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Regional Water Study of the Foothill and Mountain Areas of Eastern Fresno County

Prepared for:

Fresno County Department of Public Works and Planning
2220 Tulare Street, Courtyard Level
Fresno, California 93721

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Project 10366.000

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Mr. Phillip G. Desatoff, PG, CEG
Senior Geologist
County of Fresno Department of Public Works and Planning
2220 Tulare Street, Courtyard Level
Fresno, California 93721

Subject: Regional Water Study for the Foothill and Mountain Areas of Eastern Fresno County

Dear Mr. Desatoff:

Geomatrix Consultants, Inc. (Geomatrix), and Boyle Engineering are pleased to present the Regional Water Study for the Foothill and Mountain Areas of Eastern Fresno County. This document fulfills the Task 9 deliverable, and with the presentation to the Fresno County Board of Supervisors, completes the approved scope of work.

Geomatrix appreciates the opportunity to assist Fresno County with this interesting project. Please contact Clay Rodgers or Philip Ross if you have any questions or need additional information.

Sincerely yours,
GEOMATRIX CONSULTANTS, INC. & BOYLE ENGINEERING

Clay L. Rodgers, PG, CEG	Kenneth Swanson, PE	Philip P. Ross, PG
Senior Geologist	Senior Engineer	Principal Hydrogeologist

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EXECUTIVE SUMMARY

REGIONAL WATER STUDY OF THE FOOTHILL AND MOUNTAIN AREAS OF EASTERN FRESNO COUNTY

Geomatrix Consultants, Inc., and Boyle Engineering Corporation have completed a regional water study for the foothill and mountain areas of eastern Fresno County. This work was completed on behalf of the Fresno County Department of Public Works and Planning (FCDPWP).

PROBLEM, PURPOSE, AND APPROACH

Property owners within the foothill and mountain areas of eastern Fresno County have reported shortages of groundwater needed to meet their needs. The number of reported problems received by the County has increased over the last several years. The lack of systematic collection and evaluation of hydrogeologic data to document groundwater-related problems has inhibited the ability to identify cause(s) and/or develop policies to address these problems.

The intent of this study was to develop suitable information to support recommendations to the County regarding land-use policies, zoning, and development standards that will help protect the County's groundwater resources and sustain current and projected water use in the foothill and mountain areas. This study is the first step in evaluating the severity of water supply problems and identifying a course of action to document the availability of water to support existing and continued development.

This study required integration of information on natural resources, building development, water use, and political decision-making tools. Existing data for the area were assembled and organized in a form that allowed evaluation of trends that would indicate cause-and-effect relationships between groundwater availability and identified potential affecters. The project team also reviewed existing policies and building development standards to ascertain what Fresno County and other governmental entities are currently doing to address groundwater development issues in rural settings with limited groundwater availability. The findings from the study were used to prepare recommendations regarding limitations of existing data, interim policies for groundwater development, a data acquisition program to fill data gaps, and plans for updating water balances and interim policies.

SCOPE OF WORK

The project was designed as a dynamic and interactive process with input from County staff as well as from interested parties. To that end, six meetings were held with FCDPWP staff, one with FCDPWP management, and a presentation was made to a joint meeting of the Fresno County Board of Supervisors and Fresno County Planning Commission to present an overview of the study along with the conclusions and recommendations. Two public workshops were conducted presenting an overview of the project and providing the opportunity for interested parties to ask questions and raise concerns. In addition, several consultants who have worked in the eastern Fresno County area were interviewed to obtain their insights into the availability of groundwater in the area.

Because of the large amount of spatially-related data, a geographic information system (GIS) was created to store, manipulate, and display pertinent information. The GIS contains information on geology, wells, land use, parcel boundaries, topography, political boundaries, streets and other improvements, watershed boundaries, study boundary, and study areas. Data from available well drillers logs (2,987) were entered into an Access database that interfaced with the GIS allowing analysis of water well information. Copies of the GIS and Access database have been provided to the County.

In order to facilitate data collection and evaluation, the study area was divided into watersheds. After discussions with County staff, three areas (Shaver Lake, Auberry-Prather, and Squaw Valley) were identified as having the greatest risk of groundwater shortage and selected for more detailed analysis.

Existing data were reviewed to identify trends in population, building permits, new well permits, new parcels, and water use. Projections of water usage were prepared and potential impacts on groundwater availability identified.

Current water demands were estimated on a subwatershed basis using available data for the study area along with historical data from comparable geographic settings and water usage estimates based on commonly used engineering and planning standards. The variability in the quantity and quality of the available data and the significant differences in habitation, climate, and water consumption among the three areas required the use of different water demand type calculation methods in order to maximize the effectiveness of the available data. The different demand types were assigned to areas based on land use and building permit status. Water demand estimates for areas within existing community service districts (CSDs) were generated from the recorded well production or delivery data for that CSD. Water-demand estimates for non-CSD areas were based on demands generated from nearby CSDs.

Projected water demands were estimated for the Shaver Lake, Auberry-Prather, and Squaw Valley areas based on two scenarios: (1) projected population growth of the areas over the next 20 years using available Census data, and (2) projected water demand for each area at full buildout of permitted parcels. Under the first scenario, future water demands were estimated by projecting the development trends from the 1990 and 2000 Census data, 20 years into the future. The projected water demand analysis utilized the average annual percentage increase in housing units from 1990 to 2000 to represent general development trends within each of the areas. It is assumed that increased water demand for the three areas will be due primarily to the projected growth in housing units and that population characteristics (household densities, occupancy types, etc.) and water usage characteristics (per capita usage) will remain the same in all three areas.

Conceptual water balances were prepared for selected watersheds as the first step to assessing the capacity to meet current and future groundwater demands in the three different areas. Long-term sustainability of the groundwater supply depends on the balance between how much water is removed from a watershed by evapotranspiration, runoff, and pumping and how much enters a watershed by precipitation. Evapotranspiration was estimated from published values for the foothill and mountain areas. Precipitation was estimated using available long-term averages. Runoff was estimated using runoff coefficients developed from available stream gage data. The amount of subsurface flow into a watershed was assumed to be equal to the subsurface outflow. Using these assumptions, the estimated groundwater recharge or renewable groundwater supply for each watershed is equal to the total amount of water that falls as precipitation minus the amount of water that leaves the watershed as runoff and as evapotranspiration.

The long-term maximum renewable groundwater supply is taken to be an upper limit of the amount of water available for groundwater recharge that could occur in a watershed on a sustained basis. Although the water balances can provide a general estimate of how much recharge could occur, the estimated volumes of precipitation, runoff, and evapotranspiration are large compared to the amount of groundwater in storage so that even a small uncertainty in any one of these parameters overwhelms the amount of groundwater recharge that likely infiltrates annually. Therefore, the actual value for renewable groundwater supply may be substantially less than the calculated values, and only a portion of this water could be extracted without producing an undesirable result, primarily declining groundwater levels. In addition, undesirable effects may be produced if groundwater extraction occurs in a concentrated area.

A data acquisition program has been recommended to provide information needed to more accurately identify water demands, refine water balances, and evaluate long-term sustainability. The data acquisition program consists of measuring depth to groundwater in wells, measuring groundwater extraction volumes from water systems in the area, stream gaging in selected subwatersheds, and collecting of precipitation and other climatological data within the selected subwatersheds. It is also recommended that collected data be evaluated annually and the data acquisition program modified as appropriate. Initial capital and annual costs to implement the program and potential funding sources have also been provided.

Fresno County land division policies related to use of groundwater as a means of supplying domestic water were reviewed and compared to those adopted by other counties. The eight other counties were selected because they have areas that have similar geologic and hydrogeologic conditions as the study area.

REGIONAL SETTING

The study area comprises about 421,000 acres in the eastern portion of the County. Development consists primarily of rural residential and associated commercial activities. Elevations in the study area range from about 400 feet on the west to 6,500 feet on the east.

Mediterranean-type climates dominate eastern Fresno County with elevation changes dictating temperatures and amounts of precipitation. Most precipitation falls between November and April with precipitation increasing with elevation. Snow accumulates above about 6,000 feet elevation, storing the winter precipitation for late spring runoff. Annual precipitation in the study area varies significantly from year to year, with most years substantially lower or higher than the mean. This makes the area susceptible to drought conditions. Analysis of the Palmer Drought Severity Index indicates ten droughts lasting 4 years or longer occurred between 1701 and 1978. The data indicate that between 1820 and present, a drought of 4 years or longer occurs on average every 20 years, with the most recent one occurring from 1984 through 1992.

The foothill and mountain areas of eastern Fresno County are underlain primarily by bedrock, with minor amounts of soil and unconsolidated alluvial material within meadows, valleys, and other small drainages. The bedrock is chiefly crystalline in nature, comprising granitic to ultrabasic intrusive igneous rocks and metamorphosed volcanic and sedimentary rocks. The primary groundwater reservoir is fractured bedrock, with locally significant amounts of groundwater stored in weathered bedrock in the Shaver Lake area. The amount of water that can be stored in a fractured bedrock aquifer is dependent upon the density of fractures, size of the fracture opening, the length of the fracture, and the orientation of the fracture (horizontal to vertical). The amount of water that can be recovered from a fractured bedrock aquifer is dependent upon the amount of water stored in the fractures, the degree of interconnection of those fractures, and the connection of the fractures to a viable recharge source. Typically, the amount of water produced from fractures decreases with depth as the number and openness of the fractures decrease. Groundwater storage in fractured rock is typically on the order of 1 percent of the rock volume. In the study area, the fracture distribution and groundwater recovery capacity of the bedrock aquifer is variable, with reported yields from zero (dry well) to as much as hundreds of gallons per minute (gpm).

SHAVER LAKE AREA

The Shaver Lake area consists of about 20,700 acres that range in elevation from 4,000 to 6,500 feet above mean sea level (MSL). Subwatersheds within the area include Musick Creek, North Fork Sycamore Creek, and a portion of Bald Mill Creek.

Land Use and Development

The current land use in the Shaver Lake area is primarily rural residential and open area (includes Forest Service lands). It is estimated that 2,136 residences exist in the Shaver Lake area. Residences at higher elevations, near Shaver Lake, are mostly vacation and rental homes with less than half of the homes occupied full time. Most residences at lower elevations, however, appear to be occupied full time. According to Census data, housing units in the Shaver Lake area increased approximately 18 percent between 1990 and 2000. Water connections in Waterworks District (WWD) 41 increased 63 percent from 1993 to 2005, indicating that the growth rate was greater in the vicinity of Shaver Lake than in lower portions of the area.

A total of 329 well logs were identified in the Shaver Lake area. The number of wells drilled annually appears to be increasing, and the wells appear to be getting deeper with time.

Water Supply Evaluation

Water usage data were available from the CSDs in the Shaver Lake vicinity. Estimated current water demand for the Shaver Lake area is 352 acre-feet per year (AFY).

The water demand projections using housing unit growth trends estimated that water usage in 2025 would be 490 AFY in the Shaver Lake area. Water demands projected for full buildout of the existing permitted parcels was estimated to be 475 AFY. Because the Shaver Lake area currently demonstrates seasonal occupancy patterns, an additional scenario (maximum demand) for the Shaver Lake area assumed full buildout of permitted parcels and full-time (year-round) occupancy for households in the Shaver Lake area. The estimated water usage under this scenario is 1,087 AFY.

The estimated long-term maximum renewable groundwater supply values calculated for the Shaver Lake area were -0.39 feet per year (FPY) in the Bald Mill Creek and North Fork Sycamore Creek subwatersheds and -0.37 FPY in the Musick Creek subwatershed. The negative numbers for the long-term maximum renewable groundwater supply point out the delicate balance between recharge and discharge in this environment and emphasize the need for more detailed, local-scale data collection and evaluation. It is likely that at least 3 to 5 years of data are needed to provide significant refinement.

The Shaver Lake area relies solely on groundwater to meet current water demands. Alternative water supplies to meet current and projected future water demands include additional development of groundwater and use of surface water. Potential measures that can be implemented to mitigate impacts to the groundwater supply include development of a comprehensive water management plan (WMP) for protecting the groundwater resources, protection of groundwater recharge areas, increased groundwater recharge, storage of surface water runoff, and use of recycled water.

Review of Waterworks District 41 Water Supply

The conceptual water balance for the Shaver Lake area indicates a negative long-term maximum renewable groundwater supply. In this type of environment, where snowpack stores a significant amount of the annual precipitation, use of an average runoff coefficient may be inadequate to assess the long-term maximum renewable groundwater supply.

A better measure of whether recharge is sufficient to maintain the groundwater development is the trend in groundwater levels in the area. Limited water level data were available for analysis. Evaluation of data from WWD 41 wells indicates that water levels in 2005 are similar to those recorded when the wells were first drilled. These wells appear to recover following "wet" years when greater amounts of water are available for recharge. However, as production of groundwater increases, the ability of the groundwater system to recover from drought periods will decrease. Groundwater level monitoring is needed to evaluate trends and determine whether storage volumes are decreasing over time.

The pumping capacity of the WWD 41 well field does not appear to meet the California Department of Health Services (DHS) permit requirements. As of July 2005, 768 equivalent dwelling units (EDUs) were connected in WWD 41. The DHS requires that WWD 41 have the pumping capacity to supply 0.3 gpm per EDU for lot sizes up to 36,000 square feet and 0.5 gpm for lot sizes larger than 36,000 square feet. In addition, DHS requires WWD 41 to be able to meet peak daily demand with direct water supply (no storage). In 2004, peak daily water demand occurred over the July 4 holiday, averaging 0.28 gpm per EDU. Using 0.3 gpm per EDU for 768 EDUs indicates a required pumping capacity of 230 gpm. Fall 2004 pump tests of the 12 active wells in WWD 41 indicated a combined yield of 118 gpm. It appears that WWD 41 was able to meet the peak demand using water supplied from surface storage tanks and not from direct water supply.

AUBERRY-PRATHER AREA

The Auberry-Prather area consists of about 26,200 acres that range in elevation from 750 to 2,550 feet above MSL. Subwatersheds within the area include Little Sandy Creek, Auberry Valley, Sentinel School, and a portion of Big Sandy Valley.

Land Use and Development

The current land use in the Auberry-Prather area is primarily rural residential and open area (includes cattle grazing). According to Census data, the number of housing units in the area increased by approximately 12 percent from 1990 to 2000, while the number of residents increased by approximately 10 percent. Residences primarily are occupied full time.

A total of 750 well logs were identified in the Auberry-Prather area. No discernable trend is apparent in the number of wells drilled per year; however, the drilled depth of new wells appears to be increasing with time.

Water Supply Evaluation

Estimated current water demand for the Auberry-Prather area is 578 AFY with a projected demand of 725 AFY using housing unit growth trends. Water demand projections assuming full buildout of permitted parcels are estimated at 908 AFY.

The estimated long-term maximum renewable groundwater supply values calculated for the Auberry-Prather area were 0.04 FPY in the Little Sandy Creek and Big Sandy Valley subwatersheds and 0.06 FPY in the Sentinel School and Auberry Valley subwatersheds.

The Auberry-Prather area relies solely on groundwater to meet current water demands. Alternative water supplies to meet current and projected future water demands include additional development of groundwater and use of surface water. Potential measures that can be implemented to mitigate impacts to the groundwater supply include development of a comprehensive WMP for protecting the groundwater resources, protection of groundwater recharge areas, increased groundwater recharge, storage of surface water runoff, and use of recycled water.

SQUAW VALLEY AREA

The Squaw Valley area consists of about 49,800 acres that range in elevation from 600 to 3,600 feet above MSL. Subwatersheds within the area include Squaw Valley, Bald Mountain, Little White Deer Creek, Jorgensen Point, and portions of Hoffman Point, Metcalf Ranch, and Bull Creek.

Land Use and Development

The current land use in the Squaw Valley area is primarily rural residential and open area (includes cattle grazing). According to Census data, the number of housing units in the Squaw Valley area increased by approximately 24 percent from 1990 to 2000, while the number of residents increased by approximately 25 percent. Residences primarily are occupied full-time.

A total of 523 well logs were identified in the Squaw Valley area. No discernable trend was apparent in the number of wells drilled per year; however, the drilled depth of new wells appears to be increasing with time.

Water Supply Evaluation

Estimated current water demand for the Squaw Valley area is 354 AFY with a projected demand of 544 AFY in 2025 using housing unit growth trends. The water demand, assuming buildout of existing permitted parcels is estimated at 979 AFY.

The estimated long-term maximum renewable groundwater supply values calculated for the Squaw Valley area were 0.04 FPY in the Hoffman Point subwatershed; 0.08 FPY in the Metcalf Ranch, Bald Mountain, and Squaw Valley subwatersheds; 0.22 FPY in the Bull Creek subwatershed; and 0.29 FPY in the Little White Deer Creek and Jorgensen Point subwatersheds.

The Squaw Valley area relies solely on groundwater to meet current water demands. Alternative water supplies to meet current and projected future water demands include additional development of groundwater and use of surface water. Potential measures that can be implemented to mitigate impacts to the groundwater supply include development of a comprehensive WMP for protecting the groundwater resources, protection of groundwater recharge areas, increased groundwater recharge, storage of surface water runoff, and use of recycled water.

DATA DEFICIENCIES

Data deficiencies were identified during this study with regard to available groundwater level, well yield information, climatological, and stream gage data. Because of the paucity of critical data, a number of assumptions have been made in developing the conceptual hydrogeologic model for the area, including water balances. When additional information is collected, these assumptions will need to be reevaluated and the water balances and conceptual hydrogeologic model updated.

Existing groundwater level data are not sufficient to evaluate potentiometric trends across the study area. No long-term, reliable water level data are available for the Auberry-Prather area and limited water level data (non-continuous) are available from the Shaver Lake area. Data from wells in WWD 41 (within the Shaver Lake area) did not have significant water level changes between when they were installed and 2005. California Department of Water Resources data collected from wells in the western portion of the Squaw Valley area indicate groundwater levels have remained relatively steady for the past 30 years. Multiple years of data from several locations in each study area are needed to evaluate trends and to assess whether current and/or future estimated water demands are sustainable.

The only reliable and long-term well yield data are for the WWD 41 production wells in the Shaver Lake area. Long-term well yield data are needed to evaluate groundwater usage and the sustainability of the groundwater supply.

Discontinuous historical stream gaging data are available for a few of the smaller subwatersheds within eastern Fresno County. Only a limited amount of the available data is useful because the stream gages rarely are located in subwatersheds where most of the groundwater withdrawal or recharge takes place. At this time, no stream gage monitoring is known to occur within the study area, except on major rivers.

Precipitation data used during this investigation have been obtained from five precipitation stations in the region; however, no precipitation data are available at locations within subwatersheds where additional information is needed to provide better water balance data. In addition, few climatological stations are available for the region; the data from which are needed to prepare better estimates of evapotranspiration.

DATA ACQUISITION PROGRAM

The proposed data acquisition program consists of obtaining groundwater level data, measuring well yields, measuring stream flow, and collecting climatological data. The proposed groundwater level data includes measuring groundwater levels at 27 locations in the

Shaver Lake area, 20 locations in the Auberry-Prather area, 20 locations in the Squaw Valley area, and 15 locations in other parts of the study area where future development is anticipated.

Well yields are proposed to be collected with the installation of flow totalizing meters attached to the well-pump discharge. It is anticipated that the number of wells metered should be similar to the number and geographic distribution of where groundwater levels are measured.

Stream gages are proposed to be installed and monitored at three locations in the Shaver Lake area, three locations in the Auberry-Prather area, and two locations in the Squaw Valley area. Some of these locations are where historical data have been collected and renewed monitoring will allow incorporation of historical data into future evaluations.

Climatological stations are proposed to be installed and monitored at three locations in the Shaver Lake area, two locations in the Auberry-Prather area, and two locations in the Squaw Valley area. The climatological parameters should include precipitation, air temperature, humidity, wind speed, and solar radiation.

Estimated implementation costs are $215,000 for purchase and installation of equipment and $70,000 annual monitoring costs. The monitoring costs include preparation of an annual report documenting activities completed, identification of data gaps, and recommendations to modify the program to fill the data gaps.

EVALUATION OF POLICIES AND STANDARDS

Fresno County land division policies related to use of groundwater as the means of supplying domestic water to parcels were reviewed along with the water requirements for issuance of building permits. Fresno County has adopted specific water related requirements for issuance of building permits in water-short areas that apply to the entire project study area. In addition, the County has certain policies for well tests in the Shaver Lake vicinity. Water requirement information from eight other counties in the San Joaquin Valley and the central and northern coast areas was gathered for comparison purposes and to assist in identifying potential changes to existing Fresno County policies.

Subdivisions in Fresno County are approved subject to demonstration of a water supply that is adequate, sustainable, and will not impact surrounding properties. Groundwater-based subdivisions are approved with either a proposed community water system or use of individual private wells. In either case, on-site hydrogeologic investigations conducted by a professional geologist or civil engineer, are required prior to subdivision consideration.

For subdivisions within water-short areas of the County (includes the study area) and approved based upon use of individual private wells, additional testing is required prior to issuance of a building permit. Specifically, the homeowner must demonstrate a minimum available well yield of 5.0 gpm (with no storage requirement), or 1.0 gpm with a minimum of 2,000 gallons of storage in addition to fire-related storage requirements. The well is determined to meet the minimum yield requirements if it passes the total water volume test (4- to 48-hour pump test), meets the average discharge rate requirement for the last 60 minutes of the pump test, and meets the well recovery requirements. The specific test results for determining whether a well meets the minimum yield requirements depends on the time of year the pump test is performed.

Additional requirements for pumping tests are imposed for wells to be incorporated into the County WWD system in the Shaver Lake area. The County requires that prospective wells be tested during late summer or early fall for a minimum of 30 days at maximum drawdown. The pumping rate from the well is plotted against the logarithm of time, a best-fit line is placed on the points, and the line is projected from 30 days to 120 days. The allotted sustainable yield for the well is equal to 75 percent of the projected pumping rate at 120 days, or 50 percent of the projected pumping rate at 120 days if the well is adjacent to a stream.

Other counties require pump tests that range from 4 to 72 hours, and the length of the test is generally determined by the numbers of connections the well is intended to serve. The required well yields range from a low of 1 gpm with 1,000 gallons of storage to a high of 5 gpm per connection without storage requirements. The minimum lot size allowed for subdivisions allowing individual water system ranges from 1 to 2.5 acres in the other counties.

RECOMMENDATIONS

The following recommendations are made based on the findings of the study. The recommendations are presented by category.

Monitoring

1. Implementation of the proposed data acquisition program (see Section 6.0) is recommended to collect water level, well yield, streamflow, and climatological data within selected subwatersheds for refinement of water balances. The recommended system would include water level measurements on a minimum of 72 wells or piezometers, installation of flow meters on selected pumping wells, installation of 8 streamflow gages, and installation of 7 climatological stations.

2. Data collected during implementation of the data acquisition program and available from other sources need to be maintained in a database and organized to allow evaluation. The data should be evaluated annually and a summary report prepared documenting activities conducted. Recommendations should be made to modify the program as needed to fill identified data gaps.

3. Collection and evaluation of groundwater quality data should be incorporated into the data acquisition program.

4. Water budgets, based on detailed data, need to be established for subwatersheds where additional development of groundwater is proposed. Area-wide estimates are not sufficiently accurate to predict renewable groundwater supplies. It is estimated that at least 3 to 5 years of data, including a climatic cycle with at least 1 above average and 2 consecutive below average precipitation years, is needed so that annual variability can be evaluated.

Comprehensive Water Management Plan

5. The County should develop a comprehensive Water Management Plan (WMP) for protecting the groundwater resources of the foothill and mountain areas as part of the program to demonstrate sustainability of the resource. This WMP should include development of mandatory and recommended water conservation measures and recycled water programs. The WMP should also include investigation of the potential for installing groundwater recharge basins and surface water runoff storage facilities to enhance recharge. The WMP should also include a plan and schedule for development of surface water supplies in the study area, such as the County's CVP water supply. The WMP may take 3 to 5 years to prepare and implement.

6. Pending development of the WMP, future proposals for subdivision of lands in the study area should be required to provide a detailed watershed analysis in addition to the hydrogeologic analysis to evaluate the ability of the proposed water system to meet the water demands of all lots in the subdivision. The watershed analysis should also evaluate impacts to runoff and flora and fauna from further development of the groundwater resource.

Policies

7. In order to meet continued growth projections in the study area, the County should require community water systems for proposed developments where the minimum lot size is 10 acres or less. For the subdivisions where the minimum lot size is greater than 10 acres, current County standards should be maintained for the number of wells needed to demonstrate an adequate water supply.

8. The County should continue its policies for requiring minimum groundwater yields in water-short areas. For individual wells, these are 5.0 gpm (with no storage requirement), or 1.0 gpm with a minimum storage of 2,000 gallons in addition to fire-related storage requirements.

9. The County should develop a program to identify and protect the groundwater recharge areas in the foothill and mountain areas, including zoning regulations to prevent building in these areas. At a minimum, this would include areas within 50 feet of streams, meadows, and other recharge areas identified during hydrogeologic investigations.

10. Until the recommended data acquisition program is in place and sufficient data have been collected to substantiate how the groundwater system recharges under various climatic conditions, it is recommended that the minimum demonstrated long-term water supply be increased from 0.3 to 0.5 gpm per EDU for community water systems in water-short areas. The additional 0.2 gpm provides a factor of safety against operational interruptions, added supply for fire protection, and a buffer against long-term drought conditions.

11. Until the recommended data acquisition program is in place and sufficient data have been collected to substantiate how the groundwater system recharges under various climatic conditions, pumping tests in the Shaver Lake area should be conducted for a period of not less than 90 days and the pumping yield curve for the later-time data should be extended to 120 days. The policy of reducing the 120-day yield by 25 percent (or more if yield is anticipated to be influenced by surface water) should be continued in order to compensate for potential decline in yield during extended drought conditions.

12. The County should require that any production well proposed for incorporation into a community water system be accompanied by an observation well

representative of the specific aquifer, within 200 feet of the production well, completed to a similar depth and with similar openings to the producing formation as the production well, and fitted with a recording water level device such as a pressure transducer. These observation wells should be incorporated into the data acquisition program and would serve to monitor groundwater levels in wells that are not subjected to pumping.

13. Because of the precarious water balance in the study area and the current lack of data to refine those balances, it is recommended that the County require that the same pumping tests be conducted for all proposed community water systems in designated water-short areas as those required for the Shaver Lake area. These pump test requirements are summarized in Recommendation 11, above.

Shaver Lake Water Supply

14. The County needs to finalize agreements with SCE, PG&E, and other entities to enable diversion of its CVP surface water supply from Shaver Lake. Plans for construction of a surface water treatment plant and distribution system need to be developed now so that surface water can be utilized as soon as possible after agreements are in place.

15. Additional lots within WWD 41 should not be created until the water production deficit for the current connections is addressed.

16. The County should embark on a process to increase water production incrementally in proportion to anticipated new connections within WWD 41.

17. In WWD 41, consideration should be given to better utilization of the higher capacity wells, especially the radial wells, which have the potential for greater pumping rates during the early part of the year when recharge is actively occurring. In addition, consideration should be given to expanding the surface storage facilities in the district to maximize the ability of the system to extract groundwater over a longer period of time and to extract more when recharge is actively occurring. The extra storage also would provide additional water available to meet peak demands or to meet demands during a period of operational disruption.

REGIONAL WATER STUDY OF THE FOOTHILL AND MOUNTAIN AREAS OF EASTERN FRESNO COUNTY

1.0 INTRODUCTION

Geomatrix Consultants, Inc. (Geomatrix), and Boyle Engineering Corporation (Boyle) were retained by the Fresno County Department of Public Works and Planning (FCDPWP) to evaluate groundwater resources for the foothill and mountain areas of eastern Fresno County (Figure 1). In particular, this study addresses several areas of critical interest that were identified by the FCDPWP, namely Shaver Lake, Auberry-Prather, and Squaw Valley areas (Figures 2, 3, and 4, respectively). The assessment processes developed as part of this study are intended to be used as a model to evaluate groundwater resources in other foothill and mountain areas of eastern Fresno County.

1.1 PROBLEM

Property owners within the foothill and mountain areas of eastern Fresno County have reported experiencing a shortage of groundwater to meet their needs. This is manifested as decreasing water levels in wells, decreasing yield from wells, or inability to find enough groundwater to sustain habitation. The number of reported problems received by the County Geologist (Mr. Phillip Desatoff) has increased over the last several years and monitoring of pumping rates within Fresno County Waterworks District (WWD) 41 reportedly indicates declining well yields. The cause or causes of the groundwater shortages have been the subject of speculation. However, the lack of systematic collection and evaluation of hydrogeologic data to document groundwater-related problems has inhibited the development of policies to resolve these problems.

1.2 PURPOSE

The County has identified the need to evaluate the availability of groundwater resources in the foothill and mountain areas of eastern Fresno County as it relates to current and future land-use development. The intent of this study is to develop suitable information to support recommendations to the County regarding land-use policies, zoning, and development standards that will help protect the County's groundwater resources and sustain current and projected water use in the study area. This study is the first step in evaluating the severity of groundwater supply problems and identifying a course of action to document the availability of groundwater to support existing and continued development.

1.3 APPROACH

This study required the integration of information on natural resources, building development, water use, and political decision-making tools. The first step was to identify potential factors, both anthropogenic and natural, that could affect groundwater availability. Existing data for the area were then assembled and organized in a form that could be analyzed readily. These data were evaluated to assess whether trends could be discerned that would indicate cause-and-effect relationships between identified potential factors and groundwater availability. Based on this analysis, data gaps were identified and an assessment made of how these gaps would affect attainment of the study goals. The project team also reviewed existing policies and building development standards to ascertain what Fresno County and other governmental entities are currently doing to address groundwater development issues in rural settings with limited groundwater availability. The findings from the study were used to prepare recommendations regarding limitations of existing data, interim policies for groundwater development, monitoring programs to fill data gaps, and plans for updating water balances and interim policies.

1.4 SCOPE OF WORK

The scope of work was completed in nine specified tasks. Each task had deliverables and milestones to allow tracking of the project progress. The project was designed as a dynamic and interactive process, with input from County staff as well as from interested parties (homeowners, developers, and contractors) along the way. To that end, six meetings were held with FCDPWP staff, one with FCDPWP management, and a presentation was made to a joint meeting of the Fresno County Board of Supervisors and Fresno County Planning Commission to present the results of the study. In addition, two public workshops were conducted presenting an overview of the project and providing the opportunity for interested parties to ask questions and raise concerns. The public workshops were also opportunities to solicit participants for a future data acquisition program. The first workshop was held on July 7, 2005, at Sierra High School in Auberry and attended by 46 citizens. The second workshop was held on August 18, 2005, at the Squaw Valley Library in Squaw Valley and attended by 28 citizens. Also, several groundwater consultants who have worked in the eastern Fresno County area were interviewed to obtain their insights into the availability of groundwater in the area.

Because of the large amount of spatially-related data anticipated for this project, a geographic information system (GIS) was created to store, manipulate, and display pertinent information. The GIS utilizes ESRI's Arc-GIS family of programs as the facilitator for input and output. A copy of the GIS database has been provided to the County. The GIS contains information on water supply wells, land use (zoning, permits, etc.), topography, political boundaries, streets and other improvements, watershed boundaries, study boundary, and study areas.

Data from well drillers reports supplied by Fresno County were entered into an Access database that has been provided to the County. The well drillers reports, which are required by the California Department of Water Resources (DWR), have also been required to be submitted to Fresno County as part of their permitting process since the mid-1970s. In addition, under an agreement with DWR, Fresno County obtained a copy of the Access database for wells in the Auberry area that had been entered by the Millerton Watershed Coalition. In return for a copy of the DWR database, Fresno County agreed to provide DWR with the data entered by Geomatrix. The database for this project contains data from a total of 2,987 Well Drillers Reports. The database contains approximately 25 fields for different types of data. Some of the fields include: State well number, well owner, address, assessor's parcel number, other location information, drilling method, well drilling company, well depth, well construction information, and depth to first encountered groundwater. The database is compatible with the GIS system to allow for spatial and temporal analysis of different data fields.

In order to facilitate data collection and evaluation, the study area was divided into discrete subwatersheds. The initial approach utilized the DWR watershed boundaries (DWR, 1975). However, to better evaluate the three critical development areas (Shaver Lake, Auberry-Prather, and Squaw Valley), smaller watersheds were combined, and in some areas, boundaries were drawn along major geographical features or political boundaries. The development areas selected for detailed analysis (Figure 1) were finalized after discussions with County staff and were based on identification of areas having the greatest risk of groundwater shortage.

Current groundwater usage in the selected watersheds was estimated utilizing existing information supplied by the County as well as Census and historical data from comparable geographic settings and water usage estimates based on commonly used engineering and planning standards. Existing data were reviewed to identify trends in population, new well permits, new parcels, and water use. Building permit data were also reviewed; however, the data did not have permit-issuance dates, which prevented evaluation of trends. Projections of water usage were prepared and potential impacts on water levels identified. A series of charts were developed showing water level changes over time, number of well permits, number of building permits, and average annual precipitation. These charts were prepared for each of the three designated areas studied in detail (Shaver Lake, Auberry-Prather, and Squaw Valley). The trends identified on the charts were compared to assess cause-and-effect relationships.

Conceptual water balances were created to estimate the average annual renenewable groundwater supply per subwatershed. Estimates are based on inflow and outflow for the subwatershed. The underlying premise is that under long-term, undeveloped conditions the amount of inflow will equal the amount of outflow, and the change in groundwater storage will be zero. The components of the water balance include precipitation (inflow), surface water coming into the subwatershed (inflow), subsurface flow into the subwatershed (inflow), surface water runoff leaving the subwatershed (outflow), evapotranspiration from plants and soil surfaces (outflow), evaporation from surface water (outflow), and subsurface flow out of the subwatershed (outflow). The water balances assume the following:

- Groundwater underflow into the subwatershed equals groundwater underflow from the subwatershed.
- The subwatersheds are delineated in such a fashion as to preclude surface water inflow from other subwatersheds.
- No other groundwater or surface water is being imported or exported from the subwatershed.
- No significant ponds, lakes, or other surface-water features are present within the subwatersheds of the study areas.
- The groundwater aquifers in the subwatershed have sufficient capacity to accept groundwater recharge.

Where the data needed to calculate inflow and outflow values were not available, standard engineering principles were employed to provide reasonable estimates.

Using proposed development and land-use data supplied by the County, Census tract data, and estimated current groundwater usage, future groundwater usage was estimated. In addition, potential water supplies and mitigation measures were identified that could potentially minimize depletion of groundwater resources.

A recommended data acquisition program has been developed to fill data gaps in order to provide information needed to more accurately identify future water demands and evaluate long-term sustainability of the water supply. The data acquisition program consists of measuring depth to groundwater in wells, measuring groundwater extraction volumes from water systems in the area, stream gaging in selected subwatersheds, and collection of climatological data in the subwatersheds where stream gaging is proposed. Estimated costs to implement and carry out the program and potential funding sources have also been provided.

Fresno County policies and standards related to groundwater were reviewed and compared to those of other counties. Recommendations have been made for addressing identified groundwater-related problems, including amendments to Fresno County land division and building standards related to provision of water; changes to land-use zoning; and alternate water sources.

2.0 REGIONAL SETTING

Fresno County encompasses approximately 3.8 million acres of the central portion of California, stretching from the Coast Ranges on the west to the crest of the Sierra Nevada on the east. Most of the County is rural, with more than 1.9 million acres of agricultural land, primarily in the fertile San Joaquin Valley. The foothill and mountain areas of concern in this study comprise about 421,000 acres in the eastern portion of the County, stretching from the eastern margin of the San Joaquin Valley to the western edge of the Federal forestlands. The watersheds selected as the most critical for this study comprise the Shaver Lake area (about 20,700 acres), the Auberry-Prather area (about 26,200 acres), and the Squaw Valley area (about 49,800 acres).

The following subsections discuss the general physical features of the study area that are important to the availability of groundwater.

2.1 GEOGRAPHY

The study area is located in the central portion of the Sierra Nevada Physiographic Province of California. This portion of the province is characterized by high mountain ridges on the east grading into low foothills on the west. Terrain is varied, with highland areas cut by ancient glaciers, canyons occupied by substantial rivers, forests covering broad uplands, and brush and grasslands covering undulating foothills. Elevations in the study area range from about 400 feet on the west to 6,500 feet on the east.

The area is drained by two major rivers, the San Joaquin River on the north and the Kings River on the south. Major man-made reservoirs within the study area include Shaver Lake and Pine Flat Lake, with Millerton Lake just outside the northwestern boundary of the area.

The study area is primarily rural and much of it is undeveloped and used mostly for rangeland and recreation. Several "Census-designated places" are located within the study area: Auberry in the northwest, Shaver Lake in the northeast, and Squaw Valley in the south (Figure 5). According to the 2000 Census, Auberry had about 2,000 residents, Shaver Lake about 700 residents, and Squaw Valley about 2,700 residents. Additionally, several other communities are located in the study area including Prather, Meadow Lakes, Academy, Marshall Station, Humphreys Station, Tollhouse, Burrough Valley, Dunlap, Pine Ridge, and Alder Springs, as well as several Native American communities including Big Sandy Rancheria, Table Mountain Rancheria, and Cold Springs Rancheria.

2.2 CLIMATE

Mediterranean-type climates dominate eastern Fresno County, with elevation changes dictating temperatures and the amount of precipitation. Summers are hot and dry at the lower elevations, cool and dry in the upper elevations. Most precipitation falls between November and April. Precipitation is a function of elevation in the Sierra Nevada, as moisture-laden clouds moving eastward from the Pacific Ocean are lifted over the mountains, losing their load of water as they go. Snow typically accumulates above 6,000 feet elevation, storing the winter precipitation for late spring runoff.

The range in annual precipitation varies significantly from year to year, with most years substantially higher or lower than the mean. Figure 6 is a precipitation contour map showing average annual precipitation across the study area.

Groundwater availability from bedrock aquifers is highly dependent upon the amount and type of precipitation that has occurred in the current water year and in the recent past. Extended drought periods can severely limit the groundwater available to wells. Cook and others (1999) assessed the frequency of droughts in the central Sierra Nevada using the Palmer Drought Severity Index (DI). The DI for the central Sierra Nevada was developed for the period from 1701 to 1978 (Figure 7). The DI measures the departure of the moisture supply from average. It changes in response to weather conditions that have been abnormally dry or abnormally wet. Negative values indicate dry conditions and positive values indicate wet conditions. Analysis of the DI indicates 10 droughts during the period of record lasting 4 years or longer (Figure 7). Between 1820 and 1978, the DI indicates that a drought of 4 years or longer occurs in the central Sierra Nevada on an average of about once every 20 years. The DI also shows that the period between 4-year droughts has been shorter since about 1825, while they were numerically more severe prior to 1875. In an effort to extend the findings from the DI study beyond 1978, precipitation from the Big Creek Station (latitude 37.21 degrees and longitude 119.24 degrees) for the period from 1950 to 2005 was overlain on the DI plot (Figure 7). The overlapping data for the period from 1950 to 1978 demonstrates the strong correlation between the DI and amount of precipitation. Although the DI is not available after 1978, data from the Big Creek Station indicate another drought period of more than 4 years from 1984 through 1992 (9 years).

Evapotranspiration is the quantity of water lost to the atmosphere by evaporation and transpiration processes. Evaporation includes the amount of water lost to the atmosphere from surface water, soil surfaces, and snow cover. Transpiration is a dynamic process that includes the amount of water needed by living vegetation. The water taken in by vegetation has two pathways; transpiration to the atmosphere and retention in the plant tissue.

The evapotranspiration process is dependent on numerous variables that include net solar radiation, surface water abundance, wind speed, vegetation type and density, soil moisture, and the amount of precipitation. Long-term average annual evapotranspiration values estimated by DWR (1975) range from 1.5 to 1.9 acre-feet per acre (AF/acre or feet) depending on the average annual precipitation, elevation, and vegetation of the area.

2.3 GEOLOGY

The geology of the study area is dominated by the bedrock complex of the Sierra Nevada (Figure 8). The bedrock complex comprises primarily metamorphosed sedimentary and volcanic rocks that have been intruded from below by intrusive igneous (granitic) rocks (Macdonald, 1941). These granitic rocks have been uncovered largely by erosion, with only a few areas of metamorphic rocks remaining within Fresno County, primarily as caps or roof pendants over the underlying granitic rocks (Macdonald, 1941).

The oldest metamorphic rocks are metasediments, derived from thick sequences of sedimentary rocks that have been altered primarily to mica schists with lesser amounts of quartzites and marbles. Metavolcanic rocks overlie and are interbedded with the metasediments. Metavolcanics comprise intermediate to basic volcanic rocks that have been metamorphosed to amphibolites and schists. The metamorphic rocks have been intensely fractured and in some places folded by regional metamorphism (created by large scale mountain-building forces) and contact metamorphism (created by the intense heat of the intruding granitic plutons) (Macdonald, 1941).

Several episodes of plutonic intrusion are recorded in the geologic record. The earliest appears to be during the Jurassic period with most of the granitic batholith emplaced during the Cretaceous period (Chen and Tilton, 1982). The intrusive rocks in the western foothills of the Sierra Nevada are composed primarily of quartz diorites with some areas of more basic rocks such as gabbro and more silicic rocks such as granodiorite. To the east of the western foothills, the intrusive rocks are more silicic and composed primarily of granodiorite and quartz monzonite (Moore, 1959).

Tertiary sediments are exposed beneath Pliocene volcanic rocks (primarily basalt) that cap remnant ridges north of Little Dry Creek in the northwestern part of the study area.

Uplift of the Sierra Nevada was prominent during the Pliocene (Jones and others, 2004). This uplift is generally considered to represent a westward tilting of the Sierran block, rising along the Sierran fault, which runs along the eastern front of the Sierra Nevada. Emplacement of the granitic batholith, uplift of the Sierran block, and the subsequent unloading of the overlying metamorphic rocks by erosion produced significant fracturing in the granitic bedrock.

Erosional episodes, brought about by uplift and punctuated by wetter periods of the Pleistocene era, have given rise to alluvial deposits, which occupy the lower portions of stream valleys and extend outward into the San Joaquin Valley. In the study area, these alluvial deposits are generally only a few tens of feet thick.

The bedrock formations in the study area exhibit various degrees of weathering. Weathering is carried out by a combination of physical and chemical processes, which are enhanced by the degree of fracturing in the bedrock. Some exposures are unweathered, with fresh crystalline faces exposed. Others are highly weathered, having been reduced to grus or decomposed granite that may range up to several tens of feet thick.

Soil development in the area is generally minimal, except in meadows where 60 to 70 inches of soil may be present. Colluvial deposits, which are the result of landslide and other mass wasting processes, are limited in extent.

2.4 HYDROLOGY

The water resources of the area include both surface water and groundwater. Surface water is routed through increasingly larger streams and rivers as it travels downstream. A number of reservoirs have been built on major drainages to store surface water. Groundwater is stored primarily in bedrock aquifers beneath the study area and is recharged primarily by local precipitation and surface water flows.

2.4.1 Surface Water

Surface drainage from the study area is carried out by two major river systems, the San Joaquin River and the Kings River. The San Joaquin River traverses the northern boundary of the study area, and its tributaries drain the northern half of the area. The significant tributaries that enter the San Joaquin River from the study area include Big Sandy Creek, Jose Creek, Little Dry Creek, and Stevenson Creek. Flow from Stevenson Creek is regulated below Shaver Lake.

The Kings River splits the northern and southern halves of the study area, and its tributaries drain primarily the southern half. Significant tributaries that enter the Kings River from the study area include Mill Creek and Hughes Creek.

Stream gage data for rivers and streams throughout the country are available on the United States Geological Survey (USGS) website (http://nwis.waterdata.usgs.gov). For each stream gage site, the information available includes location, drainage area (in square miles), and the annual mean streamflow (in cubic feet per second) for the period of record. Only two USGS stream gage sites were found within the three study areas and both are located on Big Sandy

Creek near Auberry. The periods of record for the Big Sandy Creek gages were only 2 and 4 years.

Limited stream gage data were also available for two small watersheds on Musick Creek near Shaver Lake (Schmidt, 1977; Strahm, 1980). Stream flows at these sites were measured from October 1973 through May 1980 by DWR and Fresno County.

2.4.2 Groundwater

The foothill and mountain areas of eastern Fresno County are underlain primarily by bedrock, with minor amounts of soil and unconsolidated alluvial material within meadows, valleys, and other small drainages. The bedrock is chiefly crystalline in nature, comprising granitic to ultrabasic intrusive rocks and metamorphosed volcanic and sedimentary rocks. The primary groundwater reservoir is fractured bedrock, with minor amounts of groundwater stored in the alluvial materials.

Groundwater recharge occurs as infiltration of precipitation and surface runoff, primarily in the uplands where the significant elevation changes increase the amount of precipitation that falls. Groundwater discharge occurs as spring flow, streamflow, evapotranspiration by plants, and withdrawal by wells. Because groundwater recharge is at least partially dependent on infiltration of surface water, an increase in groundwater recharge may reduce the amount of runoff. An increase in groundwater recharge may also reduce the amount of water available to plants (i.e., evapotranspiration) by altering runoff patterns. Wells historically have been sparse in the study area, as land use was limited to recreation, logging, open range, minor agriculture, and widely-spaced homesteads and small housing developments.

Groundwater in the study area is stored primarily in two types of underground reservoirs or aquifers – granular porous media and fractured bedrock. The granular porous media are common to valley areas, where alluvium and soils have accumulated and become saturated. They have 3-dimensionally interconnected pores that can store relatively large amounts of water and can subsequently yield groundwater to wells, springs, and streams. These alluvial aquifers are of limited extent and therefore of limited importance in the study area.

The second type of aquifer, fractured bedrock, is extensive in the study area. The degree of fracturing within the bedrock is variable, ranging from areas with few widely-spaced fractures, to areas with a high density of fractures and joints. The amount of water that can be stored in fractures is dependent upon the size of the fracture opening, the length of the fracture, and the orientation of the fracture (horizontal to vertical). The amount of water that can be recovered from a fractured bedrock aquifer is dependent upon the amount of water stored in the fractures, the degree of interconnection of those fractures, and the connection of the fractures to a viable recharge source. In the study area, the fracture distribution and groundwater recovery capacity of the bedrock aquifer is extremely variable, with reported yields from 0 (dry well) to several gallons per minute (gpm) to as much as hundreds of gpm. Because of its wide-spread distribution, the bedrock aquifer is the most important in the study area.

Where the bedrock has been extensively weathered, it may act more like a granular porous media than a fracture-flow system. In areas where this weathered bedrock is near a recharge source, it may provide usable quantities of water to wells. The weathered bedrock is an important aquifer in parts of the Shaver Lake area.

2.5 LAND USE

Land use within the foothill and mountain areas of eastern Fresno County is diverse and changes based on elevation. In the foothill areas, developed land is used primarily for rural residential on lots that vary in size from 2 to 20 acres. Cattle grazing is the predominant land use in undeveloped areas. Limited commercial development has occurred and typically comprises small retail outlets that support local residents and tourists. Major industrial development was not identified except for a lumber mill and associated co-generation plant near Auberry that are no longer in operation.

3.0 SHAVER LAKE AREA

The Shaver Lake area is located on the western slope of the Sierra Nevada, about 40 miles northeast of downtown Fresno. The Shaver Lake area is about 6 miles long and 6 miles wide and covers about 20,700 acres (Figure 2). This area includes portions of Sections 1-12, 14-18, 20-29, 32-36, Township (T) 10 South (S), Range (R) 24 East (E), Mount Diablo Baseline and Meridian (MDB&M), and Sections 26, 33-36, T9S, R24E, MDB&M.

Understanding the interaction between the groundwater and the environment is dependent on the historical data of the region, including natural and anthropogenic factors. Geography, hydrology, land use, and water use were evaluated and compared to identify potential relationships, and various factors were quantified for input to the water balance.

3.1 GEOGRAPHY

The Shaver Lake area is located in the northeast corner of the study area. The Shaver Lake area is higher in elevation, has more precipitation, and has more tree cover than the other areas studied. The principal geographical features of interest for this study include watersheds, topography, vegetation, and precipitation.

3.1.1 Boundaries

A water-balance approach was used to evaluate the availability of groundwater resources in the foothill and mountain areas of eastern Fresno County as it relates to current and future land-use development. This approach required the quantification of data within known watersheds. The Shaver Lake area is contained within three subwatersheds: Musick Creek, North Fork Sycamore Creek, and a small portion of Bald Mill Creek (Figure 9).

Development in the Shaver Lake area has occurred primarily within community clusters. These communities have grown over the years and have projections for future expansion. It was critical for this study to select boundaries that allowed for a water balance analysis and also encompassed development areas in order to initiate discussion of growth trends and groundwater sustainability. The boundaries selected meet both of these needs (Figure 2).

3.1.2 Topography

The Shaver Lake area is in the mid-range elevation zone of the Sierra Nevada, above what are typically considered foothill areas. The elevation of the Shaver Lake area ranges from approximately 4,000 to 6,000 feet MSL, and the topography is characterized by moderately to steeply sloped granitic ridges, thin soils, and shallow stream-cut valleys. Erosion has created basins and canyons that define distinct drainage areas.

Flat terrain, which is more favorable for land planning and development, is present in some areas of the Shaver Lake area. An extensive, even-terrained basin extends almost the entire lateral distance of the Musick Creek subwatershed. The community clusters in this crescent shaped basin include Meadow Lakes, Mile High, Sierra Cedars, and Shaver Lake Heights (Figure 2).

3.1.3 Vegetation

Much of the Shaver Lake area is located in the Sierra National Forest. This area is primarily yellow pine forest and consists of a diverse range of conifer trees that are typical of middle elevations. A small amount of the area is covered by foothill woodland vegetation that includes a variety of hardwoods, shrubs, and grasses. At the lowest elevations, minimal areas are covered by chaparral plants, which include a variety of brushes.

3.2 HYDROLOGY

The major hydrologic pathways in the Shaver Lake area include precipitation, runoff into local streams, evapotranspiration, and the groundwater system.

3.2.1 Precipitation

The primary source of groundwater recharge for the western foothills and mountain areas is precipitation. Precipitation in the Shaver Lake area falls as either rain or snow with the percentage of snow increasing with elevation. Long-term estimates of precipitation for the Shaver Lake area were based on data collected from the gage at Big Creek Station. The gage, known as ‘Big Creek 1,’ is located about 5 miles northeast of Shaver Lake at an elevation of 4,878 feet MSL. Big Creek 1 has 53 years of monthly precipitation data for the period of 1950 to 2005.

The average annual precipitation for Big Creek 1 is 33 inches. For the period of record, annual precipitation was above average 37 percent of the time (maximum annual precipitation of 63.4 inches) and below average 62 percent of the time (minimum annual precipitation of 13.6 inches). Based on historical data, the typical dry season is from June through September, with average monthly precipitation below 1 inch. August is the driest month with an average monthly precipitation of 0.14 inch. The wet season runs from November through April, with an average monthly precipitation close to 5 inches per month. Approximately 88 percent of annual precipitation falls during the wet season, with January being the wettest month, averaging 6.34 inches.

3.2.2 Surface Water

The Shaver Lake area straddles the drainage divide between the San Joaquin River and Kings River systems (Figure 9). The Musick Creek subwatershed (about 9,494 acres) is drained by Musick Creek, which flows northwest to the San Joaquin River. The southeast portion of the Bald Mill Creek subwatershed (about 1,337 acres) is included in the Shaver Lake area and is also part of the San Joaquin River system.

The southern part of the Shaver Lake area consists of the North Fork Sycamore Creek subwatershed, which covers an area of about 9,850 acres. This subwatershed is drained by the north fork of Sycamore Creek, which flows southeast to the Kings River.

3.2.3 Evapotranspiration

Evapotranspiration is a significant water loss variable in the water balance. In the Shaver Lake area, evapotranspiration is limited by the availability of soil moisture and will vary from year to year depending on precipitation. A previous hydrogeologic study in the Musick Creek drainage (Schmidt, 1977) estimated evapotranspiration to be 22 and 23 inches (1.8 and 1.9 feet) per year for the 2 years of the study. A study for the Oakhurst area (Schmidt, 2005) estimated annual evapotranspiration ranging from 1.25 to 1.67 feet. These values match well with the long-term average values published by DWR (1.5 to 1.9 feet). Therefore, values between 1.5 and 1.8 feet per year were assigned to the various subwatersheds based on their elevation and average precipitation (Table 1).

3.2.4 Hydrogeology

Groundwater in the Shaver Lake area occurs in fractured bedrock, weathered bedrock, and alluvial material. The fractured bedrock and weathered bedrock provide the vast majority of groundwater to wells. Alluvial material is of limited lateral and vertical extent and may be a source of groundwater in localized areas. The weathered bedrock is an agglomeration of various stages of weathered granitic rock ranging from sand-sized to clay-sized particles. Soils formed on the bedrock surface are thicker in areas of lesser slope, such as meadows, and thinner in areas of steeper slopes. Beneath the weathered bedrock lies more competent bedrock that has a significant number of interconnected fractures and joints, which often yield usable quantities of water to wells. The degree of fracturing appears to decrease with depth, and yields from wells in deeper competent bedrock are generally substantially lower than shallower wells (Figure 10).

The water-bearing materials in the Shaver Lake area have limited groundwater storage capacity with recharge dependent on precipitation. Typically, fractured bedrock has a porosity on the order of 1 percent of the rock volume. Weathered bedrock and alluvial materials typically have a higher porosity and will yield a greater amount of water per unit volume of aquifer. Recharge occurs primarily when surface water in the form of rainfall, snowmelt, or runoff percolates into the ground refilling pore spaces and fractures that are dewatered by evapotranspiration, springflow, or groundwater pumping. The actual amount of recharge has not been determined, but will vary both spatially and temporally. Primary recharge areas will be those that have lesser slopes (less runoff and more contact time for soil/water interaction), more porous surfaces (granular material, such as soils and weathered bedrock or highly fractured bedrock surfaces), and greater accumulation of snow (to allow more time for seepage into underlying material). Recharge will also vary depending upon how much surface water is available, what type of precipitation (rainfall or snow) falls, and the temporal distribution of the precipitation.

The capability to withdraw groundwater in the dry season is dependent on storage within the water-bearing materials and the amount of recharge during the previous wet season. A prolonged drought may reduce the amount of groundwater in storage, which could lead to declining well yields and falling water levels.

3.3 LAND USE AND DEVELOPMENT

The demand for water is dependent on the type of land use and amount of development. Water use projections are based on current and projected development. This section discusses the land use, population, building permits, well permits, and development trends for the Shaver Lake area.

3.3.1 Land Use

Development in the Shaver Lake area consists primarily of low-density and rural residential land uses with extensive conservation areas that include land set aside within developments as well as land within the Sierra National Forest. The residential areas are supported by small amounts of commercial land uses, with no known manufacturing or industrial land uses within the area.

3.3.2 Population

Based on water-connection information from community service districts (CSDs) and household count information, there are an estimated 2,136 residences in the Shaver Lake area. Residences in the higher elevation portions of the area (primarily above the top of the four-lane section of State Highway 168 and nearer Shaver Lake) tend to be subject to seasonal use. Residences in the lower elevations of the area tend to be occupied permanently. The seasonal residences are generally vacation and rental homes occupied primarily during the summer months and holiday weekends. The Sewer and Water Master Plan for the Shaver Lake are (Master Plan) prepared by John Carollo Engineers and amended by Fresno County (Carrollo,

1985) indicated that approximately 43 percent of the residences in the vicinity of Shaver Lake were permanently occupied. Data from the 2000 Census indicates that 16 percent of residences in and near Shaver Lake were occupied on a full-time basis. One explanation for the discrepancy between the 2000 Census numbers and the numbers reported in the Master Plan is that during the time that numbers for the Master Plan were collected, extensive construction was occurring associated with the Helm hydroelectric project east of Shaver Lake, and many of the construction workers were living in the vicinity of Shaver Lake. Because of the discrepancy between the permanent occupancy rates estimated in the Master Plan (Carollo, 1985) and the 2000 Census data, an intermediate permanent occupancy rate of 25 percent has been used for estimation purposes.

3.3.3 Building Permits

Figure 11 is a map showing parcels with building permits in the Shaver Lake area. The permits are clustered in the Shaver Lake vicinity (WWD 41), Shaver Springs, Alder Springs, and Meadow Lakes areas. The building permit data were used to evaluate the amount of residential development and estimate the residential water use. Permit issuance dates were unavailable, preventing evaluation of trends in permitted development.

3.3.4 Well Permits

Well driller's logs were used to identify trends in the number and depth of wells constructed in the area. Well logs for the Shaver Lake area were identified using Assessors Parcel Number (APN); latitude and longitude; address; and Township, Range, and Section. Some well logs did not have any location identifiers and therefore could not be used in the analysis. A total of 329 well logs were identified as within the Shaver Lake area. The peak years for drilling wells in the Shaver Lake area were 1979, 1992, and 1999 with more than 20 wells installed each of those years. From 1971 to 2005, an average of 9 wells were drilled per year (Figure 12). Based on available data, there appears to be an increasing trend in the number of wells drilled per year.

3.3.5 Development Trends

Development trends were estimated from the 1990 and 2000 Census data and analysis of the connection history in WWD 41. Census data were used to identify the number of housing units (houses, apartments, mobile home or trailer park units, a group of rooms, or a single room) occupied as separate living quarters. The general development trends were estimated from the average annual percentage increase in housing units from 1990 to 2000. The percentage increase in housing units for the Shaver Lake Census Tract for 1990 to 2000 was 18 percent, which is approximately 1.67 percent on an annual basis.

The connection history for WWD 41 was evaluated for the period from July 1993 to July 2005 (Table 2). Based on Fresno County records, the connections over that period increased from 407 to 768, an increase of approximately 63 percent in 12 years (between 4 and 5 percent annually). This indicated that development in the CSDs increases at a higher rate than non-CSD areas.

3.4 WATER DEMANDS

Current water demand in the Shaver Lake area is supplied by groundwater. The amount of available water, by subwatershed, was estimated to assess whether the groundwater supply is sufficient to meet current and future water demands.

Water demands in the Shaver Lake area were estimated for each subwatershed and for the Shaver Lake Ultimate Master Plan Service Area (SLUMPSA). The three subwatersheds in the Shaver Lake Area include Bald Mill Creek, Musick Creek, and North Fork Sycamore Creek (Figure 9). Water demand in the watersheds varied based on the amount of development and the type of water demand. Bald Mill Creek subwatershed covers the western-most portion of the area and includes rural-residential areas such as Meadow Lakes. The Musick Creek subwatershed covers the Shaver Lake vicinity, Alder Springs, and WWD 41. The North Fork Sycamore subwatershed covers the southern half of the area.

Details of how the estimated water demands were calculated are presented in the Current and Projected Water Demand Analysis Technical Memorandum (Appendix A). Current and projected water demands are discussed in the following subsections.

3.4.1 Current Water Demands

Four different water demand types were employed to estimate current water usage in the Shaver Lake area: CSD/mobile home district (MHD), household count, area factor, and no demand. The use of the selected water demand method for various areas was based on land use and the types of data available for that area. Figure 13 shows where each water demand type was employed in the Shaver Lake area. The estimated water demand in the Shaver Lake area is 352 AFY (Table 3).

Household water demand in the lower part (below an elevation of 4,800 feet MSL) of the Shaver Lake area has been estimated at a higher rate that the upper part of the area. This is because outdoor landscaping being more prevalent in the lower areas and a greater percentage of the residences being occupied full time. These differences are discussed in more detail in the Current and Projected Water Demand Analysis Technical Memorandum (Appendix A).

The water demand of the SLUMPSA within Township 10 from the Master Plan prepared by Carollo and amended by Fresno County (1985) was also estimated. This portion of the ultimate service area encompasses approximately 3,578 acres, and its boundaries are shown on Figure 14. The Master Plan estimated that sufficient groundwater was available to serve 2,000 equivalent dwelling units (EDUs or residential lots as used in this document) based on 100 gallons per capita per day (GPCD) use and an average per capita household of 2.55 persons, or approximately 93,100 gallons per year (0.29 AFY) per household. Currently, there are an estimated 995 households in the SLUMPSA with an average annual demand of 163 AFY.

3.4.2 Projected Water Demands

Water demand in the Shaver Lake area is primarily due to domestic water usage, and it is assumed that increased water demand will be due primarily to projected growth in housing units. Water demand projections assume that household densities and per capita usage will remain the same as current usage. In addition, water demand assuming full time occupancy of residences at full buildout has been projected to present a “maximum demand scenario.” Projected water demands for nonresidential usage were increased in proportion to the change in residential water usage. The projected water demands in the Shaver Lake area were estimated for three different scenarios:

- annual water demand increases based on the Census data growth rates,
- water demand at full buildout of existing permitted parcels with a cap of 2,000 lots in the SLUMPSA, and
- full-time occupancy of residences at full buildout of permitted parcels.

Projected water demand based on Census data utilized the observed growth rates between the 1990 and 2000 Census (18 percent). Table 3 shows the projected water demands in 2025 assuming an 18 percent growth rate every 10 years. The projected water demand based on this scenario is 490 AFY.

Projected water demand at buildout of existing permitted parcels utilized building permit data supplied by Fresno County. Buildout of permitted parcels would increase the number of households from the current 2,136 to 2,694. The projected water demand at buildout of existing permitted parcels is estimated at 475 AFY (Table 3).

The estimated projected water demand in the Shaver Lake Area at full buildout of permitted parcels and assumed full-time occupancy is 1,087 AFY (Table 3).

Assuming similar occupancy characteristics and water demands as currently exist in the Shaver Lake vicinity, the projected water demand for the 2,000 households in the SLUMPSA would be 325 AFY.

3.5 WATER SUPPLY EVALUATION

The water supply for the Shaver Lake area has been evaluated using well log data and conceptual water balances. The status of the water supply in WWD 41 has also been evaluated using available information.

3.5.1 Evaluation of Well Log Data

Different parameters of the well log database were analyzed for the Shaver Lake area to assist in identifying potential trends. It is expected that more wells exist in the Shaver Lake area than the available records indicate. However, the available well driller's logs that have been inventoried for this study comprise a significant portion of the wells in the area and are believed to be representative of the wells in the Shaver Lake area.

Among the parameters evaluated was mean well depth of new wells over time. Typically, in areas of groundwater overdraft, new wells are installed to greater depths than previous wells as shallow zones become dewatered or yield less water. Figure 15 is a graph of the new well depths over time using information in the well log database. This figure shows an increase in average new well depths over time.

Average depths of wells drilled per year and annual precipitation were evaluated to identify if a correlation exists between well depth and precipitation. A slight correlation may be evident between well depth and the amount of annual precipitation in the Shaver Lake area (Figure 16). The average well depth appears to decrease during wet periods in the early 1980s and 1995. Conversely, during dry periods there appears to be an increase in well depths.

3.5.2 Long-Term Maximum Renewable Groundwater Supply

The long-term maximum renewable groundwater supply was evaluated for the Musick Creek and North Fork Sycamore Creek subwatersheds and the portion of the Bald Mill Creek subwatershed within the Shaver Lake area using a conceptual water-balance approach. The long-term maximum renewable groundwater supply calculations are presented in Table 1. Details of the long-term maximum renewable groundwater calculations are presented in the Water Balance Technical Memorandum (Appendix B).

The maximum renewable groundwater supply for each watershed, based on long-term averages, is equal to the total amount of water that falls as precipitation minus the amount of water that leaves the subwatershed as runoff and evapotranspiration. It was assumed that the amount of subsurface outflow is equal to the amount of subsurface inflow. It should also be noted that only a portion of the maximum renewable groundwater supply is available for extraction by water supply wells. Insufficient information is available to estimate how much of the maximum renewable groundwater could be developed.

Using precipitation and stream flow data, the runoff coefficient calculated for the Shaver Lake area was 0.51, which means that 51 percent of the precipitation that falls within the basin is expected to runoff over the long term (Table 1). This value compares well with the runoff coefficient calculated by Markovic (1967) for the Kings River watershed (0.49).

An evapotranspiration value of 1.8 feet was assigned to the Musick Creek subwatershed, and a value of 1.7 feet was assigned to both the Bald Mill Creek and North Fork Sycamore Creek subwatersheds. The Bald Mill Creek and North Fork Sycamore Creek subwatersheds were assigned lower evapotranspiration values because they have a lower average annual precipitation than the Musick Creek subwatershed.

In the Shaver Lake area, the calculated renewable groundwater supply values were negative, ranging from -0.39 feet per year in the Bald Mill Creek and North Fork Sycamore Creek subwatersheds to -0.37 feet per year in the Musick Creek subwatershed (Table 1). A negative number suggests that, on an average annual basis, water is being removed from groundwater storage in greater amounts than it is being replenished in order to support evapotranspiration and runoff. This would mean that under natural conditions, groundwater levels should be declining, and no renewable groundwater supply would be available for development in that watershed. However, that conclusion is not supported by observed groundwater levels within the study area, which, based on limited data, do not appear to be declining on a long-term basis.

Given the available data, it is unlikely that a better number could be derived for the renewable groundwater supply. The precipitation data for the subwatersheds are fairly reliable, and any reasonable adjustments to precipitation values are unlikely to yield significant differences in total volume of water available to the watershed. The actual evapotranspiration numbers may be more or less than those estimated; however, the estimates used are the best available numbers at this time. The negative numbers generated for renewable groundwater supply may be due to the high variability in annual runoff coefficients (ranging from 0.1 to 0.9 in the Musick Creek watershed), which reflect the dependency of runoff in the higher elevations on the amount of precipitation that falls, type of precipitation that falls (snow or rain), the time of year the precipitation occurs, and the antecedent soil moisture conditions in the subwatershed. Figure 17 shows that as precipitation increases so does the runoff coefficient. The amount of groundwater in storage is small compared to the total amount of water that falls on the subwatershed. Thus, when recharge conditions are optimum (e.g., good snow pack, slow snowmelt, and low soil-moisture conditions), sufficient water may be available to fully replenish the depletion of groundwater storage created during dry periods. In this type of a watershed environment, use of an average runoff coefficient may be inadequate to assess the long-term renewable groundwater supply. However, the negative numbers estimated for the renewable groundwater supply point out the delicate balance between recharge and discharge in this environment and emphasize the need for more detailed, local-scale data collection and evaluation.

Water budgets, based on detailed data, are needed to refine the long-term maximum renewable groundwater supply estimates. It is likely that at least 3 to 5 years of data are needed to provide significant refinement. The additional data need to be collected through a period of time that allows incorporation of at least 1 year with above average precipitation and 2 consecutive years of below average precipitation.

3.5.3 Status of Groundwater Development in Waterworks District 41

In the Shaver Lake area, new development will, in the short term, be supplied by groundwater resources. The availability and sustainability of these groundwater resources is limited by a variety of factors. This section will evaluate the existing groundwater supply system in WWD 41 to assess whether it is adequate to supply current and future demands.

It is important that new groundwater supplies intended for proposed development are both adequate and sustainable for the stated purposes. Currently, in the Shaver Lake area, an applicant is required to perform a 30-day pumping test on any well proposed for incorporation into WWD 41. These tests must be undertaken during the time of the year when the groundwater system is most stressed (generally September or October) and must be run maintaining a constant drawdown (generally just above the pump). The drawdown and yield must be recorded on a regular basis and yields generally must be adjusted periodically to keep the water level above the pump. The yield is plotted against the logarithm of time, with time on the x-axis. A trend line is fitted through the final points on the graph and the line is projected to 120 days. The projected yield at 120 days is reduced by a safety factor of 25 percent to arrive at the sustainable yield to be credited to the development. If the well is near a stream, the projected 120-day yield is reduced by a safety factor of 50 percent.

This method of determining a sustainable yield for incorporation of a well into WWD 41 has been developed empirically in recognition of the limited availability of groundwater resources in the mountainous bedrock areas of Fresno County. A question remains, however, whether this methodology is appropriate for predicting the adequacy and sustainability of the groundwater supply. Some perspective is gained by reviewing the factors that affect the yield and sustainability of groundwater in the Shaver Lake area.

As discussed in Section 3.2.4, groundwater occurs in several environments in the Shaver Lake area. The uppermost is the weathered bedrock, an agglomeration of various stages of weathered granitic rock ranging from sand-sized particles to clay-sized particles. Soils have developed on this weathered bedrock surface, with thicker soils in the meadow areas and thinner soils on the steeper slopes. Historically, the most productive wells have been the radial wells drilled in the weathered bedrock. Beneath the weathered bedrock lies more competent bedrock that has a significant number of interconnected fractures and joints, which often yield usable quantities of water to wells. The degree of fracturing appears to decrease with depth, and yields from wells in deeper competent bedrock are generally substantially lower than shallower wells. Thus, the stratigraphy of the formations beneath the area plays a significant role in water availability.

The type of well plays a significant role in groundwater production. Radial wells, which have central pumping shafts from which multiple horizontal casings extend into the weathered bedrock, are efficient collectors of groundwater, substantially increasing the effective radius of the well. Vertical wells in highly fractured bedrock rely on intercepting significant numbers of interconnected and saturated fractures to produce a sufficient yield. Deeper portions of the bedrock generally have fewer of these saturated interconnected fractures, and yields from wells completed in these deeper zones are consequently less than in wells completed in shallower zones.

The Shaver Lake area is also within an active recharge area. Primary recharge areas will be those that have lesser slopes (less runoff and more contact time for soil/water interaction), have more porous surfaces (granular material, such as soils and weathered bedrock or highly fractured bedrock surfaces), and have greater accumulation of snow (to allow more time for seepage into underlying material). Recharge will also vary depending upon how much surface water is available and the distribution and type of available precipitation (rainfall or snow).

Although water balances can provide a general estimate of how much recharge occurs, the numbers for precipitation, runoff, and evapotranspiration are so large that even a small uncertainty in any one of these parameters overwhelms the amount of groundwater recharge that likely infiltrates annually. This is evident in the water balance developed for the Shaver Lake area, which indicates a negative number for the annual average renewable groundwater supply for the area (Table 1). A better measure of whether recharge is sufficient to maintain the groundwater development is the trend in groundwater levels in the area. Table 4 shows that water levels for many of the wells in WWD 41 during 2005 were similar to those when the wells were first drilled. For example, well R-6, which was installed in 1970, has a number of water level measurements recorded from 1973-1976 (Schmidt, 1977), prior to substantial production pumpage from the well. Water levels during the period ranged from about 8 to 20 feet deep. Although production pumpage from R-6 now occurs on a regular basis, the hydrograph shows that in April 2005, the water level was about 9 feet deep, near the same level as in 1973 (Table 4). Well R-3 is similar, with shallowest water levels in 1973 of about 4.5 feet deep and water level in April 2005 of 3.8 feet deep. Table 2 shows that annual water production during the last 4 years (2001 through 2004) has averaged about 35.3 million gallons or about 108 AFY. Based on the comparison of water levels from the early 1970s to 2005, the WWD 41 area appears to be able to sustain the current magnitude of groundwater withdrawal.

As of July 1, 2005, 768 household water connections were recorded in WWD 41 (Table 2). For this analysis, a household water connection was considered to be the same as an EDU. The California Department of Health Services (DHS) requires that WWD 41 have enough pumping capacity to supply 0.3 gpm per EDU for lot sizes to 36,000 square feet (about 0.8 acres) and 0.5 gpm per EDU for lot sizes greater than 36,000 square feet. Additionally, the DHS requires WWD 41 to be able to meet the peak daily demand with direct water supply (no storage). In 2004, the peak daily water demand occurred over the July 4 holiday, averaging about 0.28 gpm per EDU, or about 192 gpm average usage for the 684 EDUs then connected (Table 5). Using 0.3 gpm per EDU (because both the peak daily demand and required pumping capacity are nearly the same) for 768 EDUs, a minimum production capacity of 230 gpm is needed. Table 4 shows that the Fall 2004, 10-day test results required by the DHS indicated a combined yield from the 12 active wells of 118 gpm, approximately 51 percent of the pumping capacity required by DHS. It appears that WWD 41 was able to meet the peak demands by utilizing water stored in the various surface tanks located throughout the area. This significant discrepancy between peak demand and rated pumping capacity needs to be addressed prior to the creation of additional lots within WWD 41. Because this discrepancy could widen if approved lots are connected without increasing the currently available water supply, the County should incrementally increase water production in proportion to anticipated new connections.

The source of this discrepancy appears to be multifaceted. Firstly, many of the lots developed early on were approved on the basis of the applicant providing one or more wells that yielded 0.177 gpm for each proposed lot (based on the Master Plan, Carrollo, 1985). Given the current 768 connections, that would be a total production capacity of only 136 gpm, which will not support the 230 gpm peak daily demand required by the DHS.

Secondly, the basis for rating wells has evolved with time. Early on, some of the pumping tests were done for relatively short periods of time, ranging from 3 to 30 days duration, with rated yields based on average pumping rates as opposed to final pumping rates. Subsequent testing has shown that wells in this area have substantially higher yields at early times, and if long-term yields are estimated from averages for short-duration tests, the yields will be overestimated. This is demonstrated on Table 4 by the initial yield ratings for 8 of the 12 current production wells, which totaled 175 gpm (Strahm, 1980). Those same wells are currently rated using the 2004 10-day State yields at a total of 78.4 gpm (Table 4), a decrease of approximately 55 percent. Additionally, many of the wells appear to encounter negative boundary conditions, significantly increasing the rate of decline in pumping yield after a certain period of time (Figures 18 and 19). These increased rates of decline typically become apparent after the currently-required 30 days of pumping and may be associated with interference effects from other wells or dewatering of upper fractures, which may supply a substantial portion of the early-time discharge to the wells. Wells with such boundary conditions that have been rated on short-term pumping tests will over-estimate the long-term sustainable yield of the well. This brings into question the validity of the State-required 10-day pumping test yields. Table 4 shows that for nearly all wells, both the historical and 2004 yield tests have lower projected (120-day) yields than the State-required tests, with total yields for the 12 wells lower by 14 to 20 percent. In looking back at the pumping tests for a number of the wells, it is clear that at longer pumping times, the projected 120-day pumping rates begin to converge (Figures 18 through 23). This would also indicate that long-term (90 days or more) pumping tests are more accurate in predicting the sustainable, season-long (120-day) pumping rates of the production wells.

Thirdly, the production wells are located in bedrock that has little groundwater storage capacity. During extended drought conditions, water levels will decline and consequently, well yields can be expected to decline below their initial rated capacity, unless the wells were rated during a similar drought period. The well tests that are generally available for the WWD 41 wells include 1976 and 1977 (substantially pre-development time), 1997 (coming off several very wet winters), and 2001 through 2004 (a time of near to slightly below normal precipitation). No well tests or water level data are available for the severe drought periods of 1984 through 1991 to compare how well yields held up to drought conditions; therefore, the well tests that are currently available may not provide a good indication of what the yield capacities will be under significantly drought-stressed conditions.

The fact that few wells have been added to the production system since 1981 (78 percent of 2004 production capacity is from wells drilled between 1970 and 1981) may indicate that most of the favorable locations for groundwater production have been exploited. However, Mr. Dirk Poeschel, who represents several developers in the area, has indicated that additional viable production wells are available to incorporate into the WWD 41 system (personal communication, Dirk Poeschel, 2005). If those wells have sustainable production capacity, their incorporation will provide some measure of relief to the currently underrated system.

The seasonal character of the occupancy in WWD 41, along with the limited groundwater resource, would point to the need for greater storage capacity within the water system. Additionally, the current system is operated on a pressure-demand basis wherein when the pressure in a supply tank drops, all wells within that system, regardless of their production capability, come on until the pressure is restored. The production system may benefit by better utilization of the higher capacity wells, especially the radial wells, which have the potential for greater pumping rates during the early part of the year when recharge is actively occurring. Use of these wells may induce additional recharge by lowering near-surface water tables and allowing more seepage of water into the ground that otherwise would be rejected and flow away as surface runoff.

The current water supply in WWD 41 has been approved based on supplying 1,298 EDUs, of which 768 EDUs existed as of July 1, 2005. The 12 production wells currently in operation in WWD 41 can sustain a rated yield of about 95 gpm based on the 2004 pump test data projected to 120-days (Table 4). As discussed earlier, the combined pumping yields from the production wells (95 to 118 gpm, depending upon the type of analysis applied) cannot meet the DHS-required peak demand of 230 gpm for the currently connected 768 EDUs, much less the 390 gpm (0.3 gpm/EDU times 1,298 EDUs) required for the current number of recorded lots. In addition, the average annual delivery rate from the current system, based on data from 2001 to 2004, is 0.11 gpm per EDU (Table 2). At 0.11 gpm per EDU, 1,298 EDUs would require an average annual pumping rate of 143 gpm, which is 50 percent greater than can be sustained by the current production system, according to the 120-day projected yields from 2004 (Table 4).

3.5.4 Alternative Water Supplies

The Shaver Lake area relies solely on groundwater for the domestic water supply. Potential alternative water supplies include additional development of groundwater and use of surface water and recycled wastewater.

Additional Development of Groundwater

It is possible that additional groundwater could be developed in the Shaver Lake area, but further data collection and analysis would be required to verify the long-term available groundwater supply and locations within the watershed where it can be developed. Based on the estimates of projected water demands and preliminary water budgets, site-specific hydrogeologic studies should be conducted prior to further groundwater development.

Surface Water

An alternative to groundwater development is the use of treated surface water for domestic purposes. The Shaver Lake area watersheds drain to the San Joaquin River or Kings River. All of the rivers and streams in these drainages are fully appropriated, and access to existing water rights on these rivers and streams would have to be obtained in order to divert water for treatment and delivery to households in the area.

Currently, no surface water supplies are developed in the Shaver Lake area, but Fresno County has an entitlement to 3,000 AF of Central Valley Project (CVP) water from the California Aqueduct. Through a series of agreements between the County, DWR, the U.S. Bureau of Reclamation (USBR), and several other water agencies in Fresno, Kern, and Tulare counties (Cross Valley Canal Exchange Agreement), Fresno County is entitled to annual delivery of a maximum 3,278 AF of CVP water from the Friant-Kern Division of the CVP. More than half of the County CVP entitlement is already committed to existing developments, such as County Waterworks District No. 38 (Sky Harbor), County Service Area (CSA) No. 34-A (Brighton Crest), and for future development in the Millerton New Town area. The remaining 1,478 AF of water is reserved for Shaver Lake area use. Waterworks District No. 41, Wildflower Village, and the Strahm Family Partnership have reserved the rights to the 1,478 AF of CVP water in the amounts of 845.7, 87.0, and 545.3 AF, respectively, which could be obtained from Shaver Lake if certain issues are resolved and additional agreements are developed.

The USBR permit with the State Water Resources Control Board (SWRCB) for operation of the CVP contains a defined area where CVP water can be delivered and used. This area is identified as being within the Consolidated Place of Use (CPOU) boundary. Currently, some uncertainty exists regarding the location of this boundary in the Millerton Lake (Friant) area, which may delay development in that area until resolved. The resolution of this CPOU boundary is important not only for development of the Friant area, but to ensure that the

County can deliver CVP water from Shaver Lake for the service area defined in the Master Plan.

The County must also develop an agreement with Southern California Edison (SCE) delineating the terms and conditions for removing water from Shaver Lake and compensation for lost power generation due to removal of water upstream from its hydroelectric generation facilities. In 1975, the County and SCE entered into a Memorandum of Understanding (MOU) to develop such an agreement. The MOU states that the agreement can be for up to 3,000 AF per year and that the County must notify SCE and provide all required information as outlined in the MOU at least one year prior to the requested date for water withdrawal initiation.

Fresno County must also enter into an agreement with Pacific Gas and Electric Company (PG&E) in order to provide compensation to PG&E for power generation lost due to the removal of water upstream from its hydroelectric generation facilities.

All CVP water is subject to annual shortages and reduced allocations due to hydrologic conditions as well as regulatory restrictions. CVP water allocations from the Friant system are also potentially subject to further restrictions pending the outcome of a scheduled court case set to be heard in February 2006. Litigation initiated by the Natural Resources Defense Fund regarding minimum flows in the San Joaquin River in an effort to restore the lost fishery due to construction and operation of Friant Dam is the basis for the case. The CVP Shortage Allocation Policy allows for the Municipal and Industrial (M&I) allocation to drop as low as 25 percent of contractual entitlement, but historically, it has never been reduced below 50 percent. This potential for water allocation shortages puts limitations on the amount of development the County's water supply can sustain.

All of the described surface water supplies would require treatment prior to use for domestic purposes. It would be economically infeasible to construct and operate a system for diverting and delivering untreated surface water for the very limited industrial and outdoor water use in the study area. The estimated cost of a diversion and construction of a treatment plant and distribution system to deliver treated lake water to the Shaver Lake area is not included in the scope of this study. Previous preliminary design and cost estimates to treat and deliver water from Shaver Lake are included in the Master Plan (Carollo, 1985).

Recycled Wastewater

Currently, two wastewater treatment plants are located in the Shaver Lake Area, and they do not recycle any treated effluent from the plants. It may not be economically feasible to install the required additional treatment processes and distribution system to recycle treated effluent from the existing plant; however, tertiary treatment plants and water reuse schemes should be considered as new developments are proposed. The use of recycled water has limited potential because of the limited manufacturing, industrial, and outdoor water use in the Shaver Lake area. However, because of the limited water resources in the study area, the feasibility of recycling water should be investigated during the subdivision approval process.

3.5.5 Potential Mitigation Measures

Potential measures that can be implemented to mitigate impacts to the groundwater supply include: development of a comprehensive WMP for protecting the groundwater resources, protection of groundwater recharge areas, increased groundwater recharge, storage of surface water runoff, and use of recycled water. The comprehensive WMP is discussed in Section 7.3.

Protection of Groundwater Recharge Areas

The reliance of the existing and future development of the Shaver Lake area on groundwater resources makes it imperative that the groundwater recharge areas be protected. The study area is underlain primarily by granitic bedrock, which has limited storage capacity. Long-term sustainability of the water supply is therefore dependent upon the ability of the groundwater system to obtain fresh supplies of water or recharge. Primary recharge areas will be those that have lesser slopes (less runoff and more contact time for soil/water interaction), have more porous surfaces (granular material, such as soils and weathered bedrock or highly fractured bedrock surfaces), and have greater accumulation of snow (to allow more time for seepage into underlying material).

As development occurs, if these recharge areas are covered by impermeable surfaces (houses, roads, storage structures, etc.) or subjected to some use that would promote contamination of the recharge water, the amount of recharge or quality of the groundwater could be impaired. In order to reduce the potential for recharge impairment, recharge areas should be identified and the areas set aside for compatible uses, such as green belt or non-vehicular recreation.

Increased Groundwater Recharge

As highlighted in the Water Balance Technical Memorandum (Appendix B), data regarding the hydrogeologic conditions in the study area are insufficient to estimate reliably the groundwater recharge potential in the area. Although constructing small local recharge basins in areas of concentrated development and groundwater usage is a possibility, no significant source of surface water has been identified to place into the basins. Currently, no developed surface water supplies or facilities to convey surface water supplies are present in the study area. Investigations regarding the development and use of surface water supplies in the study area should include the potential for construction and operation of groundwater recharge facilities to utilize excess water in wet years or for water that may be available for purchase.

Storage of Surface Water Runoff

It is possible to divert storm water runoff from developments to catch basins that may provide increased groundwater recharge. This may also assist in minimizing the flow of contaminants into the local creeks and rivers. This may only be practical in highly developed areas with increased impervious areas. The feasibility of constructing such basins should be addressed during the subdivision approval process.

Once water is in a creek or river, it is considered a water of the State and subject to the jurisdiction and control of the SWRCB. Diversion of water from the creek or river would require acquisition of the water rights and a diversion permit from the SWRCB. Any structure constructed within a streambed is also subject to Department of Fish and Game (DFG) approval and requires a Streambed Alteration Permit from the DFG. These types of facilities are unlikely to be constructed due to the need for water rights and the regulatory requirements involved in gaining project approval.

3.6 DATA NEEDS

This section discusses the adequacy of existing water level, stream gage, and climatological data for the Shaver Lake area and identifies areas where more data are needed to improve the evaluation of the water resources in the study area. These identified data gaps are substantial and comprise the basis of the data acquisition program discussed in Section 6.0.

3.6.1 Water Levels

Locations where groundwater level data were obtained for the Shaver Lake area are presented on Figure 24. The majority of the data are from locations where water levels have been measured once, usually during the design of an engineered septic system (Norbert Larsen personal communication, 2005). These data are of minimal importance to the monitoring program as many of the water levels were from pits, and the conditions under which the data were collected cannot be recreated. Also shown on Figure 24 are locations where water levels have been periodically measured in seven idle wells in the Wildflower area of Shaver Lake by Melvin Simons and Associates (Melvin Simons personal communication, 2005).

Existing groundwater level data are not sufficient to evaluate potentiometric trends across the Shaver Lake area. Multiple years of data from several locations are needed to evaluate trends and to assess whether current and future estimated water demands are sustainable.

3.6.2 Stream Gage Data

Stream gaging data are available for a few of the smaller watersheds within eastern Fresno County. The available data are of limited use to the data acquisition program because they have a limited period of record. In the Shaver Lake vicinity, Schmidt (1977) obtained streamflow data for Musick Creek from 1974-1976. Additional streamflow data were collected on Musick Creek from 1977-1980 (Strahm, 1980). These locations provide historical data for three watersheds; however, none of these locations currently are monitored. Stream gaging data are needed within the watersheds proposed for detailed study. At this time, no stream gage monitoring is known to occur within the study area, except on major rivers.

3.6.3 Climatological Data

Precipitation data used during this investigation for the Shaver Lake area have been collected at the Big Creek Station (latitude 37.21 degrees north, longitude 119.24 degrees west) and the Huntington Lake Station (latitude 37.14 degrees north, longitude 119.13 degrees west). These stations are north of the Shaver Lake area. Schmidt (1977) collected precipitation data in the Musick Creek subwatershed for water years 1974, 1975, and 1976.

Precipitation data are not available at locations within the watersheds where stream gages are proposed. In addition, other climatological data are needed to refine evapotranspiration estimates in the Shaver Lake area (such as wind speed, evaporation, temperature, and solar radiation).

4.0 AUBERRY-PRATHER AREA

The Auberry-Prather area is located on the western slope of the Sierra Nevada, about 15 miles northeast of the City of Fresno (Figure 3). The Auberry-Prather area is about 11 miles long and 6 miles wide and covers about 26,155 acres. This study area includes portions of Sections 11-16, 21-28, 31-36, T10S, R22E; Sections 4-9, 16-21, 28-32, T10S, R23E; Sections 1-9, 11,12,14,17, and 18, T11S, R22E; and Section 6, T11S, R23E, MDB&M.

4.1 GEOGRAPHY

The Auberry-Prather area is located in the northwestern portion of the study area. The geography of the Auberry-Prather area is similar to the Squaw Valley area. It is at a lower elevation, receives less precipitation, and has less tree cover than the Shaver Lake area. The principle geographical points of interest for this study include watersheds, topography, precipitation, and vegetation.

4.1.1 Boundaries

The boundaries for the Auberry-Prather area were selected to facilitate water balance analyses and to encompass development areas for analysis of future growth trends. The Auberry-Prather area includes four sub watersheds: Little Sandy Creek, Auberry Valley, Sentinel School, and a portion of Big Sandy Valley (Figure 25). The area boundary also contains numerous community clusters, including Auberry, Prather, and Marshall Station. These communities have potential for increased future development.

4.1.2 Topography

The Auberry-Prather area is in the lower to middle elevation zones of the western foothills. The elevation of the Auberry-Prather area ranges from 750 to 2550 feet MSL. The topography ranges from nearly flat in the west to gently rolling to moderately sloped in the east.

4.1.3 Vegetation

The Auberry-Prather area is covered primarily by Blue Oak woodland and Montane hardwood habitats that include a variety of hardwoods, shrubs, and grasses. The flora dynamics change with elevation. The vegetation consists primarily of thicker canopy of hardwood trees with occasional pine trees at higher elevations to savanna-like habitat that includes hardwood trees and woody shrubs at middle elevations to annual grassland with occasional hardwood trees at lower elevations. In the lower elevations, trees are more numerous on north-facing slopes. The vegetation types are indicative of the climatic conditions and water availability.

4.2 HYDROLOGY

The major hydrologic pathways in the Auberry-Prather area include precipitation, runoff into local streams, evaporation, uptake by vegetation, and the groundwater system.

4.2.1 Precipitation

The primary source of groundwater recharge for the western foothills is precipitation. The majority of precipitation in the Auberry-Prather area falls in the winter as rain. Long-term estimates of precipitation for the Auberry-Prather area were based on data collected from the gage known as 'Auberry 1 NW,' which is located less than 1 mile northeast of Auberry at an elevation of 2,240 feet MSL (Figure 26). This station has 54 years of monthly precipitation data for the period of 1950 to 2005.

The average annual precipitation for the Auberry 1 NW station is approximately 25 inches. For the period of record, annual precipitation was above average 35 percent of the time (maximum of 50.53 inches) and below average 60 percent of the time (minimum of 12.37 inches).

Based on historical data, the typical dry season is May through September, with average monthly precipitation below 1 inch. August is the driest month with an average monthly precipitation of 0.05 inch. The wet season is December through March, with an average monthly precipitation above 3 inches. January is the wettest month with an average of 4.9 inches of precipitation.

4.2.2 Surface Water

The Auberry-Prather area does not have any lakes or major rivers within the study boundary; however, Millerton Lake is approximately 2 miles to the west of the study area boundary. The Auberry-Prather area has three significant creeks: Little Sandy Creek, Big Sandy Creek, and Little Dry Creek (Figure 25).

Creeks in the Auberry-Prather area ultimately flow into the San Joaquin River. The Little Sandy Creek subwatershed covers an area of 7,729 acres, the Auberry Valley subwatershed covers an area of 9,277 acres, and the Sentinel School watershed covers an area of 5944 acres. The western portion of the Big Sandy Valley watershed is included in the Auberry-Prather area and covers an area of 3,201 acres.

4.2.3 Evapotranspiration

Evapotranspiration in the Auberry-Prather area is limited by the availability of soil moisture and will vary from year to year depending on rainfall. Long-term average annual evapotranspiration values were estimated from the DWR (1975) data. Values between 1.5 and 1.6 feet per year were assigned to the various subwatersheds based on their elevation and average precipitation (Table 6).

4.2.4 Hydrogeology

The Auberry-Prather area has a limited groundwater storage capacity as the majority of groundwater occurs in fractured bedrock. Alluvial material and weathered bedrock have potential to provide groundwater, but are believed to occur only in localized areas. Significant volumes of these materials were not identified within the Auberry-Prather area. The primary source of recharge to the groundwater system in the Auberry-Prather area is precipitation.

The capability to withdraw groundwater in the dry season is dependent on the volume of storage within the water-bearing materials and the amount of recharge during the previous wet season. Review of well records in the Auberry-Prather Area identified only vertical wells completed in fractured bedrock. Wells in fractured bedrock rely on intercepting significant numbers of interconnected and saturated fractures to produce a sufficient yield. Deeper portions of the bedrock generally have fewer of these saturated interconnected fractures, and yields from wells completed in these deeper zones typically reflect this lack of availability of groundwater.

4.3 LAND USE AND DEVELOPMENT

The demand for water is dependent on the type of land use and the amount of development. Water use projections are based on current and projected future development. This section discusses the land use, population, building permits, well permits, and development trends for the Auberry-Prather area.

4.3.1 Land Use

The land use in the Auberry-Prather area is primarily open area (assumed to be primarily cattle grazing) and rural residential. The 2000 Census data indicates that dwelling occupancy by permanent residents is greater than 90 percent. The residential areas are supported by small amounts of commercial land uses, with no identified manufacturing or industrial land uses within the area. A lumber mill is present in the area, but this facility is not currently operating. Different land uses are indicated by the water demand types shown on Figure 27.

4.3.2 Population

According to the 2000 Census, the population of the Auberry-Prather area was 2,053. The population increased by approximately 10 percent from 1990 to 2000.

4.3.3 Building Permits

Parcels with building permits in the Auberry-Prather area, based on digital information provided by Fresno County, are shown on Figure 28. The building permit data were used to estimate the amount of residential development and residential water use. The dates the permits were issued were unavailable, so development trends based on building permits could not be identified.

4.3.4 Well Permits

Well drillers logs for the Auberry-Prather area were identified by using location identifiers such as APN; latitude and longitude; address; and Township, Range, and Section. Some well logs did not have any location identifiers and therefore could not be used in the analysis. Approximately 750 well logs were identified as within the Auberry-Prather area. The peak years for drilling wells in the Auberry-Prather area were 1994 and 2002, with more than 40 wells installed each of those years (Figure 29). No discernable trend is apparent in the number of wells drilled per year.

4.3.5 Development Trends

Development trends were estimated from the 1990 and 2000 Census data. Census data were used to identify the number of housing units, which accounts for houses, apartments, mobile home or trailer park units, a group of rooms, or a single room occupied as a separate living quarter. The average annual percentage increase in housing units from 1990 to 2000 represent general development trends within the Auberry-Prather area. The percentage increase in housing units for the Auberry-Prather Census Tract for 1990 to 2000 was 12 percent, which is approximately 1 percent annually.

4.4 WATER DEMANDS

Current water demand in the Auberry-Prather area is supplied by groundwater. The amount of available groundwater, by watershed, was estimated to assess whether the groundwater supply is sufficient to meet current and future water demands.

Water demands in the Auberry-Prather area were estimated for each subwatershed: Little Sandy Creek, Auberry Valley, Sentinel School, and a portion of Big Sandy Valley (Figure 25). Water demand in the subwatersheds varied based on the amount of development and the type of water demand.

4.4.1 Current Water Demands

Four water demand types were employed to estimate current water usage in the Auberry-Prather area: CSD/MHD, household count, area factor, and no demand. The type of water demand method selected for various areas was based on land use and available data. Details of how the water demand types were selected and how the estimated water demands were calculated are discussed in detail in the Current and Projected Water Demand Analysis Technical Memorandum (Appendix A). Figure 27 shows where each water demand type was employed in the Auberry-Prather Area. The estimated current water demand in the Auberry-Prather area is 578 AFY (Table 7).

4.4.2 Projected Water Demands

Water demand in the Auberry-Prather area is due primarily to domestic water usage, and it is assumed that increased water demand will be due primarily to increases in the number of housing units. The projections also assumed that the population characteristics (household densities, occupancy types, etc.) and per capita usage will remain the same. Projected water demands for nonresidential usage were increased in proportion to the change in residential water usage. Projected water demands in the Auberry-Prather area were estimated for two different scenarios:

- Annual water demand increase based on Census data growth rates
- Water demand at full buildout of existing permitted parcels

Projected water demand based on Census data utilized the observed 12 percent growth rate between the 1990 and 2000 Census. The projected water demand in 2025 based on this scenario is 860 AFY.

Projected water demand at buildout of existing permitted parcels utilized building permit data supplied by Fresno County. Buildout of permitted parcels would increase the number of households from the current 1,135 to 1,744. The projected water demand at buildout of existing permitted parcels is estimated at 908 AFY (Table 7).

4.5 WATER SUPPLY EVALUATION

The water supply for the Auberry-Prather area has been evaluated using well log data and conceptual water balances.

4.5.1 Evaluation of Well Log Data

Various parameters from the well log database were analyzed for the Auberry-Prather area to assist in identifying potential trends. It is expected that more wells exist in the Auberry-Prather area than the available records indicate. However, the available well driller's logs that have been inventoried for this study area comprise a significant portion of the wells in the area and are believed to be representative of the wells in the Auberry-Prather area.

Among the parameters evaluated for trends was the mean depth of new wells with respect to time. Typically, in areas of groundwater overdraft, new wells are installed to greater depths than previous wells as shallow zones become dewatered or yield less water. Figure 30 is a plot of annual well depth over time. The Auberry-Prather area shows an increase in the depths of new wells over time. The mean well depth in 1975 was less than 300 feet compared with the mean well depth of 500 feet in 2005.

In areas where groundwater is recharged directly from precipitation, a correlation might be expected between well depth (assuming the drilling stops drilling once water is reached) and the amount of annual precipitation. The expected correlation would show a decrease in well depths in wet years and an increase in dry years. Figure 31 shows the mean well depth versus average annual precipitation. No direct correlation is apparent between the Auberry-Prather area's average annual well depth and annual precipitation.

4.5.2 Long-Term Maximum Renewable Groundwater Supply

The long-term maximum renewable groundwater supply was evaluated for the Sentinel School, Auberry Valley, Little Sandy Creek subwatersheds and the portion of the Big Sandy Valley subwatershed within the Auberry-Prather area using a conceptual water-balance approach. The maximum renewable water supply calculations are presented in Table 6. Details of the water balances are presented in the Water Balance Technical Memorandum (Appendix B).

The maximum renewable groundwater supply for each subwatershed, based on long-term averages, is equal to the total amount of water that falls as precipitation minus the amount of water that leaves the subwatershed as runoff and evapotranspiration. It was assumed that the amount of subsurface outflow is equal to the amount of subsurface inflow. It should also be noted that only a portion of the maximum renewable groundwater supply is available for extraction by water supply wells. Insufficient information is available to estimate how much of the maximum renewable groundwater could be developed.

Using precipitation and stream flow data, runoff coefficients (volume of stream flow divided by the volume of precipitation in a subwatershed) were calculated for each subwatershed. The runoff coefficient was 0.18 for the Little Sandy Creek and Big Sandy Valley subwatersheds and 0.11 for the Sentinel School and Auberry Valley subwatersheds (Table 6).

An evapotranspiration value of 1.6 feet per year was assigned to the Little Sandy Creek and Big Sandy Valley subwatersheds and 1.5 feet per year to the Sentinel School and Auberry Valley subwatersheds. The different values were assigned based on elevations and estimated average annual precipitation within the subwatersheds.

In the Auberry-Prather area, the calculated renewable groundwater supply values ranged from 0.04 feet per year in the Little Sandy Creek and Big Sandy Valley subwatersheds to 0.06 feet per year in the Sentinel School and Auberry Valley subwatersheds. The calculated maximum renewable groundwater supply by subwatershed is 294 AFY for Little Sandy Creek, 342 AFY for Sentinel School, 533 AFY for Auberry Valley, and 128 AFY for the portion of Big Sandy Valley in the Auberry-Prather area.

The calculated renewable groundwater supply values are based on limited data and should be used for planning purposes only. The precipitation data are fairly reliable, and any reasonable adjustments to precipitation values are unlikely to yield significant differences in the total volume of water available to the watershed. The actual evapotranspiration numbers may be more or less than those estimated; however, the estimates used are the best available numbers at this time. The amount of groundwater in storage is small compared to the total amount of water that falls on the subwatersheds in the area. Thus, when recharge conditions are optimum, sufficient water may be available to fully replenish the depletion of groundwater storage created during less than optimum conditions. In this type of a watershed environment, use of an average runoff coefficient may be inadequate to assess the long-term renewable groundwater supply. It should be pointed out that there is a delicate balance between recharge and discharge in this environment, which emphasizes the need for more detailed, local-scale data collection and evaluation.

Water budgets, based on detailed data, are needed to refine the long-term maximum renewable groundwater supply estimates. It is likely that at least 3 to 5 years of data are needed to provide significant refinement. The additional data need to be collected through a period of time that allows incorporation of at least 1 year with above average precipitation and 2 consecutive years of below average precipitation.

4.5.3 Alternative Water Supplies

The Auberry-Prather area relies solely on groundwater for the domestic water supply. Potential alternative water supplies include additional development of groundwater and use of surface water.

Additional Development of Groundwater

It is possible that additional groundwater could be developed in the Auberry-Prather area, but further data collection and analysis would be required to verify the long-term available groundwater supply and locations within the watershed where it can be developed. Site-specific hydrogeologic studies should be required for further groundwater development.

Surface Water

An alternative to groundwater development is the use of treated surface water for domestic purposes. The Auberry-Prather area drains to the San Joaquin River. All of the rivers and streams in this drainage are fully appropriated, and access to existing water rights would have to be obtained in order to divert water for treatment and delivery to households in the area.

Currently, no surface water supplies have been developed in the Auberry-Prather area, but Fresno County has an entitlement to 3,000 AF of CVP water from the California Aqueduct. A discussion of the issues surrounding surface water allocation and development are presented in Section 3.5.4, most of which also apply to the Auberry-Prather area. The main difference is that no surface water entitlements have been committed to the Auberry-Prather area.

4.5.4 Potential Mitigation Measures

Potential measures that can be implemented to mitigate impacts to the groundwater supply include development of a comprehensive WMP for protecting the groundwater resources, protection of groundwater recharge areas, increased groundwater recharge, storage of surface water runoff, and use of recycled water. Potential mitigation measures are discussed in detail in Section 3.5.5. The comprehensive WMP is discussed in Section 7.3.

4.6 DATA NEEDS

This section discusses the adequacy of existing water level, stream gage, and climatological data for the Auberry-Prather area and identifies areas where more data are needed to improve the evaluation of the water resources in the study area. These identified data gaps the basis of the data acquisition program discussed in Section 6.0.

4.6.1 Water Levels

Locations where groundwater level data were obtained during this water study for the Auberry-Prather area are presented in Figure 32. The data are from locations where water levels have been measured once, usually during the design of an engineered septic system (Norbert Larsen personal communication, 2005). These data are of minimal importance to the monitoring program as many of the water levels were from pits and the conditions under which the data were collected cannot be recreated.

Existing groundwater level data are not sufficient to evaluate potentiometric trends across the Auberry-Prather area. Multiple years of data from several locations are needed to evaluate trends and to assess whether current and/or future estimated water demands are sustainable.

4.6.2 Stream Gaging

Stream gaging data are available for a few of the smaller watersheds within eastern Fresno County; however, none of these are within the Auberry-Prather area. Stream gaging data are needed within the watersheds proposed for detailed study. No active stream gage monitoring has been identified within the study area, except on major rivers.

4.6.3 Climatological Data

Precipitation data used during this investigation for the Auberry-Prather area have been collected at the Auberry 1 NW Station. This precipitation station is in the northern part of the Auberry-Prather area (latitude 37.05 degrees north and longitude 119.30 degrees west) (Figure 26). No other published climatological data are available within the Auberry-Prather Area. Additional climatological monitoring is needed to evaluate precipitation within the watersheds where stream gages are proposed.

5.0 SQUAW VALLEY AREA

The Squaw Valley area is located on the western slope of the Sierra Nevada, about 23 miles east of the City of Fresno (Figure 4). The area is about 10 miles long and 8 miles wide and covers about 49,800 acres. This study area includes portions of Sections 22-27, 32-36, T13S, R25E; Sections 19-36, T13S, R26E; Sections 1-36, T14S, R26E; and Sections 1-5, 8-16, 21-27, 34-36, T14S, R25E, MDB&M.

5.1 GEOGRAPHY

The Squaw Valley area is location in the southern portion of the study area. The geography of the area is similar to the Auberry-Prather area.

5.1.1 Boundaries

The boundaries for the Squaw Valley area were selected to facilitate water balance analysis and to encompass development areas for analysis of future growth trends. The Squaw Valley area includes seven subwatersheds: the entirety of the Squaw Valley, Bald Mountain, Little White Deer Creek, and Jorgensen Point; and portions of three subwatersheds (Hoffman Point, Metcalf Ranch, and Bull Creek) (Figure 33). The parts of the Hoffman Point, Metcalf Ranch, and Bull Creek subwatersheds that were not included are in Tulare County.

The Squaw Valley area includes numerous community clusters, including Squaw Valley and extensive developments across the southern part of the area permitted in the 1970s. These communities have potential for increased future development and numerous permitted parcels exist that have not been built on.

5.1.2 Topography

The Squaw Valley area is in the lower to middle elevation zones of the western foothills. The elevation of the area ranges from 600 to 3,600 feet MSL. The topography ranges from nearly flat in the southwest to gently rolling to moderately sloped in the northeast.

5.1.3 Vegetation

The Squaw Valley area is primarily covered by Blue Oak woodland and Montane hardwood habitat that include a variety of hardwoods, shrubs, and grasses. The flora dynamics change with elevation. At higher elevations, vegetation consists primarily of thicker canopy of hardwood trees with occasional pine trees. Savanna-like habitat hardwood trees and woody shrubs occupy middle elevations, and annual grassland with occasional hardwood trees occupies the lower elevations. In the lower elevations, trees are more numerous on north-facing slopes. The vegetation types are those that can survive the rocky-shallow soil and extended seasonal and periodic multiyear droughts in the foothill areas.

5.2 HYDROLOGY

The major hydrologic pathways in the Squaw Valley area include precipitation, runoff into local streams, evaporation, uptake by vegetation, and the groundwater system.

5.2.1 Precipitation

The primary source of groundwater recharge for the western foothills is precipitation. Precipitation in the Squaw Valley area was estimated from data collected at the ‘Pine Flat Dam’ station, which is located about 7 miles northwest of the community of Squaw Valley at an elevation of 970 feet (Figure 34). This station has 50 years of monthly precipitation data for the period of 1950 to 2004.

The average annual precipitation for the Pine Flat Dam station is approximately 25 inches. For the period of record, annual precipitation was above average 34 percent of the time (maximum annual precipitation of 33.3 inches) and below average 52 percent of the time (minimum annual precipitation of 9 inches). The average dry season is May through September, with average monthly precipitation less than 1 inch. August is the driest month with an average monthly precipitation of 0.05 inch. The wet season is December through March, with an average monthly precipitation of more than 3 inches. January is the wettest month with an average of 4.9 inches of precipitation.

The average dry season is May through October, with average monthly precipitation below 1 inch. August is the driest month with an average monthly precipitation of 0.01 inch. December through February have an average monthly precipitation above 3 inches with January being the wettest month with an average of 3.9 inches of precipitation.

5.2.2 Surface Water

The Squaw Valley area does not have any lakes within the study boundaries; however, Pine Flat Reservoir is approximately 7 miles to the north of the Squaw Valley area boundary. Numerous creeks exist in the Squaw Valley area with the northern portion of the area draining into the Kings River. The area of the subwatersheds include: Bald Mountain (7,611 acres); Little White Deer Creek (8,451 acres); Jorgensen Point (9,542 acres); Bull Creek (2,386 acres); Metcalf Ranch (5,775 acres); Hoffman Point (7,730 acres); and Squaw Valley (8,332 acres).

5.2.3 Evapotranspiration

Evapotranspiration in the Squaw Valley area is limited by the availability of soil moisture and will vary from year to year depending on rainfall. Long-term average annual evapotranspiration values were estimated from DWR (1975) data. Values between 1.5 and 1.6 feet per year were assigned to the various subwatersheds based on their elevation and average precipitation (Table 8).

5.2.4 Hydrogeology

The Squaw Valley area has a limited groundwater storage capacity as the majority of groundwater occurs in fractured bedrock. Alluvial material and weathered bedrock have the potential to provide groundwater; however, significant volumes of these materials were not identified within the Squaw Valley area. The primary source of recharge to the groundwater system in the Squaw Valley area is precipitation.

The capability to withdraw groundwater in the dry season is dependent on the volume of groundwater storage within the water-bearing materials and the amount of recharge during the previous wet season. Review of well records in the Squaw Valley area identified only vertical wells completed in fractured bedrock. Wells in fractured bedrock rely on intercepting significant numbers of interconnected and saturated fractures to produce a sufficient yield. Deeper portions of the bedrock generally have fewer of these saturated interconnected fractures and yields from wells completed in these deeper zones typically reflect this lack of availability of groundwater.

5.3 LAND USE AND DEVELOPMENT

The demand for water is dependent on the type of land use and the amount of development. Water use projections are based on current and projected future development. This section discusses the land use, population, building permits, well permits, and development trends for the Squaw Valley area.

5.3.1 Land Use

The current land use for the Squaw Valley area is primarily low density rural residential and open area (assumed to be cattle grazing). The 2000 Census indicates that residences are occupied primarily by permanent residents. The residential areas are supported by small amounts of commercial land uses, with no identified major manufacturing or industrial land uses within the area. Different land uses are indicated by the water demand types shown on Figure 35.

5.3.2 Population

According to the 2000 Census, the population of the Squaw Valley area is 2,691. The population increased approximately 25 percent from 1990 to 2000.

5.3.3 Building Permits

Parcels with building permits within the Squaw Valley area, based on digital information provided by Fresno County, are shown on Figure 36. Fresno County provided a digitized map of the study area indicating which parcels had building permits. The building permit data was used to estimate the amount of residential development and residential water use. The dates the permits were issued were unavailable preventing identification of development trends.

5.3.4 Well Permits

Well drillers logs for the Squaw Valley area were identified by using location identifiers such as APN; latitude and longitude; address; and Township, Range, and Section. Some well logs did not have any location identifiers and therefore could not be used in the analysis. A total of 523 well logs were identified as within the Squaw Valley area. The peak years for drilling wells in the Squaw Valley area include 1994, 1995, and 2004 with 40 wells or more installed each of those years (Figure 37). No discernable trends are apparent in the number of wells drilled per year.

5.3.5 Development Trends

Development trends were estimated from the 1990 and 2000 Census data. Census data were used to identify the number of housing units, which accounts for houses, apartments, mobile home or trailer park units, a group of rooms, or a single room occupied as a separate living quarter. The percentage increase in housing units for the Squaw Valley Census Tract from 1990 to 2000 was approximately 24 percent, which is approximately 2.2 percent increase on an annual basis.

5.4 WATER DEMANDS

Current water demand in the Squaw Valley area is supplied by groundwater. The amount of available water, by watershed, was estimated to assess whether the groundwater supply is sufficient to meet the current and future water demands.

Water demands in the Squaw Valley area were estimated for each subwatershed (Figure 33). Water demand in the subwatersheds varied based on the amount of development and the type of water demand.

Current and projected water demands are discussed in the following subsections.

5.4.1 Current Water Demands

Three different water demand types were employed to estimate current water usage in the Squaw Valley area. The demand types are: household count, area factor, and no demand. The use of the selected water demand method for various areas was based on land use and the types of data available for the area. Details of how the water demand types were selected and how the estimated water demands were calculated are discussed in detail in the Current and Projected Water Demand Analysis Technical Memorandum (Appendix A). Figure 35 shows where each water demand type was employed in the Squaw Valley area. The estimated current water demand in the Squaw Valley area is 354 AFY (Table 9).

5.4.2 Projected Water Demands

Water demand in the Squaw Valley area is due primarily to domestic water usage and it is assumed that increased water demand will be due primarily to increases in the number of housing units. The projections also assumed that the population characteristics (household densities, occupancy types, etc.) and per capita usage will remain the same. Projected water demands for nonresidential usage were increased in proportion to the change in residential water usage. Projected water demands in the Squaw Valley area were estimated for two different scenarios:

- Annual water demand increase based on Census data growth rates, and
- Water demand at full buildout of existing permitted parcels

Projected water demand based on Census data utilized the observed growth rates between the 1990 and 2000 Census. The projected water demand in 2025, using the Census growth rate is 544 AFY (Table 9).

Projected water demand at buildout of existing permitted parcels utilized building permit data supplied by Fresno County. Buildout of permitted parcels would increase the number of households from the current 593 to 1,697. The projected water demand at buildout of existing permitted parcels is estimated at 979 AFY (Table 9).

5.5 WATER SUPPLY EVALUATION

The water supply for the Squaw Valley area has been evaluated using well log data and conceptual water balances.

5.5.1 Evaluation of Well Log Data

Various parameters from the well log database were analyzed for the Squaw Valley area to assist in identifying potential trends. It is expected that more wells exist in the Squaw Valley area than the available records indicate. However, the available well driller's logs that have been inventoried for this study area comprise a significant portion of the wells in the area and are believed to be representative of the wells in the Squaw Valley area.

Among the parameters evaluated for trends was mean well depth with respect to time. The Squaw Valley area shows an increase in average well depths over time (Figure 38). The mean well depth in 1977 was less than 300 feet compared with the mean well depth of greater than 400 feet in 2004.

Figure 39 shows the mean well depth versus average annual precipitation. No direct correlation is apparent between the Squaw Valley area's average annual well depths and annual precipitation.

5.5.2 Long-Term Maximum Renewable Groundwater Supply

The long-term maximum renewable groundwater supply was evaluated for the various subwatersheds within the Squaw Valley area using a conceptual water balance approach. The maximum renewable water supply calculations are presented in Table 8. Details of the maximum renewable groundwater calculations are presented in the Water Balance Technical Memorandum (Appendix B).

The maximum renewable groundwater supply for each subwatershed, based on long-term averages, is equal to the total amount of water that falls as precipitation minus the amount of water that leaves the subwatershed as runoff and evapotranspiration. It was assumed that the amount of subsurface outflow is equal to the amount of subsurface inflow. It should also be noted that only a portion of the maximum renewable groundwater supply is available for extraction by water supply wells. Insufficient information is available to estimate how much of the maximum renewable groundwater could be developed.

Using precipitation and stream flow data, the runoff coefficient calculated for the Squaw Valley area was 0.16 (Table 8).

Evapotranspiration values of 1.5 to 1.6 feet per year were used for the subwatersheds in the Squaw Valley area.

In the Squaw Valley area, the calculated long-term maximum renewable groundwater supply values included 0.04 feet per year in the Hoffman Point subwatershed; 0.08 feet per year in the Bald Mountain, Metcalf Ranch, and Squaw Valley subwatersheds; 0.22 feet per year in the Bull Creek subwatershed; and 0.29 feet per year in the Jorgensen Point and Little White Deer Creek subwatersheds. The calculated long-term maximum renewable groundwater supply by subwatershed is 609 AFY for Bald Mountain, 2,451 AFY for Little White Deer Creek, 2,767 AFY for Jorgensen Point, 667 AFY for Squaw Valley, 309 AFY for Hoffman Point, 462 AFY for Metcalf Ranch, and 525 AFY for Bull Creek.

The calculated renewable groundwater supply values were based on limited data and should be used for planning purposes only. The low numbers for the long-term maximum renewable groundwater supply (0.04 to 0.29 feet per year) indicate a delicate balance between recharge and discharge in this environment and emphasize the need for more detailed, local-scale data collection and evaluation.

Water budgets, based on detailed data, are needed to refine the long-term maximum renewable groundwater supply estimates. It is likely that at least 3 to 5 years of data are needed to provide significant refinement. The additional data need to be collected through a period of time that allows incorporation of at least 1 year with above-average precipitation and 2 consecutive years of below average precipitation.

5.5.3 Alternative Water Supplies

The Squaw Valley area relies solely on groundwater for the domestic water supply. Potential alternative water supplies include additional development of groundwater and use of surface water.

Additional Development of Groundwater

It is possible that additional groundwater could be developed in the Squaw Valley area, but further data collection and analysis would be required to verify the long-term available groundwater supply and locations within the watershed where it can be developed. Site-specific hydrogeologic studies should be performed prior to further groundwater development.

Surface Water

An alternative to groundwater development is the use of treated surface water for domestic purposes. The Squaw Valley area drains to the Kings River and Tulare Lake Basin. Rivers and streams in these drainages are fully appropriated, and access to existing water rights would have to be obtained in order to divert water for treatment and delivery to households in the area.

Because of the location of the Squaw Valley area, it is probably not economically feasible to import CVP water. It may be possible to obtain water from the Kings River; however, extensive effort would be needed. Fresno County might also need to enter into an agreement with the appropriate hydroelectric power generation company to provide compensation for power generation lost due to the removal of water upstream from any hydroelectric generation facilities.

Any surface water supply would require treatment prior to use for domestic purposes. The limited industrial water use and dispersed point of use in the study area might make it infeasible to construct a system for delivering treated surface water. The estimated cost of a diversion and construction of a treatment plant and distribution system to deliver treated lake water to the Squaw Valley area is not included in the scope of this study.

5.5.4 Potential Mitigation Measures

Potential measures that can be implemented to mitigate impacts to the groundwater supply include development of a comprehensive WMP for protecting the groundwater resources, protection of groundwater recharge areas, increased groundwater recharge, storage of surface water runoff, and use of recycled water. Potential mitigation measures are discussed in detail in Section 3.5.5. The comprehensive WMP is discussed in Section 7.3.

5.6 DATA NEEDS

This section discusses the adequacy of existing water level, stream gage, and climatological data for the Squaw Valley area and identifies areas where more data are needed to improve the evaluation of the water resources in the study area. These identified data gaps the basis of the data acquisition program discussed in Section 6.0.

5.6.1 Water Levels

Locations where groundwater level data were obtained for the Squaw Valley area are presented in Figure 40. The majority of the data have been collected from well locations in the western part of the Squaw Valley area by the DWR. In addition, Norbert Larsen (personnel communication, 2005) provided a water level for a location in the eastern portion of the area along Highway 180.

Existing groundwater level data are not sufficient to evaluate potentiometric trends across the eastern and central parts of the Squaw Valley area. In the western portion of the Squaw Valley area, the DWR data indicate groundwater levels have remained relatively steady for the past 30 years. Multiple years of data from several locations in the eastern and central portion of the area, and continued collection of data in the western part of the area, are needed to evaluate trends and to assess whether current and/or future estimated water demands are sustainable.

5.6.2 Stream Gaging

Stream gaging data are available for a few of the smaller watersheds within eastern Fresno County. In the Squaw Valley area, the USGS monitored Sand Creek from 1945-1953 and 1972-1983 and Mill Creek from 1956-1993. These locations provide historical data for three watersheds; however, none of these locations currently are monitored. Stream gaging data are needed within the watersheds proposed for detailed study. At this time, no stream gage monitoring is known to occur within the study area.

5.6.3 Climatological Data

Precipitation data used during this investigation for the Squaw Valley area have been collected at the Orange Cove Station (latitude 36.37 degrees north, longitude 119.18 degrees west) south of the study area and the Balch Power House Station (latitude 36.55 degrees north, longitude 119.05 degrees west) north of the study area.

Precipitation data are not available at locations within the watersheds where stream gages are proposed. In addition, no other published climatological data (such as wind speed, evaporation, temperature, and solar radiation) are available in the Squaw Valley area to evaluate evapotranspiration.

6.0 DATA ACQUISITION PROGRAM

This section presents the recommended data acquisition program for the foothill and mountain areas of eastern Fresno County. The program has been divided into four elements; water levels, well yields, stream flow, and climatological data. In addition, collection and evaluation of groundwater quality are discussed and estimated costs and potential funding sources to implement the program are provided. Details of the data acquisition program are presented in the Data Acquisition Program Technical Memorandum (Appendix C).

The goal of the data acquisition program should be to collect data necessary to evaluate the sustainability of the groundwater resource and identify mitigation measures that can be implemented if undesirable impacts are detected or imminent. Collection of stream flow and climatological data are proposed within subwatershed areas that are recommended for detailed study. Water level and well yield data should be collected in the subwatersheds within the Shaver Lake, Auberry-Prather, and Squaw Valley areas and in other areas of the foothill and mountain areas of eastern Fresno County where development is anticipated.

Data collected during implementation of this program and those available from other sources need to be maintained and organized to allow evaluation. The data should be evaluated annually and a summary report prepared documenting activities conducted. The data should also be evaluated for data gaps and recommendations made to modify the program as needed.

6.1 GROUNDWATER LEVELS

Collection of groundwater-level data is proposed at selected locations to assist in identification of changes in storage within the water-bearing materials. Change in storage within the water-bearing materials is one way to assess the capability of the groundwater system to meet existing and projected demands.

Water level data should consist of quarterly depth-to-groundwater measurements. Quarterly measurements are recommended so that seasonal influences can be identified. From year to year, the quarterly measurements should be collected near the same date. Typically, water levels are measured in a well, or some other suitable structure, that allows entry of a water-measuring device (electric water level sensor, chalked tape, or other appropriate equipment). If water levels are measured from an active well, the water levels should be measured a sufficient amount of time after pumping has ceased to allow an accurate measurement of the static groundwater level. Use of electronic pressure transducers and data loggers should be considered as a way to provide a detailed look at water-level changes within wells. While the initial capital cost is greater, the labor needed to install and monitor is not significantly greater than required to manually measure water levels.

Idle wells or piezometers (small wells installed for the purpose of measuring groundwater levels) are preferred. If suitable wells cannot be identified from which representative groundwater levels can be measured, installation of piezometers should be considered. While the initial capital costs would be greater to install a piezometer, the data may be better because the effects of pumping associated with an existing supply well would not be an issue. Wells selected for inclusion in the program in each of the areas should be representative of the depth and type of geologic materials encountered in that area. As an example, if wells in a particular area range from 50 to 500 feet in depth, with approximately half being deeper than 250 feet and half shallower, wells selected for the monitoring program should have a similar range and distribution in depth.

Groundwater levels can also be inferred from springs as these represent areas where the groundwater is present at the land surface. Springs may occur only during certain times of the year and inclusion of springs in the data acquisition program should include identification of when springs are flowing, damp, or dry.

The proposed groundwater level data acquisition program is presented for four areas: Shaver Lake, Auberry-Prather, Squaw Valley, and other areas within eastern Fresno County. The other areas include Burrough Valley, Wonder Valley, and an area south of the Auberry-Prather area. These areas are regions where significant additional development is anticipated and water supply problems are beginning to be reported to the County.

6.1.1 Shaver Lake Area

The proposed groundwater level monitoring system for the Shaver Lake area consists of 27 wells. The wells are grouped as follows:

- seven idle wells near the Wildflower development from which multiple water levels already have been recorded (Figure 24),
- ten wells or piezometers in the SLUMPSA,
- five wells or piezometers in the western portion of the Shaver Lake area in the vicinity of Alder Springs, and
- five wells south of Pine Ridge.

6.1.2 Auberry-Prather Area

The proposed groundwater level monitoring system for the Auberry-Prather area consists of approximately 20 wells or piezometers. The wells are grouped as follows:

- five wells or piezometers in the Auberry Valley subwatershed,
- five wells or piezometers in the Little Sandy Creek subwatershed,
- five wells or piezometers in the Sentinel School subwatershed, and
- five wells in the Big Sandy Valley subwatershed.

6.1.3 Squaw Valley Area

A groundwater level monitoring system for the Squaw Valley area is proposed that consists of 20 wells or piezometers. The wells are grouped as follows:

- four wells or piezometers in the Squaw Valley subwatershed,

- four wells or piezometers in the Little White Deer Creek subwatershed,
- four wells or piezometers in the Jorgensen Point subwatershed,
- four wells or piezometers in the Metcalf Ranch subwatershed, and
- four wells in the Hoffman Point subwatershed.

6.1.4 Other Areas

Groundwater level monitoring should also be implemented in other areas of the foothill and mountain areas of eastern Fresno County where development is occurring or anticipated. Three areas where the greatest amount of development appears to be occurring are Burrough Valley, Wonder Valley, and along Highway 168 south of the Auberry-Prather area. It is recommended that five wells or piezometers be monitored in each of these areas (total of 15 additional wells or piezometers).

6.2 WELL YIELDS

Collection of well yield data is proposed to monitor the sustainability of groundwater within the study area. These data would be collected with the installation of a flow totalizing meter attached to the pump discharge line prior to entering any pressure tank. This information is useful to identify how much water is being used and to keep track of changes with time. In areas covered by community service districts pump meter readings and connection meter readings should be obtained. It is recommended that pumping wells included in the groundwater level monitoring be metered. It is anticipated that the total number of wells with meters would be approximately the same in number and geographic distribution as the wells included in the groundwater level data acquisition program. It is recommended that meters be read when groundwater levels are measured.

6.3 STREAM GAGES

Stream gage data are needed to assess how much runoff is leaving selected subwatersheds, which is used in evaluation of water balances. Proposed stream gages are located where previous stream gage data have been collected or at strategic locations within subwatersheds proposed to be studied in detail.

The specific stream gage locations are presented by area in the following subsections.

6.3.1 Shaver Lake Area

Three stream gage locations are recommended in the Shaver Lake area. These locations are shown on Figure 41 and described below.

- At the former location of a stream gage on Musick Creek used by Schmidt (1977). This location monitors the upper portion of the Musick Creek subwatershed.
- On Jose Creek near the confluence with Musick Creek. This location captures the entire Musick Creek subwatershed. The location is accessible from Jose Creek Road.
- On Sycamore Creek downstream of the confluence with North Fork Creek. This location monitors the North Fork Sycamore subwatershed. This location is accessible from Sycamore Road.

6.3.2 Auberry-Prather Area

Three stream gage locations are recommended in the Auberry-Prather area. These locations are shown on Figure 26 and described below.

- On Little Sandy Creek north of the intersection of Auberry Road and Highway 168. This location will monitor runoff in the upper Auberry area of the Little Sandy Creek subwatershed.
- On Big Sandy Creek downstream of the confluence with Little Sandy Creek. This location will monitor runoff in the Little Sandy Creek and Big Sandy Valley subwatersheds. The site is accessible from a nearby road.
- On Little Dry Creek at the confluence with the north fork of Little Dry Creek. This location would monitor runoff from the Auberry Valley subwatershed. The site is accessible from Millerton Road.

6.3.3 Squaw Valley Area

Two stream gage locations are recommended in the Squaw Valley area. These locations are shown on Figure 34 and described below. Neither of the stream gages are actually within the Squaw Valley area; however, they will monitor runoff from subwatersheds within the area.

- On Mill Creek near Pine Flat Dam. This is the location of a former USGS stream gage that has runoff data from 1945 to 1953 and 1972 to 1983. This location will monitor runoff from several subwatersheds in the northern part of the Squaw Valley area.

- On Sand Creek south of the Squaw Valley area in Tulare County. This is also the location of a former USGS stream gage that has runoff data from 1958 to 1993. This location will monitor runoff from several subwatersheds in the southern portion of the Squaw Valley area.

6.4 CLIMATOLOGICAL STATIONS

Climatological data are needed to measure precipitation and climatological parameters that affect evapotranspiration within selected subwatersheds. The climatological parameters should include: air temperature, humidity, wind speed, and solar radiation. The stations should be placed near the center of the watershed to obtain average readings for the area. Data from existing precipitation stations should continue to be obtained along with those from proposed stations to provide more complete coverage of the foothill and mountain areas. This also allows comparison of new data with the historical record. The precipitation data are used in evaluation of the water balances. The specific locations recommended for climatological stations are presented by area in the following subsections.

6.4.1 Shaver Lake Area

Three climatological station locations are recommended in the Shaver Lake area. These locations are shown on Figure 41 and described below.

- At Schmidt's (1977) location within WWD 41. This location monitors the upper portion of the Musick Creek subwatershed.
- In the Alder Springs area to monitor the lower Musick Creek subwatershed.
- In the area where Cripe or Petersen Road crosses Sycamore Creek. Either location would monitor the North Fork Sycamore Creek subwatershed.

6.4.2 Auberry-Prather Area

Two new climatological stations are recommended in the Auberry-Prather area. These locations are shown on Figure 26 and described below.

- At the Hurley Fire Station near the intersection of Auberry and Wellbarn Roads. This location would monitor the lower Auberry watershed.
- West of Auberry near the location of the Auberry NW 1 precipitation station.

In addition, data from the existing Auberry NW 1 precipitation station, actively maintained as part of the National Weather Service system, will be utilized to monitor precipitation in the upper portion of the Auberry-Prather area.

6.4.3 Squaw Valley Area

Two climatological station locations are recommended in the Squaw Valley Area. These locations are shown on Figure 34 and described below.

- Near Hoffman Point near the boundary of the Metcalf Ranch and Hoffman Point subwatersheds. This site would monitor the Sand Creek drainage area.
- Near the intersection of Kings Canyon Road (Highway 180) and Dunlap Road. This location would monitor the Mill Creek drainage area.

6.5 ESTIMATED IMPLEMENTATION COSTS

The costs to implement the data acquisition program (installation of stream and climatological gages and collection of data), as proposed herein, have been estimated to provide Fresno County with a general cost for planning purposes. Because the program is conceptual and specific wells for inclusion (or piezometers if those need to be installed) have not been identified, the level of the effort needed to obtain access and collect data, and installation costs for stream and climatological gages can only be roughly estimated. It is not possible to provide a detailed cost estimate at this time.

Estimated costs to purchase and install flow meters on individual water supply wells and to purchase and install stream and climatological gages as proposed are $215,000. Estimated annual costs to collect the data and prepare an annual evaluation report are $70,000. Costs were estimated based on readily available cost information for labor and materials typical for similar projects. The actual costs will vary depending on contract bids, agency requirements, and/or availability of equipment, materials, and/or contractor at the time of bidding. The costs also do not include selection of actual wells to be monitored or installation of piezometers if suitable wells for measuring water levels cannot be identified. Costs also do not include any permits that may be required such as streambed alteration permits for installation of stream gages.

6.6 POTENTIAL FUNDING MECHANISMS

This section reviews potential funding mechanisms for the data acquisition program. Mechanisms reviewed include fees collected by the County and grant programs.

The data acquisition program costs could be covered through the assessment of fees collected by Fresno County. The most common fees of this type are user fees and creation of improvement districts or service areas in an amount necessary to offset the costs. User fees consist of charging a fee with the issuance of a permit (typically a building permit). Creation of service areas would consist of charging an annual fee to property owners (typically included as a part of the property taxes). Creation of service areas also allows identification of benefit zones where fees for different areas could be based on the level of benefit. Typically, the fees would be reviewed on an annual basis to evaluate whether the fee is appropriate for the benefit provided.

At this time no grant programs are available from the State to offset the financial burden of the data acquisition program. Application deadlines from recent grant programs such as AB 303 and Proposition 50 have passed. It is possible that additional grant programs will be available in the future that Fresno County could apply for to at least partially cover the costs.

Inquiries were made to other counties to identify whether they are conducting monitoring and, if so, how their programs are funded. Madera County monitors water levels through a grant funded by the State. Monterey County has an extensive monitoring system in the Salinas Valley to evaluate salt-water intrusion. The monitoring program includes water levels, pumping rates, precipitation, and stream flow. The program is funded by landowner assessments based on identified zones of benefit. No other County-run monitoring programs were identified.

6.7 GROUNDWATER QUALITY

Groundwater quality issues, while not addressed in this study, are critical to maintaining the beneficial uses of this resource. Water quality data should be collected and evaluated to identify areas where beneficial uses are impaired or threatened. The degradation of groundwater, by either natural or anthropogenic causes could significantly impact the ability of the resource to meet current or projected demands. Inclusion of a program to monitor groundwater quality is beyond the scope of this study.

7.0 EVALUATION OF POLICIES AND STANDARDS

In this section, the existing Fresno County water-related policies (Appendix D) are reviewed and these policies are compared to those of eight other counties (Table 10). The eight other counties are located in the San Joaquin Valley/Sierra Nevada foothills and the central and northern coast areas where similar geologic and hydrogeologic conditions exist.

7.1 REVIEW OF EXISTING POLICIES

Fresno County land division policies related to use of groundwater as the means of supplying domestic water to parcels were reviewed along with the water requirements for issuance of building permits. Fresno County has adopted specific water-related requirements for issuance of building permits in water-short areas that apply to the entire project study area. In addition, the County has certain policies for well tests in the Shaver Lake vicinity.

Subdivisions in Fresno County are approved subject to demonstration of a water supply that is adequate, sustainable, and will not impact surrounding properties. Groundwater-based subdivisions are approved with either a proposed community water system or use of individual private wells. In either case, on-site hydrogeologic investigations conducted by a professional geologist or civil engineer are required prior to subdivision consideration. County requirements for hydrogeologic studies are specified in Section II-H (7)d of the County Improvement Standards (Appendix D). This policy is appropriate and should be continued. Hydrogeologic studies should also identify recharge areas and appropriate set backs from those recharge areas that will protect groundwater from future water quantity and water quality impacts.

In addition, a detailed watershed analysis should be completed for future subdivision of lands in the study area. The watershed analysis should be in addition to the hydrogeologic analysis to further evaluate whether the water demands of the subdivision can be met long term.

For subdivisions within water-short areas of the County, as defined in County Ordinance Code Section 855-N-1 and approved based upon use of individual private wells, additional testing is required prior to issuance of a building permit (Appendix D). These requirements are described in Section 15.04.190 of the Ordinance Code. Specifically, the homeowner must demonstrate a minimum available well yield of 5.0 gpm (with no storage requirement), or 1.0 gpm with a minimum of 2,000 gallons of storage in addition to fire-related storage requirements. Section 15.04.190 of the Ordinance Code further states if use of a well shared by other property owners and/or a well on a nearby property is proposed, that well shall be tested under the requirements of Section II-H (7)d of the Fresno County Improvement Standards and shall be capable of yielding to each residence to be served by the well the minimum flows specified for an individual well. The entire eastern Fresno County project study area is in the area defined as being water-short and therefore subject to the specific well yield requirements for water-short areas.

Pump test requirements and procedures for demonstrating the minimum well yield for issuance of a building permit are also specified in Section 15.04.190 of the Ordinance Code. A well is determined to meet the minimum yield requirements if it passes the total water volume test (4- to 48-hour pump test) and meets the average discharge rate requirement for the last 60 minutes of the pump test and also meets the well recovery requirements. The specific test results for determining whether a well meets the minimum yield requirements depends on the time of year the pump test is performed. Individual and community wells proposed for subdivisions not in water-short areas must meet the requirements of the Fresno County Improvements Standards. The Improvement Standards outline the groundwater supply report requirements and the pump test procedures for both individual and community wells. Evidence must be submitted that the individual well can provide a minimum yield of 2 gpm, while only wells with a yield of 10 gpm or more are considered sufficient for a community well.

The County should continue its policies for strict requirements of groundwater yields in water-short areas. Uncertainties associated with the availability of water in fractured bedrock areas, the areas' reliance on groundwater as the only current water supply, the vulnerability of the groundwater system to periods of below average precipitation, and the lack of monitoring data make it imperative that a conservative course of action be taken.

Fresno County requires that a minimum number of wells be developed and tested for subdivisions where individual wells are proposed as the water supply. The requirements include a minimum of 3 wells where the subdivision is less than 100 acres, a minimum of 3 wells plus an additional well for each 100 acres where the subdivision is between 100 and 1,000 acres, and a minimum of 12 wells plus 3 additional wells for each 500 acres where the subdivision is in excess of 1,000 acres.

Fresno County currently allows lot sizes down to 2 acres with individual water systems. Water balance estimations indicate that Shaver Lake has a negative long-term maximum renewable groundwater supply, and subwatersheds in the Auberry-Prather and Squaw Valley areas are only slightly above zero. The situation is further complicated in that only a portion of the long-term maximum renewable groundwater supply can be developed in a subwatershed. The estimated current water demands for the foothill areas is 0.42 AFY per household (136,500 gallons). Small lot sizes (less than 10 acres) create a greater demand in an area and have a greater potential to deplete the available groundwater. Increasing minimum lot sizes to 10 acres may be prudent until such time as information from the data acquisition program or detailed hydrogeologic analysis of a proposed subdivision indicates that a sustainable water supply is available (without negatively impacting surrounding areas) to support smaller lot sizes. This would also apply to approval of second residences, which should be considered only on parcels larger than 20 acres.

In order to meet the continued growth projections in the study area, the County should consider requiring community water systems for proposed developments as opposed to individual wells. This is particularly true for subdivisions where the minimum lot size is 10 acres or less. Such systems would make more efficient use of scarce groundwater resources, would allow greater control over the amount of water used, and would make it easier to implement consistent and accurate data acquisition programs. Community water systems also promote groundwater development in areas of greater production and recharge potential and minimize the potential that individual lots may not have a sustainable water supply. In addition, the County should consider requiring proposed developments to install an observation well representative of the specific aquifer, within 200 feet of any new production well, completed to a similar depth and with similar openings to the producing formation as the production well, and fitted with a recording water level device such as a pressure transducer. These observation wells should be incorporated into the data acquisition program and would serve to monitor groundwater levels in wells that are not subjected to pumping.

The County currently imposes additional requirements for pumping tests on wells to be incorporated into the County waterworks district system in the Shaver Lake area. The County requires that prospective wells be tested during late summer or early fall for a minimum of 30 days at maximum drawdown and that the pumping water level be held at just above the point where the pump would begin to break suction or cavitate. During the test, water levels and pumping rates from the well are recorded. The pumping rates are plotted on the y-axis of a graph with the corresponding time in days since pumping started plotted on a logarithmic scale on the x-axis. The resulting graph generally produces a straight line, with the pumping rates decreasing exponentially with time. A best-fit line is placed on the points and the line is projected from 30 days to 120 days. The allotted sustainable yield for the well is equal to 75 percent of the projected pumping rate at 120 days, or 50 percent of the projected pumping rate at 120 days if the well is adjacent to a stream.

In reviewing pump test data for wells within WWD 41, it appears that 30 days of pump testing for community water supply wells may not be adequate to evaluate long-term trends. Significant declines in well yields during pumping tests have been documented beyond 30 days. These may occur because of dewatering of portions of the water-bearing zone or interference from other wells. Until the recommended data acquisition program is in place and sufficient data have been collected to substantiate how the groundwater system recharges under various climatic conditions, pumping tests in the Shaver Lake area should be conducted for a period of not less than 90 days and the curve for the later-time data should be extended to 120 days. The policy of reducing the 120-day yield by 25 percent (50 percent if adjacent to a stream) should be continued to allow for the potential decline in yield during extended drought conditions.

Data from WWD 41 indicates that a minimum of 0.3 gpm per household is needed to meet peak demand. The County should consider increasing the minimum demonstrated long-term water supply to 0.5 gpm per household for community water systems in water-short areas. The additional 0.2 gpm provides a factor of safety against operational interruptions, added supply for fire protection, and a buffer against long-term drought conditions.

Because of the precarious water balance in the study area and the current lack of data to refine those balances, the County should require that the same pumping tests be conducted for all proposed community water systems in designated water-short areas as those required for the Shaver Lake vicinity.

In order to maximize the available water supply, Fresno County should consider implementation of mandatory water conservation measures in water-short areas. These measures could include: a program to educate residents on the need and measures that can be taken to conserve water, prohibition of landscape watering, and accelerated water rates for overuse.

Many of these recommended modifications to water policies are similar to water policies that have been adopted by Fresno County in the General Plan Update (Fresno County, 2000). However, it appears that many of the policies have not been implemented. The adopted water policies presented in the General Plan Update have been summarized in Appendix D.

7.2 COMPARISON OF WATER POLICIES

Table 10 presents a summary of water policies for issuance of building permits and approval of subdivisions for Fresno County compared to policies of eight other counties. The eight other counties are Madera, Kern, Tulare, Mariposa, Stanislaus, Sonoma, Monterey, and San Luis Obispo.

Fresno County requires that hydrogeologic reports be prepared by a Registered Geologist (recently changed to Professional Geologist by the California Board for Geologists and Geophysicists), Certified Engineering Geologist, or Registered Civil Engineer licensed in California. The requirement that a hydrogeologic report be prepared by a licensed engineer or geologist differs from county to county, but most counties require some type of report that presents evidence that the available groundwater is sufficient to sustain the proposed development.

Fresno County requires a community water system be provided to all divided parcels whenever the smallest lot in the subdivision contains a net area of less than 2 acres. Whenever the smallest lot in the subdivision has an area of 2 acres or more, the subdivider may install private water systems (individual wells), when sufficient evidence is presented to the Board prior to the approval of the tentative map to indicate that private water systems are feasible on all lots shown on the subdivision map. The requirements for minimum parcel size for individual wells of the other eight counties range from 1 acre to 2.5 acres, and several counties have no specific requirements and address the issue on a case-by-case basis. Sonoma County has specific report requirements for areas defined as being water scarce or as having marginal water availability.

Fresno County pump test standards are discussed earlier in this section. Other counties require pump tests that range from 4 to 72 hours, and the length of the test is generally determined by the number of connections the well is intended to serve. The required well yields range from a low of 1 gpm with 1,000 gallons of storage to a high of 5 gpm per connection without storage requirements.

Fresno County requires that all new water systems incorporate sounding tubes in wells that allow the measurement of water levels. Madera County requires the installation of sounding tubes or other appropriate method of determining static water levels. The other seven counties do not identify a requirement for sounding tubes.

7.3 COMPREHENSIVE WATER MANAGEMENT PLAN

A comprehensive plan for managing the groundwater resources in the foothill and mountain areas (i.e., water-short areas) should be developed. A groundwater management plan has been adopted for Fresno County (Fresno County, 1997), but is not specific to water-short areas. The WMP should address water conservation with specific action items that focus on the special issues of the foothill and mountain areas. The WMP should also include a data acquisition program designed to gather information on groundwater levels and use in the foothill and mountain areas of the County (see Section 6). The data acquisition program needs to include comprehensive hydrogeologic studies of specific areas and watersheds that are experiencing significant growth and that may be impacting the groundwater resources in the area. The data acquisition program will provide a check on the accuracy of the assumptions and findings of this report, such as the current and projected water demands and the maximum renewable groundwater supply estimates. The WMP may take 3 to 5 years to prepare and implement.

The WMP must be developed in close coordination with the residents of the area. The success of the plan will likely be adversely affected if area residents do not support the actions outlined in the WMP. An example is the collection of groundwater level and usage data. Without cooperation of area residents, the ability to collect data will be limited to public wells and CSDs. This could severely restrict the areas from which data can be collected and analyzed, thereby limiting the extent to which actions taken by the County can be verified to have positive or negative impacts on the groundwater resources of the area and limiting the ability to analyze groundwater conditions on a watershed or area basis.

Suggested components of the WMP include:

- description of the area that the WMP would cover,

- identification of concerns and establishment of management objectives (goals) that would contribute to a reliable long-term water supply,

- description of the regional geology and hydrogeology,

- identification of subwatershed areas that need to be tracked,

- identification of existing natural groundwater recharge areas and potential artificial groundwater recharge areas,

- identification of water conservation measures and how they could be implemented,

- strategy for public involvement and potential formation of a Technical Advisory Committee,

- coordination with other public and private water entities,

- development of a monitoring program capable of tracking physical and chemical conditions of the water supply,

- periodic reporting of monitoring activities summarizing water supply conditions within the area and re-evaluation of the WMP,

- identification of and implementation of mitigation measures that would contribute to a reliable long-term water supply, and

- review of County land use/water policies and ordinances.

Many of the components of the WMP are discussed in this document. However, as additional information becomes available, conclusions and recommendations presented in this document may need to be revised. This WMP would be one portion of the program to demonstrate sustainability of the water supply in water-short areas. Funding mechanisms for the WMP include creation of a County Service Area and development fees. Details of how these funding mechanisms could be implemented are included in the Fresno County Groundwater Management Plan (Fresno County, 1997).

8.0 CONCLUSIONS AND RECOMMENDATIONS

The following are conclusions and recommendations drawn from this study.

8.1 CONCLUSIONS

- Annual precipitation in the study area varies significantly from year to year, with most years substantially lower or higher than the mean. This makes the area susceptible to drought conditions. Analysis of the DI indicates 10 droughts lasting 4 years or longer occurred between 1701 and 1978. The data indicate that between 1820 and present, a drought of 4 years or longer occurs on average every 20 years, with the most recent one occurring from 1984 through 1992.

- Groundwater in the study areas occurs primarily in fractured bedrock that has low storage capacity. Significant quantities of groundwater are produced from weathered bedrock in the Shaver Lake area.

- Because of the low storage capacity of the fractured bedrock aquifer and reliance on groundwater as the only current water supply, the available groundwater supply is highly susceptible to periods of drought and overproduction.

- Land use in the study area is primarily residential. No significant commercial or industrial water uses were identified in the three areas studied in detail. Increases in water demand in the study area will be due primarily to increased residential development.

- Analysis of current water demands and projected growth rates using Census data to 2025 indicates that water demand is anticipated to increase from 352 to 491 AFY in the Shaver Lake area, 578 to 860 AFY in the Auberry-Prather area, and 354 to 579 AFY in the Squaw Valley area. Projected water usage at full buildout of permitted lots is estimated at 475 AFY in the Shaver Lake area, 908 AFY in the Auberry-Prather area, and 979 AFY in the Squaw Valley area.

- Analysis of well depth trends indicates that average well depths are increasing with time in the three areas studied in detail.

- Calculated long-term maximum renewable groundwater supplies, based on water balances for subwatersheds, range from less than zero in the Shaver Lake area to slightly above zero in the Auberry-Prather and Squaw Valley areas. Only a portion of the maximum renewable groundwater supply is available for development.

- Currently, insufficient data are available to use water balances as a reliable means to evaluate whether current and/or projected water demands can be met by the available groundwater supply. The uncertainties in the amount of evapotranspiration and runoff are large in comparison to the amount of groundwater pumped annually in the study area.

- The current policy of requiring a minimum 30-day pumping test for community water supply wells and projecting the slope of the yield curve on a semi-logarithmic plot to 120 days does not appear sufficient to predict the long-term sustainable yield of the production wells.

- The current water supply in WWD 41 has been approved based on supplying more than 1,298 EDUs, of which 768 EDUs are currently connected. The 12 production wells currently in operation in WWD 41 can sustain a rated yield of about 95 gpm based on the 2004 pump test data projected to 120-days. The average annual delivery from 2001 to 2004 was 0.11 gpm per EDU. At 1,298 EDUs, 0.11 gpm per EDU would require an average annual pumping rate of 143 gpm (50 percent greater than can be sustained according to 2004 pump test data).

- The current water supply in WWD 41 cannot meet the peak demand requirement (0.3 gpm per EDU) of the 768 currently connected EDUs (230 gpm), much less the peak demand of the 1,298 recorded EDUs (390 gpm) required by DHS. Current peak demand is being met by using water in three large storage tanks; however, storage is not allowed to meet State regulatory requirements.

- In the Shaver Lake area, the initial policy of approving developments with community water systems on the basis of a demonstrated water supply of 0.177 gpm per EDU is insufficient to support demand. The State's policy of requiring 0.3 gpm per EDU is minimally sufficient to support the current maximum daily demand.

- Additional sources of water need to be incorporated into the WWD 41 system to meet the demand of the recorded EDUs.

- The seasonal occupancy of residences in the Shaver Lake area indicates that additional tank storage can be used to help meet short-term, high-demand periods that occur during summer holidays. However, storage is not allowed to meet State regulatory requirements.

- Greater utilization of the higher capacity wells in WWD 41 may induce additional recharge by lowering near-surface water tables and allowing more seepage of water into the ground that otherwise would be rejected and flow away as surface runoff.

- Enhancement of groundwater recharge may reduce the amount of water available for runoff and/or evapotranspiration.

- Insufficient water level data are available to evaluate groundwater level trends in the study area except in the western portion of the Squaw Valley area. This lack of data prevents identification of changes in groundwater storage. Limited amounts of data from western Squaw Valley and from community water supply wells in WWD 41 do not indicate a long-term decline in groundwater levels.

- The Fresno County requirement of a minimum of three wells per 100 acres to approve subdivisions on individual wells may not be adequate to demonstrate availability of groundwater in areas of fractured bedrock.

- Creation of community water systems for subdivisions provides a more easily managed groundwater supply than subdivisions approved with individual wells. Such systems more efficiently use scarce groundwater resources and eliminate the possibility that some lots may not be viable because groundwater cannot be developed. In addition, community water systems are more likely to provide consistent and accurate data that can be incorporated into the data acquisition program.

- Fresno County's water policies are essentially equal to or stricter than eight counties located in central and northern California that have similar geologic and hydrogeologic conditions within their borders.

8.2 RECOMMENDATIONS

The following recommendations are made based on the findings of the study. The recommendations are presented by category.

Monitoring

1. Implementation of the proposed data acquisition program (see Section 6.0) is recommended to collect water level, well yield, streamflow, and climatological data within selected subwatersheds for refinement of water balances. The recommended system would include water level measurements on a minimum of 72 wells or piezometers, installation of flow meters on selected pumping wells, installation of 8 streamflow gages, and installation of 7 climatological stations.

2. Data collected during implementation of the data acquisition program and available from other sources need to be maintained in a database and organized to allow evaluation. The data should be evaluated annually and a summary report prepared documenting activities conducted. Recommendations should be made to modify the program as needed to fill identified data gaps.

3. Collection and evaluation of groundwater quality data should be incorporated into the data acquisition program.

4. Water budgets, based on detailed data, need to be established for subwatersheds where additional development of groundwater is proposed. Area-wide estimates are not sufficiently accurate to predict renewable groundwater supplies. It is estimated that at least 3 to 5 years of data, including a climatic cycle with at least 1 above average and 2 consecutive below average precipitation years, is needed so that annual variability can be evaluated.

Comprehensive Water Management Plan

5. The County should develop a comprehensive Water Management Plan (WMP) for protecting the groundwater resources of the foothill and mountain areas as part of the program to demonstrate sustainability of the resource. This WMP should include development of mandatory and recommended water conservation measures and recycled water programs. The WMP should also include investigation of the potential for installing groundwater recharge basins and surface water runoff storage facilities to enhance recharge. The WMP should also include a plan and schedule for development of surface water supplies in the study area, such as the County's CVP water supply. The WMP may take 3 to 5 years to prepare and implement.

6. Pending development of the WMP, future proposals for subdivision of lands in the study area should be required to provide a detailed watershed analysis in addition to the hydrogeologic analysis to evaluate the ability of the proposed water system to meet the water demands of all lots in the subdivision. The watershed analysis should also evaluate impacts to runoff and flora and fauna from further development of the groundwater resource.

Policies

7. In order to meet continued growth projections in the study area, the County should require community water systems for proposed developments where the minimum lot size is 10 acres or less. For the subdivisions where the minimum lot size is greater than 10 acres, current County standards should be maintained for the number of wells needed to demonstrate an adequate water supply.

8. The County should continue its policies for requiring minimum groundwater yields in water-short areas. For individual wells, these are 5.0 gpm (with no storage requirement), or 1.0 gpm with a minimum storage of 2,000 gallons in addition to fire-related storage requirements.

9. The County should develop a program to identify and protect the groundwater recharge areas in the foothill and mountain areas, including zoning regulations to prevent building in these areas. At a minimum, this would include areas within 50 feet of streams, meadows, and other recharge areas identified during hydrogeologic investigations.

10. Until the recommended data acquisition program is in place and sufficient data have been collected to substantiate how the groundwater system recharges under various climatic conditions, it is recommended that the minimum demonstrated long-term water supply be increased from 0.3 to 0.5 gpm per EDU for community water systems in water-short areas. The additional 0.2 gpm provides a factor of safety against operational interruptions, added supply for fire protection, and a buffer against long-term drought conditions.

11. Until the recommended data acquisition program is in place and sufficient data have been collected to substantiate how the groundwater system recharges under various climatic conditions, pumping tests in the Shaver Lake area should be conducted for a period of not less than 90 days and the pumping yield curve for the later-time data should be extended to 120 days. The policy of reducing the 120-day yield by 25 percent (or more if yield is anticipated to be influenced by surface water) should be continued in order to compensate for potential decline in yield during extended drought conditions.

12. The County should require that any production well proposed for incorporation into a community water system be accompanied by an observation well representative of the specific aquifer, within 200 feet of the production well, completed to a similar depth and with similar openings to the producing formation as the production well, and fitted with a recording water level device such as a pressure transducer. These observation wells should be incorporated into the data acquisition program and would serve to monitor groundwater levels in wells that are not subjected to pumping.

13. Because of the precarious water balance in the study area and the current lack of data to refine those balances, it is recommended that the County require that the same pumping tests be conducted for all proposed community water systems in designated water-short areas as those required for the Shaver Lake area. These pump test requirements are summarized in Recommendation 11, above.

Shaver Lake Water Supply

14. The County needs to finalize agreements with SCE, PG&E, and other entities to enable diversion of its CVP surface water supply from Shaver Lake. Plans for construction of a surface water treatment plant and distribution system need to be developed now so that surface water can be utilized as soon as possible after agreements are in place.

15. Additional lots within WWD 41 should not be created until the water production deficit for the current connections is addressed.

16. The County should embark on a process to increase water production incrementally in proportion to anticipated new connections within WWD 41.

17. In WWD 41, consideration should be given to better utilization of the higher capacity wells, especially the radial wells, which have the potential for greater pumping rates during the early part of the year when recharge is actively occurring. In addition, consideration should be given to expanding the surface storage facilities in the district to maximize the ability of the system to extract groundwater over a longer period of time and to extract more when recharge is actively occurring. The extra storage also would provide additional water available to meet peak demands or to meet demands during a period of operational disruption.

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APPENDIX A

CURRENT AND PROJECTED WATER DEMAND ANALYSIS TECHNICAL MEMORANDUM

APPENDIX B

WATER BALANCE TECHNICAL MEMORANDUM

APPENDIX C

DATA ACQUISITION PROGRAM TECHNICAL MEMORANDUM

APPENDIX D

FRESNO COUNTY WATER DEVELOPMENT STANDARDS AND POLICIES