Western Canal Water District

GROUNDWATER MANAGEMENT PLAN

THIS REVISION HAS BEEN PREPARED PURSUANT TO
CALIFORNIA WATER CODE §10753 *et seq.*, AB 3030, AND SB 1938.

OCTOBER 2005

Table of Contents

Tables and Figures

Section 1
Introduction

1.1 Plan Authority and Administration

The Groundwater Management Act (AB3030) of 1992 authorizes a local agency that provides water service to adopt and implement a Groundwater Management Plan (GMP) in accordance with specified procedures. Western Canal Water District (District) is an authorized groundwater management agency as defined in California Water Code (CWC) §10753(a).[1]

On July 20, 1993, the Board of Directors of Western Canal Water District, following public hearings on June 15 and July 20, 1993, adopted a Resolution of Intention to Adopt a Groundwater Management Plan pursuant to CWC §10753, *et seq*. The subsequent Plan was adopted on March 21, 1995.

In order to provide more current management methods and objectives, and to include components required by recent law in the District's GMP, this document represents a revision of the original GMP. Adoption of this revised GMP occurred by resolution of the Board of Directors of Western Canal Water District. In order to avoid conflicts or inconsistencies with existing groundwater ordinances and groundwater management plans, the District shall endeavor to coordinate this GMP with local agencies that have adopted rules and regulations to implement and enforce their own AB 3030 plans as required by CWC §10753.9(a).

1.2 Plan Objectives

In Bulletin 118-2003, the California Department of Water Resources (DWR) defines groundwater management as the "planned and coordinated monitoring, operation, and administration of a groundwater basin or portion of a groundwater basin with the goal of long-term sustainability of the resource." To meet these objectives, the Western Canal Water District Groundwater Management Plan will enable the provision of the following benefits:

- Facilitate and protect groundwater replenishment.
- Facilitate cooperative management projects.
- Protect groundwater quality.
- Minimize the long-term drawdown of groundwater levels.

[1] CWC § 10753(a) Any local agency, whose service area includes a groundwater basin, or a portion of a groundwater basin, that is not subject to groundwater management pursuant to other provisions of law or a court order, judgment, or decree, may, by ordinance, or by resolution if the local agency is not authorized to act by ordinance, adopt and implement a groundwater management plan pursuant to this part within all or a portion of its service area.

- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality.

- Minimize the effect of groundwater pumping on surface water flows and quality.

1.3 Area Covered by the Plan

The Western Canal Water District GMP includes those areas within the delineated boundaries of the District that overlie parts of the Sacramento Valley Groundwater Basin and the associated groundwater sub-basins.

1.4 Plan Development Process

This AB 3030 Groundwater Management Plan was developed under the guidelines detailed in CWC §10753.2 through §10753.6:

- Provide public notification of a hearing on whether or not to adopt a resolution of intention to draft a GMP and subsequently complete a hearing on whether or not to adopt a resolution of intention to draft a GMP. Following the hearing, draft a resolution of intention to draft a GMP.

- Adopt a resolution of intention to draft a GMP and publish the resolution of intention in accordance with public notification (6066 Government Code). Upon written request, provide copy of resolution of intention to interested persons. The Western Canal Water District Board of Directors adopted the resolution of intention to develop a GMP on July 20, 1993.

- Prepare draft GMP within 2 years of resolution of intention adoption. Provide to the public a written statement describing the manner in which interested parties may participate in developing the GMP.

- Provide public notification (6066 Government Code) of a hearing on whether or not to adopt the GMP, followed by a hearing on whether or not to adopt the GMP.

- If protests are received for less than 50% of the assessed value of property in the area subject to groundwater management, the plan may be adopted within 35 days after completion of Step 4 above. If protests are received for greater than 50% of the assessed value of the property in the county area, the plan will not be adopted.

1.5 Management Plan Components

The Western Canal Water District Groundwater Management Plan includes the following required and recommended components:

- The seven mandatory components contained in CWC §10750 *et seq*. Recent amendments to §10750 *et seq*. require that several mandatory components be included in any GMP for the responsible agency to be eligible for funding administered by DWR for the implementation of groundwater projects.

- At least six voluntary components described in CWC §10750 *et seq*. that provide technically viable processes for overlying landowners to utilize the resources of the groundwater basin while protecting against adverse conditions.
- At least five suggested components from DWR Bulletin 118 that provide for effective implementation of management and monitoring goals.

Table 1-1 summarizes the required and recommended components included in the Plan, and where each component is addressed.

Table 1-1 AB3030 GMP Components

Plan Component Description	Plan Section
CWC §10750 *et seq*. Mandatory Components	
1. Documentation of public involvement statement	1.4
2. Establish basin management objectives	3.2.2
3. Monitoring and management of groundwater elevations, groundwater quality, inelastic land surface subsidence, and changes in surface water flows and quality that directly affect groundwater levels or quality or are caused by pumping.	3.2.1
4. Plan to involve other agencies located within groundwater basin.	3.2.1, 2, 3 & 5
5. Adoption of monitoring protocols by basin stakeholders.	3.2
6. Map of groundwater basin showing area of agency subject to GMP.	Tables & Figures
7. Prepare GMP using appropriate geologic and hydrogeologic principles.	Section 2
CWC §10750 *et seq*. Voluntary Components	
8. Administration of well abandonment and well destruction program.	3.2.2
9. Mitigation of conditions of overdraft.	3.2.3
10. Monitoring of groundwater levels and storage.	3.2.1
11. Facilitating conjunctive use operations.	3.2.4
12. Identification of well construction policies.	3.2.2
13. Development of relationships with state and federal regulatory agencies.	3.2.5
DWR Bulletin 118 Suggested Components	
14. Describe area to be managed under GMP.	1.3, 2.2
15. Describe GMP monitoring program.	3.2.1
16. Describe integrated water management planning efforts.	3.2.2 & 3
17. Report on implementation of GMP.	3.3
18. Evaluate GMP periodically.	3.4

Section 2
Water Resource Setting

2.1 History and Size

Western Canal Water District (WCWD or District) was formed by a vote of landowners on December 18, 1984 as a California Water District, and currently encompasses a land area of approximately 67,500 acres, of which 58,167 acres are considered irrigable. The District purchased the Western Canal water system from Pacific Gas and Electric Co. (PG&E), who had acquired it from the Great Western Power Company. The canal was originally developed by Western Canal Company, which began operations in 1911.

WCWD's original diversion was located at the Western Canal Company's dam on the Feather River. The Oroville Reservoir Complex displaced the diversion facilities and upstream portion of the Western Canal. The supply is now provided by two outlet structures located on the northwestern edge of the Thermalito Afterbay. The maximum combined outlet flows are 1250 cubic feet per second.

The pre-1914 surface water rights of WCWD comprise 150,000 acre feet of natural flow from the Feather River, subject to reduction during drought and 145,000 acre feet from upstream stored water (North Fork Feather River), not subject to reduction. On May 27, 1969 PG&E entered into an agreement with the California State Department of Water Resources (DWR) providing for the diversion of Feather River water below Oroville Dam. That agreement, which was reauthorized through a new agreement executed in 1986 after the District was formed, spells out the timing and quantity of deliveries by DWR to WCWD.

WCWD also has an adjudicated water right on Butte Creek subject to surplus availability: Paragraph 87 of the 1942 Butte Creek Decree No. 18917 describes the entitlement. Maximum diversion is 9,300 acre feet with the minimum being zero. Typically, between 3,000 and 5,000 acre feet are diverted each year within this right depending on hydrologic conditions.

2.2 Location, Facilities, and Surface Water Hydrology

Physical Information

WCWD is located in the northern Sacramento Valley in Butte and Glenn Counties approximately 75 miles north of Sacramento. Geographically it lies between the Sacramento River on the west and the Feather River on the east; Butte Creek bisects the District from north to south. Figure 2-1 shows the location and boundaries of the District.

The water conveyance system within the District comprises approximately 88 miles of unlined canals. Of this total, 48 miles are either District-owned or on District rights-of-way, and 40 miles are private laterals. The primary canal, known as the Western Main, flows from the Thermalito Afterbay westward to near the Butte-Glenn County border, where it turns southward to State Highway 162. The Western Main intersects four waterways in its east-west route: Cherokee Canal, Little Dry Creek, Butte Creek, and Little Butte Creek. The canal is segregated from the first three of these waterways by means of inverted siphons. District facilities do not include any lined canals or pipelines. There are approximately 40 miles of primary drains within WCWD boundaries and approximately 500 miles of secondary drains. The District does not own or maintain any drains but uses some drains for conveyance, recovery, and operational spill. There are two locations at which tailwater recovery and reuse has been implemented by use of structures installed by the District. In what is known as the O'dell Drain, there is an inverted siphon that carries tailwater to the south under the Western Main. At this point, an elevation control structure allows this water to either be diverted west to conjoin with District water at the drain's terminus with Little Butte Creek, or south to conjoin with District water diverted to the Little Butte Creek Extension. Further south, near State Highway 162, the Little Butte Creek Extension converges with the Main Drain. WCWD installed an elevation control structure at the outfall of the Main Drain to Butte Creek that, in conjunction with screwgates that control the flow to the south, provides head for lift pumps in the upstream reach of the Main Drain and enables the diversion of water to the south into Howard Slough.

The District's delivery/conveyance system is an open flow, gravity system. The District does not own or operate any irrigation wells; individual landowners provide any groundwater used within the District. Many landowners have constructed deep wells at their own expense to provide a conjunctive use capability in the event surface water delivery is curtailed. There are some points of delivery up gradient from District supplies, formerly dependent on groundwater, that now use low-lift pump stations to divert irrigation water; these stations are installed, maintained, and operated at grower expense. Water is supplied on demand to 227 metered turnouts.

Restriction of Water Sources

WCWD's entitlement to 150,000 acre feet of water from the State Water Project can be curtailed based on the amount of unimpaired runoff in the Feather River watershed. This curtailment can total 75,000 acre feet in any one year, and total 150,000 acre feet over any seven years.

When the Department of Water Resources notifies WCWD of a water deficiency and/or in the opinion of the Board of Directors of WCWD there is a water shortage, the available water will be divided on a pro-rata share among District landowners.

The portion of WCWD's entitlement derived from stored water on the North Fork Feather River (145,000 acre feet) is not subject to curtailment.

2.3 Topography and Soils

The topography within WCWD is flat, sloping slightly—approximately 3 feet per mile—from the northeast to the southwest. The soil within the District is made up of basin deposits with some alluvial deposits on the margins of the valley. Basin deposits occur as a mantel of clay, silt and some sand up to a thickness of about 50 feet. Soil profiles are well developed with horizons of hardpan layers in which low permeability restricts downward percolation of applied irrigation water.

Flat topography and low soil permeability within the WCWD service area are conditions conducive to rice production using gravity water conveyance systems. Rice production requires that the crop area remain flooded for approximately four months during the growing season, so low permeability is a desirable characteristic.

Land use within the WCWD service area is approximately 90% rice, 6% wildlife habitat, 3% orchard and 1% row crops and pasture. This land use is a result of two major factors: the suitability of the soil type for the cultivation of certain crops, and the suitability of the soil type for specific irrigation practices.

2.4 Climate

WCWD is located in the northern Sacramento Valley, which has a Mediterranean-type climate with hot summers and cool winters. High temperatures in the summer often climb to over 100° F, and lows in the winter can drop below 32° F. The average rainfall is 20 inches per year but fluctuates significantly from year to year. Less than eight inches of rainfall occurred in 1977 and more than 42 inches of rainfall occurred in 1998.

2.5 Regional Geology

Western Canal Water District is located on the east side of the Sacramento Valley, which is a structural trough oriented northwesterly, bounded on the east by the Sierra Nevada and Cascade Ranges, and on the west by the Coast Range. The older granitic, metamorphic and marine sedimentary rocks of the surrounding mountains dip down into the valley and form the bedrock basement on which younger marine and alluvial sediments were deposited. In the axis of the valley, bedrock is at considerable depth but becomes shallow near the margins.

Immediately overlying the basement rocks are Eocene age marine and continental sedimentary rocks that contain saline or brackish water. Overlying the Eocene rocks is a sequence of continental deposits of post-Eocene age, which contain freshwater; though in deeper portions of the valley brackish to saline water has intruded. Streams flowing into the valley trough from the surrounding mountains laid down the post-Eocene deposits. Included in this assemblage of predominantly sedimentary rocks are volcanic mudflows, lava flows, and volcanic ash deposits of middle to late Tertiary age. The post-Eocene assemblage extends to a depth of 1,400 - 1,600 feet below sea level and fresh water occurs to a depth of about 1,200 feet.

Several post-Eocene formations in the northeast part of the Sacramento Valley are important sources of ground water. They include the Tuscan, Tehama, and Laguna Formations, and younger unnamed overlying alluvial fan, floodplain, and recent stream deposits.

Figure 2-3 (geologic map) shows the areal distribution of the various geologic units in the Western Canal area. Figures 2-4 and 2-5 are diagrammatic cross sections that show the general relationship of the various units in the subsurface. Figure 2-2 provides a legend and description of geologic units.

The Tuscan Formation is an assemblage of Pliocene age volcanic rocks and interstratified volcanic sediments, which blankets the western foothills of the southern Cascade Range. Tuscan rocks extend southwest into the valley where they are overlain by younger alluvial deposits. In the foothills, where the gently sloping surface of the Tuscan is deeply dissected by westerly-flowing streams, exposures along canyon walls show the stratified character of the formation as well as the horizontal and vertical variation in sedimentary structures and grain sizes. Tuscan rocks include tuff-breccia, lapilli tuff, volcanic conglomerate and sandstone, with lesser quantities of tuff claystone and siltstone.

A typical tuff-breccia within the Tuscan is a hard, compact rock of low permeability, consisting of pebble- to boulder-sized clasts imbedded in a matrix of unsorted clay to sand-sized volcanic fragments. Individual beds range from three to 150 feet in thickness. At the surface, these rocks restrict percolation of water into the groundwater basin and in the subsurface they can act as confining beds that restrict the upward or downward movement of water.

Tuff and lapilli beds within the Tuscan are very similar to the tuff-breccias, they differ essentially only in the size of fragments present.

Volcanic conglomerates of the Tuscan typically consist of poorly sorted, sub-angular to sub-rounded, boulder- to pebble-sized clasts in a matrix of coarse-grained sand. Minor amounts of silt and clay may also be present. Conglomerate beds commonly contain thin, lenticular interbeds of sandstone, and often grade into normal sandstone units. However, sharp erosional contacts are also common and conglomerates in cut-and-fill channels attest to the periodic changes between depositional and erosional environments. Tuscan conglomerates are generally friable and lack significant amounts of cementing material, and because of this characteristically weak consolidation are moderately to highly permeable.

Tuscan sandstones vary from coarse- to fine-grained, and from poorly- to well-bedded. Grain size changes or stringers of tuffaceous clay or siltstone often define bedding. The coarser-grained sandstones tend to be quite friable, but at some localities weak cementing due to weathering and clay formation is found. The finer-grained sandstones tend to be moderately- to well-indurated, making them less permeable than the coarser-grained beds. Siltstone and claystone are widely distributed in the Tuscan but do not constitute a large portion of the formation. They typically occur as thin interbeds associated with coarser-grained sediments, or as thin beds up to a few feet in thickness. Most of these finer-grained sediments are typically compact and fairly hard, making them low in permeability as well as porosity.

The Laguna and Tehama Formations are upper Pliocene to lower Pleistocene age fluvial deposits of silt and clay with lenticular zones of sand and gravel which overlie and interfinger with the Tuscan. The Tehama Formation is generally on the west side of the valley and the Tuscan on the east side. In the Western Canal area, these formations are considered nearly contemporaneous in age and probably interfinger beneath the younger alluvium toward the central portion of the valley. The Laguna Formation is about 500 feet thick on the east side of the valley, and together, where the two interfinger mid-valley, probably total about 1,000 feet in thickness. In the area around the Thermalito Afterbay, a patchy veneer of weathered red gravel, identified as the Red Bluff Formation in other studies, has been lumped with the Laguna. These thin Red Bluff remnants generally lie above the saturated zone and are therefore considered unimportant as aquifer materials.

The Laguna and Tehama consist predominantly of sandy, tuffaceous siltstone and claystone with channelized and lenticular interbeds of sandstone and conglomerate. The finer-grained beds are generally well consolidated with low permeability, but the coarser beds can provide large quantities of groundwater to wells. In the subsurface, materials reported as "cemented" or "sandstone" are assumed to be Laguna or Tehama.

Older Alluvial Deposits include an assemblage of Pleistocene age stream terrace and alluvial fan deposits which form the low dissected hills on the east side of the valley from about Thermalito south. These deposits directly overlie the Laguna Formation and underlie the younger basin deposits as far west as Butte Creek. The thickness of these deposits is uncertain, but judging from well logs they may range from zero to 250 feet.

These deposits include geologic units identified as the Victor, Modesto, and Riverbank Formations by other studies. These deposits vary from unconsolidated to cemented, with some hardpan layers. Permeabilities range from low, especially with localized reduction of vertical permeability by hardpan, to high where coarser or unconsolidated materials predominate.

Younger Alluvial Deposits include alluvial fans, stream channel deposits, floodplain, and flood basin deposits. These are the most recently deposited materials and represent important ground water sources. Alluvial fans occur on the margins of the valley as wedges of coarse material that fine toward the valley and interfinger with or merge into the floodplain and basin areas. Stream channel and floodplain deposits are the materials deposited adjacent to major rivers or streams. In the Western Canal area, these include the Sacramento River and Butte Creek. Flood basin deposits are the finest materials, deposited as a thin mantel by receding floodwater in low-lying valley areas.

Alluvial fan deposits consist of heterogeneous mixtures of cobbles, gravel, sand, silt and clay. These deposits are unconsolidated and permeability is highly variable. Alluvial fan deposits are important in this area as recharge zones at the valley margins.

Basin deposits occupy the central portion of the Western Canal area as a mantel of clay, silt, and some sand up to a thickness of about 50 feet. Older basin deposits have a well-developed hardpan layer that severely restricts the downward percolation of precipitation and applied irrigation water. A few younger basin deposits occur as discontinuous stringers of sand, silt and clay deposited by the Sacramento River in historic flooding. The Basin deposits are thin and of low permeability and therefore unimportant for groundwater development.

Stream channel deposits occupy the active channel of the Sacramento River, and portions of Butte Creek where it is not channeled by levees. Floodplain deposits flank the active channels and represent overbank deposits and the lateral shifting of bank and channel deposits as these streams meander across their floodplains. These highly permeable sand and gravel deposits constitute the youngest geologic unit. Despite their high permeability, these deposits are of limited importance except in development of water wells near the stream courses.

Tailings consist of boulder and cobble debris from mining and dredging operations. They are found along the channels and floodplains of Dry Creek, Butte Creek and the Feather River. These deposits are relatively thin and of limited areal extent, so they are of limited importance for ground water.

2.6 Hydrogeology

Aquifer Characteristics

The discontinuous nature of the alluvial deposition in the Western Canal area makes correlation of aquifers from well to well difficult. As streams coursed north to south and east to west through time, new channels were created and abandoned, forming a complex system of now-buried channels. The extent of each geologic formation in the subsurface is also difficult to determine due to the lack of distinctive beds with which to correlate surface geology. The only easily identifiable, distinctive subsurface materials are volcanic sands and gravels, and lavas.

Occurrence of Groundwater

Water level measurements show that groundwater occurs in two general zones in the area. Aquifer tests show that leakance between the two zones does occur, but confining beds significantly limit hydrologic continuity between the two zones. Levels measured in shallow wells, completed only in the unconfined, free water zone, and in deep wells, completed in lower confined to semi-confined zones, fluctuated independently of one another. (Measurements taken in the DWR 1990 Western Canal Groundwater Test Program)

Groundwater Movement

The direction of groundwater movement may be determined by measuring water levels in wells and calculating variations in elevation from point to point. Since groundwater movement is influenced by gravity, direction of movement is at right angles to elevation contours from higher to lower elevations. Where contour lines are closer together, the gradient is steeper and flow is faster, although the total quantity of flow for the same cross-sectional area may not be greater. The contour map based on Spring 1997 measurements (Figure 2-6) represents the groundwater gradient in the Sacramento Valley Basin, and shows the direction of groundwater movement within the Basin.

Groundwater in Storage

Groundwater levels fluctuate annually in response to natural discharge and pumping and to recharge from stream percolation, infiltration of rainfall, and applied irrigation water. Levels are usually highest in the spring and lowest in the fall. Figure 2-7 is a groundwater contour map showing the change in groundwater levels based on measurements taken in Spring and Summer 1997 in the groundwater basin overlain by the District. The greatest changes occurred in two areas: where land use is primarily orchard irrigated by groundwater, and in the Chico urban area, which is supplied by groundwater. Orchards are located within the District in the southwestern and northern sectors, and near the District to the east.

Long-term fluctuations occur when recharge either exceeds discharge or is less than discharge. The hydrographs of two wells (Figure 2-8) illustrate the long-term fluctuations in deep irrigation wells within the District service area from 1994 through 2004. They show normal fluctuation from seasonal use and periods of drought and high precipitation. There is no evidence of long-term change in groundwater levels at either of these wells.

The annual spring-to-spring change in groundwater in storage for the Sacramento Valley portion of Butte County has been calculated by DWR over a twenty-year period from 1980 to 2000. DWR described the calculation of changes in spring-to-spring storage in the *Butte County Groundwater Inventory Analysis* (DWR, 2000). "The annual spring-to-spring change in groundwater in storage for the Sacramento Valley portion of Butte County was calculated over a twenty-year period from 1980 to 2000. The spring-to-spring change in groundwater storage was calculated using groundwater contour maps developed from spring groundwater level measurements in the upper portion of the aquifer. Digital three-dimensional surfaces were constructed for each groundwater elevation contour map and the volume differences between consecutive spring to spring groundwater elevation surfaces were calculated."

The spring-to-spring graphs start with a baseline of zero for the spring of 1980. Similar to the 1997 water year, basin-wide groundwater levels during the spring of 1980 closely characterize groundwater conditions associated with a normal water year. At any specific location, the actual changes in groundwater level and the associated groundwater in storage could vary significantly from the average conditions depicted. This research shows that there has not been a significant *net* change in groundwater in storage over the 20-year period. However, there have been significant changes in stored groundwater during periods of drought. The groundwater storage trend indicates that there was slightly more groundwater in storage preceding the 1987-1994 drought compared to 1980. Between 1987 and 1988, groundwater storage was reduced by approximately 100,000 acre feet. The observed decrease in groundwater in storage continued until 1995, when the basin recovered relatively rapidly, with an increase of approximately 100,000 acre feet in groundwater storage between 1994 and 1995.

Groundwater Quality
Recent monitoring of groundwater quality in the Sacramento Valley Basin conducted by the Department of Water Resources indicates that the basin is a high-quality freshwater basin that is free of saline intrusion and contains low concentrations of total dissolved solids.

Land Subsidence
Inelastic land subsidence occurs when the ground surface is permanently lowered from compaction of geologic materials as a result of groundwater extraction. Subsidence generally occurs in fine-grained geologic materials and may result in damage to infrastructure such as canals, levees, bridges, and wells. To date, no subsidence has been observed or recorded within the District.

2.7 Groundwater Well Infrastructure

Inventory
There are 185 groundwater wells within Western Canal Water District. These wells are classified by purpose as irrigation, domestic, municipal, or monitoring, and have been inventoried as follows:

Well Type	No. of Wells
Irrigation	130
Domestic	47
Municipal	1
Monitoring	7
Total	**185**

As of August 1, 2005, construction of eight additional dedicated monitoring wells within the District was scheduled to begin as a result of funding under AB 303. Construction of these wells should be completed by October 2005.

Well Yields
The *Butte County Groundwater Inventory Analysis* (DWR 2000) reports that well yields are similar throughout the basin area overlain by the District, averaging between 980 and 1,000 gallons per minute.

2.8 Water Demand and Demand Forecast

Most of the irrigation wells located in the District are in place for either supplemental water supply use during periods of surface water curtailment, or for future conjunctive use projects. Of the District's 58,167 irrigable acres, only about 2,120 acres are irrigated with groundwater under normal circumstances. Based on the District-wide per-acre use of applied water, this equates to a demand of approximately 10,600 acre feet per year. Domestic use is estimated to be no more than 50 acre feet per year, for a total annual demand of approximately 10,650 acre feet. The lone municipal well within the District is not currently in use. This level of groundwater demand will remain constant for the foreseeable future unless or until a conjunctive use project is implemented.

Section 3
Plan Implementation

Western Canal Water District has for many years been performing many of the groundwater management activities detailed in both its original 1995 GMP and in this revised 2005 version of the Plan. Implementation of the revised Plan will enable the District to formalize its current and planned future activities and to meet its groundwater management objectives.

3.1 Groundwater Management Objectives

The goal of groundwater management is to provide long-term sustainability of the resource through planned and coordinated monitoring, operation, and administration of a groundwater basin or portion of a groundwater basin. To reach this goal, the following management objectives are included in the Western Canal Water District Groundwater Management Plan:

- Minimize the long-term drawdown of groundwater levels.
- Protect groundwater quality.
- Prevent inelastic land surface subsidence resulting from groundwater pumping.
- Minimize changes to surface water flows and quality that directly affect groundwater levels or quality.
- Minimize the effect of groundwater pumping on surface water flows and quality.
- Facilitate groundwater replenishment and cooperative management projects.

District lands lie within two counties, Butte and Glenn, and are subject to local laws, regulations, and ordinances as established by these counties. On February 15, 2000 the Glenn County Board of Supervisors adopted Ordinance No. 1115, Groundwater Management, and integrated it into the County Code. On February 10, 2004 the Butte County Board of Supervisors approved a groundwater management ordinance, amending Chapter 33A of the County Code. Both of these ordinances call for the establishment of Basin Management Objectives (BMOs) to ensure that groundwater levels, groundwater quality, and land subsidence remain within acceptable established parameters. Integration of BMOs into this Plan will be discussed in a later section.

3.2 GMP Components

As discussed in Section 1.5 and shown in Table 1-1, a number of mandatory, recommended, and voluntary components are to be implemented within the framework of this Plan. These components have been grouped into, and are discussed in, five sections:

Groundwater Monitoring, Groundwater Resource Protection, Groundwater Sustainability, Facilitating Conjunctive Use, and Cooperating With Other Basin Agencies.

3.2.1 Groundwater Monitoring

The District, in cooperation with other local agencies, is participating in groundwater monitoring to provide information to determine current conditions, assess long-term trends, and to support the development and implementation of Basin Management Objectives associated with groundwater levels, water quality, and inelastic land subsidence.

Groundwater levels

The District has developed a regular program of monitoring groundwater levels within the District, and has acquired the appropriately trained staff personnel to conduct this program. An inventory of wells located throughout the District has been developed and refined for the purpose of monitoring groundwater levels. This inventory currently consists of 18 wells that are sounded on a monthly basis, access permitting, and the groundwater levels recorded and stored in a database at District headquarters. This program was implemented in 1994. All of the wells in this program are identified in accordance with the State Well Numbering System, and listed with the specific ground surface elevation above mean sea level at the well site.

In addition, the District has cooperated with DWR Northern District, Butte County, and Glenn County in the placement and installation of dedicated monitoring wells within District boundaries and on nearby lands. There are currently seven of these wells within the District, and three nearby, from which groundwater levels are obtained, either manually at least 4 times per year, or electronically on a continuous basis.

Eight more dedicated monitoring wells are scheduled for completion in September 2005 within the District, the construction of which are being funded through an AB 303 grant. These wells will be fitted with pressure transducers and electronic dataloggers to continuously record water levels in specific water-bearing zones. The information will be downloaded and stored as a part of DWR Northern District's ongoing monitoring program.

Within the Glenn County portion of the District, two production wells that are included in the District's monitoring program are also designated wells for Glenn County's BMO ordinance. The groundwater elevations in these wells are reported twice annually to the Glenn County Technical Advisory Committee for inclusion in the County's management process.

Groundwater Quality

The District is authorized to take reasonable and feasible steps to ensure against saline water intrusion within the groundwater basin managed by the District. There are currently no known sources of saline water intrusion within the District; however, saline water has been located in areas south of the District boundaries, principally in the area known as the

Butte Sink. The District cooperates with Butte County in a program of groundwater quality testing and monitoring that has established baseline quality criteria for groundwater generally available from within the District, including saline content, and routinely tests on a periodic basis for water quality in order to determine whether or not baseline qualities are being affected and/or deteriorating as a result of saline water intrusion and/or intrusion of other components adverse to the use of such groundwater for irrigation practices within the District.

The District recognizes the Butte County standard of 2,500 parts per million of total dissolved solids as the maximum contaminate level for action to abandon a well or make appropriate corrections.

Annual groundwater quality sampling is conducted at two locations within the District by staff from the Butte County Department of Water and Resource Conservation. These samples are tested for temperature, total dissolved solids, electrical conductivity, and pH. No problems have been detected, nor have any significant changes occurred since sampling was initiated. The District and/or other local agencies will undertake more widespread sampling if problems or significant changes become apparent.

Inelastic Land Subsidence

Land subsidence has not occurred within the District, or upon adjoining lands. At present there is one dedicated monitoring well in the District that is equipped with an extensometer, and several others on adjoining lands. Recent extensometer measurements indicate subsidence is not occurring within the groundwater basin. The District will continue to monitor results of the currently installed extensometers within the Basin, and to cooperate with local agencies in future monitoring and prevention efforts.

3.2.2 Groundwater Resource Protection

The District is committed to cooperating with local agencies and local governments in the various programs and ordinances designed to promote the protection of groundwater resources in the Sacramento Valley Groundwater Basin. These elements of basin groundwater management are discussed in the following subsections.

Well Ordinances

The California Water Code (§13700-13806) requires proper construction of wells, and minimum standards for the construction of wells are specified in DWR Bulletins 74-81 and 74-90. Chapter 23B of the Butte County General Ordinances enforces these minimum standards for the construction of wells, and provides procedures for well spacing of new wells to reduce potential well interference problems. For District lands within Glenn County, similar requirements are in place. The District supports compliance with these standards in both the legal sense and in principal, and will make every effort to ensure compliance within the District.

Establishment of Basin Management Objectives

Western Canal Water District lies within two counties, Butte and Glenn. Both counties have adopted groundwater management ordinances that call for the establishment of

Basin Management Objectives. These objectives establish generally acceptable parameters in regard to groundwater levels, groundwater quality, and inelastic land subsidence.

It is the purpose of this Plan to incorporate and implement the BMO method of groundwater management within the boundaries of the District. Glenn County Ordinance 1115 facilitated the establishment of acceptable groundwater level fluctuations in representative wells throughout the basin area of the County. Two of these wells are within District boundaries, and are hereby incorporated by the District into the management of the groundwater basin that lies within Glenn County and is overlain by the District. Butte County's amendment to Chapter 33A is more recent, and the establishment of BMOs in response to this amendment is ongoing. Western Canal Water District has been identified as one of the sub-areas in the County's basin area that will have designated wells with established acceptable parameters for groundwater fluctuation. These BMOs, after being accepted by the County, will be incorporated by the District into the management of the groundwater basin that lies within Butte County and is overlain by the District.

3.2.3 Groundwater Sustainability

Elements crucial to groundwater sustainability within the basin overlain by the District include monitoring groundwater extraction through the implementation of BMOs, providing water for recharge of the groundwater basin, and mitigating for conditions of overdraft should they occur.

Monitoring Groundwater Extraction
The District will employ two methods to monitor groundwater extraction within its boundaries. As discussed in Section 3.2.1, the District has an inventory of wells that are included in a systematic monitoring program whereby groundwater levels are measured regularly throughout the year. DWR and Butte and Glenn Counties have dedicated monitoring wells both within and adjacent to the District that similarly provide groundwater level data throughout the year. This data will clearly indicate if the volume of groundwater extraction changes significantly, or if the available supply of groundwater has decreased due to climatic conditions. The establishment and maintenance of BMOs within the District will provide this same information.

The second method to track groundwater extraction will be a land use inventory. District staff closely monitors land use within the District, and an inventory of such use is updated at least twice a year. Under normal circumstances, there is a direct correlation between land use and groundwater extraction within the District.

Replenishment of Groundwater
The District will continue to encourage, through the Butte Basin Water Users Association, the development of data with respect to the methods by which groundwater available within the District is being replenished and the District, under all circumstances,

shall maintain an active program for the protection and use of its surface water rights within the District in order to ensure that water is available for replenishment of the groundwater supply as well as to limit the amount of groundwater needed for the production of crops within the District.

Mitigation of Conditions of Overdraft

Implementation of this portion of the GMP will be dependent on two separate management tools—groundwater modeling and the establishment of basin management objectives. The former are discussed in the previous section (3.2.2) and, as elements of local government code, will be a part of this Plan's efforts to prevent and mitigate conditions of overdraft, should they occur.

The Butte Basin Groundwater Model, developed cooperatively through the Butte Basin Water Users Association (BBWUA) by their consulting engineers, Hydrological Consultants Incorporated (HCI), has confirmed that there presently is no overdraft occurring within the Western Canal Water District. However, the model identifies locations within the basin where groundwater overdraft conditions are occurring such as Durham, Honcut, and north of Chico.

Western Canal Water District, in cooperation with BBWUA, has continued to monitor and update the model, with the last update being provided in 2002. Butte County's Department of Water and Resource Conservation is undertaking the latest update of the Butte Basin Groundwater Model, which includes the conversion from the current code to IGSM II. This conversion will develop consistency with groundwater flow models in neighboring areas such as the Stony Creek groundwater model that includes portions of Tehema, Glenn, and Colusa Counties. This will provide the capability to link these models for future development of regional groundwater management.

The relationship between groundwater extractions within the District and impacts on groundwater in other parts of the basin will be subject to continued monitoring and analysis; particularly extractions that are a component of any project to export water outside the boundaries of the District. Data gathered to date indicates there has been no impact from District extractions on the overdrafted areas identified above. The District is a member of the Butte Basin Water Users Association and has in the past, and will in the future, coordinate its activities and groundwater management programs with those being conducted throughout the Sacramento Valley Groundwater Basin.

The factors to be considered annually by the Board of Directors of the District in developing, maintaining, and updating its basin management objectives and the groundwater model will include the following:

1. Determining and maintaining a safe annual yield of groundwater for use within the District in order to supplement available surface water supplies for the growing of crops on lands within Western Canal Water District without producing conditions of overdraft. As the quantification of safe

yield is difficult or impossible to achieve, BMOs will be key to this process.

2. Identifying and monitoring the relationship between groundwater extractions within the District and impacts on groundwater supplies within the District and within neighboring areas that may be affected.

3. Developing data and information which identify any impacts on groundwater within neighboring areas that might be affected by groundwater use within the District to support transfers of District surface water supplies as part of a conjunctive use program developed in cooperation with the State of California Department of Water Resources or other potential water transferees.

4. Establish mitigation measures to offset identified adverse impacts of groundwater extraction on wells within and without the District.

5. Establish quantitative limitations on groundwater extractions from particular areas and establishing criteria for well spacing and operations within the District to limit adverse impacts of groundwater extractions on wells within and without the District. Again, BMOs will be key to establishing limits on extraction, and local ordinances will be followed for well spacing and operations. Should local guidelines prove inadequate, the District will define further restrictions to groundwater extraction to prevent adverse impacts within the basin.

3.2.4 Facilitating Conjunctive Use

The District occupies a unique position in connection with the development of a groundwater management plan in that it utilizes surface water available from the State Water Project facilities at the Thermalito Afterbay, and also, through individual operations of its landowners, a substantial groundwater production system through privately-owned deep wells. The interrelationship of these two systems permits the District to develop, regulate, and facilitate conjunctive use of its surface and groundwater supplies in order to provide optimal water supplies available within the District as well as to provide for reduction in its diversion of its surface water supplies in times of need for water in other areas.

Under the District's Bylaws, the District may enter into agreements with landowners within the District requiring the landowners to utilize their deep well facilities in order to augment surface water supplies to the District and/or to alleviate shortages caused by lack of water and/or failure of facilities delivering water within the District. Landowners facing water shortages in the event they have exceeded their pro rata supply would first be encouraged to enter into private agreements with other landowners for the use of well water. If supplies are needed for District purposes, the District reserves its right to require use of groundwater in those circumstances where the water shortages and/or failure or inadequate capacity of facilities causes shortages throughout a water area of the District, upon payment of compensation. The terms and conditions of any reimbursement of landowners for use of deep wells would be a subject of negotiations between landowners and/or between the District and the landowners offering such deep well facilities.

The District has also engaged in and will continue to reserve the operational flexibility to engage in transfers of its surface water to the State of California and/or other qualified purchasers of water in circumstances where shortages of water cause potential for hardship in other areas of the state which have access to state or federal water project facilities. Prior to undertaking any program, the District will evaluate any adverse economic or environmental impact of such program. In this way, the deep well capacity of the District can be used in a conjunctive manner with surface water supplies in order to assist other areas in need of water in addition to the landowners within the District and to the benefit of the District and its landowners, as long as such programs do not: (1) exceed the safe annual yield of the aquifer; (2) result in conditions of overdraft, and; (3) result in uncompensated adverse impacts on neighboring landowners affected by the program.

In connection with conjunctive use programs, the District reserves the following authority and jurisdiction in connection with the operation of privately owned deep wells:

1. The District, upon order of the General Manager, may at any time order a discontinuance of deep well operations in the event such wells are being utilized for conjunctive use purposes either through outside-District water transfers or transfers within the District. The terminations in this regard will be based on its evaluation of impacts in adjoining areas and whether those impacts can be feasibly and reasonably mitigated.

2. The District will require that all wells, which engage in any conjunctive use operation, be metered and that such meters be regularly and thoroughly maintained by the District to ensure accuracy.

3. The District reserves the right at all times to go upon the premises of the landowner in order to inspect deep well operations and meter accuracy.

4. The District will limit production of groundwater in connection with any conjunctive use program to groundwater replacing surface water otherwise used in connection with the landholdings upon which the deep well facilities are located if it is established that additional production will adversely affect neighboring wells and landowners.

5. The District will take all other necessary and appropriate action as may be determined appropriate by the Board of Directors of the District in accordance with the provisions of Sections 35408 and 35409 of Water Code of the State of California, which provides as follows:

A district may commence, maintain, intervene in, compromise and assume the costs of any action or proceeding involving or affecting the ownership or use of waters or water rights within the district or a benefit to any land.

A district may commence, maintain, intervene in, defend and compromise actions and proceedings to prevent interference with or diminution of the natural flow of any stream or natural subterranean supply of waters which may:

(a) Be used or be useful for any purpose of the district;

(b) Be of common benefit to the land or its inhabitants; or

(c) Endanger the inhabitants or land.

3.2.5 Cooperation With Other Basin Agencies

The District is a member of the Butte Basin Water Users Association and, through such association, and independently, the District will maintain a close liaison and cooperation with California Department of Water Resources, as well as appropriate State and Federal Agencies who have jurisdiction over or interest in the groundwater resources available within the District and within the Butte Basin Water Users Association area of interest. Included within these programs will be exchange of data, development of monitoring and testing programs, cooperative work on studies such as the Butte Basin Groundwater Model, and contributions of labor, expertise, and sharing of expenses in order to ensure a cooperative development of the optimal resource and database available to the District.

District shall also, as part of its membership within the Association of California Water Agencies, and the Northern California Water Association, and other pertinent State and Federal advocacy and representation groups, participate in legislative and administrative regulatory programs which would facilitate the study and protection of groundwater resources available within the District. The District will cooperate with Glenn and Colusa counties, as well as all neighboring districts in administration of its groundwater management plan.

Members of District staff have served or are currently serving as appointees to the Glenn County Technical Advisory Committee and Water Advisory Committee for Groundwater Management, and the Butte County Water Advisory Committee for Groundwater Management. The District assists and cooperates with DWR and Glenn and Butte Counties in established programs of groundwater monitoring for quality, levels, and subsidence, and is continuing to expand these efforts with the cooperative installation of additional monitoring facilities within the District.

As a member of the Butte Basin Water Users Association, the District is a cooperative partner in groundwater management with other Association members: Biggs-West Gridley Water District, Richvale Irrigation District, Butte Water District, County of

Glenn, County of Butte, California Water Service Company, City of Biggs, City of Gridley, and Durham Mutual Water Company.

3.3 Evaluating GMP Implementation

District staff will provide an annual report to the Board of Directors summarizing the previous year's activities in regard to the components of this Plan: groundwater monitoring, resource protection, sustainability, facilitating conjunctive use, and cooperation with other basin agencies.

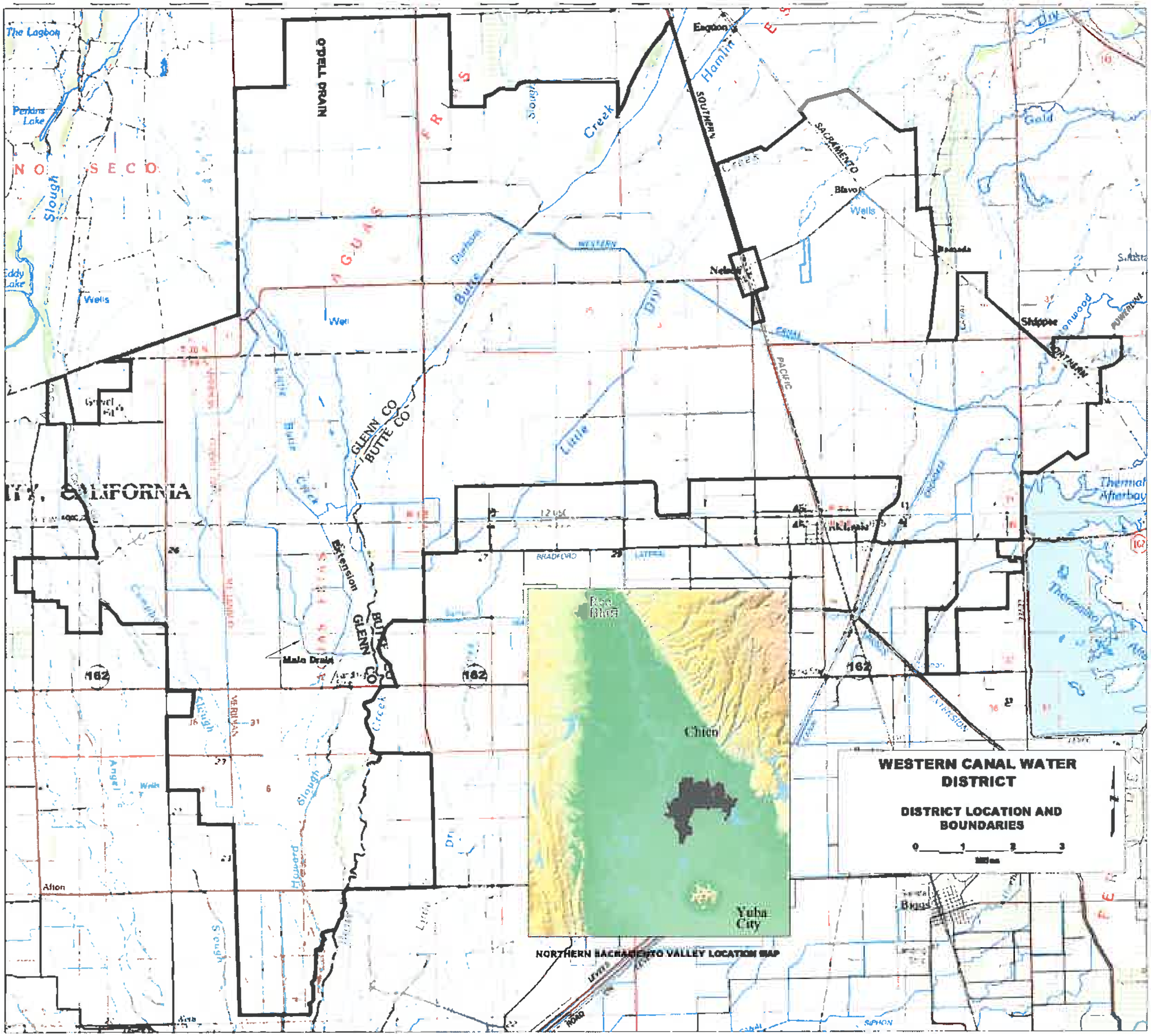
As a component of any groundwater export project, a mitigation plan will be developed to provide details for monitoring systems and impact or interference analysis, which will provide the basis for mitigation of any adverse impacts.

3.4 GMP Update

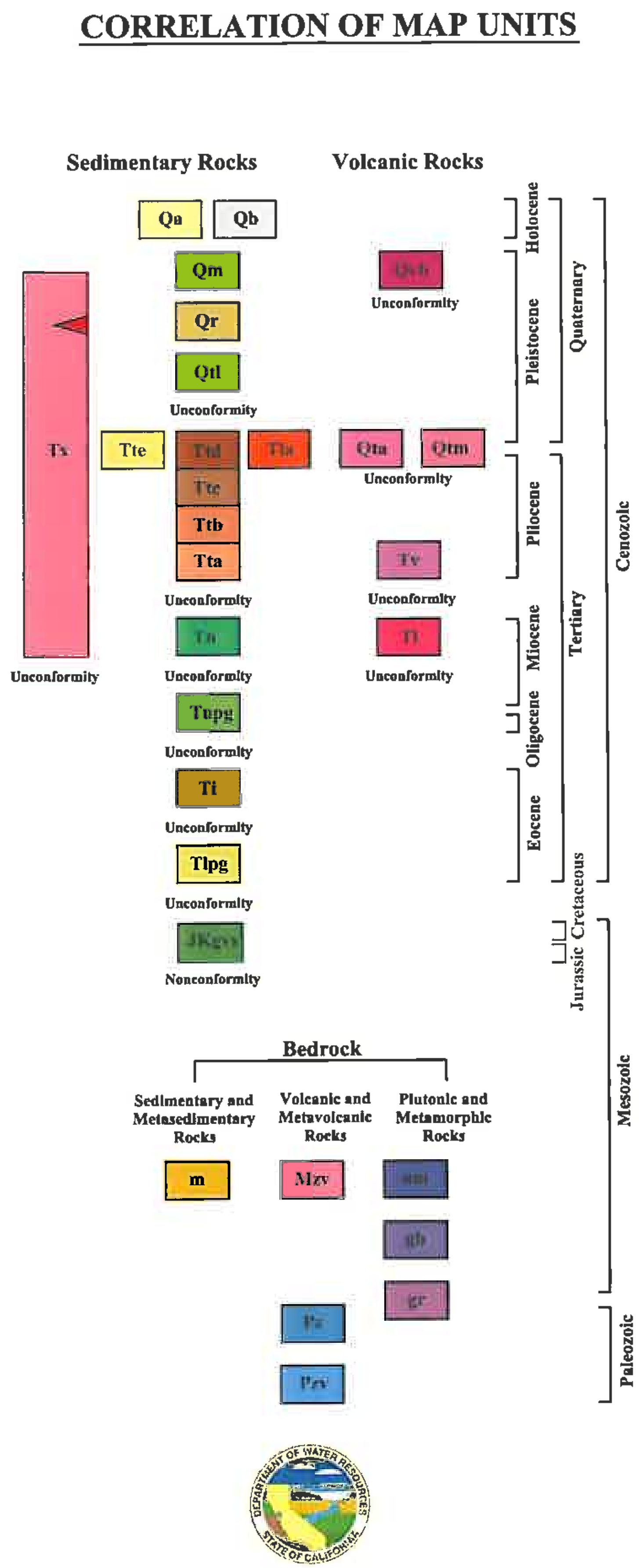
Following the annual report by District staff to the Board of Directors, staff will provide any recommendations for change or modifications to the GMP. The Board will review the Plan and all pertinent information provided by staff, and direct updates or modifications deemed appropriate. Modification of the Plan will occur only after a noticed hearing and re-adoption.

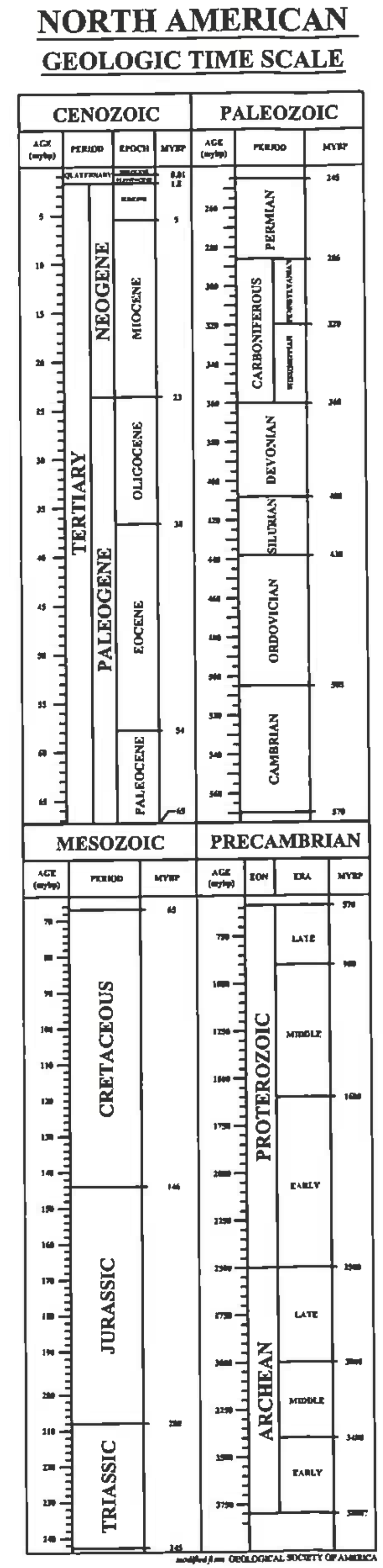
Figures

Figures appear in the following order:



WESTERN CANAL WATER DISTRICT
DISTRICT LOCATION AND BOUNDARIES
0 1 2 3
Miles
NORTHERN SACRAMENTO VALLEY LOCATION MAP
Red Bluff
Chico
Yuba City
O'DELL DRAIN
GLENN CO
BUTTE CO
Extension
Main Drain
SOUTHERN
PACIFIC
SACRAMENTO
Nelson
Biggs
Afton
Shippee
Esquon
Hamlin
Creek
Little Butte Creek
Dry
Slough
Wells
The Lagoon
Perkins Lake
Eddy Lake
Thermalito Afterbay
162





DESCRIPTION OF MAP UNITS

Qa — **Alluvium** (Holocene)-Includes surficial alluvium and stream channel deposits of unweathered gravel, sand and silt, maximum thickness 80 ft. *(adapted from Helley & Harwood, 1985)*.

Qb — **Basin Deposits** (Holocene)-Fine-grained silt and clay derived from adjacent mountain ranges, maximum thickness up to 200 ft. *(adapted from Helley & Harwood, 1985)*.

Qm — **Modesto Formation**, undifferentiated (Pleistocene)-Alluvial fan and terrace deposits consisting of unconsolidated weathered and unweathered gravel, sand, silt and clay; maximum thickness approximately 200 ft. *(adapted from Helley & Harwood , 1985).*

Qr — **Riverbank Formation**, undifferentiated (Pleistocene)-Alluvial fan and terrace deposits consisting of unconsolidated to semi-consolidated gravel, sand and silt; maximum thickness approximately 200 ft. *(adapted from Helley & Harwood, 1985).*

Qtl — **Turlock Lake** (Pleistocene)-Weathered and dissected arkosic gravels with minor amounts of resistant metamorphic rock fragments and quartz pebbles, sand and silt; maximum thickness approximately 100 ft. *(adapted from Helley & Harwood, 1985).*

Qvb — **Volcanic Basalts**, undifferentiated (Pleistocene)-Younger basalt flows found primarily on the east side of the Sacramento Valley, includes minor exposures of andesite; maximum thickness 100 ft. *(adapted from Helley & Harwood, 1985).*

Qtm — **Tuff Breccia** (Plio-Pleistocene)-Tuff breccia forming outer ring surrounding the Sutter Buttes *(adapted from Helley & Harwood, 1985)*.

Qta — **Volcanic Andesites**, undifferentiated (Plio-Pleistocene)-Younger andesites forming the center of the Sutter Buttes *(adapted from Helley & Harwood, 1985).*

Tte — **Tehama Formation** (Plio-Pleistocene)-Includes Red Bluff Formation on west side. Pale green, gray and tan sandstone and siltstone with lenses of pebble and cobble conglomerate; maximum thickness 2,000 ft. *(adapted from Helley & Harwood, 1985).*

Ttd — **Tuscan Unit D** (Plio-Pleistocene)-Fragmental flow deposits characterized by monolithic masses containing gray hornblende and basaltic andesites and black pumice, maximum thickness 160 ft. *(adapted from Helley & Harwood, 1985).*

Ttc — **Tuscan Unit C** (Plio-Pleistocene)-Includes Red Bluff Formation on east side. Volcanic lahars with some interbedded volcanic conglomerate and sandstone, and reworked sediments; maximum thickness 600 ft. *(adapted from Helley & Harwood, 1985, DWR Bulletin 118-7, 2001, draft report).*

Ttb — **Tuscan Unit B** (Pliocene)-Layered, interbedded lahars, volcanic conglomerate, volcanic sandstone and siltstone; maximum thickness 600 ft. *(adapted from Helley and Harwood, 1985; DWR Bulletin 118-7, 2001, draft report).*

Tta — **Tuscan Unit A** (Pliocene)-Interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone containing metamorphic rock fragments; maximum thickness 400 ft. *(adapted from Helley & Harwood, 1985; DWR Bulletin 118-7 (in progress), 2001).*

Tla — **Laguna Formation** (Pliocene)-Interbedded alluvial gravel, sand and silt; maximum thickness 450 feet. *(adapted from Helley & Harwood, 1985; Olmsted and Davis, 1961; DWR Bulletin 118-6, 1978).*

Tv — **Basalts and Andesites**, undifferentiated (Pliocene)-Older basalts and andesites found on the northeastern portion of the Sacramento Valley and southwest of Winters; maximum thickness up to 230 ft. *(adapted from Helley & Harwood, 1985).*

Ts — **Sutter Formation** (Late Miocene to Early Pleistocene)-Volcanic fluvatile sediments with lacustrine deposits; maximum thickness approximately 1,800 ft. *(adapted from Garrison, 1962).*

Tn — **Neroly Formation** (Miocene)-Marine to non-marine sediments, tuffaceous andesitic sandstone with interbeds of tuff and tuffaceous shales and occasional conglomerate lenses; max. thickness 500 ft. *(adapted from Redwine, 1972; Wagner and Saucedo, 1990).*

Tl — **Lovejoy Basalt** (Miocene)-Black, dense, hard microcrystalline basalt; maximum thickness 65 ft. *(adapted from Helley & Harwood, 1985).*

Tupg — **Upper Princeton Gorge** (Late Oligocene to Early Miocene)-Non-marine sediments composed of sandstone with interbeds of mudstone and occasional conglomerate and conglomerate sandstone; maximum thickness 1,400 ft. *(adapted from Redwine, 1972).*

Ti — **Ione Formation** (Eocene)-Marine to non-marine deltaic sediments, light colored, commonly white conglomerate, sandstone and siltstone, which is soft and easily eroded; max. thickness 650 ft. *(adapted from DWR Bulletin 118-6, 1978; Creely, 1965).*

Tlpg — **Lower Princeton Gorge** (Eocene)-includes Capay Formation. Marine sandstone, conglomerate and interbedded silty shale, maximum thickness 2,400 ft. *(adapted from Redwine, 1972)*

JKgvs — **Great Valley Sequence** (Late Jurassic to Upper Cretaceous)-Marine clastic sedimentary rock consisting of siltstone, shale, sandstone and conglomerate; maximum thickness 15,000 ft.

m — **Mixed Rocks** (pre-Cenozoic)-Undivided metasedimentary and metavolcanic rocks of greatly varying types *(adapted from Jennings, 1977).*

Mzv — **Volcanic and Metavolcanic Rocks** (Mesozoic)-Undivided volcanic and metavolcanic rocks, andesite rhyolite flow rocks, greenstone and volcanic breccia *(adapted from Jennings, 1977).*

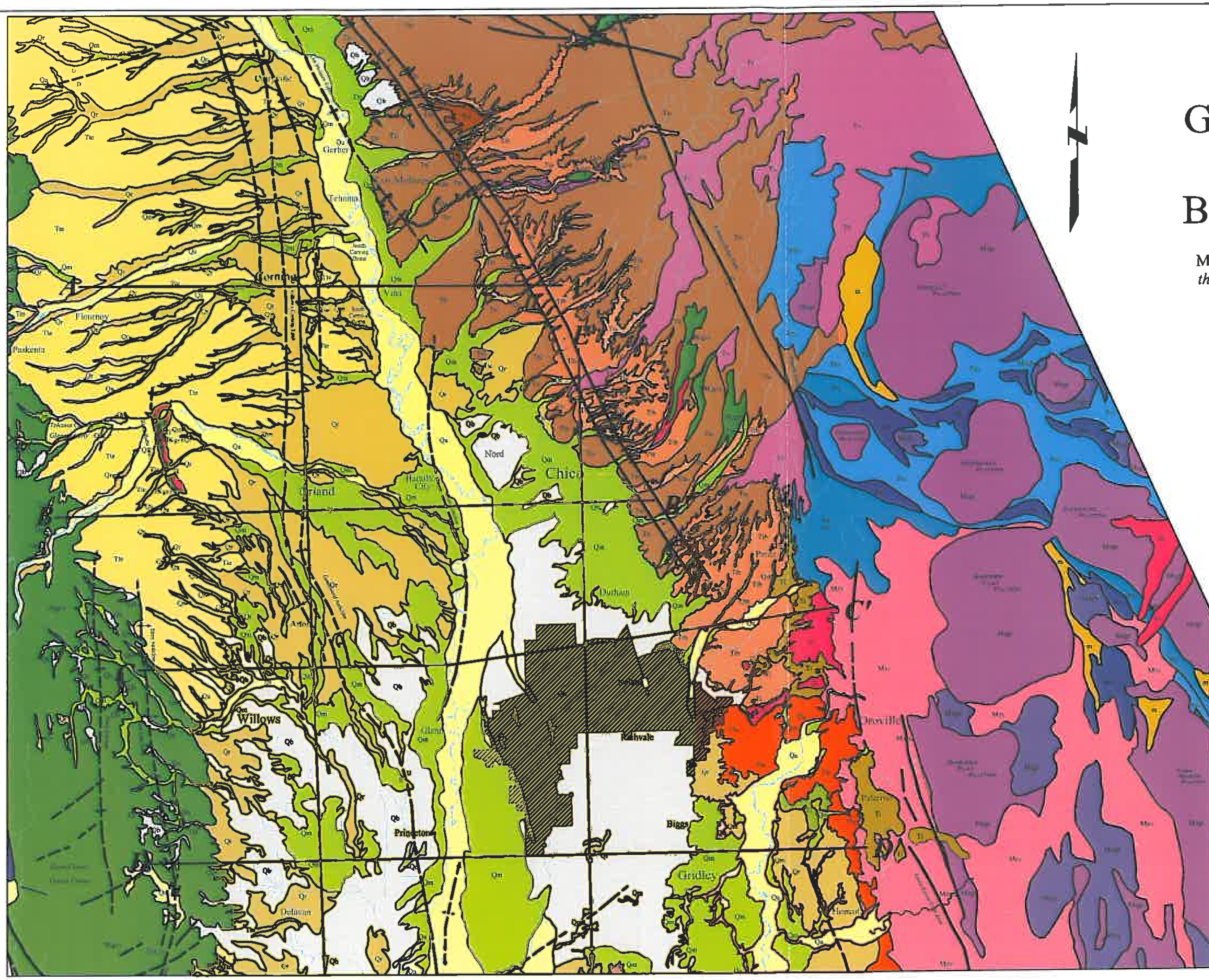
um — **Ultramafic Rocks** (Mesozoic)-Primarily composed of serpentine, with peridotite, gabbro and diabase *(adapted from Jennings, 1977).*

gb — **Gabbro** (Mesozoic)-Gabbro and dark diotric rocks *(adapted from Jennings, 1977).*

gr — **Undifferentiated Granitic Plutons** (Mesozoic-Paleozoic)-Undivided granitic plutons and related rocks *(adapted from Jennings, 1977).*

Pz — **Paleozoic Metasedimentary Rocks** (Paleozoic)-Undivided metasedimentary rocks including slate, shale, sandstone, chert, conglomerate, limestone, dolomite, marble, phyllite,schist, hornfels and quartzite *(adapted from Jennings, 1977).*

Pzv — **Paleozoic Metavolcanic Rocks** (Paleozoic)-Undivided metavolcanic rocks, primarily flows, breccia, and tuff, including greenstone, diabase and pillow lavas *(adapted from Jennings, 1977).*



GEOLOGIC MAP OF BUTTE COUNTY

Modified from - *Geology and Hydrogeology of the Freshwater Bearing Aquifer Systems of the Northern Sacramento Valley, California, California Department of Water Resources, Bulletin 118-7, 2001.*

Map Legend

Fault - dashed where location is approximate; U indicates upthrown side and D indicates downthrown side.

Anticline - Arrows indicate direction of dip.

Syncline - Arrows indicate direction of dip.

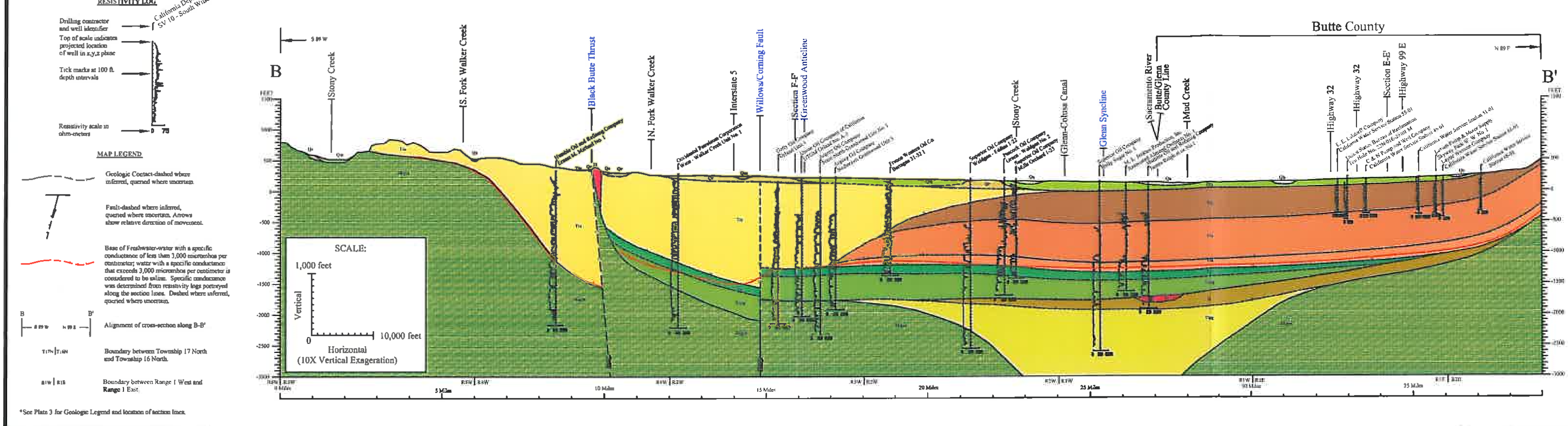
Monocline - Arrows indicate direction of dip, number indicates steepness of dip in degrees.

Location of Geologic Cross-Sections - Letters correspond to geologic sections shown in Plates 4 and 5.

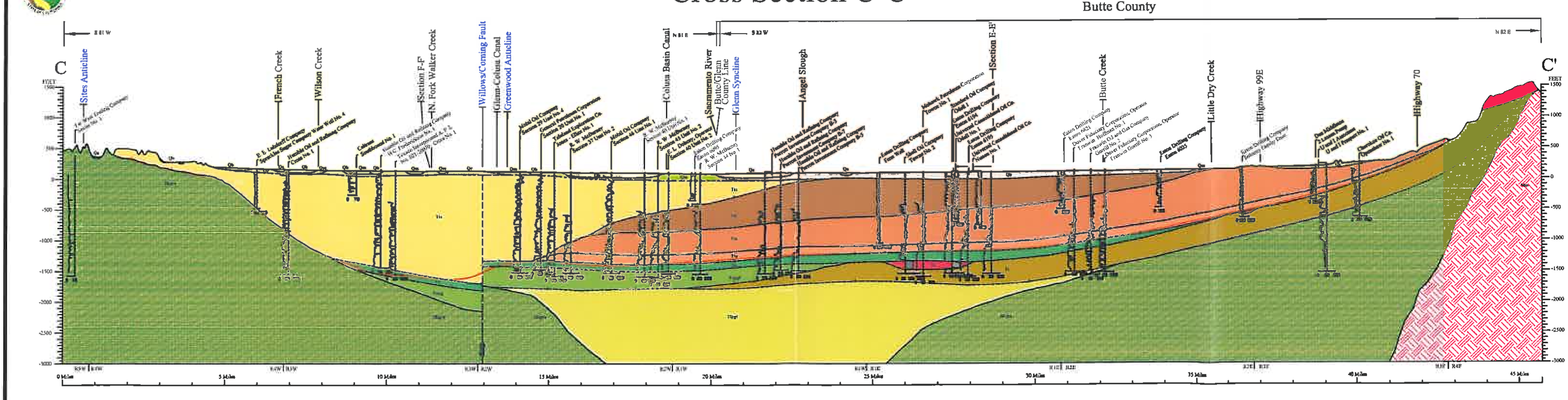
5 0 5 10

MILES

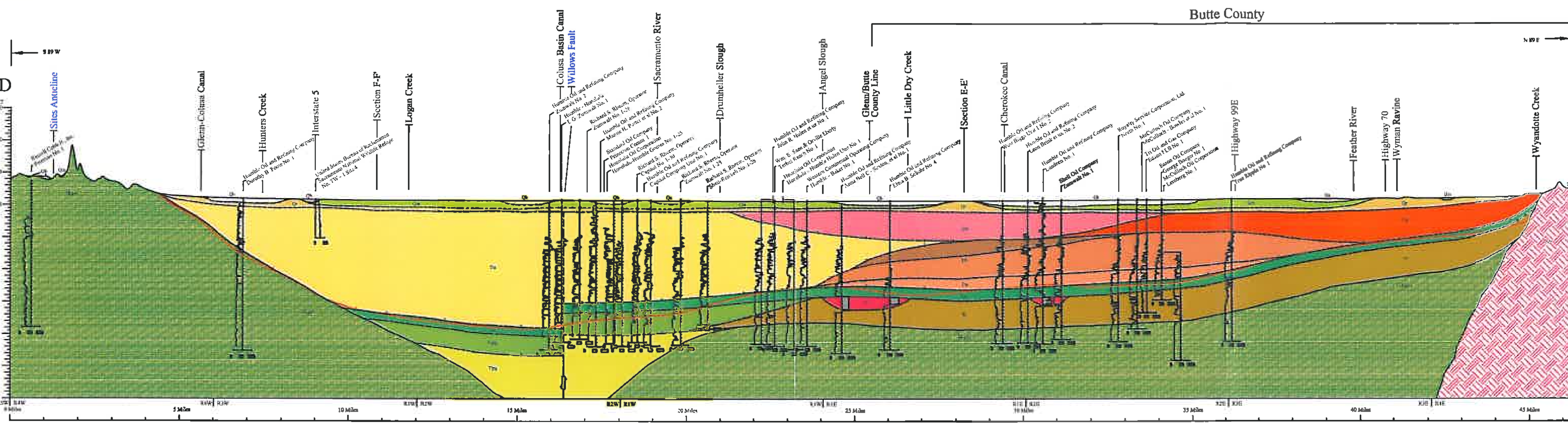
Cross Section B-B'



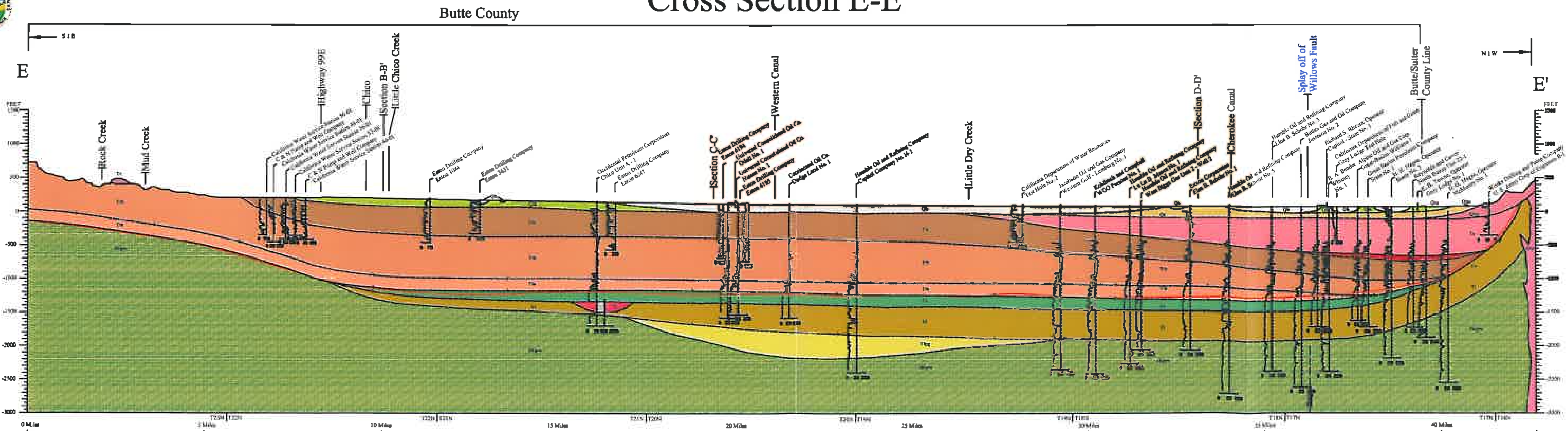
Cross Section C-C'

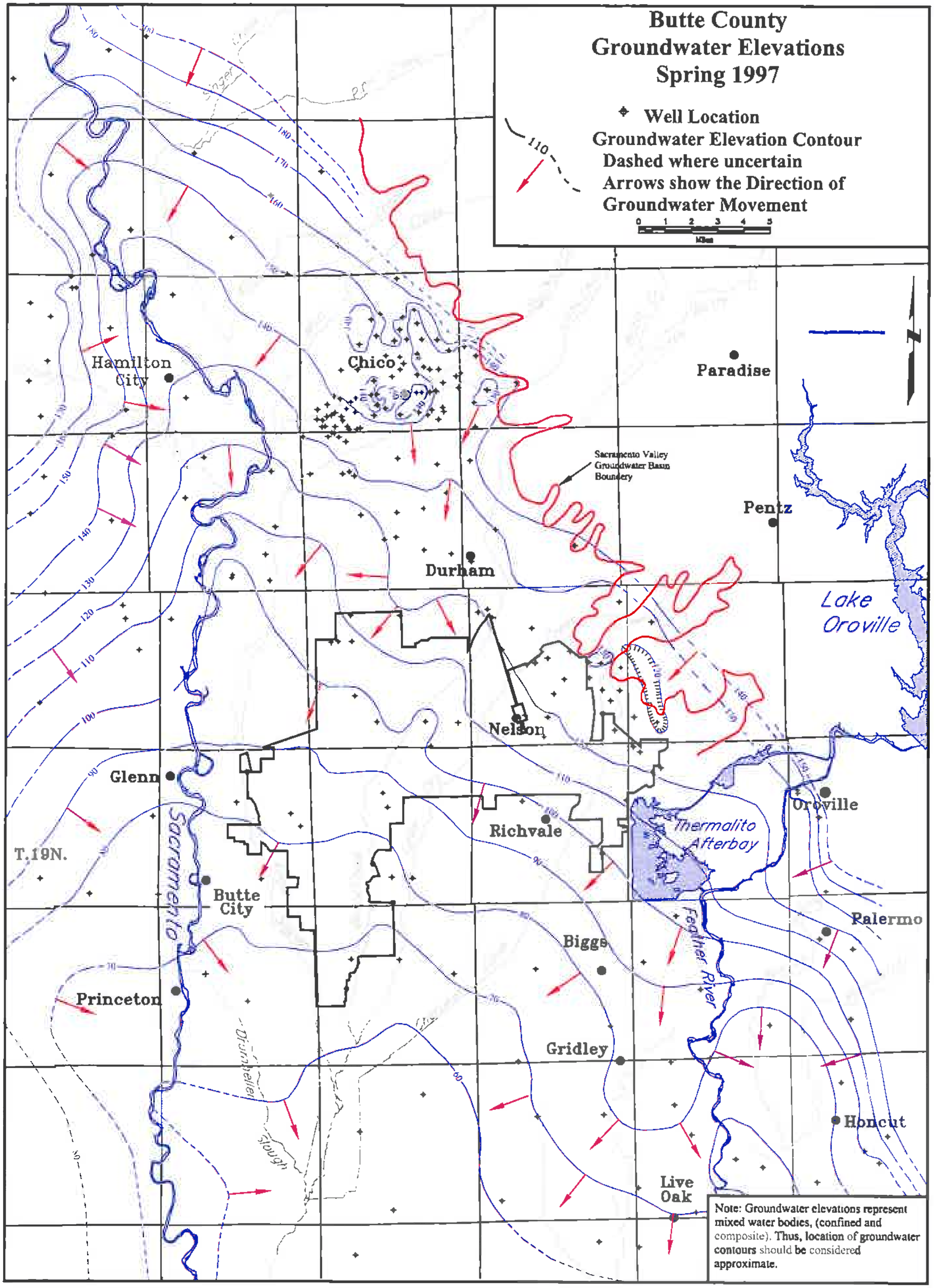


Cross Section D-D'

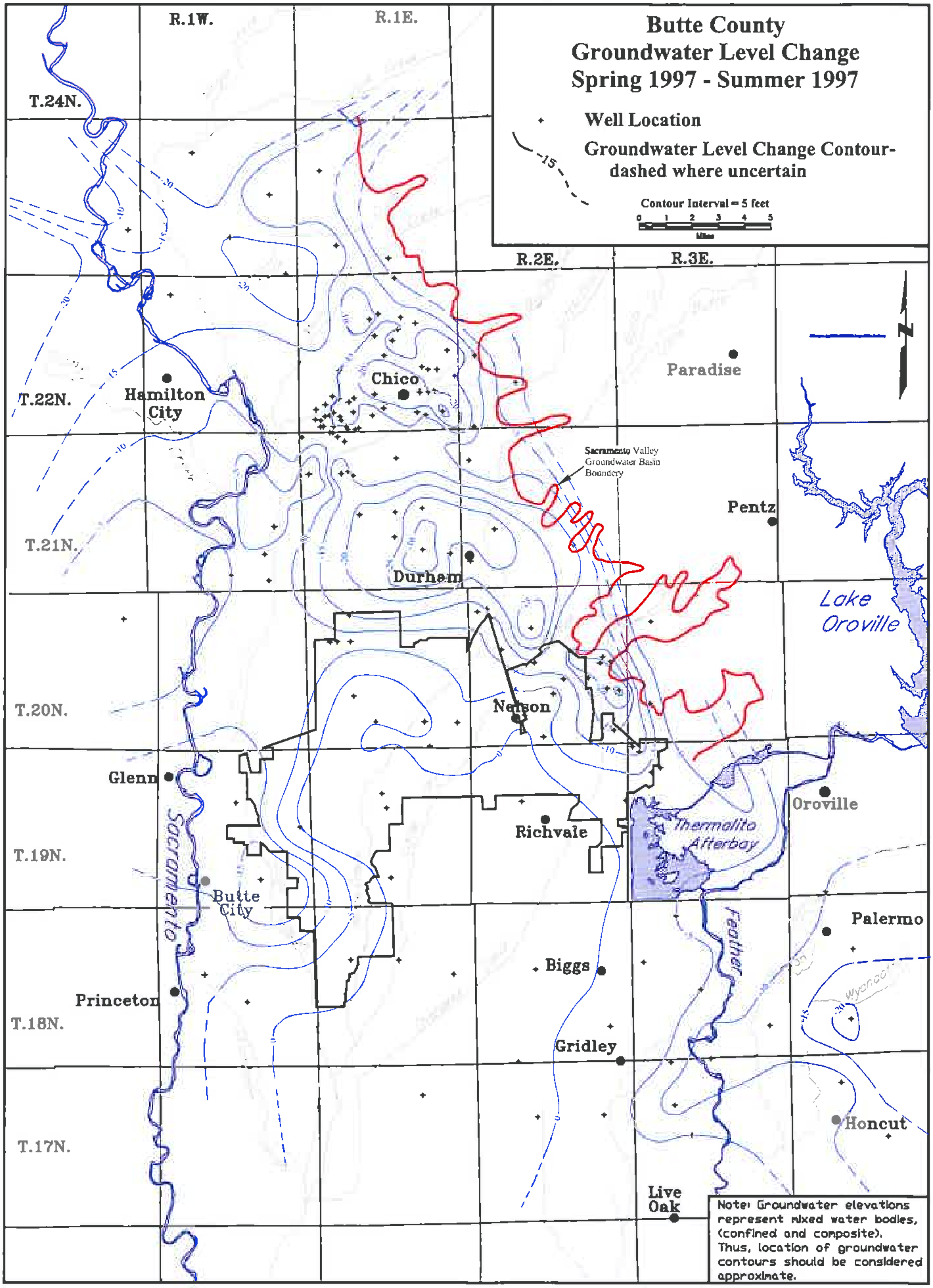


Cross Section E-E'





Butte County
Groundwater Elevations
Spring 1997
Well Location
Groundwater Elevation Contour
Dashed where uncertain
Arrows show the Direction of
Groundwater Movement
110
Hamilton City
Chico
Paradise
Pentz
Durham
Lake Oroville
Nelson
Glenn
Oroville
Thermalito Afterbay
Richvale
T.19N.
Sacramento
Butte City
Palermo
Biggs
Feather River
Princeton
Gridley
Honcut
Live Oak
Sacramento Valley Groundwater Basin Boundary
Note: Groundwater elevations represent mixed water bodies, (confined and composite). Thus, location of groundwater contours should be considered approximate.


Butte County
Groundwater Level Change
Spring 1997 - Summer 1997
Well Location
Groundwater Level Change Contour-
dashed where uncertain
Contour Interval = 5 feet
R.1W.
R.1E.
R.2E.
R.3E.
T.24N.
T.22N.
T.21N.
T.20N.
T.19N.
T.18N.
T.17N.
Hamilton City
Chico
Paradise
Sacramento Valley Groundwater Basin Boundary
Pentz
Durham
Lake Oroville
Nelson
Glenn
Richvale
Oroville
Thermalito Afterbay
Sacramento
Butte City
Feather
Palermo
Biggs
Princeton
Gridley
Honcut
Live Oak
Note: Groundwater elevations represent mixed water bodies, (confined and composite). Thus, location of groundwater contours should be considered approximate.

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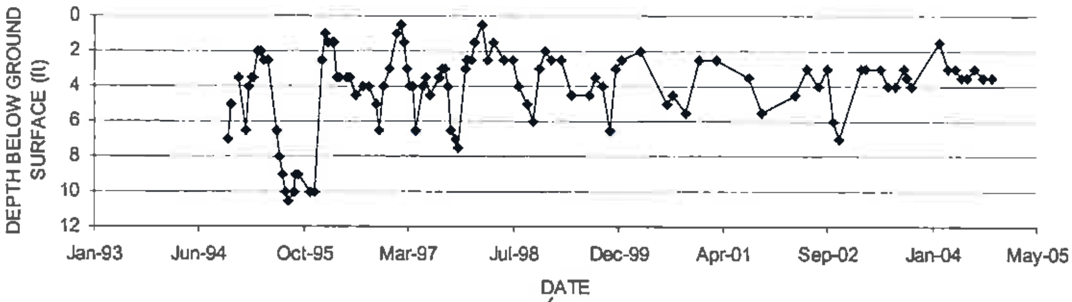

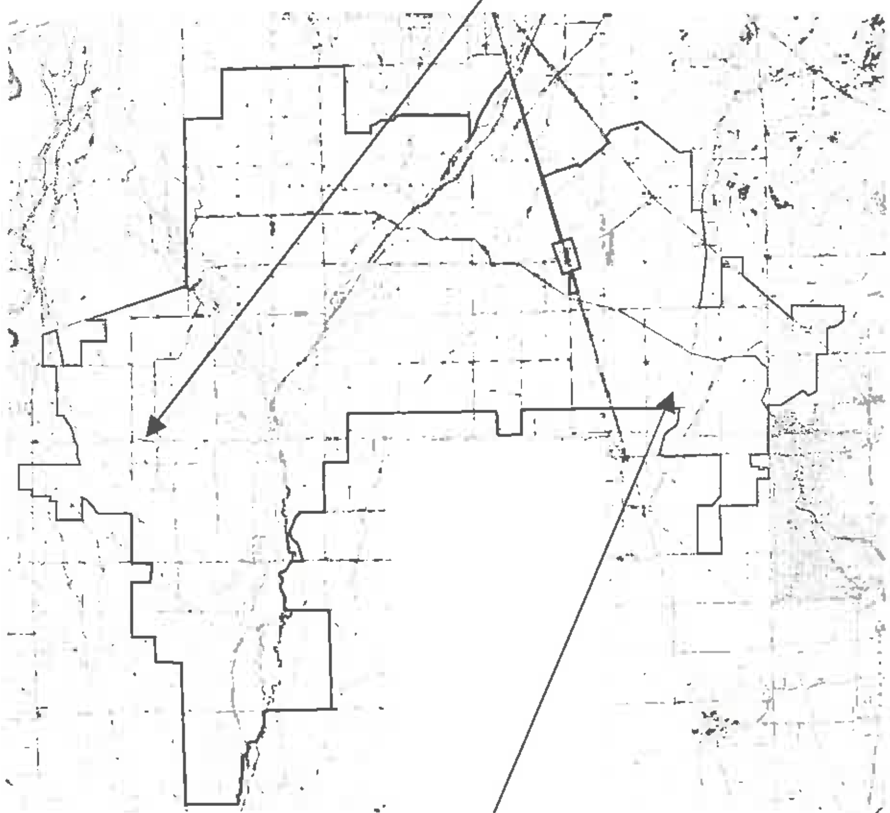

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