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Technical Memorandum 1A- Hydrogeology Evaluation for Phase 1 Conjunctive Use and Enhanced Aquifer Recharge Project:

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Technical Memorandum 1A

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Subject: **Hydrogeology Evaluation**
Santa Cruz County Conjunctive Water Use and Enhanced Aquifer Recharge Study
K/J 0864005

1. Introduction

Kennedy/Jenks Consultants (Kennedy/Jenks) is pleased to provide the Santa Cruz County Health Services Agency (County) with Technical Memorandum 1A (TM1A) in support of the Conjunctive Use and Enhanced Aquifer Recharge Project (Conjunctive Use Project). The Conjunctive Use Project is one of fifteen projects funded by a Proposition 50 Water Bond grant from the California State Water Resources Control Board to the Community Foundation of Santa Cruz County. The Conjunctive Use Project is Project #3 of the grant and is being administered by the County.

1.1. Conjunctive Use Project Overview

The objective of the Conjunctive Use Project is to assess the most appropriate approaches for coordinating water projects and increasing groundwater storage to improve the reliability of drinking water supplies primarily for the Scotts Valley Water District (SVWD) and San Lorenzo Valley Water District (SLVWD), mitigating declines in groundwater levels in the Santa Margarita Groundwater Basin (SMGB), and increasing stream baseflow in the lower San Lorenzo River Watershed. The Conjunctive Use Project evaluates the opportunities to use water exchanges, winter streamflow diversion, enhanced stormwater capture and recharge, and/or reclaimed wastewater to replenish groundwater storage.

The two goals of the Conjunctive Use Project are to increase the volume of groundwater in aquifer storage, and to increase summertime baseflow in streams by increasing groundwater levels. An understanding of geology, groundwater conditions, and groundwater-surface water interactions is important for the Conjunctive Use Project. This TM provides an overview based on a review of the existing hydrogeologic studies that have been conducted in the region.

The study area is focused on the Scotts Valley area (Figure 1A-1). For the Conjunctive Use Project, the study area covers the portion of the SMGB south of Bean Creek (Figure 1A-1).

1.2. Scope

TM1A summarizes the work performed as part of Task 1 – Hydrogeologic Evaluation of the Conjunctive Use Project Scope of Work. This TM provides a discussion of the complex hydrogeological relationships of the SMGB relevant to developing a conjunctive use project. The goal of this task is to provide a summary of the hydrogeology based on previous hydrogeological studies that are relevant to the Conjunctive Use Project. The topics addressed in this TM include discussion of the following topics:

- Regional geologic framework,
- General groundwater characteristics of the study area,
- Groundwater-surface water interactions,
- Available aquifer storage, and
- Potential water quality issues

2. Regional Geology

Below is a brief overview of the regional geology based on previous studies by the United States Geological Survey (USGS) in reports by Clark (1966 and 1981), Clark et al. (1989), Brabb et al. (1997), and McLaughlin et al. (2001). Other relevant reports on the subsurface geology include ETIC (2005, 2006), Kennedy/Jenks (2008, 2009, 2010), Johnson (2002, 2009), Todd Engineers (1984, 1994, and 1997), Stollar & Associates (1989), Watkins-Johnson Environmental (1993), and SECOR (1997).

2.1. Santa Margarita Groundwater Basin

The Santa Margarita Groundwater Basin (SMGB) is located on the southwestern slope of the Santa Cruz Mountains in western Santa Cruz County and covers over 30 square miles. The Basin forms a roughly triangular area that extends from Scotts Valley in the east, to Boulder Creek in the northwest, and to Felton in the southwest (Figure 1A-2).

The SMGB comprises a portion of the California Coast Ranges, and is a geologically complex area that was formed by the same tectonic forces that created the Santa Cruz Mountains. The SMGB lies with a major tectonic block defined by the San Andreas Fault to the northeast and the San Gregorio Fault to the southwest. The geology of this tectonic block is characterized by Cenozoic clastic sedimentary and volcanic rocks with a composite thickness of over 30,000 feet that rest upon the crystalline basement rocks composed primarily of granite (Clark, 1966, 1981; Brabb et al., 1997; McLaughlin et al., 2001).

2.2. Geologic Units

The SMGB consists of a sequence of sandstone, siltstone, and shale that is underlain by the crystalline basement. This sequence of sedimentary rocks is divided into several geologic formations that are defined on the basis of the type of rock and their relative geologic age based on studies by the USGS (Clark, 1966 and 1981; Brabb et al., 1997; McLaughlin et al., 2001). The stratigraphic column for the study area shows crystalline basement rock overlain by a Tertiary-aged sedimentary sequence and some areas of Scotts Valley, capped by Quaternary alluvium (Figure 1A-3). The geologic formations in the area (listed from youngest to oldest) include:

- **Recent Alluvial Deposits** (alluvium) – thin, surface deposits consisting of unconsolidated sands and silts found in the Scotts Valley area associated with existing and prehistoric streams.
- **Purisima Formation** (Purisima) – sandstone that forms the tops of some of the hills in the Scotts Valley area. It is a key aquifer in the Soquel area.
- **Santa Cruz Mudstone** – a dense shale that that is found near the ground surface underlying much of the northern areas of Scotts Valley.
- **Santa Margarita Sandstone** (Santa Margarita) – a thick sandstone that forms the light-colored bluffs around Scotts Valley. The local sand quarries mined this unit for its high quality sand.
- **Monterey Formation** (Monterey) – a thick shale with a few sandstone layers. It separates the Santa Margarita and Lompico, but is missing underneath parts of Scotts Valley.
- **Lompico Sandstone** (Lompico) – a thick sandstone that looks similar to the Santa Margarita; however, this unit is primarily found in the subsurface with limited surface outcrops primarily along the basin margin both to the north and south of Scotts Valley (Figure 1A-4).
- **Butano Formation** (Butano) – a thick sequence of sandstone and shale. It is found at depths greater than 1,000 feet below Scotts Valley, but it is found at the surface to the north of Scotts Valley.
- **Locatelli Formation** (Locatelli) – primarily a gray, sandy siltstone. It also contains a basal sandstone layer that supports a few domestic water wells.
- **Crystalline Basement Rock** (crystalline basement) – composed primarily granite and quartz diorite, the crystalline basement forms the base of the SMGB. The depth to the crystalline basement varies. It is exposed along the lower portions of Carbonera Creek, but is over 1,500 feet deep north of Scotts Valley

The geologic map (Figure 1A-4), from Brabb (1997), shows surface outcrop distribution of these units in the Scotts Valley area. Areas outside of the SMGB have a different sequence of sedimentary units that are not present within the SMGB.

2.3. Regional Geologic Correlations

The structural complexity in the SMGB is such that a given geologic formation or layer can be found near the surface or several hundred to a thousand feet below the ground surface in different parts of the SMGB. To illustrate this complex geologic structure, a series of geologic cross sections are presented. These cross sections are based on geologic logs from wells in the area based on previous studies including ETIC (2006), Johnson (2002), and Brabb et al. (1997). The traces of the four cross-sections presented in this report are shown on Figure 1A-5. The cross sections include:

- Cross Section A-A' runs northeast-southwest from near Felton northeast across Scotts Valley (Figure 1A-6).
- Cross Section B-B' runs east-west from near Felton east across Scotts Valley (Figure 1A-7).
- Cross Section C-C' runs southeast-northwest from south of Scotts Valley towards Bean Creek (Figure 1A-8).
- Cross Section D-D' runs southeast-northwest from south of Scotts Valley towards Bean Creek (Figure 1A-9).

These cross-sections help illustrate the hydrogeological conceptual model of geology, groundwater, and groundwater–surface water interactions. Below are discussions of some of the updated hydrogeologic data interpretations that are pertinent to this report and depicted on Figures 1A-6 through 1A-9.

The distribution of the geologic units is a result of the complex geologic history of the region. The different units show evidence of deformation from faulting and folding that has produced formations that are thick in parts of the basin and thin or absent in others. These cross-cutting relationships represent unconformities in the depositional history of the basin. This geological complexity also exerts a strong influence on groundwater occurrence and movement in the basin.

The Pleistocene and Holocene-aged alluvium forms the youngest deposits in the area. The alluvium consists of unconsolidated sands and silts along the streambeds of Carbonera and Bean Creeks, and also much of the level portions within the City of Scotts Valley. These sediments are typically less than 10 to 20 feet thick.

The Purisima unconformably overlies the Santa Cruz Mudstone. In the Scotts Valley area, the Purisima is found on hilltops and is not an important aquifer; however, in areas to the west, the Purisima is a major source of groundwater. The base of the Purisima dips uniformly toward the southeast where it has eroded into the Santa Cruz Mudstone, Monterey, Lompico and Butano

In the SMGB the Santa Cruz Mudstone is primarily found in the areas north of Scotts Valley where it conformably overlies the Santa Margarita. Where present, the Santa Cruz Mudstone forms a barrier that significantly impedes recharge from the surface to the aquifers below. .

The Santa Margarita has widespread surface exposures in southern Scotts Valley and north of Bean Creek. The Santa Margarita thins from over 400 feet thick in the western part of the basin to being absent at SVWD #7A on the eastern edge. The Santa Margarita unconformably overlies the Monterey, and has completely eroded away the Monterey in the southeast and southern portions of the basin.

The Monterey conformably overlies the Lompico. In the Scotts Valley area it ranges in thickness from zero to approximately 700 ft thick at SVWD #3B. The thickness of the Monterey varies widely across the area as a result of geologic deformation and erosion. The Monterey is considered to act as an aquitard that significantly limits groundwater flow between the Santa Margarita and Lompico. The Monterey conformably overlies the Lompico.

The Lompico is typically 200 to 300 feet thick across the study area and is highly folded. The Lompico is interpreted to cross the basin with a relatively uniform thickness. The Lompico unconformably overlies the Locatelli in the west and the Butano in the east.

The Butano is found only in the northern portion of the basin. It forms a thick wedge that extends part way across the basin before pinching out on the north limb of the Scotts Valley Syncline. The Butano ranges from 200 to approximately 1,000 ft thick

The oldest sedimentary sequence consists of erosional remnants of the Locatelli which underlies only a small area south of Scotts Valley and outcrops in the hillside along Eagle Creek and the San Lorenzo River.   The Locatelli lies nonconformably upon the crystalline basement.

2.4. Geologic Structure

The SMGB is a roughly triangular area that is bounded by the two regional faults, the Ben Lomond Fault to the west and the Zayante Fault to the north (Figure 1A-4)., The basin is bounded to the southeast by the crystalline basement. As mapped by the USGS (Brabb et al., 1997), the Ben Lomond Fault trends north-northwest and forms the western boundary of the basin Ben Lomond Mountain, which is primarily composed of crystalline basement, is located west of the fault. The Zayante Fault forms the northern basin boundary. The area north of the Zayante Fault is composed of a sequence of Tertiary-aged sedimentary formations that are not present south of the Zayante Fault within the SMGB There is a significant displacement along both of these faults, and there is not considered to be appreciable groundwater flow across either the Ben Lomond or Zayante Faults.

Regional folding has produced a major syncline, or trough, termed the Scotts Valley Syncline, which crosses through the North Scotts Valley area. The axis of the syncline has a northwest-southeast trend (Clark 1981; Brabb et al., 1997). The syncline is expressed at the surface by geologically younger geologic units outcropping in the center of the syncline, with progressively older units outcropping on the flanks of the syncline. The Scotts Valley Syncline was formed as a result of uplift along the Zayante Fault and therefore essentially parallels the fault

The deepest part of the Basin is located in northern Scotts Valley where the sedimentary rocks that form the basin aquifers are over 1,500 feet thick. The depth to the crystalline basement varies from near the surface along Carbonera Creek to over 2,000 feet in the area of SVWD Wells #3B and #7A. These two wells are located in the axis of the Scotts Valley Syncline which is the deepest part of the SMGB.

The sediments in the basin were folded during deformation associated with the development of the Coast Ranges (Clark, 1981). A period of geologic deformation preceded the deposition of the Lompico, as evidenced by the Lompico unconformably overlying the crystalline basement, the Locatelli and the Butano in different parts of the basin. Subsequent geologic deformation caused the Lompico to be steeply dipping in the Scotts Valley area resulting in an angular unconformity with the Lompico being directly overlain by the Monterey, Santa Margarita, and Santa Cruz Mudstone in different parts of the basin. These complex relationships have significant impact on how groundwater flows into, out of, and through the Lompico. Due to the geologic deformation and erosional history, the Santa Margarita directly overlies, in different locations, the crystalline basement, the Locatelli, the Lompico, and the Monterey

2.5. Assessment of Geologic Issues

The geologic complexity of the area will significantly affect the planning, design and implementation of the Conjunctive Use Project. The success of a future aquifer recharge project will be strong influenced by how well the geological conditions at the potential project site are understood. Key geologic conditions that need to be considered for the Conjunctive Use Project include:

- The distribution of the Santa Margarita, especially surface outcrops, is an important factor for locating surface recharge facilities.
- The presence or absence of the Santa Cruz Mudstone can be a key factor in controlling groundwater recharge projects from the surface.
- The Monterey, where present, forms a key aquitard that limits vertical groundwater flow. In areas where the Monterey is absent, the Lompico can be recharged through surficial recharge to the directly overlying Santa Margarita.
- The local geologic structure causes formations such as the Lompico to occur at greatly varying depths over relatively short distances within the SMGB. These depth variations will greatly affect where aquifer recharge projects that include the Lompico can be sited.

3. Groundwater

Historically, the majority of groundwater production in the SMGB has been derived from the Santa Margarita, Lompico, and Butano. Groundwater levels in many parts of the Scotts Valley area have declined significantly (by over 200 ft in some areas) over the past 25 years. Earlier water supply assessments conducted by the USGS include Akers and Jackson (1977) and Muir (1981). More recent hydrogeological assessments for the SVWD include a groundwater modeling study (ETIC, 2006), updates in recent groundwater management annual reports (ETIC, 2005, 2006, 2007; Kennedy/Jenks, 2008, 2009, 2010), and earlier groundwater management reports (Todd, 1984, 1994, 1997, 1998). For the SLVWD, hydrogeological studies of the study area include a conceptual hydrogeology model of the Pasatiempo area (Johnson, 2002), a water supply master plan (Johnson, 2009) and a watershed master plan (SLVWD, 2009). The following sections provide a summary of these previous studies for each aquifer.

3.1. Aquifers

In the SMGB, the geologic formations that contain significant sandstone layers act the primary aquifers for water supply. The primary aquifers in the basin include the Santa Margarita, Monterey, Lompico and Butano.

The Santa Margarita and Lompico have long been recognized as primary aquifers. The Santa Margarita has a long groundwater production history, with several production wells completed within this unit (Muir, 1981). Similarly, the Lompico is currently the primary groundwater-producing horizon with several large production wells completed in this unit. The sandstone interbeds and the fractured siltstones in the Monterey can locally produce groundwater. However, the Monterey has limited water supply potential and is typically used for private domestic wells rather than for municipal supply. The Butano had been mapped in surface outcrop by Clark (1966, 1981). However, it was not recognized as the deep aquifer underlying the northern Scotts Valley until more recently (ETIC, 2006).

3.2. Regional Groundwater Production

Groundwater production in the Scotts Valley area includes pumping from wells by water districts and private wells. Figure 1A-10 provides a summary of annual groundwater production by user type in the Scotts Valley areas of the SMGB. The user types include:

- SVWD – groundwater production by SVWD.
- Other Municipal Supplies – primarily includes SLVWD and the Mount Hermon Association.
- Industrial Wells – includes private wells for commercial and industrial usage.

- Environmental Remediation – includes groundwater pumped for the environmental compliance sites.
- Private Wells –groundwater production by individual private well owners.

Total groundwater pumping in the Scotts Valley area was about 2,350 acre-feet in Water Year 2009 (WY2009). A water year is defined as the period from October through September. Historically, groundwater production increased from about 1,400 acre-feet in WY1976 to about 3,600 acre-feet in WY2001 (Figure 1A-10). Groundwater production has steadily declined by an average of 155 AFY since WY2001. Production in WY2009 was about 330 acre-feet less than in WY2008. SVWD is the largest groundwater producer in the area. The trends in SVWD groundwater production are discussed above in Section 3.1. The majority (99%) of the SVWD groundwater production is derived from the Lompico and the Butano. About 900 acre-feet were produced from the Lompico making it the highest producing aquifer. The Butano is the second highest producing aquifer for the District with 590 acre-feet. Less than 1 percent of the production is derived from the Santa Margarita and Monterey.

The SLVWD supplies water to areas west of Scotts Valley. Groundwater production by SLVWD was about 370 acre-feet in WY2009. Groundwater production by SLVWD has been relatively constant with production rates fluctuating between 330 to 450 AFY from WY1995 to the present. Pumping by the Mount Hermon Association (MHA) increased from 126 acre-feet in WY1992 to 232 acre-feet in WY2008, but was down to 185 acre-feet in WY2009. All of the wells for SLVWD and MHA are completed in the Lompico.

Historically, industrial groundwater pumping occurred at the Hanson Quarry, which was a significant groundwater user up and until the quarry was closed in 2004. The decline in groundwater production in WY2002 and WY2003 was due to the decline in groundwater usage by the quarry. Earlier, most of the water used at the quarry was from the Santa Margarita, but production was shifted so that it was almost exclusively from the Lompico when the quarry was closed.

Environmental remediation activities have accounted for significant groundwater production in the basin. However, groundwater production for environmental remediation has steadily declined from 464 acre-feet in WY1986 to an estimated 28 acre-feet in WY2009. Private groundwater production has decreased over the years as properties connect to public water supplies. Most of this production is from the Santa Margarita and Lompico.

The private well production prior to 1998 is based on the Todd (1998) report. Private production has been assumed to be stable at 220 acre-feet in recent years. Private wells are typically completed in either the Santa Margarita or Monterey.

3.3. Groundwater Character of the Santa Margarita

The Santa Margarita has historically been an important aquifer in the Scotts Valley area; however, groundwater declines within this formation have diminished its water supply potential. The following assessment provides a summary of groundwater conditions in the Santa Margarita.

3.3.1. General Characteristics

The Santa Margarita is composed of massive, fine-to-medium-grained sandstone that forms the distinctive white and yellow sand cliffs in the area (Clark, 1981). Laboratory analyses indicate that the sandstone is typically 85 to 90 percent sand, 7 to 8 percent silt, and 4 percent clay (USDA 1980). The Santa Margarita acts as a key source of groundwater recharge where it is exposed at the surface due to the relatively high infiltration rates of the sandy soils (USDA 1980). In the northern Scotts Valley area, the Santa Margarita is overlain by the relatively impermeable Santa Cruz Mudstone which inhibits groundwater recharge.

3.3.2. Santa Margarita Groundwater Flow

In general, groundwater in the Santa Margarita generally flows from areas of higher elevation where the Santa Margarita is exposed and direct recharge occurs, to lower elevations where groundwater is discharged to springs or creeks. Figure 1A-11 is a groundwater elevation map of the Santa Margarita for September 2009 based on the groundwater levels measured by SVWD and others (Kennedy/Jenks 2010).

Groundwater flow within the Santa Margarita is considered to be compartmentalized (see discussion in 3.2.3) with flow directed towards the nearest local discharge point. Groundwater flow north of Scotts Valley is generally directed towards Bean Creek. In areas south and west of Scotts Valley, groundwater flow is more localized towards nearby springs (Figure 1A-11). In the areas west of Scotts Valley, groundwater flow is generally directed towards large springs such as Eagle Creek, Ferndale, Redwood, Dufour, or Camp Evers Springs. In other areas of the Santa Margarita, groundwater levels have remained stable. These areas are typically characterized by having limited pumping and located away from the effects of urbanization (Kennedy/Jenks 2010).

In an area along Mt Hermon Road, groundwater levels in the Santa Margarita form a broad depression that extends to near Scotts Valley Drive with groundwater elevations below elevation 350 feet relative to the 1988 North American Vertical Datum (NAVD 1988). The cause of this depression is considered to be due to a combination of pumping, reduced groundwater recharge from urbanization and changes in water usage (ETIC 2005, 2006; Johnson 2002, 2009; Kennedy/Jenks, 2008, 2009, 2010).

Where the Santa Margarita directly overlies the Lompico along the southeastern margin of the SGMB, declining groundwater levels in the Lompico have caused significant areas of the Santa

Margarita to become unsaturated (Figure 1A-11). Groundwater pumping in both of these areas is generally from the Lompico; therefore, trends in water levels likely indicate a lesser degree of groundwater interaction between the Santa Margarita and Lompico (Kennedy/Jenks 2010).

3.3.3. Santa Margarita Historical Levels

Groundwater within the Santa Margarita is considered “compartmentalized” because areas in close proximity showing significantly different groundwater level histories and responses to groundwater level declines (ETIC 2005, 2006; Johnson 2002, 2009; Kennedy/Jenks, 2008, 2009, 2010). Groundwater levels in the Santa Margarita are generally stable in much of the SMGB with little variation in groundwater elevations from the early 1980s through the present. However, in the areas in the western portion of Scotts Valley, groundwater levels in the Santa Margarita have declined by 50 to 200 feet during the 1990’s. In the Pasatiempo area further to the west of Scotts Valley, groundwater levels have been relatively stable, especially in areas where the Santa Margarita overlies low permeability geologic units (Johnson 2009).

An example of the variable character of groundwater levels in the Santa Margarita can be seen in the difference in groundwater level histories in SVWD Well #9 and wells at the nearby Watkins-Johnson Superfund site. Groundwater levels in SVWD Well #9 declined by as much as 200 feet over the past 20 years with an average decline of nearly 11 feet per year during this period. At the nearby Watkins-Johnson Superfund site, groundwater levels have shown little change from the mid-1980s through 2008. These two locations are only 400 feet apart, yet the water levels and response to pumping are drastically different. The water levels in SVWD Well #9 started out nearly 150 ft higher than those in the Watkins-Johnson wells in 1984, but were lower than the Watkins-Johnson wells by 1997. This happened despite the fact that the Watkins-Johnson wells pumped more groundwater during this same time period than did SVWD Well #9 (Kennedy/Jenks, 2008).

For the Conjunctive Use Project, the distribution and magnitude of the historical groundwater decline provide the potential for aquifer storage. The distribution of the historical drawdown can be evaluated using a groundwater model that was constructed for the SMGB (ETIC, 2006). This model is currently being updated by SVWD as part of their annual groundwater management program, as reported in their annual reports (Kennedy/Jenks, 2008, 2009, 2010). Figure 1A-12 shows groundwater model results of the distribution of groundwater level declines for the Santa Margarita in the Scotts Valley area as calculated by the groundwater model.

The largest declines are focused on the areas in western Scotts Valley with declines of over 150 feet. This large decline is of limited areal extent. In other parts of the Santa Margarita, groundwater level declines are minimal. In areas where the Santa Margarita and Lompico are in direct contact, groundwater level declines in the Santa Margarita are influenced by pumping in the Lompico. Due to the declines in the Lompico, there are areas where the Santa Margarita is not unsaturated.

3.3.4. Assessment of the Santa Margarita Groundwater Conditions

With respect to the potential for aquifer recharge for the Conjunctive Use Project, some areas in the Santa Margarita have significant historical groundwater level declines that provide potential storage capacity. Some of the key aspects for considering the Santa Margarita for the Conjunctive Use Project include:

- Areas where the largest groundwater level declines occurred provide the greatest potential for aquifer storage that could be utilized by the Conjunctive Use Project.
- Areas where the Santa Margarita directly overlies the Lompico provide an opportunity to recharge water in both the Santa Margarita and Lompico.
- Areas where groundwater levels are stable and/or groundwater flow is directed to a nearby spring or stream discharge provide little to no potential storage capacity, thus making these areas unfavorable for the Conjunctive Use Project.

3.4. Groundwater Character of the Lompico

The Lompico is a major source of groundwater in the Scotts Valley area for municipal, domestic, and industrial water supplies. The following assessment provides a summary of groundwater conditions in the Lompico.

3.4.1. General Characteristics

Although the Lompico is found throughout much of the basin, the unit outcrops only along the basin margins primarily north of Scotts Valley (Figure 1A-4). The Lompico occurs at significant depths ranging to over 1,000 feet below the ground surface. Few wells are drilled to those depths, so data for the Lompico is limited away from the basin margin (ETIC 2005, 2006; Johnson 2002, 2009; Kennedy/Jenks, 2008, 2009, 2010).

The limited surface exposure of the Lompico significantly restricts the potential for groundwater recharge potential from precipitation and streambed infiltration, because the Lompico is typically overlain by the relatively low-permeability Monterey. Recharge to the Lompico primarily occurs along outcrop areas especially along the San Lorenzo River (Figure 1A-4). There are few natural discharge locations from the Lompico; so pumping is the primary source of groundwater outflow from this aquifer (ETIC, 2006).

3.4.2. Lompico Groundwater Flow

Figure 1A-13 presents a groundwater elevation map of the Lompico for September 2009 based on the groundwater levels collected by SVWD, SLVWD and others (Kennedy/Jenks 2010). As noted above, wells are generally limited to the southern margin of the basin. As shown on Figure 1A-13, there is a broad area of depressed groundwater levels forming a trough along the southern margin of the basin. The individual pumping wells are surrounded by isolated areas of increased drawdown. The higher groundwater elevations to the north are interpreted to represent groundwater flow from the center of the basin towards the pumping centers in the south.

The groundwater level data indicate that there is insufficient recharge into the Lompico from the Santa Margarita at this time to offset the current volume of pumping. Groundwater inflow to this area is primarily from areas north of Scotts Valley, rather than local recharge. This inflow is assumed to be derived from recharge at outcrops of the Lompico in the northern portion of the basin. This recharge is anticipated to result from the percolation of precipitation and streamflow in streams that flow over surface outcrops of the Lompico (Kennedy/Jenks 2010).

3.4.3. Lompico Historical Levels

The Lompico is a key groundwater aquifer for the region. Most of the groundwater pumping in the Scotts Valley area is from the Lompico, and is primarily used for water supply by SVWD, SLVWD and the Mount Hermon Association (MHA). Due to this pumping, the Lompico has experienced significant and widespread groundwater level declines of up to 200 feet in some areas (ETIC 2005, 2006; Johnson 2002, 2009; Kennedy/Jenks, 2008, 2009, 2010).

SLVWD uses production wells to supply water to their Southern District in the Pasatiempo area west of Scotts Valley. Water levels in the SLVWD production wells completed in the Lompico have declined by as much as 150 feet since the 1990's, but have stabilized in recent years (Johnson 2009).

Groundwater levels have remained relatively stable since 1993 even though pumping has remained relatively steady over that period. This indicates that groundwater levels in the Lompico may have stabilized. This suggests that groundwater from other portions of the groundwater basin is now flowing into this area (Kennedy/Jenks, 2010).

The distribution of the historical drawdown in the Lompico based on the regional groundwater model (ETIC 2006, Kennedy/Jenks, 2008, 2009, 2010) is presented in Figure 1A-14. The distribution of groundwater level declines for the Lompico is more uniform in the Scotts Valley area than what was seen in the Santa Margarita (Figure 1A-14).

The largest declines (over 200 feet near the principal water supply wells) are focused in the areas along the eastern margin of the SMGB in the Scotts Valley area. The groundwater levels declines decrease to the north and west but are still over 100 feet in many areas. This demonstrates that the Lompico acts more as a regional aquifer, and is not impacted by localized conditions as is the Santa Margarita.

3.4.4. Assessment of the Lompico Groundwater Conditions

With respect to the potential for aquifer recharge for the Conjunctive Use Project, historical groundwater level declines in the Lompico are more regional in extent which provides a higher potential for aquifer storage capacity than does the Santa Margarita. Some of the key aspects for considering the Santa Margarita for the Conjunctive Use Project include:

- Areas where the largest groundwater level declines occurred provide the greatest potential for aquifer storage that could be utilized by the Conjunctive Use Project.
- Areas where the Santa Margarita directly overlies the Lompico provide the opportunity to recharge water in both the Santa Margarita and Lompico.

4. Groundwater – Surface Water Interactions

An understanding of groundwater-surface water interactions is important for the Conjunctive Use Project. The two goals of the Conjunctive Use Project are to increase the volume of groundwater in aquifer storage, and the second is to increase summertime baseflow in streams by increasing groundwater levels. These two goals are dependent on the interactions of groundwater with the streams in the region. Below is a brief summary on groundwater-surface water interactions based on earlier reports (Johnson 2002, 2009, ETIC 2005, 2006).

4.1. Stream Character

Groundwater–surface water interactions with streams, such as Carbonera and Bean Creeks, are important hydraulic features that influence groundwater levels and flow. Depending on several factors, the groundwater–surface water interaction may result in one of the following:

- a stream may recharge the groundwater (“losing reach”),
- the groundwater may discharge to the stream (“gaining reach”),
- stream locations that can vary seasonally between gaining reaches during the spring and losing reaches during the fall, or
- streams flowing over low permeability materials that restrict flow so that little interaction occurs.

The first three interaction types are primarily controlled by the relative difference between the stage, or elevation, of the water in the stream, and the elevation of the groundwater. If the stream stage is higher, then the stream will recharge the groundwater. If, however, the groundwater elevations are higher, then the groundwater will discharge to the stream either directly or as springs.

The fourth interaction type is controlled by the geologic unit the stream is traversing at a given location. If the stream flows across higher permeability aquifer material, then the groundwater–surface water interactions will be more responsive. However, if the stream is flowing across lower permeability material such as an intervening aquitard, then the groundwater–surface water interactions will be more restricted. Portions of the streams underlain by the Santa Margarita or Lompico would be in more direct hydraulic communication with the stream because of the relatively high permeability of the sandstone. In the areas underlain by the relatively low permeability Monterey or the Santa Cruz Mudstone, the groundwater–surface water interactions will be more restricted (ETIC 2005, 2006).

For Bean Creek, the nature of the interaction varies with topography and the underlying geologic unit. The northern portions of Bean Creek have eroded through the Santa Cruz Mudstone (Figure 1A-8, 1A-9). To the south, the creek has eroded through the Santa Margarita down into the Monterey. Lower Bean Creek is a gaining stream where groundwater from the Santa Margarita is discharged to the stream through springs either through the streambed or along the stream margins. In the upper reaches, Bean Creek and its tributaries are losing streams where streamflow recharges the groundwater in the Santa Margarita (ETIC 2005, 2006).

A portion of Carbonera Creek is underlain by the Santa Margarita, which represents a potential groundwater recharge zone (ETIC 2005). Surface water flows from Carbonera Creek would percolate into the underlying Santa Margarita. However, Carbonera Creek has eroded deeper into the alluvium. This downcutting by the creek has lowered the hydraulic base level of the creek (ETIC 2005, 2006). The implications of this downcutting are discussed in more detail in Tech Memo 2B (Balance Hydrologics, 2010).

In general, stream flows are highest during the winter months in response to increased rainfall. Stream flow declines in the spring as precipitation decreases. In the summer months, the flow in lower Bean Creek is sustained by groundwater discharge to the creek. A portion of Bean Creek goes dry during the summer months in many years because the percolation rate into the underlying Santa Margarita exceeds the volume of streamflow. Similarly, Carbonera Creek has its highest streamflows in the winter months. Wintertime flows have been substantially increased in recent years due to the increase in impervious surfaces, such as parking lots, in Scotts Valley, which lead to more (and more rapid) runoff. Much of Carbonera Creek through Scotts Valley has very low flows or goes dry during the summer months (ETIC 2005, 2006). A more detailed discussion of stream characteristics is presented in Tech Memo 2B (Balance Hydrologics, 2010).

4.2. Springs

The Scotts Valley area contains numerous natural springs and seeps throughout the groundwater basin. Springs represent a location where groundwater discharges to the surface.

Springs form at hydraulic low points, typically the base of the Santa Margarita where it overlies a lower permeability geologic unit such as the Monterey, the Locatelli, or the crystalline basement. Therefore, spring discharge will tend to remain relatively stable until the groundwater source feeding the spring is depleted.

Several springs have been mapped along the lower contact of the Santa Margarita and Monterey. The Ferndell Spring, Redwood Springs, and Eagle Creek are large springs that have a history of flow measurements. Redwood Springs and Ferndell Spring are located on the grounds of Mt. Hermon Conference Center. Flow measured at Ferndell Spring range from 0.33 cubic feet per second (cfs) in the spring to 0.24 cfs in the fall. Flow at Redwood Springs ranges from 0.17 cfs in the spring to 0.13 cfs in the fall. Eagle Creek is comprised of multiple springs and seeps in a small watershed that drains into the San Lorenzo River. Flow range from 0.66 cfs in the spring to 0.35 cfs in the fall. These three springs drain from the Santa Margarita. They are estimated, based on the available data, to account for a groundwater outflow from the Santa Margarita of approximately 680 acre-feet per year (AFY; ETIC 2005, 2006, Johnson 2009).

Several more springs exist whose flow have not been measured, such as those along Camp Evers Creek and Dufour Springs; therefore, substantially more discharge by springs is present (ETIC 2005, 2006). Springs form at hydraulic low points, typically the base of the Santa Margarita overlying a lower permeability geologic unit such as the Monterey, the Locatelli, or the crystalline basement. Therefore, spring discharge will tend to remain relatively stable until the groundwater source feeding the spring is depleted.

Groundwater elevations maps of the Santa Margarita (Figure 1A-11) show that groundwater flow is directed from these groundwater-elevation highs, which represent recharge areas, towards the discharge points at lower groundwater elevations, the creeks and springs. In this manner, groundwater flow within the Santa Margarita is generally compartmentalized with groundwater flow directed to the nearest local discharge point as shown on Figure 1A-11 by the groundwater flow direction arrows.

Springs also occur at the contact of the Santa Cruz Mudstone and the Purisima (ETIC 2005, 2006). These units are typically found capping topographic highs in the Scotts Valley area. Numerous wet-weather springs are found near outcrops of the Santa Cruz Mudstone and drain precipitation recharge captured by the Purisima.

4.3. Assessment of Groundwater-Surface Water Interactions

Understanding the groundwater-surface water interactions is necessary to demonstrate the degree to which the Conjunctive Use Project can meets its primary goals of increasing the volume of groundwater in aquifer storage and while also increasing the summertime baseflow in streams. Some of the key aspects of groundwater-surface water interactions in the SMGB for the Conjunctive Use Project include:

- The primary gaining reach in the Scotts Valley area is Lower Bean Creek. This reach forms a key discharge area for groundwater, and flows are sustained by groundwater, especially in the summertime.
- Upper Bean Creek and its tributaries, and Carbonera Creek are typically losing streams throughout the year.
- Much of the groundwater discharge from the Santa Margarita occurs at springs and/or discharge directly to Bean Creek. This characteristic limits its potential for aquifer storage but increases its ability to sustain higher summertime baseflow.
- There is little to no groundwater-surface water interactions with the Lompico in the Scotts Valley area. This characteristic increases its potential for aquifer storage, but limits its ability to sustain increased summertime baseflow.

5. Groundwater Storage Evaluation

Groundwater storage is a measure of the volume of groundwater present in the aquifer. The change in groundwater storage measures the increase or decrease in the volume of groundwater in the aquifer resulting from changes in groundwater levels. If historical groundwater levels were higher than current groundwater levels, then it is inferred that the volume of aquifer between the historical and current levels represents available capacity for groundwater storage. If historical and current groundwater levels are similar, then it is inferred that the basin may be full to some outflow condition controlled by discharge to springs or surface streams that will limit the potential for aquifer storage. Below is a summary of groundwater storage capacity for the SMGB.

5.1. Sustainable Yield

The sustainable yield (or safe yield) is a concept that is applied to groundwater basins as a mechanism to define the natural limit of groundwater pumping. The sustainable yield represents the annual amount of water that can be taken from a basin over a period of years without depleting it beyond its ability to be replenished naturally. Exceeding the safe yield for the basin may lead to perennial declines in groundwater levels which over time may result in widespread loss of well production and impacts to aquatic systems.

In 2006, the basin-wide Santa Margarita Basin Groundwater Model was completed. Based on the model analysis, the sustainable yield for the entire Santa Margarita Basin was estimated at 3,320 acre-feet per year (AFY) (ETIC 2006). Further analysis estimated the sustainable yield in the Scotts Valley area at 2,600 AFY (ETIC 2006). Previously, the basin-wide safe yield was estimated at 4,200 acre-feet using a water balance approach (Todd Engineers, 1998).

5.2. Change in Groundwater Storage

Changes in groundwater storage can be analyzed by either of two methods: 1) a model-based calculation; or, 2) an empirical method.

The regional groundwater model (ETIC, 2006) has been used to evaluate the change in groundwater storage (Kennedy/Jenks 2008, 2009, 2010). Because of the geologic complexity of the basin, t is difficult to easily quantify changes in storage based on water levels alone; therefore, the model, which incorporates much of the complexity, provides a comprehensive tool for evaluating changes in storage over time. The model was used to develop a water budget that quantifies the total inflow and outflow of groundwater for the Scotts Valley area. Over the past 25 years, the annual change in groundwater storage has varied from an increase of over 600 acre-feet to decreases of nearly 1,900 acre-feet (Figure 1A-15). Based on the regional groundwater model, the volume of lost groundwater storage lost over the past 25 years is estimated to be approximately 12,000 acre-feet (Kennedy/Jenks 2008, 2009, 2010).

The empirical method involves calculating the annual water level changes measured in individual wells, estimating areas over which each water level change applies, and determining representative thicknesses and storativity values for each geologic unit involved. The empirical method was used to estimate storage change from 1989 through 2005 (ETIC 2005). Over that 17-year period, the empirical method estimated an overall decline in groundwater storage of 1,800 acre-feet, compared to 5,900 acre-feet for the regional groundwater model estimated a storage loss of 5,900 acre-feet. This comparison shows that the model analysis tends to provide a more conservative analysis for groundwater management. This is primarily because the model does a better job of including widespread regional groundwater level declines especially in the Lompico. Estimates of groundwater storage loss by Johnson (2009) provide a cumulative groundwater storage loss for the Santa Margarita of 5,000 acre-feet, and an additional 10,000 acre-feet for the Lompico.

5.3. Effects of Urbanization on Recharge

The groundwater recharge in the Scotts Valley area has been impacted by urbanization. The primary cause of this impact is the covering of large areas, especially high permeability soils, with pavement and the installation of storm drains to collect and carry rainfall directly to streams such as Carbonera Creek. Historically, a portion of this rainfall would have percolated into the sandy soils and eventually into the groundwater. This is considered to be a contributing factor to the decline in groundwater levels in the Scotts Valley area along with increased groundwater pumping.

To evaluate the loss of groundwater recharge due to urbanization, the land use factors in the groundwater model were changed back to those for undeveloped lands (ETIC 2006). The groundwater recharge in Scotts Valley was recalculated and compared to the urbanized recharge volume. The amount of lost groundwater recharge is directly proportional to annual precipitation. Therefore, there is more lost recharge in an above-average precipitation years. Conversely, less groundwater recharge is lost in below-average precipitation years. The results of this analysis indicate that the volume of lost groundwater recharge due to urbanization is on the order of 500 to 1,000 AFY (Figure 1A-15). Over the past 25 years, the volume of lost groundwater recharge is estimated to be approximately 15,000 acre-feet (Kennedy/Jenks 2008, 2010). Because of the complex groundwater-surface water interactions, not all of this 15,000 acre-feet of lost recharge would be left in groundwater storage. A portion of this recharge would have eventually been discharged to streams as part of the baseflow, and a portion would have remained in aquifer storage. At this time, no analysis has been performed to determine the relative percentage that would have remained in storage.

5.4. Assessment of Regional Groundwater Storage Issues

Previous losses of groundwater from aquifer storage provide the potential for future groundwater storage through a Conjunctive Use Project.

- Cumulative declines in groundwater storage range from 12,000 to 15,000 acre-feet in the Scotts Valley area.
- Most of the groundwater level decline has occurred in the Lompico rather than the Santa Margarita. Based on available estimates, the estimated groundwater storage loss in the Lompico is twice what has occurred in the Santa Margarita.
- The loss of groundwater recharge in the Scotts Valley area is on the order of 15,000 acre-feet over the past 25 years due to increased areas of pavement and the storm drains has contributed to both declines in stream baseflow and groundwater levels..
- The primary factors for the declining groundwater levels is increased groundwater pumping water municipal water supply, and the effects of urbanization in the Scotts Valley area reducing the natural recharge to the SMGB.

The potential volume of available aquifer storage is substantial and allows for the consideration of enhanced aquifer recharge in the Scotts Valley area as viable. Understanding that loss of groundwater recharge from the infiltration of stormwater demonstrates that stormwater is a significant potential source of water to be used for aquifer recharge.

6. Water Quality

Water districts monitor the water quality for the groundwater production wells for constituents that meet Title 22 requirements as outlined in the Safe Drinking Water Act, the California Code of Regulations. These water quality parameters include major cations, anions, trace metals, total dissolved solids (TDS), pH, and volatile organic compounds (VOCs). Results of water quality analysis are reported to California Department of Health Services, Division of Drinking

Water and Environmental Management. SVWD and SLVWD monitor and sample both raw and treated water. Raw water samples represent native groundwater quality conditions prior to any treatments.

6.1. Regional Water Quality

Based on the historical trends, the major constituents of concerns in the Scotts Valley area groundwater include iron, manganese, TDS, sulfate, nitrate, and arsenic. SVWD and SLVWD treat raw groundwater extracted from the production wells for constituents that are above or approaching primary and secondary maximum contaminant levels (MCLs). The following summary is based on summaries in Kennedy/Jenks (2010) and Johnson (2009):

- **Iron and manganese** - concentrations are typically above the secondary MCL of 300 milligrams per liter (mg/L) in SVWD Wells #3B, #10, #11A and #11B and SLVWD Pasatiempo #6.
- **TDS** - concentrations are typically above the secondary MCL of 500 mg/L in SVWD Wells #3B, #7A, #9 and #11A.
- **Sulfate** - concentrations are typically below the California DHS public health goal of 250 mg/L in all wells, except in Well #9. The sulfate in SVWD Well #9 is attributed to groundwater production now coming mostly from the Monterey.
- **Arsenic** – SVWD Well #11B and SLVWD Pasatiempo #6 have on occasion exceeded the primary MCL of 10 micrograms per liter (μg/L). Other wells have stayed below the public health goals for arsenic.
- **Nitrate** – nitrate concentrations were reported non-detect in all SVWD and SLVWD production wells.

Arsenic and nitrate have concentration limits governed by primary MCLs. The other constituents of concern for taste, odor, and aesthetic factors and their concentrations are regulated based on secondary MCLs and public health goals. Volatile organic compounds (VOCs) are anthropogenic contaminants resulting primarily from industrial and commercial business activities. VOCs have impacted wells in the Scotts Valley area including the following production wells.

- SVWD Well #9 has had sporadic detections of various VOCs. SVWD is currently operating a GAC system to treat water from SVWD Well #9 prior to water distribution. SVWD will continue to monitor and treat raw water at this well.
- A GAC unit has been added to the SVWD Well #10 water treatment plant as a precautionary measure although no VOCs have been measured in water from SVWD Well #10 or #10A to date.

- SLVWD Mañana Woods well is impacted by methyl tert-butyl ether (MTBE) from the Camp Evers MTBE Plume (discussed below).

6.2. Environmental Compliance Sites

Groundwater quality has been impacted by pollution or chemical releases at several sites in the Scotts Valley area. Aquifer recharge in the areas impacted by these environmental compliance sites has the potential to redirect the flow of impacted groundwater or rising groundwater levels could potentially remobilize residual contamination that is currently isolated in the unsaturated zone. Oversight is generally provided by the United States Environmental Protection Agency (USEPA), Central Coast Regional Water Quality Control Board (RWQCB) and the Santa Cruz County Environmental Health Services (SCCEHS). Below is a brief summary of the status of the six known active environmental sites in the study area. The locations of these sites are depicted on Figure 1A-16.

6.2.1. Camp Evers MTBE Plume

The primary contaminant of concern at this site is the former gasoline additive MTBE. The Camp Evers MTBE plume is associated with four current and former gasoline stations located in the vicinity of the intersection of Scotts Valley Drive and Mount Hermon Road in western Scotts Valley. This site is located where the Santa Margarita directly overlies the Lompico. Groundwater levels have declined so portions of the Santa Margarita are unsaturated in this area; therefore, much of the contaminant plume is in the Lompico.

In addition to the multi-site groundwater plume cleanup under RWQCB oversight, investigation and potential remediation of petroleum-impacted shallow soil and groundwater identified at the former BP station is being pursued by SCCEHS in 2009. On-site remedial activities are ongoing with groundwater extraction as the current primary cleanup method. Remedial activities at this site are reported in quarterly monitoring reports and remedial system performance summary reports. A summary of key characteristics include:

- The site includes petroleum hydrocarbons and by-products from several gasoline stations near the intersection of Mt. Hermon Road and Scotts Valley Drive.
- On-site remedial activities are ongoing with groundwater extraction as the current primary treatment method. Remedial activities at this site are reported in quarterly monitoring reports and remedial system performance summary reports.
- The size of the plume has been significantly reduced by remediation and appears to be contained. Mañana Woods Well #2 has been impacted by the plume and is currently treated by a GAC treatment system.

6.2.2. Scotts Valley Dry Cleaners

The Scotts Valley Dry Cleaners Site is located on Mount Hermon Road in western Scotts Valley The primary chemical of concern from this site is tetrachloroethylene (PCE) associated with operations at the dry cleaners. Significant PCE concentrations (as high as 11,000 µg/L) have been detected historically in shallow groundwater of the Santa Margarita. This site is also located near where the Santa Margarita directly overlies the Lompico, so there is a potential threat to the Lompico. The site is under the jurisdiction of the Central Coast RWQCB.

Remediation of the PCE has consisted of groundwater extraction, soil vapor extraction and high-vacuum dual-phase extraction. These remedial measures have resulted in a general decline in concentrations over time. Groundwater extraction has continued through 2010. A summary of key characteristics include:

- The site contamination is primarily PCE and trichloroethylene (TCE) associated with operations at the dry cleaners. Based on 2007 monitoring data, PCE was detected in 11 of 16 monitoring wells with a maximum concentration of 1,300 µg/L. TCE was detected in 9 of 16 monitoring wells with a maximum concentration of 10 µg/L.
- The groundwater contaminant plume is a potential threat to SVWD Wells #10 and #10A completed in the Lompico and located about 500 feet from the suspected plume source area. SVWD installed a GAC treatment system at Well #10 WTP as a precautionary measure.
- Two deep monitoring wells were installed as early detection for potential impact to SVWD Wells #10 and #10A. No concentrations above detection limits have been measured at these two monitoring wells.
- On-site remediation and off-site monitoring efforts are ongoing using soil vapor extraction, groundwater extraction, and high-vacuum dual-phase extraction.

6.2.3. Watkins-Johnson Superfund Site

The Watkins-Johnson Site is classified as a Federal Superfund Site that is located in western Scotts Valley. The primary issue is TCE and PCE of the Santa Margarita. At this site, the Santa Margarita is underlain by a thick sequence of Monterey so that there is essentially no threat to the Lompico. Remediation activities are under the jurisdiction of USEPA Region 9. Site remediation has included soil vapor and groundwater extraction. Groundwater was extracted from one well until December 2008, at a typical pumping rate of 75 gpm. In addition to the site mitigation measures, the WTP for SVWD Well #9 includes GAC treatment as a precaution. A summary of key characteristics include:

- TCE plume originally extended over 2,000 feet toward Bean Creek, but is now only found at a few isolated locations.

- Contaminant remediation consists of groundwater extraction from one well. In 2007, the groundwater remediation system produced about 109 acre-feet of treated groundwater. No groundwater extraction is occurring in 2009 and 2010.
- A groundwater investigation is currently underway to evaluate whether increasing plume levels measured in 2006 are from an on-site or off-site source.

6.2.4. Scotts Valley Drive Dichlorobenzene Plume

VOCs, primarily dichlorobenzene (DCB) and monochlorobenzene (MCB), have been detected historically in a number of wells along Scotts Valley Drive in eastern Scotts Valley (Figure 1A-16). The MCL for MCB is 70 µg/L, for 1,2-DCB is 600 µg/L, and for the more toxic form 1,4-DCB is 5 µg/L. This site is also located where the Santa Margarita directly overlies the Lompico. Groundwater levels have declined so the Santa Margarita is unsaturated; therefore, the contaminant plume is in the Lompico.

In 2007, a soil and groundwater investigation was conducted under Central Coast RWQCB (Region 3) and SCCEHS oversight at the Shaffer, Meisser & Rogers Property at 4556 Scotts Valley Drive (Figure 1A-16). This investigation identified an area of soil contaminated with chlorobenzene compounds. The site is located near the area of highest historical concentrations of DCB from 1984 and 1985. Therefore, this site may potentially be the source of the historic Scotts Valley Drive Dichlorobenzene Plume. Site investigations are ongoing.

This groundwater plume is of concern to SVWD because of its large areal extent and proximity to active production Wells #11A and #11B. Both well #11A and former production well #11 have had these compounds and other VOCs detected, generally at very low levels below their MCLs. A summary of key characteristics includes:

- The maximum concentrations of DCB and MCB (1,500 and 76 µg/L, respectively) were detected in the mid-1980s. Historical data show that concentrations in the plume have been in decline since 1984, but that the plume has migrated over 3,000 feet in that time. The source (or sources) of DCB and MCB is unknown.
- In January through April 2007, a soil and groundwater investigation was conducted at 4556 Scotts Valley Drive that identified an area of soil contaminated with chlorobenzene compounds. The maximum soil concentration was 74,300 µg/L of 1,2,4-trichlorobenzene.
- In October 2007, a remedial soil excavation was conducted at the site to a depth of 15 feet that removed about 600 cubic yards of soil. An abandoned sewer pipe was uncovered during the excavation; this may have been the source of the contamination.

6.2.5. Hacienda Drive Shell Site

The Hacienda Drive Shell Site is located along Scotts Valley Drive in northern Scotts Valley (Figure 1A-16). A request for case closure was rejected in 2008 due to a lack of data. This site is of potential concern because of the proximity of Well #11B and Carbonera Creek; however, ongoing monitoring suggests the remaining contaminants at the site present no significant threat. The site is underlain by the Santa Cruz Mudstone so there is little direct threat to the Santa Margarita or Lompico. The primary issue is the potential for contaminants to enter Carbonera Creek where it could potentially spread to other areas. A summary of key characteristics include:

- The contaminants at the site are petroleum hydrocarbons and by-products (MTBE and TBA). An investigation and cleanup during WY2006 was overseen by SCCEHS.
- The groundwater extraction system and monitoring have shown a consistent decreasing trend of concentrations at this site.

6.2.6. Kings Cleaners

The King’s Cleaners site is located on Mount Hermon Road in western Scotts Valley (Figure 1A-16). It was opened for site assessment in 2009, apparently because the owner is pursuing environmental closure for the dry cleaning facilities and because of the site’s potential as a source for the PCE detected in groundwater at the Watkins-Johnson site, located approximately 1,900 ft down-gradient. This site is located near the Camp Evers MTBE plume where the Santa Margarita directly overlies the Lompico. Potential contamination from this site could impact both the Santa Margarita and Lompico, if present. Investigations are currently underway. A summary of key characteristics includes:

- Previous investigations had been conducted at King’s Cleaners in 2000 and 2005, with results showing maximum PCE detections of 41 µg/L in soil gas and 0.047 mg/kg in soil. No groundwater data have been reported for this site.
- A work plan for further soil and groundwater assessment was submitted to the Central Coast RWQCB and SCCEHS.

6.3. Assessment of Water Quality Issues

Water quality issues can have a significant impact on the operations of a potential aquifer recharge project. Changes in groundwater levels in the vicinity of environmental regulatory sites have the potential to remobilize contaminants that may have been trapped in the unsaturated zone above the groundwater. Existing natural groundwater may react with recharge water in a manner that may cause fouling of the recharge facility and limit the potential for recharge operations.

- High iron and manganese may have the potential for biofouling especially in wells.
- The Camp Evers MTBE plume, Scotts Valley Dry Cleaners, Kings Cleaners and the Scotts Valley Drive Dichlorobenzene Plume are all situated in areas that may have available aquifer storage potential that would be utilized by a Conjunctive Use Project. Understanding how changes in groundwater levels could affect these plumes will be necessary in later evaluations of potential projects.

7. Conclusions

TM1A provides an overview of the previous hydrogeological work that characterizes the complex hydrogeological relationships of the SMGB, and then discusses these issues relevant to developing a Conjunctive Use Project. The topics addressed in this TM include a discussion of the assessments relevant to the Conjunctive Use Project.

Enhanced aquifer recharge requires that aquifer storage capacity be available in the project area. Groundwater storage in the Scotts Valley area has been evaluated using a number of methods. In summary, estimates of the cumulative declines in groundwater storage range from 12,000 to 15,000 acre-feet in this area with most of the decline occurring in the Lompico rather than the Santa Margarita. Therefore, based on this analysis of historical groundwater data, there is sufficient capacity to store water in the aquifer for a conjunctive use project.

The Santa Margarita has several complexities related to aquifer recharge. Groundwater flow is compartmentalized with groundwater flow generally directed to a nearby spring or stream discharge. For much of the Santa Margarita, there has been little historical change in groundwater levels; therefore, this unit is generally unfavorable for the Conjunctive Use Project. The areas of greatest historical groundwater level declines in this unit that could be utilized by the Conjunctive Use Project are located in western Scotts Valley.

Historical groundwater level declines in the Lompico are more regional in extent, and providing a higher potential for aquifer storage that could be utilized by the Conjunctive Use Project. The area where Santa Margarita directly overlies the Lompico provides potential storage capacity in both the Santa Margarita and Lompico. There is little to no surface water interactions with the Lompico groundwater in the Scotts Valley area. This characteristic increases its potential for aquifer storage but limits its usefulness for increasing summertime baseflow.

This TM provides a discussion (with accompanying maps and cross sections) of the complex geology of the SMGB. The success of a future aquifer recharge project will depend upon how well the complex geological conditions at any potential project site are understood. The distribution of the Santa Margarita, Santa Cruz Mudstone and Monterey surface outcrops are an important factor for locating surface recharge facilities. An understanding of groundwater-surface water interactions is important for successful aquifer recharge by a Conjunctive Use Project. Understanding the groundwater-surface interactions is necessary to demonstrate the degree to which the Conjunctive Use Project can meets its primary goals of increasing the volume of groundwater in aquifer storage while also increasing summertime baseflow in streams. Areas where creeks are incised into aquifer units allows for greater groundwater-surface water interactions. These areas are most prevalent in the Santa Margarita rather than the Lompico. The primary gaining reach in the Scotts Valley area is the Lower Bean Creek. This reach forms a key discharge area for groundwater and the Lower Bean Creek baseflows are sustained by groundwater especially in the summertime. Additional studies are recommended to develop more site-specific recharge evaluations based on field tests at potential recharge facility locations. These tests may include aquifer pumping tests and soil infiltration tests.

Water quality can have a significant impact on the operations of a potential aquifer recharge project. The primary issue with recharge in the Scotts Valley area is the interaction of recharge water with existing environmental compliance sites that have vadose zone and/or groundwater contamination. Changes in groundwater levels in the vicinity of environmental regulatory sites have the potential to remobilize contaminants that may have been trapped in the unsaturated zone above the groundwater. The Camp Evers MTBE plume, Scotts Valley Dry Cleaners, Kings Cleaners and the Scotts Valley Drive Dichlorobenzene Plume are all situated in areas that may have available aquifer storage potential that may be utilized by a Conjunctive Use Project. Understanding how changes in groundwater levels could affect these plumes will be necessary in later evaluations of potential projects. Additionally, natural groundwater may react with recharge water in a manner that may cause fouling of the recharge facility and limit the potential for recharge operations. Additional studies are recommended to evaluate these water quality issues in bench scale tests by mixing the various groundwaters with the potential sources of aquifer recharge water.

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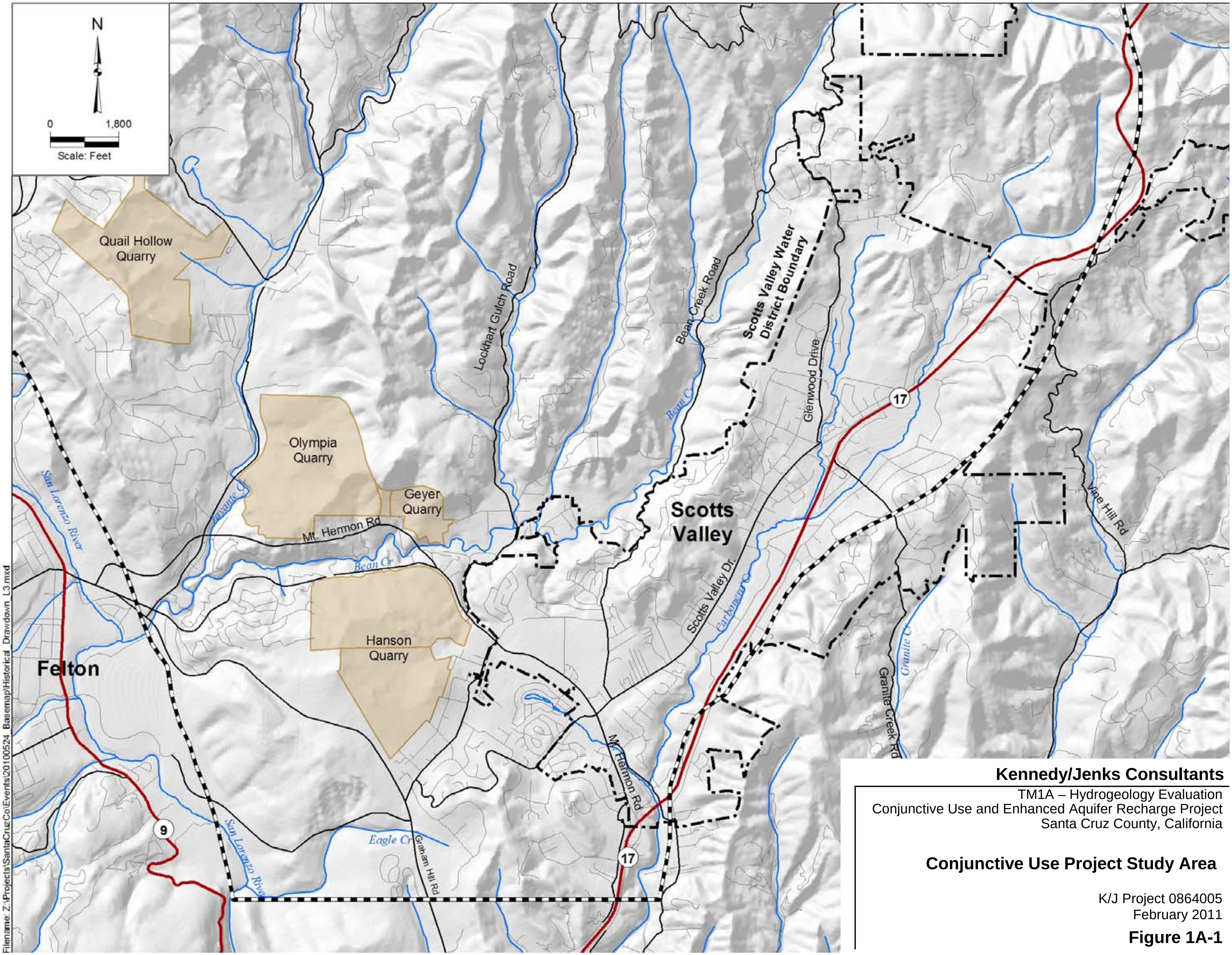
FIGURES



Kennedy/Jenks Consultants

TM1A – Hydrogeology Evaluation
Conjunctive Use and Enhanced Aquifer Recharge Project
Santa Cruz County, California

Conjunctive Use Project Study Area

K/J Project 0864005
February 2011

Figure 1A-1

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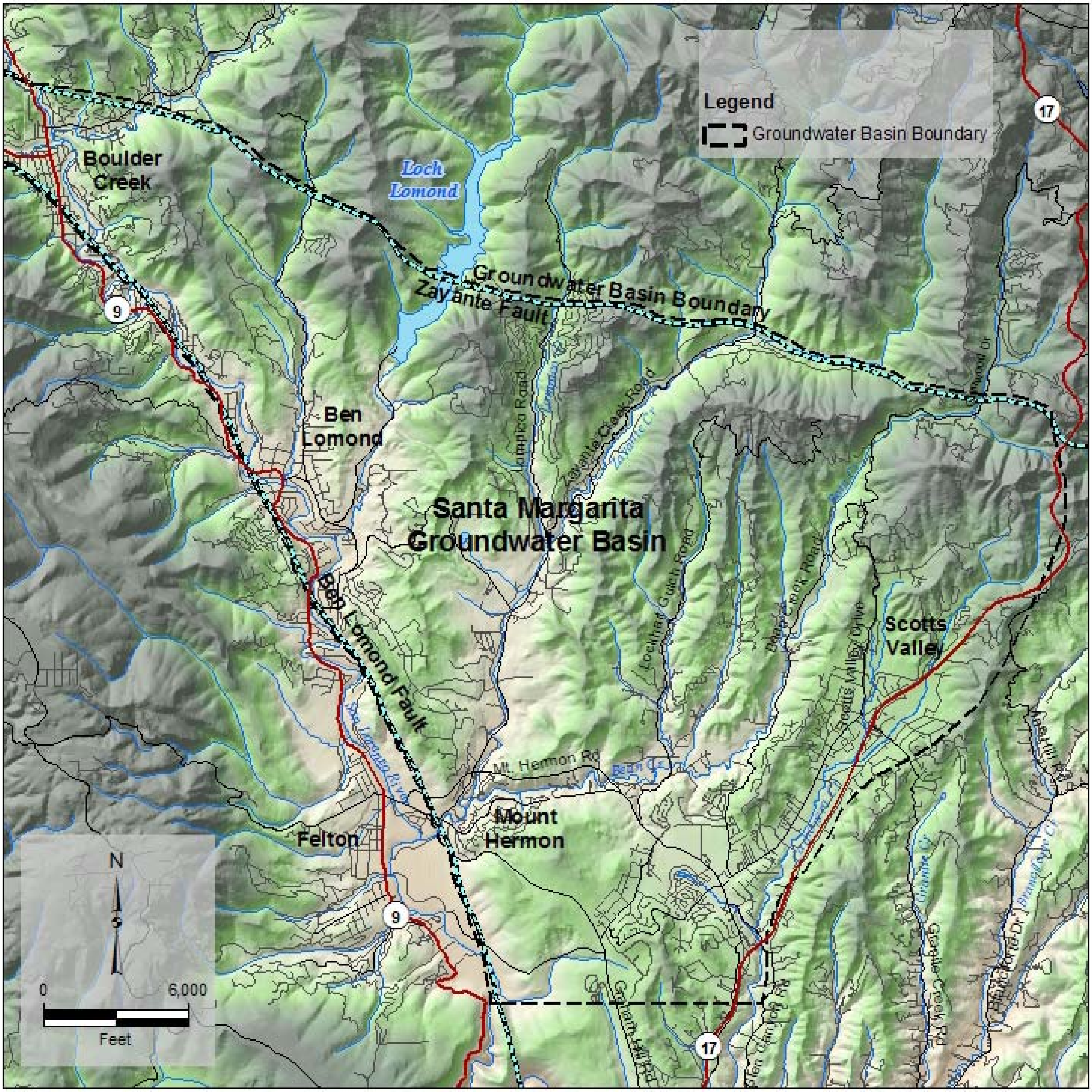

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Conjunctive Use and Enhanced Aquifer Recharge Project
Santa Cruz County, California

Santa Margarita Groundwater Basin

K/J Project 0864005
February 2011

Figure 1A-2

ERA	PERIOD	SERIES	FORMATION	LITHOLOGY	THICKNESS (feet)	DESCRIPTION
CENOZOIC	QUATERNARY	PLEISTOCENE-HOLOCENE	Terrace Alluvium		<50	Terrace deposits are weakly consolidated, poorly sorted sandy gravel to medium sands. Alluvium consists of unconsolidated, moderately sorted silt, sand and gravel along respective streams
	QUATERNARY / TERTIARY	PLEISTOCENE-HOLOCENE / PLIOCENE	Purisma Formation		500+	Very thick bedded yellowish-gray tuffaceous and diatomaceous siltstone with thick interbeds of bluish-gray semifriable andesitic sandstone
	TERTIARY	MIOCENE	*Unconformity* Santa Cruz Mudstone		0-200	Medium- to thick-bedded and faintly laminated pale yellowish-brown siliceous mudstone with scattered speroidal dolomite concretions; locally grades to sandy siltstone
	TERTIARY	MIOCENE	Santa Margarita Sandstone *Unconformity*		0-450	Very thick bedded and thickly crossbedded yellowish-gray to white friable arkosic sandstone
	TERTIARY	MIOCENE	Monterey Formation		0-2,000	Medium- to thick-bedded and laminated olive-gray subsiliceous organic mudstone and sandy siltstone with few thick dolomite interbeds
	TERTIARY	MIOCENE	Lompico Sandstone *Unconformity*		200-300	Thick-bedded to massive yellowish-gray arkosic sandstone
	TERTIARY	EOCENE	Butano Sandstone: Upper Sandstone Member		3,000	Thin- to very thick-bedded medium gray arkosic sandstone with thin interbeds of medium-gray siltstone
	TERTIARY	EOCENE	Butano Sandstone: Middle Sandstone Mem.		250-750	Thin- to medium-bedded nodular olive-gray pyritic siltstone
	TERTIARY	EOCENE	Butano Sandstone: Lower Sandstone Member *Unconformity*		1,500	Very thick bedded to massive yellowish-gray arkosic sandstone with thick to very thick interbeds of sandy pebble conglomerate in lower part
	TERTIARY	PALEOCENE	*Not in contact within area* Locatelli Formation		800	Nodular olive-gray to pale-yellowish-brown micaceous siltstone; massive arkosic sandstone locally at base
MESOZOIC	CRETACEOUS		*Non-conformable on crystalline complex of Ben Lomond Mountain* Crystalline Basement			Primary quartz diorite, light gray, medium gravel, plagioclase, and quartz with lesser amounts of feldspar, biotite, and hornblende

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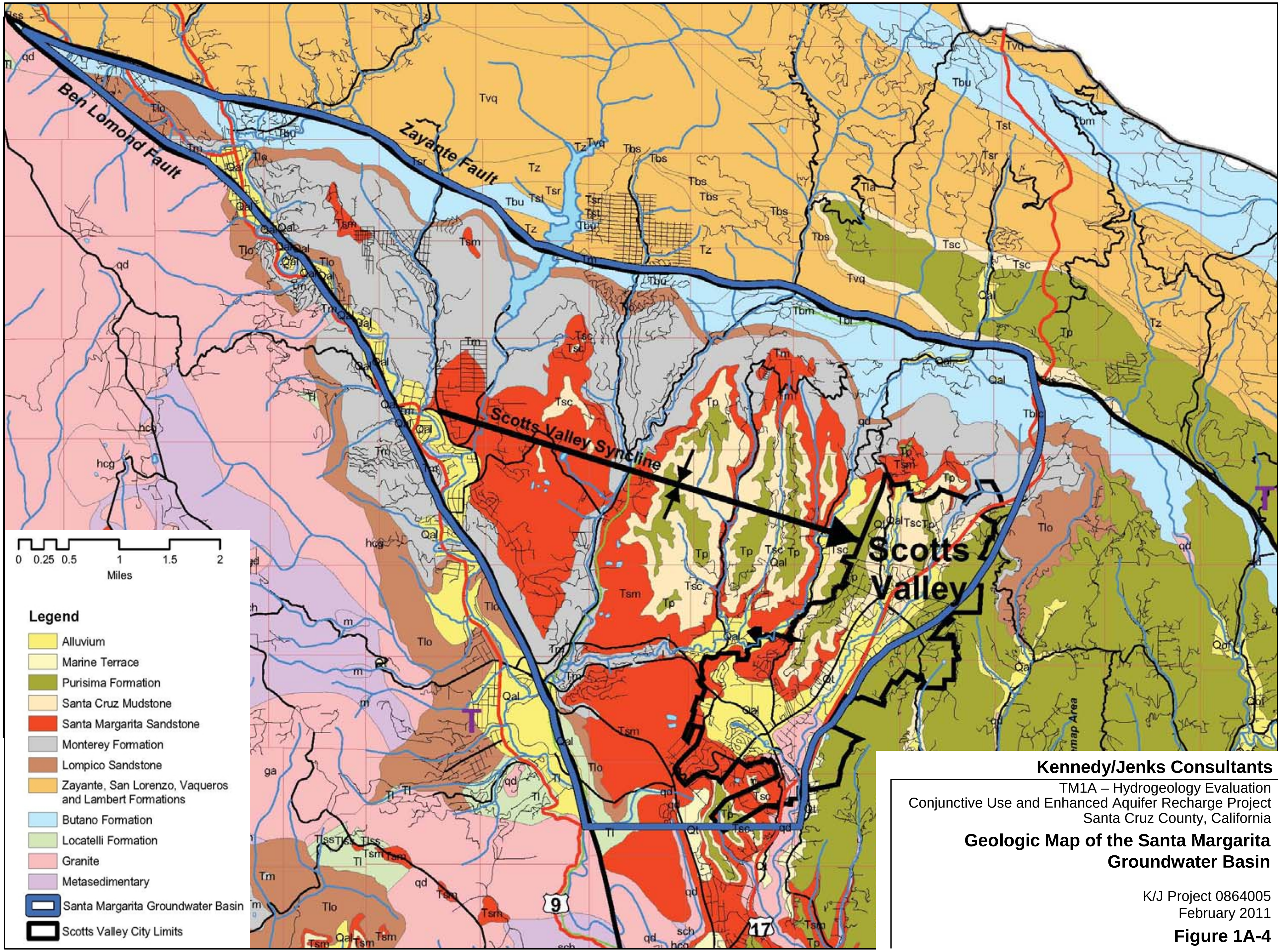
Santa Cruz County, California

Stratigraphic Column for the Santa Margarita Groundwater Basin

K/J Project 0864005
February 2011

Figure 1A-3



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Geologic Map of the Santa Margarita Groundwater Basin

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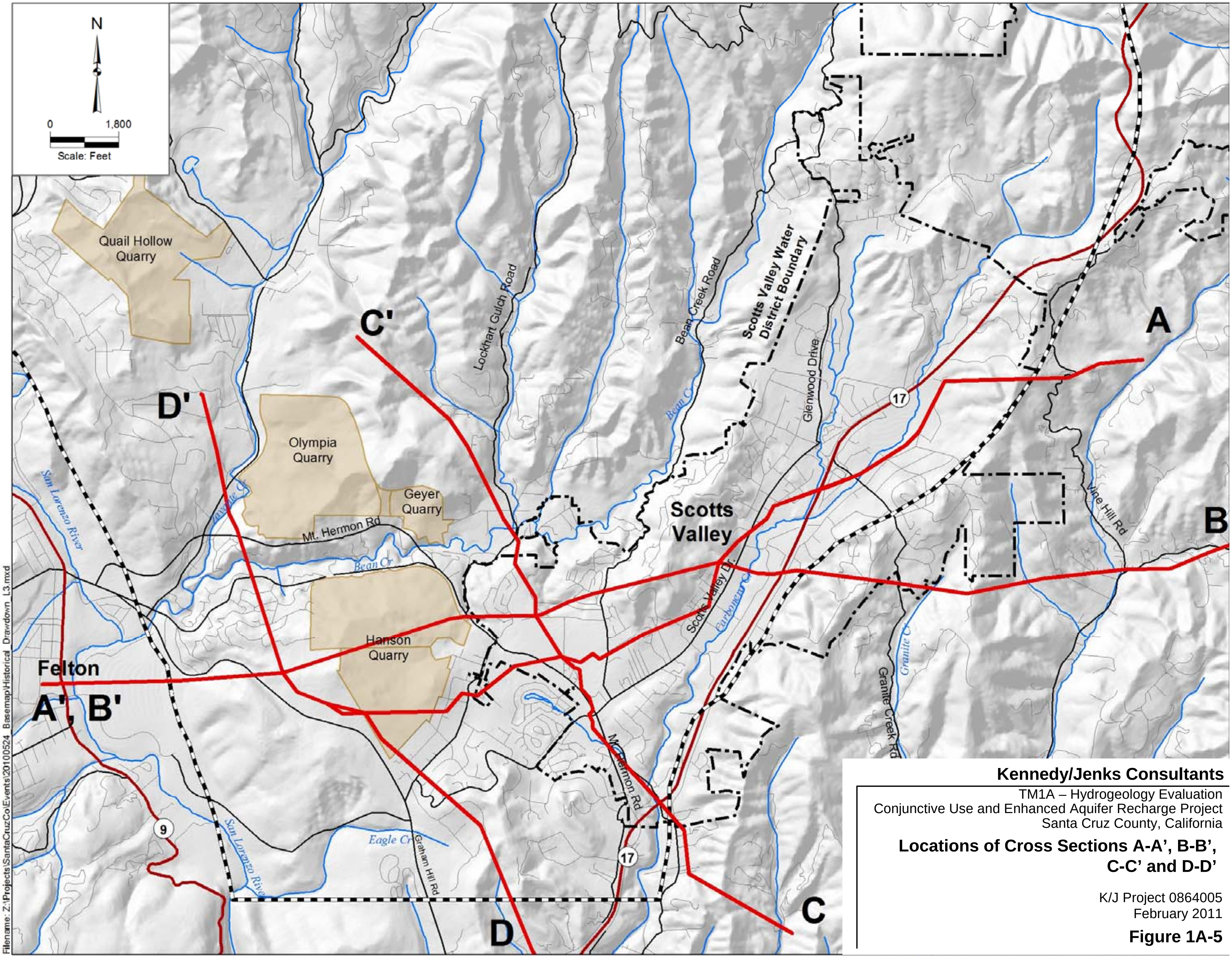
Figure 1A-4



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Locations of Cross Sections A-A', B-B', C-C' and D-D'

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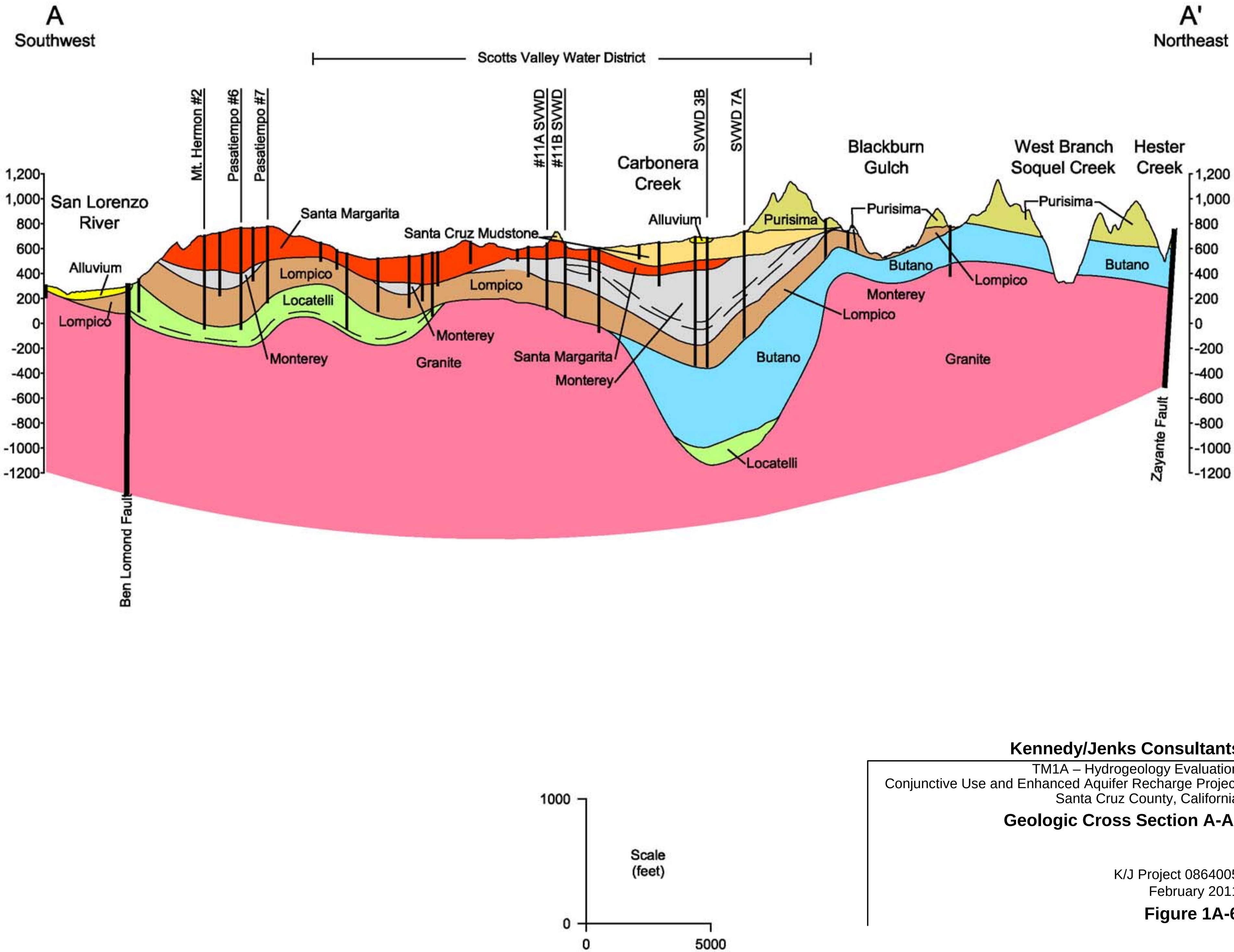
February 2011

Figure 1A-5



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Geologic Cross Section A-A'

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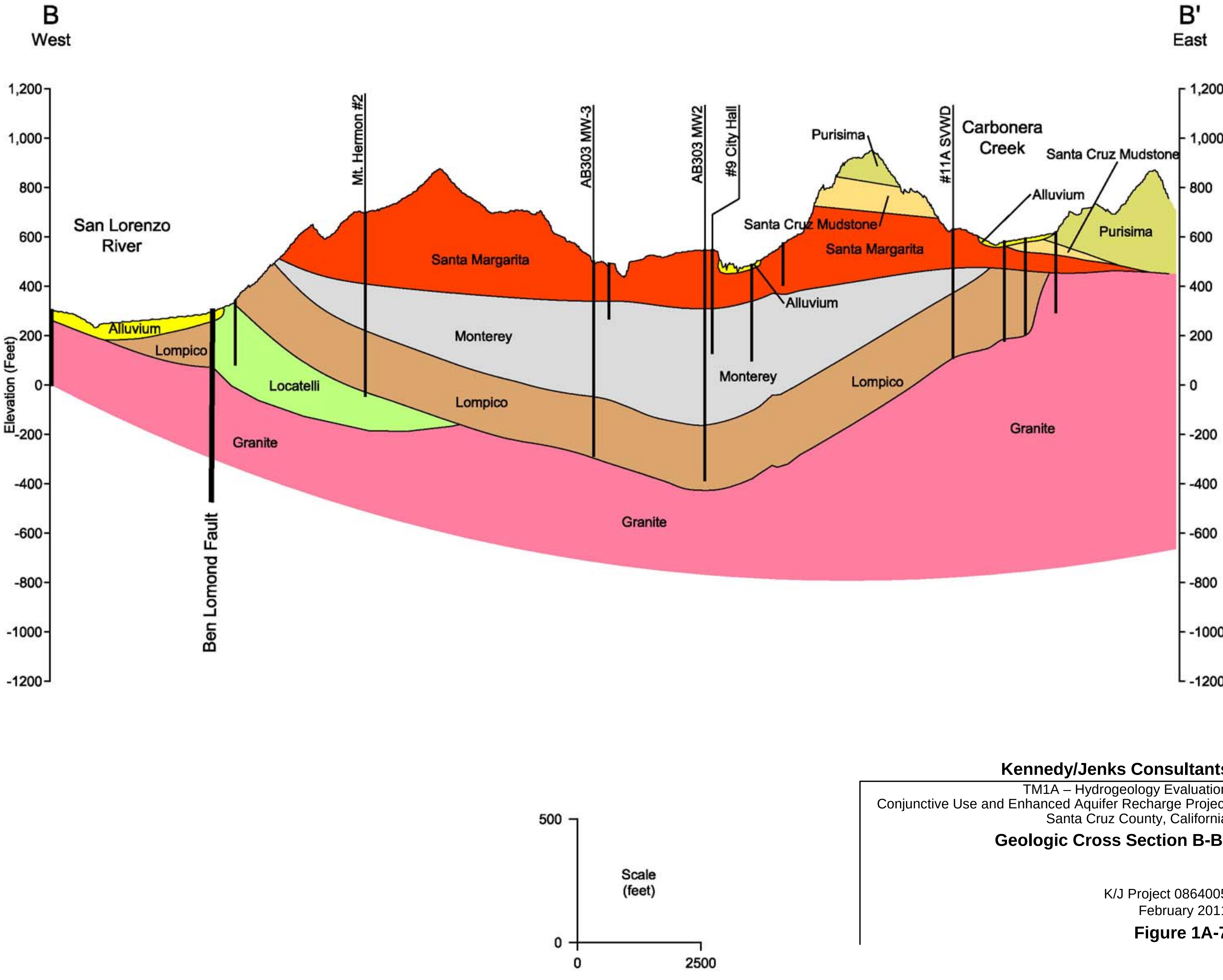
Figure 1A-6



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Geologic Cross Section B-B'

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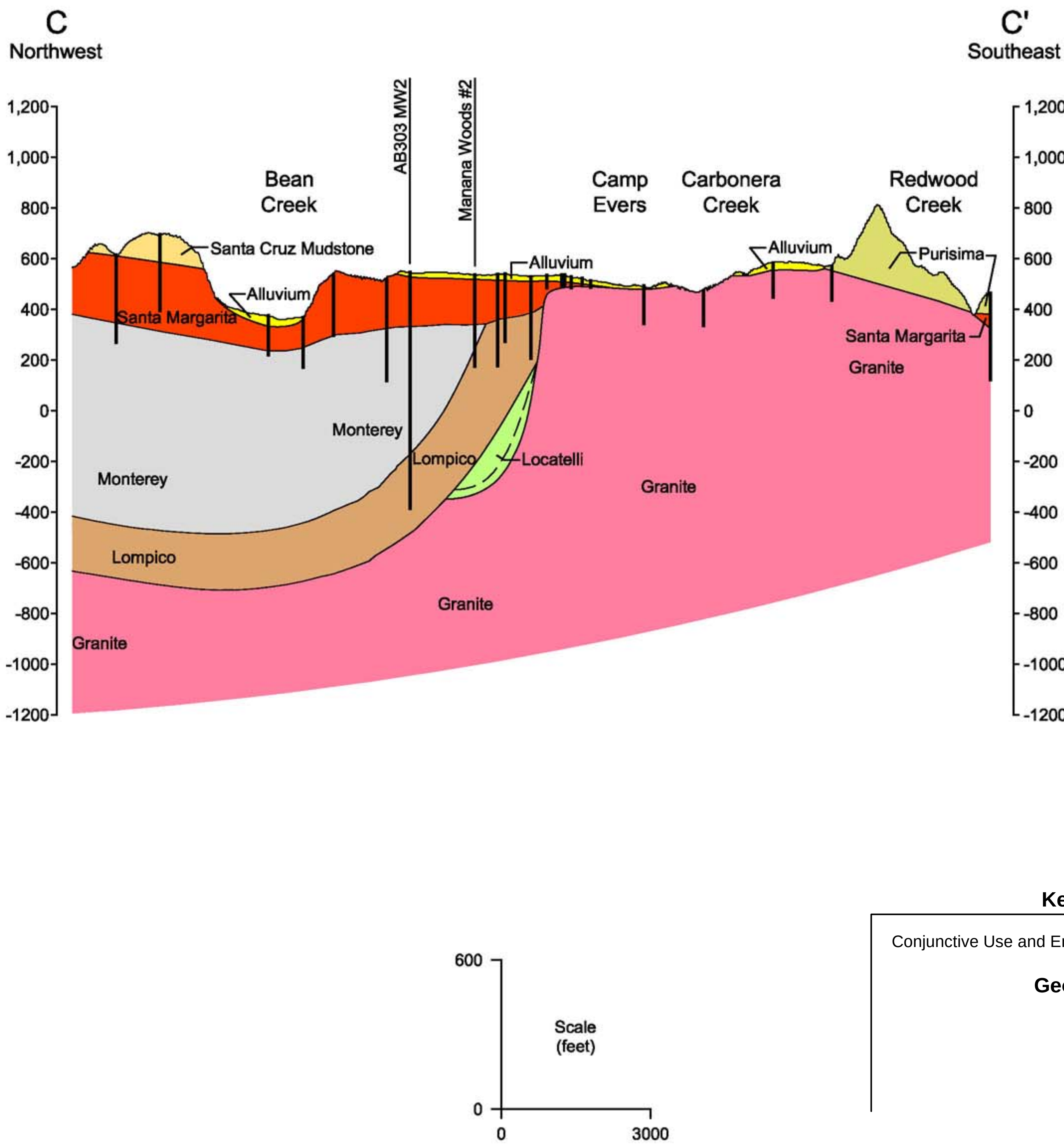
Figure 1A-7



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Geologic Cross Section C-C'

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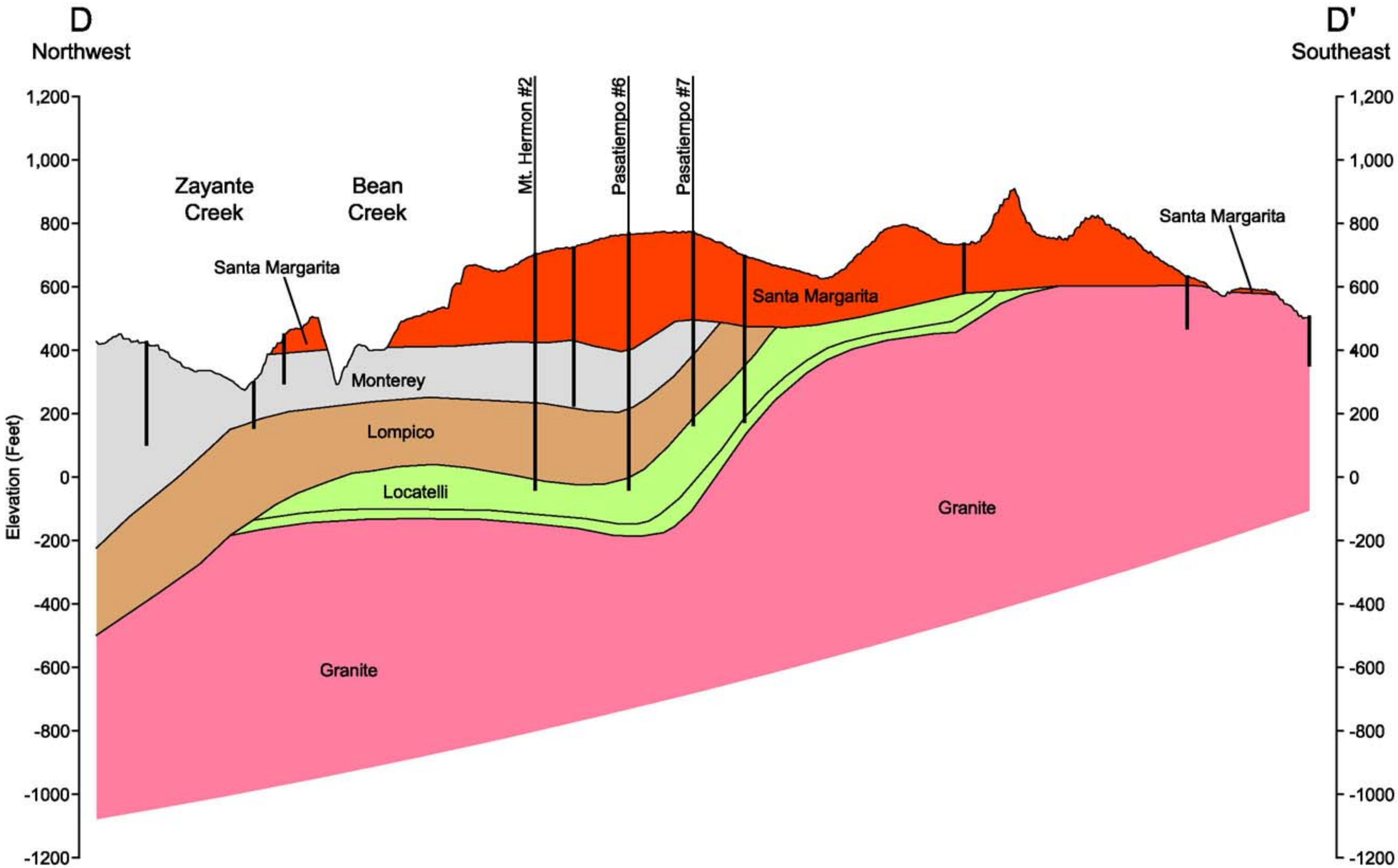
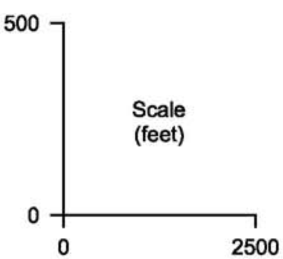
Figure 1A-8





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Geologic Cross Section D-D’

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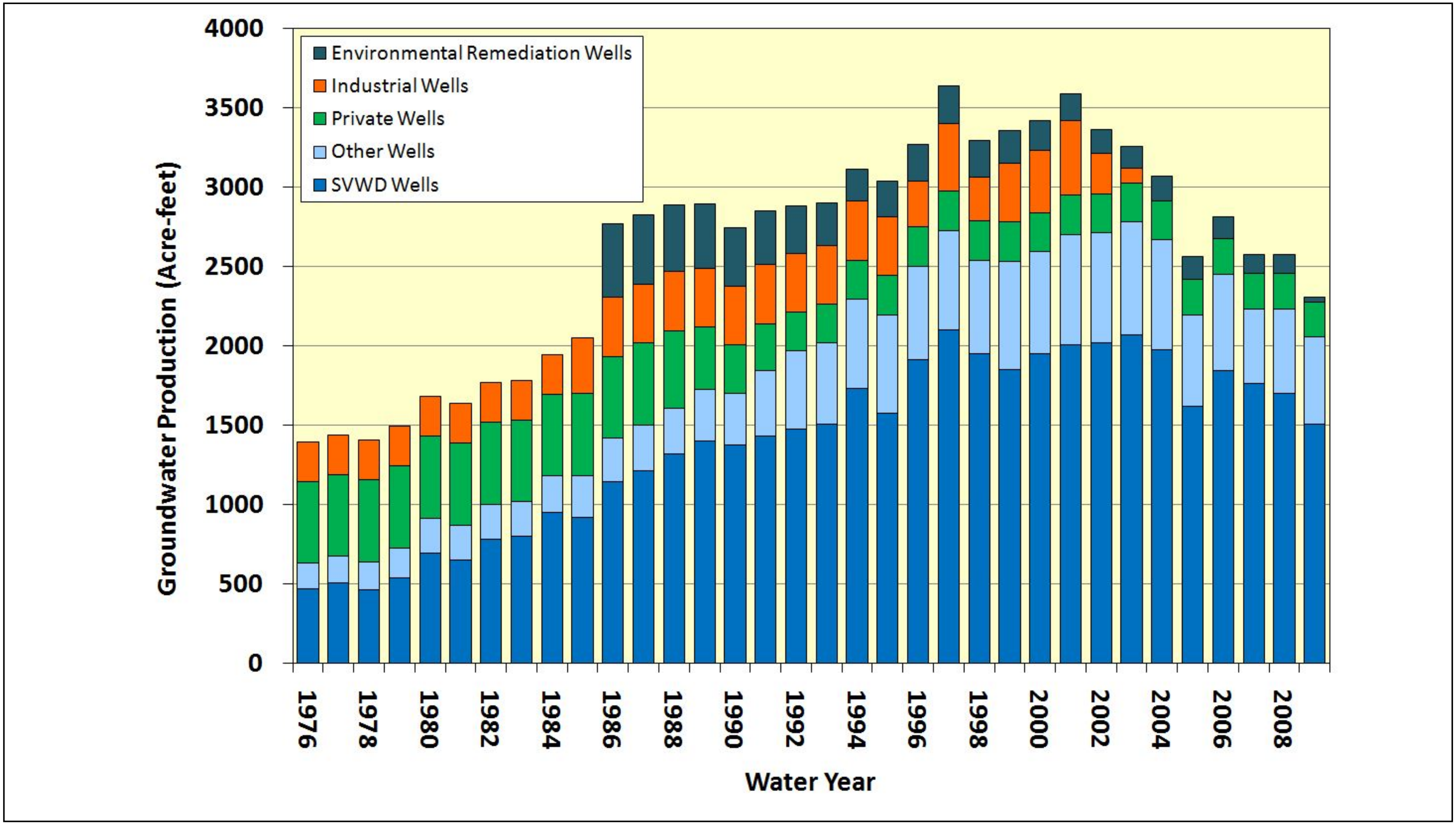
Figure 1A-9



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Historical Annual Groundwater Production from the Scotts Valley Area by User Type

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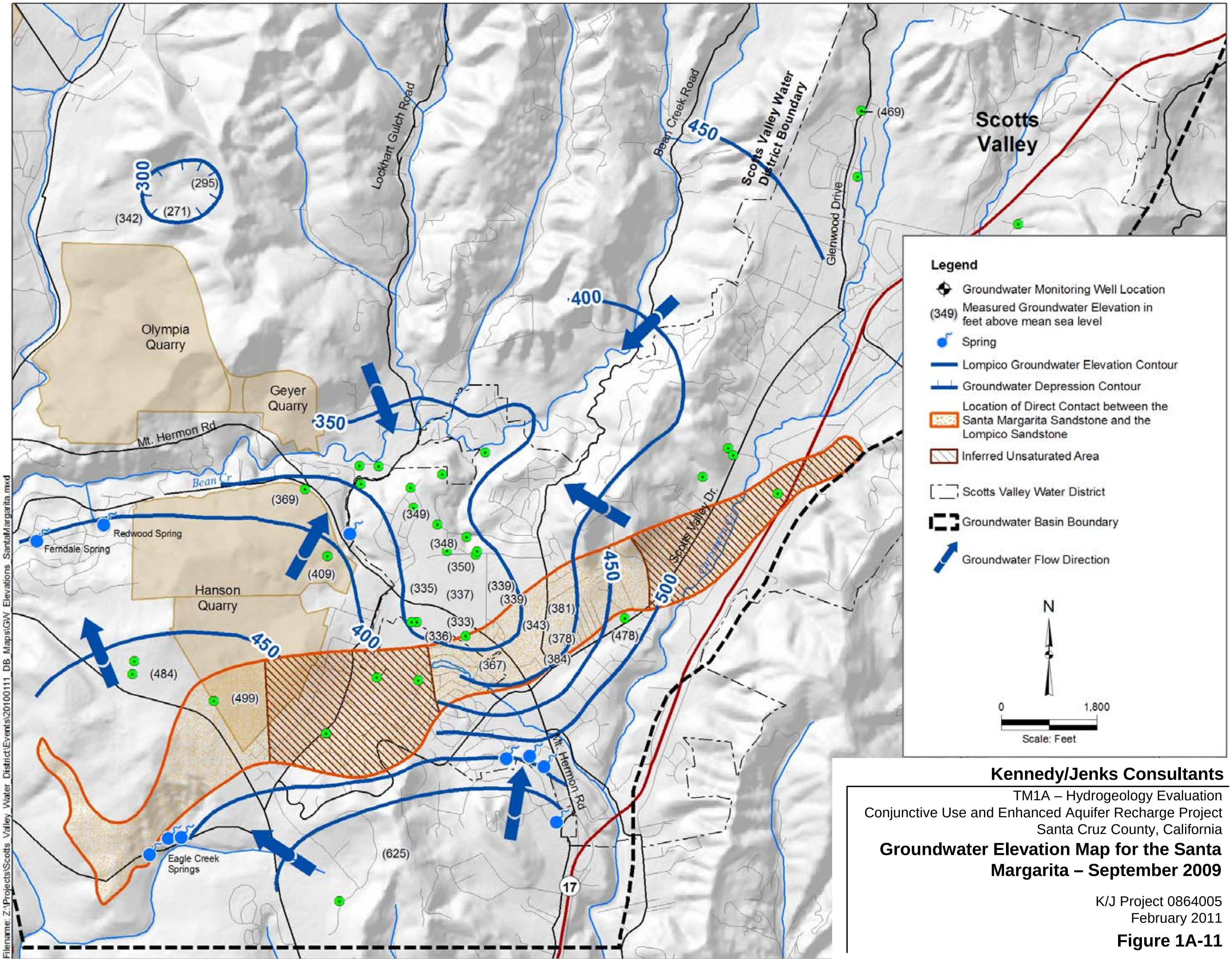
Figure 1A-10



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Groundwater Elevation Map for the Santa Margarita – September 2009

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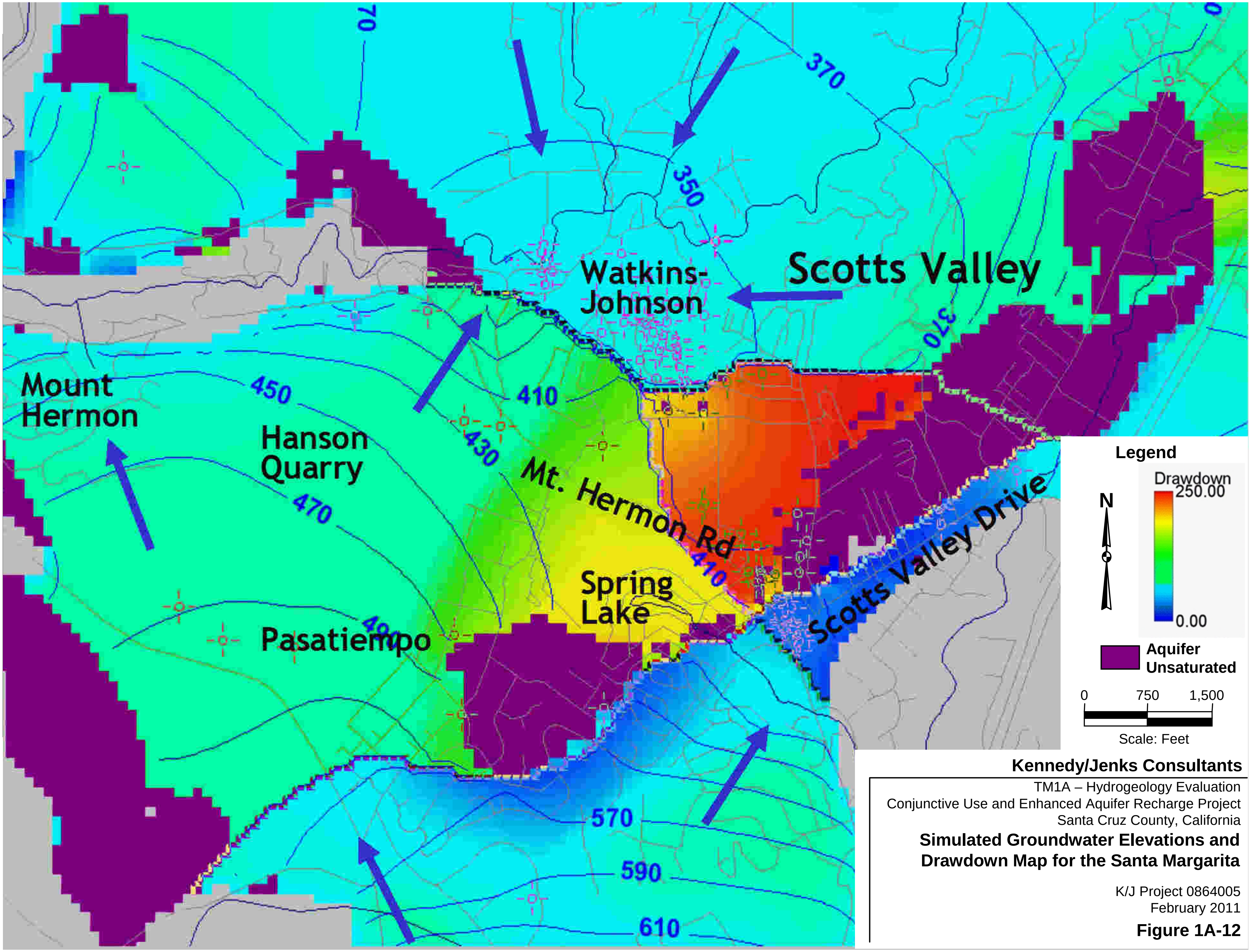
Figure 1A-11

Filename: Z:\Projects\Scotts_Valley_Water_District\Events\20100111_DB_Maps\GW_Elevations_SantaMargarita.mxd



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Simulated Groundwater Elevations and Drawdown Map for the Santa Margarita

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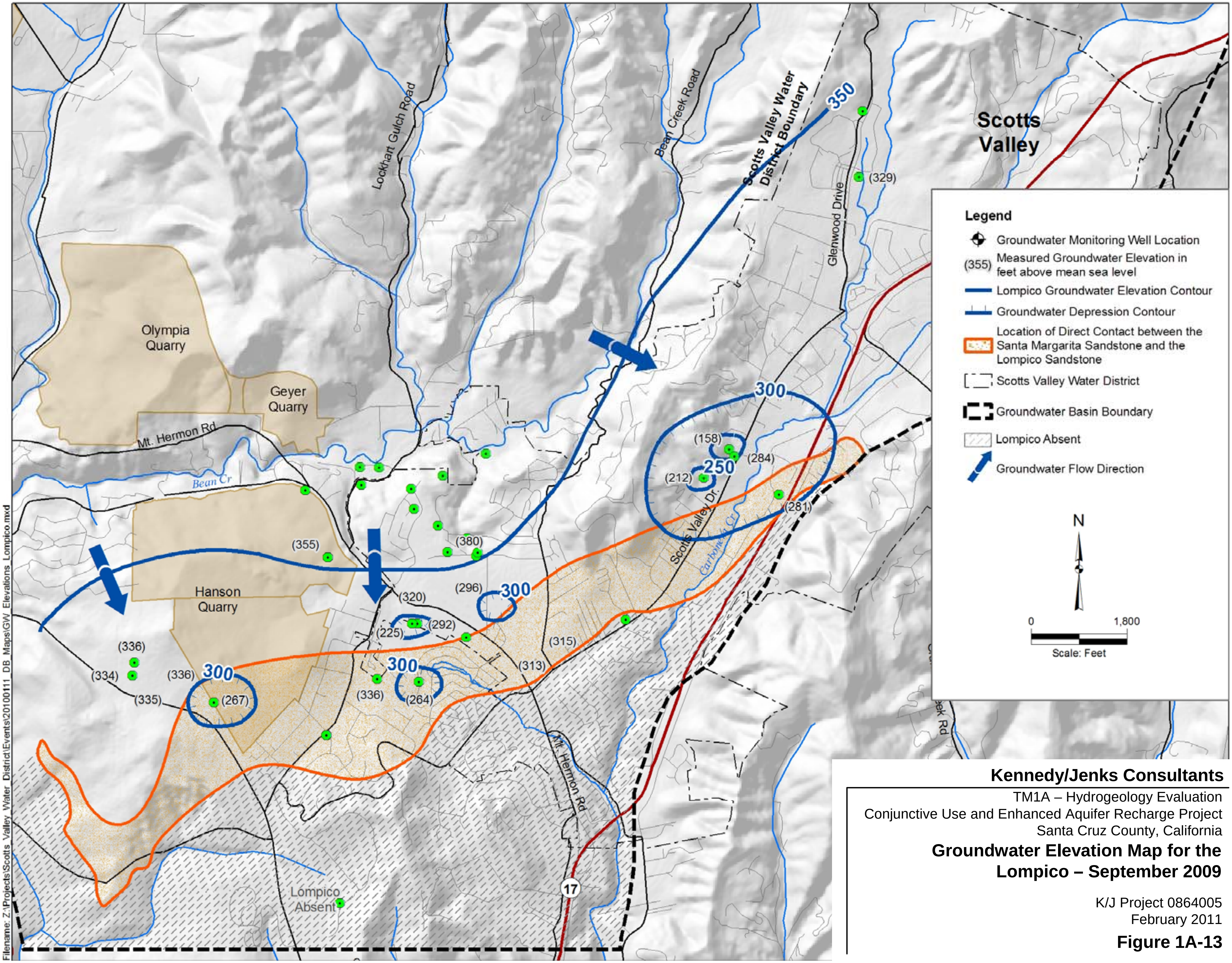
February 2011

Figure 1A-12



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Groundwater Elevation Map for the Lompico – September 2009

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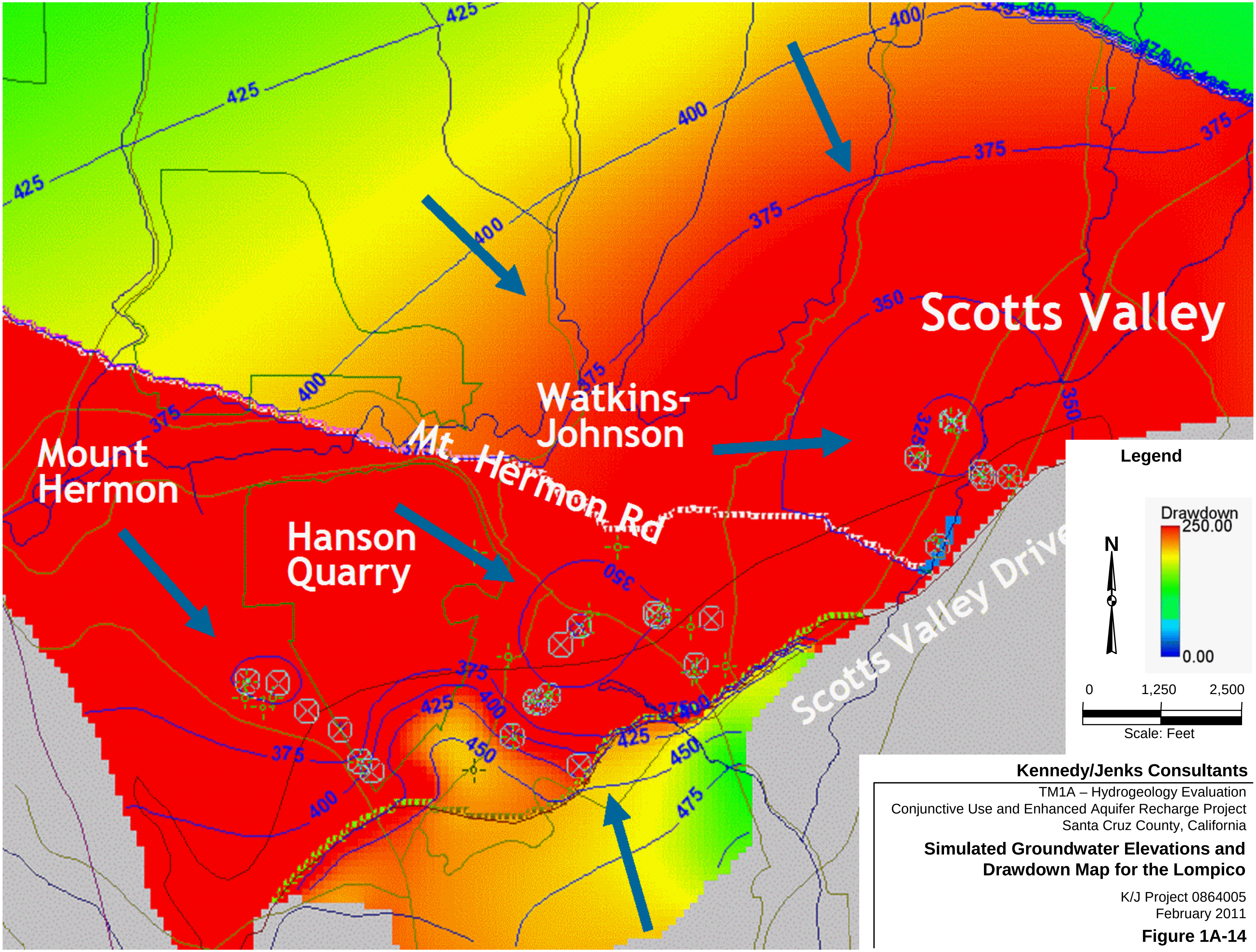
February 2011

Figure 1A-13

Filename: Z:\Projects\Scotts_Valley_Water_District\Events\20100111_DB_Maps\GW_Elevations_Lompico.mxd



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Simulated Groundwater Elevations and Drawdown Map for the Lompico

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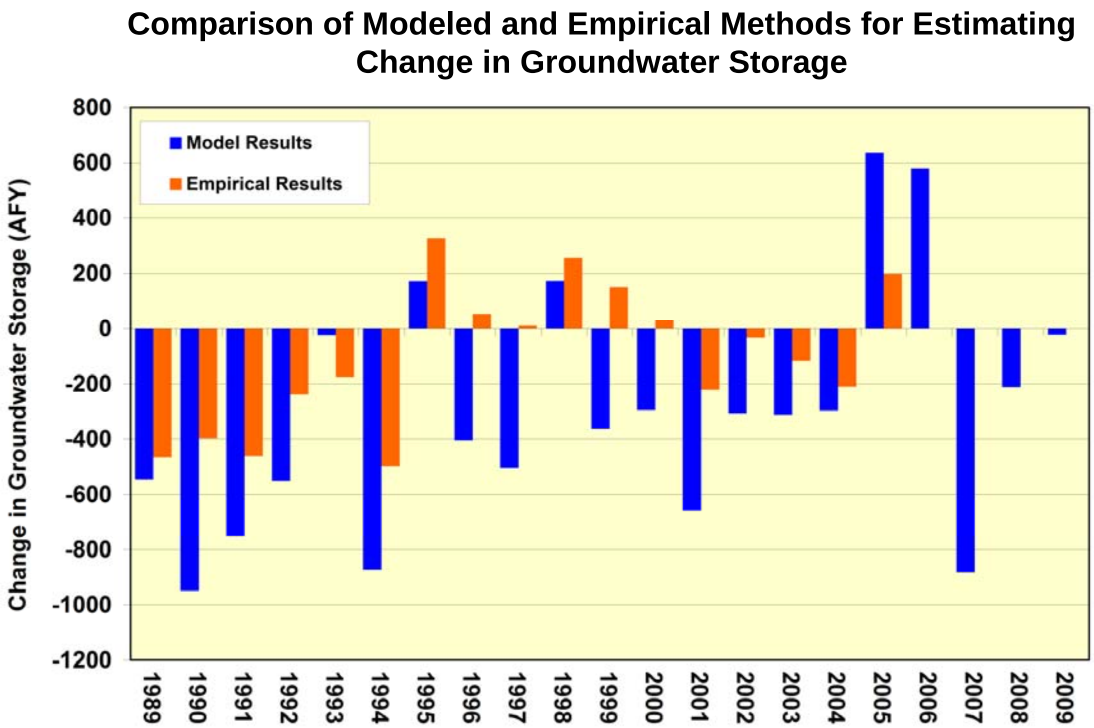
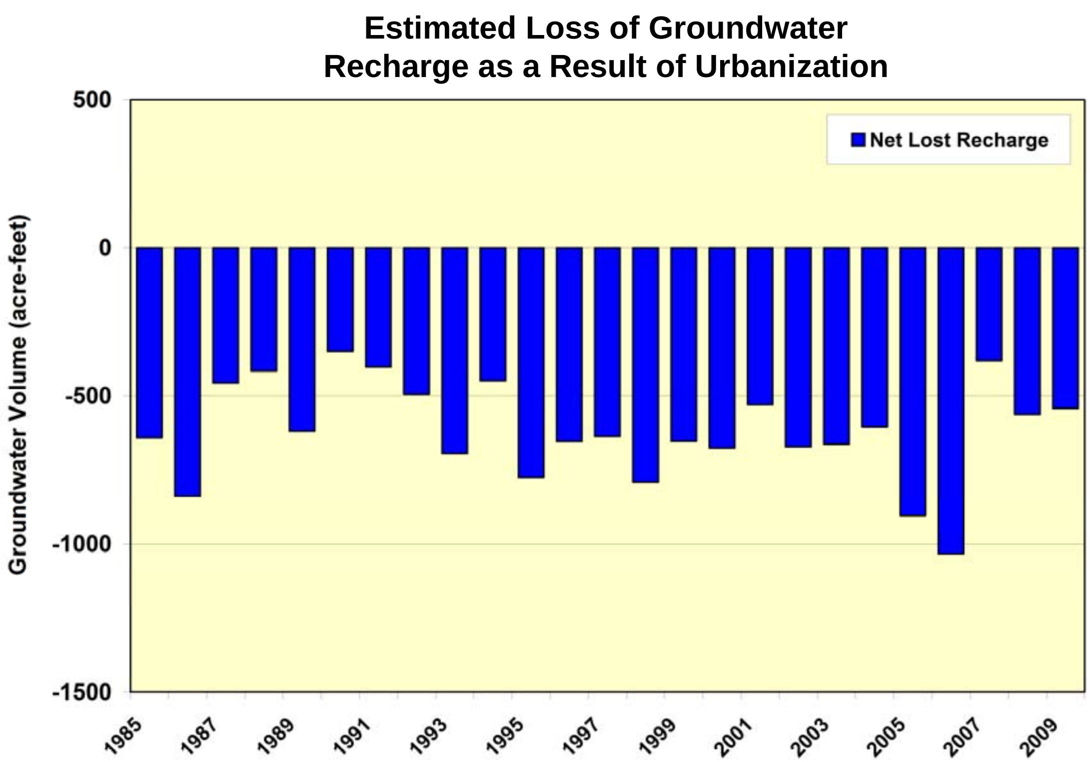
February 2011

Figure 1A-14





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Graphs for Change in Groundwater Storage over Time and Loss of Groundwater Storage due to Urbanization

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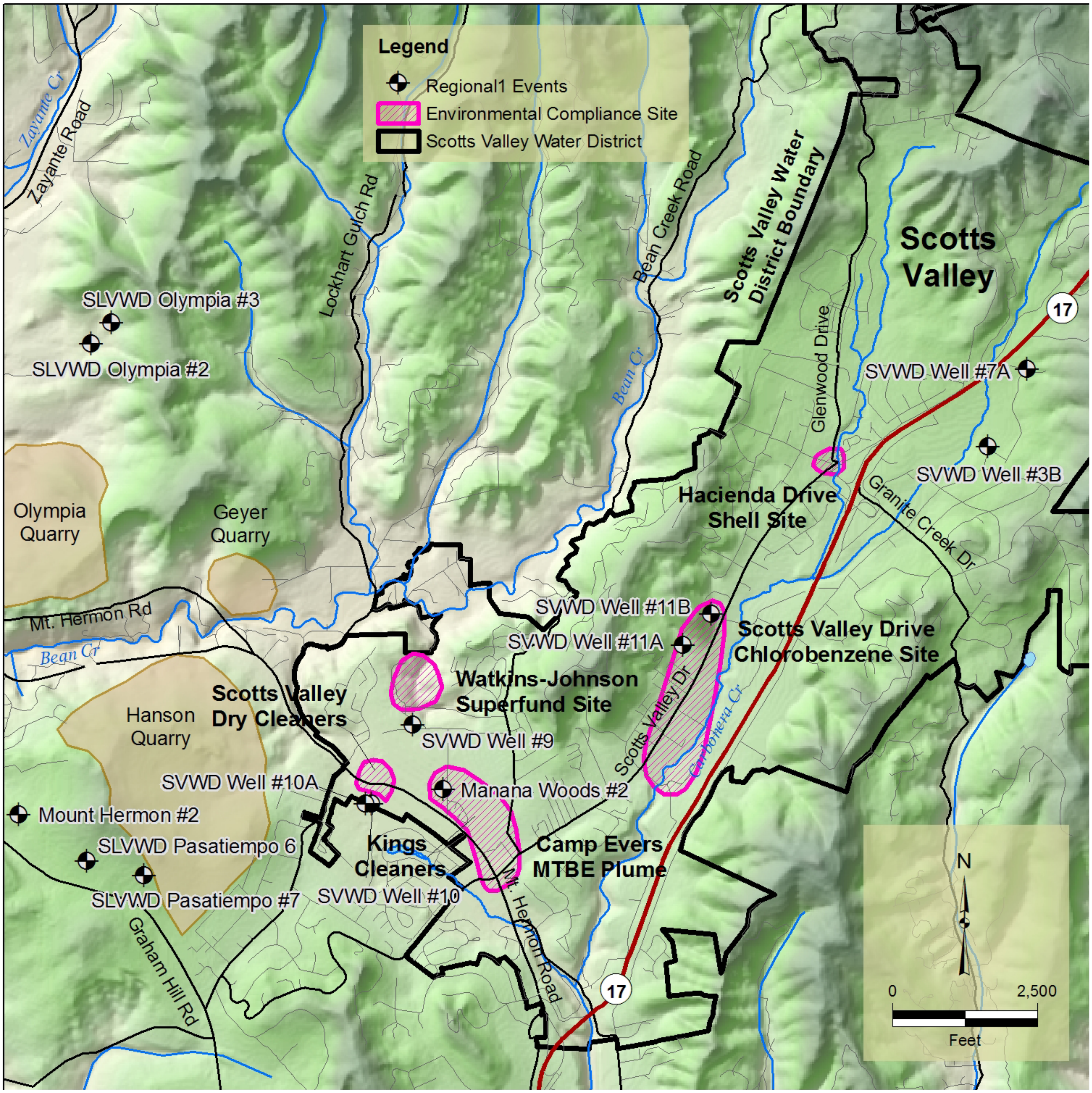
Figure 1A-15



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Locations of Known Environmental Regulatory Sites in Scotts Valley Area

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February 2011

Figure 1A-16