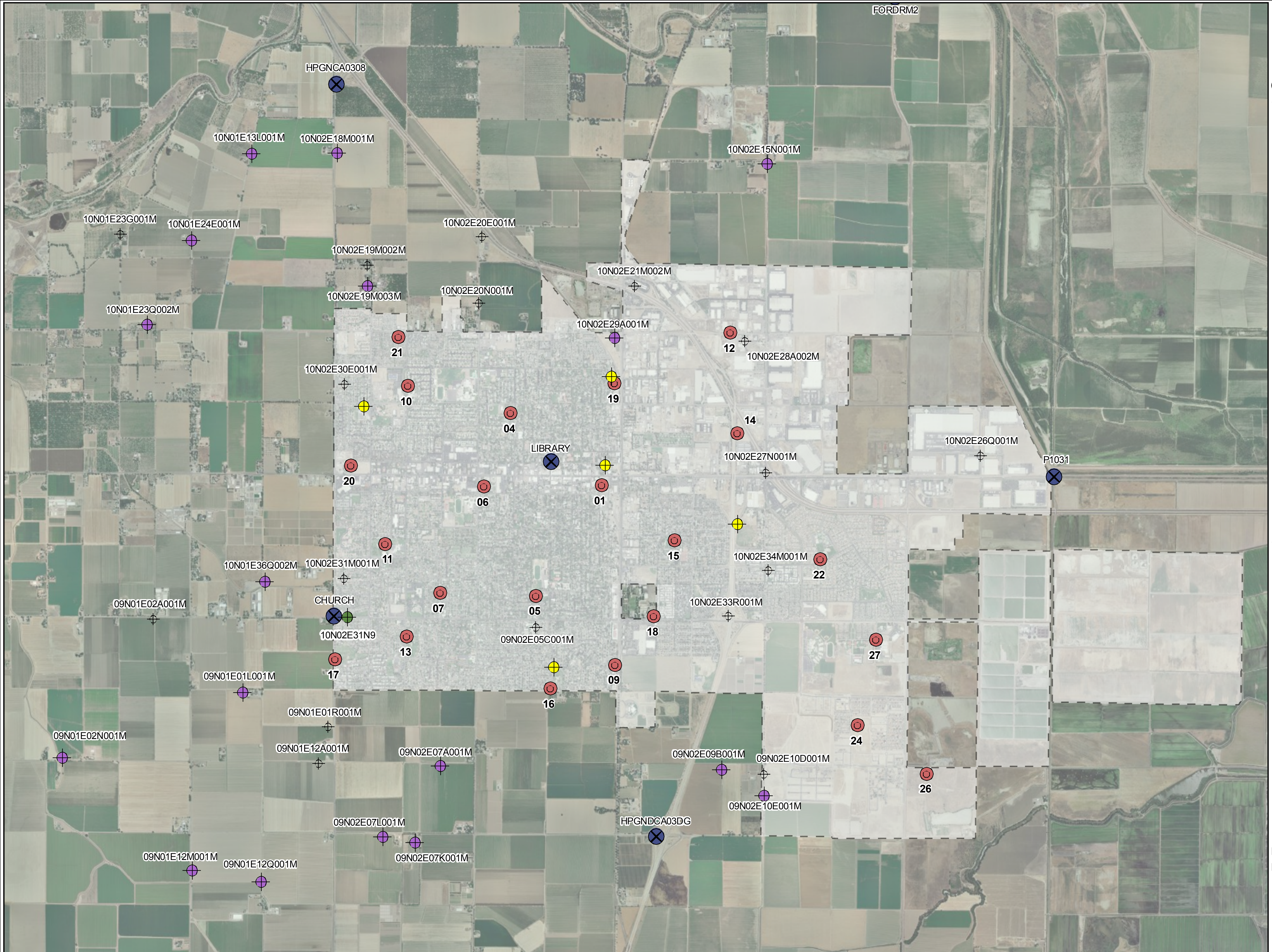

FIGURE 3-2

City of Woodland Groundwater Management Plan

MONITORING NETWORK

N

0 1,750 3,500

Scale in Feet

NOTES:

1. The multiple-completion monitoring wells (MW1 & MW2) enable long-term monitoring of groundwater levels and quality at multiple depths within the aquifer. The wells are located 20 feet apart within Streng Pond Park.

2. The City of Woodland's multiple-completion monitoring well consists of two sets of nested wells, MW1 and MW2.
MW1 contains four nested wells:
MW1A (10N02E31N901M),
MW1B (10N02E31N902M),
MW1C (10N02E31N903M), and
MW1D (10N02E31N904M).
MW2 contains two nested wells:
MW2A (10N02E31N905M) and
MW2B (10N02E31N906M).

LEGEND

- City of Woodland Multiple-Completion Monitoring Well
- Proposed City of Woodland Multiple-Completion Monitoring Well

DWR Monitoring Wells

- Monitored Before 2007
- Monitored Since 2007
- Subsidence Benchmark
- City Production Well
- City of Woodland City Limits

WOODLAND

WEST YOST ASSOCIATES Consulting Engineers

4.1 ANNUAL GROUNDWATER MANAGEMENT REPORT

The City plans to annually produce a status report to document the progress of the GWMP implementation throughout the previous year and to review and confirm actions for the next year. The report will include information regarding inelastic land subsidence, when updates are available, groundwater quality, groundwater production, and groundwater levels in relation to the established BMOs. When the DWWSP is implemented, the annual reports will document the effect that the addition of a municipal surface water supply has on the groundwater system through groundwater level, groundwater production, and groundwater quality monitoring.

4.2 FUTURE GROUNDWATER MANAGEMENT PLAN UPDATES

Periodic GWMP updates will be required as knowledge of the Yolo Sub-basin increases and groundwater management strategies evolve. The City will periodically consider new groundwater management techniques to be incorporated into the GWMP. Over time, BMOs may need to be modified based on changing groundwater conditions, the completion of the DWWSP and the addition of an operable conjunctive use system, or the development of new key groundwater management objectives. If changes must be made, the City will formalize the changes in an updated GWMP. The City plans to update this GWMP every five years on approximately the same update cycle as the City's UWMP.

4.3 FINANCING

The implementation of this GWMP will be funded by the City. Ongoing coordination activities will be performed by City staff using City funds. Most baseline data collection activities will also be funded by the City. The City plans to provide a proportional share of costs for other regional data collection efforts, such as land subsidence monitoring. State or federal funding may be pursued to support implementation of this GWMP.

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APPENDIX A

City of Woodland Resolution No. 5099, Ordinance No. 1527 and Supporting Information

CITY OF WOODLAND

RESOLUTION 5099

A RESOLUTION OF INTENT TO PREPARE A GROUNDWATER MANAGEMENT PLAN

WHEREAS, the California Legislature enacted Assembly Bill 3030 to provide local public agencies increased management authority over their groundwater resources and subsequently Senate Bill 1938 to expand the authority under AB 3030 by requiring Groundwater Management Plans to provide for eligibility for grant funds for groundwater related projects (Water Code Section 10750); and

WHEREAS, the State has emphasized the local agencies develop integrated regional solutions for water management and coordinating conjunctive management of surface and groundwater to improve the regional supply, reliability and quality of water; and,

WHEREAS, the City is an urban supplier of water providing water to a population over 55,000+ citizens; and

WHEREAS, the Plan will meet the State requirements in compliance with the California Water Code and will be coordinated with the Yolo County Integrated Groundwater Management Plan; and

WHEREAS, the Plan shall be periodically reviewed and the City shall make any amendments or changes to its plan which are indicated by the review; and

WHEREAS, the City's current Urban Water Management Plan adopted in 2005 addresses the current water supply, but does not address the increasing levels of nitrate found in the City's water supply; and

WHEREAS, the City of Woodland will file said Plan with the California Department of Water Resources upon adoption of the final Plan by the City Council.

BE IT THEREFORE, RESOLVED by the City Council of the City of Woodland, Yolo County, California hereby adopts this Resolution of Intent and directs staff to proceed with the development of a Groundwater Management Plan in accordance with the provisions of Senate Bill 1938 and pursue future grant funds.

ADOPTED this 1st day of June 2010, by the following vote:

AYES:	Council Members Dote, Marble, Monroe, Pimentel, Davies
NOES:	None
ABSENT:	None
ABSTENTIONS:	None

Marlin H. Davies, Mayor

APPROVED AS TO FORM:

Andrew Morris, City Attorney

ATTEST:

Sue Vannucci, Director of Administrative Services/City Clerk

City of Woodland

REPORT TO MAYOR AND CITY COUNCIL

AGENDA ITEM
7.

TO: THE HONORABLE MAYOR
AND CITY COUNCIL

DATE: June 1, 2010

SUBJECT: Adopt Resolution of Intent to Prepare a Groundwater Management Plan (GWMP)

Report in Brief

The proposed Ground Water Management Plan (GWMP) will address measures to monitor and manage groundwater within the service area of the City including groundwater quality degradation, inelastic land surface subsidence, and changes in surface water flow and surface water quality. These elements directly affect the City's groundwater levels and/or quality and are caused by groundwater pumping in the basin. The proposed resolution is consistent with California Legislation that establishes the framework for working cooperatively with local agencies in managing local groundwater resources. It also allows the City to become eligible for grants that could fund design and construction of groundwater projects administered by the California Department of Water Resources. State law requires the resolution to be adopted following a Public Hearing.

Staff recommends that the City Council conduct a Public Hearing, receive comments and approve Resolution No. ______ to direct staff to prepare a Groundwater Management Plan as described herein.

Background

In 1992, the California Legislature passed Assembly Bill (AB) 3030, which was designated to provide local public agencies increased management authority over their groundwater resources. In September 2002, new legislation, Senate Bill (SB) 1938, expanded AB 3030 by requiring GWMPs to include certain specific components in order to be eligible for grant funding for various types of groundwater related projects.

Recently, there has been an emphasis by the State for agencies to develop integrated regional solutions for water management (SB 1672), and to coordinate the management of surface and groundwater to work together toward improving regional water supply reliability and quality.

The GWMP provides the framework for coordinating groundwater management activities among stakeholders. The plan would identify the basin management goals and objectives needed to guide efforts to effectively manage the groundwater basin as a safe and sustainable water supply. The goal of Woodland's GWMP would be to ensure the reliability of groundwater to meet current and future municipal, industrial and agricultural purposes.

Discussion

The Council approved this Notice of Intent to prepare a GWMP on April 1, 2008. The GWMP was supposed to be completed within two years of the adoption of this Notice of Intent as required by the time frame notification provision of AB 3030. The consultant West Yost Engineering Inc could not complete the plan within this time frame due to non availability of sufficient data. Currently, the GWMP is 95% complete; the re-adoption of the Notice of Intent is required to comply with the provision of AB 3030.

California law requires that the adoption of the Notice of Intent be noticed as Public Hearing. Prior to adopting the resolution for the Notice of Intent, the City Council should receive comments from members of the public. Following adoption of the attached resolution by Council, the GWMOP would be completed and ready for Council adoption by the end of June 2010.

The City of Woodland currently relies entirely on groundwater obtained from twenty wells located throughout the City and, based on current operations, would meet future water demands by drilling new wells. The City is experiencing a trending decline in groundwater quality at a number of well sites, and this has resulted in two wells being taken out of service. In December 2005, the City developed an Urban Water Management Plan to address existing City water supply sources, reliability planning and water demand management measures. It was determined that further evaluation was needed to address the potential threat and extent of the potential nitrate contamination of the drinking water supply.

West Yost Associates (WYA) Consulting Engineers is currently assisting the City with its Water Focus Study which would be coordinated and incorporated into a GWMP. Upon adoption of this Resolution of Intent, staff will work with the consultant to complete the GWMP with a focus on protecting the groundwater resources of the City to ensure local water supply reliability and acceptable water quality. Best management objectives to be investigated would also include identification of natural recharge areas, management and optimization of well field operations and identification and feasibility study of the various area-wide water sources and use projects.

The GWMP will also qualify the City for grant funding opportunities administered by the State Water Resources Control Board and the Department of Health Services. Preference for these funds are given to proposals that include integrated projects with multiple benefits, improve local and regional water supply reliability, contribute towards improving water quality standards, reduce pollution and improve groundwater management. The following potential future projects could qualify for grant application if the GWMP is in place:

- Well Rehabilitation/ Blending
- Installation of Monitoring Wells
- Surface Water Project

Results from the GWMP will be closely coordinated with the Community Development Department for related coordination of development and redevelopment initiatives and the Finance Department prior to seeking Council approval for potential grant funding opportunities.

Fiscal Impact

There are no costs associated with the adoption of this Resolution of Intent. The cost of developing the GWMP is approximately $90,000; $60,000 of this amount is a carryover from the Public Works Operations and Maintenance budget for Fiscal Year 2007/2008. The remainder in the amount of approximately $30,000 is financed by the Public Works Utility Engineering budget for Fiscal Year 2010. Fiscal impacts may be identified and developed as a result of implementing groundwater management activities, such as studies and projects to mitigate groundwater contamination. If grant funding is pursued and received, the amount of the grant would offset the cost of implementation of these water management activities.

Public Contact

Posting of the City Council agenda.

The City Council should note that the public participation process was initially in the original Resolution of Intent and throughout the development of the management plan and there will be future opportunities for additional public input in this process. The Statement of Work for preparing the GWMP includes public outreach and stakeholder coordination including the preparation of written statements describing the manner in which interested parties may participate in the development of the GWMP. Interagency coordination will include Yolo County, Yolo County Flood Control and Water Conservation District and the Water Resources Association of Yolo County and its member agencies.

The notice of the Public Hearing required to adopt the Resolution of Intent was published in the Woodland Daily Democrat on May 18, 2010.

Recommendation for Action

Staff recommends that the City Council conduct a Public Hearing, receive comments and approve Resolution No. _______ to direct staff to prepare a Groundwater Management Plan as described herein.

Prepared by: Akin Okupe
Senior Civil Engineer

Reviewed by: Doug Baxter
Principal Civil Engineer

Reviewed by: Greg Meyer
Director of Public Works

Mark G. Deven
City Manager

Attachment: Resolution of Intent to Prepare a GWMP

ORDINANCE NO. 1527

AN ORDINANCE OF THE CITY OF WOODLAND, CALIFORNIA ADOPTING A GROUNDWATER MANAGEMENT PLAN

WHEREAS, California law requires local agencies wishing to be eligible for certain types of state funding for water-related improvements to adopt groundwater management plans; and

WHEREAS, the State of California encourages local agencies to develop integrated regional solutions for water management and to coordinate the management of surface and groundwater to work together toward improving regional water supply reliability and quality; and

WHEREAS, adoption of a groundwater management plan will provide a framework for coordinating groundwater management activities among stakeholders, and will identify the basin management goals and objectives needed to guide efforts to effectively manage the groundwater basin as a safe and sustainable water supply;

NOW THEREFORE, THE CITY COUNCIL OF THE CITY OF WOODLAND DOES ORDAIN AS FOLLOWS:

SECTION 1. The City Council adopts the recitals set forth above as its findings in connection with the adoption of this ordinance.

SECTION 2. The City Council hereby adopts the 2011 Groundwater Management Plan prepared for the City by West Yost Associates.

SECTION 3. The City Council has reviewed and considered the information in and regarding the 2011 Groundwater Management Plan and hereby determines that the implementation of the plan and adoption of this ordinance are exempt from the requirements of the California Environmental Quality Act (CEQA), pursuant to Title 14, sections 15262, 15306, 15307, and 15308 of the California Code of Regulations, which exempt from CEQA feasibility and planning studies; information collection; activities taken to maintain, restore, or enhance a natural resource; and activities to assure the maintenance, restoration, enhancement, or protection of the environment. The City Council further finds that the 2011 Groundwater Management Plan meets the requirements of these exemptions because it includes consideration of environmental factors, including the impacts of global climate change, and includes no construction activities or relaxation or environmental standards. Implementation of the 2011 Groundwater Management Plan and adoption of this ordinance are also categorically exempt pursuant to Section 15061(b)(3) because they will cause no serious or major disturbance of any environmental resource. The City Clerk shall file a Notice of Exemption with the County of Yolo.

SECTION 4. This ordinance shall take effect thirty (30) days after its adoption and, within fifteen (15) days after its passage, shall be published at least once in a newspaper of general circulation published and circulated within the City of Woodland.

PASSED AND ADOPTED by the City Council this 15th day of March, 2011, by the following vote:

AYES: Council Members Davies, Dote, Marble, Stallard and Pimentel

NOES: None

ABSENT: None

ABSTAIN: None

Artemio Pimentel, Mayor

ATTEST:

Ana B. Gonzalez, City Clerk

APPROVED AS TO FORM:

Andrew J. Morris, City Attorney

City of Woodland

REPORT TO MAYOR AND CITY COUNCIL

AGENDA ITEM

TO: THE HONORABLE MAYOR
AND CITY COUNCIL

DATE: March 1, 2011

SUBJECT: Adopt the Groundwater Management Plan

Report in Brief

The proposed Groundwater Management Plan (GWMP) addresses measures to monitor and manage groundwater within the service area of the City including: groundwater quality degradation, land surface subsidence, and changes in surface water flow and surface water quality that directly affect the City's groundwater levels or quality or are caused by groundwater pumping in the basin.

An executive summary of the GWMP is attached as Exhibit A for Council consideration. Staff recommends City Council adopt this GWMP which, under SB 1938, establishes the framework for working cooperatively with local agencies in managing local groundwater resources and establishes grant funding eligibility for construction and groundwater projects administered by the California Department of Water Resources.

Background

In 1992, the California Legislature passed Assembly Bill (AB) 3030, which was designated to provide local public agencies increased management authority over their groundwater resources. In September 2002, new legislation, Senate Bill (SB) 1938, expanded AB 3030 by requiring GWMPs to include certain specific components in order to be eligible for grant funding for various types of groundwater related projects.

Recently, there has been an emphasis by the State for agencies to develop integrated regional solutions for water management (SB 1672), and to coordinate the management of surface and groundwater to work together toward improving regional water supply reliability and quality.

The GWMP provides the framework for coordinating groundwater management activities among stakeholders. The plan identifies the basin management goals and objectives needed to guide efforts to effectively manage the groundwater basin as a safe and sustainable water supply.

Discussion

The City of Woodland currently relies entirely on groundwater obtained from twenty wells located throughout the City and meets future water demands by drilling new wells. The City also has one newly built above ground tank which is approximately 135 feet tall. This tank is used to improve and stabilize water system pressure.

The City is experiencing a gradual decline in groundwater quality at a number of well sites, and this has resulted in a couple of wells being taken out of service. In December 2005, the City developed an Urban Water Management Plan to address existing City water supply sources, reliability planning and water demand management measures. It, however, did not adequately address the potential threat and extent of nitrate contamination.

Best management objectives, identification of natural recharge areas, management and optimization of well field operations, and identification and feasibility study of conjunctive use projects were investigated as part of this study.

The GWMP will also qualify the City for grant funding opportunities administered by the State Water Resources Control Board and the Department of Health Services. Preference for these funds are given to proposals that include integrated projects with multiple benefits, improve local and regional water supply reliability, contribute towards improving water quality standards, reduce pollution, and improve groundwater management. A copy of the GWMP is available at the Library, Public Works Department, and the City Manager's office. The following potential future projects could qualify for grant application if the GWMP is adopted:

- Well rehabilitation/blending
- Installation of groundwater monitoring wells
- New ground level tank project
- Surface water project

Staff received questions on the Draft GWMP, answers were provided, the questions and answers are attached as Exhibit B.

Fiscal Impact

There are no costs associated with the adoption of this GWMP. The cost of developing the GWMP was budgeted in the Public Works Operations and Maintenance fiscal year 2007/2008. Fiscal impacts have been be identified and developed as a result of implementing groundwater management activities, such as studies and projects to mitigate groundwater contamination. If grant funding is pursued and received, the amount can be used to offset the cost of implementation of these water management activities.

Interdepartmental Coordination

Project initiatives from the GWMP will be closely coordinated with the Community Development Department for related coordination of development and redevelopment initiatives and with the Finance Department prior to seeking Council approval for potential grant funding opportunities.

Public Participation

This public hearing was published in the newspaper on February 9 & 16, 2011 pursuant to section 10753.5 of the Water Code. The Statement of Work for preparing the GWMP includes public outreach and stakeholder coordination including the preparation of written statements describing the manner in which interested parties may participate in development of the GWMP. This was published pursuant to section 6066 of the Government Code.

Interagency coordination with Yolo County and the Water Resources Association of Yolo County and its member agencies were part of the study development. A copy of the GWMP is available at the Library, Public Works Department, the City Manager's office, and can be currently found online at www.cityofwoodland.org.

Alternative Courses of Action

1. The Council adopts this GWMP in accordance with the provision of SB 1938 and pursue future grant funding.
2. The Council could decide not to adopt this GWMP and give directions to staff on changes to be made to the GWMP.

Recommendation for Action

Staff recommends that City Council approve Alternative No.1:
The Council should adopt this GWMP in accordance with the provision of SB 1938 and pursue future grant funding.

Prepared by: Akin Okupe
Senior Civil Engineer
Reviewed by: Doug Baxter
Principal Civil Engineer
Reviewed by: Greg Meyer
Director of Public Works

____
Mark G. Deven
City Manager

Attachments: Exhibit A – Executive Summary
Exhibit B – Questions & Answers from Citizens

City of Woodland

REPORT TO MAYOR AND CITY COUNCIL

AGENDA ITEM

TO: THE HONORABLE MAYOR
AND CITY COUNCIL

DATE: March 15, 2011

SUBJECT: Adoption of the Groundwater Management Plan

Report in Brief

The proposed Groundwater Management Plan (GWMP) addresses measures to monitor and manage groundwater within the service area of the City including: groundwater quality degradation, land surface subsidence, and changes in surface water flow and surface water quality that directly affect the City's groundwater levels or quality or are caused by groundwater pumping in the basin.

This item came before the City Council at the March 1 meeting. The Council conducted a Public Hearing and introduced the ordinance by waiving the first reading and reading by title only. Comments regarding the proposed ordinance were received from Christine Casey, chair of the Water Rate Advisory Committee; these comments have been addressed through a letter from West Yost Associates included as Exhibit 2.

Staff recommends that the City Council adopt Ordinance No. _____, adopting the GWMP which, under SB 1938, establishes the framework for working cooperatively with local agencies in managing local groundwater resources and establishes grant funding eligibility for construction and groundwater projects administered by the California Department of Water Resources. The preparation and adoption of the GWMP are statutorily and categorically exempt under the California Environmental Quality Act ("CEQA," Pub. Res. Code, § 21000 et seq.).

Background

The GWMP has been prepared in order to comply with three pieces of legislation (AB 3030, SB 1938, and SB 1672) which encourage local agencies to prepare groundwater management plans, require certain components to be included, and encourage regional cooperation between public agencies in managing groundwater. The GWMP provides the framework for coordinating groundwater management activities among stakeholders. The plan identifies the basin management goals and objectives needed to guide efforts to effectively manage the groundwater basin as a safe and sustainable water supply. Staff has included the Executive Summary as Exhibit A.

On March 1, the City Council conducted a Public Hearing and introduced the ordinance. Christine Casey, chair of the Water Rate Advisory Committee, presented comments regarding the GWMP and requested a response. These comments focused on the need for a strong conservation plan, actions necessary to educate citizens regarding water quality, improved system management and the need for the GWMP to include an Executive Summary. Staff has worked with West Yost Associates to provide a complete response to Ms. Casey's comments which is included as Exhibit 2. The response references sections of the GWMP as well as other water resource management documents that address these very important issues.

Discussion

The City of Woodland currently relies entirely on groundwater obtained from twenty wells located throughout the City. The decline in the quality of the groundwater and new regulatory requirements are requiring the City to plan to partially shift its source of potable water from groundwater to surface water. The GWMP addresses how to manage the groundwater in light of this shift and will also qualify the City for grant funding opportunities administered by the State Water Resources Control Board and other state agencies.

Fiscal Impact

There are no costs associated with the adoption of this GWMP. The cost of developing the GWMP was budgeted in the Public Works Operations and Maintenance fiscal year 2007/2008. Fiscal impacts have been identified in connection with potential implementation of groundwater management activities. If grant funding is pursued and received, the amount can be used to offset the cost of implementation of these water management activities.

Public Contact

The first draft of the GWMP was circulated in early December 2010 for public comment. Comments were received and have been previously addressed by staff. A notice for the public hearing conducted on March 1st was published in the Woodland Daily Democrat on February 9 and 16, 2011 pursuant to section 10753.5 of the Water Code, and further notice was published pursuant to section 6066 of the Government Code. A copy of the GWMP is available at the Library, Public Works Department, the City Manager's Office, and can be currently found online at:

www.cityofwoodland.org.

As stated previously, a response has been provided to the comments received from Christine Casey as a representative of the Water Rates Advisory Committee (WRAC). The response is included as Exhibit 2.

CEQA Compliance

If approved, the GWMP would entail a discretionary action by the City. However, the GWMP is exempt from review pursuant to CEQA under multiple exemptions, including the following:

The GWMP is statutorily exempt under California Code of Regulations, title 14 (“State CEQA Guidelines”), section 15262, because it entails identification of best management objectives, identification of potential natural recharge areas, management and optimization of well field operations, and identification and feasibility study of potential conjunctive use projects, and therefore entails feasibility and planning studies. The GWMP includes the consideration of environmental factors, including the impacts of global climate change.

It is categorically exempt under the State CEQA Guidelines section 15306 exemption for information collection, because it entails monitoring of groundwater quality and quantities within the basin and development of monitoring protocols, and will have no serious or major disturbance of any environmental resource. While well rehabilitation/blending, the installation of groundwater monitoring wells, a new ground level tank project, and surface water projects are discussed, these actions are not part of the GWMP. Instead, they entail past activities that have already been the subject of CEQA review, or possible future activities that are currently only speculative, but, once identified, are separate projects that will be the subject of appropriate CEQA review.

The GWMP is also categorically exempt under State CEQA Guidelines section 15307 exemption for activities taken to maintain, restore, or enhance a natural resource and section 15308 exemption for activities taken to assure the maintenance, restoration, enhancement, or protection of the environment, because the GWMP’s purpose is to create a monitoring program, groundwater sustainability, groundwater protection, and planning integration.

In order to protect and enhance the environment and the natural resources of groundwater and surface water, the GWMP creates Basin Management Objectives and a program for monitoring and managing the basin’s groundwater levels and preventing groundwater quality degradation, inelastic land subsidence, and changes in surface water flow and quality that directly affect groundwater levels or quality or that are caused by groundwater pumping in the basin. It also includes monitoring protocols designed to detect such changes, such that a net benefit to basin groundwater users will result. It describes potential future groundwater management actions that could be implemented in order to develop integrated regional solutions for water management and to coordinate conjunctive management of surface and groundwater to improve regional supply, reliability, and quality of water.

The GWMP does not include construction activities or relaxation of environmental standards, and no expansion of capacity will be created by the steps taken to manage groundwater. There is no possibility that implementation of the GWMP may cause a direct physical change in the environment, a reasonably foreseeable indirect physical change in the environment, or a significant impact on the environment.

Alternative Courses of Action

1. Adopt Ordinance No. _____, adopting the GWMP which, under SB 1938, establishes the framework for working cooperatively with local agencies in managing local groundwater resources and establishes grant funding eligibility for construction and groundwater projects administered by the California Department of Water Resources. The preparation and adoption of the GWMP are statutorily and categorically exempt under the California Environmental Quality Act ("CEQA," Pub. Res. Code, § 21000 et seq.).

2. Do not to adopt this GWMP and give direction to staff on changes to be made to the GWMP.

Recommendation for Action

Staff recommends that the City Council approve Alternative No.1.

Prepared by: Akin Okupe
Senior Civil Engineer

Reviewed by: Doug Baxter
Principal Civil Engineer

Reviewed by: Greg Meyer
Director of Public Works

____
Mark G. Deven
City Manager

Attachments: Exhibit 1 – Executive Summary
Exhibit 2 – Response to WRAC Comments.

The City of Woodland (City) adopted a resolution to prepare this groundwater management plan (GWMP) on June 1, 2010, pursuant to Sections 10750 *et. seq*. of the California Water Code (CWC).

This GWMP was developed in coordination with the other local agencies with adopted plans and other basin stakeholders. This plan will be administered by the City Director of Public Works with consideration of the recommendations of an advisory committee made up of members of the Water Resources Association of Yolo County (WRA) Technical Committee, which includes staff representation from the City of Woodland.

The City intends to work cooperatively with other local agencies to manage water resources in the basin. This GWMP is one of several planning documents that will support the City's efforts. In an effort to better manage groundwater resources, local agencies in the vicinity of the City have adopted and are implementing the GWMP, Urban Water Management Plans (UWMP), and Integrated Regional Water Management Plans (IRWMP). The City is an active agency member of the WRA. The WRA, in cooperation with federal, state, and local agencies, developed an IRWMP intended to identify and describe water supply projects, address flood management, protect water quality, enhance aquatic and riparian habitat, and improve recreational opportunities (WRA, 2007). The writing of the IRWMP led to close collaborative ties between City, County, and State agencies, local water resource agencies, and community organizations. The City is also a member of the Westside Regional Water Management Group (RWMG), which consists of public agencies in Yolo, Solano, Lake, Colusa, and Napa Counties. The Westside RWMG is preparing the Westside IRWMP, which will constitute an integrated Water Management Plan for the Cache and Putah Creek watersheds. The Westside IWRMP is scheduled to be completed in 2016.

Public participation was sought during the development of this plan, and this final version of the GWMP reflects input received from members of the public. Key areas were climate change and plan implementation. Input was sought through the plan's public outreach process. Comments were received in writing, and the City worked with the individual commenters to develop appropriate responses to the comments and revisions to the GWMP. The public comments and City responses are documented in the GWMP.

ES.1 AUTHORITY

The CWC provides the City's authority to adopt this GWMP. The City overlies the Yolo Groundwater Sub-basin and provides water service within its service area. The City is a local agency pursuant to CWC Section 10752 (g). The City is authorized to adopt this GWMP as provided in CWC Section 10753 (a).

ES.2 PURPOSE OF THE GROUNDWATER MANAGEMENT PLAN

The City relies on groundwater to meet the water demands of its customers. The purpose of this GWMP is to:

1. State the City's overall groundwater management goal;
2. Put forth Basin Management Objectives (BMO) applicable to the City service area;
3. Provide a mechanism for the continued collection of baseline groundwater and aquifer information; and
4. Establish management actions, including provisions for updating the plan as conditions change and new information becomes available.

The City is located in the Yolo Sub-basin (Sub-basin 5-21.67) of the Sacramento Valley Groundwater Basin as defined in the California Department of Water Resources (DWR) Bulletin 118 update (DWR, 2003). Figure ES-1 shows the location of the City in relation to the boundaries of other local agencies overlying the groundwater basin. The Yolo Sub-basin is bounded by Cache Creek on the north; the Sacramento River on the east; Putah Creek on the south; and the Coast Range on the west (DWR, 2004). This plan covers the City service area.

ES.3 OVERALL GROUNDWATER MANAGEMENT GOAL

The City's overall groundwater management goal is to work cooperatively with basin stakeholders and the public to maintain a sustainable, reliable, high-quality groundwater supply for beneficial use in the City service area and surrounding areas (Figure ES-2).

ES.4 BASIN MANAGEMENT OBJECTIVES

BMOs were developed to support the City's overall groundwater management goal. BMOs were established to address the following five areas:

- Groundwater quality
- Groundwater elevations
- Inelastic land subsidence
- Adverse impacts to surface water flows and surface water quality due to groundwater pumping
- Adverse impacts to groundwater levels and groundwater quality due to changes in surface water flow or quality

BMO-01 – Protect and maintain groundwater quality within the City service area for the benefit of basin groundwater users. Groundwater within the City's service area is affected by nonpoint sources of nitrate and salts, and localized point sources of anthropogenic contaminants. Naturally occurring contaminants, resulting from dissolution of minerals comprising the aquifer skeleton, also affect groundwater quality. The City's objective is to minimize the impact of these contaminants at the locations of individual municipal wells within its service area, and to support stakeholder efforts to protect beneficial uses in the groundwater sub-basin from adverse impacts to groundwater quality.

The City analyzes groundwater quality samples from its active production wells to comply with applicable standards in Title 22 of the CWC. The Department of Public Health (DPH) Title 22 program specifies the constituents to be tested, the detection limits for these constituents and reporting requirements. Sampling is conducted annually in a subset of the active wells such that each well is sampled on a three-year rotating cycle. Compliance with drinking water standards is a primary objective for the City. The City also uses the groundwater quality results to assess potential impacts to the municipal wastewater treatment plant, which is regulated under a Central Valley Regional Water Quality Control Board Waste Discharge Requirements Order. The primary constituents of concern for the wastewater discharge are selenium, boron and total dissolved solids (TDS). The water quality results will be evaluated on the same annual cycle under which the wells are sampled, such that each well will be evaluated every three years when new sample results are available. Temporal trends in the concentration of each constituent will be evaluated using a three-sample moving average comprised of the three most recent historical sample results for each well. Any increase in the concentration of a constituent of 20 percent or greater relative to the three-sample moving average will trigger evaluation of the need for potential actions, including:

- Consideration of possible agricultural and landscaping best management practices that could help control nitrate, nutrient and salt loading to the groundwater basin
- Additional monitoring, potentially on a more frequent basis
- Operational modifications affecting the pumping schedule and rate
- Well modifications to adjust the depth of pumping or seal zones with inferior water quality
- Well destruction, with possible replacement with a new well
- Replacement with a surface water supply
- Wellhead treatment, if feasible
- Destruction of abandoned wells

BMO-02 – Maintain groundwater elevations that result in a net benefit to basin groundwater users. Groundwater in the Yolo Sub-basin is used for municipal, domestic and agricultural supply. The City recognizes the need to support all of these uses. The City's objective is to work cooperatively with stakeholders to maintain groundwater levels at elevations that economically meet the City's municipal supply needs within its service area, and stakeholder needs for irrigation, domestic and industrial supply in surrounding areas of the sub-basin.

The City measures static water levels in its production wells on a monthly basis and uses the information to assess trends in groundwater levels. Historical data are available from 1976 through the present. This record encompasses significant variations in hydrology, including the 1976-1977, 1988-1992 and 2007-2009 droughts. Reductions in groundwater levels affect well capacity. Typically, the July-August timeframe is the most critical time of year because groundwater levels are near their annual minimum, and demands are near their maximum. Under dry conditions, the July and August groundwater levels could decline to a degree that potentially affects the City's well capacity. The monthly static groundwater levels will be compared to historical results to assess the potential need for management actions. Emphasis will be placed on evaluating April through June static groundwater levels, because groundwater levels typically reach their maximum in April. Significant reductions in April through June static groundwater levels may indicate the need for actions to mitigate reductions in well capacity caused by very low groundwater levels in July and August. Historically low groundwater levels occurred in 1977 and 1991. The lowest recorded measurements for the months of April through June occurred in 1977. The need for potential actions will be considered when April through June groundwater levels decline to levels that are within 25 percent of the April through June 1977 groundwater levels. Potential actions include:

- Outreach to encourage conservation
- Operational modifications to reduce reliance on wells most affected by groundwater level declines
- Construction of additional wells
- Use of surface water supplies

BMO-03 – Minimize the risk of future significant impact due to inelastic land subsidence. Inelastic land subsidence resulting from groundwater withdrawal has had significant consequences in the Yolo Groundwater Sub-basin. The risk of future significant impacts depends on a complex array of variables including: the degree of new groundwater development, especially in areas or at depths not previously exploited; changing land use, which could bring to light an impact that would otherwise go unnoticed; and the mineral composition of the aquifer skeleton, and its consolidation history. The City's objective is to prevent or minimize future impacts that may result from increased rates of inelastic land subsidence in and around its service area by continuing to cooperate with other stakeholders to monitor rates of inelastic land subsidence using the Yolo Subsidence Network.

Rates of inelastic land subsidence are being established by the WRA's Yolo Subsidence Monitoring Project. At present, data are insufficient to establish significance criteria for rates of inelastic land subsidence in the Woodland area. The City will participate in future surveys of the Yolo Subsidence Network and will evaluate the results with other members of the WRA.

BMO-04 – Protect against the risk of impacts to surface water flows and quality caused by groundwater pumping. The City currently does not use surface water, and there are no surface water flows within or adjacent to the City's service area. However, the City recognizes that the importance of protecting against impacts to surface water flows and surface water quality in the watershed. The City's objective is to work with basin stakeholders during integrated regional water management planning efforts to select alternatives that minimize the potential impacts to surface water flows and surface water quality caused by groundwater pumping.

BMO-05 – Protect against the risk of impacts to groundwater levels or groundwater quality caused by changes in surface water flows or surface water quality. Surface water deliveries are an important source of groundwater recharge in the Yolo Groundwater Sub-basin. Modeling studies indicate that, in the Central Valley as a whole, irrigation returns account for about 80 percent of the groundwater recharge on average (Williamson, et. al., 1989). Changes in the quantity of surface water delivered to the basin may affect both groundwater levels and groundwater quality. Changes in the sources of surface water may affect groundwater quality. The City's objective is to work cooperatively with basin stakeholders during integrated regional water management planning efforts to select water supply alternatives that minimize the potential impacts to groundwater flows and groundwater quality caused by changes in surface water flows or surface water quality.

ES.5 GROUNDWATER MANAGEMENT PLAN COMPONENTS

The BMOs are linked to management actions that are planned or triggered to attain the BMOs and overall groundwater management goal (Figure ES-1). Management actions are addressed under the six components of the GWMP:

- Agency Coordination, Stakeholder Involvement and Public Outreach
- Monitoring Program
- Groundwater Sustainability
- Adaptive Management and Mitigation in Response to Climate Change
- Groundwater Protection
- Planning Integration

Each component of the GWMP addresses related groundwater management subject matter and recommended actions. For example, the monitoring program component addresses the related topics of groundwater elevation monitoring; groundwater quality monitoring; land subsidence monitoring; groundwater-surface water interaction monitoring; and data management, quality assurance and quality control. The groundwater protection component addresses well construction and destruction policies, wellhead protection policies, protection of recharge areas, management of sources of groundwater contamination, and control of saline water intrusion.

ES.6 ADVISORY COMMITTEE FORMATION

The Advisory Committee for this GWMP is comprised of the WRA Technical Committee, which includes representation by City of Woodland staff. The City plans to continue to designate City representatives to the WRA Technical Committee and Advisory Committee during implementation of this GWMP.

ES.7 ANNUAL GROUNDWATER MANAGEMENT REPORT

The City plans to annually produce a status report to document the progress of the GWMP implementation throughout the previous year and to review and confirm actions for the next year. The report will include information regarding inelastic land subsidence, when updates are available, groundwater quality, groundwater production, and groundwater levels in relation to the established BMOs. When the Woodland-Davis Clean Water Agency's Davis Woodland Water Supply Project (DWWSP) is implemented, the annual reports will document the effect that the addition of a municipal surface water supply has on the groundwater system through groundwater level, groundwater production, and groundwater quality monitoring.

ES.8 FUTURE GROUNDWATER MANAGEMENT PLAN UPDATES

Periodic GWMP updates will be required as knowledge of the Yolo Sub-basin increases and groundwater management strategies evolve. The City will periodically consider new groundwater management techniques to be incorporated into the GWMP. Over time, BMOs may need to be modified based on changing groundwater conditions, the completion of the DWWSP and the addition of an operable conjunctive use system, or the development of new key groundwater management objectives. If changes must be made, the City will formalize the changes in an updated GWMP. The City plans to update this GWMP every five years on approximately the same update cycle as the City's UWMP.

ES.9 FINANCING

The implementation of this GWMP will be funded by the City. Ongoing coordination activities will be performed by City staff using City funds. Most baseline data collection activities will also be funded by the City. The City plans to provide a proportional share of costs for other regional data collection efforts, such as land subsidence monitoring. State or federal funding may be pursued to support implementation of this GWMP.

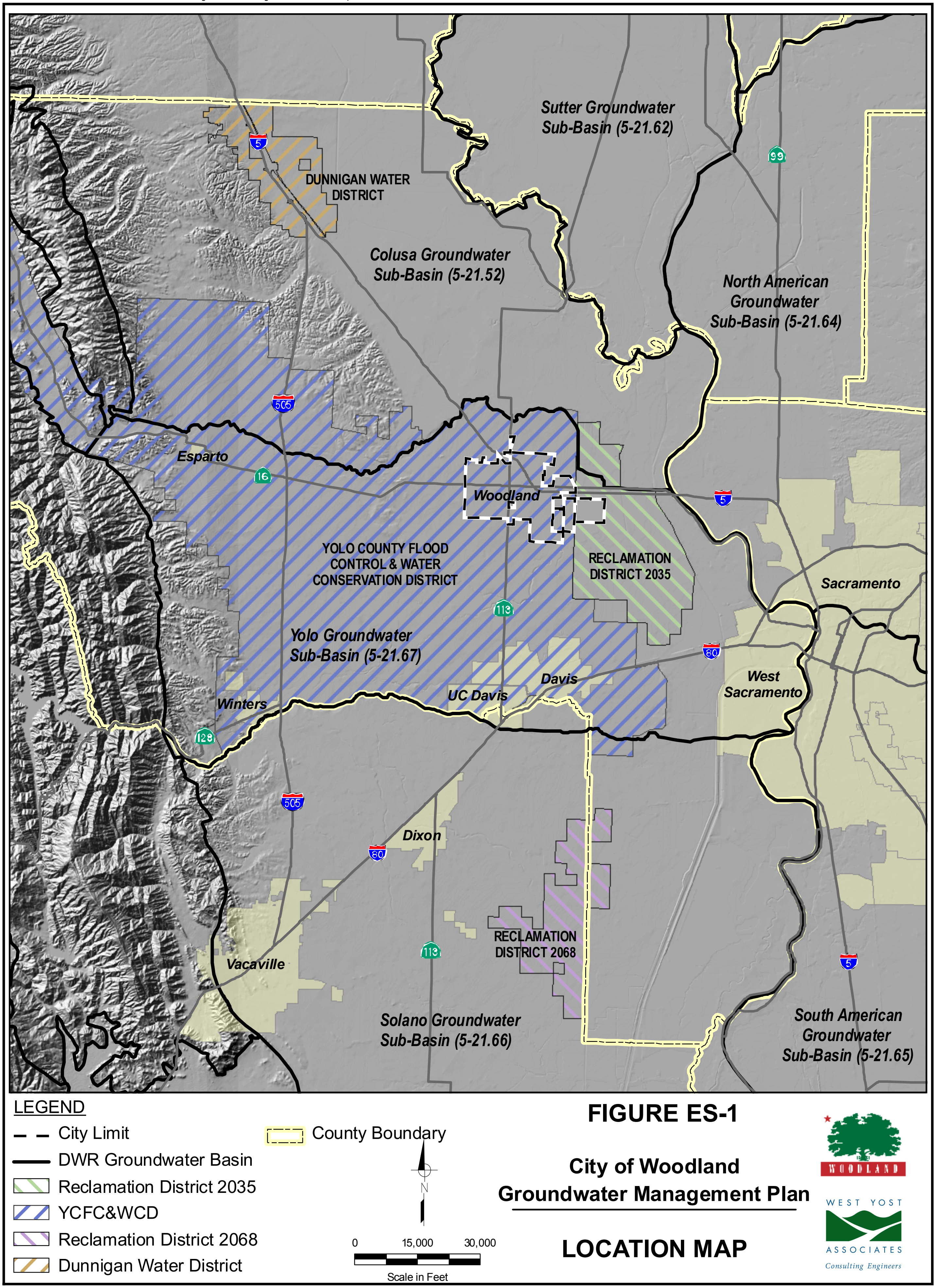

FIGURE ES-1

City of Woodland
Groundwater Management Plan

LOCATION MAP

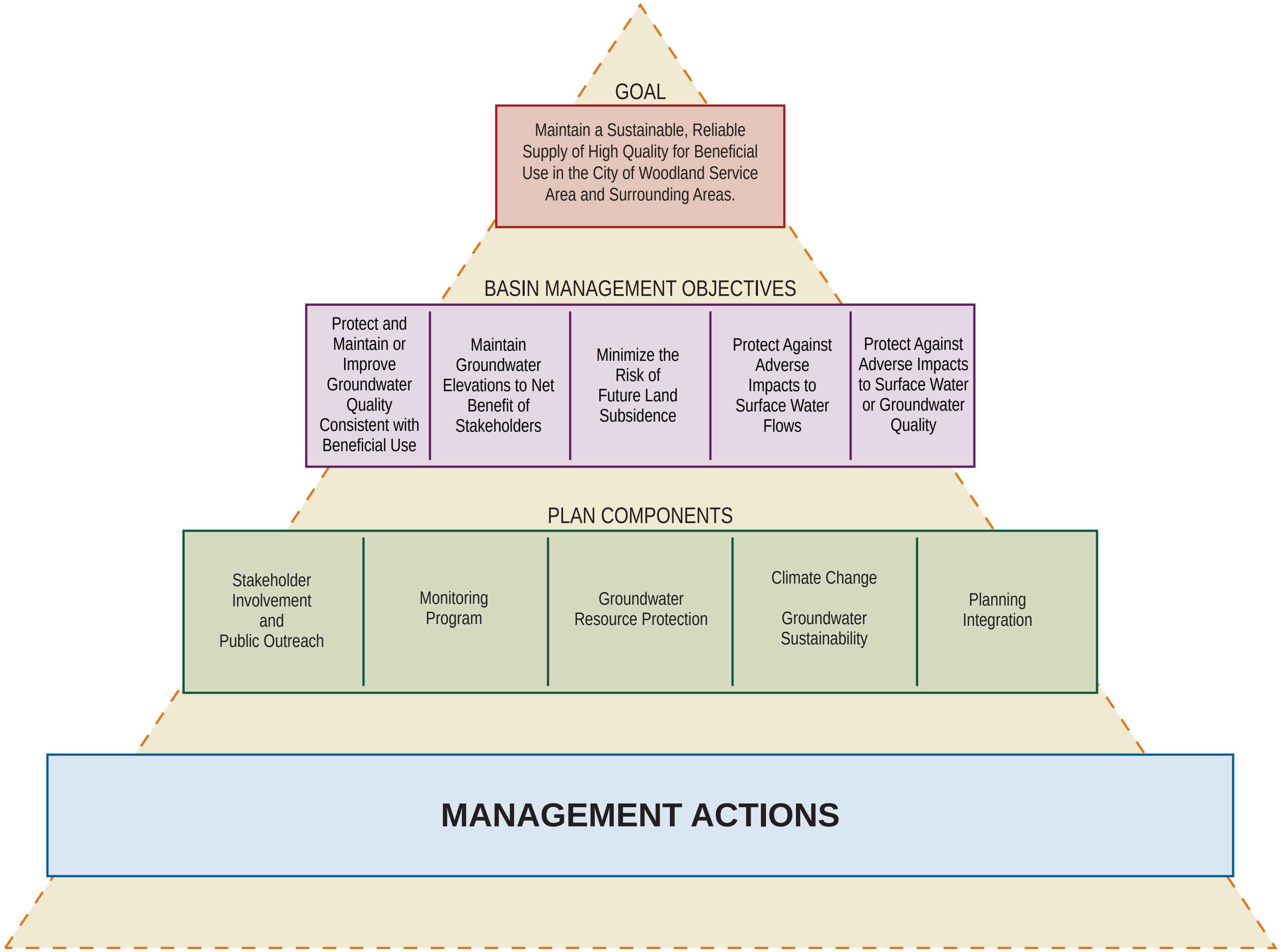

Figure ES-2

City of Woodland
Groundwater Management Plan

GROUNDWATER MANAGEMENT COMPONENTS

WOODLAND
WEST YOST ASSOCIATES
Consulting Engineers

WEST YOST
ASSOCIATES

March 7, 2011 Project No.: 204-00-08-18

Mr. Akin Okupe
Senior Civil Engineer
City of Woodland
655 N. Pioneer Avenue
Woodland CA 95776

SUBJECT: Response to Comments on the City of Woodland Draft Groundwater Management Plan from the Water Rate Advisory Committee

Dear Mr. Okupe:

This letter provides responses to comments on the City of Woodland's draft groundwater management plan received from members of the City of Woodland's water rate advisory committee. The water rate advisory committee provided comments orally at the March 1, 2011 City Council meeting. These comments were provided to City staff in writing on March 2, 2011. Attachment A contains the complete text of the water rate advisory committee's comments.

Comment 1 – Conservation. The City does not seem to have a strong conservation plan. We recognize that metering is helping.

a. We would like to see a single, comprehensive source of information on the City web site; demonstration water-wise gardens on City property; programs like in Roseville where residents who agreed to conserve received special lawn signs, etc. There are WRAC members who are willing to help with this.

b. A permanent time of day/day of week landscape irrigation plan should be a law and should be enforced.

c. Further irrigation and water use restrictions should have clear triggers, e.g. well water level.

d. Why is water recycling not even being considered? Can some of our wastewater be made available to agricultural producers?

e. Water rates should include incentives for conservation.

Response 1. The City's groundwater management plan is one of several planning documents that the City is preparing. The groundwater management plan has a limited purpose and scope, and is intended to address specific management issues identified in the California Water Code, and California Department of Water Resources guidance documents. The groundwater management plan is intended to support the City's overall goal of working,

> "…cooperatively with basin stakeholders and the public to maintain a sustainable, reliable, high-quality groundwater supply for beneficial use in the City service area and surrounding areas."

The water supply referred to in this statement is groundwater. It follows that the primary focus of the groundwater management plan is on the groundwater basin, especially the portion of the basin overlain by the City of Woodland, although the plan seeks, and includes mechanisms for, cooperative management of the resource. Water conservation and recycling clearly relate to groundwater management because these initiatives seek to reduce water demands, including demands on groundwater resources. The groundwater management plan discusses water conservation and recycling primarily in the context of how these activities may affect future demands for groundwater.

Section 3.3.3.2, Water Recycling, states,

> "There are currently no water recycling projects in the City. The City is in the early stages of evaluating recycled water use to offset potable water demands. Other potential supplies, including shallow irrigation wells in parks and other public landscape areas, are also being considered for this purpose.
>
> **Action:** Continue to evaluate alternative supplies that could offset nonpotable demands currently met with drinking water sources."

Section 3.3.3.4, Water Conservation, states,

> "The City is also implementing a water meter program and has installed meters on many customer water connections. Many of these customers began receiving sample billings based on their metered consumption in the spring of 2010. The City plans to have virtually all of the water connections in the City metered by the end of 2012. Studies by the California Public Utilities Commission have shown that communities with metered water systems use 7 to 20 percent less water than non-metered areas. Therefore, the City can expect a 7 to 20 percent reduction in water consumption once the City-wide metering is complete."
>
> **Action:** The City will continue to implement its water meter project. The City will also continue to implement various programs to increase waste reduction, reuse, recycling, and promote the safe handling of household hazardous wastes. The City will continue to monitor and evaluate water usage to ensure that conservation measures are effective and the most representative demand trends are used to project future demands.

Other water planning initiatives undertaken by the City provide a broader platform for evaluating and planning water conservation measures and recycling. The City's urban water management plan is scheduled to be completed by June 2011 and must be submitted to California Department of Water Resources by July 1, 2011. The adopted groundwater management plan needs to be attached to the urban water management plan, per California Water Code Section 10631. Recycled water will also be addressed in the City's urban water management plan. The water focus study is a water planning document with a broader scope than the groundwater management plan. Recommendations from the water rate advisory committee will be considered during preparation of these documents.

The State of California approved Senate Bill 7 (SB 7), which requires water providers to reduce their per capita water use by 20 percent by the year 2020. For consistency with the California Public Utilities Commission findings regarding metering and the requirements of SB 7, a 20 percent reduction in per capita water use rates was assumed in the demand projections documented in Section 2.2.4.2 of the groundwater management plan. This assumption is consistent with the State-mandated requirements and is appropriate for the purposes of the groundwater management plan and urban water management plan.

The City has developed a water conservation planning goal and objectives for the 2010 through 2012 timeframe. The City's water conservation planning goal is,

> "...to reduce water use 20% by 2020, measured in gallons per capita, as compared to a 10 year baseline of pre-metered use."

This goal is supported by three objectives:

- Reduce City Water Usage
- Increase Public Education and Outreach
- Conserve Water through Landscaping Practices

Each objective has sub-objectives, which address residential and industrial water conservation, reductions in water system losses, public outreach and education, and water-efficient landscaping practices. Planned actions include updating the City's urban water management plan and adopting and revising the City Water Code to reflect new state legislation regarding water conservation including the Model Water Efficient Landscape Ordinance and SB 7. The City's 2010-2012 Water Conservation Plan goal and objectives are provided in Appendix B.

Comment 2 – Water Quality. Since nitrates are a significant problem, why not implement a fertilizer education program?

For ag producers that are major source in groundwater, work with Cooperative Extension. For landscape sources that contribute nitrates to storm water, work with landscapers and homeowners through the media and educational events.

Since salts are a significant problem, why not implement an educational program to encourage residents with water softeners to switch to potassium chloride instead of sodium chloride?

Response 2. The City can choose to implement an education program as a groundwater management action. This could address fertilizer, salt and nutrient best management practices in urban settings within the City and in agricultural areas in the surrounding areas. The University of California Cooperative Extension of Yolo County could provide a resource in this effort and Yolo County Flood Control & Water Conservation District could be approached as a cooperating entity. Activities could be discussed and coordinated through the Water Resources Association of Yolo County.

The revised groundwater management plan contains a Basin Management Objective (BMO) that would support the education program. BMO reads as follows,

> "BMO-01 – Protect and maintain groundwater quality within the City service area for the benefit of basin groundwater users. Groundwater within the City's service area is affected by nonpoint sources of nitrate and salts, and localized point sources of anthropogenic contaminants. Naturally occurring contaminants, resulting from dissolution of minerals comprising the aquifer skeleton, also affect groundwater quality. The City's objective is to minimize the impact of these contaminants at the locations of individual municipal wells within its service area, and to support stakeholder efforts to protect beneficial uses in the groundwater sub-basin from adverse impacts to groundwater quality.
>
> The City analyzes groundwater quality samples from its active production wells to comply with applicable standards in Title 22 of the CWC. The Department of Public Health (DPH) Title 22 program specifies the constituents to be tested, the detection limits for these constituents and reporting requirements. Sampling is conducted annually in a subset of the active wells such that each well is sampled on a three-year rotating cycle. Compliance with drinking water standards is a primary objective for the City. The City also uses the groundwater quality results to assess potential impacts to the municipal wastewater treatment plant, which is regulated under a Central Valley Regional Water Quality Control Board Waste Discharge Requirements Order. The primary constituents of concern for the wastewater discharge are selenium, boron and TDS. The water quality results will be evaluated on the same annual cycle under which the wells are sampled, such that each well will be evaluated every three years when new sample results are available. Temporal trends in the concentration of each constituent will be evaluated using a three-sample moving average comprised of the three most recent historical sample results for each well. Any increase in the concentration of a constituent of 20 percent or greater relative to the three-sample moving average will trigger evaluation of the need for potential actions, including:
>
> - Consideration of possible agricultural and landscaping best management practices that could help control nitrate, nutrient and salt loading to the groundwater basin
> - Additional monitoring, potentially on a more frequent basis
> - Operational modifications affecting the pumping schedule and rate
> - Well modifications to adjust the depth of pumping or seal zones with inferior water quality
> - Well destruction, with possible replacement with a new well
> - Replacement with a surface water supply

- Wellhead treatment, if feasible
- Destruction of abandoned wells

This BMO is supported by a range of groundwater management plan components addressing agency coordination, stakeholder involvement and public outreach, groundwater quality monitoring, groundwater sustainability, and groundwater protection.

The revised groundwater management plan also includes discussion of the Davis Woodland Water Supply Project (DWWSP), which is being undertaken by the Woodland-Davis Clean Water Agency (WDCWA). The WDCWA is a joint powers authority including the Cities of Woodland and Davis and UC Davis. Planned implementation of the DWWSP will provide the City with treated surface water from the Sacramento River in 2016. The City's use of groundwater will continue but at a significantly reduced rate. The salinity of the treated surface water will be much lower than the City's groundwater, and the anticipated proportions of surface water to groundwater make it unlikely that customers will want to continue to use water softeners. The overall salinity of the City's supply will be significantly reduced as a direct consequence of the DWWSP. The consequential phasing out of water softeners will also decrease salinity in the City's treated wastewater effluent.

Comment 3 – System Management. Adaptive management is mentioned in the plan, but how is it being done? Why does Yolo County do the permitting of City wells rather than the City? The thought here was that we would have more control over the process.

Response 3. Section 2.1.3, Climate Change, of the draft groundwater management plan defines adaptation and mitigation of climate change and documents published adaptive management strategies developed by the California Urban Water Association (CUWA). The CUWA adaptation and mitigation examples are listed in Table 2-2 of the groundwater management plan.

Section 3.3.4, Adaptive Management and Mitigation in Response to Climate Change, of the draft groundwater management plan provides a discussion of adaptive management strategies for the City of Woodland, including:

- Development of groundwater recharge, storage and conjunctive use projects
- Water transfers
- Development of regional water projects and partnerships
- Water conservation
- Optimization of local storage

The City Department of Public Works staff has made the determination that permitting for construction of new wells and destruction of existing wells is adequately specified in California Department of Water Resources documents and implemented by Yolo County. In addition to these existing requirements, the groundwater management plan addresses well construction and destruction under its groundwater protection component. Section 3.3.3.4 states,

> "The need for special well construction and destruction policies has not been identified within the City service area. Therefore, the construction and destruction standards put forth in CWC Section 13700 and detailed in DWR Bulletins 74-81 and 74-90 have been adopted as the applicable standards. These standards are enforced through the well construction and destruction permitting process administrated by the Yolo County Department of Environmental Health.
>
> **Action:** The City will ensure that any well construction or destruction projects that it undertakes will meet the applicable standards. The City will also include information on these standards in its education and outreach activities to private well owners within the City service area. When reviewing or approving land use plans, the City will endeavor to ensure that project proponents identify and properly destroy abandoned wells within the plan area as a condition of development."

Comment 4 – Executive Summary. Requiring the consultants who write the plan to also prepare an Executive Summary written in lay terms would make the report more accessible to Woodland residents. See attached.

Response 4. The revised draft groundwater management plan includes an executive summary. The "City of Woodland Groundwater Management Plan Summary for City Residents" prepared by the water rate advisory committee is provided as Attachment C.

We appreciate water rate advisory committee's interest in reviewing the draft groundwater management plan. We hope that the revisions made to the document and the response provided in this letter address the committee's concerns and that the revised document provides the City of Woodland with the planning tools needed to address the range of groundwater management issues.

Sincerely,

WEST YOST ASSOCIATES

Kenneth L. Loy
Principal Hydrogeologist
P.G. #7008

KLL:nmp

attachments

Attachment A

City of Woodland Groundwater Management Plan
Water Rate Advisory Committee Comments

Comments provided orally at the March 1, 2011 City Council Meeting and by email on March 2, 2011.

CONSERVATION

- The City does not seem to have a strong conservation plan.

  *****We recognize that metering is helping. We would like to see a single, comprehensive source of information on the City web site; demonstration water-wise gardens on City property; programs like in Roseville where residents who agreed to conserve received special lawn signs, etc. There are WRAC members who are willing to help with this.*****

- A permanent time of day/day of week landscape irrigation plan should be a law and should be enforced.
- Further irrigation and water use restrictions should have clear triggers, e.g. well water level.
- Why is water recycling not even being considered? Can some of our wastewater be made available to agricultural producers?
- Water rates should include incentives for conservation.

WATER QUALITY

- Since nitrates are a significant problem, why not implement a fertilizer education program?

  *****For ag producers that are major source in groundwater, work with Cooperative Extension. For landscape sources that contribute nitrates to storm water, work with landscapers and homeowners through the media and educational events*****

- Since salts are a significant problem, why not implement an educational program to encourage residents with water softeners to switch to potassium chloride instead of sodium chloride?

SYSTEM MANAGEMENT

- Adaptive management is mentioned in the plan, but how is it being done?
- Why does Yolo County do the permitting of City wells rather than the City?

  *****The thought here was that we would have more control over the process*****

Requiring the consultants who write the plan to also prepare an Executive Summary written in lay terms would make the report more accessible to Woodland residents.

*****See attached*****

Attachment B

Water Conservation Plan 2010-2012

Goal

To reduce water use 20% by 2020, measured in gallons per capita, as compared to a 10 year baseline of pre-metered use.

Objective 1:

Reduce City Water Usage

- Revise the Water Conservation Section of the Urban Water Management Plan to meet the updated California Urban Water Conservation Council (CUWCC) Best Management Practices (BMPs) and SBx7-7 reduction goals.
- Revise the City Water Code to represent new state legislation regarding water conservation including the Model Water Efficient Landscape Ordinance and SBx7-7.

Sub-objective 1.1: Reduce Residential Water Waste

- Provide assistance to aid residents in detecting leaks which is a top priority with the water meters being installed and sample bills going out. Residential assistance would require additional staff and/or interns.
- Install water meters.
- After installation of water meters, begin billing with conservation tiers.
- Continue current incentives and /or provide new incentives for water conservation which could include toilet rebates, washer rebates, weather-based irrigation system rebates, rain barrel rebates and/or "Cash for Grass" programs.

Sub-objective 1.2: Reduce CII (Commerical, Industrial, Institutional) Water Waste

- Establish a relationship with the Chamber of Commerce and attend Water Committee Meetings.
- Research CII rebates and other potential savings for CII customers.
- Look into programs offered by other municipalities.
- Offer water surveys to identify water savings and check for leaks (would require additional staff and/or hiring a contractor).

Sub-objective 1.3: Reduce City Department Water Waste

- System wide water audit (leak detection survey) on the water infrastructure within the City. Phase 1 area of town to begin in summer 2011 to determine leaks in the system and to better estimate City water loss.
- Survey of water use by City Departments.
- Follow progress of Parks Irrigation Grant.

Objective 2:

Increase Public Awareness of Water Issues

Sub-objective 2.1: Increase public awareness of water issues through outreach.

- Maintain and update the water conservation website with new water conservation topics, update links to water conservation pages and data, and offer water conservation materials as downloadable PDFs.
- Provide water conservation information for City e-newsletter (once a month).
- Offer a suite of topics that groups can choose from for presentations in their area on water conservation related issues.
- Water conservation displays at the Library and City Hall.
- Create a water survey to use at events-potentially model after EBMUDs water survey. After a resident completes the survey, they are given water saving information and devices.
- Have public outreach materials and/or booth at local events.

Sub-objective 2.2: Increase educational opportunities for school aged children.

- Purchase educational materials for elementary-aged children to be given out at local events and/or to classes.
- Develop a $4^{th}/5^{th}$ grade education program on water conservation for Woodland schools.
- Offer Project WET (Water Education Training) workshops for Woodland area. Potentially co-sponsor with the Yolo County Office of Education.
- Co-sponsor the ZunZun school assembly program featuring water conservation, stormwater, and recycling.
- Consider a program like the Mayor's water readers which was a partnership among City of Tampa, the Public Library System, and Borders Books & Music. 300 participating youth (ages 6 to17) were rewarded for reading three books about water, received a certificate from the Mayor, citywide recognition and a gift from Borders.
- Offer the water drop patch for Girl Scouts and something similar for Boy Scouts or other groups. Girl Scouts worked on the patch and installed 148 storm drain markers in 2009.

Objective 3:

Conserve Water through Landscaping Practices

- Have demonstration sites for xeriscaping and native plant gardens. Potential at pond in Spring Lake and/or in the future at the new water treatment plant.
- Community water-wise awards: awards to people who redo their lawns with native plants.
- Water-wise Gardening Workshops in April/May each year. Develop partnerships with local nurseries to co-sponsor workshops to benefit the City and the nurseries. Have discount coupons from nurseries available at water conservation events. Hand out outdoor water conservation materials (two Sunset guides, soil moisture gauge, and hose nozzle).
- Landscape Irrigation Reviews. Include as part of leak detection assistance offered to high water users. Also consider offering to any interested residents in the future.
- Work with Community College and Master Gardeners on offering landscape workshops.
- Work with CDD on integrating the updated Model Water Efficient Landscape Ordinance into City Code.

Attachment C

City of Woodland Groundwater Management Plan
Summary for City Residents
Prepared by Members of the Water Rate Advisory Committee

The City of Woodland currently obtains its entire City water supply from twenty groundwater wells located throughout the City. By filing a Groundwater Management Plan with the State of California, we become eligible for grants that allow us to reduce costs, potentially saving City residents money.

The Groundwater Management Plan provides the framework for coordinating groundwater management activities among stakeholders. The plan identifies the management tools and objectives needed to guide efforts to effectively manage our groundwater as a safe and sustainable water supply.

Key concerns about the City's groundwater supply and steps taken by the City to address these include:

DECLINING GROUNDWATER QUALITY

The quality of our groundwater has been declining for several years. Woodland is under extreme regulatory pressure to have a higher-quality water supply by 2016, prior to the reconsideration of our wastewater discharge permit by the Regional Water Quality Control Board. While our water is safe to drink, it includes several components that are above the legally mandated level for wastewater discharge: boron, nitrate, selenium, chromium and Total Dissolved Solids (TDS). There is no way to cost-effectively treat our water to remove these.

The City has partnered with the City of Davis to develop a surface water supply drawn from the Sacramento River. This water supply will come on line in 2016 and will provide a high-quality water supply that meets State-mandated standards and fills most of our water needs. At that time our ground and surface water supplies will be integrated to ensure ample water supply and pressure during periods of peak demand.

LAND SUBSIDENCE DUE TO GROUNDWATER EXTRACTION

Inelastic land subsidence resulting from groundwater withdrawal can cause physical changes to our groundwater aquifers that render them unable to be recharged. To date this has had significant consequences in the Yolo Groundwater Sub-basin. The risk in each specific aquifer is determined by many factors, including the degree of new groundwater development, changing land use, and the mineral composition of the soil in the aquifer. The City's objective is to prevent or minimize future impacts from land subsidence by continuing to cooperate with other stakeholders to monitor rates of inelastic land subsidence.

Rates of land subsidence are being established though on-going county-wide monitoring. The City will continue to evaluate the results with other members of the WRA.

CHANGES IN GROUNDWATER LEVELS

Historical records show that the elevation of our groundwater declined from the 1950s to the 1970s but stabilized after that in response to regional water supply projects. Declines in groundwater levels are still a concern during drought years. It is much more expensive to pump water from lower levels, which increases system costs and strains equipment.

The City will consider several actions to maintain groundwater levels in dry years. These include outreach to encourage conservation, operational changes to rely least on wells most at risk, and construction of new wells. The implementation of the surface water supply described above will also alleviate pressure on existing groundwater supplies.

The full Groundwater Management Plan is available for viewing at City Hall or can be downloaded at www.cityofwoodland.org. Comments may be sent to xxxx or presented at the Woodland City Council meeting on yyyy.

State of California—The Resources Agency
DEPARTMENT OF FISH AND GAME
2011 ENVIRONMENTAL FILING FEE CASH RECEIPT

RECEIPT# 410965

STATE CLEARING HOUSE # *(If applicable)*

SEE INSTRUCTIONS ON REVERSE. TYPE OR PRINT CLEARLY

LEAD AGENCY: City of Woodland
DATE: 3/16/2011
COUNTY/STATE AGENCY OF FILING: Yolo County
DOCUMENT NUMBER: 711-14
PROJECT TITLE: City of Wdld 2011 Groundwater Management Plan
PROJECT APPLICANT NAME: Akin Okupe
PHONE NUMBER: 530 (661) 5966
PROJECT APPLICANT ADDRESS: 300 First Street
CITY: Woodland
STATE: CA
ZIP CODE: 95695

PROJECT APPLICANT *(Check appropriate box):*
☒ Local Public Agency ☐ School District ☐ Other Special District ☐ State Agency ☐ Private Entity

CHECK APPLICABLE FEES:

☐	Environmental Impact Report (EIR)	$2,839.25	$
☐	Mitigated/Negative Declaration (ND)(MND)	$2,044.00	$
☐	Application Fee Water Diversion *(State Water Resources Control Board Only)*	$850.00	$
☐	Projects Subject to Certified Regulatory Programs (CRP)	$965.50	$
☒	County Administrative Fee	$50.00	$ 50.00
☒	Project that is exempt from fees		
	☒ Notice of Exemption		
	☐ DFG No Effect Determination (Form Attached)		
☐	Other		$

PAYMENT METHOD:
☐ Cash ☒ Credit ☐ Check ☐ Other

TOTAL RECEIVED $ 50.00

SIGNATURE
X [signature]

TITLE
Deputy

WHITE - PROJECT APPLICANT YELLOW - DFG/ASB PINK - LEAD AGENCY GOLDEN ROD - COUNTY CLERK FG 753.5a (Rev. 11/10)

FILED
YOLO COUNTY CLERK/RECORDER
MAR 16 2011
FREDDIE OAKLEY, CLERK
BY [signature] DEPUTY
KIMBERLI QUAM

NOTICE OF EXEMPTION

TO: Yolo County Clerk-Recorder
625 Court Street, Room B01
Woodland, California 95695

FROM: City of Woodland
300 First St.
Woodland, CA
Phone: (530) 661-5850
Fax: (530) 661-1290

1. **Project Title:** City of Woodland 2011 Groundwater Management Plan ("GWMP")

2. **Project Location (specific):** The City of Woodland portion of the Yolo Groundwater Sub-Basin, see attached map.

3. (a) **Project Location - City:** City of Woodland

   (b) **Project Location - County:** County of Yolo

4. **Description of nature, purpose, and beneficiaries of Project:** The GWMP creates a framework for coordinating groundwater management activities among stakeholders and identifies basin management goals and objectives needed to guide efforts to effectively manage the groundwater basin as a safe and sustainable water supply. It addresses measures to monitor and manage groundwater within the service area of the City including: groundwater quality degradation, land surface subsidence, and changes in surface water flow and surface water quality that directly affect the City's groundwater levels or quality or are caused by groundwater pumping in the basin. It also establishes grant funding eligibility for potential future construction and groundwater projects, which will be required to undertake appropriate CEQA review when identified.

5. **Name of Public Agency Approving Project:** City of Woodland

6. **Name of Person or Public Agency Carrying Out Project:** This Notice of Exemption is submitted on behalf of the City of Woodland.

7. **Exempt status:** (Check One)
   (a) ____ Ministerial project.
   (b) __X__ Not a Project (no reasonably foreseeable direct or indirect physical changes in the environment)
   (c) ____ Emergency Project.
   (d) __X__ Categorical Exemption: State CEQA Guidelines §§ 15306, 15307, and 15308 (Classes 6, 7, and 8, exemptions for information collection; activities taken to maintain, restore, or enhance a natural resource; activities taken to assure maintenance, restoration, enhancement, or protection of the environment)
   (e) ____ Declared Emergency.

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POSTED MAR 16 2011 TO ________

(f) __X__ Statutory Exemption: State CEQA Guidelines section 15262 (feasibility and planning studies)

(g) __X__ Other: State CEQA Guidelines section 15061(b)(3) (no possibility of significant impacts on the environment)

8. Reason why project is exempt: The Project is exempt under State CEQA Guidelines section 15262 because it entails feasibility and planning studies for potential future groundwater management actions in order to develop integrated regional solutions for water management and to coordinate conjunctive management of surface and groundwater to improve regional supply, reliability, and quality of water, and it includes the consideration of environmental factors, including the impacts of global climate change. The Project is exempt under State CEQA Guidelines section 15306's exemption for information collection, because it entails monitoring of groundwater quality and quantities within the basin and development of monitoring protocols, and will have no serious or major disturbance of any environmental resource. While the GWMP discusses well construction and similar activities, these are all past or possible future activities that are not included in or required by the GWMP, but are separate projects that have been or will be the subject of appropriate CEQA review prior to implementation. It is also exempt under State CEQA Guidelines sections 15307 and 15308 exemptions for activities taken to maintain, restore, or enhance a natural resource and to assure the maintenance, restoration, enhancement, or protection of the environment because its purpose is to create a monitoring program, groundwater sustainability, groundwater protection, and planning integration. It identifies Basin Management Objectives and entails development of monitoring and managing protocols for the basin's groundwater levels, minimizing groundwater quality degradation, inelastic land subsidence, and changes in surface water flow and quality that directly affect groundwater levels or quality or are caused by groundwater pumping in the basin, such that a net benefit to basin groundwater users will result. The GWMP does not include construction activities or relaxation of environmental standards, no expansion of capacity will be created by the steps taken to manage groundwater, and no other exceptions to the above-identified exemptions apply. Because it can be seen with certainty that there is no possibility that the GWMP may cause a direct physical change in the environment, a reasonably foreseeable indirect physical change in the environment, or a significant impact on the environment, the GWMP is also exempt pursuant to State CEQA Guidelines section 15061(b)(3) and is not a project pursuant to Public Resources Code section 21065.

9. Contact Person: AKIN OKUPE, Public Works Department
Telephone: (530) 661-5960

Date Received for Filing:______________

Akin O Kupe, Senior Civil Engineer
Name, Title
City of Woodland
A Okupe

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APPENDIX B

Public Notification and Outreach Information

CITY OF WOODLAND
NOTICE OF PUBLIC HEARING TO CONSIDER ADOPTING RESOLUTION OF INTENT TO PREPARE A GROUNDWATER MANAGEMENT PLAN

NOTICE IS HEREBY GIVEN that the City Council of the City of Woodland will hold a Public Hearing on June 1, 2010 at approximately 6:00 p.m. in the Council Chambers of the City of Woodland, 300 First Street, Woodland, CA, for the following purpose:

> to consider adoption of a Resolution of Intent to prepare a Groundwater Management Plan for the City of Woodland service area pursuant to California Water Code Section 10750 *et. seq*.

The City of Woodland recognizes the importance of maintaining a sustainable, reliable, high-quality groundwater supply for the long-term benefit of its citizens. Adoption of a Groundwater Management Plan could further this goal. The City Council will hold a Public Hearing as indicated above to provide interested members of the public with an opportunity to express their opinions and hear the City Council's deliberations of whether or not to adopt a Resolution of Intent to prepare a Groundwater Management Plan. The City Council will consider adopting, and may adopt, a Resolution of Intent to prepare a Groundwater Management Plan immediately following the Public Hearing.

All interested persons may attend the Public Meeting and be heard.

Additional information and a copy of the proposed Resolution of Intent to prepare a Groundwater Management Plan may be obtained by contacting the Public Works Department at (530) 661-5960.

Dated: May 14, 2010

Susan L. Vannucci, Director of
Administrative Services

PROOF OF PUBLICATION
(2015:5 C.C.P.)

STATE OF CALIFORNIA
County of Yolo

The Daily Democrat

A newspaper of general circulation, printed and published daily in the City of Woodland, County of Yolo, and which newspaper has been adjudged a newspaper of general circulation by the Superior Court of the County of Yolo, State of California, under the date of June 30, 1952, and in accordance with the provisions of Title 1, Division 7, of the government Code of the State of California; that the notice, of which the annexed is a printed copy (set in type not smaller than nonpareil) has been published in each regular and entire issue of said newspaper and to in any supplement thereof on the following dates to-wit:

May 18th and 23rd , 2010

All in the years 2010

I certify (or declare) under penalty of perjury that the foregoing is true and correct.

Date at: Woodland
California, this 23rd day of May 2010

Signature

This space is for the County Clerk's Filing Stamp

Proof of Publication of
CITY OF WOODLAND

NOTICE OF PUBLIC HEARING

CITY OF WOODLAND NOTICE OF PUBLIC HEARING TO CONSIDER ADOPTING RESOLUTION OF INTENT TO PREPARE A GROUNDWATER MANAGEMENT PLAN

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Dated: May 14, 2010

Susan L. Vannucci, Director of Administrative Services

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June 2nd, 2010

All in the years 2010

I certify (or declare) under penalty of perjury that the foregoing is true and correct.

Date at: Woodland
California, this 2nd day of June 2010

[signature]
Signature

This space is for the County Clerk's Filing Stamp

Proof of Publication of
CITY OF WOODLAND

NOTICE OF ADOPTED RESOLUTION

CITY OF WOODLAND NOTICE OF ADOPTED RESOLUTION OF INTENT TO PREPARE A GROUNDWATER MANAGEMENT PLAN WITH PUBLIC PARTICIPATION

NOTICE IS HEREBY GIVEN that the City of Woodland adopted a Resolution of Intent to prepare a Groundwater Management Plan for the City of Woodland service area pursuant to California Water Code Section 10750, *et. seq.* The City of Woodland recognizes the importance of maintaining a sustainable, reliable, high-quality groundwater supply for the long-term benefit of its citizens. Preparation and adoption of a Groundwater Management Plan will support this goal.

The City Council of the City of Woodland held a Public Hearing on June 1, 2010 in the Council Chambers of the City of Woodland, 300 First Street, Woodland, CA to provide interested members of the public with an opportunity to express their opinions and hear the City Council's deliberations of whether or not to adopt a Resolution of Intent to prepare a Groundwater Management Plan. The City Council adopted the Resolution of Intent to prepare a Groundwater Management Plan immediately following the Public Hearing.

Preparation of the Groundwater Management Plan will be discussed periodically at publicly noticed meetings of the Water Resources Association of Yolo County Technical Advisory Committee (TAC). Interested parties may participate in the development of the City of Woodland's Groundwater Management Plan by attending these meetings and providing comments to members of the TAC. At a future date, the City Council will hold a Public Hearing to provide interested members of the public with an opportunity to express their opinions and hear the City Council's deliberations of whether or not to adopt the Groundwater Management Plan.

Additional information and a copy of the adopted Resolution of Intent to prepare a Groundwater Management Plan may be obtained by contacting the Public Works Department at (530) 661-5960.

Dated: June 2, 2010

Susan L. Vannucci, Director of Administrative Services

PROOF OF PUBLICATION

WATER RESOURCES ASSOCIATION OF YOLO COUNTY
P.O. Box 8624, Woodland, CA 95776
***Phone**: (530) 666-2733* ***Fax**: (530) 666-4257*
***Website**: www.yolowra.org* ***Email**: info@yolowra.org*

Technical Committee Meeting
Thursday, October 7, 2010, 8:30 – 10:30 am
Woodland Community & Senior Center, 2001 East St., Room 1 or 2
AGENDA

1. **Call to Order**

2. **Approve Agenda and Adding Items to the Posted Agenda:** In order to add an item to the agenda, it must fit into one of the following categories: a) A majority determination that an emergency (as defined by the Brown Act) exists; or b) A 4/5ths determination that the need to take action that arose subsequent to the agenda being posted.

3. **Approval of Minutes from Previous Committee Meeting:** Minutes will be approved by consensus through email communications. Previous meeting was held on 9/16/10. Please comment by 10/8/10.

4. **Public Comment:** The public may address the Committee relating to matters within the WRA's jurisdiction.

5. **City of Woodland Groundwater Management Plan** – Key Loy, West Yost (~25 min)

6. **DWR Update:** Update from DWR staff on topics of interest to Technical Committee

7. **Water Legislation & Regulatory Issues Update** - Tim O'Halloran, YCFC&WCD

8. **Update Proposition 84 Application Submittal/Westside RWMG**– Tim O'Halloran

9. **Yolo County IRWMP Update Process**
   a) Discuss status of completing 2010-2020 Priority List: Scope/Schedule/Budget

10. **Discuss Funded FY2010-11 Project Actions –** planning, approach, scope of work
    - Develop surface water monitoring program (Foundational Action) - $35,000
    - Support for the Yolo Bypass Integrated Project (Yolo Bypass Working Group) - $20,000
    - IRWMP/Proposition 84 (West Yost Assoc. professional services) - $25,000
    - Legislative support/administrative & legal services - $18,194

11. **Member Information & Future Agenda Items:** Committee members are invited to recommend topics or future meetings and report on current issues/events.

12. **Next Meeting Date: Thursday, November 4, 2010**, 8:30 to 10:30 am, Woodland Community Center, 2001 East St., Woodland, Meeting Room 2.
    (***Note:*** *The TC will meet monthly on the first Thursday of the month and reserve the third Thursday to meet as needed.*)

13. **Adjourn**

I declare under penalty of perjury that the foregoing agenda for the October 7, 2010 meeting of the Technical Committee for the Water Resources Association of Yolo County was posted by October 1, 2010 at the office located at 34274 State Highway 16, Woodland, CA and was available to the public during normal business hours.

Donna L. Gentile

Donna L. Gentile, WRA Secretary and Administrative Coordinator

Water Resources Association of Yolo County

Technical Committee (TC) – October 7, 2010, 8:30 – 10:30 am

Woodland Community & Senior Center, 2001 East St., Woodland

MINUTES

Committee Members:

Tim O'Halloran, YCFC&WCD
Max Stevenson, YCFC&WCD
Kathryn Chandler, RD 108
Jeanette Wrysinski, Yolo County RCD
Kenneth Loy, West Yost Associates
Bill Brewster, DWR
Donita Hendrix, Dunnigan Water District
Cindy Tuttle, Yolo County
Robin Kulakow, Yolo Basin Foundation
Donna Gentile, WRA

Committee Members Absent:

City of West Sacramento
Reclamation District 2035
City of Davis
UC Davis
Colusa County Water District
City of Winters
City of Woodland

1. **CALL TO ORDER** by Tim O'Halloran.

2. **APPROVAL AGENDA & Adding Items to Posted Agenda:** Approved as presented.

3. **APPROVE MEETING MINUTES:** Previous meeting minutes were emailed to the TC for review with today's agenda. Comments on the 9/16/10 draft minutes are due by 10/8/10.

4. **PUBLIC COMMENT:** No one from the public was in attendance.

5. **CITY OF WOODLAND GROUNDWATER MANAGEMENT PLAN:** Ken Loy, West Yost Associates, gave a PowerPoint presentation on the City of Woodland's draft groundwater management plan (GWMP). Ken's PPT will be available on the WRA's website. The goal of the plan is to maintain a sustainable, reliable, high-quality groundwater supply while providing a mechanism for cooperatively managing groundwater with other local agencies. The City of Woodland shares the Yolo sub-basin with the City of Davis, UC Davis, YCFC&WCD, and RD 2035. Dunnigan Water District, RD 108 and RD 2068 are partially in the Yolo sub-basin, but mostly share neighboring groundwater basins. All of these neighboring agencies have adopted GWMPs.

   The City of Woodland began development of their GWMP in May 2010, conducting public meetings, preparing the draft plan, and is now beginning the public review/comment period. This process has been driven by the State's water code requirements. An agency is not eligible for DWR grant funds unless they have an adopted GWMP. The GWMP is scheduled to be adopted in late December 2010/early January 2011. A link will be available on the WRA website when the draft plan is ready for review. Ken reviewed the City of Woodland's groundwater infrastructure with 19 active supply wells (21 total wells). The draft plan proposes 5 additional monitoring wells within the city limits that will hopefully be developed with future AB303 grant assistance. Specific details will be developed for the grant proposal. Ken also briefly reported that much data

MINUTES

is already available about groundwater level conditions due to the efforts of the Yolo County Groundwater Monitoring Program (YCFCWCD lead agency). There are also 5 benchmarks gathering data on subsidence through the Yolo County Subsidence Monitoring Network (State and local multi-agency effort). By the year 2016, the Woodland-Davis area anticipates adding surface water supplies to supplement local water resources by acquiring Sacramento River water rights through the Davis Woodland Water Supply Project (Woodland-Davis Clean Water Agency JPA).

Ken reviewed three major management issues related to groundwater levels: dry-year groundwater supply, groundwater quality (nitrates, boron, salinity etc.) and inelastic land subsidence. Ken summarized the five basin management objectives: protect and maintain groundwater quality; maintain groundwater elevations; minimize risk of future significant impacts of subsidence; protect against risk of impacts to surface water flows and quality caused by groundwater pumping; and protect against the risk of impacts to groundwater levels or quality cause by changes in surface water flows or water quality. There are five major plan components detailed in the GWMP (required by the water code). These components are: local agency coordination, stakeholder involvement and public outreach; groundwater monitoring program; groundwater sustainability; groundwater protection; and planning integration. The WRA Technical Committee and the Yolo County IRWMP provides an avenue for planning integration for the City of Woodland's GWMP.

The next steps will be a public/stakeholder review of the draft plan in November 2010 and a public hearing to consider adoption of the plan in December 2010. The deliverables for required reporting will be an annual groundwater management report and periodic updates to the groundwater management plan. Ken answered questions from the TC throughout the presentation.

6. **DWR UPDATE:** Bill Brewster, DWR, reported that the Proposition 84 IRWM Program received 39 Planning Grant applications for a total grant request of almost $27 million and a total project cost of $41.5 million. DWR has $20 million available for planning grant funds. Out of the 39 applications, 37 are from single regions and two are for Inter-Regional applications that involve more than one IRWM region. A list of grant applications submitted can be found on DWR's IRWM webpage at: http://www.water.ca.gov/irwm/. Awards are anticipated to be public by December. A workshop schedule for the implementation grant application process should be available today. The Northern California workshop in Sacramento is planned for November 15th. http://www.water.ca.gov/irwm/integregio_implementation.cfm . Proposition 84 implementation grant applications will be due January 7, 2011.

   Bill gave an update on the CASGEM groundwater monitoring program. The guidelines have been delayed pending internal review, but are expected to be released in about 2 weeks. The

MINUTES

YCFCWCD is prepared to accept the responsibility of being the monitoring entity for Yolo County and is required to formally notify DWR of their intent by January 1, 2011. Bill thought that the WRA could be eligible to be a monitoring entity, but will clarify whether this is accurate. Tim thought that a private association although eligible has a lower priority ranking.

No additional news about the Local Assistance Grants is available, other than the LGA process will occur after the IRWMP grant process.

7. **WATER LEGISLATION & REGULATORY ISSUES UPDATE:** Tim O'Halloran reported that the YCFCWCD and NCWA are tracking potential imbedding of water user fees within the State budget. He mentioned last year's SB x7 legislation, the water conservation and water use efficiency bill, and potential implications for agricultural water metering requirements. Tim recently met with DWR representatives to discuss DWR's interpretation of the metering methodology.

   Cindy Tuttle informed the TC that the Bay Delta Conservation Plan (BDCP) Steering Committee held a Local Issues Group meeting in West Sacramento yesterday. Although she was unable to attend, Robin Kulakow did and reported further on meeting discussions. The BDCP unveiled their Yolo Bypass conservation measure (fishery enhancement). The conservation measure included the Westside Option proposed by the Yolo Basin Foundation and supported by many Bypass stakeholders. It was not publicly presented in advance of the meeting, so some Yolo Bypass farmers and stakeholders in attendance were surprised. It is an action in the updated Yolo County IRWMP Yolo Bypass Integrated Project. Many who attended the meeting strongly expressed their displeasure with the BDCP's outreach process for the Yolo Bypass Conservation Measure described in the Plan. BDCP staff has not worked with local stakeholders in development of the Conservation Measure. Many stakeholders that have been working on Bypass issues for over 10 years and were involved in the development of the 2007 Yolo County IRWMP. Even though the BDCP has been informed that established Yolo Bypass stakeholder groups exist, they have decided to form their own local issues group. The BDCP acknowledged at the meeting that they will be coordinating with Central Valley Flood Protection Plan Program (CVFPP) staff. They have been criticized for a lack of communication between the two programs. Robin noted that as a result of Fran Borcalli's efforts to engage the CVFPP a year ago, the CVFPP has recently proposed working with Yolo Bypass stakeholders on multi-objective resource planning for the Yolo Bypass.

   Also, Yolo County submitted a list of six recommended early actions for the Delta Plan to the Delta Stewardship Council (DSC) by the October 5th deadline (Cindy will email copy to Donna). These actions affect the southern portion of Yolo County, although some actions will have a countywide impact. Robin Kulakow worked with County staff on the early action item related to the Yolo Bypass. The TC discussed whether the WRA could prepare a letter of support for Yolo

MINUTES

County's early actions for the Executive Committee to review. Robin offered to draft the WRA support letter for the proposed Yolo Bypass early actions as she has been actively participating in Delta meetings. Donna will coordinate with Robin and Cindy and will verify the public comment period deadline. The DSC has not defined the criteria they will use to decide which early actions will be considered for inclusion in the Interim Plan. Cindy will keep the TC informed.

8. UPDATE PROPOSITION 84 APPLICATION SUBMITTAL/WESTSIDE RWMG

Tim informed that a planning grant application for $1 million was submitted to DWR by the Westside Regional Water Management Group (YCFCWCD acting as applicant and fiscal agent) on September 28th. Additional information was provided by Bill Brewster under DWR's Update item.

9. YOLO COUNTY IRWMP UPDATE PROCESS:

a) *Discuss status of completing 2010-2020 Priorities List: scope, schedule, budget:* Donna provided a recap of the status of the IRWMP Update process. Two summary tables were distributed to the WRA Board on September 20th for their review – "Summary of Milestone Accomplishments" and "Projects to be Implemented by 2020". No additional updates have been given to Monique, therefore the tables are completed to the best of our ability at this time. The WRA Board gave their input on prioritizing the project list. Jacques will discuss further at the November TC meeting and the WRA Board will be presented the final IRWMP update at the November 15th meeting.

10. DISCUSS FUNDED FY2010-11 PROJECT ACTIONS: Planning, Approach, Scope of Work

Tim gave a brief summary of each action and requested the lead agencies provide additional information if needed.

- Surface Water Monitoring Program – Development of a program approach is pending by YCFCWCD. The TC requested that a conceptual scope of work and outline for developing a monitoring program be presented in January 2011 for discussion.
- Yolo Bypass Integrated Project – No additional discussion was held on this project.
- IRWMP/Prop 84 – No additional discussion was held on this project.
- Legislative/legal/administrative support – These funds are reserved in support of WRA activities. Tim O'Halloran will discuss with the Executive Committee to develop a scope and approach for YCFCWCD to provide this support to the WRA.

11. MEMBER INFORMATION & FUTURE AGENDA ITEMS:

RD 108, YCFCWCD, DWD, Yolo County RCD, and the Yolo Basin Foundation gave brief updates on their current activities. YCFCWCD informed that a Capay Dam project tour will be set-up for next week if any TC members are interested. Tim will email details to Donna and an RSVP is requested.

TC members are encouraged to request agenda items for upcoming TC meetings.

MINUTES

Future agenda items:

- CASGEM program coordination pending release of final guidelines – submit monitoring entity application by January 1, 2011 deadline.
- Ken Loy requested time on the November & December TC agenda for any brief updates on Woodland's GWMP (15 min.)

12. NEXT TC MEETING DATE: November 4, 2010, 8:30 -10:30 a.m., at the Woodland Community & Senior Center, 2001 East St**.**

13. ADJOURN at 10:30 a.m.

Respectfully submitted,

Donna L Gentile

Donna L. Gentile, WRA Secretary and Administrative Coordinator

City of Woodland
Draft Groundwater Management Plan

Water Resources Association of Yolo County
Technical Advisory Committee Meeting
October 7, 2010

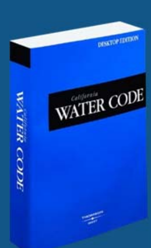
WATER WASTEWATER STORMWATER

Purpose of the Plan

To further the goal of maintaining a "sustainable, reliable, high-quality groundwater supply"

To provide mechanisms for cooperation with other local agencies managing groundwater

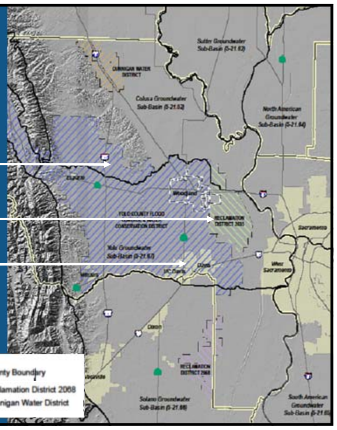
Authority and Scope



- CWC 10752 (g): Provides water service within city limits
- CWC 10753 (a): Overlies the Yolo Sub-Basin (DWR Sub-Basin 5.21-67)

Shares the Yolo Sub-Basin with

- Yolo County FC&WCD
- RD 2035
- City of Davis
- UC Davis



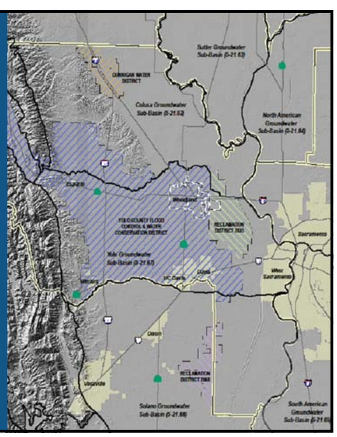
Process and Schedule

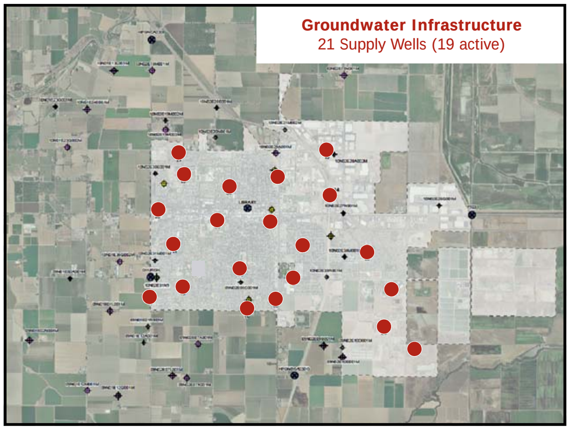
Public Noticing
Public Hearing/Notice on Intent to Adopt Plan
Draft Plan Preparation
WRA Meetings
Stakeholder/Public Review
Plan Adoption

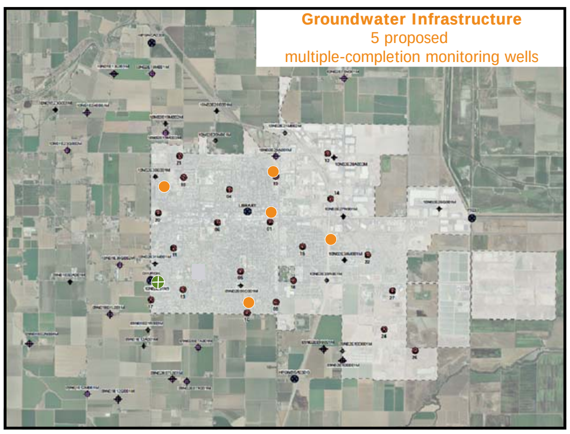
May Jun Jul Aug Sep Oct Nov Dec Jan

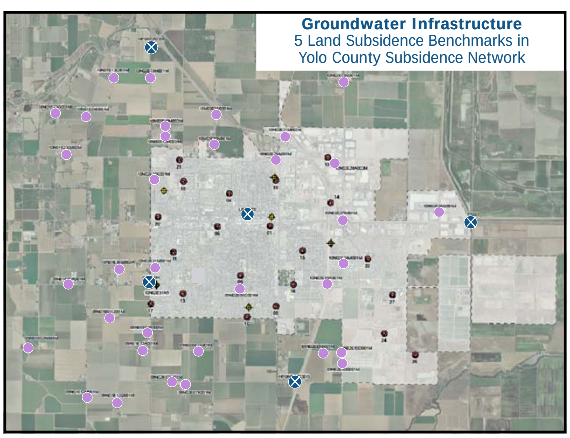
2010 2011

Yolo Groundwater Sub-Basin DWR Sub-Basin 5.21-67

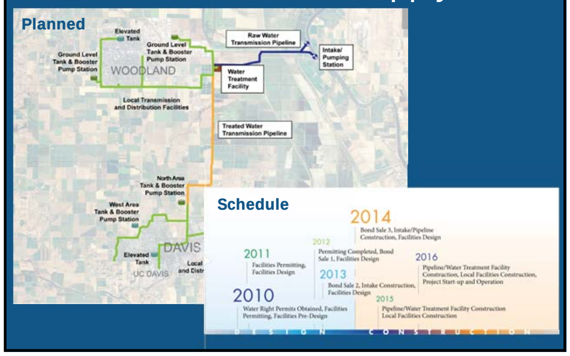



Groundwater Infrastructure
21 Supply Wells (19 active)


Groundwater Infrastructure
5 proposed
multiple-completion monitoring wells

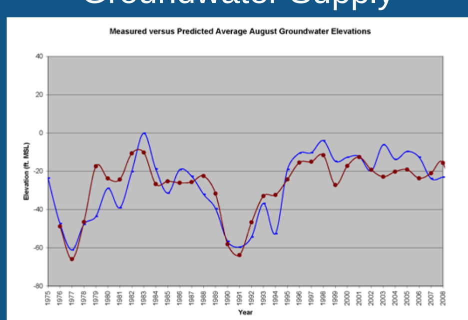

Groundwater Infrastructure
5 Land Subsidence Benchmarks in
Yolo County Subsidence Network

Surface Water Supply

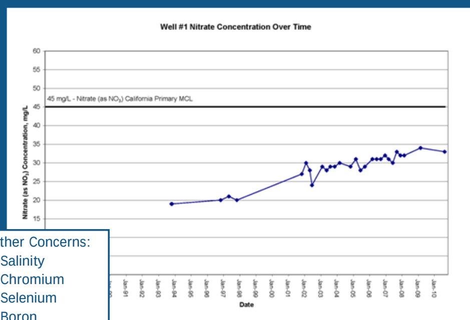


Known Groundwater Management Issues

Issue 1: Dry-Year Groundwater Supply

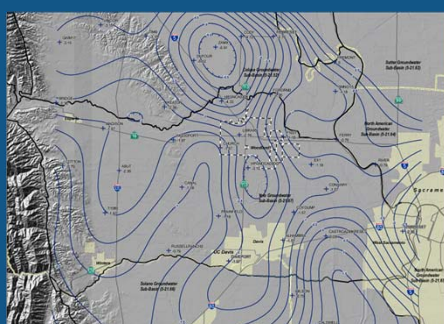


Issue 2: Groundwater Quality



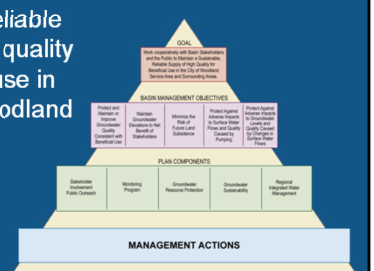
Other Concerns:
- Salinity
- Chromium
- Selenium
- Boron

Issue 3: Inelastic Land Subsidence

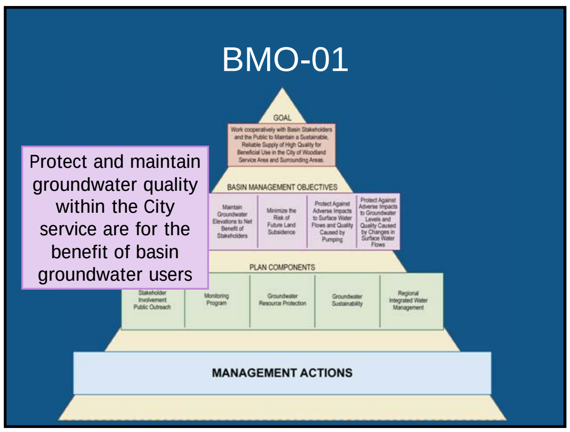


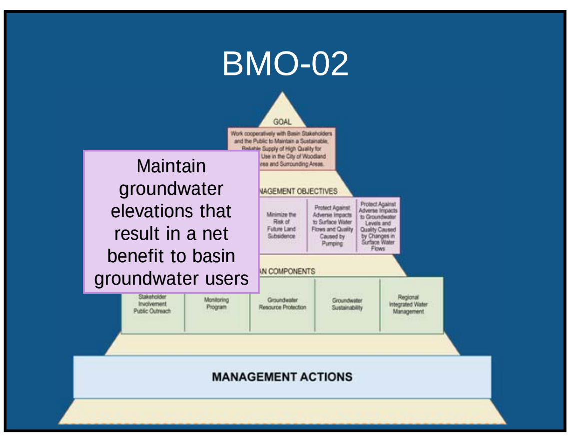
Groundwater Management Goal

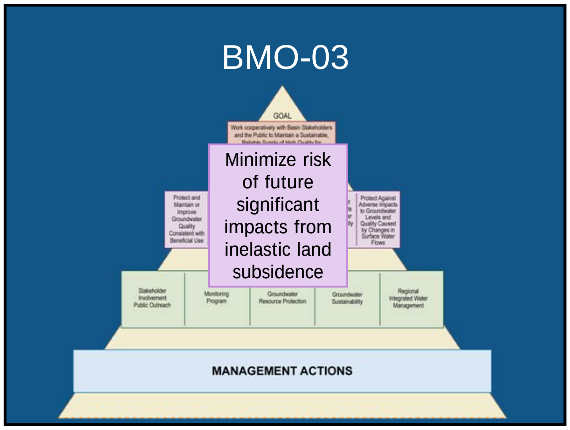
Maintain a sustainable, reliable supply of high quality for beneficial use in the City of Woodland Service Area

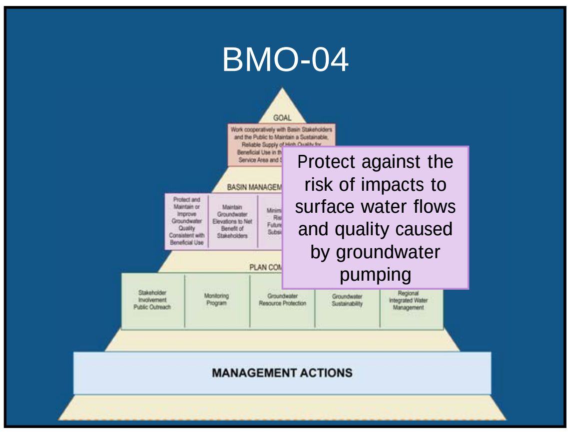


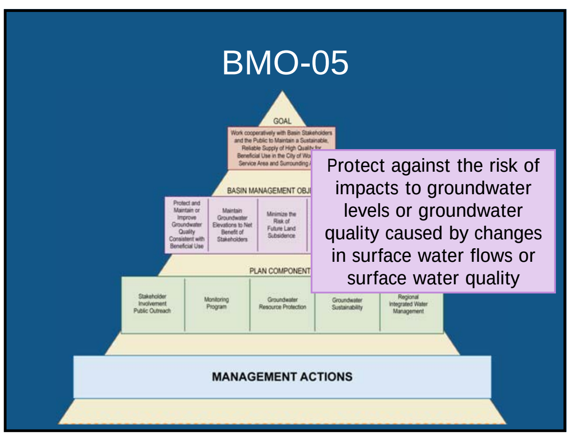

Basin Management Objectives
GOAL
Work cooperatively with Basin Stakeholders and the Public to Maintain a Sustainable, Reliable Supply of High Quality for Beneficial Use in the City of Woodland Service Area and Surrounding Areas.
BASIN MANAGEMENT OBJECTIVES
Protect and Maintain or Improve Groundwater Quality Consistent with Beneficial Use
Maintain Groundwater Elevations to Net Benefit of Stakeholders
Minimize the Risk of Future Land Subsidence
Protect Against Adverse Impacts to Surface Water Flows and Quality Caused by Pumping
Protect Against Adverse Impacts to Groundwater Levels and Quality Caused by Changes in Surface Water Flows
PLAN COMPONENTS
Stakeholder Involvement Public Outreach
Monitoring Program
Groundwater Resource Protection
Groundwater Sustainability
Regional Integrated Water Management
MANAGEMENT ACTIONS

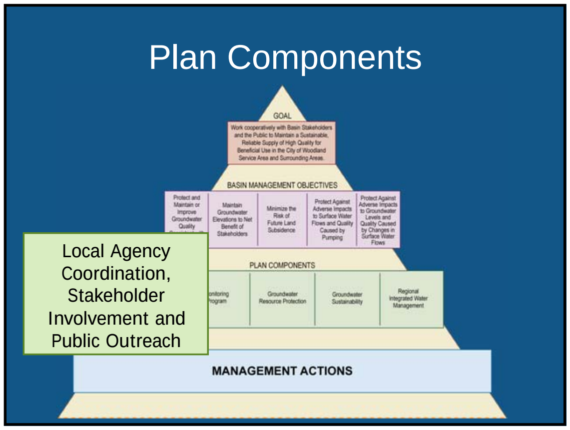

BMO-01
Protect and maintain groundwater quality within the City service are for the benefit of basin groundwater users
GOAL
BASIN MANAGEMENT OBJECTIVES
PLAN COMPONENTS
MANAGEMENT ACTIONS

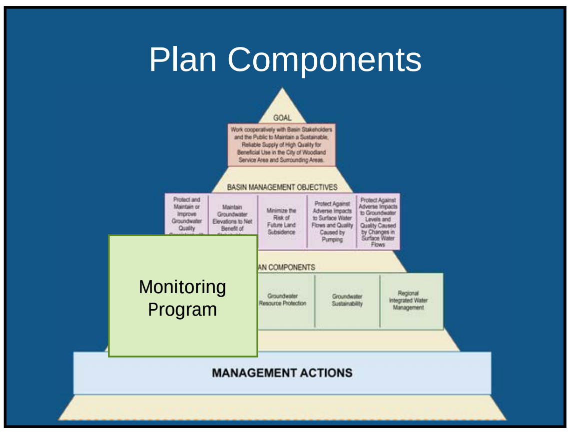

BMO-02
Maintain groundwater elevations that result in a net benefit to basin groundwater users
GOAL
MANAGEMENT ACTIONS

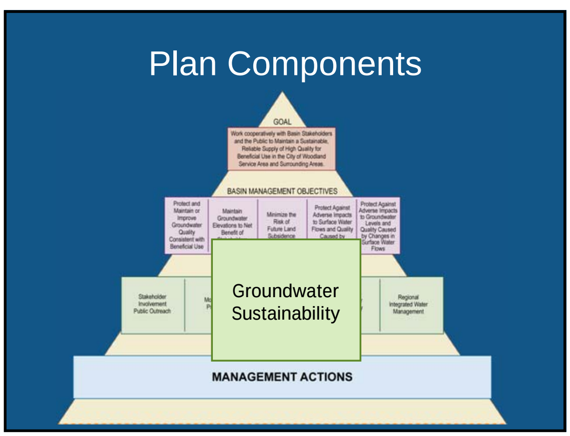

BMO-03
GOAL
Minimize risk of future significant impacts from inelastic land subsidence
MANAGEMENT ACTIONS


BMO-04
GOAL
Protect against the risk of impacts to surface water flows and quality caused by groundwater pumping
MANAGEMENT ACTIONS

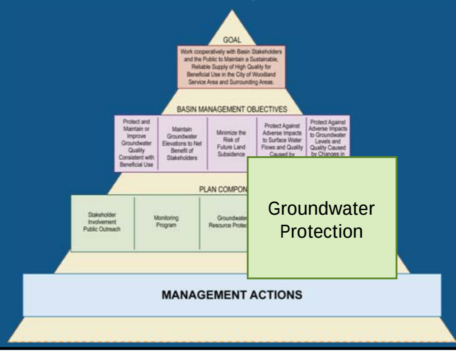

BMO-05
GOAL
Protect against the risk of impacts to groundwater levels or groundwater quality caused by changes in surface water flows or surface water quality
MANAGEMENT ACTIONS


Plan Components
GOAL
BASIN MANAGEMENT OBJECTIVES
PLAN COMPONENTS
Local Agency Coordination, Stakeholder Involvement and Public Outreach
MANAGEMENT ACTIONS

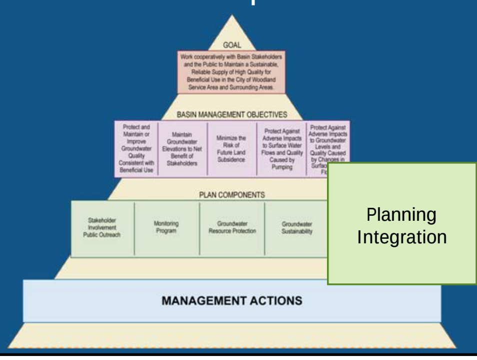

Plan Components
GOAL
BASIN MANAGEMENT OBJECTIVES
Monitoring Program
MANAGEMENT ACTIONS


Plan Components
GOAL
BASIN MANAGEMENT OBJECTIVES
Groundwater Sustainability
MANAGEMENT ACTIONS

Plan Components

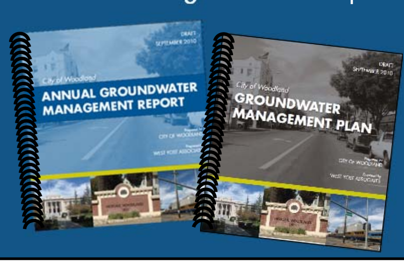


Plan Components



Plan Implementation

- Annual Groundwater Management Report
- Groundwater Management Plan Updates



Next Steps

November 2010: Public and Stakeholder Review

December 2010: Public Hearing to Consider Adoption of Plan

From: WRA [info@yolowra.org]
Sent: Wednesday, November 17, 2010 2:41 PM
To: Bair, Lewis - RD108; Balasek, Kurt; Baxter, Doug; Bell, Nicole; Borcalli, Fran (YCFC); Brewster, Bill; Chandler, Kathryn; Cherovsky, Regina (Conaway); Cocke, Mark; Curry, Cecilia; Davids, Grant; Monique de Barruel; De Bra, Jacques; Durst, Fritz; England, Sid; Gidaro, Steve; Giezentanner, Tovey; Hardesty, Mike; Hendrix, Donita; Kors, Jonathan; Kulakow, Robin; Lang, Kyle (RD 1600); Lee, Chris; Lorenzato, Stefan (DWR); Lorenzato, Stefan (YCFC); Ken Loy; Steve Macaulay; Marble, Bill; Marovich, Rich - LPPCC; Mount, Dan; Murphy, Shelly (CCWD); O'Halloran, Tim; Okupe, Akin; Peart, Don; Phillips, David; 'Rose, Chris'; Schneider (Tuleyome); Schneider, Bob; Scianna, Carol; Shpak, David; Stevenson, Max; Tuttle, Cindy; WRA; Wrysinski, Jeanette; Jim Yost; Young, John
Cc: Earthman, Libby; Aragon, Rob; Beers, Wes; Bencomo, John; Brazil, Dirk; Brice, Ann; 'Campbell, Jim'; Chamberlain, Duane; Charney, Robert; Feliz, Dave; Fields, Sue; Greenwald (2), Sue; Hansen, Craig; Henneberry, Yumiko; Hodgkins, Butch; Klasson, Mick; Knecht, Mary Lee; Kokkas, Panos; Kristoff, William; Krovoza, Joe; LeMaitre, Yvonne; Loux, Jeff; Manley, Todd (NCWA); 'Massa, Eugene'; McCord, Stephen; Najmus, Saquib; Pratt, Dave; Ramming, Robert; Rexroad, Matt; Schaad, Gary; Scholl, Marty; Shewmaker, Christine; Sutton, Jeff; Taghavi, Ali; Urkov, Mike; Wilson, Mark; Woodland Chamber
Subject: Public Comments Requested - City of Woodland Draft Groundwater Management Plan
TO: WRA Technical Committee & Interested Members of the Public

The City of Woodland is considering adopting a Groundwater Management Plan for its service area, pursuant to California Water Code Section 10750 *et. seq*. The plan states the City's overall groundwater management goal, and puts forth basin management objectives and components addressing stakeholder involvement and outreach, monitoring, groundwater resource protection and sustainability, and planning integration.

The City of Woodland recognizes the importance of maintaining a sustainable, reliable, high-quality groundwater supply for the long-term benefit of its citizens. Adoption of a Groundwater Management Plan could further this goal. The City Council will hold a Public Hearing to provide interested members of the public with an opportunity to express their opinions and hear the City Council's deliberations of whether or not to adopt the Groundwater Management Plan. The City Council will consider adopting, and may adopt, the Groundwater Management Plan immediately following the Public Hearing. Please refer to the City's website at http://www.cityofwoodland.org for scheduling of the public meeting.

The draft version of the City's groundwater management plan is available for review. Written comments may be submitted to info@yolowra.org through December 17, 2010. City of Woodland's Draft Groundwater Management Plan

Donna Gentile, Administrative Coordinator
Water Resources Association of Yolo County
P.O. Box 8624, Woodland, CA 95776
(530) 666-2733 voice, (530) 666-4257 fax
Web: www.yolowra.org

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External Ad Number	**Ad Released**	**Pick Up**	**Ad Type**			
	No		NC Legal Liner			

Ad Order Number
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Customer
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CITY OF WOODLAND, CALIFORNIA

Notice of Public Hearing to Consider Adopting a Groundwater Management Plan

NOTICE IS HEREBY GIVEN that the City Council of the City of Woodland will hold a Public Hearing and consider adopting a Groundwater Management Plan for the City of Woodland service area pursuant to California Water Code Section 10750 et. seq. The plan states the City's overall groundwater management goal, and puts forth basin management objectives and components addressing stakeholder involvement and outreach, monitoring, groundwater resource protection and sustainability, and planning integration.

The City of Woodland recognizes the importance of maintaining a sustainable, reliable, high-quality groundwater supply for the long-term benefit of its citizens. Adoption of a Groundwater Management Plan could further this goal. The City Council will hold a Public Hearing to provide interested members of the public with an opportunity to express their opinions and hear the City

Ad Order Number

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Customer

WOODLAND, CITY OF - LEGALS

Council's deliberations of whether or not to adopt the Groundwater Management Plan. The City Council will consider adopting, and may adopt, the Groundwater Management Plan immediately following the Public Hearing.

All interested persons may attend the Public Meeting and be heard.

Hearing Date:
February 1, 2011
Hearing Time:
6.00 p.m.
Place: Council Chambers, Woodland City Hall, 300 First Street, Woodland, California

Additional information and a copy of the proposed Groundwater Management Plan may be viewed at the City of Woodland's website; www.cityofwoodland.org

Original copies can be viewed at the following locations:
Municipal Service Center, 655 N. Pioneer Avenue, Woodland, CA 95776
City Manager's Office, 300 First Street Woodland CA 95695
Woodland Public Library, 250 First Street, Woodland, CA 95695

Dated: January 18, 2011

Ana B. Gonzalez
City Clerk

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DWDD CLSOnlineUpsell	Legals CLS NC	General Legal NC-1076~	01/21/11, 01/27/11	2	$2.00

Order Charges:

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$245.04	$0.00	$245.04		$0.00	$245.04

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bhernandez	2130710	2130710	
Order Taker	*Customer Address*	*Payor Address*	*Customer Fax*
bhernandez	ACCOUNTS PAYABLE, 300 FIRST ST WOODLAND CA 95695 United States	ACCOUNTS PAYABLE, 300 FIRST ST WOODLAND CA 95695 United States	530-661-5813
Order Source	*Customer Phone*	*Payor Phone*	*Customer EMail*
	530-661-5845	530-661-5845	

Current Queue	Invoice Text	Ad Order Notes
Ready	GWMP-Akin Okupe	

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0	0	0				None

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	No		NC Legal Liner			

Ad Order Number	*Customer*
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CITY OF WOODLAND, CALIFORNIA

Notice of Public Hearing to Consider Adopting a Groundwater Management Plan

NOTICE IS HEREBY GIVEN that the City Council of the City of Woodland will hold a Public Hearing and consider adopting a Groundwater Management Plan for the City of Woodland service area pursuant to California Water Code Section 10750 et. seq. The plan states the City's overall groundwater management goal, and puts forth basin management objectives and components addressing stakeholder involvement and outreach, monitoring, groundwater resource protection and sustainability, and planning integration.

The City of Woodland recognizes the importance of maintaining a sustainable, reliable, high-quality groundwater supply for the long-term benefit of its citizens. Adoption of a Groundwater Management Plan could further this goal. The City Council will hold a Public Hearing to provide interested members of the public with an opportunity to express their opinions and hear the City

Ad Order Number	*Customer*
0003860596	WOODLAND, CITY OF - LEGALS

Council's deliberations of whether or not to adopt the Groundwater Management Plan. The City Council will consider adopting, and may adopt, the Groundwater Management Plan immediately following the Public Hearing.

All interested persons may attend the Public Meeting and be heard.

Hearing Date: March 1, 2011
Hearing Time: 6.00 p.m.
Place: Council Chambers, Woodland City Hall, 300 First Street, Woodland, California

Additional information and a copy of the proposed Groundwater Management Plan may be viewed at the City of Woodland's website; www.cityofwoodland.org

Original copies can be viewed at the following locations:
Municipal Service Center, 655 N. Pioneer Avenue, Woodland, CA 95776
City Manager's Office, 300 First Street Woodland CA 95695
Woodland Public Library, 250 First Street, Woodland, CA 95695

Dated: February 2, 2011

Ana B. Gonzalez
City Clerk

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Woodland Daily Dem	Legals CLS NC	General Legal NC-1076~	02/09/11, 02/16/11	2	$245.10
DWDD CLSOnlineUpsell	Legals CLS NC	General Legal NC-1076~	02/09/11, 02/16/11	2	$2.00

Order Charges:

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WEST YOST ASSOCIATES
Consulting Engineers

February 10, 2011 Project No.: 204-00-08-18

Mr. Akin Okupe
Senior Civil Engineer
City of Woodland
655 N. Pioneer Avenue
Woodland CA 95776

SUBJECT: Response to a Public Comment on the City of Woodland Draft Groundwater Management Plan

Dear Mr. Okupe:

This letter summarizes the response to a comment received from a member of the public on the City of Woodland's draft Groundwater Management Plan during the public review period. On December 2, 2010, Ms. Christine Shewmaker, a Woodland resident, submitted a comment to members of the Woodland City Council and Water Resources Association of Yolo County. The full text of Ms. Shewmaker's comment is provided in Attachment A.

The comment included a request to address climate change in the document. The Groundwater Management Plan has been revised to reflect Ms. Shewmaker's request. Attachment B documents the changes that were made to the document. These changes are summarized as follows:

- Section 2, Basin Description and Agency Water Supplies, includes a new discussion of climate change research and potential impacts, and introduces the concepts of adaptive management and mitigation as tools for addressing the impacts of climate change and the uncertainties associated with these impacts (See Section 2.1.3, Climate Change).
- Section 3, Groundwater Management Goal and Plan Components, includes a new plan component entitled, Adaptive Management and Mitigation in Response to Climate Change. This section provides a discussion of Woodland's ongoing efforts to diversify water supplies, conserve water, participate in regional planning efforts, and other measures classified as adaptive management strategies by authoritative sources. The following actions are identified (Section 3.3.4, Adaptive Management and Mitigation in Response to Climate Change):

  > "Continue to review scientific and policy updates related to climate change as they become available through the IPCC, State, CUWA and other climate change authorities. Continue to implement the components of this groundwater management plan. Continue to include adaptive management principals in water supply and infrastructure planning."

- Figure 3-1, Groundwater Management Plan Components, now shows "Climate Change" with "Groundwater Sustainability" as a groundwater management plan component.

We appreciate Ms. Shewmaker's interest in reviewing the draft groundwater management plan and her insight on the need to address climate change in the document. We hope that the revisions made to the document fully address her concerns and that the revised document provides the City of Woodland with the planning tools needed to address the range of groundwater management issues, including climate change.

Sincerely,

WEST YOST ASSOCIATES

Kenneth L. Loy
Principal Hydrogeologist
P.G. #7008

KLL:nmp

attachments

Attachment A

On December 2, 2010, Ms. Christine Shewmaker, a Woodland resident, submitted the following comment to members of the Woodland City Council and Water Resources Association of Yolo County.

> Dear members of the WRA and the Woodland City Council:
>
> Thank you for the opportunity to comment on the Draft of the Groundwater Management Plan for the City of Woodland.
>
> The impacts of climate change are becoming ever more evident. This is very clear here in California and California may be one of the earlier geographic areas to feel the effects. The water supply in California is one of the resources that is predicted to be impacted heavily. In 2009, the California Natural Resources Agency released a study "California Climate Adaptation Strategy" (http://www.climatechange.ca.gov/adaptation/index.html) One of the areas that was highlighted in the report was water. In discussing water management challenges in a warming California at the top of the list was *"Reduced Water Supply from the Sierra Snowpack*" (See page 80 of the report for further information and figures http://www.energy.ca.gov/2009publications/CNRA-1000-2009-027/CNRA-1000-2009-027-F.PDF) Just recently the Task Force on California's Adaptation To Climate Change released a report "Preparing for the Effects of Climate Change" http://www.pacificcouncil.org/climatechange/report They highlight water as a area of risk and in an editorial (http://www.sacbee.com/2010/11/21/3199398/the-conversation-californiamust.html) they state that they "*conclude that California must prepare for a future that is likely to bring more frequent and intense rains and droughts, higher temperatures,....*." At a forum here in Woodland, Elissa Lynn with the Department of Water Resources (DWR), described what she called atmospheric rivers which are likely to be more intense in the future due to climate change. In fact, on the DWR website(http://www.water.ca.gov/climatechange/) it states that "*Climate change is having a profound impact on California water resources, as evidenced by changes in snowpack, sea level, and river flows . These changes are expected to continue in the future and more of our precipitation will likely fall as rain instead of snow. This potential change in weather patterns will exacerbate flood risks and add additional challenges for water supply reliability*". So with predicted lower Sierra Snowpack, and increased extremes in drought and rain, climate change will bring new challenges to water management in California. My opinion is that these challenges should be addressed in any plan for water in California for the future and therefore in the City of Woodland's Groundwater Plan.
>
> In reading the draft I did not see climate change addressed. There is mention of dry periods in sections 2.1.1.2 and 2.3.1 but they do not address that these are predicted to worsen with climate change. In section 3.3.3, Sustainability, they do discuss conjunctive use, recycling and conservation. These are all efforts which can be used to help adapt to some of the effects of climate change on water, but they are not discussed as such.

It is my impression that California encourages the inclusion of climate change in water planning for the future. Whether it is required, I do not know. From my perspective, required or not, it is the right thing to do.

In summary, I urge you to include climate change in this plan. Some mention of the challenges and possible solutions or approaches needs to be included. It could be a section or subsection on its own, or it could be mentioned throughout the whole document.

The City has addressed Climate Change with the formation of a clean energy committee and by passing a resolution in 2008 committing to lower emissions and energy use. The City has made steps to address climate change and including climate change in this Groundwater Management plan would be an appropriate next step.

As many of you know, climate change in general is something I feel needs to be addressed and aggressively. It needs to be considered in all areas of planning as we go forward. Water is clearly one of those areas.

I look forward to any comments and to seeing climate change addressed in the Groundwater Management Plan.

Attachment B

2.1.3 Climate Change

National and international research for the past several decades has indicated a growing concern that our climate is changing, to a large extent due to human activities related to the generation of greenhouse gasses such as carbon dioxide. In the past there has been substantial uncertainty, and some doubt in public discourse and debates. Over the last few years there have been landmark advancements in scientific studies, ultimately leading to major conclusions in the Fourth Assessment of the Intergovernmental Panel on Climate Change (IPCC).

The IPCC was established to provide the decision-makers and others interested in climate change with an objective source of information about climate change. It was set up by the World Meteorological Organization and the United Nations Environment Programme, and has served since 1988 as a clearinghouse for research and policy discussions related to climate change. The role of the IPCC "…is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation …." Agencies of the United States government have provided major input to both research and discussion, particularly through the U.S. Geological Survey. Science organizations worldwide have been following climate change research and in 2009 the Academies of Sciences from 13 nations issued a letter calling for urgent and coordinated action to combat climate change.

The IPCC has issued four major "assessments" of the status of climate change research, current levels of understanding, and potential policy implications. The Fourth Assessment Report was released throughout 2007, indicating for the first time clear links between human activities and global warming. The Fifth Assessment Report is scheduled for finalization in 2014. The historical and projected continued warming of the earth has and will continue to cause changes to our climate. While such induced "climate change" has implications to a number of environmental factors, of concern in this discussion is implications to water supply reliability.

The State of California has provided major focus and funding on climate change research and impacts, with particular focus on developing both "adaptation" and "mitigation" strategies. In the context of climate change and its impacts to water resources, "adaptation" is simply the identification and development of strategies to cope with the expected impacts to water supply reliability. "Mitigation" is the identification and development of actions that will reduce the drivers for climate change; for the most part this translates into programs to reduce greenhouse gas emissions and lower the "carbon footprint" of activities associated with water supply and use.

The State's research and continuing recommendations are readily available. The State's Climate Action Team has noted a clear connection between water use and energy consumption, and consequently also with greenhouse gas production (see California Climate Change Portal for the most recent technical and policy information: http://www.climatechange.ca.gov/). The 2005 California Water Plan Update addressed climate change and water in a general way, noting the many potential interconnections as well as the potentially serious impacts of ongoing climate change on water supply reliability. The 2009 Update to the California Water Plan addresses this topic in a more substantive way (http://www.waterplan.water.ca.gov/climate/index.cfm), and includes recommendations and advice on how to incorporate climate change into long-term water resources planning. It is also recommends specific actions in the areas of adaptation and mitigation as discussed above.

DWR maintains an updated web site on climate change and California's water resources (http://www.water.ca.gov/climatechange/). That web site notes, in part: "Climate change is already impacting California's water resources. In the future, warmer temperatures, different patterns of precipitation and runoff, and rising sea levels will profoundly affect the ability to manage water supplies and other natural resources. Adapting California's water management systems to climate change presents one of the most significant challenges for the 21st century". In 2006 DWR published a major report on climate change and California's water resources, Progress on Incorporating Climate Change Into Management of California's Water Resources. This was summarized and updated in a paper published in a special issue of the Journal of Climate Change in 2008 (http://wwwdwr.water.ca.gov/climatechange/docs/CCprogress_mar08.pdf). In 2010, DWR provided another update entitled Climate Change Characterization and Analysis in California Water Resources Planning Studies. This report provides a summary of the climate change characterization approaches and methodologies that have been used in recent planning studies conducted by DWR and its partner agencies. The report is intended for use by DWR to consider how to include climate change analyses in planning studies, with emphasis on the State Water Project planning studies.

Collectively, this State information provides the most updated information related to potential specific impacts of water supply reliability in California related to impacts of a changing climate.

DWR and others have done studies to model potential future impacts at the regional level on both streamflow and temperature. The focus has been on the Sacramento River system since it is a major source of water for much of California.

The different models are split on whether future annual average runoff will be wetter or drier. Other studies make it clear, however, that we are likely to see more extreme hydrology: more floods and droughts, regardless of the "average" hydrology. However, these same regional models agree that the future will likely be warmer than it is today.

Other potential changes include less snowpack, earlier runoff from snowmelt, more precipitation as rain than snow, changes in the amount and timing of stream flows, changes in water resources system operations, and rising sea levels. In turn, these changes could have serious impacts to water supply reliability, including water quality. DWR has confirmed that some impacts have been underway for many years. For example, the historical Sacramento River snowmelt runoff has been decreasing as a percentage of total annual flows for much of the 20^{th} century. This is an indication of a long-term decrease in snowpack, and perhaps an increase in wintertime flows and floods.

There are few published examples of water supply adaptation and mitigation strategies. In December 2007 the water user organization, California Urban Water Agencies (CUWA), published a summary report of a survey of its 11 large urban water agencies on this topic (CUWA agencies are major urban water utilities throughout the state, and include such agencies as the Metropolitan Water District of Southern California, East Bay Municipal Utility District, and the San Francisco Public Utilities District). This report, "Climate Change and Urban Water Resources, Investing for Reliability", identifies a number of adaptation and mitigation strategies currently being employed to address climate change. The table below lists some of these strategies. The CUWA report is available on their web site: http://www.cuwa.org/library/ClimateChangeReport12_2007.pdf.

CUWA Adaptation and Mitigation Examples	
Adaptation Examples	Mitigation Examples
Develop groundwater storage	Renewable energy generation
More aggressive conservation	Conserve energy in water facilities
Water transfers	Decrease energy use in fleet, equipment
Optimize local storage	Increase employee incentives for action
Develop regional water projects, partnerships	Develop methane offsets (biogas at wastewater facilities used in place of natural gas or other fuels)
Take leadership role on this issue	Take leadership role on this issue

Despite the high level of attention both in California and internationally, there is very little information developed on the potential impacts of climate change on groundwater. The principal concern is rising sea level and potential salinity intrusion into coastal groundwater aquifers. While this is a concern for coastal areas of California, it is not a concern in the portion of Yolo groundwater subbasin near the City.

While not addressed specifically in IPCC reports, there are potential impacts to groundwater resources that have been discussed over the past few years. These include the following concerns:

1. Decreased reliability of surface water supplies could lead to increased reliance on groundwater, further stressing such supplies.
2. Changes to surface water hydrology – increased winter flood flows, reduced spring and summer snowmelt runoff – could decrease groundwater recharge.
3. Increased landscape and irrigation water demands due to increased temperatures will further increase pressures on groundwater supplies.

3.3.4 Adaptive Management and Mitigation in Response to Climate Change

The City's commitment to the development of diversified water supplies, including both groundwater and surface water sources, will provide opportunities for adaptive management and mitigation in response to climate change. Some of the potential impacts of climate change on water supply are discussed in Section 2.1.3. However, specific impacts to the City's water supplies can not be predicted with certainty. The available data and information on the potential impacts to groundwater are especially limited. The City will use adaptive management and mitigation approaches to address the potential water supply-related impacts of climate change and the uncertainty associated with these impacts. The groundwater sustainability measures discussed in the previous section, including implementation of the Davis Woodland Water Supply Project (DWWSP) and water conservation, will be important tools in both strategies. Potential adaptive management strategies include:

- Development of groundwater recharge, storage, and conjunctive use projects
- Water transfers
- Development of regional water projects and partnerships
- Water conservation
- Optimization of local storage

The City's involvement in the DWWSP will enable implementation of several of these strategies, and the City has implemented the others in its service area. Groundwater storage will be increased as a natural consequence of the DWWSP. Average annual groundwater use by the City will decline because of the DWWSP, and this will result in additional groundwater in storage, assuming groundwater use by others does not increase. Through the Woodland-Davis Clean Water Agency (WDCWA), the City is also evaluating Aquifer Storage Recovery (ASR). ASR is the storage of water in the aquifer during times when water is available and recovery of the water from the aquifer when needed at a later time. There is potential to use seasonally available excess capacity in the DWWSP water treatment plant (WTP) to treat Sacramento River water, which could then be injected through existing or new municipal wells. This water could then be extracted from the same wells during times when surface water is less available to meet municipal demands. A key advantage of this ASR concept, with to respect to climate change, is that it would provide a reliable source of supply to the City without placing additional demands on the overall surface water and groundwater supply of the region. ASR could result in water quality benefits within the portions of the groundwater basin underlying the City, because the quality of the recovered water would be similar to the quality of treated surface water.

Water transfers are also a tool used in the DWWSP. The DWWSP's certified Environmental Impact Report evaluated a range of water transfer alternatives. Because the environmental review of these water transfer alternatives has been completed, they can more easily be considered as part of an adaptive strategy to mitigate future dry conditions.

The City is a member of the WDCWA, the entity implementing the DWWSP, and the WRA. The WDCWA is actively engaged in implementing the DWWSP, and the WRA is an active participant the Westside Regional Water Management Group (RWMG). The Westside RWMG represents entities in the Cache Creek and Putah Creek watersheds. The watersheds of these two creeks encompass portions of Yolo Counties, Solano, Lake, Colusa, and Napa. Public agencies in the Westside RWMG coordinate with each other at present, and in the future will cooperate more closely with overlapping and immediately adjacent regions, such as the northern Sacramento

Valley. The Westside RWMG was recently awarded a $1 million Prop 84 planning grant for use in preparing the Westside IRWMP. The Westside IRWMP is expected to be completed in 2013.

The City has also embarked on a water conservation program, as described in Section 3.3.3.4. The City's water conservation efforts are expected to result in a 20 percent in reduction in demands by 2020, as mandated by the State in SB7. In addition to the water supply benefits of this conservation program, energy will be conserved, thereby potentially aiding in the control of green house gas emissions.

The City is evaluating measures to optimize storage of potable water, potentially using ASR, as part of its ongoing planning for future capital improvements. The City is coordinating these evaluations with the DWWSP planning efforts through its involvement in the WDCWA.

Action: Continue to review scientific and policy updates related to climate change as they become available through the IPCC, State, CUWA and other climate change authorities. Continue to implement the components of this GWMP. Continue to include adaptive management principals in water supply and infrastructure planning.

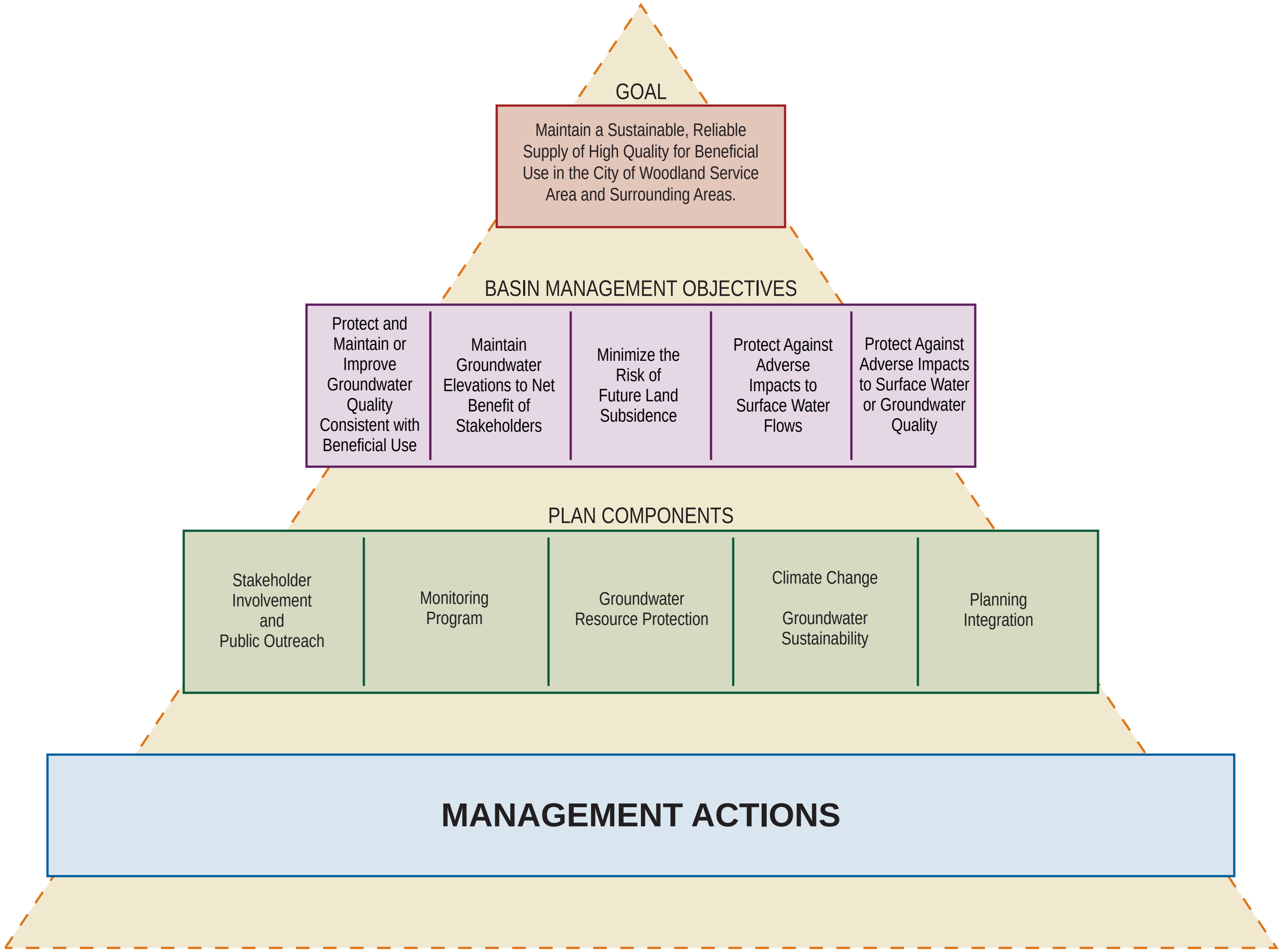

Figure 3-1

City of Woodland
Groundwater Management Plan

GROUNDWATER MANAGEMENT COMPONENTS

WOODLAND

WEST YOST ASSOCIATES
Consulting Engineers

February 14, 2011 Project No.: 204-00-08-18

Mr. Akin Okupe
Senior Civil Engineer
City of Woodland
655 N. Pioneer Avenue
Woodland CA 95776

SUBJECT: Response to a Public Comment on the City of Woodland Draft Groundwater Management Plan

Dear Mr. Okupe:

This letter summarizes the response to comments received from a member of the public on the City of Woodland's draft groundwater management plan. On January 30, 2011, Ms. Bernadette Murray, a Woodland resident, submitted comments to members of the Woodland City Council and City Manager. This letter summarizes Ms. Murray's comments and the revisions made to the groundwater management plan. The full text of Ms. Murray's comments is provided in Attachment A.

Comment 1. Ms. Murray requested a delay in adopting the groundwater management plan until after the water rate advisory committee issues its final report, because the final report may contain recommendations that could affect Section 3 of the groundwater management plan. The comment cited three topics in the groundwater management plan that could be affected by the final report of the water rate advisory committee. These were water recycling, salinity and the phasing out of water softeners.

Response 1. Section 3.3.3.2 of the revised groundwater management plan states the following,

> "There are currently no water recycling projects in the City. The City is in the early stages of evaluating recycled water use to offset potable water demands. Other potential supplies, including shallow irrigation wells in parks and other public landscape areas, are also being considered for this purpose.
>
> **Action:** Continue to evaluate alternative supplies that could offset nonpotable demands currently met with drinking water sources."

The revised groundwater management plan also includes discussion of the Davis Woodland Water Supply Project (DWWSP), which is being undertaken by the Woodland-Davis Clean Water Agency (WDCWA). The WDCWA is a joint powers authority including the Cities of Woodland and Davis and UC Davis. Planned implementation of the DWWSP will provide the City with treated surface water from the Sacramento River in 2016. The City's use of groundwater will continue but at a significantly reduced rate. The salinity of the treated surface water will be much lower than the City's groundwater, and the anticipated proportions of surface water to groundwater make it unlikely that customers will want to continue to use water softeners.

The overall salinity of the City's supply will be significantly reduced as a direct consequence of the DWWSP. The consequential phasing out of water softeners will also decrease salinity in the City's treated wastewater effluent.

The City's urban water management plan is scheduled to be completed by June 2011 and must be submitted to California Department of Water Resources by July 1, 2011. The adopted groundwater management plan needs to be attached to the urban water management plan, per California Water Code Section 10631. Delaying the adoption of the revised groundwater management plan could jeopardize the City's ability to meet the state-mandated schedule for the urban water management plan. Recommendations from the water rate advisory committee's final report can be addressed in the City's water focus study, which is under development. The water focus study is a water planning document with a broader scope than the groundwater management plan. Recycled water will also be addressed in the City's Urban Water Management Plan.

Comment 2. Prior to adoption, the Groundwater Management Plan should be revised to correctly identify the Woodland-Davis Clean Water Agency (WDCWA) rather than referencing the DWSWP (Davis Woodland Surface Water Project).

Response 2. Section 2.2.5.2, Planned Water Supplies, includes the following text.

> "The Woodland-Davis Clean Water Agency (WDCWA) is a joint powers authority including the Cities of Woodland and Davis and the UC Davis. The WDCWA is implementing a regional water supply project, known as the Davis Woodland Water Supply Project (DWWSP), to divert, treat and convey Sacramento River water to their respective service areas. The DWWSP will allow the project partners to reduce their groundwater pumping rates, a shift that will facilitate compliance with existing and anticipated wastewater discharge requirements, ensure compliance with existing and anticipated drinking water standards, and help enable adaptive management in response to climate change. The DWWSP will divert surface water from the Sacramento River using a new water intake/diversion facility. The project will also include untreated and treated-water conveyance pipelines, and a new water treatment plant (WTP). Surface water diverted from the Sacramento River will consist of water appropriated for use by the DWWSP Partners and water purchased from users with senior water rights. Local groundwater will continue to be used but at a substantially reduced rate compared with the current usage. The DWWSP Partners anticipate that surface water deliveries will begin in 2016."

The acronym, DWWSP, is used throughout the following sections of the revised groundwater management plan when referring to the water supply project. The acronym, WDCWA, is used to refer to the agency implementing the DWWSP.

Comment 3. Also the document must clarify whether 100% metering of Woodland will occur in 2018 or in 2012. Both years are stated in different sections of the document. The impact of water metering on projected water consumption is significant and six years is a huge difference in the estimated time to full metered billing.

If actual water consumption reduction exceeds the projected 15% [I estimate 25% may be the real achieved reduction], water rates will have to be increased even more than the projected 20% per year to maintain necessary funding for Capitol Improvement projects, the Surface Water Project, and the terms of the Water Purchase agreement. This should be noted.

Response 3. Section 3.3.3.4, Water Conservation, states the following,

> "The City is also implementing a water meter program and has installed meters on many customer water connections. Many of these customers began receiving sample billings based on their metered consumption in the spring of 2010. The City plans to have virtually all of the water connections in the City metered by the end of 2012. Studies by the California Public Utilities Commission have shown that communities with metered water systems use 7 to 20 percent less water than non-metered areas. Therefore, the City can expect a 7 to 20 percent reduction in water consumption once the City-wide metering is complete."

The State of California approved Senate Bill 7 (SB 7), which requires water providers to reduce their per capita water use by 20 percent by the year 2020. For consistency with the California Public Utilities Commission findings regarding metering and the requirements of SB 7, a 20 percent reduction in per capita water use rates was assumed in the demand projections documented in Section 2.2.4.2 of the revised groundwater management plan. The groundwater management plan is intended to address groundwater-related requirements under California Water Code Sections 10750 et. seq. California Water Code Section 10631 links the groundwater management plan to the urban water management plan, and a 20 percent reduction in demand by 2020 is assumed in both documents. This assumption is consistent with the State-mandated requirements and is appropriate for the purposes of the groundwater management plan and urban water management plan.

Currently, water rates are being structured with approximately a 70 percent fixed component and a 30 percent consumption-based component. This is structure is intended to reduce revenue variances, including those that might result from variation in future per capita water use rates.

Comment 4. In the section on Basin Management Objectives [3-1], the description of monitoring groundwater quality under BMO-01 appears inaccurate. The City of Woodland is investing in a Supervisory Control and Data Acquisition System (SCADA) that will replace the manual sampling process that is described in BMO-01. This section should be revised to describe when that SCADA system is anticipated to be fully operational and how the data will be used for monitoring groundwater quality.

Response 4. BMO-1, entitled, "Protect and maintain groundwater quality within the City service area for the benefit of basin groundwater users" pertains to the water quality aspects of groundwater management. SCADA will only monitor nitrate at a few wells that have relatively high levels of nitrate. SCADA will help protect water users. BMO-1 is intended to be proactive in working with groundwater stakeholders to protect the groundwater aquifer. The SCADA will be used for production and operational management by the City, but will not have the capability of automating the groundwater quality sampling needed to support BMO-1. With SCADA, City staff will have the ability to control the wells remotely, but the groundwater quality results discussed under BMO-1 would still have to be monitored through current sampling procedures. The sampling requirements are largely driven by California Department of Public Health drinking water requirements, which are described in the text. Appendix I describes groundwater sampling procedures.

Comment 5. Also the composition of the members of the GWMP Advisory Committee is represented differently in 1-1 and 3-16 subsection 3.3.5.2 Advisory Committee Formation. The first states that the Advisory Committee is composed of the "WRA". The second states that the Advisory Committee is composed of the "WRA TAC and the Woodland Planning Commission." Not only should the mystery of the real intended composition of the Advisory Committee be solved prior to adoption of the Groundwater Management Plan, but the process whereby the Advisory Committee generates recommendations for the Woodland City Council should be spelled out. Also if indeed. the Woodland Planning Commission is part of the Advisory Committee, then funding for an orientation workshop for Planning Commissioners on basic components of water management should be included as implementation costs ('fiscal impacts") of adopting this Groundwater Management Plan.

Response 5. Section 1.0, Introduction, and Section 3.3.6.2, Advisory Committee Formation, state the groundwater management plan advisory committee will consist of the members of the WRA, including representation by the City of Woodland. Section 3.3.6.2 states,

> "The City is an active member of the WRA. The Advisory Committee for this GWMP is comprised of the WRA Technical Advisory Committee (TAC).
>
> **Action:** Continue to designate City representatives to the WRA TAC and GWMP Advisory Committee during implementation of this GWMP."

We appreciate Ms. Murray's interest in reviewing the draft groundwater management plan. We hope that the revisions made to the document address her concerns and that the revised document provides the City of Woodland with the planning tools needed to address the range of groundwater management issues.

Sincerely,

WEST YOST ASSOCIATES

Kenneth L. Loy

Kenneth L. Loy
Principal Hydrogeologist
P.G. #7008

KLL:nmp

attachments

Attachment A

From: Bernadette Murray [mailto:bemurray2008@gmail.com]
Sent: Sunday, January 30, 2011 6:28 PM
To: Art Pimentel; William L. Marble; Skip Davies; Martie Dote; Mark Deven
Subject: RE: Agenda Item 8 Groundwater Water Management Plan Public Hearing

Dear Woodland City Council members and City Manager:

I am writing to comment on the proposed adoption of the Groundwater Management Plan prepared by West Yost Associates.

I would request that you delay adoption of this GWMP until after you have received the Final Report of the Water Rate Advisory Committee.

There are recommendations from the Water Rate Advisory Committee that I believe will materially impact the implementation actions in section 3 of the Groundwater Management Plan. Specifically, the committee will comment on creating a master plan for the installation of purple piping (for recycled water). Also, salinity and water softeners particularly in future public outreach efforts to phase out the use of water softeners should be included in this GWMP in the section 3 on salinity.

Additionally:

Prior to adoption, the Groundwater Management Plan should be revised to correctly identify the Woodland-Davis Clean Water Agency (WDCWA) rather than referencing the DWSWP (Davis Woodland Surface Water Project).

Also the document must clarify whether 100% metering of Woodland will occur in 2018 or in 2012. Both years are stated in different sections of the document. The impact of water metering on projected water consumption is significant and six years is a huge difference in the estimated time to full metered billing.

If actual water consumption reduction exceeds the projected 15% [I estimate 25% may be the real achieved reduction], water rates will have to be increased even more than the projected 20% per year to maintain necessary funding for Capitol Improvement projects, the Surface Water Project, and the terms of the Water Purchase agreement. This should be noted.

In the section on Basin Management Objectives [3-1], the description of monitoring groundwater quality under BMO-01 appears inaccurate. The City of Woodland is investing in a Supervisory Control and Data Acquisition System (SCADA) that will replace the manual sampling process that is described in BMO-01. This section should be revised to describe when that SCADA system is anticipated to be fully operational and how the data will be used for monitoring groundwater quality.

Also the composition of the members of the GWMP Advisory Committee is represented differently in 1-1 and 3-16 subsection 3.3.5.2 Advisory Committee Formation. The first states that the Advisory Committee is composed of the "WRA". The second states that the Advisory Committee is composed of the "WRA TAC and the Woodland Planning Commission." Not only should the mystery of the real intended composition of the Advisory Committee be solved prior to adoption of the Groundwater Management Plan, but the process whereby the Advisory Committee generates recommendations for the Woodland City Council should be spelled out. Also if indeed. the Woodland Planning Commission is part of the Advisory Committee, then funding for an orientation workshop for Planning Commissioners on basic components of water management should be included as implementation costs ('fiscal impacts") of adopting this Groundwater Management Plan.

For all the above listed reasons, I urge the Woodland City Council to choose course of action number 2 which is to not adopt the Groundwater Management Plan at this time and direct City Staff to address the issues listed above.

Respectfully,

~Bernadette Murray

--
Bernadette E. Murray,
L.M.T. C.M.T.
TX MT license #4270
CAMTC certificate #222
(530) 661-1950
443 1st Street, Suite 2
Woodland, CA 95695-4023

March 7, 2011 Project No.: 204-00-08-18

Mr. Akin Okupe
Senior Civil Engineer
City of Woodland
655 N. Pioneer Avenue
Woodland CA 95776

SUBJECT: Response to Comments on the City of Woodland Draft Groundwater Management Plan from the Water Rate Advisory Committee

Dear Mr. Okupe:

This letter provides responses to comments on the City of Woodland's draft groundwater management plan received from members of the City of Woodland's water rate advisory committee. The water rate advisory committee provided comments orally at the March 1, 2011 City Council meeting. These comments were provided to City staff in writing on March 2, 2011. Attachment A contains the complete text of the water rate advisory committee's comments.

Comment 1 – Conservation. The City does not seem to have a strong conservation plan. We recognize that metering is helping.

a. We would like to see a single, comprehensive source of information on the City web site; demonstration water-wise gardens on City property; programs like in Roseville where residents who agreed to conserve received special lawn signs, etc. There are WRAC members who are willing to help with this.

b. A permanent time of day/day of week landscape irrigation plan should be a law and should be enforced.

c. Further irrigation and water use restrictions should have clear triggers, e.g. well water level.

d. Why is water recycling not even being considered? Can some of our wastewater be made available to agricultural producers?

e. Water rates should include incentives for conservation.

Response 1. The City's groundwater management plan is one of several planning documents that the City is preparing. The groundwater management plan has a limited purpose and scope, and is intended to address specific management issues identified in the California Water Code, and California Department of Water Resources guidance documents. The groundwater management plan is intended to support the City's overall goal of working,

> "…cooperatively with basin stakeholders and the public to maintain a sustainable, reliable, high-quality groundwater supply for beneficial use in the City service area and surrounding areas."

The water supply referred to in this statement is groundwater. It follows that the primary focus of the groundwater management plan is on the groundwater basin, especially the portion of the basin overlain by the City of Woodland, although the plan seeks, and includes mechanisms for, cooperative management of the resource. Water conservation and recycling clearly relate to groundwater management because these initiatives seek to reduce water demands, including demands on groundwater resources. The groundwater management plan discusses water conservation and recycling primarily in the context of how these activities may affect future demands for groundwater.

Section 3.3.3.2, Water Recycling, states,

> "There are currently no water recycling projects in the City. The City is in the early stages of evaluating recycled water use to offset potable water demands. Other potential supplies, including shallow irrigation wells in parks and other public landscape areas, are also being considered for this purpose.
>
> **Action:** Continue to evaluate alternative supplies that could offset nonpotable demands currently met with drinking water sources."

Section 3.3.3.4, Water Conservation, states,

> "The City is also implementing a water meter program and has installed meters on many customer water connections. Many of these customers began receiving sample billings based on their metered consumption in the spring of 2010. The City plans to have virtually all of the water connections in the City metered by the end of 2012. Studies by the California Public Utilities Commission have shown that communities with metered water systems use 7 to 20 percent less water than non-metered areas. Therefore, the City can expect a 7 to 20 percent reduction in water consumption once the City-wide metering is complete."
>
> **Action:** The City will continue to implement its water meter project. The City will also continue to implement various programs to increase waste reduction, reuse, recycling, and promote the safe handling of household hazardous wastes. The City will continue to monitor and evaluate water usage to ensure that conservation measures are effective and the most representative demand trends are used to project future demands.

Other water planning initiatives undertaken by the City provide a broader platform for evaluating and planning water conservation measures and recycling. The City's urban water management plan is scheduled to be completed by June 2011 and must be submitted to California Department of Water Resources by July 1, 2011. The adopted groundwater management plan needs to be attached to the urban water management plan, per California Water Code Section 10631. Recycled water will also be addressed in the City's urban water management plan. The water focus study is a water planning document with a broader scope than the groundwater management plan. Recommendations from the water rate advisory committee will be considered during preparation of these documents.

The State of California approved Senate Bill 7 (SB 7), which requires water providers to reduce their per capita water use by 20 percent by the year 2020. For consistency with the California Public Utilities Commission findings regarding metering and the requirements of SB 7, a 20 percent reduction in per capita water use rates was assumed in the demand projections documented in Section 2.2.4.2 of the groundwater management plan. This assumption is consistent with the State-mandated requirements and is appropriate for the purposes of the groundwater management plan and urban water management plan.

The City has developed a water conservation planning goal and objectives for the 2010 through 2012 timeframe. The City's water conservation planning goal is,

> "…to reduce water use 20% by 2020, measured in gallons per capita, as compared to a 10 year baseline of pre-metered use."

This goal is supported by three objectives:

- Reduce City Water Usage
- Increase Public Education and Outreach
- Conserve Water through Landscaping Practices

Each objective has sub-objectives, which address residential and industrial water conservation, reductions in water system losses, public outreach and education, and water-efficient landscaping practices. Planned actions include updating the City's urban water management plan and adopting and revising the City Water Code to reflect new state legislation regarding water conservation including the Model Water Efficient Landscape Ordinance and SB 7. The City's 2010-2012 Water Conservation Plan goal and objectives are provided in Appendix B.

Comment 2 – Water Quality. Since nitrates are a significant problem, why not implement a fertilizer education program?

For ag producers that are major source in groundwater, work with Cooperative Extension. For landscape sources that contribute nitrates to storm water, work with landscapers and homeowners through the media and educational events.

Since salts are a significant problem, why not implement an educational program to encourage residents with water softeners to switch to potassium chloride instead of sodium chloride?

Response 2. The City can choose to implement an education program as a groundwater management action. This could address fertilizer, salt and nutrient best management practices in urban settings within the City and in agricultural areas in the surrounding areas. The University of California Cooperative Extension of Yolo County could provide a resource in this effort and Yolo County Flood Control & Water Conservation District could be approached as a cooperating entity. Activities could be discussed and coordinated through the Water Resources Association of Yolo County.

The revised groundwater management plan contains a Basin Management Objective (BMO) that would support the education program. BMO reads as follows,

> "BMO-01 – Protect and maintain groundwater quality within the City service area for the benefit of basin groundwater users. Groundwater within the City's service area is affected by nonpoint sources of nitrate and salts, and localized point sources of anthropogenic contaminants. Naturally occurring contaminants, resulting from dissolution of minerals comprising the aquifer skeleton, also affect groundwater quality. The City's objective is to minimize the impact of these contaminants at the locations of individual municipal wells within its service area, and to support stakeholder efforts to protect beneficial uses in the groundwater sub-basin from adverse impacts to groundwater quality.
>
> The City analyzes groundwater quality samples from its active production wells to comply with applicable standards in Title 22 of the CWC. The Department of Public Health (DPH) Title 22 program specifies the constituents to be tested, the detection limits for these constituents and reporting requirements. Sampling is conducted annually in a subset of the active wells such that each well is sampled on a three-year rotating cycle. Compliance with drinking water standards is a primary objective for the City. The City also uses the groundwater quality results to assess potential impacts to the municipal wastewater treatment plant, which is regulated under a Central Valley Regional Water Quality Control Board Waste Discharge Requirements Order. The primary constituents of concern for the wastewater discharge are selenium, boron and TDS. The water quality results will be evaluated on the same annual cycle under which the wells are sampled, such that each well will be evaluated every three years when new sample results are available. Temporal trends in the concentration of each constituent will be evaluated using a three-sample moving average comprised of the three most recent historical sample results for each well. Any increase in the concentration of a constituent of 20 percent or greater relative to the three-sample moving average will trigger evaluation of the need for potential actions, including:
>
> - Consideration of possible agricultural and landscaping best management practices that could help control nitrate, nutrient and salt loading to the groundwater basin
> - Additional monitoring, potentially on a more frequent basis
> - Operational modifications affecting the pumping schedule and rate
> - Well modifications to adjust the depth of pumping or seal zones with inferior water quality
> - Well destruction, with possible replacement with a new well
> - Replacement with a surface water supply

- Wellhead treatment, if feasible
- Destruction of abandoned wells

This BMO is supported by a range of groundwater management plan components addressing agency coordination, stakeholder involvement and public outreach, groundwater quality monitoring, groundwater sustainability, and groundwater protection.

The revised groundwater management plan also includes discussion of the Davis Woodland Water Supply Project (DWWSP), which is being undertaken by the Woodland-Davis Clean Water Agency (WDCWA). The WDCWA is a joint powers authority including the Cities of Woodland and Davis and UC Davis. Planned implementation of the DWWSP will provide the City with treated surface water from the Sacramento River in 2016. The City's use of groundwater will continue but at a significantly reduced rate. The salinity of the treated surface water will be much lower than the City's groundwater, and the anticipated proportions of surface water to groundwater make it unlikely that customers will want to continue to use water softeners. The overall salinity of the City's supply will be significantly reduced as a direct consequence of the DWWSP. The consequential phasing out of water softeners will also decrease salinity in the City's treated wastewater effluent.

Comment 3 – System Management. Adaptive management is mentioned in the plan, but how is it being done? Why does Yolo County do the permitting of City wells rather than the City? The thought here was that we would have more control over the process.

Response 3. Section 2.1.3, Climate Change, of the draft groundwater management plan defines adaptation and mitigation of climate change and documents published adaptive management strategies developed by the California Urban Water Association (CUWA). The CUWA adaptation and mitigation examples are listed in Table 2-2 of the groundwater management plan.

Section 3.3.4, Adaptive Management and Mitigation in Response to Climate Change, of the draft groundwater management plan provides a discussion of adaptive management strategies for the City of Woodland, including:

- Development of groundwater recharge, storage and conjunctive use projects
- Water transfers
- Development of regional water projects and partnerships
- Water conservation
- Optimization of local storage

The City Department of Public Works staff has made the determination that permitting for construction of new wells and destruction of existing wells is adequately specified in California Department of Water Resources documents and implemented by Yolo County. In addition to these existing requirements, the groundwater management plan addresses well construction and destruction under its groundwater protection component. Section 3.3.3.4 states,

> "The need for special well construction and destruction policies has not been identified within the City service area. Therefore, the construction and destruction standards put forth in CWC Section 13700 and detailed in DWR Bulletins 74-81 and 74-90 have been adopted as the applicable standards. These standards are enforced through the well construction and destruction permitting process administrated by the Yolo County Department of Environmental Health.
>
> **Action:** The City will ensure that any well construction or destruction projects that it undertakes will meet the applicable standards. The City will also include information on these standards in its education and outreach activities to private well owners within the City service area. When reviewing or approving land use plans, the City will endeavor to ensure that project proponents identify and properly destroy abandoned wells within the plan area as a condition of development."

Comment 4 – Executive Summary. Requiring the consultants who write the plan to also prepare an Executive Summary written in lay terms would make the report more accessible to Woodland residents. See attached.

Response 4. The revised draft groundwater management plan includes an executive summary. The "City of Woodland Groundwater Management Plan Summary for City Residents" prepared by the water rate advisory committee is provided as Attachment C.

We appreciate water rate advisory committee's interest in reviewing the draft groundwater management plan. We hope that the revisions made to the document and the response provided in this letter address the committee's concerns and that the revised document provides the City of Woodland with the planning tools needed to address the range of groundwater management issues.

Sincerely,

WEST YOST ASSOCIATES

Kenneth L. Loy
Principal Hydrogeologist
P.G. #7008

KLL:nmp

attachments

Attachment A

City of Woodland Groundwater Management Plan
Water Rate Advisory Committee Comments

Comments provided orally at the March 1, 2011 City Council Meeting and by email on March 2, 2011.

CONSERVATION

- The City does not seem to have a strong conservation plan.

  *****We recognize that metering is helping. We would like to see a single, comprehensive source of information on the City web site; demonstration water-wise gardens on City property; programs like in Roseville where residents who agreed to conserve received special lawn signs, etc. There are WRAC members who are willing to help with this.*****

- A permanent time of day/day of week landscape irrigation plan should be a law and should be enforced.
- Further irrigation and water use restrictions should have clear triggers, e.g. well water level.
- Why is water recycling not even being considered? Can some of our wastewater be made available to agricultural producers?
- Water rates should include incentives for conservation.

WATER QUALITY

- Since nitrates are a significant problem, why not implement a fertilizer education program?

  *****For ag producers that are major source in groundwater, work with Cooperative Extension. For landscape sources that contribute nitrates to storm water, work with landscapers and homeowners through the media and educational events*****

- Since salts are a significant problem, why not implement an educational program to encourage residents with water softeners to switch to potassium chloride instead of sodium chloride?

SYSTEM MANAGEMENT

- Adaptive management is mentioned in the plan, but how is it being done?
- Why does Yolo County do the permitting of City wells rather than the City?

  *****The thought here was that we would have more control over the process*****

Requiring the consultants who write the plan to also prepare an Executive Summary written in lay terms would make the report more accessible to Woodland residents.

*****See attached*****

Attachment B

Water Conservation Plan 2010-2012

Goal

To reduce water use
20% by 2020, measured in gallons per capita,
as compared to a 10 year baseline of pre-metered use.

Objective 1:

Reduce City Water Usage

- Revise the Water Conservation Section of the Urban Water Management Plan to meet the updated California Urban Water Conservation Council (CUWCC) Best Management Practices (BMPs) and SBx7-7 reduction goals.
- Revise the City Water Code to represent new state legislation regarding water conservation including the Model Water Efficient Landscape Ordinance and SBx7-7.

Sub-objective 1.1: Reduce Residential Water Waste

- Provide assistance to aid residents in detecting leaks which is a top priority with the water meters being installed and sample bills going out. Residential assistance would require additional staff and/or interns.
- Install water meters.
- After installation of water meters, begin billing with conservation tiers.
- Continue current incentives and /or provide new incentives for water conservation which could include toilet rebates, washer rebates, weather-based irrigation system rebates, rain barrel rebates and/or "Cash for Grass" programs.

Sub-objective 1.2: Reduce CII (Commerical, Industrial, Institutional) Water Waste

- Establish a relationship with the Chamber of Commerce and attend Water Committee Meetings.
- Research CII rebates and other potential savings for CII customers.
- Look into programs offered by other municipalities.
- Offer water surveys to identify water savings and check for leaks (would require additional staff and/or hiring a contractor).

Sub-objective 1.3: Reduce City Department Water Waste

- System wide water audit (leak detection survey) on the water infrastructure within the City. Phase 1 area of town to begin in summer 2011 to determine leaks in the system and to better estimate City water loss.
- Survey of water use by City Departments.
- Follow progress of Parks Irrigation Grant.

Objective 2:

Increase Public Awareness of Water Issues

Sub-objective 2.1: Increase public awareness of water issues through outreach.

- Maintain and update the water conservation website with new water conservation topics, update links to water conservation pages and data, and offer water conservation materials as downloadable PDFs.
- Provide water conservation information for City e-newsletter (once a month).
- Offer a suite of topics that groups can choose from for presentations in their area on water conservation related issues.
- Water conservation displays at the Library and City Hall.
- Create a water survey to use at events-potentially model after EBMUDs water survey. After a resident completes the survey, they are given water saving information and devices.
- Have public outreach materials and/or booth at local events.

Sub-objective 2.2: Increase educational opportunities for school aged children.

- Purchase educational materials for elementary-aged children to be given out at local events and/or to classes.
- Develop a 4th/5th grade education program on water conservation for Woodland schools.
- Offer Project WET (Water Education Training) workshops for Woodland area. Potentially co-sponsor with the Yolo County Office of Education.
- Co-sponsor the ZunZun school assembly program featuring water conservation, stormwater, and recycling.
- Consider a program like the Mayor's water readers which was a partnership among City of Tampa, the Public Library System, and Borders Books & Music. 300 participating youth (ages 6 to17) were rewarded for reading three books about water, received a certificate from the Mayor, citywide recognition and a gift from Borders.
- Offer the water drop patch for Girl Scouts and something similar for Boy Scouts or other groups. Girl Scouts worked on the patch and installed 148 storm drain markers in 2009.

Objective 3:

Conserve Water through Landscaping Practices

- Have demonstration sites for xeriscaping and native plant gardens. Potential at pond in Spring Lake and/or in the future at the new water treatment plant.
- Community water-wise awards: awards to people who redo their lawns with native plants.
- Water-wise Gardening Workshops in April/May each year. Develop partnerships with local nurseries to co-sponsor workshops to benefit the City and the nurseries. Have discount coupons from nurseries available at water conservation events. Hand out outdoor water conservation materials (two Sunset guides, soil moisture gauge, and hose nozzle).
- Landscape Irrigation Reviews. Include as part of leak detection assistance offered to high water users. Also consider offering to any interested residents in the future.
- Work with Community College and Master Gardeners on offering landscape workshops.
- Work with CDD on integrating the updated Model Water Efficient Landscape Ordinance into City Code.

Attachment C

City of Woodland Groundwater Management Plan
Summary for City Residents
Prepared by Members of the Water Rate Advisory Committee

The City of Woodland currently obtains its entire City water supply from twenty groundwater wells located throughout the City. By filing a Groundwater Management Plan with the State of California, we become eligible for grants that allow us to reduce costs, potentially saving City residents money.

The Groundwater Management Plan provides the framework for coordinating groundwater management activities among stakeholders. The plan identifies the management tools and objectives needed to guide efforts to effectively manage our groundwater as a safe and sustainable water supply.

Key concerns about the City's groundwater supply and steps taken by the City to address these include:

DECLINING GROUNDWATER QUALITY

The quality of our groundwater has been declining for several years. Woodland is under extreme regulatory pressure to have a higher-quality water supply by 2016, prior to the reconsideration of our wastewater discharge permit by the Regional Water Quality Control Board. While our water is safe to drink, it includes several components that are above the legally mandated level for wastewater discharge: boron, nitrate, selenium, chromium and Total Dissolved Solids (TDS). There is no way to cost-effectively treat our water to remove these.

The City has partnered with the City of Davis to develop a surface water supply drawn from the Sacramento River. This water supply will come on line in 2016 and will provide a high-quality water supply that meets State-mandated standards and fills most of our water needs. At that time our ground and surface water supplies will be integrated to ensure ample water supply and pressure during periods of peak demand.

LAND SUBSIDENCE DUE TO GROUNDWATER EXTRACTION

Inelastic land subsidence resulting from groundwater withdrawal can cause physical changes to our groundwater aquifers that render them unable to be recharged. To date this has had significant consequences in the Yolo Groundwater Sub-basin. The risk in each specific aquifer is determined by many factors, including the degree of new groundwater development, changing land use, and the mineral composition of the soil in the aquifer. The City's objective is to prevent or minimize future impacts from land subsidence by continuing to cooperate with other stakeholders to monitor rates of inelastic land subsidence.

Rates of land subsidence are being established though on-going county-wide monitoring. The City will continue to evaluate the results with other members of the WRA.

CHANGES IN GROUNDWATER LEVELS

Historical records show that the elevation of our groundwater declined from the 1950s to the 1970s but stabilized after that in response to regional water supply projects. Declines in groundwater levels are still a concern during drought years. It is much more expensive to pump water from lower levels, which increases system costs and strains equipment.

The City will consider several actions to maintain groundwater levels in dry years. These include outreach to encourage conservation, operational changes to rely least on wells most at risk, and construction of new wells. The implementation of the surface water supply described above will also alleviate pressure on existing groundwater supplies.

The full Groundwater Management Plan is available for viewing at City Hall or can be downloaded at www.cityofwoodland.org. Comments may be sent to xxxx or presented at the Woodland City Council meeting on yyyy.

APPENDIX C

LSCE Report 2004: Hydrologic Conceptualization of Deep Aquifer Units

Hydrogeologic Conceptualization of Deep Aquifer Units

Woodland - Davis Area
Yolo County, California

DRAFT

Luhdorff and Scalmanini
Consulting Engineers

October 2004

Table of Contents

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List of Figures

I. Introduction

This report extends a previous study of the Deep Aquifer underlying the greater Davis area (LSCE May 2003). In that study, Deep Aquifer referred to aquifer materials occurring at depths on the order of 600 feet to 1,500 feet. The Deep Aquifer is a term that has been used locally to distinguish wells completed deeper than the majority of historical municipal wells constructed and operated by the City of Davis and agricultural and utility wells on the University of California Davis campus. Those wells constructed to depths shallower than the Deep Aquifer are locally classified as Intermediate Aquifer wells.

The 2003 study consisted of a detailed examination of geologic and hydrologic data, most prominently well logs from oil and gas exploration and existing water supply wells completed in the Deep Aquifer depth interval. Though that report employed the term Deep Aquifer, it was more useful for the purposes of the study to delineate discrete aquifer units and trends related to apparent depositional processes. For example, it was found that within the traditional Deep Aquifer depth interval, wells might encounter units having little apparent horizontal correlation from the east side of Davis to the west. Distinct horizontal and vertical variations were better explained through informal stratigraphic classifications that grouped units according to apparent fluvial depositional relationships. This approach is carried through the evaluation of deeper aquifer materials north of the Davis area into Woodland. For long-range planning and water supply development purposes, it is implied herein that subdividing the deeper aquifer materials into stratigraphic units may prove more useful than the traditional distinction between the Deep and Intermediate aquifers.

The description of aquifer units contained in the 2003 and current studies are viewed as a precursor to using other tools, such as ground-water flow models, to evaluate a variety of ground-water issues. It was prepared to ultimately aid in the assessment of the extent and adequacy of local ground water to meet long-term projected water demands. More specifically, the updated conceptualization of the character and distribution of Deep Aquifer units has implications with regard to long-term ground-water resource development and potential mutual impacts between the Woodland and Davis areas.

Conceptual Model

As with the 2003 study of the greater Davis area, this report presents a hydrogeologic conceptualization of aquifer materials targeted as a long-term supply source. The term "conceptual" still applies to this study as the attributes of the ground-water system are beneath the ground surface and can only be inferred, or interpreted, from related observations or measurements. As stated in the previous report:

> *The conceptualization includes identification of major geologic features, hydrologic processes, boundary conditions, temporal and spatial scale factors, hydrologic variations, and hydraulic conditions that qualitatively describe the occurrence and movement of ground water so that the system can be understood well enough to be more precisely assessed with other tools such as analytic or numerical models.*

The conceptualization as presented herein provides a basis for developing and testing hypotheses about factors that are related to long-term reliability for municipal water supply within the area encompassing the City of Davis, the City of Woodland, and the University of California, Davis. Of course, in the long-term there may be other entities that may target deep aquifer materials and the conceptualization might need to expand to assess additional possible mutual impacts.

Methods and Study Area

For this update, evaluation of the Deep Aquifer was expanded to encompass the area north of Davis. The work presented here merges stratigraphic relationships and models interpreted from cross sections and maps presented in LSCE's 2003 report with new cross sections and interpretations north of Davis that focus particularly on the Woodland area. In addition, this work is consistent and parallels LSCE's report on a ground-water monitoring program in Yolo County under an AB303 grant obtained by the Yolo County Flood Control and Water Conservation District (July 2004).

Because the recent and current work on the Deep Aquifer aims to provide a fundamental description (i.e., conceptualization) of aquifer materials, the evaluation is regional in scope. Such a scope was necessary because it was apparent that the occurrence of aquifer materials in the deeper strata (that is, deeper than historical municipal supply development in Woodland and Davis), is controlled by depositional processes that extend beyond city limits, for example.

The study area for the combined scope of the 2003 report and the current evaluations extends to the City of Winters and the Coast Range, which likely served as source material for geologic formations that occur at the depth of the Deep Aquifer in Davis. To the east, the area extends to the Sacramento River, which was recognized as a significant depositional feature that could have a bearing on depositional processes in Davis. To the south, the evaluation extended six miles on a judgment of how far hydrological influences might propagate. Finally, the model extended northward beyond the City of Woodland to take into account possible questions related to mutual pumping impacts between Davis and that community. Figure 1 shows the regional study area of the current study.

Results

The expanded conceptualization of the Deep Aquifer system provides a working hypothesis for water supply targets in the greater Woodland-Davis area. The occurrence and distribution of aquifer units below 600 feet, nominally the top of the local delineation of the Deep Aquifer, is viewed as a complex of fluvial deposits that vary horizontally and vertically throughout the study area. Importantly, the distribution appears to have stronger correlation in the north-south direction which is explained through north-to-south fluvial depositional patterns. The implications of the correlations and depositional model are that east-west relationships between aquifer units may not be as important as those in the north-south direction and that in the long-term, extensive water supply development in the deeper aquifers in the Davis Woodland areas may warrant testing hypotheses about potential mutual interference.

II. Regional Geologic Setting

The ground-water basin in the Woodland-Davis 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. 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 ground water extends to an elevation of –3,000 feet.

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. Through the oil and gas exploration activities, four early Tertiary submarine canyons have been identified, which were carved into the older marine deposits, and infilled 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 overlying the 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 ground water and represent the ground-water basin beneath Yolo County and within the subject study area. 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 are described below.

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.

Along the eastern side of the Sacramento Valley, nonmarine sedimentary deposits have been defined as Miocene-Pliocene Mehrten Formation, Pliocene Laguna Formation, Pleistocene Turlock Lake Formation, younger Pleistocene Riverbank Formation, and Pleistocene and Holocene alluvium. Along the western side of the Valley, the stratigraphy has been described as Pliocene to Pleistocene Tehama Formation and younger (Pleistocene-Holocene) alluvium, both derived from streams flowing off the Coastal Range to the west. Beneath the Valley floor, it is envisioned that the western-sourced Tehama Formation and alluvium interfinger and interbed with the eastward-sourced formations along the center of the Valley, with a zone of mixing caused by a central fluvial system (Sacramento River).

In the subsurface, where information is based solely on interpretation of borehole data, separation and correlation of the nonmarine deposits to basin-margin and surface exposed formations is difficult for several reasons. Water well data largely consist of driller's descriptions from boreholes less than 600 feet deep, with relatively few electrical logs to provide a quantitative assessment of strata. Only a few water wells have been drilled to depths of 1,500 feet and only the most recent wells (the last 10 to 20 years) have quantitative electrical log surveys. Natural gas test holes are numerous throughout the area, with electrical logs conducted in all of them. However, little lithologic information above the older marine deposits is available from these sources since these wells only target the deeper formations below the base of fresh water.

The stratigraphy of the nonmarine deposits is extremely complex because of the interaction of the three different source areas cited above: the western Coast Range, the eastern Sierra Nevada, and the northern-sourced Sacramento River system. In addition, the similar depositional environments of the nonmarine deposits have produced a relatively indistinguishable stratigraphic character as reflected in the available borehole data. Bedding of coarse-grained (sand and gravel) beds tends to be relatively thin, elongated stream channel deposits surrounded by thin discontinuous, somewhat laterally more extensive sheet sands of flood plain and alluvial plain deposits. All of the sand beds are inter-layered and contained within fine-grained flood plain and flood basin clays and silts. Correlation of individual sand beds is extremely difficult because of their thin and discontinuous nature. Correlation and tracing of sequences of a number of sand beds related to a stream channel system or alluvial plains appears valid, at least locally, until their nature and depositional settings change, which apparently occurs often in the regional study area.

Previous Studies

Ground-water resources in Yolo County have been investigated by numerous studies over the last century; the most significant or relevant reports arc cited below. An early reconnaissance report of the Sacramento Valley ground-water resources was presented by Bryan (1923). The California Division of Water Resources (1955) encompassed most of the ground-water 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 ground-water resources. A DWR report (1978) covered the evaluation of the ground-water 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 ground-water 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 ground-water 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. 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 ground-water investigation of eastern Yolo County. LSCE (2003) presented a conceptualization of the deep freshwater stratigraphy around Davis.

Additional references on Yolo County 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; however, these studies focus on shallow hydrogeologic conditions and are not considered important sources for the description of the deeper aquifer materials that are the subject of the current study.

III. New Cross Section Construction

In order to extend the Deep Aquifer conceptualization from the Davis area (LSCE, 2003) northward into Woodland, similar methodologies were used. Work cross sections were constructed in Township 10 North Ranges 1, 2, and 3 East to examine stratigraphic relationship from oil and gas test hole geophysical logs. These work cross sections, delineated in Figure 2, were oriented east-to-west and spanned a six-mile length across an entire township and range. Because of the relatively thin-bedded nature of the sand gravel beds, a vertical scale of one-inch equal to 100 feet was used with a horizontal scale of one-inch equal to 1,000 feet, which produces a vertical exaggeration of ten. Because the total stratigraphic section being examined was about 4,000 feet in thickness, this required two 24" x 36" sheets to depict each Township and Range cross section.

Work cross sections were located at just a mile apart north-south in the Township 10 North (see Figure 2). Because of their size, number and intended use to develop a working level conceptualization conveyed in other forms, the work cross sections are not included in this report. Just within the City of Woodland area, these work cross sections entailed 10 cross section lines for a total of twenty 24" X 36" sheets.

From these Woodland area work cross sections, questions were raised about the complexity of stratigraphic relationships of sand sequences above –1500 feet further south between Woodland and Davis. Additional work cross sections in Township 9 North Ranges 1, 2, and 3 East were constructed or reinterpreted from the previous study (LSCE, 2003). These cross sections were located one-mile apart oriented east-to-west, while earlier cross sections were two to three miles apart. These additional cross sections totaled 13, or an additional twenty-six 24" X 36" sheets. All work cross section locations from Davis north are shown on Figure 2 and distinguished as either previous (LSCE, 2003) or new cross sections; eight additional well cross sections were constructed oriented north-south, but are not shown on the figure.

From the work cross section described above, broader patterns and relationships became apparent that were difficult to ascertain from smaller scale cross sections or by examination of individual well logs. From these work cross sections, regional cross sections were developed which show the interpreted geologic relationships from the coast range to the Sacramento River for the entire nonmarine, fresh-ground-water bearing deposits. The location of these regional cross sections are shown in Figure 3.

IV. Ground-Water Bearing Units

The regional geologic cross sections that are the primary focus of this report are depicted in Figures 4 to 7 and they reflect the interpreted stratigraphic sequence of the non-marine deposits based on sequences of sand-rich bodies distinguishable by bed character and varying depositional environments. The sequences were labeled and designated alphabetically, A through F, from lowest (oldest) deposits upward. The result is an informal stratigraphic classification that is ultimately useful in the conceptualization of deep aquifer materials that occur in the Woodland-Davis study area. Correlation of the informal units to surficial mapped and formal stratigraphic units was not attempted, except in a general way. The following discussion of the ground water bearing units is divided into lower and upper nonmarine deposits (Figures 4 to 7) with a brief discussion of overlying alluvium.

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-Pliocene 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. In the central portion of the study area, 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 alluvial plain deposits, which rise toward the east (A-, B-, C-East; see Figures 4 to 7). To the west, at least partially equivalent deposits appear to be alluvial fan to alluvial plain deposits from a western source (A/B-, C-West).

Below the A sand sequence on the east 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 westward thinning nature of these sands (Figures 4 to 7).

The A- and B-East sand intervals are believed to be equivalent to the Late Miocene-Pliocene Mehrten Formation. ~~The central~~ A and B sand sequences are believed to be Miocene and Pliocene fluvial or stream deposits. The A/B-West sand sequence may represent possibly unexposed Miocene and Pliocene deposits, and Pliocene lower Tehama Formation.

The C-East sand interval may represent the Pliocene lower Laguna Formation and 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. While the Mehrten and Laguna Formations are significant water-producing zones in eastern Sacramento County, the possible equivalent units were not studied in detail for this report primarily because the lower nonmarine deposits have not been targeted for water supply in the study area.

Upper Nonmarine Deposits

The upper nonmarine deposits overlie the lower nonmarine deposits in the south center of the basin from –1,500 feet elevation to depths of 100 to 200 feet (Figure 4). 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 (Figures 4 to 7). The western lateral equivalents to these units appear to be alluvial plain to alluvial 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 were not extensively examined for this report, but are addressed in the recent Yolo County Flood Control and Water Conservation District monitoring report (LSCE, 2004).

The stratigraphic nomenclature of the upper nonmarine deposits in this report differs somewhat from the previous study of the greater Davis area (LSCE 2003) based on the construction of a series of new work cross sections near Woodland and revised work cross sections south of Woodland (Figure 2). In particular, as was anticipated at the time, a more extensive examination of data north of Davis reveals a more complex E sand sequence. The revised stratigraphic interpretation is based on log information nearer Woodland than those incorporated in the 2003 study.

The E-Lower sand (E_{ls}) sequence consists of six to seven major sand beds (Figure 7) 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 Aquifer (600 to 1,500 feet) 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 central upper nonmarine sand sequences with the exception of the E-Upper sands.

The E-Lower/Upper sand (E_{lus}) sequence extends southward in a similar manner, but occurs further eastward beneath the eastern margin of Davis (Figure 4). A higher concentration of E_{lus} beds occurs below the Yolo flood bypass near Davis, but it is missing near Woodland. This may represent an eastern-sourced tributary fluvial system. Some secondary E_{lus} beds may extend into north central Davis, possibly inter-fingered with D sands. The character of the E_{lus} suggests that they extend somewhat further south before entering a lower-energy depositional environment than the E_{ls}.

The D sand sequence (Figures 4 to 6) appears to be partially contemporaneous with the E_{lus}, 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 aquifer 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 (Figure 4). 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 (E_{us}) appear as a sequence of thick-bedded fluvial channel and floodplain sands, which extend southeastward from Woodland to east of Davis. The E_{us}

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 E sand deposits. The increase in sand bed concentration may indicate 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 though 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 well log 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.

In the south (Figures 4 and 5), there appears to be an eastern-sourced alluvial plain, or tributary fluvial system, of E_{ls}-East sands. Further north (Figures 6 and 7), these sands appear to be lacking. A similar eastern-sourced E_{lus}-East sands occurs in the south and is lacking in the north (Figures 4 to 7). In contrast, an E_{us}-East sand in the north (Figure 7) includes a possible eastern-sourced alluvial plain or tributary fluvial system.

As cited previously, the uppermost 500 to 600 feet of the upper nonmarine deposits were not examined in detail for this study. From other 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.

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. The alluvium appears to be a complexly stratified sequence of unconsolidated, interbedded sands and gravels and 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 alluvial sheets and distributary channels across the alluvial plain areas of the west. To the east, more fine-grained, floodplain and flood basin 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 alluvium 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 alluvium deposits.

V. Summary of Findings

Through extensive cross section construction and interpretation, a stratigraphic model of the Deep Aquifer is presented in this report which encompasses the Davis and Woodland areas. The report complements and expands the interpretations presented in a previous report that focused primarily on the Davis area (LSCE, 2003).

The term Deep Aquifer is meant to correspond to nonmarine sedimentary deposits in the depth interval between about 600 and 1,500 feet. Historically, municipal and agricultural pumping has been predominantly from shallower strata including the Intermediate Aquifer occurring nominally between 200 and 600 feet.

The Deep Aquifer is interpreted to consist of complex sand units that are fluvial in origin and appear to trend from north to south in the central portion of the study area. The distribution of these aquifer materials varies in both vertical and horizontal directions with strongest correlations of individual sand beds between wells in the north-to-south direction. The correlations between bed units and stratigraphic classifications presented here reflects a north-south fluvial depositional pattern. If, in fact, the dominant depositional processes occurred with this directional tendency, long-term development of the Deep Aquifer for water supply in both the Davis and Woodland areas may see mutual impacts in the future, though possibly not for years or decades. This model can be assessed further through future ground-water monitoring and aquifer testing.

The conceptualization for the Woodland area suggests potential water supply targets and some system attributes including number of beds, their thickness, and their vertical and horizontal distribution. Thus, it provides basic input into well development planning that can be updated through new logs acquired from a systematic drilling program that is, at last initially, based on these attributes.

Like the 2003 study that focused on the Davis area, the conceptualization presented here is intended to serve the use of other tools, such as numerical ground-water flow models, which might ultimately be employed to address questions concerning long-term reliability of supply from the Deep Aquifer system in the Woodland-Davis area.

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FIGURES

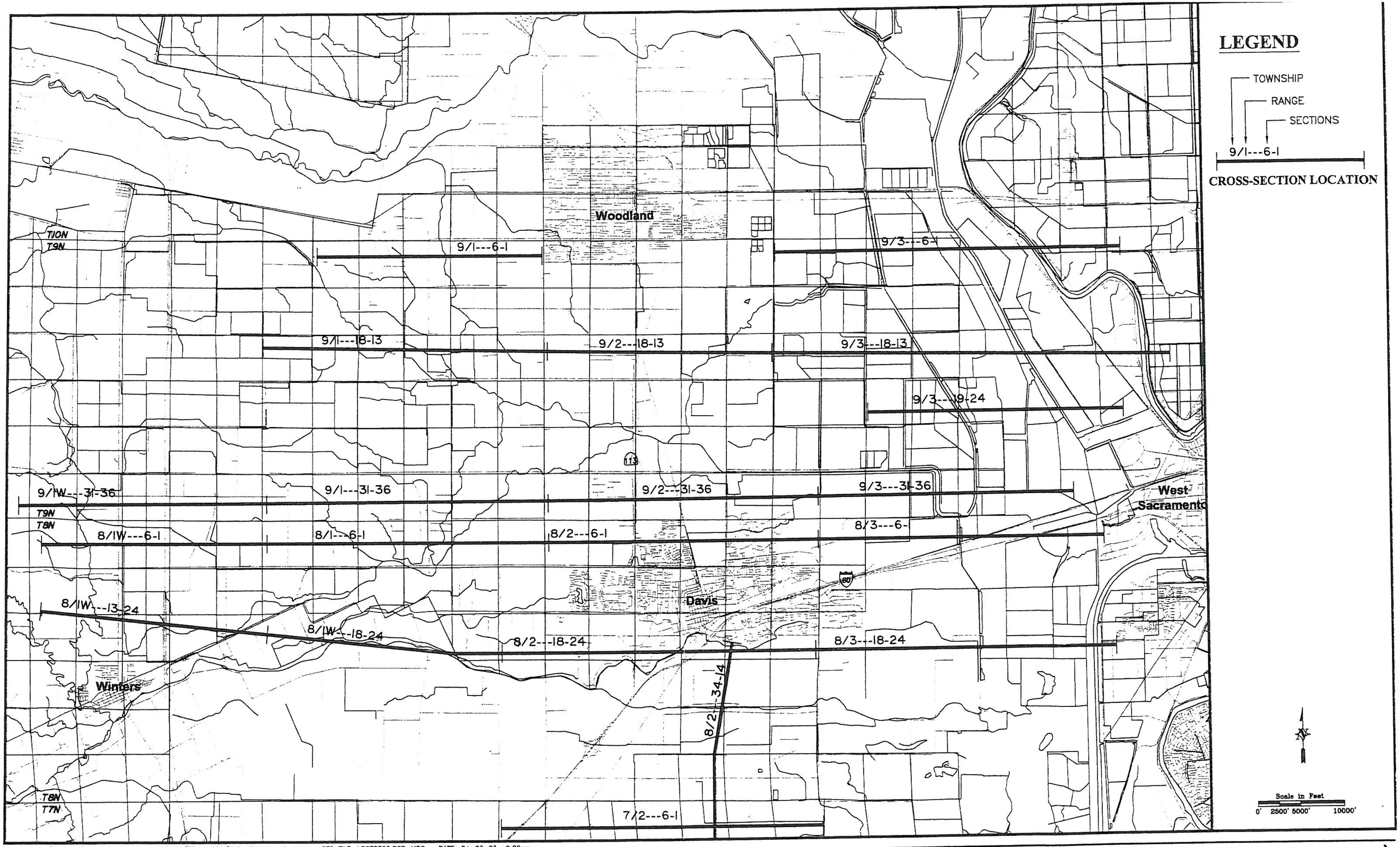

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Figure ~~2~~ 1
~~Cross Section~~ Location Map
University of California Davis

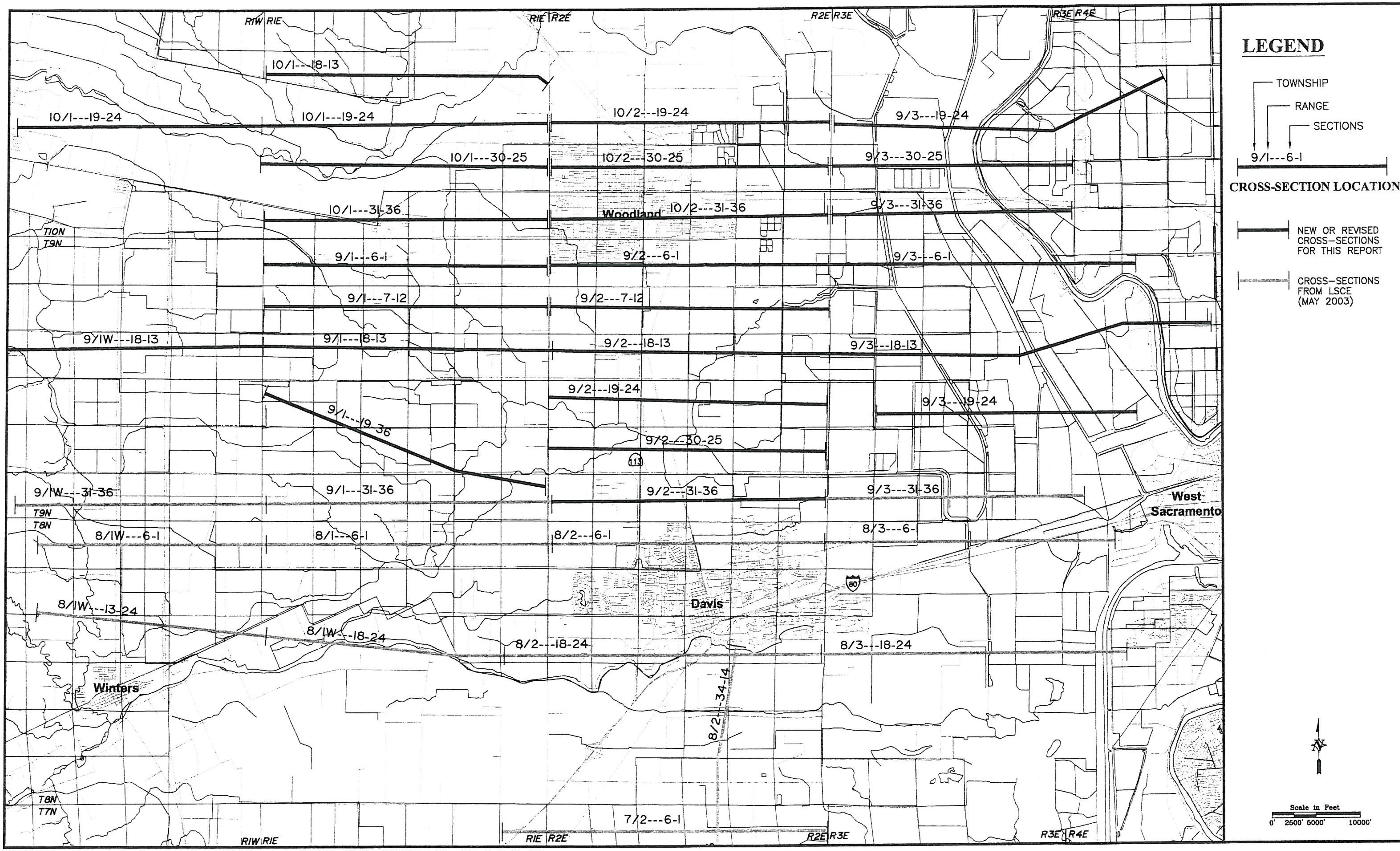

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Figure 2
Work Cross Section Location Map
University of California Davis

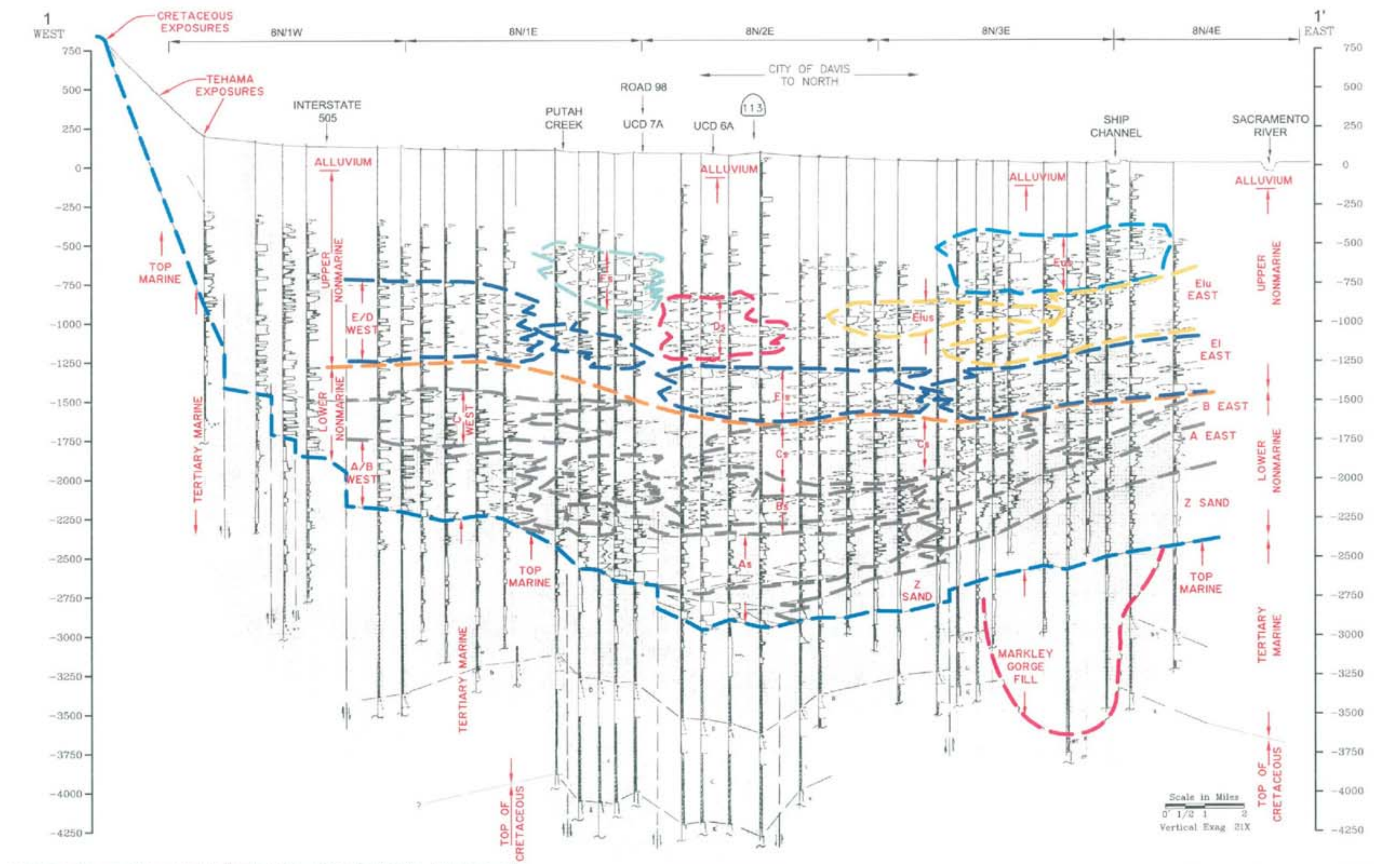

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Figure 4
Geologic Cross Section 1-1'
Yolo County Area

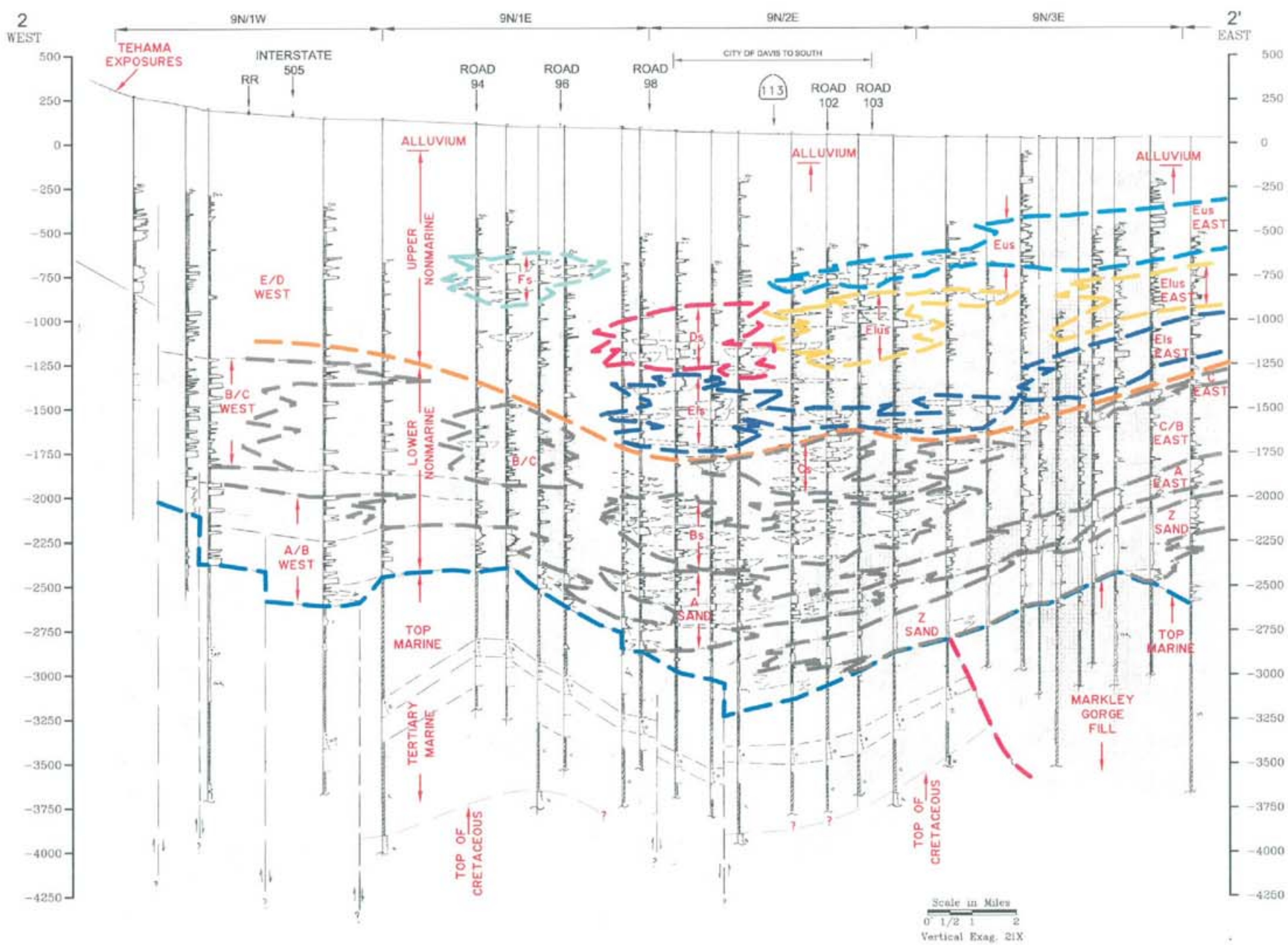

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Figure 5
Geologic Cross Section 2-2'
Yolo County Area

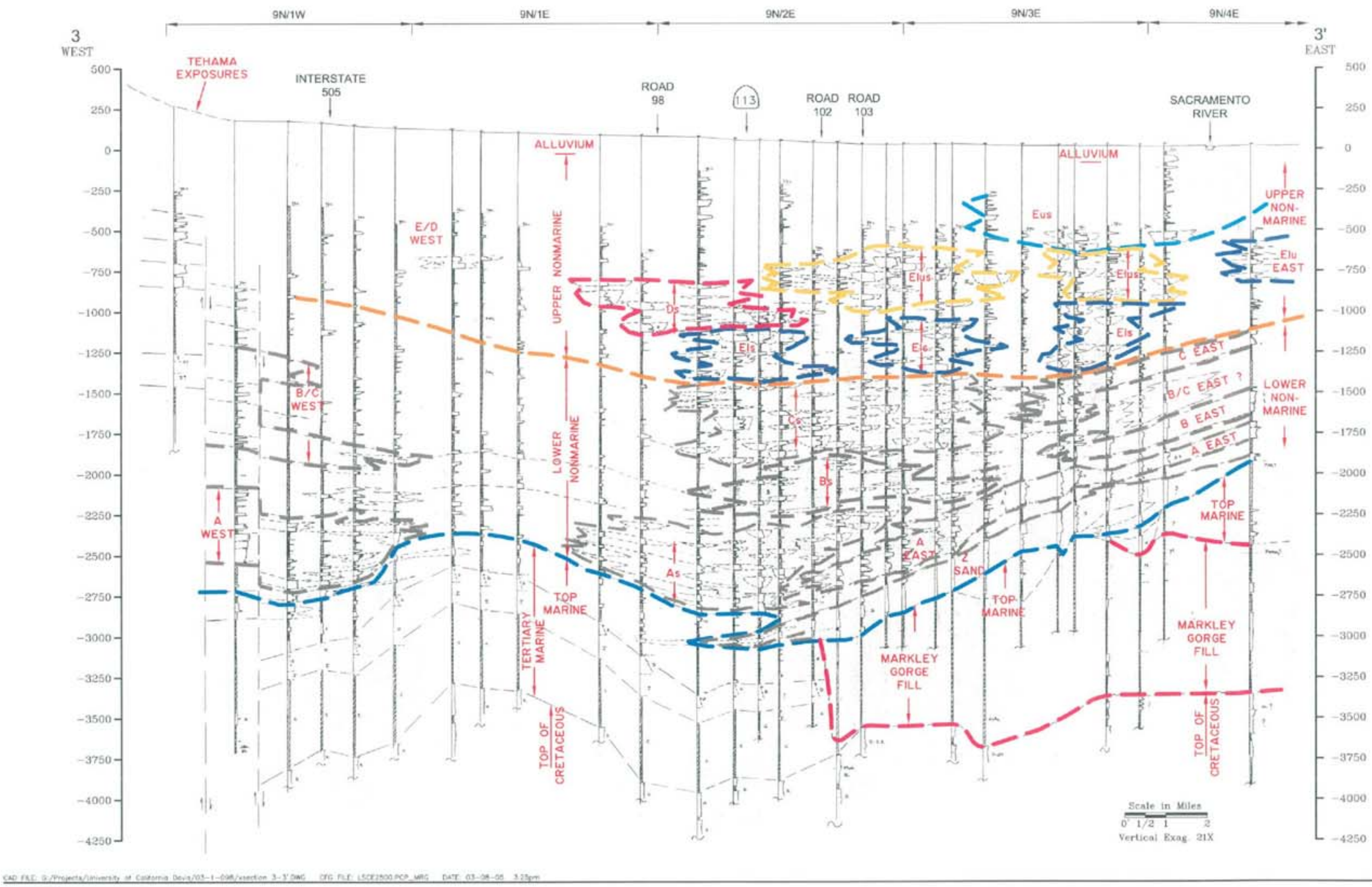

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Figure 6
Geologic Cross Section 3-3'
Yolo County Area

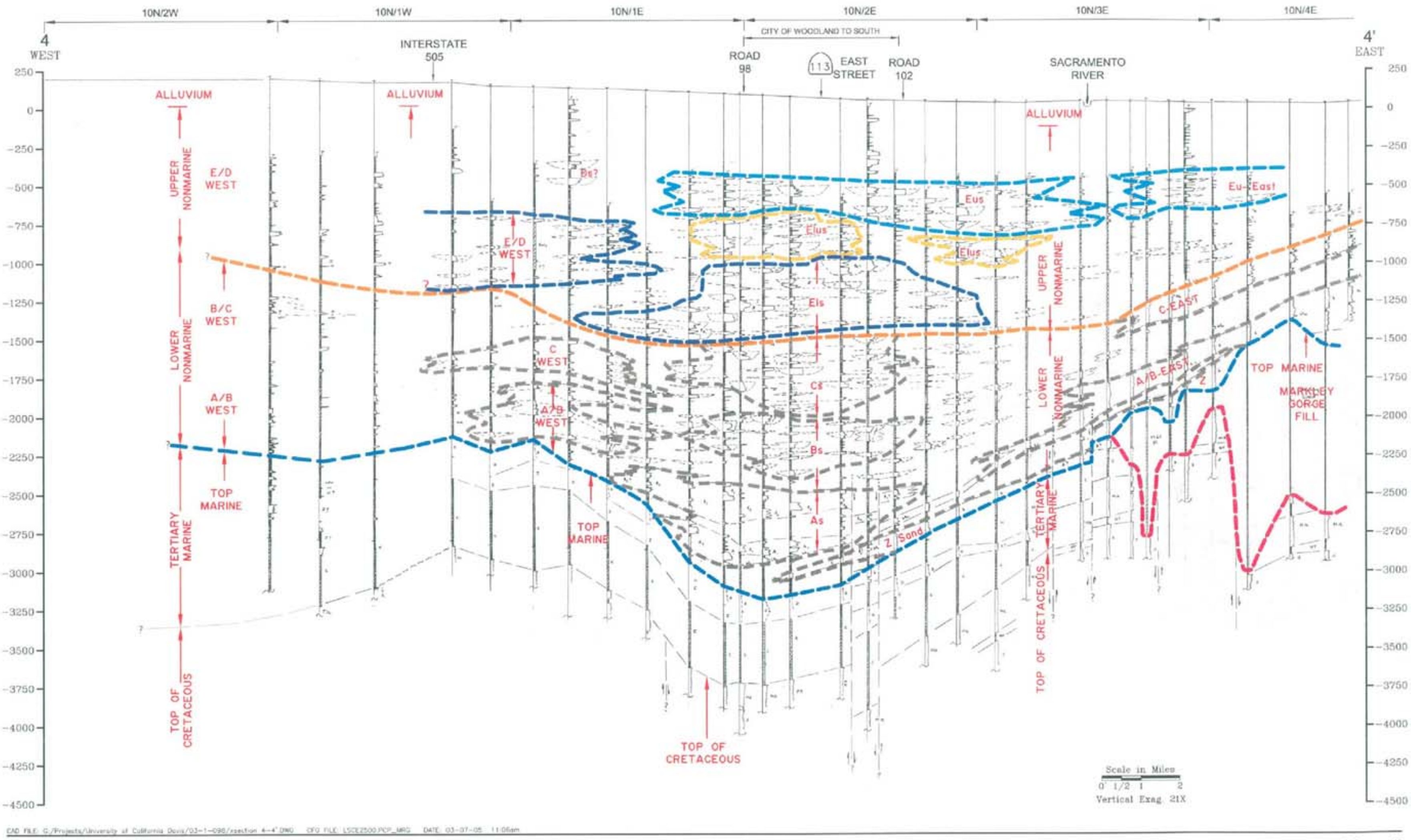

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Figure 7
Geologic Cross Section 4-4'
Yolo County Area

APPENDIX D

Yolo County GPS Subsidence Network Recommendations and Continued Monitoring Report 2006

The Yolo County GPS Subsidence Network

Recommendations and Continued Monitoring

(Photo: Station LIBRARY, in Woodland)

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March, 2006

Executive Summary

From July through September, 2005 the third set of observations of the Yolo County GPS Subsidence Network were obtained. This marks the third time the Yolo network has been observed. The original observations were obtained in 1999. The second observation of the network was obtained in 2002. In 2002 the network was expanded to include stations south of the Highway 80 corridor. Also, the City of Sacramento added several stations to the network for the 2002 observations. In the 2005 project a few new stations were added to the network.

The results of the 2005 observations validate the findings of the 2002 results. The results show continuing subsidence in the Davis to Zamora corridor. The 2005 observations also provide an opportunity to take a more in-depth look at the underlying assumptions of subsidence based on the issue of what is believed to be stability. The project incorporates a few continuously operating GPS sites. These sites provide a continuous record of ground movements, both horizontal and vertical. It is in light of these data that we may now be able to refine some of our assumptions about stability against which subsidence is measured.

The 2005 project included the addition of one station (RWF1) that is part of the Davis Deep Aquifer study, and one station (RD2068) that was established for Reclamation District 2068 in Solano County. Both were established in 2004. Including RD2068 entailed adding two additional stations (SURVEYOR and MILLAR) in order to meet the network geometry specification. These two stations were part of earlier subsidence network observations in the Sacramento/San Joaquin River Delta.

Station ellipsoid heights for the 1999, 2002 and 2005 projects, as developed by CSRC, are included in **Appendix A**.

The provisional results of the elevations (orthometric heights) for the 2005 project are included in **Appendix B.** Also included in this appendix are the values obtained from the earlier 1999 and 2002 projects along with the inter-survey subsidence values.

A map of the project showing the local network stations, cumulative subsidence contours and water source information, may be found in **Appendix C**.

The hypothetical results of continued subsidence at rates seen to date is shown for selected stations in **Appendix F**.

The report of the 1999 survey (The Yolo County Subsidence Network: Recommendations for Future Recommendations, Frame and D'Onofrio, 1999) included a series of ten recommendations. The 2002 report (The Yolo County GPS Subsidence Network: Recommendations and Continued Monitoring, Frame and D'Onofrio, 2003) added an additional two recommendations. All of these recommendations are further discussed in Section IV of this report.

I. INTRODUCTION

This report outlines the results of the 2005 Yolo County GPS Subsidence Project. It also includes comparisons with the earlier 1999 and 2002 projects. Each of the recommendations in the 1999 and 2002 reports are addressed with updated comments. This report also includes a discussion of the subsidence findings with respect to a more thorough review of the relationship of subsidence areas to neighboring stable areas and/or subsiding areas with continuous records of earth movement.

As with the earlier 1999 and 2002 projects, the 2005 project was accomplished with cooperation from several agencies. Observation personnel were provided by the California Department of Water Resources, the cities of Woodland and Davis, the US Bureau of Reclamation, the Yolo County Planning, Resources & Public Works Department, and Frame Surveying & Mapping. GPS equipment was supplied by the University of California Davis, the US Bureau of Reclamation, and Frame Surveying & Mapping.

II. BACKGROUND

The 2005 GPS subsidence survey is the third in the series of observations. These observations have been conducted at three year intervals, the previous observations being in 1999 and 2002. The greatest portion of the GPS network has been the same. Several new stations were added in 2002 and four additional stations were added in the 2005 survey.

The results of the 2005 survey indicate that subsidence trends throughout much of the county are continuing. The largest amount of subsidence occurs in the Zamora area, especially near the Zamora extensometer (station ZAMX) which has subsided a total of about 12 to 15 centimeters (roughly 6 inches) over the six years of the project. A map of the subsidence contours based upon the CSRC ellipsoid height analysis is provided in **Appendix C.**

It should be noted that only a very few stations in the network showed no subsidence. It should also be noted that the accuracy of the subsidence values is +/- 2 centimeters.

III. PROJECT ISSUES

All stations observed in the 2002 project were recovered in good condition. There were four additional stations added to the network. One of the stations is part of the Davis Deep Aquifer Study (station RWF1), and one was established in 2004 for Reclamation District 2068 (station RD2068). Station RD2068 is in Solano County. Two additional stations in Solano County (SURVEYOR and MILLAR) were added to allow for a more complete relationship with RD2068. The two additional Solano County stations were part of earlier GPS subsidence projects. Station RWF1 is inside Yolo County and required no additional station observations.

The City of Sacramento stations included in the 2002 survey were not observed in 2005.

There were a greater percentage of re-observations required for this project than for previous projects. All baselines (those inter-station lines indicated on the project map – see **Appendix D**) are observed at least twice. Baseline comparisons must agree within 2 centimeters. In the 2005 project over 15 percent of the baselines did not meet this criterion. All were re-observed and all ultimately met the 2 centimeter criterion.

All other activities associated with the 2005 project were routine.

Provisional coordinates (latitude, longitude and elevations) are included in **Appendix E.**

IV. RECOMMENDATIONS AND COMMENTS

After the 1999 project was completed a series of ten recommendations was made. After the 2002 project an additional two recommendations were made. We will include two additional recommendations in **Section V. NEW RECOMMENDATIONS.**

A summary of the recommendations is immediately below, followed by more detailed information.

Summary of Recommendations

Recommendation	Year	Status
1. Inform the public & make data easily available	1999 2002 2005	Implemented for 1999 & 2002; in process for 2005.
2. Annual field review of network station condition	1999 2002 2005	Not formally implemented.
3. Pre-emptive replacement of endangered station marks	1999 2002 2005	Untested.
4. Re-observe network every 3 years	1999 2002 2005	Implemented.
5. Consider more frequent observations	1999 2002	Discontinued due to lack of demand.
6. Network densification	1999 2002 2005	Limited implementation near Davis.
7. Non-financial support for continued operation of UCD1	1999 2002 2005	Not formally implemented.
8. Establish a new CORS in the north county	1999 2002	Obsolete.
9. Encourage FEMA to adopt network results	1999 2002 2005	Not formally implemented. Early attempt to involve FEMA met no response.
10. Investigate supplemental detection technologies	1999 2002 2005	Not implemented due to lack of demand.
11. Incorporate extensometer data	2002 2005	Implemented.
12. Extend network into Solano County near Davis	2002 2005	Limited implementation in 2005.
13. Review technical approach to data analysis	2005	In process.
14. Document subsidence effects	2005	New.

Recommendation 1. Inform public and private agencies involved in construction, utilities management, public works and related activities in the county about the network and the location of all stations. Information about the project's web site should be included in this information. (Note: As of the date of this report, the website – http://www.yarn.org/subsidence/about.html – not has not been updated. The update is pending final publication of station positions by NGS.)

As noted in the report after the 2002 observations there continues to be anecdotal information about the utility of the network, especially among the surveying community. Survey painting and flagging indicate that the network stations are being used. The County Surveyor reports that many of the stations are used and reported in Records of Survey submitted to him.

Recommendation 2. Task a single entity with visiting each monument in the network annually to assess the integrity of the individual monuments. Any discrepancies in the monument description and condition should be brought to the attention of the interested parties and to the National Geodetic Survey (NGS). Follow proper steps for reporting such discrepancies.

It continues to appear that no agency has accepted this responsibility. It might appear that this is unnecessary since all stations used in the 2005 survey were recovered in good condition. As the network ages experience indicates that some stations may be destroyed due to construction or other activities. It becomes more imperative that this recommendation be followed. In the absence of an agency accepting this responsibility a private entity should be considered to undertake this responsibility on a contractual basis.

Recommendation 3. Identify stations in imminent danger of destruction and replace them in advance, following National Geodetic Survey guidelines. (A copy of these guidelines may be obtained from the NGS California State Geodetic Advisor, Marti Ikehara – Marti.Ikehara@noaa.gov). A station destroyed before replacement represents a permanent break in the subsidence history for that station.

As indicated in Recommendation 2, above, the absence of occasional visits to each of the stations increases the possibility of stations being lost. While there is no difference in the cost of replacing a monument either before or after it is destroyed, replacing it after it has been destroyed breaks the subsidence history of the mark.

Recommendation 4. Re-observe the entire network in three years. Depending on the results of the re-observation, the county can better determine the time period for subsequent re-observations.

It appears that the decision to re-observe the network on a three-year cycle is acceptable to project participants. A review of the latest three-year cycle (2005 – 2002) indicates a slightly larger amount of subsidence at several of the stations than that observed in the first three year cycle (2002 – 1999). The next three year cycle should provide a more definitive overview of subsidence effects. The fact that subsidence rates over one cycle differ from those of another cycle provide additional information about the nature of subsidence. Because subsidence is a result of several factors (e.g., aquifer re-charge, amount of pumping, etc.) it tends to be a non-linear phenomenon.

Recommendation 5. Investigate the benefits of more frequent re-observation of particular areas of the county.

Based on the results of the 2005 survey and its comparison with the 1999 and 2002 surveys it does not appear that more frequent observations of the network will add significantly more reliable information than is provided under the current 3-year observation cycle.

Recommendation 6. Investigate densification of the network in areas of particular interest.

The approach made for this recommendation after the 2002 survey still seems valid. If an area of the county is deemed to need a more densified approach this can be accomplished by either GPS or a combination of GPS and terrestrial observations. In the areas of greatest subsidence this might be worthwhile. This assumes that there is a need for such densified observations. Planned construction in these areas might necessitate that this option be considered.

Recommendation 7. Provide continuing non-financial support for the Continuously Operating Reference Station (CORS) at the University of California, Davis. This site can be of significant value in ongoing subsidence measurement operations.

The CORS site at UC3D provides the only continuous record of land movement in the area. The following figure shows the downward (subsiding) trend of the site as well as the seasonal trends of the site. This seasonal trend seems to be symbolic of sites in subsiding areas. Efforts should be made to ensure continuous operation of the site. As long as it continues in operation it will continue to provide a piece of the framework for continued, accurate monitoring of subsidence in the county.

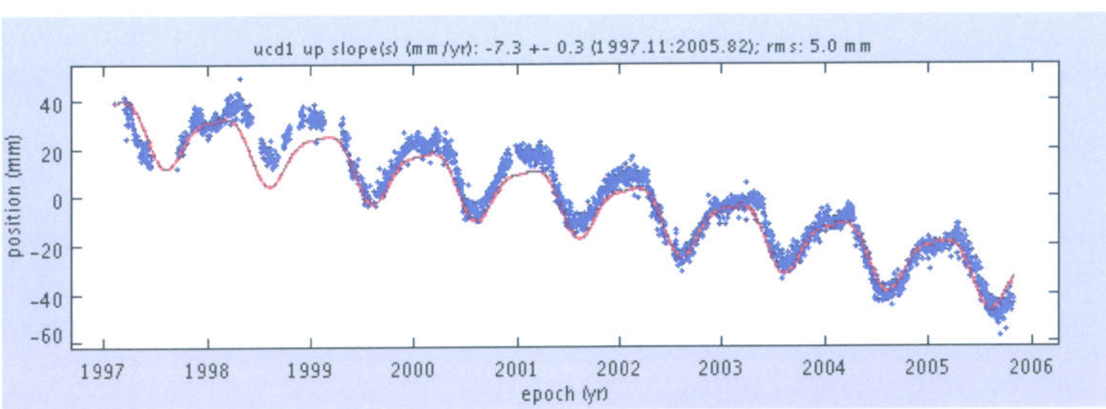

Fig. 1. UCD CORS site vertical record, 1997 through 2005.

Recommendation 8. Investigate the establishment of a CORS site in the north county area.

This recommendation was made prior to the establishment of the Plate Boundary Observatory (PBO) program. The PBO program includes the establishment of over 400 continuous GPS sites in California. Four of these have been established in the vicinity of Yolo County: three in the county (near Woodland, Dixon and Winters), and one to the north in Colusa County (near the city of Colusa). These should help with long term measurements of earth movement and obviate the need for a station in northern Yolo County. This recommendation will be removed from future reports unless there is a need to re-consider the need for a station in that vicinity.

There is an additional continuous tracking GPS site in the Sutter Buttes. This station has been part of the three Yolo County surveys.

Recommendation 9. Consider the merits of encouraging the Federal Emergency Management Agency (FEMA) to adopt the results of the project in its flood plain mapping efforts.

The county should consider following up on this recommendation with FEMA. Since accepting the results of the 1999 survey it appears that FEMA would be receptive to such a request. The 2002 City of Woodland Flood Insurance Rate Maps (FIRMs) were developed using vertical control from the 1999 Yolo project. These FIRMS indicate flood contours in both the NGVD29 and NAVD88 datums.

Recommendation 10. Investigate other supporting technologies as an adjunct to the GPS Subsidence Network within Yolo County.

The 2002 report suggested considering the use of either LIDAR or Synthetic Aperture Radar (SAR) technology which could provide more densified coverage of the project area. Because the accuracy of LIDAR technology is currently less than what is required for Yolo County subsidence monitoring, its application is not recommended at this time.

In the absence of any apparent interest in more densified measure of subsidence, the use of SAR is similarly not recommended at this time. SAR technology offers a potentially better alternative to LIDAR. However, the use of SAR continues to be somewhat more problematic in agricultural areas.

Recommendation 11. Incorporate measurements to relate the two DWR extensometers (at Zamora and Conaway ranch) to the Yolo County Subsidence network.

In July of 2005 DWR personnel took measurements relating both the Conaway and Zamora extensometers to their respective adjacent network station marks (CONAWAY and ZAMX). Continued annual measurements of this nature will simplify tracking the relationship between movement indicated by the extensometers and that indicated by the GPS measurements.

In the 2002 survey, a discrepancy was noted between the amount of subsidence indicated by the GPS results and that indicated by the Stevens chart recorders mounted on the extensometers. This trend – which is attributed to the fact that the extensometers only reflect subsidence in the upper region of the ground (716 feet at Conaway, 1003 feet at Zamora) – continues. See **Appendix H** for details.

Recommendation 12. Seek cooperation with the County of Solano to determine the magnitude and extent of the subsidence in the vicinity of Davis.

The addition of station RD2068 of the Davis Deep Aquifer project and two of its neighboring stations (SURVEYOR and MILLAR) in Solano will help resolve this issue. The inclusion of up to three additional stations in Solano County that were part of the San Joaquin/Sacramento Delta project would provide the necessary observations to complete this recommendation. In the absence of working with Solano County these stations could be added into the base Yolo project. The candidate stations are CURREY (PID AE9856), STORE (PID AE9852) and X 128 RESET (PID JS1613).

V. ADDITIONAL RECOMMENDATIONS

There are now five continuous GPS sites in or near the county. Two of these stations, at UC Davis and Sutter Buttes, have been in continuous operation since 1997. They provide the potential to form a better basis for measuring and monitoring subsidence in the county. These stations are on a more or less north-south axis so might not account for an east-west bias, if any, in the GPS observations. The three additional PBO sites, especially the two in Woodland and Winters, should help resolve this issue. These stations (and the Dixon station) have not been operational long enough to provide any useful data for the current survey but should prove more beneficial in future surveys.

Recommendation 13. Given the longer continuous time series now available at the Sutter Buttes and UC Davis sites, and the apparent subsidence at sites previously believed to be stable, we recommend that the 2005 data be reviewed more thoroughly.

When the Yolo project was initiated in 1999, the survey results were constrained to ellipsoid height values based upon the best information available from NGS. At the time, relatively little work had been done to comprehensively analyze the data being accumulated at northern California continuous GPS monitoring sites.

For the 2005 project, CSRC reanalyzed the data from the 1999, 2002 and 2005 surveys with regard to ellipsoid heights. This analysis was informed by the analysis of data gathered continuously over the 1999-2005 period at the Sutter Buttes and UC Davis permanent GPS stations. Although some discrepancies between the CSRC and NGS values remain, the relative ellipsoid heights derived from the CSRC analysis are considered to be the most reliable indicator of cumulative subsidence at this time. The subsidence contour map (Appendix B) reflects this analysis.

The most significant discrepancies between the NGS and CSRC analyses are found toward the periphery of the county. The magnitude of the discrepancies range from 2cm to 9cm. It is important to note that both analyses show the same areas of concentrated subsidence, in particular the area centered on station ZAMX.

Once the NGS and CSRC height values are reconciled, updated values for the project station positions will be incorporated into the NGS database.

Recommendation 14. Establish a coordinated interagency approach to the identification and documentation of subsidence effects. This would require agencies to gather supplemental data that demonstrates the impact of subsidence upon facilities and operations. Photographs and descriptions of observed impacts (e.g., raised well pads and crushed well casings) will assist in rounding out the understanding of subsidence impacts among the project partners, non-technical officials and the general public. (See **Appendix G** for example photographs.)

VI. CONCLUSION

With the completion of the 2005 project observations, a clearer picture of ongoing subsidence begins to emerge. The 2002 survey indicated subsidence, but the time frame between the 1999 and 2002 surveys was too short to allow definitive measures of subsidence given the myriad potential causes. The 2005 survey results, when compared with the earlier surveys, provide definitive proof of such subsidence. It begins to give a clearer picture of the amount and distribution of subsidence across the project area. As indicated in the 2002 report, the central corridor of the project is undergoing the greatest subsidence. The corridor runs north from Davis, through Woodland, north to Zamora and through to the northeast corner of the county. It is generally characterized as having little or no surface water availability and substantial groundwater pumping. The subsidence does not appear to be strictly uniform – a common characteristic of the phenomenon – but rather the result of several factors. For this reason it is recommended that continued re-observations of the network be planned on a 3-year cycle. It is recommended that other studies of ground water pumping, water usage and related issues be studied as well.

Please note that the horizontal coordinates (latitude and longitude) have changed again for all stations in the network. The county is in the area of the North American and Pacific tectonic plate boundary. This tectonic motion causes all stations in the project move northwesterly a few centimeters per year.

Respectfully submitted:

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Geodetic Consultant

APPENDIX A.

CSRC NAD83 Ellipsoid Height Values from 1999, 2002 and 2005 Surveys (with differences)

4-CH ID	1999	2002	Change 02-99	2005	Change 05-02	Change 05-99
0308	-6.842	-6.880	-0.038	-6.910	-0.030	-0.068
03BG		-21.122		-21.120		0.002
03DG	-6.730	-6.759	-0.029	-6.762	-0.003	-0.032
03EH	-19.335	-19.347	-0.012	-19.339	0.008	-0.004
1031	-20.402	-20.401	0.001	-20.418	-0.017	-0.016
1069	23.627	23.646	-0.019	23.630	-0.016	0.003
1075	-15.424	-15.424	0.000	-15.425	-0.001	-0.001
1200	47.507	47.483	-0.024	47.494	0.011	-0.013
1699	21.812	21.833	0.021	21.829	-0.004	0.017
2068				-19.213		
ABUT	22.034	22.033	-0.001	22.034	0.001	0.000
ALHA	-18.089	-18.106	-0.017	-18.127	-0.011	-0.038
ANDR		-27.837		-27.845	-0.008	
B849	8.482	8.459	-0.023	8.482	0.023	0.000
BIRD	63.747	63.773	0.026	63.780	0.007	0.033
BRID	33.505	33.527	0.022	33.510	-0.017	0.005
CALD		-25.915		-25.904	0.011	
CANA	-1.250	-1.235	0.015	-1.246	-0.011	0.004
CAST	-25.680	-25.690	-0.010	-25.680	0.010	0.000
CHUR	-6.689	-6.675	0.014	-6.694	-0.019	-0.005
CODY	-17.502	-17.551	-0.049	-17.586	-0.035	-0.084
CONA	-23.079	-23.091	-0.012	-23.088	0.003	-0.009
COTT	60.663	60.711	0.048	60.710	-0.001	0.047
COUR		-23.354		-23.358	-0.004	
COY1	-22.381	-22.383	-0.002	-22.400	-0.017	-0.019
CVAP	-22.180	-22.187	-0.007	-22.217	-0.030	-0.037
DAVE	-11.868	-11.872	-0.004	-11.876	-0.004	-0.008
DRAI	-17.049	-17.053	-0.004	-17.050	0.003	-0.001
DUFO	-10.193	-10.232	-0.039	-10.284	-0.052	-0.091
EX11	-22.835	-22.865	-0.030	-22.863	0.002	-0.028
F859	-16.022	-16.028	-0.006	-16.066	-0.038	-0.044
FERR	-18.509	-18.498	0.011	-18.510	-0.012	-0.001
FORD	-12.948	-12.953	-0.005	-12.989	-0.036	-0.041
FREM	-17.820	-17.782	0.038	-17.798	-0.016	0.022
GAFF		-30.304		-30.294	0.010	
GW17	54.278	54.292	0.014	54.302	0.010	0.024
GW32	82.143	82.169	0.026	82.140	-0.029	-0.003
HERS	-16.223	-16.210	0.013	-16.205	0.005	0.018
JIME	-17.587	-17.586	0.001	-17.586	0.000	0.001
KEAT	5.083	5.112	0.029	5.093	-0.019	0.010
LIBR	-10.801	-10.810	-0.009	-10.824	-0.014	-0.023
MADI	16.177	16.170	-0.007	16.196	0.026	0.019
MILL				-20.869		
PLAI	-11.133	-11.142	-0.009	-11.124	0.020	0.011

RIVE	-18.667	-18.673	-0.006	-18.678	-0.005	-0.011
RUSS	-1.918	-1.899	0.019	-1.916	-0.017	0.002
RWF1				-16.414		
SM15	-23.150	-23.128	0.022	-23.161	-0.033	-0.011
SURV				-18.080		
SUTB	617.087	617.078	-0.009	617.070	-0.008	-0.017
SYCA	-22.449	-22.426	0.023	-22.435	-0.009	0.014
T462		-21.893		-21.889	0.004	
T849	5.687	5.702	0.015	5.684	-0.018	-0.003
TYND	-20.949	-20.936	0.013	-20.965	-0.029	-0.016
UCD1	0.197	0.190	-0.007	0.171	-0.019	-0.026
VINC	17.812	17.828	0.016	17.800	-0.028	-0.012
WILS		-21.685		-21.700	-0.015	
WOOD	8.873	8.892	0.019	8.841	-0.051	-0.032
X200	-0.315	-0.309	0.006	-0.310	-0.001	0.005
YCAP		-1.558		-1.566	-0.008	
Z585	-24.492	-24.521	-0.029	-24.520	0.001	-0.028
ZAMX	-17.289	-17.357	-0.068	-17.411	-0.054	-0.122

Notes:

1. All height values are expressed in meters.

2. The 1999 height value shown for station VINCOR was calculated from the 1999 height value for station PHILLIPS (not shown). PHILLIPS was rendered unsuitable for GPS observations prior to the 2002 monitoring event. VINCOR was installed nearby, and a leveling tie made to transfer the 1999 elevation from PHILLIPS to VINCOR.

APPENDIX B.

FSM Provisional NAVD88 Orthometric Height Values from 1999, 2002 and 2005 Surveys (with differences)

4-CH ID	1999	2002	Change	2005	Change	Change
			02-99		05-02	05-99
0308	23.78	23.73	-0.05	23.67	-0.06	-0.11
03BG	9.91	9.91	0.00	9.91	0.00	0.00
03DG	24.13	24.09	-0.04	24.05	-0.04	-0.08
03EH	10.75	10.73	-0.02	10.74	0.01	-0.01
1031	10.26	10.26	0.00	10.23	-0.03	-0.03
1069	54.73	54.71	-0.02	54.68	-0.03	-0.05
1075	14.90	14.87	-0.03	14.85	-0.02	-0.05
1200	77.38	77.38	0.00	77.38	0.00	0.00
1699	52.52	52.50	-0.02	52.46	-0.04	-0.06
2068				12.42		
ABUT	53.03	53.01	-0.02	52.97	-0.04	-0.06
ALHA	12.99	12.97	-0.02	12.95	-0.02	-0.04
ANDR	3.68	3.68	0.00	3.70	0.02	-0.02
B849	39.68	39.68	0.00	39.69	0.01	-0.01
BIRD	94.13	94.11	-0.02	94.08	-0.03	-0.05
BRID	64.21	64.20	-0.01	64.15	-0.05	-0.06
CALD	5.42	5.42	0.00	5.43	0.01	0.01
CANA	29.80	29.79	-0.01	29.77	-0.02	-0.03
CAST	5.27	5.27	0.00	5.28	0.01	-0.01
CHUR	24.13	24.12	-0.01	24.09	-0.03	-0.04
CODY	12.80	12.75	-0.05	12.68	-0.07	-0.12
CONA	7.72	7.71	-0.01	7.68	-0.03	-0.04
COTT	91.51	91.52	0.01	91.49	-0.03	-0.02
COUR	8.06	8.06	0.00	8.06	0.00	0.00
COY1	8.56	8.55	-0.01	8.52	-0.03	-0.04
CVAP	8.05	8.01	-0.04	7.96	-0.05	-0.09
DAVE	19.44	19.39	-0.05	19.39	0.00	-0.05
DRAI	12.99	12.97	-0.02	12.93	-0.04	-0.06
DUFO	20.31	20.25	-0.06	20.18	-0.07	-0.13
EX11	7.88	7.86	-0.02	7.85	-0.01	-0.03
F859	14.23	14.21	-0.02	14.16	-0.05	-0.07
FERR	12.12	12.13	0.01	12.10	-0.03	-0.02
FORD	17.55	17.53	-0.02	17.49	-0.04	-0.06
FREM	12.54	12.56	0.02	12.54	-0.02	0.00
GAFF	0.99	1.00	0.01	1.02	0.02	0.03
GW17	84.85	84.79	-0.06	84.77	-0.02	-0.08
GW32	112.58	112.58	0.00	112.50	-0.08	-0.08
HERS	13.99	13.97	-0.02	13.94	-0.03	-0.05
JIME	12.30	12.30	0.00	12.25	-0.05	-0.05
KEAT	35.84	35.83	-0.01	35.78	-0.05	-0.06
LIBR	19.93	19.90	-0.03	19.86	-0.04	-0.07
MADI	47.03	47.00	-0.03	46.98	-0.02	-0.05
MILL				10.88		
PLAI	19.99	19.96	-0.03	19.96	0.00	-0.03

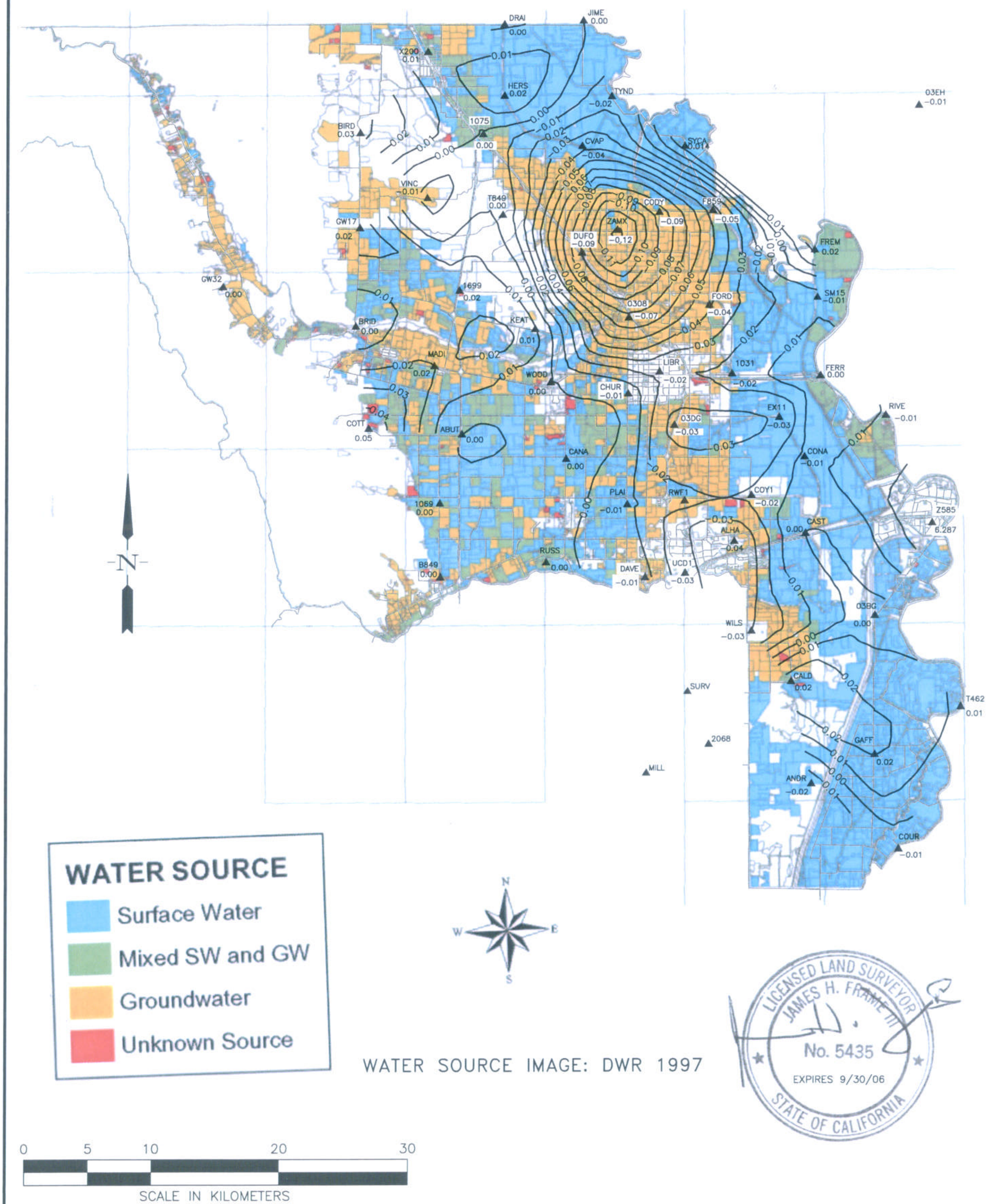
RIVE	12.03	12.02	-0.01	12.01	-0.01	-0.02
RUSS	29.38	29.37	-0.01	29.36	-0.01	-0.02
RWF1				14.60		
SM15	7.30	7.33	0.03	7.27	-0.06	-0.03
SURV				13.45		
SYCA	7.67	7.66	-0.01	7.65	-0.01	-0.02
T462	9.14	9.14	0.00	9.15	0.01	0.01
T849	36.20	36.17	-0.03	36.12	-0.05	-0.08
TYND	9.10	9.08	-0.02	9.04	-0.04	-0.06
UCD1	31.50	31.44	-0.06	31.42	-0.02	-0.08
VINC	48.32	48.28	-0.04	48.24	-0.04	-0.08
WILS	9.61	9.60	-0.01	9.59	-0.01	-0.02
WOOD	39.75	39.74	-0.01	39.70	-0.04	-0.05
X200	29.91	29.88	-0.03	29.85	-0.03	-0.06
YCAP		29.61		29.61	0.00	
Z585	6.35	6.30	-0.05	6.29	-0.01	-0.06
ZAMX	13.10	13.03	-0.07	12.95	-0.08	-0.15

Notes:

1. All height values are expressed in meters.

2. The 1999 height value shown for station VINCOR was calculated from the 1999 height value for station PHILLIPS (not shown). PHILLIPS was rendered unsuitable for GPS observations prior to the 2002 monitoring event. VINCOR was installed nearby, and a leveling tie made to transfer the 1999 elevation from PHILLIPS to VINCOR.

3. The orthometric values shown for 2005 may change following reconciliation between NGS and CSRC methodology.



FRAME SURVEYING & MAPPING
609 A Street
Davis, CA 95616
(530) 756-8584 (TEL)
(530) 756-8201 (FAX)

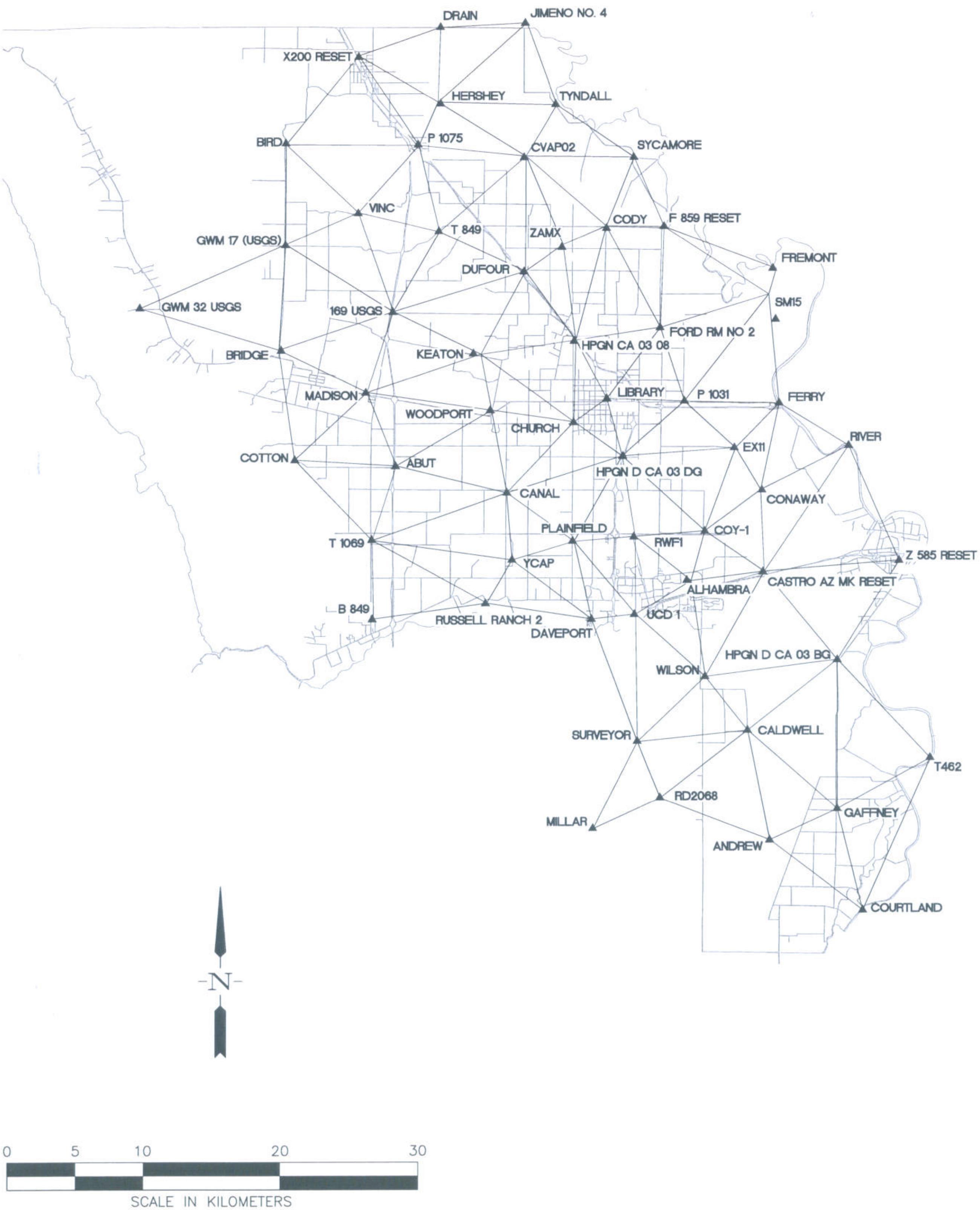
1280-039D

APPENDIX C

CUMULATIVE SUBSIDENCE, 1999 - 2005

SOURCE: CSRC ELLIPSOID HEIGHT DATA

FEBRUARY, 2006 SCALE: 1"= 10KM



FRAME SURVEYING & MAPPING
609 A Street
Davis, CA 95616
(530) 756-8584 (TEL)
(530) 756-8201 (FAX)
1280-039D

APPENDIX D
YOLO SUBSIDENCE NETWORK
LOCAL NETWORK DIAGRAM
FEBRUARY, 2006 SCALE: 1"= 10KM

APPENDIX E.

NAD83/NAVD88 Station Coordinates

From the provisional NAD83/NAVD88 orthometric height adjustment performed by Frame Surveying & Mapping, epoch 2005.53.

Name	Latitude	Longitude	Elevation
0308	38°43'01.99912"N	121°48'07.54199"W	23.67m
1031	38°40'38.14545"N	121°42'34.07851"W	10.23m
1069	38°35'09.99988"N	121°58'17.45682"W	54.68m
1075	38°50'51.29614"N	121°56'00.25863"W	14.85m
1200	38°47'09.87441"N	121°14'32.09663"W	77.38m
1699	38°44'12.69655"N	121°57'15.85761"W	52.46m
2068	38°24'54.17942"N	121°43'48.53696"W	12.43m
03BG	38°30'20.00966"N	121°34'55.09259"W	9.91m
03DG	38°38'27.43783"N	121°45'39.59676"W	24.05m
03EH	38°51'59.61326"N	121°32'32.95872"W	10.74m
ABUT	38°38'05.70691"N	121°57'06.70369"W	52.97m
ALHA	38°33'31.09844"N	121°42'26.68932"W	12.95m
ANDR	38°23'12.17822"N	121°38'18.72121"W	3.70m
B849	38°32'01.29164"N	121°58'15.18465"W	39.69m
BIRD	38°50'54.73577"N	122°02'37.47813"W	94.08m
BRID	38°42'41.39602"N	122°02'50.18451"W	64.15m
CALD	38°27'33.51381"N	121°39'24.21525"W	5.44m
CANA	38°37'02.05496"N	121°51'30.11681"W	29.77m
CAST	38°33'50.77672"N	121°38'37.80451"W	5.28m
CHUR	38°39'48.00606"N	121°48'09.05896"W	24.09m
CNDR	37°53'47.04470"N	121°16'42.53232"W	11.68m
CODY	38°47'30.59822"N	121°46'29.02105"W	12.68m
CONA	38°37'05.49521"N	121°38'40.42972"W	7.68m
COTT	38°38'20.24510"N	122°02'08.12319"W	91.49m
COUR	38°20'24.76030"N	121°33'40.05187"W	8.06m
COY1	38°35'28.05177"N	121°41'31.83561"W	8.52m
CVAP	38°50'19.76454"N	121°50'39.17729"W	7.96m
DAVE	38°31'59.46481"N	121°47'14.17767"W	19.39m
DRAI	38°55'31.04609"N	121°54'52.46304"W	12.93m
DUFO	38°45'48.09680"N	121°50'39.06873"W	20.18m
EX11	38°38'46.40956"N	121°40'03.02645"W	7.85m
F859	38°47'34.20154"N	121°43'36.01819"W	14.16m
FERR	38°40'32.00765"N	121°37'49.18140"W	12.10m
FORD	38°43'33.23620"N	121°43'47.39279"W	17.49m
FREM	38°45'52.89431"N	121°38'08.00645"W	12.54m
GAFF	38°24'25.68547"N	121°34'56.13691"W	1.02m
GW17	38°46'52.25893"N	122°02'38.10825"W	84.78m
GW32	38°44'21.97173"N	122°09'59.02874"W	112.50m
HERS	38°52'28.84831"N	121°54'51.96597"W	13.94m
JIME	38°55'39.86256"N	121°50'35.87572"W	12.25m
KEAT	38°42'33.52335"N	121°53'11.08379"W	35.78m
LIBR	38°40'44.18520"N	121°46'28.10144"W	19.86m
MADI	38°41'00.22860"N	121°58'36.36143"W	46.98m
MILL	38°23'41.28013"N	121°47'10.32967"W	10.88m
P268	38°28'24.67974"N	121°38'47.02602"W	7.94m

P271	38°39'26.44695"N	121°42'52.32465"W	13.10m
PLAI	38°35'05.49797"N	121°48'11.62253"W	19.96m
RIVE	38°38'50.46155"N	121°34'20.06352"W	12.01m
RUSS	38°32'38.06565"N	121°52'33.83899"W	29.37m
RWF1	38°35'09.99921"N	121°45'05.10194"W	14.60m
SM15	38°43'51.60440"N	121°37'59.39294"W	7.27m
SURV	38°27'08.54500"N	121°44'56.17353"W	13.45m
SUTB	39°12'20.99549"N	121°49'14.10261"W	646.08m
SYCA	38°50'19.12405"N	121°45'06.39012"W	7.65m
T462	38°26'25.99278"N	121°30'17.76296"W	9.15m
T849	38°47'24.93361"N	121°54'56.34535"W	36.12m
TYND	38°52'26.17801"N	121°49'03.81267"W	9.04m
UCD1	38°32'10.44819"N	121°45'04.37875"W	31.42m
VINC	38°48'08.11990"N	121°59'00.32287"W	48.24m
WILS	38°29'41.85159"N	121°41'31.51549"W	9.59m
WOOD	38°40'17.76208"N	121°52'20.38185"W	39.70m
X200	38°54'20.73206"N	121°58'59.79260"W	29.85m
YCAP	38°34'20.34492"N	121°51'18.37410"W	29.61m
Z585	38°34'15.79736"N	121°31'49.55629"W	6.29m
ZAMX	38°46'45.78557"N	121°48'44.63079"W	12.95m

APPENDIX F.

Subsidence Projections

Quantitative monitoring of subsidence in Yolo County has been conducted over a relatively short time span, and presently comprises only 3 monitoring events (1999, 2002 and 2005). The monitoring measurement technology and its associated analytical tools continue to evolve, which may necessitate a comprehensive review of prior analyses. Nevertheless, it may be useful to consider the potential long-term effects of land subsidence by projecting the rates of subsidence observed to date.

In the examples below, a range of cumulative subsidence has been projected to the year 2030 at selected stations in Davis (ALHAMBRA), Woodland (LIBRARY) and the area of most rapid subsidence (ZAMX). The ranges are bounded by the more conservative ellipsoid height results returned by CSRC following a readjustment of the 1999 through 2005 data sets, and on the higher end by values derived from the published 1999 and 2002 NGS orthometric heights and the provisional 2005 orthometric heights produced by Frame Surveying & Mapping.

As more data are gathered in future years and the analytical tools refined, these rates will likely change. Caution is advised in applying these projected results to subsidence mitigation planning efforts.

Site	Cumulative Subsidence 1999 to 2030 Low Projection	Cumulative Subsidence 1999 to 2030 High Projection
ALHAMBRA	-0.20	-0.21
LIBRARY	-0.12	-0.36
ZAMX	-0.63	-0.78

Subsidence values are in meters.

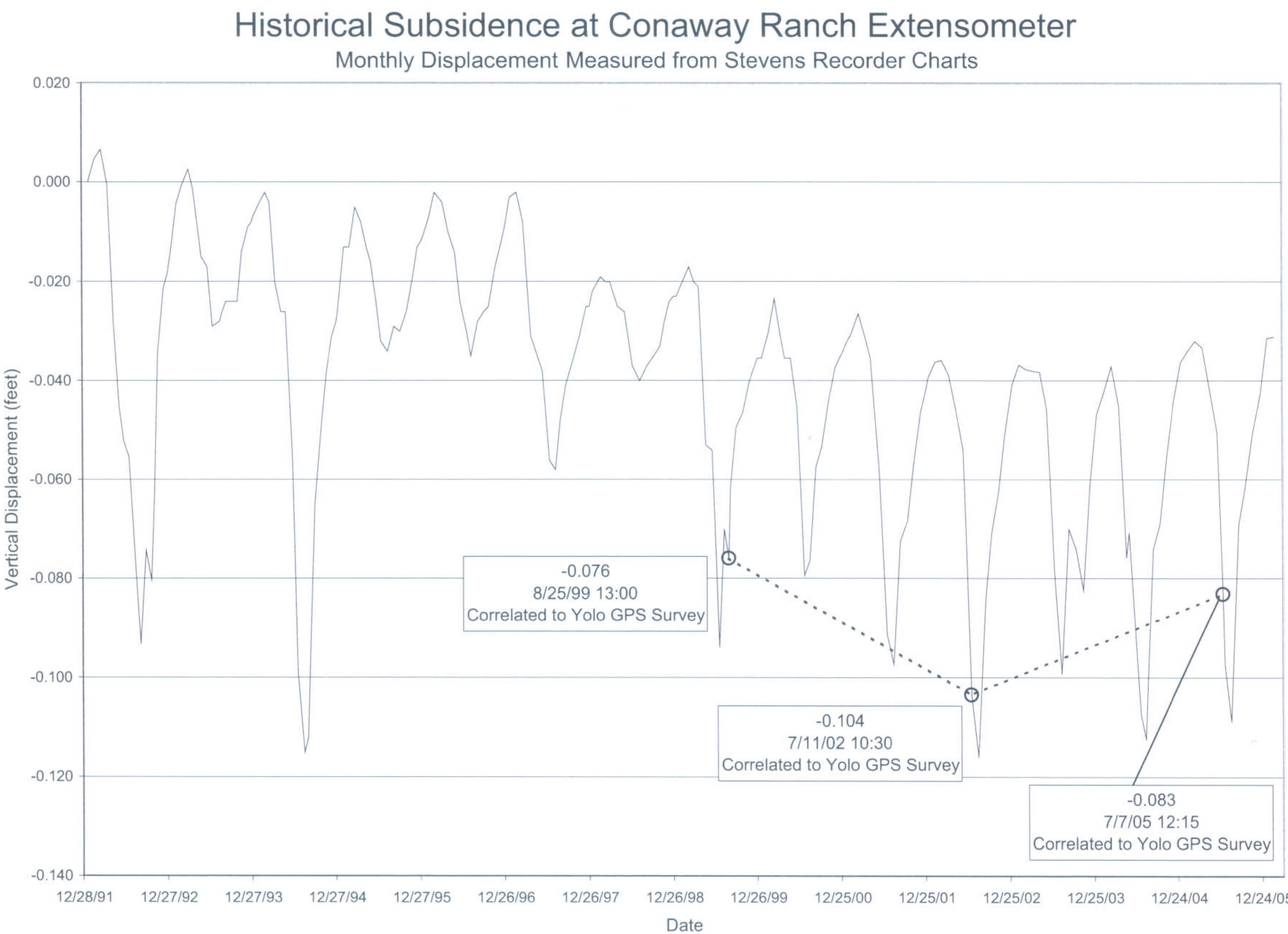
APPENDIX G.

Subsidence Impact Evidence

Well pad near Zamora. The pad appears to be fixed to the well casing, while the adjacent ground surface appears to have subsided.

Crushed well screen, Well 22, City of Davis. This is a photo of a monitor displaying a well inspection video. The well screen at 316 feet below the surface appears to have deflected inward in response to downward pressure on the casing above. This might occur when the friction of a subsiding land mass upon a well casing exceeds the compressive strength of the well screen.

APPENDIX H


Historical Subsidence at Conaway Ranch Extensometer
Monthly Displacement Measured from Stevens Recorder Charts
Vertical Displacement (feet)
0.020
0.000
-0.020
-0.040
-0.060
-0.080
-0.100
-0.120
-0.140
-0.076
8/25/99 13:00
Correlated to Yolo GPS Survey
-0.104
7/11/02 10:30
Correlated to Yolo GPS Survey
-0.083
7/7/05 12:15
Correlated to Yolo GPS Survey
12/28/91
12/27/92
12/27/93
12/27/94
12/27/95
12/26/96
12/26/97
12/26/98
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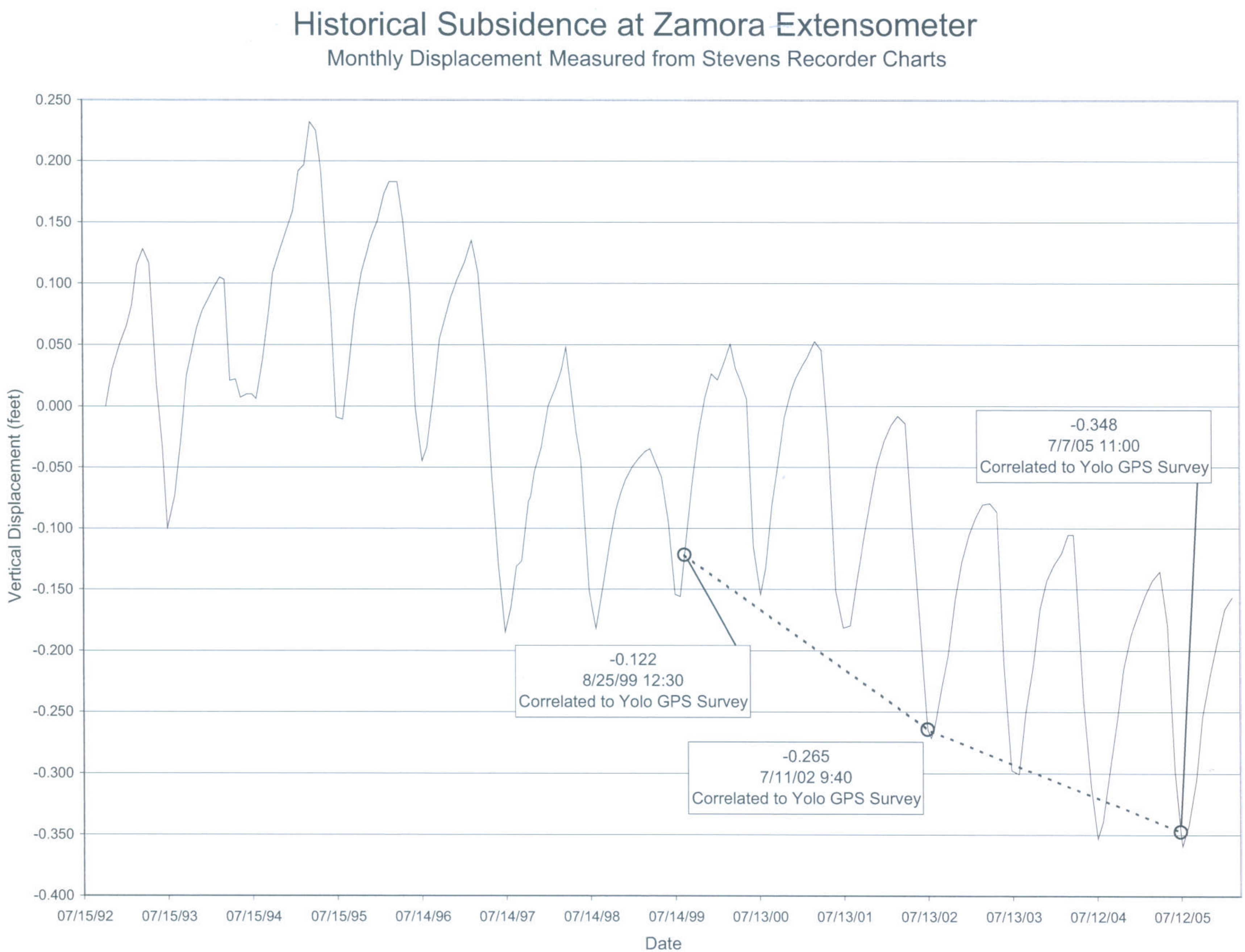
12/25/00
12/25/01
12/25/02
12/25/03
12/24/04
12/24/05
Date



Historical Subsidence at Zamora Extensometer
Monthly Displacement Measured from Stevens Recorder Charts
Vertical Displacement (feet)
0.250
0.200
0.150
0.100
0.050
0.000
-0.050
-0.100
-0.150
-0.200
-0.250
-0.300
-0.350
-0.400
07/15/92
07/15/93
07/15/94
07/15/95
07/14/96
07/14/97
07/14/98
07/14/99
07/13/00
07/13/01
07/13/02
07/13/03
07/12/04
07/12/05
Date
-0.122
8/25/99 12:30
Correlated to Yolo GPS Survey
-0.265
7/11/02 9:40
Correlated to Yolo GPS Survey
-0.348
7/7/05 11:00
Correlated to Yolo GPS Survey

Yolo Subsidence Network **GPS/Extensometer Comparisons** **March, 2005**

SITE	SOURCE	YEAR 1999	YEAR 2002	YEAR 2005	NET CHANGE (2005 - 1999)	GPS - EXTENSOMETER (DISCREPANCY)
CONAWAY	GPS	-22.835	-22.865	-22.863	-0.028	
	EXTENSOMETER	-0.023	-0.032	-0.025	-0.002	-0.026
ZAMORA	GPS	-17.289	-17.357	-17.411	-0.122	
	EXTENSOMETER	-0.037	-0.081	-0.106	-0.069	-0.053

GPS SOURCE: 2005 CSRC ELLIPSOID HEIGHTS
EXTENSOMETER SOURCE: DWR
VALUES SHOWN ARE IN METERS

APPENDIX E

Groundwater Hydrographs

List of Figures

List of Figures, cont'd…

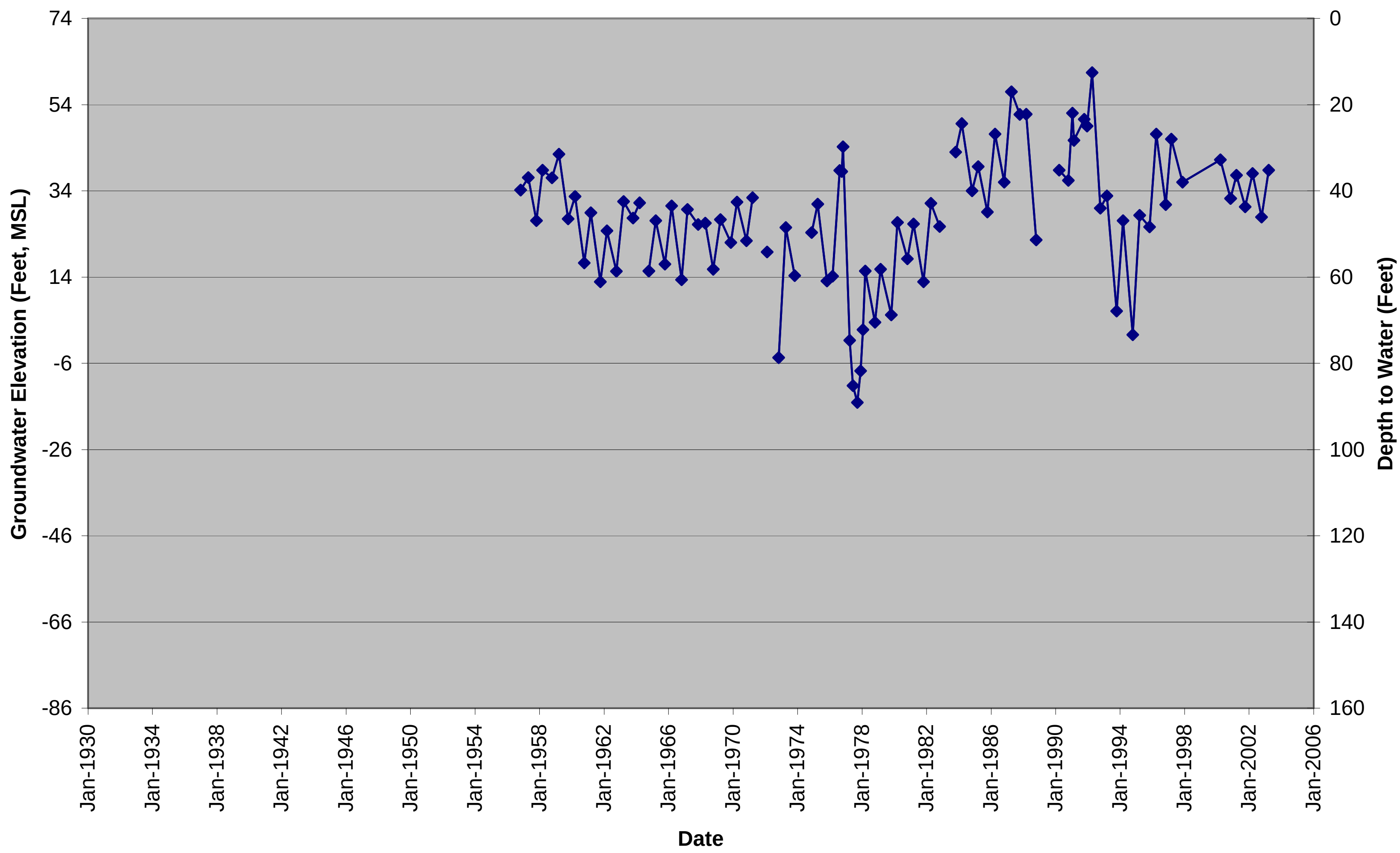


Figure E-1

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N01E01L001M

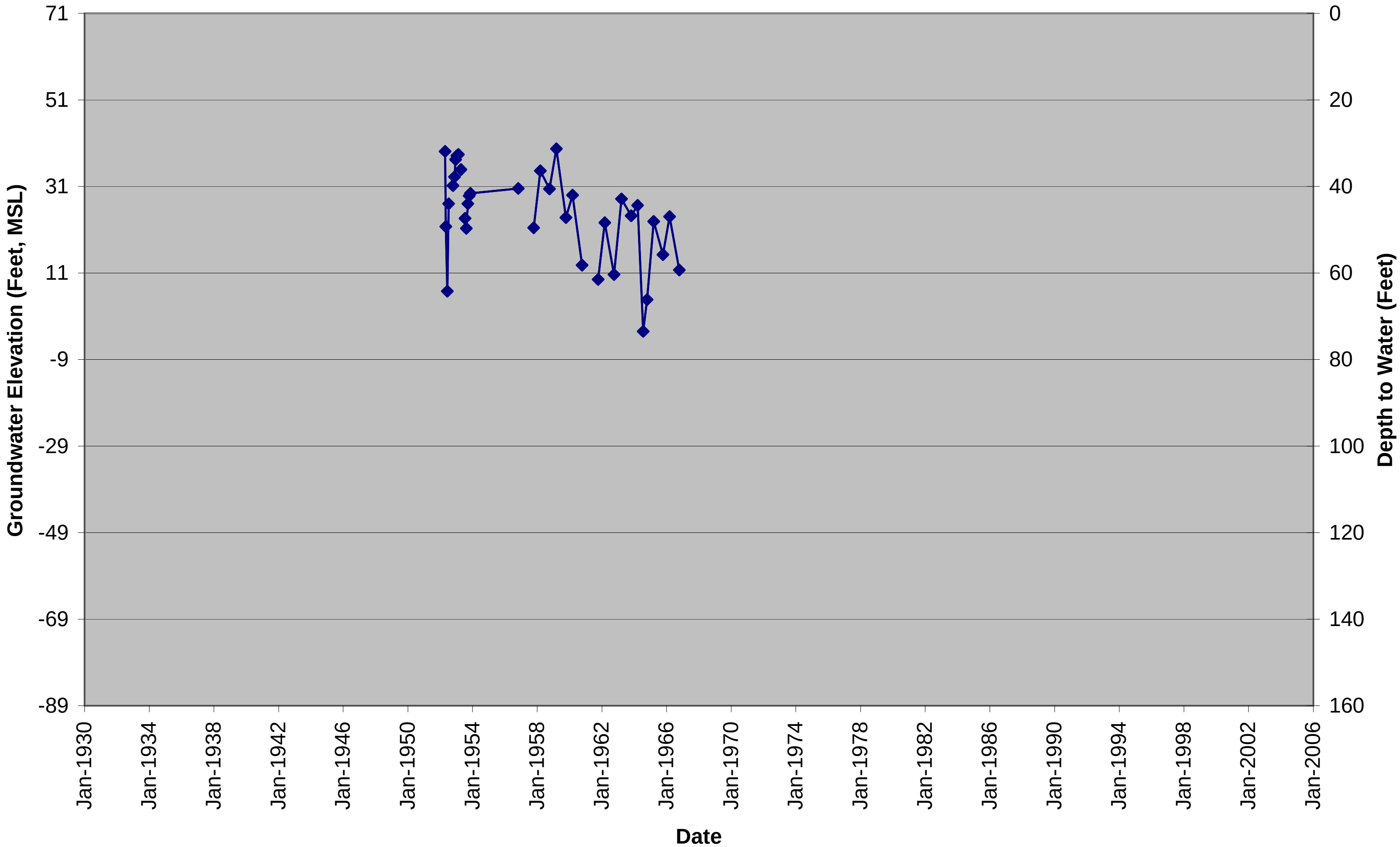


Figure E-2

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N01E01R001M

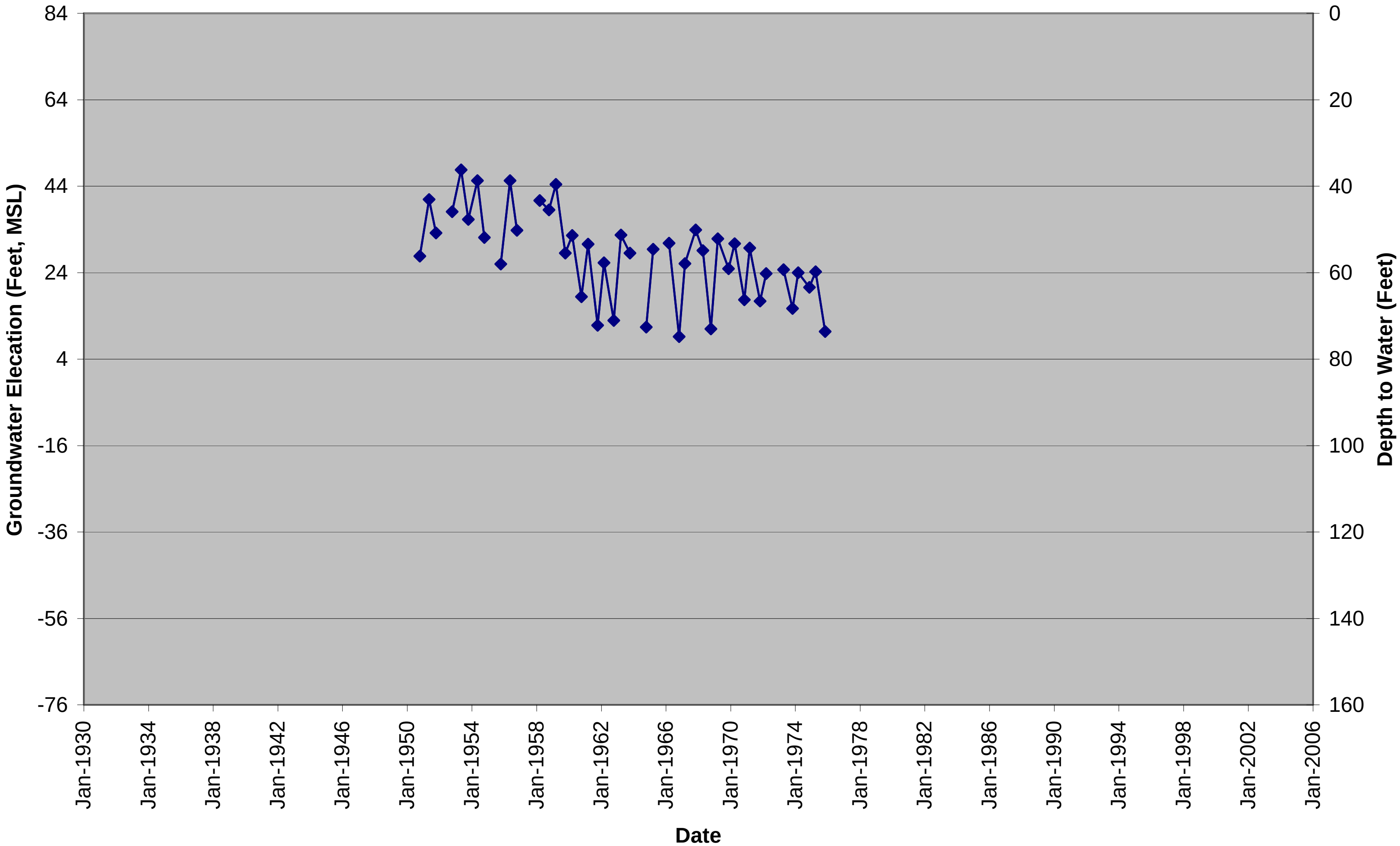


Figure E-3

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N01E02A001M

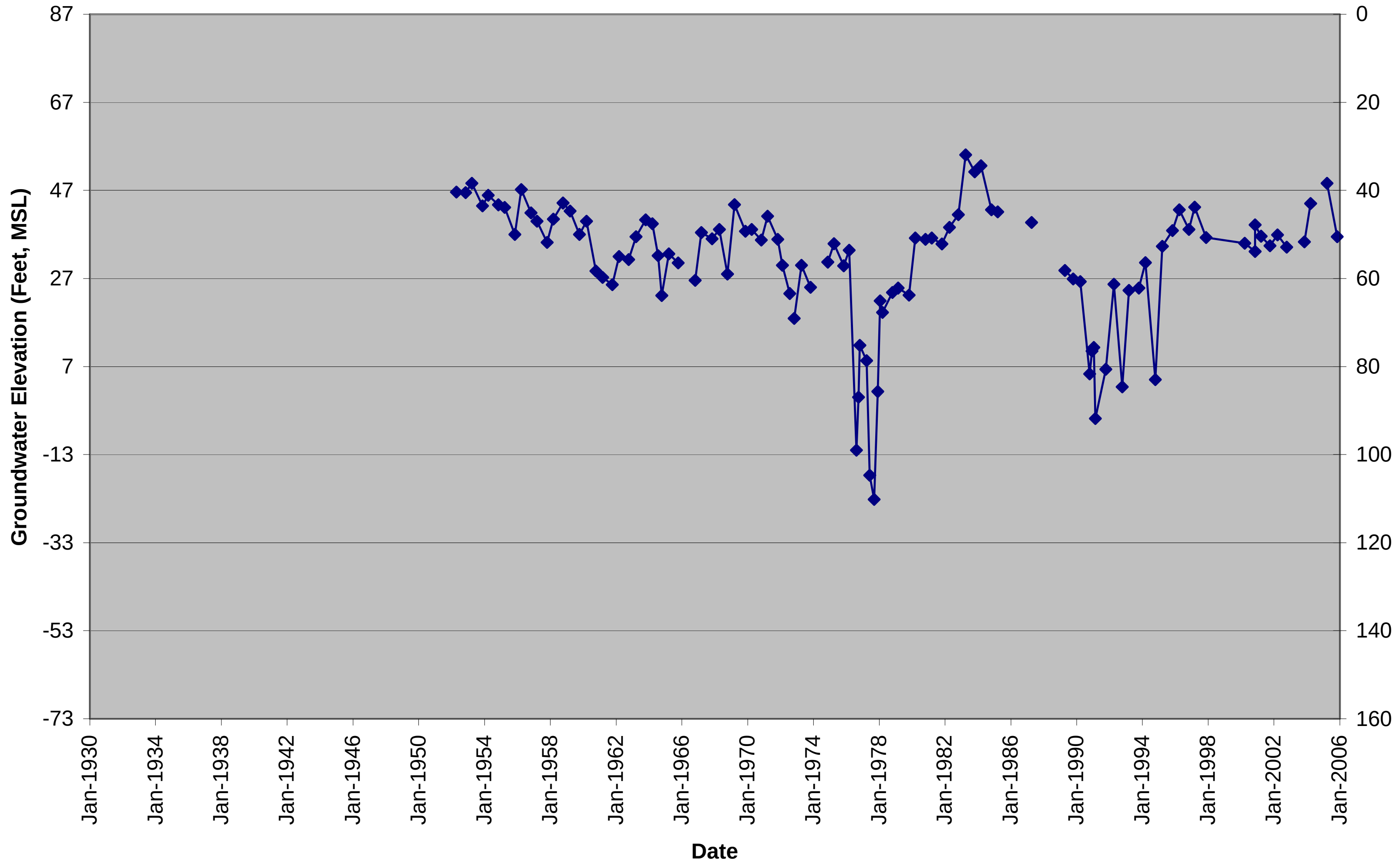


Figure E-4

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N01E02N001M

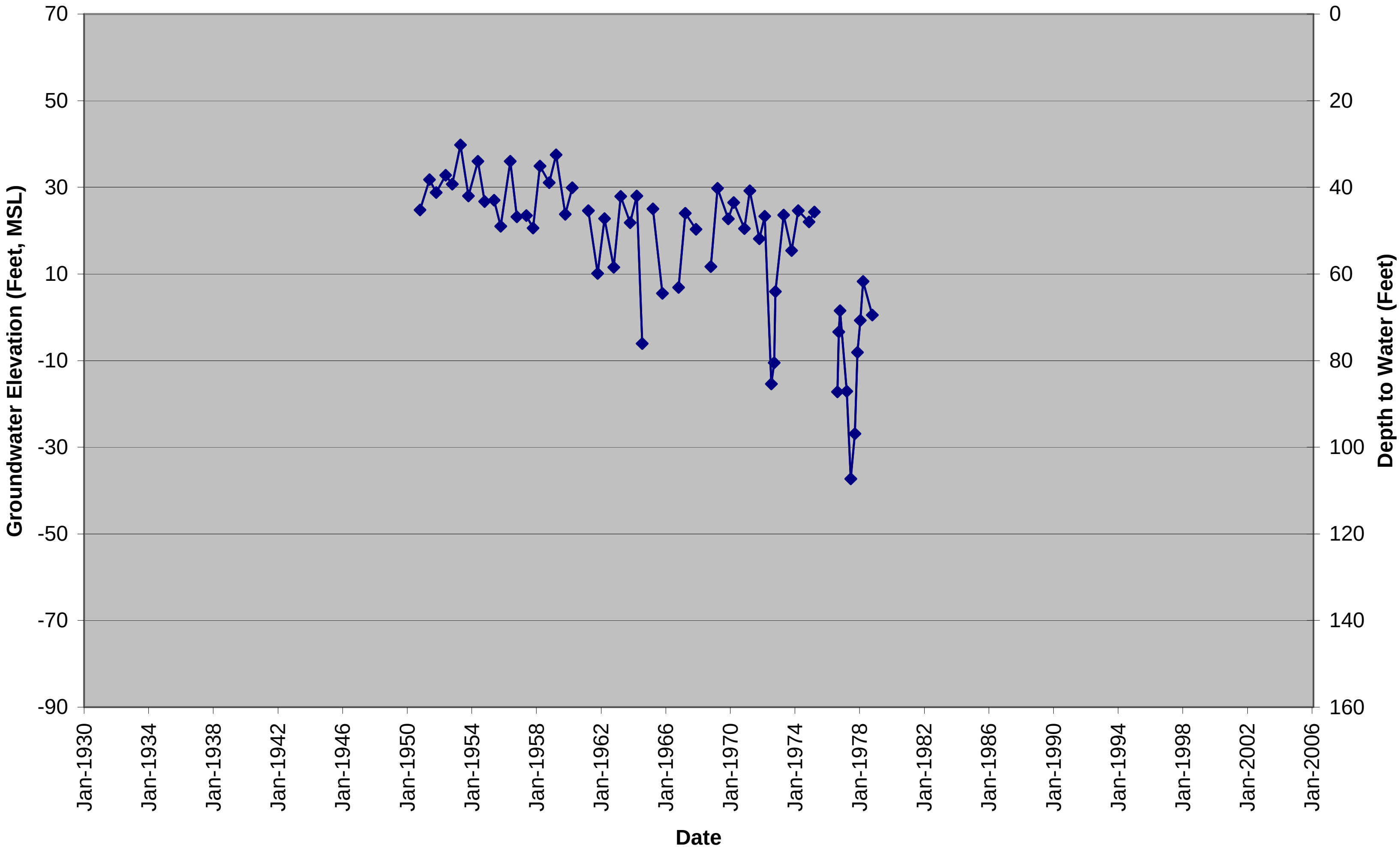


Figure E-5

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N01E12A001M

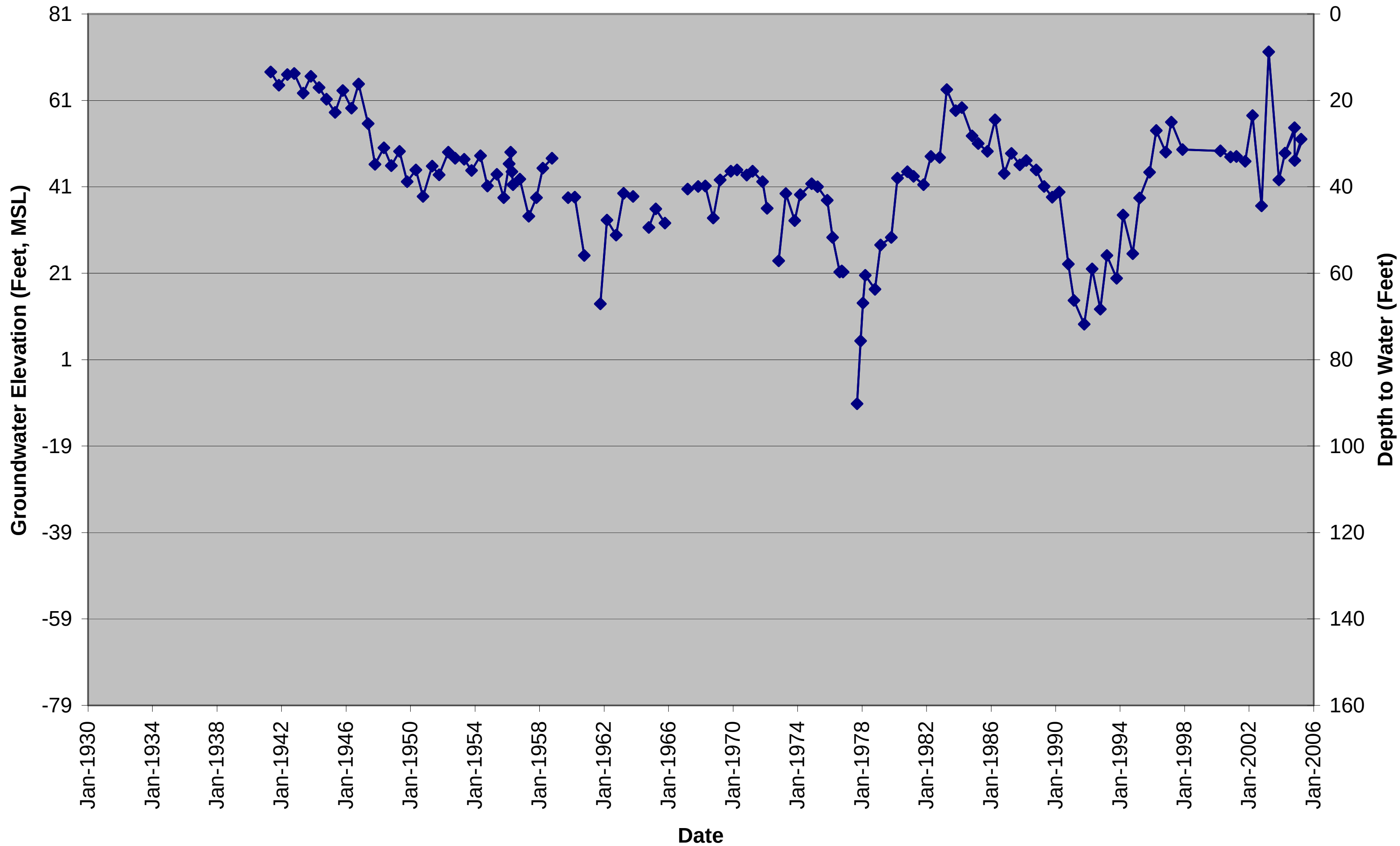


Figure E-6

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N01E12M001M

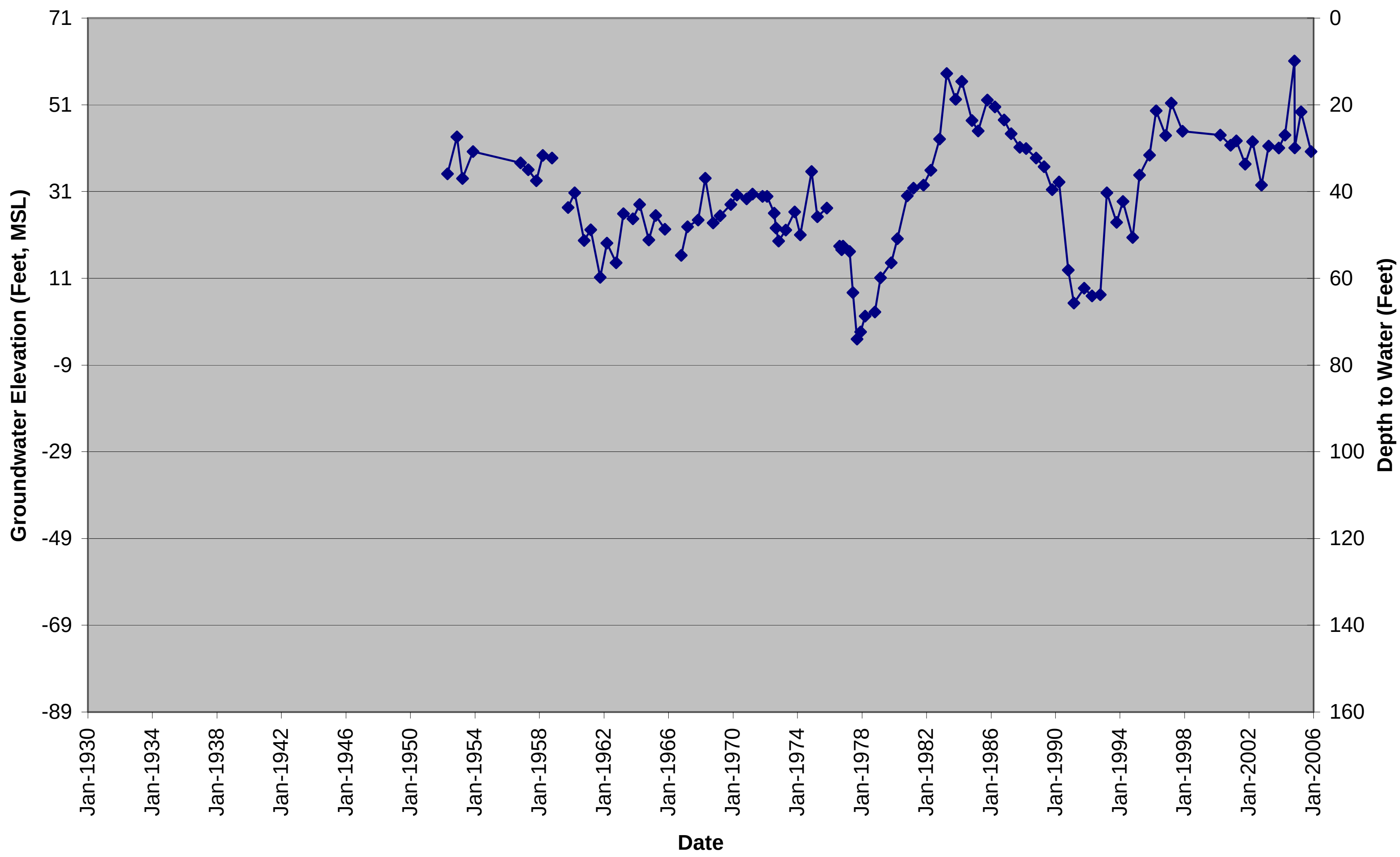


Figure E-7

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N01E12Q001M

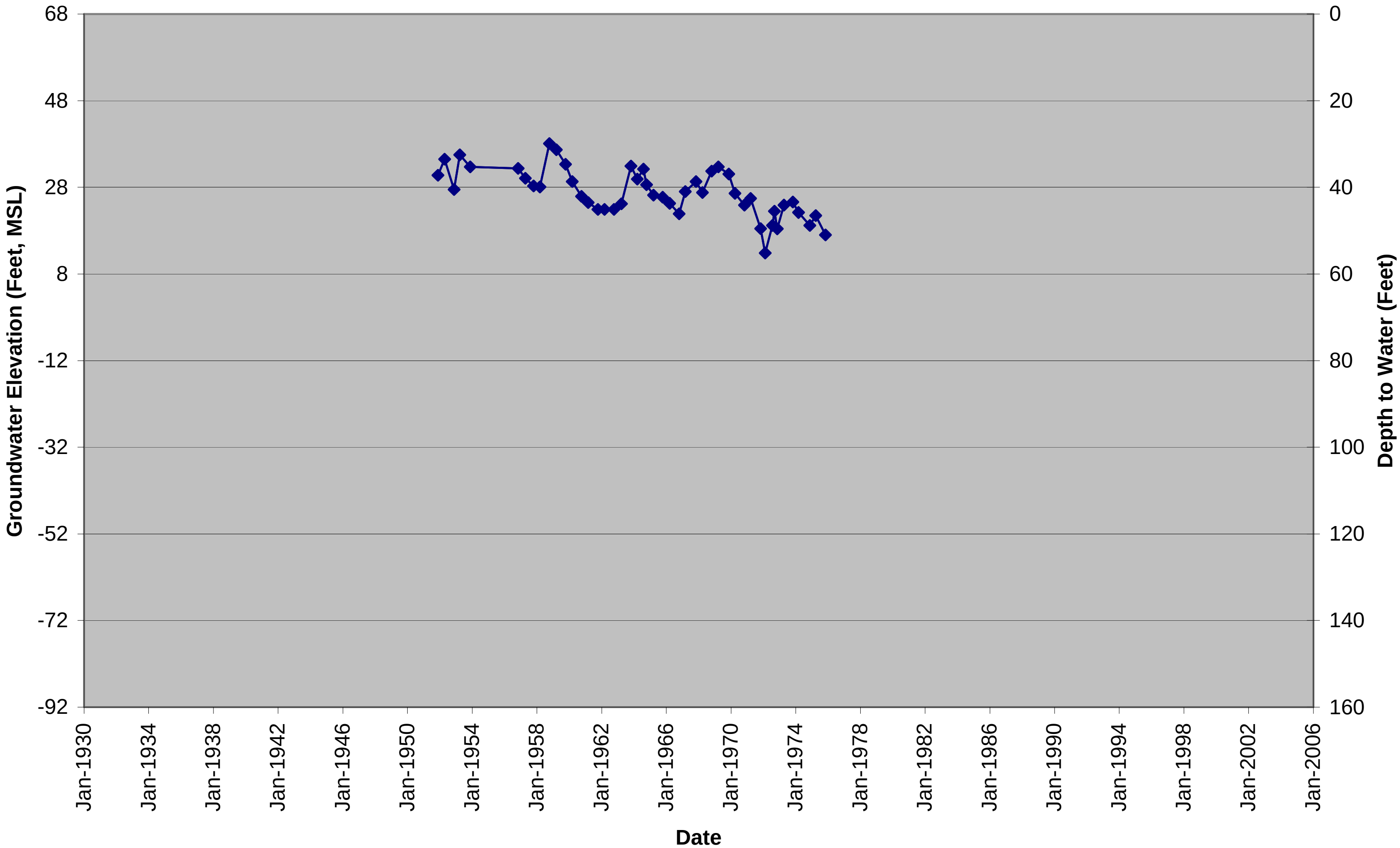


Figure E-8

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N02E05C001M

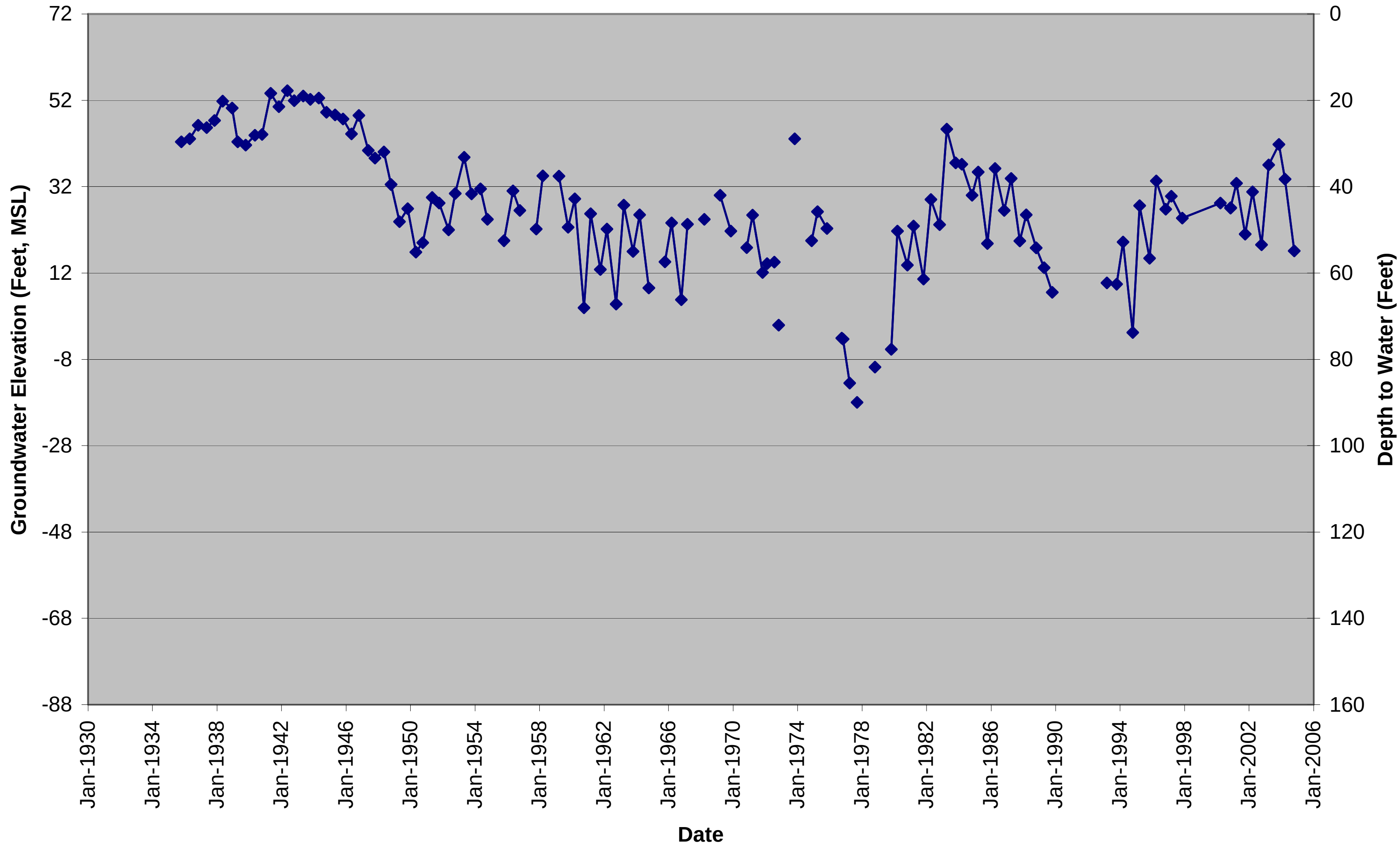


Figure E-9

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N02E07A001M

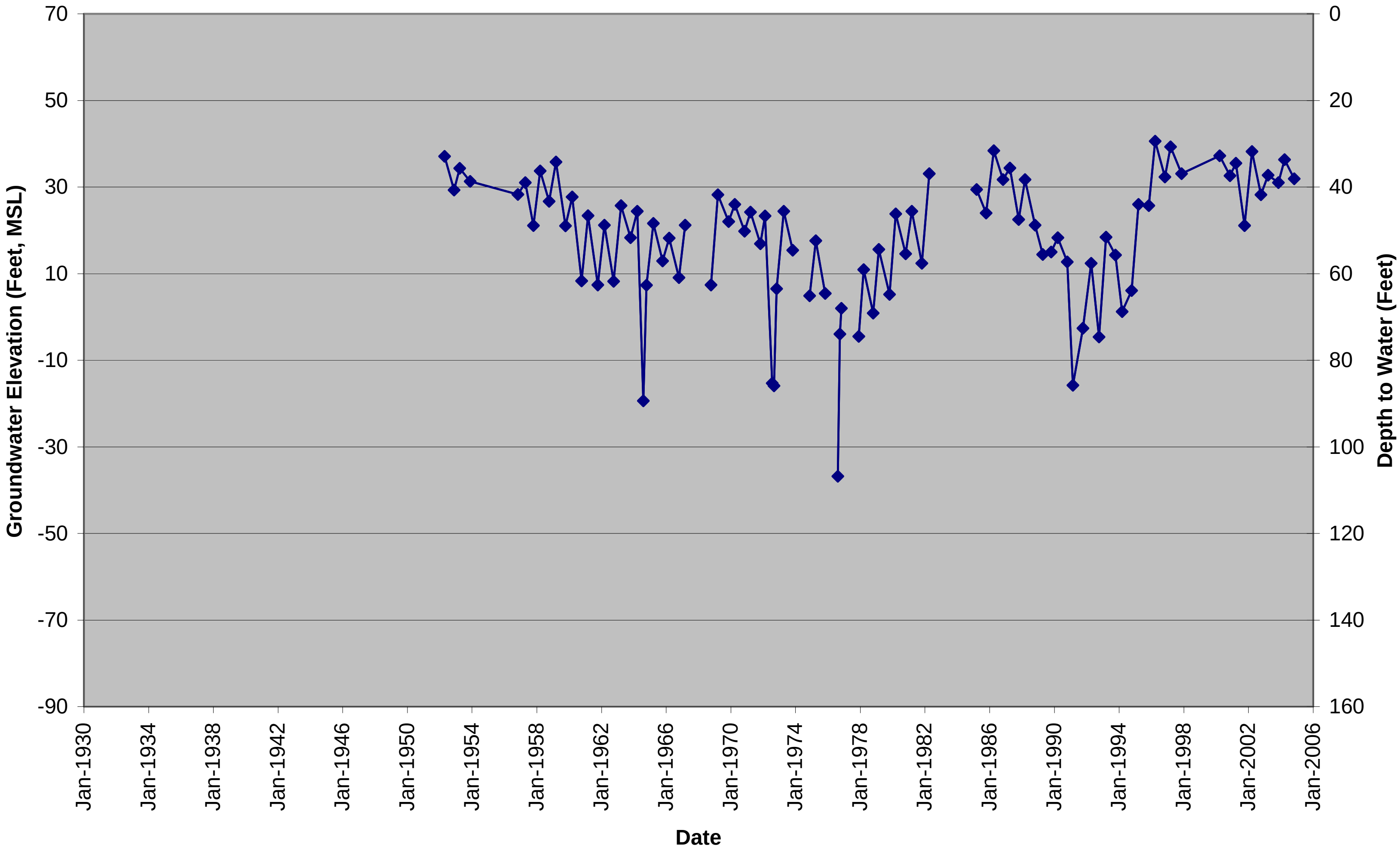


Figure E-10

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N02E07K001M

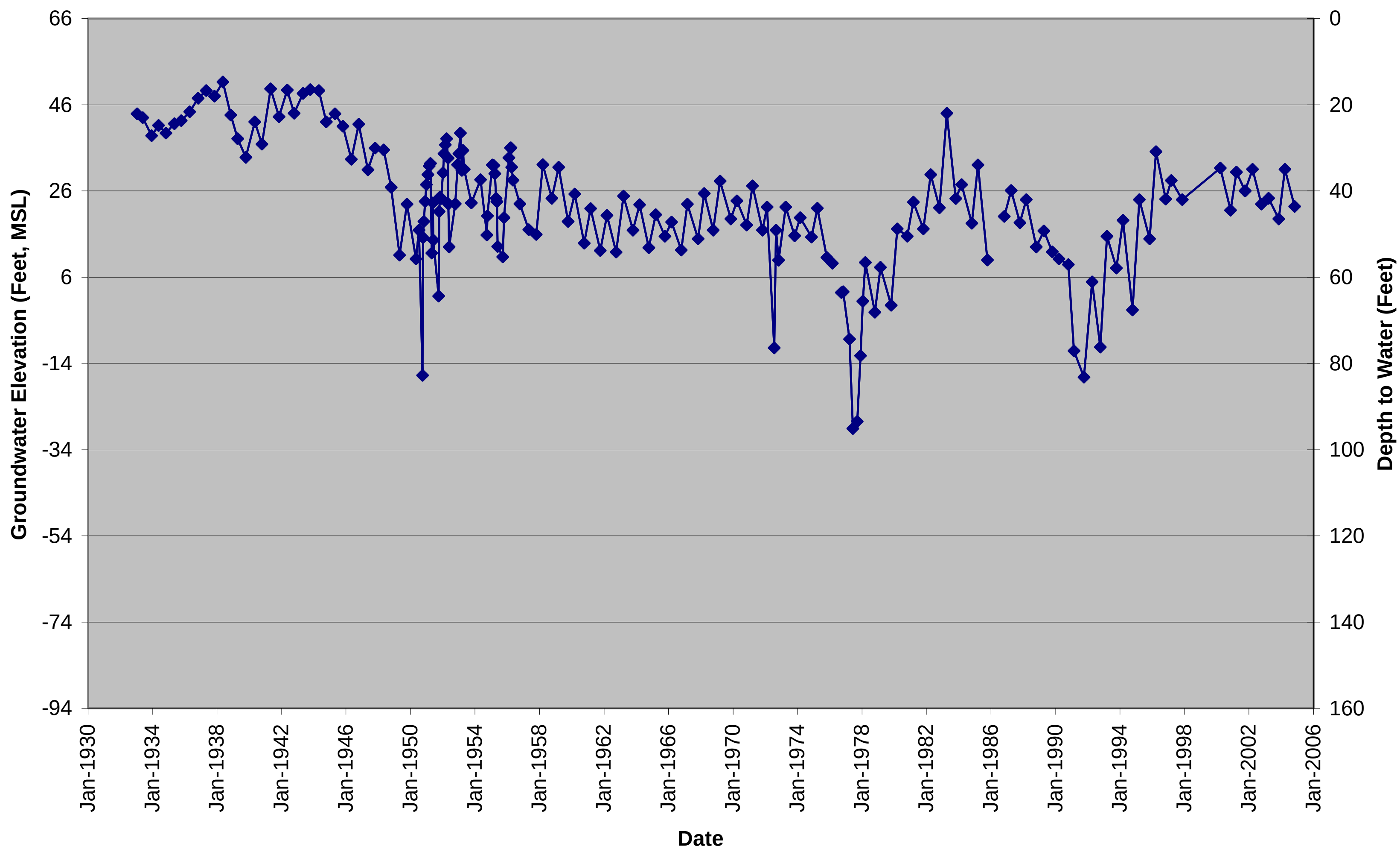


Figure E-11

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N02E07L001M

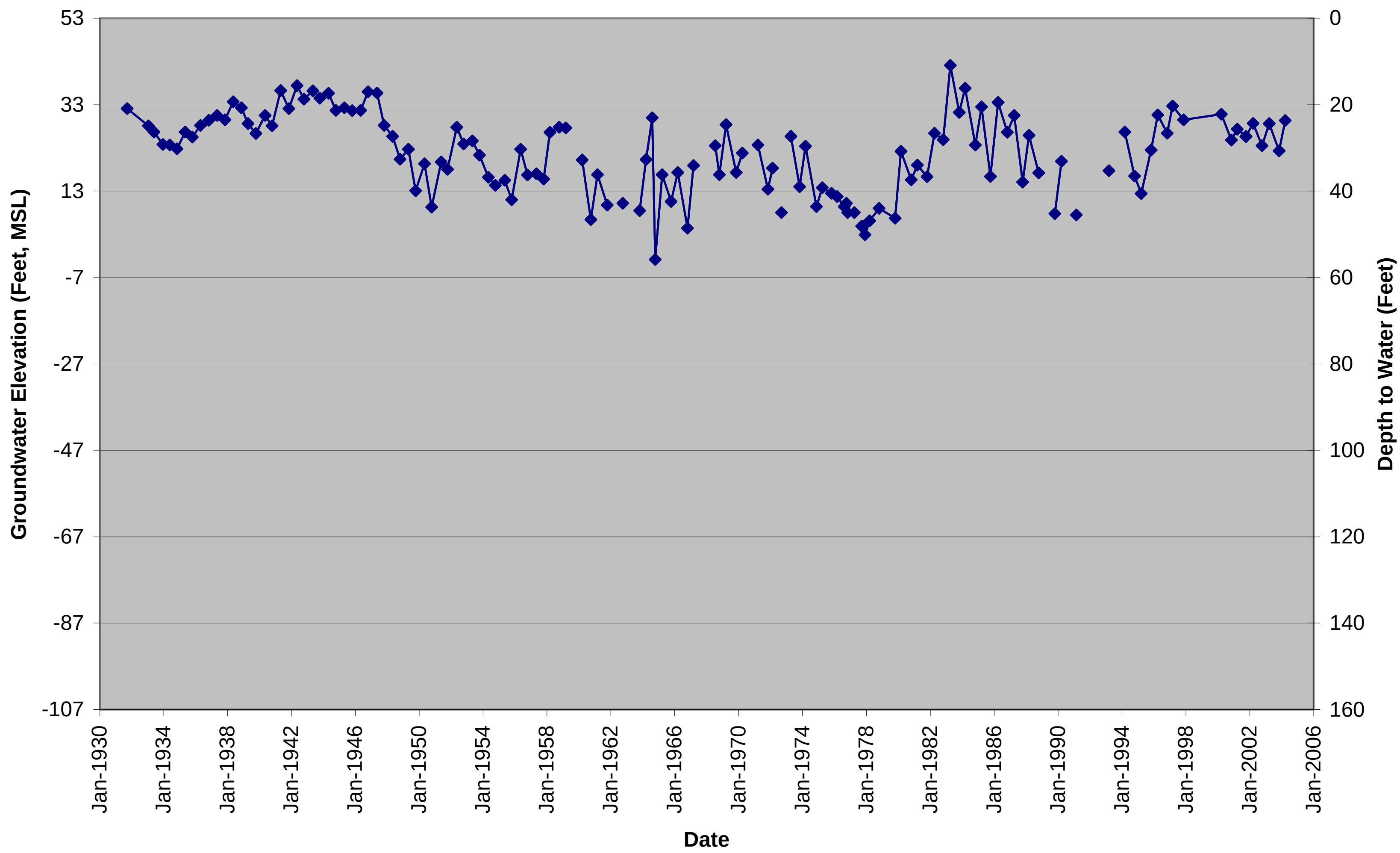


Figure E-12

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N02E09B001M

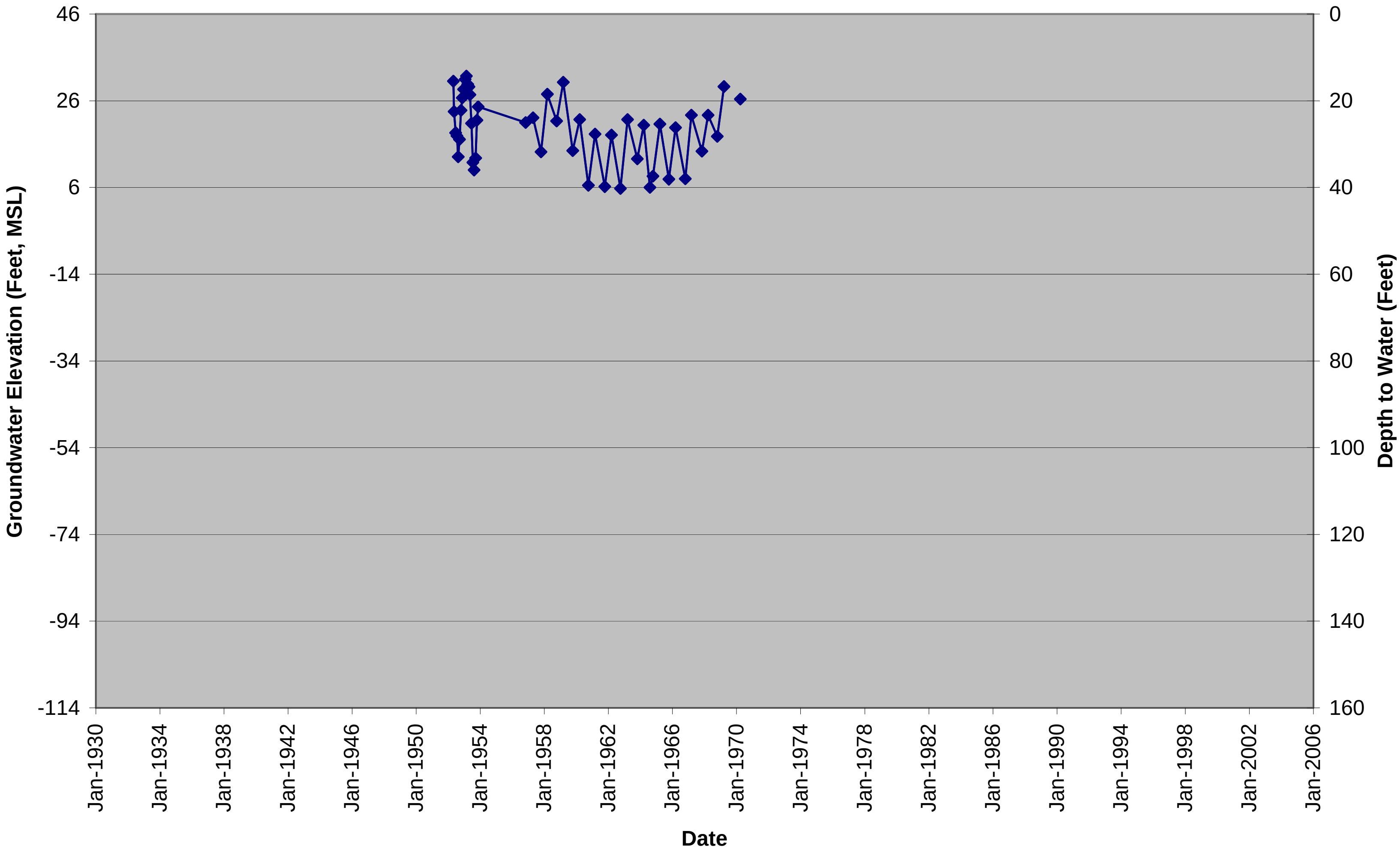


Figure E-13

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N02E10D001M

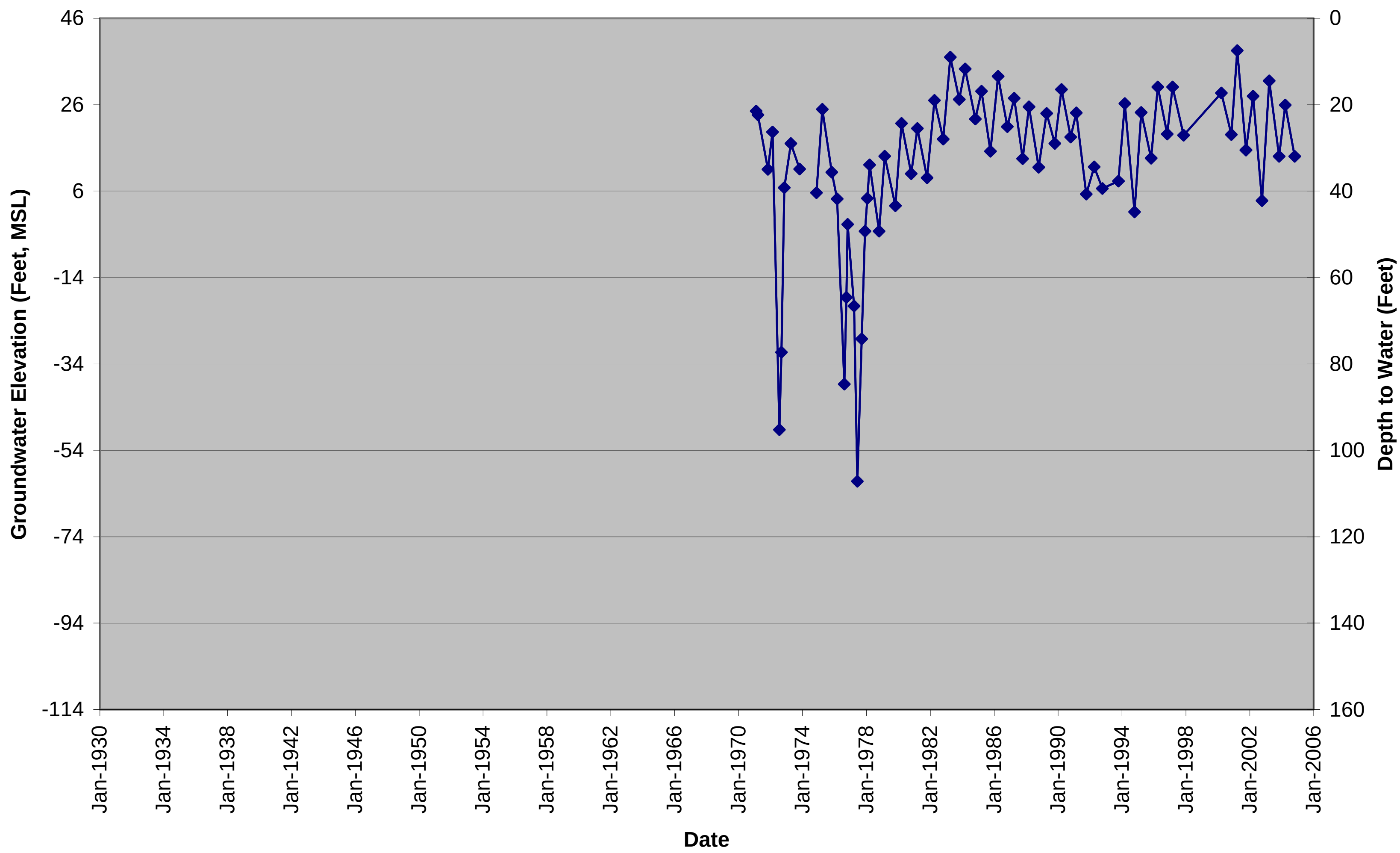


Figure E-14

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 09N02E10E001M

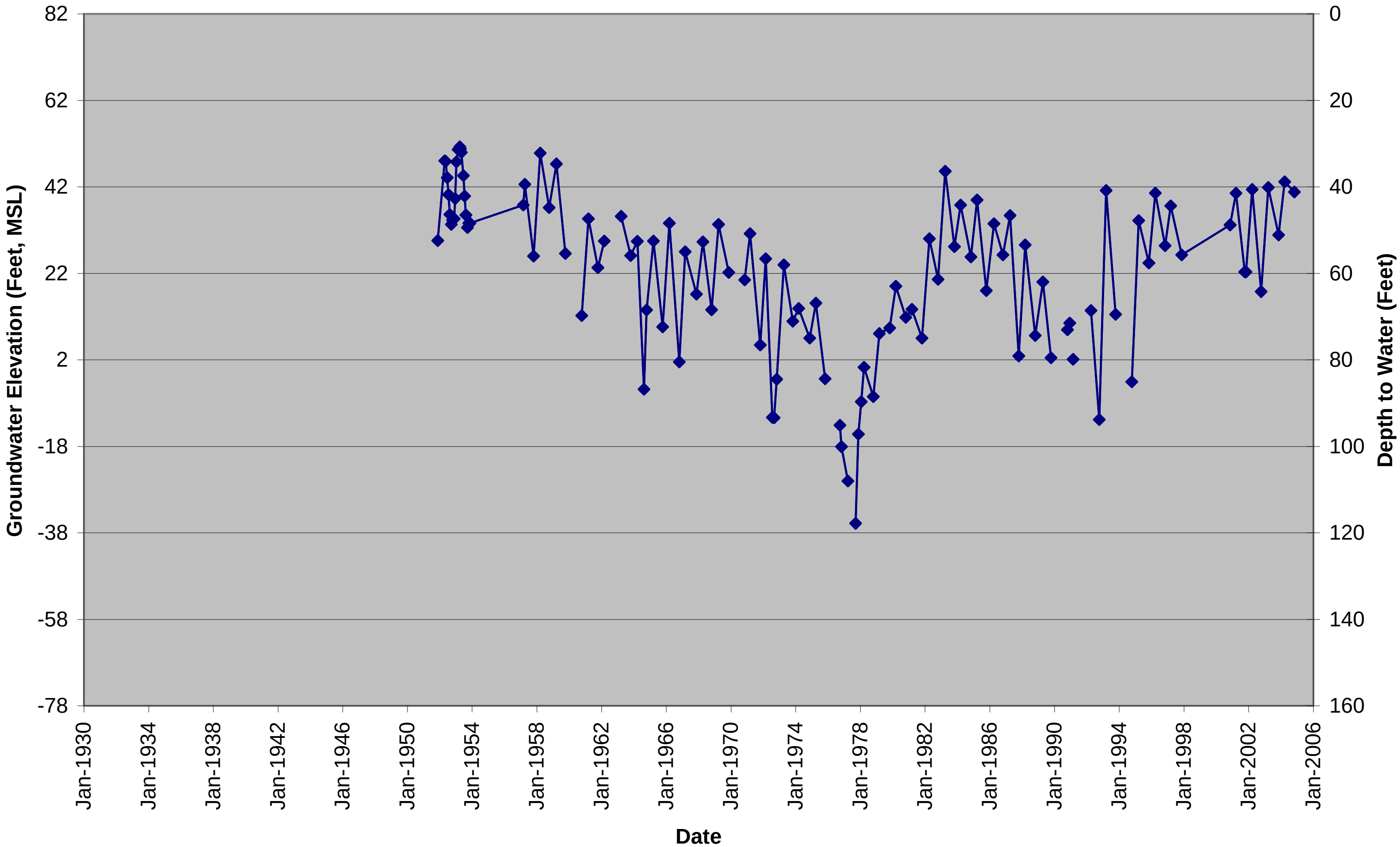


Figure E-15

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N01E13L001M

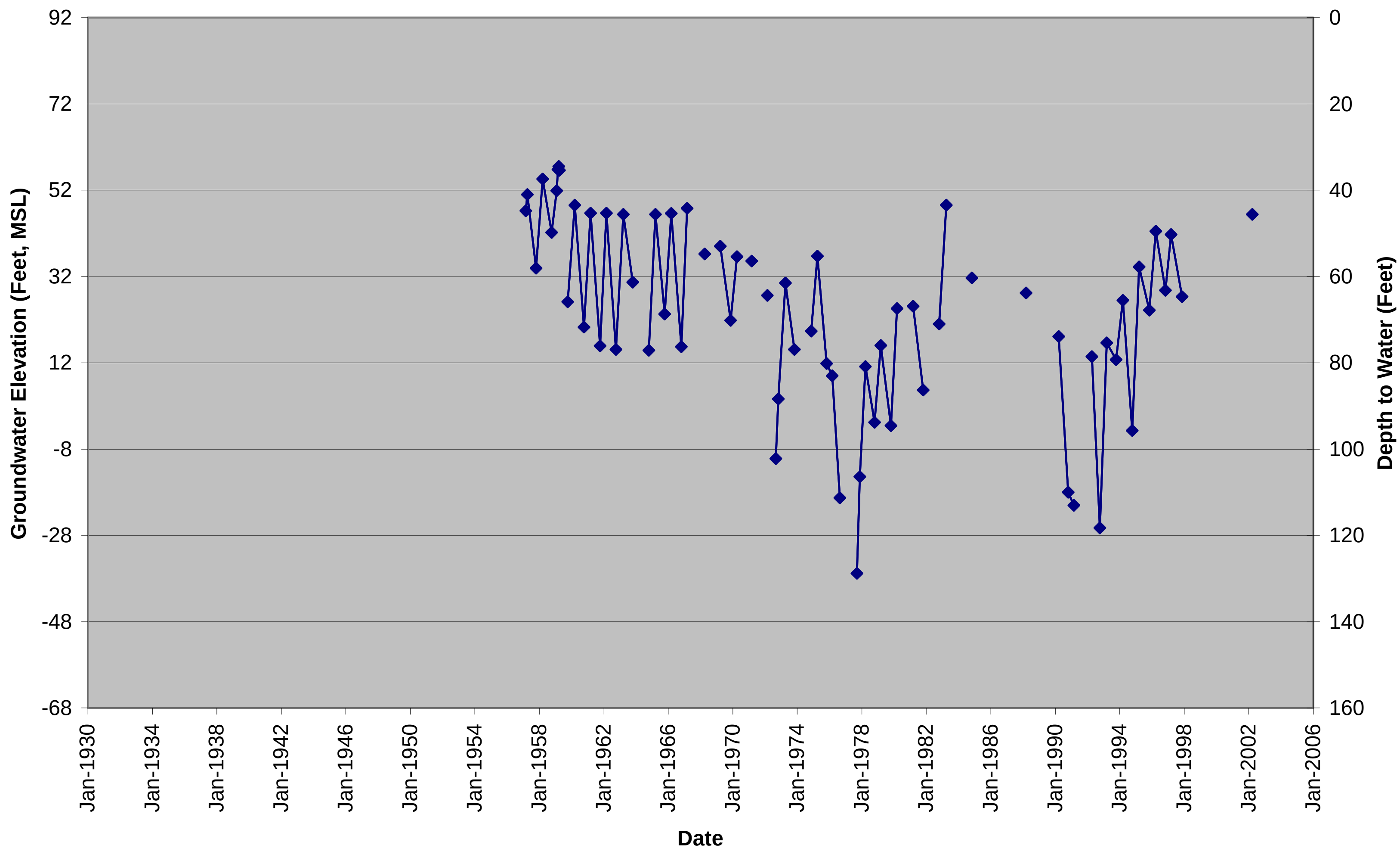


Figure E-16

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N01E23G001M

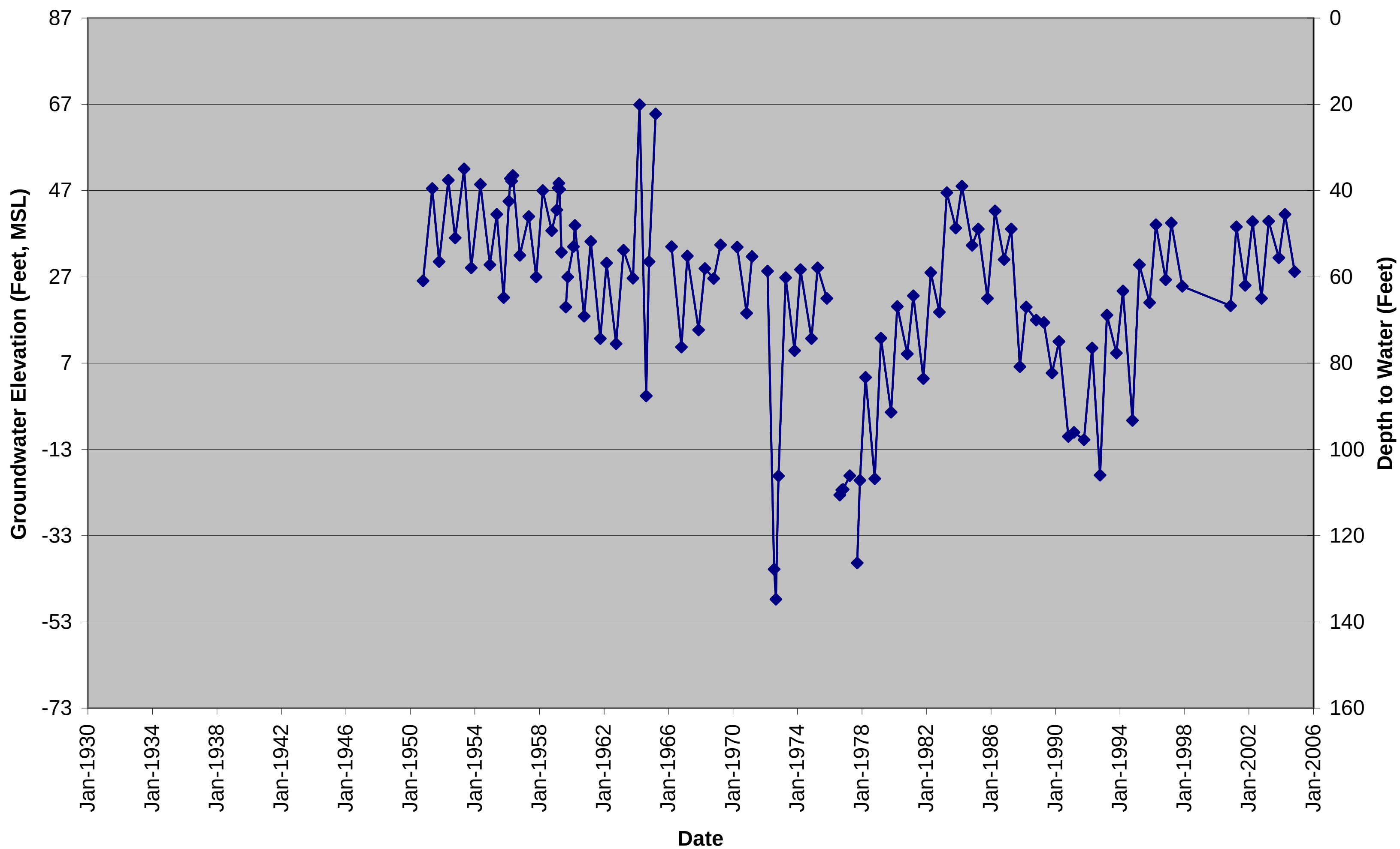


Figure E-17

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N01E23Q002M

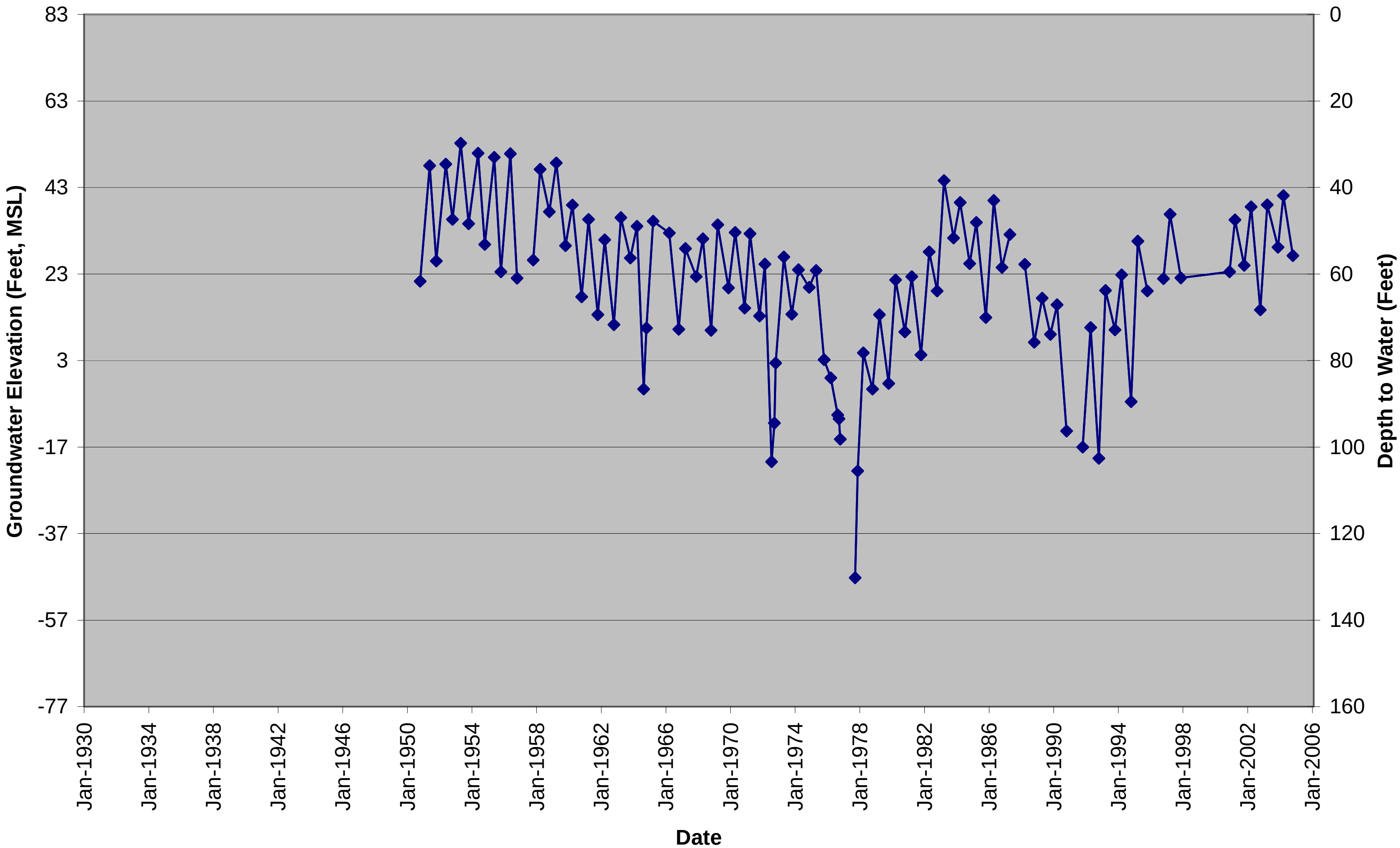


Figure E-18

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N01E24E001M

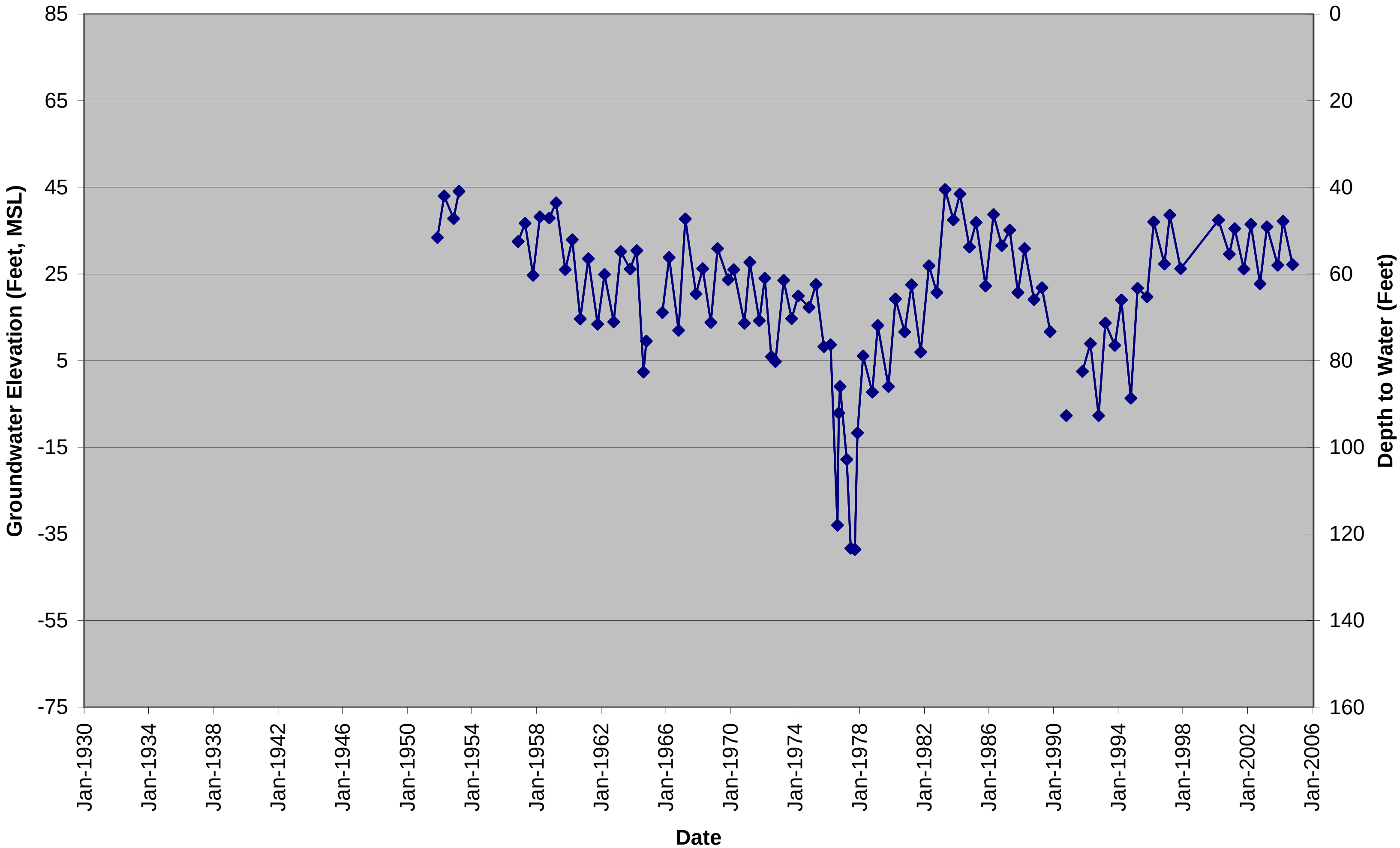


Figure E-19

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N01E36Q002M

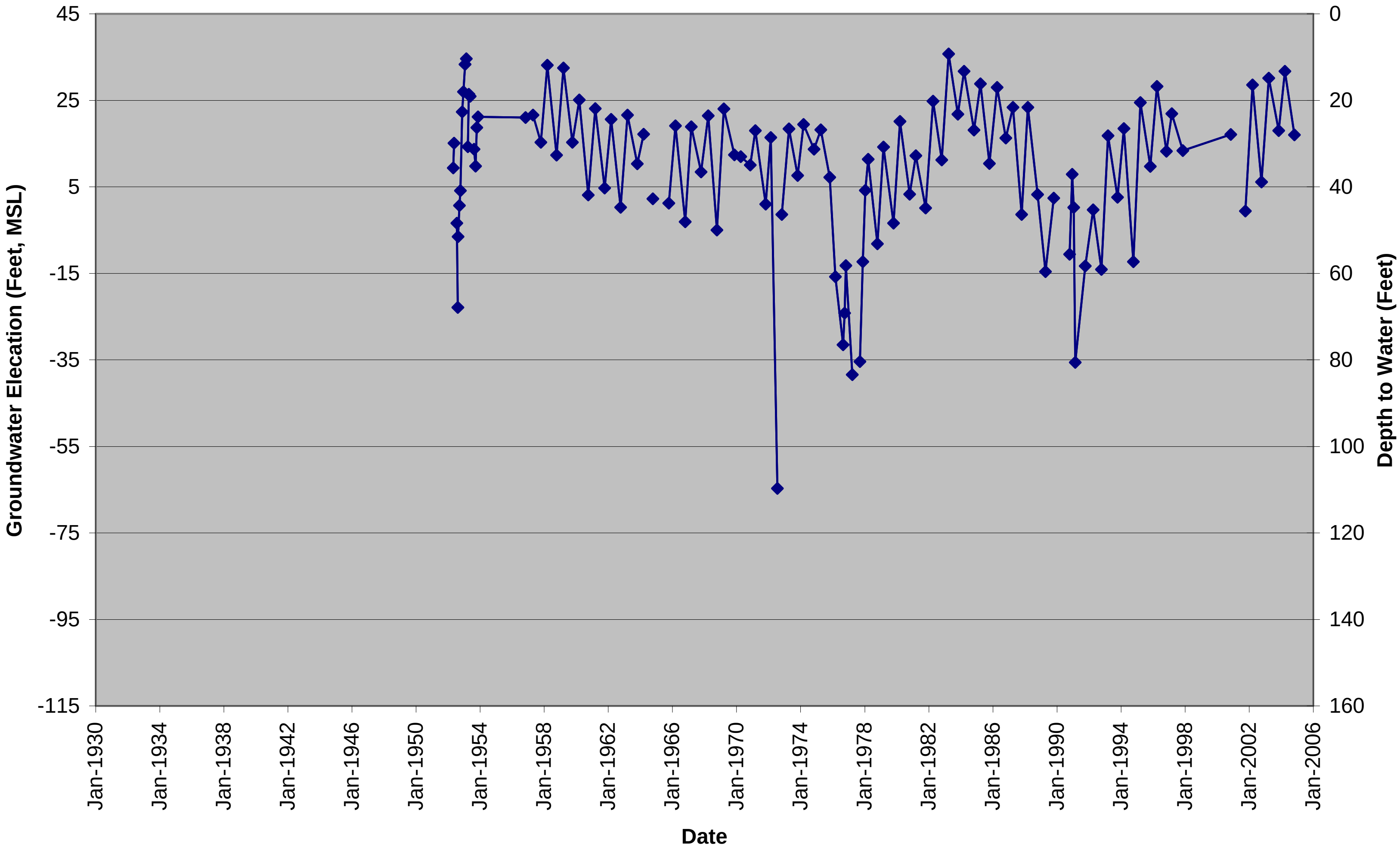


Figure E-20

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E15N001M

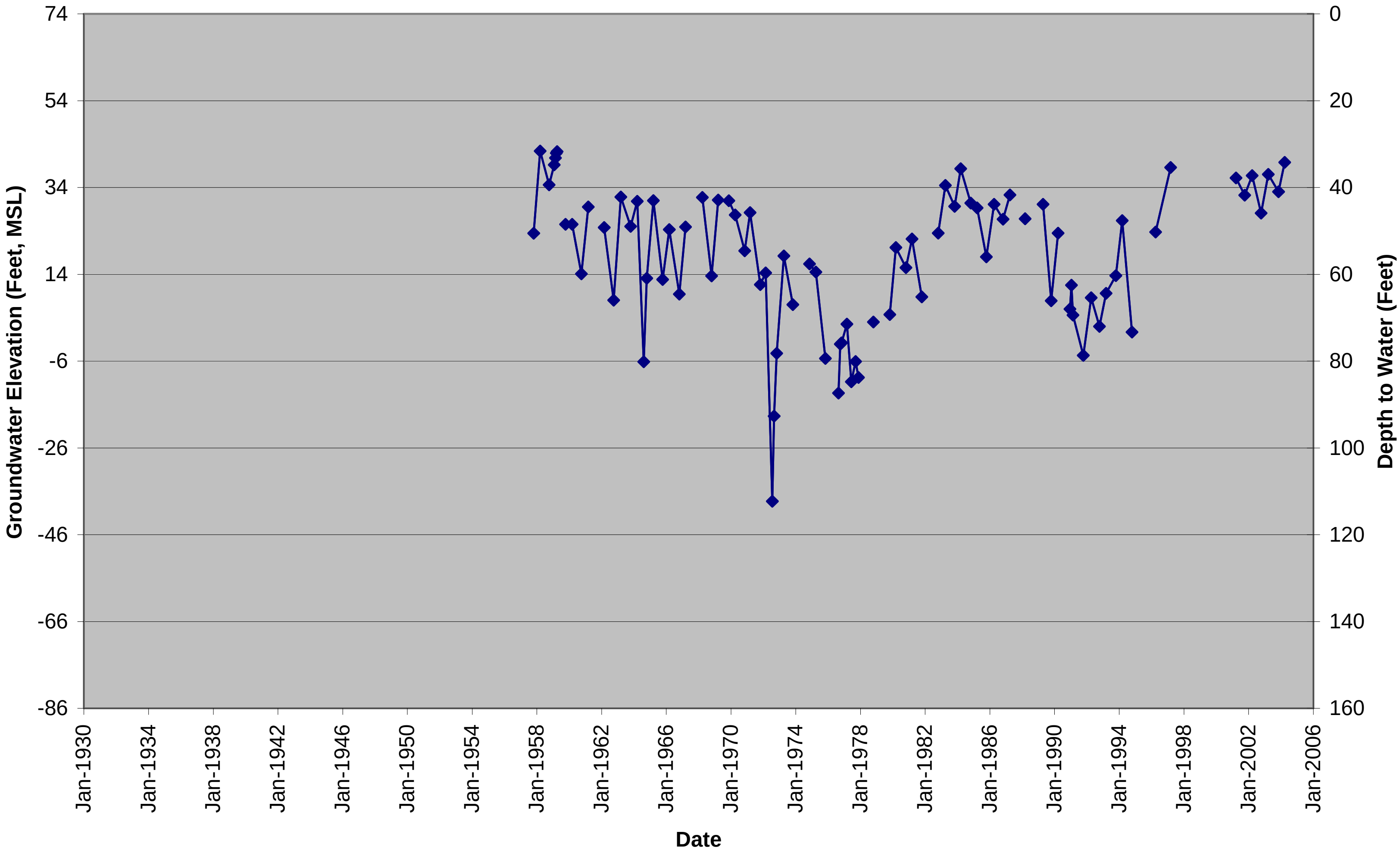


Figure E-21

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E18M001M

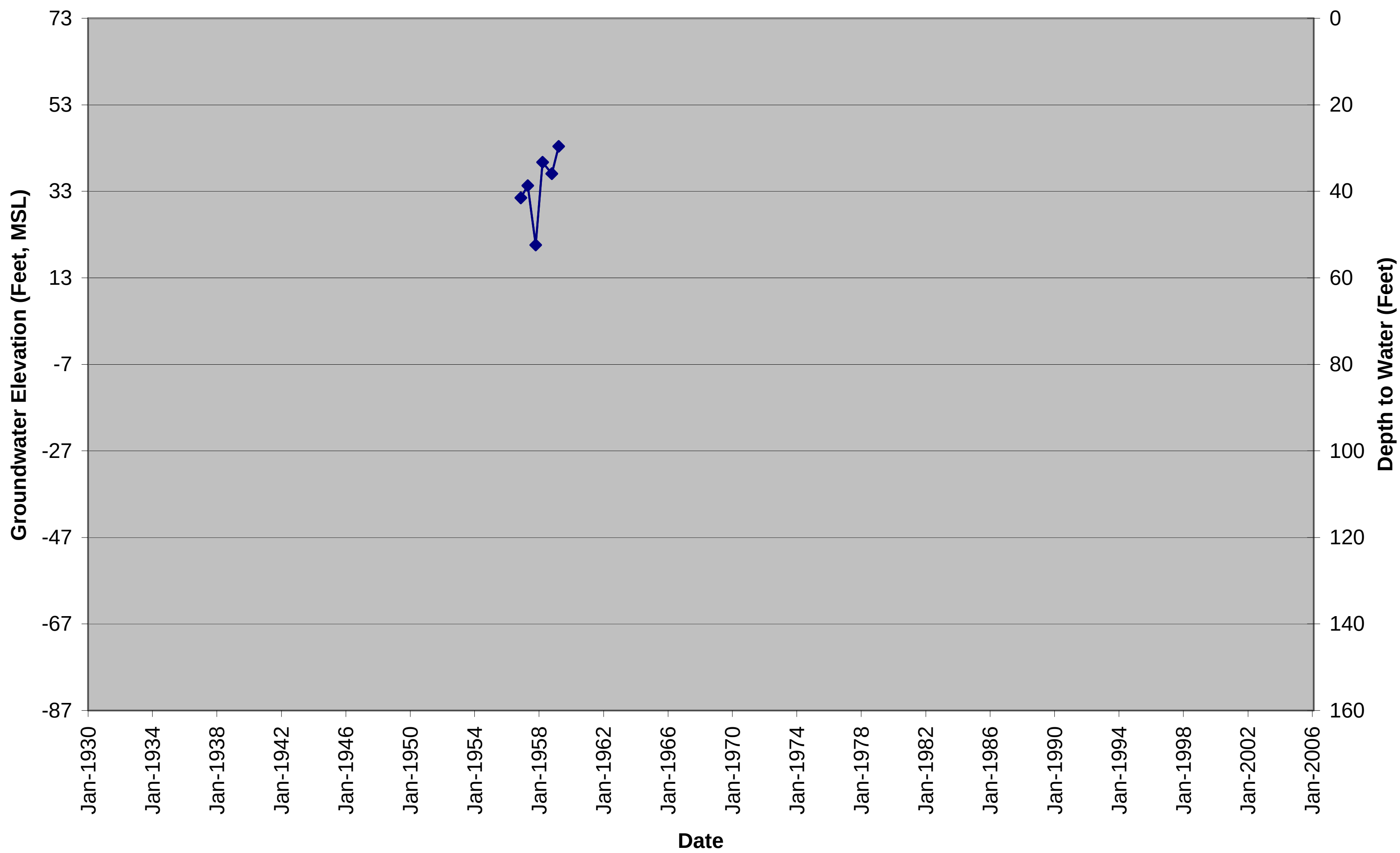


Figure E-22

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E19M002M

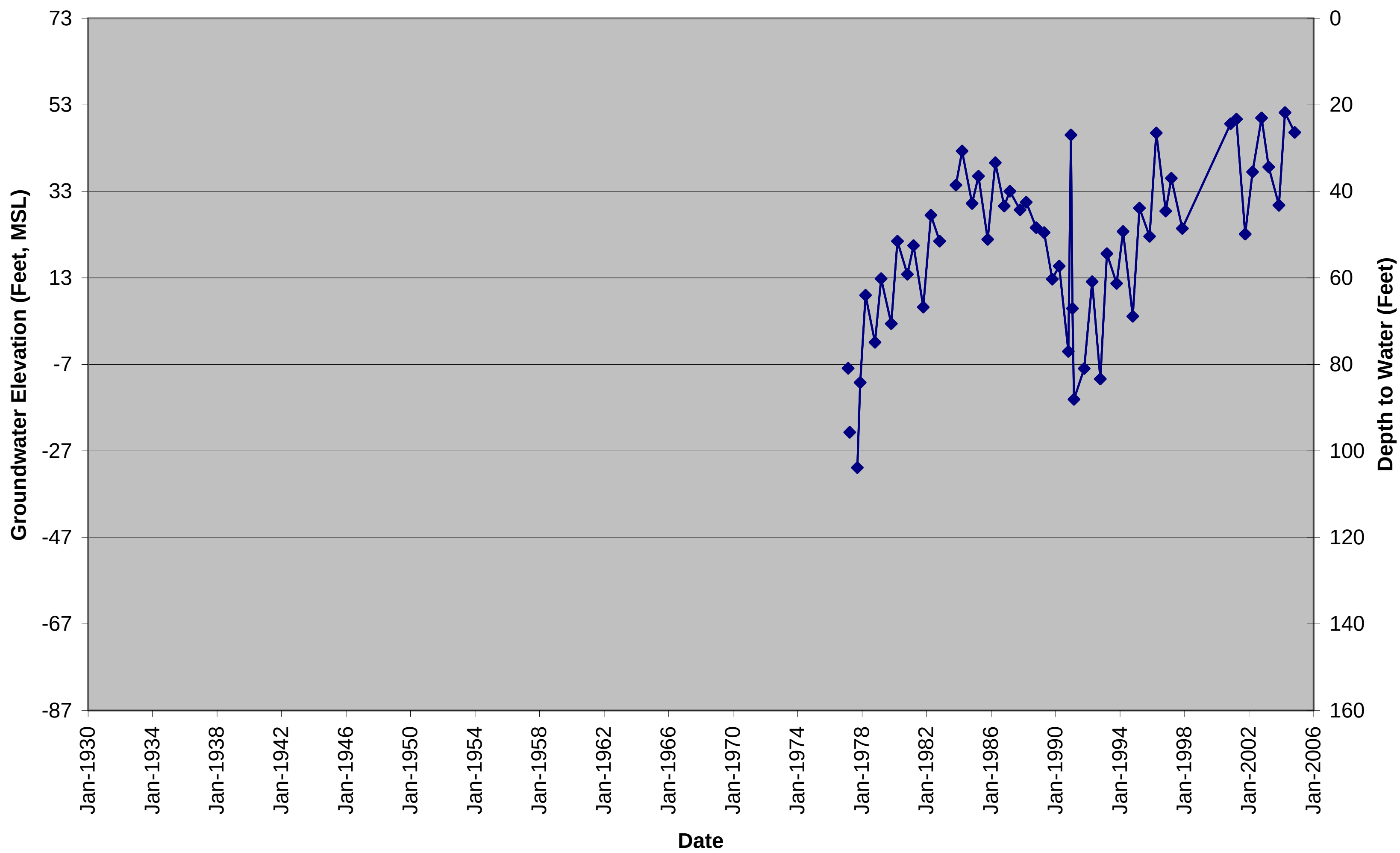


Figure E-23

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E19M003M

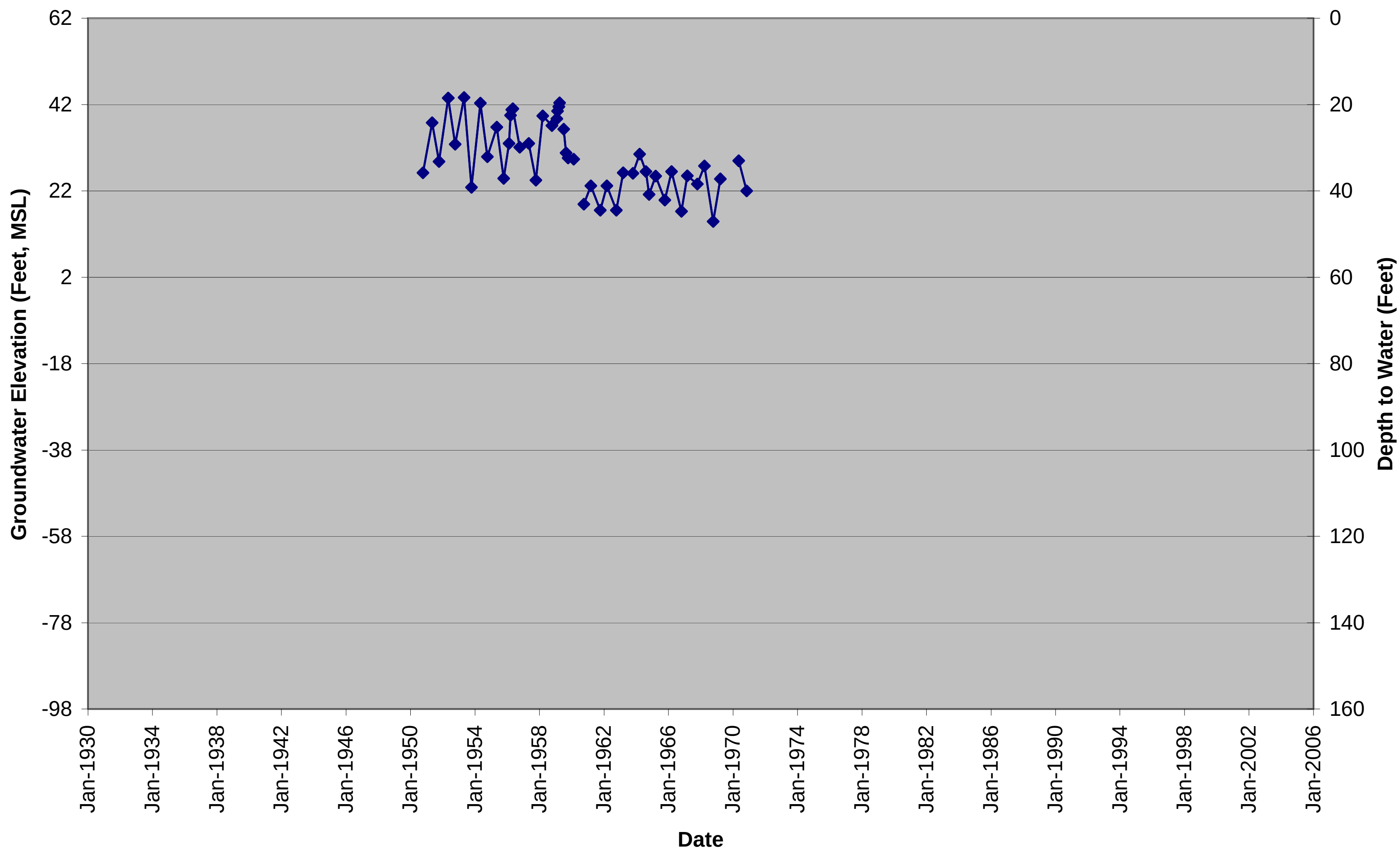


Figure E-24

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E20E001M

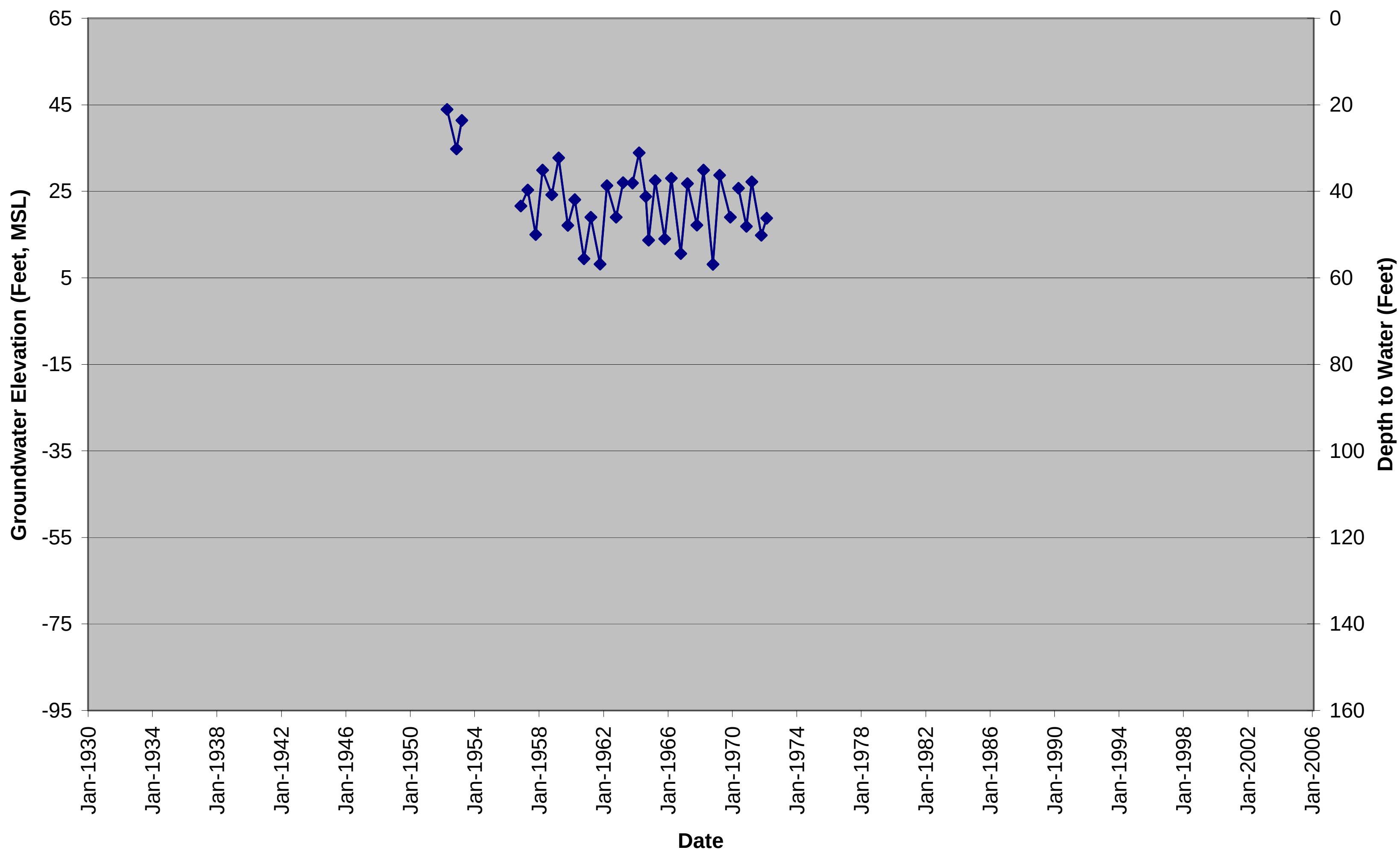


Figure E-25

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E20N001M

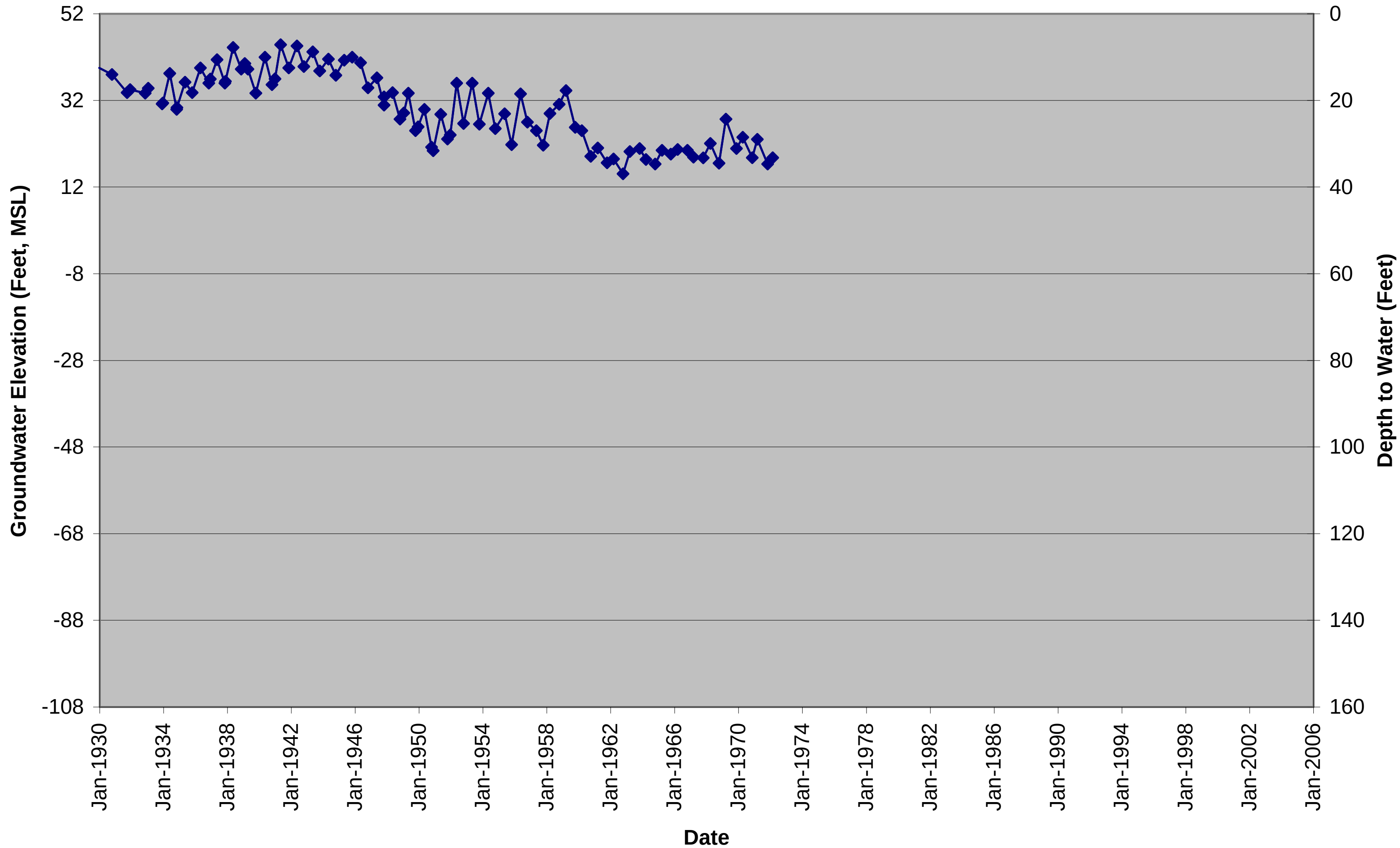


Figure E-26

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E21M002M

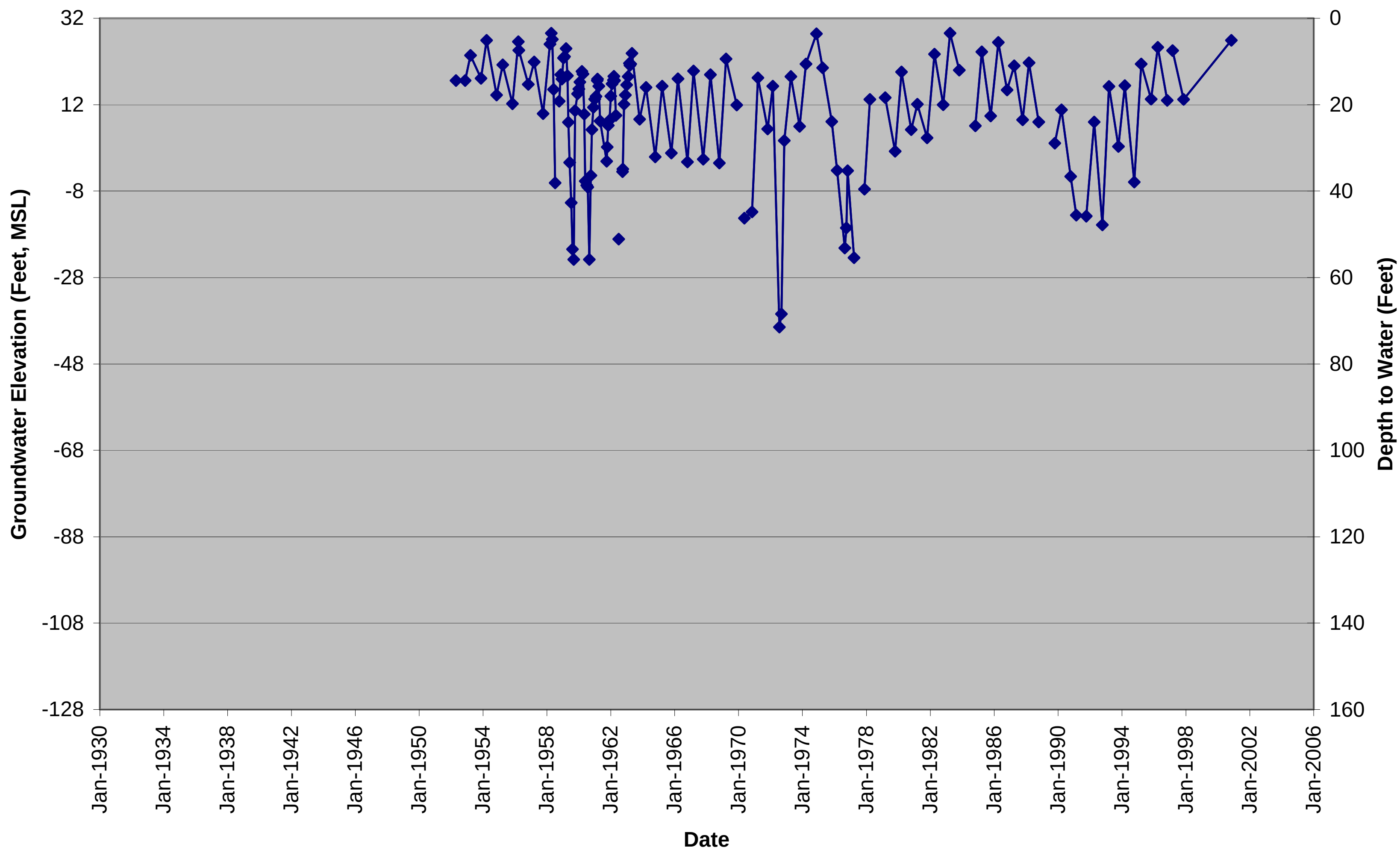


Figure E-27

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E26Q001M

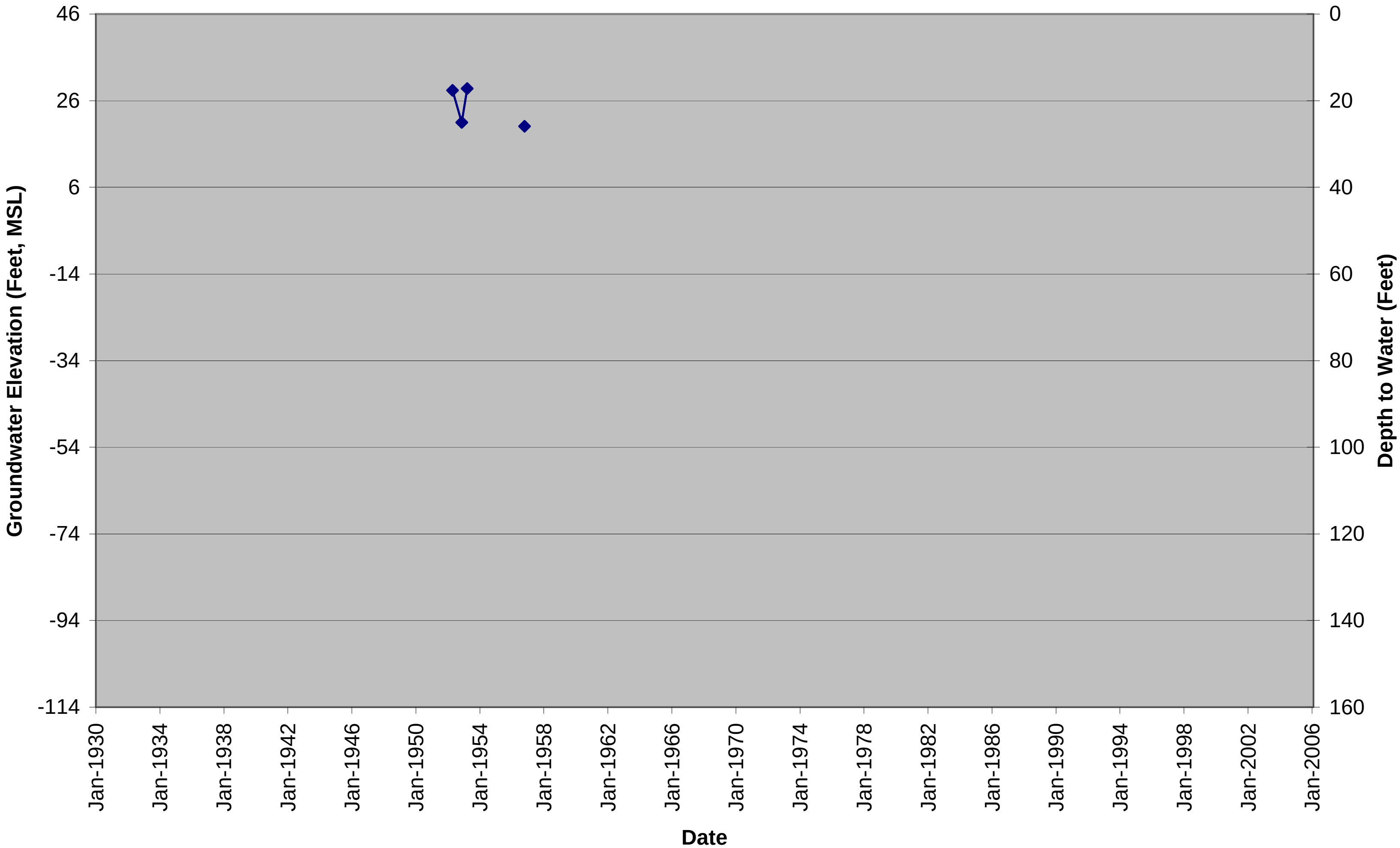


Figure E-28

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E27N001M

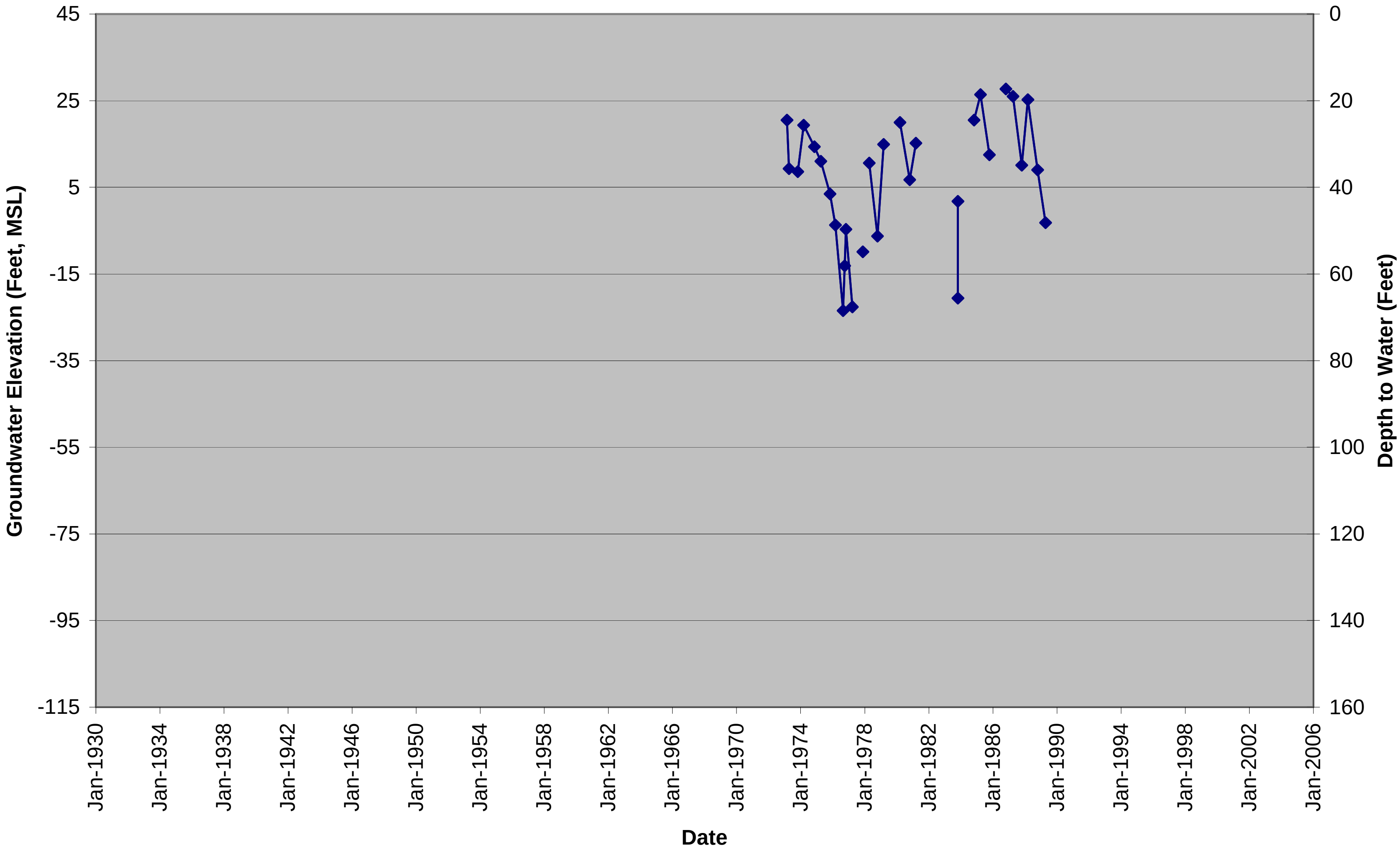


Figure E-29

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E28A002M

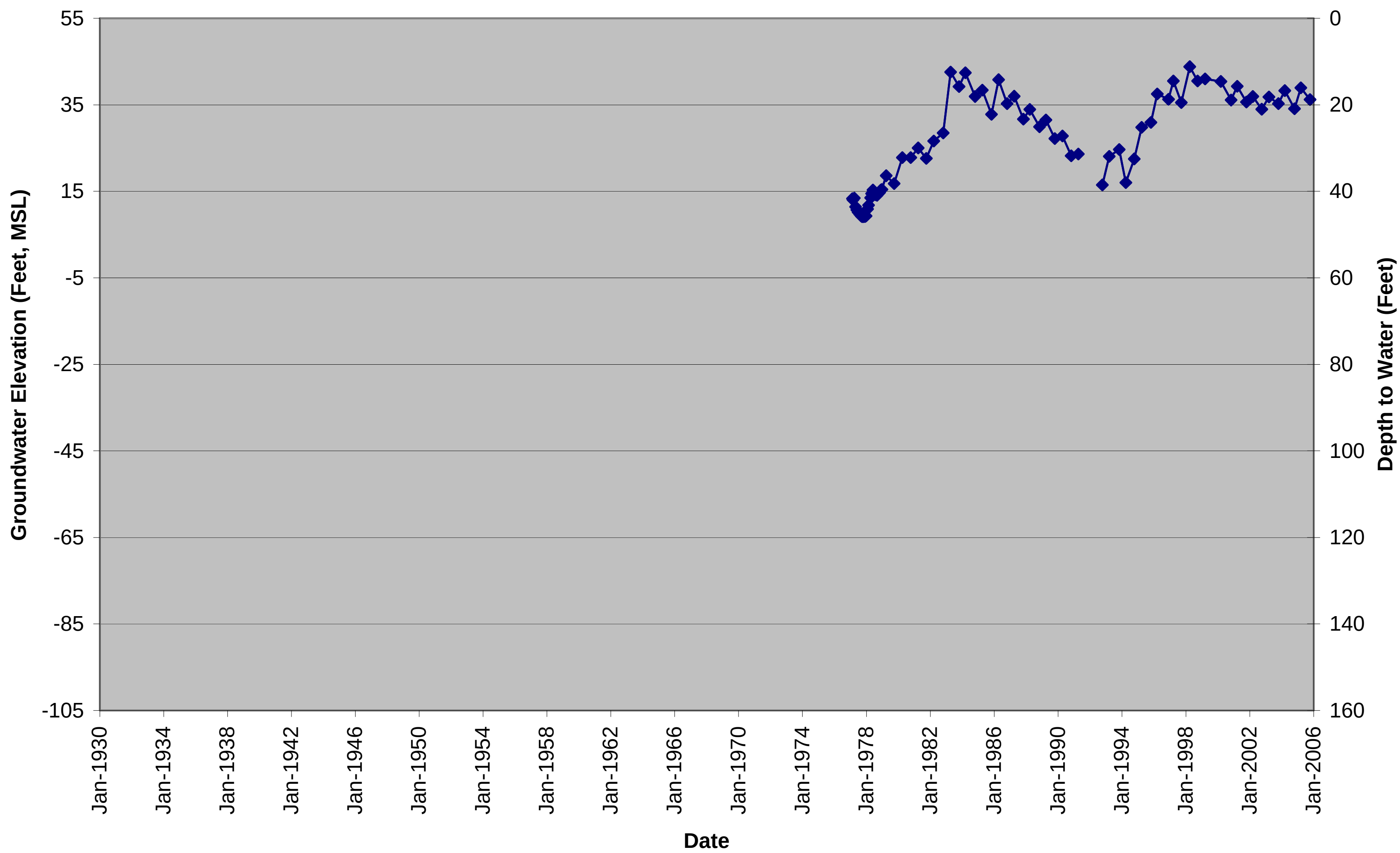


Figure E-30

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E29A001M

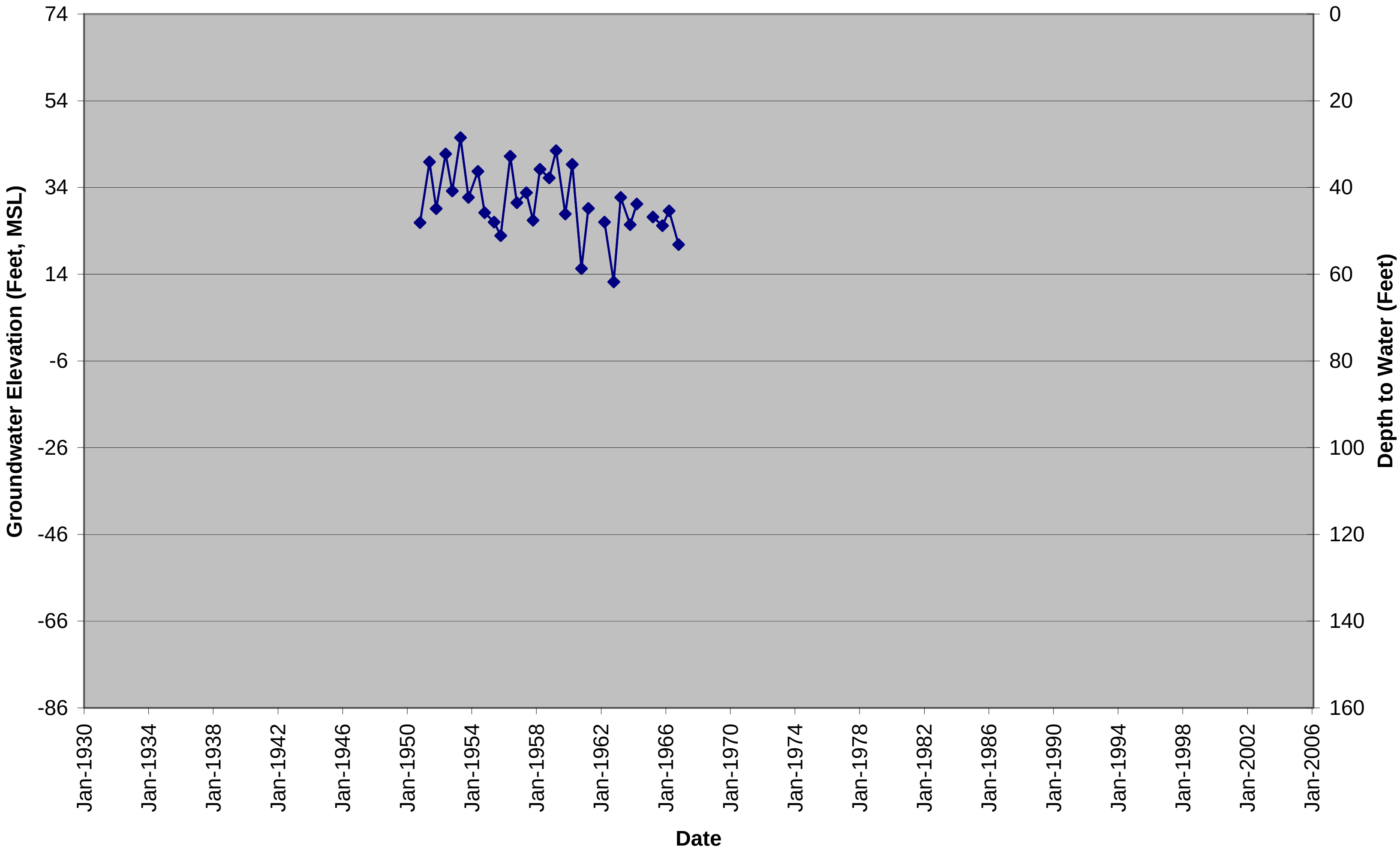


Figure E-31

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E30E001M

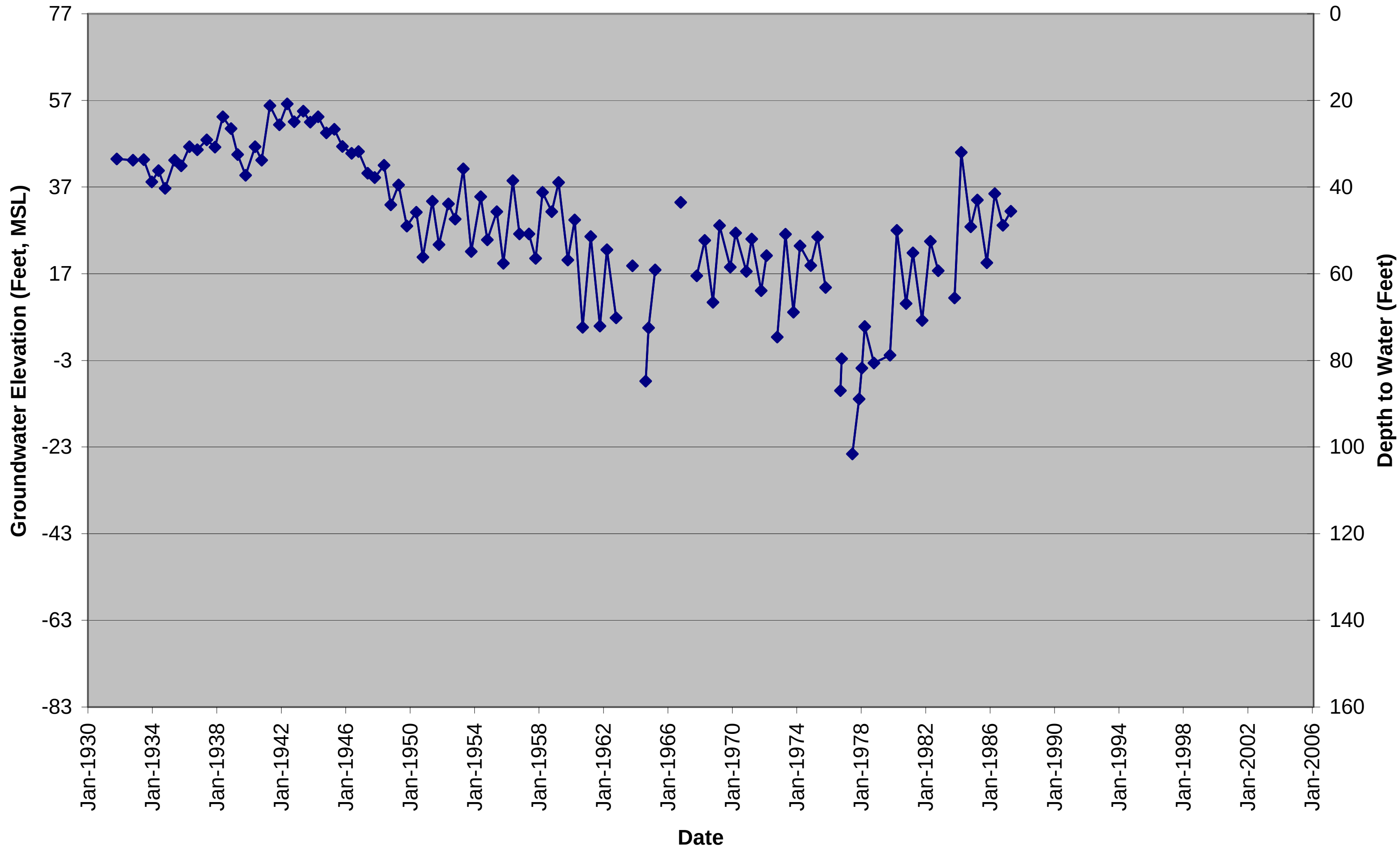


Figure E-32

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E31M001M

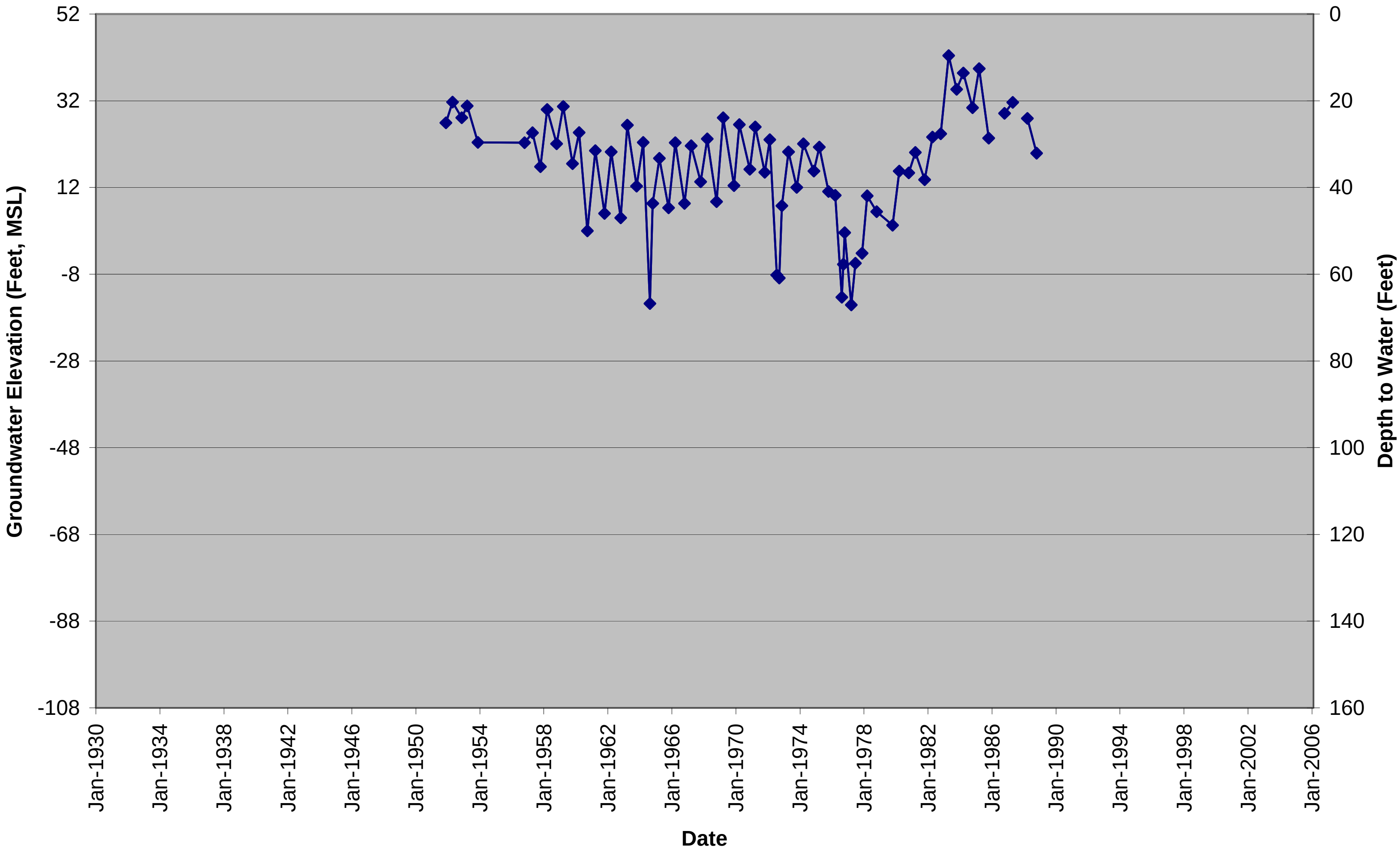


Figure E-33

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E33R001M

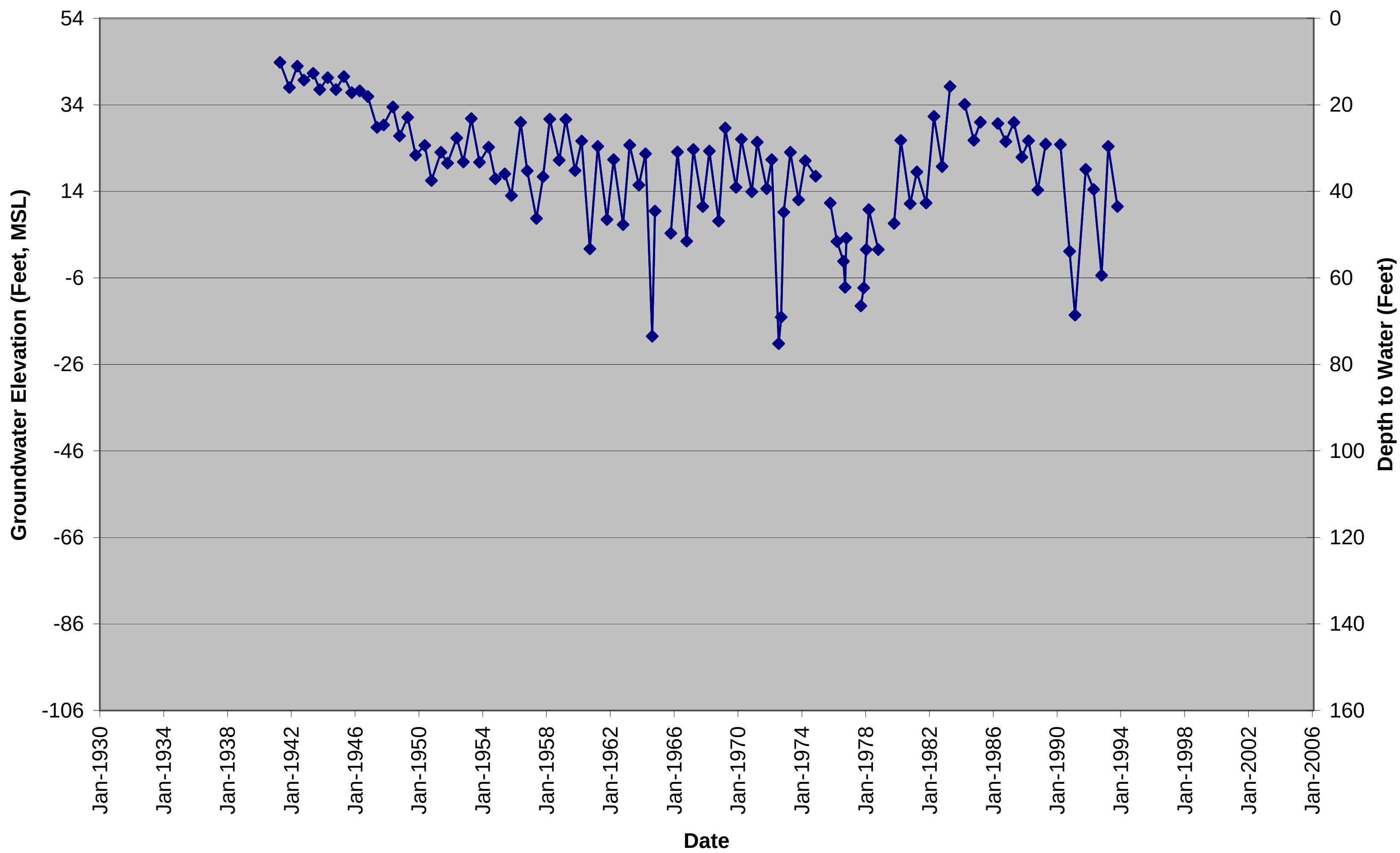


Figure E-34

City of Woodland
Groundwater Management Plan

HYDROGRAPH FOR WELL 10N02E34M001M

APPENDIX F

Groundwater Quality Charts

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List of Figures, cont'd…

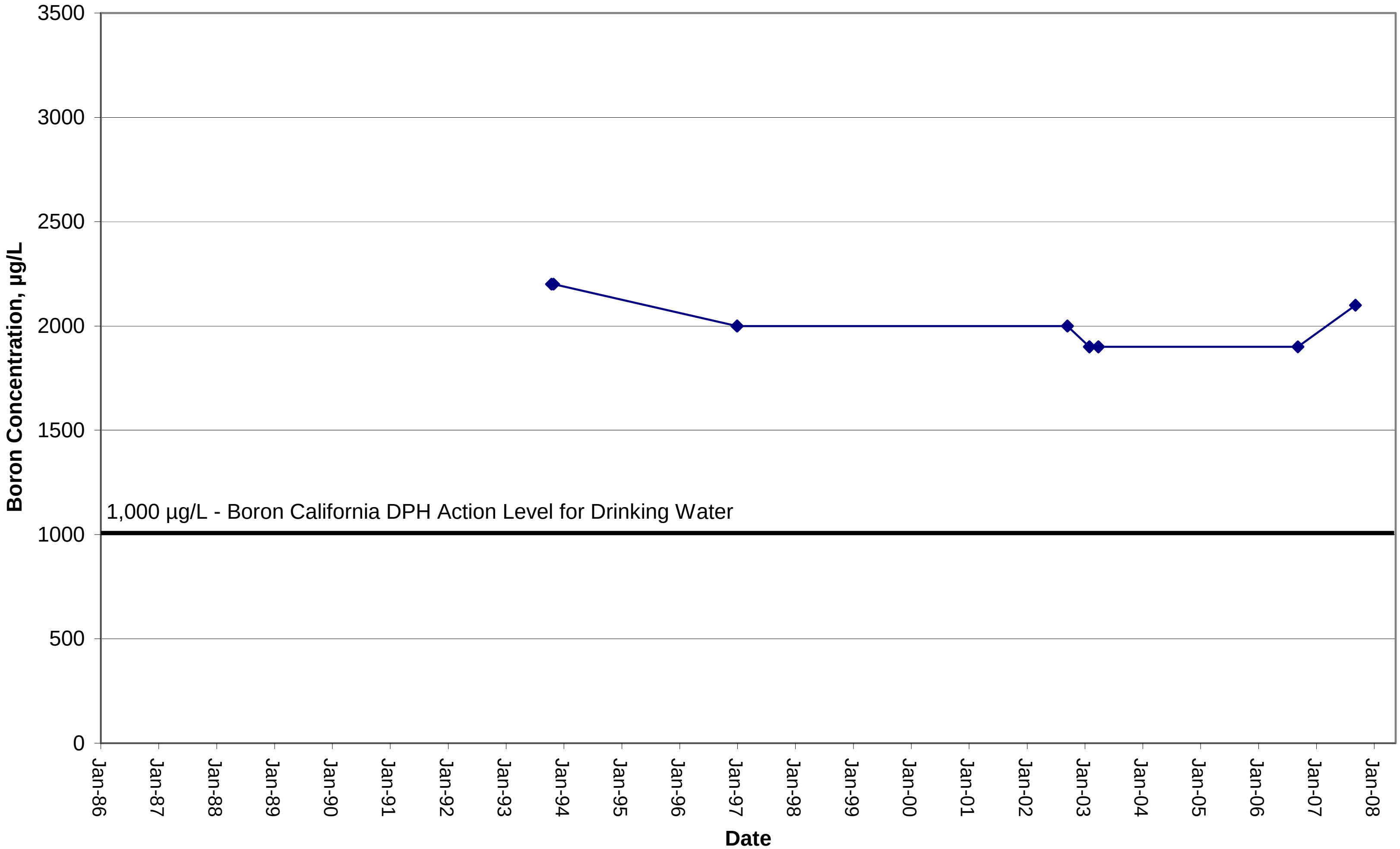

Figure F-1a

City of Woodland
Groundwater Management Plan

WELL #1 BORON CONCENTRATION OVER TIME

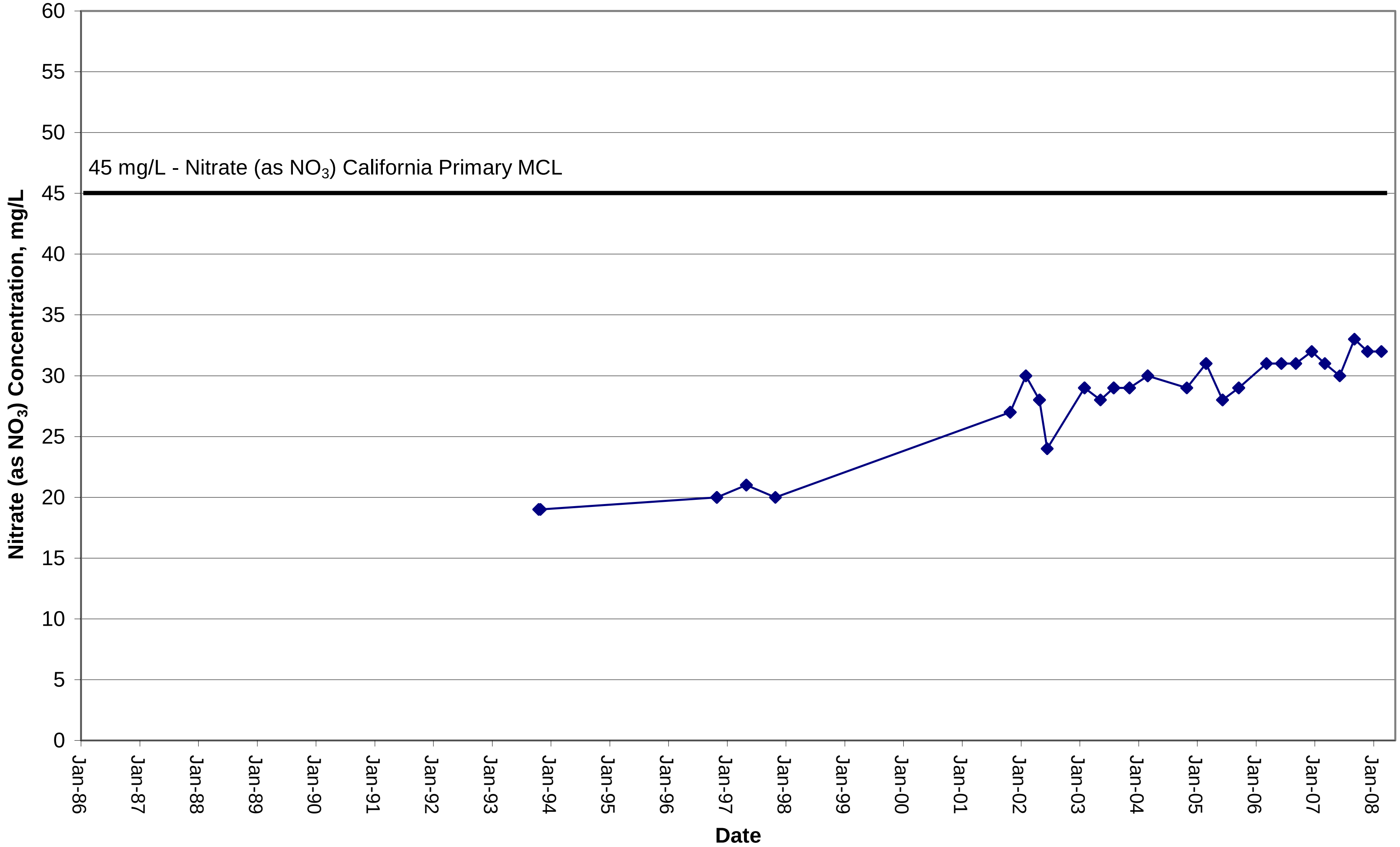

Figure F-1b

City of Woodland
Groundwater Management Plan

WELL #1 NITRATE CONCENTRATION OVER TIME

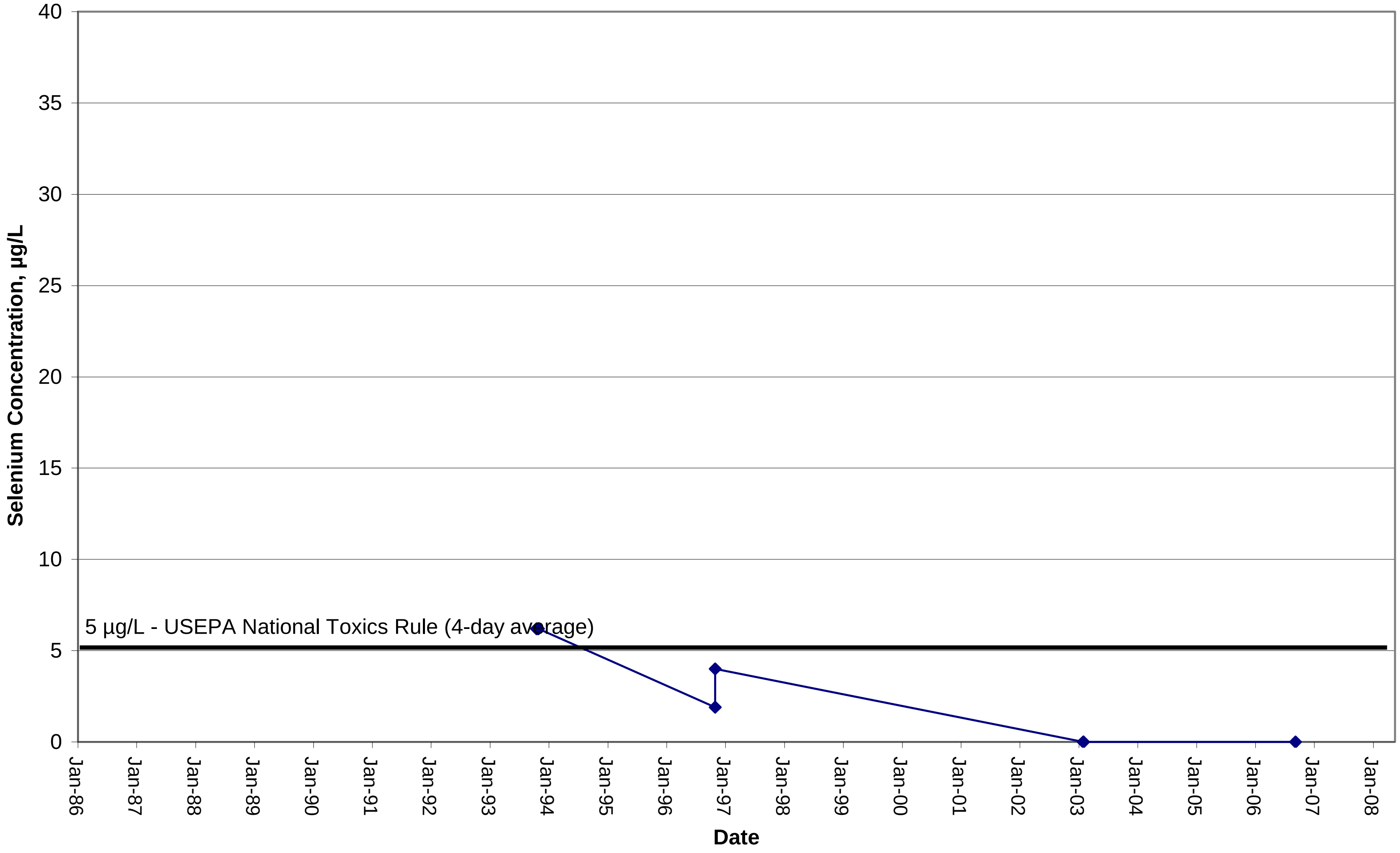

Figure F-1c

City of Woodland
Groundwater Management Plan

WELL #1 SELENIUM CONCENTRATION OVER TIME

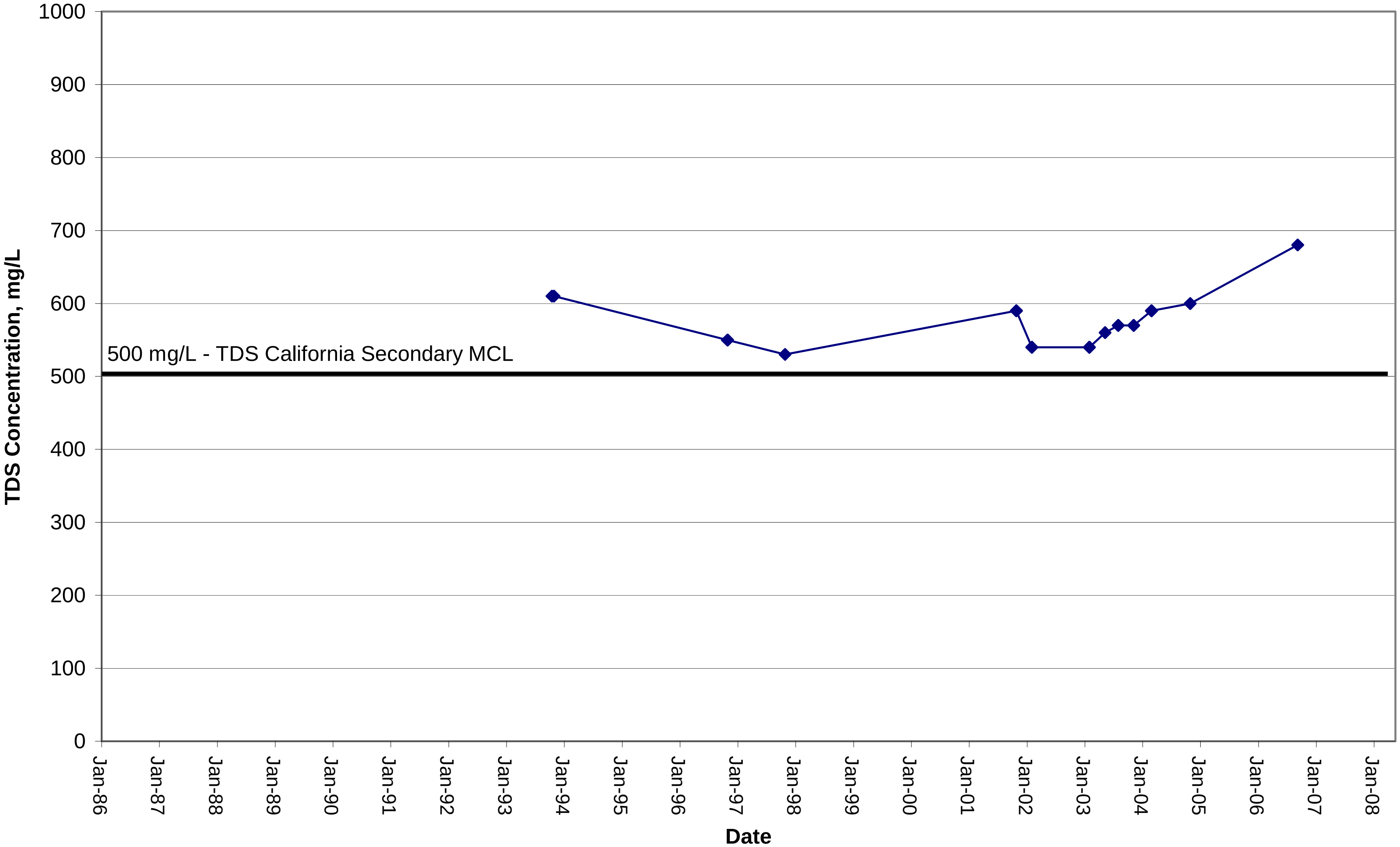

Figure F-1d

City of Woodland
Groundwater Management Plan

WELL #1 TDS CONCENTRATION OVER TIME

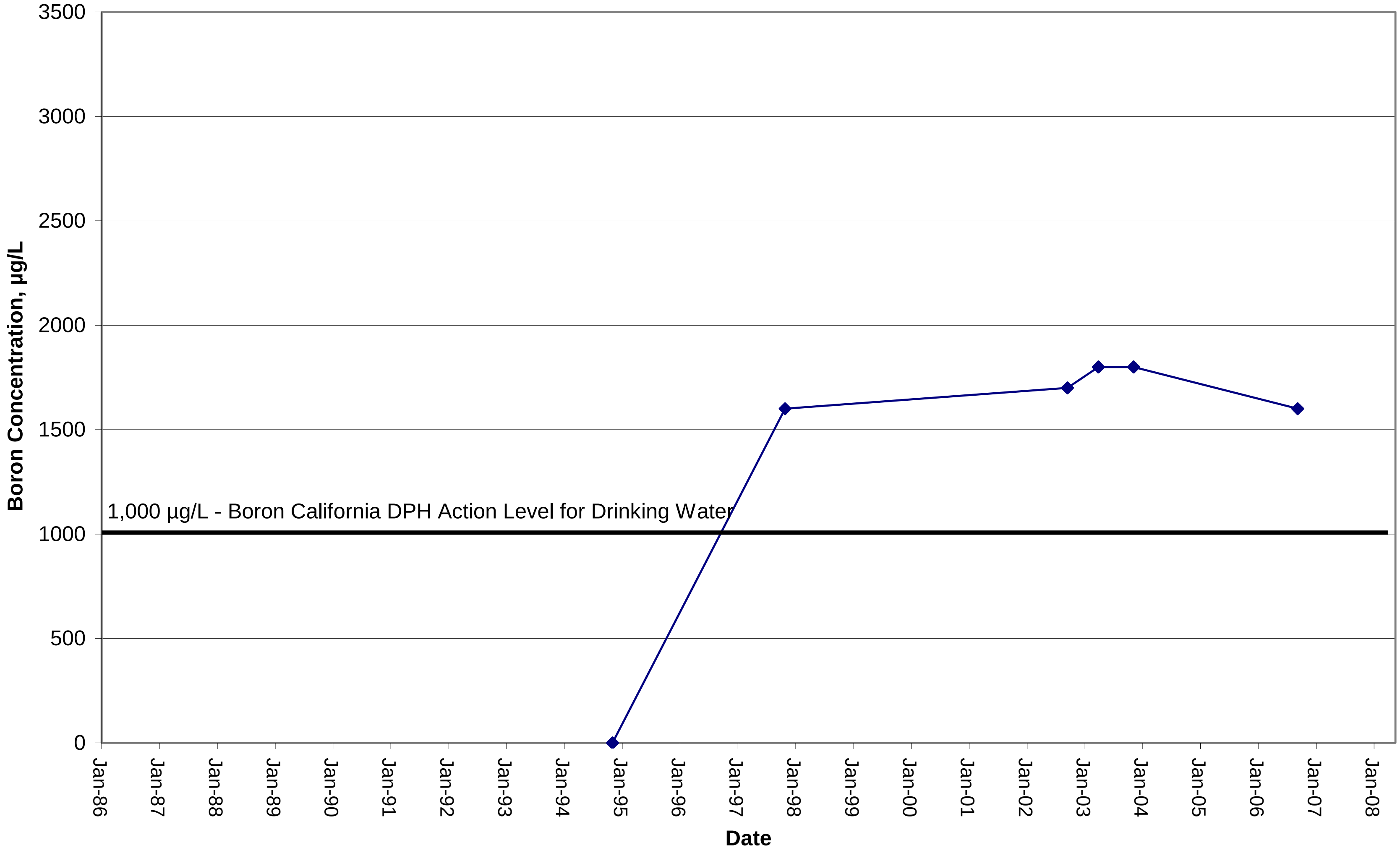

Figure F-2a

City of Woodland
Groundwater Management Plan

WELL #4 BORON CONCENTRATION OVER TIME

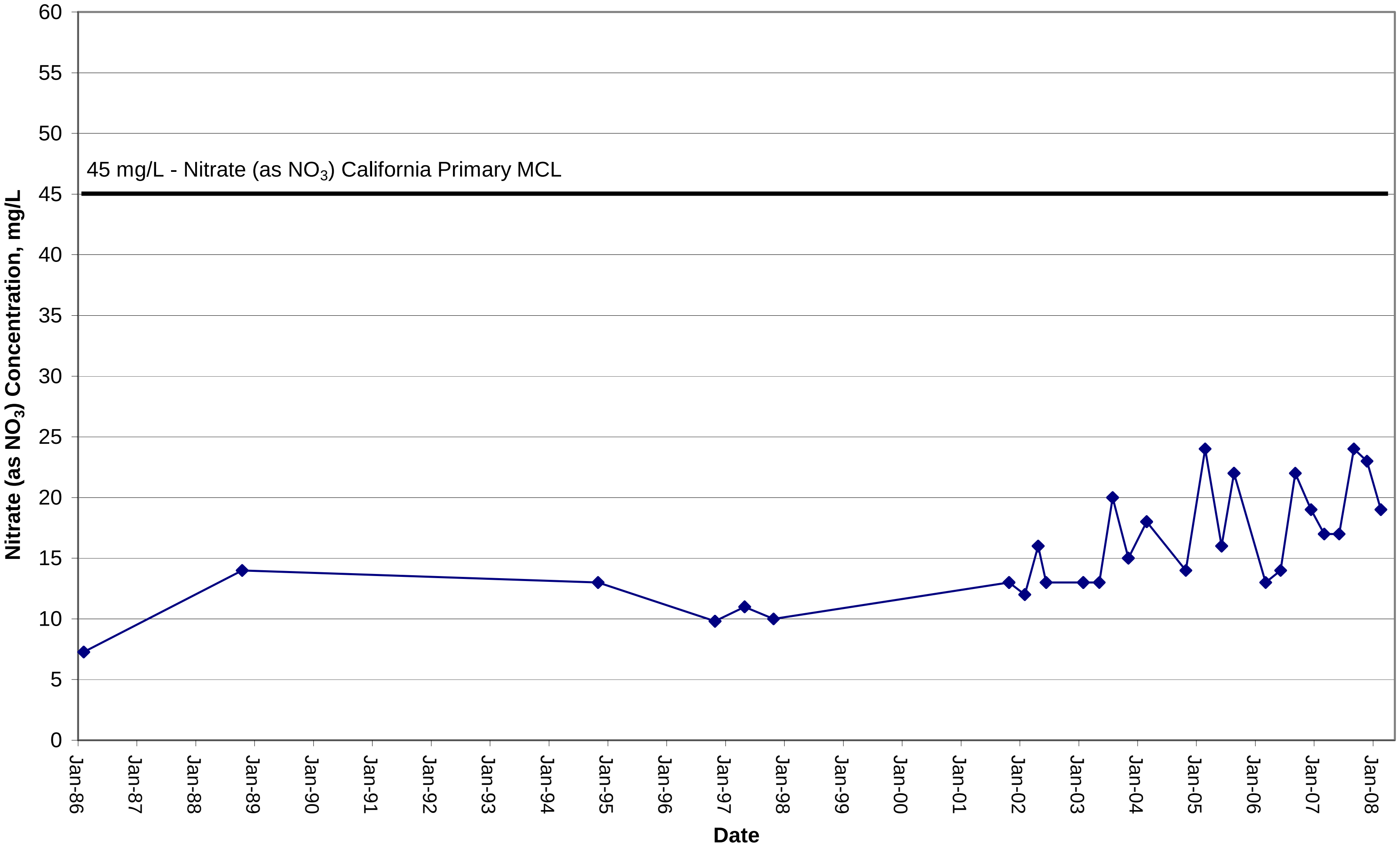

Figure F-2b

City of Woodland
Groundwater Management Plan

WELL #4 NITRATE CONCENTRATION OVER TIME

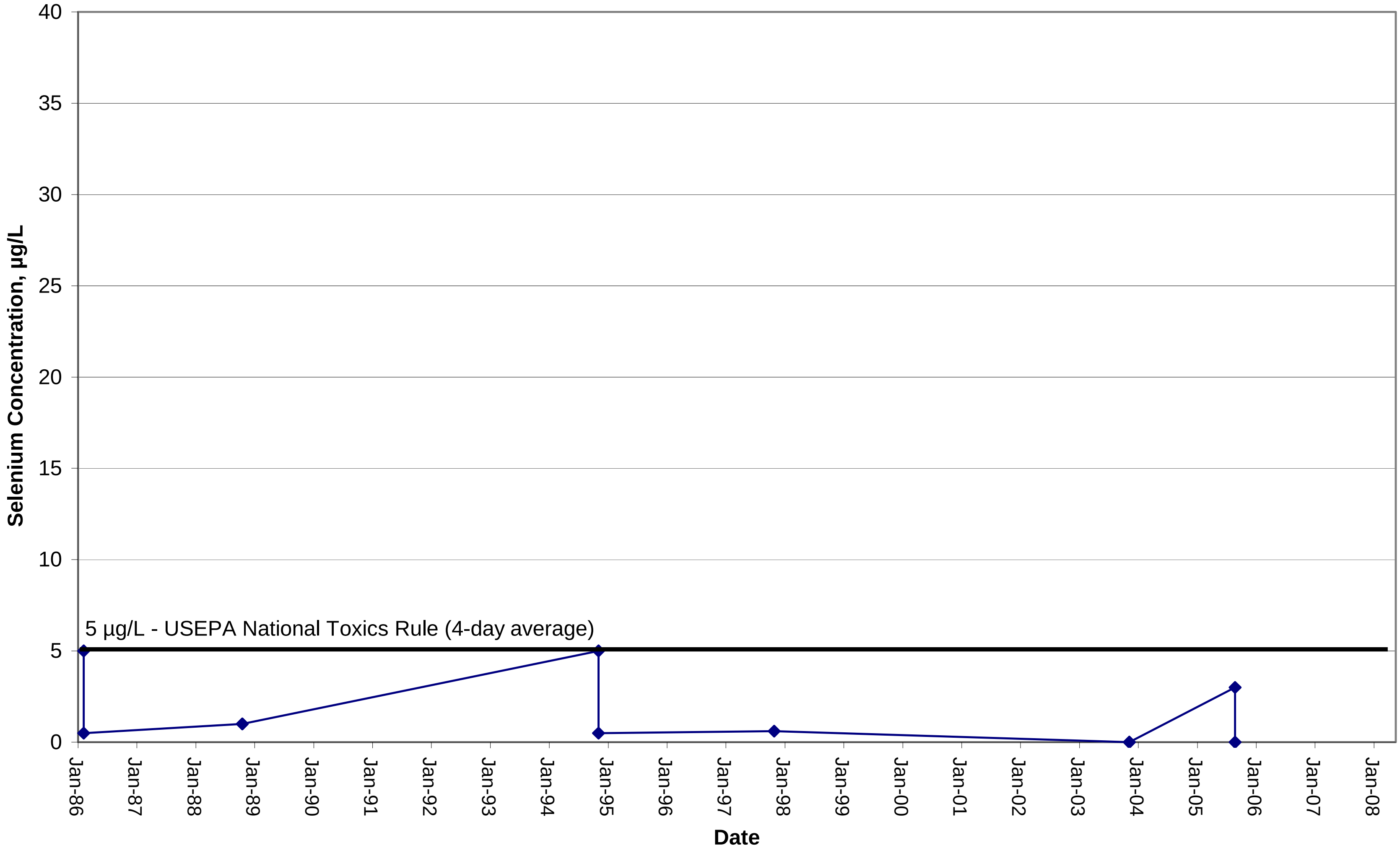

Figure F-2c

City of Woodland
Groundwater Management Plan

WELL #4 SELENIUM CONCENTRATION OVER TIME

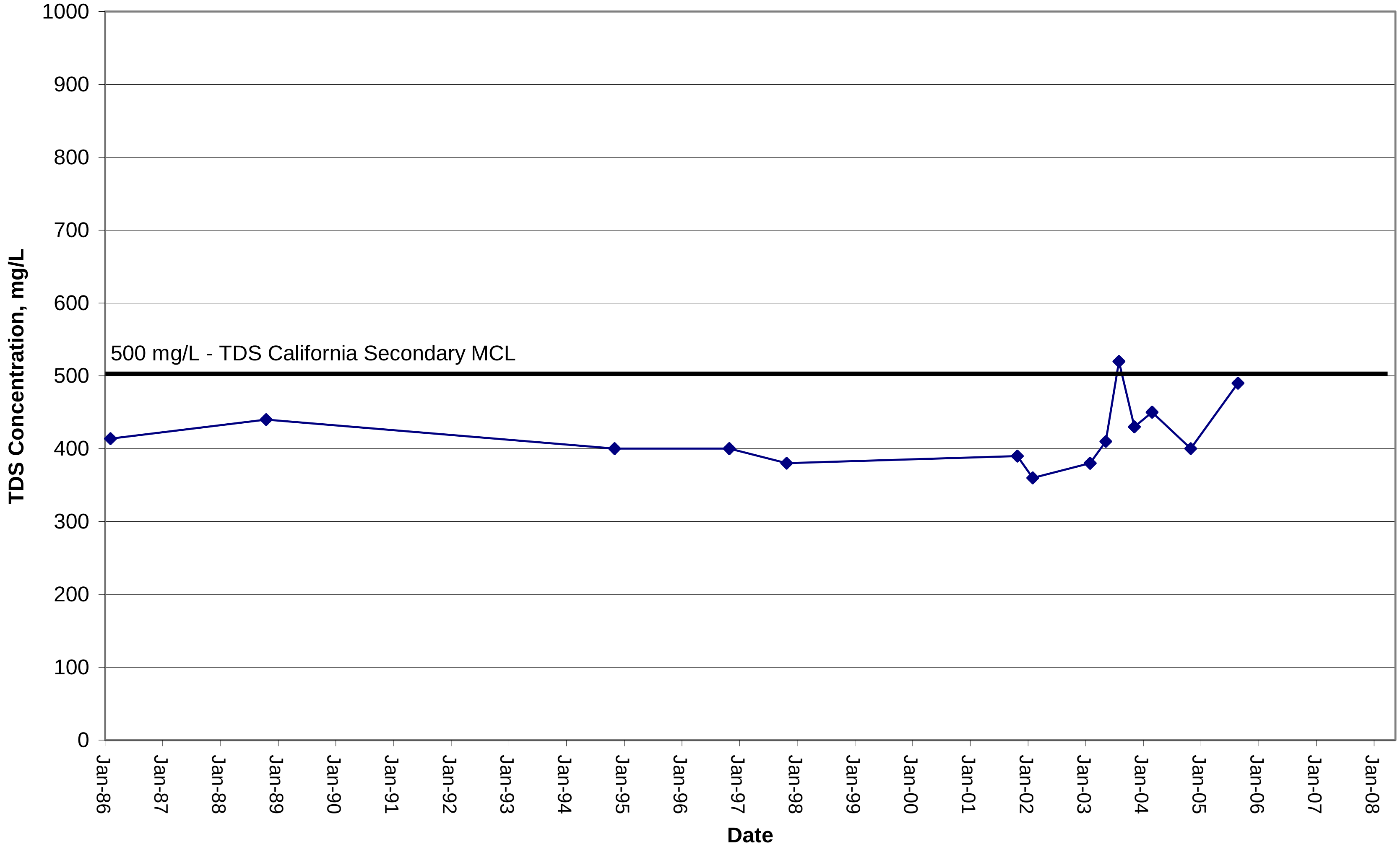

Figure F-2d

City of Woodland
Groundwater Management Plan

WELL #4 TDS CONCENTRATION OVER TIME

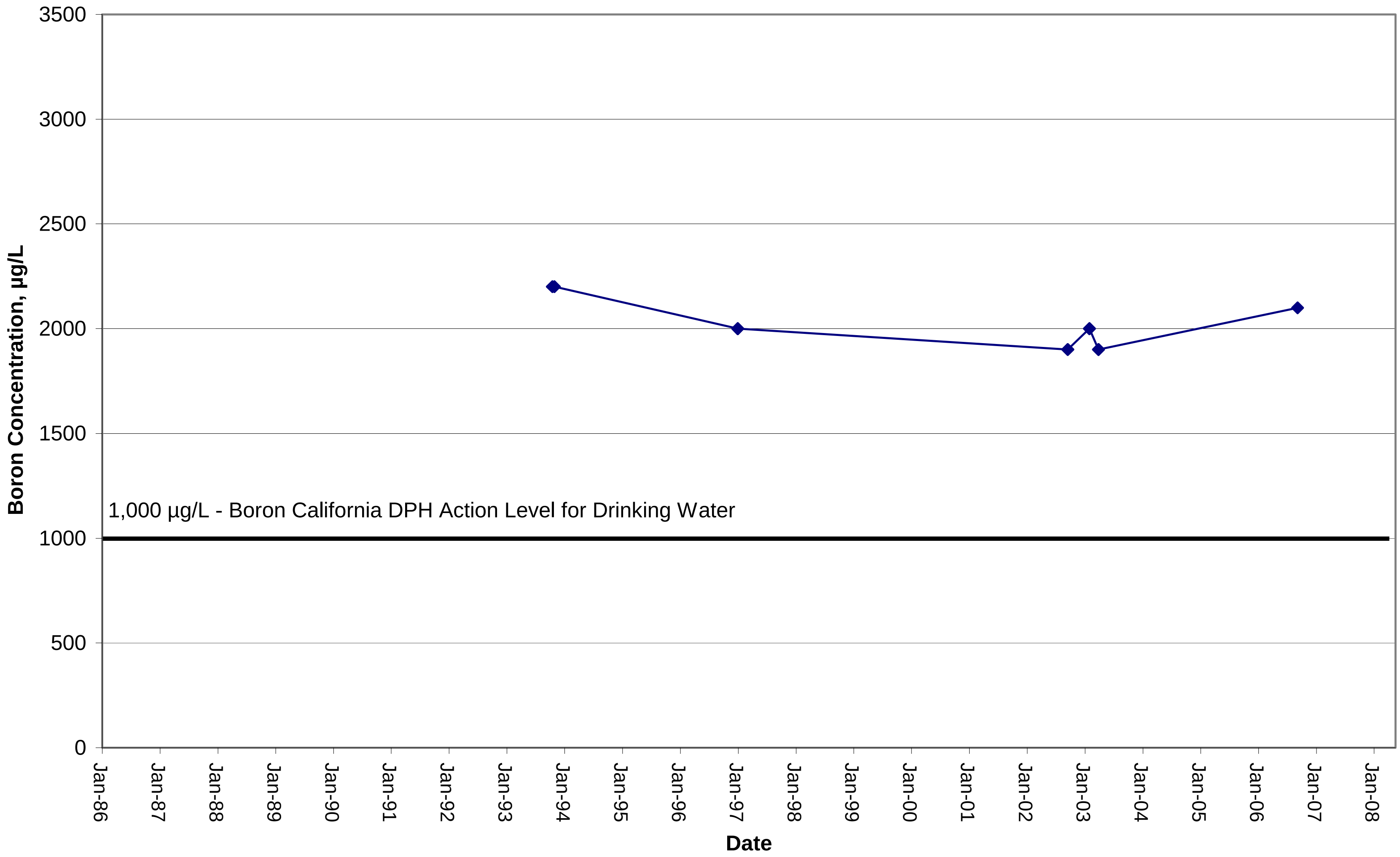

Figure F-3a

City of Woodland
Groundwater Management Plan

WELL #5 BORON CONCENTRATION OVER TIME

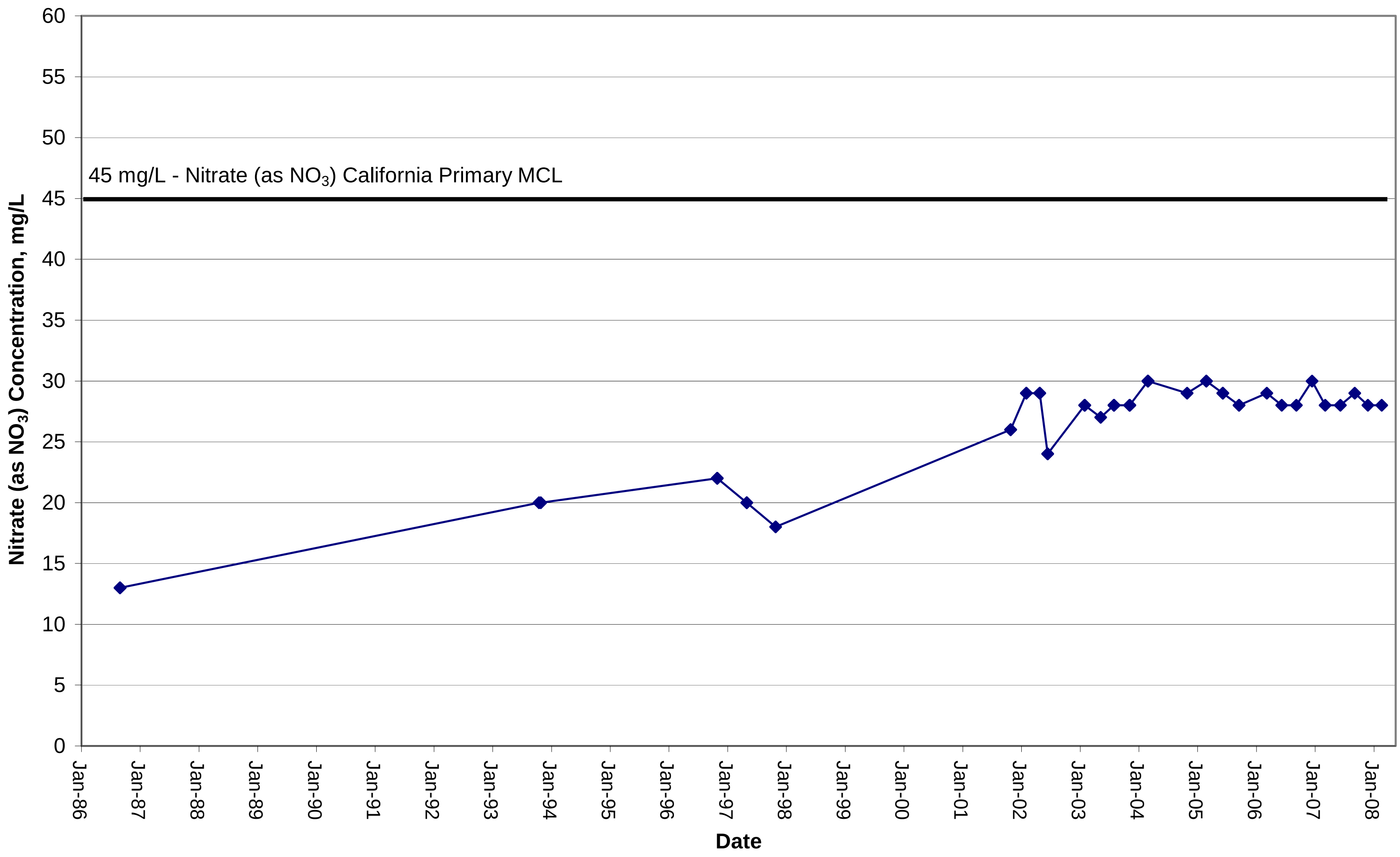

Figure F-3b

City of Woodland
Groundwater Management Plan

WELL #5 NITRATE CONCENTRATION OVER TIME

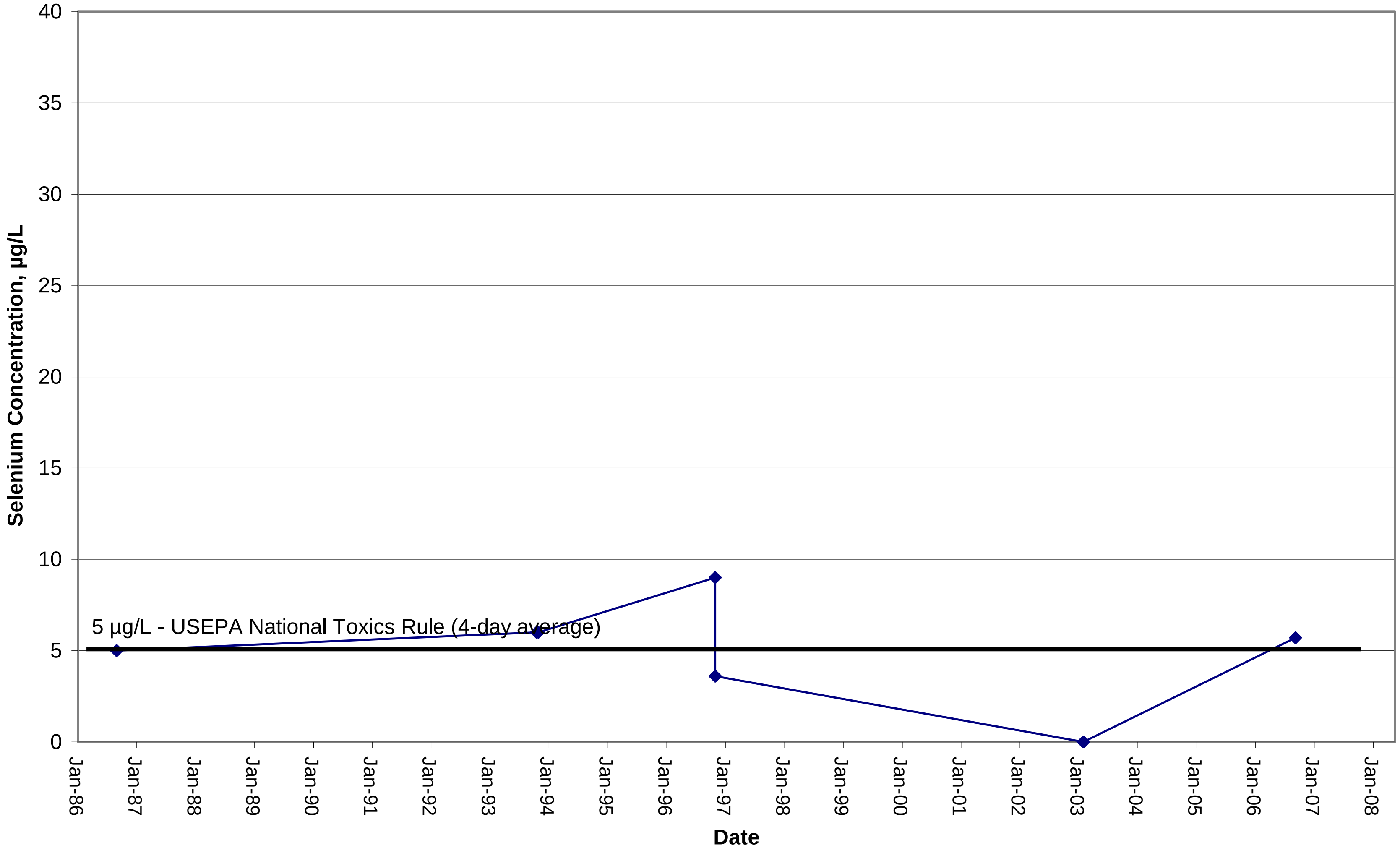

Figure F-3c

City of Woodland
Groundwater Management Plan

WELL #5 SELENIUM CONCENTRATION OVER TIME

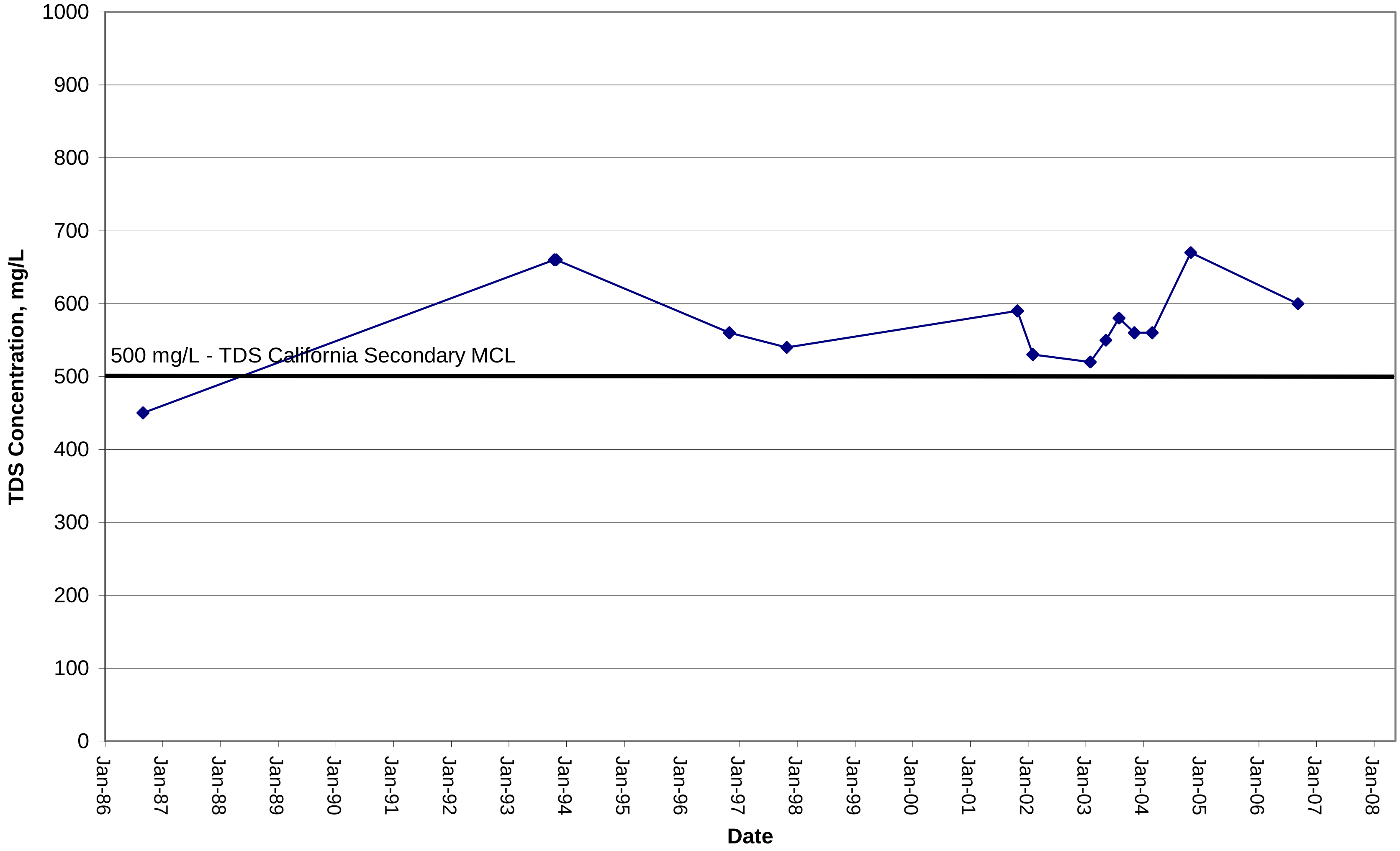

Figure F-3d

City of Woodland
Groundwater Management Plan

WELL #5 TDS CONCENTRATION OVER TIME

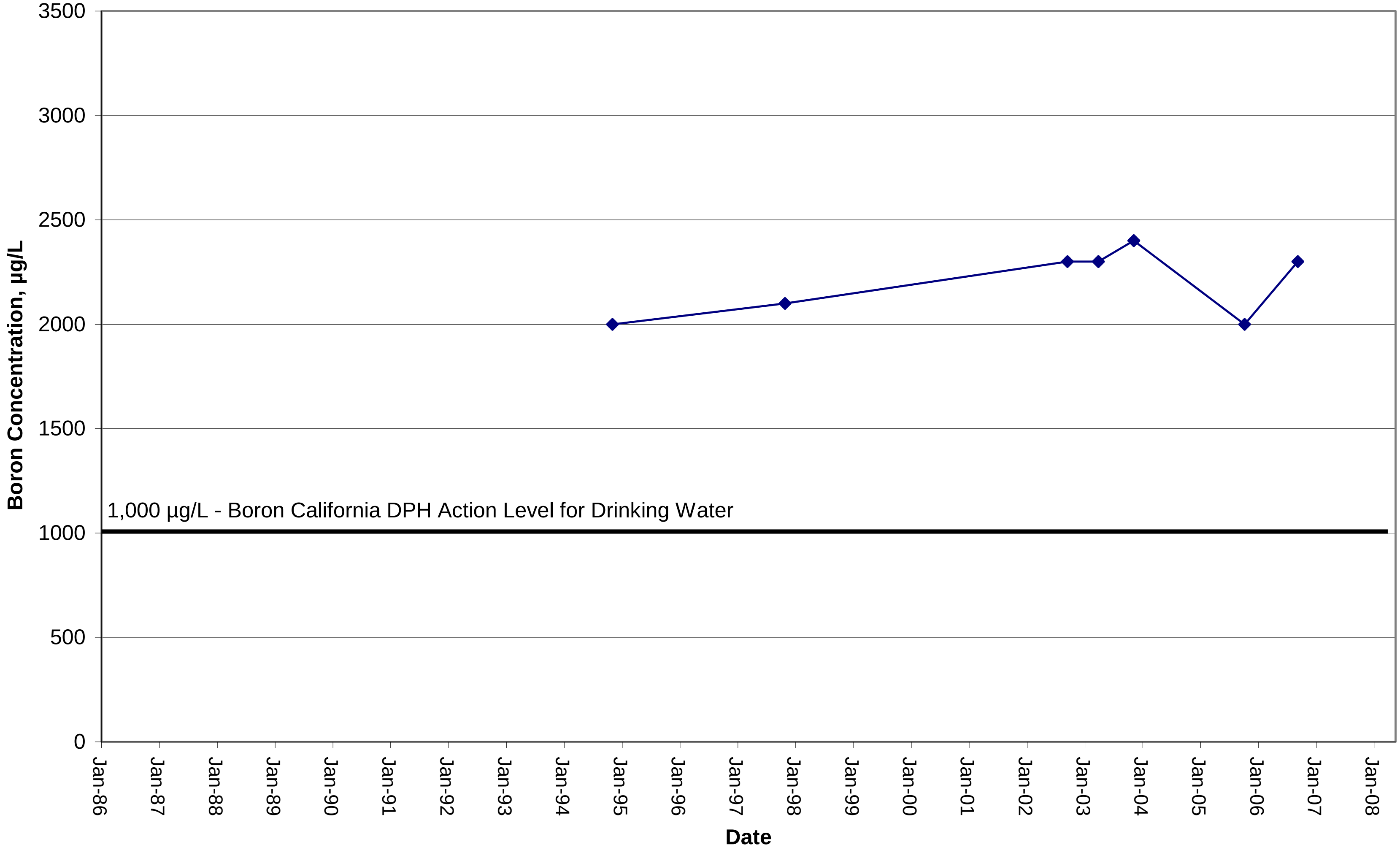

Figure F-4a

City of Woodland
Groundwater Management Plan

WELL #6 BORON CONCENTRATION OVER TIME

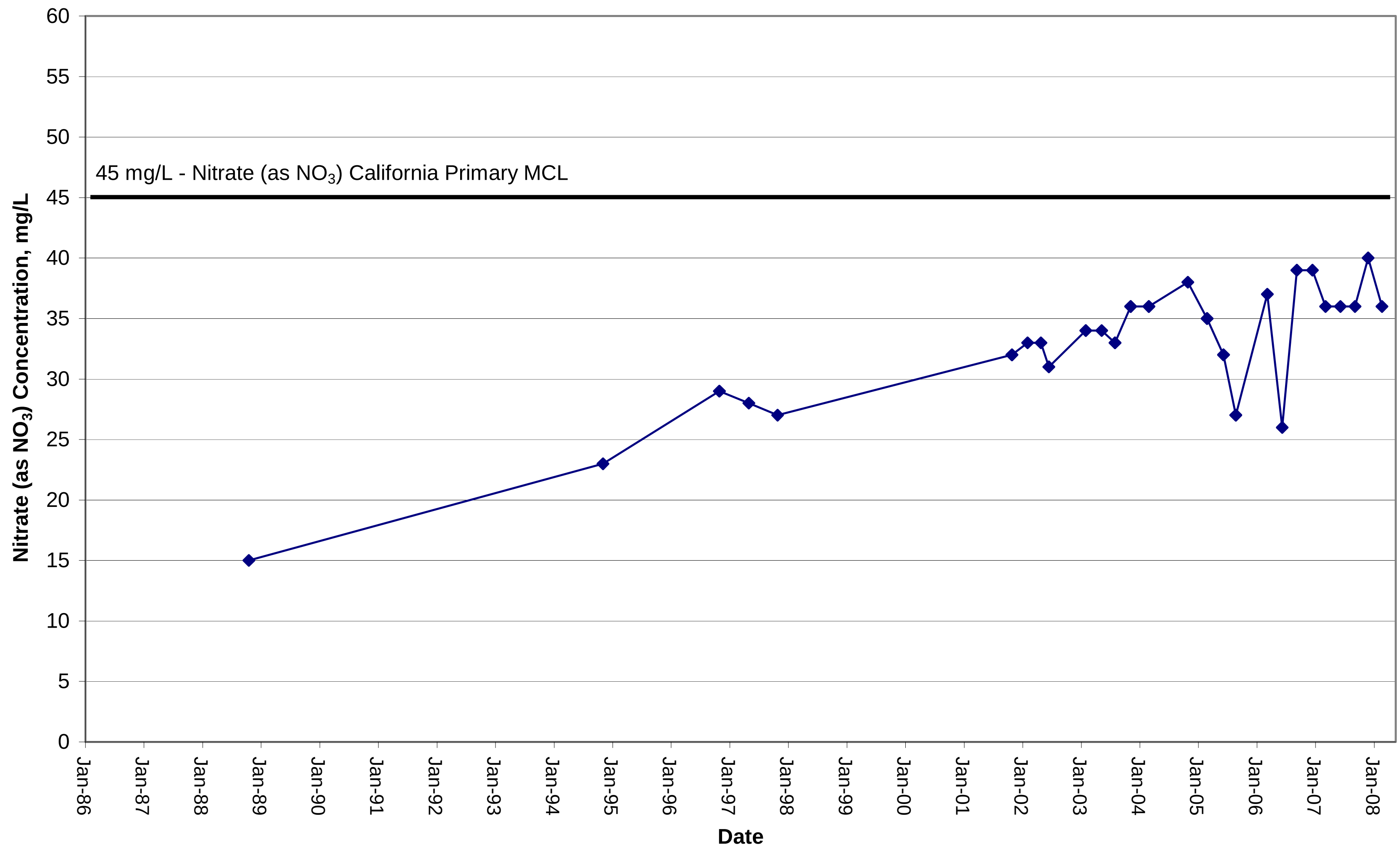

Figure F-4b

City of Woodland
Groundwater Management Plan

WELL #6 NITRATE CONCENTRATION OVER TIME

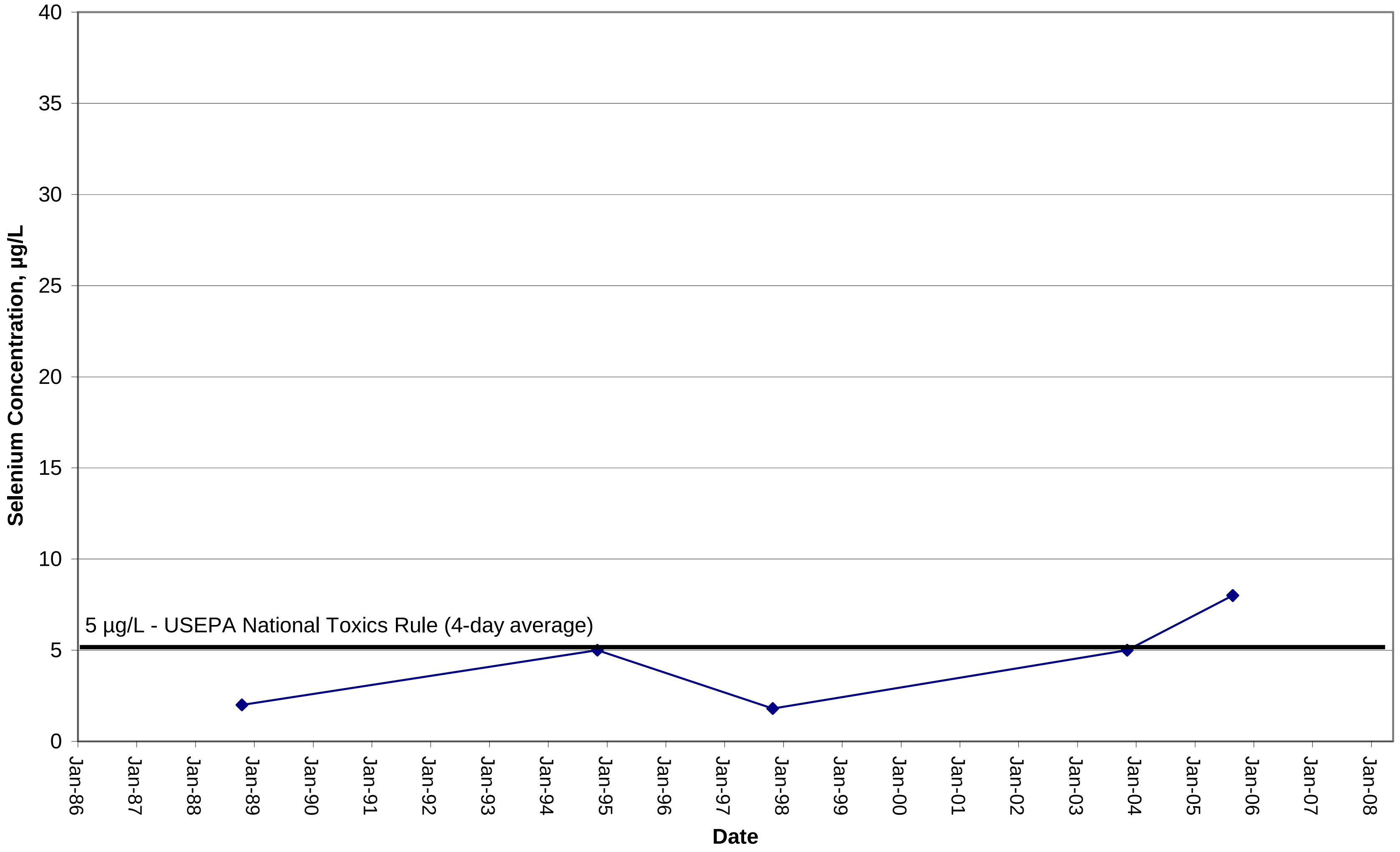

Figure F-4c

City of Woodland
Groundwater Management Plan

WELL #6 SELENIUM CONCENTRATION OVER TIME

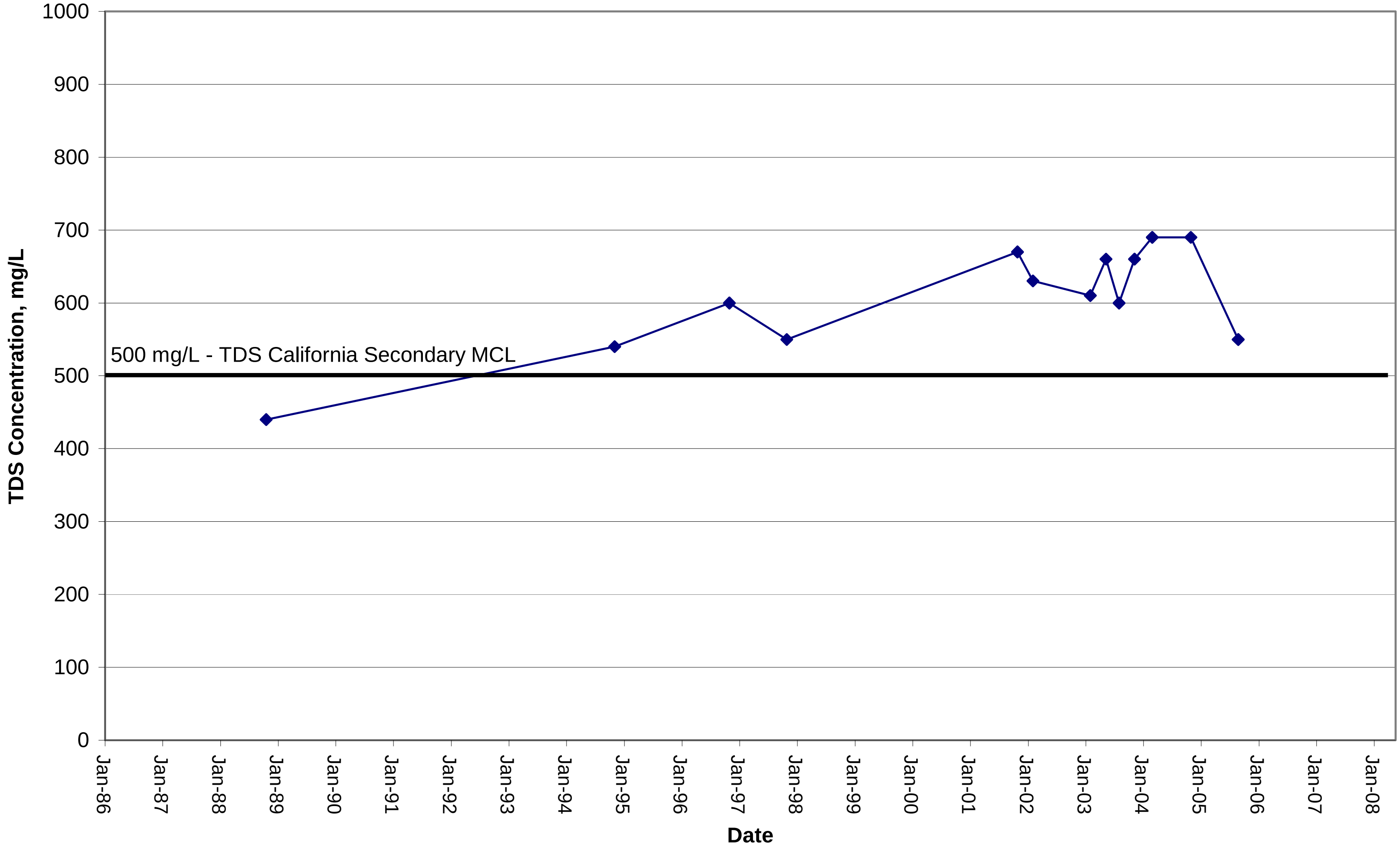

Figure F-4d

City of Woodland
Groundwater Management Plan

WELL #6 TDS CONCENTRATION OVER TIME

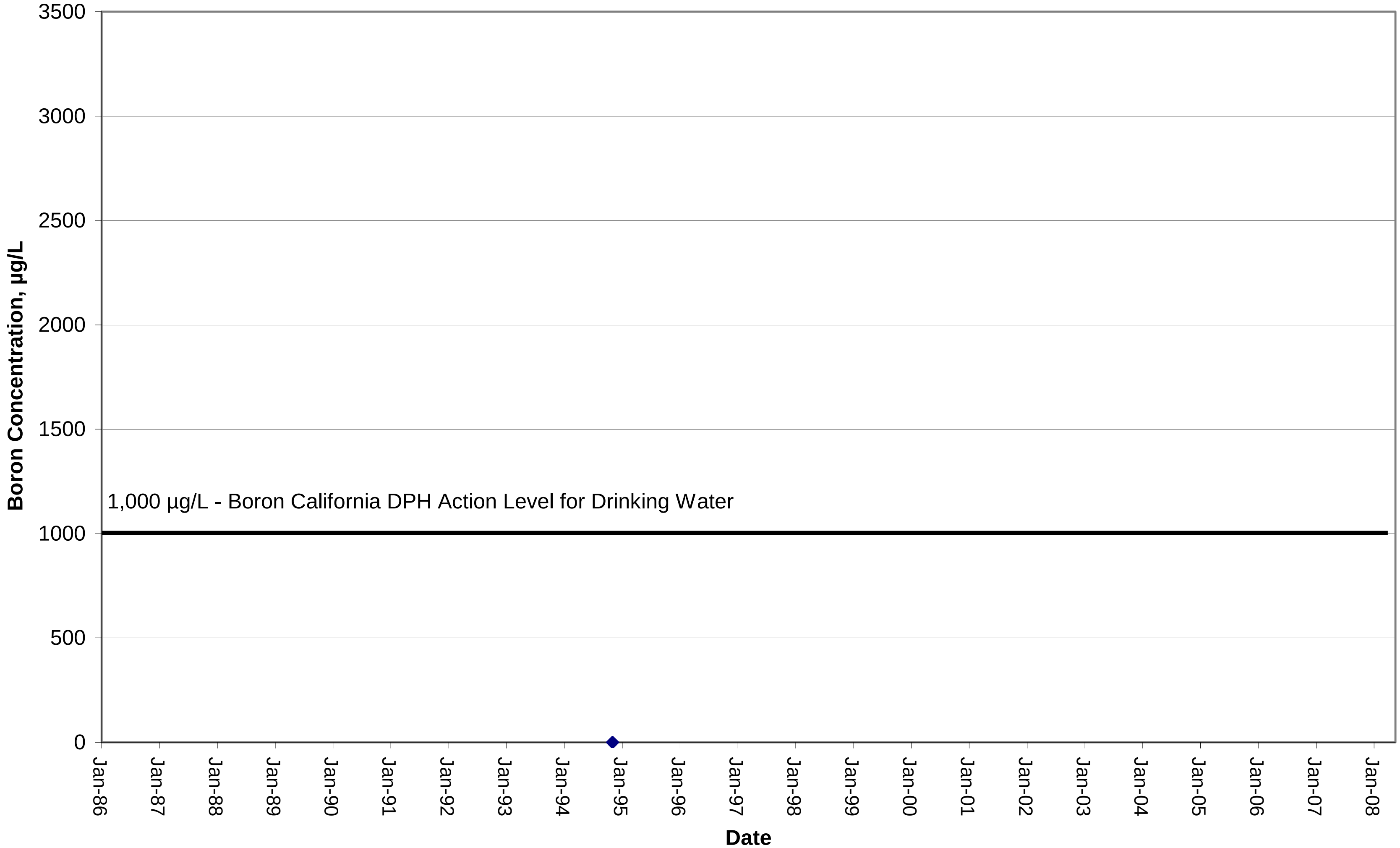

Figure F-5a

City of Woodland
Groundwater Management Plan

WELL #7 BORON CONCENTRATION OVER TIME

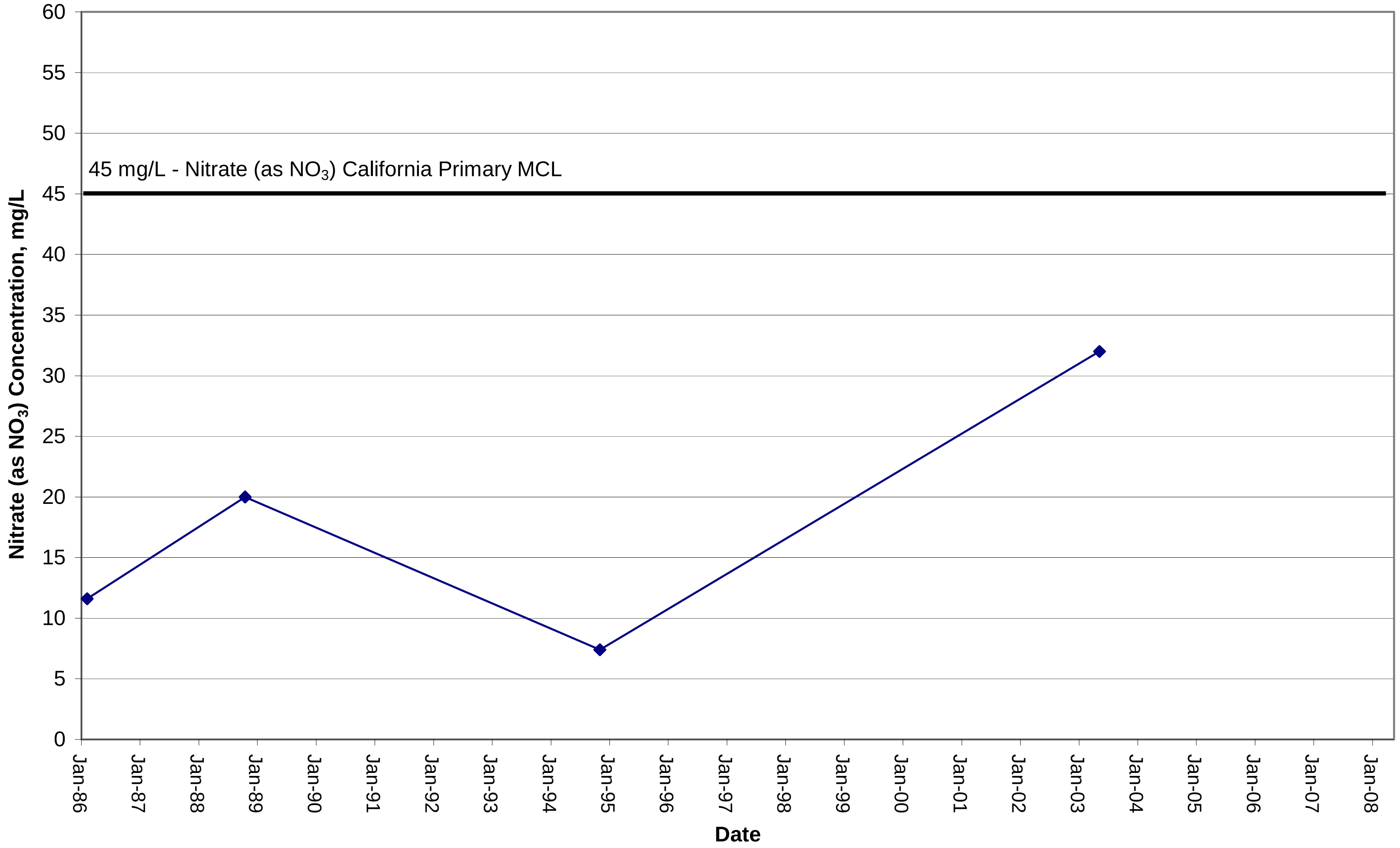

Figure F-5b

City of Woodland
Groundwater Management Plan

WELL #7 NITRATE CONCENTRATION OVER TIME

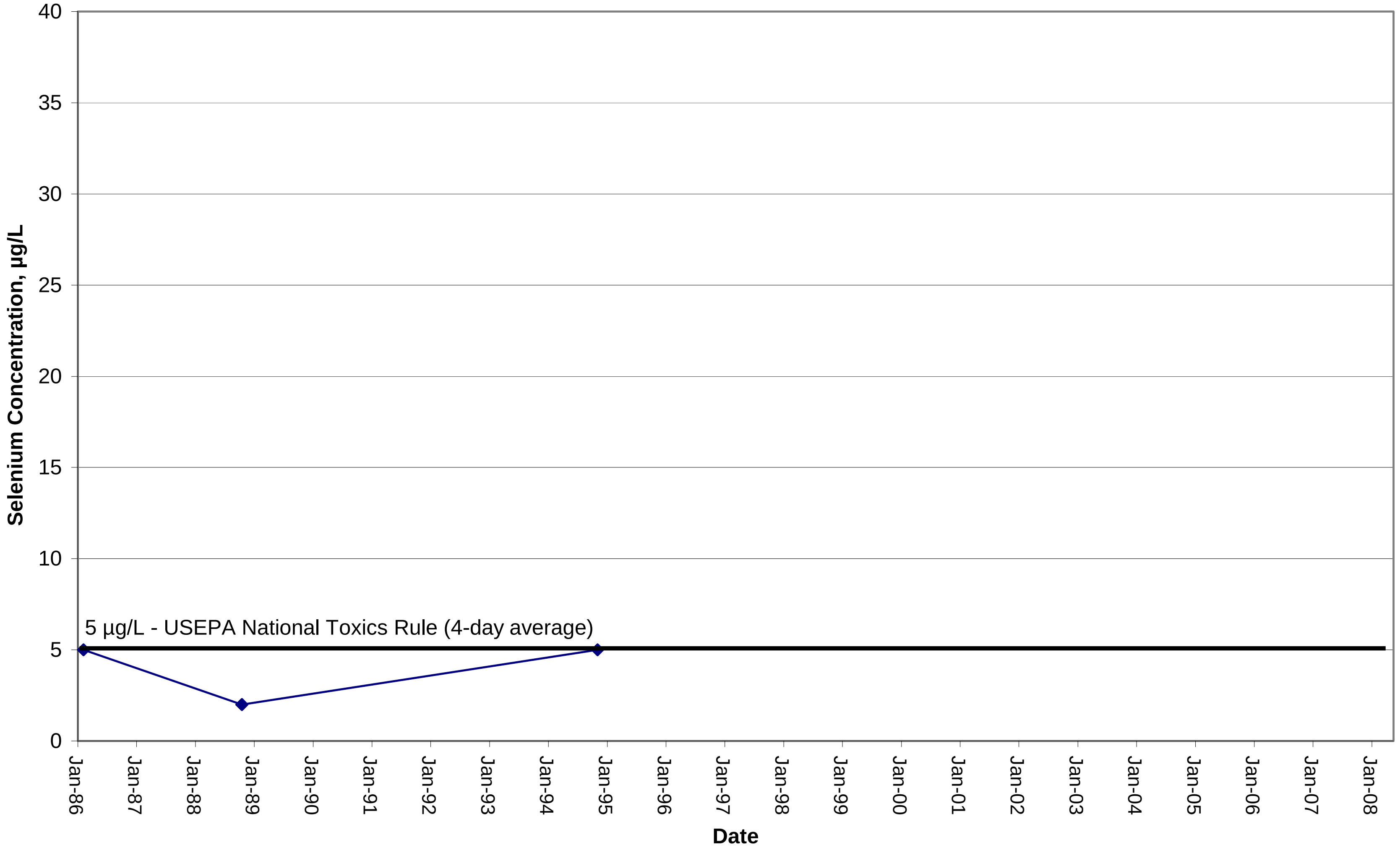

Figure F-5c

City of Woodland
Groundwater Management Plan

WELL #7 SELENIUM CONCENTRATION OVER TIME

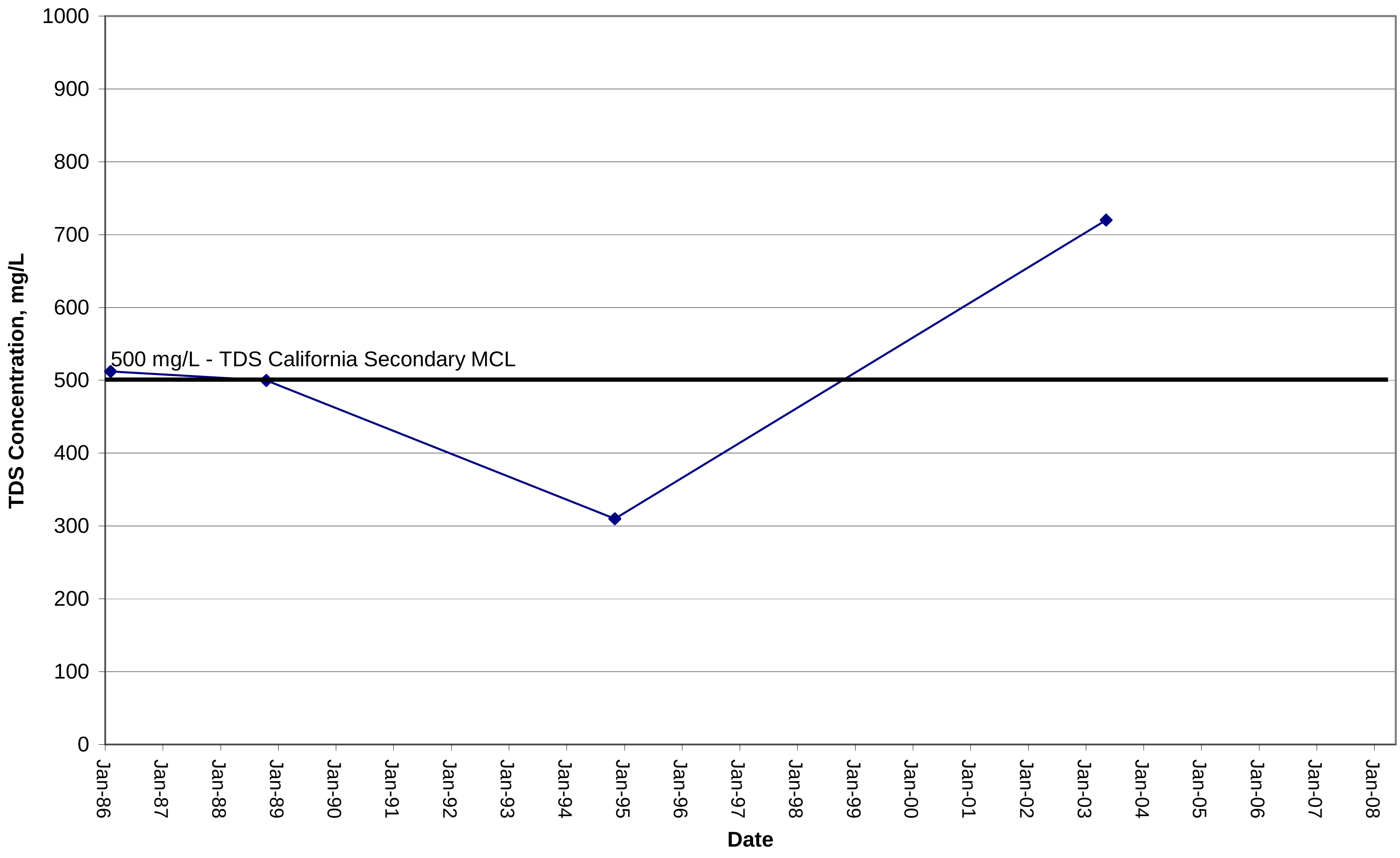

Figure F-5d

City of Woodland
Groundwater Management Plan

WELL #7 TDS CONCENTRATION OVER TIME

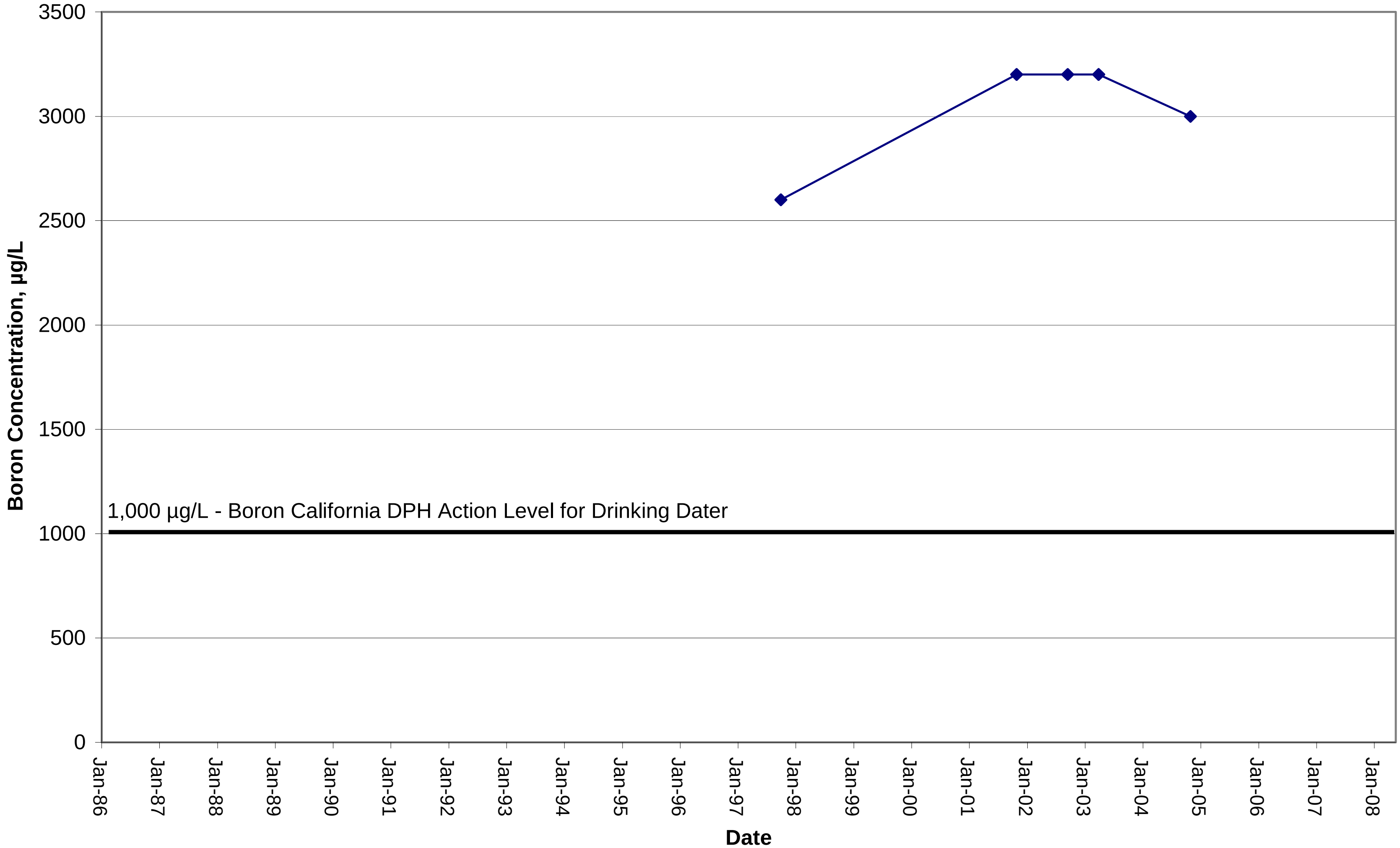

Figure F-6a

City of Woodland
Groundwater Management Plan

WELL #9 BORON CONCENTRATION OVER TIME

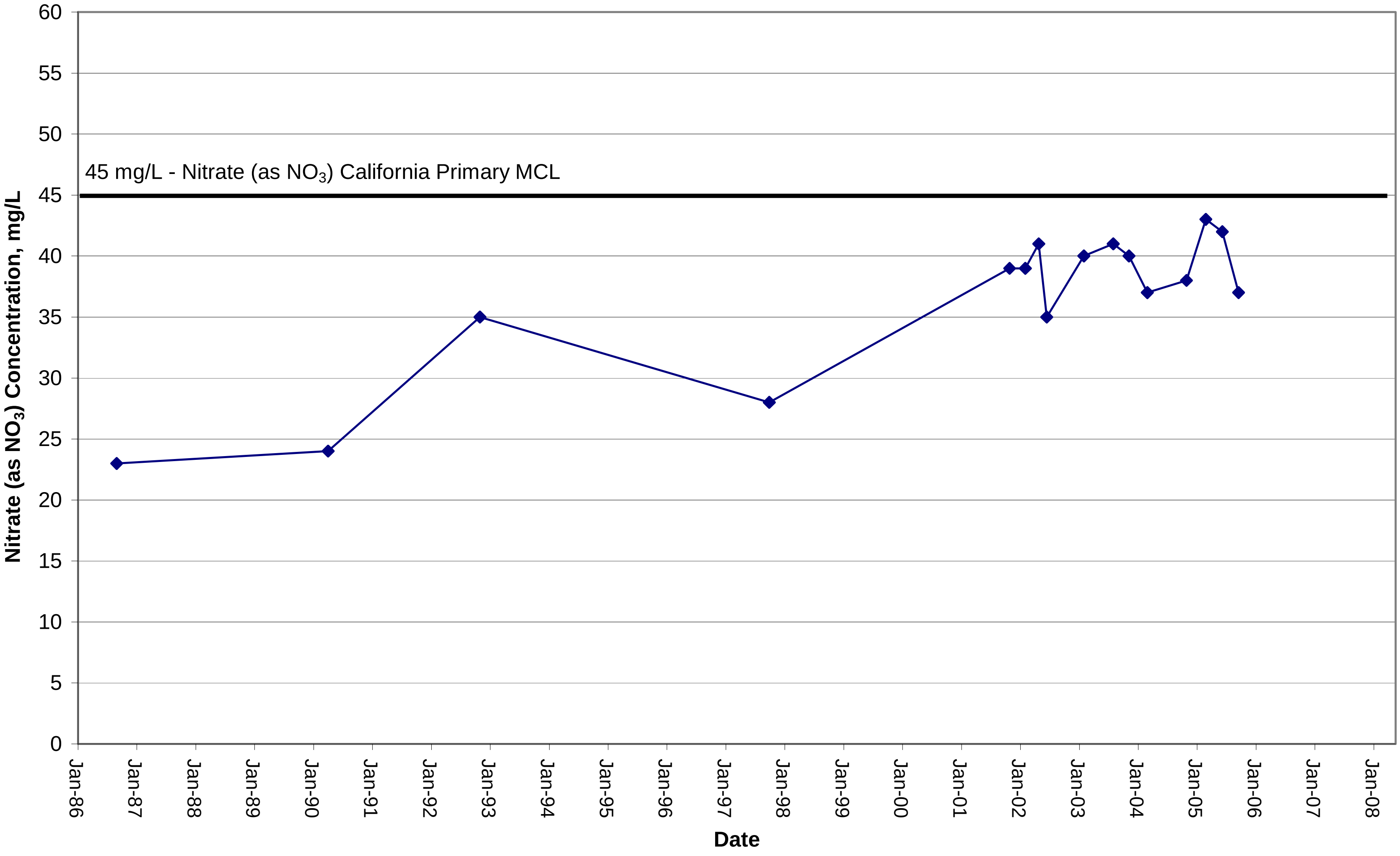

Figure F-6b

City of Woodland
Groundwater Management Plan

WELL #9 NITRATE CONCENTRATION OVER TIME

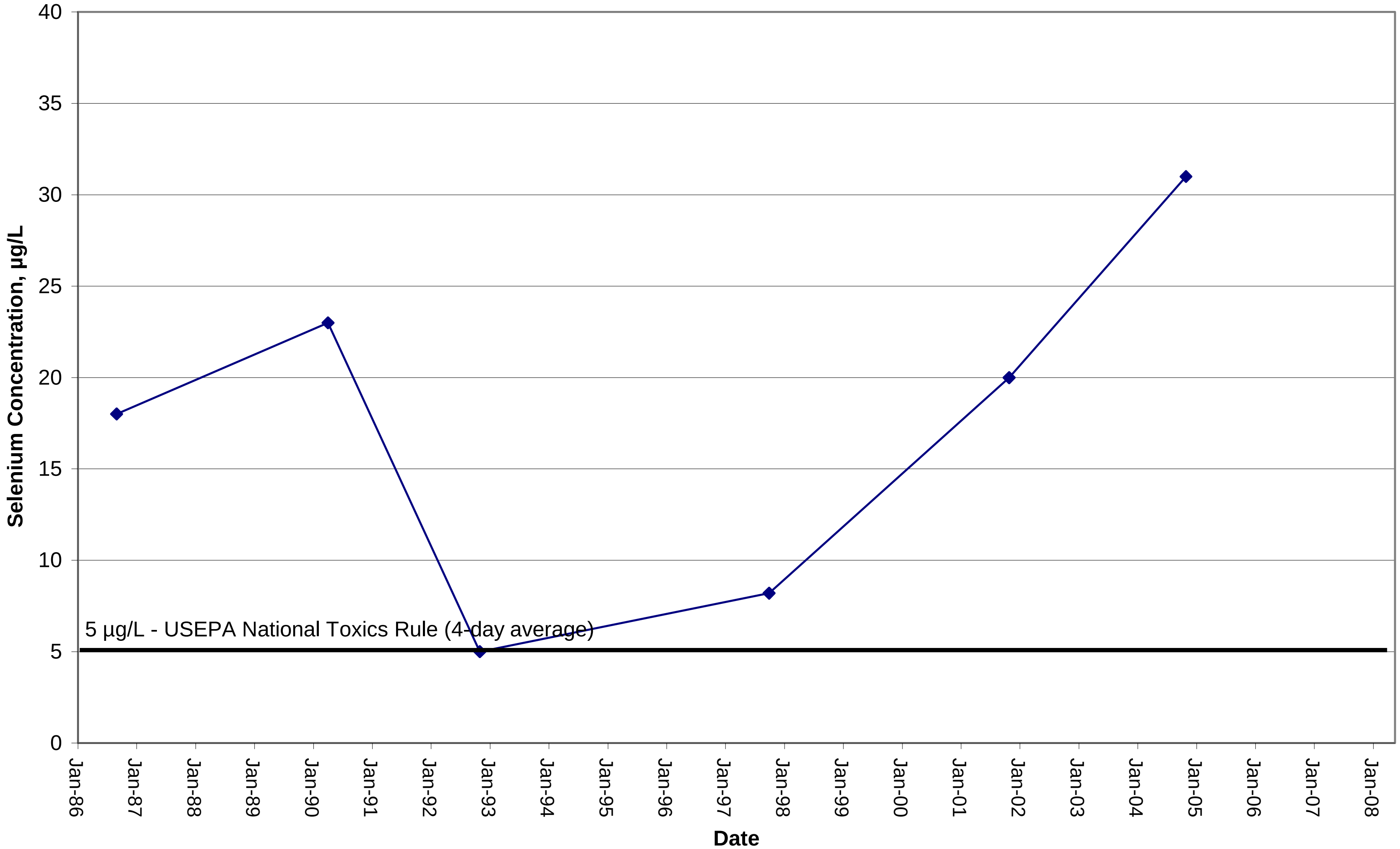

Figure F-6c

City of Woodland
Groundwater Management Plan

WELL #9 SELENIUM CONCENTRATION OVER TIME

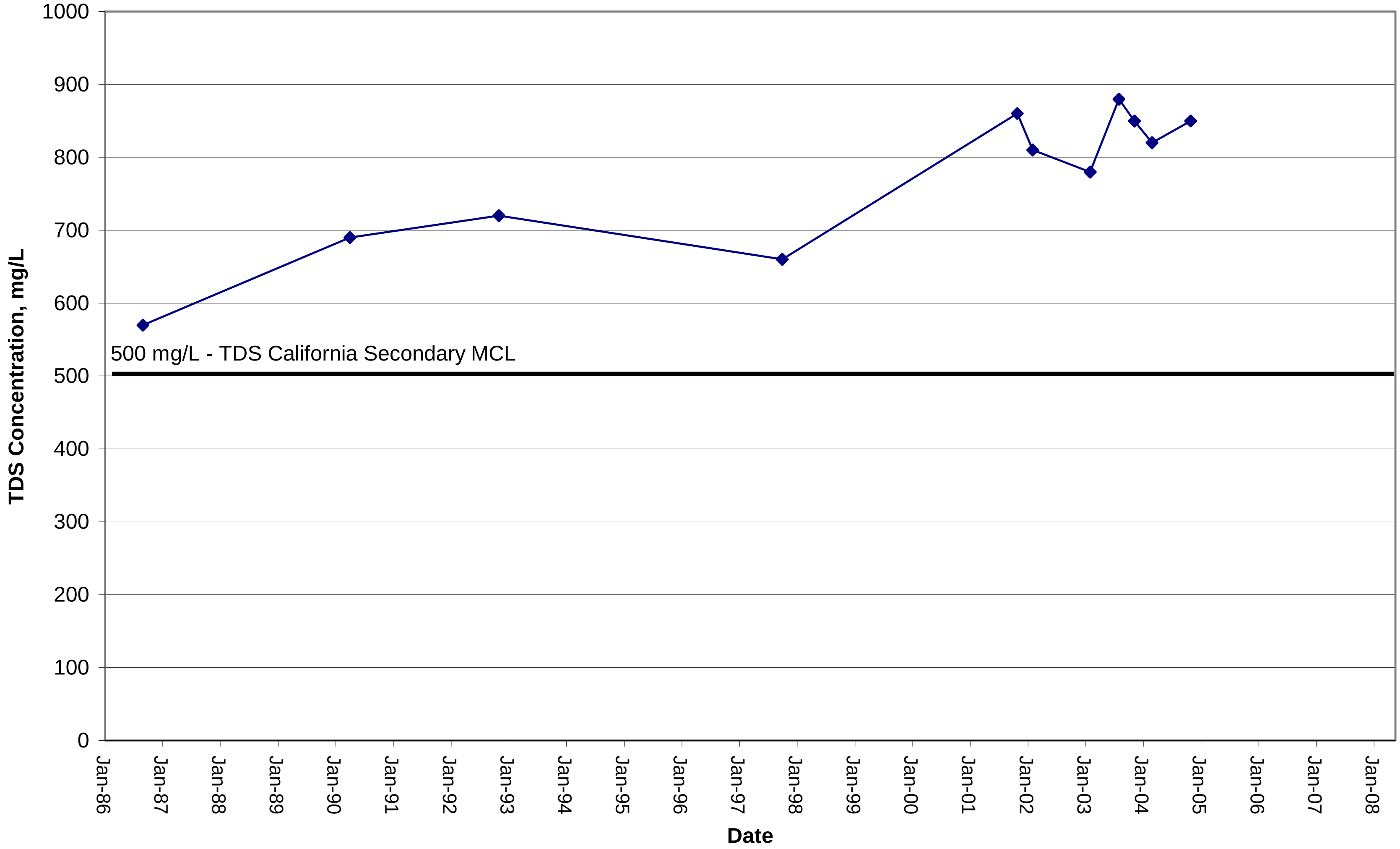

Figure F-6d

City of Woodland
Groundwater Management Plan

WELL #9 TDS CONCENTRATION OVER TIME

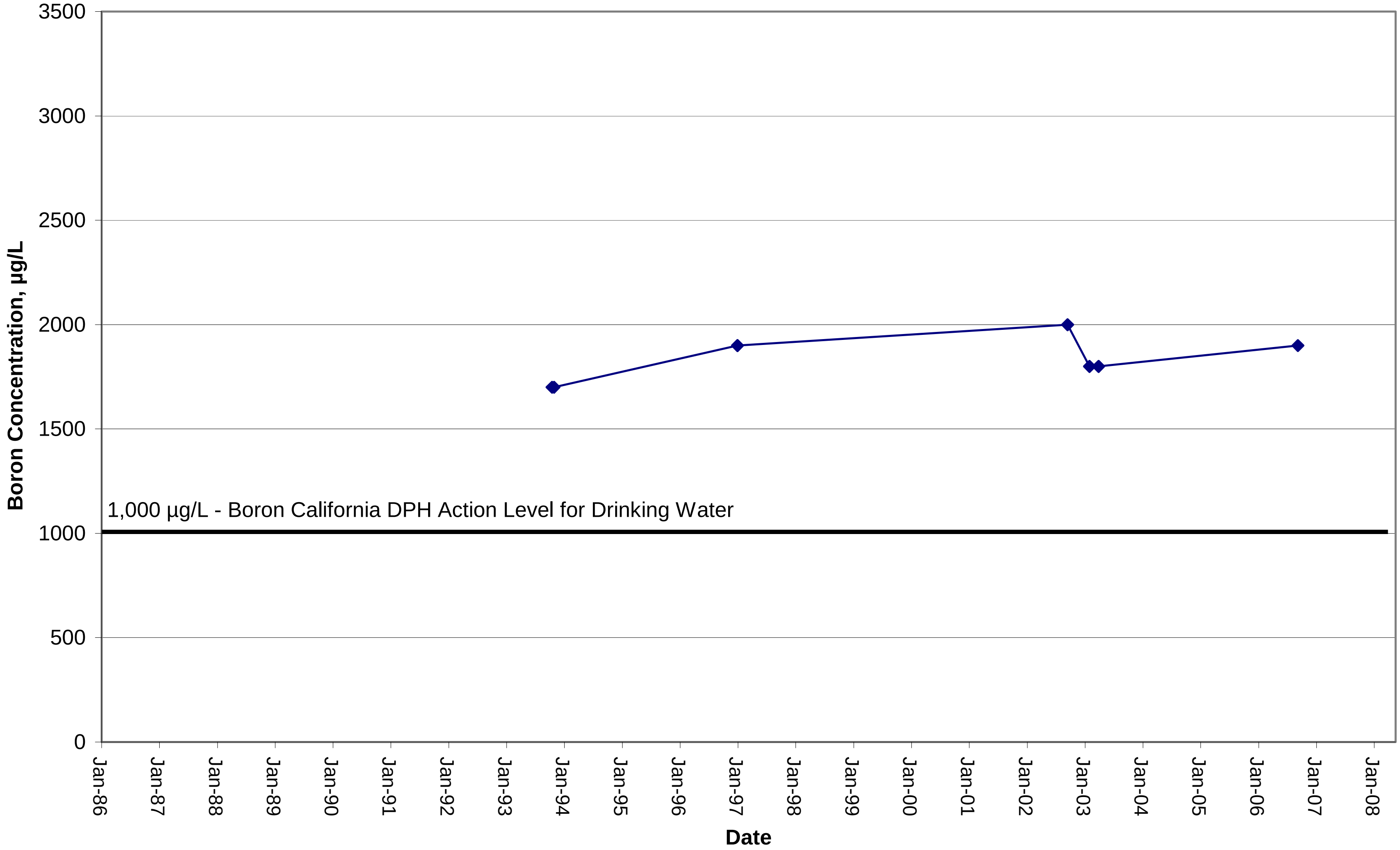

Figure F-7a

City of Woodland
Groundwater Management Plan

WELL #10 BORON CONCENTRATION OVER TIME

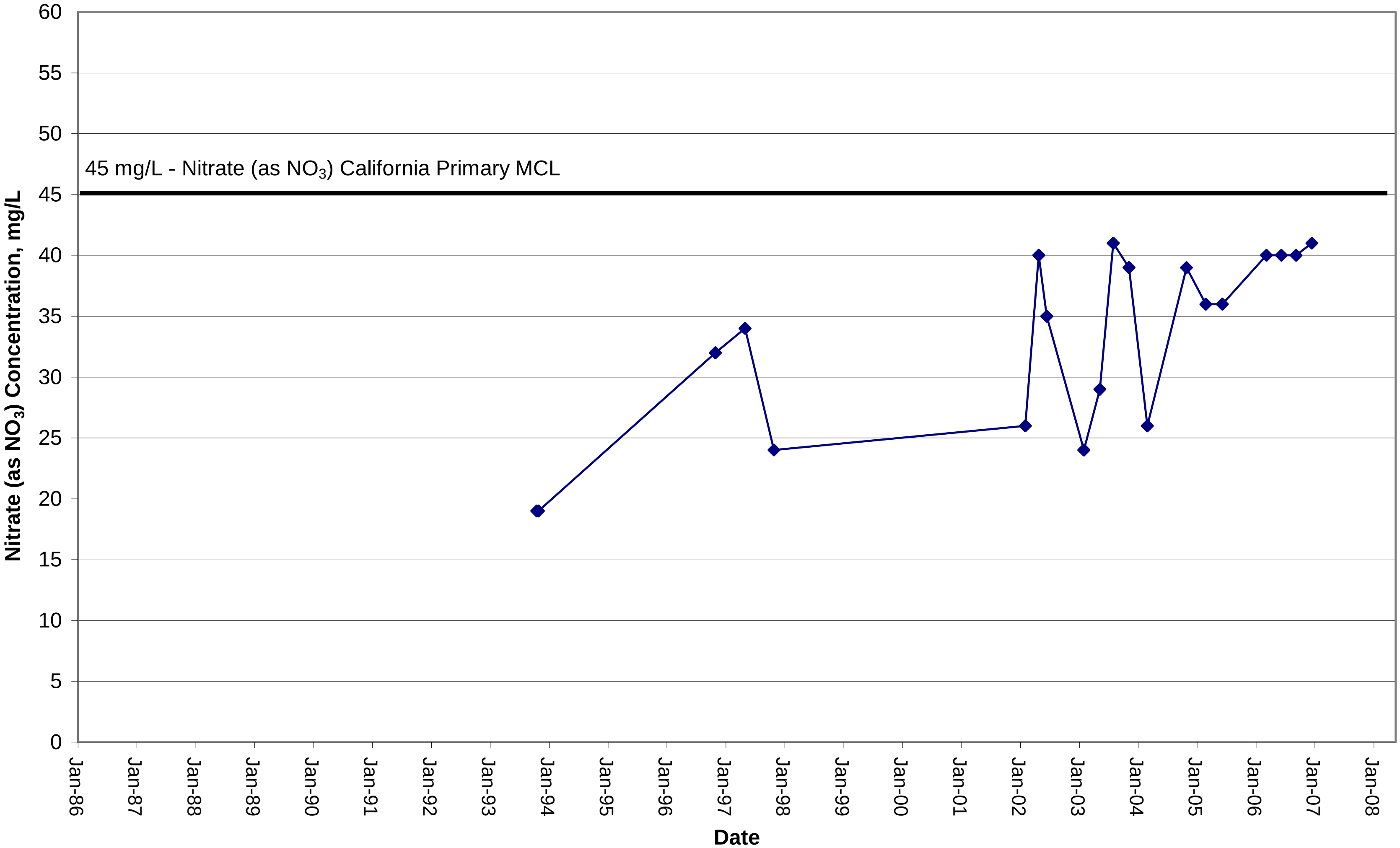

Figure F-7b

City of Woodland
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WELL #10 NITRATE CONCENTRATION OVER TIME

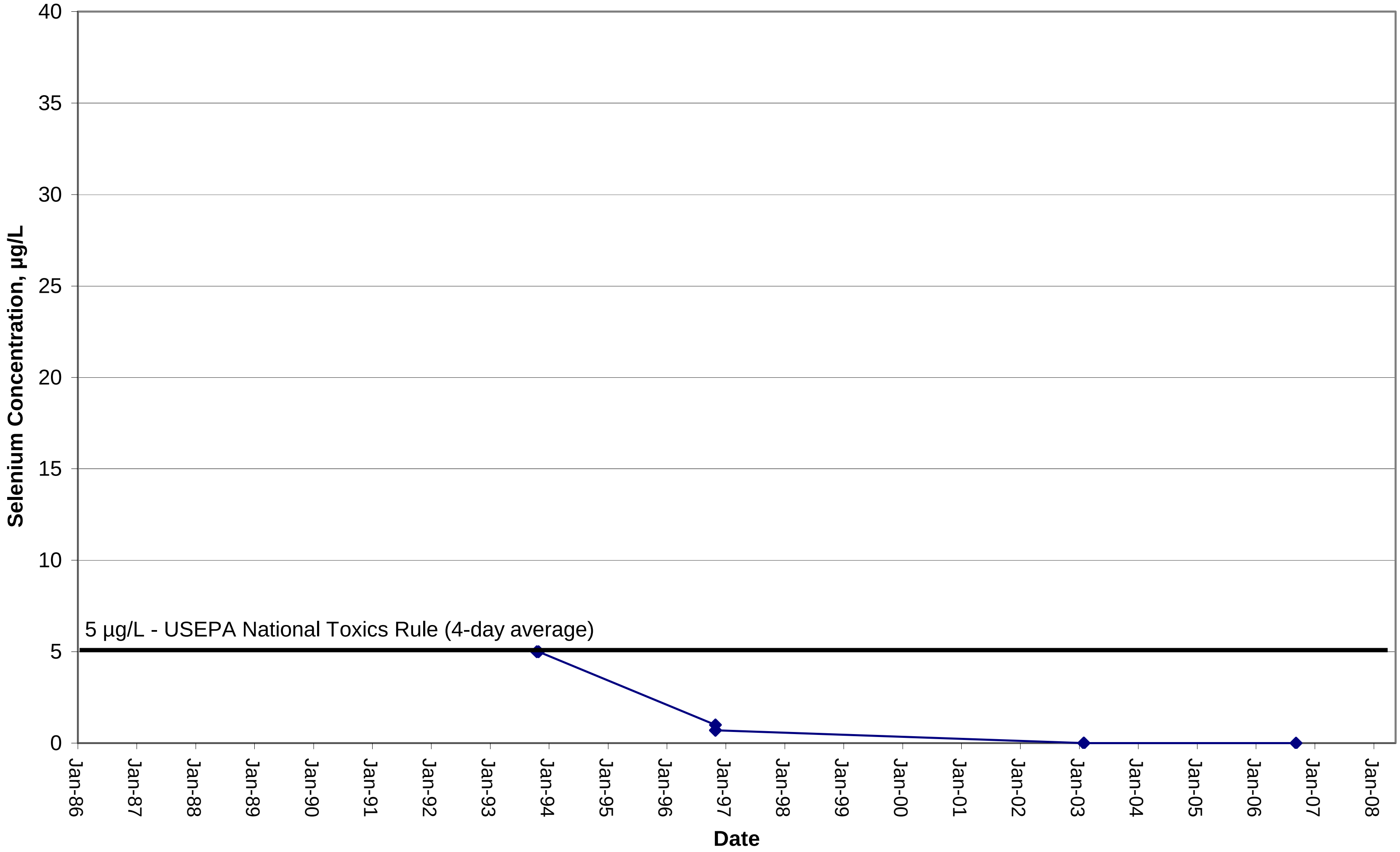

Figure F-7c

City of Woodland
Groundwater Management Plan

WELL #10 SELENIUM CONCENTRATION OVER TIME

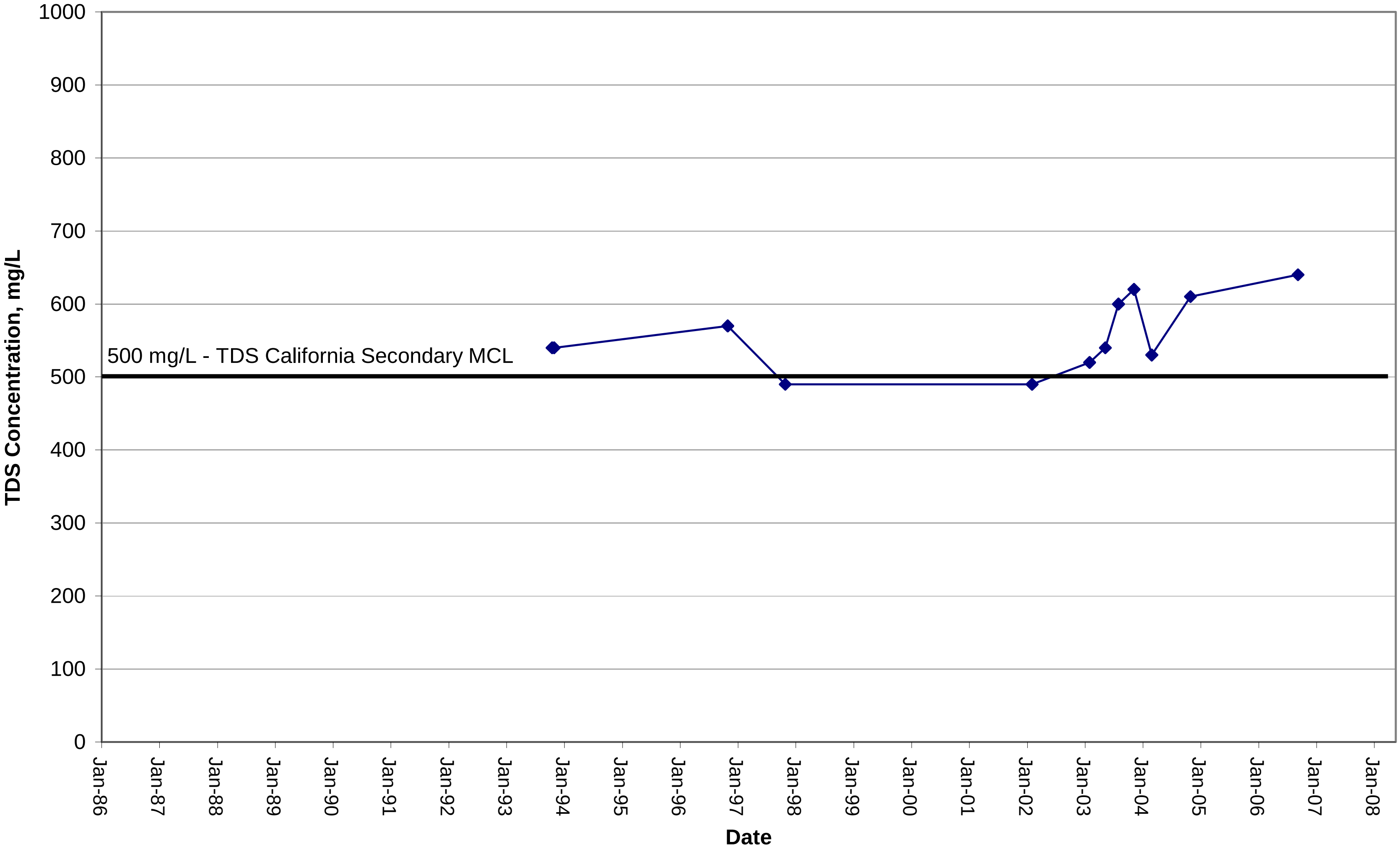

Figure F-7d

City of Woodland
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WELL #10 TDS CONCENTRATION OVER TIME

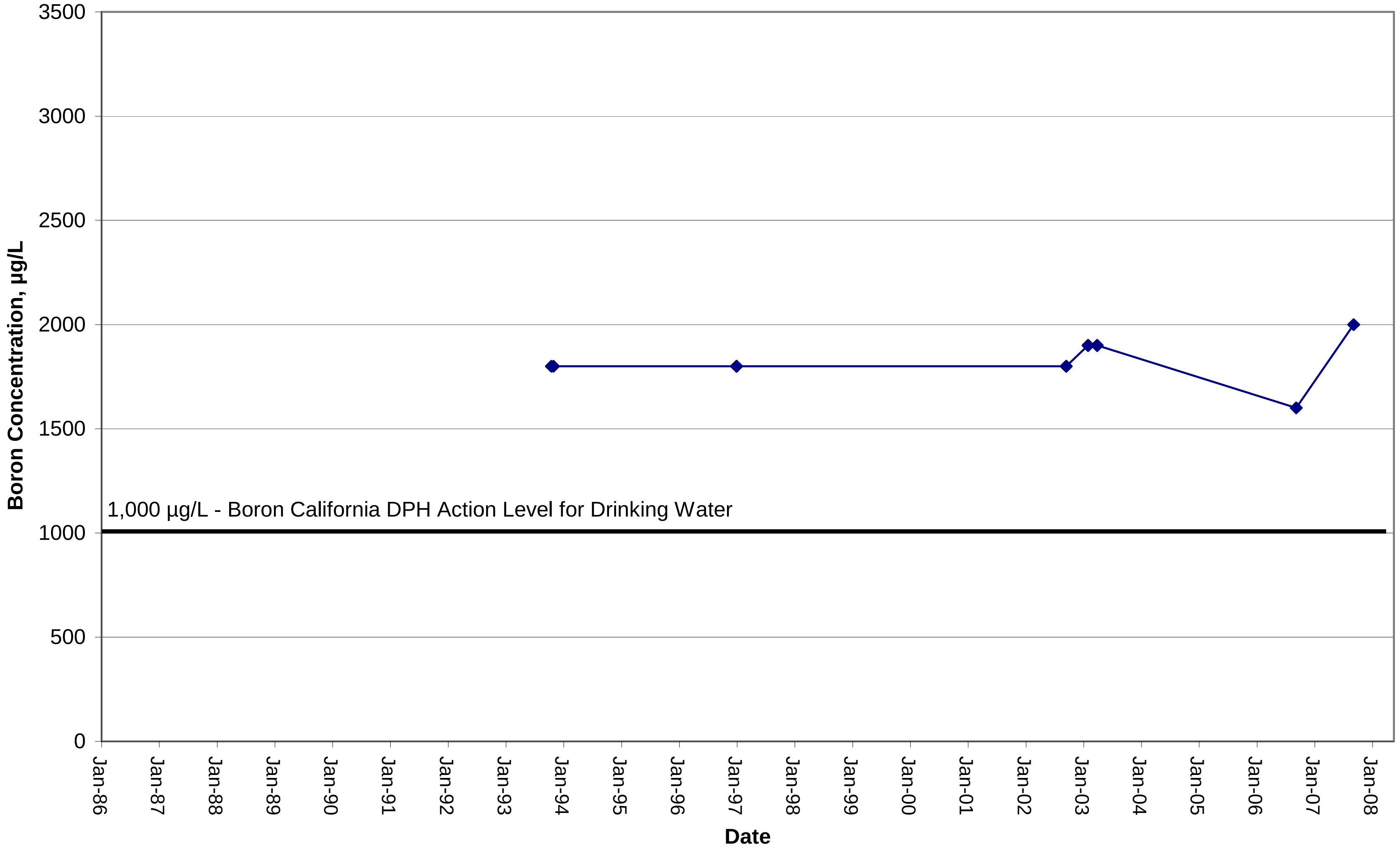

Figure F-8a

City of Woodland
Groundwater Management Plan

WELL #11 BORON CONCENTRATION OVER TIME

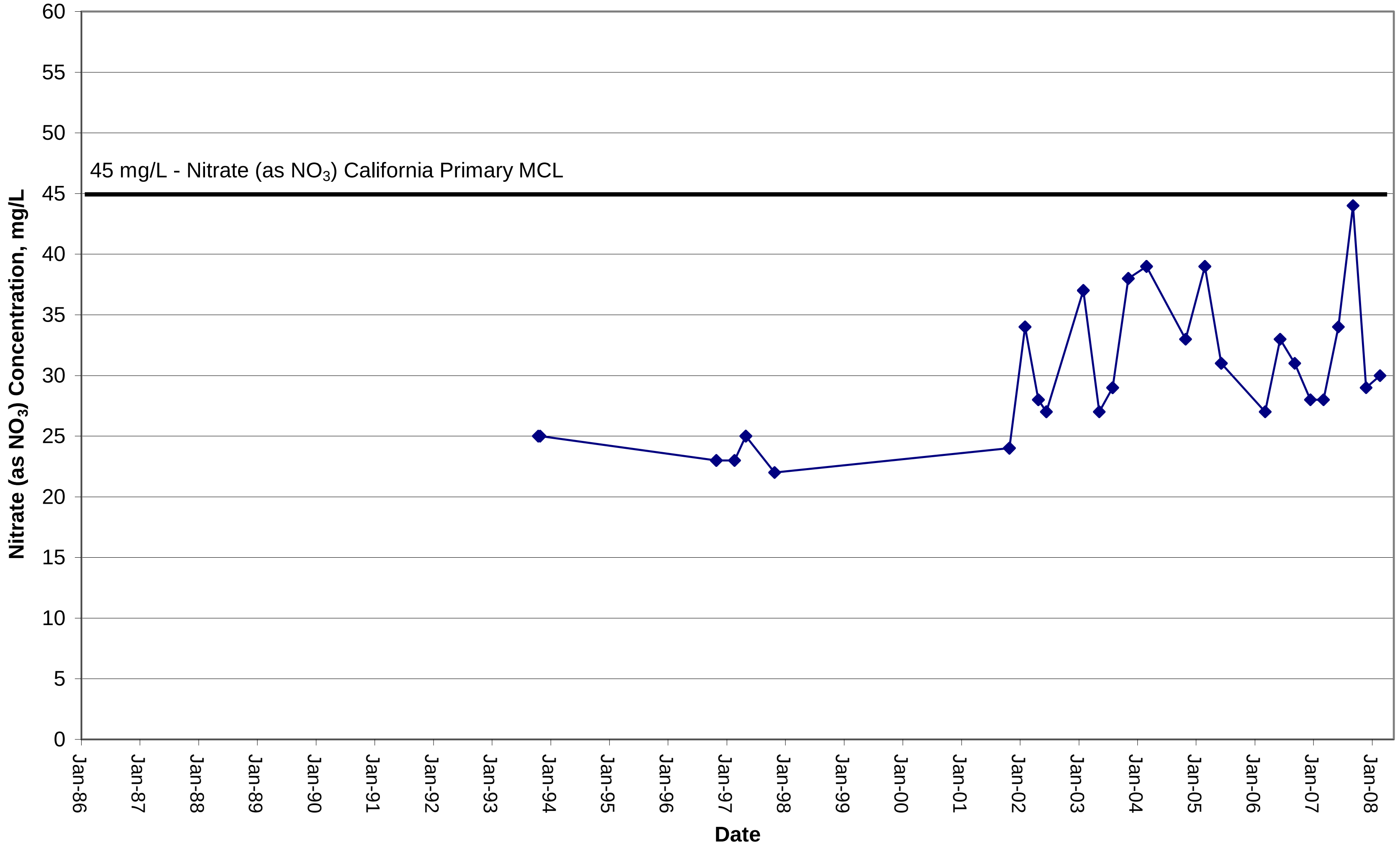

Figure F-8b

City of Woodland
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WELL #11 NITRATE CONCENTRATION OVER TIME

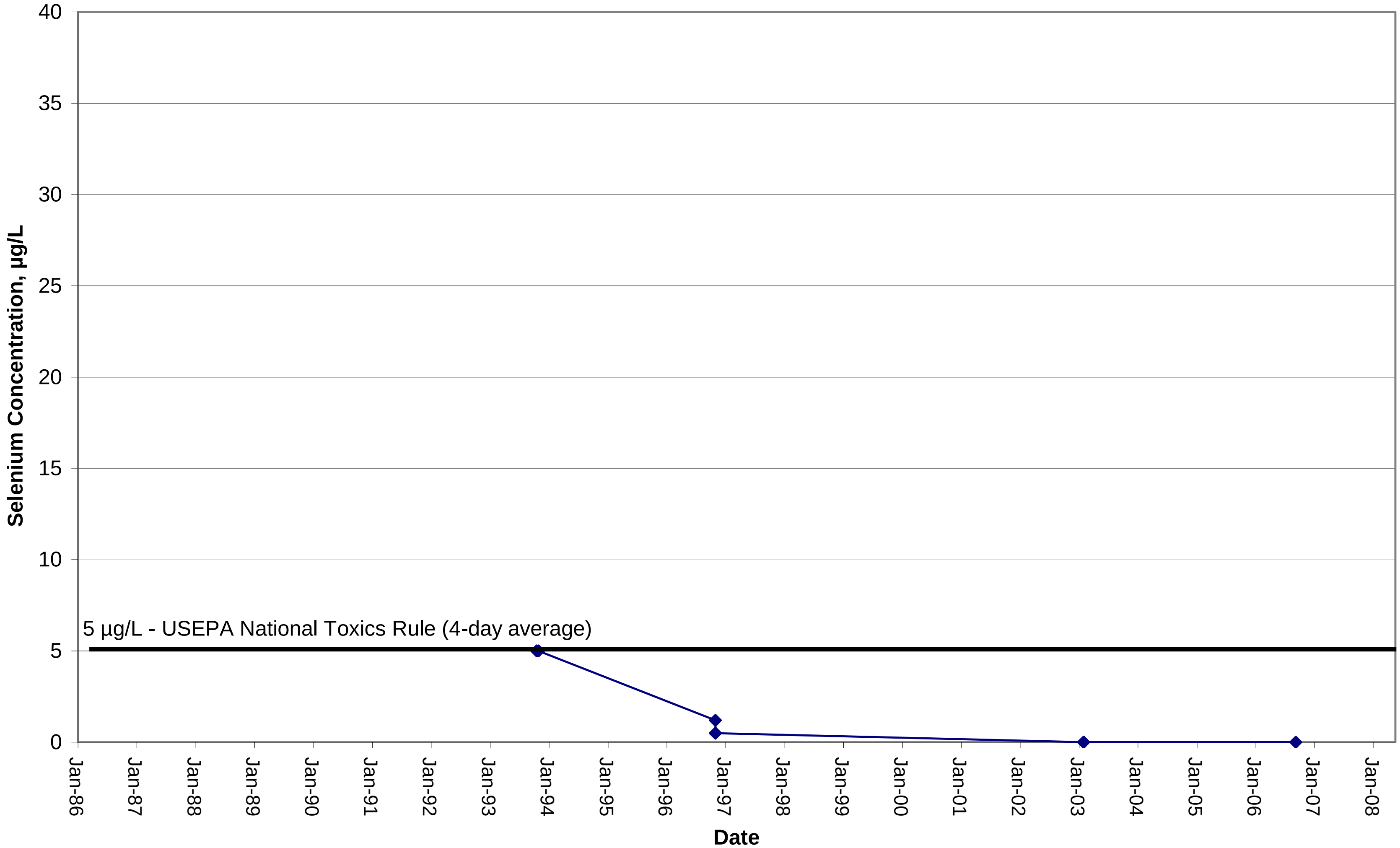

Figure F-8c

City of Woodland
Groundwater Management Plan

WELL #11 SELENIUM CONCENTRATION OVER TIME

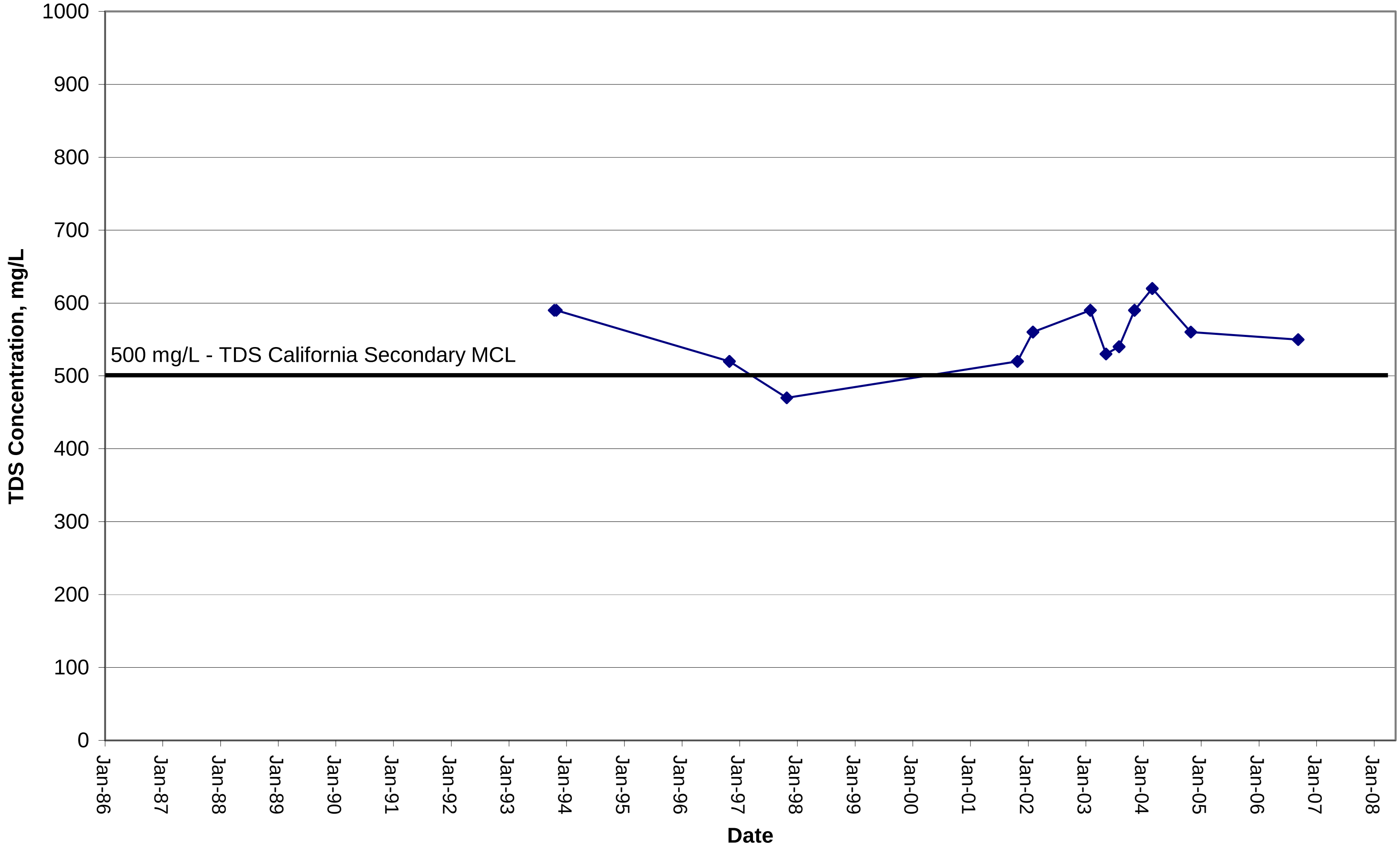

Figure F-8d

City of Woodland
Groundwater Management Plan

WELL #11 TDS CONCENTRATION OVER TIME

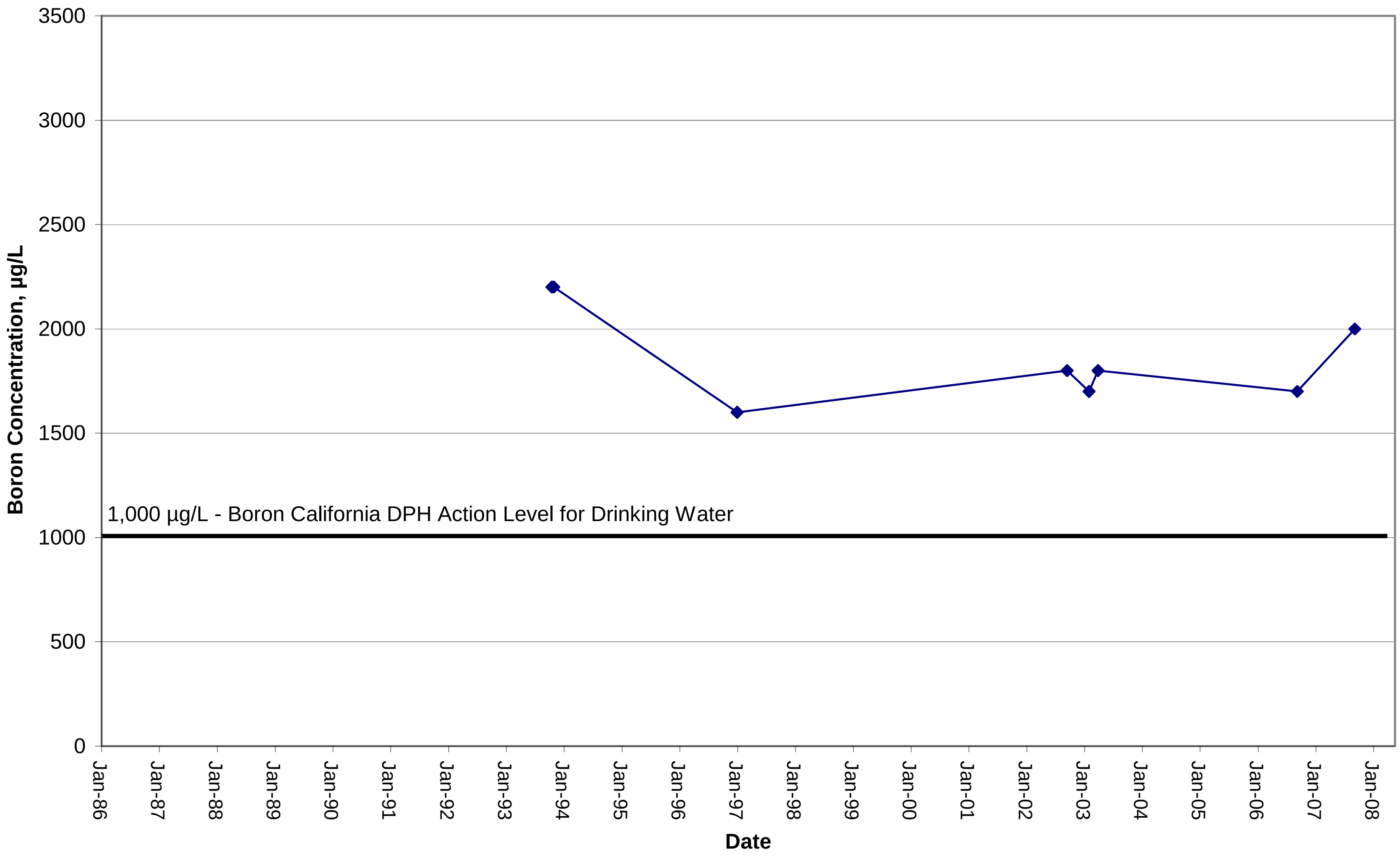

Figure F-9a

City of Woodland
Groundwater Management Plan

WELL #12 BORON CONCENTRATION OVER TIME

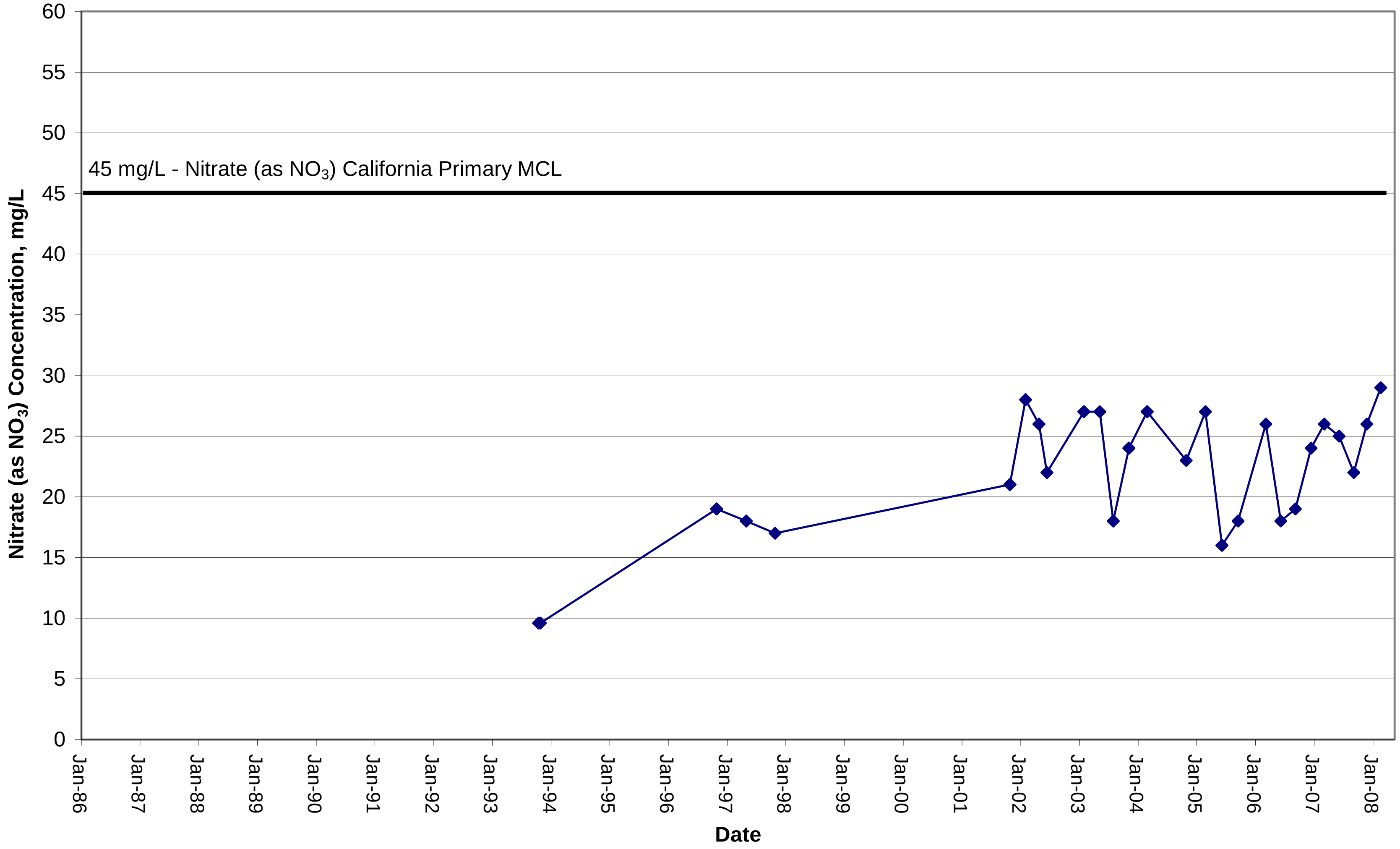

Figure F-9b

City of Woodland
Groundwater Management Plan

WELL #12 NITRATE CONCENTRATION OVER TIME

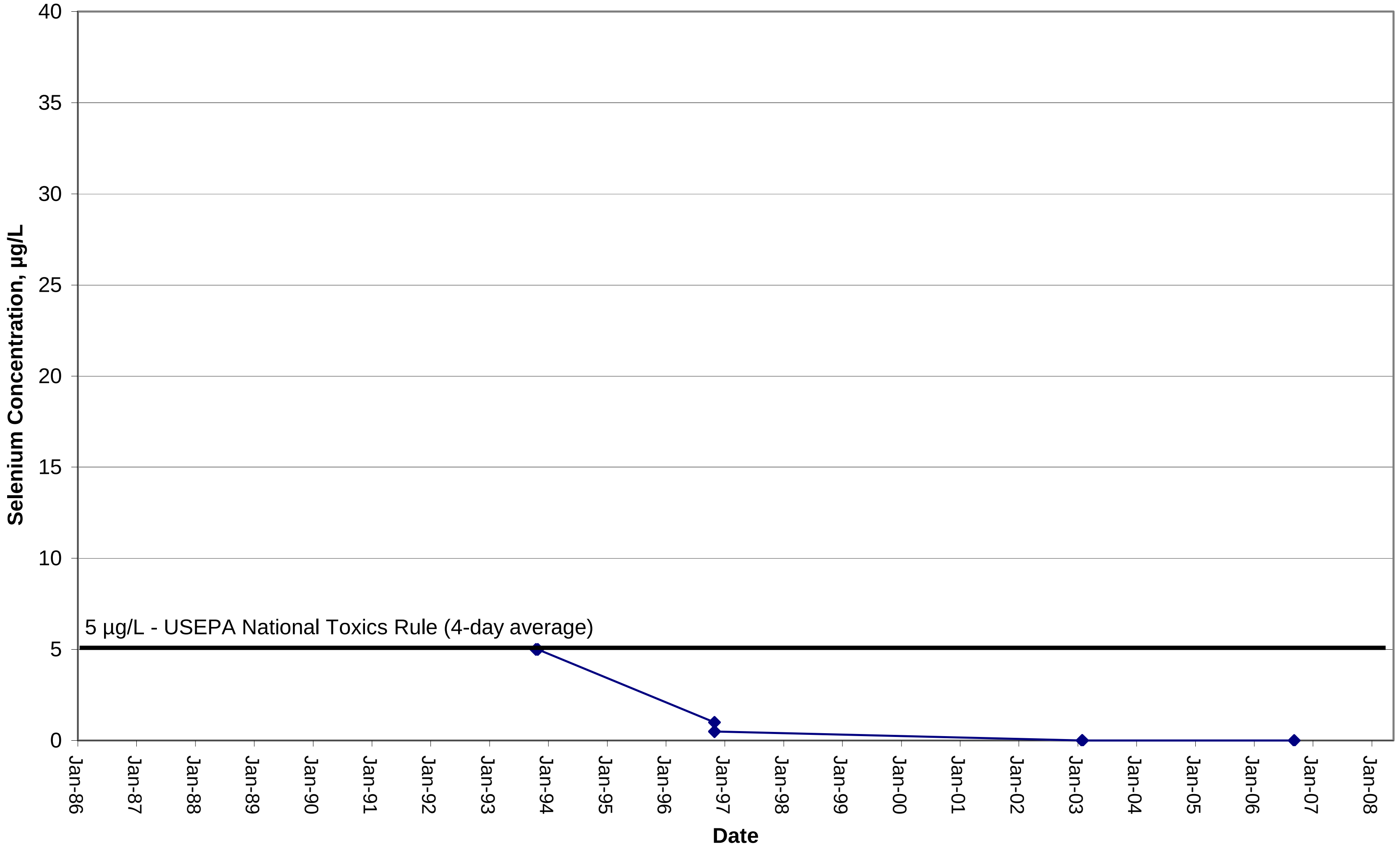

Figure F-9c

City of Woodland
Groundwater Management Plan

WELL #12 SELENIUM CONCENTRATION OVER TIME

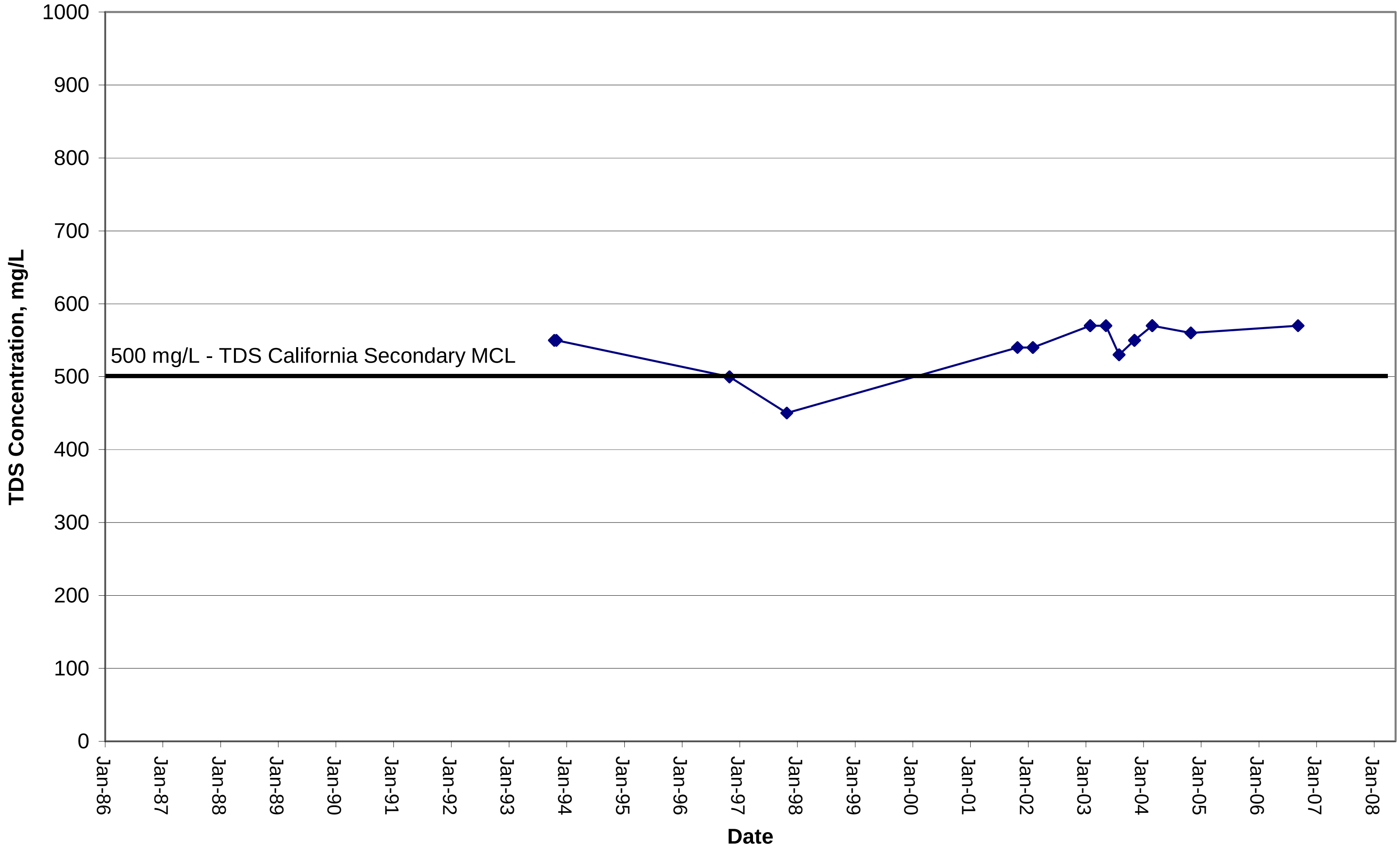

Figure F-9d

City of Woodland
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WELL #12 TDS CONCENTRATION OVER TIME

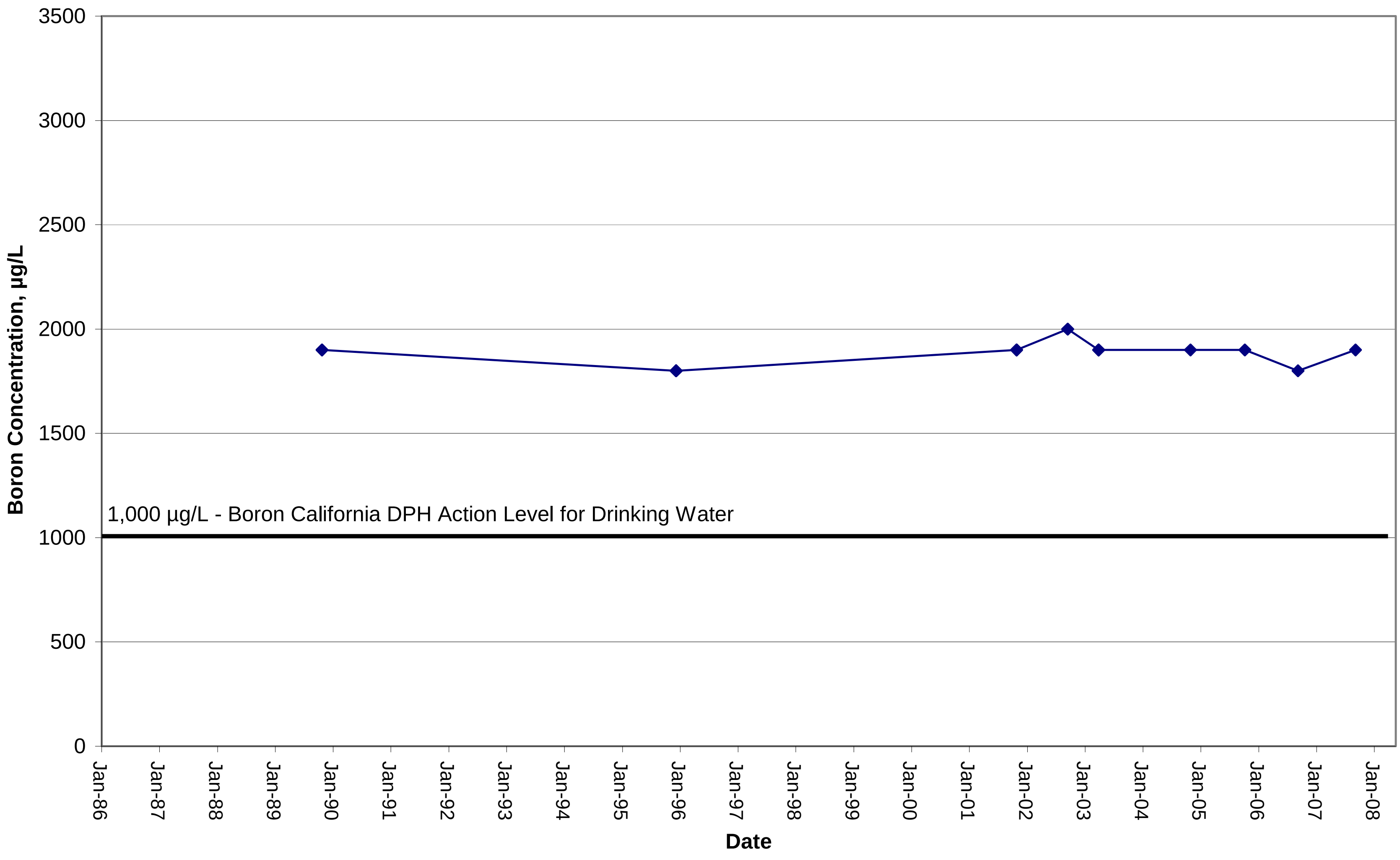

Figure F-10a

City of Woodland
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WELL #13 BORON CONCENTRATION OVER TIME

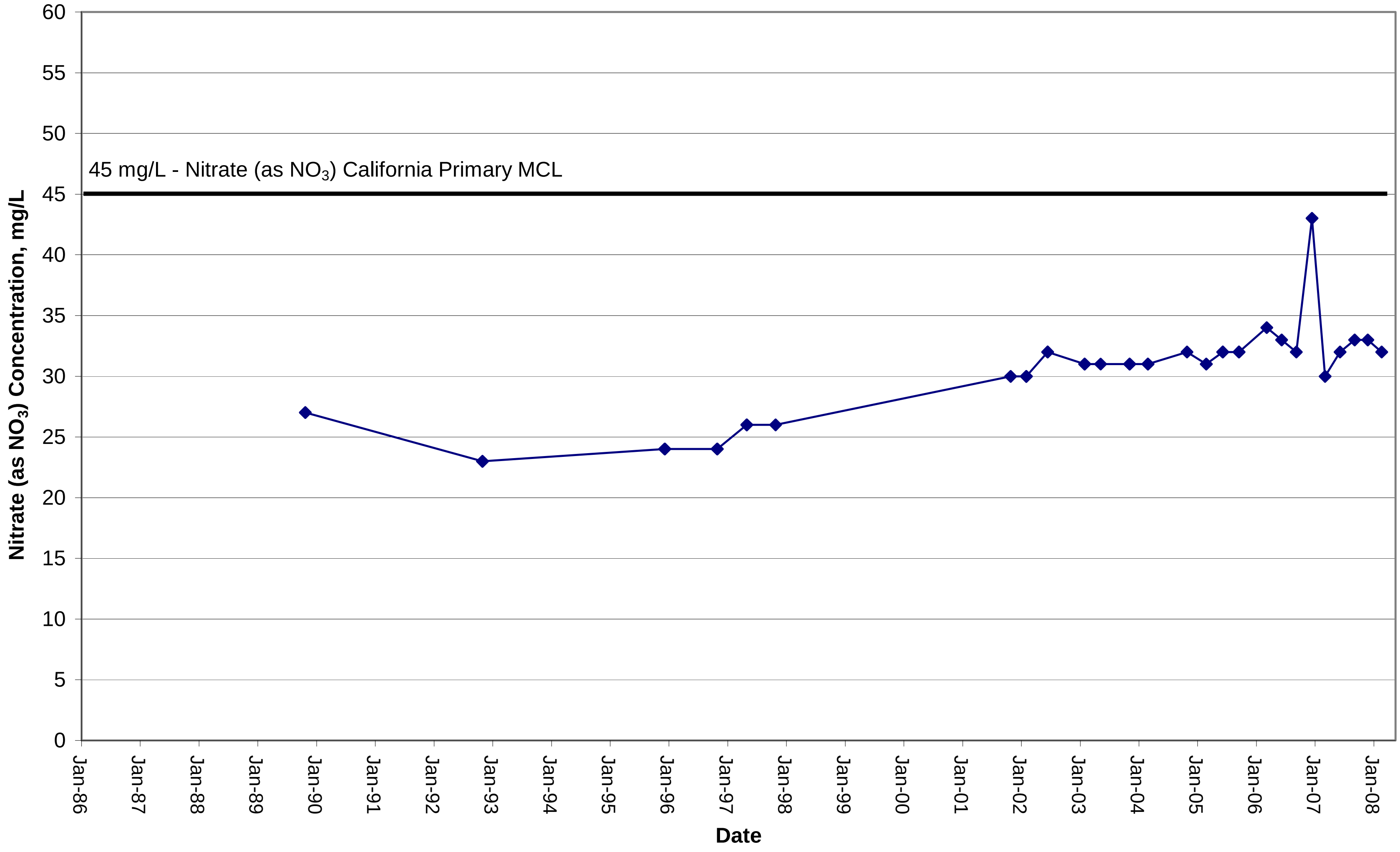

Figure F-10b

City of Woodland
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WELL #13 NITRATE CONCENTRATION OVER TIME

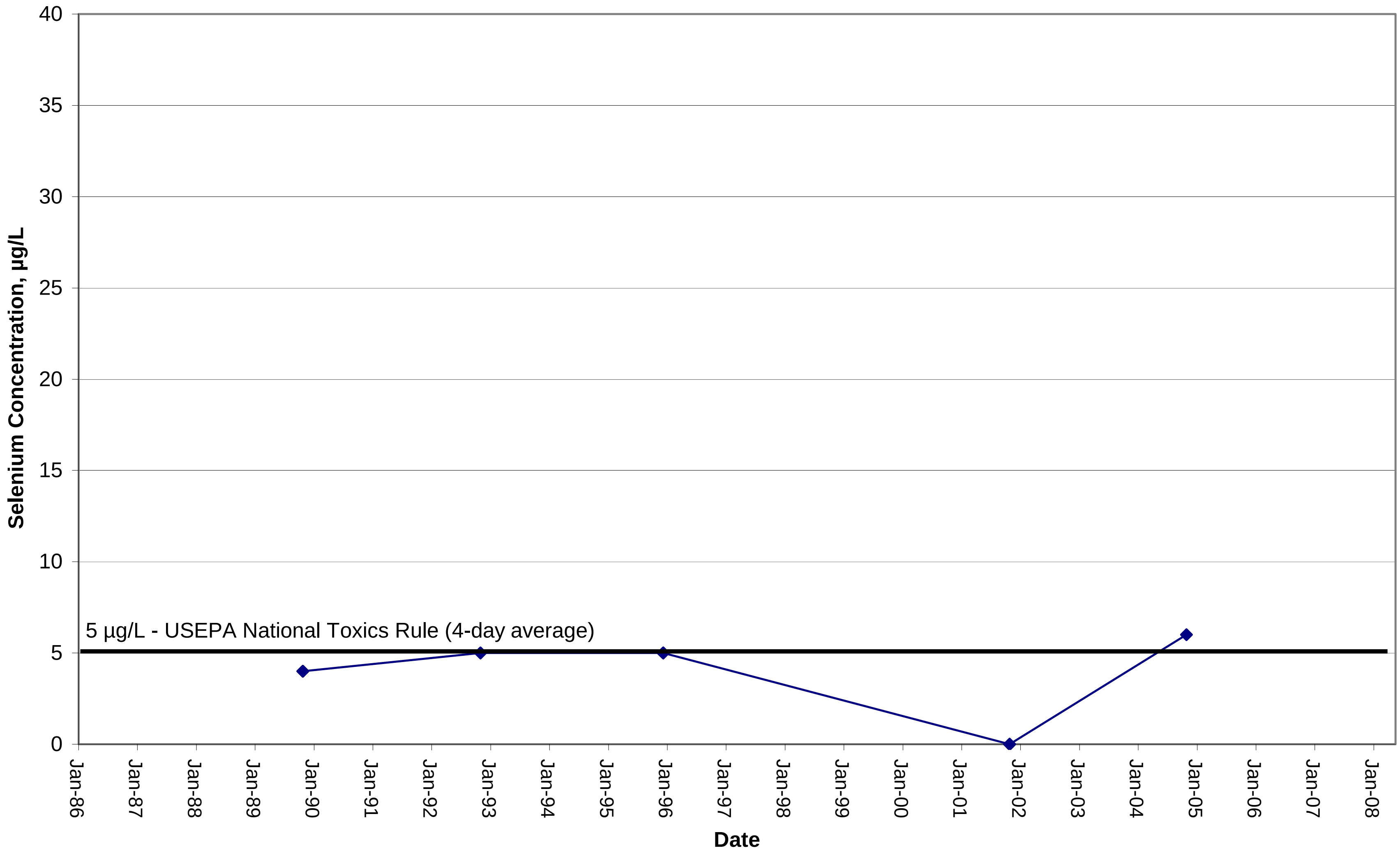

Figure F-10c

City of Woodland
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WELL #13 SELENIUM CONCENTRATION OVER TIME

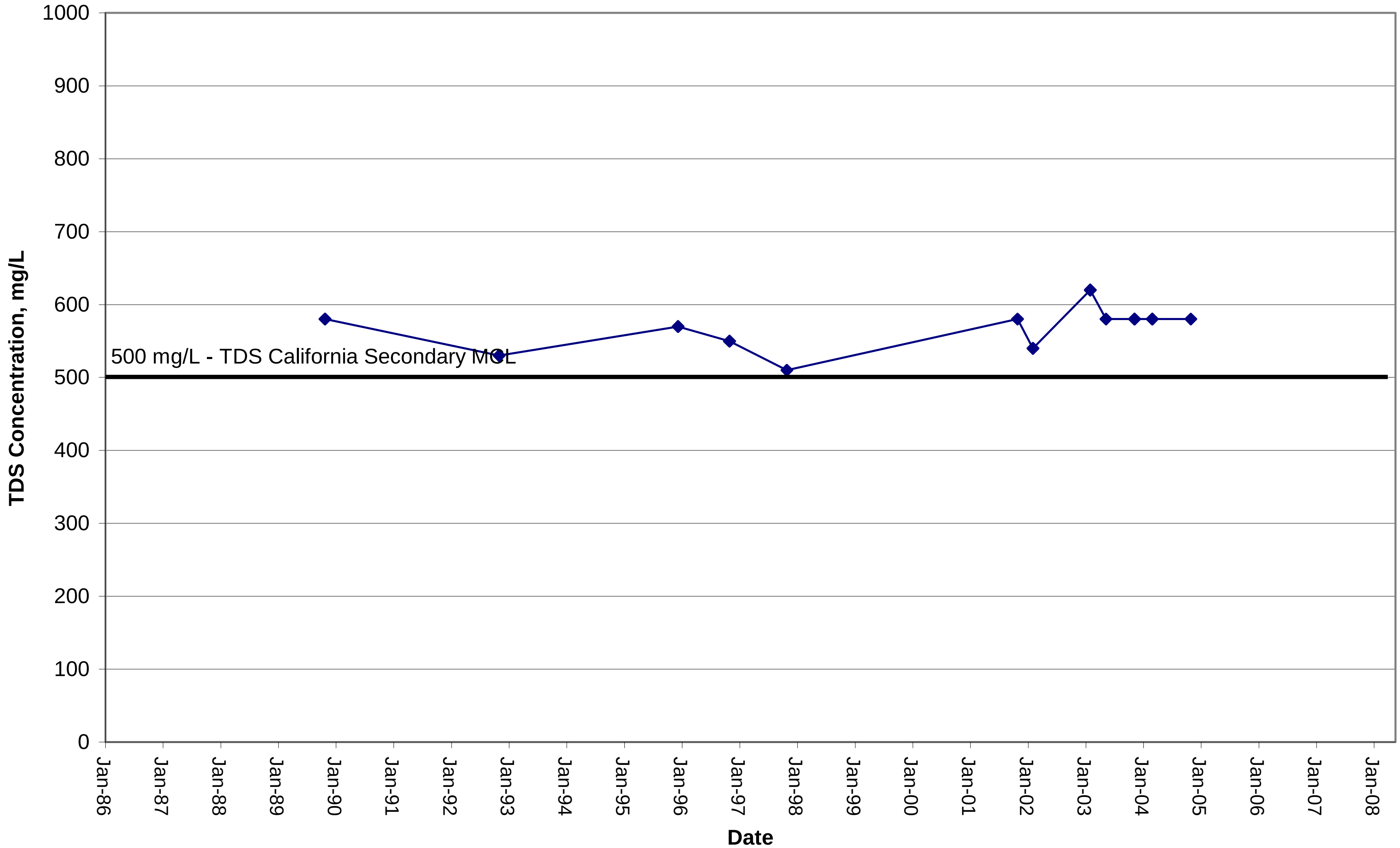

Figure F-10d

City of Woodland
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WELL #13 TDS CONCENTRATION OVER TIME

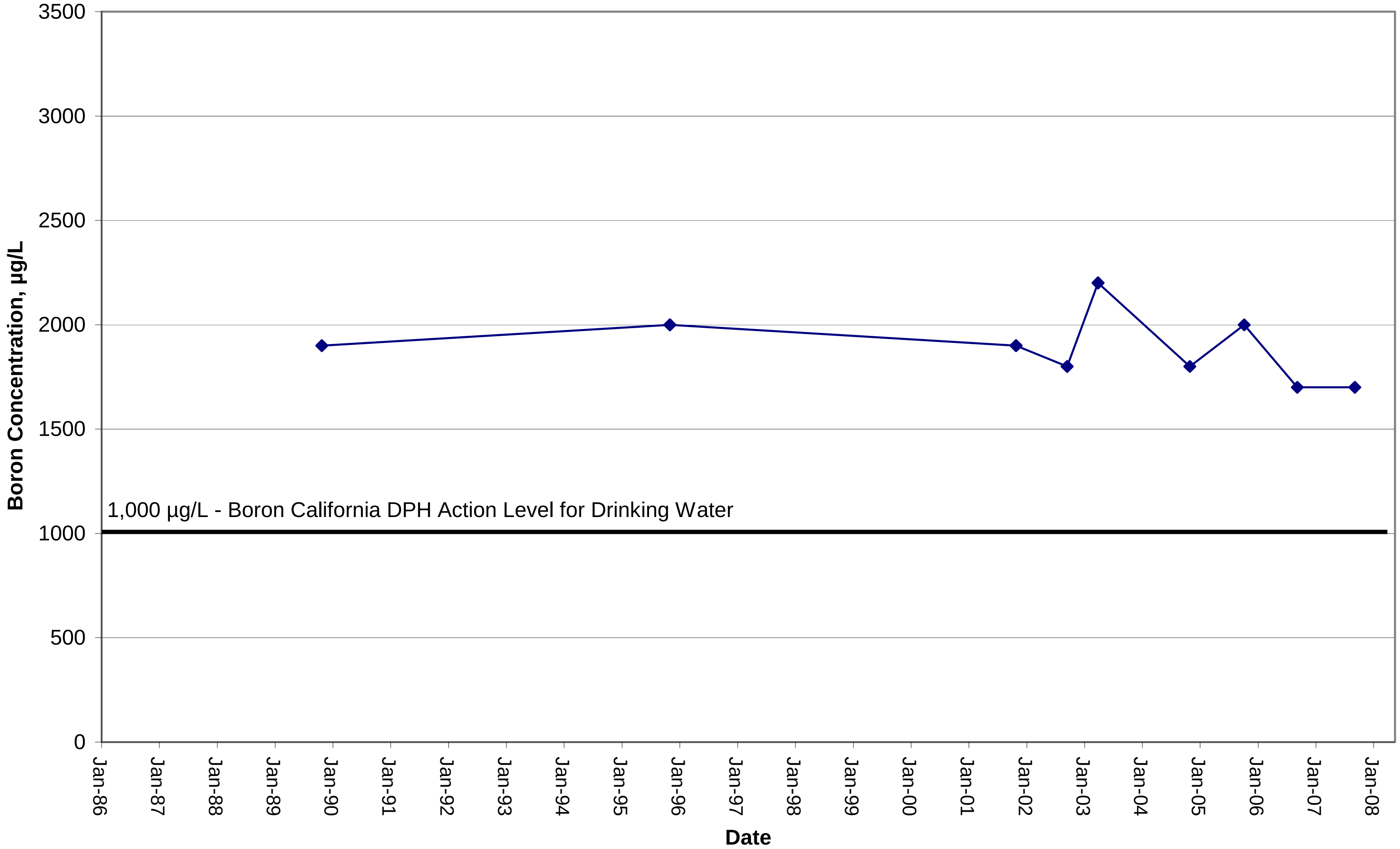

Figure F-11a

City of Woodland
Groundwater Management Plan

WELL #14 BORON CONCENTRATION OVER TIME

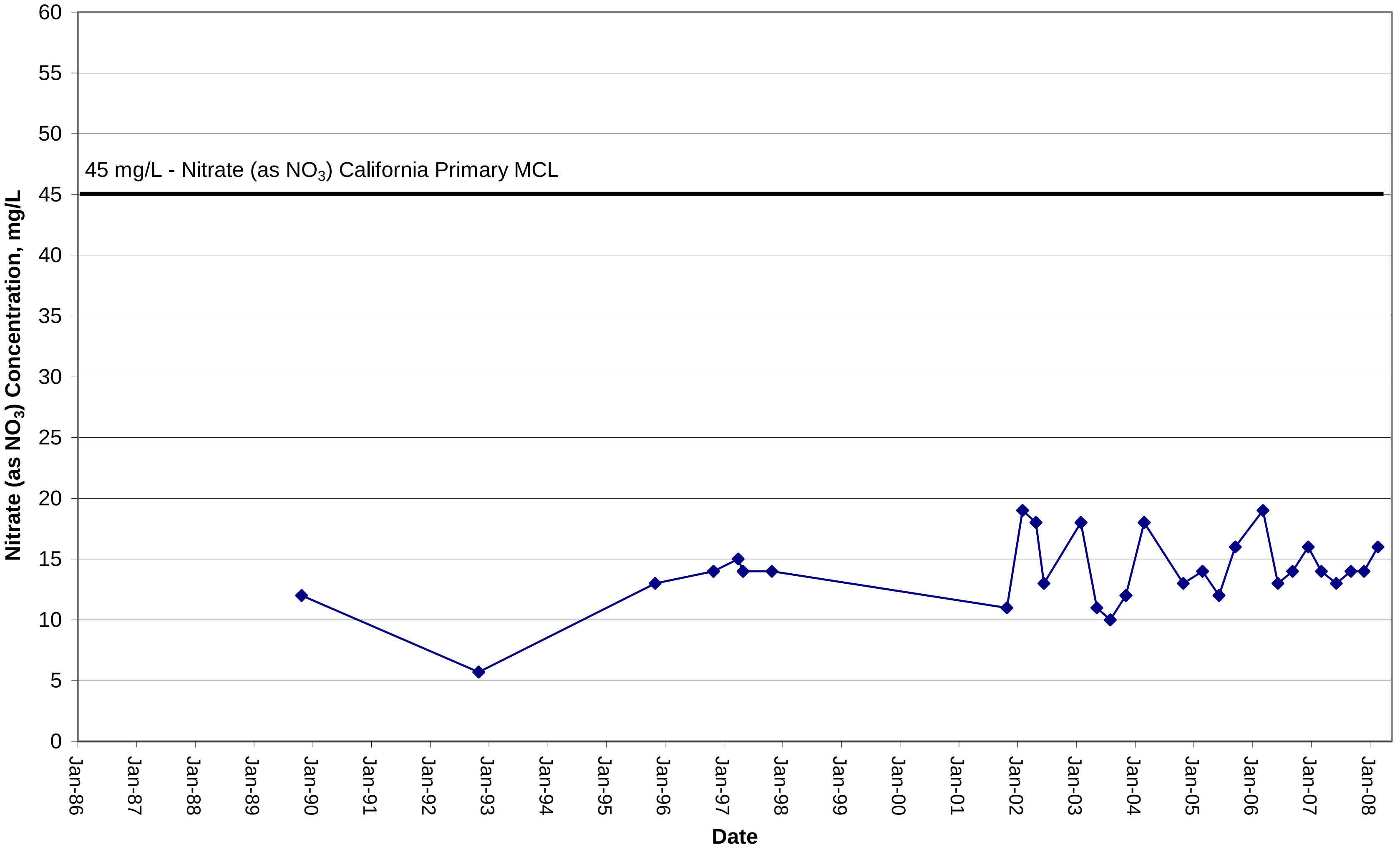

Figure F-11b

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WELL #14 NITRATE CONCENTRATION OVER TIME

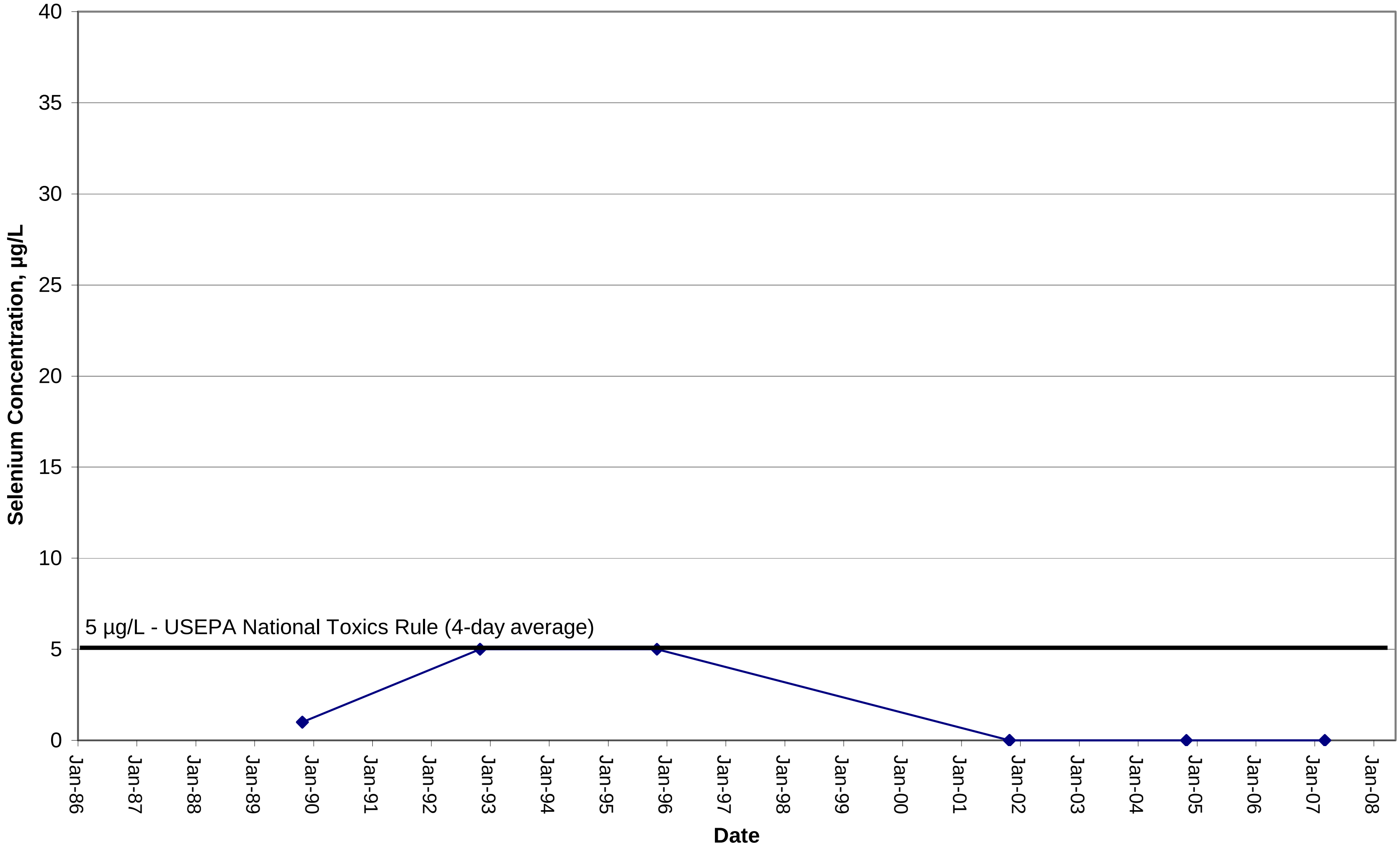


Figure F-11c

City of Woodland
Groundwater Management Plan

WELL #14 SELENIUM CONCENTRATION OVER TIME

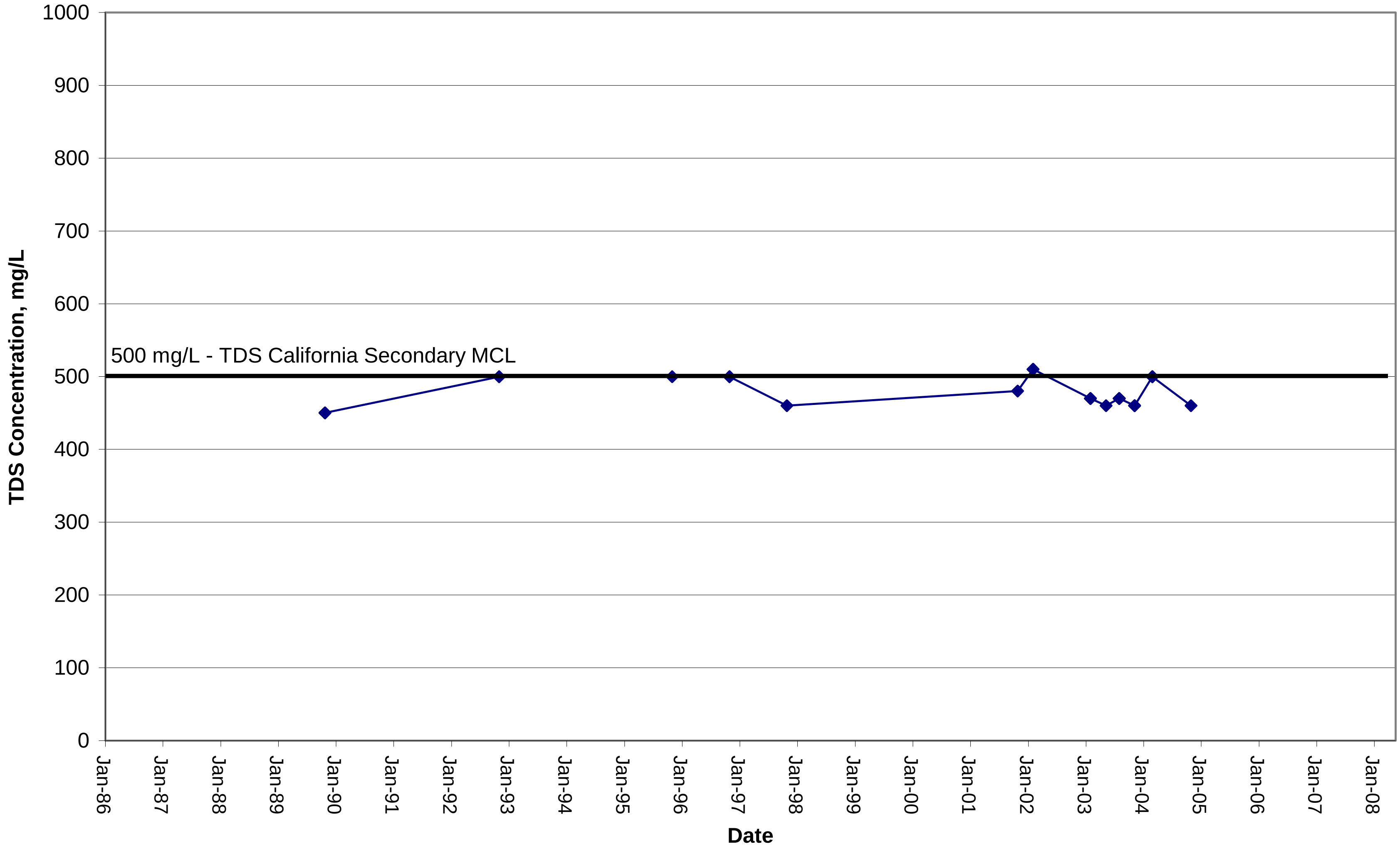
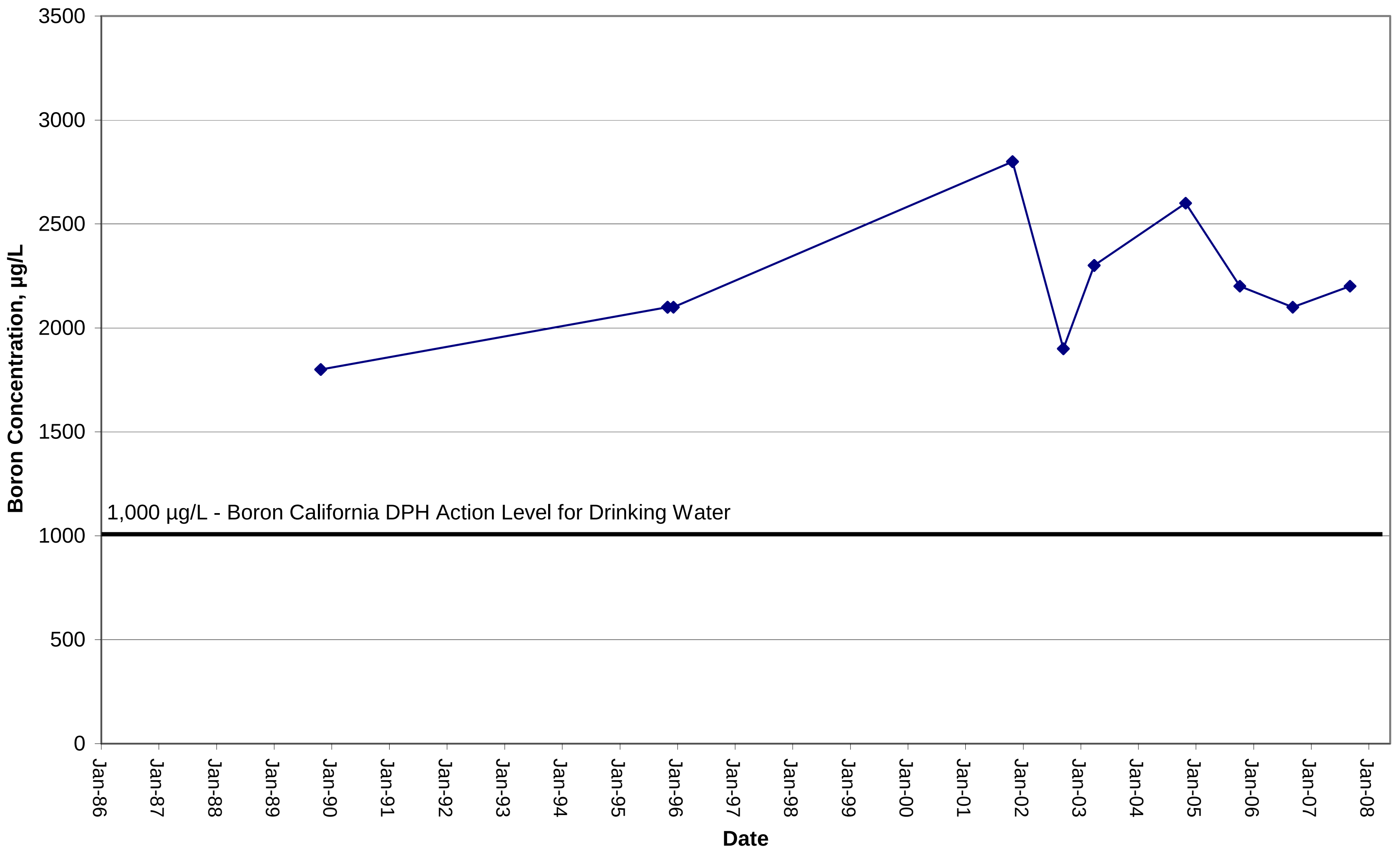


Figure F-11d

City of Woodland
Groundwater Management Plan

WELL #14 TDS CONCENTRATION OVER TIME

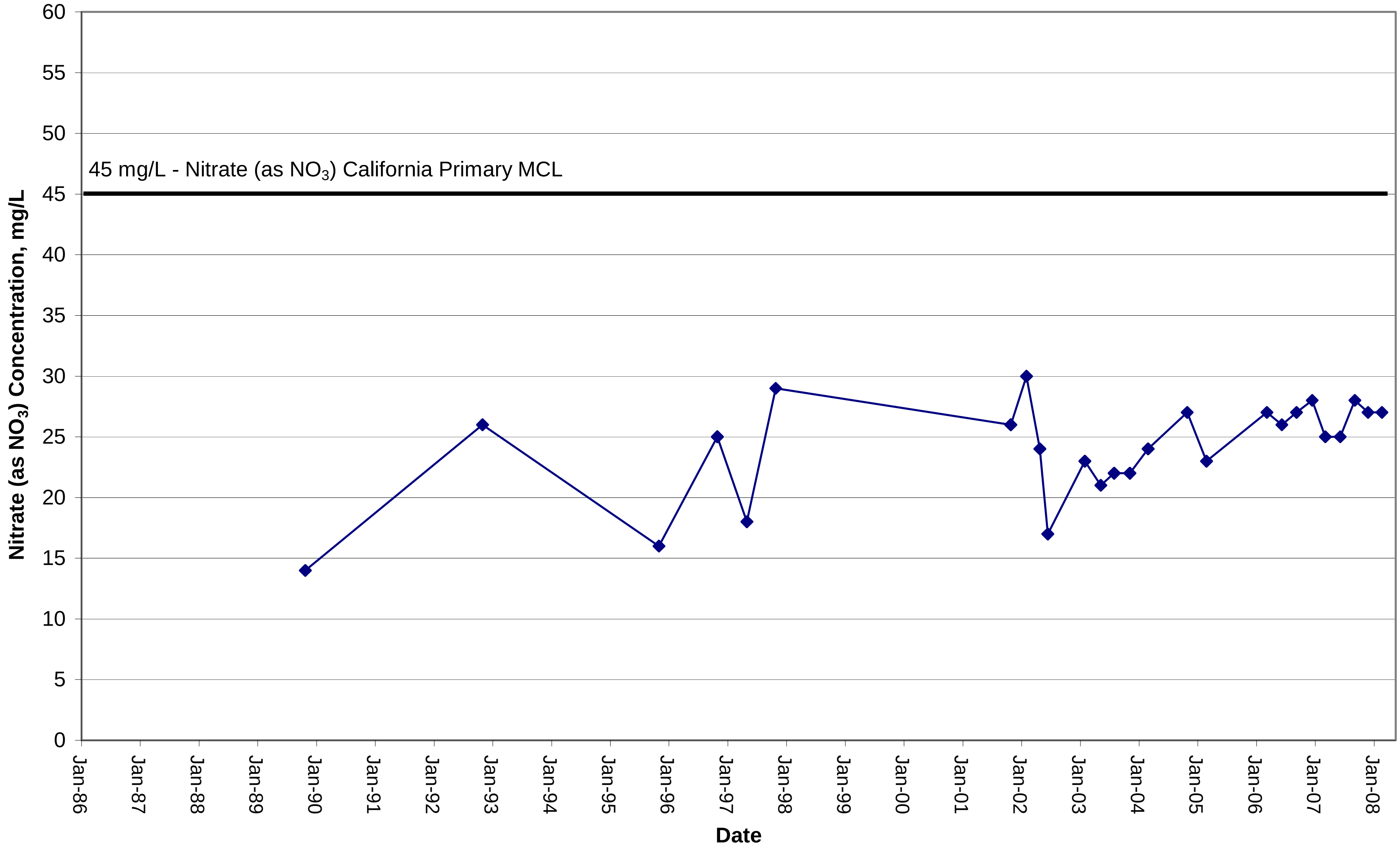


This water quality data was collected from the original Well 22 which went offline in 2008.

Figure F-12a

City of Woodland
Groundwater Management Plan

WELL #15 BORON CONCENTRATION OVER TIME

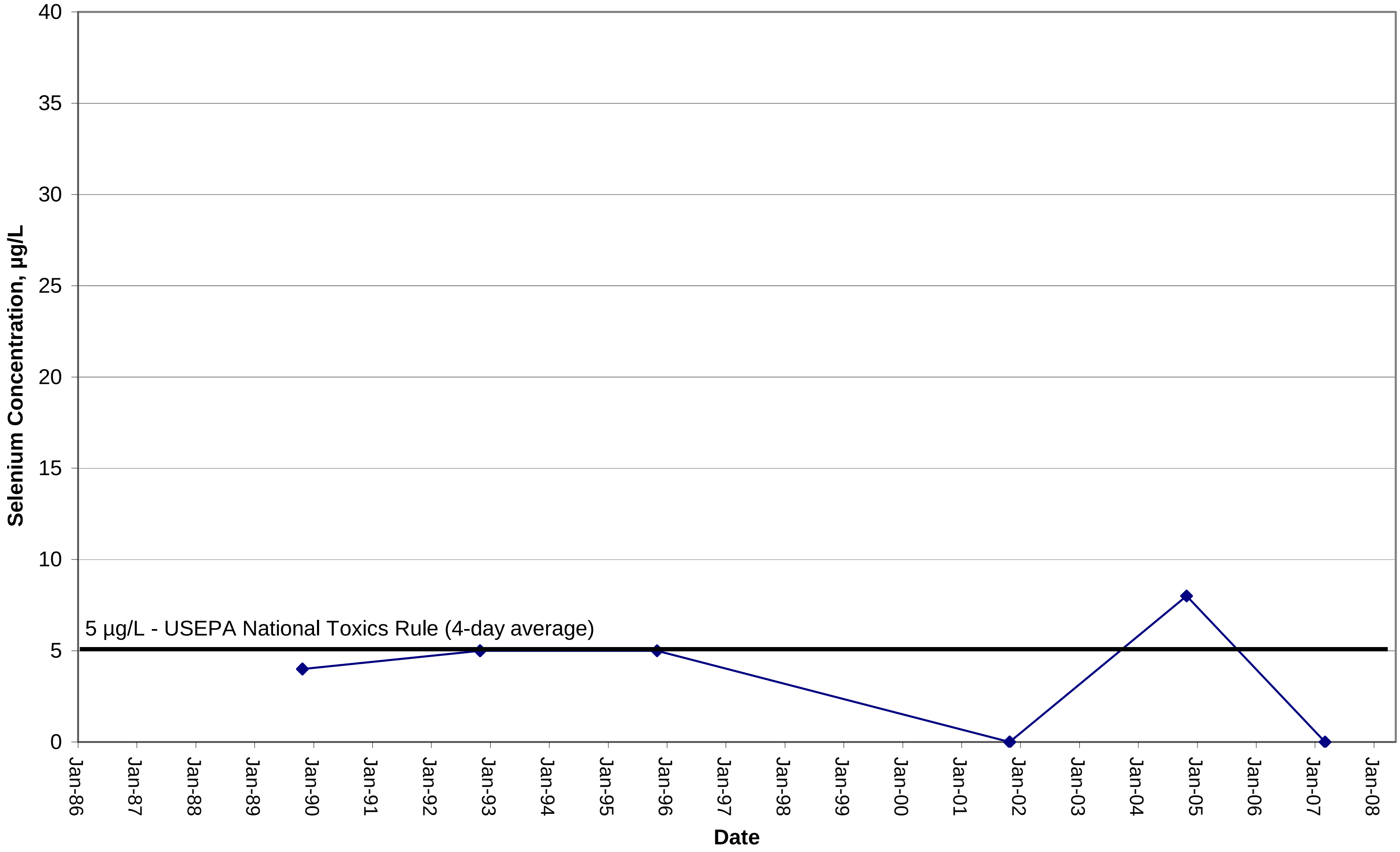


This water quality data was collected from the original Well 22 which went offline in 2008.

Figure F-12b

City of Woodland
Groundwater Management Plan

WELL #15 NITRATE CONCENTRATION OVER TIME

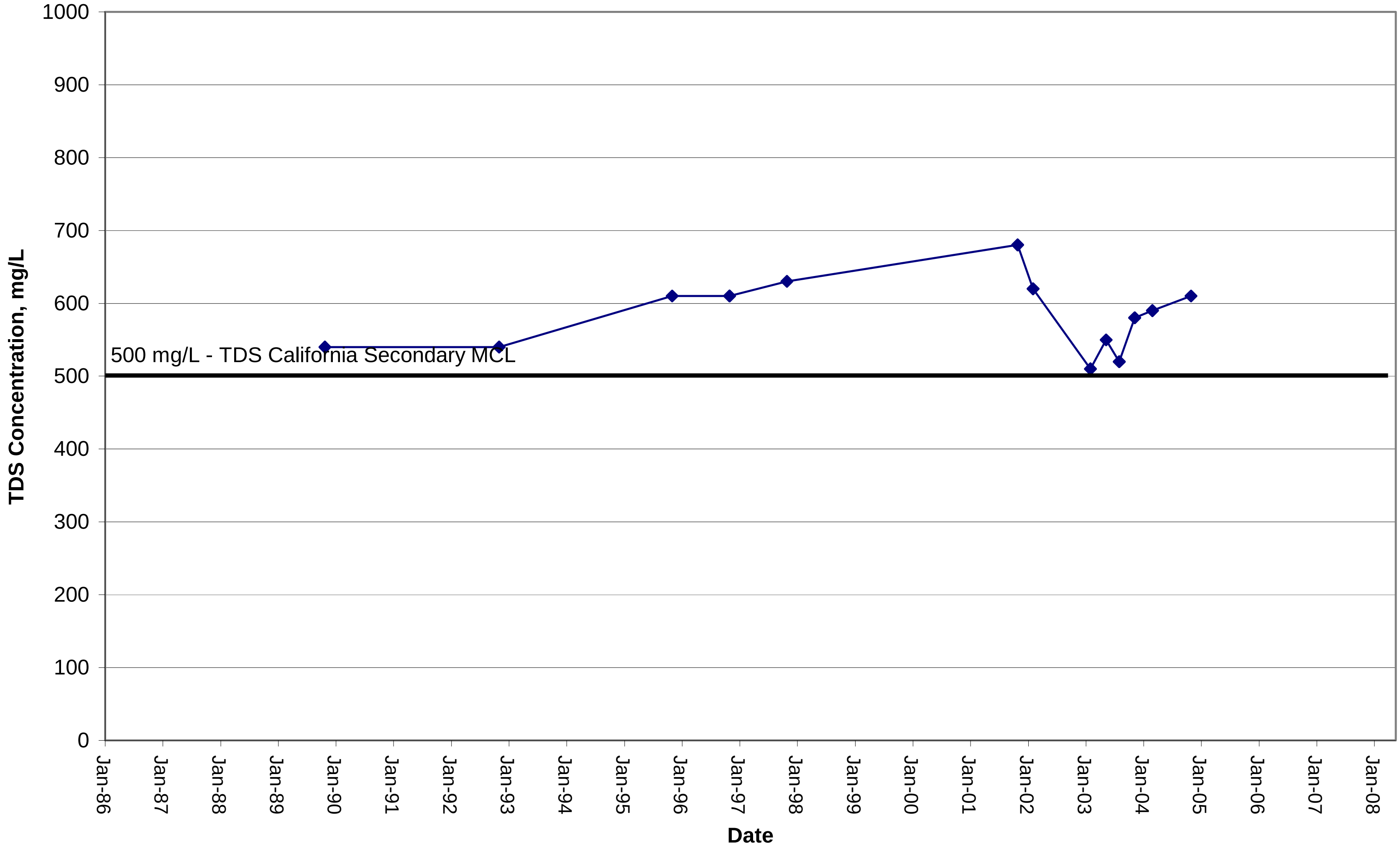


This water quality data was collected from the original Well 22 which went offline in 2008.

Figure F-12c

City of Woodland
Groundwater Management Plan

WELL #15 SELENIUM CONCENTRATION OVER TIME



This water quality data was collected from the original Well 15, which went offline in 2008.

Figure F-12d

City of Woodland
Groundwater Management Plan

WELL #15 TDS CONCENTRATION OVER TIME

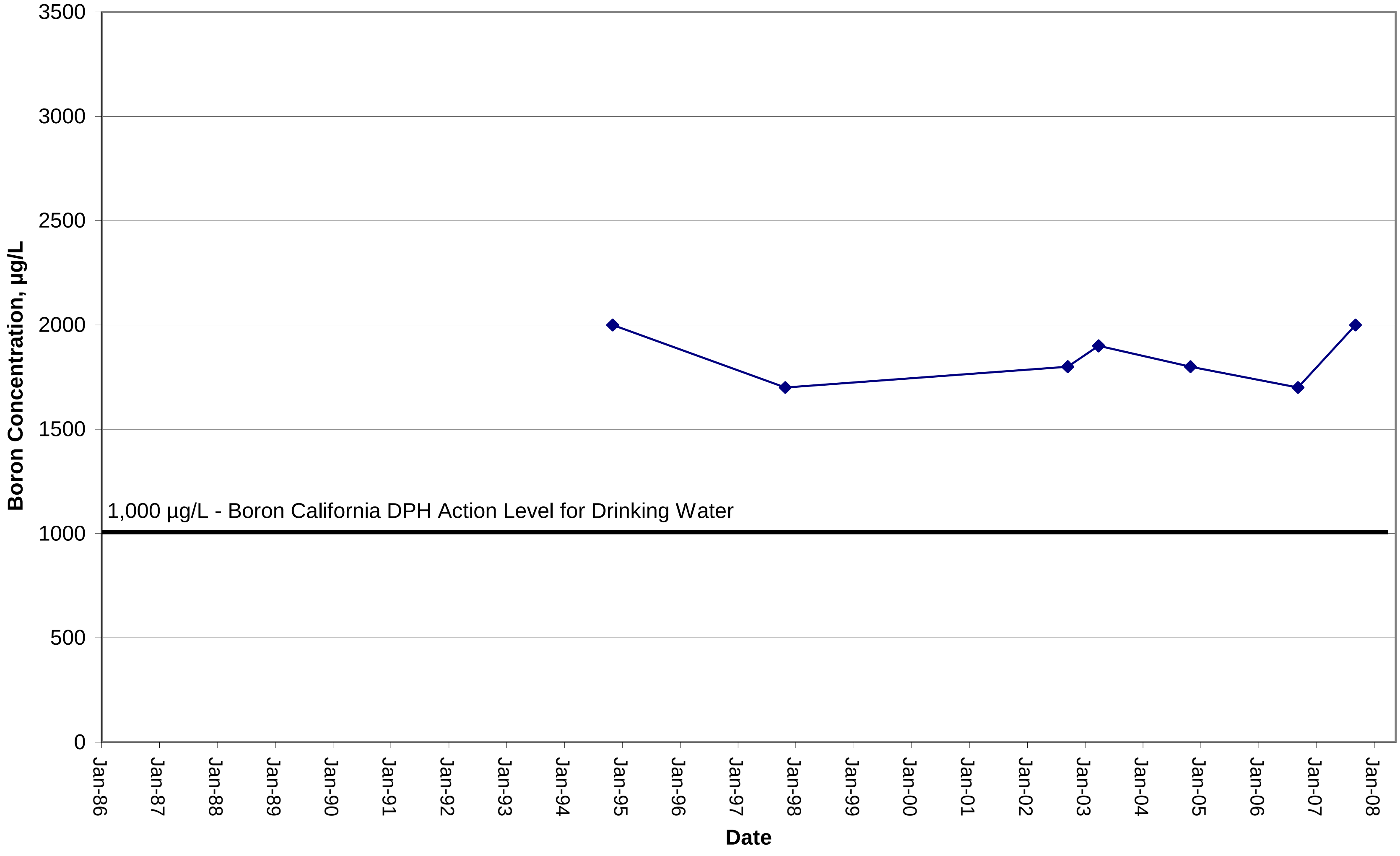


Figure F-13a

City of Woodland
Groundwater Management Plan

WELL #16 BORON CONCENTRATION OVER TIME

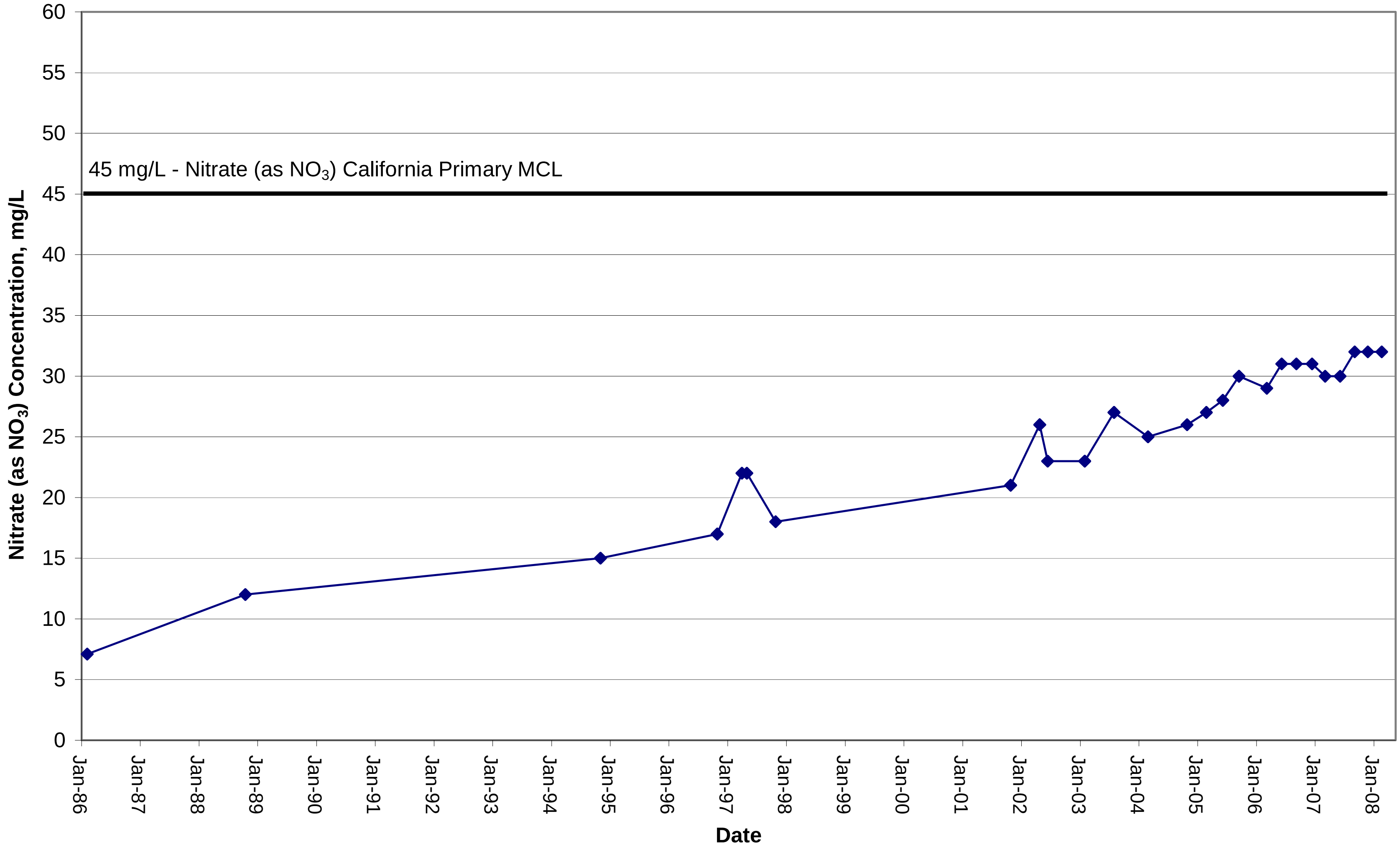


Figure F-13b

City of Woodland
Groundwater Management Plan

WELL #16 NITRATE CONCENTRATION OVER TIME

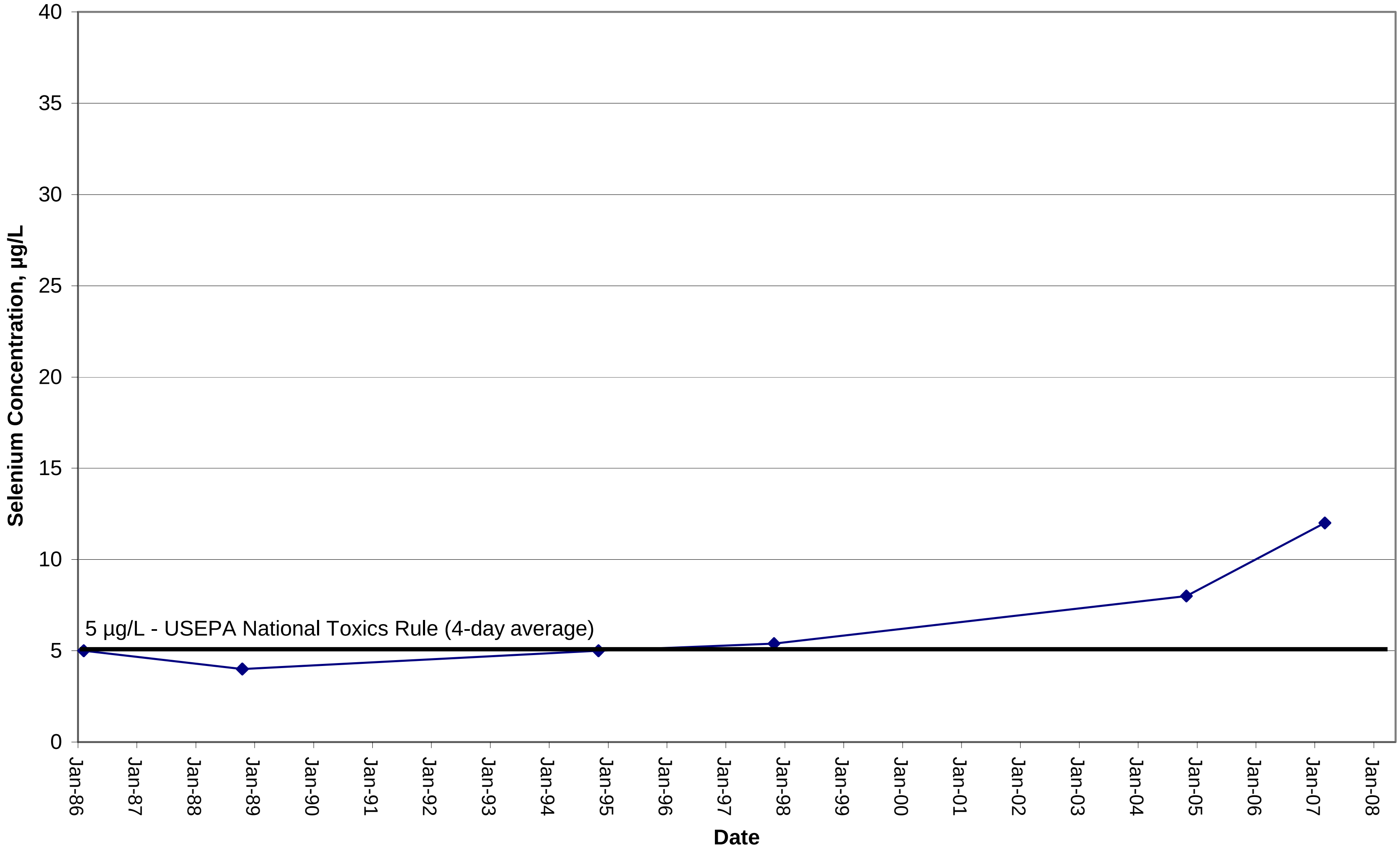


Figure F-13c

City of Woodland
Groundwater Management Plan

WELL #16 SELENIUM CONCENTRATION OVER TIME

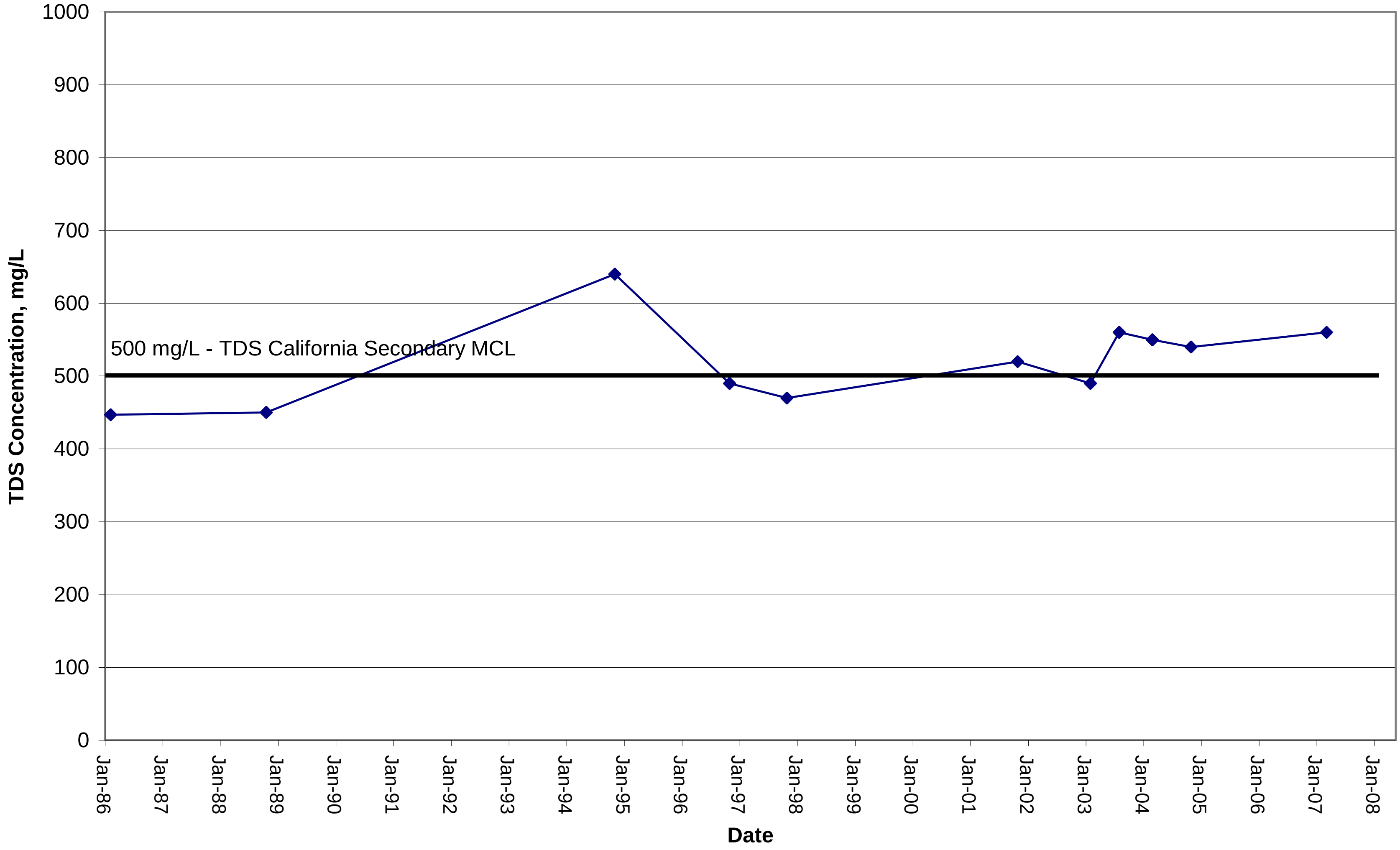


Figure F-13d

City of Woodland
Groundwater Management Plan

WELL #16 TDS CONCENTRATION OVER TIME

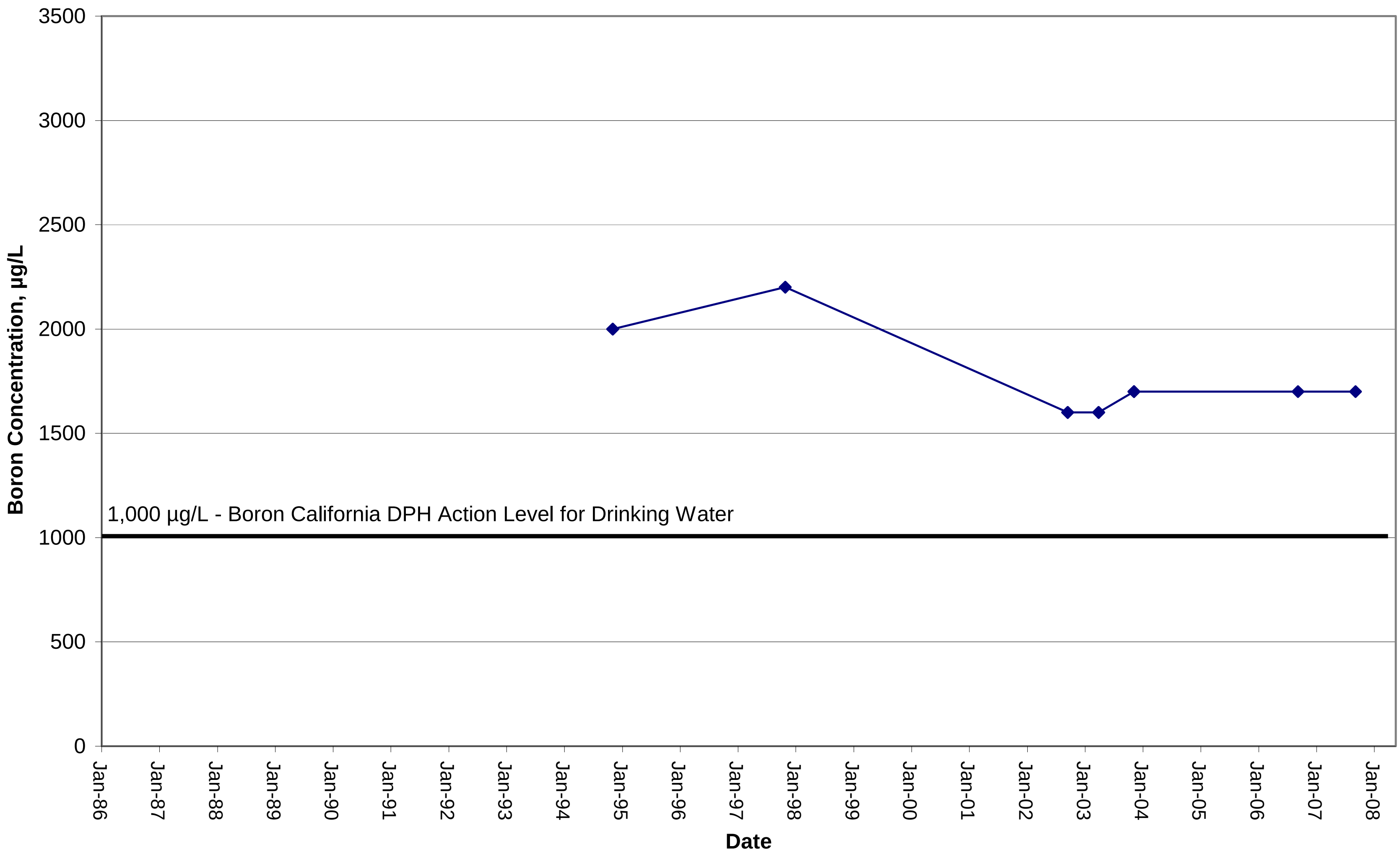


Figure F-14a

City of Woodland
Groundwater Management Plan

WELL #17 BORON CONCENTRATION OVER TIME

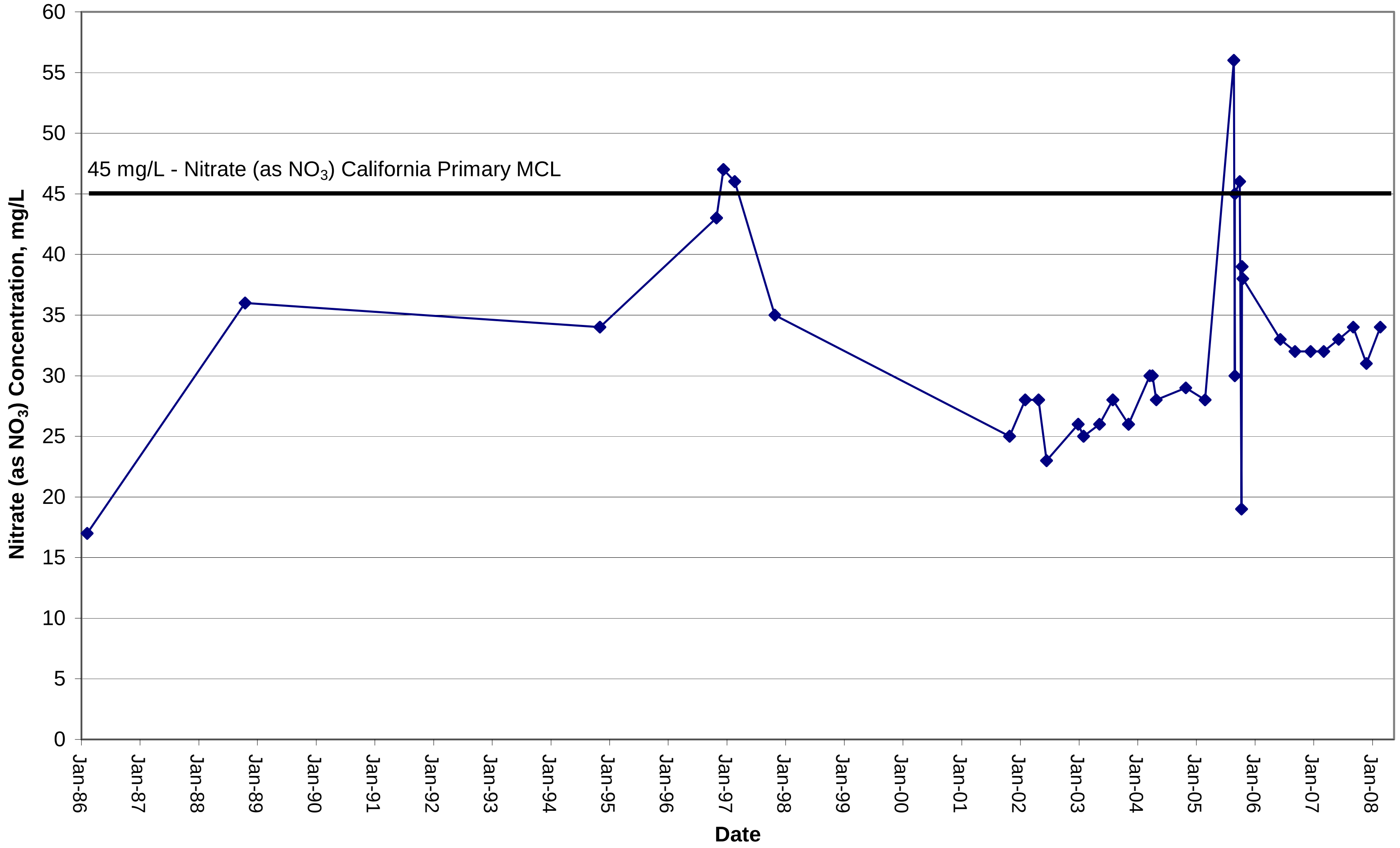


Figure F-14b

City of Woodland
Groundwater Management Plan

WELL #17 NITRATE CONCENTRATION OVER TIME

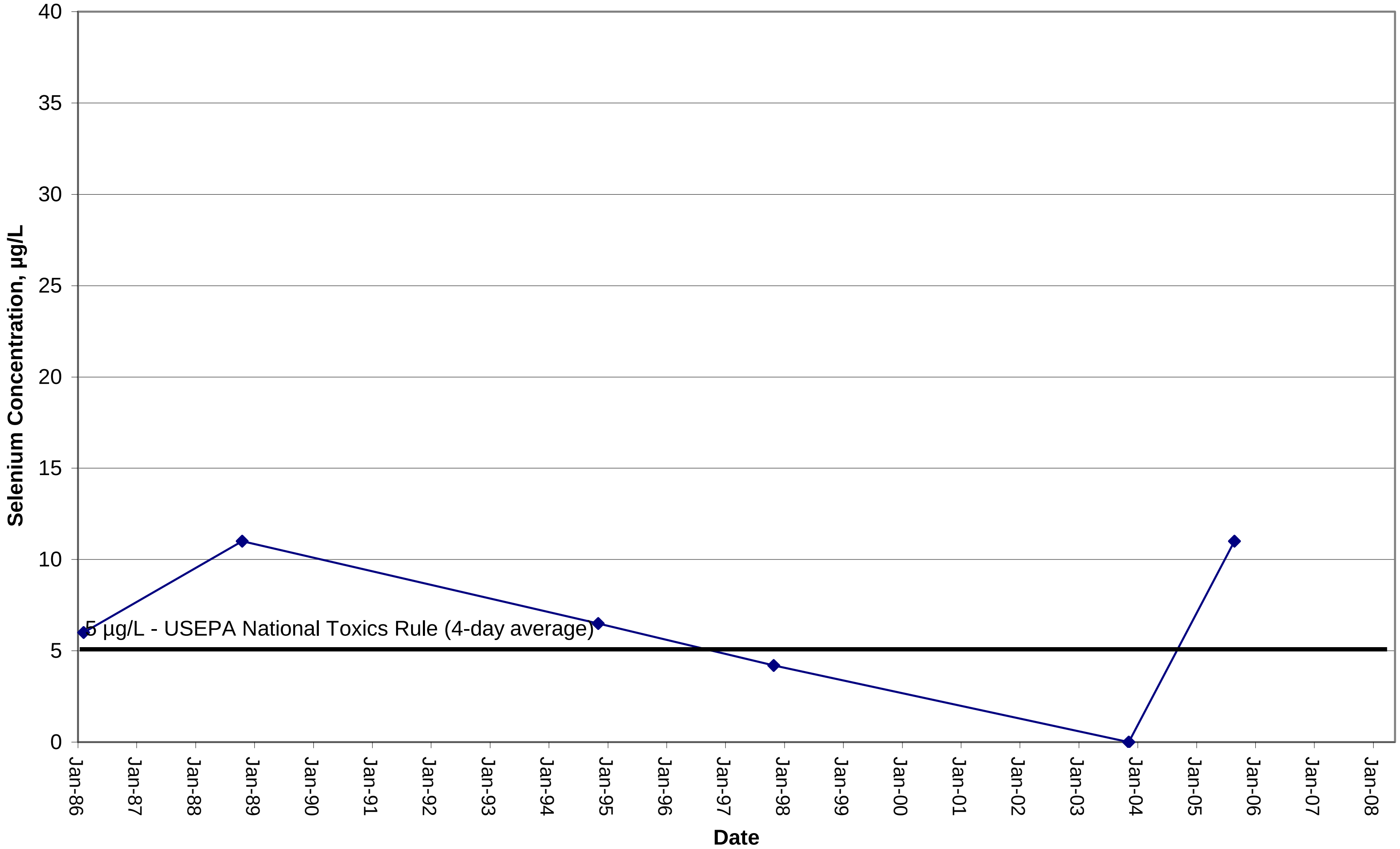


Figure F-14c

City of Woodland
Groundwater Management Plan

WELL #17 SELENIUM CONCENTRATION OVER TIME

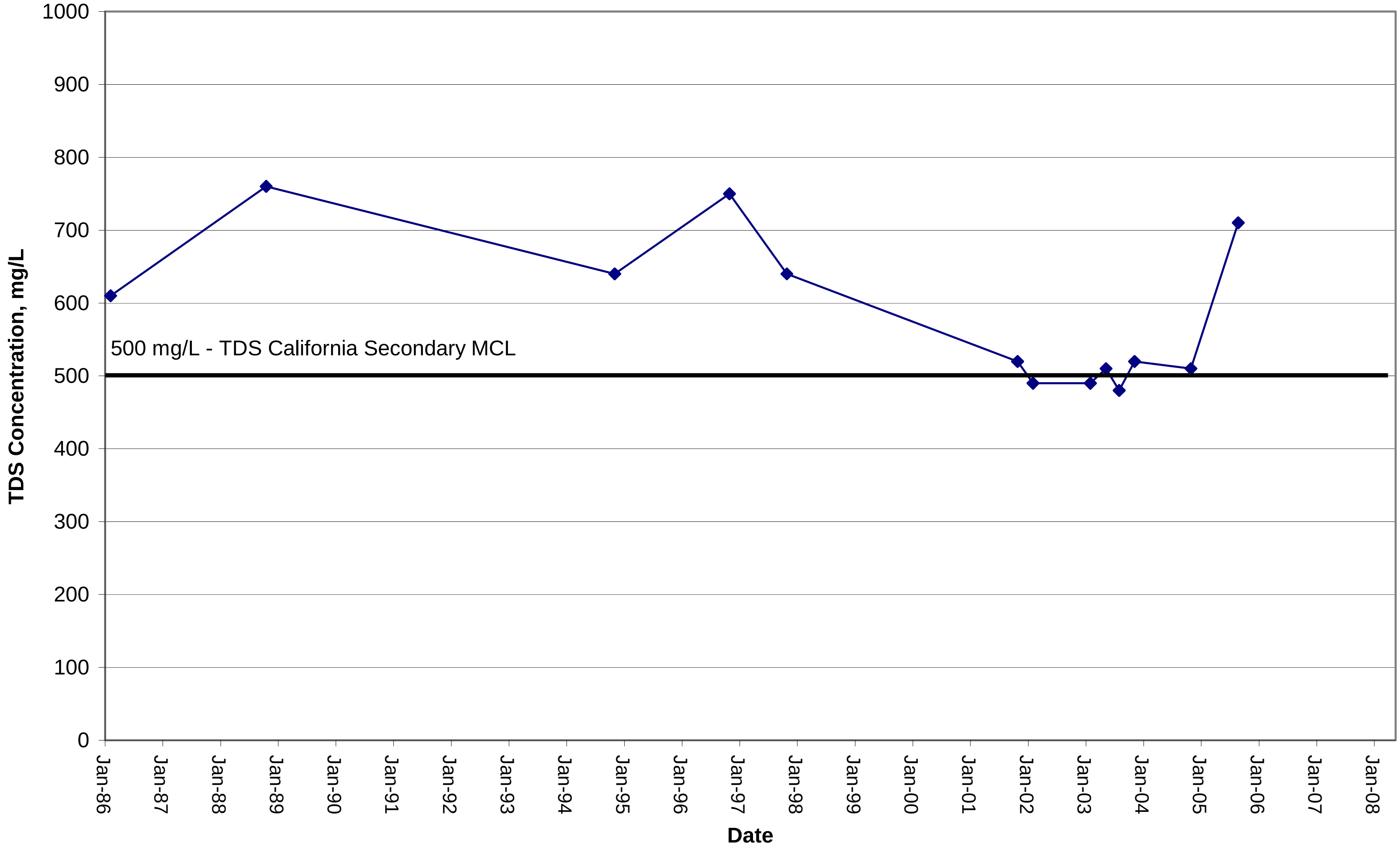


Figure F-14d

City of Woodland
Groundwater Management Plan

WELL #17 TDS CONCENTRATION OVER TIME

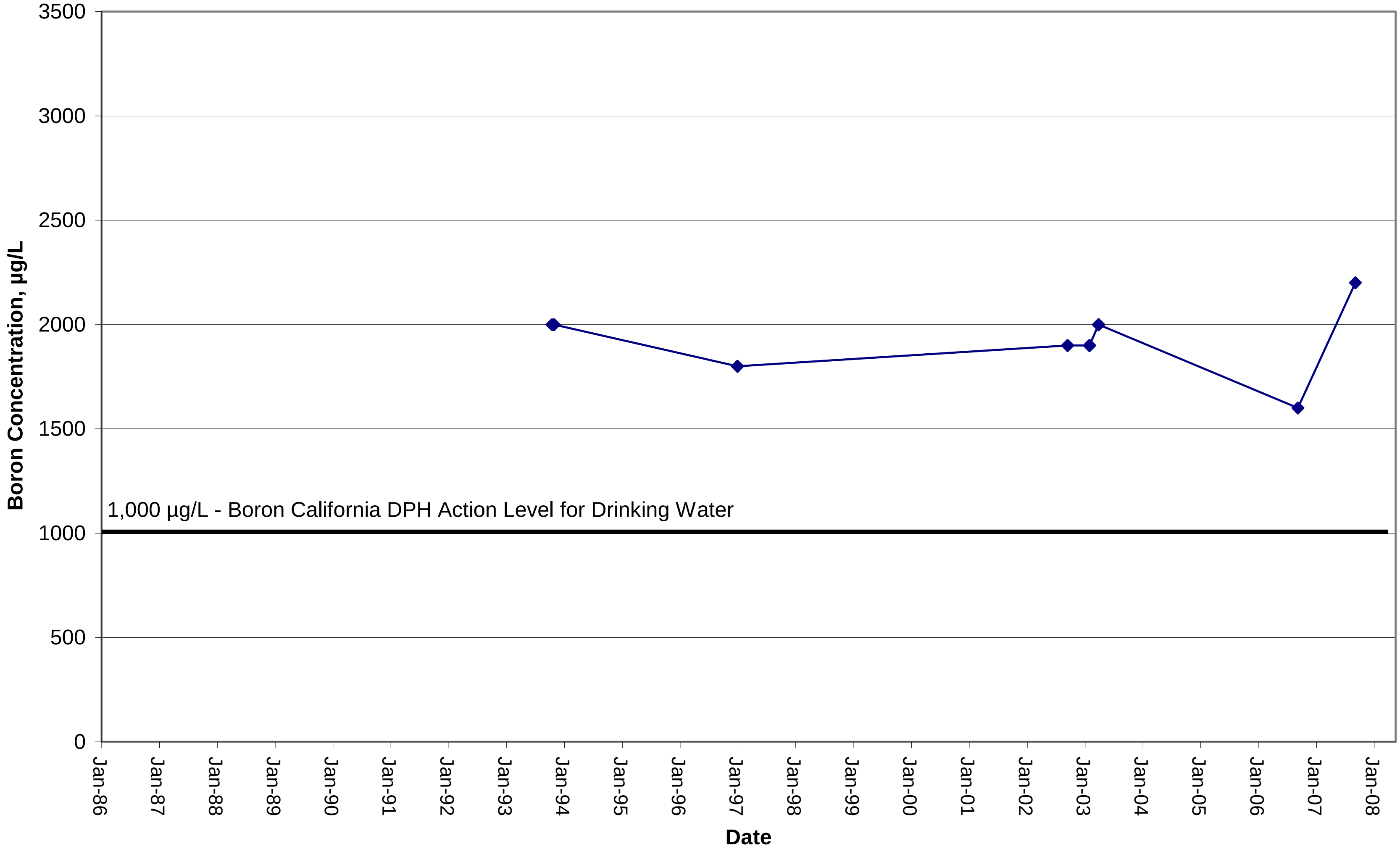


Figure F-15a

City of Woodland
Groundwater Management Plan

WELL #18 BORON CONCENTRATION OVER TIME

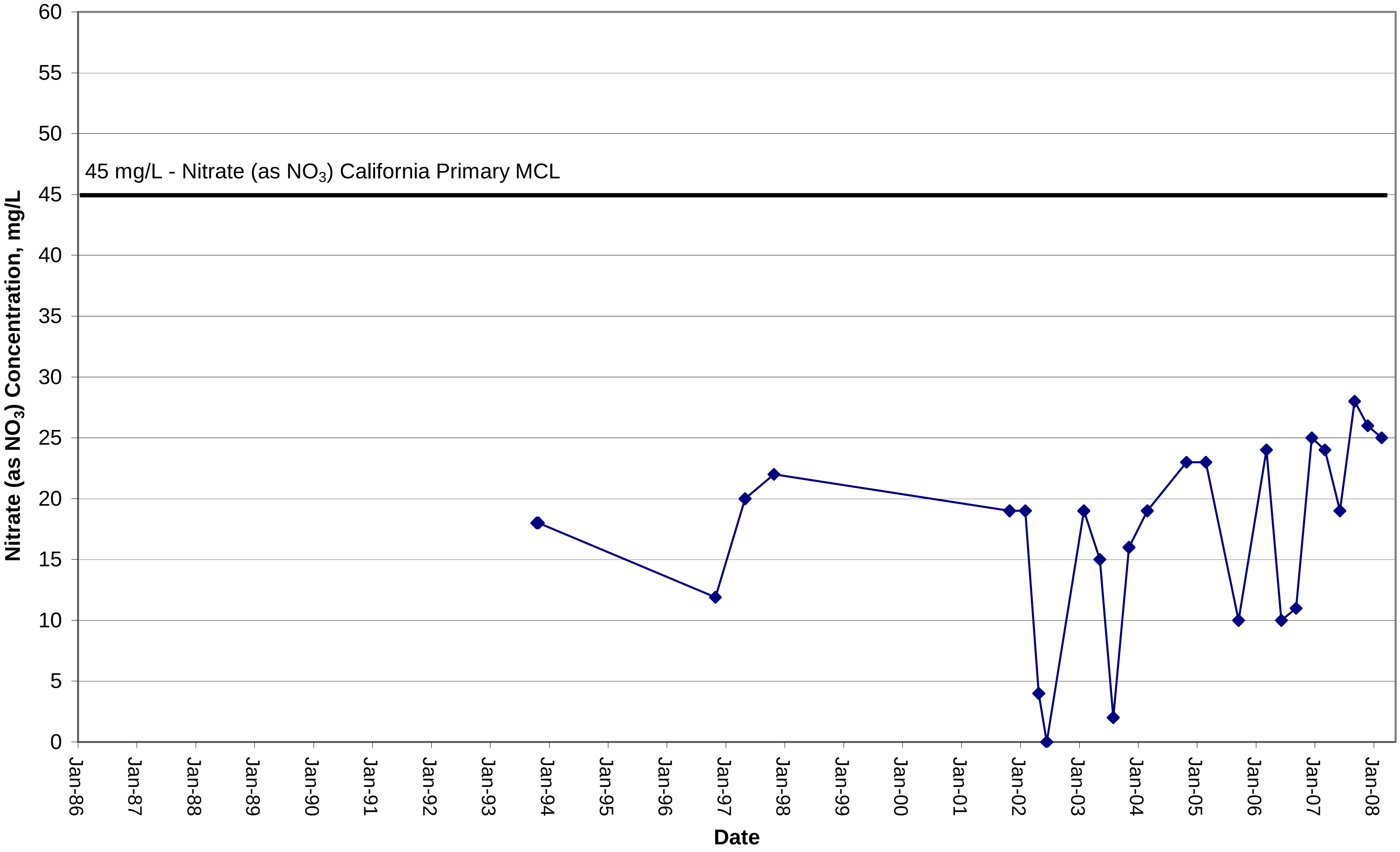


Figure F-15b

City of Woodland
Groundwater Management Plan

WELL #18 NITRATE CONCENTRATION OVER TIME

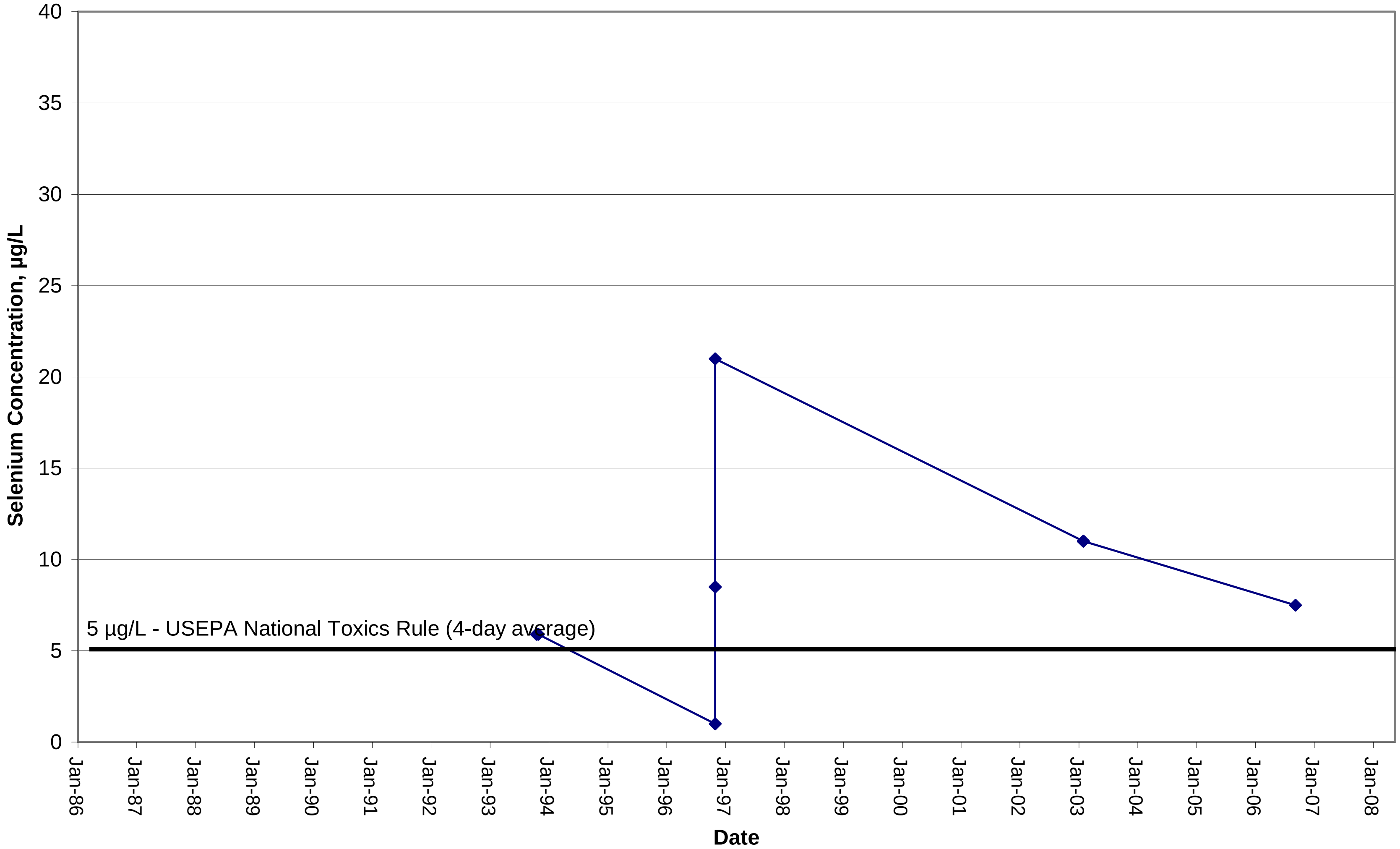


Figure F-15c

City of Woodland
Groundwater Management Plan

WELL #18 SELENIUM CONCENTRATION OVER TIME

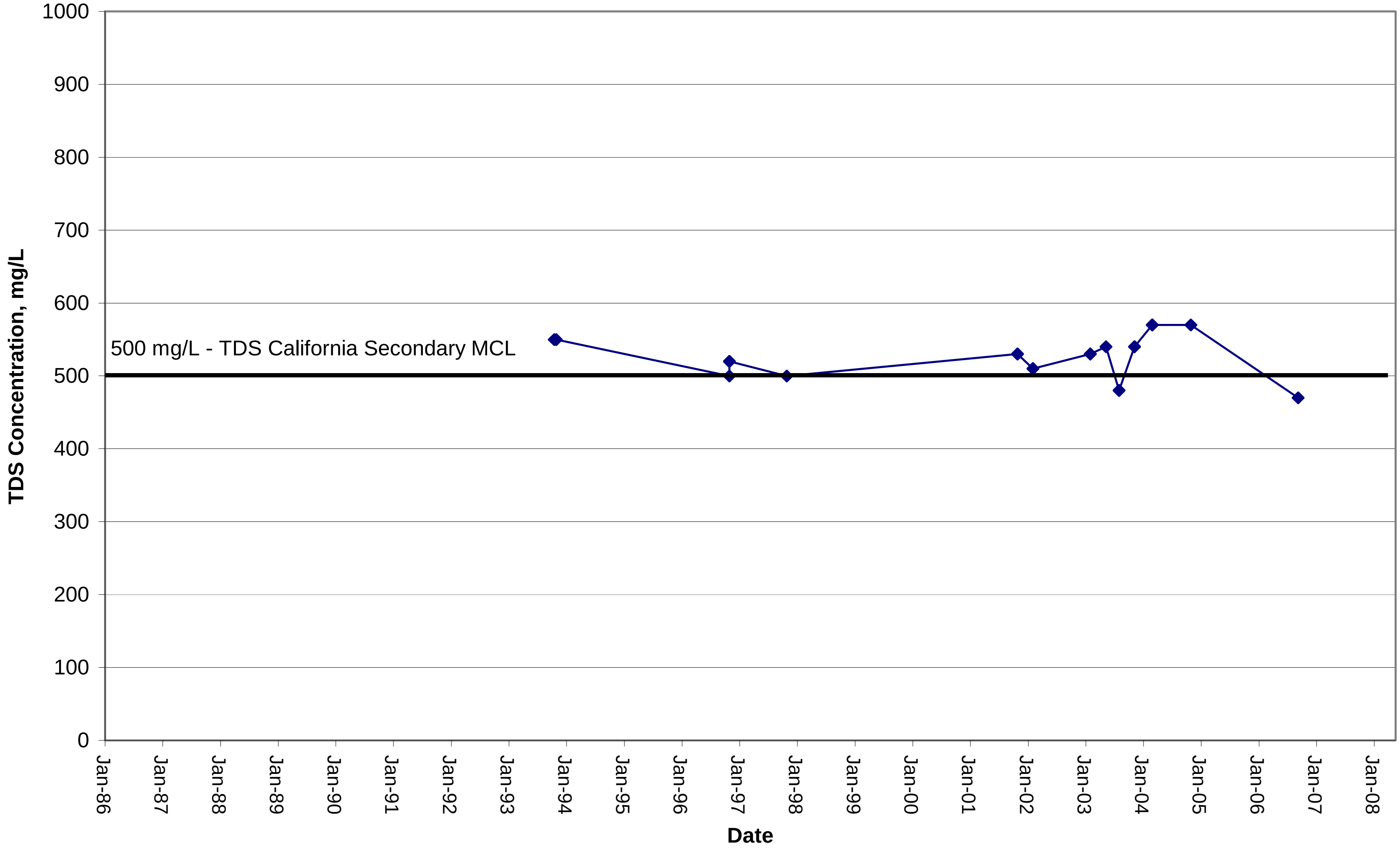


Figure F-15d

City of Woodland
Groundwater Management Plan

WELL #18 TDS CONCENTRATION OVER TIME

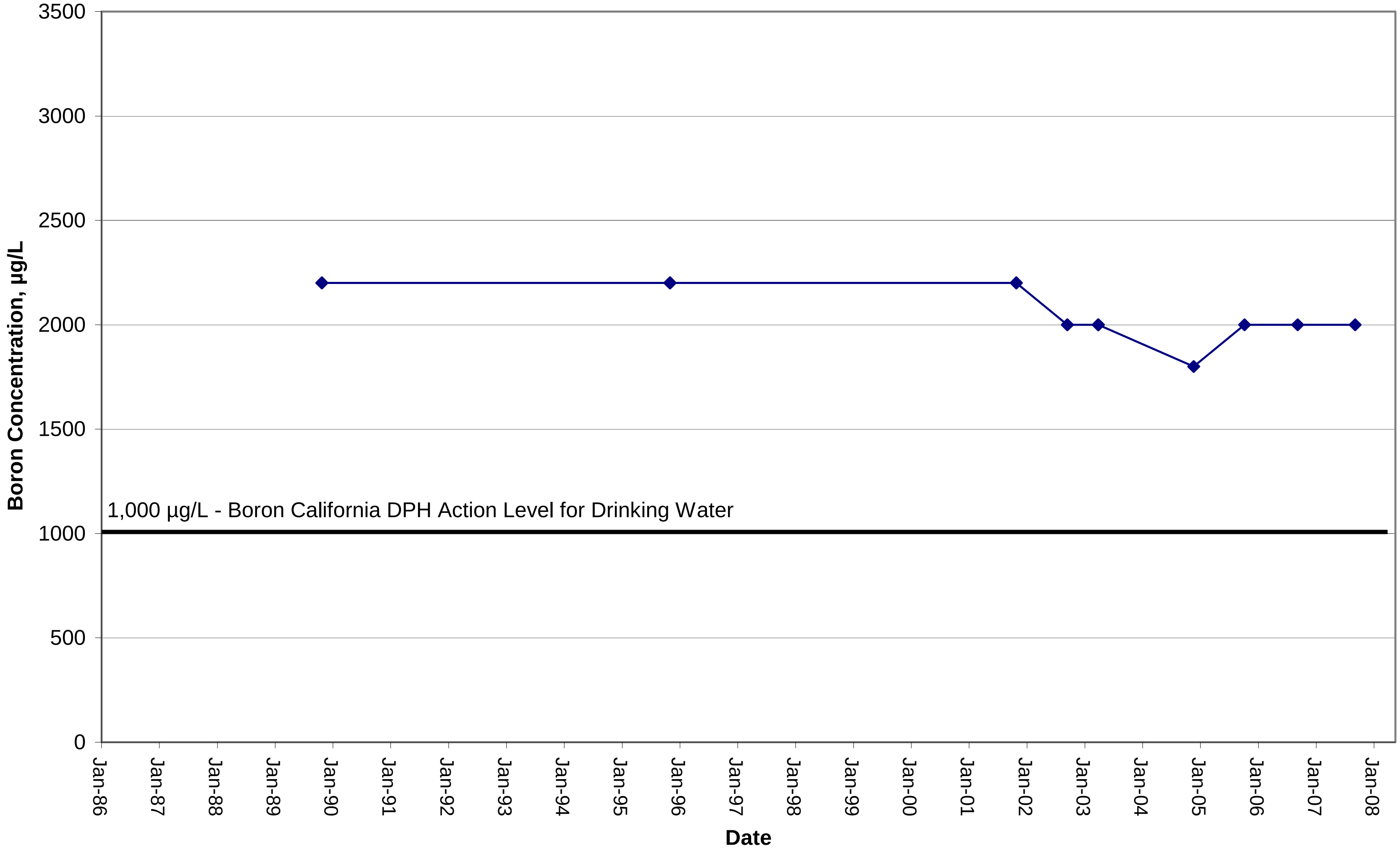


Figure F-16a

City of Woodland
Groundwater Management Plan

WELL #19 BORON CONCENTRATION OVER TIME

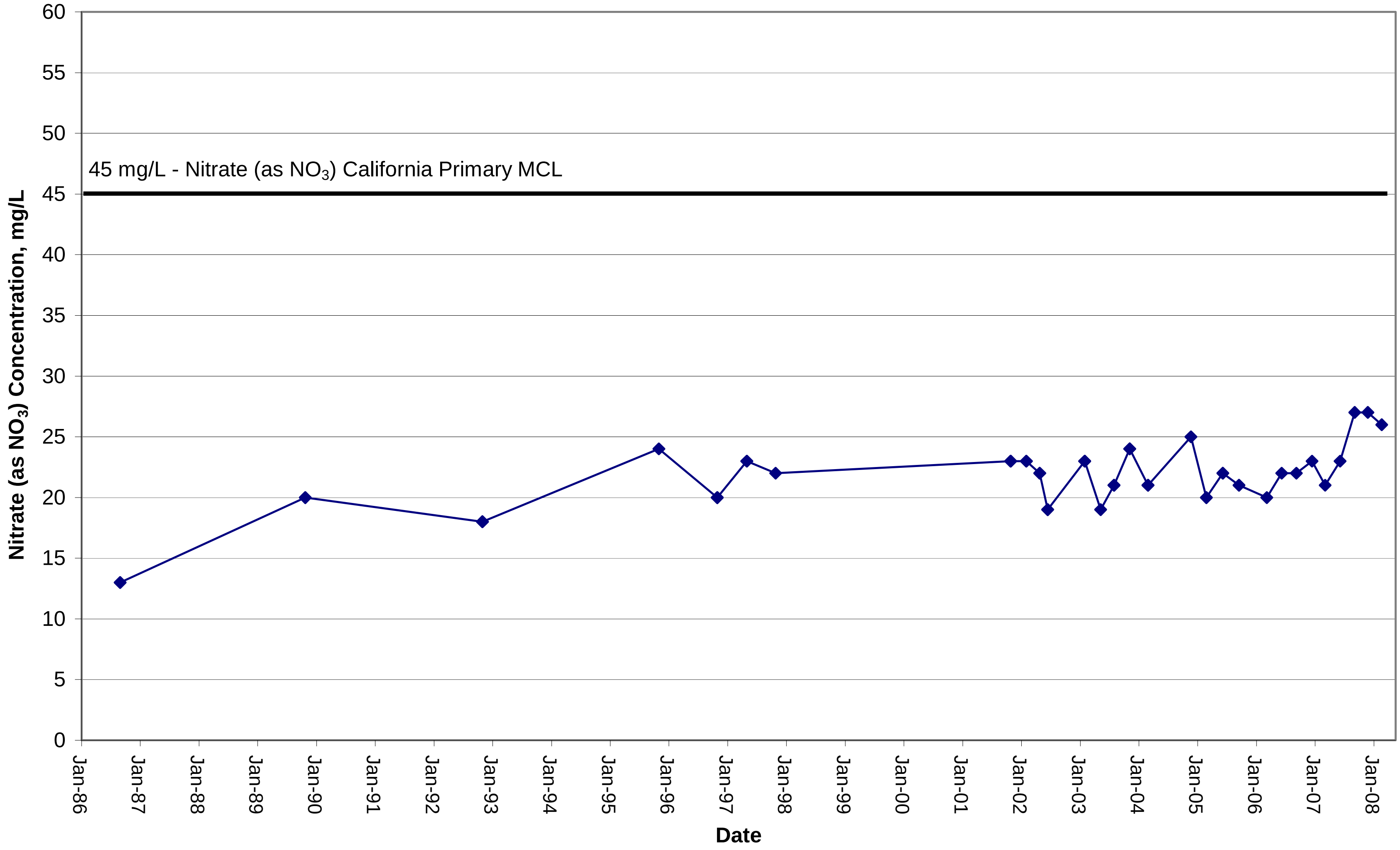


Figure F-16b

City of Woodland
Groundwater Management Plan

WELL #19 NITRATE CONCENTRATION OVER TIME

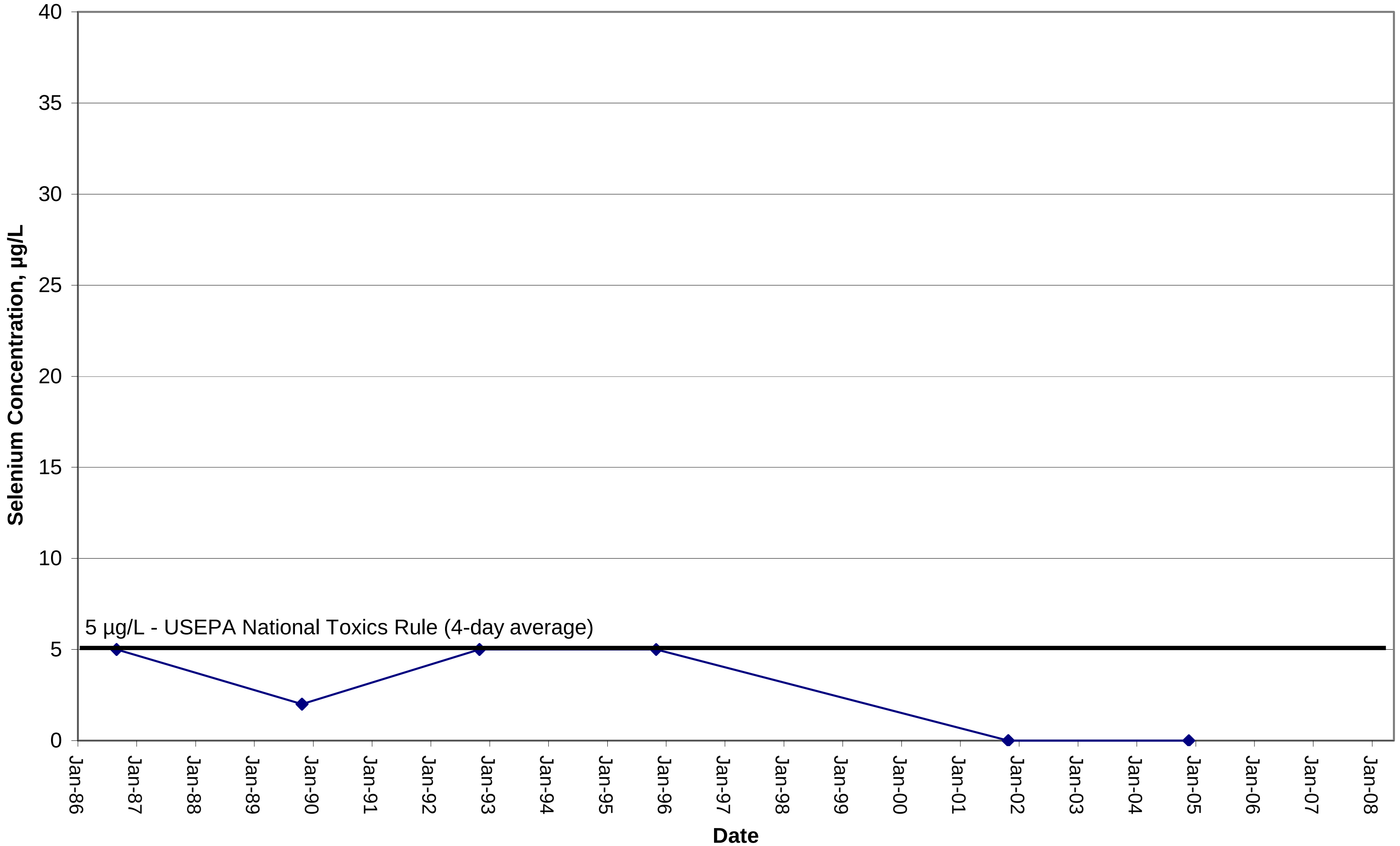


Figure F-16c

City of Woodland
Groundwater Management Plan

WELL #19 SELENIUM CONCENTRATION OVER TIME

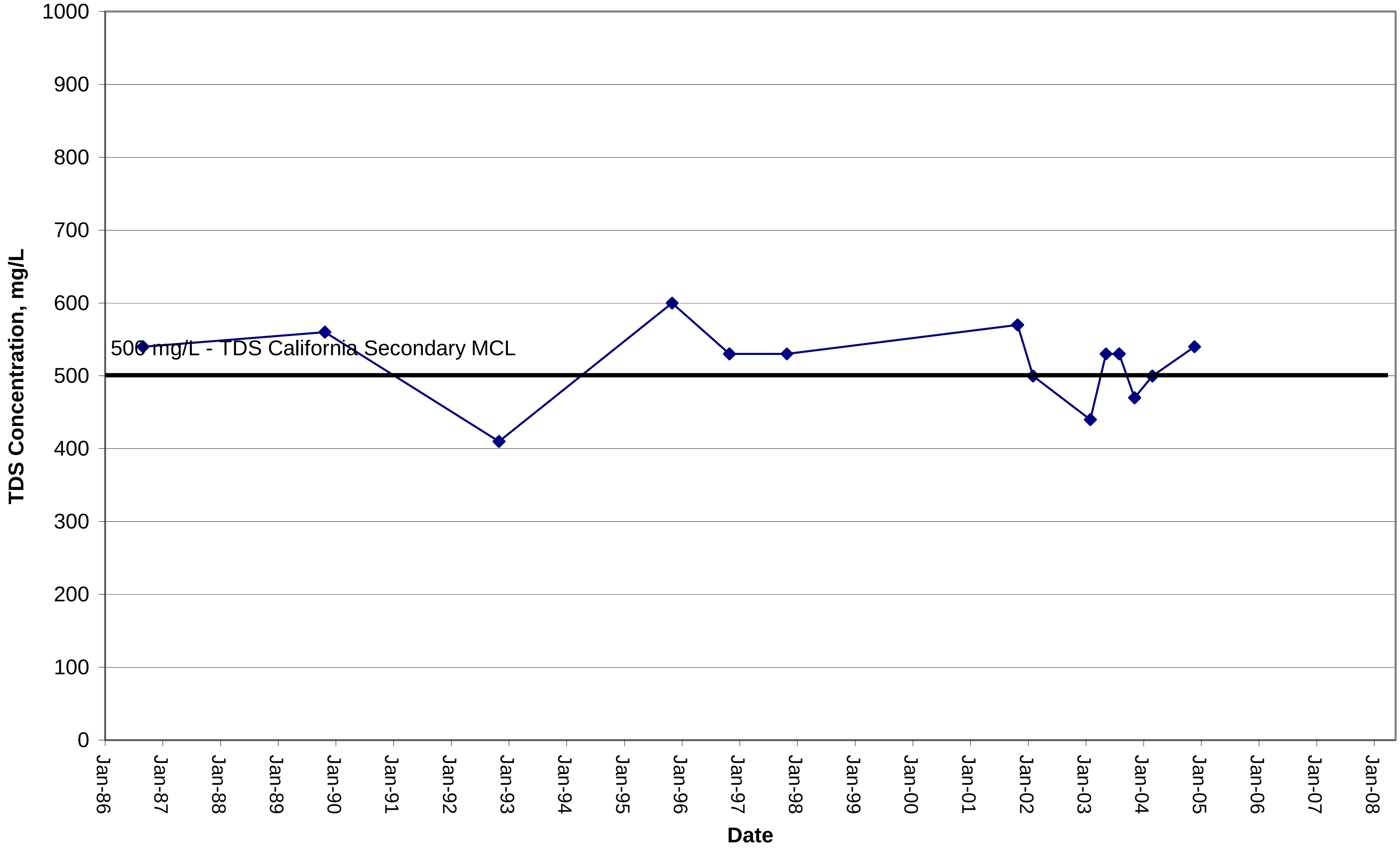


Figure F-16d

City of Woodland
Groundwater Management Plan

WELL #19 TDS CONCENTRATION OVER TIME

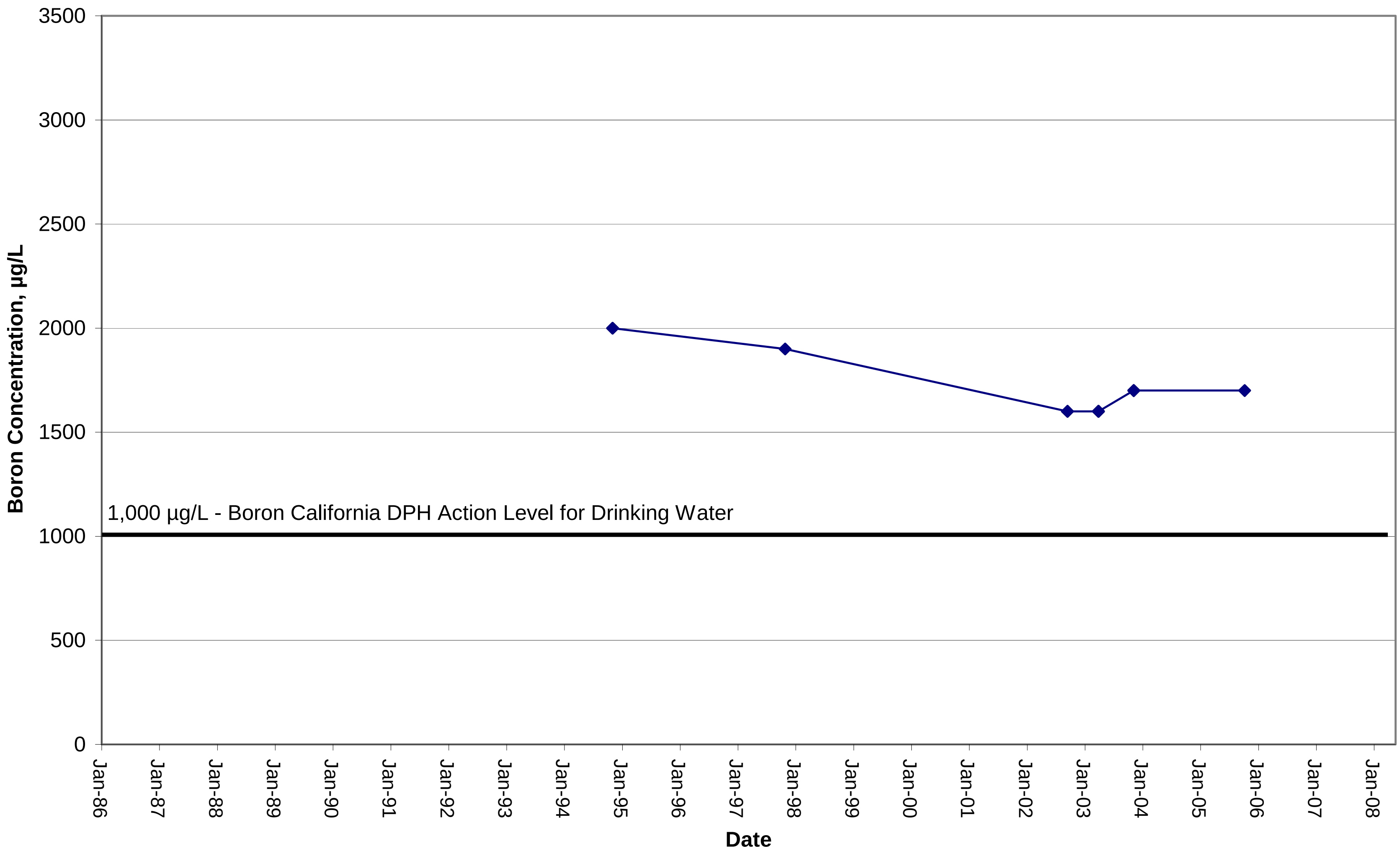


Figure F-17a

City of Woodland
Groundwater Management Plan

WELL #20 BORON CONCENTRATION OVER TIME

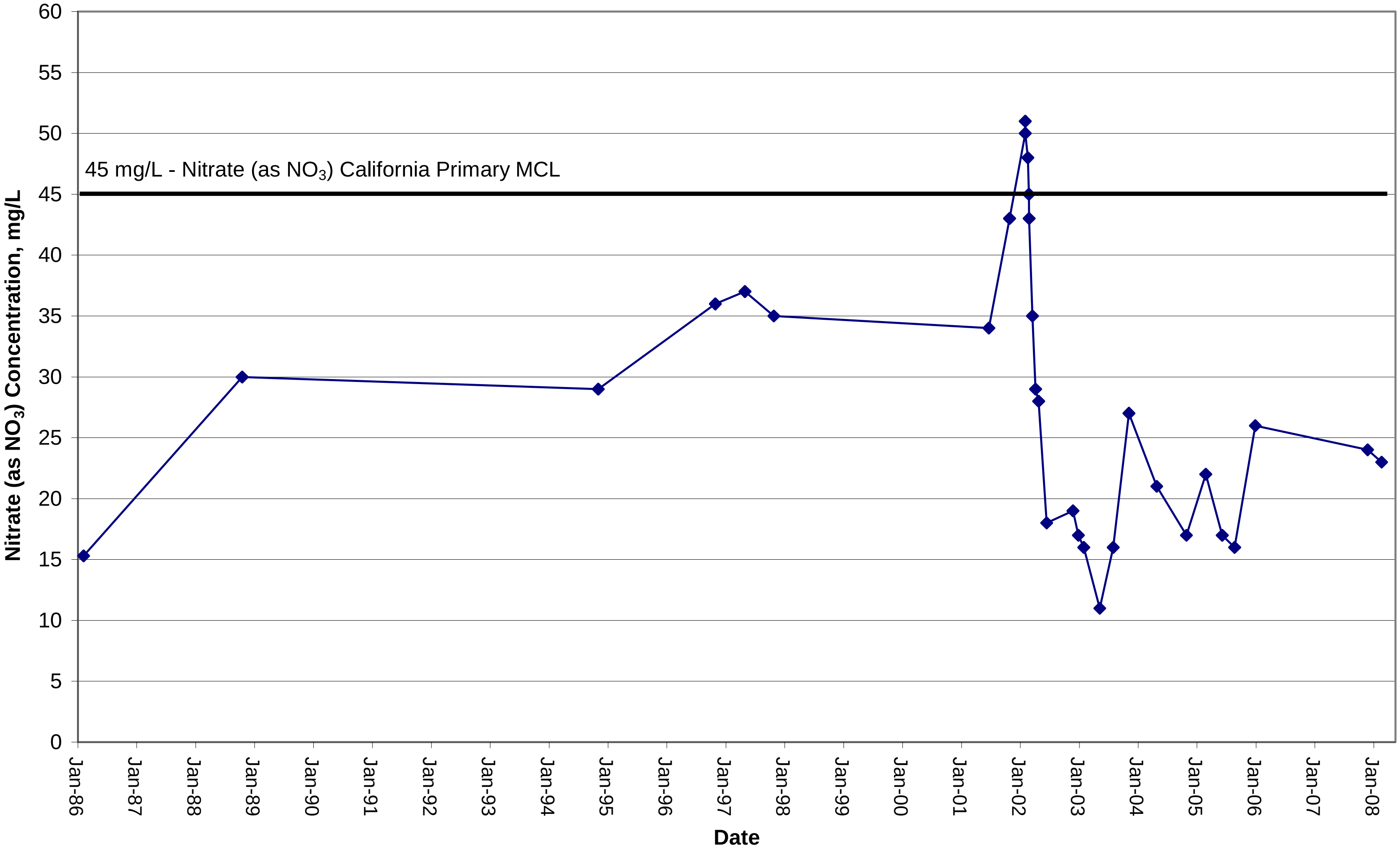


Figure F-17b

City of Woodland
Groundwater Management Plan

WELL #20 NITRATE CONCENTRATION OVER TIME

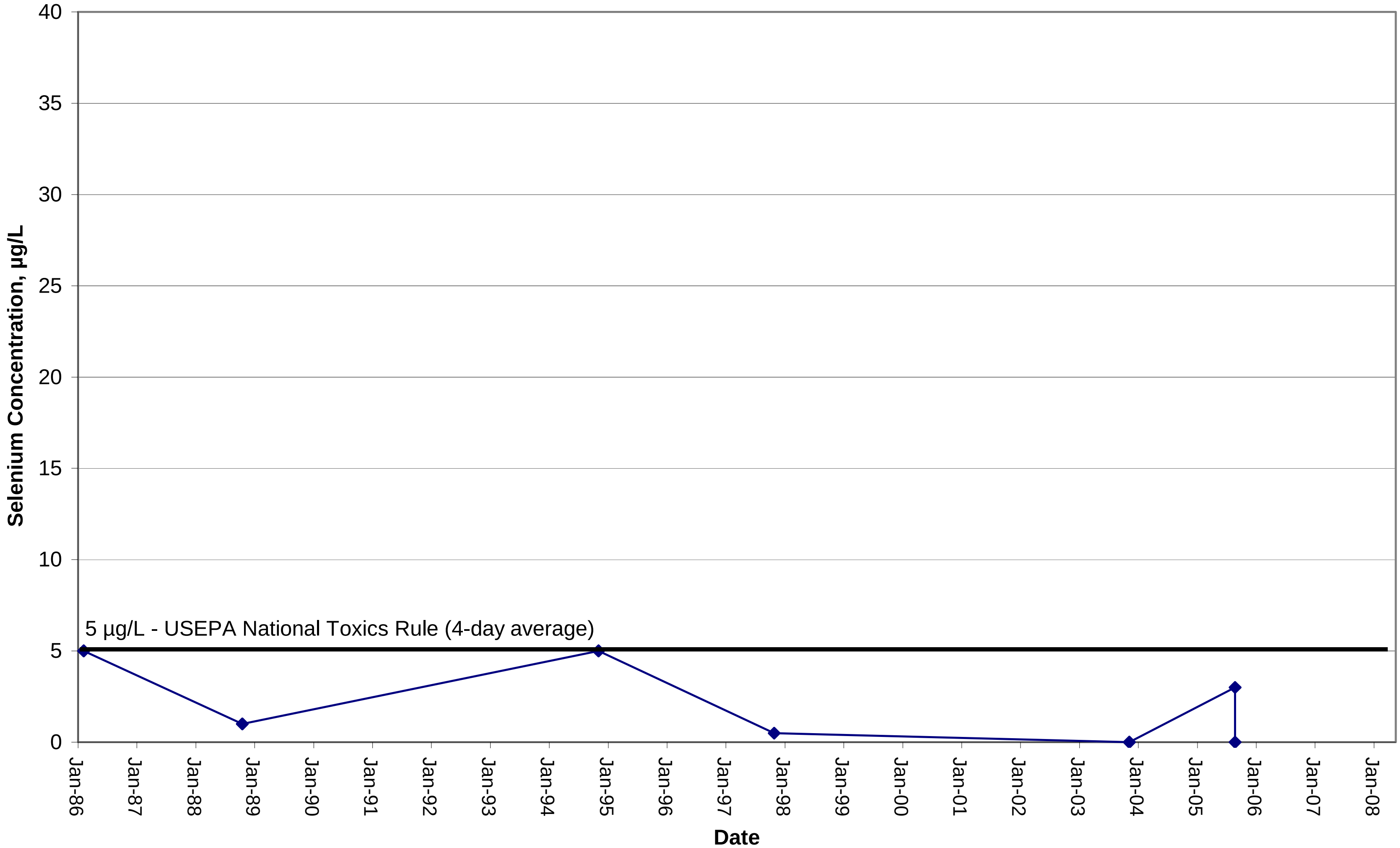


Figure F-17c

City of Woodland
Groundwater Management Plan

WELL #20 SELENIUM CONCENTRATION OVER TIME

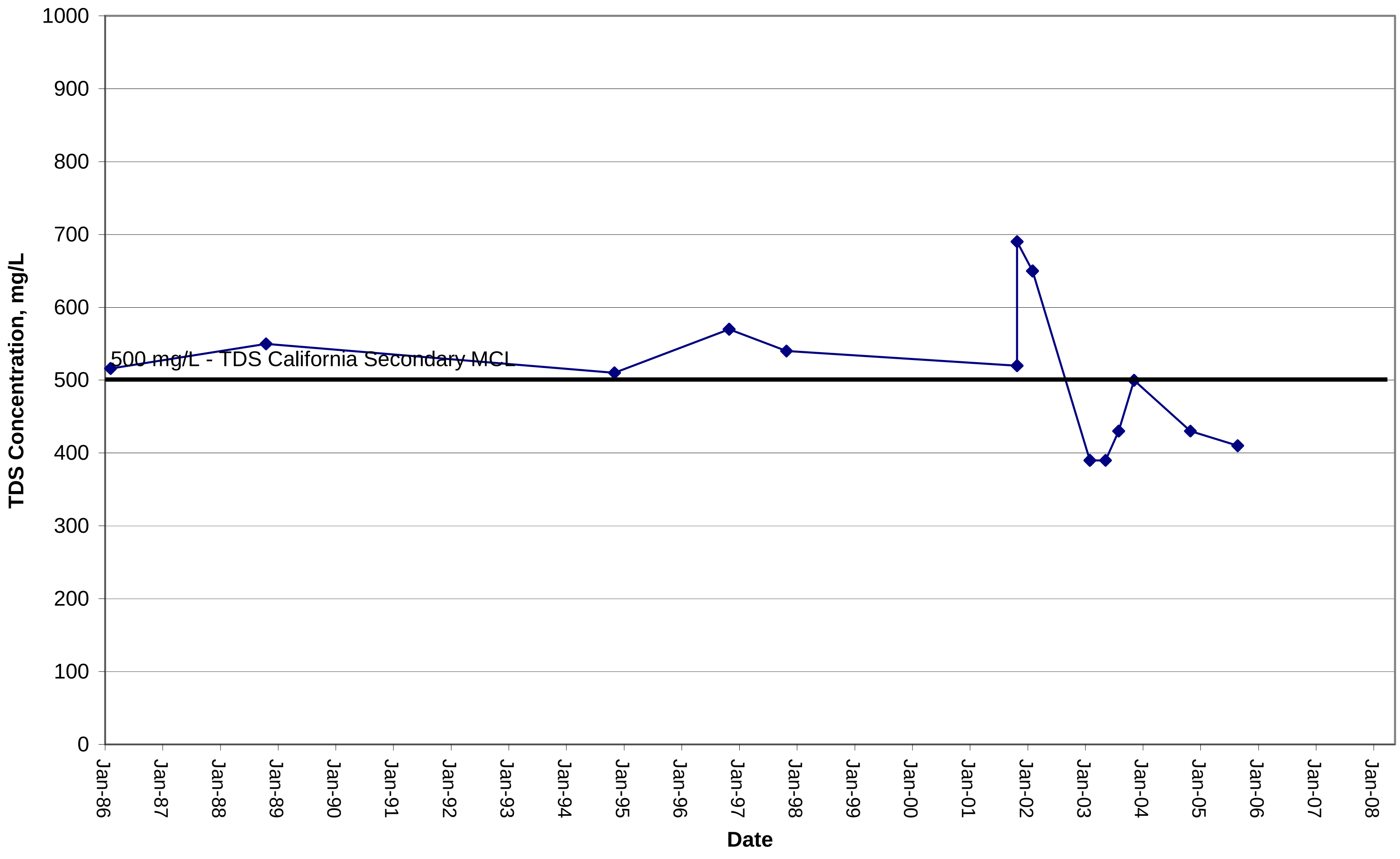


Figure F-17d

City of Woodland
Groundwater Management Plan

WELL #20 TDS CONCENTRATION OVER TIME

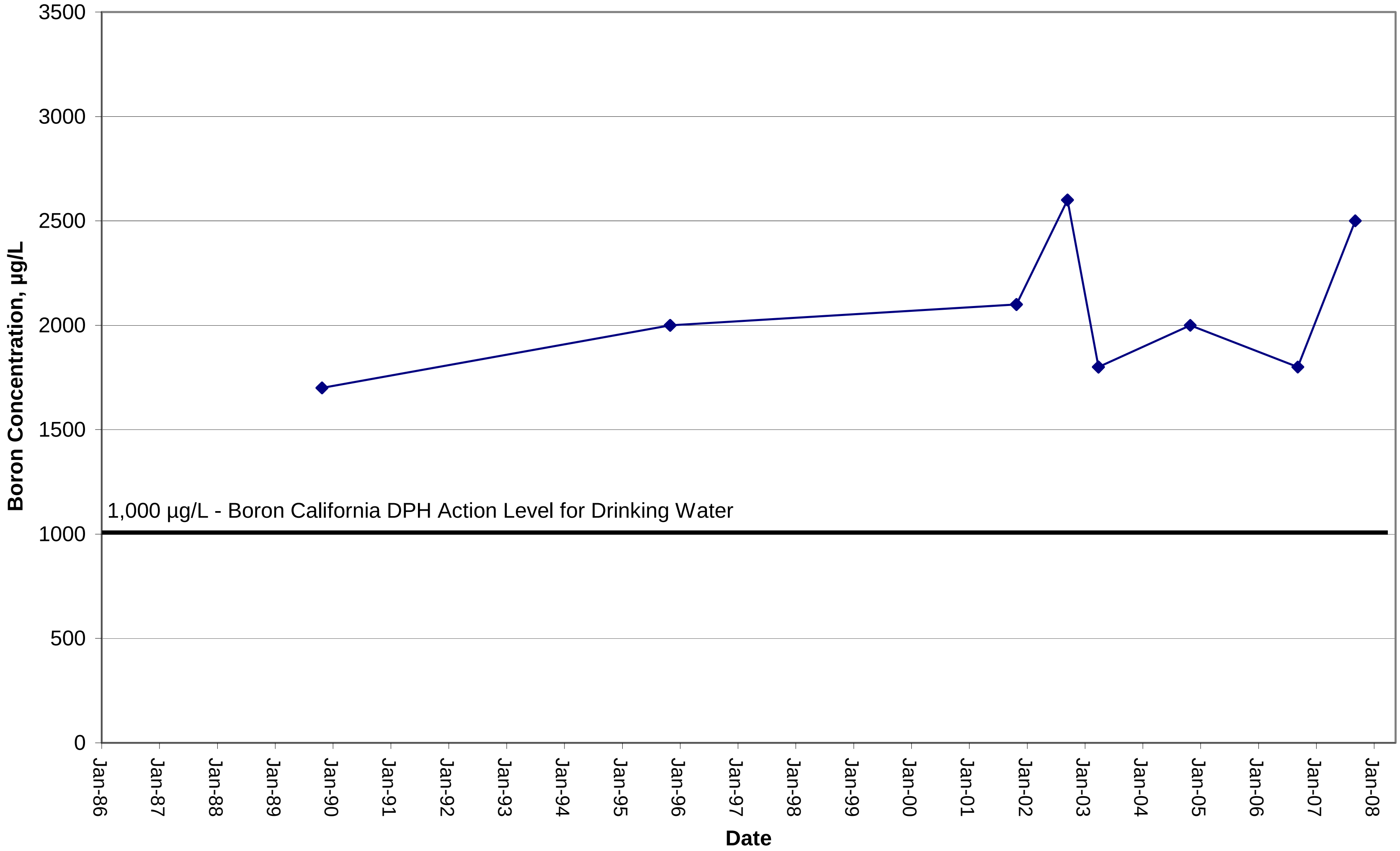


Figure F-18a

City of Woodland
Groundwater Management Plan

WELL #21 BORON CONCENTRATION OVER TIME

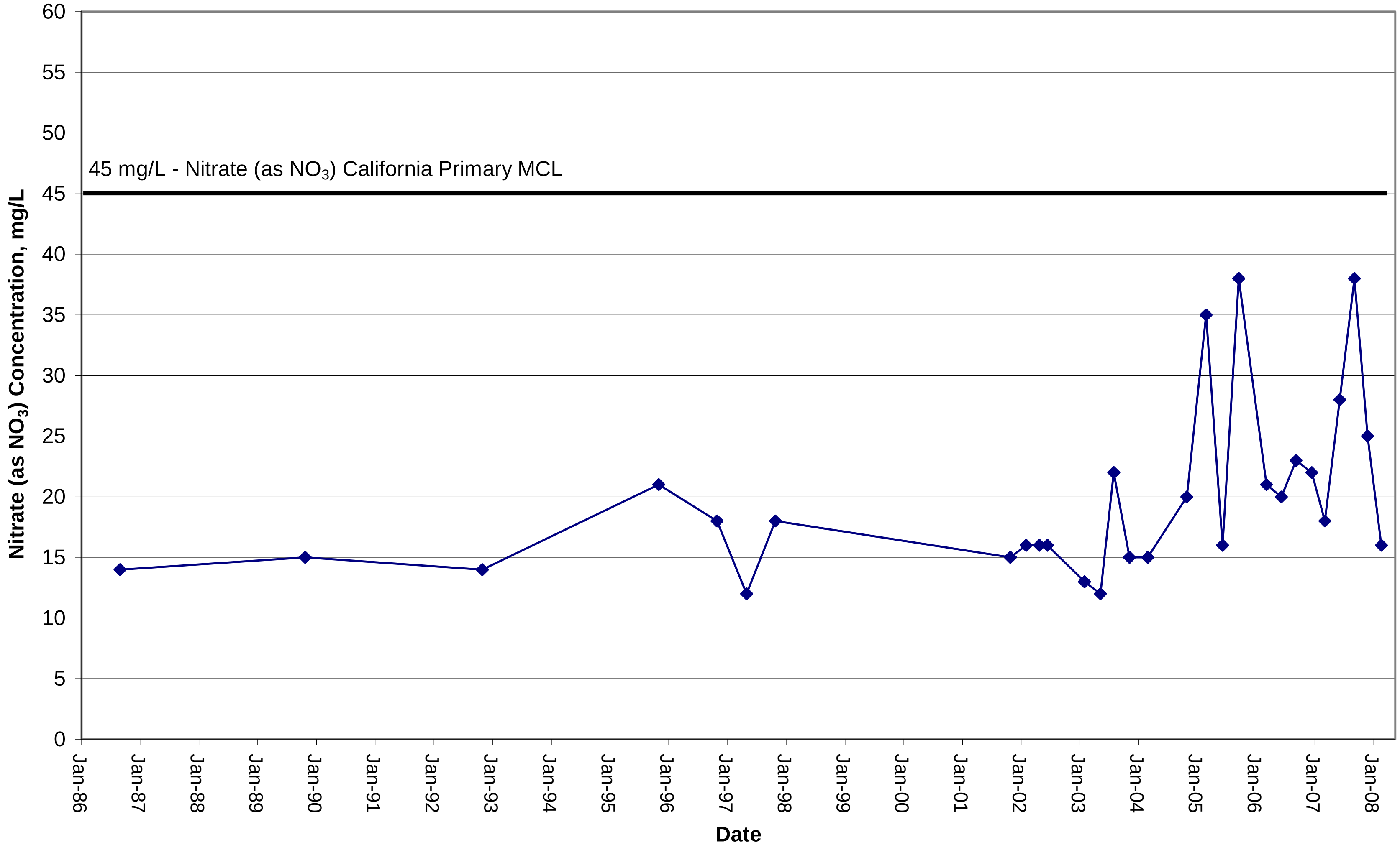


Figure F-18b

City of Woodland
Groundwater Management Plan

WELL #21 NITRATE CONCENTRATION OVER TIME

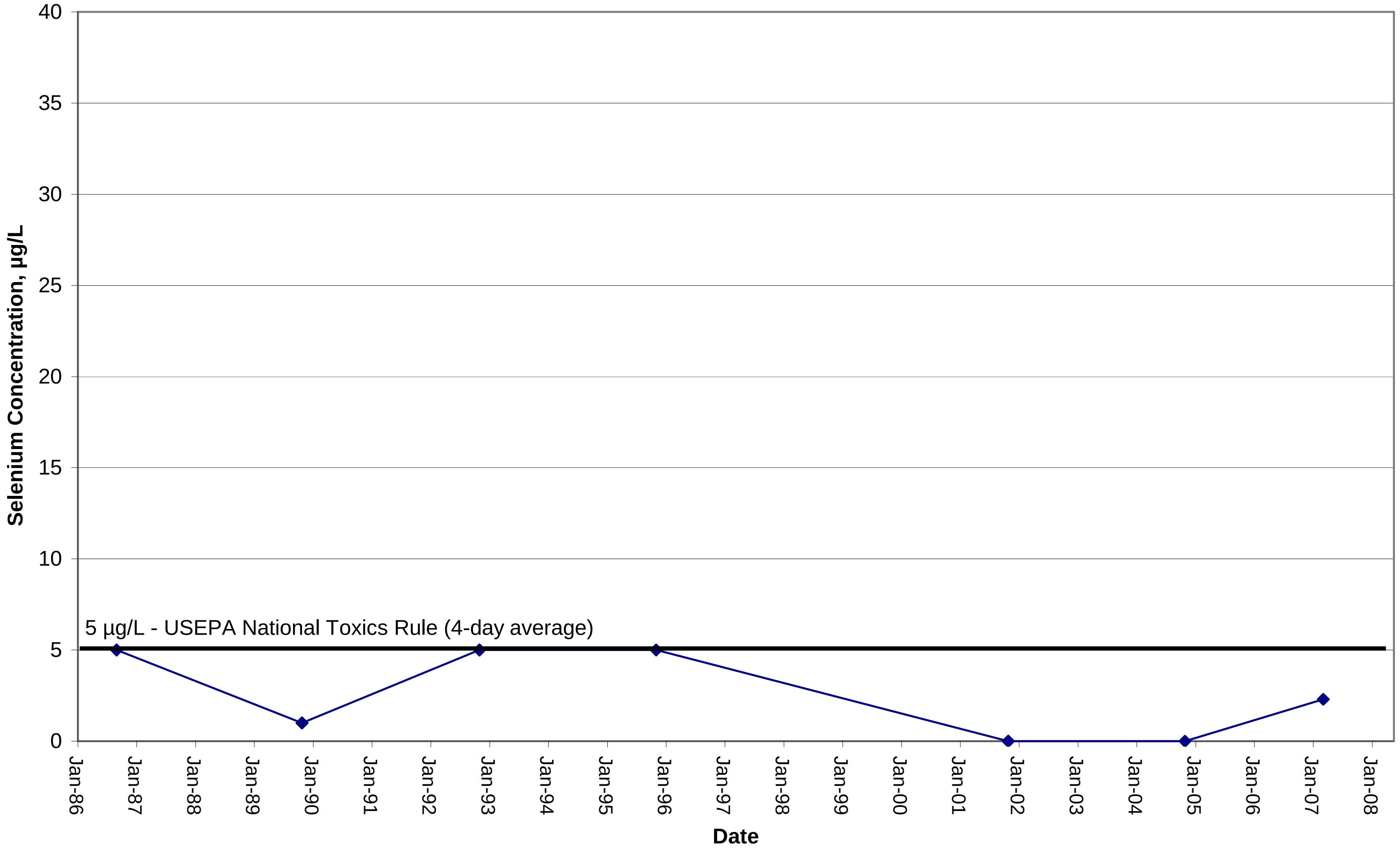


Figure F-18c

City of Woodland
Groundwater Management Plan

WELL #21 SELENIUM CONCENTRATION OVER TIME

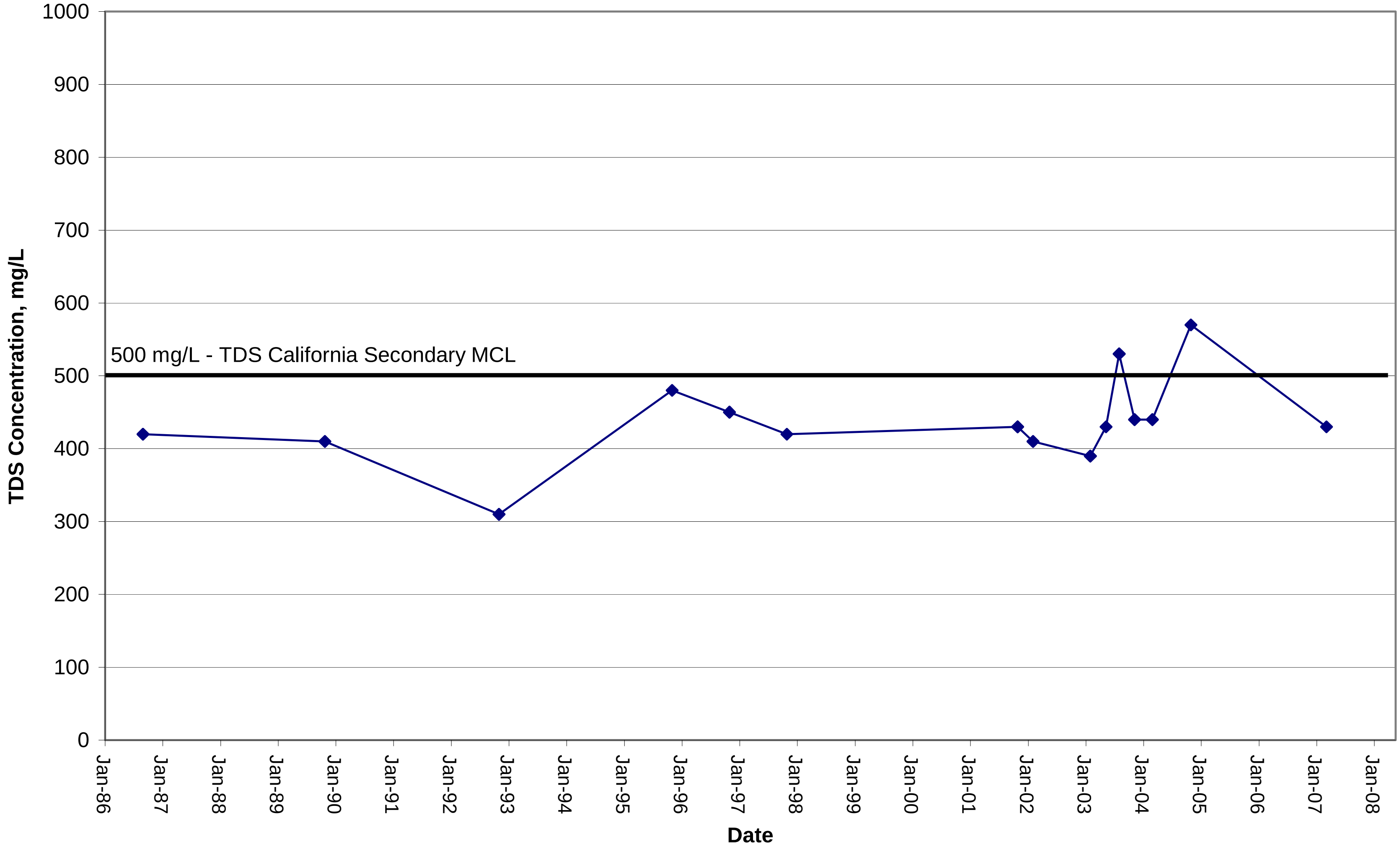
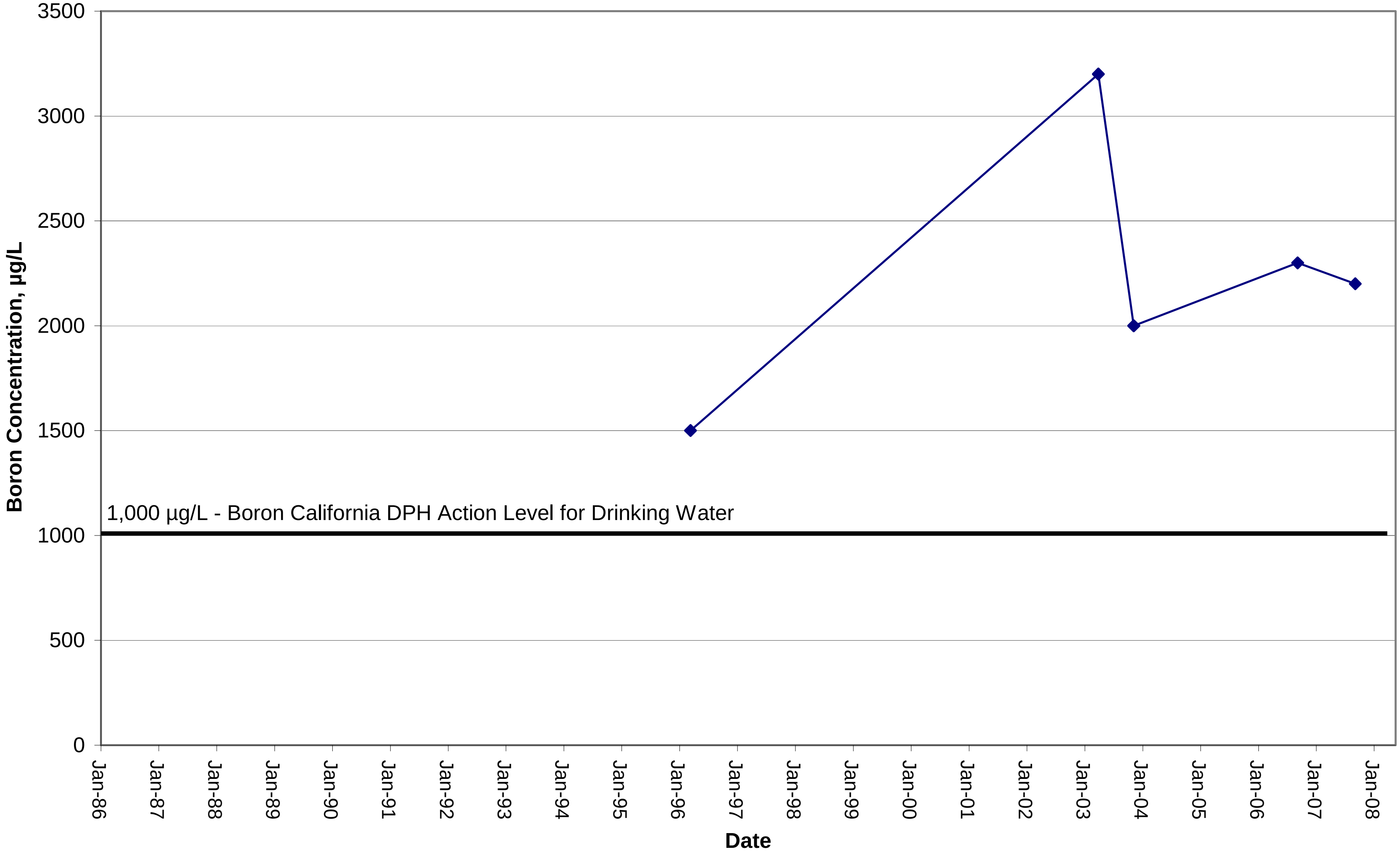


Figure F-18d

City of Woodland
Groundwater Management Plan

WELL #21 TDS CONCENTRATION OVER TIME

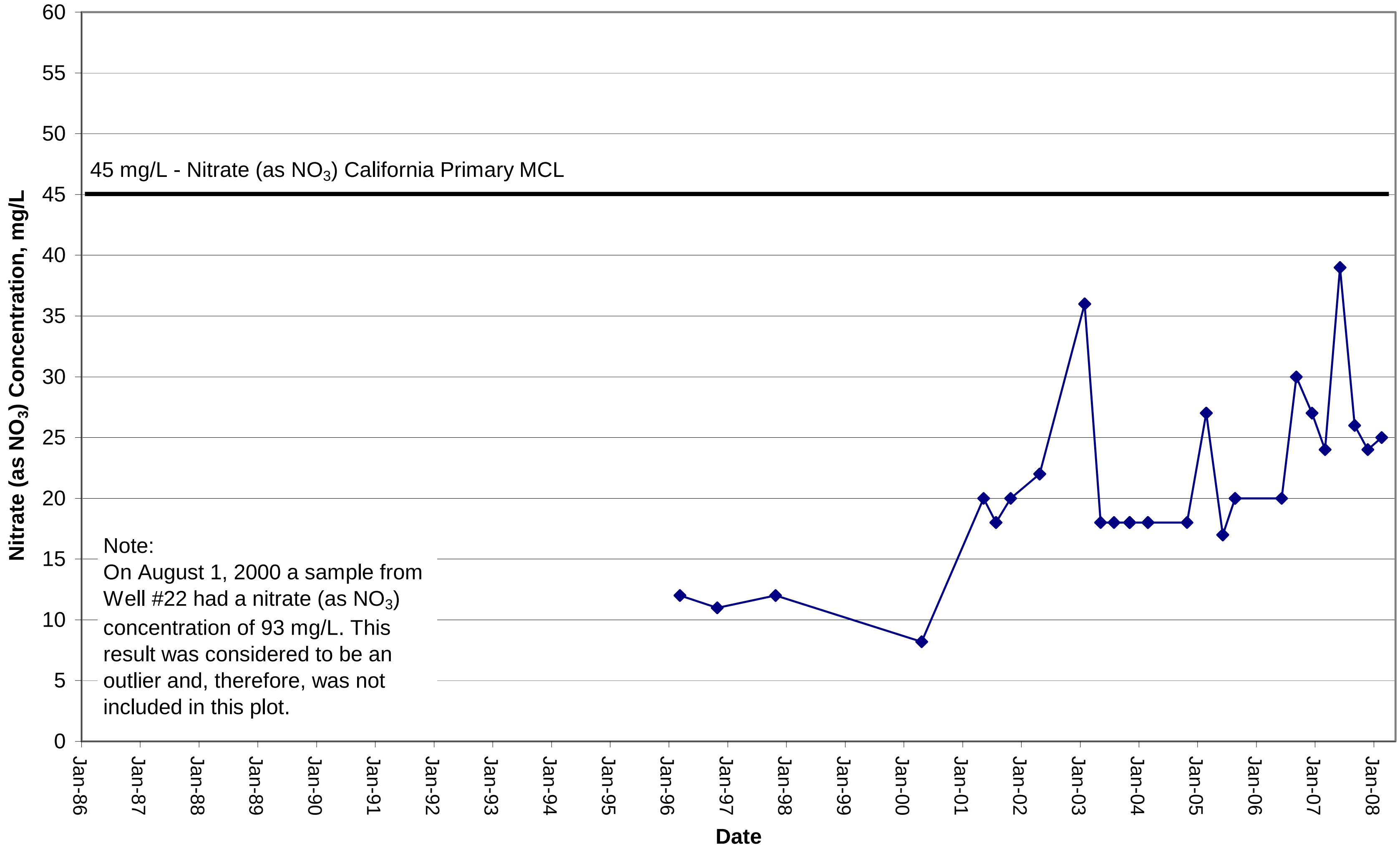


This water quality data was collected from the original Well 22 which went offline in 2008.

Figure F-19a

City of Woodland
Groundwater Management Plan

WELL #22 BORON CONCENTRATION OVER TIM

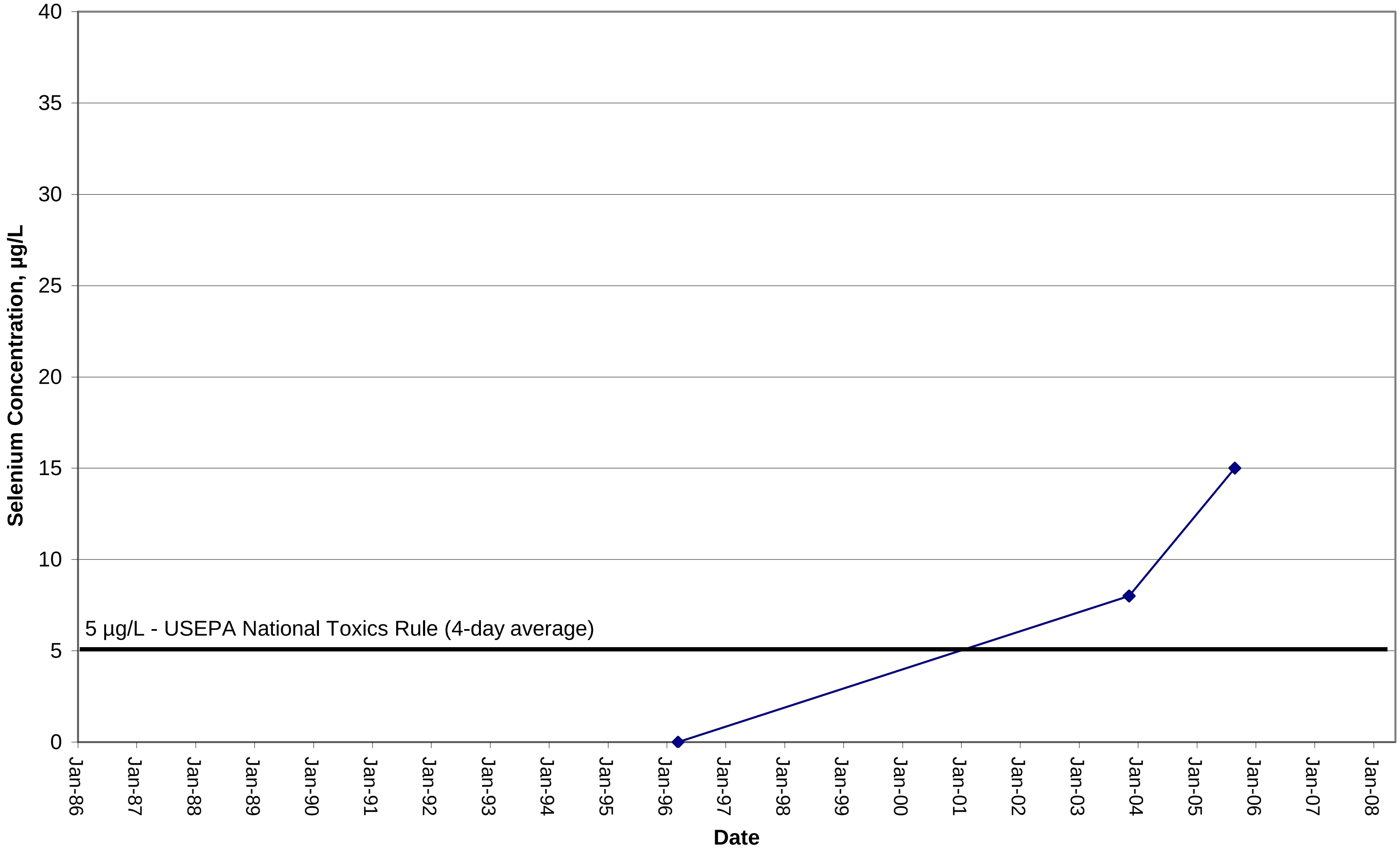


This water quality data was collected from the original Well 22 which went offline in 2008.

Figure F-19b

City of Woodland
Groundwater Management Plan

WELL #22 NITRATE CONCENTRATION OVER TIME

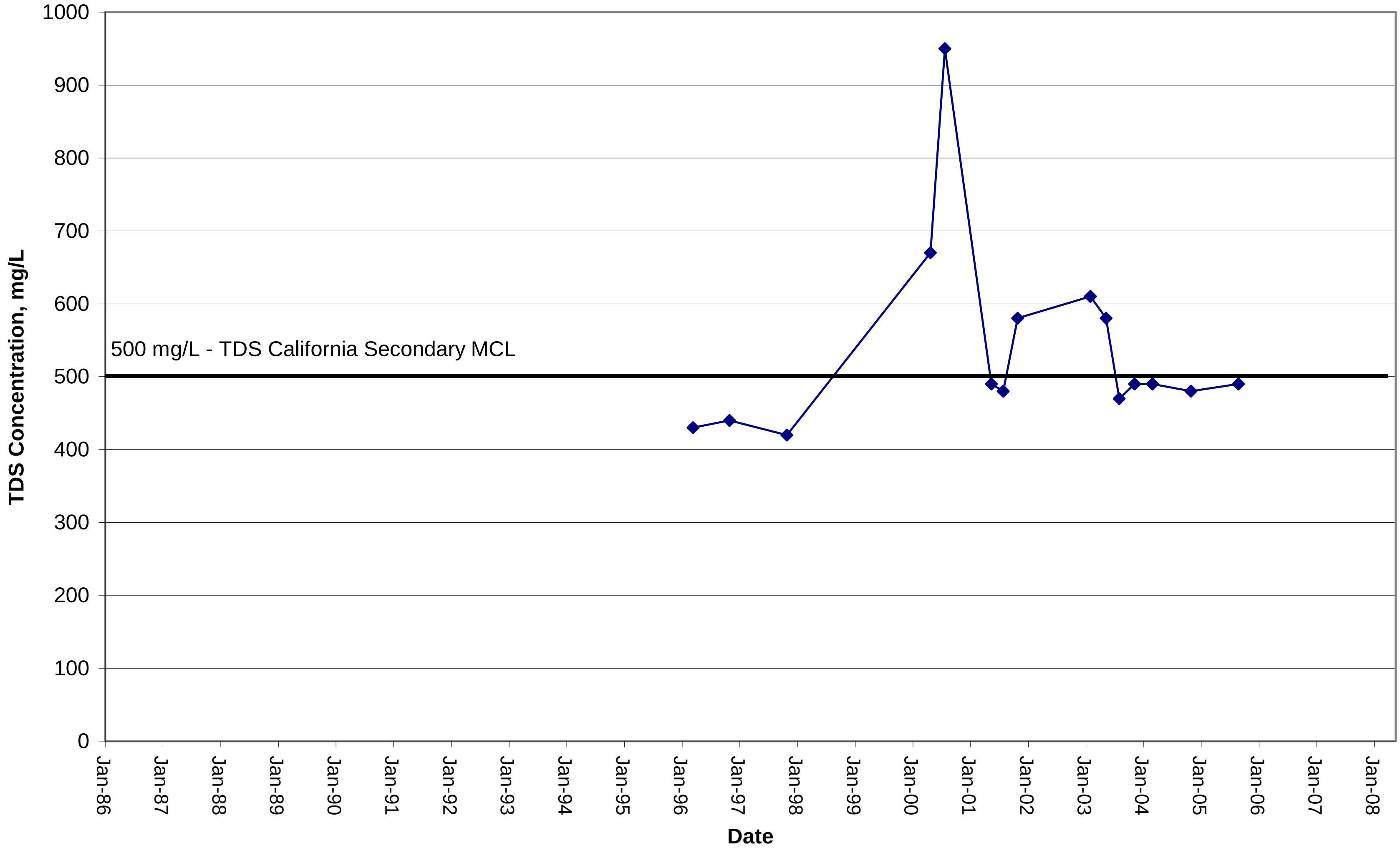


This water quality data was collected from the original Well 22 which went offline in 2008.

Figure F-19c

City of Woodland
Groundwater Management Plan

WELL #22 SELENIUM CONCENTRATION OVER TIME



This water quality data was collected from the original Well 22 which went offline in 2008.

Figure F-19d

City of Woodland
Groundwater Management Plan

WELL #22 TDS CONCENTRATION OVER TIME

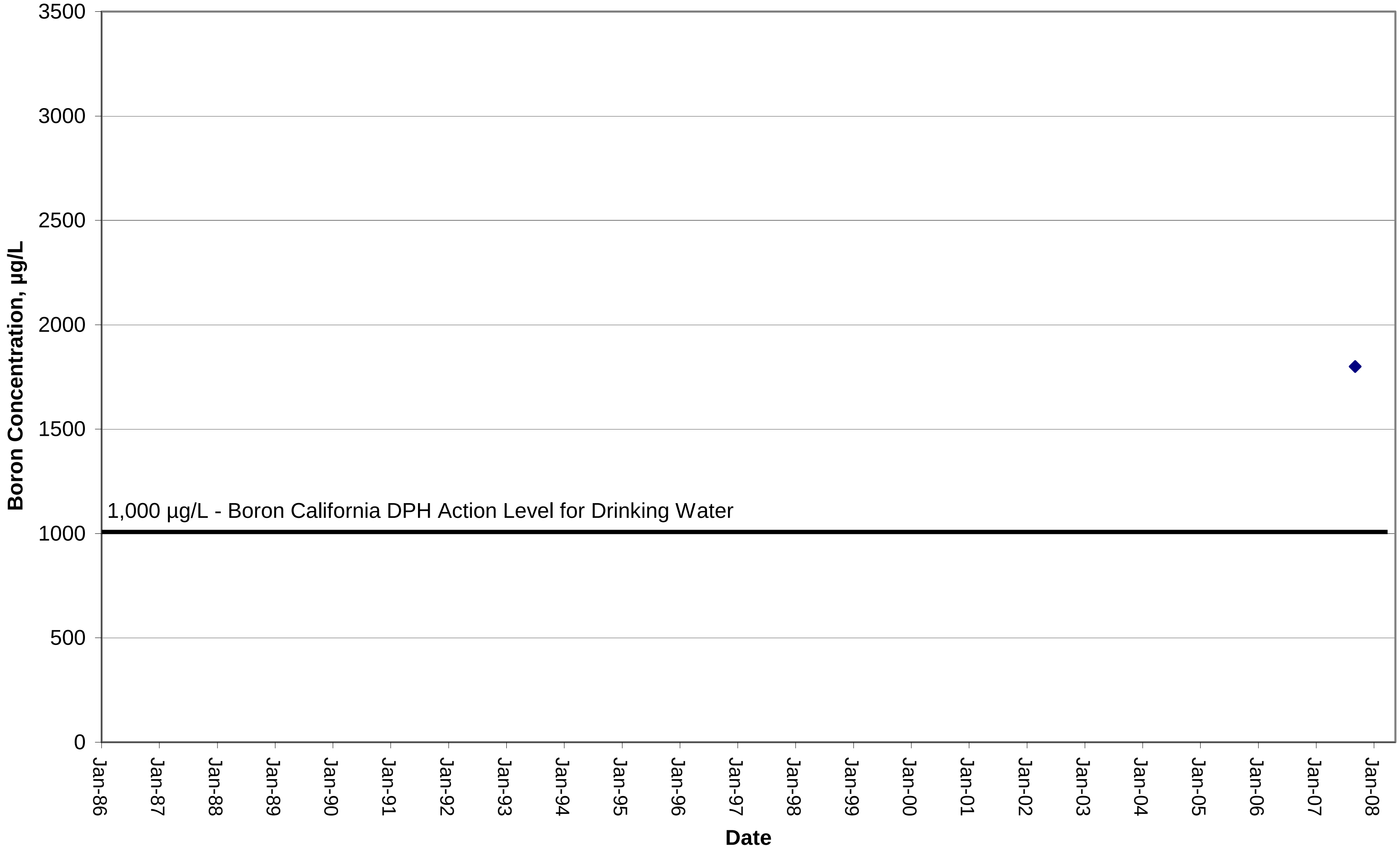


Figure F-20a

City of Woodland
Groundwater Management Plan

WELL #24 BORON CONCENTRATION OVER TIME

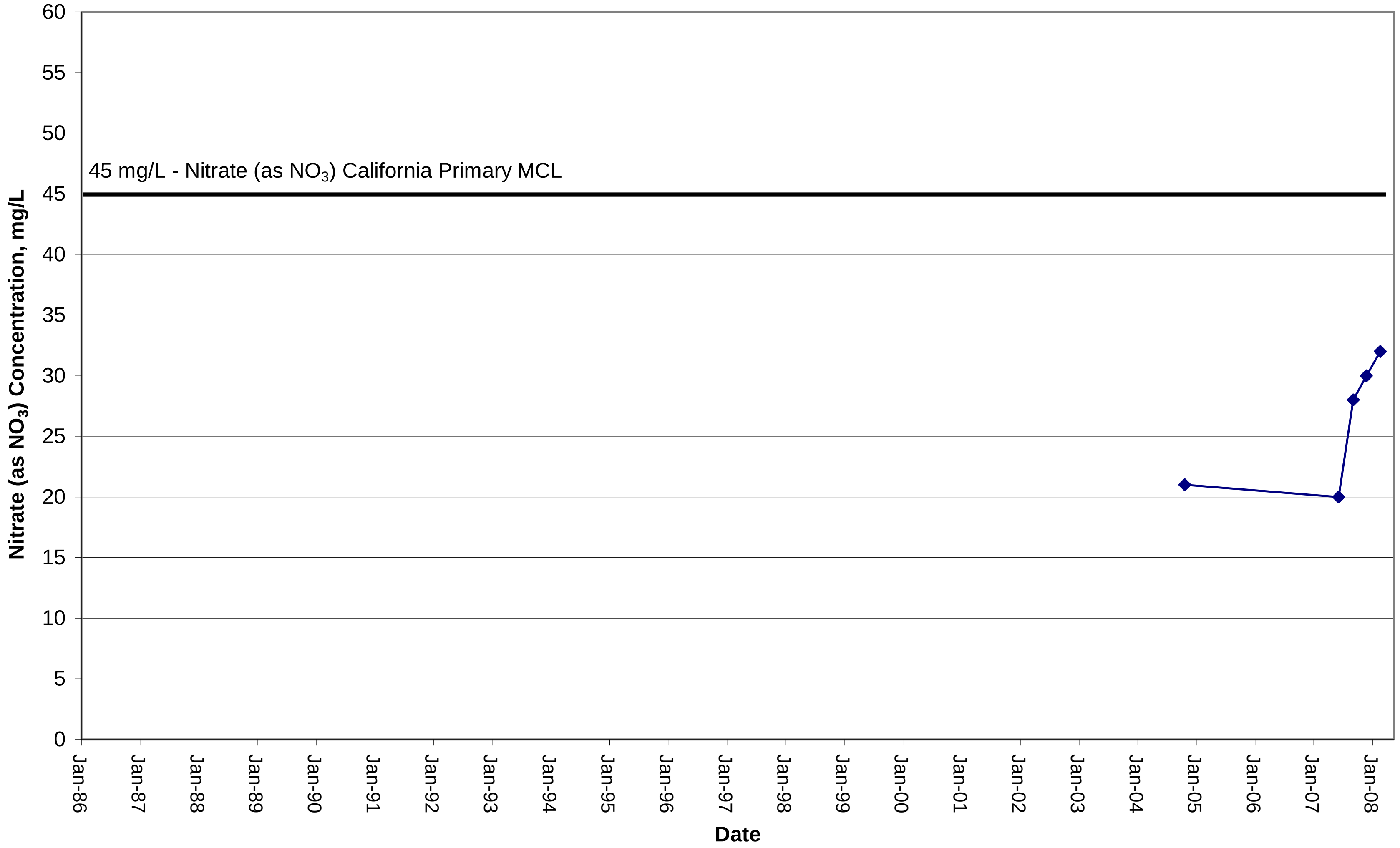


Figure F-20b

City of Woodland
Groundwater Management Plan

WELL #24 NITRATE CONCENTRATION OVER TIME

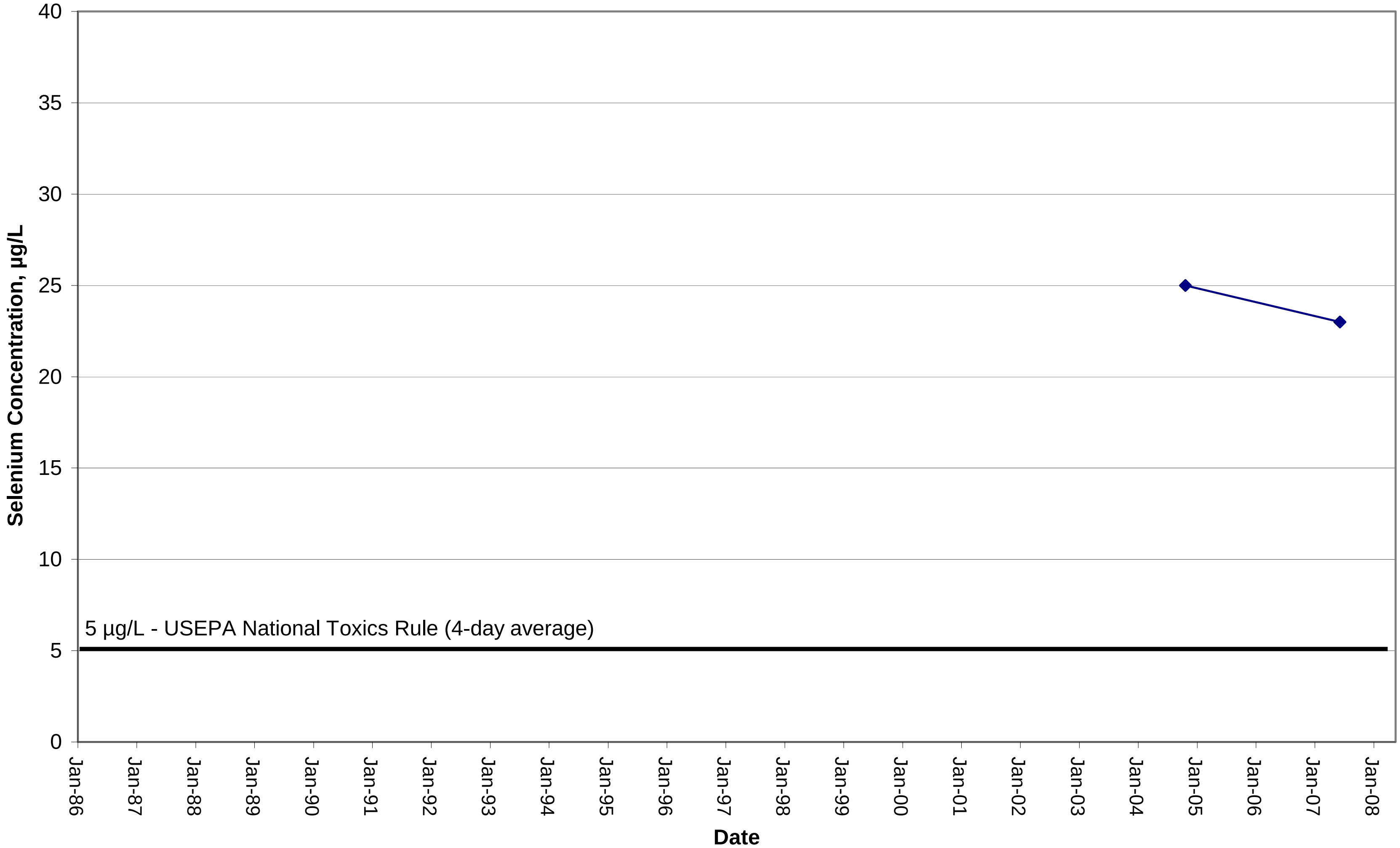


Figure F-20c

City of Woodland
Groundwater Management Plan

WELL #24 SELENIUM CONCENTRATION OVER TIME

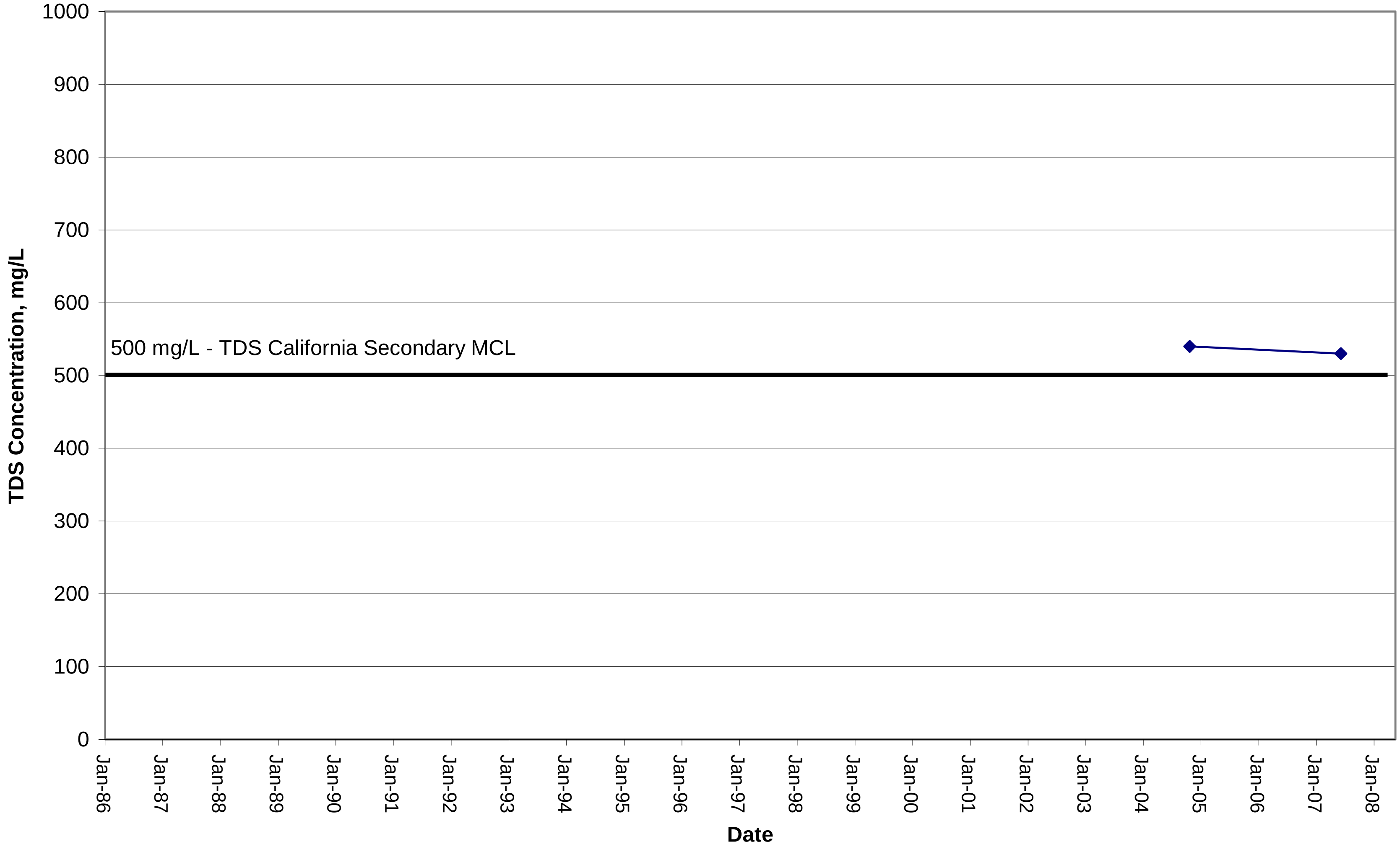


Figure F-20d

City of Woodland
Groundwater Management Plan

WELL #24 TDS CONCENTRATION OVER TIME

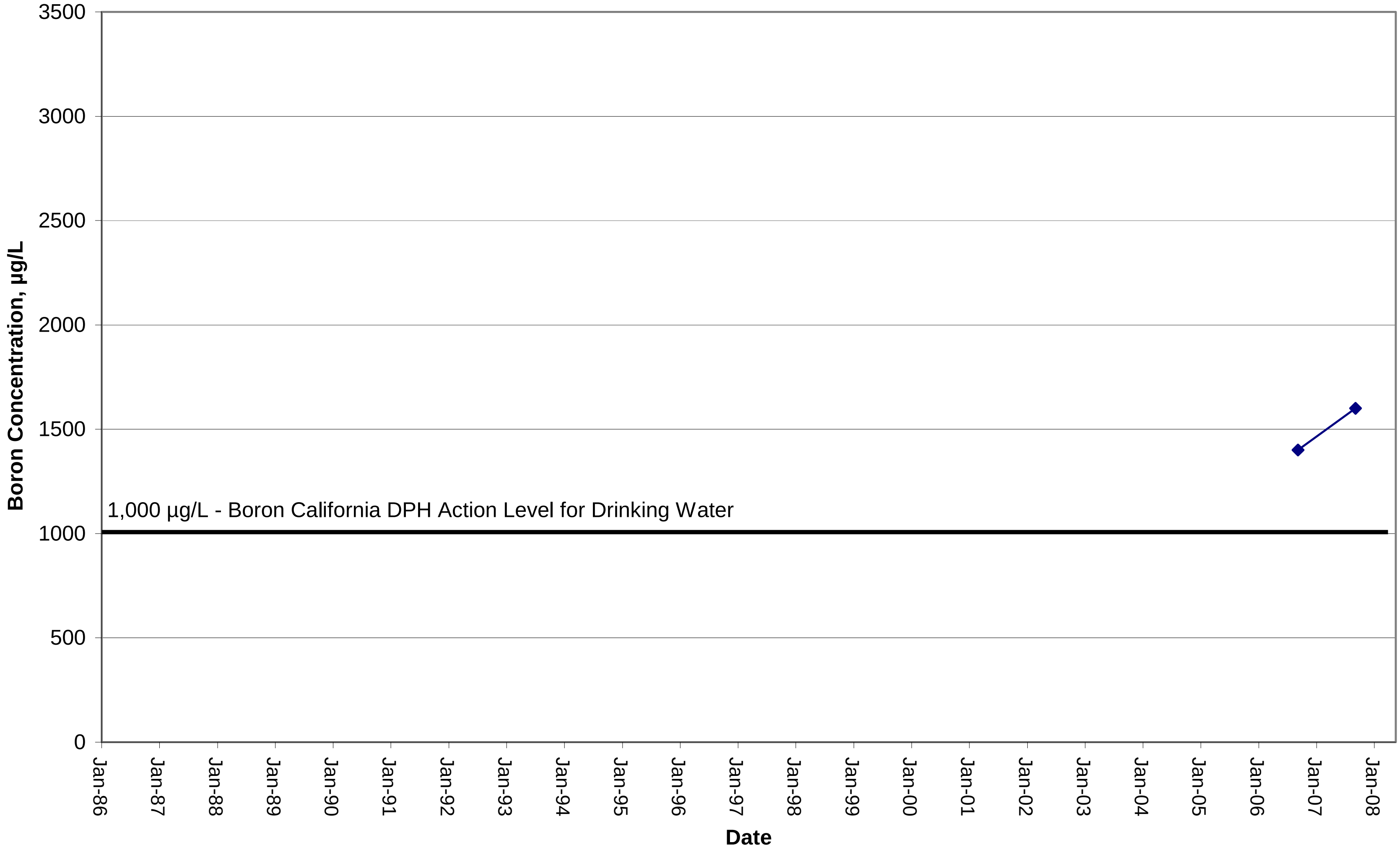


Figure F-21a

City of Woodland
Groundwater Management Plan

WELL #26 BORON CONCENTRATION OVER TIME

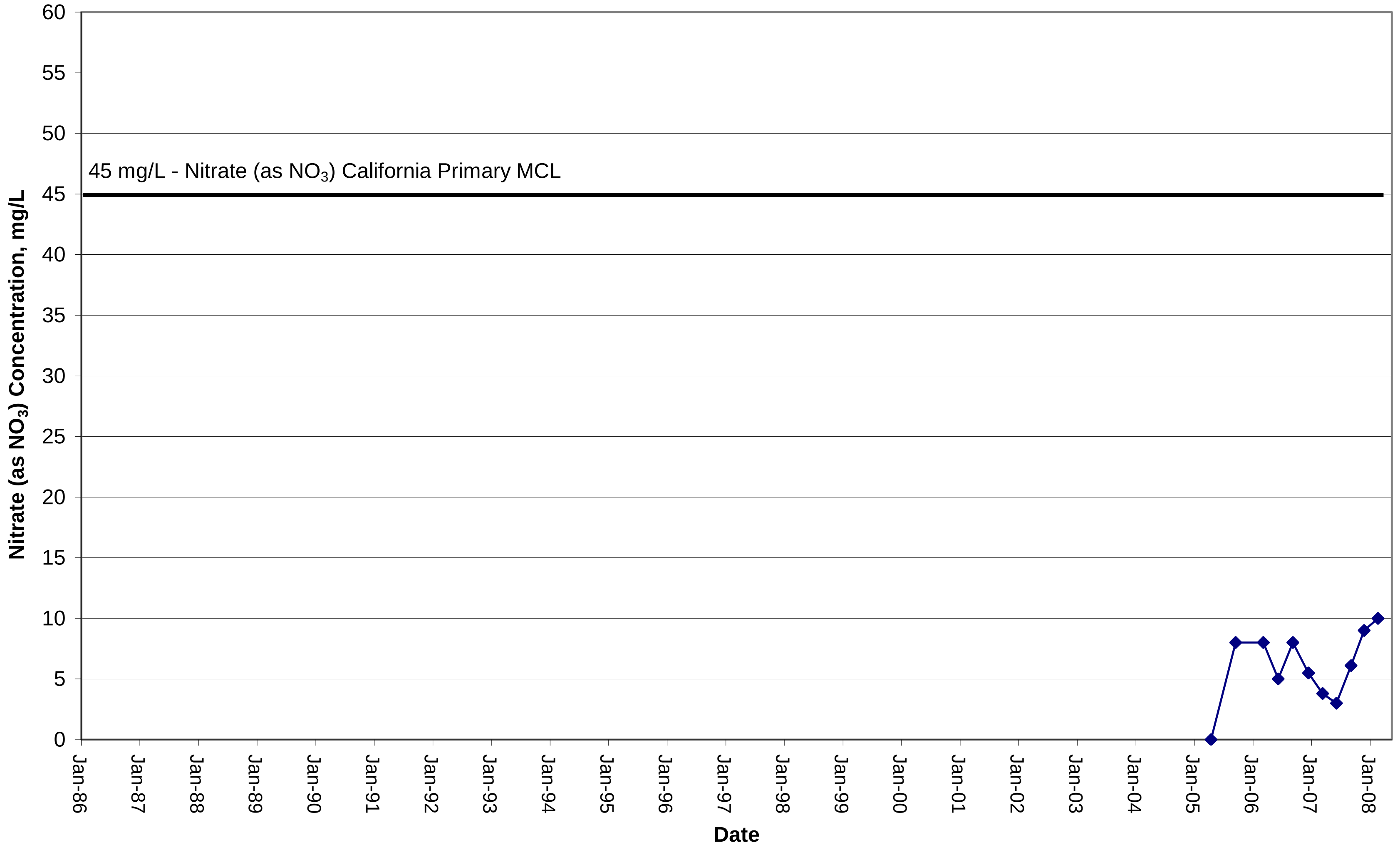


Figure F-21b

City of Woodland
Groundwater Management Plan

WELL #26 NITRATE CONCENTRATION OVER TIME

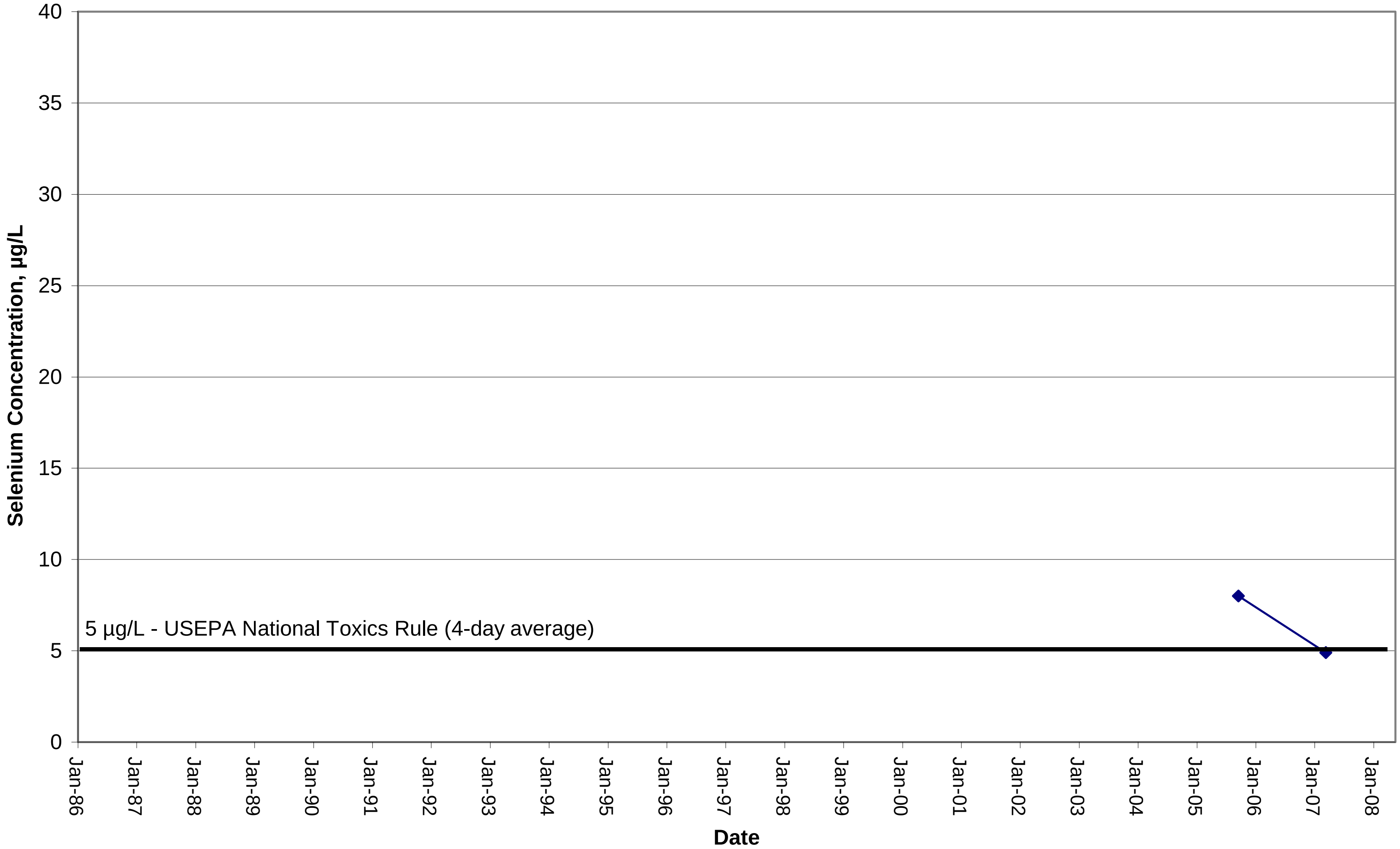


Figure F-21c

City of Woodland
Groundwater Management Plan

WELL #26 SELENIUM CONCENTRATION OVER TIME

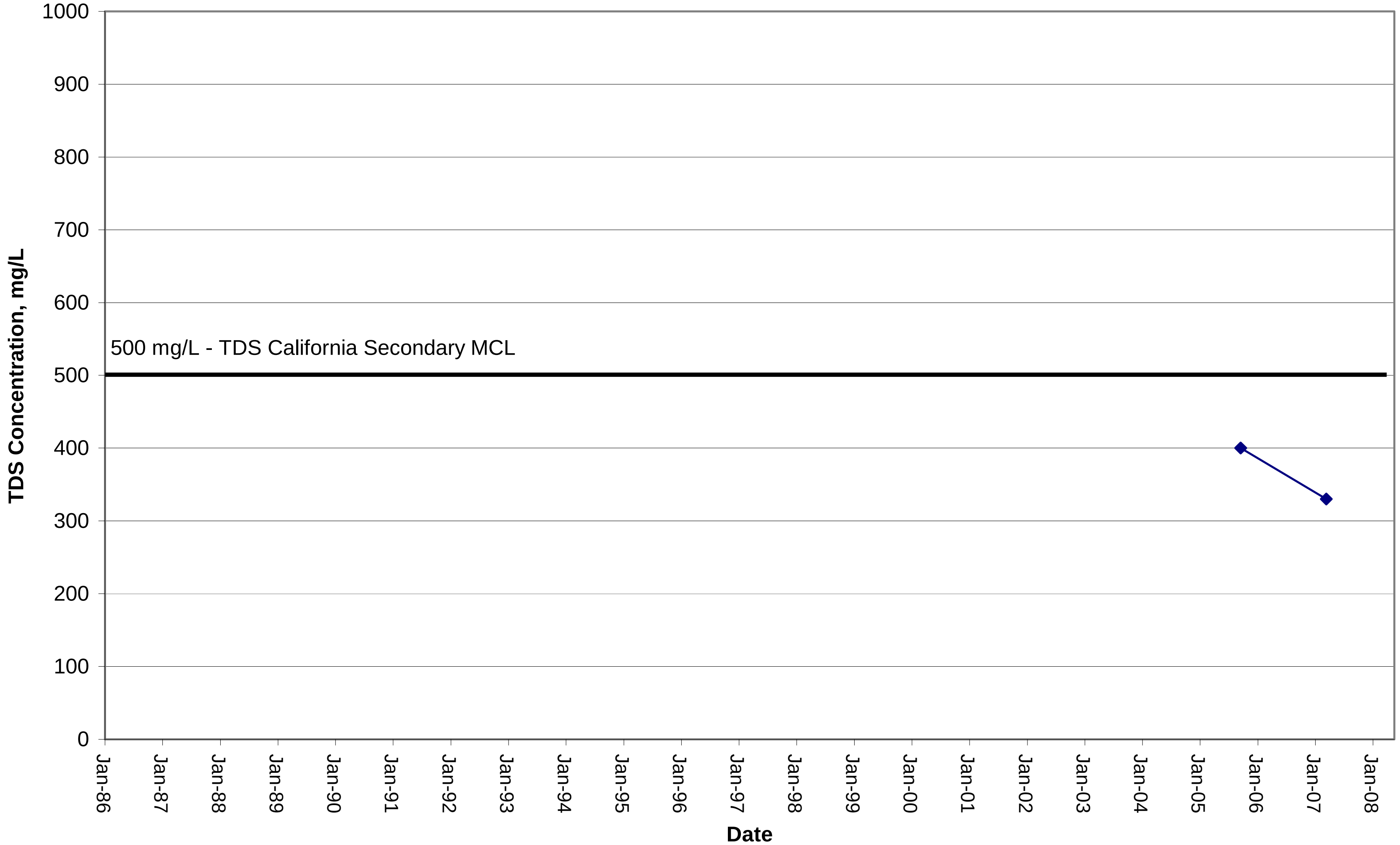


Figure F-21d

City of Woodland
Groundwater Management Plan

WELL #26 TDS CONCENTRATION OVER TIME

APPENDIX G

Technical Memo No. 1: Assessment of Dry Year Municipal Well Capacity

WEST YOST
ASSOCIATES
Consulting Engineers

PROFESSIONAL GEOLOGIST
KENNETH L. LOY
NO. 7008
EXP. 11/30/09
STATE OF CALIFORNIA

TECHNICAL MEMORANDUM NO. 1

DATE: April 15, 2009

Project No.: 204-00-08-18

TO: Mr. Doug Baxter
City of Woodland

CC: Akin Okupe
Dave Settles
Sherry Salas

FROM: Kenneth Loy, P.G. 7008 KLL

Reviewed By: Tim Durbin
Brenda Estrada
Monique deBarruel
Dave Anderson

SUBJECT: Assessment of Dry Year Municipal Well Capacity

This technical memorandum (TM) provides a planning-level assessment of the City of Woodland's (City) dry year municipal well pumping capacity. Continuing dry conditions, which have persisted since 2007, have led to concerns that groundwater levels could decrease to levels that could adversely affect the City's ability to meet maximum day water demand requirements.

PURPOSE

This TM provides a preliminary assessment of the potential impact of the continuing drought on the City's municipal groundwater pumping capacity. This TM provides an assessment of gradually declining well pump capacity caused by increasing depth to groundwater and potentially abrupt loss of capacity due to the lowering of groundwater levels to critical levels with respect to pump intakes. This analysis was based on average groundwater levels throughout the City's well network and therefore, provides only generalized information and conclusions on the well capacity. Because of the uncertainties inherent in the analysis, additional groundwater level monitoring and evaluation of conditions at specific municipal wells will be required to manage the City's pumping through the drought period.

APPROACH

Empirical relationships were evaluated between spatially averaged groundwater levels in the City municipal wells and potential explanatory variables, including precipitation, average monthly temperature, municipal pumping by the City and agricultural surface water deliveries. Surface water deliveries for agricultural irrigation by the Yolo County Flood Control & Water Conservation District (District) and annual precipitation were found to be the most significant variables. A regression relationship between groundwater levels, surface water deliveries and annual precipitation was then used to project the average groundwater levels in the City municipal wells for August 2009 and August 2010. These projected average groundwater levels were next used to adjust graphs showing the relationship between the system curve and pump curve for each municipal well. These graphs were developed from the hydraulic modeling efforts conducted as part of the City's Water Focus Study and represent the assumed maximum day demand conditions as measured in August 2007 (West Yost Associates, in preparation). The graphs show the rate at which pump capacity declines as system head increases. For this analysis, the system head was assumed to remain constant except for a linear shift caused by increases in the depth to groundwater. Each system curve was adjusted by increasing the static head by an amount equal to the difference between the average August 2007 and projected average August groundwater levels. The projected capacity of each well was then read from the intersection of the new system curve and the pump curve, tabulated and compared to the assumed maximum day demand for 2009 and 2010. Also, the pump setting of each well was plotted on the system curve versus pump curve graphs to provide an indication of whether or not the drought conditions might cause groundwater levels to fall to critical levels with respect to the pump intakes.

BACKGROUND

Governor Schwarzenegger proclaimed a state-wide drought and signed Executive Order S-06-08 on June 4, 2008. The governor declared a state emergency on February 27, 2009, in anticipation of the third consecutive year of drought conditions and the potential that these conditions could persist for several years into the future. Dry conditions have prevailed locally, but these did not lead to significant curtailment in surface water deliveries by the District through the 2008 irrigation season. These deliveries, defined for this TM as diversions at the Capay diversion dam, have averaged approximately 161,000 acre-feet between 1975 and 2008. However, recent projections by the District have ranged from no deliveries to a current projection of approximately 30,000 acre-feet in the 2009 irrigation season (District, 2009). The projection has increased in response to recent precipitation, which increased the volume of water stored in Indian Valley Reservoir.

The District's surface water deliveries are an important consideration for two reasons. First, surface water deliveries are an important source of groundwater recharge. Modeling studies indicate that, in the Central Valley as a whole, irrigation returns account for about 80 percent of the groundwater recharge on average (USGS, 1989). Therefore, reductions in surface water deliveries result in reduced recharge and lower groundwater levels. Second, in dry years when surface water deliveries are curtailed, irrigators shift to groundwater for agricultural supply. The increased agricultural demand also leads to lower groundwater levels.

State-wide, multiyear droughts are documented in 1912-1913, 1918-1920, 1923-1924, 1929-1934, 1947-1950, 1959-1961, 1976-1977, and 1987-1992 (Governor's Advisory Drought Planning Panel, 2000). Indian Valley Reservoir was completed 1976, enabling the District to store approximately 300,000 acre-feet of water under permitted water rights. Indian Valley Reservoir also provides the District with carry over storage from one season to another, which did not exist prior to the completion of the project (Boracalli & Associates, 2000). Indian Valley Reservoir significantly improved the reliability of the District's surface water deliveries, which in turn has had a stabilizing effect on groundwater elevations after 1977 (DWR, 2004). Because of the hydrologic significance of the Indian Valley Reservoir project, and data deficiencies prior to this time, this evaluation was limited to the period 1975 through 2008. During this period, significant reductions in diversions at the

Capay diversion dam occurred only in 1977 and in 1990-1992, consistent with the record of the state-wide droughts. No diversions were made in 1977 and 1990. Diversions returned to typical levels in 1978, but were only 50 to 60 percent of average in 1991 and 1992. Historically low groundwater levels were experienced in the City's wells during these two time periods.

The City currently relies exclusively on groundwater from 19 active wells. One of these wells (Well 27) is owned by Yolo County but operated by the City when needed. Two other City wells, Wells 9 and 10, are currently not used due to elevated nitrate concentrations. Wells 9, 10 and 27 were not included in this assessment. Wells 15 and 22 are being re-drilled. Wells 15 and 22 were evaluated based on their historical records. These wells could have different capacities after re-drilling.

HISTORICAL DATA

The assessment was based on evaluation of the empirical relationships between historical groundwater levels in the City's municipal wells and the following potential explanatory variables for the period 1975 through 2008:

- Annual precipitation measured at Woodland 1WNW
- Average monthly air temperature measured at California Irrigation Management Information System (CIMIS) station #6
- Annual municipal groundwater pumping by the City
- Annual surface water diversions at Capay dam by the District.

The analysis included the 18 municipal wells listed in Table 1. Monthly groundwater level data were provided by the City as spatial averages for the period 1975 through 2008. City staff calculated the spatial averages by averaging the groundwater levels measured in the wells for each month from 1975 through 2008.

RESULTS

The annual diversions at Capay and annual precipitation were found to be the best predictors of groundwater levels. Appendix A contains graphs of groundwater levels versus precipitation, air temperature, municipal groundwater pumping by the City, and surface water deliveries by the District.

Figure 1 shows the average monthly groundwater levels for the 18 municipal wells for the period 1975 through 2008. For simplicity, only the groundwater elevations for January and August are shown. Typically, groundwater levels are near their maximum in January and near their minimum in August. Therefore, the January and August groundwater levels are a good representation of the annual range of groundwater elevations for the 1975 through 2008 period. A linear regression relationship was developed between the average August groundwater levels and the annual diversion and precipitation amounts. The regression relationship had the form:

Table 1. August 2007 and Projected Well Capacity

Well	August 2007 Pumping Capacity (gpm)	Projected Pumping Capacity (gpm)				
		Scenario 1: 10 ft	Scenario 2: 20 ft	Scenario 3: 30 ft	Scenario 4: 40 ft	Scenario 5: 50 ft
1	1863	1743	1614	1486	1343	1171
4	1579	1443	1329	1229	1086	942
5	1421	1271	1143	986	814	600
6	1568	1486	1386	1271	1143	985
11	1550	1486	1371	1257	1129	985
12	1851	1729	1614	1514	1386	1257
13	1947	1871	1743	1629	1486	1342
14	1474	1414	1314	1214	1100	971
15[a]	2,259	2157	2043	1943	1829	1686
16	1700	1643	1543	1429	1314	1185
17	1381	1257	1143	1043	900	757
18	1632	1543	1457	1357	1243	1128
19	1550	1500	1400	1286	1171	1042
20	1606	1543	1500	1443	1400	1357
21	1338	1243	1143	1043	943	814
22	958	900	843	771	686	600
24	2023	1914	1829	1729	1643	1528
26	1547	1529	1486	1443	1400	1357
Total	26987	25514	23857	22129	20186	18029

(a) Not included in total due to DPH requirement that the City’s well system have the capacity to meet the maximum day demand with the largest capacity well out of service. Well 15 is the City’s highest capacity well.

Maximum day demand, August 2007: 20,500 gallons per minute (gpm)

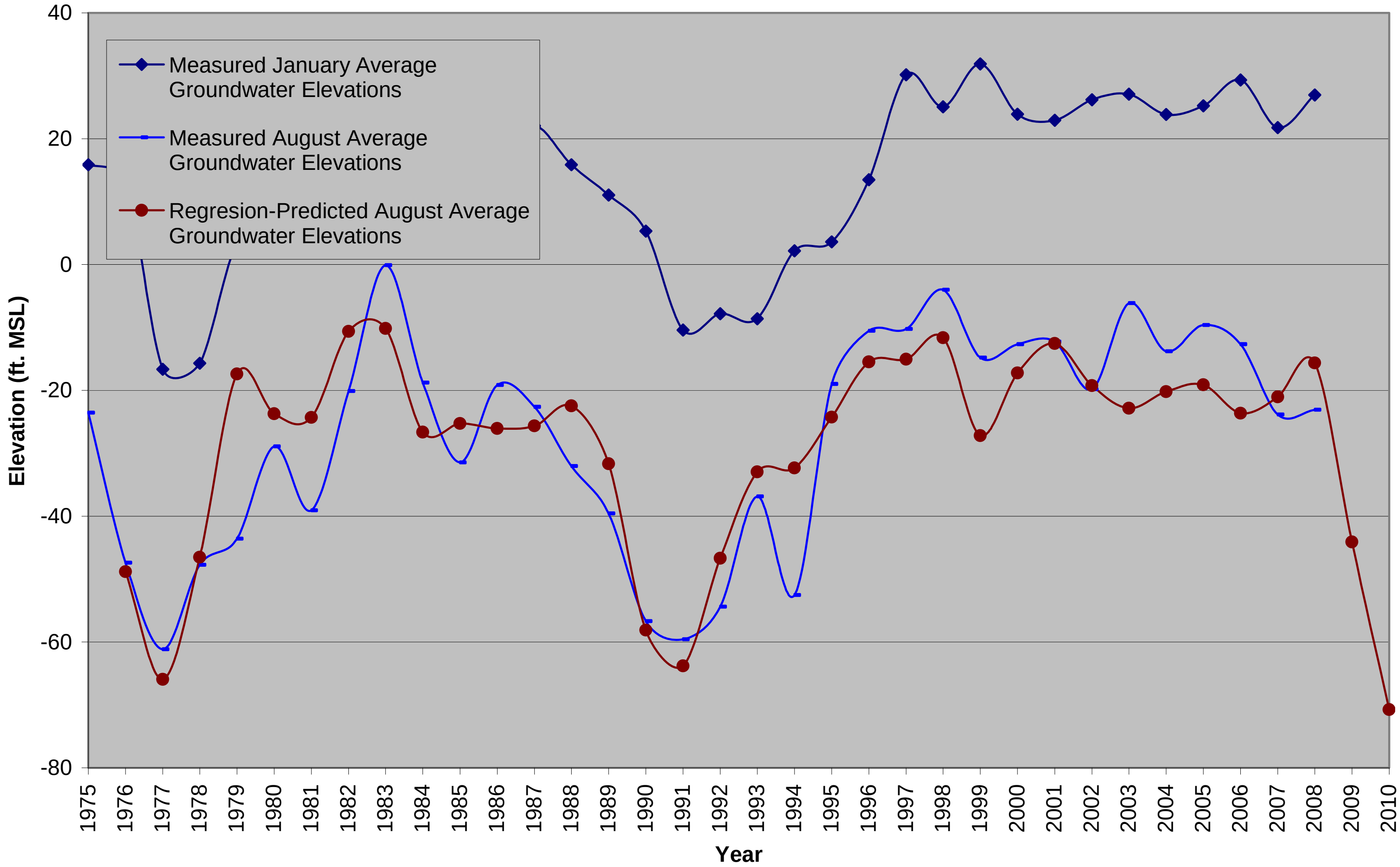


Figure 1

City of Woodland
Dry-Year Pumping TM

MEASURED AND PREDICTED AVERAGE AUGUST GROUNDWATER LEVELS

WEST YOST ASSOCIATES Consulting Engineers

$$h_i = a_0 + a_1 d_i + a_2 d_{i-1} + a_3 p_i + a_4 p_{i-1} \quad (1)$$

where

h_i = Average August groundwater level in year i (feet)

d_i = Annual diversion at Capay in year i (acre-feet)

d_{i-1} = Annual diversion at Capay in year i-1 (acre-feet)

p_i = Annual precipitation at Woodland 1 WNW in year i (feet)

p_{i-1} = Annual precipitation at Woodland 1 WNW in year i-1 (feet)

Regression Coefficients

a_0 = feet

a_1 = feet/acre-feet

a_2 = feet/acre-feet

a_3 = feet/feet

a_4 = feet/feet

The 1975 through 2008 average August groundwater levels, annual diversions at Capay and annual precipitation were used to calculate values of a_0, a_1, a_2, a_3 and a_4 that minimized the sum of the squared residuals (sum of the squares of the differences between observed and predicted groundwater levels). These values were as follows:

- a_0 = -95.62 feet
- a_1 = 0.0001375 feet/acre-feet
- a_2 = 0.0001516 feet/acre-feet
- a_3 = 10.30 feet/feet
- a_4 = 3.651 feet/feet

The regression statistics included a coefficient of determination (R^2) of 0.71 and a standard error (S_e) of 10.1 feet. The R^2 result indicates that most of the variation in average August groundwater levels can be explained by variation in the annual diversions at Capay and, to a lesser extent, annual precipitation. The S_e result indicates that groundwater levels predicted for the 1975 to 2008 period by the regression equation have a precision of ±10.1feet. These results show that although diversions at Capay and precipitation are significant influences on average August groundwater levels, they are not the only influence. Hydrologic modeling or further analysis of regression relationships would be required to improve the average groundwater level projections.

Figure 1 also shows the projected average August groundwater level in the City municipal wells. The average August 2009 and August 2010 groundwater levels were projected using equation 1 and the regression coefficients listed above. Diversions at Capay were assumed to be 30,000 acre-feet in 2009 and 2010. The assumed 2009 diversions are based on email communication with District staff (District, 2009). Annual precipitation was assumed to be 1.16 feet in 2009 and 2010. This is the average of the annual precipitation in 2007 and 2008. The 2010 diversions and precipitation will depend on unknown weather conditions in late 2009 and 2010 and are highly uncertain. The average 2008 and projected average 2009 and 2010 groundwater elevations were:

- Measured August 2008: -23 feet
- Projected August 2009: -44 feet
- Projected August 2010: -71 feet

Based on these results, the average static head in the City's wells is projected to increase by approximately 20 feet in August 2009 and approximately 50 feet in August 2010. These projections of the average static head are based on the projected decrease in average groundwater levels in August 2009 and 2010 relative to the measured average August 2008 groundwater level.

Appendix B contains graphs of the system versus pump curves for the 18 municipal wells listed in Table 1. The system and, in most cases, pump curves are based on the City's hydraulic model developed for the Water Focus Study (West Yost Associates, in preparation). The model represents assumed maximum day demand conditions as measured in August 2007. Model curves were used for most wells because the reported pump curves did not produce realistic pressure and flow conditions in the hydraulic model. Because many of the pumps have been in service for many years, it was assumed that the original pump curves no longer reflect the operating conditions for most of the pumps. Actual pump curves were used for Wells 15, 20 and 26.

The system curve on each graph was shifted in a series of constant increments representing 10-foot increases in static head. In addition to the August 2007 system head conditions, the following scenarios are represented:

- Scenario 1: 10-foot increase in static head
- Scenario 2: 20-foot increase in static head
- Scenario 3: 30-foot increase in static head
- Scenario 4: 40-foot increase in static head
- Scenario 5: 50-foot increase in static head

The five scenarios represent incremental increases in the average depth to groundwater relative to August 2007, as might be expected to occur in a prolonged drought. The intersection of the system curve and pump curve for each well provides an estimate of the pumping capacity for that well. Wells 11, 19 and 24 are equipped with variable frequency drives, which provide greater operational flexibility in pumping water. In essence, the pump curves for these wells are not constant but instead change with the operating frequency. It was assumed in this study that all of the wells have fixed pump curves as shown in Appendix B.

Well Capacity

Table 1 lists the August 2007 pumping capacity of each well, as represented in the hydraulic model and the projected capacity of each well under the five scenarios listed above. The total capacities of the 18 wells, except Well 15, are also shown in Table 1. Well 15 was omitted from the total capacity calculation, based on the California Department of Public Health (DPH) requirement that the well system have the capacity to meet the maximum day demand with the largest capacity well out of service. Well 15 is the highest capacity well.

Figure 1 shows that the average August 2009 groundwater levels are projected to decline by approximately 20 feet relative to August 2007. This matches Scenario 2 in Table 1 and on the graphs provided in Appendix B. The average August 2010 groundwater levels are projected to decline by approximately 50 feet relative to August 2007. This corresponds to Scenario 5 in Table 1 and on the graphs provided in Appendix B.

The capacity results were compared to the assumed maximum day demand for 2009 and 2010. The maximum day demand was assumed equal to the demand conditions measured in August 2007. These August 2007 demand conditions are the assumed maximum day demand conditions used in the hydraulic model for the Water Focus Study (West Yost Associates, in preparation).

The results of the analysis indicate that there is enough capacity in 2009, but not enough in 2010, if the drought continues. The assumed maximum day demand and projected well pumping capacities were:

- Assumed maximum day demand: 20,500 gallons per minute (gpm)
- Projected August 2009 well pumping capacity with Well 15 out of service: 24,000 gpm
- Projected August 2010 well pumping capacity with Well 15 out of service: 18,000 gpm

Again, these projections are based only on the 18 wells listed in Table 1. The City also has capacity in County-owned Well 27 and may be able to get additional capacity from Wells 11, 19 and 24, because these wells are equipped with variable frequency drives. Also, Wells 15 and 22 are being redrilled and may have larger capacity than shown in Table 1 and Appendix B. Finally, drought conditions that would result in significantly reduced Capay diversions and annual precipitation may not persist in 2010. On the other hand, the historical record on which the regression relationship relating Capay diversions and precipitation to average August groundwater levels is based is limited. A longer or more severe drought than has been experienced in the 1975 to 2008 period could lead to groundwater level declines greater than projected. The City's pumping has increased substantially since the 1976-1977 and 1987-1992 droughts (Appendix B). Although the historical records do not show a positive correlation between annual City pumping and average August groundwater levels, physical principals dictate that increased pumping causes increased drawdown. Also, other factors, such as pumping by others, groundwater quality or hydraulic conditions at specific City municipal wells could affect pumping capacity. One such factor is the pump intake setting of the municipal wells.

Pump Settings

The system versus pump curve graphs in Appendix B show the depth of the pump intake for each well. More than half of the wells appear to be at risk due to shallow pump settings relative to pumping conditions in the wells.

These wells are (Appendix B):

- Well 4
- Well 5
- Well 12
- Well 13
- Well 15
- Well 16
- Well 18
- Well 19
- Well 21
- Well 22

Groundwater levels in individual wells were not included in this evaluation. Therefore, the list above should be viewed as providing an indication of which wells may be most at risk due to prolonged drought conditions. Additional monitoring and analysis of the wells is warranted to ensure that the capacity of individual wells is adequate to meet the anticipated demands.

CONCLUSIONS

This preliminary analysis shows that well capacity appears to be adequate to meet the assumed 2009 maximum day demands. However, if drought conditions persist through summer 2010, the well capacity does not appear to be adequate to meet the assumed 2010 maximum day demands. In addition, the capacity of a significant number of the municipal wells appears to be at risk under continued dry conditions because the pump settings of the wells is shallow relative to the apparent operating conditions in the wells. The apparent operating conditions are based on the hydraulic model of the system.

RECOMMENDATIONS

This TM should be viewed as a starting point in the evaluation of the City’s municipal well capacity under continued drought conditions in 2009 and, potentially, 2010 and beyond. The evaluation presented in this TM should be critically reviewed by City staff and consultants, and updated as necessary.

The City should continue to monitor and evaluate the groundwater levels, production and power consumption in its wells at least monthly for signs of reduced capacity due to declining groundwater levels. The mechanical condition of the wells and pumping equipment should also be considered in evaluating dry-year capacity. Groundwater quality should continue to be monitored and evaluated. Poor mechanical condition or groundwater quality could lead to loss of a well at a critical time, and this should be considered in drought contingency planning efforts by the City.

The City may be able to reduce water demands by 12 percent through water metering and water conservation programs. A 12 percent reduction in the assumed 20,500-gpm maximum day demand would reduce the well capacity requirement to approximately 18,000 gpm. This may mean that the 18 wells evaluated in this study could meet the maximum day demand. However, this is subject to the effectiveness of demand reduction measures, further evaluation of the individual wells and approval by DPH.

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Yolo County Flood Control & Water Conservation District (District), 2009, Email Correspondence with Max Stevenson, District Engineer, March 26, 2009.

KLL:mal

APPENDIX A

Dry Year Pumping Analysis

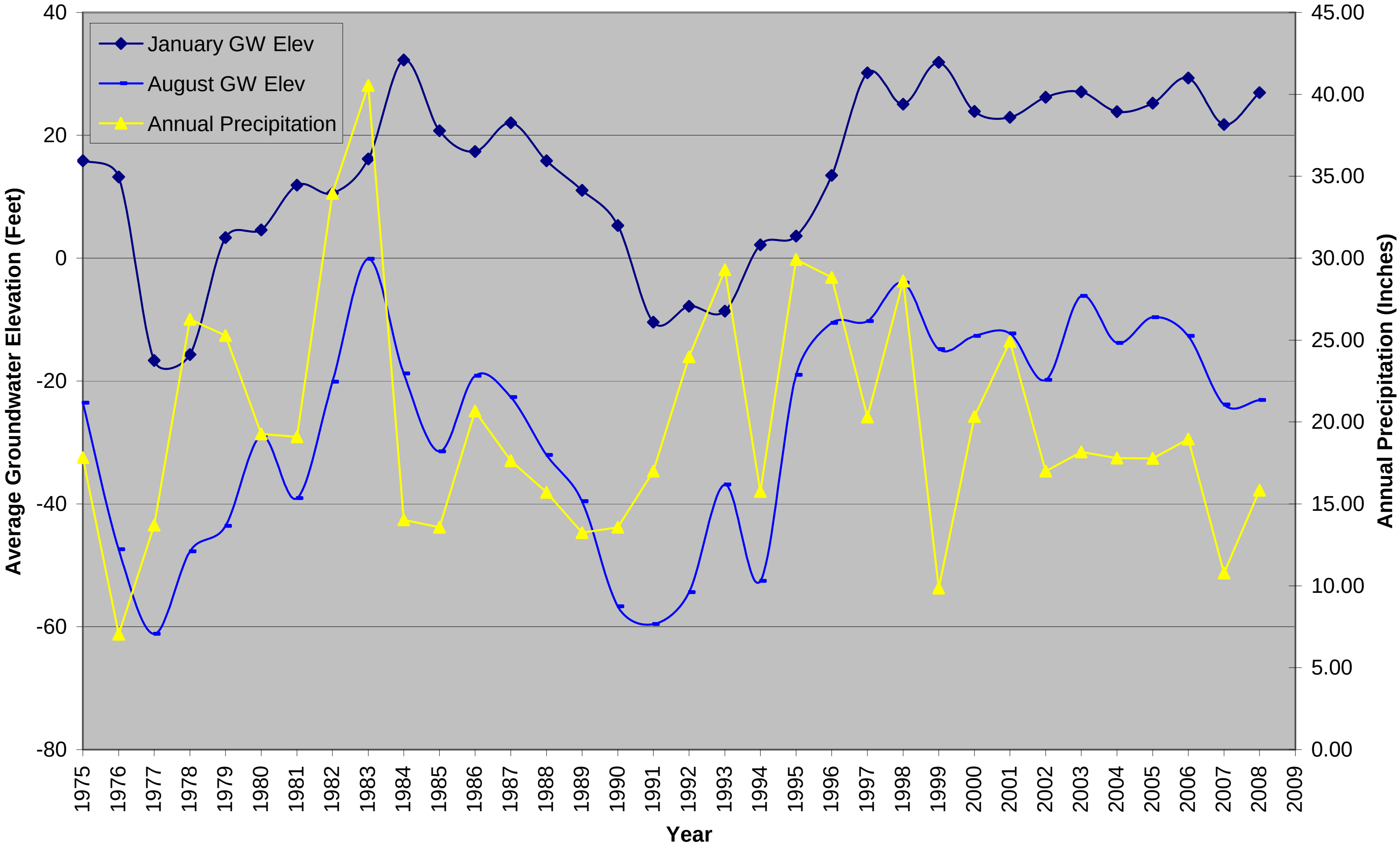

Figure A-1

CITY OF WOODLAND
DRY-YEAR PUMPING TM

AVERAGE GROUNDWATER ELEVATIONS VERSUS ANNUAL PRECIPITATION

WEST YOST ASSOCIATES
Consulting Engineers

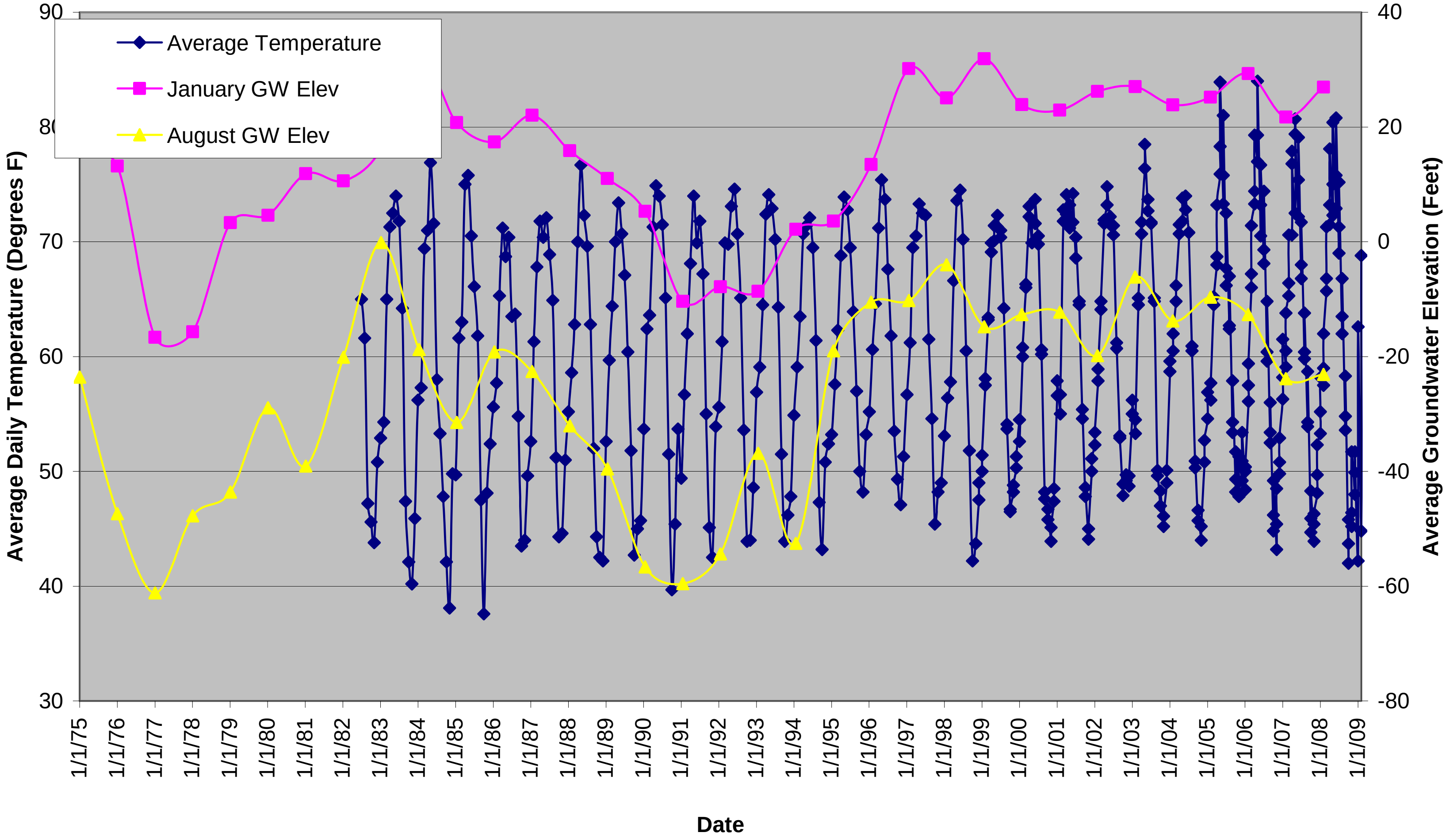

Figure A-2

CITY OF WOODLAND
DRY-YEAR PUMPING TM

AVERAGE GROUNDWATER ELEVATIONS VERSUS AVERAGE DAILY TEMPERATURE

WEST YOST ASSOCIATES
Consulting Engineers

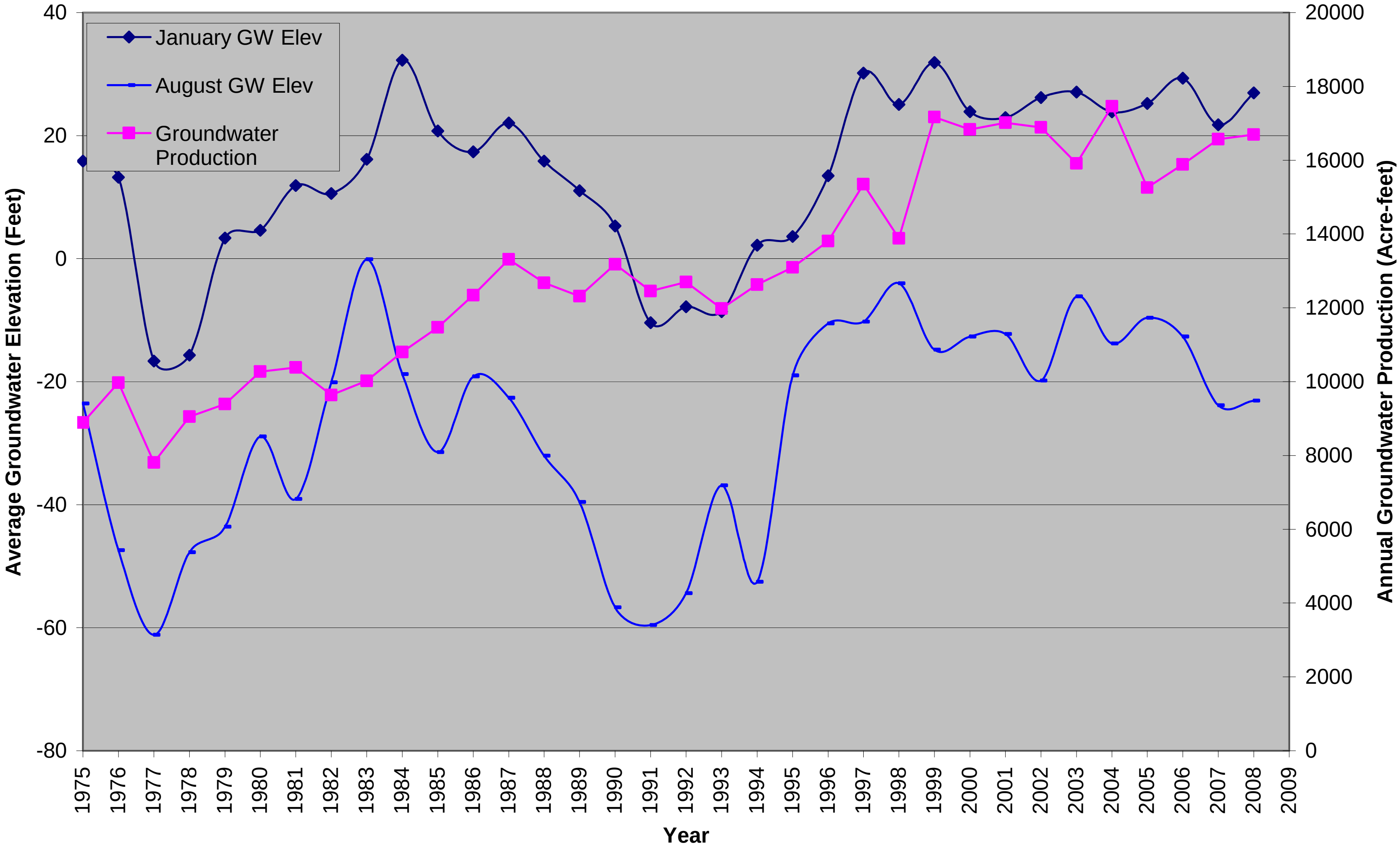

Figure A-3

CITY OF WOODLAND
DRY-YEAR PUMPING TM

AVERAGE GROUNDWATER ELEVATIONS VERSUS
CITY OF WOODLAND GROUNDWATER PRODUCTION

WEST YOST ASSOCIATES
Consulting Engineers

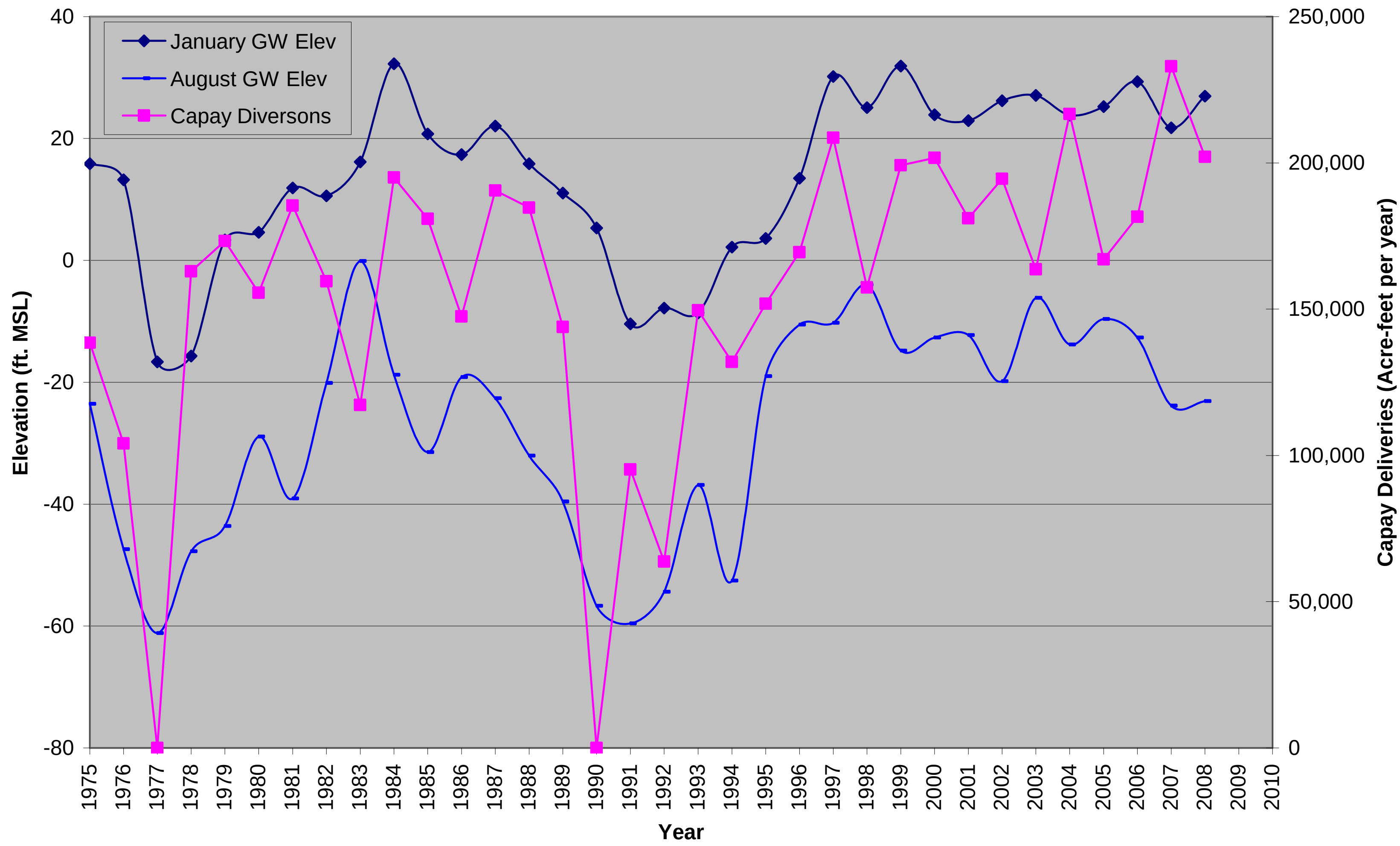

Figure A-4

CITY OF WOODLAND
DRY-YEAR PUMPING TM

AVERAGE GROUNDWATER ELEVATIONS VERSUS
DIVERSIONS AT CAPAY

WEST YOST ASSOCIATES
Consulting Engineers

APPENDIX B

System Head Curves

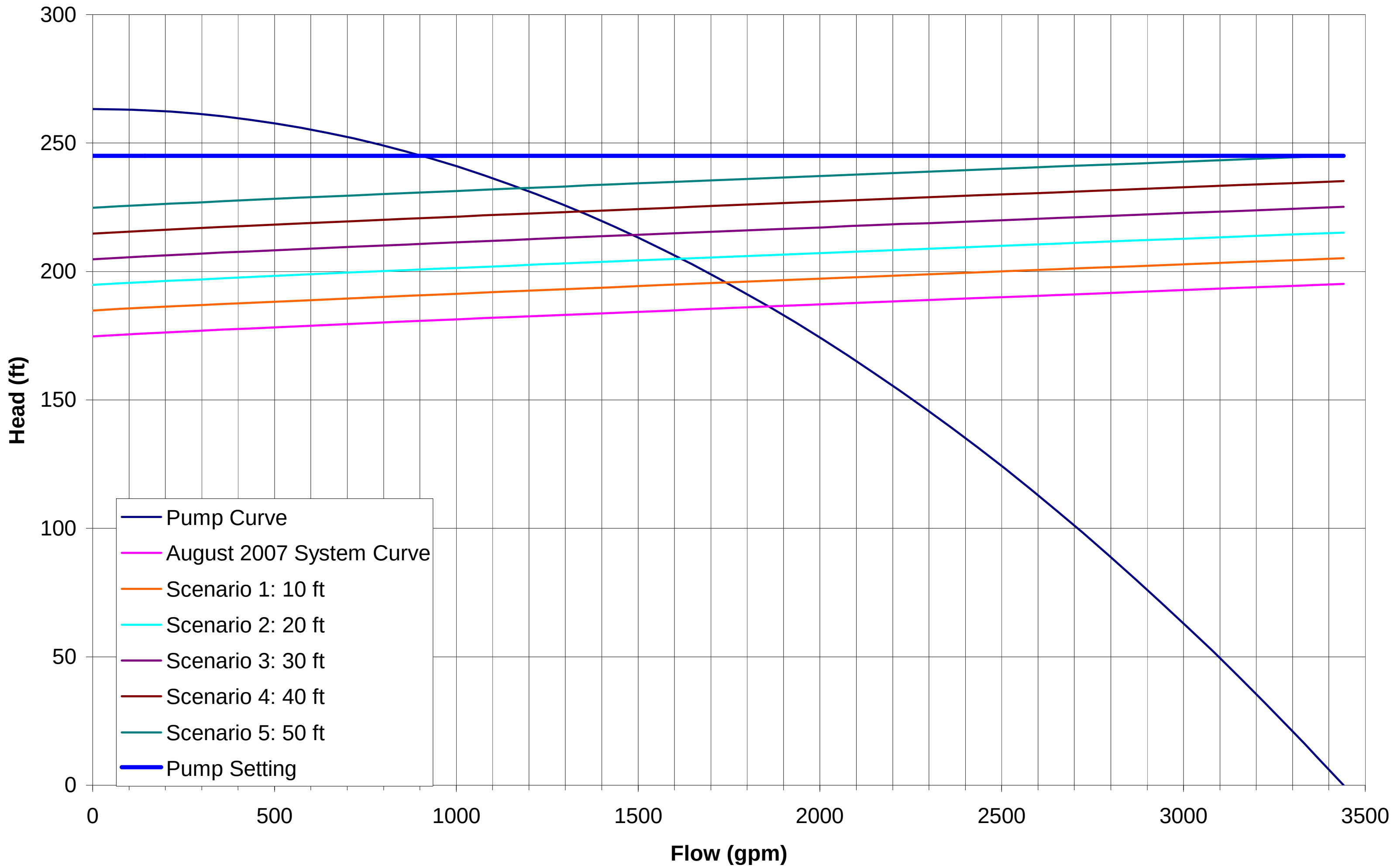

Figure B-1

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 1
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES Consulting Engineers

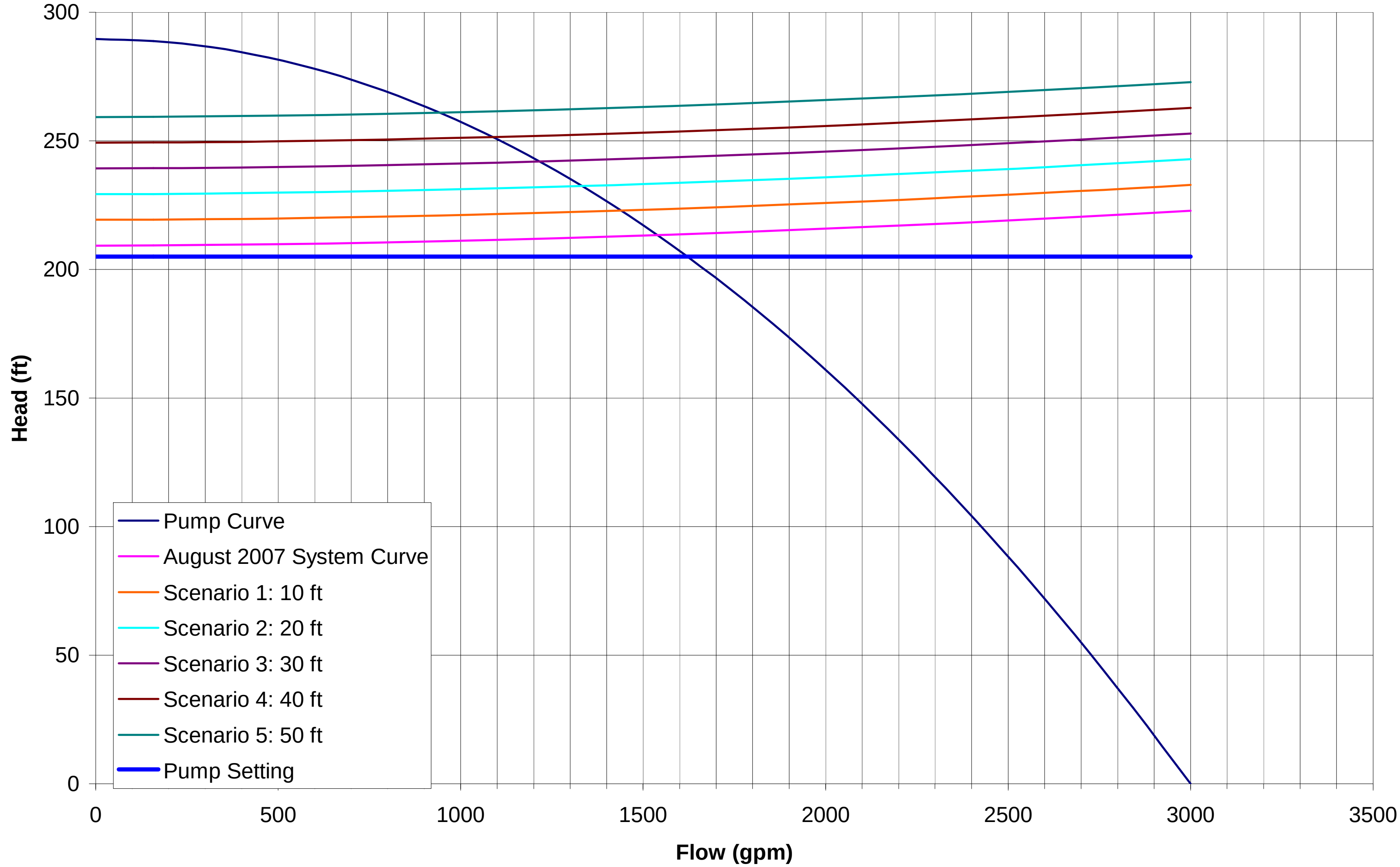

Figure B-2

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 4
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

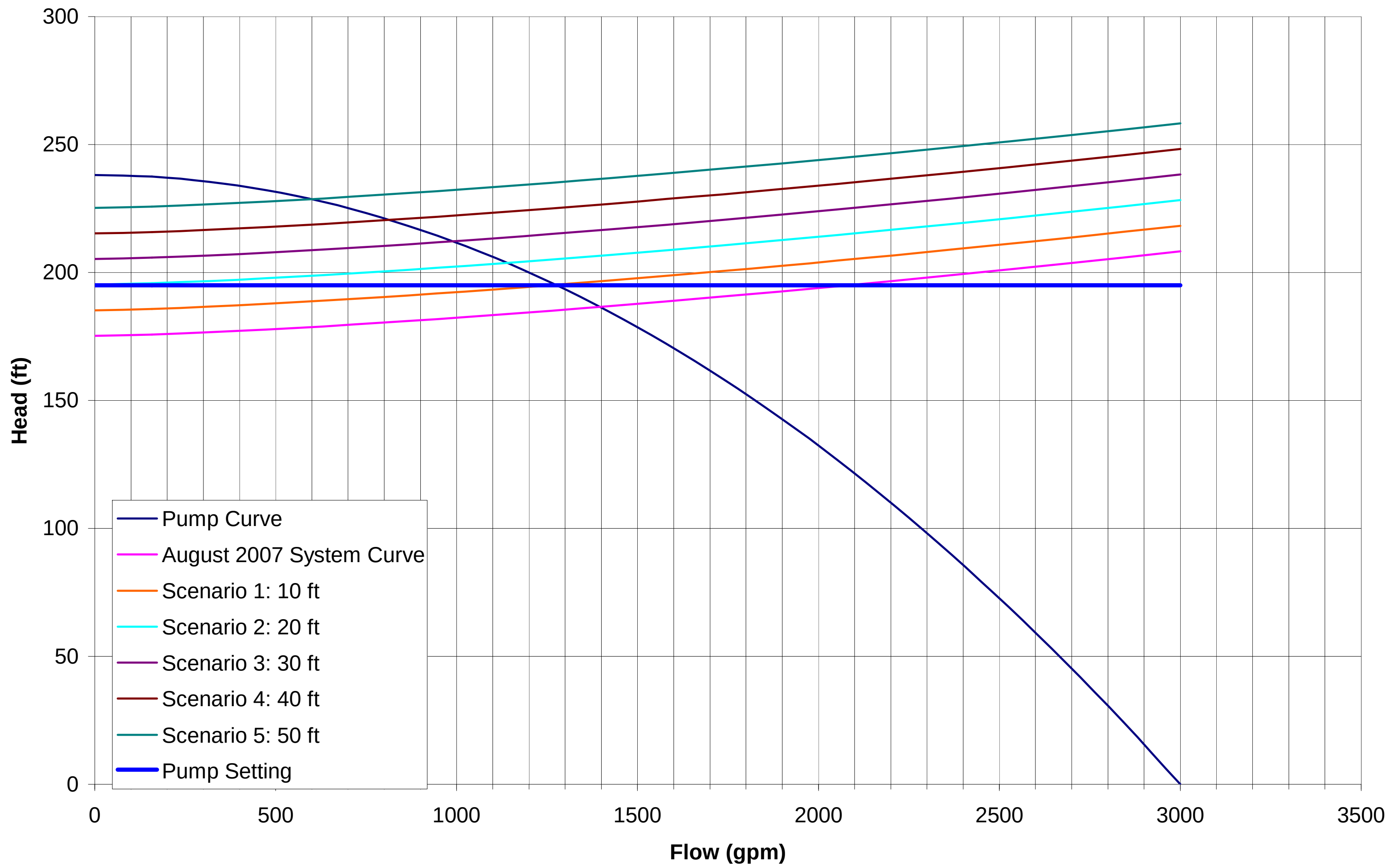

Figure B-3

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 5
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

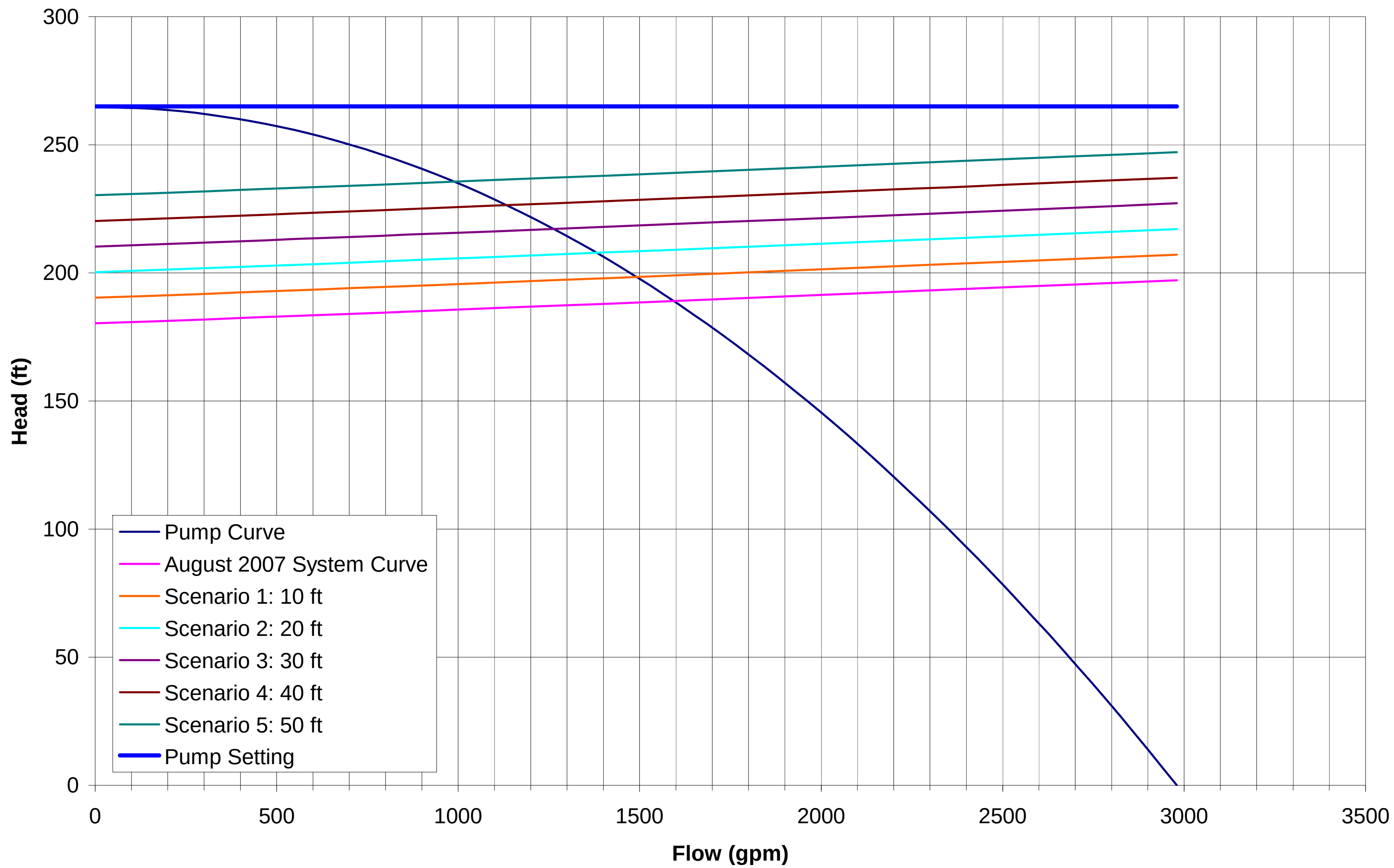

Figure B-4

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 6
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

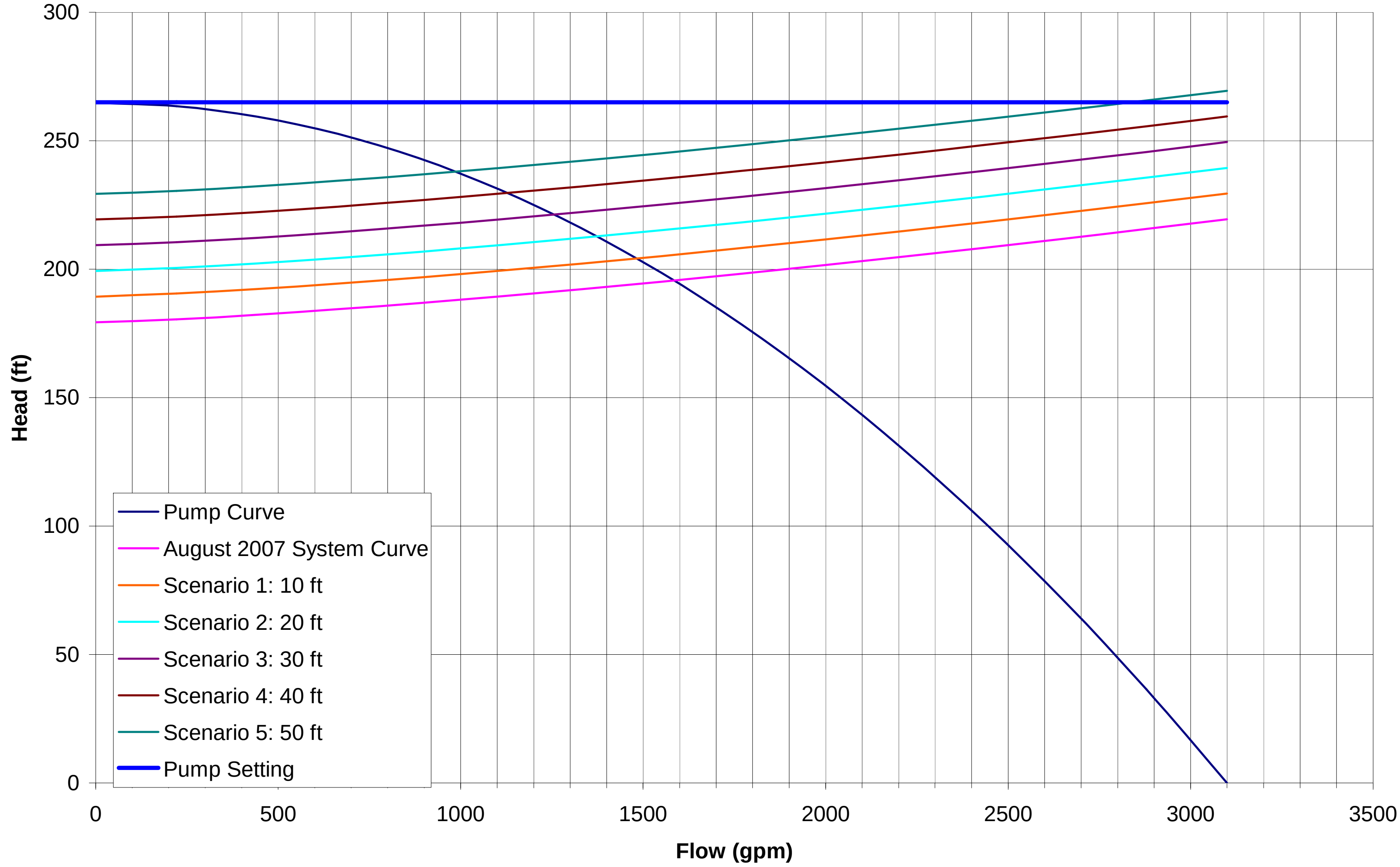

Figure B-5

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 11
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

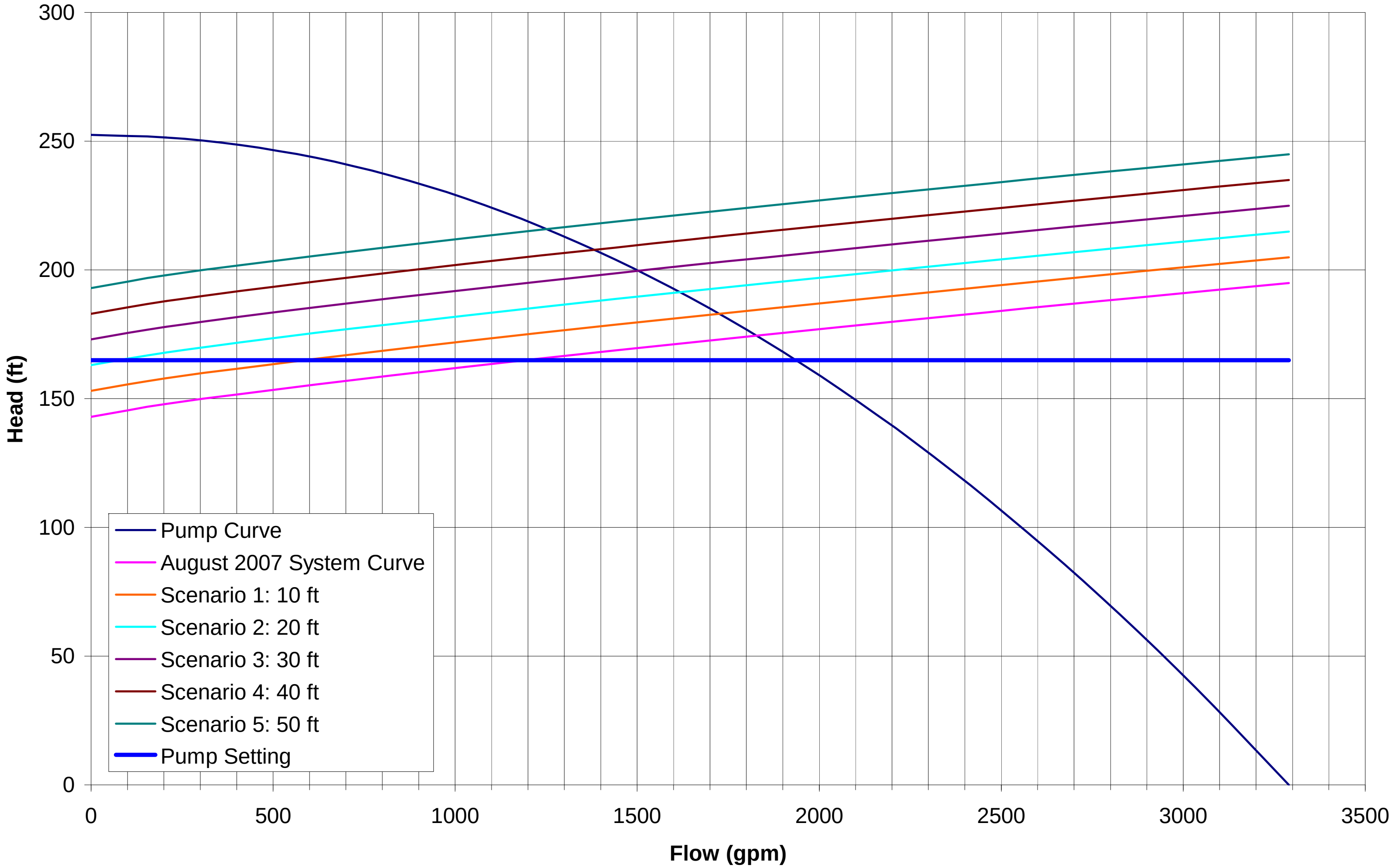

Figure B-6

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 12
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES Consulting Engineers

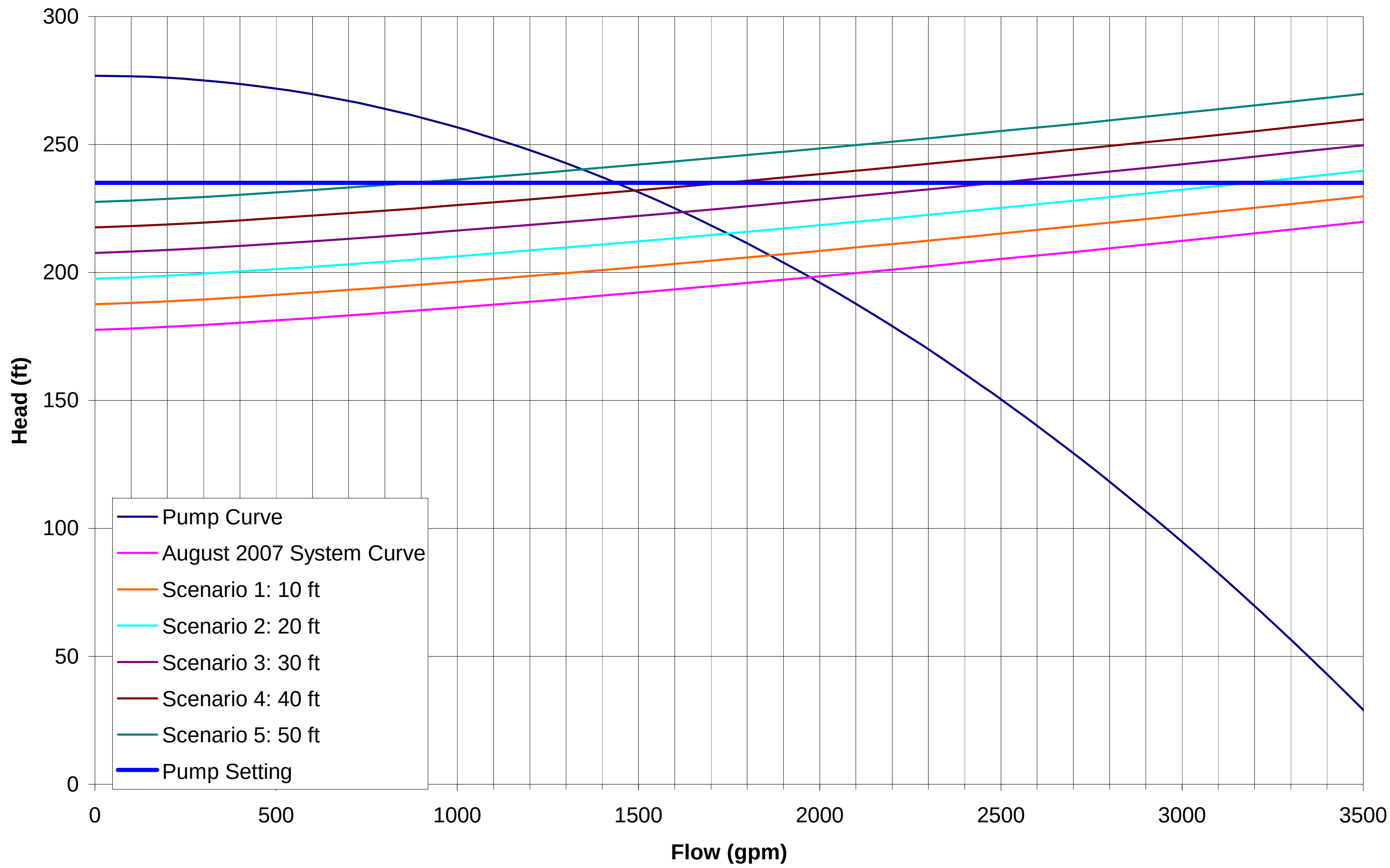

Figure B-7

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 13
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

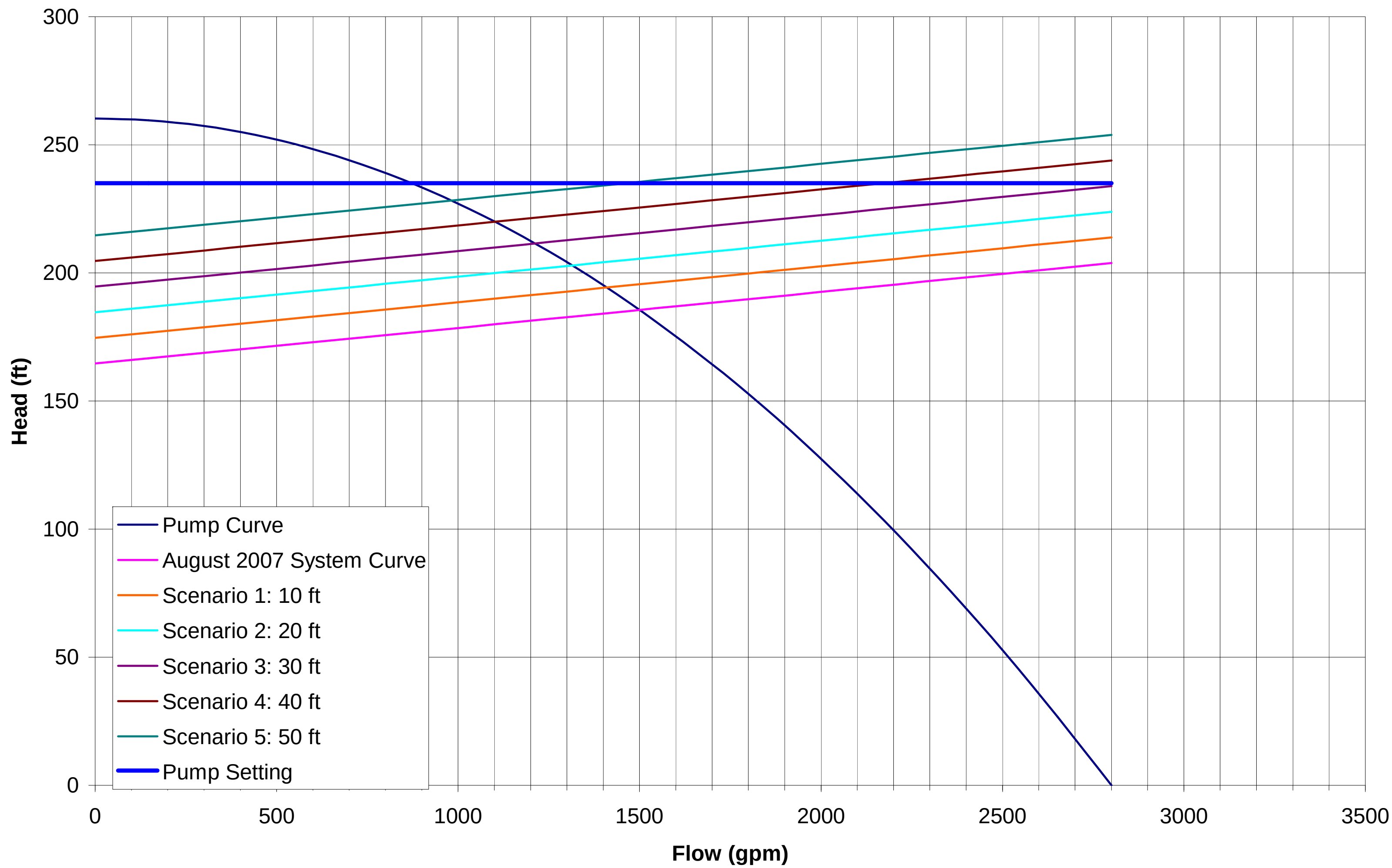

Figure B-8

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 14
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES Consulting Engineers

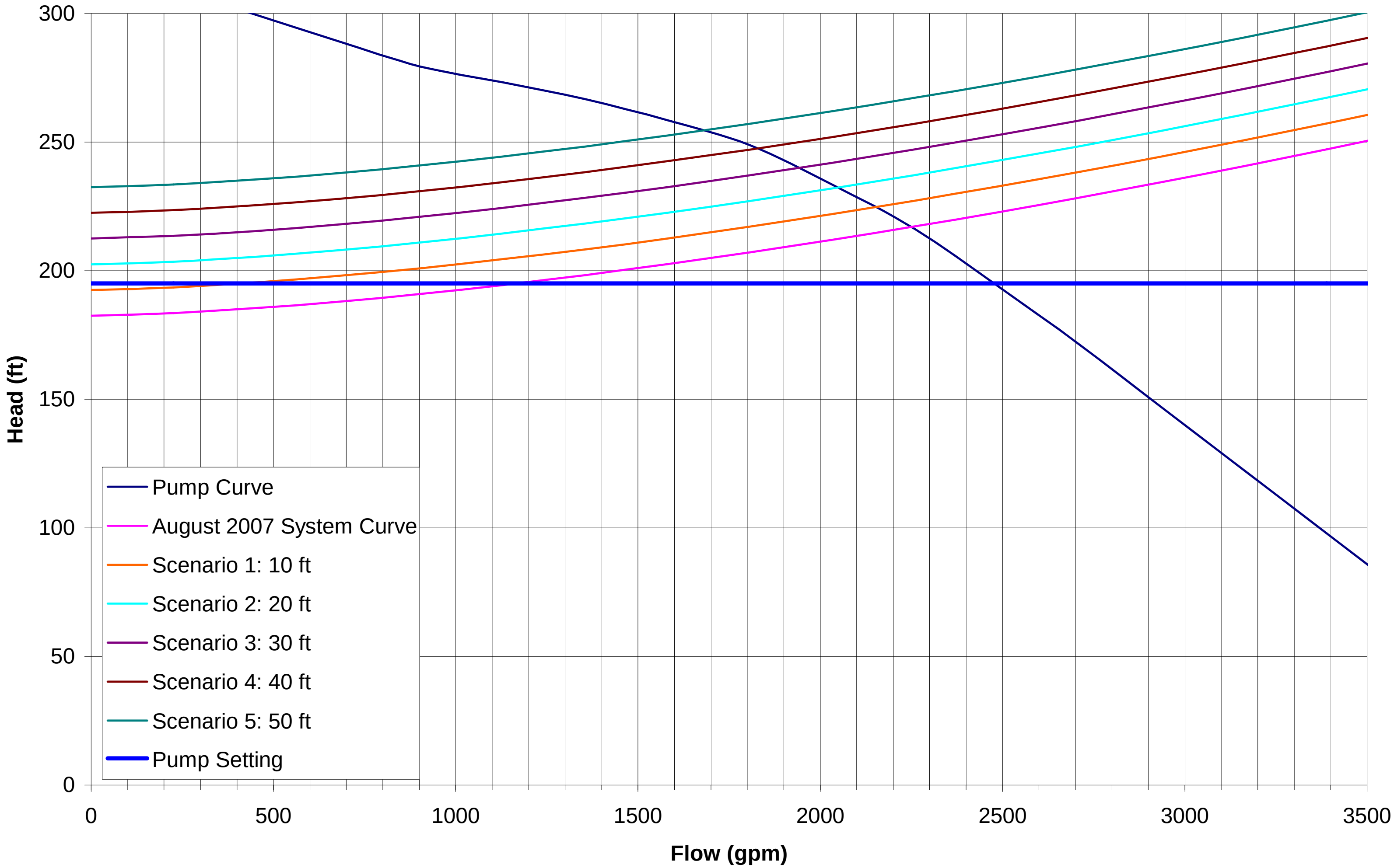

Figure B-9

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 15
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

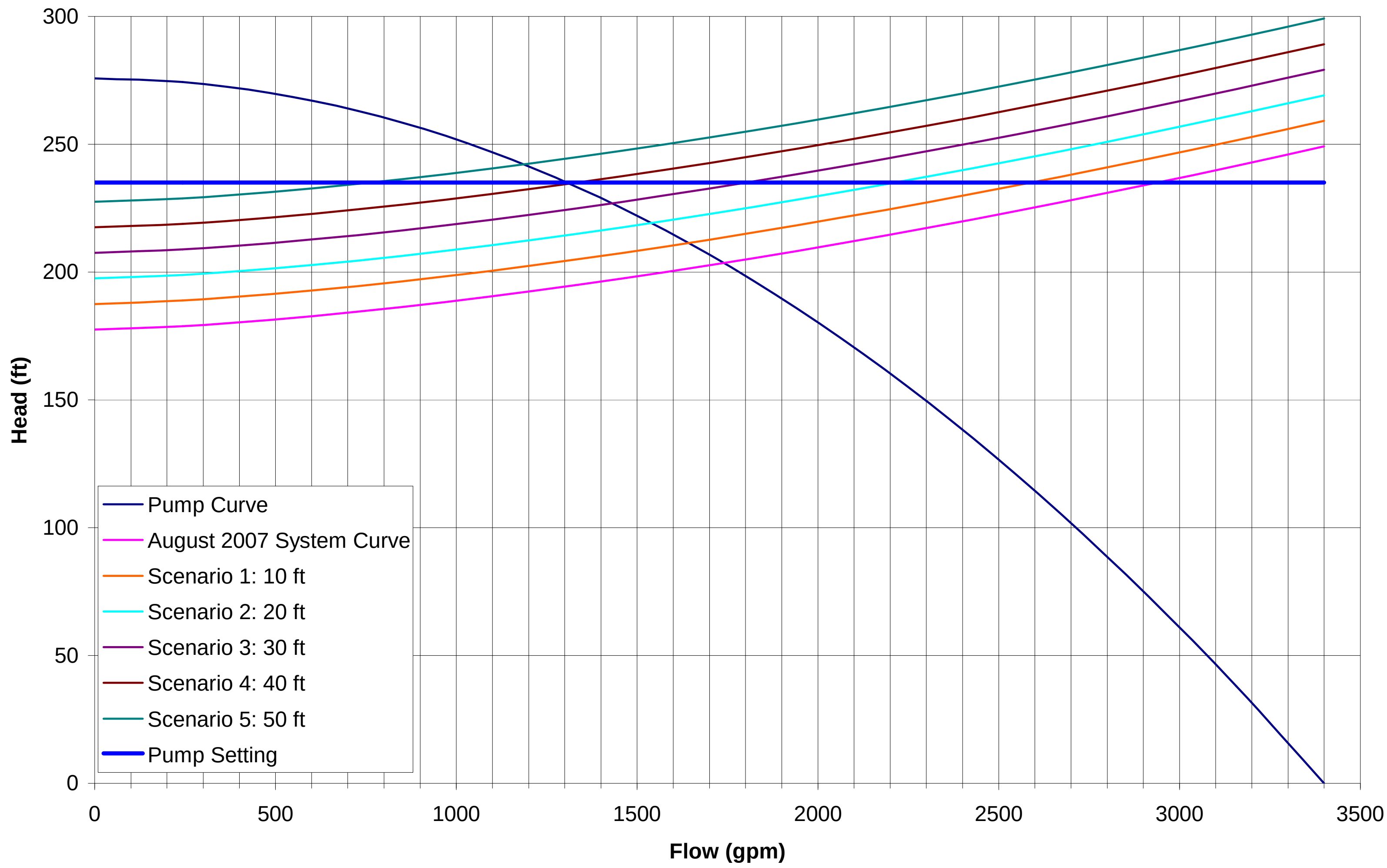

Figure B-10

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 16
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

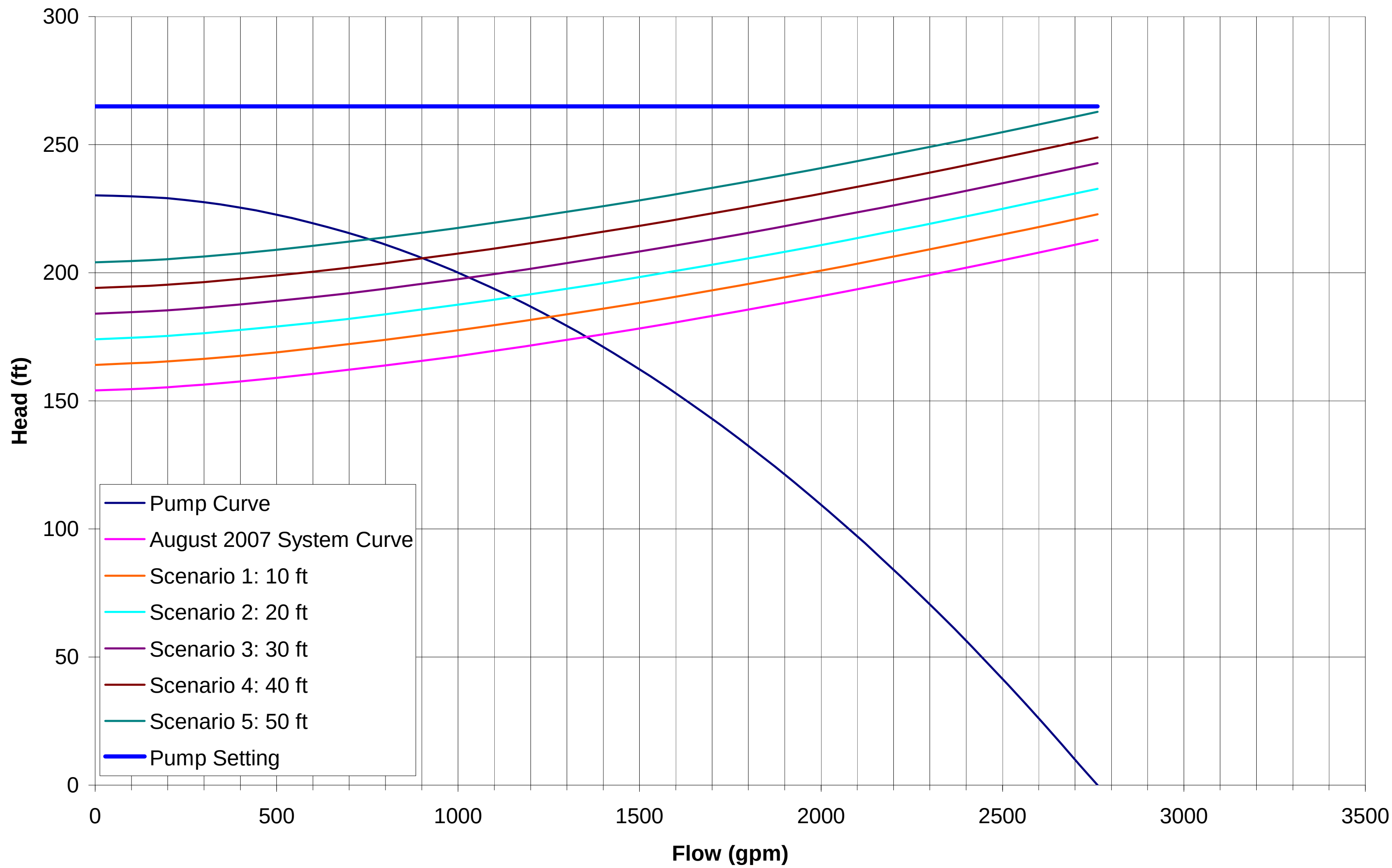

Figure B-11

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 17
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

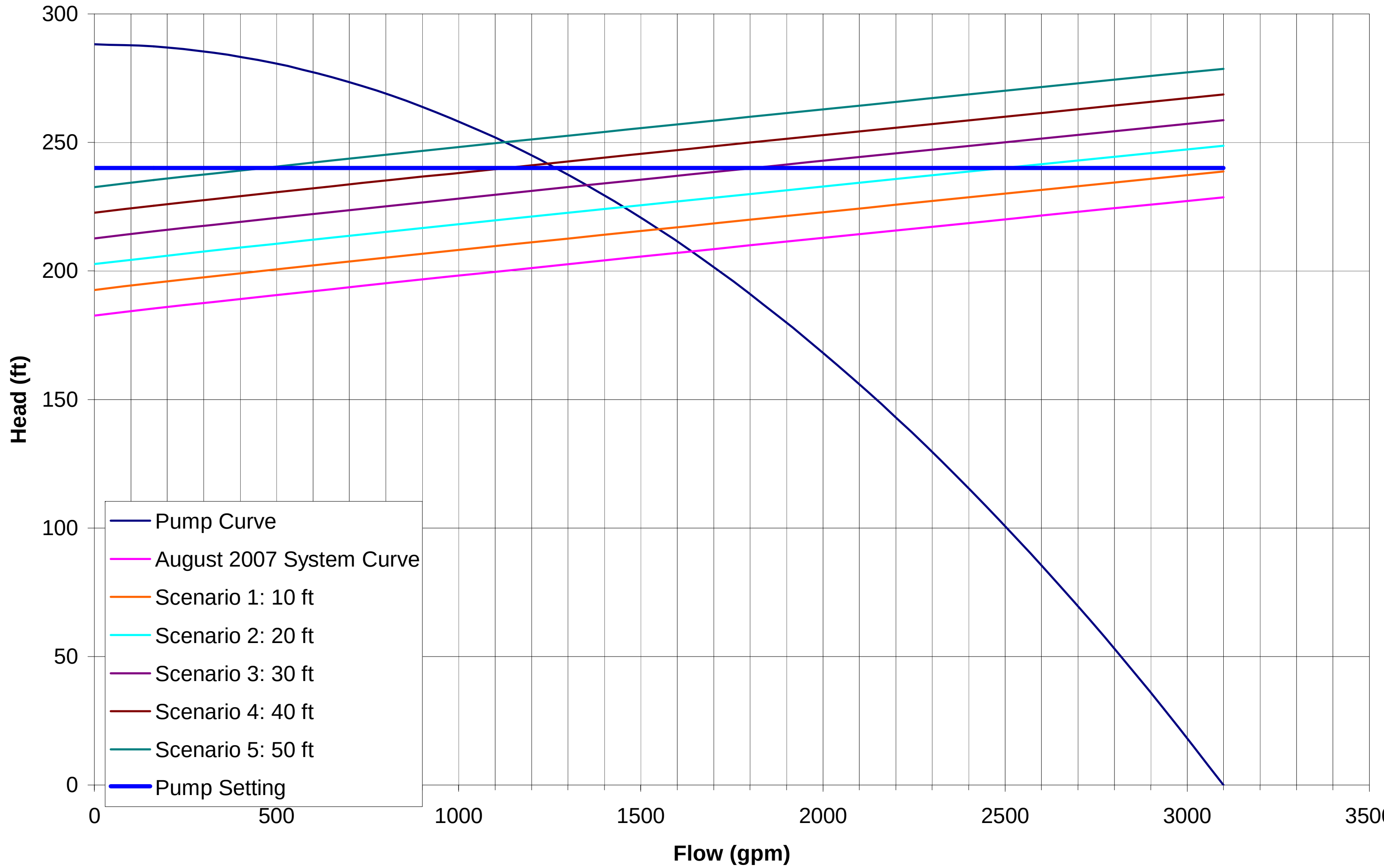

Figure B-12

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 18
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

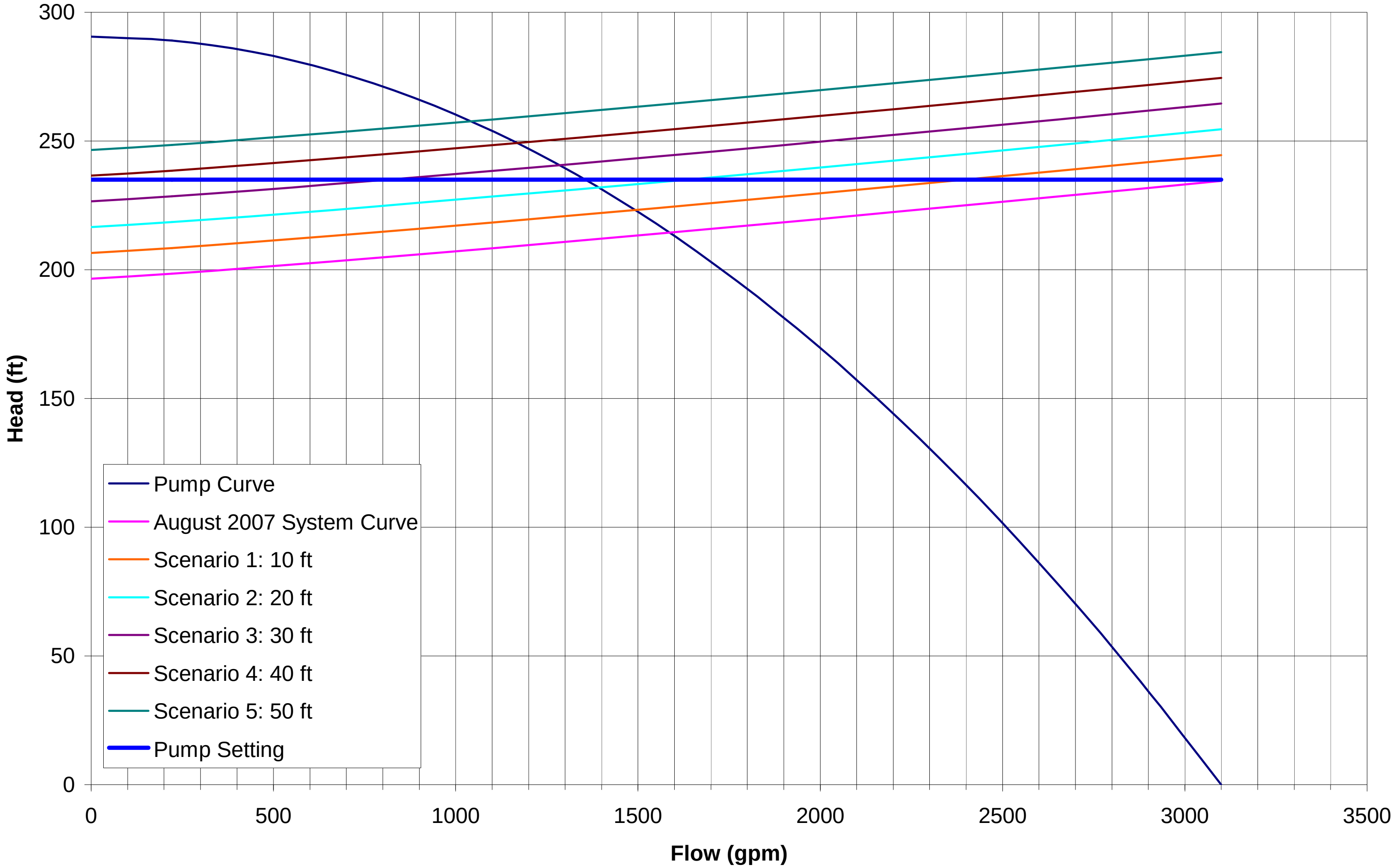

Figure B-13

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 19
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

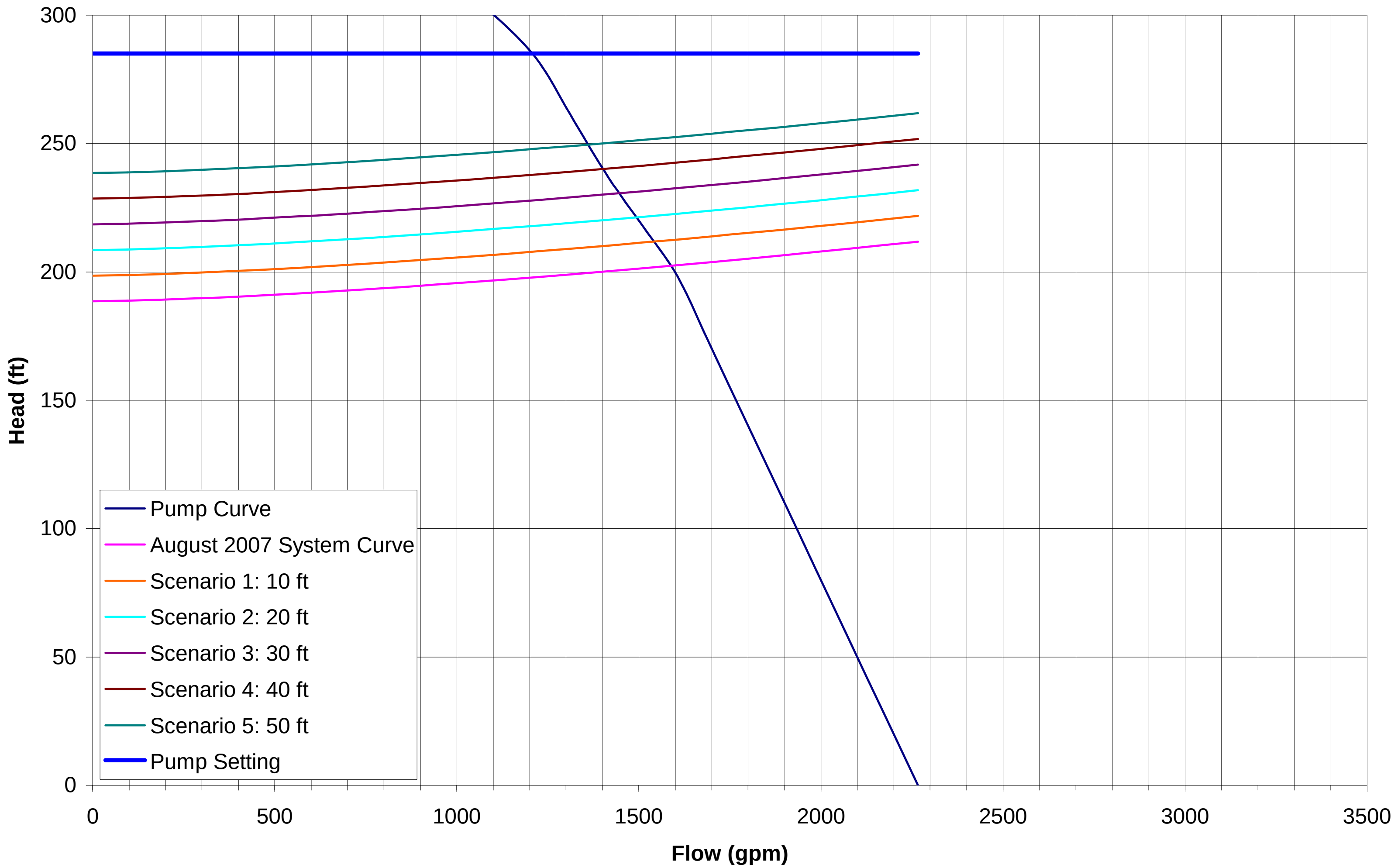

Figure B-14

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 20
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES Consulting Engineers

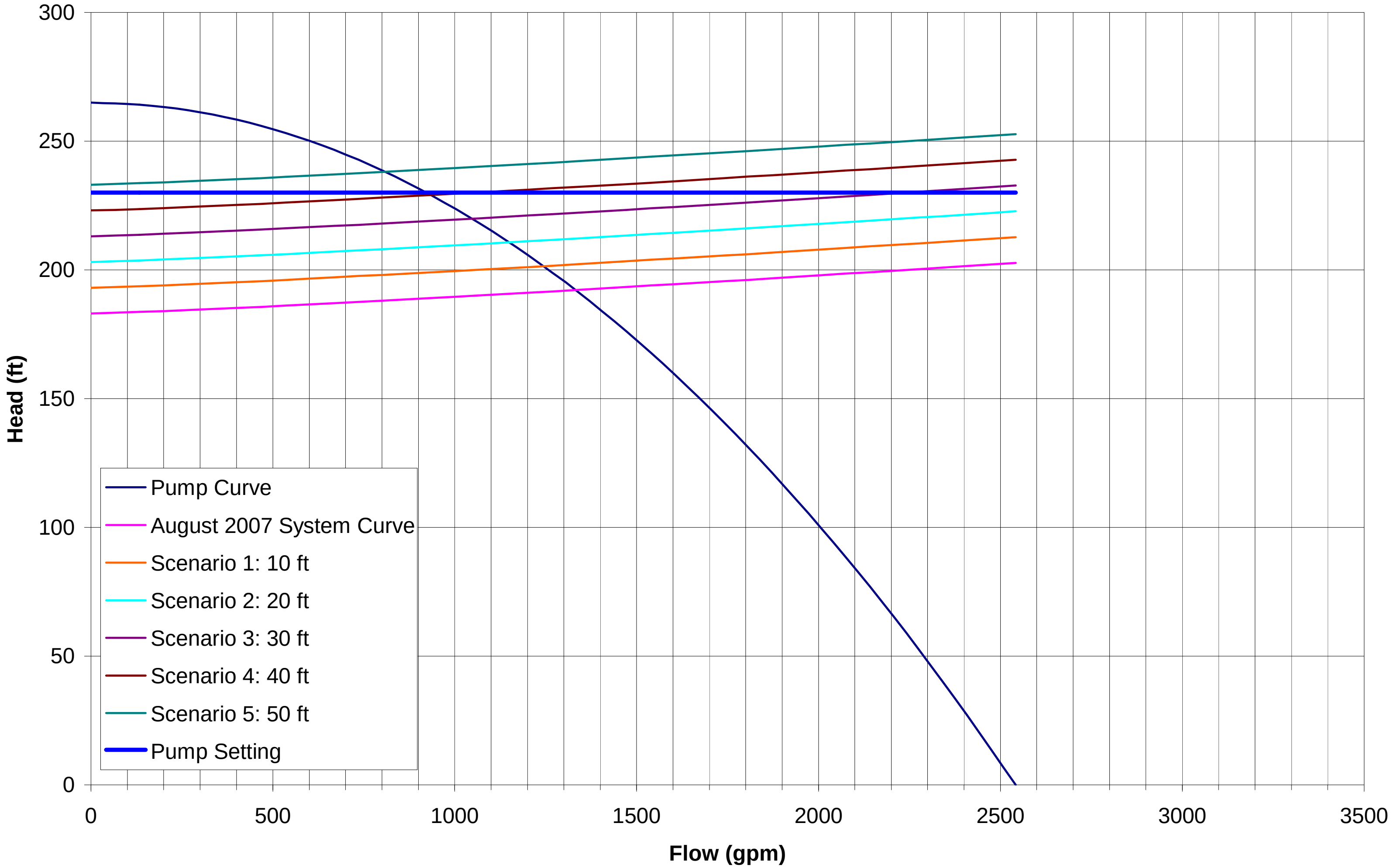

Figure B-15

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 21
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

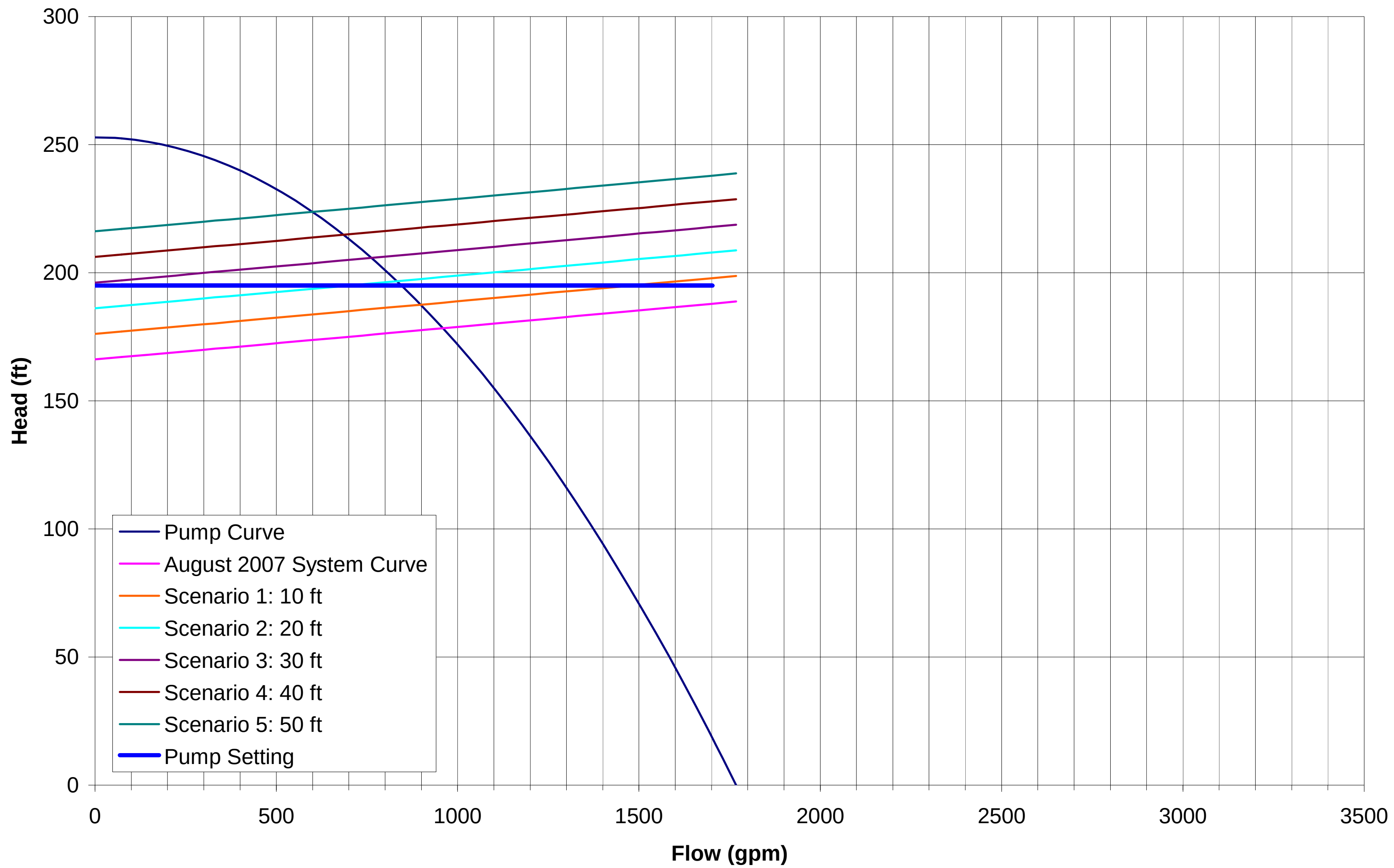

Figure B-16

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 22
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES
Consulting Engineers

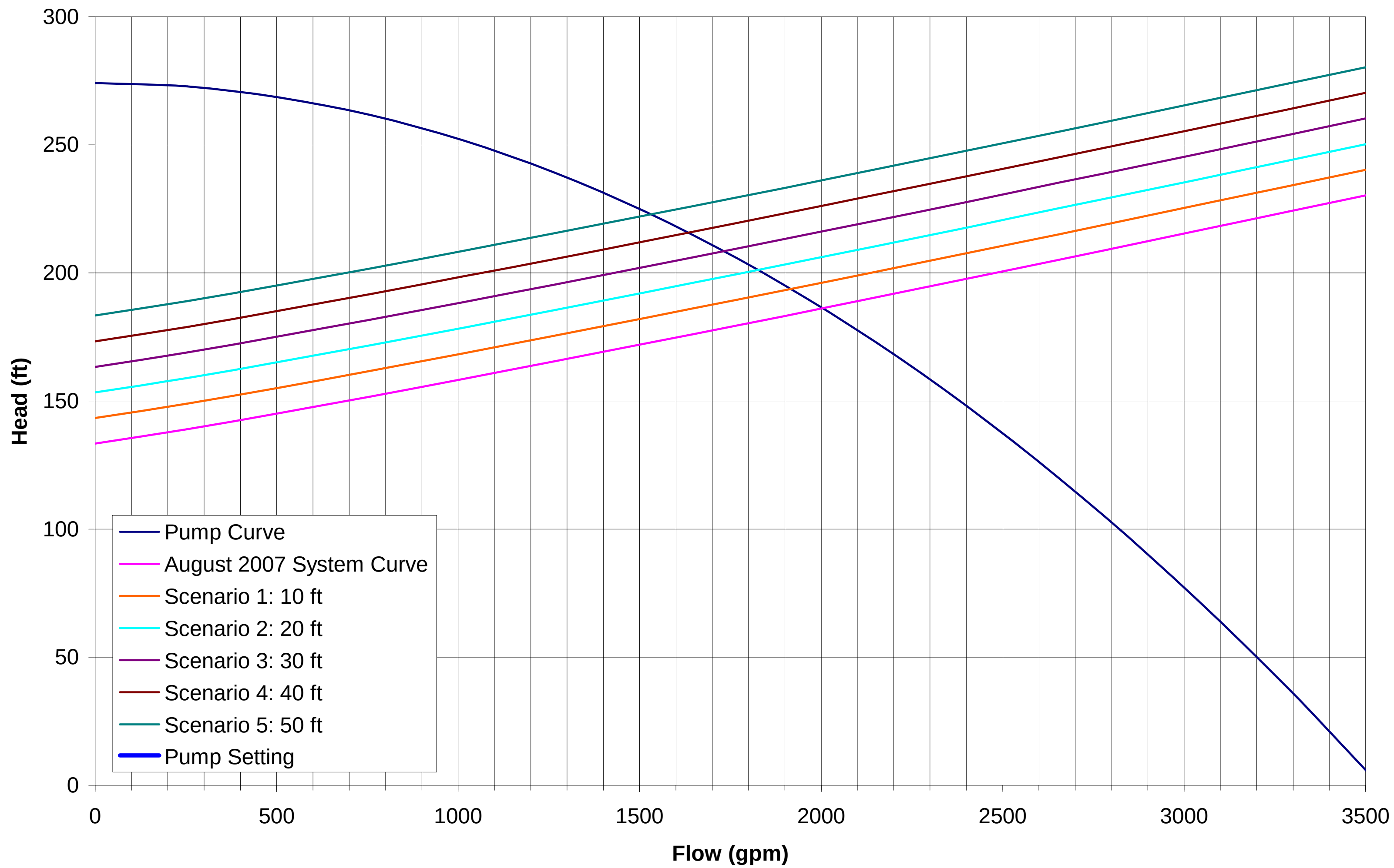

Figure B-17

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 24
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES Consulting Engineers

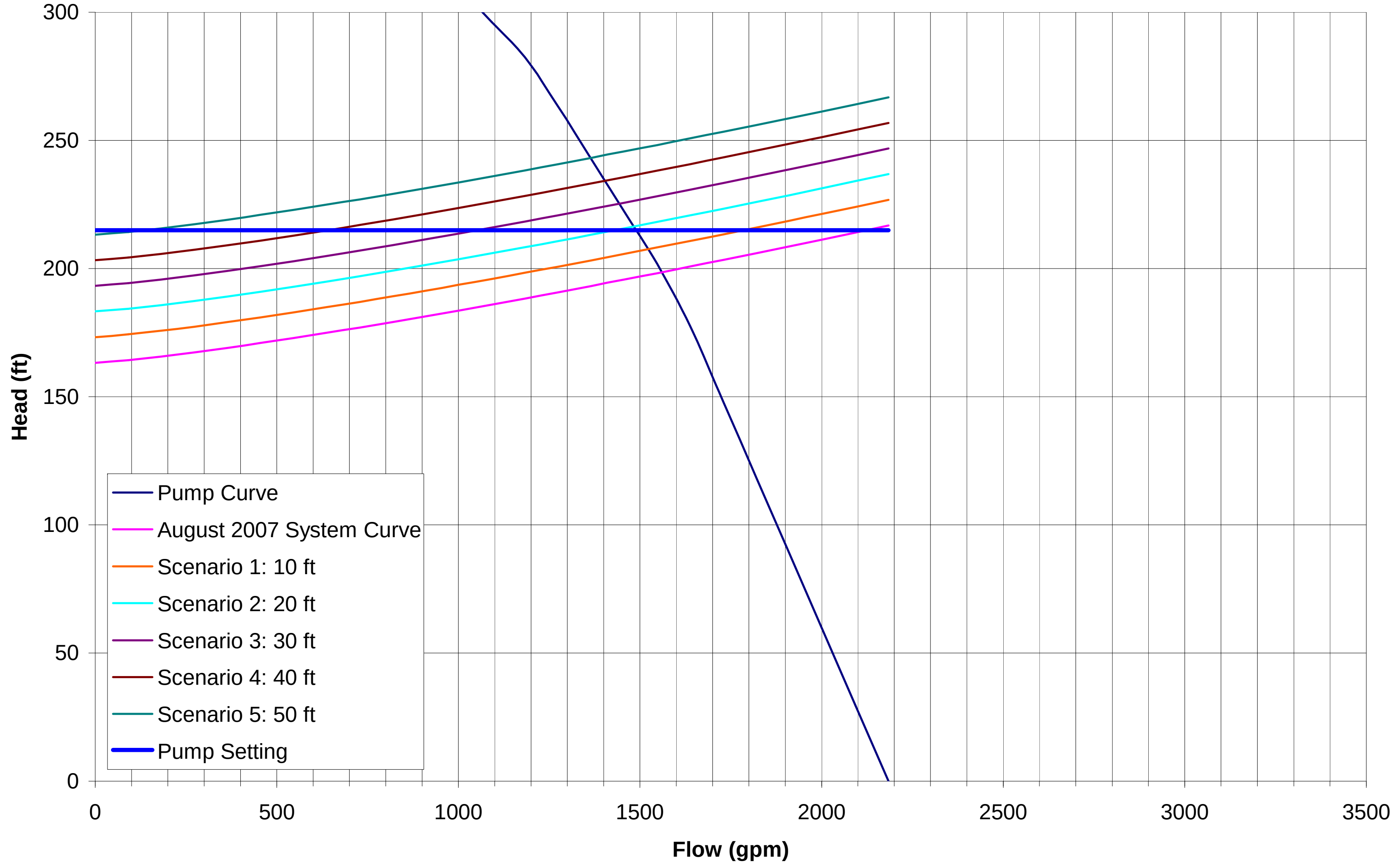

Figure B-18

CITY OF WOODLAND
DRY-YEAR PUMPING TM

WELL 26
SYSTEM AND PUMP CURVES

WEST YOST ASSOCIATES Consulting Engineers

APPENDIX H

Recommended Procedures for Groundwater Level Monitoring

APPENDIX H. RECOMMENDED PROCEDURES FOR GROUNDWATER LEVEL MONITORING

Water levels in monitoring wells should be measured to the nearest 0.01-foot on a semiannual basis, at minimum, to allow resolution of minimum and maximum groundwater elevations each year. The measurements should be made in the spring and the fall of each year, preferably in the March-April and September-October time frames, when groundwater levels are their maximum and minimum values, respectively. Each measurement event should be conducted in as short a time period as possible to minimize the effects of time varying groundwater elevations. If possible, monitoring should be conducted in wells specifically designed for monitoring, or inactive wells. If active wells are used, water level measurements should be taken after the well pump has been turned off and water levels have recovered for a minimum of 48 hours.

Water level measurements should be made from a reference point established for each monitoring well. All reference point elevations should be surveyed to the nearest 0.01-foot and referenced to the North American Vertical Datum of 1988 (NAVD88), or similar datum. All horizontal coordinates should be referenced to California State Coordinate System. If the reference point is not level with the ground surface, the distance to ground surface should be measured to the nearest 0.01-foot and noted.

Water level measurements logs should be used to record level measurements. At minimum, the logs should include:

- Date and time of measurement
- Reference point
- Depth to water
- If pumping is known to have occurred at, or near, the well in the last 48 hours

APPENDIX I

Recommended Procedures for Groundwater Sampling

APPENDIX I. RECOMMENDED PROCEDURES FOR GROUNDWATER SAMPLING

All sampling equipment should be decontaminated prior to sample collection and all field test equipment should be calibrated according to the manufacturer's specifications. Methods for cleaning equipment depend on a variety of factors including parameters being tested, purpose of the investigation, type and make of equipment, and regulatory guidelines that apply to the project.

Prior to any disruption of the water column, the depth to water should be measured to the nearest 0.01 foot using an electronic sounder, the total depth of the well should be measured with a weighted sounding tape, and the well bore volume and the required purge volumes should be calculated.

WELL PURGING PROCEDURES

The well should be pumped using a Grundfos Redi-Flo2® (or equivalent) submersible sampling pump, and the physical parameters (pH, specific conductance and temperature) of the purge water should be measured and recorded along with the date and time of measurement. Pumping should continue until physical parameters are stable or three to five cased well volumes have been purged. Stabilization should be defined as agreement between the last two sets of readings within plus or minus 0.1 pH units, plus or minus 1.0º C, and plus or minus 10 percent of full scale reading for specific conductivity. If these parameters have not stabilized during the removal of three cased well volumes, then a maximum of five well volumes should be removed. The purging and sampling should be documented using a well purging and sampling form.

WATER QUALITY PROCEDURES

Water quality sampling should be conducted on a semiannual basis. The water quality sampling should be conducted concurrent with the spring and fall groundwater level monitoring events to evaluate seasonal changes in water quality. At least one field duplicate should be collected per sample event.

The initial groundwater sampling of new monitoring wells should be performed at least 48 hours after well development.

Sample Collection

The necessary sample containers and preservatives must be obtained and labeled before the sampling event. Containers and preservatives are normally provided by the laboratory responsible for the analyses. Container labels should include the following information:

- Date and time
- Sample ID
- Parameter being tested

- Method to be used
- Preservative
- Name of the person collecting the samples
- Project number

Groundwater samples should be collected using dedicated disposable polyethylene bailers with monofilament cord or a Grundfos Redi-Flo2® (or equivalent) submersible sampling pump with dedicated disposable Teflon® tubing. Samples should be transferred directly into the appropriate container as specifically prepared by the laboratory for each type of analysis. The samples should be placed on ice and transported under chain-of-custody to a California-certified laboratory.

Additional samples should be collected for quality assurance quality control (QA/QC) of the field sampling procedures. The type and frequency of QA/QC sampling should be specified within the specific project documentation. QA/QC samples can either be collected in the field or conducted within the laboratory. Some examples of QA/QC samples include field blanks, blind duplicates, and matrix spikes.

Laboratory Analyses and Parameters

Laboratory analyses should be conducted for, at minimum, general minerals, metals, total dissolved solids (TDS), nitrate as nitrogen, electrical conductance, and pH. Table C-1 lists the analytical method, practical quantitation limit, sample containers, preservatives, and holding time for each parameter.

Table C-1. Analytical Methods for Groundwater Monitoring Well Samples

Parameter	Analytical Method	Practical Quantitation Limit	Sample Container/Preservatives	Holding Times
TDS	EPA 160.1	10 mg/l	500 milliliter (ml) polyethylene, cool[a]	7 days
Nitrate as nitrogen	EPA 300.0	0.5 mg/l	500 ml, polyethylene cool[a]	2 days
Electrical conductance	EPA 120.1	10 µmhos/cm	500 ml, polyethylene cool[a]	28 days
pH	EPA 150.1	0.01 SU	500 ml, polyethylene cool[a]	1 day
Aluminum	EPA 6020/200.7	50 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Antimony	EPA 6020/200.8	6.0 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Arsenic	EPA 6020/200.8	2.0 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Barium	EPA 6020/200.7	100 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Beryllium	EPA 6020/200.8	1.0 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Boron	EPA 200.7	100 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Cadmium	EPA 1638/200.8	1.0 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Chromium	EPA 6020/200.7	10 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Copper	EPA 6020/200.7	50 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Cyanide	EPA 9012A	100 µg/l	500-ml polyethylene, NaOH, pH < 14	14 days

Parameter	Analytical Method	Practical Quantitation Limit	Sample Container/Preservatives	Holding Times
Iron	EPA 6020/200.7	100 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Lead	EPA 6020/200.8	5.0 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Manganese	EPA 6020/200.7	10 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Mercury	EPA245.2	1.0 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Nickel	EPA 6020/200.8	10 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Selenium	EPA 6020/200.8	5.0 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Silver	EPA 6020/200.7	10 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Thallium	EPA 6020/200.8	1.0 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Zinc	EPA 6020/200.7	50 µg/l	1-liter polyethylene, HNO_3, pH < 2	6 months
Alkalinity (total) as $CaCO_3$	EPA 310.1	1.0 mg/l	1-liter polyethylene	14 days
Bicarbonate Alkalinity as $CaCO_3$	EPA 310.1	1.0 mg/l	1-liter polyethylene	14 days
Carbonate Alkalinity as $CaCO_3$	EPA 310.1	1.0 mg/l	1-liter polyethylene	14 days
Hydroxide Alkalinity as $CaCO_3$	EPA 310.1	1.0 mg/l	1-liter polyethylene	14 days
Calcium	EPA 200.7	1.0 mg/l	1-liter polyethylene	6 months
Chloride	EPA 300	0.25 mg/l	1-liter polyethylene	28 days
Fluoride	EPA 300	0.1 mg/l	1-liter polyethylene	28 days
Foaming Agents (MBAS)	EPA 425.1	0.5 mg/l	1-liter polyethylene	2 days
Hardness (Total) AS $CACO_3$	EPA 200.7	1.0 mg/l	1-liter polyethylene	6 months
Magnesium	EPA 200.7	1.0 mg/l	1-liter polyethylene	6 months
Potassium	EPA 200.7	1.0 mg/l	1-liter polyethylene	6 months
Sodium	EPA 200.7	1.0 mg/l	1-liter polyethylene	6 months
Sulfate	EPA 300	0.5 mg/l	1-liter polyethylene	28 days
Color	EPA 140.1	NA[b]	1-liter polyethylene	2 days
Odor Threshold @ 60 C	EPA 110.2	NA[b]	1-liter glass	1 day
Turbidity	EPA 180.1	0.5 NTU	1-liter glass	2 days

[a] A single 500 ml polyethylene bottle will provide sufficient volume for TDS, nitrate, electrical conductance and pH analyses.

[b] Not Applicable

Field Records

Accurate field records must be maintained in order to best document groundwater sampling activities. These field records include sample container identification labels, copies of the chain-of-custody, and any information or comments collected in the field.

Field records should include, at minimum:

- Date and time
- Sample location
- Project name or identification
- Well condition and any comments regarding disrepair, missing parts, etc.
- Depth to water, prior to sampling
- Depth to bottom of the well
- Well volume
- Purging method
- Purged volume
- Sample collection method
- Sample description
- Field meter data
- Water quality measurements
- General comments

APPENDIX J

Accessing the Yolo County WRID and Data Submission Guidelines

APPENDIX J. ACCESSING THE YOLO COUNTY WRID AND DATA SUBMISSION GUIDELINES

1.0 WRID DATA SUBMISSION

There are two ways to submit water data to the WRID:

1) Directly input the data into the WRID web interface, or
2) Email a Microsoft Excel spreadsheet containing the water data to Max Stevenson at the Yolo County FC&WCD (mstevenson@ycfcwcd.org). The spreadsheet must be specifically formatted to be entered into the WRID database. Formatting is discussed in more detail in Section 2.0.

Directly inputting the data into the WRID interface is the preferred method. Training and login information can be provided to anyone needing direct access to the interface. Requests for registration may take a day or two to be processed. The current WRID user for the City of Woodland is Sherry Salas. Adding data directly into the WRID is discussed in more detail in Section 5.2.

2.0 WRID DATA FORMAT

Data formatting is important when entering data into the WRID. The WRID web interface contains a variety of data for numerous wells within Yolo County. Data input consistency between wells is vital in order to minimize confusion.

2.1 General Format – Water Levels

The general format is used by the Yolo County FC&WCD when inputting water level data received by various agencies throughout Yolo County. All Excel spreadsheets submitted to the Yolo County FC&WCD for data entry into the WRID must be formatted to match this general format. Figure 2-1 is an example of how the Excel spreadsheet should be set up.

Figure 2-1. Example Yolo County FC&WCD General Format for Excel Data Submission

WELL_NUMBER	WL_DATE	RPE	DTW	WL_TYPE	WL_SOURCE	GQC_CODE	GNC_CODE	WL_COMMENT	QA_QC_STATUS
Example Well Number 1	12/15/2009	110	13		WOODLAND	8			
Example Well Number 2	12/15/2009	163	23		WOODLAND				1
Example Well Number 3	12/15/2009	245	29.1		WOODLAND				1
Example Well Number 4	12/15/2009				WOODLAND		2		
Example Well Number 5	12/15/2009	416	65.2		WOODLAND				1

The column headings, in order of left to right, should be:

WELL_NUMBER – Official State assigned State Well Number (SWN). This number contains no dashes, slashes, or spaces and should follow the format "##X##X##X###X" (e.g. 09N12E26R001M).

WL_DATE – Date, with the year, on which the water level was measured. All dates should be formatted as mm/dd/yyyy hr:min, with the hr:min being optional. The hours, if used, should be entered as military time (24 hour).

RPE – Reference point elevation, in feet, above mean sea level.

DTW – Depth to water from the RPE, in feet.

WL_TYPE – Water level measurement type. This field is used by a few agencies and may be left blank.

WL_SOURCE – Name of the agency that took the water level measurement. These entries should exactly match one of the agency names… (e.g. "WOODLAND", "DAVIS", "RD2035", "UCD", etc.)

GQC_CODE – DWR quality code or questionable measurement code; listed in some reports as QMC. If there were questionable conditions around the time of water level measurement, a code is entered into this field to explain why. Further explanation can be entered into the WL_COMMENT field. The DWR quality codes are listed in Table 2-1.

Table 2-1. DWR "Questionable Measurement" Codes[(a)]

Code	Definition
0	Caved or deepened
1	Pumping
2	Nearby pump operating
3	Casing leaking or wet
4	Pumped recently
5	Air or pressure gauge measurement
6	Other
7	Recharge operation at nearby well
8	Oil in casing
9	Acoustical sounder measurement

[(a)] http://www.water.ca.gov/waterdatalibrary/includes/Key_Codes_Abb_gw.cfm

GNC_CODE – No measurement code; listed in some reports as NMC. If no measurement could be taken, a code is entered into this field to explain why. Further explanation can be entered into the WL_COMMENT field. The no measurement codes are listed in Table 2-2.

Table 2-2. DWR "No Measurement" Codes[a]

Code	Definition
0	Discontinued
1	Pumping
2	Pumphouse locked
3	Tape hung up
4	Can't get tape in casing
5	Unable to locate well
6	Well destroyed
7	Special
8	Casing leaking or wet
9	Temporarily unavailable
D	Dry well
F	Flowing well

[a] http://www.water.ca.gov/waterdatalibrary/includes/Key_Codes_Abb_gw.cfm

WL_COMMENT – Comments regarding well condition, explaining questionable measurements or why no measurement was taken, or any other notable observations at time of water level measurement.

QA_QC_STATUS – Quality control status. Those entries that have been checked and quality controlled have a "1" in this field.

3.0 LOGGING INTO THE YOLO COUNTY WRID

The login page for the Yolo County WRID can be accessed from the following URL: http://wrid.facilitiesmap.com.

Microsoft Internet Explorer is the only web browser supported by the Yolo County WRID. The WRID uses Autodesk MapGuide software. The MagGuide plug-in can be installed directly from the login window. Pop-ups for this website should be temporarily enabled in order to fully utilize the WRID.

After logging in, a map of Yolo County will appear in your web browser. Two GIS related toolbars should be displayed along the top and left-hand side of the map. These tools allow the user to navigate and modify the map display. An information sidebar, displaying retrieved data, should also be visible to the left of the map.

4.0 DATABASE SEARCH

The database search sidebar is located to the left of the map display. In order to find information on a certain well, enter the desired State Well Number (SWN) into the “Enter Well Number” field within the sidebar. If the entire SWN is unknown, entering in a portion of the well number will select all wells that correspond to that number. For example, if only the township and range portion of the SWN is known, then entering in the township and range will select all wells that fit that criterion. If the location of the desired well is known, then the cursor can be used to select that well directly from the map display.

The data displayed by the interface for the selected well(s) will show up either in the sidebar or as a pop-up window. Clicking the “Forward” or “Back” buttons on the web browser allows the user to navigate forward or backwards within the sidebar.

The options that appear once a well has been selected allow the user to (1) view available data pertaining to:

- Well construction,
- Water quality,
- Water levels,
- Associated aquifers and zones, and
- Any available attachments.

(2) edit or add water level data, or (3) export water quality or water level data in an Excel spreadsheet.

Selecting “Construction” from the “Reports and Charts” sidebar will display any available information regarding well specifications for that well.

Selecting “Water Quality” from the “Reports and Charts” sidebar will display a secondary sidebar where the desired date range and parameter can be entered for that well. If all available parameters are desired, then no one parameter should be specified. After the desired water quality information has been entered in, clicking “Generate Report” will display a table of the desired water quality data. Then, clicking the “Graph” button will display a time-plot of the desired water quality data.

Selecting “Levels” from the “Reports and Charts” sidebar will display a secondary sidebar where the desired date range and statistic (depth to water) can be entered for that well. After the desired water level information has been entered in, clicking “Generate Report” will display a table of the desired water level data. Then, clicking the “Graph” button will display a time-plot of the desired water level data.

Selecting “Depth Zones” from the “Reports and Charts” sidebar will display information regarding the aquifers that the well penetrates. This option will also display information regarding the well perforations.

Selecting “Photos and Docs” from the “Reports and Charts” sidebar will display a secondary sidebar containing four icon options. These icons are “Zoom to Well”, “Generate Report”, “Attach a Document”, and “Attach a Note”. These four icons will allow the user to either (1) view documents or photos that have been uploaded or (2) upload a relevant photo or document.

5.0 ADDING, EDITING, AND EXPORTING DATA

Data can only be added, edited, or exported for one well at a time. Refer to Section 4.0 of this report for instructions on how to select a specific well.

5.1 Editing Data

After a well has been selected, a section titled “Edit or Add Data” will appear in the sidebar to the left of the map. Only groundwater level data can be edited. Click the “Edit” button next to “Levels” under “Edit or Add Data”. Select the date range for the data to be edited and click “Filter Dates”. Select a measurement to be edited and change the incorrect entry.

As of September 2009 there is no way to perform quality control of data entered through the WRID web interface. Be sure that all data has been inputted carefully and correctly.

5.2 Adding Data

After a well has been selected, a section titled “Edit or Add Data” will appear in the sidebar to the left of the map. Only groundwater level data can be edited. For adding water level data, click the “Add” button next to “Levels” under “Edit or Add Data”. A sidebar should appear that contains spaces for the:

- Sample date,
- Reference elevation,
- Depth to water,
- Q code (quality code),
- No code (code for the reasoning behind why there was no measurement taken),
- WL_Source (water level source), and
- WL_Comment (comments regarding the water level measurement).

Formats for the input data, such as the sample date and WL_Source, should follow the requirements discussed Section 2.0. The coding system for the quality code and no codes are also included in Section 2.0.

5.3 Exporting Data

After a well has been selected, a section titled “Export Data” will appear in the sidebar to the left of the map. Both water quality and groundwater level data can be exported. Select the type of data to be exported, either water quality of levels. Specify the date range to be exported before clicking “Export Dates”. The resulting Excel spreadsheet can either be saved or opened.

APPENDIX K

Recommended Groundwater Quality Assurance/Quality Control Plan

APPENDIX K. RECOMMENDED GROUNDWATER QUALITY ASSURANCE/QUALITY CONTROL PLAN

STANDARD OPERATING PROCEDURES

Standard operating procedures (SOPs) are necessary to establish a uniform methodology for the collection of groundwater samples and information. SOPs reduce the variability in the procedures used to collect groundwater samples and measure groundwater elevations.

STAFF QUALIFICATIONS

Staff selected to conduct groundwater level monitoring and groundwater quality sampling should be trained to follow the conditions set in this appendix. If needed, they should be trained to conduct any sampling event that requires different procedures. Staff training should be updated with the addition of any new detailed SOPs.

GROUNDWATER LEVEL MEASUREMENTS

Groundwater levels should be measured on wells that are either inactive or have been turned off for at least 48 hours. Pumping water levels should be measured for wells that have been pumping for at least 24 hours. Static water level measures should be conducted on wells that have been turned off for at least 2 hours. For static water level measurements, the data and time of both the well shutoff and water level measurement should be recorded for each well.

Any groundwater level measurements that appear questionable due to some outside factor such as field conditions or equipment behavior should be recorded. Water level measurements should be compared to groundwater level trends for the region. Any measurements that appear to be out of reasonable bounds should be recorded. If necessary, the equipment should be recalibrated and additional measurements should be taken.

All water quality measurements should be formatted and submitted to the Yolo County FC&WCD to be incorporated into the WRID.

GROUNDWATER QUALITY SAMPLING

Depth to water should be measured prior to all purging and water sampling events.

Sampling equipment and field meters should be standardized to get comparable data. Field equipment should be routinely calibrated to the manufacturer’s specifications.

Purging

Applying a standard, consistent procedure for purging is important for obtaining comparable data. For a reliable purging event, wells should be pumped five times the volume of the well before being checked for parameter stabilization. Some of the main parameters to check for stabilization include specific conductance (EC), pH, and temperature.

Sample Containers and Shipping

All sample containers and preservatives must be either provided by the laboratory completing the testing or be lab-approved. The containers, preservatives, samplers, and any tubing used during the sampling event must be such that they will not adversely react to the constituents of interest.

Chain-of-custody forms must be used for all groundwater sampling events. Samples should be held on ice or correctly preserved from the time they are collected until they reach their destination laboratory. All sample deliveries should follow the QA/QC recommendations from the analytical laboratory.

Field Records

Accurate field records should be maintained to document groundwater sampling events. Field record forms should be started prior to sampling. More detail about what should be included in the field records is included in Appendix I of this report.

Field QA/QC Samples

To better document the QA/QC of the field sampling procedures, additional samples should be collected. Field QA/QC samples provide evidence to support the reproducibility and overall quality of the groundwater samples. The laboratory responsible for the analyses will normally specify the QA/QC sample. A few examples of field QA/QC samples include field blanks, equipment blanks, trip blanks, and blind duplicates. Instructions on the processes required to collect the QA/QC samples will be specified by the analytical laboratory.

QUALITY ASSURANCE/QUALITY CONTROL

QA/QC protocol should be coordinated with the analytical laboratory. The steps in developing the QA/QC protocol include:

1) Define quality control parameters;
2) Target analyte list;
3) List maximum reporting limits and proper limits;
4) Determine spike recovery limits (based laboratories abilities and project data quality objectives);
5) Determine duplicate frequency and maximum relative percent difference; and,
6) Specify adequate numbers of blanks.

After receipt of analytical results from the laboratory, the lab report should be checked to insure that the data quality is reasonable. The following should be checked:

- Completeness and accuracy of data transfer
- Laboratory case narrative and data qualifiers
- Holding times

- Reporting limits
- Blanks (should be checked for contamination)
- Spike recoveries
- Precision of duplicate samples

After checking the quality of the laboratory results, the data usability should be summarized. This includes the percent complete, rejected data, qualified data, and statement of the data usability. Any data that has been qualified as rejected or estimated during the review process should be marked as such before being formatted and exported for use in the WRID.

DATA COMPILATION AND MANAGEMENT

All collected groundwater data should be compiled and formatted to be entered into the Yolo County WRID (see Appendix J for correct data format). The formatted data should be exported to the Yolo County FC&WCD at least once annually to be entered into the WRID.


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HISTORY


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