CDM Camp Dresser & McKee

Butte County Department of Water and Resource Conservation

Butte County Water Inventory and Analysis

March 30, 2001

Water Inventory and Analysis Report

Executive Summary

California's water resources are highly variable, geographically, seasonally, and annually. Managing these resources in the face of increasing and competing demands will become increasingly difficult. Demand will increase as the state's population of 34 million increases by 30 percent between 2000 and 2020. The competition for water expanded beginning in the early 1990's as changes in water management resulted in increased environmental water use. Competition for water by urban, agricultural and environmental users is magnified during periods of drought. Water users both inside and outside of the county are interested in management of the water resources to meet demands.

Photograph by Chuck Lowery

The Butte County Board of Supervisors and Water Commission recognize that such management is essential to the long-term economic and environmental health of the county. To accomplish it, the Board has initiated an Integrated Watershed and Resource Conservation Program.

A major step in the program is to document the county's water resource inventory. The Butte County Water Inventory and Analysis provides a summary of Butte County's water resources through a collaborative effort between the Camp Dresser & McKee Inc. team, Butte County Department of Water and Resource Conservation staff, and the Department of Water Resource's Northern District staff. The Department of Water Resource's Northern District staff prepared a report, *Butte County Groundwater Inventory Analysis*, to support data needs for the overall inventory project. The results are used extensively in this report.

This report presents an overview of current water resource-related programs in addition to the water inventory. The county's urban, agricultural, and environmental water needs are estimated, reflecting current uses. Water supplies available to meet the needs are analyzed reflecting normal and drought hydrologic conditions. On this basis, potential imbalances between needs and corresponding water supplies are assessed for each hydrologic condition.

These budgets cover only the managed and measurable "applied" component of the water cycle. In California, only a small part of the total precipitation is part of this managed and measurable component. Approximately 65% of the precipitation is used by trees and other plants, and does not generate runoff through rivers or streams. Only part of the remaining precipitation produces runoff that is dedicated and managed. This water inventory only considers the dedicated runoff portion of the state's water.

The water inventory was performed to a considerable level of detail by dividing the county into water inventory units and sub-units. The six inventory units are Vina, West Butte, East Butte, North Yuba, Foothill, and Mountain. Within these, twenty inventory sub-units represent water districts or unorganized areas with common water sources and uses. Background supply and demand information for each region was compiled on the basis of interviews with sixteen water purveyors and users, discussions with numerous parties involved in water-related activities and assimilation of existing data.

The general methodology of the inventory parallels that used by DWR to produce Bulletin 160. However, this analysis focuses on Butte County with a greater level of detail than was used in Bulletin 160 for the whole state.

The supply and demand analysis was performed according to the following steps:

- For each sub-unit, demands were estimated from water usage for each sector (urban, agricultural and environmental) for normal and drought conditions;
- Available supplies during normal and drought years were estimated, from records of water deliveries, water demand estimates, major water rights, interviews with key water providers, and allowable allocation cutbacks;
- Applied water budgets and shortages were estimated by inflow-outflow analysis; and
- Regional impacts on groundwater were estimated by comparing groundwater extraction estimates with groundwater hydrology data.

For this analysis, the year 1997 was chosen to represent a normal year. The County was very close to current development patterns for agricultural, urban, environmental, and other water uses. In addition, this year was one of the few recent years with a long agricultural growing season. Many residents remember the flooding during January 1997, and assume that it was a very wet year. The precipitation, however, was very close to average values within Butte County, and the floods were caused because the rainfall came primarily during January. There was minimal rainfall after January, which meant that January's flooding did not result in wet soil conditions when the growing season started. The combination of a long growing season, full water supplies, and full development patterns make 1997 the best option to represent a normal year.

Summarized findings for this normal year scenario include:

- During normal years, the supplies are equal to the demands, with no shortages.

- Agriculture produces the majority of county demand, with 71% of the total demand. The remaining demand is composed of conveyance losses (15%), environmental demands (10%), and urban demands (4%).
- The primary water source within the county is surface water (55%), followed by groundwater (31%) and surface water reuse (14%).
- Supplies are distributed throughout the county in approximately the same pattern as demands, with the most water going to the East Butte inventory unit (64%), followed by West Butte (18%), Vina (10%), North Yuba (5%), Foothill (2%) and Mountain (1%).

The drought year proved to be more difficult to select than the normal year because all drought conditions (such as precipitation, evaporation rates, and surface hydrology) did not exist in a single year. Therefore, several years were used to illustrate the worst recent examples of drought-year impacts. The 1976-77 drought had the lowest precipitation in recent years, but it was a relatively cool year and therefore had low levels of ET. From October 1976 to September 1977, the rain station in Chico is the lowest on record (10.55 inches) for a period from 1906 to 1999. The precipitation of 1976-77 is used, but the ETs from 1997 are used. The weather was very hot during 1997, which produced high pan evaporations and therefore high ETs. Per capita use information for urban demands was examined for recent years, and 1987 was chosen to represent urban per capita use because it was a hot, dry year with high demand. Key results of the drought scenario include:

- Shortages are primarily in the southwest portion of the county. Shortages are defined by lack of supply, which in most cases is limited by the groundwater infrastructure available, not by total water supply. The water shortage in the Ridge is somewhat different than the other sub-units, and is caused by a lack of surface water conveyance infrastructure.
- The composition of agricultural, municipal and industrial, and environmental demands does not appear to change substantially from the normal year. In a drought year, the majority of the demand is agricultural, at 74%, followed by conveyance losses (11%), environmental demand (10%) and urban demand (5%).
- There is more groundwater pumping and less surface water use than in the normal year. Surface water decreases from 55% of supply in normal years to 41% during a drought, and groundwater increases from 31% to 44%. Surface water reuse stays essentially the same, going from 14% in a normal year to 15% during a drought.

Butte County currently has adequate water resources available to meet demand within most areas of the county under normal hydrologic conditions. However, planning will be required to continue to meet the increasing and competing county

water resource needs and to develop a further understanding of the resource as solutions to increasing statewide water demand are pursued.

From the results of the water inventory, the following conclusions are drawn:

- The portion on the Sacramento Valley aquifer system under Butte County has recovered from the 1988-1994 drought. Long-term trends in groundwater storage indicate the basin groundwater aquifer is not in a state of decline. During normal to wet years, the aquifer system recharges to its maximum storage capacity by the following spring.
- Within the Foothill Inventory Unit and Mountain Inventory unit, overall groundwater supply is limited because groundwater occurs primarily in fractures and joints of the volcanic bedrock. Shallow, domestic wells could be susceptible to dewatering during periods of drought.
- Under the normal hydrologic scenario, Butte County currently has an adequate surface water and groundwater supply to meet current demands.
- Under the drought scenario evaluated, current demand can generally be met through increased groundwater extraction provided groundwater extractions are increased to offset reduced surface supplies. Additional groundwater wells and conveyance and distribution systems may be required to fully utilize the groundwater resource.
- Under the drought scenario evaluated, the Ridge Inventory Unit experiences water shortages.
- Future increases in demand will be associated with population growth and environmental regulatory requirements, both within and outside of the county.
- A significant amount of water supplied to meet demand remains available for use through deep percolation to groundwater and outflow to other areas.
- Environmental water use constitutes a substantial part of water demand in the county, extending water demand past the typical irrigation season. The trend in environmental water has increased in the recent past due to regulatory requirements.
- Impacts of normal and drought year water use on groundwater levels have been estimated for the Sacramento River Basin and Foothill areas.

With increasing pressure to meet current and projected water needs on a statewide level, northern California supplies will be evaluated by others as a component of the solution. A comprehensive Integrated Watershed and Resource Conservation Program is required to protect Butte County's interest and needs, as well as to adequately assess impacts of proposed state-initiated water resource projects. Initial key activities for formulating such a program should include:

- Facilitation and outreach with the county's stakeholders to develop water resource management goals and objectives, and for coordination of county interests with DWR and CALFED interests.
- Enhancement of the current land use, surface water monitoring, and groundwater monitoring data collection programs for use in a long-range integrated watershed and resource conservation plan.
- Groundwater is an important water source to Foothill and Mountain areas, but the fractured geology makes it very difficult to characterize. Additional monitoring and assessment should be performed in these areas to enhance understanding of groundwater availability and movement.
- Enhanced forecasting of agricultural, environmental and urban demand for use in such an integrated plan.
- Assessment of the Butte Basin Water Users Association groundwater flow model for use in the integrated plan.

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Cover photos: Rice photograph by Chuck Lowery, remaining photographs from the California Department of Water Resources

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Section 1
Introduction to the Water Inventory and Analysis Project

1.1 Background

California's water resources are highly variable, geographically, seasonally, and annually. Managing these resources in the face of increasing and competing demands will become increasingly difficult.

Photograph by Chuck Lowery

There is a broad geographical mismatch between the location of California's water resources and demands. More than 70 percent of the state's runoff occurs in the northern portion of the state, while more than 75 percent of its urban and agricultural demands occur south of Sacramento (DWR 160-98).

A seasonal mismatch exists between the occurrence of precipitation in the state and that of the water demands. More than 75 percent precipitation normally occurs between November and March, while the peak urban and agricultural demands occur during the summer months.

Precipitation within the state is highly unreliable. Numerous multi-year droughts have occurred in this century. The 1987-1994 drought is notable for its six-year duration and its statewide impacts. For example, the State Water Project terminated deliveries to agricultural contractors and provided only 30 percent of the total urban deliveries in 1991, the driest year of the drought. In that year, Governor's Executive Order No. W-3-91 created a Drought Action Team and directed the Department of Water Resources (DWR) to implement a drought water bank. By the end of the year, twenty-three counties had declared local drought emergencies.

DWR's drought water bank has operated three times, in 1991, 1992 and 1994. Utilizing the bank, DWR purchased water under short-term agreements. Water for the bank was obtained from land fallowing, groundwater substitution, and reservoir storage. Some water users and residents in regions of bank sales expressed concerns over third party impacts, primarily associated with fallowing and groundwater substitution. Within Butte County, drought water bank sales encouraged some groundwater users, not participating in the bank, to file claims against participating users regarding impacts to their water supplies.

Several factors that have emerged since 1994 will make conditions even more severe under similar climatic conditions to those in 1987-94. The population of the state has increased by six million since the drought and is expected to continue to increase at substantial rates. There have also been major changes in the state water management framework, primarily related to the reduced allocation of Colorado River water and

the environmental concerns associated with the Sacramento-San Joaquin River Delta and San Francisco Bay (Bay-Delta).

From a northern California perspective, the Bay-Delta environmental problems of water quality and supply are generally viewed in the context of water uses south and west of the delta. In the northern portion of the state, there is general consensus that, while the chronic environmental and water resources problems in the Bay-Delta need to be resolved, their resolution should not limit the ability of the northern counties to meet their present and future land use and water resource needs.

Significant surface-water and groundwater resources exist within Butte County. The county is in the Sacramento River hydrologic region, where about 32 percent of the state's runoff occurs. Figure 1-1 shows the location and key features of Butte County, including the major surface water bodies. As with the drought water bank, there will be continuing interest by water users both inside and outside of the county in management of the water resources to meet demands outside as well as within the county.

The Butte County Board of Supervisors and Water Commission recognize that managing the surface-water and groundwater resources of the county to meet current and future demands is essential to the long-term economic and environmental health of the county. To accomplish this, the Board has initiated an Integrated Watershed and Resource Conservation Program to ensure sound management of the county's social, water, and environmental resources.

A major step in the program is the identification of the natural resources of the county. The Butte County Water Inventory and Analysis (the Inventory), which is presented in this report, has been developed to provide a summary of Butte County's water resources to support proper management of those resources.

1.2 Purpose and Scope

The purpose of this report is to present an overview of current county water resources management issues and trends in the context of state water issues in addition to the water inventory. Urban, agricultural, and environmental water needs are estimated, reflecting current uses. Water supplies available to meet the needs are analyzed reflecting normal and drought hydrologic conditions. On this basis, potential imbalances between existing demands and corresponding water supplies are assessed for each hydrologic condition.

The information presented in this report provides water managers and interested parties fundamental information regarding the county's water resources. It can assist resource managers in formulating the scope of work for the Integrated Watershed and Resource Conservation Program.

1.3 Involved Parties

In June 1997, the county Board of Supervisors directed the Water Division and County Counsel to enter into discussions with the DWR to request funding for a countywide Water Management Plan. A sub-committee was set up in August under the Water Commission to identify important water resource issues and participate in the development of the inventory process. The sub-committee included the following members:

Supervisor Mary Anne Houx
Supervisor Curt Josiassen
Water Commissioner Mark Kimmelshue
Water Commissioner Lance Tennis
Chairman Don Heffren of the Butte Basin Water Users Association
County Counsel Susan Minasian
Agriculture Commissioner Richard Price
Mike McEnespy, TAC
Vickie Newlin, Water Division Analyst

The sub-committee met on August 29, 1997 and reviewed an outline of potential water-related issues to be included in a Water Management Plan. This outline went through several revisions that were presented at meetings of both the Water Commission and the Butte Basin Water Users Association in order to obtain public input (9/2/97, 9/10/97, 10/7/97, 10/8/97, 11/4/97, 11/12/97).

A Request for Proposal (RFP) was sent out to 14 consulting firms on December 1, 1997 using the outline of water issues as the framework document. The return date for the RFP was January 16, 1998. The county received proposals from three firms that met the criteria. Those firms were:

CH2MHill from Redding, California
Hydrologic Consultants, Inc. from Sacramento, California
Camp Dresser and McKee Inc. in Association with Anthony Saracino from Sacramento, California

A sub-committee screened the proposals and raised issues of concern regarding various concepts that were thought to be important components of the project. It compared the differences and similarities of the approaches to the project proposed by the three firms. The members of this screening team were:

Lance Tennis - Water Commission
Don Heffren - Chair BBWUA
Richard Price - Agriculture Commissioner
Glen Pearson - Water Commission TAC and DWR Representative
Mike McEnespy - Water Commission TAC
Vickie Newlin - Water Division Analyst

The full sub-committee interviewed all three firms on February 9, 1998. The sub-committee voted on February 19, 1998 to recommend Camp Dresser and McKee Inc. in association with Anthony Saracino to complete the inventory phase. At their April 17, 1998 meeting, the Butte County Water Commission voted to recommend to the Board of Supervisors to continue with the process to obtain funding for the countywide inventory / analysis.

The project was initiated with financial support from DWR through the Division of Planning and Local Assistance. The report represents a collaborative effort between the Camp Dresser & McKee Inc. (CDM) team, Butte County Department of Water and Resource Conservation (DW&RC) staff, and DWR's Northern District staff. The CDM team consists of staff from CDM, JNM Consulting, and Saracino • Kirby Inc. From the time that funding was secured and the project began, the Board of Supervisors transformed the Water Division into the Department of Water and Resource Conservation.

During the development of the data sets, DW&RC formed a Focus Group to help truth test the data in relation to local perspectives. The Focus Group includes representatives from Butte County agricultural and urban water purveyors, local water resource interest groups, and local environmental interest groups. Most of the varied interests that are actively involved with water management within Butte County are represented on the Focus Group.

Additionally, community stakeholders participated in the inventory process through two public meetings. The first meeting, held on July 17, 2000, focused on sharing the purpose and objective of the project, the proposed inventory methodology, and receipt of comments and questions from those attending. The goal of the second public meeting, held on March 8, 2001, was to present the results of the water inventory and to recommend future water management activities to the county's water resource stakeholders.

1.4 Contents of the Report

The Butte County Water Inventory Report is intended to provide the reader with an understanding of current water resource issues and an inventory of Butte County's water resources. With an understanding of how the county water resources are currently utilized and with a clear picture of water resource issues facing the county, stakeholders will have the basic wherewithal to address water resource challenges and opportunities. The report includes the following Sections:

Section 1: Introduction
The introductory Section provides a description of the purpose and objectives of the water inventory report. Parties involved in development of information provided in the report are identified.

Section 2: Background and Overview of Water Resource Issues
Section 2 identifies current water resource management issues that may impact Butte County. Following a short review of Butte County water history, current state and local programs and policies affecting water resource management within the county are described, followed by a summary of Butte County water management issues and concerns.

Section 3: Butte County Setting
Section 3 describes the aspects of the physical setting of Butte County, that are relevant to the presentation of its water resources, and the inventory of those resources, in subsequent sections. The physical characteristics of the county that are relevant to water resource management include climate, geology, hydrogeology and hydrology.

Section 4: Butte County Water Resource Inventory
Butte County's water resources are discussed in Section 4. Section 4 provides information on water rights, water purveyors, and water users within the county. This information serves as the foundation for the water source and use data in the succeeding analysis.

Section 5: Water Supply and Demand Analysis
Estimates of water demand and available supply are presented for the current water resource infrastructure under differing climatic conditions, represented by a normal scenario and a drought scenario. Water resource management opportunities and challenges are discussed based upon analysis of output from the scenarios.

Section 6: Additional Water Management Issues
This inventory and analysis of Butte County water resources focuses on the county's supply and demand of surface and groundwater resources, and does not cover the breadth of all water resource issues. This section addresses the range of issues identified at many forums on Butte county water resource issues, and suggests how the data or analysis could be improved in the future.

Section 7: Conclusions and Recommendations
Water resource issues faced by local stakeholders are summarized together with future water resource management decisions that will likely result from consideration of these issues in a statewide context. Water resource opportunities and challenges within Butte County are identified on the basis of the results of the supply and demand analysis. Recommendations for near-term future water management activities are developed.

The Butte County Water Inventory and Analysis Report includes a significant amount of data consolidated by the DWR Northern District. DWR will be publishing two documents that include supplemental information for use by the public. The Groundwater Section of DWR's Northern District will publish a report on *Butte*

County Groundwater Inventory Analysis during the early summer of 2001. Also, the Land and Water Use Section of DWR's Northern District will publish a report during the summer or early fall of 2001 describing land and water use within the county. Both reports will be formatted consistent with the Inventory Units described below.

1.5 Inventory Units

The water inventory was performed to a considerable level of detail by dividing the county into water inventory units and sub-units. These units were developed on the basis of hydrologic basins and common water sources. The water supplies and demands were assessed for each sub-unit for both normal and dry years under 1997 population and land use conditions.

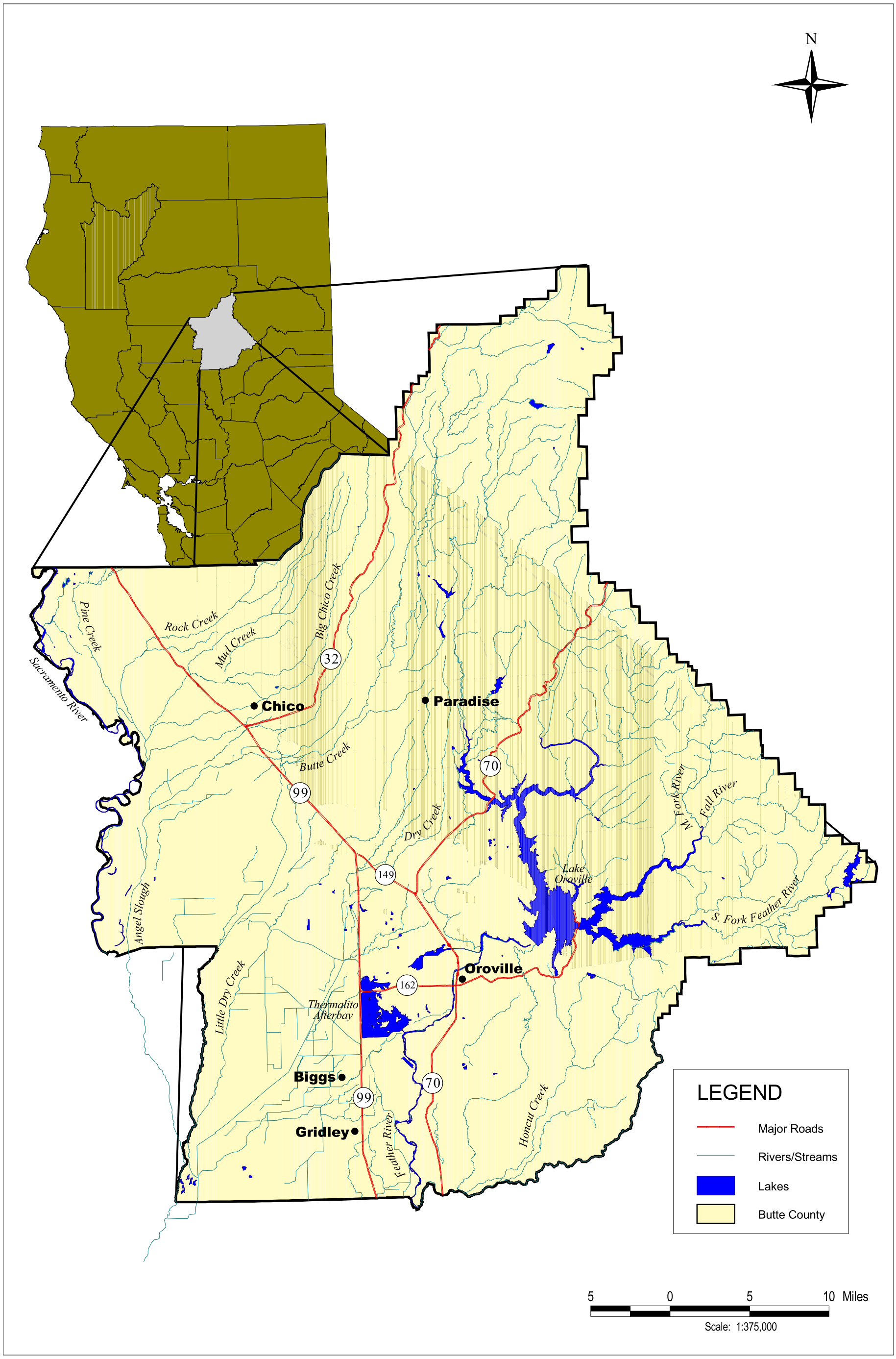
The principal basins within the county have been designated as inventory units. These six resulting inventory units are Vina, West Butte, East Butte, North Yuba, Foothill, and Mountain. Each inventory unit has been further divided into inventory sub-units. Twenty inventory sub-units are included within the county, representing water suppliers or unorganized areas with common water sources and uses. The Butte County inventory units and inventory sub-units are shown on Figure 1-2. The inventory units are described in greater detail in Section 4.

The process of developing the inventory units included a review of the major surface hydrologic features within the county, including the Sacramento River, Feather River, Butte Creek, Big Chico Creek, and other waterways. The geographic boundaries of the inventory units are based upon the county's hydrologic features, hydrogeologic characteristics, and, to a lesser degree, administrative boundaries such as the county border. Table 1-1 lists all of the inventory units and sub-units and includes water suppliers within inventory unit boundaries. Table 1-1 lists the units and the water suppliers within them.

Table 1-1
Description of Inventory Units and Sub-Units

Inventory Units	Sub-Units	Water Suppliers Within Sub-Units
East Butte	Biggs-West Gridley	Biggs-West Gridley Water District
	Butte	Butte Water District City of Biggs City of Gridley
	Butte Sink	
	Cherokee	
	Esquon	Durham Mutual Water District
	Pentz	
	Richvale	Richvale Irrigation District
	Thermalito	Thermalito Irrigation District
	Western Canal	Western Canal Water District
Foothill	Cohasset	
	Ridge	Del Oro Water Company Paradise Irrigation District
	Wyandotte	Oroville Wyandotte Irrigation District
Mountain	Mountain	
North Yuba	North Yuba	California Water Service, Oroville
Vina	Vina	California Water Service, Chico
West Butte	Angel Slough	
	Durham/ Dayton	California Water Service, Chico Dayton Mutual Water District Durham Irrigation District
	Llano Seco	
	M&T	
	Western Canal	Western Canal Water District

Figures



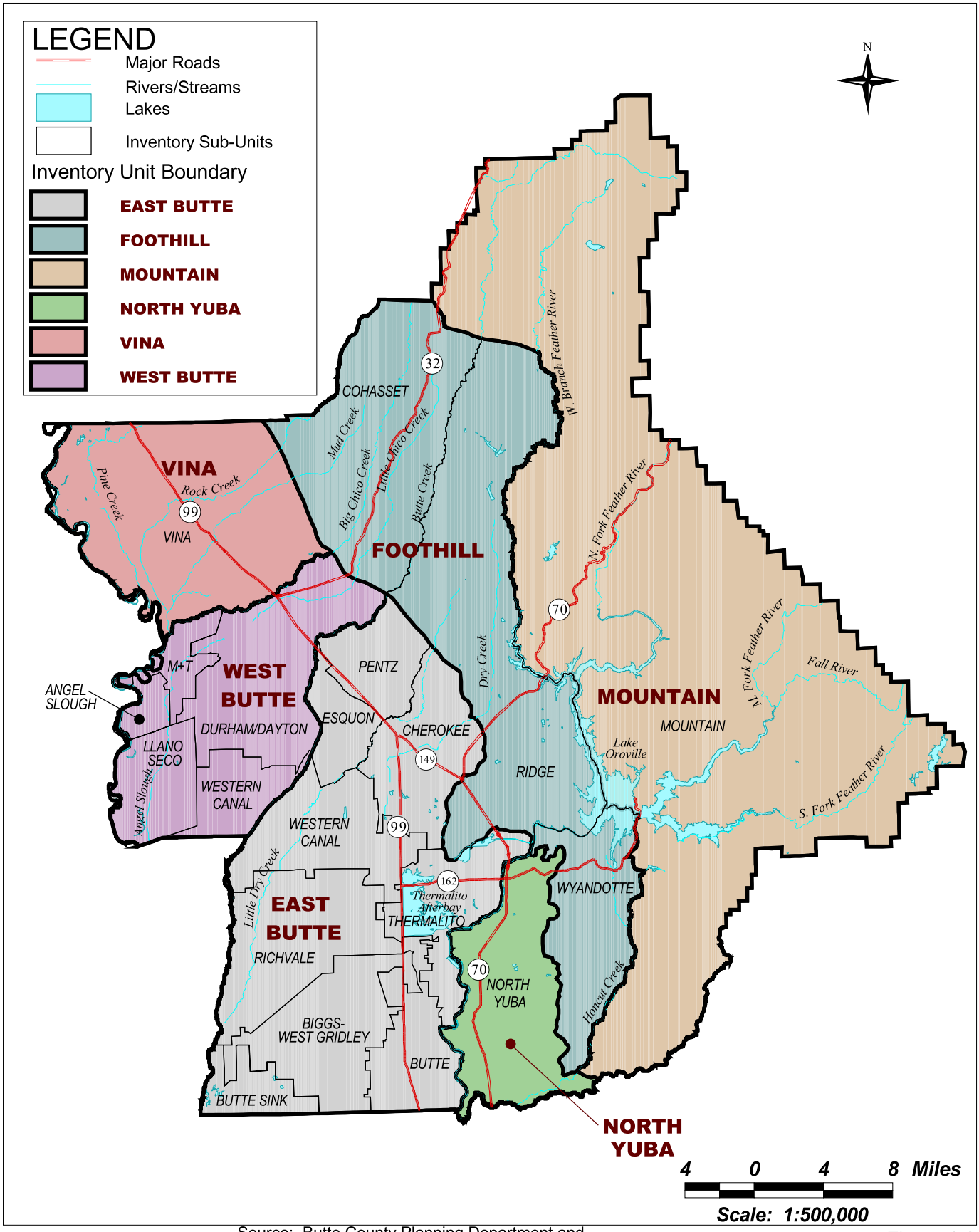
Butte County
Department of Water & Resource Conservation

Source: Butte County Planning Department

Figure 1-1

LOCATION MAP

CDM Camp Dresser & McKee Inc.



Source: Butte County Planning Department and
Butte County Department of Water & Resource Conservation

Figure 1-2

Butte County
Department of Water & Resource Conservation

WATER INVENTORY UNITS

CDM Camp Dresser & McKee Inc.

Section 2
Water Resource Overview and Current Issues

Providing adequate water resources to meet the diverse range of water demands in California is a challenging endeavor. Much of the state's supply originates in northern California, while the majority of use occurs in southern California. The competition for water is increased by new and expanding demands on existing resources. Periods of drought additionally magnify the challenge of meeting water needs.

California is the nation's most populous state, increasing in population by 11 percent over the past ten years to more than 33 million residents. The population is projected by the Department of Finance to increase an additional 30 percent between 2000 and 2020. Large urban areas continue to attract the most new residents, however, rural counties are experiencing a significant percentage growth in population. During the past ten years, Butte County's population increased over 11 percent to an estimated 204,000 residents (California Department of Finance, 2001). The state's continuing population growth will require additional water to meet demand, with much of the new demand for water originating in Southern California. Water planning will focus on conservation, reuse and identification of additional supplies.

In addition to the demands from an increasing population, the competition for water continued to expand beginning in the early 1990's as changes in water management resulted in increased environmental water use. Actions such as the Bay-Delta Accord, Central Valley Project Improvement Act, and the implementation of CALFED result in increased dedication of water for environmental purposes. Changes in legislation and program management associated with environmental water needs reduce water supplies historically available to agricultural and urban water users. As a result, additional efforts to improve water supply reliability will focus on existing water management practices and implementation of new water management programs.

Water management issues are magnified during periods of drought. New or accelerated practices may be implemented in response to drought, often times with little time for planning. The Governor's Executive Order W-3-91 in 1991 directed DWR to implement a water purchase and allocation program, known as the drought water bank. In Butte County, additional water was made available by land fallowing, pumping groundwater in lieu of using surface water, and purchase of water from reservoir storage. Impacts to third parties and the environment were a subject of concern in Butte County during the operation of the 1994 water bank.

Historic water resources development in Butte County focused on local needs associated with agricultural irrigation and urban development. As local and statewide competition for the resource has increased over time, state and federal actions now play a much larger role in water resource management decisions. Many of these actions are discussed in the following sections. The water inventory was triggered by

the events and actions described within this section, wherein local policy-makers discovered the need to understand the technical information as well as the political climate. When the information discussed in this section is considered in conjunction with the water inventory results discussed in Section 5, water resource stakeholders are presented with a summary of both current issues and an inventory of how the county's water resources are currently allocated. This information provides valuable tools to assist in planning for future water resource management.

2.1 Development of Water Resources in Butte County

As with many California counties abutting the Sierra Nevada, the lure of gold resulted in the first organized use of the county's water resources. With the population growth that followed, other demands for waters within the county quickly developed. Today, Butte County's water resources are utilized for a wide range of activities, including mining, agriculture, urban, hydroelectric, and environmental demands. Today's water managers meet many varying water resource needs by optimizing use of the resource. As an example, the same water can be used to generate power, then be applied to crops, and then assist in meeting environmental water needs.

Photograph by Chuck Lowery

Mining companies in Butte County began constructing ditches for hydraulic mining as early as 1860. Examples include the Powers Ditch, which used water from Little Butte Creek, and the Cherokee Ditch, which used water from Big Butte Creek and the West Branch of the Feather River.

Prior to 1870, only a few farmers experimented with irrigating their lands with water from wells or streams—as noted by the statistic that only 12,000 acres were irrigated within the Sacramento Valley in 1869. Many of the pioneer farmers that made their way to the Sacramento Valley were from the Midwest and practiced "dry farming." However, Butte County's farmers soon began tapping the Feather River as the first source of irrigation water for their farmland.

Rice, as a commodity crop, made its first appearance in the Sacramento Valley in the early 1900s. The United States Department of Agriculture was interested in the potential for rice growth in Butte County and performed several experiments with different rice strains to discover what could grow in the area. The results were excellent and triggered the expansion of the rice industry in Butte County. The rapid growth in the agriculture industry resulted in a corresponding growth in irrigation systems.

As the agricultural industry expanded in Butte County, local water districts began to look for more secure water supplies. Several districts constructed upstream reservoirs

to capture heavy winter and spring flows for use during the irrigation season. Other areas of the county, without access to surface water supplies, began to become increasingly dependent on groundwater as a reliable source of water. Section 4 contains additional historical details for regions within the county.

At the state level, California voters approved $1.75 billion for construction of the State Water Project in 1960, and the Department of Water Resources (DWR) started construction of Oroville Dam in 1961. Oroville Dam created Lake Oroville, a 3.5 MAF storage reservoir. Oroville Dam is on the Feather River, which has a drainage area above Oroville that encompasses approximately 3,600 square miles. Above Oroville, the mean seasonal runoff of the stream is approximately 4.5 million acre-feet (MAF), varying between 1.2 and 9 MAF. The dam was completed in 1968 and at 770 feet is the tallest earthfill dam in the United States.

Land and water use within Butte County was impacted by the construction of Oroville Dam. Existing facilities for water suppliers within the county were flooded, and the upstream migration of fish was halted at Oroville. As a part of the construction of the dam, Thermalito Forebay and Afterbay were also built to regulate the temperature of the water before it is released into the Feather River. If the water is too cold, it has the potential to damage rice production.

To mitigate the impacts of the dam on fisheries, DWR built a fish hatchery, the Feather River Salmon and Steelhead Hatchery, at the base of the dam, representing an early effort to mitigate the environmental effects associated with development of water resources within the county. As the salmon or steelhead swim upstream to spawn, they are diverted from the river into the hatchery with a diversion dam. The hatchery artificially spawns the fish, and then rears the young hatchlings until it is safe to release them into the wild.

Although the majority of high quality cropland is currently in production and irrigated agricultural lands are generally fully developed, some additional agricultural lands are being developed in the northern part of the county and are being reviewed in certain areas in the southern part of the county. Regardless, changes in crop types and irrigation practices will continue in response to evolving markets, and may increase water demands for agriculture within the county. Additional demands for the county's water resources will likely be associated with a growing population and environmental water demands in addition to agricultural build-out in these other areas.

2.2 Recent Events in California Water

In addition to the development of agricultural land and the growth in population, many actions have been pursued on a statewide and local level resulting in increased competition for available water resources. This section focuses on identifying many of those actions that potentially impact water management in Butte County. Included in

the discussion is state and federal legislative actions, state and federal programmatic actions, programs associated with the San Francisco Bay and Sacramento-San Joaquin Delta, and interstate water issues. The discussion focuses on actions that have occurred since the 1976/77 drought because they are the most relevant to current water resource practices.

2.2.1 Legislative

Selected state and federal legislation impacting water resource management is summarized below. Many of these legislative actions provide state or federal funding for water resources actions to encourage local areas to complete projects that they previously found cost prohibitive. By offering financing to help with water resource issues, the government is raising awareness of these issues while helping to work towards solutions.

State Statutes

Local Water Supply Reliability

Three bills were passed to emphasize local long-term water planning to help ensure reliability during all types of water years. Two of the bills (Statutes of 1995, Chapters 330 and 854) require local water agencies to assess the reliability of their water supplies. The other bill (Statutes of 1995, Chapter 881) requires consultation with local water agencies to determine if an adequate water supply is available to accommodate pending land use planning decisions.

Proposition 204

Proposition 204 (the Safe, Clean, Reliable Water Supply Act) was passed in 1996. It authorized $995 million for water and environmental restoration. Of the $600 million approved as the state share of costs associated with projects to benefit the Bay-Delta and its watersheds, $390 million is allocated to implement CALFED's ecosystem restoration program of the Bay-Delta. A portion ($117 million) of Proposition 204's total was designated for water supply reliability projects.

Proposition 218

In 1996, the California voters passed Proposition 218, which requires a local vote to increase any fees that are "incident of property ownership." This category of fees includes several water-related fees, such as meter charges, acreage-based irrigation charges, or standby charges.

Proposition 13

The 2000 Water Bond (the Safe Drinking Water, Clean Water, Watershed Protection and Flood Protection Act) authorized $1.97 billion for water projects. The following types of work received allocations:

- Supply, reliability, and infrastructure $630 million
- Watershed protection $468 million

- Clean water and water recycling $355 million
- Flood protection $292 million
- Water conservation $155 million
- The Safe Drinking Water Program $70 million

The State Water Resources Control Board (SWRCB) is allocated $695 million under Proposition 13. SWRCB projects under the 2000 Water Bond Program include:

- Southern California Integrated Watershed Program: $235 million for a variety of water quality activities, including basin water banking; contaminant and salt removal processes; water conservation; stormwater management; flood control; and wastewater discharge abatement
- Watershed Program: $90 million for grants to local watershed organizations or public agencies to develop and implement local watershed management plans
- Nonpoint Source Pollution Control: $100 million to public agencies and nonprofit organizations to fund nonpoint source pollution control projects
- Clean Water Program: $100 million for grants and low-cost loans for capital improvement and upgrades to wastewater treatment facilities throughout the state
- Other programs totaling approximately $170 million for water recycling, coastal nonpoint source control, joint watershed management and seawater intrusion control.

The Department of Water Resources (DWR) is allocated $1.16 billion under Proposition 13. DWR projects under the Program include:

- Bay-Delta Multipurpose Water Management Program: $250 million to fund projects identified in the CALFED environmental document (EIS/EIR) as Stage 1 actions
- Groundwater Storage Program: $200 million for grants for feasibility studies, project design, and construction of facilities for conjunctive use projects
- Interim Water Reliable Supply and Water Quality Infrastructure and Management Program: $180 million for grants to local agencies in the Delta export service area for programs and projects designed to increase water supplies, enhance water supply reliability or improve water quality
- Watershed Protection Program: $103 million to fund water and watershed educational programs and to fund the River Parkway Program for the acquisition

and restoration of riparian habitat and riverine aquatic habitat, and for development of trails along rivers

- Flood Protection Programs: $272 million to fund a variety of flood protection, mitigation, and cleanup projects
- Infrastructure Rehabilitation Program: $60 million for grants to develop infrastructure rehabilitation projects in economically disadvantaged areas and for financing feasibility study grants for projects potentially eligible for the grant program
- Urban and Agricultural Water Conservation Programs: $65 million to fund loans for water conservation projects and for financing feasibility study grants for projects potentially eligible for the loan programs
- Groundwater Recharge Facilities Program: $30 million to fund loans for the construction of groundwater recharge facilities and for financing feasibility study grants for projects potentially eligible for the loan program.

The Department of Fish and Game has been allocated $25 million under Proposition 13 for projects to protect, restore, acquire, and enhance salmon habitat.

The Department of Health Services has been allocated $70 million under Proposition 13. $68 million of this will be used as the state match to access approximately $340 million in federal capitalization grant funds to be used for public water system infrastructure improvements. $2 million will be used for providing technical assistance to public water systems including disadvantaged communities.

The Sacramento Area Flood Control Agency has been allocated $20 million under Proposition 13 as a one-time appropriation to pay the state's share of the nonfederal costs of the flood management project authorized by the federal government to improve flood protection in the Sacramento region.

Federal Statutes

Safe Drinking Water Act

The Safe Drinking Water Act (SDWA), passed in 1974, is the initial federal legislation passed to ensure the quality of drinking water. In 1996, the SDWA was amended with changes emphasizing sound science and risk-based standard setting, small water supply system flexibility and technical assistance, community-empowered source water assessment and protection, public right-to-know, and water system infrastructure assistance. Required by the amendments, California became the first state to receive unconditional approval of its source water assessment program. Implemented by the Department of Health Services, California's *Drinking Water Source Assessment and Protection Program* will evaluate contamination threats to over

16,000 public supply wells. The Department of Health Services is responsible for the completion of all assessments by May 2003.

Clean Water Act Reauthorization
The Clean Water Act (CWA) is a 1977 amendment to the Federal Water Pollution Control Act of 1972, which set up the basic structure for regulating discharges of pollutants to waters of the United States. Both point and nonpoint source discharges to surface water are regulated by the CWA. Additionally, wetland protection is addressed under the CWA.

Endangered Species Act Reauthorization
Passed in 1973, the Endangered Species Act provides a program for the conservation of threatened and endangered plants and animals and the habitats in which they are found.

Reclamation, Recycling, and Water Conservation Act
The Reclamation, Recycling, and Water Conservation Act was passed in 1996. It authorized 25 percent federal cost-sharing for higher level wastewater treatment plants. Higher level wastewater treatment plants treat the water to a higher standard so it can be used in reclamation or recycling projects.

2.2.2 State and Federal Programmatic Actions

In addition to funding certain types of work, the state and federal governments have been initiating programs to help with water and resource issues. These programs have significant impacts on water and resource management.

Photograph from DWR

SWP Monterey Agreement Contract Amendments

The SWP Monterey Agreement is a contract between DWR and various SWP contractors. The agreement allows for flexible operation of SWP facilities, permanent transfers of contractual entitlement between contractors, and transfer of land to certain contractors in exchange for entitlements from the SWP. The agreement serves as an amendment to existing SWP contracts. The amendment was signed in December 1994. Some of the more important provisions include:

- *Drought Supplies.* The agreement states that available supplies during droughts are distributed in proportion to original contract amounts. The original contracts required an initial reduction to agricultural users.

- *Permanent Transfers.* Agricultural contractors can permanently sell portions of their entitlement back to the SWP to reduce SWP's total commitment or to urban agencies.

- *Wheeling*. Wheeling is a term used to describe the transfer of water through a facility that does not belong to the buyer or seller. The agreement established a method for SWP contractors to transfer non-SWP water through project facilities.

- *Turnbacks*. Before the agreement, no credit was given to contractors who did not use their full SWP allotment, and the water could not be sold to anyone else. The "Turnback Pool" is a method developed by the DWR, which allows for the sale of unused supplies back to other SWP contractors or the SWP itself. DWR established this pool to encourage contractors to identify any unused water early in the season, when placing their water year supply order in October of the year proceeding the water year.

The Planning and Conservation League, a statewide environmental group, filed suit challenging the adequacy of the Environmental Impact Report (EIR) prepared for the Central Coast Water Authority, which serves as the lead agency for the Monterey Agreement. An appellate court decision challenged the adequacy of the EIR, and the California State Supreme Court has refused to hear the case, thereby upholding the appellate court decision forcing the EIR to be re-done.

The county currently holds entitlement to 27,500 acre-feet of SWP water captured in Lake Oroville, representing mitigation granted the county for housing the dam. The size of the entitlement was based on forecasted future demands, but was too expensive (compared to other sources) for the county to use immediately. After the dam was built, the county participated in an Entitlement Reduction Program so that they would not need to pay for the entire entitlement when they could not utilize the water. By participating in the Monterey Agreement, the county has been able to reduce its required purchase through the year 2000 to 1,200 acre-feet without losing its right to the full entitlement at a later date. The county has since negotiated an allocation of 3,500 acre-feet until the issues surrounding the Monterey Agreement and amendments are settled.

CVPIA Implementation

The Central Valley Project Improvement Act is a federal law that was passed on October 30, 1992. Resulting changes place fish and wildlife mitigation and restoration on par with water supply needs of agricultural and urban users.

The major areas of change to the CVP cited by the U.S. Bureau of Reclamation are as follows:

- 800,000 acre-feet of water dedicated to fish and wildlife annually;

- Tiered water pricing applicable to new and renewed contracts;

- Water transfers provisions, including sale of water to users outside the CVP service area;

- Special efforts to restore anadromous fish population by 2002;
- Restoration fund financed by water and power users for habitat restoration and enhancement and water and land acquisitions;
- No new water contracts until fish and wildlife goals are achieved;
- No contract renewals until completion of a Programmatic Environmental Impact Statement;
- Terms of contracts reduced from 40 to 25 years with renewal at the discretion of the Secretary of the Interior;
- Installation of the temperature control device at Shasta Dam;
- Implementation of fish passage measures at Red Bluff Diversion Dam;
- Increased flow in the Trinity River, which decreases water availability to power and water users;
- Curtailment of SWP and CVP pumps in the Delta during the April-May period because of striped bass;
- Firm water supplies for Central Valley wildlife refuges; and
- Development of a plan to increase CVP yield. (http://www.mp.usbr.gov/regional/cvpiamain/index.html)

FERC Relicensing

The Federal Energy Regulatory Commission (FERC) licenses all non-federal hydroelectric plants. The Federal Power Commission (FPC), FERC's predecessor, licensed the Oroville facilities on February 11, 1957, for a period of 50 years. The major features of the Oroville facilities include Oroville Dam and Reservoir, the Edward Hyatt Powerplant, Thermalito Forebay and Afterbay, and associated recreational, fish, wildlife, and enhancement facilities. The Oroville facilities are scheduled to be relicensed in 2007, and DWR is planning to file a Notice of Intent to reapply by 2002 and file the application by 2005.

Photograph from DWR

A FERC license establishes operational parameters for the facility, including conditions such as instream flow requirements and fishery protection measures. An important element of the application is a full environmental analysis of the impacts of the facility. When FPC first licensed hydroelectric facilities, environmental issues had not achieved the same level of awareness as they currently have. It is possible that the

relicensing could alter operations, depending on FERC's interpretation of the environmental analysis.

FERC recently approved the Alternative Application Process (AAP) submitted by the DWR. Through the AAP, the DWR has started a public involvement process to accompany the relicensing application in 2005. The DWR is taking this approach in hopes of eliminating or reducing conflicts in the application itself.

Mono Lake Decision

In 1940, Los Angeles was allowed to divert water from four of the seven tributaries feeding Mono Lake. The diversions caused a reduction in the lake's water level by 40 feet (over a period of 40 years), jeopardizing the unique bird and shrimp population. Efforts to lessen diversions began in 1979, culminating in a victory for area-of-origin and environmental rights in a court case against the Los Angeles Department of Water and Power in 1994. Since then, Los Angeles has been restricted to 16 TAF per year of water diversions until the lake rises 20 feet from 1994 levels, with the hopes of restoring the lake and its tributary creeks. When the lake reaches the designated level, Los Angeles can increase diversions to approximately 31 TAF per year, which is about one third of historic diversion levels. Today, more importance is placed on environmental issues and area-of-origin rights.

The case against Los Angeles was based on the public trust doctrine, which provides the state with authority to protect all navigable waters of the state because they are a public resource. The case charged that the state must protect Mono Lake from environmental damage caused by Los Angeles' diversions. The California Supreme Court decided that protecting wildlife habitat is a part of the state's obligation under the public trust doctrine to protect commerce, navigation, and fishing.

The hydrologic conditions and environmental setting of Mono Lake are much different than those in Northern California. However, some the basic concerns regarding water exports from the area-of-origin and the protection of public trust resources are similar.

2.2.3 San Francisco Bay and Sacramento-San Joaquin Delta

The unique position of the San Francisco Bay and Sacramento-San Joaquin Delta has been recognized in recent years. Many people within the State of California, including the majority of SWP and CVP contractors, receive water from the Delta. The Delta is also a productive estuary system that provides environmental benefits to fish and wildlife. In recent years, several actions have been taken to try to protect all beneficial uses of the Bay-Delta region.

CALFED

CALFED is a cooperative effort of 15 state and federal agencies to address the problems in the Bay-Delta. Efforts started in 1994 with the signing of the Framework

Agreement, which committed these agencies to develop water quality standards, coordinate SWP and CVP operation, and develop long-term solutions to the Bay-Delta's problems. The program objectives are to:

- Restore the ecological health of a fragile and depleted Bay-Delta estuary;
- Improve the water supply reliability for farms and growing cities that draw water from the Delta and its tributaries, including 7 million acres of the world's most productive farmland;
- Protect the drinking water quality of the 22 million Californians who rely on the Delta for their supplies; and
- Protect the Delta levees that ensure its integrity as a conveyance and ecosystem.

In June 2000, CALFED published "California's Water Future: A Framework for Action" to address its program objectives. This document described actions for ecosystem restoration, watersheds, water supply reliability, storage, conveyance, environmental water account and ESA commitments, water use efficiency and conservation, water quality, water transfers, levees, science, governance, and a regional approach to ecosystem / water management. The Framework document described the larger vision for where CALFED needs to move in the future, but did not give details about each recommendation. CALFED also published a Final Programmatic EIS / EIR in July 2000, with a Final Record of Decision (ROD) following in August.

CALFED is also developing a Water Management Strategy to improve water supply reliability that recognizes the variability of water supply and demand in California. The objective of the Water Management Strategy is to reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system.

To evaluate the appropriate role of storage in the Water Management Strategy, CALFED initiated the Integrated Storage Investigation (ISI). Through ISI, existing storage investigations by individual CALFED agencies and CALFED-initiated storage evaluations are being coordinated. The ISI is evaluating the relationship between various types of storage and the utility of storage as part of the Water Management Strategy. The ISI also is analyzing the proper mix of groundwater and surface storage facilities, evaluating reoperation of certain hydroelectric power reservoirs, and providing a comprehensive assessment of prioritization of capital fish migration barriers for modification or removal.

One element of ISI is the Surface and Groundwater Conjunctive Management program. The goal of this program is to assist local agencies with improving regional water supply reliability by increasing the coordinated use of surface water and

groundwater. Working cooperatively, local agencies, basin stakeholders, and DWR on behalf of CALFED, are conducting a technical, economic, social, and environmental feasibility evaluation of possible conjunctive management projects within each basin. Full-scale project development and implementation will proceed in basins that demonstrate local approval of feasible alternatives, subject to funding availability. The program has the following principles:

- Local planning process
- Local control of proposed projects
- Voluntary implementation of projects
- Priority for in-basin water needs
- Compensation for out-of-basin transfers
- Basin-wide planning and monitoring

Butte County is receiving financial and technical assistance as part of the ISI Surface and Groundwater Conjunctive Management program.

To partially address water supply reliability, the Governor's Advisory Drought Planning Panel was established under CALFED. The panel members represent local government, water agencies, environmental interests, and other stakeholders. The panel was tasked with development of a *Water Shortage Contingency Plan* focusing on water banking and transfers, groundwater programs, and local partnerships. The document was completed on December 29, 2000.

Water Quality Control Plan

In 1995, the State Water Resources Control Board (SWRCB) published a Water Quality Control Plan for the Bay-Delta, also known as D-1485. This decision includes flow objectives that must be met to ensure water quality in the Bay-Delta. Because there is very little extra water in the Bay-Delta system, there are significant challenges to meeting the flow objectives. Water users throughout the state have expressed concern regarding the potential of water being diverted to meet Bay-Delta water-quality standards to the detriment of their historical use.

The SWRCB published D-1641 in December 1999 to establish policies regarding the responsibilities of water rights holders to meet Bay-Delta standards. D-1641 covered all areas except for the Sacramento Valley. Hearings to receive evidence regarding the course of action in the Sacramento Valley (also known as the SWRCB Phase 8 Hearings) had been scheduled to start on August 8, 2000. However, the SWRCB encourages local parties to develop negotiated settlements independently and bring these settlements to the board. The Phase 8 Hearings were postponed to allow parties

to negotiate independently. Public meetings to be held in early 2001 are intended to establish a timeframe for continuance of the Phase 8 Hearings.

2.2.4 Interstate Issues

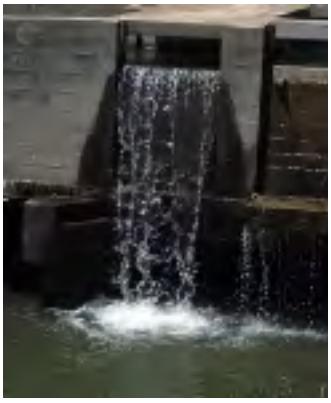
Most interstate issues do not affect Butte County's management of water resources. However, action taken on the Colorado River has the potential to affect the county by increasing water demand on the State Water Project and therefore altering Oroville operations or jeopardizing the county's SWP supply.

Colorado River

The Colorado River flows through seven states in the southwest before entering Mexico and ending at the Gulf of California. The Colorado is both a significant source of water and controversy. The Colorado is divided into an upper basin (New Mexico, Utah, Wyoming and Colorado) and a lower basin (California, Nevada, and Arizona), and both basins have an allocation of 7.5 MAF per year. Conflicts on water allocations within the lower basin have been a constant source of struggle, and have resulted in interstate compacts, a U.S. Supreme Court decision, a treaty with Mexico, and state and federal legislation.

Of the 7.5 MAF annually allocated to the lower states, California has rights to 4.4 MAF of water, plus half the surplus water that is still in the river after traveling through the other states. For many years, California has annually taken up to 800 TAF of water above its 4.4 MAF allocation, which was possible because several upstream states were not using their full allocation. However, population increases in Arizona and Nevada will result in loss of surplus water in California.

While California recognizes the need to reduce use of Colorado River water to 4.4 MAF annually, a grace period of 15 years to gradually lessen dependence has been proposed. The water is shared by several Southern California water districts, including Imperial Irrigation District, Palo Verde Irrigation District, Metropolitan Water District of Southern California, Los Angeles Department of Water and Power, San Diego County Water Authority, and Coachella Valley Water District. These districts will need to find ways to decrease demand through conservation and recycling or find sources of additional water. It is possible that the reduced dependence on Colorado River water will result in a greater dependence on SWP water that is conveyed from Lake Oroville and other sources through the Delta to southern California.



Photograph by Chuck Lowery

2.3 Butte County Water Management Organizations and Plans

Water management within the county involves numerous stakeholders with various interests. As part of the water

inventory process, the objectives and issues of concern of many of the stakeholder groups within the county are described in this section. Additionally, many of the water management tools currently in use are described, including various water management plans and ordinances intended to provide guidance in water resource management.

2.3.1 Butte County Water Management Organizations

Local water resource stakeholders range from Butte County, to water purveyors, to water user groups and watershed conservation organizations. The mission and issues of many of the groups are described in the following sections.

County Agencies

Butte County Department of Water and Resource Conservation

In recognition of the growing number of issues associated with water, the Board of Supervisors voted to elevate the Water Division to a stand-alone department of the county. Through a unanimous vote of the Board of Supervisors, Butte County's Department of Water and Resource Conservation was formed on July 1, 1999. The mission of the DW&RC is to manage and conserve water and other resources for the citizens of Butte County. DW&RC is currently involved in a wide range of activities, including:

- Providing support to the Butte County Water Commission in the implementation of Chapter 33 of the Butte County Code, which is the codified version of the Groundwater Protection Ordinance passed by majority vote at the November 1996 election;
- Developing and expanding the well-monitoring grid for evaluating groundwater levels to avoid third-party impacts;
- Managing Butte County's State Water Project entitlement of 27,500 acre-feet and the contract with the California Department of Water Resources (including the county's water supply contracts with Del Oro Water Company and California Water Service Company);
- Creating an inventory and analysis of Butte County's water resources, including supplies and demands for urban, agricultural, and environmental water now and into the future;
- Providing information for the development of a Butte County Resource Conservation District as proposed by the Board of Supervisors;
- Participating in watershed planning activities with local watershed groups;
- Participating in the DWR's Integrated Storage Investigation (ISI) stakeholder process;

- Maintaining the Butte Basin Water Users Association groundwater flow model under a lease agreement with the Association.

The Department is currently staffed by three employees; future plans are to add a watershed coordinator position through grant funding to coordinate the numerous watershed management efforts underway in the county.

Butte County Department of Public Works
Flood control issues have recently been assigned to the Butte County Department of Public Works, Drainage Section. The Office of Emergency Services provides flood control support to the Public Works Department. The general goal of the flood control program is to obtain the optimum use of water resources of the county while protecting life and property. In addition to the inherent values of flood protection and water conservation, the Public Works Department works to correlate water control projects with urban development plans and protection of prime agricultural lands. The department is currently focusing on flood issues associated with Rock Creek/Keefer Slough in north Chico, the Butte Basin Overflow Area, and the Feather River.

Butte County Water Purveyors and Users

Butte County's water purveyors and users are an integral part of water resource management within the county. The water purveyors of the county provide water for urban, agricultural, and environmental water use. Water purveyors in Butte County are discussed in detail in Section 4. Recognizing that water resources boundaries are not aligned with property and political boundaries, many of the county's stakeholders have formed water management associations to better manage the resource. A description of the largest organization, the Butte Basin Water Users Association, follows.

Butte Basin Water Users Association
Butte Basin Water Users Association (BBWUA) was formed in 1992, in response to the following issues:

- The 1987-92 drought;
- The failure to build additional state and federal water storage facilities to accommodate the state's rapid population growth:
- The publicly expressed opinion that Butte Basin groundwater basin was an underutilized resource; and
- The need to manage Butte Basin's surface water and groundwater resources to ensure that water transfers in or outside the basin do not adversely impact other water users.

The main purpose of the BBWUA is to keep its membership informed of current and potential future changes in local, state, and federal policies that could affect water supplies.

BBWUA was formed by a Memorandum of Understanding between various water suppliers and users in the Butte-Sutter area, which provides an open forum for discussion of mutual concerns regarding water-related issues. Current members of the BBWUA include:

- Biggs-West Gridley Water District
- Richvale Irrigation District
- County of Butte
- California Water Service Company
- Western Canal Water District
- Butte-Sutter Basin Area Groundwater Users Corporation
- City of Biggs
- City of Gridley
- Durham Mutual Water Company

BBWUA contracted with a consulting firm, Hydrologic Consultants, Inc. (HCI), to develop a groundwater model for the service area of the membership. The intended use of the model is to assess the basin groundwater resources, quantify the resources of the basin, and to assess the hydrologic impacts on the groundwater system for various water management alternatives (Hydrologic Consultants, Inc., 1996).

Watershed and Other Environmental Groups

Recent policy and programs encourage local organizations to participate in the identification of concerns and development of solutions for water resource issues in the local community. Following is a description of a cross section of local organizations currently working to manage and enhance the use of water resources within the county. Although these groups have no regulatory power, the Board of Supervisors has chosen to work with them in hopes of generating ideas about alternative ways to manage the resources. The land use and decision-making authority, however, still lies with the Board of Supervisors under the police powers bestowed upon them in the Constitution.

The Big Chico Creek Watershed Alliance
The mission of the Big Chico Creek Watershed Alliance is to "seek to establish a local community-stakeholder partnership effort to develop a unified watershed management process that will promote the protection, enhancement, and stewardship of Big Chico Creek and its tributaries and to provide educational and informational benefits to all interested parties." (Big Chico Creek Watershed Alliance, 2000.)

The Alliance published a watershed management strategy for the watershed in November 2000. The strategy includes the alliance goals, as well as management strategies and recommended actions to meet the goals.

The Butte Creek Watershed Conservancy
The Butte Creek Watershed Conservancy was formed in September 1995 to address headwater issues. It covers the area from the source of Butte Creek, in Lassen National Forest, to Hwy 162. The Lower Butte Creek Project covers the area downstream to the confluence with the Sacramento River on the valley floor. The impetus for formation was the competition for use of the many resources in the watershed and the stakeholder concern that all these benefits should be maintained for enjoyment and use in the future.

The mission statement includes these goals: "The Butte Creek Watershed Conservancy was established to protect, restore, and enhance the cultural, economic, and ecological heritage of the Butte Creek watershed through cooperative landowner action." (Butte Creek Watershed, 2000)

The Conservancy published its *Watershed Management Strategy*, which was available for public comment from September 13 to November 15, 2000. This document is the result of a cooperative approach between various stakeholders to minimize resource conflicts and develop a future management strategy for the watershed.

Little Chico Creek Watershed Group
The Little Chico Creek Watershed Group was formed to look at the water quality issues associated with agricultural and urban use of the creek. This group is working with the county to develop Phase I of their Existing Conditions Report, which includes sections on a stream survey, a fish survey, a land use review and a management plan review. The funding for this project was secured under Proposition 204, Delta Tributaries. The Little Chico Creek Group is also looking to secure funding under Proposition 13 to perform additional water quality monitoring.

Butte Environmental Council
Founded in 1975, the Butte Environmental Council (BEC) is a non-profit corporation devoted to environmental education and information referral services and advocacy. The organization's current water resource focus centers on responsible land use and development coupled with preservation of the environment.

BEC is currently involved with a number of water resource issues within Butte County. Current water quality issues include pesticides in surface waters and groundwater contamination in the Chico area associated with nitrates, solvents, and hydrocarbons. At the local level, BEC is promoting watershed management techniques and assurance of water supply for the local environment and rural domestic water users. On the state level, BEC actively promotes water conservation by all water users within the state (L. Barris, 2000).

Cherokee Watershed Group

The Cherokee Watershed Group began in 1995 with a few farmers in the lower section of the Cherokee Watershed following the 1994 Drought Water Bank. The group formed in order to have a voice in local water issues and to gather and disseminate information more effectively. Cherokee Watershed Group is mainly concerned with water quality, water quantity/supply, protection from groundwater overdraft, and the environmental impacts of mining. The Cherokee Watershed Group feels that the main water resource issue facing Butte County today is CALFED. They are concerned that Butte County and Northern California will bear the burden of Bay/Delta solutions, with potential impacts to aquifers, water supply, and the existing groundwater extraction infrastructure. (G. Cole, 2000)

Durham Library Group (California Communities for Water Protection)

The Durham Library Group (also known as California Communities for Water Protection) is composed of citizens around the areas of Durham, Dayton, and Chico. The Group started meeting in 1997 to address what they considered to be two important issues: 1) an under-consideration of citizens and farmers in water issues and 2) their vision of an unbalanced representation of the public as a whole on the Butte County Water Commission. Durham Library Group concerns itself mainly with issues relating to groundwater and domestic wells. The Group feels that the main water resource issues facing Butte County are the preservation (and discovery) of groundwater recharge areas, the protection of groundwater as a resource for farmers, towns, etc, water quality, and the protection of watersheds. The Group is also concerned that factual and accurate data is used in decision-making, which affects the fate of Butte County water use. (R. Cartwright, 2001)

Sacramento River Conservation Area

The Sacramento River Conservation Area Advisory Council was formed as a part of Senate Bill 1086, which spurred the development of a management plan for the Sacramento River and its tributaries to protect, restore, and enhance fisheries and riparian habitat. The council includes local landowners, state, federal, and local government officials, environmental interests, water suppliers, and representatives of commercial and sports fishery organizations.

In 1989, the council produced the *Upper Sacramento River Fisheries and Riparian Habitat Management Plan*, which included specific actions to improve Sacramento River fisheries and a conceptual plan for riparian habitat. To further develop the riparian

plan, the council published the *Sacramento River Conservation Area Handbook* in 1998; this handbook contained action-oriented plans for riparian habitat in the conservation area (approximately 210,000 acres).

Under the Handbook, a Non-profit Organization (NPO) was developed comprised of 1 landowner and 1 public interest representative from each county within the conservation area, as well as 1 public interest representative appointed by the Secretary of Resources. There are seven counties within the conservation area, and Butte County's representatives are Jane Dolan and Shirley Lewis. There is also a Technical Advisory Committee (TAC) made up of agency representatives appointed by the NPO. (California Department of Water Resources, 1998)

Sacramento River Preservation Trust

The Sacramento River Preservation Trust (SRPT) is a non-profit organization, incorporated in 1984. The organization was formed in response to the Bank Protection project with the purpose of promoting an ecological approach to river preservation. SRPT has since then been working to protect the natural values of the Sacramento River ecosystem. SRPT is a dues-paying organization with 750 members and an elected board. The organization's main water resource areas of interest include wildlife issues (both aquatic and terrestrial), groundwater issues, and water quantity/supply. Within Butte County SRPT has worked with the Butte Creek Watershed project, but the focus of the organization is more regional in scope. SRPT feels that the understanding and proper application of the relationship between surface water and groundwater is the main water resource issue facing Butte County. (J. Merz, 2001)

Valley Water Protection Association

The Valley Water Protection Association (VWPA) began in 1994 after the Drought Water Bank. At that time many were either dependant upon groundwater or saw it as critical and felt that there was no advocate in the area for groundwater. The organization formed in order to be that voice. The VWPA is concerned mainly with water supply and the environmental, political, geographical, and economic impacts of water decisions. Since their organization the VWPA has written many letters of support/concern for various water-related projects like CALFED and other Environmental Impact Reports involving local development. They also played a critical role in petitioning for Measure F, the alternative Groundwater Protection proposition on the ballot in 1996. (L. Cole, 2000)

Photograph from DWR

2.3.2 Water Management Plans

Within Butte County, water ordinances have been approved by county voters, and management plans under state legislation have been prepared to support planning and use of water resources. The following sections describe current ordinances and management

plans within the county.

Local Ordinances

Butte County Groundwater Protection Ordinance (Chapter 33)

In November 1996, Butte County voters approved a groundwater conservation ordinance intended to provide groundwater conservation through local regulation of water transfers outside of the county with a groundwater component. A permit is now required for both exportation of groundwater outside the county and groundwater pumping as a substitute for surface water exported outside the county. A permit for water transfer outside of the county would be denied if the proposed activity would:

- Cause or increase an overdraft of the groundwater underlying the county;
- Bring about or increase saltwater intrusion;
- Exceed the safe yield of the aquifer or sub-basins underlying the county;
- Result in uncompensated injury to overlying groundwater users or other users; or
- Cause subsidence.

Conservation Element of Butte County General Plan

Butte County's General Plan includes a Conservation Element that emphasizes the importance of Butte County's natural resources, and outlines methods to protect these resources. The Conservation Element includes information on the following resources:

- Water, including water conservation, flood control, and water pollution;
- Air pollution;
- Soils, including conservation and erosion;
- Urban encroachment on soils, fisheries, and wildlife;
- Wildlife; and
- Fisheries.

Butte County Well-Spacing Ordinance (Chapter 23B)

This legislation provides minimum procedures for the proper construction of water wells and for the proper destruction of abandoned wells within the county in order to ensure that water obtained from wells within the county of Butte will be suitable for use and will not cause pollution or impairment of the quality of the groundwater within the county.

In addition, this section is intended to reduce potential well interference problems to existing wells and potential adverse impacts to the environment, which could be cause by the construction of new wells or the repair or deepening of existing wells.

Groundwater Management Plans (AB 3030)

Assembly Bill AB 3030 (Groundwater Management Act) was passed in September 1992 and became law in January 1993. The law was enacted because of the lack of coordinated groundwater management in California. Participation in this voluntary program allows local public agencies greater management authority over local groundwater issues.

Groundwater management is defined in DWR's Bulletin 118-80 as:

- "Protection of natural recharge and use of artificial recharge;
- "Planned variation in amount and location of pumping over time;
- "Use of groundwater storage conjunctively with surface water from local and imported sources;
- "Protection and planned maintenance of groundwater quality."

An AB 3030 plan is a groundwater management plan for local agencies whose service area includes all or part of a groundwater basin. The plan outlines the agency's management activities and encourages coordinated management of the groundwater basin.

In Butte County, the following agencies have AB 3030 plans:

- Biggs-West Gridley Water District,
- Butte Water District,
- Richvale Irrigation District, and
- Western Canal Water District.

Urban Water Management Plans (AB 797)

The Urban Water Management Planning Act, passed in 1983, requires urban water agencies to prepare a management plan if they serve more than 3,000 customers, or more than 3,000 acre-feet of water per year. The management plan is a tool for water management planning and must identify water supplies and demands, as well as potential additional supplies to meet future demands. Plans are completed every 5 years. The most recent plans were due on December 31, 2000. A 20-year projection of

demand is included in the plan. The following urban water agencies are required to submit Urban Water Management Plans:

- California Water Service, Chico;
- California Water Service, Oroville;
- Del Oro Water Company;
- Paradise Irrigation District;
- Thermalito Irrigation District; and
- Oroville Wyandotte Irrigation District.

Agricultural Water Management Plans (AB 3616)

The California Agricultural Water Management Planning Act of 1986 (AB 1658) and the Federal Reclamation Reform Act of 1982 historically governed agricultural water management. The Reclamation Reform Act of 1982 required federal water contractors to prepare Water Conservation Plans. AB 1658 focused on opportunities to conserve water or reduce the quantity of saline or toxic drainage water through improved irrigation water management within districts delivering over 50,000 acre-feet of water per year.

Enactment of AB 3616 in 1990 formed a committee that resulted in the development of a list of Efficient Water Management Practices (EWMPs) for agricultural water supplies. Approximately 29 practices have been considered, focusing on irrigation management, physical improvement, and institutional adjustments. The AB 3616 process replaces that contained in AB 1658. Governor Wilson charged the AB 3616 committee with developing a Memorandum of Understanding similar to the urban water management planning process. Water management plans developed under AB 3616 identify water conservation opportunities and set a schedule for implementation. DWR cooperates with many local agencies to implement measures that are potentially included on the list of EWMPs.

Section 3
Physical Setting

Many aspects of the physical setting of Butte County play a role in the hydrologic cycle within the county. The range of topography within the county significantly impacts precipitation patterns. Temperature variations influence whether precipitation falls as rainfall or snowfall, which in turn impacts the timing of surface water runoff. As surface water flows through the county, permeable geologic units recharge the subsurface aquifers. Both surface water and extracted groundwater are used to meet the water demands within the county. Each component of the physical setting described in Section 3 impacts water resources in the county.

3.1 Topography

A valley area, foothill area, and mountain region generally represent Butte County's topography. Of the roughly 1,670 square miles (1.07 million acres) within the county, the valley area accounts for 45 percent, foothills 23 percent and mountains 32 percent of the total area. The valley area is in the west and southwest part of the county. The foothill and mountain regions comprise the eastern and northeastern portion of the county. Figure 3-1 illustrates Butte County topography.

The Vina, West Butte, East Butte and North Yuba Inventory Units lie within the valley area. The Foothill Inventory Unit and the Mountain Inventory Unit represent these respective areas of the county.

Photograph from DWR

The valley area dips gently from the northeast to the southwest, with elevations ranging from less than 100 feet to approximately 300 feet above mean sea level (msl). A notable feature within this region is the Butte Basin. This area lies south of Chico and west of the Feather River. This area is characterized by an expansive, flat topography. South of the Butte County line, the Sutter Buttes provide the only significant topographic relief on the valley floor.

The Foothill Region of Butte County lies between the valley area and the Mountain Inventory Unit. The Foothill Region ranges in elevation from approximately 200 feet msl at the base of the Campbell Hills on the margin of the Sacramento Valley to approximately 4,100 feet msl north of Stirling City where it merges into the Mountain Region.

The Mountain Inventory Unit is the easternmost region in Butte County. Elevation ranges from around 300 feet at the southernmost boundary of Butte County near the confluence of Honcutt and Wilson Creeks to over 7,000 feet in the northeastern part of the county at Humboldt Peak.

3.2 Climate

Butte County has a Mediterranean-like climate with cool, wet winters and hot, dry summers. However, unlike many locations in California, rainfall and winter snowpack in the Sierra Nevada provide Butte County with significant surface water flows and groundwater recharge as water drains through the county.

The temperature varies within the county due to elevation; temperatures are warmer in the valley and cooler in the foothill and mountain areas. Representative climatic data are summarized below with particular reference to two weather stations in the valley area (West Butte and North Yuba Inventory Units) and two stations in the Foothill Inventory Unit.

3.2.1 Precipitation

Average annual precipitation increases from west to east across Butte County, associated with increasing elevations. Moisture-laden weather patterns from the Pacific Ocean travel west to east across California and Butte County during the winter months. Orographic cooling occurs as the moving air mass is forced upward over the Sierra Nevada, resulting in condensation of moisture and precipitation.

Precipitation from orographic cooling is evidenced by the annual rainfall zones for Butte County shown on Figure 3-2. Four weather stations have been selected to provide further detail on both the seasonal variation in precipitation and variation in rainfall and snowfall over different elevations. The four stations are:

Chico University Farm: with records extending up to 94 years through 1999, in West Butte Inventory Unit, elevation 185 feet above msl

Oroville: with records extending 41 years through 1999, in North Yuba Inventory Unit, elevation 171 feet above msl

De Sabla: with records extending 52 years through 1999, in Foothills Inventory Unit, elevation 2,710 feet above msl

Paradise: with records extending 43 years through 1999, in Foothills Inventory Unit, elevation 1,750 feet above msl

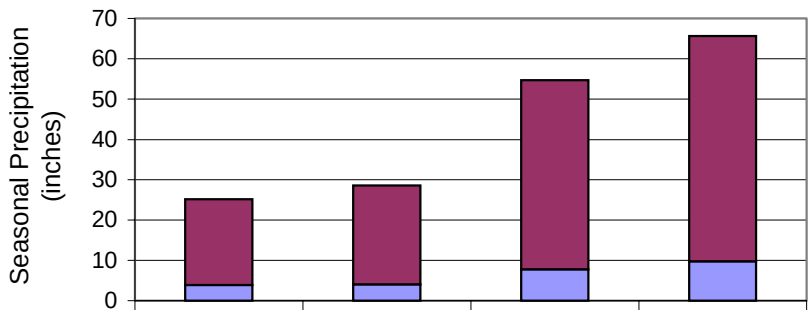
Table 3-1 presents minimums, averages and maximums of annual precipitation and snowfall for the above four stations, illustrating the significant year-to-year variability in rainfall and snowfall in Butte County.

Table 3-1
Annual Precipitation and Snowfall at Four Stations (Inches)

	Chico Univ. Farm	Oroville	De Sabla	Paradise
Precipitation				
Average	25	30	66	54
Maximum	46	60	121	100
Minimum	10	14	22	18
Snowfall				
Average	0.12	0.04	26	3.0
Maximum	4.3	1.3	140	32
Minimum	0	0	0	0

Precipitation is strongly seasonal, occurring generally in the period October through March or April but with about half of the total annual precipitation generally occurring from November through mid-February.

Figure 3-3 Average Precipitation at Four Stations



	Chico Univ. Farm	Oroville	Paradise	De Sabla
winter	21.33	24.56	46.92	55.98
summer	3.83	4.03	7.78	9.71

Table 3-2 depicts the monthly precipitation variability over the period of record for all four stations, while Figure 3-3 illustrates the strong relationship between average precipitation and both winter (October – March) / summer (April – September) seasons and location / elevation.

Table 3-2
Monthly Precipitation at Four Stations (Inches)

Station	Chico Univ. Farm			Oroville			De Sabla			Paradise		
Mo.\Statistic	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
January	5.10	16.97	0.15	5.65	16.29	0.49	13.03	40.06	0.63	11.05	32.29	0.50
February	4.32	14.96	0.08	4.87	14.35	0.20	10.29	29.28	0.42	8.70	25.3	0.29
March	3.51	11.67	0	4.20	14.48	0.04	9.31	27.60	0.30	8.27	27.14	0.98
April	1.80	7.13	0	2.06	6.89	0.02	4.86	14.10	0.01	3.94	11.61	0
May	0.98	4.11	0	0.96	4.20	0	2.34	11.52	0.02	1.76	8.78	0
June	0.47	2.17	0	0.38	1.69	0	0.96	4.04	0	0.70	4.32	0
July	0.02	1.02	0	0.05	1.60	0	0.10	2.67	0	0.09	2.50	0
August	0.10	1.48	0	0.16	1.50	0	0.30	2.23	0	0.29	1.76	0
September	0.46	5.90	0	0.42	3.10	0	1.15	6.73	0	1.00	5.47	0
October	1.29	9.86	0	1.65	11.85	0	3.53	24.15	0	3.03	19.00	0
November	2.88	10.68	0	3.78	10.38	0	8.73	30.22	0	7.43	25.21	0
December	4.23	12.92	2.95	4.41	14.82	0	11.09	34.04	0	8.44	23.15	0

Source: Climate data from Hydrosphere, Boulder Colorado, National Climatic Data Center Summary of the Day - West I volume 10.0

3.2.2 Temperature

In Table 3-3 are shown the average, maximum and minimum monthly mean air temperatures at the same four stations, shown on Figure 3-2, over the periods of record, indicating wide seasonal variability in temperature at each site. Although there is a significant amount of seasonal variability at each site, there is not a substantial difference in temperature between sites at lower and higher elevations. For example, in spite of the difference in elevation of approximately 2,200 feet between Chico University Farm and De Sabla, the maximum difference in monthly average air temperature (which occurs in the summer) is only seven degrees.

Table 3-3
Monthly Air Temperatures at Four Stations (Degrees F)

Station	Chico Univ. Farm			Oroville			De Sabla			Paradise		
Mo.\Statistic	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
January	44.80	53.91	35.7	45.77	54.87	36.70	41.35	51.09	31.58	45.55	53.73	37.38
February	49.50	60.30	38.69	50.57	60.72	40.41	43.95	54.53	33.37	48.36	56.63	40.08
March	53.25	65.53	40.95	54.32	65.29	43.34	46.00	57.31	34.70	50.69	59.67	41.70
April	58.68	72.74	44.60	59.21	72.16	46.22	51.30	64.15	38.45	55.81	66.17	45.44
May	65.77	81.08	50.47	66.56	80.66	52.38	58.17	72.28	44.07	62.92	74.68	51.15
June	73.00	89.67	56.37	73.89	89.58	58.21	65.95	81.41	50.50	71.15	84.08	58.21
July	78.34	96.41	60.23	79.36	96.42	62.31	72.02	89.02	55.01	77.63	91.54	63.70
August	76.42	94.80	58.03	77.47	94.85	60.07	71.01	88.31	53.71	76.58	90.51	62.72
September	71.79	89.49	54.10	72.33	89.04	55.62	66.79	83.38	50.22	71.92	85.01	58.83
October	62.95	78.83	47.12	64.13	79.04	49.20	58.18	72.57	43.78	63.03	74.23	51.83
November	52.54	65.03	40.05	53.44	64.72	42.13	47.39	58.36	36.41	51.74	60.48	42.99
December	45.37	54.84	35.89	46.09	55.08	37.08	41.95	51.76	32.13	45.71	53.90	37.53

Source: Climate data from Hydrosphere, Boulder Colorado, National Climatic Data Center Summary of the Day - West I volume 10.0

3.3 Geology and Soils

Understanding the geology and soils of any area is critical when evaluating water resources. Some subsurface geologic units can act as an aquifer to store groundwater, while other units prevent or restrict the flow of groundwater. Certain surface soils and rock units are permeable, allowing for percolation of water to recharge groundwater. Others have low permeability, restricting groundwater recharge. Understanding how geologic units were deposited and their relationship to surrounding geologic units is the first step to understanding the interaction of surface water and groundwater resources.

DWR Northern District recently completed an evaluation of the geology and hydrogeology of Butte County. In addition to using previous studies and reports, DWR evaluated electrical resistivity logs from oil and gas wells in the area to identify geologic units, water bearing intervals, and to assess the contact between fresh water and saline water in the basin. The electrical resistivity logs provide additional detail not commonly included on well completion reports filed with DWR. The following discussion of the geology and occurrence and movement of groundwater in Butte County summarizes the findings of DWR's recent effort (DWR, 2000). Additional detail on Butte County geology and water bearing units is provided in Appendix A and in DWR's *Butte County Groundwater Inventory Analysis* report, prepared in support of the county's Water Inventory and Analysis Project.

3.3.1 Geologic Features

Butte County covers several geologic regions and a wide range of diverse groundwater bearing units. The county is comprised of a diverse mix of geologic units ranging from very productive water-bearing sedimentary units, to non-water-bearing plutonic and metamorphic rocks. In an effort to display and support better understanding of the groundwater resources of the Sacramento Valley groundwater basin, the DWR developed a series of maps and cross sections illustrating the surface and subsurface geology. The Butte County portions of these maps and sections are presented as Figures 3-4 through 3-7. The following discussion is organized into areas encompassing the inventory units of the Sacramento Valley, Foothill, and Mountain Regions.

The Sacramento Valley Basin (Vina, West Butte, East Butte and North Yuba Inventory Units)

The major groundwater bearing aquifers in Butte County lies within the larger Sacramento Valley groundwater basin. The Sacramento Valley groundwater basin extends south from Red Bluff to the Sacramento-San Joaquin Delta and is bordered by the Coast Range to the west and the Cascade Range and Sierra Nevada to the east. It covers an area of 4,900 square miles. Within Butte County, the Sacramento Valley Region includes the Vina, West Butte, East Butte and North Yuba Inventory Units.

The Sacramento Valley is a structural basin filled with up to 19,000 feet of sediment along the valley axis, west of the present day Sacramento River. These marine and continentally derived sediments have been deposited almost continuously from Late Jurassic time to the present. Of these deposits, older sediments in the basin were emplaced in a marine environment and usually contain saline or brackish groundwater. Younger sediments were deposited under continental conditions and generally contain fresh groundwater. Sediments thin near the margins of the basin exposing the older metamorphic and granitic rocks underlying and bounding the Sacramento Valley sediments.

The marine sediments are Jurassic to Eocene in age. Groundwater contained within these sediments is almost exclusively saline. The oldest of the marine sediments is known as the Great Valley Sequence (JKgvs), which is Jurassic to Cretaceous in age. The Lower Princeton Gorge fill (Tlpg) of Eocene age consists of a mixture of marine sediments and continental material derived from the walls of an eroded sub-marine canyon that was carved into the Great Valley sediments (Redwine, 1972). In most locations, the Lower Princeton Gorge fill is unconformably overlain by the Eocene Ione Formation or the Miocene Upper Princeton Gorge fill.

Following deposition of the Ione Formation, several volcanic eruptions in the Cascade Range produced a series of basalt flows that spread across the valley sediments during the Miocene Period. These flows comprise the hard, black, microcrystalline Lovejoy Basalt. Groundwater, primarily saline or brackish, is transmitted and stored within the secondary porosity created by the fracturing and jointing of the basalt. Either the Upper Princeton Gorge fill or the Neroly Formation overlies the Lovejoy Basalt in most locations. The Miocene age Upper Princeton Gorge fill is widespread throughout the Sacramento Valley, and depending on location, the Upper Princeton Gorge fill may overlie portions of the Lower Princeton Gorge fill, the Ione Formation, or the Lovejoy Basalt. The Upper Princeton Gorge fill is overlain by the Neroly Formation in nearly all locations within the valley. As mentioned above, groundwater within these Jurassic to Eocene age sediments is almost exclusively saline.

Overlying the Neroly Formation are the Pliocene age Tuscan, Tehama and Laguna Formations. In the Sacramento Valley Region of Butte County, fresh groundwater-bearing units include the Tuscan, Laguna, Riverbank and Modesto Formations. Groundwater in these formations largely exists within the primary porosity associated with the spaces between the individual sand and gravel deposits, and within the secondary porosity associated with fractures and jointing of the more competent volcanic rocks.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccias, tuffaceous sandstone, and volcanic ash layers. The Tuscan Formation is described as four separate but lithologically similar units, Units A through D, which in some areas are separated by layers of thin tuff or ash units (Helley and Harwood, 1985). These units are discussed in greater detail in Section 3.5.

The Laguna Formation, also of the Pliocene Period, is composed of continental deposits containing predominantly fine-grained, poorly bedded and compacted sediments. West-flowing rivers and streams draining the Sierra Nevada Mountains deposited the Laguna Formation. These rivers and streams spilled over their banks and spread out across the broad flood plains of the valley depositing eroded material from the Sierra Nevada Mountains. These deposits are composed of a heterogeneous mixture of interbedded alluvial silt, clay and fine sand of granitic and metamorphic origin, with minor conglomerate lenses (Olmsted and Davis, 1961). Clay is more predominate in the fine-grain sediments south of Oroville.

The surface geology of the Sacramento Valley portion of Butte County is comprised primarily of alluvial deposits whose source area is the eroded material derived from surrounding mountain ranges. Along the front of the foothills, alluvial fan and terrace deposits of the Riverbank and Modesto Formations mark the edge of the valley sedimentary units.

The Pleistocene Riverbank Formation (Qr) represents the oldest of the alluvial fan and terrace deposits. It is present in discontinuous surface exposures, primarily from west of Oroville southward. In many places the Riverbank Formation has been covered by more recent alluvial fan development. The thickness of the Riverbank Formation varies from less than one foot to over two hundred feet depending upon location (Helley and Harwood, 1985). The Riverbank Formation primarily overlies the Laguna Formation in the southern portion of Butte County and the Tuscan Formation in the northern portion of the county. Overlying the Riverbank Formation in many locations is the Modesto Formation.

The alluvial fans and terrace deposits of the Pleistocene Modesto Formation were deposited in a similar manner to those of the Riverbank, but mark a more recent period of erosion and deposition, from 42,000 to 14,000 years ago (Marchand and Allwardt, 1981). The terrace deposits of the Modesto Formation are exposed in many of the presently active stream-cut canyons along the foothills. Extending into the valley, Modesto Formation deposits widen into broad fans. As with the Riverbank Formation, the thickness of the Modesto Formation varies from less than ten feet in many of the terraces to nearly two hundred feet across the valley (Helley and Harwood, 1985). The Modesto Formation overlies the Riverbank Formation or Laguna Formation in the southern portion of Butte County, and overlies the Riverbank Formation or Tuscan Formation in the northern portion of Butte County.

Overlying the alluvial fans of the Riverbank and Modesto Formations are the fine silts and clays of the basin deposits (Qb) of Holocene age. Basin deposits are the result of sediment-laden floodwaters that rose above the natural levees of streams and rivers to spread out across vast low-lying areas. Basin deposits are seen primarily in the western and southern Butte County portion of the valley region (Helley and Harwood, 1985). Thickness of the basin deposits vary generally from less than ten feet along the margins of the exposure to more than one hundred feet in the center of the

valley. Basin deposits provide limited quantities of groundwater to shallow wells due to the fine-grained nature of the sediments.

The Foothill Inventory Unit

The Foothill Region occupies the transitional geologic zone between Tertiary sediments in the west part of Butte County and Mesozoic-Paleozoic rocks in the east part of the county. Jurassic and Cretaceous sedimentary rocks outcrop in the northern Foothill Region.

Paleozoic rocks are exposed mainly in the eastern and southern margins of the Foothill Inventory Unit. Resting unconformably on top of the Paleozoic deposits are sedimentary rocks of the Late Mesozoic Era. These older sediments are seen in outcrops above Little Chico, Big Chico and Butte Creek drainages.

Overlying the Late Mesozoic marine deposits are a series of Tertiary age continental deposits. The major unit exposed in the northern and western part of the Foothill Region is the Tuscan Formation, which was deposited as a series of mudflows originating from ancient, eroded volcanoes of the Cascade Range. Other Tertiary units in the Foothill Region consist of older, undifferentiated andesites and basalts.

Quaternary deposits situated on the western margin of the Foothill Region consist of the Modesto Formation and alluvium. These sediments were deposited along the streams and creeks draining the Foothill Inventory Unit, creating stream terraces and alluvial fans with thickness ranging from one foot to 200 feet. The Modesto Formation is widespread throughout the Sacramento Valley, occurring from Redding south into the San Joaquin Valley, especially along the Sacramento and Feather Rivers. The Modesto Formation is exposed along the upper reaches of Butte Creek in the northern part of the Foothill Inventory Unit.

The major geologic fault structure in the Foothill Inventory Unit is the Foothill Fault system. The Foothill Fault system includes the Cohasset Ridge Fault, the Magalia Fault, and a mapped, but as yet unnamed, fault located south of Magalia. These faults are included in a system of northwest trending, steeply east-dipping to vertical faults that have experienced up to 100 feet of movement.

The Mountain Inventory Unit

The Mountain region is the easternmost region in Butte County. Mesozoic and Paleozoic age plutonic, volcanic, and metamorphic rocks make up the majority of the surface and subsurface geology. Other geologic formations consist of Tertiary volcanic sediments, including the Tuscan formation, exposed in the northern part of the Mountain Inventory Unit.

Primary porosity is virtually non-existent in the Mesozoic and Paleozoic rocks due to the amount of cementation, consolidation, crystallization, or metamorphism that has occurred.

The Tuscan Formation in the Mountain Region was deposited as a series of mudflows, or lahars, over a period of about one million years and extends from east of Redding to west of Oroville, and from the Sierra Nevada Cascade Range into the subsurface about 5 miles west of the Sacramento River (Page, 1986). The formation generally ranges in thickness from about 1,700 feet in the east to approximately 300 feet at the westward extent.

Plutonic, volcanic, and metamorphic rocks of Mesozoic and Paleozoic age are found throughout the Mountain Region. Paleozoic rocks were deposited during periods of volcanic activity and then metamorphosed due to tectonic compression and contact metamorphism.

Plutonic rock demarcates the boundary between the Sierra Nevada and the Cascade Range to the north, and generally coincides with the divide of the Feather River drainage. The limited amount of groundwater encountered in this type of geologic environment is derived primarily through secondary porosity associated with fracturing and jointing.

3.3.2 Soils

There are seven basic soil categories represented in Butte County, as illustrated by Figure 3-8. The soils associated with the valley area and alluvial fans of Butte County are deep, nearly level, very fertile, and support agricultural practices. The Butte Basin was, prior to the implementation of flood control on the Feather and Sacramento Rivers, an area of extensive seasonal flooding. Early reports depict a slow-moving sea of water covering from 30 to nearly 150 square miles (Bryan, 1923). This slow-moving floodwater deposited the fine clay that now provides the rich agricultural soil utilized primarily for rice production.

The soils associated with the foothills can be characterized as shallow, gentle to steep sloping, less fertile, and residual. The high mountain area soils are shallow to deep, moderate to steep sloping, residual. They support forestry and wildlife habitat and also include rangeland.

3.4 Hydrogeology

Figures 3-4 through 3-7 detail the range and extent of geologic units within Butte County. Of the various geologic units described, the main hydrogeologic unit and source of groundwater in Butte County is the Tuscan Formation. Other units that supply lesser amounts of groundwater to Butte County are the Laguna, Riverbank and Modesto Formations. In addition, fractures in terrace deposits in the foothill region are a source of groundwater in that area and contribute to the recharge of aquifers in the valley.

The water bearing units (aquifers) both store and transmit water in the subsurface. As a general rule, the direction of groundwater flow generally follows the local

topography, but groundwater always flows from areas with higher hydraulic head to areas of lower hydraulic head. The hydraulic head elevation is determined through the measurement of the water level in monitoring wells. The measured water level represents the hydraulic head in the aquifer at the average depth interval of the well screen. A comprehensive monitoring network must be maintained and monitored to accurately assess the direction of groundwater movement.

The specific storage of an aquifer represents the volume of water that can be taken into or released from storage per unit volume of aquifer per unit change in head (Fetter, 1994). Calculation of the volume of water in storage requires knowledge of the average specific yield, thickness of aquifer and area of the aquifer. Similar to the method for evaluating the direction of movement of groundwater, a comprehensive monitoring well network is the backbone of a program intended to monitor groundwater in storage. Data collected through monitoring can be used to evaluate if groundwater extraction exceeds the safe yield of the aquifer.

The following sections describe the principle water bearing units, water levels and trends in storage within the county. Further detail is provided in Appendix A and DWR's *Butte County Groundwater Inventory Analysis* report prepared in support of Butte County's Water Inventory and Analysis Project. Relating to the geology and water bearing formations discussed here, the infrastructure of the county's domestic, municipal and agricultural water wells is discussed in Section 4.

3.4.1 The Sacramento Valley Basin (Vina, West Butte, East Butte and North Yuba Inventory Units)

Photograph by Chuck Lowery

The Sacramento Valley Basin includes the Vina, West Butte, East Butte and North Yuba Inventory Units, as shown on Figure 1-2. Discussion of principal water bearing units, groundwater levels, groundwater movement and specific storage within the Butte County portion of the Sacramento Valley Basin follows. Additional detail is provided in Appendix A and DWR's *Butte County Groundwater Inventory Analysis* report.

Fresh Water Bearing Units

On a regional scale, the base of post-Eocene continental deposits is commonly considered the approximate base of fresh groundwater in the Sacramento Valley (Page, 1974). The base of freshwater is defined by water with a specific conductance of less than 3,000 micromhos per centimeter, water with a specific conductance that exceeds 3,000 micromhos per centimeter is considered to be saline. The approximate depth at the deepest portion of the aquifer to the base of fresh water within each of the inventory units is:

- Vina Inventory Unit 1,600 feet
- West Butte Inventory Unit 1,500 feet
- East Butte Inventory Unit 1,400 feet
- North Yuba Inventory Unit 600 feet

The existing water well infrastructure within Butte County, as described in Section 4, generally consists of wells completed to the depth necessary to produce adequate volumes of groundwater to meet the intended use. As a result, the majority of domestic wells within the county have been completed in the upper 200 feet of the aquifer. Ninety percent of the agricultural and municipal wells are completed in the upper 600 feet and 750 feet of the aquifer, respectively.

In the Sacramento Valley Region of Butte County, fresh groundwater-bearing units include the Tuscan, Laguna, Riverbank and Modesto Formations. Groundwater in these formations largely exists within the primary porosity associated with the spaces between the individual sand and gravel deposits, and within the secondary porosity associated with fractures and jointing of the more competent volcanic rocks. The Riverbank and Modesto Formations yield water to the shallower domestic wells, while the Tuscan, Laguna, and Tehama Formations are the sources of water for deep irrigation and municipal wells.

Tuscan Formation

The Tuscan Formation is described as four separate but lithologically similar units, Units A through D (Helley and Harwood, 1985). Unit A consists of the oldest deposits of the Tuscan Formation and is about 250 feet thick. Units B and C are about 600 feet thick each and overly Unit A in most locations in Butte County. Unit D is the youngest unit and is not exposed in Butte County. The total thickness of the Tuscan Formation is approximately 1,450 feet in Butte County. Groundwater in the Sacramento Valley portion of Butte County is contained primarily within the two lower units of the Tuscan Formation, Units A and B.

Tuscan Formation groundwater in the Sacramento Valley Region is contained primarily within the pore spaces of the reworked sand and gravel layers. Much of the groundwater in the Tuscan Formation is confined under pressure by layers of impermeable clays, lahars or tuff breccia. The permeable layers of the Unit B sediments compose the main aquifer material for groundwater storage in the valley. The fine-grained, consolidated lahars of Unit C form thick, low permeability confining layers for groundwater contained in the more permeable sediments of Unit B.

Utility pump test results from 2,662 pump tests on 944 wells revealed an average well yield ranges from a low of 976 gallons per minute (gpm) in the North Yuba Inventory Unit, to a high of 1,395 gpm in the Vina Inventory Unit. Specific capacities for the

valley inventory units ranged from a low of 48 gpm per foot in the North Yuba Inventory Unit to a high of 87 gpm per foot in the Vina Inventory Unit. Additional information from California Water Service wells in the Chico indicates well yields ranging between 900 and 3,000 gpm (DWR Bulletin 118-6, 1978).

Transmissivity values within the Butte Basin portion of the East and West Butte Inventory Units ranged from 97,000 to 182,000 gallons per day (gpd) per foot. Storativity values ranged from .0003 to .0015. Specific capacity measurements made for wells reported in a previous study provided a range of 45.7 to 104.7 gpm per foot of drawdown (DWR Memorandum Report, 1991).

Laguna Formation

Exposure of the Laguna Formation is discontinuous and extends from Oroville southward to Lodi. The thickness of the Laguna Formation is difficult to determine because the base of the unit is rarely exposed. Estimates of the maximum thickness range from 180 feet (Helley and Harwood, 1985) to 1,000 feet (Olmsted and Davis, 1961).

Quantitative water-bearing data for the Laguna is very limited, especially in the Butte County area. Wells completed in the finer-grained sediments of the Laguna Formation yield only moderate quantities of water. Well yield data from the Sacramento-American River area indicate yields as high as 1,000 gpm, with specific capacities values ranging between 24 and 42 gpm per foot of drawdown (Olmsted and Davis, 1961). In areas where soft, well-sorted granitic sand dominates, well yields are much higher. Some of the sand aquifers are highly permeable, but the average permeability is low to moderate. In the Gridley area, a sand unit that is stratigraphically equivalent to the Laguna Formation was reported to have a specific capacity of 60 gpm per foot of drawdown (Olmsted and Davis, 1961).

Riverbank Formation

The Riverbank Formation consists of gravel, sand, and silt eroded from the surrounding Coastal, Klamath, Cascade and Sierra Nevada Mountain Ranges and deposited in the Sacramento Valley. Exposures of the Riverbank Formation within Butte County are observed primarily west of Oroville and southward. Thickness of the Riverbank Formation ranges from less than one foot to over 200 feet depending on location.

The thickness of the Riverbank Formation can be a limiting factor to the water-bearing capabilities of the formation. The Riverbank Formation is moderately too highly permeable and yields moderate quantities of water to domestic and shallow irrigation wells. It also provides water to deeper irrigation wells that have multiple zones of perforation. Well yields are higher in areas where concentrations of gravel and sand are present. Groundwater occurs generally under unconfined conditions.

Modesto Formation

The Modesto Formation consists of gravel, sand, and silt. The most notable occurrences are found along the Sacramento and Feather Rivers. Similar to the Riverbank, the Modesto Formation ranges in thickness from less than ten feet in many of the terraces and along the margins of the valley to nearly two hundred feet across the valley floor (Helley and Harwood, 1985).

Like the Riverbank Formation, the thickness of the Modesto Formation limits the water-bearing capabilities of the formation. These deposits provide water to domestic and shallow irrigation wells as well as to deeper wells with multiple zones of perforations. In locations where gravel and sand predominate, groundwater yields are moderate. Lesser yields are found in areas with high silt and clay content. Groundwater occurs generally under unconfined conditions.

Groundwater Levels

Groundwater level monitoring in the Sacramento Valley portion of Butte County is currently being conducted by a number of different private and public agencies. Historically, the DWR has maintained the most comprehensive, long-term groundwater level monitoring grid, with from 50 to 180 different wells monitored over the last 50 years in the Sacramento Valley portion of Butte County. Since 1997, Butte County and DWR have coordinated water level monitoring efforts.

Summary results of this work are presented in the DWR's *Butte County Groundwater Inventory Analysis* report. This shows that seasonal fluctuation of groundwater levels in the unconfined portion of the aquifer system averages between 3 to 5 feet during years of normal precipitation, and 7 to 9 feet during periods of drought. The annual fluctuation of groundwater levels in the confined or semi-confined portion of the aquifer system averages about 10 feet during periods of normal precipitation and about 20 feet during times of drought.

Review of the hydrographs for long-term comparison of spring-to-spring groundwater levels indicates a decline in groundwater levels associated with the 1976-77 and 1986-94 droughts, followed by a recovery in groundwater levels to pre-drought conditions of the early 1970's and 1980's. Valley-wide comparison of spring-to-spring groundwater level data also indicate that there has been very little change in groundwater levels in most areas of valley since the 1970's and 1980's. However, further long-term comparison of spring-to-spring groundwater levels from the 1950's and 1960's with today's levels indicates a trend of slightly declining groundwater levels in some areas of the West Butte and Vina Inventory Units.

Groundwater hydrographs for the California Water Service Company (CWSC) monitoring wells in the vicinity of Chico were developed by DWR using static groundwater level data collected and provided by CWSC. These indicate a rather uniform seasonal fluctuation of 15 to 20 feet during normal years. During drought years, there tends to be a wider range of fluctuation depending upon the individual

well. Many wells show little or no seasonal change between wet, normal, and dry years, whereas other wells show large differences. The wide range of responses is probably due to the wide range of operational scenarios that can be imposed upon these active production wells.

Figure 3-9 is a groundwater elevation contour map for the spring of 1997, prior to the annual period of agricultural use of groundwater. Spring groundwater levels are commonly the highest of the year and, in areas unaffected by municipal use of groundwater, reflect the natural groundwater table distribution and direction of movement. Figure 3-9 shows that the spring groundwater levels vary from an elevation of about 60 feet in the Butte Sink Inventory Unit, to about 170 feet above msl in the Northeastern part of the Vina Inventory Unit.

Figure 3-10 shows the seasonal change in groundwater levels between the spring and summer of a normal water year. The contour lines in Figure 3-10 represent lines of equal groundwater change between the spring and summer measurement periods. These show that the seasonal decline in groundwater level for a normal year in the Sacramento Valley region of Butte County ranges from zero to 30 feet. No change was identified in the southeastern portion of the East Butte Inventory Unit where limited groundwater extraction is balanced by deep percolation of applied surface waters and lateral inflow of groundwater.

The areas of greatest groundwater level decline are those where groundwater is extracted for agricultural and/or municipal use during the summer months. These areas include portions of the Vina and North Yuba Inventory Units, the Durham area of the West Butte Inventory Unit, and the Cherokee Strip portion of the East Butte Inventory Unit. However, hydrographs indicate that decreases in water level are seasonal and the basin groundwater typically recharges during the winter months.

In general, wells in the southern portion of the county (East Butte Inventory Unit) show less seasonal fluctuation than those in the northern county (West Butte and Vina Inventory Unit) largely because of recharge of the upper aquifer system from applied surface-water and limited agricultural use of groundwater from the middle and lower aquifer system in the southern area.

Wells constructed in unconfined parts of the aquifer system tend to show less seasonal fluctuation in groundwater level than those in the lower, confined aquifer system because of the greater interconnection between the shallow groundwater and the surface-water systems.

Groundwater Movement

The direction of groundwater movement is illustrated in Figure 3-9 by a series of small arrows perpendicular to the groundwater elevation contours. The overall pattern of groundwater movement during spring is southwesterly toward the Sacramento River. North of Princeton, the Sacramento River is a gaining river with

net inflow from the valley aquifer system. In this reach, the river acts as a drain being recharged by groundwater from the valley aquifer system. South of Princeton, surface-water flows from the Sacramento River recharge the groundwater system along most of its course through the south Sacramento Valley. In other parts of the valley, the general direction of groundwater flow is toward Butte Creek and away from the Feather River.

Locally, the movement of groundwater varies. As indicated in Figure 3-9, there is a groundwater mound just south of the Thermalito Afterbay that is associated with recharge from that facility, and another just west of Hamilton City, associated with the Stony Creek Fan. Isolated areas of groundwater depression are located in the City of Chico resulting from year-around pumping of groundwater for municipal use. A more widespread depression is in the southwest portion of the North Yuba Inventory Unit.

An interesting flow pattern is also present in the southeastern corner of the East Butte Inventory Unit. In this area, groundwater flow converges toward the Butte Sink Inventory Sub-Unit from the Sacramento River to the west and the basin to the east. The valley sediments, deformed by the intrusion of the Sutter Buttes and the buried Colusa Dome, west of the Sutter Buttes, partially control groundwater flow in this area. The Sutter Buttes block the general north-to-south trend of groundwater migration, forcing groundwater to the surface. The upward movement results in a shallow groundwater table and the formation of wetlands along the west side of the Sutter Buttes.

Groundwater in Storage

Change in groundwater storage is dependent upon many factors including climatic conditions, the annual rate of groundwater extraction and the annual rate of groundwater recharge. Groundwater storage commonly fluctuates within a given year and from year to year. During periods of drought, groundwater in storage will typically decline and during periods of above normal precipitation, groundwater in storage will typically increase. Within the same year, groundwater in storage will decline through the summer months as groundwater is extracted for municipal and agricultural use, then recover as extraction slows and seasonal precipitation increases recharge.

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. 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.

Changes in spring-to-spring storage in subsequent years are shown as cumulative change, and are calculated based on the difference between groundwater levels during the 1980 base-year and the spring of a given year. Additionally, the corresponding average change in the groundwater level resulting from changes in storage is shown. However, actual changes in groundwater level at any specific location could vary significantly from conditions such as localized groundwater extraction. Figure 3-11 depicts the twenty-year trend in groundwater storage for the Sacramento Valley portion of Butte County. Figures 3-12 through 3-15 provide detail of the groundwater storage trend within the Vina, West Butte, East Butte and North Yuba Inventory Units, respectively.

The groundwater in storage trend for the Sacramento Valley portion of Butte County, shown on Figure 3-11, indicates slightly more groundwater in storage preceding the drought (1987) than in 1980, followed by less groundwater in storage during the drought (1988-1994). Then, most importantly, a rapid recovery of approximately 100,000 acre-feet in the first year (1995) following the drought to a volume exceeding that in storage immediately prior to the drought. The aquifer appears to be very responsive when an adequate volume of recharge is available.

The amount of groundwater in storage during the spring of 2000 is about 15,000 acre-feet greater than that of 1980, indicating the groundwater aquifer is not in a state of decline. The range of groundwater storage, between the peak in 1983 and the low in 1991, is estimated at 200,000 acre-feet.

Figures 3-12 and 3-13 for the Vina and West Butte Inventory Units, respectively, indicate a similar pattern of change in spring-to-spring groundwater storage as the pattern described above for the whole valley section of Butte County. Within the Vina Inventory Unit shown on Figure 3-12, the range of spring to spring groundwater storage change, between the peak in 1983 and the low in 1991, is estimated at about 83,000 acre-feet. The amount of groundwater in storage, in the Vina Inventory Unit, during the spring of 2000 is about the same as during the spring of 1980.

Within the West Butte Inventory Unit, shown on Figure 3-13, the range of spring to spring groundwater storage change, between the peak in 1983 and the low in 1991, is estimated at about 66,000 acre-feet. Overall, Figure 3-13 shows that the amount of groundwater in storage, in the West Butte Inventory Unit, during the spring of 2000 is about 12,000 acre-feet less than the spring of 1980.

Estimated cumulative storage in the East Butte Inventory Unit, shown in Figure 3-14, ranged from 30,500 acre-feet less than the 1980 datum in 1987-88, to a 22,800 acre-feet above the 1980 datum in 1997-98. A significant decline in average cumulative storage is not observed during the 1988-1994 drought period within the East Butte Inventory Unit area. The amount of groundwater in storage during the spring of 2000 is about 12,000 acre-feet more than the spring of 1980.

Similar to the East Butte Inventory Unit, a significant decrease in average cumulative storage is not observed in the North Yuba Inventory Unit, shown in Figure 3-15, during the drought period. A general upward trend in groundwater in storage began in 1993. The amount of groundwater in storage during the spring of 2000 is about 17,400 acre-feet more than during the spring of 1980.

3.4.2 The Foothill Region

The Foothill Inventory Unit is a recharge area for the Butte County portion of the Sacramento Valley groundwater basin aquifer. Groundwater recharge occurs in the form of precipitation and deep percolation of runoff from nearby creeks, streams and reservoirs. Following is a summary of the hydrogeology in the Foothill Inventory Unit, focusing on the fresh groundwater bearing units of the region.

Fresh Groundwater Bearing Units

The Tuscan Formation is the major source of groundwater in the Foothill Region. Lesser amounts of groundwater are found in the Modesto Formation, which is a localized source of groundwater and supplies moderate amounts of water to shallow wells.

Tuscan Formation

The Tuscan Formation is the major source of groundwater in the Foothill Region. Groundwater occurs in the fractures and joints of the volcanic mudflows, as well as in the weathered horizons between buried mudflows (Slade, 2000).

The Tuscan Formation exposed in the Foothill Region acts as a recharge area for the aquifer system in the Sacramento Valley. Groundwater recharge occurs in the form of precipitation and deep percolation of runoff from nearby creeks, streams, and reservoirs. Aquifers intercepted by wells in this region are generally unconfined, with groundwater levels reflecting rainfall patterns. However, in the foothill region, aquifer specific yields are much lower than those in the Sacramento Valley.

Modesto Formation

In areas where silt and clay predominate, permeability of the Modesto Formation is variable and well yields are limited. In locations where gravel and sand predominate, groundwater yields to domestic wells are higher. Groundwater in the Modesto Formation occurs under unconfined conditions.

Groundwater Levels

Adequate data does not exist to characterize regional groundwater levels within the Foothill Inventory Unit.

Groundwater Movement

Although there is not sufficient data to determine the direction or velocity of groundwater movement, groundwater generally follows the contour of the

topographic surface. In the Foothill Region, this can be interpreted as groundwater flowing from high to low elevations, following drainages toward the center of the valley, where it tends to track the course and direction of the Sacramento River.

The northwest-southeast trending Magalia Fault may act as a barrier to groundwater movement from the upgradient northeast side to the downgradient southwest side.

Groundwater in Storage

Adequate data does not exist for calculation of groundwater in storage within the Foothill Inventory Unit.

3.4.3 The Mountain Region

Only the Tuscan Formation, located in a small northwestern segment of the Mountain Region, is considered to act as a groundwater bearing unit. Although the Tuscan Formation is the main groundwater bearing unit for the Foothill Inventory Unit and the Sacramento Valley Region, in the Mountain Inventory Unit it is tightly cemented and consolidated and supplies only limited amounts of water. Where groundwater does occur, it is limited to the fractures and joints within the volcanic mudflows and breccias.

Although groundwater is encountered in the Ione Formation (sandstone and siltstone in the southwest part of the region), the quality is brackish. In general, the limited amount of fresh groundwater encountered in the Tertiary sediments is associated with secondary porosity.

Although there are no data to determine the direction or velocity of groundwater movement, groundwater can be assumed, in general, to follow the contour of the topographic surface. In the Mountain Region, this can be assumed in general to follow from high to low elevations, following drainages toward the center of the valley where the groundwater tends to track the course and direction of the Sacramento River.

3.5 Surface Water Hydrology

Photograph from DWR

The following description of surface water flow structures, management and quantities is generalized and relative. More specific information is provided in a DWR-Northern District 1993 memorandum (Department of Water Resources, Northern District, *Butte and Sutter Basins*, June 15, 1993).

3.5.1 Surface Water Sources and Channels

Figure 3-16 shows the principal entry points to Butte County for surface water, and the major channels, natural

and modified, by which it flows through the county.

The principal waterways originating outside the county are:

- The Sacramento River (conveyance of Central Valley Water Project allocations from Lake Shasta)
- The Feather River (the North, Middle and South Forks originate outside the county and, together with the West Branch, supply water to Lake Oroville with a portion of flow routed through the Thermalito forebay and afterbay facilities to generate hydropower and deliver irrigation water supply, with the remaining water returning to the Feather River)
- Big Chico Creek
- Butte Creek
- Pine Creek

Runoff and groundwater flows within the county contribute to the flows in the above waterways and also to those arising within the county. These include:

- The West Branch of the Feather River (which joins the forks originating outside the county and supplies water to Lake Oroville and then to the Thermalito forebay and afterbay)
- Little Chico Creek
- Rock Creek
- Dry Creek
- Little Dry Creek
- Clear Creek
- Angel Slough
- Wyandotte Creek
- Honcutt Creek

The above waterways are shown on Figure 3-16, which includes the major streams and water supply and drainage features in the county.

From the Thermalito afterbay, water is distributed to multiple users by canals. Water from the West Branch of the Feather River is diverted to the Toadtown Canal for power generation by PG&E. The Butte Canal carries Toadtown Canal and Butte Creek water to the De Sabla power plant forebay. Hydropower is also generated at several

other locations. Operations at all of these sites affect the timing of water releases. At Oroville-Thermalito, Toadtown and De Sabla-Centerville, water for power generation is transferred from the Feather River drainage to the Butte Creek drainage basin.

3.5.2 Surface Water Flows

Surface water flows in Butte county are, as for the Sacramento basin as a whole, extremely variable, both seasonally and annually. Their partial dependence on annual snow melt tends to mitigate the seasonal variability.

Annual Flows and Variability

A good indicator of annual surface flow variability in the region is the Sacramento River Water Supply Index. This is a regional indicator of surface flow for the northern Sacramento Valley. It incorporates the sum of the unimpaired monthly runoff measured at the Sacramento River at Bend Bridge, the Feather River inflow to Lake Oroville, the Yuba River at Smartville and the American River inflow to Folsom Lake. Unimpaired runoff represents the natural water production of a river basin unaltered by upstream diversions, storage, and export of water to or import of water from other basins. The Index is the sum of 40 percent of the current April through June flow, 30 percent of the current October through March flow and 30 percent of the index for the previous water year. Based on the calculated runoff in million acre-feet, each year of the index is then classified as wet, above normal, below normal, dry or critical. Figure 3-17 shows the Sacramento River Index annually since 1906 and the classification range for each type-year.

From Figure 3-17, it can be seen that the just-completed five water years comprise the longest continuous period of above average flows in the period of record but were preceded by an eight-year period of mostly dry and critical years.

Table 3-4 presents summary monthly flow data at streamflow measurement sites, the locations of which are shown on Figure 3-16.

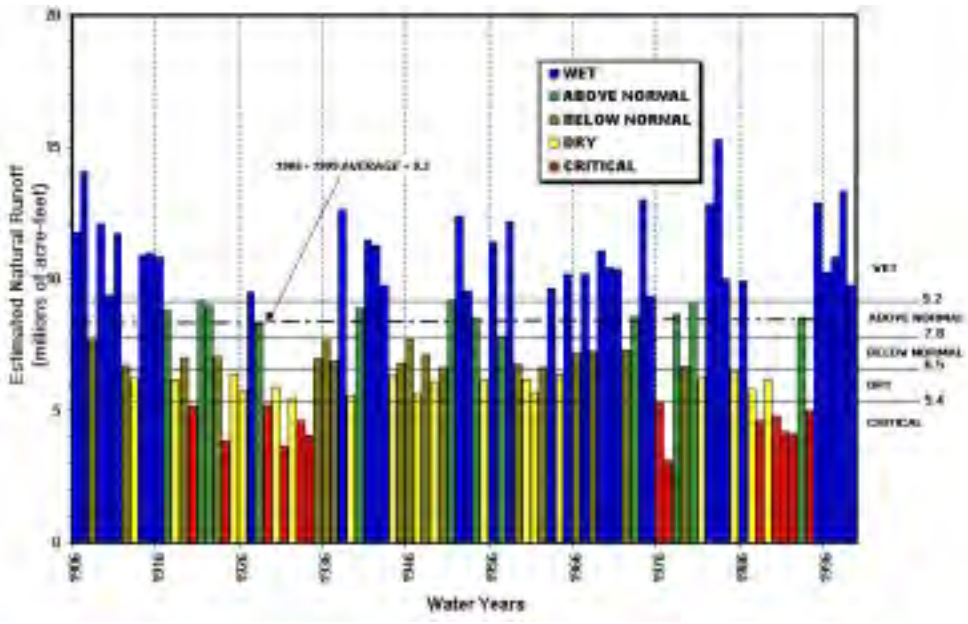
Table 3-4 County Surface Water Inflows (cfs)		
Month	**Big Chico Creek Near Chico, CA**	**Butte Creek Near Chico, CA**
January	165	347
February	197	416
March	164	389
April	111	343
May	45	254
June	22	145
July	14	84
August	12	67
September	12	60
October	18	70
November	42	114
December	109	228
Period	30 - 86	30-01
Mean Monthly cfs	76	209
Max.Monthly cfs	760	1474
Min.Monthly cfs	7	23

From Table 3-4, it can be inferred that:

- For Big Chico Creek, over the 57-year period of record, the wide variability of flow is illustrated by the fact that the sole-maximum-month-to-mean ratio was 10.0 and the mean-to-sole-minimum-month ratio was 10.2; the maximum month occurring in January 1970 and the minimum in August 1931.

- For Butte Creek, over the 72-year period of record, the somewhat reduced but very significant variability of flow is shown by the sole-maximum-month-to-mean ratio of 7.0 and the mean-to-sole-minimum-month ratio of 9.0; the maximum month occurring in February 1986 and the minimum in August 1931.

From Figure 3-18, where the period of record is adequate, it shows that the maximum and near-maximum monthly flows occur generally in the period January - April and the minima and near-minima occur in the period July - September. This is a similar pattern to that of precipitation as shown in Table 3-2.



(Source: Department of Water Resources)

Figure 3-17 - Sacramento River 40-40-30 Water Supply Index

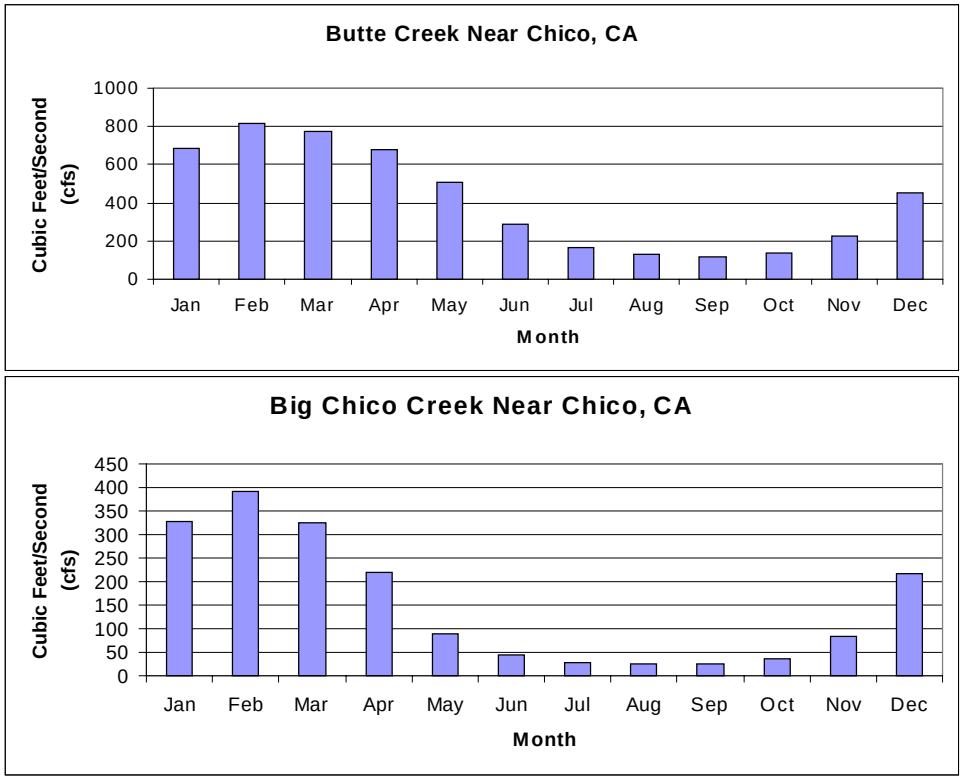


Figure 3-18
Variability of Monthly Average Flow

Surface Water Storage

Butte County has numerous water storage reservoirs within the county boundaries. DWR Bulletin 17 provides information on 24 dams in Butte County, which fall under the jurisdiction of DWR's Division of Dam Safety (DWR, Bulletin 17, June 1993). Table 3-5 lists dams within Butte County within jurisdiction of the Division of Dam Safety, including information on the dam name, owner, year completed, stream dammed and storage capacity.

Table 3-5
Butte County Dams Under Division of Dam Safety Jurisdiction

Name	Owner	Year Completed	Stream	Storage Capacity (Acre-Ft.)
Al Chaffin	George Chaffin	1957	Cottonwood Creek Tributary	450
California Park	California Park Homeowners Association	1986	Dead Horse Slough	335
Cannon Ranch	Spring Valley Minerals	1870	Oregon Gulch Tributary	176
Concow	Thermalito Table Mountain Irrigation District	1925	Concow Creek	8,600
Desabla Forebay	Pacific Gas and Electric Company	1903	Middle Butte Creek	280
Feather R Hatchery	State Department of Water Resources	1964	Feather River	580
Forbestown Division	Oroville Wyandotte Irrigation District	1962	South Fork Feather River	358
Grizzly Creek	Mr. & Mrs. Ronald T. Dreisbach	1964	Grizzly Creek	76
Kunkle	Pacific Gas and Electric Company	1907	West Branch Feather River Tributary	253
Lake Madrone	Lake Madrone Water District	1931	Berry Creek	200
Lake Wyandotte	Oroville Wyandotte Irrigation District	1924	North Honcut Creek	1,300
Lost Creek	Oroville Wyandotte Irrigation District	1924	Lost Creek	5,680
Magalia	Paradise Irrigation District	1918	Little Butte Creek	2,900
Miners Ranch	Oroville Wyandotte Irrigation District	1962	North Honcut Creek Tributary	912
Oroville	State Department of Water Resources	1968	Feather River	3,537,577
Paradise	Paradise Irrigation District	1957	Little Butte Creek	11,500
Philbrook	Pacific Gas and Electric Company	1926	Philbrook Creek	5,180
Poe	Pacific Gas and Electric Company	1959	North Fork Feather River	1,150
Ponderosa Division	Oroville Wyandotte Irrigation District	1962	South Fork Feather River	4,750
Round Valley	Pacific Gas and Electric Company	1877	West Branch Feather River	1,147
Sly Creek	Oroville Wyandotte Irrigation District	1961	Lost Creek	65,050
Thermalito Ab	State Department of Water Resources	1967	Feather River Tributary	57,041
Thermalito Division	State Department of Water Resources	1967	Feather River	13,328
Thermalito Fb	State Department of Water Resources	1967	Cottonwood Creek Tributary	11,768

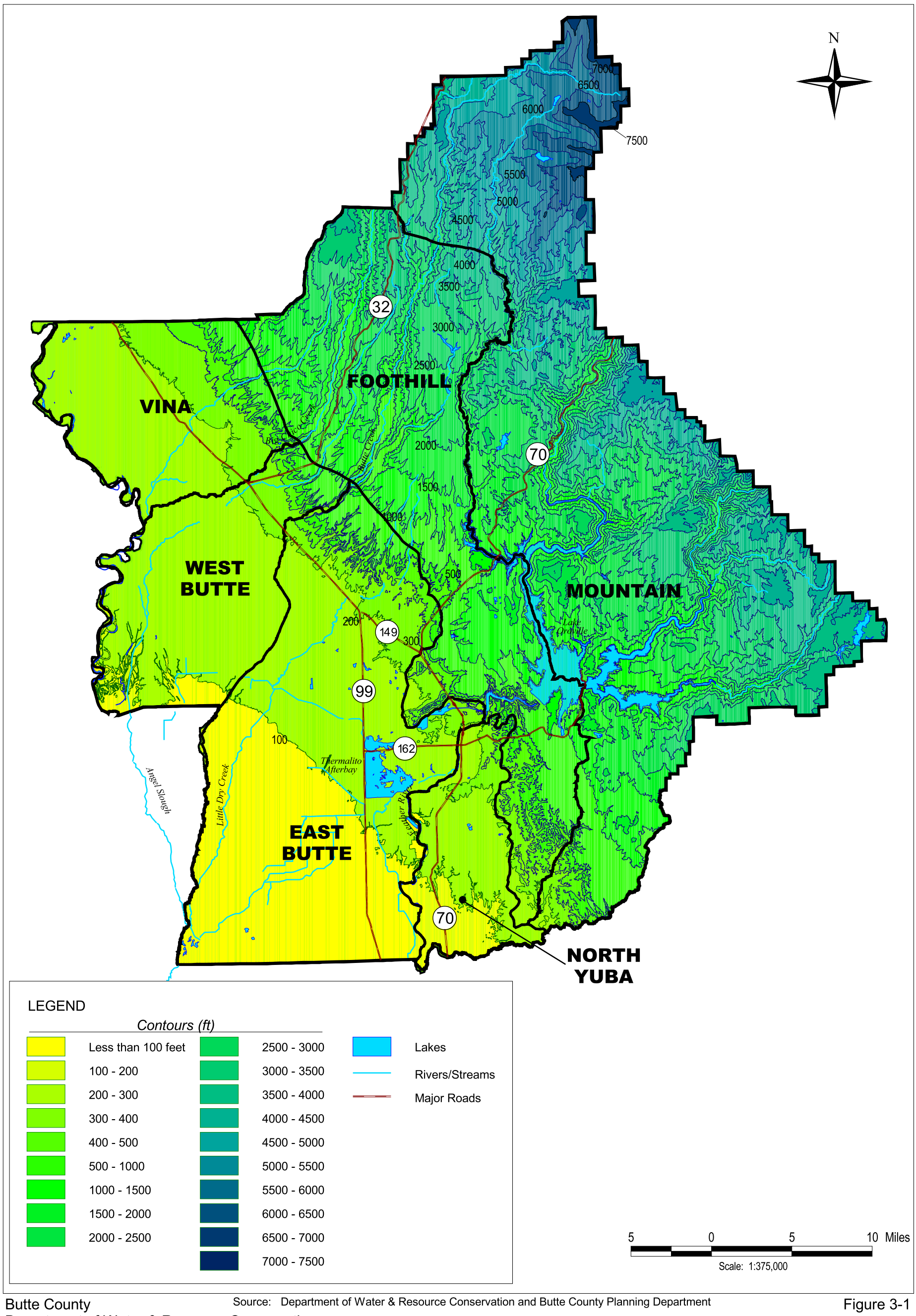
3.5.3 Flood Protection

Several structures in the county provide needed protection against flooding. These are shown on Figure 3-19 and include:

Photograph from DWR

- The Cherokee Canal: levees along both sides of the Cherokee Canal and extending a short distance from the Cherokee Canal along one bank of both Cottonwood Creek and Gold Run Creek
- Mud Creek and Sycamore Creek, west and north of Chico, both sides
- Butte Creek, south of Chico, both sides
- Feather River, south of the Thermalito afterbay, west side only
- Little Chico Creek
- Big Chico Creek, Lindo channel

Figures



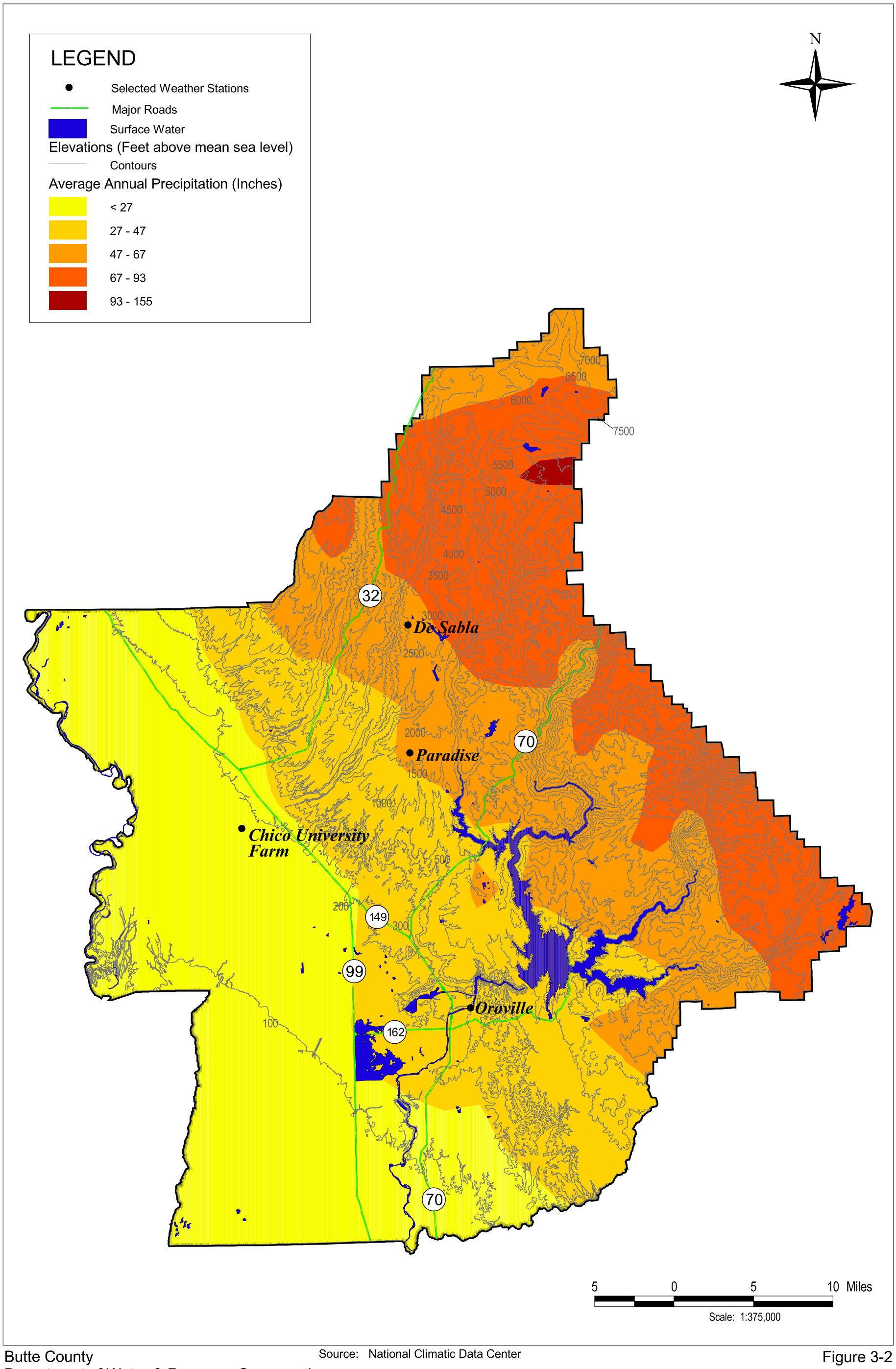
Source: Department of Water & Resource Conservation and Butte County Planning Department

Butte County
Department of Water & Resource Conservation

Figure 3-1

TOPOGRAPHY

CDM Camp Dresser & McKee Inc.



Butte County
Department of Water & Resource Conservation

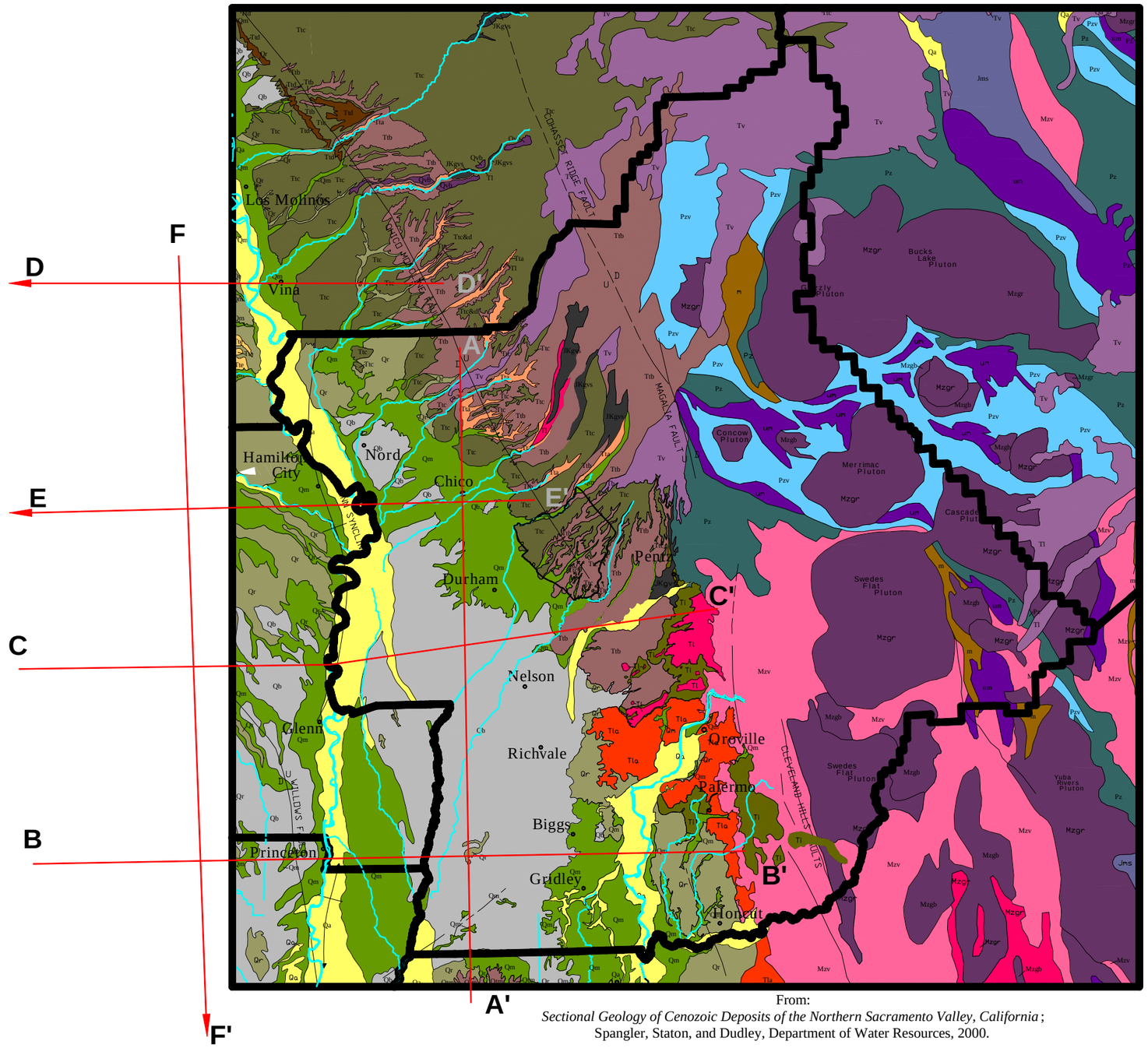
Source: National Climatic Data Center

Figure 3-2

AVERAGE ANNUAL PRECIPITATION

CDM Camp Dresser & McKee Inc.

GEOLOGIC MAP OF BUTTE COUNTY



Map Legend

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

Thrust Fault - dashed where location is approximate; barbs are on the upthrown side.

Anticline

Syncline

Base of Fresh Water-Base of fresh water was determined from electric log resistivity and represents a specific conductance of less than 3,000 micromhos per centimeter.

D D'

Location of Geologic Cross-Sections: Letters correspond to geologic sections shown in Plates 4 and 5. Arrows indicate that cross-section extends beyond the shown area.

5 0 5 10

MILES

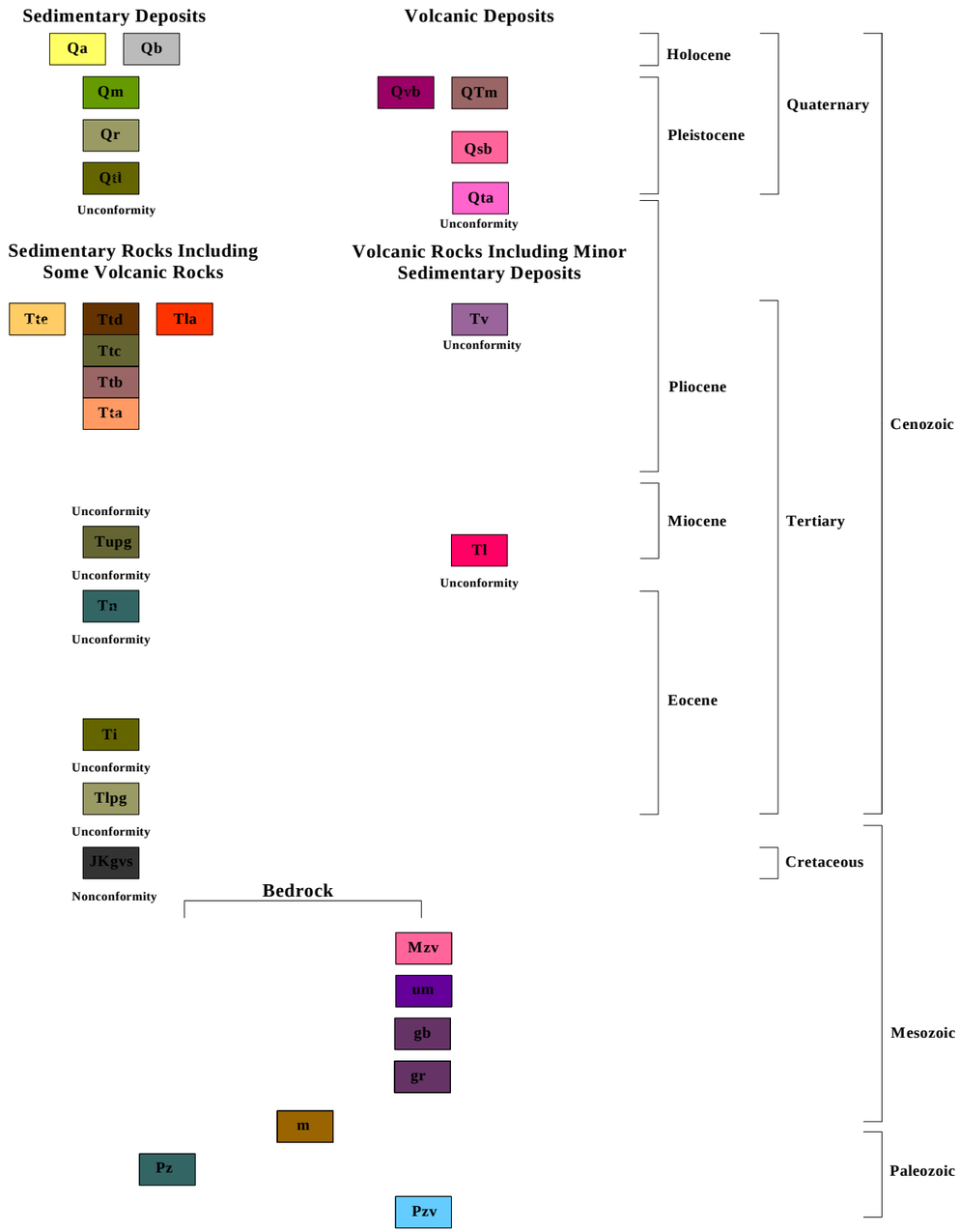
From:
Sectional Geology of Cenozoic Deposits of the Northern Sacramento Valley, California;
Spangler, Staton, and Dudley, Department of Water Resources, 2000.

CDM Camp Dresser & McKee Inc.

Source: Department of Water Resources

Figure 3-4
GEOLOGY MAP OF BUTTE COUNTY

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

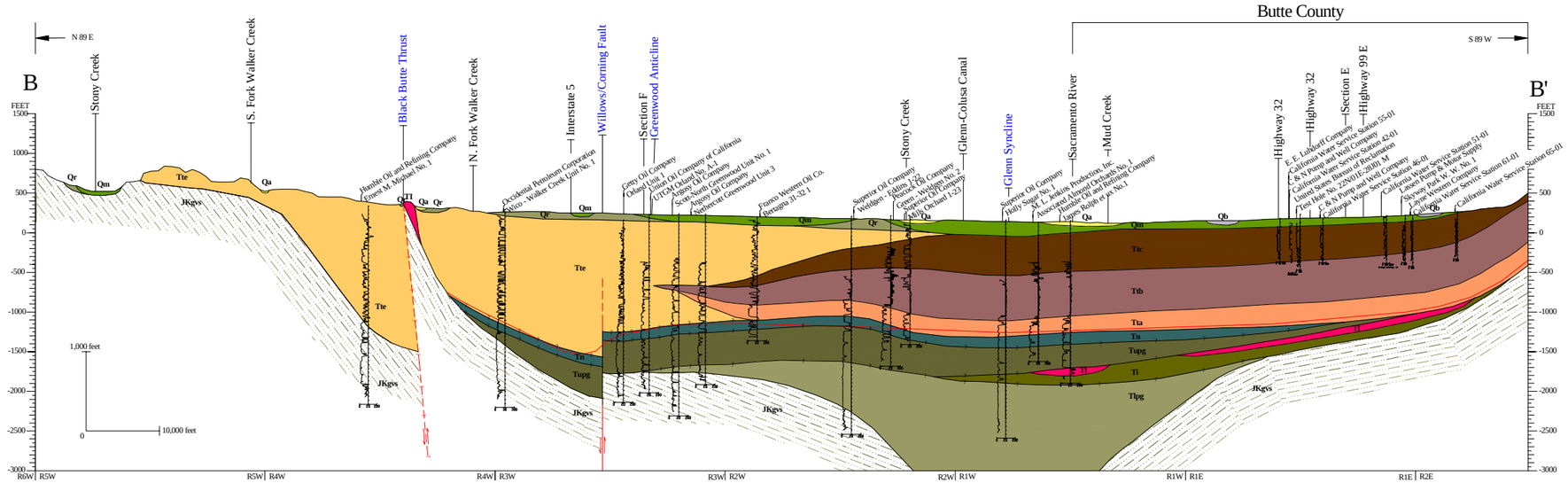
Qa	**Alluvium** (Holocene)-Includes surficial alluvium and stream channel deposits of unweathered gravel, sand and silt, maximum thickness 80 ft. *(adapted from Harwood and Helley, 1985)*.
Qb	**Basin deposits** (Holocene)-Fine-grained silt and clay derived from adjacent mountain ranges, maximum thickness up to 200 ft. *(adapted from Harwood and Helley, 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 Harwood & Helley, 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 Harwood and Helley, 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 Harwood and Helley, 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 Harwood and Helley, 1985).*
QTm	**Tuff Breccia** (Pliocene-Pleistocene)-tuff breccia forming outer ring surrounding the Sutter Buttes *(adapted from Harwood and Helley, 1985).*
Qsb	**Alluvium of the Sutter Buttes** (Pliocene-Pleistocene)-Volcanic fluvatile sediments, maximum thickness 980 ft.
Qta	**Volcanic Andesites**, undifferentiated (Pleistocene-Pliocene)-younger andesites forming the center of the Sutter Buttes *(adapted from Harwood and Helley, 1985).*
Tte	**Tehama Formation** (Pliocene)-includes Red Bluff Formation. Pale green, gray and tan sandstone and siltstone with lenses of pebble and cobble conglomerate, maximum thickness 2,000 ft *(adapted from Harwood and Helley, 1985)*.
Ttd	**Tuscan Unit D** (Pliocene)-Fragmental flow deposits characterized by monolithic masses containing gray hornblende and basaltic andesites and black pumice, maximum thickness 160 ft. *(adapted from Harwood and Helley, 1985)*
Ttc	**Tuscan Unit C** (Pliocene)-Volcanic lahars with some interbedded volcanic conglomerate and sandstone, maximum thickness 600 ft. *(adapted from Harwood and Helley, 1985; Staton (unpublished), 2000)*
Ttb	**Tuscan Unit B** (Pliocene)-Layered, interbedded lahars, volcanic conglomerate, volcanic sandstone and siltstone, maximum thickness 600 ft. *(adapted from Harwood and Helley, 1985; Staton (unpublished), 2000)*
Tta	**Tuscan Unit A** (Pliocene)-Interbedded lahars, volcanic conglomerate, volcanic sandstone, and siltstone containing metamorphic rock fragments, maximum thickness 400 ft. *(adapted from Harwood and Helley, 1985; Staton (unpublished), 2000)*
Tla	**Laguna Formation** (Pliocene)-Interbedded alluvial gravel, sand and silt, maximum thickness 1,000 feet. *(adapted from Harwood and Helley, 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 Harwood and Helley, 1985)*.
Tupg	**Upper Princeton Gorge** (Miocene-Eocene)-Non-marine sediments composed of sandstone with interbeds of mudstone and occasional conglomerate and conglomerate sandstone, maximum thickness 1,400 ft.
Tn	**Neroly Formation** (Miocene)-marine to non-marine sediments, blue-gray tuffaceous andesiticsandstone with interbeds of light grey tuff and tuffaceous shales and occasional conglomerate lenses, maximum thickness 500 ft.
Ti	**Lovejoy Basalt** (Miocene)-Black, dense, hard microcrystalline basalt, maximum thickness 65 feet. *(adapted from Harwood and Helley, 1985)*
Ti	**Ione Formation** (Eocene)-Marine to non-marine deltaic sediments, light colored, commonly white conglomerate, sandstone and siltstone, which is soft and easily eroded, maximum thickness 650 ft.
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.
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	**Undifferenciated Granitic Plutons** (Paleozoic-Mesozoic)-Undivided granitic plutons and related rocks. (*adapted from Jennings, 1977*)
m	**Mixed Rocks** (pre-Cenozoic)-Undivided metasedimentary and metavolcanic rocks of greatly varying types. (*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*)

CDM Camp Dresser & McKee Inc.

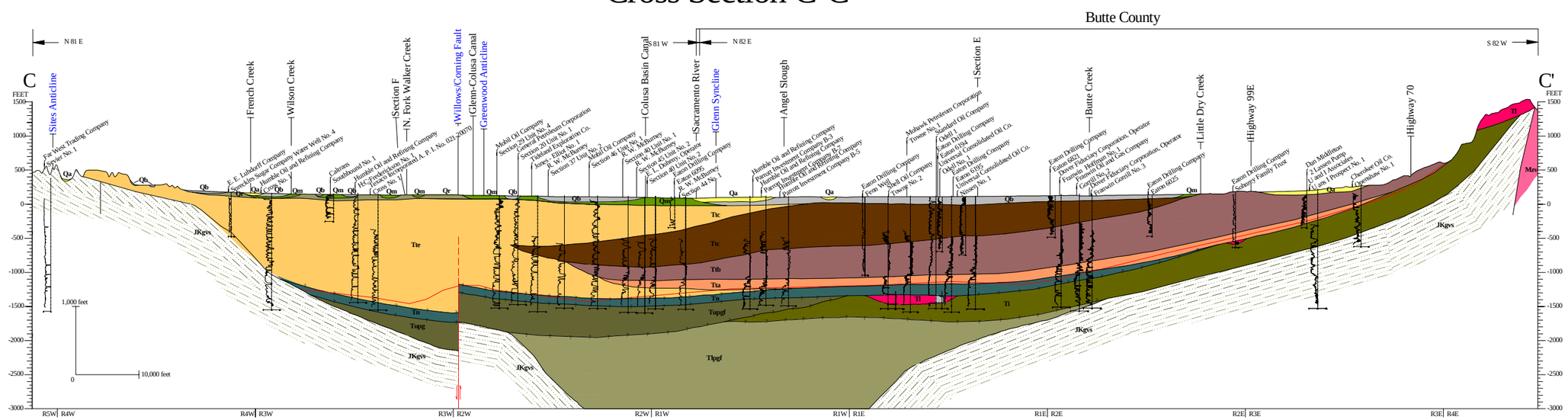
Source: Department of Water Resources

Figure 3-5
GEOLOGIC LEGEND

Cross Section B-B'



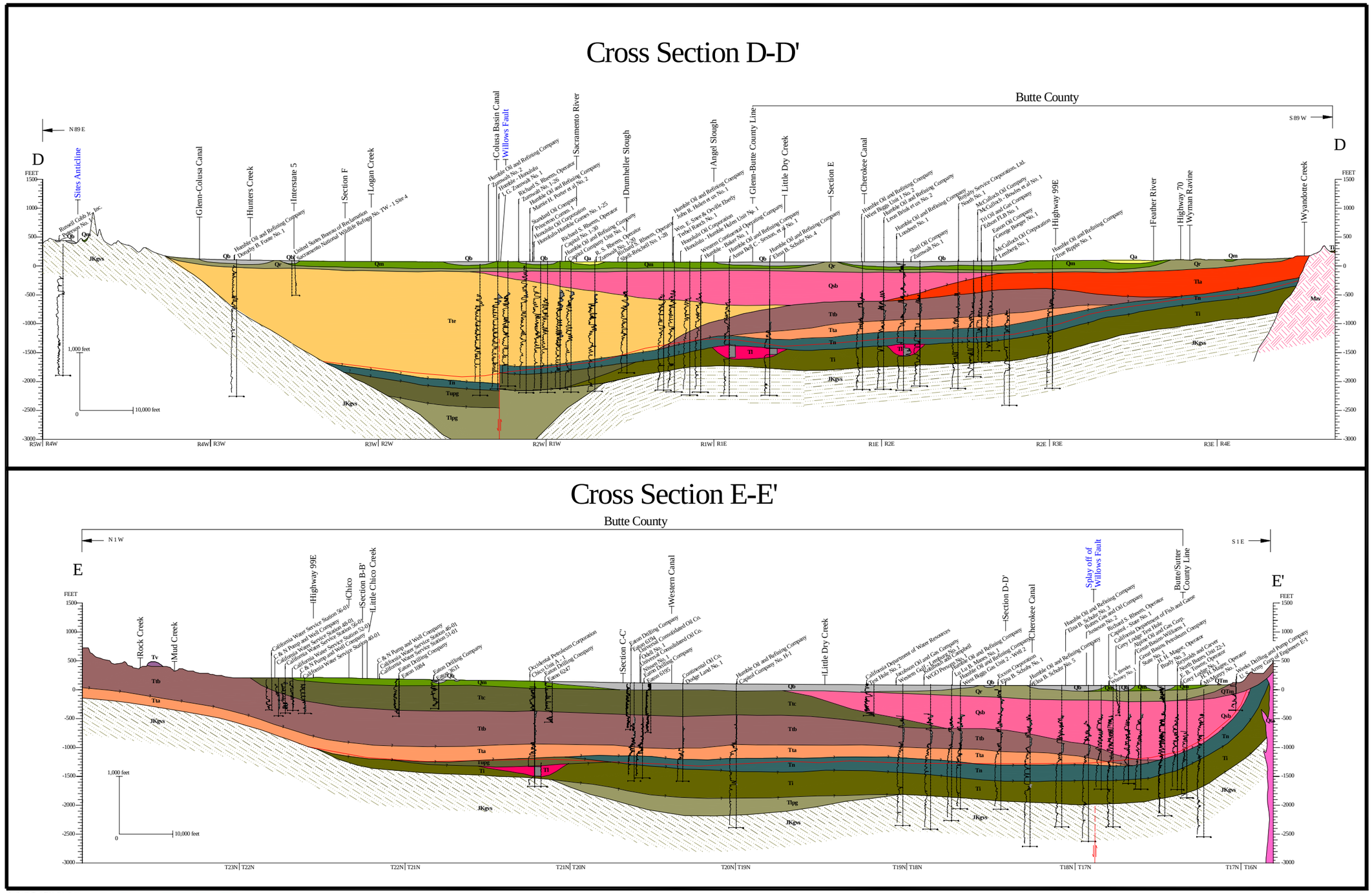
Cross Section C-C'



CDM Camp Dresser & McKee Inc.

Source: Department of Water Resources

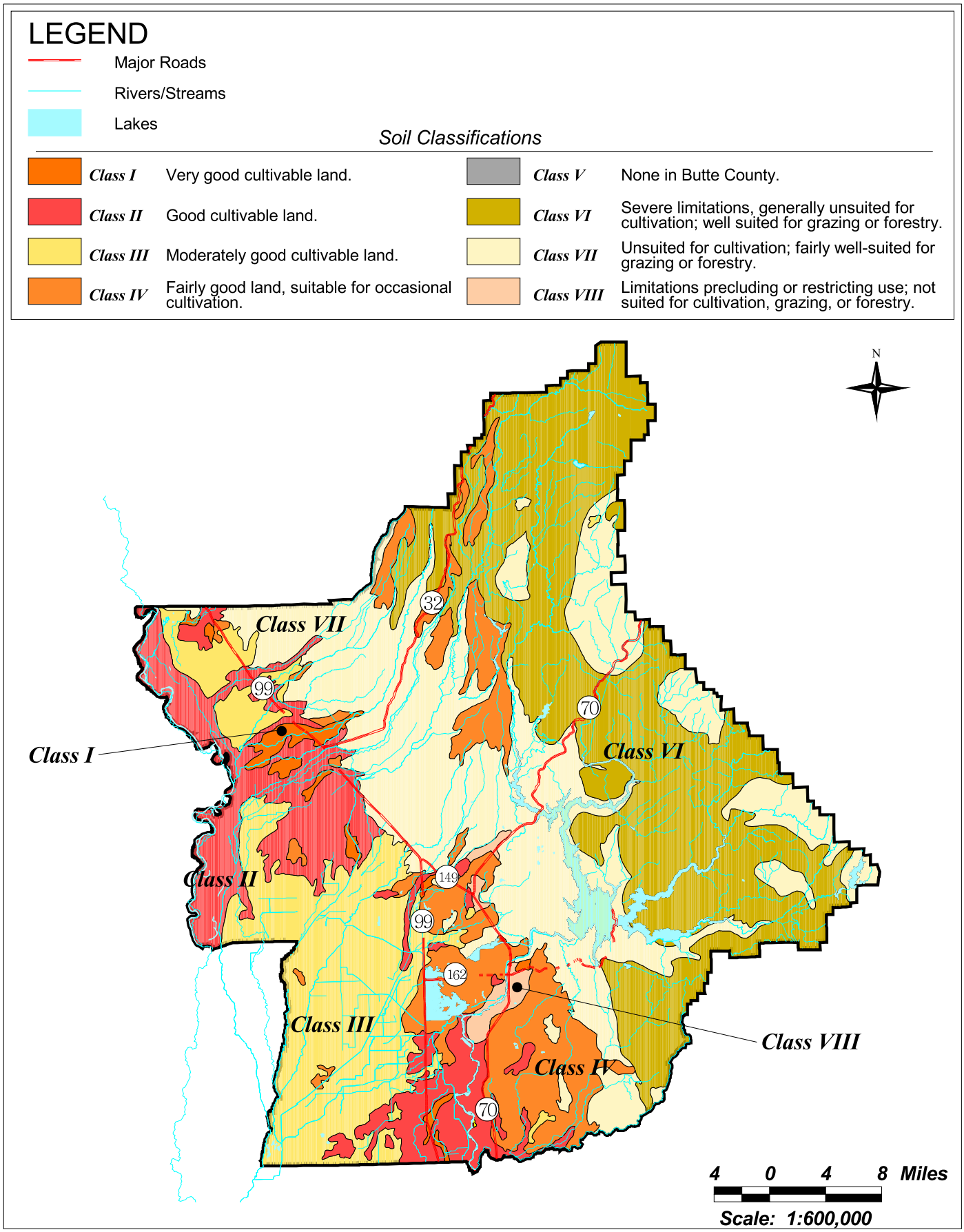
Figure 3-6
BUTTE COUNTY GEOLOGIC MAP
CROSS SECTION B-B' AND C-C'



Source: Department of Water Resources

CDM Camp Dresser & McKee Inc.

Figure 3-7
BUTTE COUNTY GEOLOGIC MAP
CROSS SECTION D-D' AND E-E'



Source: Butte County Planning Department

Butte County
Department of Water & Resource Conservation

Figure 3-8
Soils

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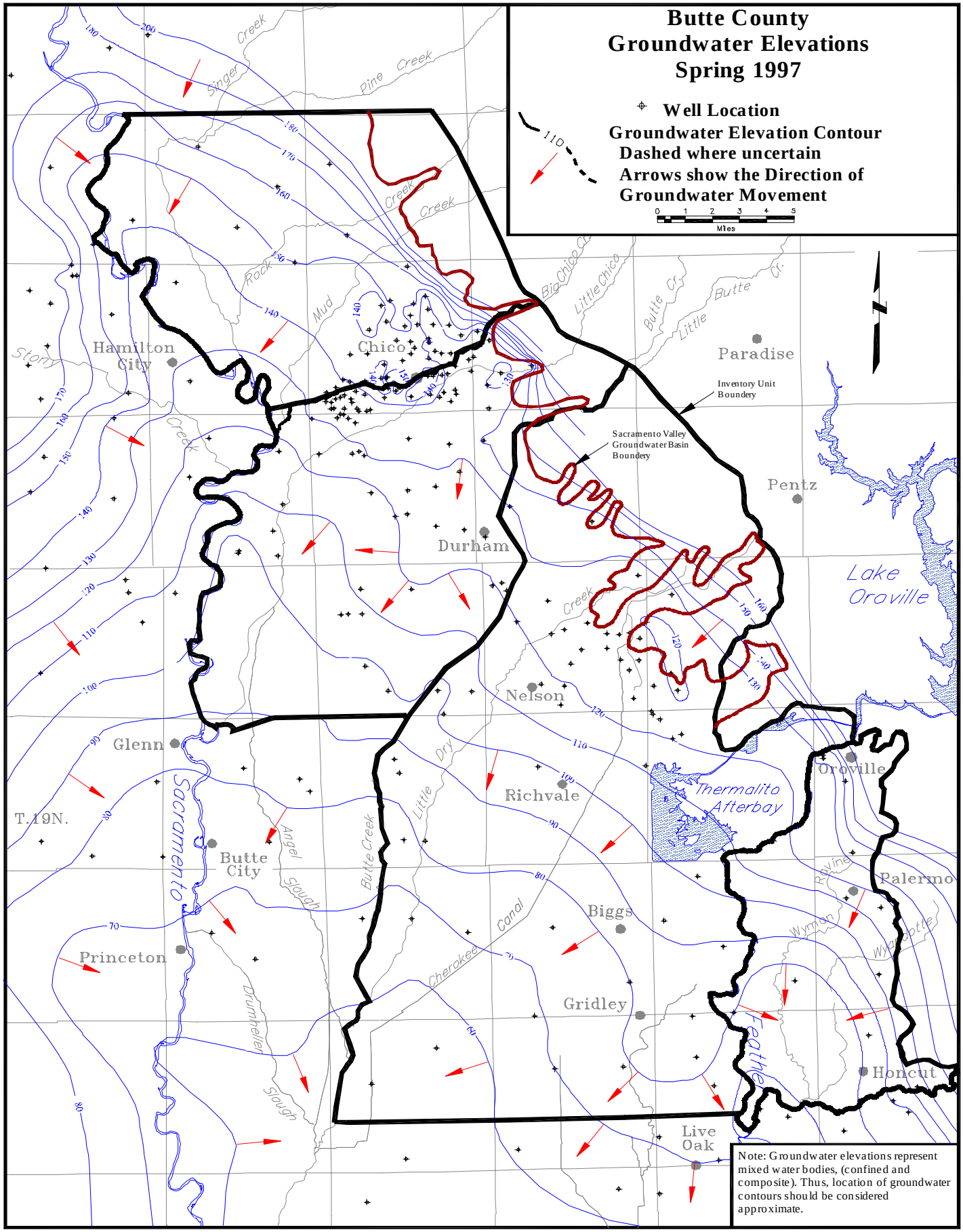
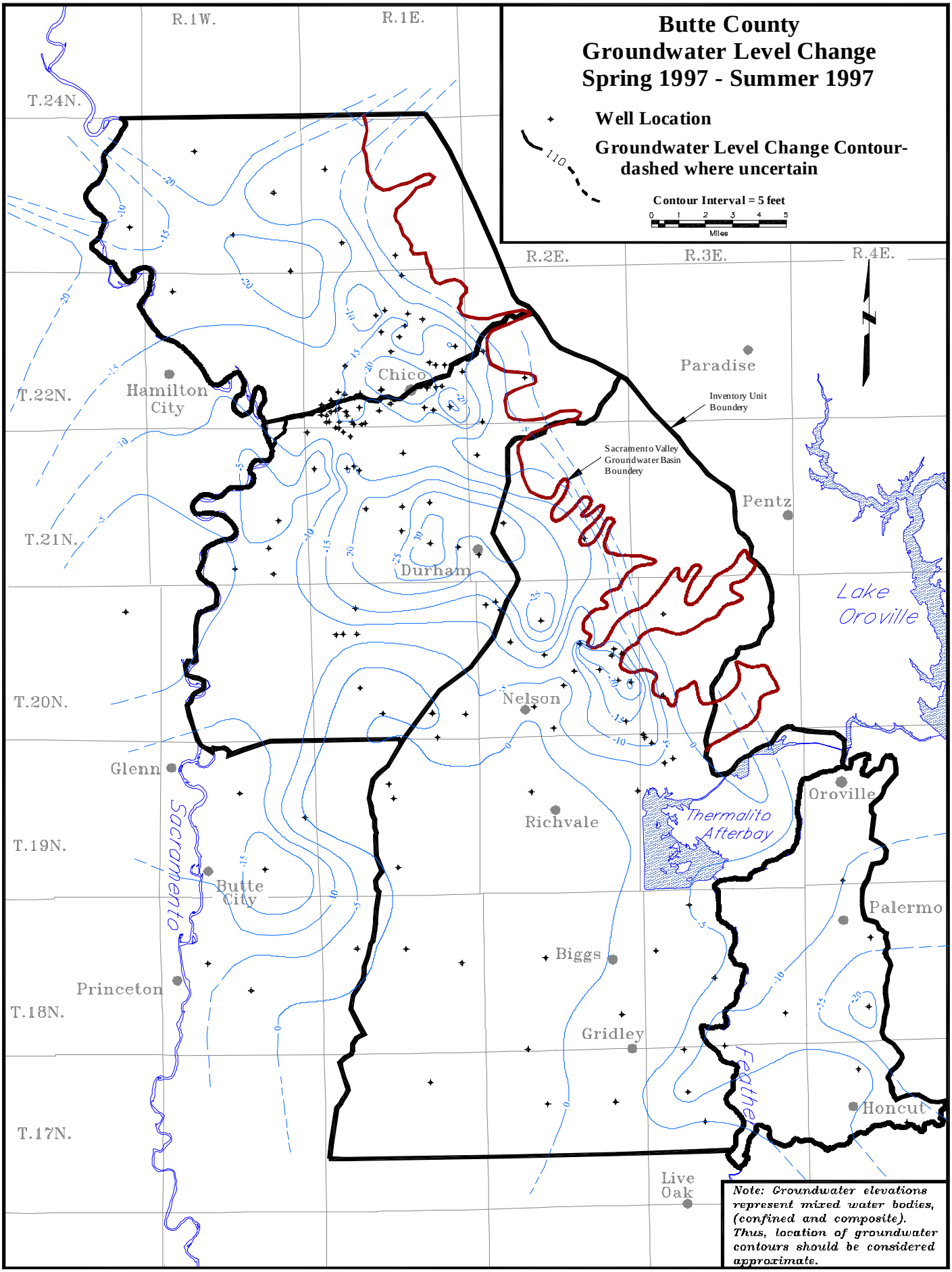


CDM Camp Dresser & McKee Inc.

Sources: Department of Water Resources

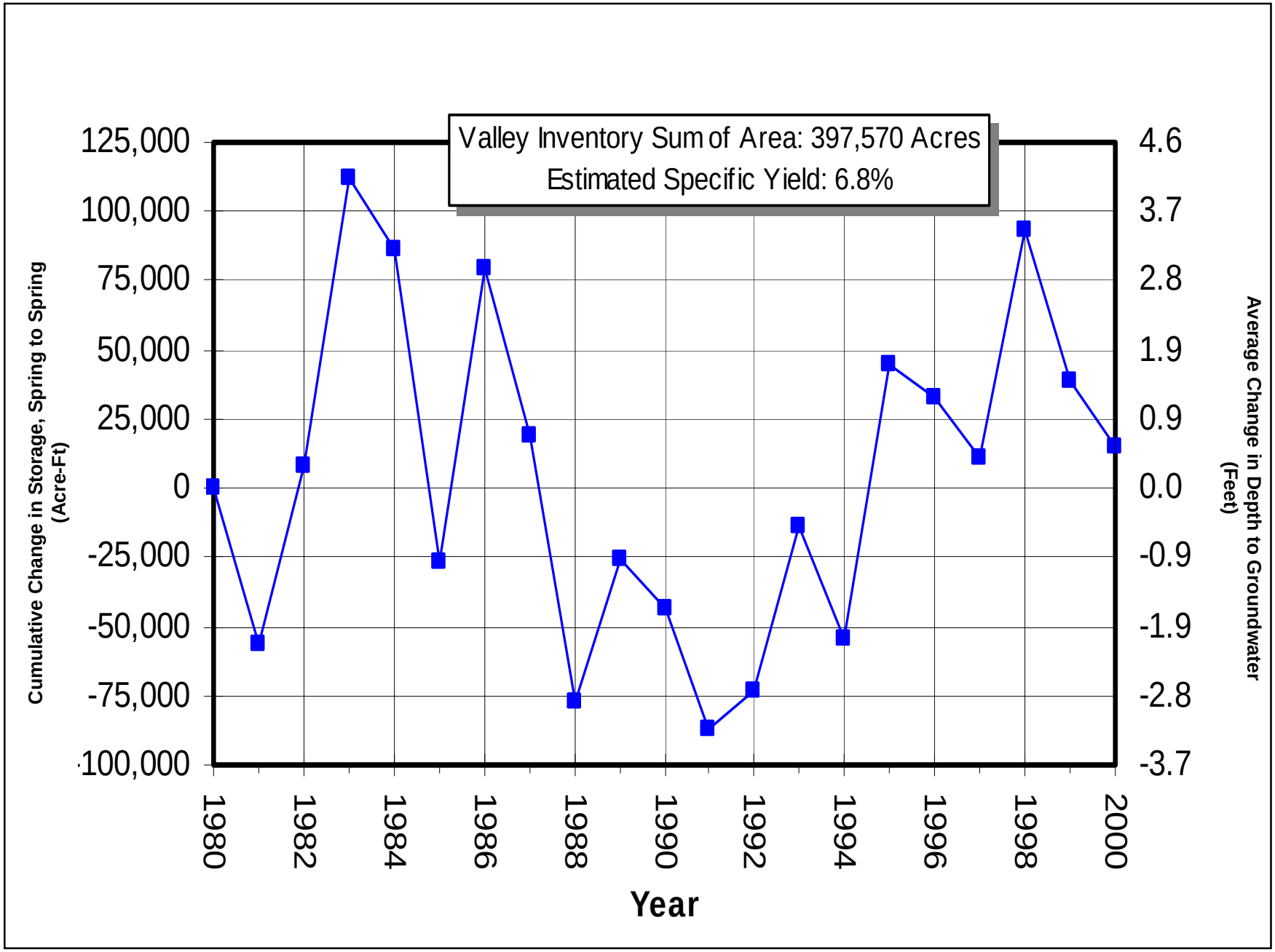
Figure 3-9



CDM Camp Dresser & McKee Inc.

Sources: Department of Water Resources

Figure 3-10

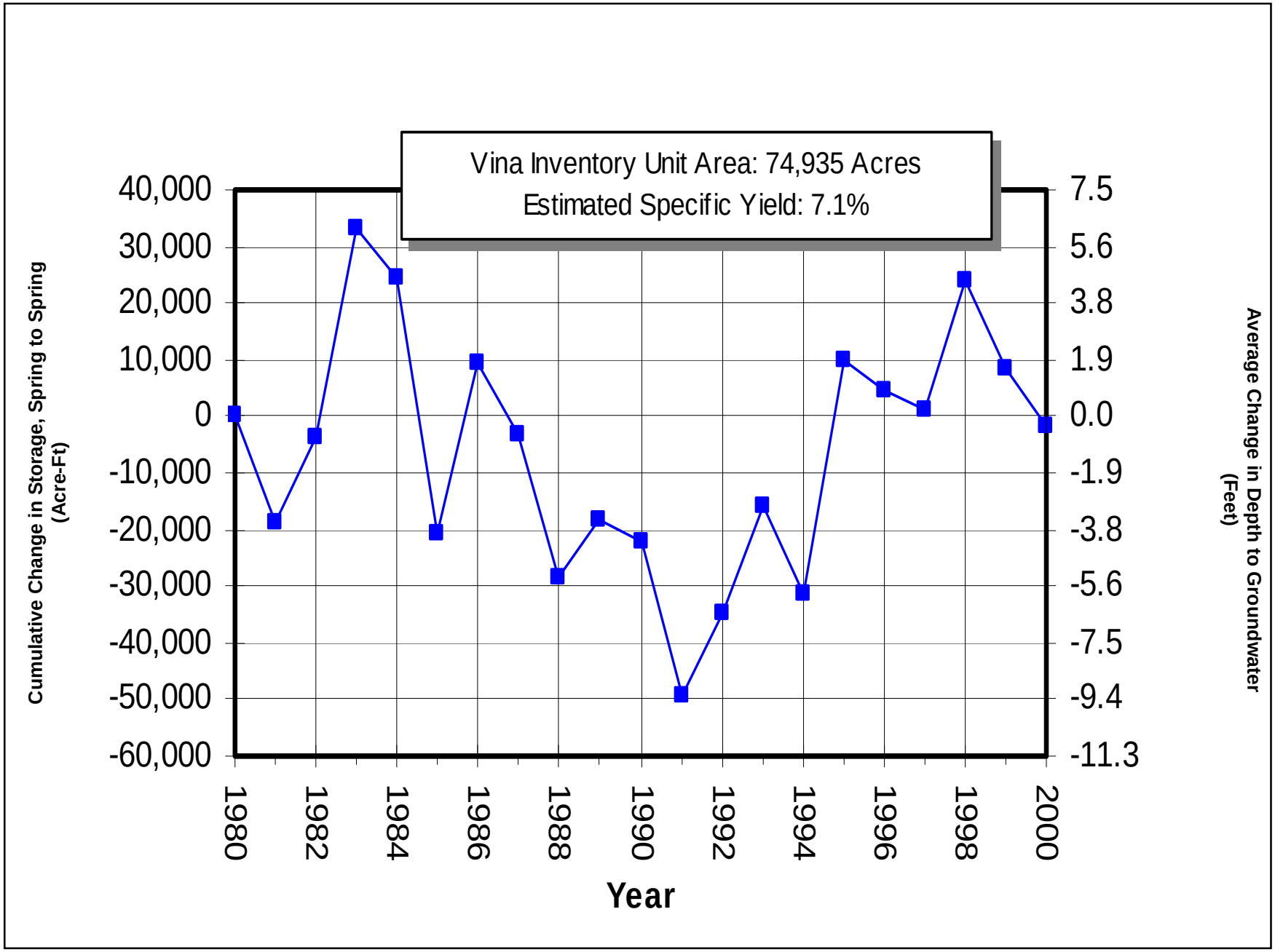


CDM Camp Dresser & McKee Inc.

Sources: Department of Water Resources

Figure 3-11

Estimated Cumulative Change in Spring-to-Spring Storage
SUM OF VALLEY INVENTORY UNITS (1980-2000)

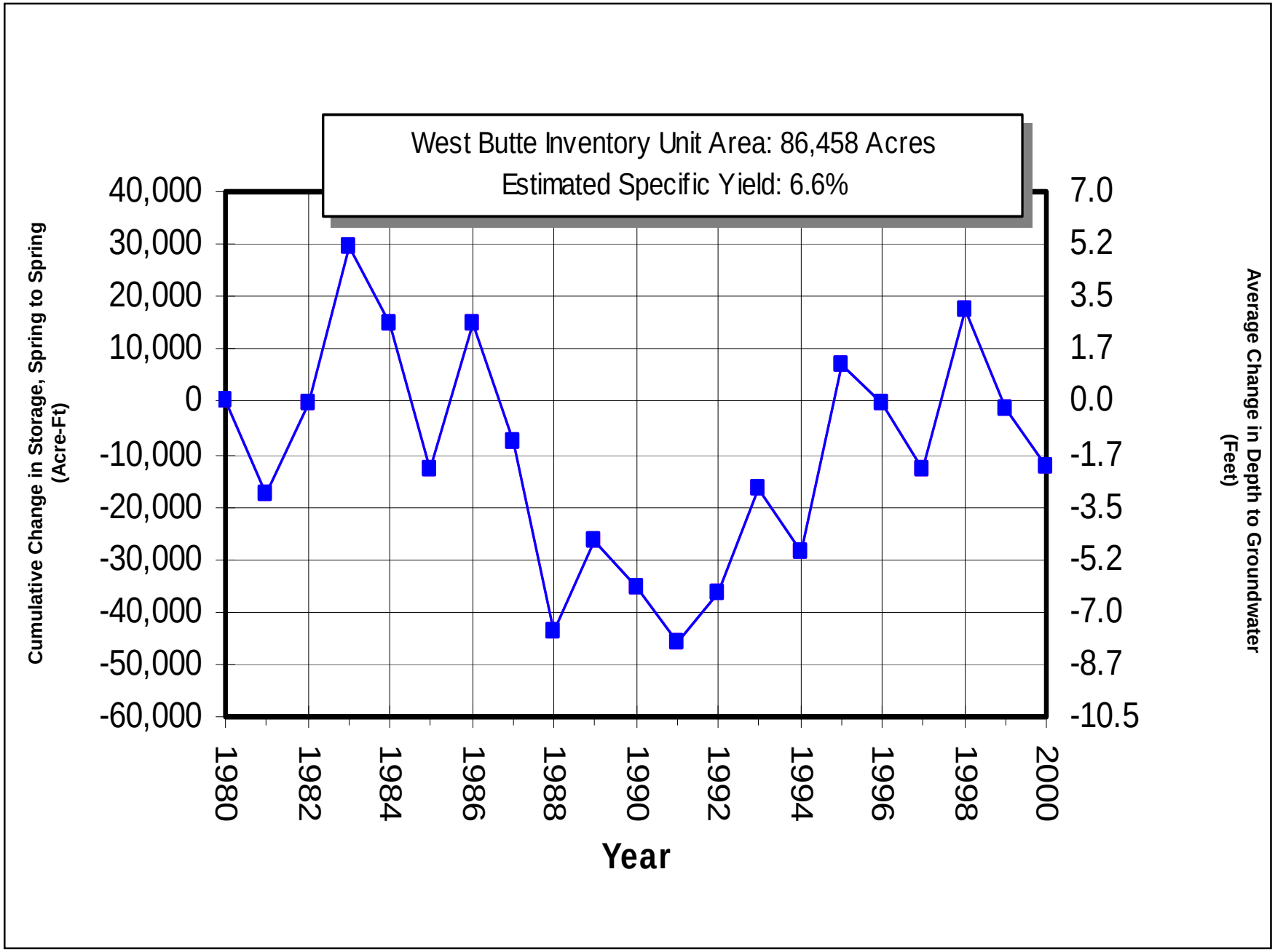


CDM Camp Dresser & McKee Inc.

Sources: Department of Water Resources

Figure 3-12

Estimated Cumulative Change in Spring-to-Spring Storage
VINA INVENTORY UNITS (1980-2000)

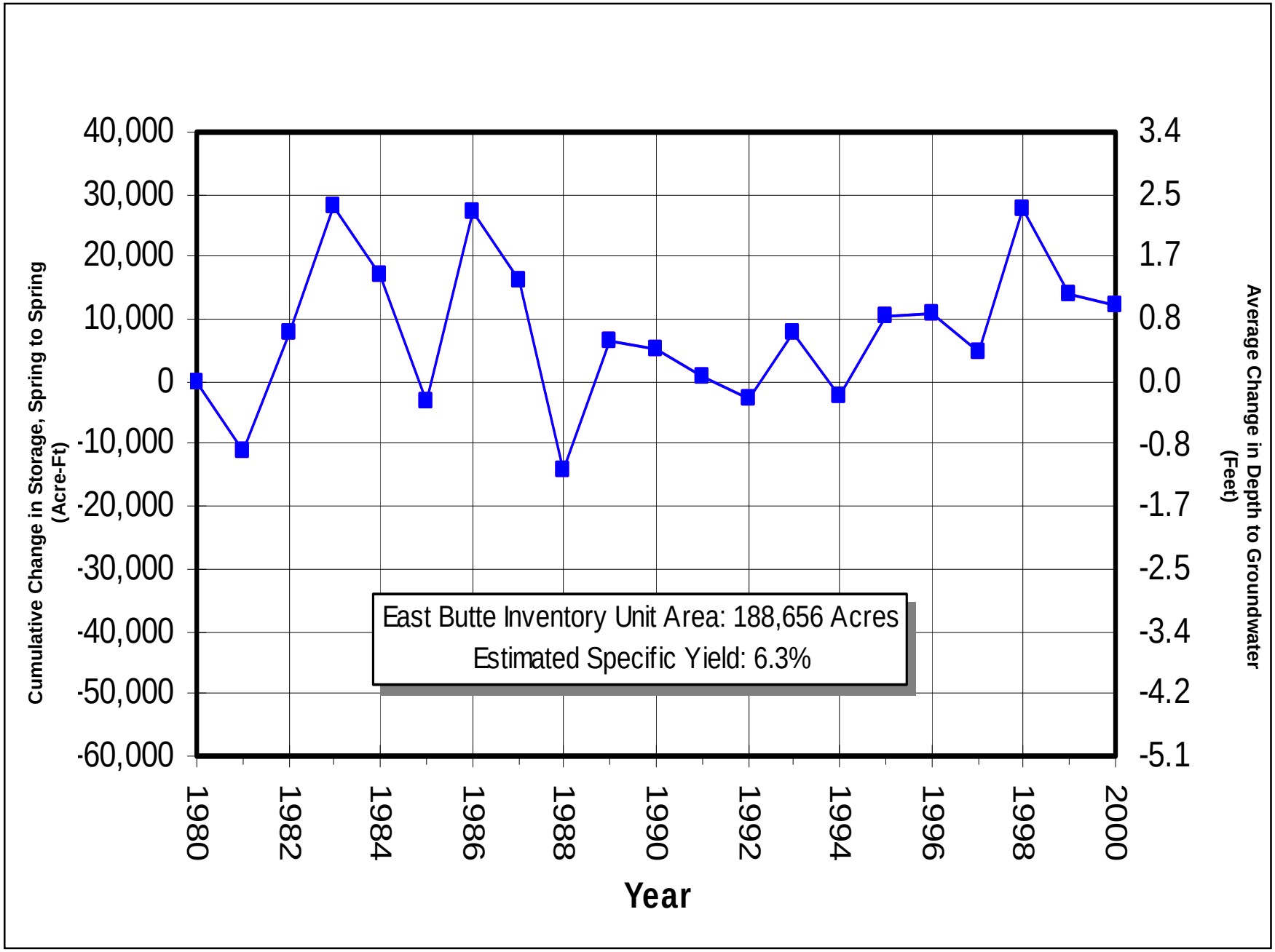


CDM Camp Dresser & McKee Inc.

Sources: Department of Water Resources

Figure 3-13

Estimated Cumulative Change in Spring to Spring Storage
WEST BUTTE INVENTORY UNITS (1980-2000)

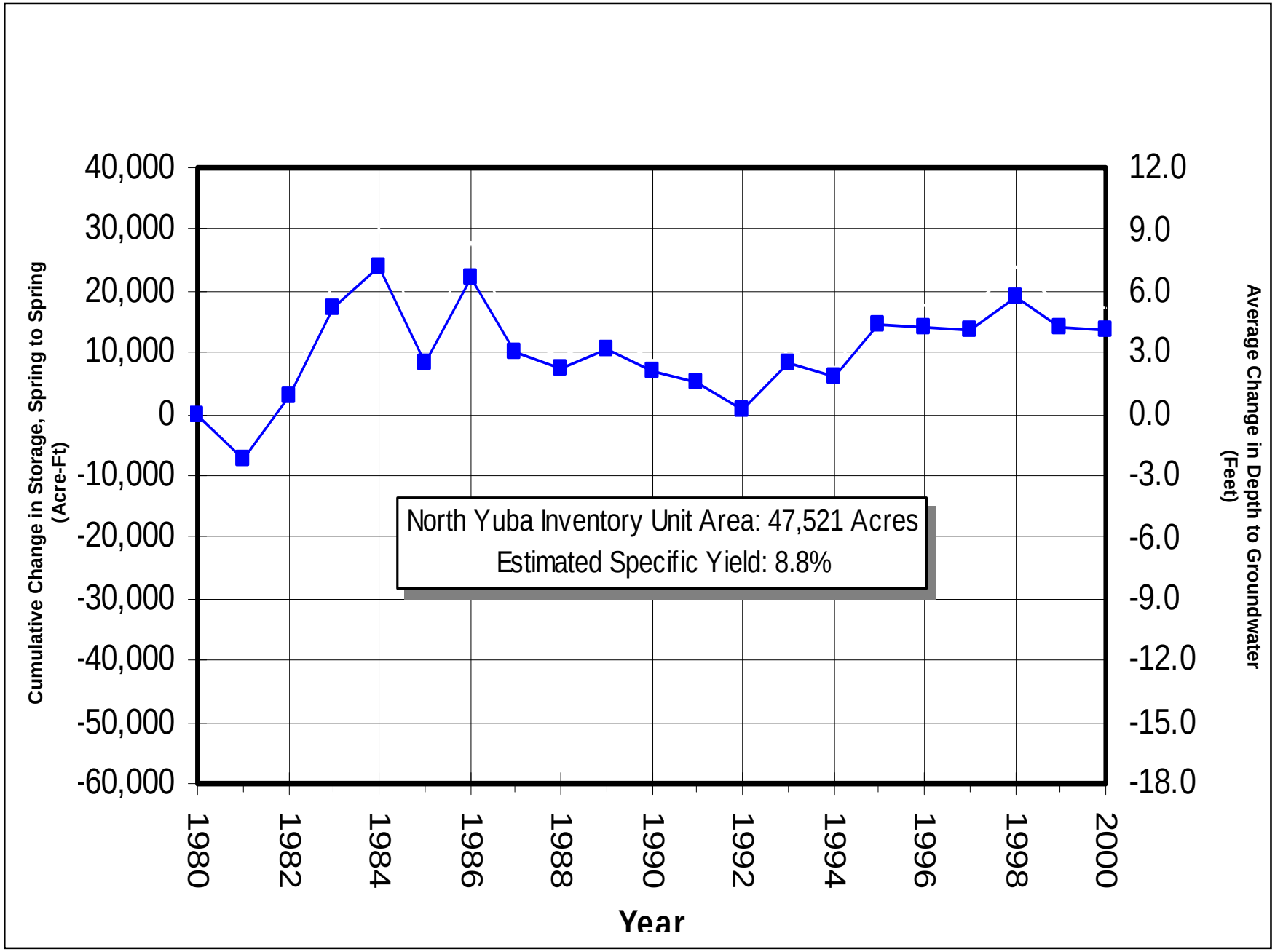


CDM Camp Dresser & McKee Inc.

Sources: Department of Water Resources

Figure 3-14

Estimated Cumulative Change in Spring to Spring Storage
EAST BUTTE INVENTORY UNITS (1980-2000)

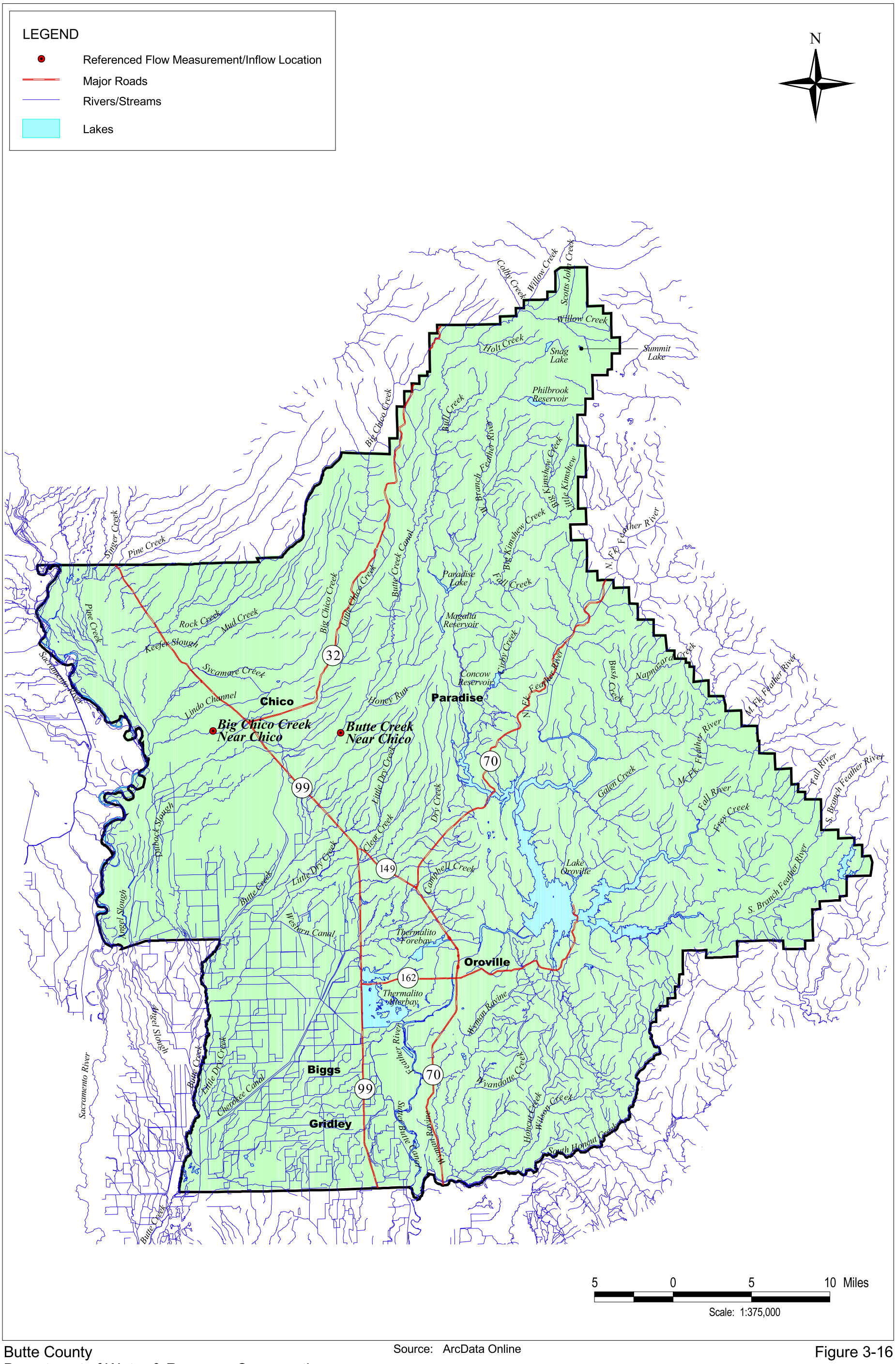


CDM Camp Dresser & McKee Inc.

Sources: Department of Water Resources

Figure 3-15

Estimated Cumulative Change in Spring to Spring Storage
NORTH YUBA INVENTORY UNITS (1980-2000)



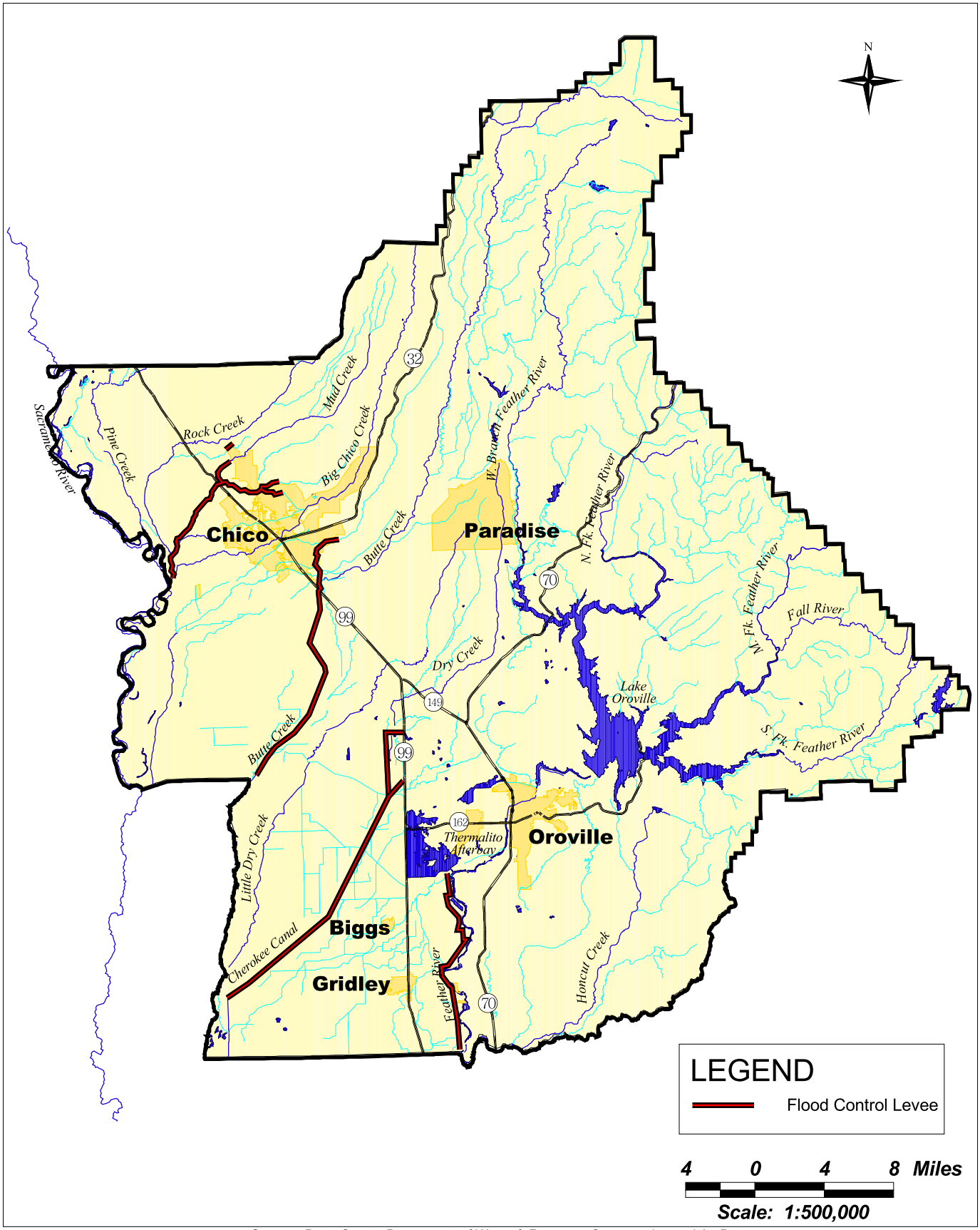
Butte County
Department of Water & Resource Conservation

Source: ArcData Online

Figure 3-16

SURFACE WATER FEATURES
AND KEY ENTRY POINTS
TO BUTTE COUNTY

CDM Camp Dresser & McKee Inc.



Source: Butte County Department of Water & Resource Conservation and ArcData

Butte County
Department of Water & Resource Conservation

Figure 3-19

FLOOD CONTROL STRUCTURES

CDM Camp Dresser & McKee Inc.

Section 4
Water Management and Conditions

Photograph by Chuck Lowery

4.1 Water Rights and Deliveries

Butte County residents receive water from both surface water and groundwater sources. Surface water deliveries are dictated by an extensive water rights law doctrine that establishes uses of water and priority of different users. California does not have a similarly defined system of groundwater rights, although there are some statutes that regulate uses of groundwater.

4.1.1 Surface Water

Surface Water Rights

Water has always been an important commodity in California, and a complex system of water rights has developed. Water resources were first significantly used during the Gold Rush of 1848, and competition for water resources intensified with the growth of agriculture and industry.

The highest priority rights are "riparian rights," which are attached to properties that border natural waterways. Water from riparian rights can be used only on the property adjacent to the waterway, and riparian right-holders cannot transfer their water. Originally, riparian water rights secured water with no limits placed on its use. However, a later court case changed this position and established that water users with riparian rights must be held to a standard of "reasonable use."

The second type of water rights are appropriative rights, which can be secured by properties not immediately adjacent to waterways. This water rights system was initiated by miners, who would post a notice to divert water and that posting would secure the water right. Appropriative water rights were recognized legally in 1855, and are prioritized according to a "first in time, first in right" hierarchy. Appropriative water rights are dependent on the water being put to beneficial use. If the water is not used for a period of 5 years, the water rights can expire.

The two types of water rights systems created conflicts between water users, so the Water Commission Act of 1913 was passed to allow more rational control of water rights. The act declared that water is a property of the state and established a permit process to control water rights. The State Water Resources Control Board (SWRCB) was established to govern the permit process. The Water Commission Act became the basis for appropriating water, but it does not apply to groundwater, riparian rights or appropriative rights established prior to 1914 ("Pre-1914" rights).

Water use must be "reasonable and beneficial." Beneficial uses include irrigation, domestic, municipal and industrial, hydroelectric power, recreational uses, protection and enhancement of fish, wildlife habitat, fire protection, frost protection, stock watering, and aesthetic enjoyment.

In years of water shortage, appropriative right-holders must reduce their water use according to inverse priority. Priority is established by the year that the rights were secured, so the most recent right-holders are the most junior and will be subject to cutbacks first during shortages. Appropriative right-holders will continue to be cutback in inverse priority until the shortage is corrected. If the shortage is so severe that a shortfall remains after all appropriative right-holders have stopped using water, then the riparian right-holders must share the remaining reduction.

The many natural waterways in Butte County allow riparian rights for landowners bordering these waterways. Several large water users with riparian rights are discussed in Section 4.2.

The major individual appropriative water right holders in Butte County are shown in Appendix B, and a full list is available from the Butte County Department of Water and Resource Conservation library. The major water right holders are defined as those holders having right(s) that provide quantities of water equal to or greater than 1,000 acre-feet. The water rights shown in Appendix B are summarized from the State Water Resources Control Board's HydroGraphic Report as of August 2000. The listed water rights do not include those holders that are part of the Butte and Pine Creek adjudications, water or irrigation districts, pre-1914 water rights or State of California rights. The listing represents 47 percent of all appropriative rights in Butte County.

No central depository exists of records for pre-1914 water rights. The State Water Resources Control Board does not have jurisdiction over pre-1914 water rights, since those rights were claimed prior to the existence of the SWRCB. There is also no mandatory requirement for the holders of pre-1914 water rights to report to the SWRCB their annual diversions. There exists within SWRCB's yearly water diversion records some pre-1914 water right diversions that have been reported by holders, but certainly not all.

The only certain way to determine pre-1914 water right holders with any precision would be to investigate the individual land holdings and water users along major water courses within Butte County, excluding those which have already been adjudicated (e.g., Butte Creek) to determine which landholders or water users have pre-1914 water rights.

Adjudicated rights are those assigned by a court judgment that divides the water of a natural waterway between all of the parties within the drainage area. There are two adjudications of water rights in Butte County. One adjudication is known as the Pine Creek adjudication (No. 7814) and involves lands located in the northwestern corner of Butte County and a portion of Tehama County.

The major adjudication within Butte County is known as the Butte Creek adjudication (No. 18917). The water right owners affected by the Butte Creek adjudication are shown in Appendix B. The locations of the adjudicated water rights are shown on Figure 4-1.

The State Water Project

In 1960, California voters approved the Burns-Porter Act, a $1.75 billion bond issue to finance development of the State Water Project (SWP). Designed and implemented by the DWR, the SWP's main purpose was management of water resources in northern California, the San Francisco Bay area, the San Joaquin Valley, the Central Coast, and southern California. Today, the SWP management goals include supply (maximizing diversion, storage, and redistribution of surplus water from wet periods), flood control, power generation, recreation, fish and wildlife protection and habitat enhancement, and water quality improvement. The SWP manages 29 water storage facilities, 18 pumping plants, five hydroelectric power plants, four pumping-generating plants, and 660 miles of canals and pipelines. The SWP has contracts for 4.2 million acre-feet of water, but not all of this water has been developed. Approximately 70 percent of SWP deliveries go to urban users, and 30 percent to agricultural uses. The SWP is the largest state-built, multipurpose water project in the United States.[1]

Photograph from DWR

When the SWP was first under consideration, residents of northern California were concerned that the project would impact their water rights. The state addressed these concerns by including an "area-of-origin" statute, which protects water within areas that the water originates.

The SWP has entered into several contracts within Butte County. Water right settlement agreements were executed with the districts shown in Table 4-1 to settle protests over the construction of State Water Project facilities at Oroville. The locations of SWP facility at Lake Oroville is shown on Figure 4-1. Under these agreements, the DWR provides the districts with a water supply from Lake Oroville in exchange for the districts exercising their individual water rights.

Butte County has contracted with the DWR for a water supply to supplement existing municipal and industrial supplies. The county has an allocation of 27,500 acre-feet that was agreed upon as a mitigation measure for accepting Oroville Dam.

When Butte County was negotiating its contract with the DWR, it wanted to reserve water for future growth, but was not ready to use the water immediately. The county did not want to pay for water it could not use, so it developed an agreement where the amount of water available each year would start small and slowly grow to the full

[1] wwwdwr.water.ca.gov/dir-state_water_projectR2/State_Water_Project_R2.html

allocation. There have been a series of amendments to delay the time when the full 27,500 acre-feet is allocated to the county because the county is still not ready to use the full allocation. The county currently contracts with Del Oro Water Company and California Water Service Company in Oroville to sell the water.

Table 4-1
Settlement Agreements

Water District	Allocation[2]
Joint Water Districts Board[3,4]	555,000 acre-feet[5]
Western Canal Water District[6]	295,000 acre-feet

Butte County negotiated a contract in 1990 to reduce its annual allocation to 1,200 acre-feet until 2000 without losing the right to the full amount at a future date. After 2000, the county will have an allocation of 3,500 acre-feet until the appeal on the Monterey agreement is settled.

Thermalito Irrigation District and Oroville-Wyandotte Irrigation Districts divert water through SWP facilities under their own water rights. Thermalito can divert 8,200 acre-feet a year, and Oroville-Wyandotte can divert 17,555 acre-feet per year. These diversions are discussed in more detail in Section 4.2.

Central Valley Project

In the 1930s, as an attempt to protect the Central Valley from water shortages and flooding, the state formulated the Central Valley Project (CVP). However, due to its coincidence with the depression era, the state was unable to finance the project. Despite the shortfall, Federal funding and authorization was provided in 1935 for the U.S. Bureau of Reclamation (USBR) to begin work on the project. The CVP includes 18 reservoirs (with four additional reservoirs jointly owned with the SWP), the largest of which is Lake Shasta on the Sacramento River. The CVP delivers approximately seven million acre-feet (MAF) of water per year, with 6.2 MAF to agricultural uses, 0.5 MAF to urban uses, and 0.3 MAF to wildlife refuge use (DWR Bulletin 160-98).

The USBR entered into water rights settlement contracts with various water right holders along the Sacramento River in 1964. The purpose of entering into those contracts was to provide for partial repayment of the construction costs of Shasta Dam, which recognized the benefits they received from that facility, and provided

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2 Certain contract provisions provide for reduction in deliveries under specific hydrologic conditions.

3 Joint Water District Board members include Biggs-West Gridley Water District, Butte Water District (partially in Butte County, partially in Sutter County), Richvale Irrigation District, and Sutter Extension Water District (in Sutter County).

4 Districts may divert additional water for beneficial use within their districts from November 1 to April 1.

5 Of the total allocation to the Joint Water Districts Board, 176,000 acre-feet is allocated to Sutter Extension Water District, which is not within Butte County.

6 District may divert additional water for beneficial use within the district from November 1 to March 1.

agreement with those having water rights for diversions from the Sacramento River (the contracts are for a period of 40 years and are subject to renewal in 2004). The USBR also determined deficiencies of those water rights in the critical summer months and provided in the contracts for the delivery of CVP water during those summer months. One water right holder in Butte County included in this program is M&T, Incorporated. Under its contract with USBR, the total amount of water rights agreed upon is 16,980 acre-feet and a Project water supply of 976 acre-feet for a total of 17,956 acre-feet.

The Gray Lodge Wildlife Area is in the southern portion of Butte County, and a portion of its water supply is served by the CVP. It is covered in greater detail in Section 4.

4.1.2 Groundwater Extractions

Groundwater Rights

Groundwater use is not governed by the SWRCB, which is the agency set up to regulate surface water rights. There is no system of groundwater rights except in adjudicated basins, therefore people do not need to apply for rights before groundwater can be used.

Adjudicated basins occur when the local landowners turn to the courts to decide how to fairly distribute limited groundwater resources. A watermaster is appointed to monitor the basin to ensure that all parties are using the appropriate amounts of groundwater. Several examples of adjudicated basins include the West Coast Basin and Chino Basin, both of which are in Southern California.

Well Distribution

There are over 14,000 wells in Butte County. The wells are classified by purpose as domestic, irrigation, municipal, monitoring and other. Figure 4-2 indicates the densities of wells, regardless of type of use, throughout the county. Table 4-2 presents the numbers of wells by type, inventory unit, and inventory sub-unit throughout the county.

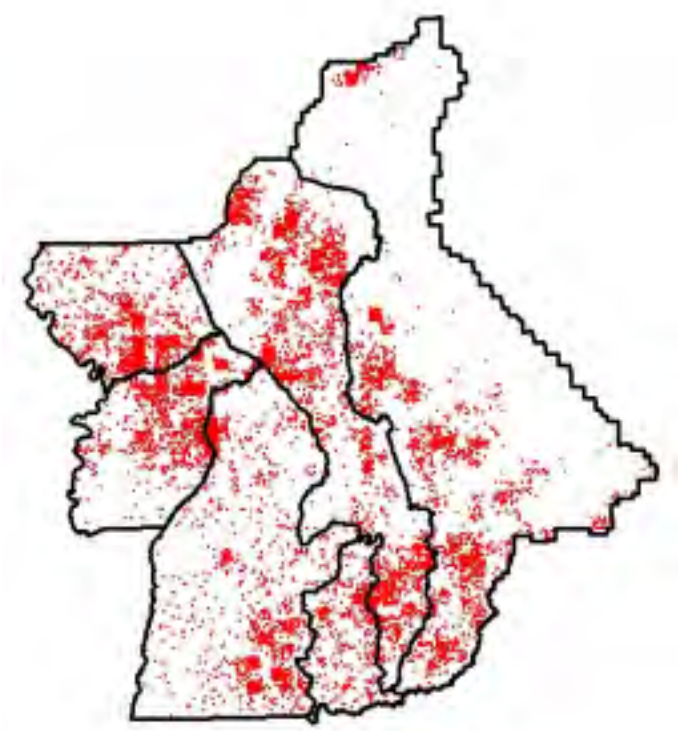


Figure 4-2 - Distribution of Wells in Butte County (all types)

Table 4-2 and Figure 4-2 were prepared by the DWR on the basis of analysis of information in the Well Completion Report database on file at the DWR. The accuracy of the well-location information varies according to the source of the particular data. Although most locations are correct to within 1 mile (300 feet for monitoring wells) some Well Completion Report data may be in error by up to several miles.

Well Depths

Well depth and well use data were collected from Well Completion Reports filed with the DWR. A total of approximately 12,500 well records having depth data were evaluated and classified into three well-type categories: domestic, irrigation, and municipal/industrial. The minimum, maximum, and average well depth, listed by well type and by Inventory and Inventory Sub-Unit, is presented in Table 4-3. This information is summarized in Table 4-4.

The statistical distribution of the well-depth data was also evaluated though a series of cumulative frequency distribution curves for domestic, irrigation, and municipal wells. These curves are included in the DWR's Butte County Groundwater Inventory Analysis Report.

The cumulative frequency distribution of well depth data for domestic, irrigation, and municipal/industrial wells is also evaluated in the DWR's Butte County Groundwater Inventory Analysis Report. The depths of the 5,484 domestic wells range from 14 to 860 feet, and 50 percent of them are installed to a depth of about 117

feet or less. The depths of the 2,198 irrigation wells range from 28 to 1,050 feet, and 50 percent of them are 275 feet or less in depth. Municipal/industrial well depths range from 36 to 924 feet, and 50 percent of them are installed to a depth of 485 feet or less.

Table 4-2
Number of Wells By Inventory Unit and Inventory Sub-Unit

INVENTORY UNIT	IINVENTORY SUB-UNIT	Domestic Wells	Irrigation Wells	Municipal Wells	Monitoring Wells	Other Wells	Totals
Vina	Vina	2,096	621	55	138	299	**3,209**
West Butte	Durham/Dayton	1,195	568	40	248	310	2,361
	M&T	18	38	0	2	6	64
	Angel Slough	8	43	0	2	2	55
	Llano Seco	1	16	0	5	10	32
	Western Canal (33%)	15	36	0	0	12	63
	Totals:	1,237	701	40	257	340	**2,575**
East Butte	Pentz	172	39	0	12	20	243
	Esquon	291	108	0	2	26	427
	Cherokee	104	62	0	2	15	183
	Western Canal (67%)	32	76	0	2	17	128
	Richvale	87	72	0	4	21	184
	Thermalito	140	56	0	9	36	241
	Biggs-West Gridley	246	92	4	10	33	385
	Butte	571	183	8	29	115	906
	Butte-Sink	4	11	0	1	4	20
	Totals:	1,647	699	12	71	287	**2,717**
North Yuba	North Yuba	504	178	8	95	81	**866**
Foothill	Cohasset	885	20	11	0	37	953
	Ridge	1,081	50	17	47	58	1,253
	Wyandotte	638	16	0	7	12	673
	Totals:	2,604	86	28	54	107	**2,879**
Mountain	Mountain	1,954	11	20	13	29	**2,027**
TOTAL FOR ENTIRE BUTTE COUNTY:		10,042	2,296	163	628	1,143	**14,272**

NOTE: Municipal includes wells classified as Municipal and Public

Source: Department of Water Resources

Table 4-3
Butte County Well Depth Summary

INVENTORY UNIT	INVENTORY SUB-UNIT	IRRIGATION					DOMESTIC					MUNICIPAL & PUBLIC					Well Totals
		Count	Max	Min	Median	Mean	Count	Max	Min	Median	Mean	Count	Max	Min	Median	Mean	
Vina	**Vina**	621	1,050	42	250	332	2,096	754	14	137	145	55	830	72	574	530	
	All Wells:	621	1,050	42	250	332	2,096	754	14	137	145	55	830	72	574	530	2,772
West Butte	**Durham Dayton**	568	750	40	325	348	1,195	680	15	124	134	40	924	36	541	511	1,803
	M&T	38	920	115	350	397	18	640	54	120	147						56
	Llano Seco	15	592	110	301	311	1	56	56	56	56						16
	Angel Slough	43	400	60	223	229	8	125	35	92	86						51
	AVERAGE:	166	666	81	300	321	306	375	40	98	106	40	924	36	541	511	
	All Wells:	664	920	40	315	342	1,222	680	15	123	134	40	924	36	541	511	1,926
East Butte	**Pentz**	39	740	62	255	299	172	860	35	150	245						211
	Esquon	108	883	74	341	368	291	482	25	120	125						399
	Cherokee	62	871	89	506	446	104	575	35	165	181						166
	Western Canal	112	880	108	500	470	47	540	50	125	145						159
	Richvale	72	855	80	260	303	87	500	40	104	114						159
	Thermalito	56	460	36	132	158	140	480	37	80	98						196
	Biggs-west Gridley	92	707	40	196	221	246	243	32	87	92	4	362	260	344	328	342
	Butte	183	750	35	136	165	571	399	32	80	83	8	381	70	250	228	762
	Butte Sink	11	616	130	500	446	4	200	90	110	127						15
	AVERAGE:	82	751	73	314	320	185	475	42	113	134	6	372	165	297	278	
	All Wells:	735	883	35	245	299	1,662	860	25	97	120	12	381	70	314	261	2,409
North Yuba	**North Yuba**	178	983	28	271	288	504	575	25	120	139	9	210	98	181	171	
	All Wells:	178	983	28	271	288	504	575	25	120	139	9	210	98	181	171	691
Foothill	**Cohasset**	20	875	55	102	228	885	1,060	25	121	227	11	930	100	670	562	916
	Ridge	50	770	30	190	215	1,081	1,030	18	190	258	17	740	100	325	381	1,148
	Wyandotte	16	580	88	215	252	638	860	25	200	226						654
	AVERAGE:	29	742	58	169	232	868	983	23	170	237	14	835	100	498	472	
	All Wells:	86	875	30	190	225	2,604	1,060	18	175	240	28	930	100	415	452	2,718
Mountain	**Mountain**	11	450	45	174	204	1,954	970	11	180	205	20	970	100	240	240	
	All Wells:	11	450	45	174	204	1,954	970	11	180	205	20	970	100	240	240	1,985
Cal Water	**Cal Water**	149	620	40	235	262	907	754	14	129	138	66	968	402	586	603	66

Table 4-4
Summary of Well Numbers and Depths in Butte County by Region[1]

Region	Irrigation		Domestic		Municipal/Public		Total	
	No.	Av depth (ft)	No.	Av depth (ft)	No.	Av depth (ft)	No.	Av depth (ft)
Valley exc. CalW	1,893	373	3,591	202	116	461	5,600	265
CalWater	-	-	-	-	66	603	66	603
Total Valley	1,893	373	3,591	202	182	513	5,666	269
Foothill	86	232	2,604	237	28	472	2,718	239
Mountain	11	204	1,954	205	20	240	1,985	205
Total County	1,990	366	8,149	214	230	484	10,369	249

[1]Limited to wells for which depth information is available.

Well depth distributions by type, Inventory Unit, and Inventory Sub-Unit are included in the Department of Water Resources' *Butte County Groundwater Inventory Analysis*.

Well Yields

Selected data on water utility well yields are provided in the DWR's *Butte County Groundwater Inventory Analysis*. The average pumping rates for the wells covered appear to trend slightly downward from Vina southeasterly to North Yuba; with average rates as follows:

Vina, West Butte	1,000gpm
East Butte	980gpm
North Yuba	840gpm

Specific Capacity

Specific capacity test averages are presented in the DWR's *Butte County Groundwater Inventory Analysis*. The averages for tests conducted by the USGS in three areas in the Butte County portion of the Sacramento River Valley reported therein are:

Vina, West Butte	51 gpm/ft
East Butte	58 gpm/ft
North Yuba	60 gpm/ft

4.2 Supplies and Demands

The water inventory has divided Butte County into inventory units and inventory sub-units so that information can be fully understood by region. This section includes the background for supplies and demands for each region within the county. This

information was compiled to determine the numbers to be included in Section 5, which has a detailed account of the water inventory. For the numbers and details to be clearly understood, it is important to understand the activities that create demand and potential sources of supply.

This section describes each inventory sub-unit, as well as any urban or agricultural water suppliers that may be within the area. Figure 4-3 illustrates water suppliers within the county, and it shows how these providers fall within the inventory sub-units. The descriptions of each area include water supplies, demands, and any local concerns that residents or districts might have. Table 4-5 has an overview of county water suppliers, with their source of supply, water uses, and general concerns.

Table 4-5 Water Supplier Overview

	Water Type		Water Uses			Primary Concerns of Suppliers								
Water Supplier	Surface Water	Groundwater	Agricultural	M&I	Environmental	CALFED	SWRCB Findings	Water Quality Regs.	Endangered Species Act	Water Transfers	DWR Credit for Return Flows	Water Supply	Internal Infrastructure	Drought Management
Biggs-West Gridley	◆		◆		◆	◆	◆	◆	◆					
Butte	◆		◆		◆					◆	◆		◆	
Calwater-Chico		◆		◆										
Calwater-Oroville	◆	◆	◆	◆							◆	◆		
City of Biggs		◆		◆									◆	
City of Gridley		◆		◆										
Del Oro Water Company	◆	◆		◆								◆		
Durham Irrigation		◆		◆						◆		◆		
Durham Mutual Water Company*														
Oroville-Wyandotte	◆		◆	◆		◆				◆	◆		◆	
Paradise	◆	◆	◆	◆										◆
Richvale	◆		◆		◆	◆								
Thermalito	◆	◆		◆		◆	◆	◆				◆	◆	
Western Canal	◆		◆		◆	◆	◆		◆	◆				

* Durham Mutual Water Company did not participate in the interviews or surveys.

Much of the information within this section was gathered through interviews with water suppliers, or surveys completed by water suppliers. Table 4-6 shows the providers that were interviewed, and the names of several of the staff that helped to supply information.

Table 4-6
Water Supplier Interviews

Water Supplier	Interviewee	Water Supplier	Interviewee
Biggs-West Gridley Water District	Bernoy Bradford	Joint Water District	Doak Cotter
Butte Water District	Mark Orme	Oroville-Wyandotte Irrigation District	Michael Glaze
California Water Service, Chico	Mark Lightcap, Mike Pembroke	Paradise Irrigation District	Ray Auerbach
California Water Service, Oroville	Gary Alt	Richvale Irrigation District	Troy Kellet
Del Oro Water Company	Robert Fortino	Thermalito Irrigation District	David Bird
Durham Irrigation District	Jerry Morrision	Western Canal Water District	Matt Colwell

4.2.1 East Butte Inventory Unit

The East Butte Inventory Unit includes approximately 219,000 acres in the southern part of the valley, as shown in Figure 4-4. It is bordered by Butte Creek to the north and west, the Butte County line to the south, the foothills to the northeast and the Feather River to the southwest. East Butte contains the cities of Biggs and Gridley, and a portion of the city of Oroville. The primary crop types in the region are rice and orchards. The Gray Lodge Wildlife Area is in the southwestern corner of the unit. The cities of Biggs and Gridley use groundwater, but the remainder of the unit primarily utilizes surface-water supplies.

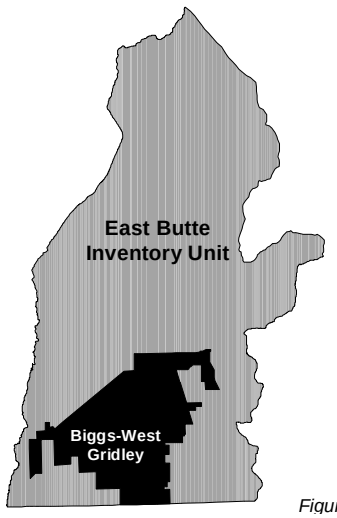


Figure 4-5

Biggs-West Gridley Inventory Sub-Unit

Biggs-West Gridley is located in the southwest corner of the East Butte Inventory Unit, as shown in Figure 4-5. The majority of the inventory sub-unit is composed of Biggs-West Gridley Water District, an agricultural water supplier that provides surface water from the Feather River. The inventory sub-unit also contains a small part of Gray Lodge Wildlife Area, roughly 2600 acres, which is within the boundaries of the Biggs-West Gridley Water District.

Biggs-West Gridley Water District

Biggs-West Gridley Water District was formed in 1942, and has grown to occupy 32,000 acres. Of Biggs-West Gridley's total area, 27,346 acres are irrigated for agriculture and managed wetland uses. The district's primary crop is rice, with 21,596 acres dedicated to the crop in 1999. Biggs-West Gridley also provides water to 8,500 acres of the Gray Lodge Wildlife Area, of which

2,600 acres are within their service area. In addition to providing water to the portion of the refuge within their service area, they provide water to the remainder of the refuge as part of an agreement with the USBR to meet CVPIA requirements. There are three other areas south of Gray Lodge (outside of Butte County) to which Biggs-West Gridley also provides a total of 800 acre-feet of water. Biggs-West Gridley does not make additional deliveries to these areas, but the areas recapture drainage water to use for irrigation purposes.

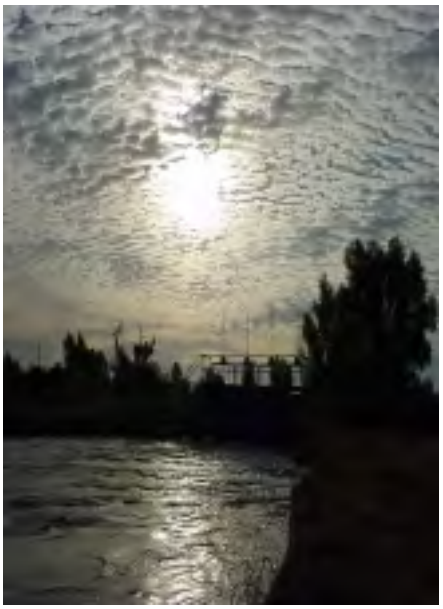
Photograph by Chuck Lowery

Biggs-West Gridley joined together with Butte Water District, Richvale Irrigation District, and Sutter Extension Water District to coordinate the acquisition, maintenance and operation of a water supply and distribution facility. Sutter Extension is entirely within Sutter County, and parts of Butte Water District and Biggs-West Gridley are within Sutter County, while Richvale is entirely within Butte County. These districts cooperated to purchase water rights and a canal system from the Sutter Butte Canal Company. The four districts and the Sutter Butte Canal Company entered into an agreement dated July 12, 1956, covering the maintenance and operation of the canal system. This agreement was amended by: (a) an agreement and conveyance dated September 21, 1966, entered into by the District; and (b) an agreement and conveyance dated April 11, 1969, entered into at Biggs and Richvale and consented to by Butte and Sutter. The districts then entered into four additional agreements affecting their operation, diversion facilities, main canal, and available water. These included: (a) an agreement dated July 6, 1964, entered into by the DWR; (b) an agreement on diversion of water from the Feather River, dated May 27, 1969, entered into by the DWR; (c) a water sale and exchange agreement entered into by PG&E and the districts on or about May 27, 1969; and (d) a consent agreement, dated May 27, 1969, entered into by PG&E and the districts.

The four districts created the Joint Water District in 1968 with powers to control, maintain, and operate the joint water distribution facilities of each district, and required the continued maintenance of rainfall, snowfall, weather, evaporation, hydrographic, engineering, and other data and records available and continuously accumulated relating to Feather River water flows, water diversion rights and the use of water within the districts.

The Joint Water District's settlement agreement with DWR establishes their settlement agreement, which traded pre-1914 water rights to the Feather River for supplies to be diverted from the Thermalito Afterbay at no charge. The settlement agreement supplies are subject to reductions in water-short years of up to 50% in any one year and not to exceed a total of 100% in any 7 year period.

Some landowners within the District have backup wells to make up for water lost during droughts, or to provide all water during droughts so that the remaining surface water can be marketed. However, the District itself has no production wells. Biggs-West Gridley has up to 3,000 acres of "second status" lands that were brought into the District after 1979. During years when the DWR reduces water deliveries, the second status lands are the first to have their water deliveries reduced.



Photograph by Chuck Lowery

Biggs-West Gridley is chronically water short. They have an entitlement of 160,958 acre-feet as an upper limit for their District, but they have been 5 TAF short for the past 5 years. In these years, they have bought added supply from other districts within the Joint Board. They also have a recapture system that provides approximately 25 TAF and could serve as an additional drought management tool. There are no surface storage facilities within the District.

Biggs-West Gridley has a system of canals to distribute water throughout their service area, and they estimate that the system has approximately 1% losses per mile, which include seepage, evapotranspiration, and associated losses. They are 17 miles wide, which results in a 17% loss as canals traverse the district. The conveyance system in Biggs-West Gridley is currently handling 700 cfs of diversions during the summer, but it was not designed for this flow. The DWR and the USBR are considering paying to expand the conveyance system to 850 cfs to provide the capacity to send more water through Biggs-West Gridley's system to Gray Lodge.

Of pressing concern for Biggs-West Gridley is the need to expand its conveyance capacity, which it must do to serve its existing customers. If the state or federal government does not pay for the expansion, Biggs-West Gridley will try to expand the system incrementally to 750 cfs instead of 850 cfs.

Biggs-West Gridley has the following statewide concerns:

- CALFED governance might include only agency representatives, without non-agency stakeholder representation;
- CALFED could result in agricultural land conversion and does not give adequate credit to farmers for wetlands on their lands;
- Phase 8 of the SWRCB hearings could set unpopular precedents;
- TMDL could impact agricultural drainage implementation; and

- Endangered Species Act requirements to protect habitat could limit maintenance activities within their distribution system.

Gray Lodge Wildlife Area

Portions of Gray Lodge Wildlife Area are located within the Biggs-West Gridley inventory sub-unit. The refuge is described as part of the Butte Sink inventory sub-unit because the majority of the refuge is located in that area.

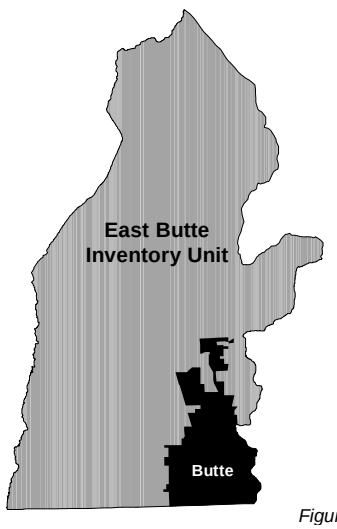


Figure 4-6

Butte Inventory Sub-Unit

The Butte Inventory Sub-Unit is located in the southeast portion of the East Butte Inventory Unit, as shown in Figure 4-6. The Butte Inventory Sub-Unit includes Butte Water District, which provides Feather River water for agricultural uses, and the cities of Biggs and Gridley.

Butte Water District

In the spring of 1952, the Sutter Butte Canal Company implemented a 30 percent rate increase. The landowners in the Gridley and Biggs area were concerned about the rising cost of water, and this additional increase provided a strong motivation to take action. The Butte Water District (Butte) was formed in 1953 with plans to acquire 11 percent of the Sutter Butte Canal Company's original water right on the Feather River as well as some of its canals. The District was formed primarily to provide irrigation water for farms in the Gridley and East Biggs area. Butte Water District is slightly more that 18,000 acres in size at present. Butte's surface water is diverted from the Thermalito Afterbay through the Sutter Butte Canal.

Almost all of Butte's acreage is irrigated for agricultural use. The District borders the Feather River, so it has mostly permanent crops such as orchards (10,000 are permanent, which represents 55% of its total irrigated acres). Because it borders the river, Butte has predominantly sandier soils, such as Gridley Loam to Columbia Loam. Farmers grow peaches, prunes, walnuts, almonds, kiwis, melons, rice, small grains, pasture, and alfalfa. At present there are no anticipated changes in crop mix, but city growth has begun to penetrate into agricultural areas.

Butte provides surface water, but many individual farmers have groundwater wells for backup. Surface water is often cheaper than groundwater because customers pay only for the operations and maintenance of the conveyance system that delivers the water, and not for the water itself. The use of surface water instead of groundwater is dependent on the irrigation method. If a farmer is using micro-jet irrigation, it works better with groundwater because it does not require filtration and has adequate pressure for distribution. Farmers sometimes prefer this method because they can

easily inject fertilizers, and it is less labor-intensive. However, surface water is much cheaper for rice irrigation.

Butte Water District is a member of the Joint Water District, as discussed in the above description under the Biggs-West Gridley Water District. Butte Water District is allotted a portion of 133,000 acre-feet/year out of the total Joint Water District entitlement, and they currently use 70-80% of this total.

During water-short years, farmers with annual crops only get 50% of their usual water allocation. Permanent crops get half as many irrigation applications, usually 3 instead of 6 for the season. Water deliveries were cut back in 1991 and 1992 in response to the drought, so many farmers installed backup wells for water short years.

Photograph from DWR

Butte will often sell extra water to other agencies within the Joint Water District as a part of its agreement. The District sells the water for a nominal fee. However, the Joint Water District agreement with the DWR says that it cannot transfer water outside of its service area.

The conveyance system is metered only at the point of diversion for each district from the Joint Water District canals. The districts have estimated that the canals have losses of 1% per mile.

Butte has several concerns in dealing with the DWR. The DWR does not give Butte, or any district within the Joint Water District, any credits for water returned to the system. Butte is also frustrated because it does not receive credits for conserved water. It would like to be able to sell conserved water to other districts, and to use the money to update its system. Also, Butte recently had a problem with the DWR because the agreement says that the DWR will deliver water of a certain temperature, but the water was delivered too cold. The DWR wanted the cooler water for fish, but the water temperature was damaging to rice production. The DWR and Butte solved this problem through a negotiated agreement. In addition, the Butte Water District is concerned about protecting the Joint Water District's water right.

Butte also has a moss and weed problem. Moss and other weeds are entering the canals at the afterbay, which can plug off pipelines to farmers as well as meters and weirs. In addition, these obstructions can slow down and decrease capacity of conveyance facilities, which are already limited.

The Joint Water District also has a safety issue where canals run through towns. As developers build housing projects, there is more development adjacent to canals, which can lead to safety concerns. The District wants developers to move the canals underground, but many developers do not want to assume this financial responsibility.

City of Biggs

The City of Biggs began to provide water to its residents through the Public Works Department in 1904. There are approximately 338 acres within the city limits.

In 1997, the population of Biggs was 1,640, consisting of approximately 600 households. The City supplied water only for residential, commercial, and fire protection purposes.

All water delivered to its customers by the City of Biggs is groundwater from three wells: Well No. 1, Willard Well, and Well No. 3. Well No. 1 is located adjacent to the City's water tower and serves as the primary source of water throughout the year. The well pump is activated as the storage tank is drawn down. Willard Well is located on C Street between First Street and Second Street. Well No. 3 is located near the southern end of Second Street and will replace Willard Well as a primary source of water. Well No. 3 was completed in 1997 and operates at variable rate in response to water demand and system pressure. In 1995, the City delivered 194 million gallons of water to its customers.

Water storage for the City is provided by a 40,000-gallon elevated steel water tank. This tank has been serving the City since before 1940 and is considered to be in good condition.

System-wide losses are estimated at 15%, but there is no metering performed. There is a daily reading at each well in cubic feet, but it is not known how that number relates to consumption.

There are 656 households in the City of Biggs with sewer connections. The average dry weather flow is 0.27 mgd. The collection system consists of 6" to 12" diameter lines which complete a primarily gravity driven system that conveys sewage to the southwest. At the City limits, all the flow enters a pump station which lifts and transports the flow to the City treatment plant approximately one-quarter mile to the west of town. The wastewater treatment plant is a grade 1 pond system and is located on a nine-acre site about one-half mile west of West Biggs Gridley Road. The effluent is discharged into the Reclamation District 833 drain. The plant has a design capacity of 0.35 mgd dry weather flow.

There are some citywide concerns. The lack of pipeline crossings under the railroad presently results in pressure loss on the East Side of the City during periods of high water demand. The water distribution system has 2,640 feet of substandard mains and 14 dead end lines. The delivery lines that dead-end result in reduced water flow capacity. The City is in the draft stages of preparing a master plan that will address these water distribution issues. The plan includes 9 projects with an estimated total cost of $4 .5 million. The plan will address specifically the aforementioned problems as well as the issue of metering.

The existing wastewater system is plagued by excessive flows caused by the infiltration of rainwater and high groundwater into the system through cracked pipes, faulty joints, and manholes. Although substantial effort was made to mitigate the inflow problem, this effort did not significantly reduce the inflow. In addition, performance of the treatment facilities is impaired during periods of heavy rainfall due to the naturally high water table and generally poor drainage in the vicinity of Biggs. The City is currently designing a major treatment plant and collection facility improvements to eliminate these existing system problems and to provide reliable capacity for future growth.

City of Gridley

The City of Gridley (Gridley) began to provide water to its residents through the Public Works Department around 1949. There are approximately 960 acres within the city limits.

In 1999, the population of Gridley was just over 5,000 people. The City supplies groundwater from five wells for residential, commercial, and fire protection purposes. Annual metered water deliveries averaged 412 million gallons over the past 4 years.

A single 300,000 gallon elevated tank provides fire protection for Gridley. The tank is in good repair, however, because it is elevated only 100 feet above the ground, the pressure is too low to be included in the system and it is considered unavailable for delivery for purposes other than fire protection. Water within a delivery system must maintain a high enough pressure to carry water throughout the entire system and have high enough water pressure to meet customer needs at the delivery points.

Losses are calculated by measuring the total metered water entering the system with the City's total sales. Typical losses within the system are 15-20%. The metered water figures are fairly accurate due to the fact that all but 10 services within the City are metered.

There are 1,800 households in the City of Gridley with sewer connections. The average day flow for those with sewer connections is 0.69 mgd. The treatment facility is owned and operated by the City. The facility provides secondary treatment with aeration and uses a percolation pond. There is no reuse of the effluent produced by the treatment plant.

The City of Gridley voiced several concerns. Gridley recently completed the construction of a fifth well and is now looking at the possibility of constructing an additional well to meet demand. There are also water quality concerns, as traces of iron, manganese and arsenic have been found in some wells. In the future, new well sites will undergo an intensive site-selection process. Gridley believes that their groundwater supply is adequate during dry years because the City's wells are located in the recharge plume of the Thermalito Afterbay. During the 1987-1991 drought, groundwater levels varied by no more than 5-6 feet from normal conditions.

On a countywide level, Gridley is concerned that Butte County's many Leaky Underground Storage Tanks and their MTBE plumes could be affecting local water quality. The City also has a water quality concern at a statewide level associated with the state's talk of extended conjunctive use.

Butte Sink Inventory Sub-Unit

Butte Sink is located in the southwest corner of Butte County, as shown in Figure 4-7, and receives much of the runoff from the remainder of the county. The Gray Lodge Wildlife Area is located within Butte Sink. Part of the Butte Sink still remains comparatively unchanged from its original condition, although water developments have reduced the amount of flooding. Water for wetlands in the Butte Sink is derived from flood waters, Butte Creek, Sacramento River, and agricultural return flows from rice fields. Within the Butte Basin, 67 organized hunting clubs are now maintained over 52,000 acres of habitat including over 22,000 acres of flooded lands.

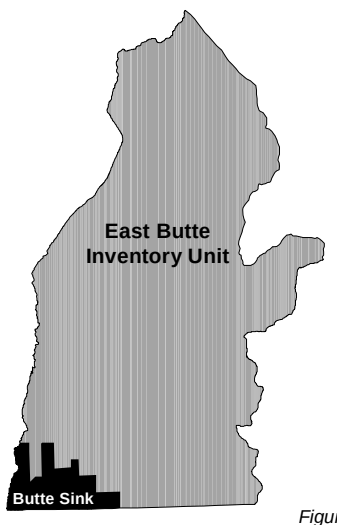


Figure 4-7

Gray Lodge Wildlife Area

In 1931 the DFG purchased the 2,540-acre Gray Lodge Gun Club to establish the first Sacramento Valley wildlife refuge. In 1971, an additional 5,860-acres were purchased, which increased the refuge area to 8,400 acres. The Refuge is located adjacent to the Butte Sink, which is an overflow area of Butte Creek and the Sacramento River.

The Refuge's 8,000 acre-feet of firm water supplies are from the Biggs-West Gridley Water District. In addition, Biggs-West Gridley has allocated 12,000 acre-feet of water per year to the Refuge. However, only 8,000 acre-feet are available during the irrigation season from April to November.

The Refuge also diverts water from the Reclamation Districts 833 and 2054 Drains, which convey agricultural return flows. The return flows are available only during the summer and early fall when the rice fields are drained. The Reclamation Districts relinquish any right to the water that leaves their boundaries during the period of time that the rice fields are being drained. This water then becomes abandoned and DFG has filed water rights permits on this abandoned water. Based upon existing data, water quality appears to be adequate for refuge management.

In October 1992, the United States Congress passed Public Law 102-575, known as the Central Valley Project Improvement Act. Part of that legislation made the Secretary of the Interior (Secretary) responsible for providing firm water supplies of suitable quality to maintain and improve wetland habitat areas on units of the National Wildlife Refuge System in the Central Valley of California, including Gray Lodge Wildlife Area.

The Secretary is to provide up to current average annual water deliveries, known as level 2, and optimum management water supplies, known as level 4. The amount of water the Secretary is responsible for is that quantity of water less any other water supplies that are available from existing water rights, long-term contracts, and groundwater to the refuges. The refuge has a fairly extensive groundwater well network that provides over four thousand acre-feet per year.

Since the Secretary is responsible, it becomes an obligation of USBR, the operator of the CVP. The USBR does not have facilities to directly serve water to Gray Lodge and must rely on the State Water Project to provide the water from Thermalito Afterbay. The USBR will then enter into a long-term contract with the DWR that will provide replacement for the water delivered from Thermalito Afterbay by making Central Valley Project water available in the Sacramento-San Joaquin Delta.

Additional water potentially may be obtained from Thermalito Afterbay and conveyed through Biggs-West Gridley facilities, the Cherokee Canal, or Western Canal Water Users Association (WCWUA) facilities. The Cherokee Canal, an old mining drainage channel, is operated by Richvale Irrigation District, a member of the Joint Water District. Water from the Cherokee Canal could be diverted to BWGWD for delivery to the Refuge. The WCWUA facilities divert water from Thermalito Afterbay and are operated year-round to deliver water to hunting clubs in the Butte Sink.

The Refuge ultimate demand (level 4) is estimated to be 44,000 acre-feet at optimum management. The level 2 demand is 35,400 acre-feet, and level 4 is to be reached by 2002.

Table 4-7 shows the sources and total diversions to Gray Lodge in 1999. These flows are indicative of recent years, where the refuge is trying to accommodate level 2 demands.

Table 4-7
Gray Lodge Water Sources

Water Source	Water Amount
BWGWD, RD 833 and 2054	18,476 acre-feet
Groundwater	4,224 acre-feet
USBR (CVP)	10,551 acre-feet
Total	**33,241 acre-feet**

Cherokee Inventory Sub-Unit

The Cherokee Inventory Sub-Unit is located on the northeast side of the East Butte Inventory Unit, as shown in Figure 4-8. Cherokee is approximately 45.9 square miles, and does not contain any established water purveyors. Cherokee has an approximate population of 1000 people, and the primary land use is for agriculture. The main crops are rice, almonds, pasture, and subtropical.

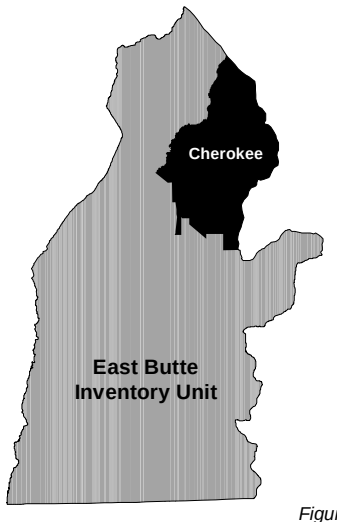


Figure 4-8

The main water source in Cherokee is groundwater, but there is some surface water use within the area. The Miocene Canal delivers water from PG&E to Calwater-Oroville, and passes through Cherokee. Farmers along the canal purchase water from Calwater, but they do not have priority to the water during dry years. During dry years, Calwater sells the water to urban users in Oroville with higher priority to the water.

Residents of Cherokee are concerned that surface water transfers that include groundwater substitution for local use will negatively impact their groundwater source.

Esquon Inventory Sub-Unit

The Esquon Inventory Sub-Unit is in the northern portion of the East Butte Inventory Unit, as shown in Figure 4-9. Esquon contains the Durham Mutual Water Company, an agricultural water supplier. Adams-Esquon Ranch, a large, privately owned agricultural facility, is also in the Esquon Inventory Sub-Unit. The majority of land use within Esquon is agricultural, with crops including rice, almonds, corn, pasture, and others.

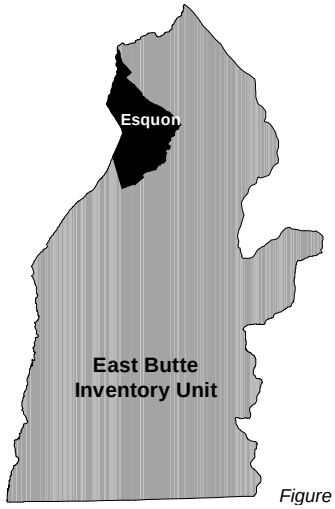


Figure 4-9

Durham Mutual Water Company

Durham Mutual Water Company was created by area residents. The company provides surface water for agricultural uses from Butte Creek. Durham Mutual Water Company is part of the Butte Creek adjudication, and has first priority rights to 44.7 cubic feet per second (cfs). The water is diverted at Durham Mutual Dam, and is then conveyed to customers in the service area.

Adams-Esquon Ranch

Adams-Esquon Ranch is a major landowner within the Esquon Inventory Sub-Unit. Adams-Esquon is also part of the Butte Creek adjudication, and has water rights to divert water from Adams-Esquon Dam. They have rights (of varying priority) to 7.14 cfs of water throughout the year, with an additional 13.25 cfs from April 1 to September 30 and 8 cfs from April 1 to June 15. In addition to the diversion from Butte Creek, Adams-Esquon has water rights to Hamlin Slough, which is a tributary to Butte Creek and also part of the Butte Creek adjudication. The ranch utilizes groundwater to meet demands not met by surface water.

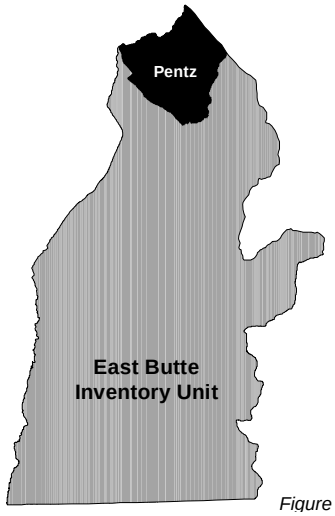


Figure 4-10

Pentz Inventory Sub-Unit

The Pentz Inventory Sub-Unit is located at the northern tip of the East Butte Inventory Unit, as illustrated in Figure 4-10. It has a population of roughly 85 people, and very little farming in the area. Pentz is located at the edge of the foothills, so the terrain is starting to become rocky and more difficult to develop. The low levels of development correspond to low water uses in the region. The main source of water is groundwater, and it is used for domestic water supply.

Richvale Inventory Sub-Unit

The Richvale Inventory Sub-Unit is located on the west side of the East Butte Inventory Unit, as shown in Figure 4-11. Richvale contains Richvale Irrigation District, an agricultural surface water supplier, and the Little Dry Creek Unit of the California Department of Fish and Game.

Richvale Irrigation District

Richvale Irrigation District was formed by a vote of the landowners on June 23, 1930 to provide agricultural water. Richvale is allocated 27% of 555,000 acre-feet (i.e. 149,850 acre-feet) of water annually acquired by the Joint Water District pursuant to pre-1914 water rights, subject to deficiency limitations in the May 1969 agreement. The Joint Water District and associated agreements are described in greater detail under the Biggs-West Gridley Water District. In addition, Richvale has a riparian water right on Little Dry Creek for 18,300 acre-feet that can only be used during April – September. The District encompasses a land area of approximately 33,000 irrigable acres in Butte County.

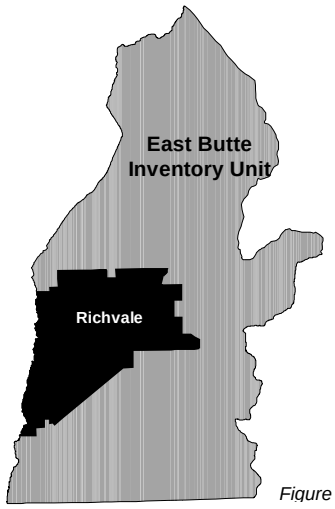


Figure 4-11

Richvale distributes its water supplies annually during the irrigation season, generally commencing by charging its water distribution system with surface water supplies from Thermalito Afterbay in April each year, and generally completing its water distribution by October 31 each year. The District may continue water distribution from November to January for rice straw decomposition, to benefit wildlife habitat in the Butte Basin, and to comply with restrictions on rice straw burning. Water supplies distributed during times of shortage are allocated pursuant to a proration and water duty imposed upon crops grown by district landowners as determined by the Board of Directors.

Richvale's cropping pattern for the period 1995 – 1999 was 99% rice and less than 1% pasture. The cropping patterns are determined for the District by the Farm Service Agency. Richvale does not anticipate any changes to this crop pattern in the near future. Some groundwater pumping occurs within Richvale, which is used primarily as a supplemental source of water during the initial flooding of rice fields. Richvale does not have estimates of the quantity of groundwater pumped.

The major concern of the District is the outcome of the CALFED process and its potential impact on water resources within Butte County.

Little Dry Creek Unit (DFG)

DFG bought 3,736 acres of what was formally the Schour Ranch in 1988 and 1999. This property is a secondary annex to the Richvale Irrigation District and the Biggs-West Gridley Water District. It has water rights to Butte Creek, the 833 drain, and the Cherokee Canal. The main source of water is the 100 drain from Richvale Irrigation District, which enters approximately the center of the Unit from the north and eventually flows into Butte Creek (within the Unit). Water is lifted primarily by low lift pumps into delivery channels to be distributed throughout the area. The water issues in the Little Dry Creek Unit are layered with legal easements and court decisions as to how the water is to be shared with the neighbors.

There are six agricultural wells on the property located along the northern boundary. The water flow is primarily north to south. Five of these wells came with the purchase of the property. DFG installed one well on the area, which has a 16-inch casing and is 500-feet deep to produce approximately 5,000 gpm. Well water is used primarily in the spring before irrigation water is available and in the fall when the agricultural canals are down for rice harvest. In addition, the wells are used to irrigate many wildlife plantings.

Water rights to Butte Creek have not been used so that the water can be left in the channel for in-stream flows to help with the salmon issues in Butte Creek.

The Little Dry Creek Unit has not been fully developed or funded by DFG, and water allotments have not been fully used.

Table 4-8 shows the estimated water use for the Little Dry Creek Unit under present management on a normal water year. Drought years reduce irrigation district water and drastically increase well water use.

Table 4-8
Water Use for the Little Dry Creek Unit

Water Purpose	Source	Amount used (af)
Irrigation	Richvale Irrigation District	6,500
Irrigation	Groundwater wells	500
Fall flooding	Richvale Irrigation District	4,500
Fall flooding and maintenance	Groundwater Wells	1,000
	Total	12,500

Estimated water use at full development is approximately 16,000 acre-feet.

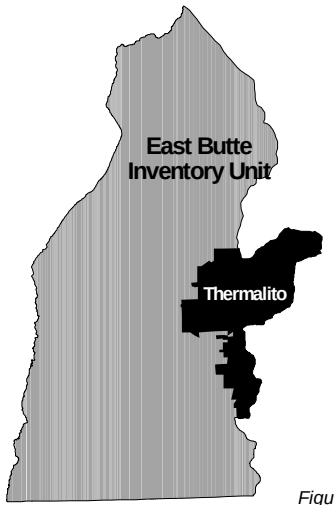


Figure 4-12

Thermalito Inventory Sub-Unit

The Thermalito Inventory Sub-Unit is located on the east side of the East Butte Inventory Unit, which is shown on Figure 4-12. Thermalito contains part of the City of Oroville, as well as agricultural areas that are not served by a water supplier. Portions of Thermalito Irrigation District and California Water Service Company-Oroville are both included within the Thermalito Inventory Sub-Unit, and they both provide urban water to Oroville residents. The southern portion of the Thermalito Inventory Sub-Unit is south of the Thermalito Afterbay, and consists primarily of agricultural land that uses groundwater to irrigate crops.

Thermalito Irrigation District

Thermalito Irrigation District was originally organized as an agricultural water supplier in 1922. There are approximately 14,000 acres within the service area, with 4,000 to 5,000 acres being served by Thermalito.

There is a population of approximately 9,400 in the District and around 2,500 connections. The farmers that originally used the majority of the water in Thermalito farmed olives, figs, cotton, and oranges. Agriculture slowly declined within the District due to a combination of factors, including marginal soil. Thermalito now delivers only potable water to a combination of residential, industrial, and governmental users.

Thermalito obtains its surface water from the Concow Reservoir (also known as Wilenor Reservoir). The water enters the West Branch of the Feather River through Concow Creek, then is released from Oroville Dam and delivered to the District through the Thermalito Power Canal. Thermalito also has five groundwater wells, that combine with surface water for a total capacity of 10 mgd (11.2 TAF/yr). However, it is more energy efficient to deliver surface water, so groundwater is used only as a backup. Last year, approximately 2,800 acre-feet of water were supplied within the service area.

Thermalito obtained appropriative water rights in 1928 and 1929 to 45% of the stored water in Concow Reservoir, which amounts to a total of 7,225 acre-feet. In 1985, a SWRCB decision allowed the District to receive 8,200 acre-feet. Thermalito uses about 2,800 acre-feet of the 8,200 acre-feet water allotment.

The District stores some of its water in a 2.5 million-gallon storage tank in the distribution center, and another 7,225 acre-feet within Concow Reservoir. Losses of water within the District are believed to be insignificant. Thermalito discovered that

many of the apparent leaks were caused by old meters, which had slowed down and were under-indicating the water delivered. As the old meters are replaced, calculations indicate that less water is lost throughout the system.

Thermalito collects sewage within its service area, which is conveyed to a plant run by the Joint Powers Authority, which includes Thermalito, the Sewer Commission Oroville Region (SCOR), and the Lake Oroville Area Public Utilities District. Together they send around 200-230 gallons per day of treated wastewater into the Feather River.

Thermalito has some concerns within its District. It is trying to extend water mains to vacant land to help accelerate development. The District also has estimated that the water treatment plant will need to be expanded within 8-10 years. The plant does not have sedimentation basins, so it cannot handle increased turbidity. During times with high turbidity, Thermalito uses its groundwater wells to supplement supplies. Thermalito is planning to add sedimentation basins when it can acquire the land to make additions to the plant.

Thermalito is concerned on a county-wide level about groundwater overdraft, and believes that surface water options should be fully utilized. The county has a State Water Project allocation of 27,500 acre-feet, but they have never exercised the full allocation because the water is more expensive than other sources in the County. The District fears that if Butte County does not use their SWP allocation, they could lose it.

Statewide, Thermalito representatives expressed the following concerns:

- CALFED will not be able to supply adequate quantities of water to a growing California population;
- The SWRCB water rights hearings to set aside environmental water are very controversial, and will not be popular in Butte County;
- The EPA is considering implementing drinking water standards that would be extremely difficult to meet.

California Water Service Company, Oroville

California Water Service Company, Oroville (Calwater-Oroville) is a private water supplier that purchased a local water district in Oroville in 1927. Calwater-Oroville provides water within the Oroville city limits, minus areas served by other Oroville water suppliers (Thermalito Irrigation District and Oroville-Wyandotte Irrigation District).

The population within Calwater-Oroville is approximately 9,620 and almost all of the water that Calwater-Oroville provides is dedicated to urban use (residential, industrial, and commercial). The company does provide agricultural water to farmers

along the delivery canal. However, during a drought the agricultural users are the first to be cut back.

Calwater-Oroville purchases its raw water supply from PG&E, which diverts water from the West Branch of the Feather River into the Miocene Canal to the Coal Canyon Powerhouse. After the water passes through the power plant, the Miocene Canal continues conveying the water to Calwater-Oroville. The company also buys SWP water from the county when necessary because of droughts, high demands, or PG&E maintenance. The SWP water is much more expensive than the PG&E water. Calwater-Oroville has four groundwater wells, but they are only used during PG&E shutdowns or droughts. The average water quantity supplied by the company is 4.85 TAF/yr. The peak daily use is approximately 6.5 mgd. The average daily use during high demand is 5.5 mgd.

Calwater-Oroville has two reservoirs and two storage tanks, providing a total of 7.209 million gallons of storage. Conveyance losses from the Miocene Canal do occur, but they are difficult to determine with any certainty because routine operations spill water from the system into the Feather River. They also vary with deliveries, with more water being lost during higher deliveries.

Losses in the distribution system are a minor concern. Calwater-Oroville detects major losses through pressure gauges on pumps, and the company has a leak detection program that checks the entire system for leaks once or twice a year. This program has found and repaired several leaks. Also, operators check daily for unusual changes in meter readings, which may indicate a leak or other anomaly.

Calwater-Oroville has several concerns within their service area. It would first like to expand supply. Future options for more water include building more storage tanks and drilling new wells. The City of Oroville is prepared to help with some of this expansion, and has set aside parcels of land for these facilities. Currently, water is usually spilled from the Miocene Canal into the state's system. The state charges Calwater-Oroville for any SWP water that it uses, but does not provide a credit for water spilled from the canal. Calwater-Oroville is also concerned that the county will not fully utilize its allotment of SWP water, which could mean that the water entitlement would be decreased or lost.

PG&E's divestiture of its hydro facilities was a major concern to Calwater-Oroville. Under a proposed settlement agreement, PG&E was negotiating for the option to sell any low production facility, which could include the Miocene Canal or Coal Canyon Powerhouse. These facilities were not going to be part of the larger package of hydro facilities, but rather might have been sold outright. Calwater-Oroville looked into buying the canal and powerhouse, but the purchase price was too expensive for them. The proposed settlement agreement did not reach fruition and therefore PG&E is not presently planning to separate these facilities, which has reduced Calwater-Oroville's level of concern about the divestiture process.

Western Canal Inventory Sub-Unit

The Western Canal Inventory Sub-Unit is on the west side of the East Butte Inventory Unit, approximately in the center of the unit (see Figure 4-13). Western Canal contains the portion of the Western Canal Water District that is east of Butte Creek.

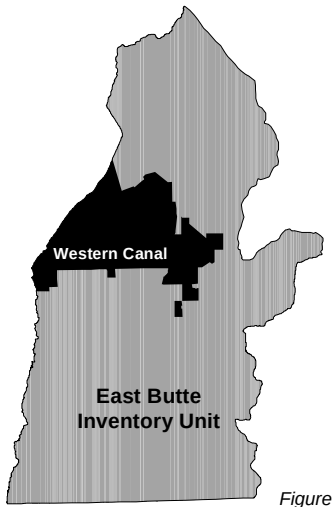


Figure 4-13

Western Canal Water District

The Western Canal Water District was formed to provide agricultural water by vote of landowners on December 18, 1984. The District purchased the Western Canal Company water system from the PG&E, which had acquired it from Great Western Power Company. The canal was originally developed by the Western Canal Company, which began operations in 1915. The District encompasses a land area of approximately 59,000 irrigable acres in both Butte and Glenn Counties, with approximately 30,700 acres in the East Butte Inventory Unit and 14,000 in the West Butte Inventory Unit.

Western Canal's original diversion was located at the Western Canal Company's Dam on the Feather River. The diversion facilities and upstream portion of the Western Canal were displaced by the Oroville Reservoir Complex. The supply is now provided by two outlet structures located on the northwest corner of the Thermalito Afterbay. The maximum combined outlet flow is 1,250 cubic feet per second.

The pre-1914 surface water rights of the District comprise 150,000 acre-feet of natural flow of the Feather River, subject to reduction during drought, and 145,000 acre-feet from upstream stored water that is not subject to reduction. Water from the North Fork of the Feather River is stored in a series of reservoirs, known as the Feather River North Fork Project. This water must be taken during the period of March through October. There also exists a water right on Butte Creek for 11,400 acre-feet, which can be diverted only during the period of April 15 through June 15. On May 27, 1969, PG&E entered into an agreement with the DWR to provide for the diversion of Feather River water below Oroville Dam. This agreement spells out the timing and quantity of deliveries by the DWR to Western Canal. During water-short years, Western Canal's rights to natural flows are reduced up to 50% in any one year, not to exceed 100% in seven years.

The District does not own any irrigation wells. Any groundwater used within the District is from individual landowners' wells. Many landowners have constructed deep wells (at their own expense) to provide a conjunctive-use capability. A number of the farms to the north of the main canal were entirely dependent upon groundwater supplies until canals and low-lift pumps were installed (at landowners'

expense) to provide surface water supply. Current groundwater use within the district boundaries is estimated to be 7,000 acre-feet.

Western Canal's cropping pattern for the period 1995 – 1999 was approximately 95% rice and 5% in other uses (50% of which is for wildlife habitat and alfalfa). The cropping pattern is determined through user applications to the District and the use of aerial photographs. Western Canal does not foresee any changes to this crop pattern in the near future.

The conveyance losses within the District are estimated to be about 12%-13%. The losses are calculated from the total diversions from Thermalito Afterbay less the total metered water diversions from the delivery system. Conveyance losses also include losses from water that is conveyed to lands in Glenn County. A portion of Western Canal is in Glenn County, and the water must be transported through the Butte County part of the District before it is delivered. In addition, Western Canal provides refuge water to the Howard Slough Unit of the California Department of Fish and Game in Glenn County, and to DFG's Llano Seco Unit of the Upper Butte Basin Wildlife Area.

Western Canal also provides water to 1922 Agreement Lands located in Butte Sink. Originally, these lands were managed for waterfowl habitat using natural flow and return rice flows. These flows were not adequate, however, so they entered into an agreement with Western Canal. The agreement stated that they will use all rice drainage water first, and then contact Western Canal for additional water, which is released into Butte Creek for conveyance to these lands.

The issues and concerns of the District include:

- State Water Resources Control Board past and future decisions;
- Conjunctive use concerns that may be mandated by county ordinances or state and federal laws;
- CALFED endangered species operational impacts associated with the re-allocation of water supplies; and
- Water transfer laws instituted by state and federal governments.

Figure 4-15

4.2.2 Foothill Inventory Unit

The Foothill Inventory Unit encompasses approximately 217,300 acres in the foothills of Butte County, as shown in Figure 4-14. The approximate change in elevation within the unit is 1,200 feet. The Foothill Unit contains the city of Paradise as well as a portion of the city of Oroville. The foothills have limited groundwater, and the majority of the

water is supplied from surface-water.

Cohasset Inventory Sub-Unit

The Cohasset Inventory Sub-Unit is located at the northern end of the Foothill Inventory Unit, as shown in Figure 4-15. The terrain in Cohasset is not conducive to agriculture, so the water use within the area is mainly domestic. The population is approximately 3,500 residents, and they utilize groundwater. The per capita water use is limited in the area because of low yields from wells.

Ridge Inventory Sub-Unit

The Ridge Inventory Sub-Unit is in the center of the Foothill Inventory Sub-Unit, bordered on the north by Butte Creek and on the south by the Feather River (see Figure 4-16). The Ridge contains the City of Paradise and surrounding urban developments, and water supply is a mix of surface water and groundwater. Del Oro Water Company and Paradise Irrigation District provide water to these urban areas.

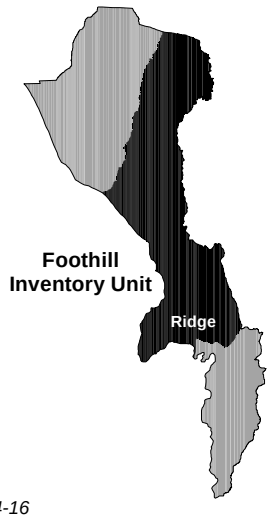


Figure 4-16

Del Oro Water Company

Del Oro Water Company serves the unincorporated urban areas around the Town of Paradise. Del Oro has four separate service areas: Lime Saddle, Magalia, Paradise Pines, and Stirling Bluffs. The service areas are separated geographically and by the source of water they utilize.

The Lime Saddle District is approximately 4.3 square miles, with 265 service connections (primarily residential). All connections are metered, and losses are not found to be significant. Lime Saddle has two groundwater wells, and has an agreement with Paradise Irrigation District to receive treated surface water. The agreement stipulates that they will treat up to 266 acre-feet per year, and will deliver that amount minus 10% assumed conveyance losses. The groundwater wells in Lime Saddle do not bear much water, and have produced slightly less than 50 acre-feet per year in recent years.

The Magalia District has 258 connections, which are primarily residential. Magalia has two groundwater wells, which produced approximately 38 acre-feet in 1999. Magaila also receives some water from Paradise Irrigation District. All connections are metered.

The Paradise Pines District utilizes groundwater, with 4,440 metered connections and 562 additional services. In addition to local groundwater wells, Paradise Pines receives surface water from the Stirling Bluffs District. The primary water service is for single family residential dwellings. Paradise Pines has five active groundwater wells, which produced 1,375 acre-feet in 1999.

The Stirling Bluffs District has 157 active service connections and 23 inactive service connections. Water use in the area is primarily residential. Stirling Bluffs has a contract to receive up to 365 acre-feet per year of water from PG&E through the Hendrick Canal. In 1999, they diverted 86.64 acre-feet of this water. All connections in the District are metered.

The remaining water from Stirling Bluffs is available for transfer to Paradise Reservoir, which Paradise Irrigation District treats and wheels to Paradise Pines, Magalia, or Lime Saddle. Of the 365 acre-feet, 266 acre-feet is dedicated to Lime Saddle as described above, and most of the remaining water is currently used in Paradise Pines.

Del Oro purchased additional surface water from Paradise Irrigation District in 1996-97 and 1999-2000. An additional 125 acre-feet was purchased from October 1999-March 2000.

Paradise Irrigation District

Paradise Irrigation District was formed in 1916 and is approximately 11,250 acres in size. By 1917, the Magalia Reservoir was in operation, providing approximately 1,950 acre-feet of water storage. The District suffered numerous repair expenses and shortages during the 1930's, and financial limitations during the 1940's. During the early 1950's, the District recognized the area's significant population growth, and the limitations of the District's insufficient water storage and distribution system capacity. During the mid-1950's, the District replaced the canal conveyance from Magalia Reservoir to the District with a steel pipeline to reduce losses. In 1956, the District constructed the new Paradise Dam and Reservoir, with a storage capacity of 8,350 acre-feet. The Dam was raised by 24.5 feet in 1976, which increased the capacity to 11,497 acre-feet. In 1996, seismic concerns in Magalia Reservoir forced the District to keep water levels below the maximum capacity, which has reduced the capacity from 2,500 acre-feet to approximately 800 acre-feet. The District completed construction of a new water treatment plant in 1995 with the capacity to treat 22.8 million gallons of water per day. During 2000, the District used approximately 8,200 acre-feet of water within their service area, including water losses.

Paradise serves 25,772 people, and has 10,000 current connections serving 13,000 dwelling units. Paradise anticipates an approximately 20% growth rate through 2020, as explained in the Paradise General Plan. This growth will increase the current population of 25,772 people to approximately 31,000. Treated water in the District is used for both agricultural and domestic purposes, with approximately 6% of the District's water used to irrigate orchards.

Paradise currently has 18,300 acre-feet of water rights from Little Butte Creek. In 1916, Paradise obtained a year-round right for approximately 9,800 acre-feet to divert water to storage. In 1954, it obtained an additional 8,500 acre-feet that could be diverted to storage during October-May.

Paradise built a new water treatment plant in 1995 with a design capacity of 19 mgd. After construction, the plant was tested and rated by the California Department of Health Services at 22.8 mgd.

There is a 15% (1,250 acre-feet) system-wide loss from the distribution system. In 1994, Paradise began to repair the distribution system because losses had reached 30%. Older steel pipelines are being replaced by PVC to reduce system leakage.

Paradise does not have supply problems in normal runoff years, but is vulnerable to several dry years in a row. In addition, Paradise is surrounded by the Del Oro Water Company's service area, and is potentially impacted by its problems. The Paradise Pines and Lime Saddle areas currently rely on Stirling Bluffs water. Del Oro has no storage, so it is very susceptible to droughts. Discussions are underway to consider a 2-mile pipeline that would carry water from Lake Oroville to Lime Saddle and Paradise Irrigation District. Current estimates of cost range from $300-$350 per connection for Pines and Lime Saddle users.

Paradise has some additional District-wide concerns. Its staff believes that a long-term drought would require demand reduction. Paradise currently has one well to use as a drought management tool, and they have plans to install an additional well that would provide 200 to 300 acre-feet of supply. A study is underway to determine the feasibility of additional water sources. There are no groundwater quality concerns, although septic tanks are the only means of sewage disposal in the District.

Wyandotte Inventory Sub-Unit

The Wyandotte Inventory Sub-Unit is the southern-most area of the Foothill Inventory Unit, as shown in Figure 4-17. Wyandotte contains a portion of the City of Oroville, as well as agricultural areas with a variety of crops. Much of the area receives surface water from Oroville-Wyandotte Irrigation District.

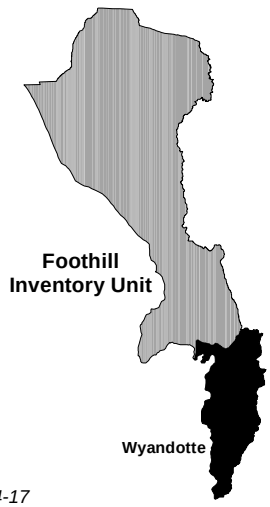


Figure 4-17

Oroville-Wyandotte Irrigation District

Oroville-Wyandotte Irrigation District was formed in 1919. Originally, the canals in Oroville-Wyandotte were constructed to convey water for hydraulic mining. Most of the infrastructure was built in the 1850s and 1860s, but due to severe environmental damage and associated erosion, hydraulic mining was outlawed in 1884. Two land and water companies, Palermo and South Feather, emerged in the area to take advantage of the existence of the infrastructure.

The land and water companies formed with the intent to sell land to Southern Californians to grow citrus fruits and olives, and they thought that the land would be

attractive because it had a water supply. However, the companies fell onto hard times because the construction costs exceeded original estimates, and the land was not selling as quickly as expected. Around this time, the Wright Act was passed, allowing the formation of irrigation districts that could levy land taxes. The prospect of collecting taxes was very appealing to the struggling companies, so they formed the Oroville-Wyandotte Irrigation District in 1919.

All residents in the area were not in favor of forming the irrigation district because they did not want to pay the land taxes. Therefore, when Oroville-Wyandotte was formed, customers of the original land and water companies were allowed to receive Oroville-Wyandotte water without needing to join the irrigation district. These customers would receive water at the same priority level as district customers and pay the same rate.

In the years following its formation, Oroville-Wyandotte was constantly faced with problems due to inadequate funding and lack of water supply. To alleviate both problems, it proposed and constructed the South Fork Power Project, which built 8 dams, 17 tunnels, 21 miles of canals and conduits, 3 hydroelectric power plants and 21 miles of road. As a part of this plan, water from the facilities must be delivered to Yuba County Water Authority to fulfill its water rights on the system. Power from the hydroelectric plants (as well as a hydro-plant built later) was and continues to be sold to PG&E. Today, Oroville-Wyandotte encompasses 38,320 acres.

Oroville-Wyandotte serves a population of 17,000, with 6,120 domestic water accounts and 525 irrigation accounts. Urban demand is expected to rise as the historical growth rate of 1.2% is increased because of the Oroville community's accelerated expansion plans.

Supplied water is used for agricultural, residential, and commercial purposes. Oroville-Wyandotte does not keep track of cropping patterns within the District. The land has been subdivided into small parcels, or ranchettes, most of which are not commercial farms. Some farms irrigate, but some do not, such as those producing olive crops. The primary crops are citrus and olives, and viticulture is increasing as well. Viticulture is not commercial yet, but produces wines that are only sold locally.

Oroville-Wyandotte has four major reservoirs: Sly Creek, Lost Creek, Ponderosa, and Miner's Ranch, which total approximately 172 TAF of storage. Sly Creek Reservoir is fed partially by Slate Creek, which is part of the Yuba River system. Yuba County Water Authority receives water through the Forbestown Ditch from Sly Creek Reservoir. The remainder of the water is for Oroville-Wyandotte Irrigation District use. There are three canal systems within the District that provide raw water to agricultural customers: Forbestown, Bangor, and Palermo. Oroville-Wyandotte does not use groundwater but there are some pockets of land within the District that have independent private wells.

Oroville-Wyandotte has both pre-1914 and appropriative water rights totaling 800 TAF, which is more water than is available from within the watershed. The District can take 172,145 acre-feet of water from the South Fork of the Feather River and the Yuba River and store it in its reservoirs. Oroville-Wyandotte uses 27 TAF of water within their service area.

The system is 100% metered (or volume-measured for raw water delivery systems, using instruments such as "miner's-inch" boxes). Losses within the domestic system are believed to be negligible. In 1990, there were up to 160 leaks due to the poor condition of the old steel pipeline system, but with repairs there are now only 6-7 leaks. Oroville-Wyandotte now has an aggressive steel pipeline replacement project underway for their urban deliveries.

Losses in the agricultural systems are more significant, with 93% in the Forbestown Canal, and approximately 70-80% in the remainder of the system. In recent years, it has coated canal areas with profuse leaks with concrete, and fixed sections with major leaks. Consideration has been given to rehabilitating the entire ditch system, but the cost is estimated between $15-$20 million. The ditch system is already subsidized by the power division, so the District cannot justify spending additional money on that system. The District would consider repairing the leaks if it could sell the water, but wheeling fees charged by the DWR have made transfers financially prohibitive.

On a statewide level, Oroville-Wyandotte believes that storage is necessary to meet water needs, but it is not politically palatable. Even if storage is constructed, the next problem to face would be the conveyance method to get water from the north to the south.

4.2.3 Mountain Inventory Unit

The Mountain Inventory Unit includes approximately 407,100 acres in the mountains on the eastern side of the county, as shown in Figure 4-18. The steep terrain limits groundwater accessibility to areas of fractured or jointed rock. There is limited development in the mountain area, so there is little water demand. There are no inventory sub-units within Mountain, but a portion of the area is provided water from Oroville-Wyandotte Irrigation District.

Oroville-Wyandotte Irrigation District

Oroville-Wyandotte Irrigation District provides surface water for urban and agricultural uses. The majority of the District is within the Wyandotte Inventory Sub-Unit, so the District is described in detail in that section.

4.2.4 North Yuba Inventory Unit

The North Yuba Inventory Unit covers about 47,300 acres in the southeastern portion of the county, as shown in Figure 4-19. The Feather River to the north and west, the Butte County lines to the south, and the foothills to the east border it. North Yuba

contains part of the city of Oroville, with a variety of agricultural crops in the remainder of the unit. The primary source of agricultural water is groundwater.

North Yuba does not contain any inventory sub-units, but some areas receive water from Oroville-Wyandotte Irrigation District and California Water Service Company, Oroville.

Oroville-Wyandotte Irrigation District
Oroville-Wyandotte is described in greater detail in Section 4.2.2, under the Wyandotte Inventory Sub-Unit.

California Water Service Company, Oroville
California Water Service Company, Oroville is described in greater detail in Section 4.2.1, under the Thermalito Inventory Sub-Unit.

4.2.5 Vina Inventory Unit

The Vina Inventory Unit includes approximately 88,100 acres in the northern valley area of Butte County, as shown in Figure 4-20. The Butte County line to the north, Big Chico Creek to the south, Sacramento River to the west, and the foothills to the east border it. Vina includes part of the city of Chico and agricultural land in the western half, with orchards as the major crop type. The predominant source of water is groundwater.

There are no inventory sub-units within Vina, but the Chico area receives water from California Water Service Company, Chico.

California Water Service Company, Chico
California Water Service Company, Chico (Calwater Chico) is a private company that has been serving the water supply needs of the greater Chico area since 1926, when it purchased three smaller districts in the area. The greater Chico area includes some areas of Butte County as well as the City of Chico.

There are approximately 90,000 people in the service area, but Calwater Chico does not provide water to the entire population within the service area because there are some private wells sprinkled within this area. Supplied water is used solely for urban purposes. Some water is provided to businesses for landscaping.

Calwater Chico has no surface water supply, so it takes all of its water from 63 deep wells. On average, the company supplies 25.4 TAF a year. Calwater Chico believes that droughts are not a major concern because the groundwater supply in the area is plentiful and easily accessible.

There are 5 tanks (4 above ground) that are used for storage, for a total combined storage of 1.375 million gallons. In principle, losses are tracked by Calwater Chico's central engineering department. The company started a leak detection program a few years ago using sounding and meters (in the areas with enough meters for this to be

possible). The company found a few leaks in the Calwater Chico's distribution system, but the leaks were minimal. All wells are monitored and approximately 50% of the connections were metered by the end of 1999. Additional meters are gradually being installed.

Within the Chico urban area, there are 21,602 sewer connections and 12,000 septic tank users. The county has published the Chico Urban Area Nitrate Compliance Plan, available online at www.buttecounty.net/cob, which will transfer 7,800 of the area's septic tank users to sewers. The sewage flows for a single-family residential unit for an average day average month are 210 gal/day.

The treatment facility for the City of Chico is owned and operated by the City. The treatment plant is a 9 mgd facility, of which 3 mgd of the capacity is the result of a brand new expansion. The facility is in good to excellent condition and has good performance. There is a one year certification period for the 3 mgd expanded portion. The effluent is discharged into the Sacramento River from an outfall located 8,600 feet west of the wastewater treatment plant.

Calwater Chico does not foresee any supply problems within its service area. Its management believes that the water supply is adequate for future growth. This assumption is reinforced by the Butte Basin Water Users Association groundwater model. The company plans to drill additional wells and pump more water to fulfill higher future demands. On a county-wide level, Calwater Chico plans to ensure that groundwater is utilized within the Butte basin before it is transferred elsewhere.

4.2.6 West Butte Inventory Unit

The West Butte Inventory Unit encompasses approximately 93,900 acres on the west side of Butte County, as shown in Figure 4-21. It is bordered by Big Chico Creek to the north, the foothills to the northeast, the County line to the south, the Sacramento River to the west, and Butte Creek to the east. West Butte includes the town of Durham and part of the city of Chico, as well as agricultural land and environmental refuge areas. The primary source of water is groundwater, although Llano Seco Rancho and M&T Incorporated receive Sacramento River water through the CVP, and several water suppliers have water rights on Butte Creek.

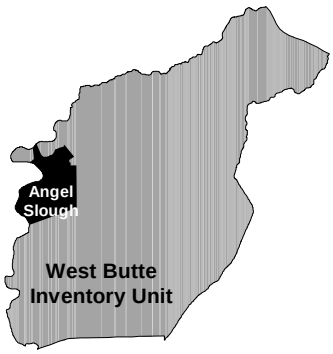


Figure 4-22

Angel Slough Inventory Sub-Unit

Angel Slough Inventory Sub-Unit is approximately 7.7 square miles, located on the west side of West Butte Inventory Unit along the Sacramento River, as shown in Figure 4-22. The primary land use in the area is agricultural, with crop types including grain, dry beans, almonds, walnuts. The majority of the land utilizes

groundwater as a water supply, except for a small area that has riparian rights to the Sacramento River.

Durham/Dayton Inventory Sub-Unit

Durham / Dayton Inventory Sub-Unit is the area surrounding the communities of Durham, Dayton and part of Chico, located in the northeast of the West Butte Inventory Sub-Unit (Figure 4-23). Land use in the area includes urban land use around Durham, Dayton, and Chico, as well as extensive agricultural use, with primarily orchard crops.

California Water Service Company, Chico

California Water Service Company, Chico, serves the city of Chico and urban areas that immediately surround the city. The majority of the water supplier is within the Vina Inventory Unit, so it is described in greater detail in Section 4.2.5.

Dayton Mutual Water Company

Dayton Mutual Water Company provides surface water to meet the area's agricultural water needs. Rice is the primary crop in the area, with small pockets of other crops. Dayton Mutual has water rights to Butte Creek and the West Branch of the Feather River (diverted through Butte Creek).

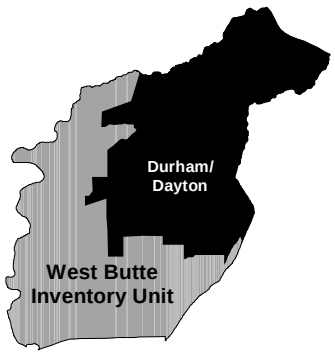


Figure 4-23

PG&E diverts water from the West Branch of the Feather River through the Toadtown Canal to generate hydroelectric power before discharging flows to Butte Creek. Dayton Mutual has rights to 3.334 cfs of this water. In addition, Dayton Mutual has first priority rights to 16 cfs of water from Butte Creek.

Durham Irrigation District

In 1935, the Bidwell Municipal Utility District took over a small private water utility that was inadequately serving the town of Durham. The new utility district drilled a new well, installed pumping equipment, and started delivering water to customers. The service area soon embraced the entire town of Durham, supplying 86 services with domestic and commercial water supplies, as well as water for fire protection.

Bidwell Municipal Utility District was dissolved by voter mandate and all of its properties were turned over to Butte County. The county water works district (Butte County Water Works District No. 1) was then organized to operate the Durham water system under the County Board of Supervisors. However, this method of operation resulted in the rendering of unsatisfactory service and local interests expressed a desire to convert to the type of district that could be managed by a local board of directors. The Durham Irrigation District was formed to provide domestic water and was approved by the voters on February 17, 1948. At that time the District encompassed a total area of 93 acres.

During the District's formation, there were approximately 115 residential and commercial service connections, and their demands overtaxed the water system. Improvements were needed requiring the installation of additional wells, pumping equipment, and service mains. Later in 1948, the District received approval to issue warrants with the proceeds received to be used in rehabilitating and augmenting the existing system.

The population currently residing within the District is approximately 1,500 with service connections numbering about 400. Expected growth is estimated to be 20 to 30 connections per year. The average annual water delivery for the period 1995 – 1999 was 345 acre-feet. The average water supplied per capita is estimated at 200 gallons per day. The projected increase in demand is expected to be 4 to 5 acre-feet per year. The District's current water source comes from three groundwater wells. The District also has 5,000 gallons of storage in the system. The area does not have sewer service, so all customers have septic tanks.

The major concerns of the District include:

- A lowering of the groundwater table and potential drinking water contamination due to an increase in the number of independent domestic and agricultural wells; and

- Potential damage to the groundwater basin due to "out of basin" transfers of groundwater, either directly or by in-lieu groundwater substitution pumping associated with surface water transfers.

Durham Mutual Water Company
Durham Mutual Water Company provides water to agricultural water users in the Durham / Dayton Inventory Sub-Unit and the Esquon Inventory Sub-Unit. It is described in greater detail in Section 4.2.1.

Llano Seco Inventory Sub-Unit

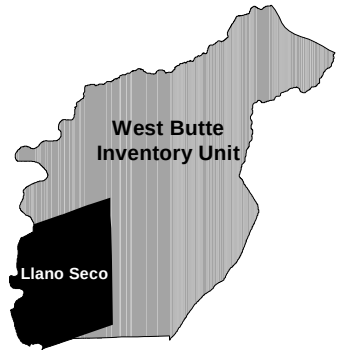


Figure 4-24

The Llano Seco Inventory Sub-Unit is located in the southwest corner of the West Butte Inventory Unit, as shown in Figure 4-24. It is composed of the Llano Seco Rancho, which is largely a refuge area.

Llano Seco Rancho
Llano Seco Rancho (also known as Parrott Ranch) was historically agricultural, but a portion of the land was purchased by the U.S. Fish and Wildlife Service (FWS) in 1990. Approximately 2,570 acres were purchased outright, and is now owned by FWS as a reserve (see description below). The remaining 6,580 acres still belongs to the Parrott Investment Company, Inc. (PIC), but FWS purchased conservation easements, which are essentially

the developmental rights to the land. PIC owns all other rights within the conservation easement areas.

On the conservation easements held by FWS, PIC has converted some agricultural acres (mainly rice acreage) to wetland type habitats as well as grasslands. The conservation easement lands are categorized into the following:

- *Easement*. These are lands that have developmental rights to benefit wildlife with emphasis on waterfowl and sandhill cranes. PIC retains and controls all other rights to the property; e.g., hunting, fishing, grazing.

- *Riparian Easement*. These are lands that also have developmental rights for benefit of wildlife but are currently undeveloped. PIC also controls hunting, fishing, and other activities, on these lands.

The Ranch has two water rights, one to the Sacramento River and one to Butte Creek. The major water right is a riparian right on the Sacramento River, which is delivered to the Ranch through the M&T pumping plant. In addition, the Ranch has a water contract with PG&E to the West Branch Feather River water delivered into Butte Creek through the Toadtown Canal. Finally, the Ranch has a low priority water right to Butte Creek water. Feather River and Butte Creek water is diverted at Parrott-Phelan Dam, and then conveyed to Llano Seco through Edgar Slough and the Parrott Lateral. The FWS and the DFG have an agreement with the Ranch and M&T to have their portion of the Butte Creek water right stay in Butte Creek for in-stream flow benefit for salmon. This agreement allows for the pooling of water during portions of the year to help meet salmon needs.

Llano Seco Rancho (FWS)

In addition to the conservation easements, FWS created refuge lands on a portion of Llano Seco Rancho that they purchased outright as fee title lands. FWS converted or is in the process of converting some agricultural acres on its fee title land to appropriate wildlife habitats; i.e., wetlands, grasslands, and riparian habitats.

The fee title lands are categorized into the following:

- *Riparian Sanctuary*. These are lands that protect existing riparian habitat and restore agricultural acres to riparian habitat for riparian dependent species.

- *Sanctuary I & II*. These are lands that protect existing wetland and grassland habitats and restore some agricultural areas to wetland / grassland / riparian habitats for wildlife, with emphasis on waterfowl and sandhill cranes.

The estimated quantities of water in the last 5 years are based upon consumptive use, and are shown in Table 4-9.

Table 4-9 Consumptive Use in Llano Seco Unit of the Sacramento River			
Land Use	**Area (acres)**	**Unit Applied Water Use (ac-ft/ac)**	**Total Water Use**
Seasonal Marsh	112	3.5	392 acre-feet
Irrigated Marsh	589	4.8	2,827 acre-feet
Permanent Ponds	25	10.8	220 acre-feet
Total Estimated Annual Use			**3,389 acre-feet**
Source: Vega, 2000.			

Llano Seco Rancho (DFG)

The California Department of Fish and Game (DFG) bought 1521 acres of the Llano Seco Rancho, also known as Parrott Ranch, which it calls the Llano Seco Unit of the Upper Butte Basin Wildlife Area. Llano Seco Rancho maintains the water rights to the property purchased by DFG. However, DFG was granted in the deed to the property the ability to buy water from Llano Seco Rancho.

In addition to surface water purchased from Llano Seco Ranch, the Llano Seco Unit has one deep well on the property that produces approximately 5,000 gpm. This well was primarily installed for drought protection but is used when water is needed for crop purposes during delays in water delivery and when water is unavailable from other sources. The well was installed in 1994 and has a 16-inch casing and a depth of 500 feet.

In addition, the Llano Seco Unit will receive (and pay for) water from the neighboring Western Canal Water District. DFG has an agreement that was negotiated with the Butte Creek Siphon Project, which allows for water delivery to the Llano Seco Unit.

The Llano Seco Unit has not been fully developed due primarily to the lack of supply, and DFG has not been able to allocate budget to meet full water needs. The estimated water use at full development would be approximately 7,500 acre-feet.

Normal water year use within the Llano Seco Unit is shown in Table 4-10. Drought years reduce ranch water, eliminate out-of-district water, and drastically increase well water use. Out-of-district water includes return flows from upstream districts, which is composed primarily of water drained from rice fields.

Table 4-10 Water Use within the Llano Seco Unit of the Upper Butte Basin	
Water Source	**Water Amount (acre-feet)**
Well Water	1,000
Ranch Summer Water	1,000
Ranch Fall and Winter Water	2,000
Out-of-District Fall Water	1,000
Total Water Use	**5,000**
Source: Blake, 2000.	

M&T Inventory Sub-Unit

M&T Inventory Sub-Unit is in the northwest corner of the West Butte Inventory Unit (Figure 4-25), and contains the M&T Chico Ranch, Inc.

M&T Chico Ranch

M&T Chico Ranch is a large agricultural land owner, with primary crops including grain, rice, dry beans, safflower, walnuts, and prunes. It is approximately 13.5 square miles, bordered by Big Chico Creek and part of the Sacramento River.

M&T receives water from primarily surface water sources, although a portion of the ranch utilizes groundwater. M&T has surface water rights to the West Branch of the Feather River water in Butte Creek, and to surplus Butte Creek flows. M&T also has water rights to a small amount of water from Little Chico Creek. M&T has a settlement contract with USBR that was created to address the impacts of constructing Shasta Dam. Under its contract with USBR, the total amount of water rights agreed upon is 16,980 acre-feet of Sacramento River water and a Project water supply of 976 acre-feet for a total of 17,956 acre-feet.

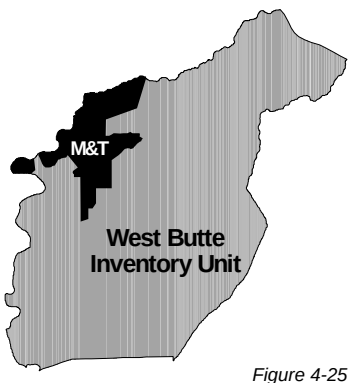


Figure 4-25

As part of the approval process on M&T's pumping plant relocation, they developed an agreement with the U.S. Fish and Wildlife Service (FWS) to bypass certain flows in Butte Creek to improve the fishery. The bypassed water, also known as (b)(2) water, will amount to 20,000 acre-feet annually and will be considered a part of the habitat restoration program of the Central Valley Project Improvement Act (CVPIA). Since this will be part of the CVPIA, USBR has discussed the possibility of providing a substitute supply of 20,000 acre-feet of CVP water on the condition that FWS and M&T guarantee that the bypassed flows reach the Sacramento River to keep the CVP whole.

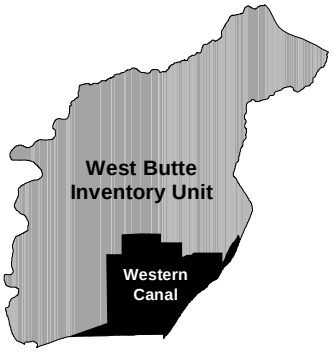


Figure 4-26

If M&T leaves water in Butte Creek, there are potential groundwater impacts because the water will no longer be in Edgar Slough. Edgar Slough is a canal conveyance facility that carries Butte Creek water to M&T. The slough loses approximately 20% of its flow to groundwater, so reducing flows to M&T could reduce percolation to groundwater.

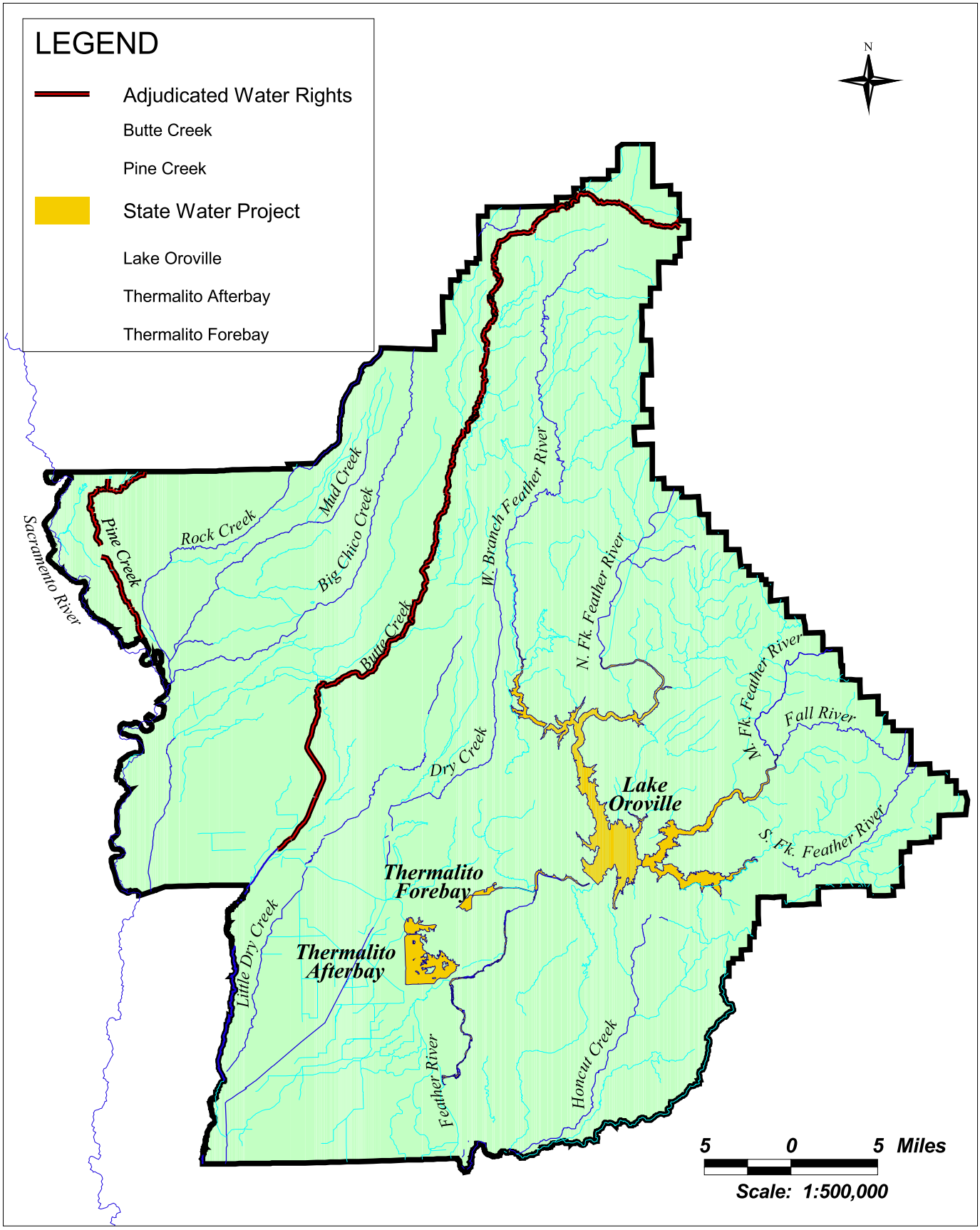
Western Canal Inventory Sub-Unit

The Western Canal Inventory Sub-Unit is in the southeast corner of the West Butte Inventory Unit, as shown in Figure 4-26. It contains the portion of the Western Canal Water District that is northwest of Butte Creek.

Western Canal Water District

The Western Canal Water District is an agricultural water district that provides surface water to an area that primarily grows rice. The District is split by Butte Creek, with approximately 24% in the West Butte Inventory Unit, 52% in the East Butte Inventory Unit, and the remaining 24% in Glenn County. The District is described in greater detail in Section 4.2.1.

Figures



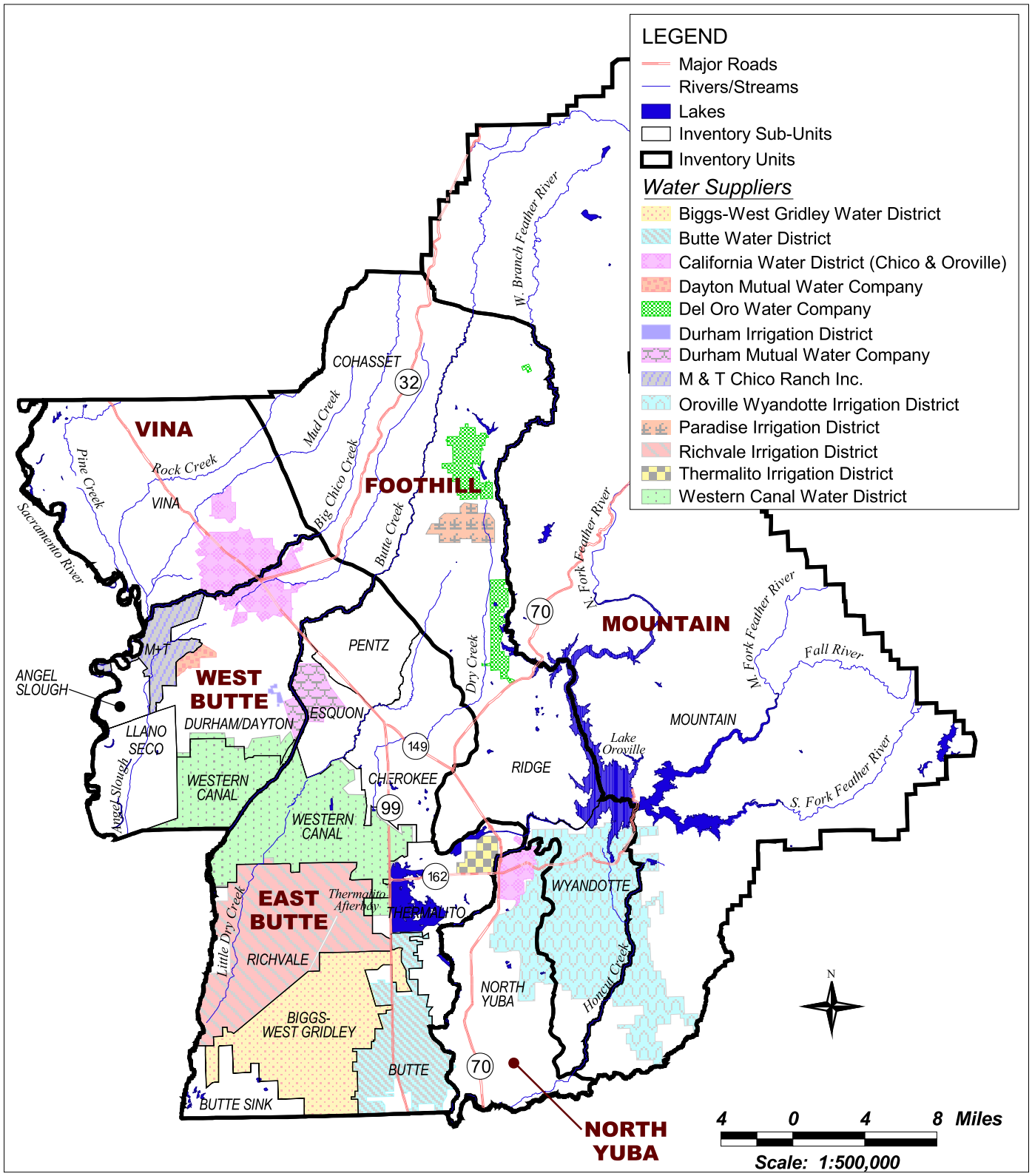
Butte County
Department of Water & Resources

Source: Butte County Planning Department

Figure 4-1

CDM Camp Dresser & McKee Inc.

WATER PROJECTS
AND ADJUDICATIONS



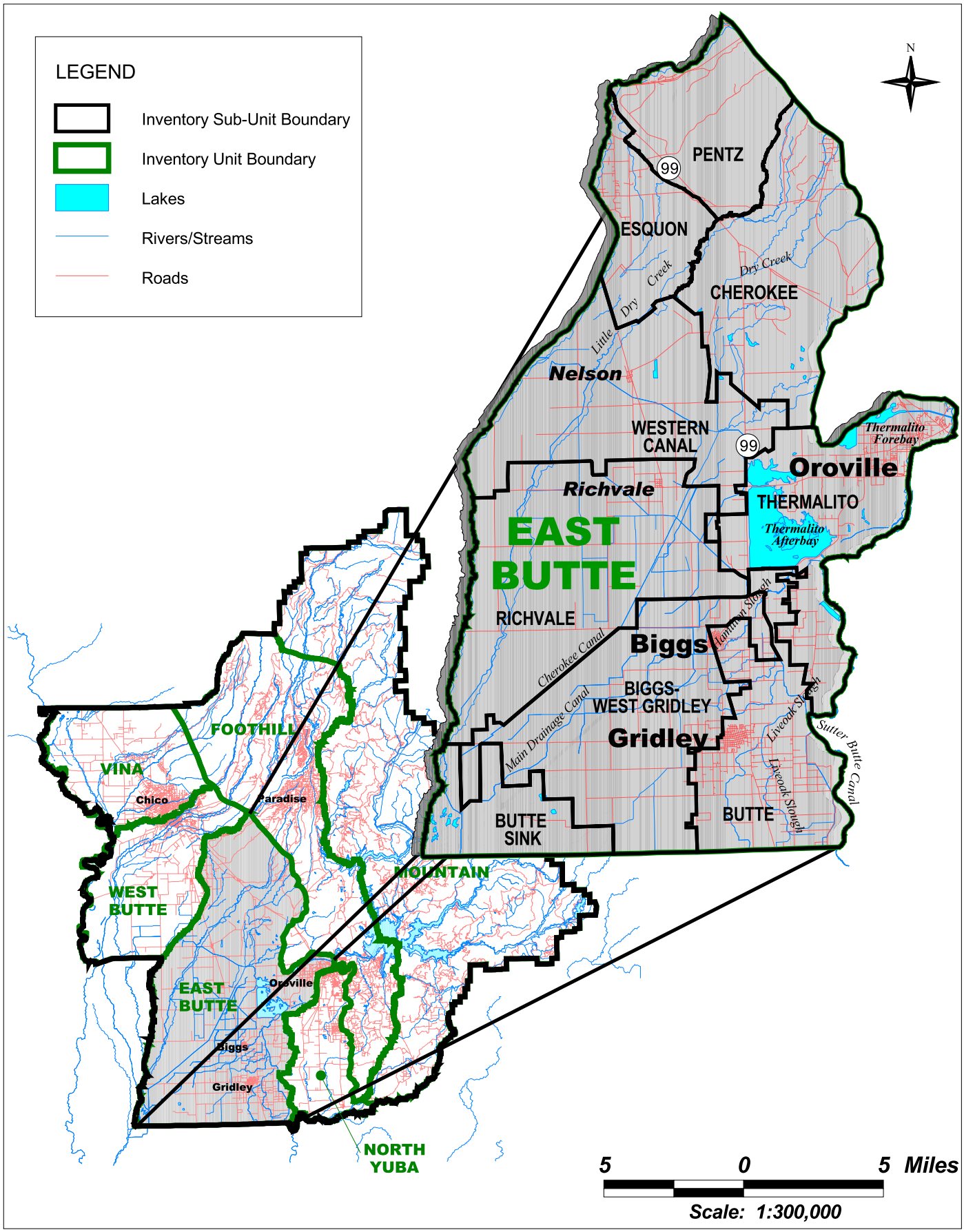
Butte County
Department of Water & Resource Conservation

Source: Butte County Planning Department, US Department of Natural Resources

Figure 4-3

WATER SUPPLIERS

CDM Camp Dresser & McKee Inc.

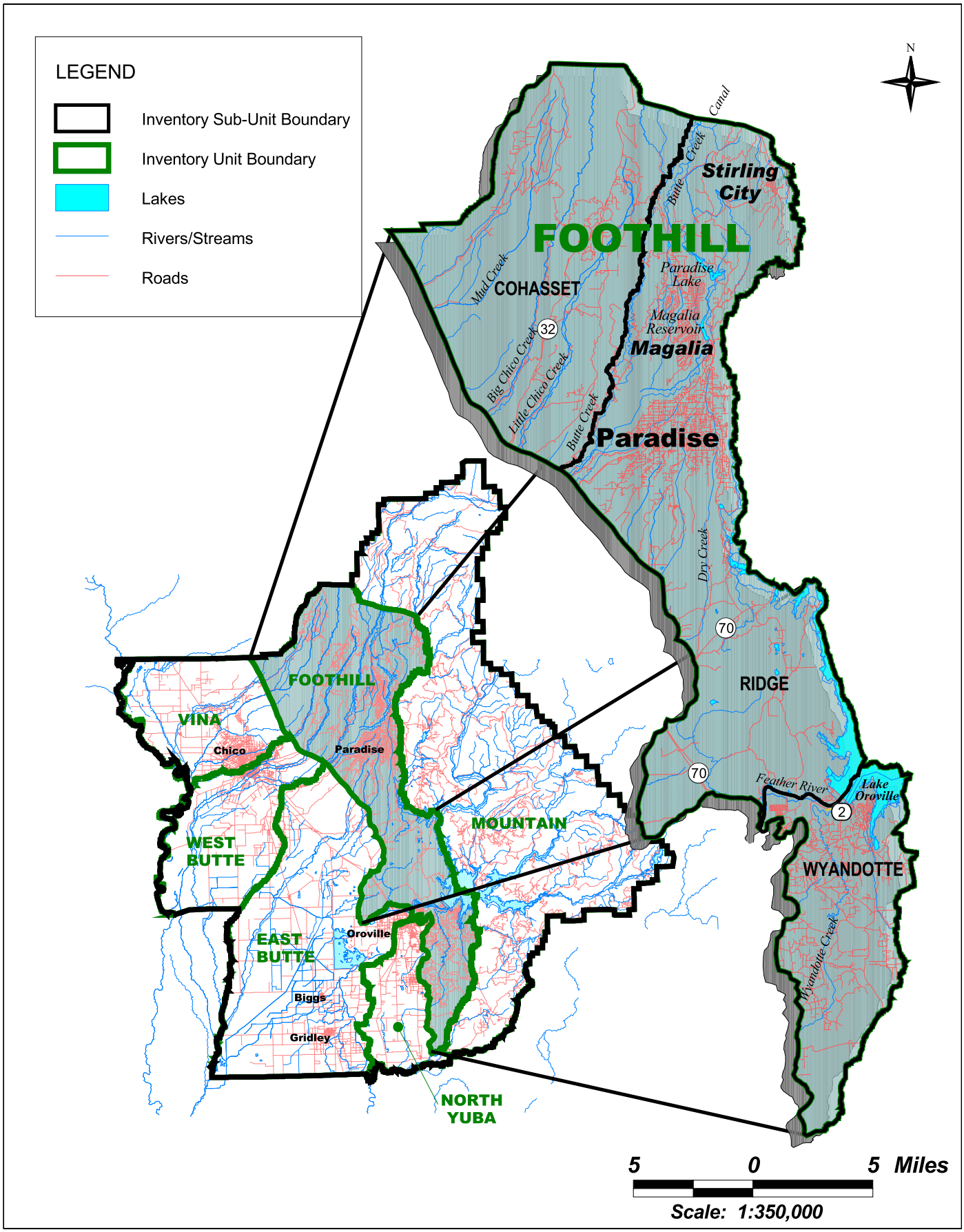


Source: Butte County Planning Department

Butte County
Department of Water & Resource and Conservation

CDM Camp Dresser & McKee Inc.

Figure 4-4
Water Features by Inventory Unit
EAST BUTTE

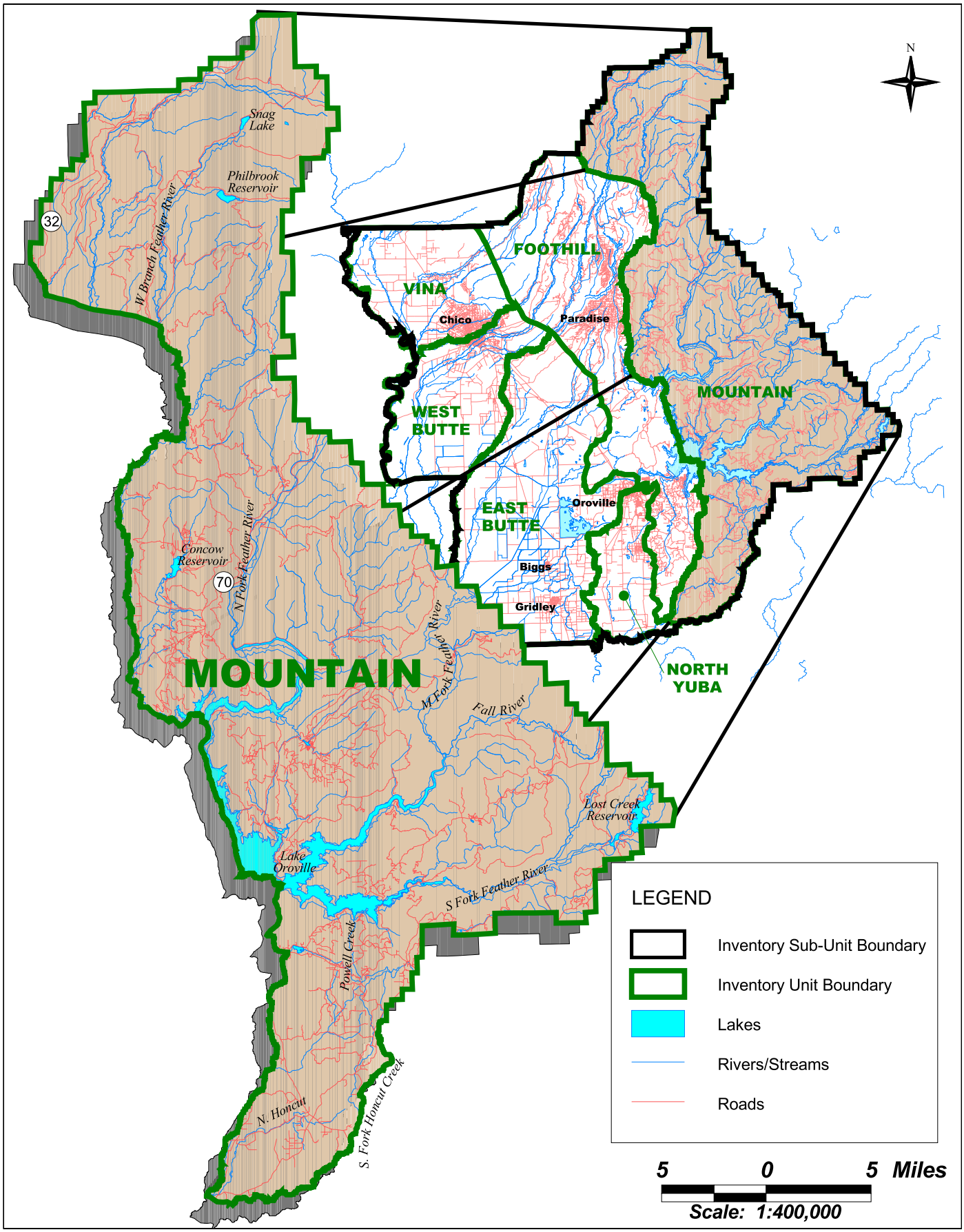


Source: Butte County Planning Department

Butte County
Department of Water & Resource Conservation

CDM Camp Dresser & McKee Inc.

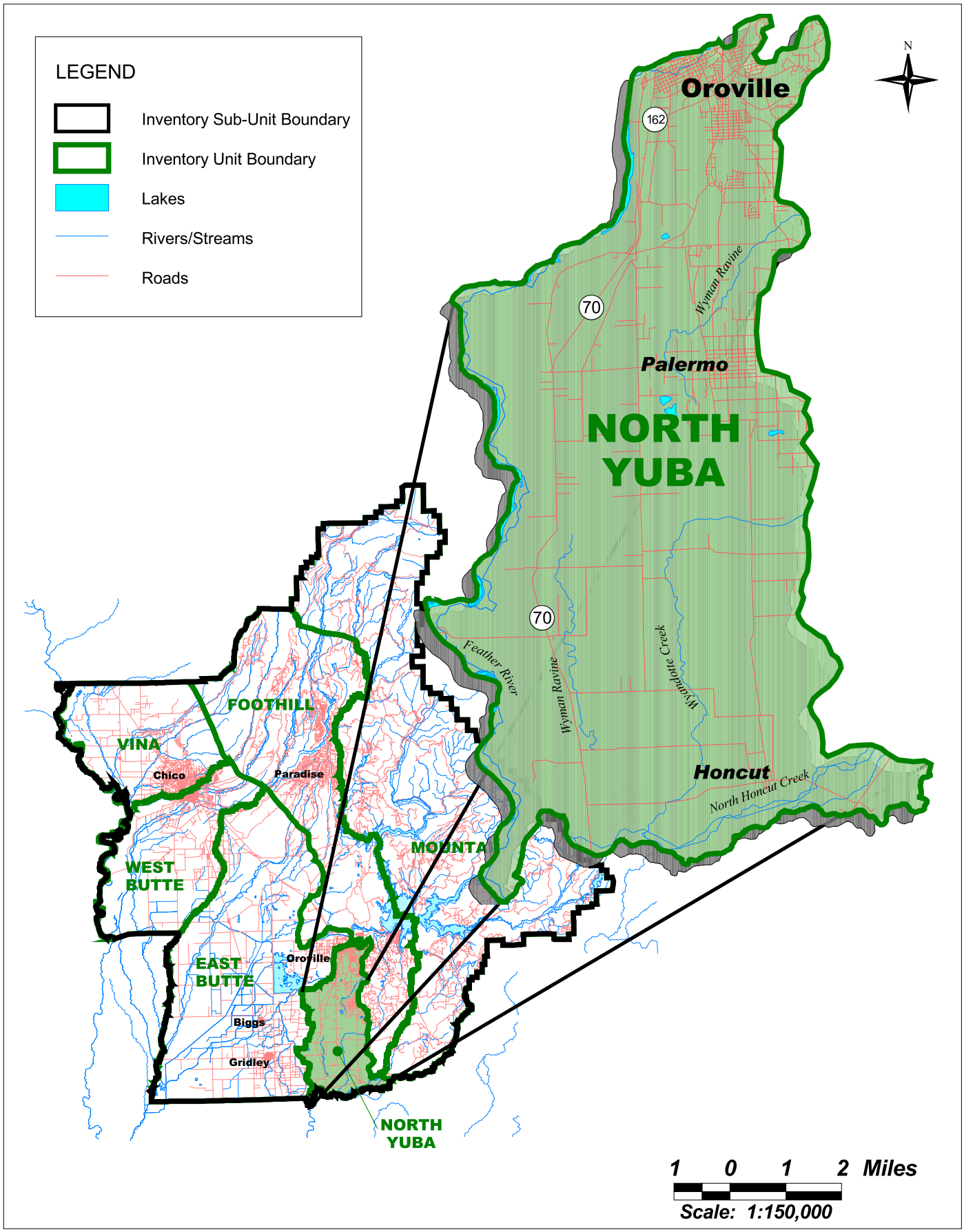
Figure 4-14
Water Features by Inventory Unit
FOOTHILL



Source: Butte County Planning Department

Butte County
Department of Water & Resource Conservation
CDM Camp Dresser & McKee Inc.

Figure 4-18
Water Features by Inventory Unit
MOUNTAIN

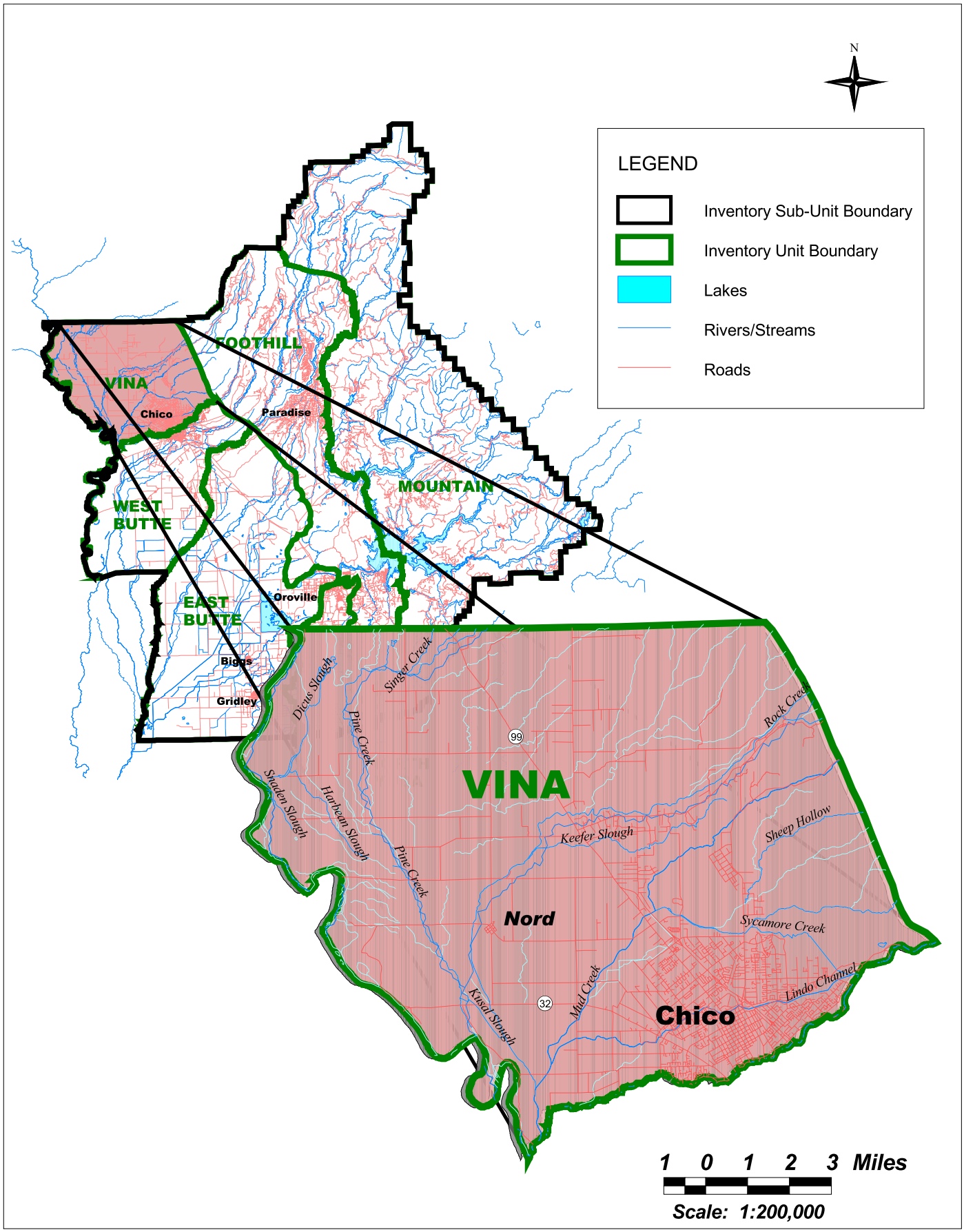


Source: Butte County Planning Department

Butte County
Department of Water & Resource Conservation

CDM Camp Dresser & McKee Inc.

Figure 4-19
Water Features by Inventory Unit
NORTH YUBA

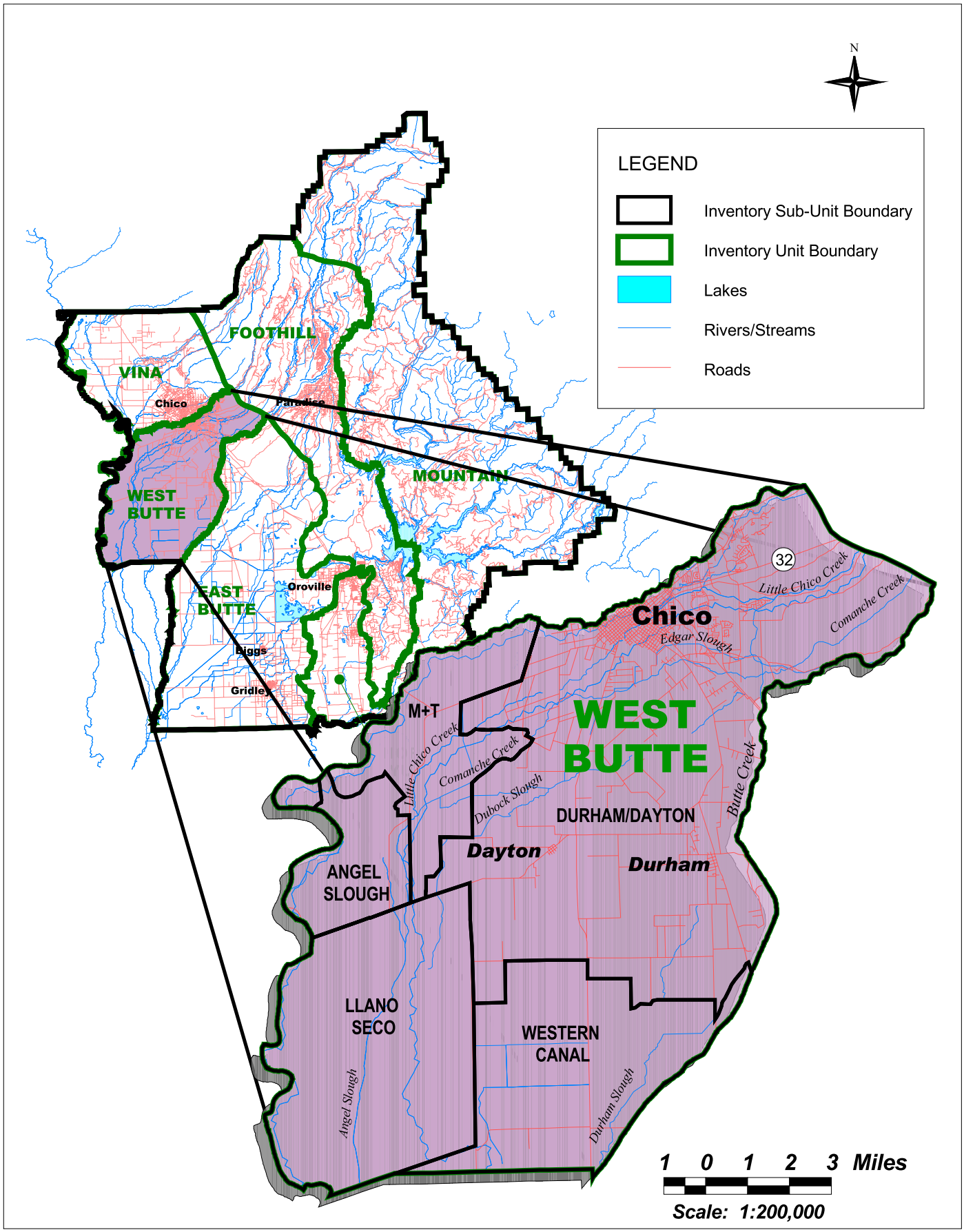


Source: Butte County Planning Department

Butte County
Department of Water & Resource Conservation

CDM Camp Dresser & McKee Inc.

Figure 4-20
Water Features by Inventory Unit
VINA



Source: Butte County Planning Department

Butte County
Department of Water & Resource Conservation

CDM Camp Dresser & McKee Inc.

Figure 4-21
Water Features by Inventory Unit
WEST BUTTE

Section 5
Supply and Demand Analysis

An analysis of water supply sources and demands within the county was performed to provide baseline water balance information and a methodological tool for forward projection of supply and demand. The results of this analysis will provide both a viable basis for planning and support information dissemination and consensus development among the county stakeholders.

Photograph from DWR

The supply and demand analysis was performed according to the following steps:

- The county was divided into six inventory units and 20 inventory sub-units;
- Demands were estimated by inventory sub-unit by calculating water usage for each sector (urban, agricultural and environmental) for normal and drought conditions;
- Available supplies were estimated for each inventory sub-unit by evaluating historical records of water deliveries during normal and drought years and DWR land surveys, studying water rights and conducting interviews with water suppliers;
- An inflow-outflow analysis was performed for managed supplies within each inventory sub-unit;
- The inflow-outflow data was used to compile an applied water balance to compare managed supplies and demands for applied water;
- Water use information was used in conjunction with information on groundwater hydrology to determine regional impacts on groundwater.

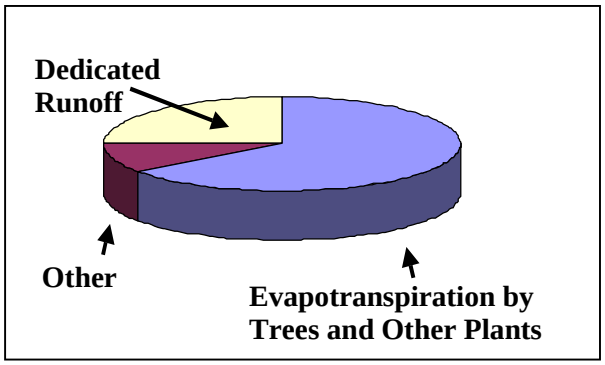
The general methodology of the inventory parallels that used by DWR to produce Bulletin 160. However, Bulletin 160 covers the entire State of California at a relatively large scale, whereas this analysis focuses on Butte County with a greater level of detail. The supply / demand analysis process creates a baseline water balance to support the county's role in developing sound monitoring and management of its water resources.

5.1 Methodology

Agricultural, environmental, and urban water use data are combined with water supply information to determine the overall water budget for individual inventory units and for the county as a whole. These budgets cover only the managed and

measurable "applied" component of the water cycle. The State of California adopted the applied water method in the mid-1990's because applied water data are generally analogous to agency water delivery data, making it easier for water agencies to review. Use of consistent, statewide terminology allows Butte County to compute its water demands and supplies on the basis of available information and to compare the county's water resource data with that from other areas.

The figure below illustrates the composition of the state's runoff. Approximately 65% of the precipitation is used by trees and other plants, and does not generate runoff through rivers or streams. Only part of the remaining precipitation produces runoff that is dedicated and managed. This water inventory only considers the dedicated runoff portion of the state's water.



The inventory and analysis uses the inflows from dedicated water to produce an inflow-outflow analysis. For each area, the inflows are compared to all outflows, including depletion, percolation, or outflow from the area. Depletion is water that is used in the area, and does not return to the water system. Percolation and outflow remain in the system, and can be re-used.

The inflow-outflow analysis is used to produce an applied water budget for each area. The applied water budget combines various components of the inflow-outflow analysis to allow a comparison of water demands to available water supplies. Water demands include agricultural, environmental, and urban demands, as well as system losses. Supplies examine available surface and groundwater, and downstream re-use of any available supplies. This data is presented in the following sections to compare supplies and demands by area of the County.

Butte County's hydrologic system links many of these systems, so outflows from one area are sometimes inflows to another. Linkages between inflows, outflows, and losses were also calculated in the inventory. Losses are primarily conveyance losses, which include evaporation and percolation from conveyance system, riparian evapotranspiration, and conveyance system spill and seepage. Available surface water and groundwater supplies were estimated for comparison with the gross demands, for individual inventory units, and for the county as a whole.

5.1.1 Water Demand Methodology

The individual system and inter-system water demands and losses were estimated by type of water use. Agricultural, urban, and environmental water demands were compiled separately, then combined to understand the complete demands within an area.

Agricultural Water Demand

Agricultural water demand was estimated by multiplying the irrigation season crop water requirements by the associated irrigated acreages. The unit irrigation water requirements and irrigated acreages were determined for each crop, then all crop water needs were totaled by inventory unit to produce the final agricultural demand.

Photograph by Chuck Lowery

Irrigated acreage was calculated using DWR agricultural survey data, Butte County Agricultural Commissioner reports, and the results of discussions with water suppliers and landowners. DWR land use surveys are developed by delineating boundaries from aerial photography and confirming land use by field verification, with the latest survey in 1994. DWR information was updated by reference to Butte County reports and from discussions with local water agencies. The gross acreages for each crop were then reduced by 5 percent to yield the net irrigated acreages, with the 5 percent reduction to account for the areas of roads, ditches, laterals, canals, and other areas that are not cropped. The most recently mapped land use data, from the DWR 1994 land use survey, is included on Figure 5-1 to provide a representation of land use in the county.

The irrigation water requirements for each crop are determined through a complex process that is described in greater detail in Appendix C. The first step is to determine the evapotranspiration (ET) for each crop. Evapotranspiration is defined in Bulletin 160-98 as “the quantity of water transpired (given off), retained in plant tissues, and evaporated from plant tissues and surrounding soil surfaces.” The ET values account for water used from both precipitation and applied water, but only the applied water (irrigation) component of ET, the Evapotranspiration of Applied Water (ETAW), is included in the water budget. ETAW represents the evapotranspiration of the crop supplied by irrigation water and not precipitation.

The ETAW defines the amount of applied water for each crop that must be included in the agricultural demand. However, the amount of applied water required to meet the ETAW is generally greater than the ETAW due to losses associated with irrigation system application and soil variability. To account for these losses, seasonal application efficiencies have been developed by the Department of Water Resources (DWR) that are specific to the type of irrigation system for each crop. Seasonal application efficiencies indicate a percentage of the applied water that contributes to the ETAW. Seasonal application efficiency is sometimes confused with irrigation

efficiency. Irrigation efficiency represents the efficiency of one irrigation, whereas seasonal application efficiency represents the average irrigation efficiency for all events over a season. The applied water necessary for each crop can be calculated by dividing the ETAW by the seasonal application efficiency, and represents the amount of water delivered to a farmer's headgate. The applied water values are combined with land use information to produce the amount of water required by each field.

Environmental Water Demand

Applied water demands for managed wetlands were included in the assessment of environmental water use. These wetlands include state and federal wildlife refuges, publicly or privately managed wetland habitat, and agricultural lands flooded for rice straw decomposition or duck habitat.

Within Butte County, much of the rice acreage is flooded following harvest for the purpose of decomposing the remaining rice straw, which provides some habitat value to migratory birds. In addition, some rice fields are managed specifically to provide duck habitat. Water suppliers were interviewed to determine trends in rice decomposition activities and to estimate the volume of applied water used for rice decomposition.

Information to estimate acres of wetlands and habitat types was gathered from DWR studies, interviews with area water suppliers, and information from the Gray Lodge Wildlife Area. Information on wetland habitat types and water management practices in each area was used to estimate flood-up and draw-down dates, flooding depths, and circulation rates. Water circulation is especially important when managing an area for waterfowl habitat because harmful diseases can breed in stagnant water. These factors were combined to develop an ETAW for each wetland area that was included in the regional demand projections. As for agricultural lands, the ETAW for these areas was estimated using the habitat types within each wetlands area.

Applied water use associated with the above environmental demands was estimated within each inventory sub-unit. The various environmental water uses were summed to determine the overall environmental water demand for each inventory sub-unit and unit and for the county.

Urban Water Demand

Water delivered to meet urban demand was assessed through a review of local urban water management plans (AB 797), interviews with water managers, and annual summaries of urban water production data submitted by urban suppliers to DWR.

The urban water production data submitted to DWR were compared to area populations to determine per capita water needs. Several areas with urban development are not served by an urban water supplier, so these data are not available. Per capita estimates of urban areas with similar characteristics were applied

to these areas to produce urban demands for all areas. In addition, rural per capita use was estimated to establish domestic well extractions throughout the county. Table 5-1 shows the 1997 population in each inventory sub-unit.

Table 5-1
1997 Population by Inventory Sub-Unit[1]

Inventory Unit/Sub-Unit	Population	Inventory Unit/Sub-Unit	Population
East Butte Inventory Unit	*25,438*	*Foothill Inventory Unit*	*56,256*
Biggs-West Gridley Sub-Unit	1,365	Cohasset Sub-Unit	3,500
Butte Sub-Unit	11,240	Ridge Sub-Unit	40,226
Butte Sink Sub-Unit	35	Wyandotte Sub-Unit	12,530
Cherokee Sub-Unit	931	*North Yuba Inventory Unit*	*19,142*
Esquon Sub-Unit	1,424	*Vina Inventory Unit*	*61,062*
Pentz Sub-Unit	84	*West Butte Inventory Unit*	*30,871*
Richvale Sub-Unit	430	Angel Slough Sub-Unit	56
Thermalito Sub-Unit	9,670	Durham/Dayton Sub-Unit	30,731
Western Canal Sub-Unit	259	Llano Seco Sub-Unit	18
Mountain Inventory Unit	*5,729*	M&T Sub-Unit	24
		Western Canal Sub-Unit	42
		Butte County Total Population	**198,498**

Water managers were interviewed to evaluate changes in urban per capita water use during periods of drought and patterns of water use following drought. Water rationing procedures, short-term restrictions, and other demand management tools implemented during droughts were also discussed.

After urban applied water was determined by per capita water needs, additional analysis was performed to determine the amounts of this water that are returned to the system. The amount of water that was used for indoor or outdoor uses was calculated by assuming that during the winter, the only uses are indoors. These indoor uses are constant throughout the year, so any use above these numbers was outdoor use. Approximately 85% of the outdoor use was ETAW for landscapes, and the remaining water percolated into the ground. Indoor use was returned to the system as treated wastewater (usually discharged into a waterway) or as groundwater percolation through a septic tank.

5.1.2 Water Supply Methodology

This water inventory analysis includes managed water supplies designated for agricultural, environmental, and urban use. The supplied water is classified by origin into two categories, surface water and groundwater. Figure 5-2 depicts the source water (groundwater, surface water, or a combination of both) available to water users within the county, which were determined as part of the DWR's 1994 land use survey. Surface water includes natural and developed supplies from the CVP, the SWP, and local water supply projects. Surface-water supplies include those supplies available for reapplication downstream, such as urban wastewater discharges and agricultural

[1] Butte County Population from the California Department of Finance projection for the California Water Plan Update, DWR Bulletin 160 series.

return flows. Groundwater includes developed well supplies and includes deep percolation water recovered for use.

Records of water rights were collected and reviewed in an effort to estimate the effects of various rights throughout the county, and these rights were summarized in Chapter 4, with large water-right holders listed in Appendix B. Key users of surface water were interviewed to collect information associated with the points of diversion, diversion records, delivery records, and associated information. Groundwater use was determined by assuming that enough water is pumped to meet the needs of the agricultural and domestic demands of the land with wells. Selected typical groundwater users were interviewed, and available records were reviewed, to verify quantities of water pumped.

5.2 Definition of Normal and Drought Scenarios

Historical records of hydrologic conditions were reviewed to identify appropriate periods of record that could be used to represent normal and drought water supply and demand within Butte County. The normal and drought scenarios represent different conditions to assess the range of water supply and demand.

5.2.1 Definition of the Normal Hydrologic Scenario

Agricultural, environmental, and urban water supply patterns were reviewed to establish typical demand patterns for water, and select a year that best represented a typical pattern. The following activities were pursued:

- For agricultural demand and supply, the following data was reviewed:
  - DWR land use survey information and Butte County Agricultural Commissioner's data, which provided cropping data to determine a year that had a full cropping pattern;
  - Long-term rainfall and pan-evaporation records, which established a year that had a growing season climate that best represents normal hydrologic conditions and growing conditions;
  - Crop ET records (established through crop coefficients and pan evaporation data) to examine patterns of ET values; and
  - Applied water demand, to compare irrigation practices.
- For environmental water use, required surface water deliveries associated with environmental water use were gathered and compiled. Areas for which environmental supplies were evaluated included the following:
  - Private and government-managed lands administered for wildlife or riparian habitat; and

- Rice land acreage associated with rice straw decomposition;

- For urban water use, per capita and total water use and related losses were compared historically. These values were compared to DWR Bulletin 166 series, Urban Water Use in California, to determine how the calculated local values compare to published values. This information was compiled to identify periods of record with typical per capita use.

Normal Year Scenario
1997 cropping pattern
1997 precipitation
1997 ET values
1997 urban per capita data

Following the review of urban, environmental, and agricultural water demand, a period of record consistent with normal water demand was selected. For this analysis, the year 1997 was chosen to represent a normal year. During 1997, the Chico University Farm precipitation station recorded 26.5" of precipitation, and the historical average at this location is 26.09". Out of all recent years, this year was one of the few with long growing seasons. Many people remember the flooding that occurred during 1997, however, the precipitation throughout the entire year was very close to average. Extensive flooding resulted because nearly all of the rainfall occurred during January. There was minimal rainfall after January, which meant that January's flooding did not result in wet soil conditions when the growing season started. The combination of a long growing season, full water supplies, and complete cropping patterns make 1997 the best option to represent a normal year.

5.2.2 Definition of the Drought Hydrologic Scenario

Development of the drought condition followed a similar approach to that outlined in the above section. The drought is represented by a selected period of record with increased applied water demands due to reduced rainfall and reduced flows in the Butte Creek and delivery cutbacks defined in water contract/right stipulations. Agricultural cropping patterns were assumed to remain the same as in the normal year. Supply records and delivery contract/right stipulations were reviewed to assess impact on committed water supply due to drought conditions. The drought scenario was developed using a similar data review of the agricultural, environmental, and urban components as the review for normal conditions.

Photograph by DWR

Following the review of agricultural, environmental, and urban water demand, conditions consistent with low water availability and high water demand were

selected as the representative conditions for the drought scenario. The drought period therefore is represented by the following conditions:

- High evaporative demand (corresponding to high ET);
- Low effective precipitation;
- Normal cropping pattern;
- High urban demand (generally associated with exterior water uses such as garden irrigation); and
- Restricted water supply based on flow records and delivery contract stipulations (which may reduce the benefits of carryover storage in surface-water facilities).

The drought year proved to be more difficult to select than the normal year because all the conditions did not exist in a single year. Therefore, several years were used to illustrate the worst recent examples of drought-year impacts. In this study, the purpose of the drought-year water budget is to examine an extreme scenario to draw conclusions about maximum demand and reduced available supplies. Using information from several years produces results that combine the most severe situations in recent years.

Drought Year Scenario
1997 cropping pattern
1977 precipitation
1997 ET values
1987 urban per capita data

The 1976-77 drought had the lowest precipitation (10.55 inches) in the period of record of 1906-1999, but it was a relatively cool year and therefore had low levels of ET. The precipitation of 1976-77 is used, but the ETs from 1997 are used. The weather was very hot during 1997, which produced high pan evaporations and therefore high ETs. Per capita use information for urban demands was examined for recent years, and 1987 was chosen to represent urban per capita use because it was a hot, dry year with high demand.

5.3 Summary of Normal Year Inventory

The normal year inventory highlights the usual water conditions within Butte County. More detailed land and water use information will be available in a report from DWR's Northern District that will be published during the summer or early fall of 2001, and available in the Butte County Department of Water and Resource Conservation library.

5.3.1 Demands

Table 5-2 illustrates the results of the demand analysis for normal years. Each sector (agricultural, municipal and industrial, and environmental) is separately delineated, with an additional section for conveyance losses. The conveyance losses represent the

amount of water required to convey supplies to their destination, and include free water surface evaporation, evapotranspiration by canal riparian areas, percolation into the groundwater, and spillage from the system. Some of these losses (evaporation and evapotranspiration) are lost from the system for future use, but deep percolation and spillage are available for future use.

Figure 5-3 includes pie charts to illustrate the composition of demand in each inventory sub-unit, and the size of the pie chart shows the magnitude of the demand. Figure 5-3 illustrates several interesting points:

- The majority of the demand occurs in the valley area, due to increased urban population and extensive farming areas. Inventory units in the valley have higher demands than those in the foothill or mountain ranges. The greatest demand is in the East Butte inventory unit (64%), followed by West Butte (18%), Vina (10%), North Yuba (5%), Foothill (2%) and Mountain (1%).

- Agriculture produces the majority of county demand, with 71% of the total demand. The remaining demand is composed of conveyance losses (15%), environmental demands (10%), and urban demands (4%).

- The Mountain Inventory Unit has very high conveyance losses compared to the water use. These losses are attributed to the large losses through Oroville-Wyandotte's delivery canals, which are very leaky and date back to the Gold Rush era, as described in Section 4.2.2.

Table 5-2
Normal Year Water Demand (in thousands of acre-feet)

Inventory Unit	Sub-Unit	Agricultural Demand	M&I Demand	Environmental Demand	Conveyance Losses[1]	Total Applied Water
East Butte	Biggs-West Gridley	137.6	0.4	28.3	51.8	218.1
	Butte	73.7	4.4	0.6	31.5	110.2
	Butte Sink	6.3	0.0	38.7	2.7	47.7
	Cherokee	27.4	0.4	0.5	1.1	29.4
	Esquon	35.6	0.5	5.8	6.2	48.1
	Pentz	0.0	0.1	0.0	0.0	0.1
	Richvale	182.5	0.1	30.8	33.6	247.0
	Thermalito	18.8	3.5	1.7	0.4	24.4
	Western Canal	147.7	0.1	17.6	40.3	205.7
	Total	**629.6**	**9.5**	**124.0**	**167.6**	**930.7**
Foothill	Cohasset	0.0	0.5	0.0	0.0	0.5
	Ridge	2.0	9.9	0.0	0.5	12.4
	Wyandotte	5.3	4.4	0.0	4.5	14.2
	Total	**7.3**	**14.8**	**0.0**	**5.0**	**27.1**
Mountain	Mountain	1.1	1.8	0.0	9.4	12.3
North Yuba	North Yuba	54.0	6.7	1.2	5.2	67.1
Vina	Vina	121.5	19.7	0.0	2.7	143.9
West Butte	Angel Slough	10.3	0.0	0.0	0.4	10.7
	Durham/ Dayton	91.8	10.3	0.6	6.6	109.3
	Llano Seco	14.7	0.0	4.0	5.5	24.2
	M&T	19.0	0.0	1.0	6.3	26.3
	Western Canal	65.3	0.0	8.4	21.4	95.1
	Total	**201.1**	**10.3**	**14.0**	**40.2**	**265.6**
Butte County Total		**1,014.6**	**62.8**	**139.2**	**230.1**	**1,446.7**

Notes:
(1) Conveyance Losses include evaporation and percolation from conveyance system, riparian evapotranspiration, and conveyance system spill and seepage.

5.3.2 Supplies

Table 5-3 illustrates the normal year supplies for each inventory unit and sub-unit. These supplies indicate the amount of water necessary to meet demands. Therefore, the supplies will be equal to or less than the demand amount in each area.

The various surface water supply sources are separated, including local surface water, Feather River water, and deliveries from the SWP or CVP. The total amount of groundwater pumped in each sub-unit is presented. Surface-water reuse illustrates the amount of water that is used more than once after it is diverted from the original surface-water body. Figure 5-4 contains pie charts that illustrate the composition of surface water, groundwater, and surface water reuse within each sub-unit. The size of

the pie charts represents the amount of total supplies in each area. Several observations are important to note from the figure and table:

- The East Butte and Foothill Inventory Units primarily use surface-water, and the remainder of the county primarily uses groundwater.
- The primary water source within the county is surface water (55%), followed by groundwater (31%) and surface water reuse (14%).
- Supplies are distributed throughout the county in the same pattern as demands, with the most water going to the East Butte inventory unit (64%), followed by West Butte (18%), Vina (10%), North Yuba (5%), Foothill (2%) and Mountain (1%).
- Butte County's supply of 1.4 million acre-feet is approximately 1.8 percent of the total California water supply of 79.5 million acre-feet.

Table 5-3
Normal Year Supplies (in thousands of acre-feet)

Inventory Unit	Sub-Unit	Local Surface Water	Feather River	SWP	CVP	Ground-water	Surface water reuse	Total Supplies
East Butte	Biggs-West Gridley	0.0	178.8	0.0	0.0	13.1	26.2	218.1
	Butte	0.0	70.0	0.0	0.0	26.5	13.7	110.2
	Butte Sink	2.2	0.0	0.0	11.2	6.3	28.0	47.7
	Cherokee	0.0	4.6	0.0	0.0	24.0	0.8	29.4
	Esquon	25.4	0.0	0.0	0.0	17.2	5.5	48.1
	Pentz	0.0	0.0	0.0	0.0	0.1	0.0	0.1
	Richvale	0.0	182.3	0.0	0.0	0.3	64.4	247.0
	Thermalito	0.0	2.0	0.0	0.0	22.0	0.4	24.4
	Western Canal	10.7	138.3	0.0	0.0	15.1	41.6	205.7
	Total	**38.3**	**576.0**	**0.0**	**11.2**	**124.6**	**180.6**	**930.7**
Foothill	Cohasset	0.0	0.0	0.0	0.0	0.5	0.0	0.5
	Ridge	10.0	0.0	0.0	0.0	2.0	0.4	12.4
	Wyandotte	0.0	12.4	0.0	0.0	0.7	1.1	14.2
	Total	**10.0**	**12.4**	**0.0**	**0.0**	**3.2**	**1.5**	**27.1**
Mountain	Mountain	0.0	8.4	0.0	0.0	2.0	1.9	12.3
North Yuba	North Yuba	0.0	13.3	0.0	0.0	50.2	3.6	67.1
Vina	Vina	0.0	0.0	0.0	2.8	138.2	2.9	143.9
West Butte	Angel Slough	0.0	0.0	0.0	0.2	10.0	0.5	10.7
	Durham/ Dayton	9.8	3.0	0.0	0.0	95.0	1.5	109.3
	Llano Seco	1.4	5.6	0.0	11.1	2.3	3.8	24.2
	M&T	1.3	2.9	0.0	15.3	6.8	0.0	26.3
	Western Canal	5.2	59.2	0.0	0.0	6.9	23.8	95.1
	Total	**17.7**	**70.7**	**0.0**	**26.6**	**121.0**	**29.6**	**265.6**
Butte County Total		**66.0**	**680.8**	**0.0**	**40.6**	**439.2**	**220.1**	**1,446.7**

5.3.3 Net Groundwater Extraction

Table 5-3 included the total amount of groundwater that is pumped for consumptive use within each sub-unit of the county, but that does not provide a complete picture of the groundwater use because it does not include water that is concurrently percolating into the ground. Table 5-4 illustrates the amounts of deep percolation from surface water supplies and groundwater supplies, which are subtracted from the total groundwater extraction to result in net groundwater pumping. The net pumping illustrates areas that are pumping more groundwater than is percolating into the ground from applied water in that area. However, the net groundwater pumping does not consider the amount of recharge that enters the groundwater through natural processes. Areas with no net pumping include the areas where an equivalent amount or more applied water percolates into the ground than is pumped out.

It appears in Table 5-4 that some areas of the county have a net groundwater extraction in normal years. However, the data does not include the effects of natural recharge, which generally occurs during the winter months. Although local pumping may seasonally depress groundwater levels, pumping generally does not result in a long-term decrease of storage. Use of a comprehensive groundwater modeling tool would be necessary to rigorously evaluate groundwater level changes due to pumping. Figure 5-5 graphically illustrates the net pumping amounts in each of the inventory sub-units.

Table 5-4
Normal Year Net Groundwater Extraction (in thousands of acre-feet)

Inventory Unit	Sub-Unit	Total GW	Deep Perc. from SW	Deep Perc. from GW	Net GW Extraction
East Butte	Biggs-West Gridley	13.1	31.1	3.8	0
	Butte	26.5	14.8	6.0	5.7
	Butte Sink	6.3	1.8	0.3	4.2
	Cherokee	24.0	0.6	6.1	17.3
	Esquon	17.2	4.4	4.1	8.7
	Pentz	0.1	0.0	0.0	0.1
	Richvale	0.3	19.8	0.2	0.0
	Thermalito	22.0	0.2	4.8	17.0
	Western Canal	15.1	26.1	3.7	0.0
	Total	**124.6**	**98.8**	**29.0**	**53.0**
Foothill	Cohasset	0.5	0.0	0.3	0.2
	Ridge	2.0	0.4	5.9	0.0
	Wyandotte	0.7	1.9	2.1	0.0
	Total	**3.2**	**2.3**	**8.3**	**0.2**
Mountain	Mountain	2.0	5.1	1.1	0.0
North Yuba	North Yuba	50.2	1.8	13.8	34.6
Vina	Vina	138.2	0.2	27.3	110.7
West Butte	Angel Slough	10.0	0.0	1.5	8.5
	Durham/ Dayton	95.0	4.2	18.6	72.2
	Llano Seco	2.3	3.0	0.3	0.0
	M&T	6.8	3.8	1.6	1.4
	Western Canal	6.9	7.5	0.7	0.0
	Total	**121.0**	**18.5**	**22.7**	**82.1**
Butte County Total		**439.2**	**126.7**	**102.2**	**280.6**

5.3.4 Shortages

Shortages indicate the differences between supply and applied water demands, including depletion, losses, and required or operational outflows. During normal years, the demands (in Table 5-2) are equal to the supplies (in Table 5-3), which indicates that there are no shortages.

5.3.5 Impacts on Groundwater

In a groundwater basin, groundwater levels fluctuate as a result of changes in the amount of groundwater in aquifer storage. Factors that affect the amount of groundwater in storage include the seasonal and annual amount of groundwater extraction and aquifer recharge. The aquifer system is recharged from subsurface inflow to the basin and percolation of precipitation, streams, and irrigation water. Aquifer discharge occurs when groundwater is extracted by wells, discharges to streams, or flows out of the groundwater basin in the subsurface. Seasonally, the majority of the aquifer discharge happens during the summer because of groundwater extraction for beneficial uses, but the aquifer recharge occurs during the winter. The most extreme impacts to groundwater take place seasonally, and have the

potential to decrease groundwater levels to the point that some wells may not function without lowering the pump impeller.

Table 5-5 illustrates the impacts of groundwater pumping on the amount of groundwater in storage. The average depth-to-groundwater is estimated from field measurements. The estimated change in depth during the growing season illustrates the groundwater changes during the time of year where the groundwater will change the most dramatically because there is the most pumping and very little natural recharge. To determine the groundwater changes during the growing season, the volume of groundwater extracted for all uses during this period must be estimated. The volume of groundwater extracted represents the sum of agricultural demands during the growing season plus seventy percent of the yearly M&I demand less thirty percent of yearly deep percolation. The seasonal change in groundwater level can be calculated by dividing the volume of extracted groundwater by the product of the surface area and specific yield of the aquifer. The estimated change in depth does not consider the details of local groundwater formations, but is purely based on aquifer storage characteristics of each inventory sub-unit and the volume of groundwater pumped.

The total depth-to-groundwater (average depth plus the maximum depth change) was then compared to the well depths in each sub-unit. Table 5-5 also illustrates the percentage of wells that will remain under the groundwater table at the end of the growing season. The results indicate that most wells in the county will not be affected by the seasonal change in groundwater during the course of a normal year. The Foothill and Mountain Inventory Units were not included because their groundwater is more difficult to predict, and they have fewer wells. The table indicates the wells that would be dewatered to their total depth, and does not include wells that would be partially dewatered. However, local groundwater conditions are not included, so the results may not be indicative of actual performance. To fully understand the groundwater impacts, a groundwater modeling tool should be used.

Table 5-5
Normal Year Seasonal Groundwater Impacts

Inventory Unit	Inventory Sub-Unit	Avg. Depth to GW (ft)	Estimated Drawdown During Growing Season (ft)	% Wells Below GW Level		
				Domestic	Irrigation	Municipal
East Butte	Biggs-West Gridley	13	1	100	100	NC
	Butte	13	14	100	100	
	Butte Sink	13	0	NC	NC	NC
	Cherokee	13	23	100	100	NC
	Esquon	13	17	99.7	100	NC
	Pentz	13	1	100	100	NC
	Richvale	13	0	100	100	NC
	Thermalito	13	12	100	100	NC
	Western Canal	13	2	100	100	NC
North Yuba	North Yuba	37	11	99.8	100	NC
Vina	Vina	26	27	98.8	99.4	100
West Butte	Angel Slough	22	6	100	NC	NC
	Durham/ Dayton	22	32	97.7	99.6	NC
	Llano Seco	22	1	NC	NC	NC
	M&T	22	10	NC	100	NC
	Western Canal	22	2	NC	NC	NC

NC – Not Calculated (because well data is not available)

5.4 Summary of Drought Year Inventory

The drought year inventory was created to understand the changes that could occur within Butte County in years with little precipitation.

5.4.1 Demands

Table 5-6 illustrates the demands for water for the drought-year scenario. Demands have increased from the normal year, although the changes are not dramatic. The increase is caused because there is less effective precipitation and therefore less moisture left in the ground after the wet season.

The drought year scenario assumes that the cropping patterns do not change from normal years. However, it is likely that farmers would fallow land or plant less water-intensive crops when they realize that the winter had not been wet enough to provide them with adequate water. This analysis assumes that all areas are fully planted in the same manner as an average year during the drought year to illustrate the full amount of shortage.

Figure 5-6 illustrates the composition of drought year demand. This figure can also be compared to Figure 5-3, Normal Year Water Demands, to highlight some of the changes that occur during different water year types. Important features include:

- The composition of agricultural, municipal and industrial, and environmental demands does not appear to change substantially. In a drought year, the majority of the demand is agricultural, at 74%, followed by conveyance losses (11%), environmental demand (10%) and urban demand (5%). Part of the reason that demand composition remains the same is the assumption that cropping patterns do not change.

- Conveyance losses are less during droughts because less surface water is being conveyed through the system, so there is less water available for evaporation, evapotranspiration, percolation, or spillage.

- The composition of demand by Inventory Unit also does not change significantly. The highest demands are in East Butte (61%), followed by West Butte (20%), Vina (11%), North Yuba (5%), Foothill (2%) and Mountain (1%).

Table 5-6
Drought Year Water Demand (in thousands of acre-feet)

Inventory Unit	Sub-Unit	Agricultural Demand	M&I Demand	Environmental Demand	Conveyance Losses[1]	Total Applied Water
East Butte	Biggs-West Gridley	147.1	0.5	28.3	32.3	208.2
	Butte	86.3	4.9	0.8	19.5	111.5
	Butte Sink	6.6	0.0	43.0	2.6	52.2
	Cherokee	30.1	0.5	0.6	0.7	31.9
	Esquon	38.2	0.6	7.1	4.6	50.5
	Pentz	0.0	0.1	0.0	0.0	0.1
	Richvale	192.2	0.2	37.9	22.6	252.9
	Thermalito	21.4	3.3	2.2	0.4	27.3
	Western Canal	155.3	0.1	22.2	37.9	215.5
	Total	**677.2**	**10.2**	**142.1**	**120.6**	**950.1**
Foothill	Cohasset	0.0	0.5	0.0	0.0	0.5
	Ridge	2.1	10.5	0.0	0.5	13.1
	Wyandotte	6.0	5.4	0.0	5.5	16.9
	Total	**8.1**	**16.4**	**0.0**	**6.0**	**30.5**
Mountain	Mountain	1.0	2.0	0.0	11.6	14.6
North Yuba	North Yuba	66.4	7.7	1.2	6.1	81.4
Vina	Vina	146.2	22.2	0.0	3.4	171.8
West Butte	Angel Slough	13.1	0.0	0.0	0.5	13.6
	Durham/ Dayton	114.2	11.6	0.6	5.8	132.2
	Llano Seco	18.5	0.0	3.8	5.1	27.4
	M&T	23.5	0.0	1.0	6.2	30.7
	Western Canal	72.3	0.0	12.3	19.8	104.4
	Total	**241.6**	**11.6**	**17.7**	**37.4**	**308.3**
Butte County Total		**1,140.5**	**70.1**	**161.0**	**185.1**	**1,556.7**

Notes:
(1) Conveyance Losses include evaporation and percolation from conveyance system, riparian evapotranspiration, and conveyance system spill and seepage.

5.4.2 Supplies

Many areas with surface water have their supplies reduced during droughts. Table 5-7 includes the figures to illustrate the various types of supplies during a drought year.

Surface-water deliveries for the drought-year scenario were determined according to the maximum cutbacks that could occur to the water right or contract. For areas along Butte Creek or the tributaries, the surface-water deliveries reflecting 1977 hydrologic conditions were used to provide a realistic estimate of drought supplies.

After surface-water deliveries were calculated, groundwater was assumed to provide the remaining water to meet demand if the infrastructure is available. DWR land use surveys delineate the available water sources as a part of the survey, and thus indicates if each field has groundwater access. Any fields that do not receive surface water were assumed to pump groundwater if they have the infrastructure. However, the most recent DWR survey was performed in 1994, and some landowners could have installed wells since that time. Drilling new wells would increase supplies in the appropriate area.

Figure 5-7 shows the composition of supplies for each inventory sub-unit. This figure can be compared with Figure 5-4, Normal Year Water Supplies, to determine changes during drought years. Several noteworthy features include:

- There is more groundwater pumping and less surface water. Surface water decreases from 55% of supply in normal years to 41% during a drought, and groundwater increases from 31% to 44%. Surface water reuse stays essentially the same, going from 14% in a normal year to 15% during a drought.

- In several service areas, surface-water reuse increases in drought years because these water suppliers are more careful with the water that can leave their system. By reducing outflows, the water remains in the system for a longer time and is often reused. However, increased surface water reuse has the potential to degrade water quality.

- Distribution of supplies among the Inventory Units is roughly similar to demands: East Butte is 59% of total supplies, West Butte is 20%, Vina is 12%, North Yuba is 6%, Foothill is 2%, and Mountain is 1%.

Table 5-7
Drought Year Supplies (in thousands of acre-feet)

Inventory Unit	Sub-Unit	Local Surface Water	Feather River	SWP	CVP	Ground-water	Surface Water Reuse	Total Supplies
East Butte	Biggs-West Gridley	0.0	113.0	0.0	0.0	28.0	29.8	170.8
	Butte	0.0	50.0	0.0	0.0	34.6	13.4	98.0
	Butte Sink	2.1	0.0	0.0	10.8	15.1	21.1	49.1
	Cherokee	0.0	1.3	0.0	0.0	27.2	0.2	28.7
	Esquon	15.3	0.0	0.0	0.0	29.8	5.4	50.5
	Pentz	0.0	0.0	0.0	0.0	0.1	0.0	0.1
	Richvale	0.0	118.6	0.0	0.0	30.5	70.2	219.3
	Thermalito	0.0	2.8	0.0	0.0	24.1	0.4	27.3
	Western Canal	3.3	125.1	0.0	0.0	51.8	35.3	215.5
	Total	**20.7**	**410.8**	**0.0**	**10.8**	**241.2**	**175.7**	**859.3**
Foothill	Cohasset	0.0	0.0	0.0	0.0	0.4	0.0	0.4
	Ridge	9.6	0.0	0.0	0.0	2.1	0.2	11.9
	Wyandotte	0.0	14.8	0.0	0.0	0.7	1.4	16.9
	Total	**9.6**	**14.8**	**0.0**	**0.0**	**3.2**	**1.6**	**29.2**
Mountain	Mountain	0.0	10.1	0.0	0.0	2.1	2.4	14.6
North Yuba	North Yuba	0.0	15.4	0.0	0.0	62.1	3.9	81.4
Vina	Vina	0.0	0.0	0.0	3.3	164.8	3.7	171.8
West Butte	Angel Slough	0.0	0.0	0.0	0.3	12.8	0.5	13.6
	Durham/ Dayton	7.1	3.3	0.0	0.0	118.9	2.9	132.2
	Llano Seco	0.0	5.2	0.0	11.1	3.2	7.9	27.4
	M&T	5.3	4.7	0.0	11.8	8.9	0.0	30.7
	Western Canal	0.0	46.8	0.0	0.0	23.3	34.3	104.4
	Total	**12.4**	**60.0**	**0.0**	**23.2**	**167.1**	**45.6**	**308.3**
Butte County Total		**42.7**	**511.1**	**0.0**	**37.3**	**640.5**	**233.0**	**1,464.6**

5.4.3 Net Groundwater Extraction

Table 5-8 indicates deep percolation to groundwater and net groundwater pumping during a drought year. Figure 5-8 illustrates these results by inventory sub-unit and can be compared to Figure 5-5, Normal Year Net Groundwater Pumping. During a drought year, the net groundwater pumping increases significantly in many inventory sub-units in the valley.

Table 5-8
Drought Year Net Groundwater Extraction (in thousands of acre-feet)

Inventory Unit	Sub-Unit	Total GW	Deep Perc. From SW	Deep Perc. From GW	Net GW Extraction
East Butte	Biggs-West Gridley	28.0	21.9	7.4	0
	Butte	34.6	11.4	7.6	15.6
	Butte Sink	15.1	1.3	0.5	13.3
	Cherokee	27.2	0.3	6.8	20.1
	Esquon	29.8	3.6	6.8	19.4
	Pentz	0.1	0.0	0.0	0.1
	Richvale	30.5	15.8	0.2	14.5
	Thermalito	24.1	0.3	5.3	18.5
	Western Canal	51.8	25.6	7.9	18.3
	Total	**241.2**	**80.2**	**42.5**	**119.8**
Foothill	Cohasset	6.4	0.0	0.3	0.1
	Ridge	2.1	0.4	5.2	0.0
	Wyandotte	0.7	2.4	2.5	0.0
	Total	**3.2**	**2.8**	**8.0**	**0.1**
Mountain	Mountain	2.1	6.5	0.9	0.0
North Yuba	North Yuba	62.1	2.1	16.5	43.5
Vina	Vina	164.8	0.2	32.3	132.3
West Butte	Angel Slough	12.8	0.0	1.9	10.9
	Durham/ Dayton	118.9	3.4	21.1	94.4
	Llano Seco	3.2	3.1	0.6	0.0
	M&T	8.9	4.2	2.0	2.7
	Western Canal	23.3	7.4	1.0	14.9
	Total	**167.1**	**18.1**	**26.6**	**122.9**
Butte County Total		**640.5**	**109.9**	**126.8**	**418.6**

5.4.4 Shortages

Figure 5-9 compares normal supplies, demands, and shortages to those during drought years. In most areas, drought demands are greater than normal year demands. Applied water shortages occur only during drought years in the areas shown in Table 5-9. These shortages indicate the amount of demand that is not met by surface water or groundwater sources. Surface water cutbacks during drought years could be much greater than these shortages, but some of the cutback is made up by pumping additional groundwater.

Table 5-9 Drought Year Water Shortages			
Inventory Unit	**Sub-Unit**	**Shortage (TAF)**	**Total Demand (TAF)**
East Butte	Biggs-West Gridley	37.4	208.2
	Butte	13.5	111.5
	Butte Sink	3.1	52.2
	Cherokee	3.2	31.9
	Richvale	33.6	252.9
	Total	**90.8**	**655.7**
Foothill	Cohasset	0.1	0.5
	Ridge	1.2	13.1
	Total	**1.3**	**13.6**
Total		**92.1**	**669.3**

Shortages are primarily in the southwest portion of the county. Shortages are defined by lack of supply, which is limited by the groundwater infrastructure available in the southwest, not by total water supply.

The water shortage in the Ridge is somewhat different than the other sub-units, and is caused by a lack of surface water infrastructure. The shortage in Cohasset is due to a lack of groundwater depth and infrastructure.

Richvale, Biggs-West Gridley, and Butte are all part of the Joint Water District, which has adequate surface water supplies during normal years. Figure 4-2 illustrated the distribution of wells within the county, and there are not enough wells in these areas to provide groundwater during droughts. During normal years, it is not economical for farmers to pump groundwater, so many farmers do not have the necessary infrastructure. Shortages only occur in areas that do not receive surface water and do not have the infrastructure to pump groundwater.

5.4.5 Impacts on Groundwater

Table 5-10 illustrates how seasonal groundwater pumping changes the depth of groundwater and how this change could impact area wells. Most wells remain below the estimated groundwater level during periods of drought.

Estimated additional drawdown was calculated to assess the potential change in groundwater levels for areas with projected water shortages under the drought scenario. Shortages result from a lack of wells to extract groundwater from the aquifer and/or a lack of conveyance, adequate supplies of groundwater exist to meet all shortages. Additional drawdown calculations include the total projected shortage volume without consideration of deep percolation recharge of the additional waters. Estimates of additional drawdown to meet shortages would result in the lowering of groundwater levels from three feet in the Cherokee inventory unit to 18 feet in the Biggs West Gridley inventory unit.

Table 5-10
Drought Year Seasonal Groundwater Impacts

Inventory Unit	Inventory Sub-Unit	Avg. Depth to GW (ft)	Estimated Drawdown During Growing Season (ft)	% Wells Below GW Level			Additional Estimated Drawdown to Meet Shortages
				Domestic	Irrigation	Municipal	
East Butte	Biggs-West Gridley	13	8	100	100	NC	18
	Butte	13	21	100	100	NC	10
	Butte Sink	13	2	NC	NC	NC	5
	Cherokee	13	27	100	100	NC	3
	Esquon	13	30	99.7	100	NC	N/A
	Pentz	13	1	100	100	NC	N/A
	Richvale	13	10	100	100	NC	13
	Thermalito	13	13	100	100	NC	N/A
	Western Canal	13	17	100	100	NC	N/A
North Yuba	North Yuba	37	13	95.4	98.9	NC	N/A
Vina	Vina	26	28	98.8	0.6	100	N/A
West Butte	Angel Slough	22	34	90	NC	NC	N/A
	Durham/ Dayton	22	41	97.7	99.6	NC	N/A
	Llano Seco	22	1	NC	NC	NC	N/A
	M&T	22	13	NC	100	NC	N/A
	Western Canal	22	2	NC	NC	NC	N/A

NC – Not Calculated (because well data is not available)
N/A – Not Applicable (because sub-unit does not have a shortage)

5.5 Limitations

The supply and demand inventory was designed to be a tool for decision making and looks simply at a snapshot in time. There are limitations on how accurate the results can be, based on the inputs and the style of analysis.

5.5.1 Data Collection

Collecting additional data could further refine the analysis. The following information would be important next steps to continue to improve the understanding of Butte County's water resources:

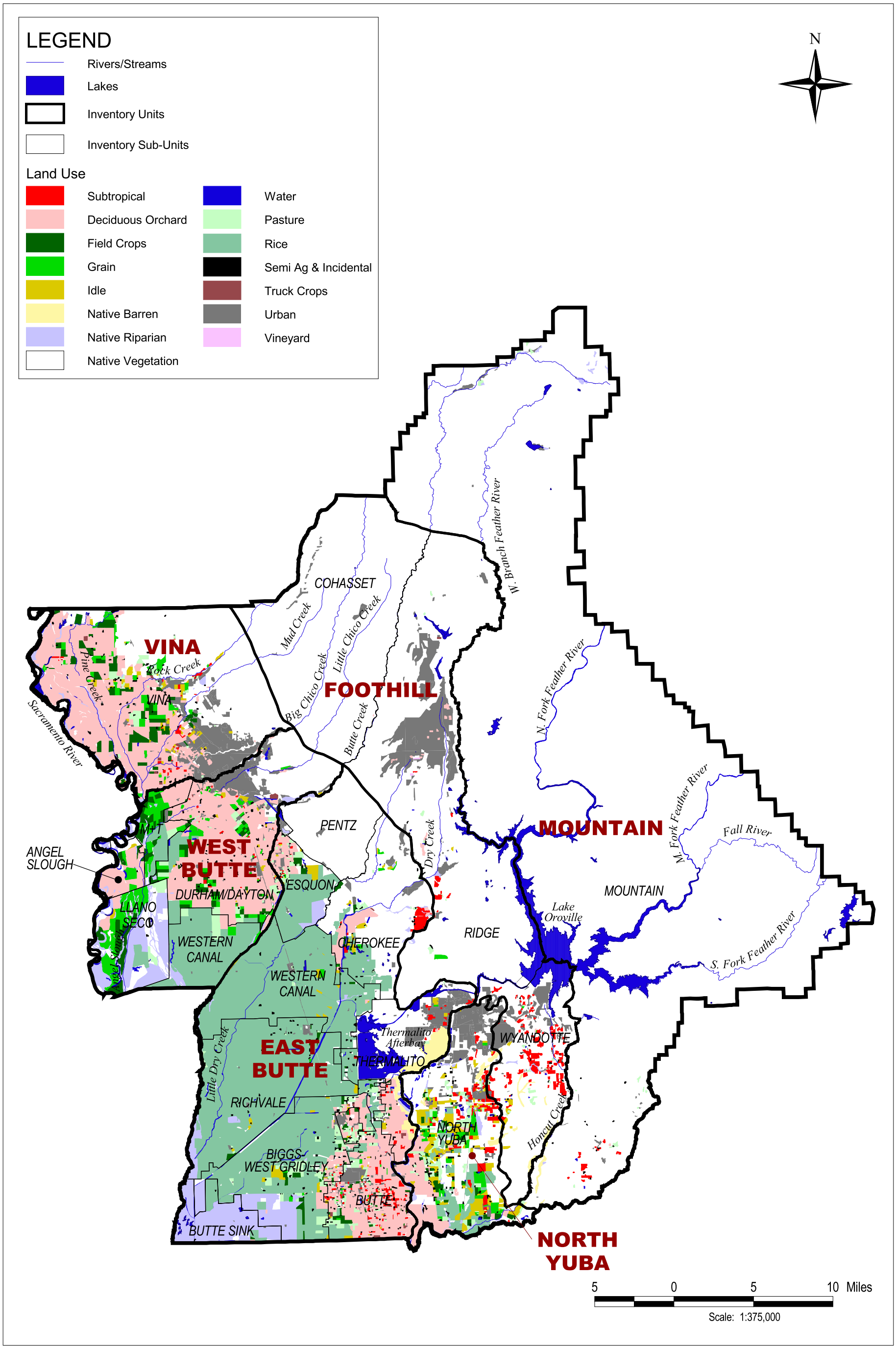
- Additional groundwater-level data;
- Return flows; and
- Deep percolation.

5.5.2 Analysis

The greatest limitation to the inventory was the analysis method. The inventory creates a snapshot picture of 1 normal year and 1 dry year. However, it cannot display links between years. Most droughts in California include multiple years, so looking at 1 drought year does not completely illustrate a drought scenario.

The groundwater analysis in this report is a simple analysis performed to illustrate potential impacts of how supply and demand are distributed. The Butte Basin Water Users' Association is working on a groundwater model that should be a better tool to understand the groundwater within the county, and the information in this inventory can be used as input information for that model.

Figures



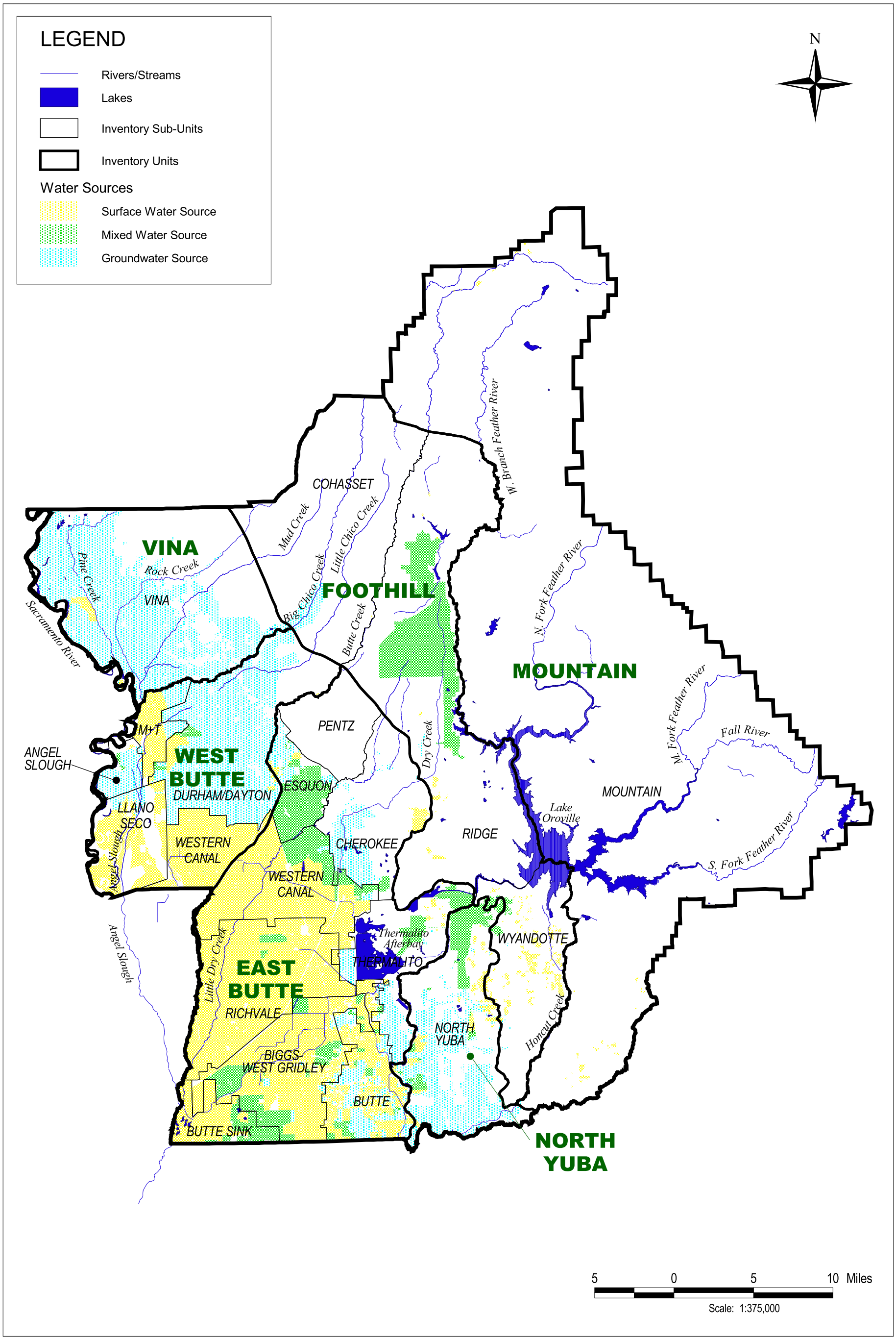
Source: Department of Water Resources and Butte County Planning Department

Butte County
Department of Water & Resource Conservation

Figure 5-1

LAND USE

CDM Camp Dresser & McKee Inc.



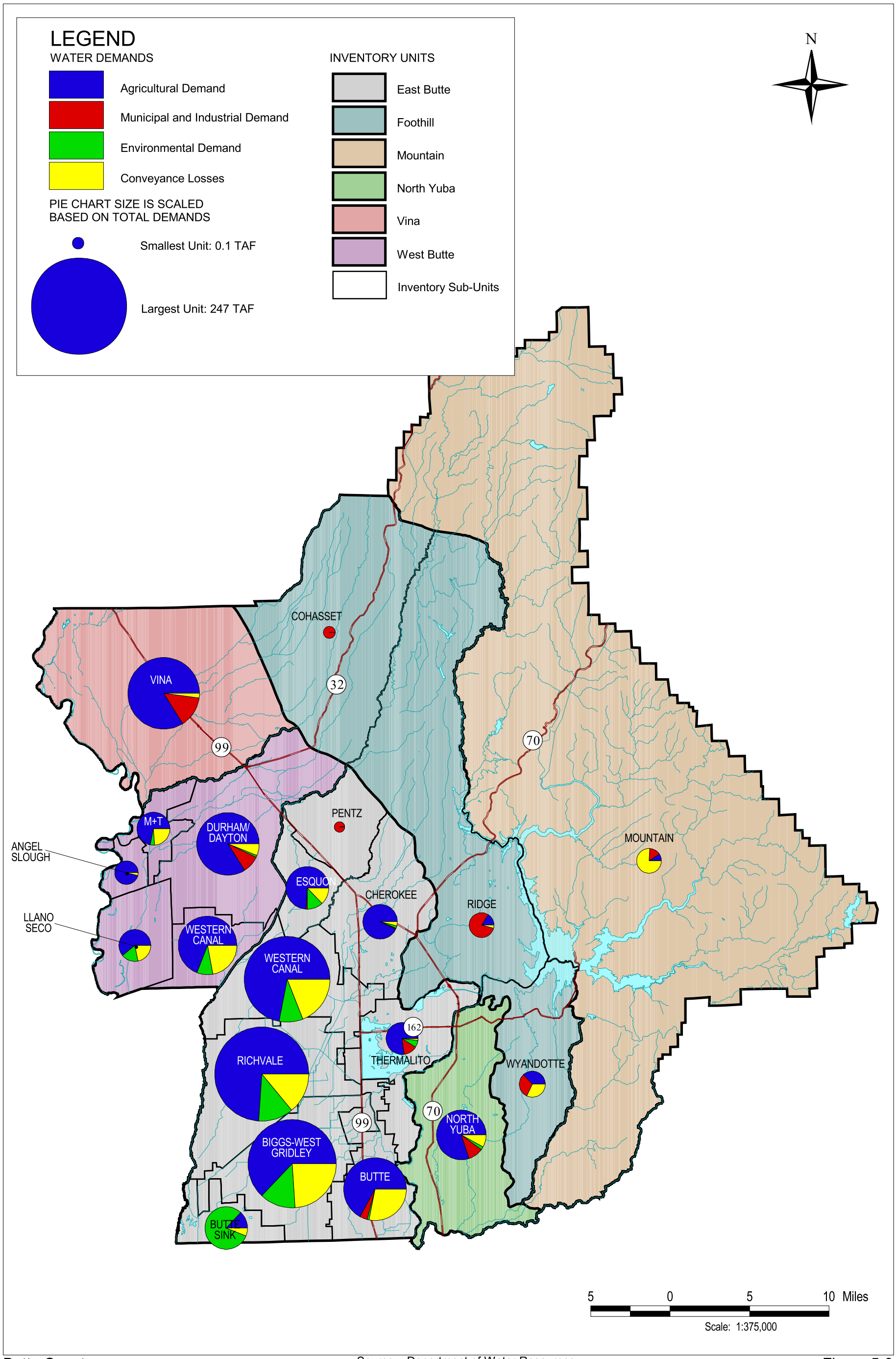
Butte County
Department of Water & Resource Conservation

Source: Department of Water Resources, Butte County Planning Department, and US Bureau of Reclaimation

Figure 5-2

WATER SOURCES

CDM Camp Dresser & McKee Inc.



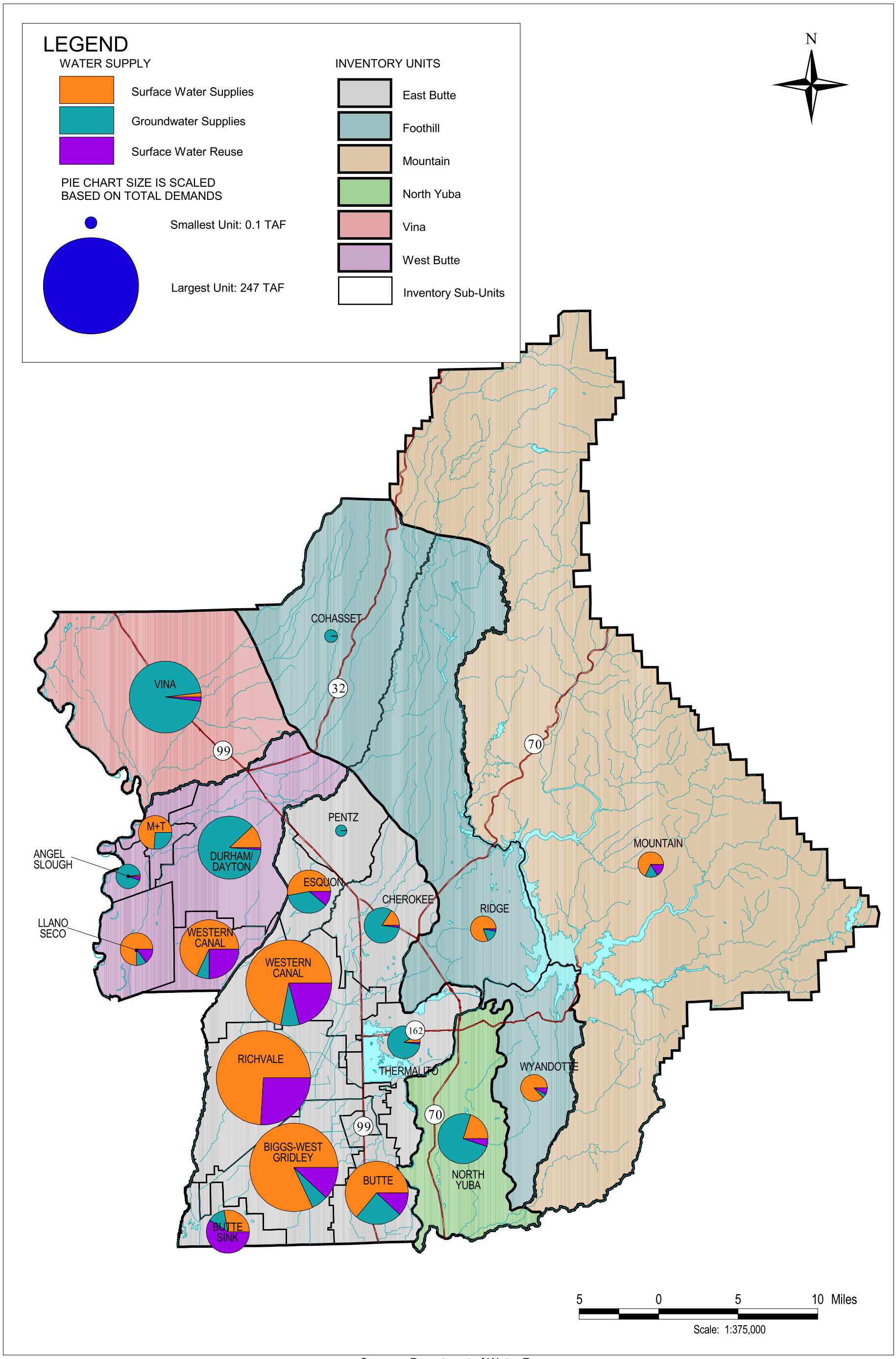
Butte County
Department of Water & Resource Conservation

Source: Department of Water Resources

Figure 5-3

NORMAL SCENARIO WATER DEMAND

CDM Camp Dresser & McKee Inc.



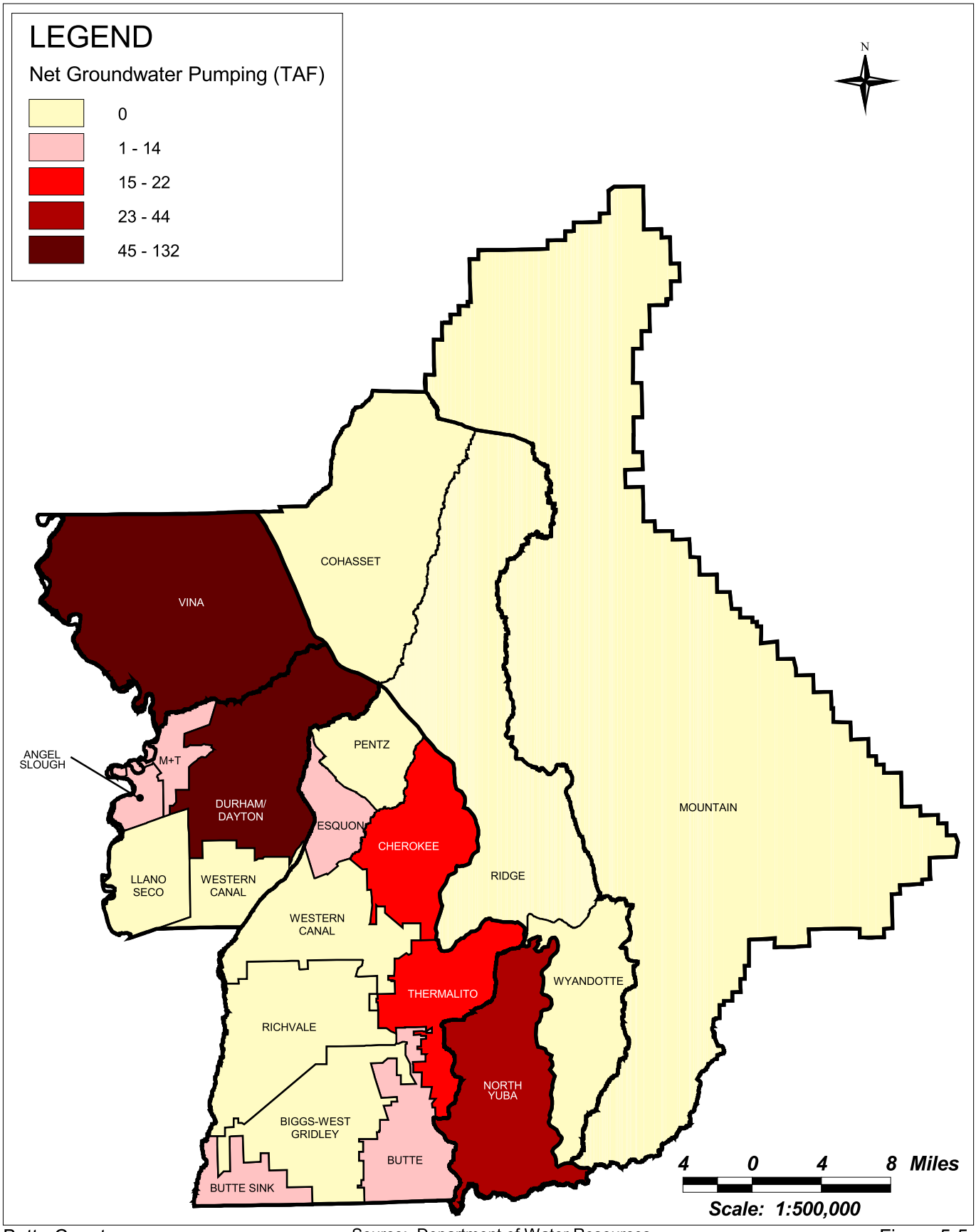
Butte County
Department of Water & Resource Conservation

Source: Department of Water Resources

Figure 5-4

NORMAL SCENARIO WATER SUPPLY

CDM Camp Dresser & McKee Inc.



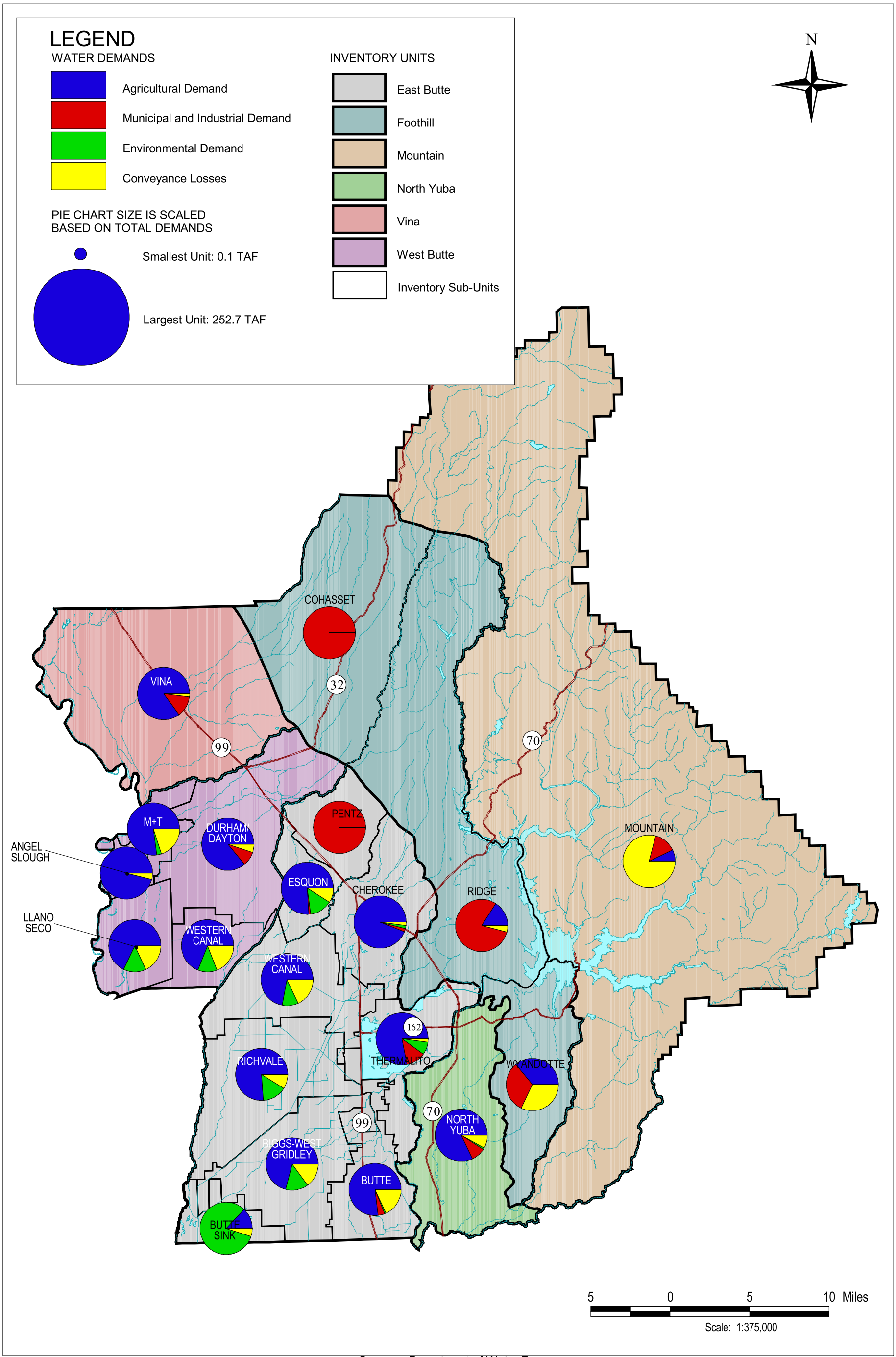
Butte County
Department of Water & Resource Conservation

Source: Department of Water Resources

Figure 5-5

NORMAL NET GROUNDWATER EXTRACTION

CDM Camp Dresser & McKee Inc.



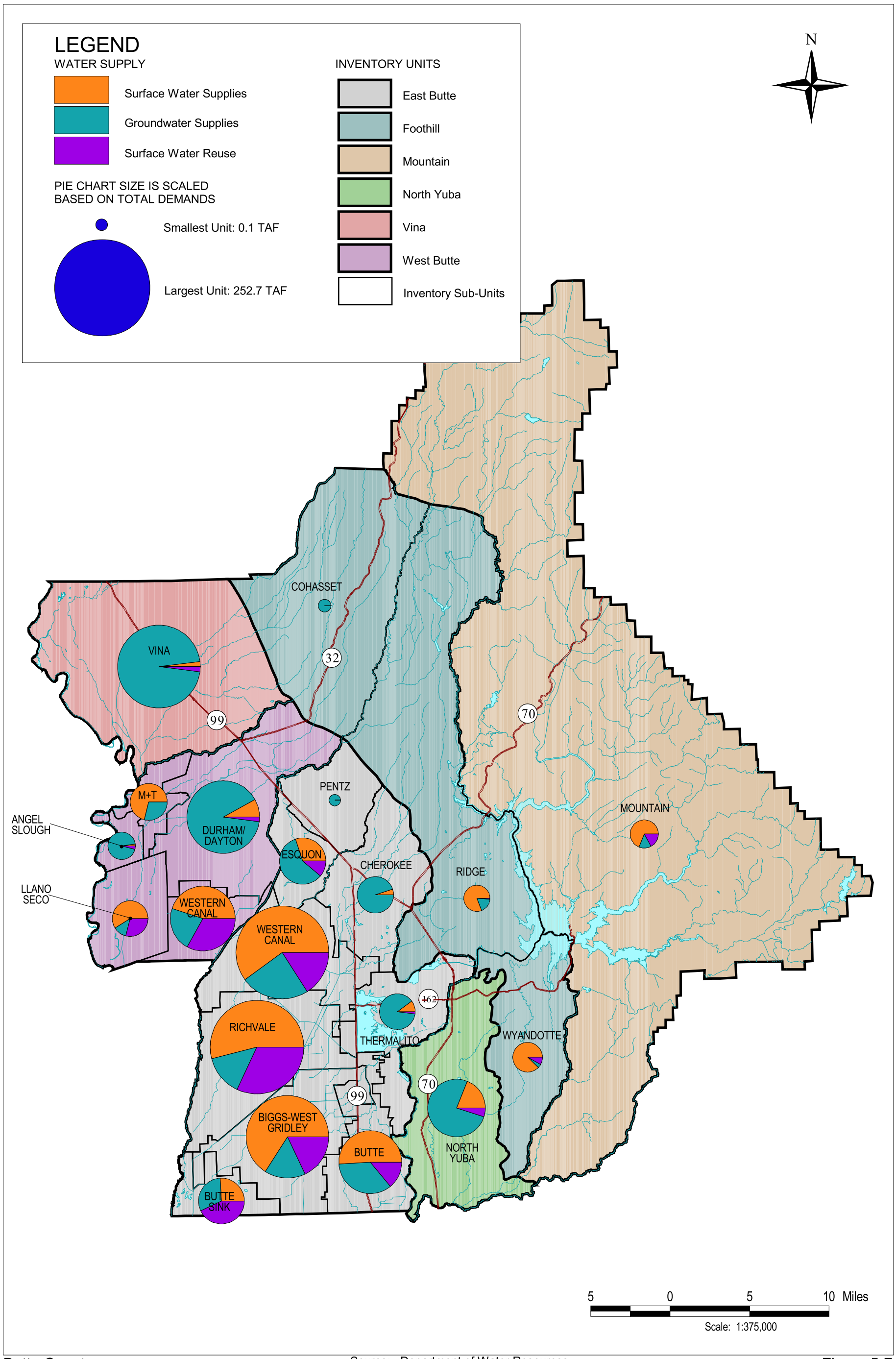
Butte County
Department of Water & Resource Conservation

Source: Department of Water Resources

Figure 5-6

DROUGHT SCENARIO WATER DEMAND

CDM Camp Dresser & McKee Inc.



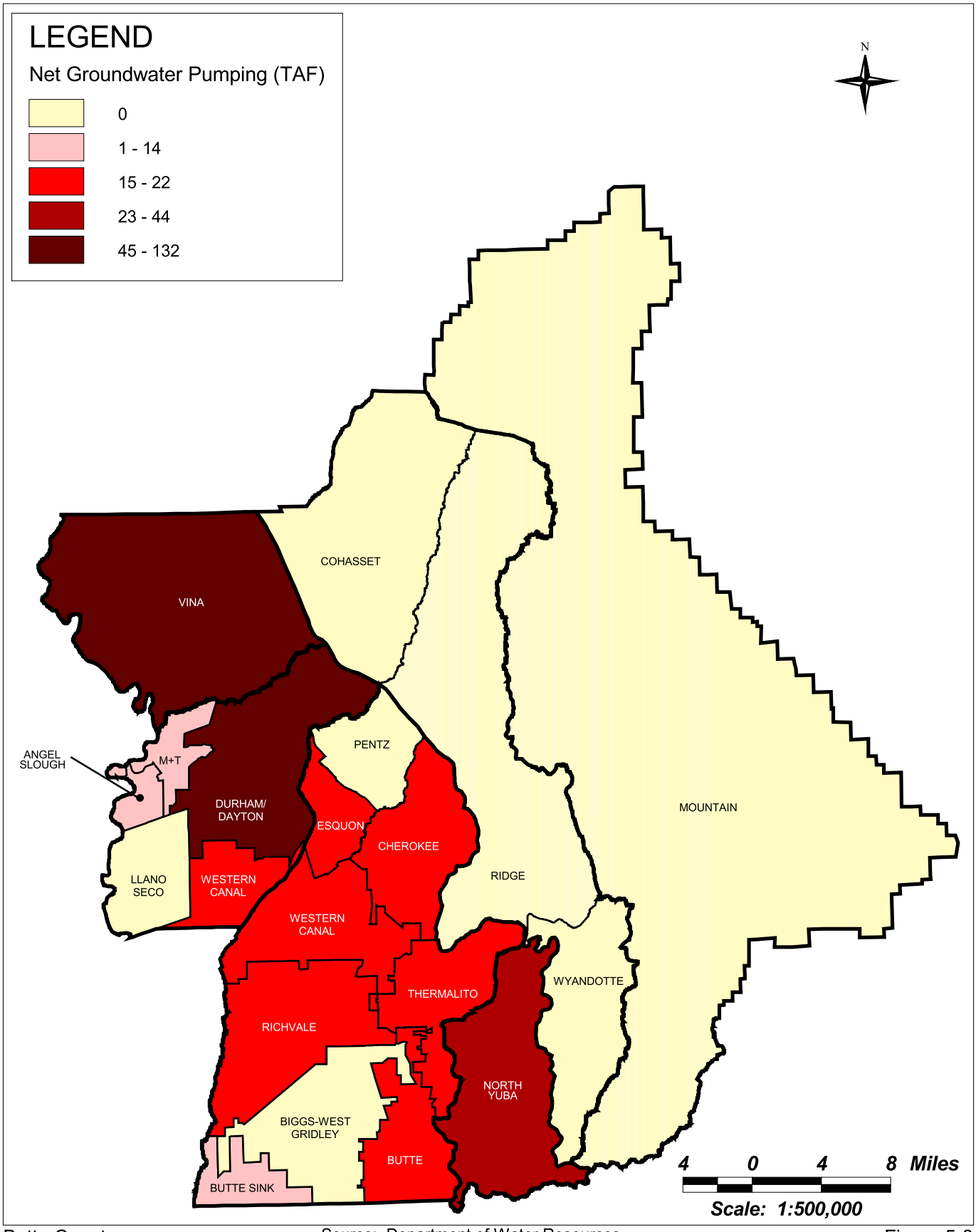
Butte County
Department of Water & Resource Conservation

Source: Department of Water Resources

Figure 5-7

DROUGHT SCENARIO WATER SUPPLY

CDM Camp Dresser & McKee Inc.



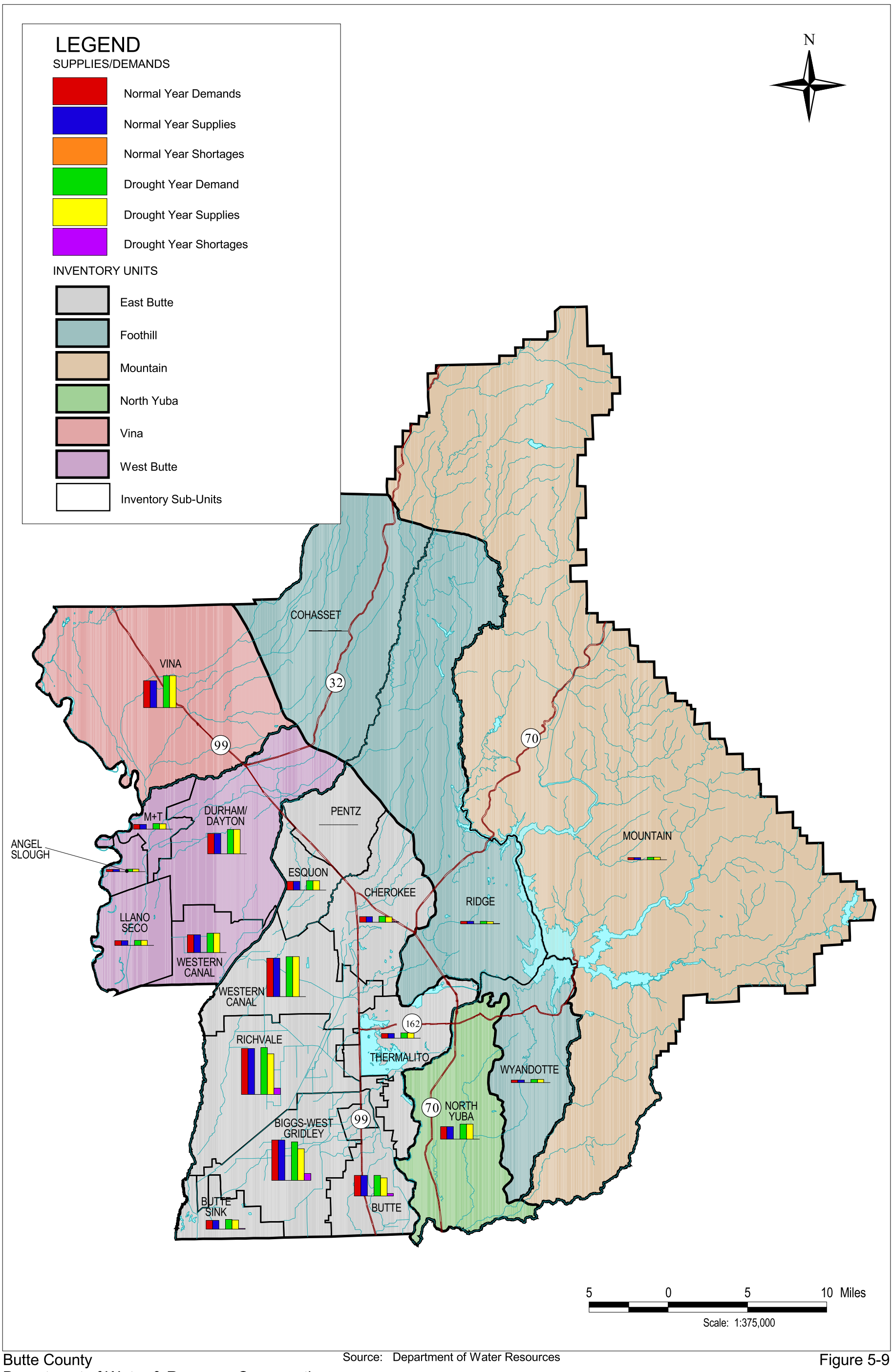
Butte County
Department of Water & Resource Conservation

Source: Department of Water Resources

Figure 5-8

DROUGHT NET GROUNDWATER EXTRACTION

CDM Camp Dresser & McKee Inc.



Butte County
Department of Water & Resource Conservation

Source: Department of Water Resources

Figure 5-9

SUMMARY OF SUPPLY AND DEMAND

CDM Camp Dresser & McKee Inc.

Section 6
Additional Water Management Issues

This inventory and analysis of Butte County water resources focuses on the county's supply and demand of surface and groundwater resources, and does not cover the breadth of all water resource issues. This section addresses the range of issues identified at many forums on Butte County water resources, and suggests how the data or analysis could be improved in the future. These recommendations are included in the conclusions of this report and the executive summary. The issues to be discussed include:

- Water Quality
- Environment
- Flood Control
- Water Use Efficiency
- Water Demand Forecasting

6.1 Water Quality

While substantial, the current status of ground-and surface-water quality and water quality data needs improvement in Butte County. Requirements for the control of non-point sources of urban and agricultural runoff will be discussed briefly. Nitrate pollution of groundwater will be highlighted, along with the general water quality data available from various groundwater sources. Surface-water quality data from DWR and local urban and agricultural water districts will be illustrated.

Surface Water

Point and Nonpoint Source Discharge

Butte County faces several major future challenges to continue to meet water quality standards and National Pollutant Discharge Elimination System (NPDES) permitting processes. It is likely that future regulatory changes will affect existing effluent limits for point source discharges and increased control of nonpoint sources. Municipal and industrial discharges in areas where water quality standards have not been attained may be subject to limiting their discharges for specific pollutants even more than they are now.

Litigation from the environmental community has been a primary motivation for the increased focus and faster pace for the development of Total Maximum Daily Load (TMDL) standards in recent years. For example, consent decrees resulting from EPA's settlement of lawsuits by environmental groups have set the pace of TMDL development in southern California and on the north coast.

In general, the Clean Water Act does not authorize EPA to regulate nonpoint source pollution. Nevertheless, EPA has consistently taken the position that nonpoint sources must be included in TMDLs and has confirmed that position in recently issued TMDL guidance. In Pronsolino v. EPA, landowners within California's Garcia River Watershed and the California Farm Bureau Federation allege, among other things, that EPA exceeded its statutory authority when it placed the Garcia River on the list requiring the establishment of a TMDL. The plaintiffs contend that Clean Water Act section 303(d) specifically limits the listing of waters to those that fail to meet water quality standards due to point sources of pollution. Because EPA determined that the Garcia River was impaired due to nonpoint sources of pollution, and natural background conditions, the plaintiffs contend that EPA exceeded its authority in listing the river under section 303(d).

Groundwater

The nitrate contamination in the Chico area is a concern for the long-term continued use of groundwater supply for residents. In response, the Chico Urban Area Nitrate Compliance Plan was developed to address nitrate contamination problems of groundwater in the Chico urban area, report actions taken and recommend solutions. The report concludes that septic tank discharge is the primary source of groundwater nitrate in the area, and identifies specific regions that must be sewered to eliminate contamination. Transfer of 7,800 of the areas 12,000 septic tank users to sewer connections is proposed. Other proposed actions include public education for owners of septic systems and the limiting of new residential development on septic systems.

Additional nitrate contamination issues are possible in the future within the Paradise Irrigation District and Del Oro Water Company service areas because all residents and commercial enterprises are currently on septic systems. New water supply wells are also being considered for drought protection within these areas.

Another issue has been raised over the past few years regarding the overall water quality of supplies from the Lime Saddle Marina Area of Lake Oroville. While the overall quality of water from the lake is excellent, there is concern that it varies substantially as the lake level lowers in the Lime Saddle area of the West Branch. Recently, the issue has expanded into specific concerns over pollution caused from the MTBE additive to fuel.

An issue raised at a number of forums is the quality of groundwater pumped from private wells. One issue is the amount of industrial, commercial, and residential water use that is self-produced. While the amount of self-produced groundwater in relation to the total water use is relatively small, a survey method for gathering these data is suggested for future water inventories.

Information sources

There are many varied sources of water quality information that are important to Butte County. For example, DWR prepares an annual water quality assessment of the State Water Project (SWP), and has completed an analysis of MTBE in the SWP. DWR also prepares surface water quality monitoring station reports for the Sacramento and Feather Rivers, Butte Creek, and Big Chico Creek. In addition, water quality data is accumulated by the Central Valley Regional Quality Control Board, California Department of Health Services, and the Butte County Environmental Health Department. The amount of data gathered is generally less extensive for groundwater than surface water. However, given that the data is collected form the wide array of sources, it is difficult to analyze the overall trends in the Quality of Butte County's water resource. Future water inventories would be improved, if all these data were summarized in one chapter on water quality.

6.2 Environmental Issues

There has been an attempt to cover the wide range of environmental issues that affect water supplies and demands in this report. Nevertheless, many county residents have raised issues relating to the impact of water demands on environmental habitat and endangered species. The total amount of environmental demands need to be addressed more comprehensively in future inventories.

Environmental Water

The primary focus of this report, related to environmental water use, has been on water supplied to wildlife refuges and flooding of rice fields for rice straw decomposition and waterfowl habitat. The attention to environmental water demands and supplies increased substantially during the 1990s, but the assessment of overall environmental demands lags behind that of the agricultural and urban sectors. For example, much research has focused on estimating the consumptive use of agricultural crops, but little to the water demands of various habitat types. The design and implementation of a program to estimate the acreage of various habitat types, and establish unit water use values for those habitats, is a critical need for Butte County and the state. However, funding for the acquisition of basic land and water use data has been a low priority for state and federal programs over the past two decades.

Endangered Species

The presence of threatened and endangered species (T & E species) affects the management and maintenance of water resources in Butte County. Project construction or modification generally requires consideration of endangered species through a biological consultation to discover possible impacts and mitigation requirements. Permitting can be expensive and time consuming and can potentially delay or halt projects. New projects must receive suitable approval, and significant impacts must be properly mitigated. Elderberry bushes, for example, that are within a

proposed project must be relocated or replaced based on guidelines by the U.S. Fish and Wildlife Service associated with protection of the elderberry beetle.

In the presence of T & E species, routine maintenance can also require increased planning and effort. Guidelines for lessening impacts on T & E species limit times for maintenance. For example, Western Canal Water District grades its water supply canals one side of the ditch at a time and never during dawn or dusk to lessen the impact on the state and federally threatened giant garter snake. In addition, elderberry bushes impeding maintenance cannot be removed without mitigation. Because of these requirements, the cost of routine maintenance can increase significantly. Also, adequate instream flows must be maintained while chinook salmon are migrating and spawning; therefore, valley farmers must adhere to an irrigation prohibition.

Photograph from DWR

Water dams and diversions can pose a significant risk to threatened and endangered aquatic species by impeding upstream migration of anadromous species. Water diversions can entrain juveniles, resulting in increased mortality. Many dams and water diversions have been removed along the length of Butte Creek in an effort to restore fish passage for spring-run Chinook salmon. The work has been completed as a cooperative effort between Western Canal Water District (Western Canal), Department of Interior, and California Urban Water Agencies. Western Canal removed the Point Four Dam in 1993. During 1998, 4 dams were removed and 12 unscreened water diversions were eliminated, including the Western Canal Main Dam, Western Canal East Channel Dam, McGowan Dam, and McPherrin Dam.

In 1998, Durham Mutual Water Company, working in conjunction with the U.S. Bureau of Reclamation (USBR), DWR, and Department of Fish and Game (DFG), installed two fish screens and an improved high-volume fish ladder to eliminate entrainment and improve fish passage on Butte Creek and the Durham Mutual Dam. Additionally, in 1995, a pool-and-chute fish ladder was designed and installed at Parrot-Phelan Dam by DFG, USBR and DWR to improve fish passage. In 1998, Gorrill Ranch and Rancho Esquon installed new fish screens and fish ladders on Butte Creek.

Two additional dams owned by Pacific Gas and Electric Company are currently under assessment to determine the potential for modification or removal to allow fish migration into the upper canyon reach of Butte Creek.

6.3 Flood Control

Butte County has major flood control problems. The Butte Basin Overflow Area is an essential element of the flood management system of the Sacramento River. The Rock

Creek / Keefer Slough area north of Chico has been subject to repetitive flood damage. Major floods in the Feather River area have occurred largely outside of the county, but a major proposal under the Proposition 13 (2000 Water Bond) by Yuba County Water Agency affects DWR's Butte County Facilities.

Regional efforts are ongoing to address flooding issues. Following the devastating floods of 1997, the state formed a Flood Emergency Action Team (FEAT) to recommend a series of potential strategies that would improve flood management. As part of the strategy, the Sacramento and San Joaquin River Basins Comprehensive Study includes a comprehensive study and framework plan focusing on the immediate need for flood protection with integrated ecosystem restoration. Initial projects proposals include the *Glenn and Butte Counties Flood Damage Reduction and Ecosystem Restoration*, located within the Sacramento River riparian corridor on the western boundary of Butte County immediately south of Highway 32.

Photograph from DWR

Butte Basin Overflow Area

The Butte Basin Overflow Area lies from the confluence of Big Chico Creek and the Sacramento River near Chico landing and extends outside the county to the Butte Slough outfall gates near Meridian in Sutter County. Overflows eventually enter the Sutter Bypass. At high stages of the Sacramento River, water flows into the Butte Basin at several locations, thus reducing the peak discharge and stage between the main levees of the Sacramento River Flood Control Project. The northernmost overflow point is at a degraded levee called the M&T flood relief structure, the next is at a natural overflow area known as the 3 B's, and the southernmost in Butte County is at another degraded levee known as the Goose Lake flood relief structure. There is much concern over the long-term management of the Butte Basin overflow area, because of the maintenance of flood control facilities in concert with the management of the Sacramento River Conservation Area.

Rock Creek Keefer Slough

Subdivisions were developed in the Keefer Slough area based on the flood plain maps prepared by the Federal Emergency Management Agency (FEMA) in 1988. Subsequent flooding showed the flood plain maps to be in error. However, newly proposed flood plain maps appear to show flood prone areas more accurately. The area was severely damaged by floods in 1995, 1997, and 1998 and was designated as a Federal disaster area. The total cost of these disasters has been calculated at over $76 million. Currently, Butte County is working with the U.S. Army Corps of Engineers and DWR to develop flood control alternatives. The objectives of these alternatives are to:

- Eliminate repetitive residential and agricultural flooding caused by excessive peak flood flows in Rock Creek and its tributaries;
- Reduce flood flows to volumes that can be retained in channels;
- Maintain natural low flows in existing channels
- Develop environmentally compatible facilities that enhance habitat; and
- Develop low maintenance facilities.

Long-term funding for the Rock Creek / Keefer Slough flood management effort will be sought from a wide array of sources. The project will also provide useful data on the effectiveness of environmentally compatible flood control solutions. Funding will be sought from the Proposition 13 (2000 Water Bond) Flood Corridor Protection Program to implement environmentally compatible practices.

Feather River

A significant component of Proposition 13, the Costa-Machado Water Act of 2000, was the Yuba-Feather Flood Protection Program, which provides for flood protection along the Feather and Yuba Rivers. Two of the features of this program are proposed for the State Water Project in Butte County. These elements involve the reoperation of Thermalito Afterbay and increased flood storage in Lake Oroville.

Analyses by the Yuba County Water Agency indicate that modifying the operation of the afterbay could result in a reduction in flood volume on the Feather River. A reduction of 36,000 acre-feet in floodflows would occur below the confluence of the Feather and Yuba Rivers. This option is the most cost-effective element of the program, and needs to be analyzed carefully to determine its impacts on agricultural and environmental water management needs in Butte County.

The option of increasing the flood storage behind Oroville Dam could have the most direct flood management benefits to Butte County. There is a potential for additional flood storage of 75,000 acre-feet or more by the installation of a series of 10-foot-high inflatable rubber dams called Obermeyer Gates. The rubber dams would be placed across the emergency spillway to increase flood storage. The additional storage would also reduce the frequency and need for releases over the emergency spillway, causing additional downstream problems.

Other Flooding Concerns

There are other flood management concerns in Butte County in addition to those previously mentioned. The flood management needs of other areas in the county as documented by the Butte County Office of Emergency Services are:

- Sedimentation of the Cherokee Canal;
- Drainage and flood control in the Palermo area; and

- Drainage and flood control in the Durham area.

6.4 Water Supply Reliability

Both recent updates of the California Water Plan (Bulletins 160-93 and 160-198) and CALFED recognized that, critical water shortages may occur which severely impact the health, welfare, and economy of California. To avoid such serious impacts, the Governor convened a panel in July 2000, chaired by the Director of the Department of Water Resources, for the purpose of developing a contingency plan to reduce the impacts of critical water shortages. Butte County was represented on the panel.

The plan identifies available resources (e.g., water transfers, water exchanges, groundwater programs, local partnerships), building upon the experience gained with Governor's Water Bank, to minimize such shortages. However, many on the panel, particularly those from Northern California, are concerned that the report did not represent a comprehensive drought contingency plan. The Governor's Panel will submit the plan to the Governor early in 2001, but the Northern California Water Association is requesting that a panel be convened to continue the work of developing a comprehensive drought plan.

Agricultural Water Use Efficiency

For many years many parties have disagreed as to the efficiency of agricultural water use. One of the reasons for the disagreement is the definition of irrigation efficiency. For example, an economist might describe irrigation efficiency in terms of agricultural production per unit of water. The term irrigation efficiency is often used interchangeably with agricultural water use efficiency in the agricultural community. However, irrigation efficiency is a term developed for the design and management of irrigation systems on individual farm fields. In many cases, the equations used to calculate irrigation efficiency have been misused when applied to larger geographic areas. Recently, a mathematical expression has been developed that relates on-farm irrigation efficiency, and the efficiency of a district or basin, to the amount of reuse. The reuse coefficient, ranging from zero to 1, is estimated from drainage water, tailwater and groundwater that was previously applied on-farm and reused. When there is no reuse, the coefficient is zero, hence the on-farm efficiency will be equal to the district or basin efficiency. The coefficient moves toward 1 as the number of times irrigation water is reused within a basin or district, thus the regional efficiency is higher than the on-farm efficiency. Although no detailed calculations were made for this report, it is apparent that the Butte Basin has much reuse of surface water between farms and districts, and by the management of ground and surface water.

Another concept that has been formulated in the past decade is that of “irrigation sagacity.” This concept expands the notion that there are other beneficial uses of applied on-farm irrigation water that are not accounted for in expressions of on-farm or regional irrigation efficiency. For example, many farms in the Butte Basin support additional habitat with applied irrigation water. Some practices, such as flooding rice

fields to increase fall/winter waterfowl habitat and to decompose rice straw to improve air quality, use additional water that is not part of agricultural water demands, but can be considered sagacious uses of water.

Using the concepts outlined above, the Agricultural Water Management Council, formed in July 1997, comprised of signatories to the *Memorandum of Understanding Regarding Efficient Water Management Practices by Agricultural Water Suppliers in California,* adopted a list of Efficient Water Management Practices (EWMPs). These practices can be evaluated to take into account regional efficiencies and sagacities. However, on-farm irrigation management is still important to many individual growers in Butte County in terms of yields, pesticide and fertilizer applications, and disease. The EWMPs go beyond a water supplier assisting with information for traditional on-farm irrigation management practices. The EWMPs that could be implemented if cost-effective are shown in Table 6-1. Western Canal Water District and Butte County are currently signatories to the Agricultural MOU.

The information necessary to evaluate the expressions of regional irrigation efficiency, sagacity, and thus cost-effectiveness, in most agricultural areas of California including the Butte Basin, are not readily available. These data will need to be collected in order to evaluate the effectiveness of agricultural water use efficiency options the next inventory and analysis of Butte County's Water Resources.

Table 6-1
Efficient Agricultural Water Management Practices

Generally Applicable EWMPs (considered cost-effective for all water suppliers) • Prepare and adopt a water management plan; • Designate a water conservation coordinator; • Support the availability of water management services to water users; • Where appropriate, improve communication and cooperation among water suppliers, water users, and other agencies; • Evaluate the need, if any, for changes in policies of the institutions to which the water supplier is subject; and • Evaluate and improve efficiencies of water supplier's pumps.
Conditionally Applicable EWMPs (cost-effective practices subject to net benefit analysis outlined in the MOU, or those that are demonstrably inappropriate) • Facilitate alternative land use (in drainage problem areas); • Facilitate use of available recycled water that would not be used beneficially; • Facilitate the financing of capital improvements for on-farm irrigation systems; • Facilitate voluntary water transfers that do not unreasonably affect the water user, water supplier, and the environment or third parties; • Line or pipe ditches and canals; • Increase flexibility in water ordering by, and delivery to, the water users within operational limits; • Construct and operate water supplier spill and tailwater recovery systems; • Optimize the conjunctive use of surface-and groundwater; and • Automate canal structures.
Other EWMPs (must go through net benefit analysis) • Water measurement and water use report; and • Pricing or other incentives.

Urban Water Use Efficiency

A difference between urban and agricultural water management is that urban water use is not generally described in terms of efficiency. The most commonly used term for comparison has been per-capita water use, expressed as gallons per-capita daily (gpcd), which is the water produced by the system of a water supplier divided by the population served. All categories of urban use - residential, commercial, industrial, and institutional - are included in gpcd. Analyzing the change in gpcd can help an agency track changes in its use patterns and conservation, but it is not a useful comparative tool when comparing one agency to another. For example, a large manufacturing sector in a small community will result in high gpcd values, whereas a community with largely multi-family housing (apartments, trailer courts, etc.) and little manufacturing or commercial enterprises will normally have low gpcd values.

Another difference between urban and agricultural water use efficiency is that over 400 urban water suppliers having more than 3,000 connections, or delivering over 3,000 acre-feet of water annually, have been required to prepare urban water management plans since 1983. The Urban Water Management Planning Act (California Water Code Sections 10610-10656) requires that plans be developed every 5 years. Completed plans were due on December 31, 2000. For example, Paradise Irrigation District held public hearings on its plan update during December 2000. The plan covered all areas required under the law, including:

- Plan Adoption, Public Participation, and Planning Coordination
- Paradise Irrigation District—History and Water Facilities
- Past, Current, and Projected Water Use
- Water Shortage Contingency Analysis
- General Water Use Information
- Water Demand Management Measures

The other agencies in Butte County that are required to submit plans are California Water Service Company (Chico & Oroville), Del Oro Water Company, Thermalito Irrigation District, Oroville-Wyandotte Irrigation District, and the cities of Gridley and Biggs. The urban water management plans require projections of demands to 2020. In most cases these forecasts are made using a time series analysis based on the assumption that past trends in water use will continue into the future.

As might be expected, good urban water use efficiency analysis requires data on water pricing and other water conservation factors. The Urban Water Conservation Council was formed in 1991 to provide statewide leadership in urban conservation practices and analyses. The Best Management Practices (BMPs) promulgated in the

•*Memorandum of Understanding Regarding Urban Water conservation in California,"* have provided the basis for the demand management measures in the Urban Water Management Planning Act and in forecasts of future urban demands. The urban BMPs are listed in Table 6-2.

Table 6-2
Urban Best Management Practices

- Water survey programs for single-family and multi-family residential customers;
- Residential plumbing retrofit;
- System water audits, leak detection, and repair;
- Metering with commodity rates for all new connections and retrofit of existing connections;
- Large landscape conservation programs and incentives;
- High-efficiency washing machine rebate programs;
- Public information programs;
- School education programs;
- Conservation programs for commercial, industrial, and institutional accounts;
- Wholesale agency assistance programs;
- Conservation pricing;
- Conservation coordinator;
- Water waste prohibition; and
- Residential ULFT replacement programs.

Many of the BMPs are applicable to Butte County urban water suppliers if proven to be cost-effective. California Water Service Company, and Del Oro Water Company, are signatory to the Urban MOU.

Water Recycling

Water recycling is normally considered another water use efficiency action. It could form a potential source of supply for groundwater recharge. The amount of treated effluent generated in Butte County is small compared to the overall water supply. Additionally, like conservation, it will be most cost-effective in coastal areas where the effluent is lost to the ocean and can't be reused. There is little need for much analysis in this area, but it could become more important in the future as the number of sewer connection increases.

6.5 Forecasts and Trends in Water Use

No forecasts or detailed analysis of trends are part of this inventory and analysis, but the public has insisted that good estimates of forecasted urban and agricultural water use are very important to Butte County. Various methods are used to project or forecast demands. This discussion focuses on methods that could be adopted by the county for future updates of this inventory and analysis. General trends are identified from other sources or observations.

Urban Water Use

Butte County's urban water needs will certainly increase in the future. For example, Paradise Irrigation District estimates that trends in its demands indicate an increase of

about 10 percent by 2020 in their most recent urban water management plan. When all the urban water management plans are completed for the agencies mentioned previously, DW&RC can estimate trends in overall urban demands in the county.

In order to increase the precision of urban demand estimates in the future a forecasting model is preferred. The most sophisticated model currently available is the IWR Main Model originally refined by the Corps of Engineers Institute for Water Resources. The most recent version of the model runs on Windows 95, 98, and NT, under copyright to Planning and Management Consultants Ltd. This model prepares forecasts for all categories of urban water use based on a number of factors. The information requirements are shown in Table 6-3.

Agricultural water use

Current trends in agricultural water use indicate little change in demand in the Sacrament Valley. However there has been no attempt to forecast future cropping patterns, irrigation methods, and water supplies. One option in future reports is to develop a computer simulation similar to the Central Valley Production Model for Butte County. This regional model of irrigated agricultural production and economics simulates the decisions of agricultural producers in the Central Valley. The model assumes that growers maximize profits subject to resource, technical, and market constraints. The model has been run for a region that includes most Feather River riparian and appropriative users and would need to be tailored to fit Butte County. Rigorous agricultural water forecasts are necessary to conserve and protect the county's agricultural and water resources.

Table 6-3
IWR Main Information Requirements

- Definition of the study area including base and forecast years to be used and sectors to be evaluated;
- Weather data encompassing cooling degree days, total rainfall, and average daily maximum temperatures;
- Conservation data from statistical abstracts, manufacturer estimates, published studies, and surveys;
- Employment data by major industry groups;
- Definition of the study area including base and forecast years to be used and sectors to be evaluated;
- General study area data for base and forecast years to include population, housing units, employment, and unaccounted water;
- Housing data for base and forecast years by number of housing units and housing types; and
- Residential base and forecast year variables for each housing type incorporating median household income, persons per household, housing density, and water and wastewater prices.

Environmental Water Use

Based on the data accumulated to data, and analyses to date, it could be assumed that environmental water demands would continue to increase. More wildlife and waterfowl areas will continue to be set aside, instream flows will continue to increase, and more flooding of rice land will be necessary for air quality and waterfowl purposes. However, as noted previously, there has been little analysis of environmental water use in this, or other reports, that is as rigorous as that found in the other sectors.

Section 7
Conclusions and Recommendations

Increasing and competing demands from environmental, urban and agricultural water interests pose a challenge for county water managers. The Butte County Water Inventory and Analysis Report provides an estimate of existing demands (environmental, urban and agricultural) and corresponding surface water and groundwater supplies available to satisfy the demand. Supply and demand estimates from normal year and drought year scenarios reflect changes in water supply and management under differing hydrologic conditions. The results of this inventory will provide a viable basis for planning and will support information dissemination and consensus development among the county's stakeholders as further work is completed under the county's Integrated Watershed and Resource Conservation Program.

7.1 Conclusions

Butte County currently has adequate water resources available to meet demand within most areas of the county under normal hydrologic conditions. However, planning will be required to continue to meet the increasing and competing county water resource needs and to develop a further understanding of the resource as solutions to increasing statewide water demand are pursued. Managing the surface water and groundwater resources within the county is essential to the long-term economic and environmental health of the county.

With consideration of the results of the water inventory, the following conclusions are presented:

- The portion on the Sacramento Valley aquifer system under Butte County has recovered from the 1988-1994 drought. Long-term trends in groundwater storage indicate the basin groundwater aquifer is not in a state of decline. During normal to wet years, the aquifer system recharges to its maximum storage capacity by the following spring.

- Within the Foothill Inventory Unit and Mountain Inventory unit, overall groundwater supply is limited because groundwater occurs primarily in fractures and joints of the volcanic bedrock. Shallow, domestic wells could be susceptible to dewatering during periods of drought.

- Under the normal hydrologic scenario, Butte County currently has an adequate surface water and groundwater supply to meet current demands.

- Under the drought scenario evaluated, current demand can generally be met through increased groundwater extraction provided groundwater extractions are increased to offset reduced surface supplies.

- Under the drought scenario evaluated, additional groundwater wells and conveyance and distribution systems may be required to fully utilize the groundwater resource.
- Under the drought scenario evaluated, the Foothill Inventory Unit experiences water shortages.
- Future increases in demand will be associated with population growth and environmental regulatory requirements, both within and outside of the county.
- A significant amount of water supplied to meet demand remains available for use through deep percolation to groundwater and outflow to other areas.
- Environmental water use constitutes a substantial amount of water demand in the county, extending water demand past the typical irrigation season. The trend in environmental water has increased in the recent past due to regulatory requirements.
- Water quality is generally adequate to meet current needs, however groundwater nitrate contamination could threaten supply in areas with a high density of septic systems. Regulation of non-point source agricultural return water may become an issue in the near future.

7.2 Recommendations

With increasing pressure to meet current and projected water needs on a statewide level, northern California supplies will be evaluated as a component of the solution. A comprehensive Integrated Watershed and Resource Conservation Program is required to protect Butte County's interest and needs, as well as to adequately assess impacts of proposed state-initiated water resource projects. Initial key activities for formulating such a program would include:

- Facilitation and outreach with the county's stakeholders to develop water resource management goals and objectives and coordination of county interests with DWR and CALFED interests.
- Enhance the current land use, surface water monitoring, and groundwater monitoring data collection program for use in developing a long-range integrated watershed and resource conservation plan.
- Groundwater is an important water source to Foothill and Mountain areas, but the fractured geology makes it very difficult to characterize. Additional monitoring and assessment should be performed in these areas to enhance understanding of groundwater availability and movement.

- Enhance forecasting of agricultural, environmental and urban demand for use in developing a long-range integrated watershed and resource conservation plan.
- Assess the Butte Basin Water Users Association groundwater flow model for use in developing a long-range integrated watershed and resource conservation plan.

Section 8
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Appendix A
Summary Hydrogeology of Butte County

DWR prepared the *Butte County Groundwater Inventory Analysis* in support of this report. Pieces of DWR's report are excerpted in this appendix and the full text is available from DWR, Northern District.

Summary Topography, Geology and Hydrogeology of Butte County

The following is a discussion of the geologic units and their hydrogeologic properties found within the Sacramento Valley, Foothill and Mountain Regions of Butte County.

SACRAMENTO VALLEY REGION

Topography

The Sacramento Valley Region of Butte County lies within the Sacramento Valley groundwater basin, as shown in Figure 3-1. Upland portions of the Sacramento Valley Region range in elevation from 300 to 400 feet above mean sea level (msl). This upland topography consists of low hills, dissected uplands, and alluvial fans of moderate relief. The land surface slopes downward toward the axis of the valley where the elevation is generally about 70 to 90 feet above msl, with ground surface elevation decreasing southward toward the Sutter Buttes.

The Butte Basin lies south of Chico and west of the Feather River and is characterized by an expansive, flat topography. Prior to flood control on the Feather and Sacramento Rivers, it was subject to extensive seasonal flooding. Slow-moving floodwater deposited the fine clay that now comprises rich agricultural soil.

South of the Butte County line, the Sutter Buttes comprise a small-scale volcanic mountain range intruded the valley sediments during the early Pleistocene period (1.2 million years ago). The intrusion buckled the valley sediments upward forming a barrier to groundwater flow. The Sutter Buttes block the general north-to-south trend of groundwater migration, forcing groundwater to the surface. The upward movement results in a shallow groundwater table and the formation of wetlands along the west side of the Sutter Buttes.

In an effort to better display and support understanding of the groundwater resources of the Sacramento Valley groundwater basin, the Department of Water Resources developed a series of maps illustrating the surface and subsurface geology. The surface geology of the Butte County portion of these maps is shown in Figure 3-1, and in the four geologic cross-sections shown in Figures 3-2, 3-3 and 3-4. The cross-sections also illustrate the subsurface geology, base of fresh water, geologic structure and stratigraphic sequence beneath the Sacramento Valley portion of Butte County.

Surface and Subsurface Geology

The regional structure of the Sacramento Valley groundwater basin consists of an asymmetrical trough tilting to the southwest, with a steeply dipping western limb and a gently dipping eastern limb (Page, 1986). Older granitic and metamorphic rocks underlie the valley forming the basement bedrock on which younger marine and continentally derived sediments and volcanic rock have been deposited. Along the valley axis, and west of the present day Sacramento River, basement rock is at considerable depth, ranging from 12,000 to 19,000 feet below ground surface. Immediately overlying the basement bedrock is a thick sequence of sandstone, shale and conglomerate rocks of marine origin, ranging from Jurassic to Eocene in age. Within the Butte County portion of the Sacramento Valley, these sediments are saline or brackish, and serve as the base of fresh groundwater.

The oldest of the Jurassic to Eocene marine sediments is known as the Great Valley Sequence, which is Jurassic to Cretaceous in age. Water contained within the Great Valley Sequence is primarily saline. The Lower Princeton Gorge fill of Eocene age consists of a mixture of marine sediments and continental material derived from the walls of an eroded sub-marine canyon that was carved into the Great Valley sediments (Redwine, 1972). Groundwater contained within these sediments is almost exclusively saline.

In most locations, the Lower Princeton Gorge fill is unconformably overlain by the Eocene Ione Formation or the Miocene Upper Princeton Gorge fill, as shown in the *Butte County Groundwater Inventory Analysis*. Groundwater within the Ione Formation is primarily saline. The Ione Formation is present both in the surface and subsurface of the Sacramento Valley region. In Butte County, surface exposure of the Ione Formation is limited to areas protected by the overlying Lovejoy Basalt.

Following deposition of the Ione Formation, several volcanic eruptions in the Cascade Range produced a series of basalt flows that spread across the valley sediments during the Miocene Period. These flows comprise the hard, black, microcrystalline Lovejoy Basalt. Groundwater, primarily saline or brackish, is transmitted and stored within the secondary porosity created by the fracturing and jointing of the basalt. The Lovejoy Basalt can be seen as the caprock for Table Mountain on cross-section C-C' in Figure 3-4.

The Miocene age Upper Princeton Gorge fill is widespread throughout the Sacramento Valley, but present only in the subsurface. This formation consists primarily of sandstone with interbedded layers of conglomerate. Water contained within the Upper Princeton Gorge fill is primarily saline to brackish. The Upper Princeton Gorge fill is overlain by the Neroly Formation in nearly all locations. The Neroly Formation is overlain by Tuscan Formation on the east side of the valley, the Tehama Formation on the west side of the valley and the Laguna Formation in the southeast portion of the valley. Also of Miocene age, the Neroly Formation is the

youngest formation in the northern Sacramento Valley that is not exposed at the surface.

Overlying the Neroly Formation are the Pliocene age Tuscan, Tehama and Laguna Formations, which are the major fresh groundwater bearing units in the northern Sacramento Valley. Only the Tuscan and the Laguna Formations are exposed at the surface in Butte County. Surface exposures of the Tehama Formation can be seen along the western side of the Sacramento Valley. Dipping eastward, the Tehama Formation interfingers with the Tuscan Formation in the subsurface along the central north-south axis of the valley.

The Pliocene Tuscan Formation is composed of a series of volcanic mudflows, tuff breccias, tuffaceous sandstone, and volcanic ash layers. Mudflows originated in the vicinity of present-day Lassen Peak and most likely filled ancient stream channels as they flowed toward the valley. Upon reaching the valley the mudflows fanned out across the valley floor. Some larger lahars may have continued to flow southward in the valley along drainage channels in the sediment.

West-flowing rivers and streams draining the Sierra Nevada Mountains deposited the Laguna Formation. These rivers and streams spilled over their banks and spread out across the broad flood plains of the valley depositing eroded material from the Sierra Nevada Mountains. The only exposures within Butte County occur southwest of Oroville. More recent alluvial fan and terrace deposits overlie the Laguna Formation in the valley portion of Butte County.

The surface geology of the Sacramento Valley portion of Butte County is comprised primarily of alluvial deposits whose source area is the eroded material derived from surrounding mountain ranges. These sediments were deposited as alluvial fan, terrace, and basin deposits by a network of streams and rivers flowing into the Sacramento Valley. Along the front of the foothills, alluvial fan and terrace deposits of the Riverbank and Modesto Formations mark the edge of the valley sedimentary units.

The Pleistocene Riverbank Formation represents the oldest of the alluvial fan and terrace deposits. The thickness of the Riverbank Formation varies from less than one foot to over two hundred feet depending upon location (Helley and Harwood, 1985). The Riverbank Formation primarily overlies the Laguna Formation in the southern portion of Butte County and the Tuscan Formation in the northern portion of the county. Overlying the Riverbank Formation in many locations is the Modesto Formation. The terrace deposits of the Modesto Formation are exposed in many of the presently active stream-cut canyons along the foothills.

Overlying the alluvial fans of the Riverbank and Modesto Formations are the fine silts and clays of the basin deposits of Holocene age. Basin deposits are seen primarily in the western and southern Butte County portion of the valley region, forming the

highly productive agricultural soils characteristic of these areas. The thickness of the basin deposits varies generally from less than ten feet along the margins of the exposure to more than one hundred feet in the center of the valley. Basin deposits provide limited quantities of groundwater to shallow wells due to the fine-grained nature of the sediments.

Holocene age Alluvium is the youngest of the geologic units present within the Sacramento Valley Region.

Alluvial deposits primarily overlie the Modesto Formation and basin deposits, except where the alluvium is composed of mine tailings. Due to the limited extent and thickness, Alluvium is not considered to be a significant water-bearing unit.

Deformational structures within the Sacramento Valley Region of Butte County include several faults and folds. Offset on the Chico Monocline Fault formed a monoclinal flexure, the Chico Monocline, that forms the eastern boundary of the Sacramento Valley Region north of Durham. North of Chico, the Chico Monocline deforms the Tuscan Formation and acts as an eastward aquifer boundary (DWR Bulletin 118-6, 1978). South of Chico, beds have a gentler slope of approximately 2 to 5 degrees and evidence of the monocline disappears north of Oroville.

North of the Sutter Buttes, a minor splay fault associated with the Willows Fault system is present at depth and displaces only Jurassic-Cretaceous age sediments (see Figure 3-1). In the western portion of Butte County, the Glenn Syncline has produced some minor downward flexure of the deeper sedimentary units, as seen in cross-section C-C' in Figure 3-4.

Fresh Groundwater Bearing Units

On a regional scale, the base of post-Eocene continental deposits is commonly considered the approximate base of fresh groundwater in the Sacramento Valley (Page, 1974). Locally, the base of fresh groundwater varies depending upon local subsurface geology and geologic formational structure.

The approximate base of fresh groundwater is shown in the geologic cross-sections in Figures 3-3 and 3-4. It was determined through examination of electrical resistivity logs, which were derived from criteria established by C.F. Berkstresser, Jr., in *Base of Fresh Ground Water in the Sacramento-San Joaquin Delta California*; United States Geological Survey, prepared in cooperation with the California Department of Water Resources, 1973. This report determined that the base of freshwater is water with a specific conductance of less than 3,000 micromhos per centimeter; water with a specific conductance that exceeds 3,000 micromhos per centimeter is considered to be saline.

In the Sacramento Valley Region of Butte County, fresh groundwater-bearing units include the Tuscan, Laguna, Riverbank and Modesto Formations. Groundwater in

these formations largely exists within the primary porosity associated with the spaces between the individual sand and gravel deposits, and within the secondary porosity associated with fractures and jointing of the more competent volcanic rocks.

Tuscan Formation

Age and Composition. The Tuscan Formation is described as four separate but lithologically similar units, Units A through D, which in some areas are separated by layers of thin tuff or ash units (Helley and Harwood, 1985). Stratigraphic position and general lithologic character distinguish each unit. Unit A consists of the oldest deposits of the Tuscan Formation. Units B and C overly Unit A in most locations in Butte County. Unit D is the youngest unit and is exposed only in localized areas northeast of Red Bluff. Groundwater in the Sacramento Valley portion of Butte County is contained primarily within the two lower units of the Tuscan Formation, Units A and B.

Unit A (Tta) is the oldest water-bearing unit of the Tuscan Formation. This unit is characterized by the presence of metamorphic clasts within the interbedded lahars, volcanic conglomerate, volcanic sandstone and siltstone. Unit A contains the Nomlaki Tuff, a dacitic pumice tuff, at its base or within the basal portion of the unit. The presence of the Nomlaki Tuff within the basal sections of the Tuscan, Tehama, and Laguna Formations indicates simultaneous deposition of these units.

Unit A is distinguished from the other units by the presence of metamorphic clasts within the lahars and conglomerates. Exposures of Unit A are shown on the geologic map and underlying Butte County on all four cross sections of the Sacramento Valley. Unit B overlies Unit A in most locations.

Unit B is composed of a fairly equal distribution of lahars, tuffaceous sandstone, and conglomerate. These evenly layered, moderately thin beds form the characteristic look of the Tuscan Formation seen in the foothills of Butte County. Extending eastward into the subsurface, the sediments of Unit B form a very productive water-bearing system. In most locations, Unit C overlies Unit B. Unit B can be seen on the geologic map and underlying Butte County on all four cross sections of the Sacramento Valley.

Unit C consists of massive mudflow or lahar deposits with some interbedded volcanic conglomerate and sandstone. In the foothills, these lahars are well cemented and form the cap-rock for the ridges in Butte County. Evidence of wood fragments found in Unit C suggests fast-moving, massive mudflows at the time of deposition. In the subsurface, these low permeability lahars form thick, confining layers for groundwater contained in the more permeable sediments of Unit B. Unit C is the youngest unit of the Tuscan Formation that is present in Butte County and can be seen on the geologic map and all four cross sections of the Sacramento Valley. Unit C is overlain is some locations by Unit D.

Unit D is the youngest depositional unit and is characterized by large masses of grey hornblende andesite. Exposures of Unit D are found in limited extent northeast of Red Bluff. No exposures of Unit D are mapped at the surface or in the subsurface within Butte County.

The Tuscan Formation is overlain by Holocene and Pleistocene alluvial sediments, which include the Modesto and Riverbank Formations, and younger stream channel and basin deposits. In most places, the Tuscan Formation unconformably overlies either Upper Cretaceous marine sedimentary rocks or the basement complex with angular unconformity (Olmsted and Davis, 1961). In other areas the Tuscan Formation rests unconformably on the Neroly Formation, the Ione Formation and/or the Lovejoy Basalt.

The volcanic sediments of the Tuscan Formation interfinger with the non-marine and non-volcanic sediments of the Tehama Formation in the subsurface (Lydon, 1969). This contact is considered to occur at depth in the vicinity west of the Sacramento River. As mentioned previously, the presence of the Nomlaki Tuff at the base of the Tuscan, Tehama, and Laguna Formations suggests simultaneous deposition and an age correlation of these units.

Depositional Environment and Source Area. The Tuscan was deposited as a series of volcanic lahars over a period of about one million years (Lydon, 1969). The source area of the lahars were eroded volcanoes historically located northwest and south of Lassen Peak. Mudflows most likely followed ancient stream channels and valleys while travelling in a southwestward direction. The flows then fanned out upon reaching the valley floor, causing deposition to vary in thickness and in topographic elevation. As areas of the well-cemented volcanic lahars were eroded and redeposited, aquifer material on the valley floor resulted in a heterogeneous, and in some areas, unconsolidated mass of sediments.

Extent and Thickness. The Tuscan Formation extends from east of Redding to west of Oroville, and from the base of the Cascade/Sierra Nevada Mountain Range into the subsurface about 5 miles west of the Sacramento River (Page, 1986). Maximum thickness of the formation ranges from about 1,700 feet in the east, and thins to approximately 300 feet at the westward extent (Lydon, 1968). Unit C and Unit B have a mapped thickness of about 600 feet each and Unit A averages around 250 feet thick, for a total approximate thickness of about 1,450 feet in Butte County.

Water-bearing Properties. Groundwater in the Sacramento Valley Region is contained primarily within the pore spaces of the reworked sand and gravel layers. Much of the groundwater in the Tuscan Formation is confined under pressure by layers of impermeable clays, lahars or tuff breccia.

Groundwater encountered within Unit A is associated with primary porosity of the conglomerate and sandstone layers, and also with secondary porosity associated with

the fractured tuff breccia. Within Unit B, the interbedded, permeable layers of reworked sand and gravel act as a conduit for groundwater movement, transmitting water into the aquifer from recharge areas in the Cascade foothills. The permeable layers of the Unit B sediments compose the main aquifer material for groundwater storage in the valley. The fine-grained, consolidated lahars of Unit C form thick, low permeability confining layers for groundwater contained in the more permeable sediments of Unit B.

Volcanic sands of the Tuscan Formation yield high amounts of water to wells in many areas of the eastern Sacramento Valley. California Water Service wells in the Chico area have specific yields that range between 900 and 3,000 gallons per minute (gpm) (DWR Bulletin 118-6, 1978). Three wells at the Chico Airport produce between 900 and 950 gpm with specific capacities between 26 and 45 gpm per foot of drawdown (Olmsted and Davis, 1961).

Well yields and specific capacities for the Sacramento Valley Region were also calculated on data obtained from utility pump tests. Results from 2,662 pump tests on 944 wells revealed an average well yield ranges from a low of 976 gpm in the North Yuba Inventory Unit, to a high of 1,395 gpm in the Vina Inventory Unit. The average specific capacity calculated from 974 pump tests on 433 wells was 78 gpm per foot for the entire Sacramento Valley region. Specific capacities for the valley inventory units ranged from a low of 48 gpm per foot in the North Yuba Inventory Unit to a high of 87 gpm per foot in the Vina Inventory Unit.

Aquifer performance tests have been performed in several areas of Butte County. These tests were used to evaluate the water-bearing characteristics of the Tuscan Formation. Transmissivity values within the Butte Basin portion of the East and West Butte Inventory Units ranged from 97,000 to 182,000 gallons per day (gpd) per foot. Storativity values ranged from .0003 to .0015. Specific capacity measurements made for wells in this study provided a range of 45.7 to 104.7 gpm per foot of drawdown (DWR Memorandum Report, 1991).

A similar test was performed on a well located in the East Butte Inventory Unit. The extraction well utilized for this test was designed and constructed to draw water only from the lower-confined portion of the Tuscan Formation. Aquifer transmissivity was calculated to be approximately 75,000 gpd per foot. Storativity was estimated between .0001 and .00001. The specific capacity of the extraction well was measured at 23 gpm per foot of drawdown (DWR Memorandum Report, 1996).

Laguna Formation

Age and Composition. The Pliocene age Laguna Formation (Tla) is composed of continental deposits containing predominantly fine-grained, poorly bedded, and compacted sediments. These deposits are composed of a heterogeneous mixture of interbedded alluvial fine sand, silt and clay of granitic and metamorphic origin with

minor conglomerate lenses (Olmsted and Davis, 1961). Clay is more predominant in the fine-grained sediments south of Oroville. The sand is arkosic and contains abundant weathered feldspar, biotite, and angular quartz clasts. The Arroyo Seco gravels are considered to be part of the Laguna Formation by some sources. Near Oroville, the gravel deposits are of granitic or metamorphic composition and are contained within a silty to sandy matrix.

Depositional Environment and Source Area. West-flowing rivers and streams draining the Sierra Nevada Mountains deposited the Laguna Formation. Uplift of the Sierra Nevada Mountains during their formation increased erosion of the metamorphic and plutonic rocks. Rivers and streams carried this eroded material to the valley floor where they overtopped their banks and spread out across the broad flood plains of the valley, depositing eroded material into broad alluvial fans.

Extent and Thickness. Exposure of the Laguna Formation is discontinuous and extends from Oroville southward to Lodi. The only exposures within Butte County occur southwest of Oroville. The thickness of the Laguna Formation is difficult to determine because the base of the unit is rarely exposed. Estimates of the maximum thickness range from 180 feet (Helley and Harwood, 1985) to 1,000 feet (Olmsted and Davis, 1961). The position and thickness of the Laguna Formation can be seen in cross section D-D' in Figure 3-4.

Water-bearing Properties. Quantitative water-bearing data for the Laguna is very limited, especially in the Butte County area. Wells completed in the finer-grained sediments of the Laguna Formation yield only moderate quantities of water. Well yield data from the Sacramento-American River area indicate yields as high as 1,000 gpm, with specific capacities values ranging between 24 and 42 gpm per foot of drawdown (Olmsted and Davis, 1961). In areas where soft, well-sorted granitic sand dominates, well yields are much higher. Some of the sand aquifers are highly permeable, but the average permeability is low to moderate. In the Gridley area, a sand unit that is stratigraphically equivalent to the Laguna Formation was reported to have a specific capacity of 60 gpm per foot of drawdown (Olmsted and Davis, 1961).

Riverbank Formation

Age and Composition. The Riverbank Formation was deposited between 450,000 and 130,000 years ago forming wide alluvial fans and terrace deposits. Stream terrace deposits of the Riverbank Formation appear topographically above younger, Modesto age terrace deposits. Due to post-depositional weathering of the Riverbank Formation, deposits exhibit a reddish color. Topographic location and the weathered red color distinguish the Riverbank from more recent alluvial fan and terrace deposits (Helley and Harwood, 1985).

Depositional Environment and Source Area. The Riverbank Formation consists of gravel, sand, and silt eroded from the surrounding Coastal, Klamath, Cascade and

Sierra Nevada Mountain Ranges and deposited in the Sacramento Valley. The source area determines the mineral constituents of the deposits. Near Sacramento, the deposits are primarily arkosic; however, mafic content of igneous rock fragments increases northward.

Extent and Thickness. Exposures of the Riverbank Formation within Butte County are observed primarily west of Oroville and southward. Thickness of the Riverbank Formation ranges from less than one foot to over 200 feet depending on location. More recent deposition of the Modesto Formation and basin deposits has produced the limited surface exposure of this formation. It is indicated in Figure 3-3.

Water-bearing Properties. The thickness of the Riverbank Formation can be a limiting factor to the water-bearing capabilities of the formation. The Riverbank Formation is moderately to highly permeable and yields moderate quantities of water to domestic and shallow irrigation wells. It also provides water to deeper irrigation wells that have multiple zones of perforation. Well yields are higher in areas where concentrations of gravel and sand are present. Groundwater occurs generally under unconfined conditions.

Modesto Formation

Age and Composition. Radiocarbon dating indicates that the Modesto Formation is Pleistocene in age, with the upper and lower members dated at 14,000 and 42,000 years old, respectively (Marchand and Allwardt, 1981). The Modesto Formation consists of tan and light grey gravelly sand, silt and clay. Where it overlies the Tuscan Formation, the clasts within the Modesto are distinctly red, brown, or black. The upper member shows no indication of weathering while the lower member shows slight weathering (Helley and Harwood, 1985).

Depositional Environment and Source Area. The Modesto Formation consists of gravel, sand, and silt eroded from the surrounding Coastal, Klamath, Cascade and Sierra Nevada Mountain Ranges and deposited in the Sacramento Valley. The Modesto forms coalescing alluvial fans and stream bank terraces. Exposures of the Modesto Formation are present along most of the major streams and rivers within Butte County.

Extent and Thickness. The Modesto Formation is widespread throughout the Sacramento Valley, occurring from Redding south into the San Joaquin Valley. The most notable occurrences are found along the Sacramento and Feather Rivers. Similar to the Riverbank, the Modesto Formation ranges in thickness from less than ten feet in many of the terraces and along the margins of the valley to nearly two hundred feet across the valley floor (Helley and Harwood, 1985).

Water-bearing Properties. Like the Riverbank Formation, the thickness of the Modesto Formation limits the water-bearing capabilities of the formation. These deposits provide water to domestic and shallow irrigation wells as well as to deeper

wells with multiple zones of perforations. In locations where gravel and sand predominate, groundwater yields are moderate. Lesser yields are found in areas with high silt and clay content. Groundwater occurs generally under unconfined conditions.

Movement of Groundwater

Groundwater movement in the Sacramento Valley Region was evaluated utilizing groundwater elevation contours developed for Butte County. The contours shown in the *Butte County Groundwater Inventory Analysis* were developed using March 1997 groundwater level data collected by DWR and local cooperators. The flow arrows indicate the general direction of groundwater movement.

The directional flow arrows illustrate that regional groundwater movement in Butte County is southwestward from the foothills towards the Sacramento River. This indicates that the Sacramento River drains groundwater from the northern and central portions of the county. Some localized contour anomalies along the boundary between the West and East Butte Inventory Units can be attributed to the draining of groundwater toward Butte Creek. The general southwest flow pattern within Butte County is disrupted in the Chico Urban Area by municipal groundwater extraction. This disruption is indicated in the *Butte County Groundwater Inventory Analysis* by small-scale localized groundwater depressions and mounds. A larger scale groundwater depression is depicted in the southwest portion of the North Yuba Inventory Unit.

Another notable anomaly is located in the southwest portion of Butte County. In this area, groundwater converges under the Butte Sink and Biggs-West Gridley Inventory Units. Groundwater from the East Butte Inventory Unit flows southwestward while groundwater from the Sacramento River flows southeast and eastward. Deformation of the valley sediments by the Sutter Buttes and the buried Colusa Dome, located west of the Sutter Buttes, cause this anomalous flow pattern.

Outside of Butte County, a change occurs in the groundwater flow along the Sacramento River near Princeton. North of this location the groundwater flows toward the Sacramento River where it drains groundwater from the Northern Sacramento Valley. South of Princeton, groundwater flows away from the river acting to recharge the groundwater system.

FOOTHILL REGION

Topography

The Foothill Region of Butte County lies between the Sacramento Valley Region and the Mountain Region. It ranges in elevation from 50 feet above msl at the base of the Campbell Hills on the margin of the Sacramento Valley, to 1,250 feet msl north of Stirling City where it merges into the Mountain Region.

The Foothill Region is a recharge area for the Butte County portion of the Sacramento Valley groundwater basin aquifer. Groundwater recharge occurs in the form of precipitation and deep percolation of runoff from nearby creeks, streams and reservoirs.

Surface and Subsurface Geology

The Foothill Region occupies the transitional geologic zone between Tertiary sediments in the west part of Butte County and Mesozoic-Paleozoic rocks in the east part of the county (see Figure 3-1 and, for more detail, the *Butte County Groundwater Inventory Analysis*). Mesozoic rocks encompass the Jurassic and Cretaceous age rock ranging in age from 245 to 65 mybp. Older Paleozoic rocks range in age from 544 to 245 mybp. The Jurassic and Cretaceous sedimentary rocks outcrop in the northern Foothill Region.

Paleozoic rocks consist of metavolcanic and metasedimentary geologic units. These units, exposed mainly in the eastern and southern margins of the Foothill Region, were deposited during periods of volcanic activity and subsequently metamorphosed due to tectonic compression and contact metamorphism. Metavolcanic rocks (Pzv) consist primarily of breccia and tuff, with lesser amounts of greenstone, diabase and pillow lavas. Metasedimentary rocks (Pz) are composed of slate, shale, sandstone, chert, conglomerate, limestone, dolomite, marble, phyllite, schist, hornfels and quartzite. Groundwater found in these areas is associated mainly with secondary porosity.

Resting unconformably on top of the Paleozoic deposits are rocks of the Late Mesozoic Era. Late Mesozoic rocks were deposited in a marine forearc-basin setting. After deposition, tectonic stress caused the eastern limb of the Sacramento Valley trough to be uplifted, raising Great Valley sediments (JKgvs) to their present elevation above the valley floor. These older sediments are seen in outcrop above Little Chico, Big Chico and Butte Creek drainages (see the *Butte County Groundwater Inventory Analysis*).

Unconformably overlying Late Mesozoic marine deposits are a series of Tertiary age continental deposits. The major geologic unit exposed in the northern and western part of the Foothill Region is the Tuscan Formation, composed of Units A, B and C (Tta, Ttb, Ttc). The Tuscan Formation was deposited as a series of mudflows originating from ancient, eroded volcanoes of the Cascade Range. Other Tertiary units in the Foothill Region consist of older, undifferentiated andesites and basalts of the Tertiary Volcanics (Tv), basalt deposits of the Lovejoy Formation (Tl) and marine to non-marine sandstone and siltstone deposits of the Ione Formation (Ti). Although the continentally derived Laguna Formation (Tla) is marginally exposed in the southern portion of the Foothill Region, the majority of this unit falls within the Sacramento Valley portion of Butte County, as seen in the *Butte County Groundwater Inventory Analysis*.

Quaternary deposits situated on the western margin of the Foothill Region consist of the Modesto Formation and alluvium (see Figure 3-1). These sediments were deposited along the streams and creeks draining the Foothill Region, creating stream terraces and alluvial fans. The Modesto Formation (Qm) consists of unconsolidated, unweathered to slightly weathered gravel, sand, silt and clay, with thickness ranging from 1 to 200 feet.

The major geologic structure in the Foothill Region is the Foothill Fault system. The Foothill Fault system includes the Cohasset Ridge Fault, the Magalia Fault and a mapped, but as yet unnamed fault, located south of the Magalia and shown in Figure 3-1. These faults are included in a system of northwest trending, steeply east-dipping to vertical faults that have experienced up to 100 feet of movement in the past 2.4 million years (Helley and Harwood, 1985).

Another major structural feature in the Foothill Region is the Chico Monocline. The Chico Monocline is a northwest-trending southwest-facing flexure that roughly follows the northwestern boundary of the Foothill Region, extending from Chico to Red Bluff. North of Chico, the Chico Monocline deforms the Tuscan Formation and has a dip of up to 25 degrees where it acts as an eastward aquifer boundary (DWR Bulletin 118-6, 1978). South of Chico, beds have a gentler slope of approximately 2 to 5 degrees and evidence of the monocline disappears.

Fresh Groundwater Bearing Units

The Tuscan Formation is the major source of groundwater in the Foothill Region. Groundwater occurs in the fractures and joints of the volcanic mudflows, as well as in the weathered horizons between buried mudflows (Slade, 2000).

Lesser amounts of groundwater are found in the Modesto Formation, which is a localized source of groundwater and supplies moderate amounts of water to shallow wells.

Tuscan Formation

Age and Composition. The Pliocene Tuscan Formation is composed of tuff breccia, lapilli, tuff, and volcanic conglomerate, sand and silt (Lydon, 1969). The Tuscan Formation is described as four separate but lithologically similar units, Units A through D, which in some areas are separated by layers of thin tuff or ash units (Helley and Harwood, 1985). In the Foothill Region, only Units A through C are exposed at the surface.

Unit A (Tta) is the oldest water-bearing unit of the Tuscan Formation and consists of fragmented metamorphic rocks found within the interbedded lahars, volcanic conglomerate, sandstone and siltstone. Unit B (Ttb) is defined along the Chico Monocline as a series of interbedded lahars, volcanic conglomerate, sandstone and siltstone. It is characterized on resistivity curves by its distinctive and consistently

high deflections seen in cross-section on Figure 3-4. Unit B is differentiated from Unit A by its lack of metamorphic content.

Unit C (Ttc) consists of lahars with some interbedded volcanic conglomerate and sandstone. Evidence of wood fragments found in Unit C suggests fast-moving, massive mudflows at the time of deposition. Unit C is exposed as the cap-rock on the hills east of Chico and acts as a confining layer in the subsurface for Unit B. Unit C is differentiated from Unit B by its fine-grained, more consolidated nature, whereas Unit B consists of coarser-grained sediments, providing it with a higher groundwater storage capacity. In the Foothill region of Butte County, Unit D, the youngest unit of the Tuscan Formation, is not present.

Depositional Environment and Source Area. The Tuscan was deposited as a series of mudflows, or lahars, over a period of about one million years (Lydon, 1969). The source area of the lahars were eroded volcanoes historically located northwest and south of Lassen Peak. Mudflows most likely followed ancient stream channels and valleys while travelling in a southwestward direction. The flows then fanned out upon reaching the valley floor, causing deposition to vary in thickness and in topographic elevation. As areas of the well-cemented volcanic lahars were eroded and redeposited, aquifer material on the valley floor resulted in a heterogeneous, and in some areas, unconsolidated mass of sediments.

Extent and Thickness. The Tuscan Formation extends from east of Redding to west of Oroville, and from the Cascade/Sierra Nevada Mountain Range into the subsurface about 5 miles west of the Sacramento River (Page, 1986). Maximum thickness of the formation ranges from about 1,700 feet in the east, and thins to approximately 300 feet at the westward extent (Lydon, 1968). Unit C and Unit B have a mapped thickness of about 600 feet each and Unit A averages around 250 feet thick, for a total approximate thickness of about 1,450 feet.

Water-bearing Properties. The Tuscan Formation exposed in the Foothill Region acts as a recharge area for the aquifer system in the Sacramento Valley. In addition, the Tuscan Formation is the primary source of fresh groundwater to wells in the northern and western areas of the Foothill Region. Groundwater intercepted in wells in this region is generally of an unconfined nature, with groundwater levels reflecting rainfall patterns. Most groundwater in the formation is confined under pressure by layers of impermeable clays and tuff-breccia (DWR Bulletin 118-6, 1978). On average, specific yields for the Tuscan Formation range from 900 gpm to 3,000 gpm (DWR Bulletin 118-6, 1978). However, in the foothill region specific yields are much lower.

Based on work done by Slade and Associates LLC, transmissivity values in the Tuscan Formation are approximately 10,000 gallons per day per foot. in Paradise Irrigation District D Tank Well, located on Clark Road in Paradise. However, in the Lime Saddle area, Slade and Associates LLC have determined that transmissivity values in the confined portion of the Tuscan Formation are an extremely low 1,100 gpd per foot.

A third study, also conducted by Slade and Associates LLC, was based on the results of PG&E pumping tests in the Magalia area. These results presented transmissivity rates ranging from 10,000 gpd per foot to approximately 20,000 gpd per foot.

Modesto Formation

Age and Composition. Radiocarbon dating indicates that the Modesto Formation is Pleistocene in age, with the upper and lower members dated at 14,000 and 42,000 years old, respectively (Marchand and Allwardt, 1981). It consists of tan and light grey gravelly sand, silt and clay; where it overlies the Tuscan Formation clasts are distinctly red, brown or black (Helley and Harwood, 1985). Both members contain unconsolidated sediments, however the upper member is unweathered, whereas the lower member is slightly weathered.

Depositional Environment and Source Area. The Modesto Formation was deposited under fluvial conditions as a series of coalescing alluvial fans by streams that still exist today (Helley and Harwood, 1985). The lower member forms terraces that are topographically higher than the upper member. The source area for the Modesto Formation is the Cascade and Sierra Nevada Mountain Ranges.

Extent and Thickness. The Modesto Formation is widespread throughout the Sacramento Valley, occurring from Redding south into the San Joaquin Valley. The most notable occurrences are found along the Sacramento and Feather Rivers. The Modesto Formation is exposed along the upper reaches of Butte Creek in the northern part of the Foothill Region. Thickness of the unit ranges up to 200 feet in the basin, and thinning toward the foothills (Marchand and Allwardt, 1981, DWR, 1999).

Water-bearing Properties. Shallow domestic wells can draw moderate amounts of groundwater from these terrace deposits. Alluvial deposits (Qa) range in size from boulders to sand and silt and have high infiltration rates (DWR, 1978). These deposits are thin at higher elevations, thickening downstream to a maximum thickness of 80 feet, providing low to moderate amounts of groundwater. In areas where silt and clay predominate, permeability of the Modesto Formation is variable and well yields are limited. In locations where gravel and sand predominate, groundwater yields to domestic wells are higher. In the Foothill Region, the Modesto Formation is thin to moderate in thickness and yields only moderate amounts of water to wells. Groundwater in the Modesto Formation occurs under unconfined conditions.

The eastern Mesozoic-Paleozoic deposits exhibit very little, if any, primary porosity. However, due to secondary porosity, small amounts of water can be found within the fractures and joints of these dense, hard rocks.

Tertiary sediments (65 to 1.8 mybp) are exposed in the northern and western zones of the region tend to contain fresh groundwater mainly through primary porosity. Surficial Quaternary sediments found along a few of the drainages in the Foothill Region supply modest amounts of groundwater to shallow domestic wells.

Groundwater in the outcropping Late Mesozoic sedimentary rocks is usually brackish and does not contribute to the region's potable groundwater supply.

Movement of Groundwater

Although there is no data to determine the direction and /or velocity of groundwater movement, groundwater generally follows the contour of the topographic surface. In the Foothill Region, this can be interpreted as groundwater flowing from high to low elevations, following drainages towards the center of the valley, where it tends to track the course and direction of the Sacramento River.

The Magalia fault may act as a barrier to groundwater movement (Slade, 2000).

MOUNTAIN REGION

The Mountain Region is the easternmost region in Butte County. There are no appreciable geologic units supplying groundwater to the mountain area. Elevation ranges from around 230 feet at the southernmost boundary of Butte County near the confluence of Honcutt and Wilson Creeks, to 2,180 feet in the northeastern part of the county at Humboldt Peak.

Surface and Subsurface Geology

Mesozoic and Paleozoic age plutonic, volcanic and metamorphic rocks make up the majority of the surface and subsurface geology of the Mountain Region. Mesozoic rocks encompass the Jurassic and Cretaceous age rock ranging in age from 245 to 65 mybp. Older Paleozoic rocks range in age from 544 to 245 mybp.

Primary porosity is virtually non-existent in these rocks due to the amount of cementation, consolidation, crystallization or metamorphism that has occurred (Slade, 2000). Other geologic formations consist of Tertiary volcanic sediments exposed in the northern part of the Mountain Region. Of these units, only the Tuscan Formation, located in a small northwestern segment of the Mountain Region, is considered to act as a groundwater-bearing unit. There are no significant surficial alluvial deposits in this region.

Plutonic, volcanic and metamorphic rocks of Mesozoic and Paleozoic age are found throughout the Mountain Region. Paleozoic rocks consisting of metasedimentary (Pz) and metavolcanic (Pzv) rocks were deposited during periods of volcanic activity and then metamorphosed due to tectonic compression and contact metamorphism. Metasedimentary rocks consist of slate, shale, sandstone, chert, conglomerate, limestone, dolomite, marble, phyllite, schist, hornfels and quartzite. Metavolcanic sediments are composed primarily of breccia and tuff, and also include greenstone, diabase and pillow lava.

Granitic plutonic rocks (Mzgr) were emplaced during the Mesozoic Era, as were gabbro and dioritic rocks (Mzgb). Ultramafic rocks (um) composed of serpentine,

peridotite, gabbro and diabase are exposed primarily in the central and southern portions of the Mountain Region. Mixed rocks (m) are composed of undifferentiated metasedimentary and metavolcanic rocks. The plutonic rock demarcates the boundary between the Sierra Nevada Mountain Range and the Cascade Mountain Range to the north, and generally coincides with the divide of the Feather River drainage.

Tertiary sediments (65 to 1.8 mybp) are exposed in the northern, southeastern and southwestern portions of the Mountain Region. The major geologic unit of any importance for the occurrence of groundwater is the Tuscan Formation Unit B (Ttb). This unit was deposited as a series of mudflows originating from ancient, eroded volcanoes of the Cascade Range. It is exposed only in the northwestern portion of the region. Additional Tertiary units include the Tertiary Volcanics (Tv) and the Ione Formation (Ti). The Tertiary Volcanics are exposed in the north and southeastern areas and are composed of older, undifferentiated andesites and basalts. The Ione Formation is composed of sandstone and siltstone and was deposited in a marine to non-marine environment. A small exposure of the Ione Formation is exposed in the southwestern portion of the Mountain Region.

Fresh Groundwater Bearing Units

Groundwater found in the Mesozoic and Paleozoic rocks is very limited and associated mainly with secondary porosity.

The limited amount of groundwater encountered in the Mesozoic rocks environment is derived primarily through secondary porosity associated with fractured and jointed rock.

Although groundwater is encountered in the Ione Formation, the quality is poor due to its brackish nature. In general, the limited amount of fresh groundwater encountered in the Tertiary sediments is associated with secondary porosity.

Although the Tuscan Formation is the main groundwater-bearing unit for the Foothill and Sacramento Valley Regions, in the Mountain Region it is tightly cemented and consolidated, and it too supplies only limited amounts of water. Where groundwater does occur, it is limited to the fractures and joints within the volcanic mudflows and breccias.

Tuscan Formation

Age and Composition. The Pliocene Tuscan Formation is composed of tuff breccia, lapilli, tuff, and volcanic conglomerate, sand and silt (Lydon, 1969). The Tuscan Formation is described as four separate but lithologically similar units, Units A through D, which in some areas are separated by layers of thin tuff or ash units (Helley and Harwood, 1985). Unit B (Ttb) is the only unit exposed in the Mountain Region and is described as a series of interbedded lahars, volcanic conglomerate,

sandstone and siltstone. It is characterized on resistivity curves by its distinctive and consistently high deflections seen in cross-section on Figure 3-3.

Water-bearing Properties. In the Mountain Region, groundwater is related largely to secondary porosity and is not available in appreciable amounts. Where groundwater does occur, it is found in the fractures and joints of the volcanic mudflows and breccias.

Movement of Groundwater

Although there is no data to determine the direction and /or velocity of groundwater movement, groundwater generally follows the contour of the topographic surface. In the Mountain Region, this can be interpreted as groundwater flowing from high to low elevations, following drainages towards the center of the valley where it tends to track the course and direction of the Sacramento River.

Appendix B
Water Rights

Table B-1 Major Appropriative Right-Holders In Butte County				
Source	**Owner Name**	**Type of Use**	**Type of Right**	**Approx. Max. Acre-Feet**
R.D.Main drain	Calthie Walton	Irrig.	Direct Diversion	5,880
Hamlin Slough	Rancho Esquon Partners	Irrig.	Direct Diversion	4,416
Hamlin Slough	Rancho Esquon Partners	Irrig.	Direct Diversion	5,106
Philbrook Creek	PG&E	Storage	Power	5,060
Cottonwood Creek	PG&E	Irrig.	Direct Diversion	1,350
West Branch Feather River	PG&E	Power	Storage	1,196
West Branch Feather River	PG&E	Power	Direct Diversion	91,250
Butte Creek	PG&E	Power	Direct Diversion	69,350
Butte Creek	PG&E	Power	Direct Diversion	131,400
West Branch Feather River	PG&E	Power	Direct Diversion	54,750
Inskip Creek	PG&E	Power	Direct Diversion	2,700
Butte Creek	PG&E	Power	Direct Diversion	365
Butte Creek	PG&E	Power	Direct Diversion	365
Butte Creek	PG&E	Power	Direct Diversion	180
Kelsey Creek	PG&E	Power	Direct Diversion	1,460
Stevens Creek	PG&E	Power	Direct Diversion	1,460
Butte Creek	PG&E	Power	Direct Diversion	365
Butte Creek	PG&E	Power	Direct Diversion	365
Clear Creek	PG&E	Power	Direct Diversion	29,200
Butte Creek	PG&E	Power	Direct Diversion	120
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	730
Butte Creek	PG&E	Power	Direct Diversion	540
West Branch Feather River	PG&E	Power	Direct Diversion	1,460
West Branch Feather River	PG&E	Power	Direct Diversion	1,905
Long Ravine	PG&E	Power	Direct Diversion	94,900
Little West Branch	PG&E	Power	Direct Diversion	2,700
Cunningham Ravine	PG&E	Power	Direct Diversion	3,650
West Branch Feather River	PG&E	Power	Direct Diversion	1,460
West Branch Feather River	PG&E	Power	Direct Diversion	2,190
Helltown Ravine	PG&E	Power	Direct Diversion	131,400
Butte Creek	PG&E	Power	Direct Diversion	365
North Canyon Creek	PG&E	Power	Direct Diversion	1,825
Little Butte Creek	PG&E	Power	Direct Diversion	4,200
North Fork Feather River	PG&E	Power	Direct Diversion	1,536,650
North Fork Feather River	PG&E	Power	Direct Diversion	584,000
North Fork Feather River	PG&E	Power	Direct Diversion	365,250
Butte Creek	PG&E	Power	Direct Diversion	730
Hamlin Slough	Gorrill Land Co.	Irrig.	Direct Diversion	4,500
Hamlin Slough	Gorrill Land Co.	Irrig.	Direct Diversion	8,029
Little Dry Creek	Gorrill Land Co.	Irrig.	Direct Diversion	6,000
District 100 Main Drain	Lucky Ten Ranch	Irrig.	Direct Diversion	1,688
RD100 Main Drain	Charles Sheppard	Irrig.	Direct Diversion	2,673

Table B-1
Major Appropriative Right-Holders In Butte County

Source	Owner Name	Type of Use	Type of Right	Approx. Max. Acre-Feet
RD833 Lateral A	Garaventa Family Trust	Irrig.	Direct Diversion	4,800
District 100 Main Drain	Edgar Meyer	Irrig.	Direct Diversion	3,300
West Branch Butte Creek	Vaughn Franklin	Mining	Direct Diversion	1,825
RD833 Lateral A-N	Cherokee Farms Inc.	Irrig.	Direct Diversion	750
RD833 Lateral A	Cherokee Farms Inc.	Irrig.	Direct Diversion	330
RD833 Lateral A	Paul Minasian	Irrig.	Direct Diversion	1,008
RD833 Lateral A	Paul Minasian	Irrig.	Direct Diversion	2,562
RD833 Lateral E	Rudd Farming Inc.	Irrig.	Direct Diversion	990
RD833 Lateral E	Rudd Farming Inc.	Irrig.	Direct Diversion	4,140
RD833 Main Drain	Birdie Vanderford Trust B	Irrig.	Direct Diversion	3,400
Hamilton Slough	Lund Parker Ranches	Irrig.	Direct Diversion	2,880
Hamilton Slough	Walter Owen	Irrig.	Direct Diversion	1,260
Slate Creek	Yuba Co.Water Dist.	Storage	Power	34,200
Rock Creek	Emerald C Kiwi Fruit Corp	Irrig.	Direct Diversion	571
Rock Creek	Emerald C Kiwi Fruit Corp	Irrig.	Direct Diversion	1,170
Rock Creek	Emerald C Kiwi Fruit Corp	Irrig.	Direct Diversion	1,170
Butte Creek	McPherrin Land Co.	Irrig.	Direct Diversion	6,300
Butte Creek	McPherrin Land Co.	Irrig.	Direct Diversion	1,500
Dry Creek	Casey Sohnrey	Irrig.	Direct Diversion	2,520
Butte Creek	Nevis Industries Inc.	Irrig.	Direct Diversion	3,440
Durham Slough	Nevis Industries Inc.	Irrig.	Direct Diversion	840
Odell Drain	Nevis Industries Inc.	Irrig.	Direct Diversion	3,780
Ditchh 100	Robert Loring	Irrig.	Direct Diversion	41,400
Cottonwood Creek	Bar-X Goose Ranch	Irrig.	Direct Diversion	2,520
Cottonwood Creek	George Chaffin	Irrig.	Storage	450
Flag Canyon Creek	George Chaffin	Irrig.	Direct Diversion	720
Coal Canyon Creek	George Chaffin	Irrig.	Direct Diversion	840
Coal Canyon Creek	George Chaffin	Irrig.	Direct Diversion	180
Coal Canyon Creek	George Chaffin	Irrig.	Direct Diversion	1,440
Coal Canyon Creek	George Chaffin	Irrig.	Direct Diversion	1,440
Butte Creek	Butte Sink Waterfowl Association	Irrig.	Direct Diversion	75,000
South Honcut Creek	Big Land Development Corp.	Irrig.	Direct Diversion	2,700
Pine Creek	Metropolitan Life Insurance Co.	Irrig.	Direct Diversion	8,400
Sacramento River	Metropolitan Life Insurance Co.	Irrig.	Direct Diversion	17,688
Gold Run	Table Mountain I.D.	Irrig.	Direct Diversion	2,700
Butte Creek	Energy Growth Group	Irrig.	Direct Diversion	182,500
East Branch Mud Creek	Mud Creek Hydro Partners	Power	Direct Diversion	7,300
East Branch Mud Creek	Mud Creek Hydro Partners	Power	Direct Diversion	7,560
Camp Creek	Solar Research Corp	Power	Direct Diversion	21,900
RD100 Main Drain	Charles Sheppard	Recreation	Direct Diversion	2,040
Cherokee Canal Cottonwood Creek	Cherrywood Farms	Irrig.	Direct Diversion	5,400
Berry Creek	Berry Creek Water Users Inc.	Irrig.	Direct Diversion	3,650
Little Butte Creek	Lucian Vandegrift	Irrig/ Other	Direct Diversion	2,920
Little Butte Creek	Lucian Vandegrift	Storage	Direct Diversion	70

Table B-2
Water Rights in DWR Butte Creek Watermaster Service Area

				Priority			Priority								SWRCB
Diversion Number		**Water Right Owner**	**Import (a) (cfs)**	**1st (cfs)**	**2nd (cfs)**	**3rd (cfs)**	**1st (b) (cfs)**	**2nd (c) (cfs)**	**3rd (d) (cfs)**	**4th (e) (cfs)**	**5th (f) (cfs)**	**6th (g) (cfs)**	**7th (h) (cfs)**	**8th (I) (cfs)**	**Appropriative (j) (cfs)**
Butte Creek				(Schedule 7, Decree 18917)			(Paragraphs 80 through 87, Decree 18917. Note: Inferior to Schedule 7)								
50		M&T Chico Ranch, Inc.	53.333									25.000	2.500		
		Parrot Ranch Company	53.333									25.000			
		Dayton Mutual Water Co.	3.334	16.000											
		Parrot & M&T		0.170											
		John McAmis		0.120											
		John Drake		0.100											
		Tom Kniffin		0.050											
		Raynor Gimbal		0.115											
		Frank Solinsky		0.155											
		D.B Hall		0.180											
		Tim Hutzler		0.040											
		J.W. Holt		0.040											
		Robert Shepherd		0.040											
		Terry Arthur		0.040											
		Barbara Allen		0.250											
		Patrick Conroy		0.880											
		M. Leen		0.820											
53	(pump)	U.S. Dept. of Agriculture		2.000											
		J.R. Kennedy		1.850											2.96 (k)
54		Hester Patrick		3.150											5.04 (k)
55		J.E. Camenzind		0.780											0.59 (l)
		A. Kent Garrett		0.540											0.40 (l)
		Michael Brown		0.430											0.32 (l)
		Kenneth Houser		0.490											0.37 (l)
		Clifford Johnsen		0.870											0.65 (l)
56		Durham Mutual Water Co.		44.700											
		Butte Creek Country Club		2.000											
		Carolyn Geiger		0.480											
		Dixon Family Trust		0.390											
		Norman Domon		0.670											

Table B-2
Water Rights in DWR Butte Creek Watermaster Service Area

				Priority			Priority								SWRCB
Diversion Number		**Water Right Owner**	**Import (a) (cfs)**	**1st (cfs)**	**2nd (cfs)**	**3rd (cfs)**	**1st (b) (cfs)**	**2nd (c) (cfs)**	**3rd (d) (cfs)**	**4th (e) (cfs)**	**5th (f) (cfs)**	**6th (g) (cfs)**	**7th (h) (cfs)**	**8th (I) (cfs)**	**Appropriative (j) (cfs)**
Butte Creek				(Schedule 7, Decree 18917)			(Paragraphs 80 through 87, Decree 18917. Note: Inferior to Schedule 7)								
		Kevin Lemos		0.010											
		Stephen Vomoga		1.447											
		P.J. Konyn		0.020											
		Doris Picchi		0.020											
		Ranko Bebich		0.446											
		Deborah Humphreys		0.447											
		Durham House Preservation		0.260											
	(pump)	Sam G. Lewis		2.000											
57	(pump)	William H. Coats		3.890											
58	(pump)	M. Wakenfield		0.430											
	(pump)	Norman Domon		0.180											
58A		C.M. Hansen											2.500		
60		Rancho Esquon Partners		0.390	6.000	0.750		13.250	8.000						66.00 (m)
60A	(pump)	M.J. Keeney		0.660											
61	(w)	Gorrill R Ranch				1.000	14.000			15.000					25.80 (n)
		Western Canal												33.330	
62		Elma J. Ryon				0.570					4.290				
		Skinner Brothers				0.120					0.650				
		Eldo McAllister				0.310					4.560				
Hamlin Slough				(Paragraphs 71 through 76, Decree 18917)											
64,65		Rancho Esquon Partners		3.82 (p)											
64,65		Rancho Esquon Partners		4.58 (q)		3.22 (s)									
64,65		Rancho Esquon Partners		3.60 (r)		1.38 (t)									
66	(w)	Gorrill R Ranch			15.00 (u)	6.70 (v)									

Table B-2
Water Rights in DWR Butte Creek Watermaster Service Area

Notes:
(a) This water is imported from the West Branch Feather River to Butte Creek by PG&E via Toadtown Canal, De Sabla Power Plant, and centerville Power Plant. The import water is measured by a 10-foot parshall flume designated by PG&E as BW-12. Five percent is subtracted from the water measured at the parshall flume as conveyance loss between the flume and diversion 50. See paragraph 37.
(b) July 1 to September 30. Total decreed diversions from Butte Creek and Hamlin Slough not to exceed 21.7 cfs. See paragraph 80.
(c) April 1to September 30. See paragraph 81. April 1to September 30. See paragraph 81.
(d) April 1 to June 15. See paragraph 82.
(e) 15.00 cfs from April 1 to June 30 and 6.70 cfs from July 1 to September 30. Total decreed diversions from Butte Creek and Hamlin Slough not to exceed 21.7 cfs. See paragraph 83.
(f) April 1 to September 30. See paragraph 84.
(g) 25.00 cfs from April 1 to October 15 and 5.00 cfs from October 16 to March 31. See paragraph 85.
(h) Entire year. See paragraph 86.
(I) April 1 to June 15. See paragraph 87.
(j) All SWRCB Appropriative water rights are inferior to the adjudicated water rights defined in Decree 18917 and 60 cfs for fish flows. See license Nos. 11046 and 11044 for details.
(k) Application No. 22534, License No. 10432 March 1 to June 15.
(l) Application No. 22564, License No. 10433 March 1 to June 15.
(m) Application No. 22039, License No. 11046 April 1 to June 15.
(n) Application No. 22321, License No. 11044 April 1 to June 15.
(p) 0.82 cfs for the entire year plus 3.00 cfs from May 1 to October 1. See paragraph 71.
(q) 1.00 cfs for the entire year plus 3.58 cfs from May 1 to October 1. See paragraph 71.
(r) 0.60 cfs for the entire year plus 3.00 cfs from May 1 to October 1. See paragraph 72.
(s) April 1 to September 15. See paragraph 74.
(t) April 1 to September 15. See paragraph 75.
(u) 1.00 cfs for the entire year plus 14.00 cfs from April 15 to June 30. See paragraph 73.
(v) 6.70 cfs from April 1 to June 30 and 21.70 cfs from July 1 to September 15. See paragraph 76.
(w) Total decreed diversions from Butte Creek and Hamlin Slough not to exceed 21.7 cfs. See paragraphs 73, 80, and 83.