Calaveras County Water District

Camanche/Valley Springs Area Hydrogeologic Assessment

July 2003

List of Preparers:

Michael Cornelius, R.G.
Saquib Najmus, Ph.D., P.E.
Leah Briney
Richard Shatz, R.G., C.E.G.
Juliana Herrington

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Calaveras County Water District (District) has received an AB 303 Grant from the California Department of Water Resources (DWR) to develop a Groundwater Monitoring and Data Collection Program (GMDCP) for the Camanche/Valley Springs Area of Calaveras County. The purpose of the study is to develop a better understanding of the groundwater resources in western Calaveras County to improve groundwater management in the future, possibly including conjunctive use of the District's groundwater and surface water resources. This project is divided into two primary components:

- Annual Groundwater Assessment
- Hydrogeologic Assessment

The purpose of the Annual Groundwater Assessment is to develop a groundwater level and water quality monitoring program consistent with the groundwater management goals of the AB 3030 Groundwater Management Plan adopted by the District. It is intended that the groundwater monitoring program will be continued by the District to improve their understanding of the available groundwater resources and to meet future groundwater monitoring and data collection needs as outlined in SB 1938.

The purpose of the Hydrogeologic Assessment is to develop some initial hydrogeologic data about the Camanche/Valley Springs study area based on the available information. This information is required to develop a better understanding of potential groundwater management opportunities in the study area.

CALAVERAS COUNTY WATER DISTRICT

The District is a political subdivision of the State of California. It was formed in 1946 under the laws of the State of California as a public agency for the purpose of developing and administering the water resources of Calaveras County. The District is governed by the California Constitution and the California Government and Water Codes.

CALAVERAS COUNTY

Calaveras County is located in the Central Sierra Nevada foothills. The county is bordered by San Joaquin and Stanislaus Counties to the west, Amador County to the north, Alpine County to the east, and Tuolumne County to the south. Topographically, the county is situated in the

Mother Lode region of the Sierra Nevada foothills, between the Central Valley to the west and the Sierra Nevada Mountains to the east. Elevations vary dramatically across the county, from approximately 200 above mean sea level (msl) in the west to 8,170 feet near Alpine County.

Historically, the District has met a significant portion of the water needs of Calaveras County with surface water from the Mokelumne, Calaveras, and Stanislaus Rivers. The District has access to surface water on these rivers. All of these rivers flow west to the San Joaquin Delta, which is 25 miles west of Calaveras County. Figure 1.1 shows the location of watersheds of these three rivers. Groundwater is used by other local water purveyors and individuals to meet domestic and agricultural demands..

Calaveras County is underlain by the faulted and folded igneous and metamorphic rocks of the Sierra Nevada. Groundwater occurs along the faults and fractures of these rocks. Wells drilled into these rocks may yield small amounts of water to domestic wells; however, water supply and availability are unpredictable.

In the northwest portion of Calaveras County the bedrock of the Sierra Nevada is overlain by the alluvial sediments of the Central Valley. Groundwater in the alluvial aquifer yields more water to wells than that in the bedrock, and is more reliable and manageable.

PROJECT STUDY AREA

The northwestern portion of Calaveras County known as the Camanche/Valley Springs Area is the study area for this project. The study area overlies the largest alluvial aquifer in Calaveras County, which is part of the Eastern San Joaquin County Groundwater Basin (DWR, Bulletin 118-80, California's Groundwater) as shown in Figure 1.2. The Eastern San Joaquin County Basin has been identified in Bulletin 118-80 as being in a state of overdraft.

In 2001, the District began pursing increased groundwater management in the Camanche/Valley Springs Area. This included adopting an AB 3030 Groundwater Management Plan in September 2001 and submitting an AB 303 grant application to develop the Groundwater Monitoring and Data Collection Program. The work completed for this study was funded by the AB 303 grant application.

SCOPE OF WORK

The scope of work included three tasks:

- Task 1 Annual Groundwater Assessment

- Task 2 Hydrogeologic Assessment
- Task 3 Public Outreach

The *Camanche/Valley Springs Area Groundwater Monitoring Report for Spring 2003* was completed as part of Task 1.

The *Camanche/Valley Springs Area Hydrogeology Assessment Report* (this report) was completed as part of Task 2.

Public Outreach (Task 3) involved making presentations to local groups interested in groundwater and assisting the District in developing public information for groundwater issues in the study area.

REPORT OUTLINE

The Hydrogeologic Assessment Report for the Camanche/Valley Springs Area is organized into the following sections:

Section 1: Introduction describes the project purpose, study area, and organization of this report.

Section 2: Hydrogeologic Setting describes the soils, geologic setting, and hydrogeologic setting of the study area.

Section 3: Water Balance describes the overall water balance for the study area.

Section 4: Potential Recharge Opportunities describes potential recharge areas, and completes a conceptual recharge analysis.

Section 5: Summary and Recommendations presents a summary of the project and recommendations on additional actions.

Section 6: References lists the references cited in this report.

Appendix A: *Camanche/Valley Springs Area Groundwater Monitoring Report for Spring 2003* presents the information from the initial groundwater monitoring of the GMDCP.

This section presents the hydrogeologic setting of the Camanche/Valley Springs Area. It includes:

- Soils and Near-Surface Conditions
- Geologic Setting
- Hydrogeologic Setting

SOILS AND NEAR-SURFACE CONDITIONS

The soil and near-surface conditions are of interest in this study because of their potential influence on groundwater recharge conditions (natural or artificial). Typically, regional soil mapping is available from the Natural Resource Conservation Service (NRCS), formerly the Soil Conservation Service. NRCS does not have any soil mapping available for the study area. Regional soil mapping information from the California Department of Forestry was collected and analyzed as part of this study.

The California Department of Forestry published several soil vegetation surveys as a portion of the U. S. Department of Agriculture Service Resource Bulletin PSW-13/1974. These maps provide basic information about soils and vegetation; their characteristics, location, extent and relationships. There are four 7.5-minute quadrangle maps detailing the vegetation and soils of the study area that are included in this bulletin. Each map has a separate booklet containing six tables describing the map symbols, and there is one general booklet describing the entire study.

For the purposes of hydrologic analysis, soil types can be classified into four hydrologic soil groups: A, B, C, and D. This categorization system is based on estimates of runoff potential and water intake of a saturated soil profile, Group A having the lowest runoff potential and Group D having the highest. Table 2.1 summarizes the runoff potential for each of the soil groups. From a groundwater perspective, Group A and B soils (which have the lowest runoff potential) have the highest infiltration potential. These are soils that may be conducive to surface recharge operations.

Table 2.1
Soil Runoff Potential

Hydrologic Soil Group	Runoff Potential
A	Low runoff potential: mainly sands and gravel that are deep and well to excessively drained; high transmissivity.
B	Low to moderate runoff potential: soils of moderately fine to moderately coarse textures; moderately deep and drained; medium transmissivity.
C	Moderate to high runoff potential: soils of moderately fine texture, with an impeding clay layer; low transmissivity.
D	High runoff potential: mainly clay soils with a high swelling potential, shallow soils over nearly impervious materials and soil with high permanent water table; poor transmissivity.

There are no Group A soils in the study area, making areas overlain with Group B type soils, with moderate to low runoff potential, the best candidates for recharge projects. Table 2.2 identifies the Group B soils in the study area and presents some of their characteristics. Figure 2.1 shows the location of the three types of Group B soils recognized in the survey;

- Areas with 80% or greater Group B soils (B),
- Areas with 51 to 80% Group B and 20 to 49% Group C soils (Groups B and C),
- Areas with 51 to 80% Group B and 20 to 49% Group D soils (Groups B and D).

Figure 2.1 shows that approximately 10% of the study area is underlain by Group B soils, and that the Group B soils are distributed throughout the study area.

GEOLOGIC SETTING

The study area lies in the foothills of the Sierra Nevada. The ridge and valley topography of the area marks the transition between the flat-lying, sediment-filled basin of the Central Valley and the uplifted and faulted metamorphic rocks of the Sierra Nevada. The evolution of the valley to the mountain topography is demonstrated in the subsurface as well as in the topography of the

TABLE 2.2 GROUP B SOILS IN STUDY AREA

FIGURE 2.1 LOCATION OF GROUP B SOILS

study area. The relatively flat-lying sedimentary deposits, which are thinning eastward from the valley, overlie an eroded faulted and folded bedrock surface.

GEOLOGIC UNITS

The geologic units in the study area consist of relatively flat–lying, westward-dipping Tertiary and Quaternary sediments overlying the tilted Sierra Nevada bedrock complex. The geologic units in the study area are summarized in Figure 2.2 and described below. They include: the Eocene Ione Formation, the Miocene Valley Springs Formation, the Miocene to Pliocene Mehrten Formation, the Pliocene to Pleistocene Laguna Formation, and the Pliocene to recent alluvial deposits. The surface geology for the study area is shown in Figure 2.3.

Bedrock

The sedimentary deposits in the study area rest unconformably on top of the Sierra Nevada bedrock complex. The study area exists in the Foothills Copper-Zinc Belt, a massive-sulfide deposit that extends 400 kilometers (km) along the western Sierra Nevada. Typical minerals of this volcanogenic zone are gold, chromium, nickel, copper, zinc, manganese, and mercury. Lithology of the bedrock complex includes slate, schist, quartz, phyllite, and greenstone.

Fracture sets and joints within the resistant metamorphic and igneous rocks of the Sierra Nevada bedrock complex may contain sufficient groundwater for well supply; however, water supplies and occurrence are unpredictable. Individual wells tapping the bedrock may intersect several larger joint and fracture systems that are saturated, yielding significant quantities of water. In general, bedrock wells show a high degree of variability of well yields, even over short distances.

Ione Formation

The Eocene Ione Formation unconformably overlies the Sierra Nevada bedrock complex and is composed of marine to non-marine clay, sand, sandstone, and conglomerate. The thick beds of clay range in color from white to red, and from blue to gray with lignite. These clay beds, along with the typically medium-grained quartz rich sand and sandstone, may also contain anauxite, a characteristic clay mineral of the Ione Formation. The conglomerate generally is composed of quartz and metamorphic rock material derived from the Sierra Nevada bedrock complex. Clean white sands and clays distinguish this formation from others in the area.

FIGURE 2.2 GEOLOGIC UNITS IN STUDY AREA

FIGURE 2.3 SURFACE GEOLOGY MAP

In localized areas near the Sierra Nevada foothills, the formation contains fresh water. The relatively impervious deposits of the Ione Formation result in the overall low permeability of this unit, while local coarser beds may yield small quantities of water to domestic wells.

Valley Springs Formation

The Miocene Valley Springs Formation lies unconformably (i.e., contact between layers is irregular due to a lack of sediment deposition or active erosion for a period of time) on the Ione Formation and is composed of tuffs, ash, clay, sandstone, and conglomerates, all of rhyolitic origin. The Valley Springs deposits are distinguished from the Ione deposits by their volcanic nature. Typical tuff deposits are either a white vitric tuff or a fine-grained green tuff. These tuffs may display alteration to clays, and in extreme cases, only a claystone bed with relict tuffaceous texture remains. Pure deposits of rhyolitic ash exist in areas, while many sand and ash beds are present. In general, the clay beds of the Valley Springs Formation are greenish in color, and may contain silt, sand, and large pumice fragments. The sandstones range in grain-size from fine to coarse, and are typically well cemented. Predominantly composed of quartz and pre-Cretaceous material, the relatively sparse conglomerate lenses within the tuff, clay, and sandstone may also contain pumice fragments. In general, the Valley Springs Formation is predominantly fine-grained, containing less coarse-grained deposits than fine-grained. The Valley Springs Formation is the predominant lithology of the alluvial aquifer in the study area. This formation outcrops over most of the study area as it is present at ground surface throughout the study area.

The Valley Springs Formation is the primary water-producing deposit in the study area, as it composes most of the tapped alluvial aquifer. Although the large amount of clay and pumiceous material results in an overall low permeability, the Valley Springs Formation is regarded as a reliable source and good producer of good quality groundwater near areas of outcrop.

In many areas of the Central Valley, the Valley Springs Formation is considered to be largely non-water-bearing. This is likely due to the great depths at which this formation occurs beneath the valley floor. The formation occurs below the base of freshwater in many locations, and may also be too deep to be tapped by traditional domestic and irrigation wells. The Valley Springs Formation is also known to contain highly mineralized water of an unknown source beneath the valley floor. It also occurs beneath the more permeable Mehrten Formation, which supplies much of the groundwater for the San Joaquin County.

Mehrten Formation

The Miocene to Pliocene Mehrten Formation unconformably overlies the Valley Springs Formation. In the Sierra Nevadas, this formation is composed of andesite and basalt lava flows with volcanic mudflows (lahars). Further from the mountains, and closer to the Central Valley, this formation consists of fluviatile sandstone interbedded with conglomerate, siltstone, claystone, and mudflows, all of andestic and basaltic origin. In many areas, basal deposits contain reworked detritus of the Valley Springs and older formations. The dark gray to blue and black sandstone is very widespread and composes approximately 50% of the Mehrten deposits. The lenticular conglomerate beds vary in degree of cementation, resulting in their presence as resistant ledges as well as friable, easily eroded beds. Well-cemented siltstones and claystones are generally gray to blue and dark brown, and exist in thin to massive beds. The hard, impervious mudflows are composed of weakly graded, angular, andesitic detritus. The Mehrten Formation is thin and discontinuous over much of the study area. This formation can be seen capping hilltops in some areas of the county.

The Mehrten Formation is the primary water-bearing unit in the neighboring San Joaquin County. However, this formation lacks sufficient widespread presence in the study area to be the predominant water source for Calaveras County. Typically, in the sparse locations where the Mehrten Formation is present within the study area, wells tap the underlying Valley Springs Formation. Permeability within the Mehrten deposits varies from highly permeable sandstone and conglomerate beds to impervious mudflow deposits. The high percentage of sandstone versus fine-grained deposits results in an overall high to moderate permeability.

Laguna Formation

The Pliocene to Pleistocene Laguna Formation is composed of granitic, metamorphic, and volcanic clay, sand, silt, and gravel. Typically these poorly exposed stream-laid alluvial deposits form high terraces and are associated with the last major uplift in the Sierra Nevadas.

The discontinuous nature of these deposits limits the water-bearing capabilities of the Laguna Formation in the study area. Permeable sand lenses and occasional perched water zones may supply water to domestic wells. In general, gravel deposits do not yield significant amounts of water.

Alluvium

In the study area the alluvium consist of all the deposits younger than the Laguna Formation. Although these deposits encompass a long depositional period, they are of common lithology. These unconsolidated deposits are composed of clay, silt, sand, and gravel, and form a thin veneer over the older deposits in the study area. These deposits can be found forming terraces as well as in stream and river channels.

The alluvial deposits in the study area are typically moderately permeable throughout and generally more permeable than the underlying layers. However, these deposits lack widespread presence and thickness to be a reliable source of water.

GEOLOGIC CROSS SECTIONS

Three geologic cross sections were developed using existing available information to present the local hydrogeology. More than 200 well logs were used to create the cross sections. The District previously collected most of the well logs for the wells included in the analysis. Additional sources of data were used to supplement this information. The well logs used in this analysis were selected based on the quality of the well driller's description and the detail provided an the well locations. The approximate location of each well used in this analysis is shown in Figure 2.3.

The generalized topography on the cross sections was interpreted from USGS 7.5 minute quadrangle maps. The elevation scale is exaggerated to emphasize well characteristics. These sections are intended to show the general trends of the subsurface geology. These cross sections should be updated as additional information becomes available.

Cross section A-A′

Cross section A-A′ is oriented east-west and roughly follows Highway 12 through the towns of Valley Springs and Burson (Figure 2.3). Approximately 41 well logs were used to develop this section. Only the Program Monitoring Wells are shown on Cross section A-A′ (Figure 2.4a). The Program Monitoring Wells are those wells included in the Spring 2003 Groundwater Monitoring and Data Collection Program (Appendix A). This section demonstrates the east-west thickening of the sedimentary beds overlying the westerly deepening bedrock. The contact between the alluvial sediments and the bedrock on the eastern side of the section marks the boundary of the alluvial aquifer.

Program Monitoring Well 13 is located just outside the study area. Although the driller's log suggests that this well is drilled through 230 feet of Valley Springs deposits, these sediments are hydraulically cut off from the rest of the alluvial aquifer by the bedrock. In the area of Valley Springs, the bedrock is at or close to ground surface. Wells in this area generally receive their groundwater from fracture zones in the bedrock.

FIGURE 2.4A AND B GEOLOGIC SECTION A-A′, B-B′

Near Burson, where the bedrock occurs at an average elevation of around 200 feet, wells derive their water from both the bedrock and sedimentary layers. Wells tapping the alluvial aquifer typically receive their water from sand, sand and gravel, or water-bearing sedimentary layers within both the Valley Springs and Ione Formations. Well intersection with the bedrock in this area is irregular. Wells appearing to pump from the bedrock are situated in very close proximity to wells showing a deep subsurface sedimentary section. This indicates that the bedrock/sedimentary contact is highly irregular and that the surface of the bedrock reflects a very intricate ridge and valley system of the relict topography.

Wells near the Calaveras County Line generally pump from the sedimentary beds of the Valley Springs Formation as the Ione Formation and bedrock occur at significant depths relative to other areas in the Study Area. Although wells in the area along this section are not deep enough to come in contact with the bedrock, it is inferred that bedrock depth continues to increase towards the west.

Cross section B-B′

Cross section B-B′ is oriented from northwest to southeast, and is roughly parallel to the Calaveras/San Joaquin County Line. Approximately 43 well logs were used to develop this cross section. Only the Program Monitoring Wells are shown on Cross section B-B′ (Figure 2.4b). This area is of particular importance as it represents the location of thickest sedimentary deposits in the study area.

The northern portion of this section includes the town of Wallace and nearby Lake Camanche. The wells in this area appear to be sensitive to surface water levels in the nearby lake. Similar to Cross section A-A′, the contacts between the bedrock and the alluvial aquifer and between the Ione and the Valley Springs Formations are highly irregular. All of these irregularities are not called out in the section because of the great degree of variation in lithologic contact elevation, great projection distances from the actual well location onto the section line, questionable reliability of well logs, and uncertain well locations. One such bedrock ridge near the Wallace area is shown in the section. There is a higher level of confidence associated with the well logs for Program Monitoring Wells 18, 19, and 20. These wells have a highly accurate location, descriptive well logs, and are spaced closely together.

Along the southern end of Cross section B-B′, the majority of the wells used to develop this section intersect the alluvial aquifer only. This is shown in section with the thick sedimentary layers.

Cross section C-C′

Cross section C-C′ is oriented from northwest to southeast and generally connects the towns of Burson, Jenny Lind, and Milton. It extends north from the Calaveras/Amador County line at the Mokelumne River to the Calaveras/Stanislaus County line in the south. Approximately 64 well logs were used to develop this section. Only the Program Monitoring Wells are shown on Cross section C-C′ (Figure 2.4c).

The northern portion of this section is particularly important because many wells in this area are currently running dry and well owners are reporting poor quality groundwater. The geologic map indicates that the Ione Formation is exposed at ground surface in the area to the north of Burson. Many of the wells in this area tap the bedrock, indicating the alluvial cover in this area is thin. Analysis of the Program Monitoring Wells in this area indicates that the Ione Formation here is potentially dry and that the wells are receiving all of their water from the underlying bedrock. Several wells in the Burson area indicate the presence of a bedrock subsurface ridge approximately parallel to Campo Seco Road. This ridge may act as a hydraulic barrier, separating the groundwater from those areas north of Burson from the main alluvial aquifer to the south.

To the south of the subsurface ridge extending nearly to the town of Jenny Lind, the wells tap the Valley Springs and Ione Formations as well as the bedrock. The well logs indicate that the lithologic contacts are highly irregular. The number of available well logs decreases as the section continues to the Calaveras/Stanislaus County line. These sparsely spaced logs indicate the presence of the Valley Springs and Ione Formations as well as the bedrock. Because of the limited data in this area, little is known about the nature of the subsurface.

Geologic History

The present day bedrock is a complex zone of metamorphic rocks that formed as part of a Jurassic island-arc. Metamorphism occurred during the late Jurassic uplift of the Sierra range and accretion of this island-arc terrane, geologically represented by greenstones and slates of the bedrock complex. During the Eocene, much of the Central Valley was inundated by an inland sea, and the climate was warm temperate or subtropical. These factors encouraged a period of intensive weathering of the exposed Sierra Nevada bedrock complex, resulting in an ancestral ridge and valley topography of moderate relief. The result of this intense weathering of the bedrock complex was the deposition of the Ione Formation on the newly eroded bedrock surface.

By the end of the Eocene, deposition of the Ione Formation had ceased. Renewed uplift in the Sierra Nevada and an introduction of a new river system to the valley encouraged erosion of the

FIGURE 2.4C GEOLOGIC SECTION C-C′

Ione Formation surface. The Oligocene is marked by Sierran volcanic activity and deposition of the Valley Springs Formation in the valley. The explosive volcanic activity produced a large amount of rhyolitic material in the higher elevations that was then brought down, filling stream valleys and blanketing the valley slopes.

The Oligocene volcanic activity was followed by andesitic flows and lahars (mudflows) in the Miocene which buried the valley under a thick layer of debris. This resulted in the deposition of the Mehrten Formation. Later erosion removed most of the Mehrten Formation from the study area, exposing the Valley Springs Formation and in some places the Ione Formation. Following this period of erosion, beginning in the Quaternary and continuing to the present, a thin veneer of alluvium was deposited.

Although there were multiple periods of uplift over the geologic time, the sedimentary formations are relatively flat-lying in the study area subsurface. However, erosional episodes between depositional periods of the different formations have resulted in highly irregular lithologic contacts.

HYDROGEOLOGIC SETTING

GROUNDWATER BASIN DEFINITION

The study area is located in the northeast corner of the Eastern San Joaquin County Groundwater Sub-Basin (5.22.01). Deposits composing the alluvial aquifer in the study area include: the Eocene Ione Formation, the Miocene Valley Springs Formation, and the Pliocene to recent alluvial deposits. The primary water-bearing deposits in the Eastern San Joaquin County Groundwater Basin include the Alluvium and Modesto/Riverbank Formations, Flood Basin Deposits, Laguna Formation, and Mehrten Formation. The Mehrten Formation is considered to be the oldest significant fresh water–bearing formation on the east side of the basin. Where the Laguna Formation and Mehrten Formation are present, the underlying Valley Springs Formation and Ione Formation are not utilized extensively. Figure 2.5 shows the extent of the Eastern San Joaquin County Groundwater Basin.

DWR, San Joaquin County Flood Control and Water Conservation, Department of Health Services, and co-operators collectively monitor approximately 926 wells within this groundwater subbasin. Water level data from these wells are used to develop water level contour maps. Groundwater elevations for Spring 1998, shown in Figure 2.5, show a groundwater cone of depression near the center of the basin, just to the east of Stockton.

FIGURE 2.5 EASTERN SAN JOAQUIN COUNTY GROUNDWATER BASIN

GROUNDWATER LEVEL TRENDS

This basin was identified in Bulletin 118-80 as being in a state of overdraft. While the groundwater contours shown in Figure 2.5 do not extend in to the study area, the groundwater level trends near the study area can be derived from existing individual well hydrographs. The location of selected well hydrographs used to identify long-term groundwater trends are shown in Figure 2.6. These well hydrographs are grouped as follows:

- Wells near the Calaveras River,
- Wells located midway between the Calaveras River and Mokelumne River,
- Wells near the Mokelumne River, and
- Study Area Wells.

Wells Near the Calaveras River

The groundwater level trend for three wells near the Calaveras River is shown in Figure 2.7. The groundwater level pattern for each of these wells is in good agreement with one another over the 54-year period of record. In general, these hydrographs show an overall decreasing groundwater level. These wells are likely receiving water from the unconfined aquifer in the area, causing groundwater levels to be heavily influenced by the flows in the Calaveras River. The yearly variations in groundwater levels reflect wet and dry periods. For example, the decreasing water levels during 1976 and 1977, followed by the increasing water levels in 1983, show the aquifer response to the 1976/77 drought followed by the 1983 wet season. These three hydrographs show a decrease in groundwater levels of approximately 40 feet over the past 54 years, which corresponds to an average annual decline in groundwater elevation of about 0.75 feet per year.

Wells Located Midway Between the Calaveras and Mokelumne Rivers

The groundwater level trend for wells located midway between the Mokelumne River and the Calaveras River is shown in Figure 2.8. These wells show a decreasing groundwater level trend of approximately 44 feet over the period from 1960 to 1997, which corresponds to an average decline in groundwater elevations of about 1.2 feet per year.

FIGURE 2.6 LOCATION OF SELECTED HISTORICAL WELL HYDROGRAPHS

FIGURE 2.7 GROUNDWATER HYDROGRAPH FOR WELLS NEAR THE CALAVERAS RIVER

FIGURE 2.8 GROUNDWATER HYDROGRAPH FOR WELLS LOCATED MIDWAY BETWEEN THE MOKELUMNE RIVER AND CALAVERAS RIVER

Wells Located Near the Mokelumne River

The groundwater level trend for wells located near the Mokelumne River is shown in Figure 2.9. Well 04N08E14K001M is located below Lake Camanche and shows a decrease in groundwater levels of approximately 43 feet over the past 42 years, which corresponds to an average yearly decrease in groundwater elevations of approximately 1 foot per year. The other two wells are located above the Lake Camanche spillway. These wells show a sharp drop in groundwater levels from about 1965 to 1970. After the initial decline during this period, the rate of groundwater level decline has been reduced significantly. These wells are likely influenced by Lake Camanche water levels resulting in the large fluctuation in groundwater levels beginning in 1970 and continuing to the present. Overall, these wells show a groundwater level decrease of approximately 20 feet over their 44-year period of record, corresponding to an average drop in elevations of 0.5 feet per year.

These hydrographs demonstrate the fairly continuous declining groundwater elevations since the 1940s. Bulletin 118-80 estimated the average basin-wide rate of decline to be 1.7 feet per year. The hydrographs discussed above show an average decline rate of 0.9 feet per year in wells near the Calaveras/San Joaquin County line.

Study Area Wells

Groundwater levels in the Study Area were collected as part this project and are presented in the *Camanche/Valley Springs Area Groundwater Monitoring Report for Spring 2003* which is included as Appendix A. The Spring 2003 groundwater contours for the Valley Springs Formation and Ione Formation are shown in Figure 2.10. Groundwater levels in the Study Area range from about 700 feet above msl in the eastern edge of the Study Area to about 100 feet above msl near the San Joaquin/Calaveras County line.

As shown in Figure 2.6, well 03N09E25R001M is located near the Calaveras/San Joaquin County line, just north of the Calaveras River. The well hydrograph for this well (Figure 2.7) shows a 2001 water level of about 95 feet above mean sea level (msl). This is in relative agreement with the water level data observed from the Spring 2003 water levels. In the future, groundwater levels near the county line will be more clearly understood as additional wells are added to the monitoring program and as sampling and measurements are coordinated with water level monitoring in San Joaquin County.

FIGURE 2.9 GROUNDWATER HYDROGRAPH FOR WELLS NEAR THE MOKELUMNE RIVER

FIGURE 2.10 GROUNDWATER CONTOURS FOR THE VALLEY SPRINGS AND IONE FORMATION, SPRING 2003

SPECIFIC YIELD ANALYSIS

Specific yield is defined as the percentage of water stored in the pore spaces of a unit of saturated material that will drain under the influence of gravity. This measurement indicates the quantity of water available for use based on the amount of water a specific type of rock can hold and release. The primary purpose of determining the specific yield is to estimate the storage capacity of the aquifer in the study area. Calculation of average well specific yield provides generalizations concerning the overall specific yield of the materials composing the aquifer.

Specific Yield Analysis References

The following sources were consulted when constructing a material classification system for the study area:

- *Groundwater and Wells, Second Edition*, Fletcher G. Driscoll,
- *Evaluation of Groundwater Resources: Sacramento County,* DWR Bulletin 118-3,
- *Groundwater Flow in The Central Valley, California,* USGS Open-File Report 85-345, and
- *Basic Ground-Water Hydrology*, USGS Water-Supply Paper 2220.

The classification in Bulletin 118-3 served as the primary model for the Calaveras County Material Classification.

Specific Yield Analysis Methodology

Specific yield for the upper 200 feet of the aquifer was calculated for 145 wells. The driller's lithologic interpretation (driller's call) and associated unit thickness were read from the well logs and entered as data into an Excel spreadsheet. All driller's calls were compared with the classifications listed in Bulletin 118-3. The calls were organized based on material type and each group was assigned a specific yield (Table 2.3). Often the calls were vague and were made in relative terms; efforts were made to interpret the driller's call and assign appropriate specific yield. The values presented in Table 2.3 are estimates based on the interpretation of the driller's calls.

Most driller's calls from the Calaveras well logs coincided with calls listed in Bulletin 118-3. However, this bulletin did not consider fractured bedrock. Although fractured bedrock may contain groundwater sufficient for a well supply, it is highly unpredictable. For this study, a

TABLE 2.3 SPECIFIC YIELD MATERIAL CLASSIFICATION

value of 1% was assigned to fractured bedrock to acknowledge that this material type may be water-bearing. This low value was chosen in an effort to avoid influencing the numerical characterization of the sedimentary aquifer.

The average specific yield was calculated for the 145 wells. First, each bed defined by the driller's call was assigned a specific yield percentage. The thickness of each bed was divided by the total well depth to calculate the thickness percentage for each bed intersected by the well. This number was multiplied by the assigned specific yield. The addition of all of these values provided the average specific yield for each well. The specific yield was calculated for the top 200 feet for each of the 145 wells.

The average specific yield for each well provides preliminary estimates regarding the overall specific yield of the aquifer in the study area. Based on this analysis, the average specific yield for the wells ranged from zero to 17%. Wells with a zero value are located in bedrock, while those with higher specific yield values are located in a sand- and gravel-rich area. The average well specific yield for the study area is 5.4%. This is most likely a result of the high clay content (poorly water-bearing, with a specific yield of 3%) in the sedimentary deposits and the scarcity of sand and gravel deposits (highly water-bearing with a specific yield of 10 to 25%).
Figure 2.11 shows the distribution of areas of low (generally less than 6%) and high (generally greater than 6%) specific yield in the study area.

This map indicates that the alluvial aquifer in the central area of the Study Area has the highest percent of coarse grained material. Areas with high specific yield are good potential candidates for further investigation of aquifer recharge projects.

DRILLER'S WELL LOGS

Driller's well logs were one of the primary sources of data used in this analysis and were collected to characterize regional well construction patterns of the study area. WRIME obtained well logs from two sources:

- DWR, Central District, and
- Calaveras County Department of Environmental Health.

Department of Water Resources, Central District

Calaveras County Water District obtained approximately 1,100 well logs for existing wells in the study area from the DWR, Central District. The District provided WRIME with photocopies

FIGURE 2.11 SPECIFIC YIELD ESTIMATES IN THE STUDY AREA

of all these well logs. This includes wells that were drilled between 1950 and 1995. These well logs are identified by the Department of Water Resources by their State Well Number (SWN). This number was assigned by DWR through location identification on topographic maps and it includes the township, range, and section location of each well. Few wells have SWNs that are more specific than their section location. Because there has been significant development in Calaveras County since 1950, the SWN is often inadequate in locating a well, and their locations should be considered approximate until it is verified in the field.

County Environmental Health Department

The well log database located at the Calaveras County Department of Environmental Health includes information pertaining to wells drilled in Calaveras County after 1998. There are over 1,000 wells within this database, all of which have been surveyed with a Global Positioning System (GPS) device. The District provided WRIME this information in the form of ArcView Geographic Information System (GIS) data files. Of these wells, there are approximately 335 wells located within the study area (Figure 2.12). In addition to the driller's well log and surveyed well location, well information within this database may include water quality laboratory test results. WRIME and the District collected over 40 well logs from this database.

FIGURE 2.12 LOCATION OF NEW WELLS SINCE 1998

PURPOSE

The purpose of this section is to develop a water balance to preliminarily quantify the groundwater level decline observed in the study area during the 1970–1993 period. A water balance was developed for most of the study area as part of a larger study of the Eastern San Joaquin County Groundwater Basin. A hydrologic model called the San Joaquin County Integrated Groundwater and Surface water Model (San Joaquin County IGSM) was developed as part of a previous investigation of the basin. This section provides some summary information about the San Joaquin County IGSM, but focuses on the groundwater balance developed for the area representing the Camanche/Valley Springs Study Area.

SAN JOAQUIN COUNTY IGSM

The San Joaquin County IGSM was originally developed as part of the American River Water Resources Investigation (ARWRI) for the U.S. Bureau of Reclamation in 1996. The San Joaquin County IGSM studied the groundwater depression in the central part of the basin and evaluated its potential impacts on available groundwater supplies, including the intrusion of brackish water from the Sacramento–San Joaquin Delta. Because the focus of the original model was not on the Camanche/Valley Springs area, the data utilized in the model in this area may not include all available local data. Also, limited water level data in Camanche/Valley Springs area was available locally to calibrate the model in the Study Area. Even with these potential limitations, the San Joaquin County IGSM may be used to estimate the changes in groundwater conditions for the Camanche/Valley Springs Study Area.

The San Joaquin County IGSM requires a comprehensive set of geologic, hydrologic, and land and water use input data. The key model output includes groundwater levels as well as hydrologic budgets. The San Joaquin County IGSM can simulate complex stream and multilayered aquifer systems using the basic principle of tracking the movement of water and the interaction of flows between streams and groundwater aquifers.

MODEL AREA

A finite element grid network was developed to model the groundwater flow in the San Joaquin County area. The entire model area consists of about 1,585 square miles. The San Joaquin County IGSM model grid (shown in Figure 3.1) was divided into 1,536 elements and

FIGURE 3.1 SAN JOAQUIN COUNTY IGSM MODEL AREA

1,445 model nodes. The average size of a single element is about one square mile (640 acres). The IGSM grid was developed to reflect local conditions including:

- Geologic and hydrogeologic considerations, such as geologic contacts and groundwater flow direction;
- Hydrologic considerations, such as rivers and creeks; and
- Local water management areas that have similar water and land use management (model subregions).

The San Joaquin County IGSM is divided into 30 model subregions. In the San Joaquin County IGSM, the Wallace Subregion (Subregion 17) represents the area in the Eastern San Joaquin Groundwater Basin located in Calaveras County between the Mokelumne River and the Calaveras River. With a total area of about 75 square miles, the Wallace Subregion is used in this analysis to represent the groundwater balance for the Camanche/Valley Springs Area. Figure 3.1 shows the location of the Wallace Subregion relative to the San Joaquin County IGSM.

STUDY PERIOD

The study period for the San Joaquin County IGSM is the 24-year period representing water years 1970 to 1993. This period was chosen in part because there is a relatively good set of land and water use data as well as hydrologic data, such as rainfall, streamflow, and groundwater levels. This period also includes two historic drought events (1976–1977 and 1987–1992) and two historic wet periods (1983 and 1986).

MODELING OF HYDROLOGIC PROCESSES

The hydrologic system is divided into four major subsystems, as shown in Figure 3.2. These are:

- Soil Zone,
- Stream System,
- Unsaturated Zone, and
- Groundwater Zone.

FIGURE 3.2 HYDROLOGIC SYSTEM INTERACTIONS

The hydrologic components of these physical subsystems that are considered in the integrated hydrologic model are shown in Figure 3.3.

Soil Zone — The San Joaquin County IGSM can simulate soil zone processes including evapotranspiration, direct runoff infiltration, and deep percolation from rainfall and applied water.

Stream System — The water balance equation is solved to simulate streamflow in San Joaquin County IGSM.

Unsaturated Zone — Water that percolates down from the soil zone travels through the vadose zone as unsaturated flow and eventually reaches the saturated groundwater zone. The input data for vadose zone simulation includes thickness of vadose zone layers, vertical hydraulic conductivity, and effective porosity.

Groundwater Zone — Saturated groundwater flow is simulated in the San Joaquin County IGSM by solving the governing groundwater flow equation by the Galerkin finite element technique. The model flow domain has been broken down horizontally into a collection of small polygonal areas. These areas are called finite elements and they can be either three-sided or four-sided polygons. The vertices of these elements are called nodes. The network of finite elements and nodes is called a model grid (described above).

MODEL DATA

Some of the San Joaquin County IGSM data for the Wallace Subregion is presented to provide context of the groundwater analysis. It includes model data on land use, water demand, water supply, and hydrology.

LAND USE

The distribution of the agricultural and urban land use in the Wallace Subregion for the 1970–1993 period is shown in Figure 3.4. Urban land use for the area totaled about 1,000 acres for the entire period. Irrigated agricultural acreage ranged from 1,200 to 1,400 acres for the 1970–1988 period. Acreage increased to over 2,000 acres in 1989, then declined steadily through the 1993 period. The trends in irrigated crop acreage are shown in Figures 3.5a, 3.5b, and 3.5c. The primary crops grown in the Study Area include pastures and orchards, which accounts for about half of the total cropped area.

FIGURE 3.3 HYDROLOGIC COMPONENTS

FIGURE 3.4 GENERAL LAND USE FOR WALLACE SUBREGION

FIGURE 3.5A CROP ACREAGE FOR WALLACE SUBREGION (ORCHARD, PASTURE, AND GRAINS)

FIGURE 3.5B CROP ACREAGE FOR WALLACE SUBREGION (ALFALFA, CITRUS AND OLIVES, AND FIELD CROPS)

FIGURE 3.5C CROP ACREAGE FOR WALLACE SUBREGION (RICE, SUGAR BEET, TOMATO, VINEYARDS, AND TRUCK CROPS)

WATER DEMAND

The water demands associated with the land use described above are shown in Figure 3.6. There is little change in urban demand, reflecting the small change in urban acreage for the study period. The annual urban demand ranges from about 1,300 to 1,500 acre-feet during the study period.

The agricultural demand shows more variability than the urban demand because of changes in crop acreage and crop mix, and hydrologic conditions. Annual agricultural demands range from a low of about 4,000 acre-feet to about 6,000 acre-feet in 1989 and 1992, respectively. The total water demand ranges from about 6,000 to 7,500 acre-feet per year.

WATER SUPPLY

The primary sources of water supply for the area include surface water and groundwater. In this analysis, surface water supply was assumed to be constant at about 5,100 acre-feet per year as shown in Figure 3.7. This appears to be a generalized assumption, and may be an estimate necessitated by a lack of data. Groundwater pumping is typically also estimated because of the lack of available long-term pumping data for regional areas, and is assumed to meet any demands not met by surface water. Figure 3.7 shows the annual groundwater pumping in the Wallace Subregion ranges from about less than 500 acre-feet to more than 2,000 acre-feet. Groundwater pumping increases significantly in 1989 in response to increased agricultural acreage.

HYDROLOGY

The local hydrologic conditions presented have included precipitation and corresponding stream flow data. Precipitation in the study area is usually in the form of rain. Rainfall in the Wallace Subregion of the 1970–1993 period ranges from less than seven inches (1977) to almost 41 inches (1983) per year, and averages about 21 inches per year. The variable annual rainfall pattern for the Wallace Subregion is shown in Figure 3.8.

The Wallace Subregion is bounded on the north by the Mokelumne River, between Pardee Reservoir and Lake Camanche, and on the south by the Calaveras River. The total annual stream flow for these two rivers within the Wallace Subregion is presented in Figure 3.8. The annual stream flow ranges from less than 150,000 acre-feet (in several years, including 1977 and 1988–1991) to more than 1,700,000 acre-feet (1983). As shown in Figure 3.8, the annual stream flow reflects the annual rainfall totals.

FIGURE 3.6 WATER DEMAND FOR WALLACE SUBREGION

FIGURE 3.7 WATER SUPPLY FOR WALLACE SUBREGION

FIGURE 3.8 RAINFALL AND STREAMFLOW FOR WALLACE SUBREGION

GROUNDWATER BALANCE

The following groundwater budget is based on the data described above as it is incorporated in to the San Joaquin IGSM. The components of the groundwater budget are listed below:

- **Deep Percolation** represents the rainfall and applied water that recharges the aquifer system. Deep percolation is an addition to the local groundwater storage. The annual variation in deep percolation directly corresponds to annual rainfall conditions.

- **Gain from Stream** represents the water infiltrating through the stream bed and reaching the aquifer system. Depending on the relationship between the groundwater levels and the elevation of the water surface in local streams, stream seepage may either add or remove water from the local groundwater system. In this area, there is a net loss from the aquifer system to the Mokelumne and Calaveras Rivers.

- **Boundary Inflow** represents the subsurface flow that enters the subregion from the areas outside the model area. In this case it represents water entering the aquifer system from the bedrock areas to the east of the model area.

- **Groundwater Pumping** represents groundwater that is pumped from the aquifer system to the ground surface. Groundwater pumping is estimated by the San Joaquin IGSM to meet any demand not met by surface water.

- **Subsurface Inflow** represents groundwater that is moving across subregion boundaries within the model area. In this case, subsurface inflow primarily represents groundwater flowing from the Wallace Subregion to the west into San Joaquin County.

- **Change in Groundwater Storage** represents the change in groundwater storage within the Wallace Subregion.

STUDY PERIOD WATER BUDGET

A schematic representation of the groundwater budget for the Wallace Subregion for the 1970–1993 period is presented in Figure 3.9. During this period, groundwater storage in the subregion declined by about 12,700 acre-feet per year. One of the primary components of the groundwater decline is subsurface outflow. It is estimated that about 30,500 acre-feet per year of groundwater left the area, mostly toward the west into San Joaquin County.

FIGURE 3.9 ANNUAL GROUNDWATER BUDGET FOR WALLACE SUBREGION AVERAGE ANNUAL AMOUNT FOR 1970 – 1983 STUDY PERIOD

DRY YEAR WATER BUDGET

In 1977, the area received less than seven inches of rain, the lowest amount during the 1970-1993 period. Therefore, it is assumed to be representative of dry year conditions. A schematic representation of the groundwater budget for 1977 is presented in Figure 3.10. Due to the reduced rainfall, deep percolation totaled only 4,400 acre-feet. Groundwater storage was reduced by about 32,700 acre-feet in this year. Subsurface outflow totaled 28,600 acre-feet in 1977.

WET YEAR WATER BUDGET

In 1983, the area received more than 40 inches of rain, the highest amount during the 1970–1993 period. Therefore, it is assumed to be representative of wet year conditions. A schematic representation of the groundwater budget for 1983 is presented in Figure 3.11. The high rainfall in 1983 resulted in over 62,000 acre-feet of deep percolation. While many of the groundwater budget components did not change significantly from other years, the increased deep percolation resulted in an increase in groundwater storage by about 26,000 acre-feet.

GROUNDWATER STORAGE

The annual change in groundwater storage in the Wallace Subregion for the 1970–1993 period is shown in Figure 3.12. The change in groundwater storage decreases in most years. Increases in groundwater storage only occur in very wet years. Only four years showed an increase in the groundwater storage during the study period. The overall change in groundwater storage, shown in Figure 3.12, depicts the gradual decline of total groundwater storage in the area.

Figure 3.13 compares the groundwater storage decline in the Wallace Subregion with long-term groundwater level hydrographs in wells located just west of the area. The location of these wells is shown in Figure 2.6. The overall decline in groundwater storage estimated for the Wallace Subregion is corroborated by the groundwater level decline in the well hydrographs.

This correspondence of the estimated groundwater storage decline and the observed groundwater level decline provides confidence that the San Joaquin County IGSM is providing a reasonable estimate of groundwater storage decline within the Study Area and subsurface outflow from the Study Area.

FIGURE 3.10 ANNUAL GROUNDWATER BUDGET FOR WALLACE SUBREGION DRY YEAR (1977)

FIGURE 3.11 ANNUAL GROUNDWATER BUDGET FOR WALLACE SUBREGION WET YEAR (1983)

FIGURE 3.12 CHANGE IN GROUNDWATER STORAGE FOR WALLACE SUBREGION

FIGURE 3.13 GROUNDWATER STORAGE AND GROUNDWATER HYDROGRAPHS FOR WALLACE SUBREGION

SECTION 4 POTENTIAL RECHARGE OPPORTUNITIES

The two previous sections in this report document the available information, which indicate declining groundwater levels in the study area. The groundwater monitoring program has been established as part of this project to improve the understanding of groundwater resources in the study area. One of the goals of the District is to develop additional information that may be used to support the development of conjunctive use projects. This section provides some generalized information about groundwater recharge potential in the study area, including identifying potential recharge areas and completing a conceptual recharge analysis.

POTENTIAL RECHARGE AREAS

Areas that may be conducive to surface recharge operations based on soil mapping and review of well logs are shown in Figure 4.1. Soils mapping identifies areas where groundsurface conditions are suitable for recharge projects while the well log analysis identifies area with favorable subsurface conditions for surface recharge.

SOILS MAPPING

Soil mapping identifies areas with higher permeability at the ground surface that may be suitable for surface recharge projects. Figure 4.1 identifies areas overlain by Group B soils, which have a low to moderate runoff potential (described in Section 2). These areas are dispersed throughout the Study Area, with many of the sites located between Highway 12 and Highway 26. From a groundwater recharge perspective, these soils may present an opportunity for surface recharge.

WELL LOGS ANALYSIS

The well log analysis identifies areas where subsurface conditions are suitable for recharge analysis. These areas include locations that have gravels near the ground surface, or have an overall higher percentage of sands and gravels in the upper 200 feet of the aquifer system (higher specific yield). Figure 4.1 also shows areas of high specific yield and the location of wells with gravels listed at the ground surface. About 20% of the well logs reviewed to develop the hydrogeologic assessment contained gravel at the ground surface. Like the Group B soils, these wells are dispersed throughout the Study Area, but most of the wells are located between Highway 12 and Highway 26, which roughly corresponds with the zone of higher specific yield.

FIGURE 4.1 AREAS OF POTENTIALLY FAVORABLE RECHARGE OPPORTUNITIES

From a groundwater recharge perspective, areas with gravel present at the ground surface and areas with a higher specific yield may present an opportunity for surface recharge.

Wells that have more sand and gravel have a higher specific yield. Figure 4.1 also identifies those areas with a relatively higher specific yield compared to other areas within the study area. The aquifer in these areas is better suited for surface recharge projects than those areas with a lower specific yield.

The soil mapping and well log analysis provide generalized information on recharge site suitability. In general, the soil and well log analysis identifies the areas between Highway 12 and Highway 26 as the most suitable areas for potential surface recharge projects. Additional site-specific analysis would need to be conducted to determine the localized soil and aquifer characteristics in order to identify sites suitable for recharge projects.

CONCEPTUAL RECHARGE ANALYSIS

A conceptual recharge analysis was completed to illustrate the dynamics of a recharge project within the Study Area using the WRIME Recharge Drawdown Model (WRDM). WRDM is a simplified recharge drawdown model developed to facilitate quick but reliable analysis of multiple scenarios for recharge, pumping, or damping. WRDM describes the vertical and lateral extent of groundwater mounding because of recharge projects. Both short-term (days) and long-term (months) periods of operation can be analyzed.

For this conceptual recharge analysis, the overall recharge performance was analyzed based on:

- Recharge Basin Size,
- Recharge Duration, and
- Hydraulic Conductivity.

WRDM ASSUMPTIONS

WRDM relies on certain basic assumptions about underlying groundwater conditions. The most important among these are that: (1) all aquifer properties are homogeneous and isotropic, and (2) ground and initial groundwater surfaces are flat. The hydrogeologic context of the project site is generally consistent with these assumptions. The model is therefore applicable to this project for obtaining useful insight into probable recharge performance.

A conceptual project site was selected in the Wallace area based on data collected as part of this hydrogeologic assessment. The following information was used in the recharge analysis to represent the overall characteristics of a potential Wallace area recharge project:

- Average ground-surface elevation = 250 feet above msl
- Average groundwater elevation = 165 feet above msl
- Aquifer parameters:
  - Specific Yield = 6%
  - Hydraulic conductivity = 10 feet/day, 50 feet/day
  - Effective aquifer thickness = 120 feet

Hydraulic Conductivity

Hydraulic conductivity has been estimated based on boring logs and other studies in the region. Like any model, there is always uncertainty in input parameters. Data for hydraulic conductivity is not readily available at the site. As hydraulic conductivity can range by orders of magnitude, producing significant effects on model results, analysis were run for two potential conductivities for the project site.

For this study, analyses were run with a hydraulic conductivity of 50 feet/day, representative of a fine sand, and with a hydraulic conductivity of 10 feet/day, representative of a silty sand.

Basin Size

For this analysis, three recharge basin sizes were analyzed to explore relationships between project size and recharge volume/recharge rate over time. Basin sizes of 20, 40, and 80 acres were selected for this analysis, and each is assumed to have a square configuration.

Recharge Duration

Model runs were conducted for recharge delivery durations of 30, 90 and 180 days to show the relationship between the length of the recharge period and the recharge rate, volume, and capacity.

Recharge Performance

In each recharge scenario, the objective was to estimate the maximum recharge performance (by achieving the greatest volume and corresponding recharge and water delivery rate[s] without mounding water closer than 20 feet below ground surface).

The mounding beneath the recharge basin was not allowed to rise within 20 feet of the ground surface to minimize potential impacts to nearby septic systems, or orchards or vineyards. Actual siting of recharge projects need to account for adjacent land use conditions.

RECHARGE ANALYSIS RESULTS

The results of the recharge analysis are summarized on Table 4.1 and described below.

Effect of Hydraulic Conductivity on Recharge Performance

Two different conductivity values were analyzed to test the effect on recharge performance, 10 feet/day and 50 feet/day. The difference in the recharge mound beneath the basin for the 10 feet/day recharge scenario and the 50 feet/day recharge scenario are shown in Figures 4.2 and 4.3, respectively. These recharge scenarios used a 40-acre recharge basin and a 90-day recharge duration.

During the analysis, mounds were allowed to rise within 20 feet of the ground surface in all scenarios. For the 10 feet/day recharge scenario, 660 acre-feet of water was recharged at a rate of about 0.18 feet per day. For the 50-feet/day recharge scenario, about 2,200 acre-feet of water was recharged at a rate of about 0.61 feet per day.

As shown by comparing the size and shape of the recharge mounds in Figures 4.2 and 4.3, the 50 feet/day recharge scenario allows for a greater volume of water (more than three times) to be recharged compared to the 10 feet/day recharge scenario. The recharge rate for the 50 feet/day scenario is more than three times the rate of the 10 feet/day recharge scenario. This agrees with the general understanding recharge basins should be located in areas that have more permeable aquifer materials (corresponding to higher hydraulic conductivity values).

Effect of Basin Size on Recharge Performance

Three different recharge basin sizes were analyzed to test the effect on recharge performance, 20-acre basin, 40-acre basin, and 80-acre basin. The difference in the recharge mound beneath the basin for the 20-acre recharge scenario and the 80-acre recharge scenario are shown in

TABLE 4.1 RECHARGE ANALYSIS SUMMARY RESULTS

FIGURE 4.2 RECHARGE PROFILE FOR HYDRAULIC CONDUCTIVITY OF 10 FEET/DAY SCENARIO

FIGURE 4.3 RECHARGE PROFILE FOR HYDRAULIC CONDUCTIVITY OF 50 FEET/DAY SCENARIO

Figures 4.4 and 4.5 respectively. These recharge scenarios used a 50 feet/day hydraulic conductivity value and a 90-day recharge duration.

During the analysis, mounds were allowed to rise within 20 feet of the ground surface in all scenarios. For the 20-acre recharge scenario, 1,932 acre-feet of water was recharged at a rate of about 1.07 feet per day. For the 80-acre recharge scenario, about 2,593 acre-feet of water was recharged at a rate of about 0.36 feet per day.

As shown by comparing the size and shape of the recharge mounds in Figures 4.4 and 4.5, the 80-acre basin recharge scenario allows for a greater volume of water (about 33% more) to be recharged than the 20-acre basin scenario. The recharge rate for the 20-acre basin recharge scenario is more than three times that of the 80-acre basin recharge scenario.

Effect of Recharge Duration on Recharge Performance

Three different recharge durations were analyzed to test the effect on recharge performance: 30 days, 90 days, and 180 days. The difference in the recharge mound beneath the basin for the 30-day recharge scenario and the 180-day recharge scenario are shown in Figures 4.6 and 4.7, respectively. These recharge scenarios used a 40-acre basin and a 50 feet/day hydraulic conductivity value.

During the analysis, mounds were allowed to rise within 20 feet of the ground surface. For the 30-day recharge scenario, 960 acre-feet of water was recharged at a rate of about 0.80 feet per day. For the 180-day recharge scenario, about 3,827 acre-feet of water was recharged at a rate of about 0.53 feet per day.

As shown by comparing the size and shape of the recharge mounds in Figures 4.6 and 4.7, the 180-day recharge scenario allows for a greater volume of water (about four times more) to be recharged than the 30-day recharge basin scenario. The recharge rate for the 30-day recharge scenario is about 50% higher than the recharge rate of the 180-day recharge scenario. The longer-duration recharge scenario allows for a greater volume of water to be recharged, but at a slower rate than the shorter-duration scenario.

Recharge Analysis Summary

The relationship between recharge volumes and recharge rates are presented in Figures 4.8 and 4.9, respectively. In general, increases in recharge duration or recharge basin area increase the total volume of recharged water as presented in Figure 4.8, but reduce the recharge rates as shown in Figure 4.9. Potential recharge projects should be located in areas that have higher hydraulic conductivity values. Higher conductivity values correspond to increased recharge volumes and recharge rates.

FIGURE 4.4 RECHARGE PROFILE FOR 20 ACRE RECHARGE BASIN SCENARIO

FIGURE 4.5 RECHARGE PROFILE FOR 80 ACRE RECHARGE BASIN SCENARIO

FIGURE 4.6 RECHARGE PROFILE FOR 30 DAY RECHARGE DURATION SCENARIO

FIGURE 4.7 RECHARGE PROFILE FOR 180 DAY RECHARGE DURATION SCENARIO

FIGURE 4.8 RELATIONSHIP BETWEEN BASIN AREA AND RECHARGE VOLUME

FIGURE 4.9 RELATIONSHIP BETWEEN BASIN AREA AND RECHARGE RATE

SECTION 5 SUMMARY AND RECOMMENDATIONS

SUMMARY

Calaveras County Water District received an AB303 grant from the Department of Water Resources to complete the Groundwater Monitoring and Data Collection Program.

The purpose of the Groundwater Monitoring and Data Collection Program is three-fold:

1. Develop a groundwater level monitoring program for the District in the Camanche/Valley Springs Area (Task 1),
2. Develop additional hydrogeologic data for the Camanche/Valley Springs Area (Task 2), and
3. Continue the District's public outreach program with individuals and organizations interests in the water resources of Calaveras County (Task 3).

The project deliverables included:

Camanche/Valley Springs Area Hydrogeologic Assessment (this report)

- Hydrogeologic data was developed for the Camanche/Valley Springs Area from an analysis of drillers logs and additional reports. This included an estimate of the variation of specific yield throughout the area based on an analysis of the drillers logs. Section 2 also includes an evaluation of groundwater levels for areas to the west of the study area.
- A groundwater budget analysis of the study area was completed based on the previously developed San Joaquin County IGSM. The water budget allows preliminary estimates of the change in groundwater storage in the study area and estimates of groundwater outflow.
- A conceptual recharge analysis was completed comparing the effects of various hydraulic conductivity values, the size of recharge basins, and duration of recharge events.

The Camanche/Valley Springs Area Groundwater Monitor Report for Spring 2003

(Included as Appendix A of this report) developed the first groundwater monitoring program for the study area.

As part of developing the groundwater monitoring program the following items were also provided to the District:

- *Camanche/Valley Springs Area Groundwater Data Management System (CVSAGDMS)*, and
- *Camanche/Valley Springs Area Groundwater Sampling and Analysis Plan*.

The CVSAGDMS provides the District a tool to store, and manage the data collected from the Spring 2003 monitoring, and any future groundwater monitoring efforts. The Camanche/Valley Springs Area Groundwater Sampling and Analysis Plan provides the District guidelines to continue the monitoring program that was implemented in Spring 2003.

RECOMMENDATIONS

The District needs to continue developing groundwater-related data to improve their understanding of the available groundwater resources in the Camanche/Valley Springs Area with the goal of improving groundwater management in the area. Some specific recommendations are listed below:

- Continue the monitoring program initiated as part of this project. This includes adding new wells to the monitoring program and continuing to monitor groundwater levels and groundwater quality. Several areas within the study area that need additional monitoring have been identified:
  - Areas south of the Calaveras River,
  - Burson/Wallace Area, and
  - Campo Seco/Camanche Area.
- Coordinate water level sampling times with groundwater level monitoring activities in San Joaquin County.
- Continue to pursue funding to install dedicated monitoring wells, which will provide additional water level data collection locations as well as provide more detailed hydrogeologic data.
- Continue to investigate the relationship between wells tapping the alluvial aquifer system and the bedrock system.
- Update the District's Groundwater Management Plan to meet the requirements of SB 1938, including the initial development of basin management objectives.

- Continue to coordinate with other local agencies within Calaveras County, such as the Calaveras County Environmental Health Department.
- Continue to provide public outreach to local groups, such as the Burson Water Committee.
- Continue to work with other agencies with groundwater management responsibilities within the Eastern San Joaquin Groundwater Basin.
- Continue to pursue sources of funding to further develop groundwater management opportunities within the Camanche/Valley Springs Area, including potential conjunctive use opportunities.

California Environmental Protection Agency (*www.calepa.ca.gov/Publications/Reports AP2000B/water.htm*).

California's Water: Bulletin 118, Draft, DWR April 2003. (http://www.waterplan.water.ca.gov/groundwater/118index.htm).

Camanche Dam and Reservoir Geologic Report: by Bechtel Corporation for EBMUD, 1961.

Camanche Reservoir Seepage Report: Mokelumne River Project, Bechtel Corporation for EBMUD, 1964.

Camanche/Valley Springs Area Groundwater Monitoring Report for Spring 2003, WRIME, Inc., 2003.

East Bay Municipal District, Mokelumne River History: (www.ebmud.com/water&environment/environment/mokelumne/history/default.htm).

Evaluation of Groundwater Resources: Sacramento County, Bulletin 118-3 DWR, 1974.

Geochemical Analysis of Rock Samples collected at the Penn Mine, Calaveras County, California: Jocelyn A. Peterson, 1985, USGS Open-File Report 85-588.

Geologic Features and Groundwater Storage Capacity of the Sacramento Valley, California: F.H. Olmsted, 1961, U.S. Geological Survey Paper 1497.

Geologic Map of the Sacramento Quadrangle: California Division of Mines and Geology Geologic Map 1A.

Geologic Map of the San Francisco-San Jose Quadrangle: California Division of Mines and Geology Geologic Map 5A.

Geology and Groundwater Hydrology of the Mokelumne Area, California: USGS Paper 780, 1939.

Groundwater Supply for the Lancha Plana District: W.P. Fuller, 1989.

Hydrogeology of Acid Mine Drainage in Groundwater in the Vicinity of Penn Mine and Camanche Reservoir, Calaveras County, California: Second Year Summary, 1992-1993, Scott N. Hamlin and Charles N. Alpers, 1996, USGS Water Resources Investigations Report 96-4257.

Report on Pollution of the Mokelumne River by the Penn Mine, Calaveras County, California: Ray Dunham, 1961, Department of Fish and Game.

San Joaquin County Groundwater Investigation: DWR Bulletin 146, 1967.

Soil Vegetation Maps of California, Cowell, Wilmer L. Jr., USDA Forest Service Resource Bulletin PSW-13, 1974.

Technical Information to Support Development of AB3030 Groundwater Management Plan for the Camanche/Valley Springs Area, Bookman-Edmonston Engineering, Inc., 2001.

Toxicity of Copper and Zinc from the Penn Mine Area on King Salmon and Stealhead trout in the Mokelumne River Basin, California: Brian J. Finlayson and Harry J. Rectenwald, 1978, Department of Fish and Game Fish and Wildlife Water Pollution Control Laboratory, Environmental Services Branch Administrative Report 78-1.

Use of Groundwater Reservoirs for Storage of Surface Water in the San Joaquin Valley, California: USGS Water Supply Paper 1618, 1964.

Western Calaveras Irrigation District Water Supply and Conveyance System:Project Report and Draft Environmental Impact Report: Tudor Engineering Company, 1974.

.

APPENDIX A. CAMANCHE/VALLEY SPRINGS AREA GROUNDWATER MONITORING REPORT FOR SPRING 2003