Prepared for

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REVIEW OF WELL TESTING AND SUSTAINABLE YIELD ASSESSMENT

PROPOSED LAETITIA AGRICULTURAL CLUSTER SUBDIVISION
SAN LUIS OBISPO, CALIFORNIA

Prepared by

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engineers | scientists | innovators

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Project Number WR1387

October 2011

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Proposed Laetitia Agricultural Cluster Subdivision

San Luis Obispo, California

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Geosyntec consultants

EXECUTIVE SUMMARY

Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

At the request of San Luis Obispo County (the "County") Geosyntec Consultants (Geosyntec) has conducted a third-party review of well testing and an assessment of sustainable yield by Cleath Harris Geologists (CHG) for the proposed Laetitia Agricultural Cluster Subdivision Project in San Luis Obispo County. As described in the Draft Environmental Impact Report (DEIR) (SWCA Morro Group, 2008), the Laetitia Agricultural Cluster Subdivision Project is a proposed development of 102 one-acre residential lots and four buildable open space lots totaling approximately 1,787 acres. Based on analysis by Cleath and Associates[1] (C&A, 2005), the estimated total water demand of the project reported in the DEIR was 143 acre-feet per year (AF/Y), which is equivalent to 89 gallons per minute (gpm). However, with revisions and water conservation measures the estimated project demand was reduced to 46.3 AF/Y (CHG, 2010), which is equivalent to approximately 29 gpm.

Groundwater pumped from four new wells completed in fractured bedrock (Wells 10, 11, 14, and 15) is proposed as the sole water supply for the proposed Agricultural Cluster Subdivision (Figure ES-1). Wells 10 and 11 are screened in the fractured resistant volcanic tuff of the Obispo Formation and Wells 14 and 15 are screened in the siliceous shale of the Monterey Formation. The original project description in the DEIR included use of Wells 12 and 13, but these wells were replaced by Wells 14 and 15 due to concern about potential influence of pumping from Wells 12 and 13 on perennial pools along Los Berros Creek (DEIR, SWCA Morro Group, 2008; Fugro, June 2009; C&A, November 2008; CHG, July 2010). Long-term testing of Wells 10, 11, 14, and 15 was recommended by Fugro (April 2009) and required by the County to provide data to further evaluate feasibility of the long-term groundwater yield from the four wells to meet the water supply demand of the proposed project.

Three phases of cyclic pumping were conducted at the Project Site between 16 October 2009 and 31 December 2010. The third phase of pumping was conducted from late September 2010 through December 2010 at the estimated sustainable yield rate of

[1] Subsequent references to Cleath and Associates are abbreviated C&A. In 2009, the name Cleath and Associates was changed to Cleath Harris Geologists, which is abbreviated as CHG.

87 AF/Y (54 gpm), which was based on the first two phases of testing (CHG, July 2010). The Phase 3 testing established that water levels continued to drop at three of the four wells with pumping at the estimated sustainable yield rates. Thus, equilibrium groundwater conditions were not attained with the Phase 3 production rates and depletion of groundwater storage continued.

Scaling down the production rates to account for time for water levels to return to levels at the beginning of the Phase 3 testing, which is the approach used by CHG (July 2010) for the Phase 1 and 2 data, reduces the estimates of viable long-term production rates for Wells 10, 14, and 15 by 35%, 52%, and 45%, respectively. Scaling of the production rate was not applied to the Phase 3 testing data recorded at Well 11 because prominent recharge influence on water levels at this well occurred that was independent of pumping.

Although the production capacity of Well 11 was substantially higher than the other wells, water level data in this well show rapid recharge likely due to good hydraulic connection between the aquifer and base flow in Los Berros Creek. Since pumping of Well 11 likely reduces base flow in Los Berros Creek, the recommended water production schedule includes curtailment of pumping from Well 11 from August through November each year to help preserve base flow in Los Berros Creek during the dry season, but a slight increase in Well 11 pumping from December through July.

Well 15 is the deepest of the four wells and has the largest available drawdown between the water level attained during Phase 3 pumping and the top of the well screen—approximately 80 feet. Consequently, a production rate from Well 15 that results in continuing gradual drawdown is more sustainable at Well 15 than at the other wells. Accordingly, the recommended long-term production rate for Well 15 includes a 25% increase to the revised calculated sustainable pumping rate that is based on the Phase 3 production and recovery data.

The table below lists the estimates by CHG (July 2010) of sustainable yields from each of the wells and the revised estimates that incorporate analysis of the Phase 3 testing data, adjustment of pumping schedule at Well 11 to lessen impact to the Los Berros Creek riparian corridor, and a 25% increase all year from Well 15 (relative to the revised rate scaled to the Phase 3 recovery). The resulting total production rate is approximately 62 AF/Y or 39 gpm. This is a 28% decrease compared to the sustainable rate estimated by CHG (July 2010) on which the Phase 3 testing pumping rates were based, but 135% of the allocated project demand of 46.3 AF/Y (29 gpm).

The revised estimate of a viable long-term production rate of 62.4 AF/Y, or 39 gpm, is less than the maximum daily demand (MDD) of 46 gpm. However, based on the testing data, the capacity of the four wells is more than adequate to sustain a continuous flow of 46 gpm for a month. Moreover, water in storage tanks can be used to supplement groundwater pumping during periods of short-term high demand.

	Well 10	Well 11	Well 14	Well 15	Total	% of project demand*
	CHG Estimated Sustainable Yield based on Phase 1 & 2 Testing (Table 7 July 2010 & Table 1 Mar 2011)					
AF/Y	10	38	19	20	**87.0**	**188%**
annualized gpm	6.2	23.6	11.8	12.4	53.9	
	Revised Estimated Sustainable Yield & Recommended Pumping based on Phase 3 Testing & Adjustment to Protect Creek Baseflow					
AF/Y	6.5	28.1	9.1	18.8	**62.4**	**135%**
annualized gpm	4.0	*26.1***	5.6	11.7	38.7	
% decrease relative to CHG estimate	35%	26%	52%	6%	28%	

Notes and abbreviaions
***Allocated project demand: 46.3 AF/Y (28.7 gpm)**
** annualized gpm for Well 11 is actually the avg rate for 8 months (no pumping Aug-Nov),
but Q for Wells 10, 14, and 15 is avg rate for 12 months
gpm = gallons per minute
AF = acre feet AF/Y = acre feet per year
Q = pumping rate

Estimates of transmissivity of the fractured rock aquifers based on analysis of data recorded during the three phases of pumping tests are substantially lower than previous estimates based on shorter term pumping tests (C&A, October 2005; Fugro, June 2009). This indicates that the long-term capacities of the fractured bedrock aquifers to transmit groundwater are lower than previously estimated and sustainable production potential of the Project Site wells based on the short-term tests were unrealistically high. Initial yields from wells in fractured bedrock aquifers often are not representative of longer-term yields, which are typically lower.

The estimates of viable long-term groundwater production rates reported herein are based on evaluation of water levels recorded in four wells for the period from October 2009 to March 2011, which included several months of pumping. We caution that rainfall during the testing program was 138% of average, and that long-term yields from water wells producing from bedrock aquifers, which may have linear fracture systems, commonly are substantially less than short-term yields. Nonetheless, long-term groundwater production rates of 21 AF/Y reported by CHG (July 2010) for each of two irrigation wells at the Project Site supports that 62 AF/Y is a viable long-term groundwater production rate from the four project wells combined.

The primary purpose of the well testing program was to evaluate sustainable yield of the proposed project wells. Sustainable yield does not have a "correct" value, but is a subjective concept, and its evaluation is an interdisciplinary issue that depends on time-frame on interest. As also discussed by CHG (July 2010), the concept of sustainable yield has been broadly defined as the amount of water that can be pumped indefinitely without unacceptable environmental, economic, or social consequences (e.g. Alley et al., 1999). The World Commission on Environment and Development (1987) stated that sustainable development must meet the needs of the present without compromising the ability of future generations also to meet their needs. Typically, however, sustainable yield must also allow for sufficient natural discharge of groundwater to preserve streams, springs, wetlands, and riparian corridor ecosystems (e.g. Sophocleous, 1997; 2000). Accordingly, curtailment of pumping from Well 11 from July through November is recommended for a more sustainable water supply with reduced impact on the riparian corridor ecosystem of Los Berros Creek.

1. INTRODUCTION AND BACKGROUND

At the request of San Luis Obispo County (the County) Geosyntec Consultants (Geosyntec) has prepared this report that provides a third-party review of well testing and an assessment of sustainable yield by Cleath Harris Geologists (CHG) for the proposed Laetitia Agricultural Cluster Subdivision Project in San Luis Obispo County.

The Project Site is a proposed new development located between Highway 101 and Upper Los Berros Road, south of the City of Arroyo Grande. Figure 1 is a map showing the Project Site location and setting in context with the Santa Maria Groundwater Basin and hydrologic subareas (HSAs- watersheds) and as delineated by California Department of Water Resources (DWR, 2002). Groundwater pumped from four wells completed in fractured bedrock is proposed as the sole water supply for the project. Figure 2 is a topographic map of the Project Site that shows the water supply well locations for the proposed development.

1.1 Proposed Development and Water Demand

As described in the Draft EIR (DEIR, SWCA Morro Group, 2008), the Laetitia Agricultural Cluster Subdivision Project is a proposed development of 102 one-acre residential lots and four buildable open space lots totaling approximately 1,787 acres. The development would also include approximately 25 acres of internal residential roads, and approximately 113 acres of existing vineyard would be removed to accommodate proposed development and buffer zones. Approximately 140 acres of replacement vineyard would be replanted on-site. Development proposed within the open space lots includes a homeowner’s association facility, recreation center, and a community center (“ranch headquarters”). The original project evaluated in the DEIR included an equestrian facility, which no longer is proposed.

The estimated total water demand of the project reported in the Draft Environmental Impact Report (DEIR) for the project (SWCA Morro Group, 2008) was 143 acre-feet per year (AF/Y) based on analysis by Cleath and Associates[2] (C&A, 2005). However, with required water conservation measures such as limitations on area of turf and residential irrigation and removal of the equestrian center, C&A (November 2008)

[2] Subsequent references to Cleath and Associates are abbreviated C&A. In 2009, the name Cleath and Associates was changed to Cleath Harris Geologists, which is abbreviated as CHG.

reported that the project water demand was reduced nearly 50 percent to 73.7 AF/Y, which is equivalent to 45.7 gallons per minute (gpm). With additional limitations on landscape irrigation, the estimated project demand was further reduced to a total of 46.3 AF/Y (CHG, 2010).

1.2 Oversight and Review of Well Testing

The County requested that a third party provide review of existing information, conduct independent testing, and evaluate if the existing wells can provide a sustainable water supply to meet the needs of the proposed development project. The California Water Code outlines two methods for evaluation of well capacity in fractured bedrock[3]. Method 1 requires a report that includes well testing, evaluation of hydrogeology, historical use, and monitoring data from other local wells. Method 2 is either a 72 hour or 10 day test without the more comprehensive report[4].

At a meeting in the County's offices[5] on 7 January 2010, the applicant's consultants (CHG) explained that long-term testing of the wells began in October 2009 and they proposed a well testing program specifically designed for the project and setting, which would be consistent with Method 1 of the California Water Code Methods for Well Capacity Determination in fractured rocks. The County agreed that instead of the third party consultant (Geosyntec) conducting the testing, it was acceptable for CHG to conduct the testing with oversight and review by Geosyntec.

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[3] http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Lawbook.aspx
Section 64554 (g) (h) and (i) are the basis for the guidance. These regulations were part of the California Water Works Standards which became effective in March 2008.

[4] Method 2 specifies that if the water level recovery requirements are met, a production rate equal to 25% of the pumping rate during the 72-hour test will be granted by the Department of Public Health (DPH), or 50% of the pumping rate will be granted by DPH for a 10-day test. The tested well must demonstrate that, within a length of time not exceeding the duration of the pumping time of the pump test (72 hours or 10 days), the water level has recovered to within two feet of the static water level measured at the beginning of the well capacity test or to a minimum of ninety-five percent of the total drawdown measured during the test, whichever is more stringent.

[5] The 7 January 2010 meeting was attended by County Planning Staff, SWCA, Geosyntec, CHG, and the applicant.

At the 7 January 2010 meeting, the parties agreed that CHG would prepare a workplan for Geosyntec to review that presented the proposed testing methodology, and that CHG would provide Geosyntec monitoring data for review during the testing period. However, contractual engagement of Geosyntec as a subconsultant to SWCA for the third party review did not occur until July 2010, and Geosyntec was not provided with a workplan or testing data during the initial two phases of testing. In late July 2010, Geosyntec received the *Laetitia Well Testing and Sustainable Yield Assessment* Report (CHG, July 2010), which documented the first two phases of testing and presented an estimate of sustainable yield from the four project wells of 87 AF/Y**.**

Based on continuing decline of water levels exhibited in three of the four wells tested during the seven-month period, Geosyntec expressed concern that the average pumping rates from these three wells used during the testing is not sustainable. Accordingly, prior to further evaluation of the testing data and estimates of production capability, Geosyntec requested additional testing during the dry season. In addition, Geosyntec requested all available historical data and water level data in other wells in the vicinity to help assess seasonal variation (Geosyntec, September 2010).

A third phase of test pumping from the four project wells at a rate equivalent to the sustainable yield estimated by CHG (July 2010) started in late September 2010 and continued through December 2010. On 31 March 2011, CHG submitted an addendum presenting the Phase 3 testing data and results.

This report presents a summary of the hydrologic and geologic setting of the site, an overview of wells in the vicinity, a description of the testing program and water level data recorded during testing of the wells, an analysis of the testing data, and review of the *Laetitia Well Testing and Sustainable Yield Assessment* Report by CHG dated July 2010 and the Phase 3 Addendum by CHG dated March 2011.

2. HYDROLOGY

2.1 Precipitation

The DWR (2002) study of Water Resources of the Arroyo Grande-Nipomo Mesa Area[6] included compilation of historical records of precipitation for 36 stations in the San

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[6] http://www.dpla.water.ca.gov/sd/water_quality/arroyo_grande/arroyo_grande-nipomo_mesa.html

Luis to Santa Maria vicinity. Mean annual rainfall ranged from 12 to 35 inches with 75 percent occurring between December and March. Based on a contour map of equal mean precipitation for the period of record from 1870 to 1995 (Plate 7, DWR, 2002), the expected mean annual rainfall for the project site is approximately 17 inches.

Beginning in January 2010, rainfall was recorded at three rain gauges installed at the Site. The rain gauges were monitored following storm events, and CHG developed a single continuous rainfall record for the 2009-2010 water year from the on-site data. Based on correlation of the on-site data with a private gauge in east Arroyo Grande Valley the rainfall record was extended back to the beginning of the Phase 1 testing (CHG, July 2010).

Figure 3a shows monthly rainfall during the testing program compared to average monthly rainfall based on rainfall data from 1920 to 2010 at the Nipomo Mehlschau Station. The average Nipomo rainfall data used were increased by a factor of 1.15 to represent average rainfall in the Project Site based on correlation between the Laetitia and Nipomo rainfall data for the period from July 2009 to June 2010, which is shown by Figure 3b. This analysis indicates that the total rainfall in the Laetitia area between July 2009 and March 2011 was 138 percent of average.

2.2 Surface Water

The Project Site is within the upper portion of the Los Berros Canyon Watershed, which is delineated in Figure 4. Los Berros Creek borders the southeast margin of the Site and is a tributary of Arroyo Grande Creek, which flows into the Pacific Ocean near the community of Oceano (Figure 1). Flow in Los Berros Creek is intermittent and influenced by the distribution and depth of alluvial deposits along the creek (C&A, 2004; CHG, July 2010).

The headwaters of Los Berros Creek are located northeast of Temettate Ridge and south of Newsom Ridge. The Los Berros Creek Watershed is 28 square miles in area and has a length of approximately 14 miles. Runoff from Temettate Creek and numerous other small tributaries accumulates prior to emptying into Los Berros Creek. DWR reported annual runoff between 800 and 1100 acre feet for the entire Los Berros Creek watershed for the base period (1984 to 1995) used for a study of Water Resources of the Arroyo Grande-Nipomo Mesa Area (DWR, 2002).

A gauge was established on Los Berros Creek in August 1968 by L. Lopp in cooperation with San Luis Obispo County Flood Control. The gauge monitors runoff from the upper 54 percent of the Los Berros watershed. The United States Geologic

Survey (USGS) maintained a continuous daily record of streamflow at the gauging station from 1968 to 1978[7]. In October 1979, San Luis Obispo County Engineering Department assumed control of the gauge[8].

The gauging station is northeast of Highway 101 at the mouth of the upper canyon near the middle of the southeast margin of the Site, 0.8 miles downstream from Adobe Creek and 3.7 miles north of Nipomo on the upstream side of the bridge where Los Berros Road crosses the creek. The location of the Los Berros Creek gauging station is shown in Figure 3. The road crossing is a box culvert with a 15-foot concrete lip that has become a grade control structure. The channel downstream has been down-cut significantly and consequently the culvert can be a barrier to fish passage (Central Coast Salmon Enhancement, 2005). Downstream of the gauge most of the surface flow in Los Berros Creek seeps into the alluvial deposits of the lower valley.

For this period of the USGS records (1968-1978), the mean flow rate of Los Berros creek was in the range of 1 and 8 cubic feet per second (cfs)[9] during the months of January to May, and 0.16 to 0.68 cfs during the months of June to December. Based on the minimum flow in the USGS record, the resolution of low flow at the Los Berros Gauging station was 0.01 cfs (4.5 gpm). During the period of the USGS record (1968-1978), the only days with zero flow at the Los Berros Gauging Station were during a continuous period without any flow from early October to late December in 1977.

The County Department of Public Works provided available daily flow data for the Los Berros Creek gauging station for the period from 1978 to March 2011. However, no gauging data for Los Berros Creek are available for the period from 2002 to 2005. Some field records with the County indicate that the creek was dry during that period but no data logs have been found to confirm the creek stage or flow during this period.

As reported by C&A (2005), the Bartleson Development Plan (Morro Group, 1996) indicated that discharge of groundwater maintained base flow in Los Berros Creek

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[7] USGS 11141600 LOS BERROS C NR NIPOMO CA
http://ca.water.usgs.gov/waterdata/DiscontinuedSites2006/SurfaceWater.pdf
http://waterdata.usgs.gov/ca/nwis/inventory/?site_no=11141600

[8] San Luis Obispo County Gauge #5
http://www.slocountywater.org/weather/alert/stream/losberros.htm

[9] 1 cfs = 449 gpm

during the dry season prior to approximately 1981 when groundwater pumping was increased from the fractured tuff aquifers of the Obispo Formation. The stream gauging data (Table 1), however, also show zero flow prior to 1981 in the creek during the dry season in 1977, 1979, and 1980. Figure 5 shows the estimated mean monthly flow rate in Los Berros Creek both for the entire period of record, 1968 to 2001, and for the period from 1981 to 2001.

3. HYDROGEOLOGY AND WELLS AT THE PROJECT SITE

3.1 Hydrogeology

The Project Site is underlain by Early Miocene age rocks of the Obispo and Monterey Formations, Pliocene-Pleistocene age rocks of the Paso Robles Formation, and localized shallow unconsolidated alluvial deposits along Los Berros Creek, Adobe Creek, and other drainages. Figure 6 shows a generalized geologic map of the region and Figure 7 is a local geologic map that shows locations of wells within and near the Project Site[10]. Figure 8 is a geologic cross-section through the northern portion of the Project Site that shows the screened interval of the wells. The majority of wells in the vicinity of the Project Site are completed within fractured bedrock aquifers in the Obispo and Monterey Formations.

A study of the water resources of the Arroyo Grande - Nipomo Mesa Region by DWR (2002) reported that the Early Miocene Obispo Formation and the Miocene Monterey Formation are both important sources of water supply in the vicinity. The Obispo Formation consists of resistant mineralized tuff and fine- to coarse-grained crystalline tuff, interbedded with lava flows and fine-grained calcareous sediments. Locally the tuffs are intruded by dikes and sills. Portions of the lava flows, dikes, sills, and the majority of the ashy matrix of the coarse-grained tuff are commonly altered to clay. Groundwater within the Obispo Formation occurs primarily within fractures in the relatively unaltered resistant mineralized tuff.

The Monterey Formation, which is often called Monterey "Shale" actually consists of a range of sedimentary rock types including silicified siltstone, claystone, and sandstone, well-bedded claystone, cherty or porcelaneous shale, and dolomitic shale. Much of the

[10] Addition detail of geologic structure of the project area is shown by the geologic map provided as Figure 2 of the CHG report dated July 2010.

Monterey Formation is fractured and sheared. Groundwater within the Monterey Formation occurs mainly within fractures and parting parallel to bedding.

The Pliocene-Pleistocene Paso Robles Formation is present in the western portion of the project area (Figure 7) and includes unconsolidated to poorly consolidated gravel and clay, sand and clay, silty clay, conglomerate with clasts of Monterey Formation, and some lenses of gravel and sand.

Localized unconsolidated Holocene alluvial sedimentary deposits are present along the lower portion of Los Berros Creek and other drainages in the area. Some shallow wells are completed in the alluvial deposits along creeks.

3.2 Wells and Springs

Seven wells were constructed at the Project Site between 1983 and 1999. Historically, the water supply at the Project Site included separate domestic and irrigation systems. The domestic supply included two wells (FV Wells-2 and -4) that provided water for a winery, a shop, and two single-family residences. The irrigation system included four wells (FV Wells-1 and -3, F&T-1 and -2) and two reservoirs each with storage capacity of 25 acre-feet. Wells F&T-1 and -2 were installed in 1998 to allow vineyard expansion to the west and east (C&A, 2004)[11].

The domestic well (FV Well-2) and the four irrigation wells are all completed in the fractured tuff of the Obispo Formation. Additional wells included a shallow well (Enloe -1) completed in alluvium adjacent to Los Berros Creek and an older windmill-powered well near the maintenance shop (C&A, 2004).

Nearby off-site wells are also completed in the fractured tuff of the Obispo Formation and include the Tremper irrigation well, which is approximately 800 feet southeast of FV Well-1, and three irrigation wells (Bartleson 35Ka, 35Ra, and 35Rb), which are southwest of the Project Site along Highway 101.

Springs occur in some places where the fractured rock aquifers are exposed along slopes. Water from a spring northwest of Well F&T-1 with a reported flow rate of 2 to 5

[11] F&T and F.V Wells are abbreviations for Filipponi-Thompson Drilling, Inc., of Atascadero, California and Floyd.V. Wells, Inc. of Santa Maria, California

gpm was piped to a storage tank that supplied water to the Ranch headquarters (C&A, 2004). Three spring locations are shown in Figure 2.

Table 2 provides a summary of information for the wells including production rates for the irrigation wells and domestic wells based on reports by C&A (2004) and CHG (2010). Based on the reported flow meter records, average annual production from the irrigation wells at Project Property between 1999 and 2003 was 161 AF/Y. The domestic wells are not metered, but water supply to the winery production facility is. C&A (2004) estimated the total water production from the two domestic wells was 6.72 AF/Y in 2003. In addition, a shallow well (only six-feet deep) in the Los Berros Creek channel reportedly provides water to a residence near the southeast corner of the Project Site property (C&A, 2004).

Six new wells that range in total depth from 305 feet to 560 feet were drilled in the northeastern portion of the Project Site property between 2003 and 2006 (C&A October 2005, November 2008). Table 2 includes a summary of information for the new wells and Figures 2 and 7 show the well locations. Available boring logs and driller's well completion reports for the wells at the Project Site are provided in Appendix A.

Groundwater pumped from four of the new wells completed in fractured bedrock (Wells 10, 11, 14, and 15) is proposed as the sole water supply for the proposed Laetitia Agricultural Cluster Subdivision. Wells 10 and 11 are screened in the fractured resistant volcanic tuff of the Obispo Formation and Wells 14 and 15 are screened in the siliceous shale of the Monterey Formation. The DEIR project description included use of Wells 12 and 13, but these wells were replaced by Wells 14 and 15 due to concern about potential influence of pumping from Wells 12 and 13 on perennial pools along Los Berros Creek (DEIR, SWCA Morro Group, 2008; Fugro, June 2009; C&A, November 2008; CHG, July 2010).

Additional longer-term testing of Wells 10, 11, 14, and 15 was recommended by Fugro (April 2009) and required by the County to provide data for further evaluation of the feasibility of the long-term groundwater yield from the four wells to meet the water supply demand of the proposed Laetitia Agricultural Cluster Subdivision project.

4. TESTING AND ANALYSIS

4.1 <u>Pump Testing of the Project Wells</u>

Three phases of cyclic pumping were conducted at the Project Site between 16 October 2009 and 31 December 2010 by CHG. For each phase the pumping alternated between two pairs of wells: simultaneous pumping at Wells 10 and 11, which are completed in cemented tuffaceous rocks of the Obispo Formation, alternating with simultaneous pumping at Wells 14 and 15, which are completed in the siliceous shales of the Monterey Formation. During the first phase of pumping from 16 October 2009 to 16 January 2010, which CHG termed the dry season, the wells were pumped for 2 to 5 days and then shut off for 4 to 15 days. During the second phase of pumping from 16 January to 10 May 2010, which CHG termed the wet season, the wells were pumped for 3 to 8 days and then shut off for 2 to 9 days.

Following the completion of the first two phases of testing CHG prepared and submitted a report on 23 July 2010. After review of the report Geosyntec prepared a letter dated 10 September 2010 requesting that an additional phase of pumping be conducted during the late summer and early autumn months when the well production capacity typically is lowest because the base flow in the creeks and groundwater elevations generally drop. The third phase of pumping was conducted from 27 September to 31 December 2010. The wells were pumped for 2 to 3 days and then shut off for 4 to 5 days. The Phase 3 pumping was conducted at the sustainable yield rates that were estimated by CHG (July 2010), which was 87 acre feet per year (AF/Y).

During the three phases of pumping, the total volume of groundwater production from the four wells over the fifteen months was 93 acre feet (AF), equivalent to 74.4 AF/Y, which is substantially more than the allocated project demand of 46.3 AF/Y. Table 3 summarizes the three phases of pump testing.

Each well was equipped with a submersible pump and a flow meter. Discharge piping installed in September and October 2009 conveyed the well water to an existing vineyard pipeline near Well 9 and on to a reservoir. From the reservoir, water can be pumped to vineyard blocks or a second reservoir. Figure 3 shows the pipeline routing.

Transducers and data loggers within one-inch PVC sounding tubes in the wells recorded water levels once per hour. Recording of water levels began in Wells 10 and 11 on 29 September 2009; in Wells 12 and 13 on 8 October; and in Wells 14 and 15 on 2 October. The date, time, and meter reading were recorded whenever one of the four wells was turned on or off. Water levels were also recorded with transducers and data loggers in Wells 5, 8, 9, 12 and 13.

4.2 Discussion and Analysis of Hydrographs for Wells 10, 11, 14 & 15

The water level data recorded in the four pumped wells (Wells 10, 11, 14, and 15) were used to prepare time-series charts of groundwater elevation, which are called hydrographs. Figures 9 and 10 present the hydrographs at scales that facilitate including elevations of the ground surface and top and bottom of the screened intervals (also called perforated intervals) in addition to the groundwater elevation for each well.

Figures 11 and 12 present the hydrographs at a more detailed scale. These hydrographs illustrate that water levels in Wells 10, 14, and 15 never stabilized, but exhibited continuing drawdown throughout the course of the three phases of pumping. The detailed hydrographs also illustrate that recovery of water levels was incomplete at Wells 14 and 15 between the pumping phases.

In Well 10, recovery of water level was incomplete after Phase 1 and Phase 2 testing, but a rapid rise in water level occurred after the Phase 3 pumping, which is attributed to period of abundant rainfall (Figure 11). The recovery of water level in Well 10 after Phase 2 pumping is considered more typical.

Full recovery of water levels occurred only at Well 11, which is within a few hundred feet of Los Berros Creek. The hydrograph for Well 11 shows a strong correlation between rainfall and groundwater levels in the vicinity of Well 11. As reported by CHG (July 2010), these data indicate that groundwater levels in the vicinity of Well 11 are influenced by base flow of Los Berros Creek[12]. Conversely, pumping from Well 11 likely influences base flow of Los Berros Creek.

Wells 10, 14, and 15 are much further from Los Berros Creek (thousands of feet away). Also, these wells are more isolated stratigraphically from the creek compared to Well 11 (see Figures 7 and 8). Based on the fact that water levels in three of the four wells (Wells 10, 14, and 15) were still generally dropping during the Phase 3 pumping, the groundwater in the aquifers near these wells did not reach equilibrium levels, and continued pumping at the Phase 3 rates will continue to deplete aquifer storage.

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[12] The water level at Well 11 was actually higher in mid May 2010 after the Phase 2 pumping was terminated compared to mid October 2009 before the Phase 1 pumping began. Beginning in June 2010, a couple of weeks following the termination of the Phase 2 pumping, the water level in Well 11 began dropping.

Figures 13, 14, and 15 provide zoomed-in hydrographs for Wells 10, 14, and 15 during the Phase 3 pumping. On the lower graph in each of these figures, the X-axis is elapsed time since the beginning of Phase 3 pumping at a logarithmic scale. The combined average pumping rates for the four wells during Phase 3 was equivalent to approximately 87 AF/Y (54.7 gpm), which by design is about the same as the sustainable yield from four wells estimated by CHG (July 2010) based on interpretation of the results of the Phase 1 and 2 testing.

Projections of trend lines fitted to the water level data provide estimates of future decreases in water levels and continued depletion of aquifer storage if the Phase 3 pumping rates were continued and equilibrium conditions are not attained in the aquifers. The graphs of water levels shown by Figures 13, 14, and 15 include computer-fitted trend lines projected hundreds of days into the future. The graphs include both a linear trend line (solid line) and a logarithmic trend line (dashed line) fitted to the data. Generally the linear trend lines provide a slightly better fit to the data. Each figure also includes two versions of the graphs: the upper graph uses a linear scale for the X axis (elapsed time), and lower graph uses logarithmic scale to facilitate illustration of recorded data and projection of trends more than 10 years into the future.

Both the linear and logarithmic trends lines provide reasonable fits to the water level data from the Phase 3 pumping, but the two trends are very different in the long-term. If the linear trends continue, in a few years water levels would be significantly below the top of the well screens and production rates from the wells would likely drop off considerably. However, with a logarithmic trend line, the rate of drop in water level decreases with time, and the projected water level remains above the well screen for decades. Moreover, as discussed further below, the water levels may stabilize if the groundwater flow regime attains a new equilibrium condition, but this could take decades or even centuries (e.g. Bredehoeft and Durbin, 2009; Walton 2011).

4.3 <u>Discussion of Hydrographs for Other Wells at the Project Site</u>

Hydrographs are also provided for Wells 5, 8, 9, 12 and 13 (Figures 16 and 17), which were not part of the pumping test program, but were instrumented with transducers and data loggers. Daily rainfall and the test pumping schedule are included on the hydrographs (Figures 16 and 17) to facilitate evaluation of potential influence of both rainfall recharge and the project test pumping on water levels in these wells.

The hydrograph for Well 8 (Figure 16), which is completed in shallow alluvium along Los Berros Creek, shows a rapid 30-foot increase in water level in response to abundant rainfall in December 2010 and January 2011.

Although there are discontinuous water level records and there is uncertainty about pumping limit interpretation, the hydrographs for Wells 5 and 9 (Figure 16), which are completed in the Obispo Tuff, also show increases in water level following periods of abundant rainfall. Water level rise is particularly evident in Well 9 in response to the heavy rainfall in December 2010 and January 2011.

Hydrographs for Wells 12 and 13 (Figure 17), which are deeper and completed within the Monterey, show only a few feet of fluctuation in water level over the entire period of the testing program. Although these wells show an increase in water level in the range of 2 to 4 feet that is clearly related to the heavy rainfall in December 2010 and January 2011, the time frame for replenishment of groundwater flowing within the deeper Monterey Formation aquifers is expected to be much longer, likely years, decades, or more.[13]

As also discussed by CHG (July 2010), water levels recorded in Wells 5, 9, 12, and 13 during the testing program show no significant response to the three phases of pumping from Wells 10, 11, 14, and 15. No water level monitoring data are available from off-site wells such as the Tremper and Fitzgerald Wells to evaluate potential interference between the project wells and off-site wells during the production testing conducted at Wells 10, 11, 14, and 15. Based on available data, pumping from the project wells is not expected to provide significant drawdown interference with other wells due to the additive overlap of the pumping cone of depression. However, production rates from other wells in the area could decrease if pumping from project wells is conducted in excess of sustainable yields of the aquifers, which would result in general lowering of the water levels due to depletion of groundwater storage.

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[13] Analyses of groundwater samples for stable isotopes of oxygen ($^{16}O/^{18}O$) and deuterium/hydrogen ($^{2}H/^{1}H$) would provide insight into the origin and age of groundwater. Isotopes are atoms of the same element that have differing numbers of neutrons. Stable isotopes are those that do not undergo nuclear decay. For example, both hydrogen and oxygen have two stable isotopes (^{1}H and ^{2}H, and ^{16}O and ^{18}O, respectively). Natural hydrologic processes including precipitation segregate these isotopes of hydrogen and oxygen, which makes them ideal tracers of water.

Figure 18 graphically depicts additional water level data available for four other irrigation wells at the project site (Wells F&T-1, F&T-2, FVW-1, and FVW-3, from Table 4 of C&A, January 2004). Although there are only a few data points for each well over periods of several years, the data show a general decline in groundwater elevation at these wells over 30 years.

4.4 Estimates of Sustainable Pumping Rates

4.4.1 Sustainable Yield

The primary purpose of the well testing program was to evaluate sustainable yield of the proposed project wells. Sustainable yield does not have a "correct" value, but is a subjective concept, and its evaluation is an interdisciplinary issue. As also discussed by CHG (July 2010), the concept of sustainable yield has been broadly defined as the amount of water that can be pumped indefinitely without unacceptable environmental, economic, or social consequences (e.g. Alley et al., 1999). According to the World Commission on Environment and Development (1987), sustainable development must meet the needs of the present without compromising the ability of future generations to also meet their needs. Typically, however, sustainable yield must also allow for sufficient natural discharge of groundwater to preserve streams, springs, wetlands, and riparian corridor ecosystems (e.g. Sophocleous, 1997; 2000).

As groundwater in storage is depleted and groundwater elevations continue to drop with ongoing pumping, the "cone of depression" associated with each pumping well (or group of wells) expands and groundwater within an increasing area flows toward the well. The extent of groundwater that ultimately flows to the pumping well is sometimes termed the extent of groundwater "capture" (e.g. Bredehoeft, 1997). The groundwater captured by pumping is derived from decreases in natural discharge and increases in recharge. Natural groundwater discharge commonly supports riparian and wetland ecosystems as well as the base flow of streams and rivers. The groundwater "captured" can also include increased recharge induced by pumping if the boundaries of the groundwater system include a surface water body or adjacent aquifer, but typically the majority of the capture associated with pumping consists of intercepted groundwater that would otherwise discharge or transpire elsewhere. Accordingly, the quantity of sustainable groundwater development usually depends on how much natural groundwater discharge can be captured (e.g. Bredehoeft, 1997; 2002; Ponce, 2007).

With continued pumping, the water level in an aquifer near a well can continue to drop ("drawdown") until it reaches the bottom of the well screen or pump intake, or the water levels may stabilize if capture expands to equal the pumping rate and a new equilibrium groundwater condition is attained. If a new equilibrium condition is attained the pumping rate theoretically may be sustainable with no further decline in water level (i.e., no additional depletion of groundwater in storage). However, the time to achieve equilibrium pumping conditions can take decades or centuries. And if the groundwater pumping exceeds the potential for capture, new equilibrium conditions are not possible (e.g. Bredehoeft and Durbin, 2009; Walton, 2011; Alley and Leake, 2004).

4.4.2 Calculations of Sustainable Pumping based on the Test Pumping

For the proposed Laetitia project, based on the Phase 1 and 2 pumping and recovery data, CHG calculated an estimated long-term sustainable yield for each of the four wells totaling to 87 AF/Y with allowance for full recovery of water levels during average years to "operational static water levels established during Phase 1" pumping (CHG, Table 7, July 2010). Table 4 lists the annualized average pumping rates for each of the four wells.

The Phase 3 testing established that water levels continued to drop at three of the four wells with pumping at the estimated sustainable yield rates based on evaluation of the Phase 1 and 2 data (CHG, Table 7, July 2010). Thus, equilibrium groundwater conditions were not attained with the Phase 3 production rates and depletion of groundwater storage continued.

The "equilibrium discharge rate" (Q_{eq}) approach used by CHG (July 2010) for the Phase 1 and 2 data was also used to calculate revised estimates of "equilibrium interval" sustainable pumping rates by accounting for the time for groundwater levels to recover to pre-Phase 3 "operational static" elevations and scaling the Phase 3 pumping rates accordingly. The Phase 3 pumping and recovery periods and the "equilibrium interval" pumping rate calculation are shown with the hydrographs in Figures 11 and 12.

The rapid rise in water level in Well 10 after Phase 3 pumping appears related to a period of abundant rainfall near the end of Phase 3 testing. Recovery after Phase 2 pumping is considered more typical. Accordingly, the sketched recovery curve after the Phase 3 pumping was used for the equilibrium pumping calculation instead of the rapid recovery.

Scaling down the production rate to account for time for water levels to return to those at the beginning of the Phase 3 testing reduces the estimates of viable long-term production rates for Wells 10, 14, and 15 by 35%, 52%, and 45%, respectively. Q_{eq} was not calculated from the Phase 3 testing data recorded at Well 11 because the prominent recharge influence on water levels at this well occurred that was independent of pumping and complicates interpretation of the aquifer response to pumping.

The resulting revised estimate of sustainable yield from the four wells is approximately 65 AF/Y, which equates to an average pumping rate of 42 gpm. Table 4 lists the estimated sustainable pumping rates calculated by CHG using the Phase 1 and 2 data, the actual Phase 3 pumping rates, and the revised estimates of viable long-term pumping rates based on the water levels recorded in the four wells during the Phase 3 pumping and subsequent recovery.

4.4.3 Potential Impact of Well 11 on Los Berros Creek

Although the production capacity of Well 11 was substantially higher than the other wells, the rapid recharge response, close proximity to the creek, and dropping water level beginning in June even without pumping indicates that the production capacity of Well 11 is dependent on base flow in Los Berros Creek and will likely decrease during summer and drought conditions. Moreover, pumping from Well 11 during late summer and autumn would likely substantially reduce base flow in the Los Berros Creek channel. Figure 19a shows the pumping rate proposed by CHG (July 2010) for Well 11 (38.2 AF/Y = 23.7 gpm) compared to average monthly flow rate in Los Berros Creek based on available data for the period from 1981 to 2001. During the months of August through November, the proposed pumping rate from Well 11 exceeds 30 percent of the average flow in Los Berros Creek.

An alternative to help preserve base flows in the creek and decrease impact to the Los Berros Creek riparian corridor would be to not operate Well 11 during the months of August, September, October, and November. However, a higher pumping rate than that used for the Phase 3 testing can likely be sustained at Well 11 the rest of the year (December through July) with insignificant impact to Los Berros Creek. Accordingly, the suggested optimized pumping scheme includes a 10 percent increase to the pumping rate at Well 11 from December through July. Based on average conditions for the period from 1981 to 200, with the proposed 10 percent increase in pumping from Well 11 from December through July, the pumping rate is less than 15 percent of the creek flow. Figure 19b shows the recommended revised pumping schedule for Well 11 compared to average monthly flow rate in Los Berros Creek.

4.4.4 Increased Production from Well 15

Well 15 is the deepest of the four wells and has the largest available drawdown between the water level attained during Phase 3 pumping and the top of screen—approximately 80 feet. Consequently, a production rate from Well 15 that results in continuing gradual drawdown is more sustainable at Well 15 than at the other wells.

Although equilibrium conditions were not attained during the Phase 3 pumping rate, based on evaluation of the water level response to testing at Well 15, the Phase 3 pumping rate can likely be sustained for a few years before the water level would drop below the top of the screen.

Based on review of the pumping test data and well construction details, our estimated long-term viable production rate for Well 15 includes a 25 percent increase to the revised calculated sustainable pumping rate for Well 15 based on the Phase 3 production and recovery. A 25 percent increase in the long-term pumping rate calculated for Well 15 can likely be sustained for many years and can make-up a portion of the decrease in production from Well 11.

4.4.5 Recommended Production Rates and Schedule

Table 4 provides our revised estimates of viable long-term flow rates from the four wells with a net 26 percent reduction of pumping from Well 11 (relative to the Phase 3 rate) to lessen impact to Los Berros Creek (no pumping from August to November), and a 25 percent increase all year from Well 15 (relative to the revised rate scaled to the Phase 3 recovery). The revised resulting total production rate is 62.4 AF/Y or 38.7 gpm. This is a 28 percent decrease compared to the sustainable rate estimated by CHG (July 2010) on which the Phase 3 testing was based, but 135 percent of the allocated project demand of 46.3 AF/Y.

4.5 <u>Source Capacity is Adequate to Achieve Maximum Daily Demand</u>

Community water supply systems are required to have adequate source capacity to meet maximum daily demand (MDD) at all times. In accordance with State guidelines, CHG (July 2010) estimated the MDD for the proposed Laetitia project as 1.5 times the average daily demand (ADD) for the maximum demand month, which based on evapotranspiration requirements would be June. The calculated project water demand in June is 4.06 AF, which equates to 30.6 gpm for continuous flow. And, the MDD during June would be a factor of 1.5 higher, which is approximately 46 gpm (Appendix A of CHG, July 2010).

The sustainable rate estimated by CHG (July 2010) based on Phase 1 and 2 data and pumped from the four wells during Phase 3 was equivalent to 87 AF/Y, or approximately 54 gpm, which exceeds the maximum MDD value of 46 gpm. However, based on evaluation of the Phase 3 data and including measures to conserve base flow in Los Berros Creek, the revised estimated viable long-term production rate of 62.4 AF/Y, which equates to 38.7 gpm, is less than the MDD of 46 gpm. Nonetheless, based on the testing data, the capacity of the four wells is more than adequate to sustain a continuous flow of 46 gpm for a month. Moreover, water in storage tanks can be used to supplement groundwater pumping during short-term high demands.

4.6 Estimates of Aquifer Properties

Portions of the water level data recorded at Wells 10, 11, 14 and 15 during the testing program were analyzed to estimate transmissivity of the aquifers[14]. Aquifer type-curves used for analyses included the Theis confined solution, Copper-Jacob approximation of the Theis solution, and the Hantush-Jacob Leaky Aquifer solution (e.g. Kruseman and de Ridder, 1992). Subsets of the water level data recorded during the testing were analyzed to estimate aquifer transmissivity using standard graphical aquifer testing analysis methods both by hand and with computer software. Water levels recorded both during pumping and recovery were analyzed. Four general methods were used to estimate transmissivity, each of which are discussed below. The aquifer testing analyses are provided in Appendix B and the estimates of transmissivity and hydraulic conductivity are summarized in Table 5.

[14] Transmissivity (T) is the capacity of an aquifer to transmit water. The volume of water (e.g. ft^3) that flows through a unit width (ft) of the aquifer during a unit duration of time (e.g. a day) for a unit hydraulic gradient (e.g. 1ft/1ft): ft^3 per ft-day = ft^2/day. Transmissivity equals hydraulic conductivity time aquifer thickness.
As indicated in by Table 5, a 75% well efficiency was assumed for the calculations of transmissivity based on analyses of the water level recorded in the pumping wells. With a 75% well efficiency the drawdown in the aquifer just outside the well would be 25% less, and the calculated transmissivity is thus 25% higher.

4.6.1 Type-Curve Analyses of Detailed Pumping Test Data

Graphical-visual fits to the data were conducted using the aquifer testing analysis software called AQTESOLV™ (Duffield, 2007), which facilitates type-curve analysis with variable pumping rates and concurrent analysis of pumping and recovery data. Based on fitting of the detailed type-curves to the water level data accounting for each pumping cycle, the approximate estimated transmissivities (T) are 8, 110, 50, and 120 ft^2/d and calculated bulk hydraulic conductivity values[15] are 0.06, 0.56, 0.14, and 0.61 ft/d respectively for Wells 10, 11, 14 and 15.

4.6.2 Cooper-Jacob Analyses of Simplified Pumping Test Data

Simplified approximations of the hydrographs were analyzed using the Cooper-Jacob approximation of the Theis confined solution for each of the three phases by neglecting the off-on cycles within each phase and using average pumping rates.

When drawdown associated with the first pumping cycle for each phase of testing was analyzed, the operational pumping rate was used instead of the averaged production rate during the phase of testing. Generally, the transmissivity calculated from the first cycle of pumping was substantially higher than the estimates based on long-term pumping. The initial yield from fractured bedrock commonly is not representative long-term yield.

Based on the Cooper-Jacob analyses of simplified representations of the testing data, approximate representative average values of transmissivities (T) are 35, 105, 40, and 85 ft^2/d and calculated bulk hydraulic conductivity values are 0.25, 0.55, 0.11, and 0.42 ft/d, respectively, for Wells 10, 11, 14, and 15.

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[15]For all the analyses, the bulk hydraulic conductivities were calculated from the estimated transmissivities assuming aquifer thicknesses equal to the well screen lengths. This provides upper limit values for bulk hydraulic conductivity because a thickness of the aquifer greater than the length of the well screen likely contributes flow of groundwater to the wells. Accordingly, the actual bulk K values are likely lower. If a thickness of aquifer greater than the screen length contributes to flow toward the well, the actual bulk hydraulic conductivities would be lower than calculated.

4.6.3 Theis Recovery Analysis following Phase 2 Pumping

Analysis of recovery of water levels after Phase 2 pumping using the Theis Recovery method was conducted for Wells 10, 14, and 15. The approximate respective resulting estimates of transmissivity are 17, 24, and 49 ft^2/d, and calculated bulk hydraulic conductivity values are 0.12, 0.07, and 0.25 ft/d. No correction for well efficiency is made for analysis of recovery data.

4.6.4 Transmissivity Estimated from Specific Capacity

Estimates of transmissivity were also calculated from specific capacity, (Q/S, pumping rate divided by drawdown, e.g. gpm per foot of drawdown) for Wells 10, 11, 14, and 15. Two approaches were used for calculation of drawdown from specific capacity: (1) using the initial static water level before the Phase 1 testing; and (2) using "reset" initial water levels at the beginning of each phase of testing.

Because water levels did not equilibrate, but continued to drop during the pumping tests, using Approach 1 for Wells 10, 14, and 15 results in generally decreasing specific capacities and transmissivities with time. With this method, the specific capacity at Well 10 ranged from 3.6 to 0.6 gpm/ft, and the specific capacities at Wells 14 and 15 ranged from approximately 2 to 0.5 gpm/ft. Transmissivity calculated from the specific capacity values using the following formula (e.g. Heath, 1989):

$T = (300/0.75)(Q/S)$,

for the following units: T ft^2/d, Q gpm, and S ft

results in transmissivity values ranging from 1400 to 250 ft^2/d for Well 10, and 900 to 200 ft^2/d for Wells 14 and 15. Bulk hydraulic conductivities calculated from the transmissivity values range from 8 to 1.5 ft/d for Well 10, 2.5 to 0.6 ft/d for Well 14, and 4 to 1 ft/d for Well 15.

Using Approach 2, generalized average specific capacities values were also calculated for each of the three phases using the initial and ending water levels during each phase and average pumping rate. For these calculations a "reset" initial water level prior to Phase 2 and Phase 3 pumping was used to calculate drawdown and specific capacity during the Phase 2 and Phase 3 pumping. Accordingly the drawdown is less and the specific capacity values are higher than when calculated using Approach 1, which used the initial water level prior to Phase 1 pumping for all calculations of drawdown.

Transmissivities calculated from specific capacities using Approach 2 range from 5000 to 350 ft^2/d for Well 10, and 900 to 300 ft^2/d for Wells 14 and 15. Bulk hydraulic conductivities calculated from the transmissivity values range from 28 to 2 ft/d for Well 10, 2.5 to 1 ft/d Well 14, and 1 to 4 ft/d for Well 15.

The higher values reflect short-term transmissivity of local fracture systems and the longer term values are better estimates of bulk hydraulic conductivities of the aquifer, but still are substantially higher than estimates based on the other aquifer analysis methods discussed above.

4.6.5 Summary of Estimates of Aquifer Properties

The values for transmissivity and bulk hydraulic conductivity calculated from specific capacity data are considered less reliable than the values based on detailed type-curve analysis, Cooper-Jacob analysis of simplified aquifer response to average pumping, and analysis of recovery after Phase 1 and 2 pumping. The results of the aquifer test analyses excluding the specific capacity methods are listed in Table 5 and summarized below.

Well	Transmissivity (ft^2/d)	Transmissivity (gpd/ft)	Bulk Hydraulic Conductivity (ft/d)
Well 10	8 to 35	60 to 260	0.06 to 0.25
Well 11*	100	750	0.6
Well 14	25 to 50	190 to 375	0.07 to 0.14
Well 15	50 to 120	375 to 900	0.25 to 0.6

* Few estimates of transmissivity and hydraulic conductivity were possible for Well 11 because the aquifer response to pumping was complicated by influence of base flow at Los Berros Creek.

The estimates of transmissivity of the fractured rock aquifers based on the analysis of data recorded during the three phases of pumping tests are substantially lower than previous estimates based on shorter term pumping tests (C&A, October 2005; Fugro, June 2009). This indicates that the long-term capacities of the fractured rock aquifers to transmit groundwater are lower than previously estimated and sustainable production potential of the Project Site wells based on the short-term tests were unrealistically high.

Although the estimates of viable long-term groundwater yields reported herein are based primarily on evaluation of hydrographs and pumping history, the bulk hydraulic conductivities based on analysis of the aquifer testing data are useful for providing a basis for aquifer properties that would be needed if groundwater modeling or other calculations are conducted to further evaluate groundwater production and possible long-term drawdown of groundwater levels in response to proposed pumping (e.g. Bredehoeft, 2002).

4.7 Fractured Bedrock Aquifers

The methods used for estimating transmissivity and hydraulic conductivity of the aquifers tapped by the wells at the Project Site are based on the assumption that the aquifers are homogeneous and isotropic—which means uniform throughout and in all directions. However, the aquifers are in fractured bedrock, so they are not uniform and isotropic. Nonetheless, at a large scale, fractured bedrock aquifers can often be reasonably represented by an equivalent homogenous porous media, although a directional bias (anisotropy) of hydraulic conductivity is common.

Initial yield from wells in fractured bedrock aquifers often is not representative of longer-term yields, which are typically lower. As groundwater is released from storage in fractures, the hydraulic gradient toward the well becomes progressively lower, which causes the well yield to decline. And, a relatively lower hydraulic gradient at the end of the pumping period limits the rate of groundwater flow back into the area of drawdown, so recovery is often substantially slower than drawdown (e.g. Robinson, Noble & Saltbush, 2004; Morrison-Maierle, 2002).

Although the standard analytical techniques for groundwater flow assume uniform radial flow of groundwater toward a pumping well, flow within fracture systems commonly have more linear geometry (e.g. Morrison-Maierle, 2002). For radial flow systems, the rate of drawdown gradually decreases with pumping duration because the volume of aquifer influenced by pumping increases by the distance squared. However, for a system of linear fractures tapped by a well in bedrock, the volume of aquifer influence by pumping can increase linearly with distance, so the rate of drawdown with pumping will be faster than for radial systems.

5. CONCLUSIONS AND RECOMMENDATIONS

Continuing general decline of water levels in Wells 10, 14, and 15 during the three phases of pumping indicates that stable equilibrium groundwater conditions were not attained. Moreover, continued decline in water levels at three of the four wells during the Phase 3 pumping indicates that the 87 AF/Y sustainable yield estimated by CHG (July 2010) will not result in full recovery to "the Phase 1 operational static water levels," but will cause additional depletion of groundwater storage.

The projections of downward water level trends exhibited during testing and the unknown time to possibly achieve equilibrium pumping conditions underscores that time frame is an important issue with respect to long-term viability of the wells to meet the proposed project demands. Climate change is predicted to result in rainfall occurring in fewer and more intense periods (DWR, 2003), which would likely result in more runoff, perhaps less recharge to groundwater, and possibly long-term decrease in base flow of creeks.

With continued pumping at Phase 3 rates, an expanding cone of depression of groundwater elevation will result in capture of more groundwater and an equilibrium condition accompanied by stable water levels may be attained. However, equilibrium groundwater flow conditions may not occur for decades or longer (e.g. Alley et al., 1999; Bredehoeft, 2002; Bredehoeft and Durbin, 2009). Based on the water level records during Phase 3 pumping, if the linear trend in decreasing groundwater elevations continues at the rates observed during the Phase 3 testing, the water levels in the wells will likely drop below the top of the well screens-- within months in Wells 10 and 14, and within a few years in Well 15.

The long screened intervals (i.e., the large thickness of aquifer screened by the project wells) provide the opportunity to install the pumps hundreds of feet deep and continue pumping when water levels drop well below the top of the screened interval. However, drawdown of water level below the top of the screen typically decreases the production capacity of the wells because as the water level drops, the aquifer saturated thickness (and thus the transmissivity) near the wells will decrease. Nonetheless, the long screened intervals may allow pumping to be sustained with gradually decreasing water levels for many years.

As reported by CHG (July 2010) and discussed above, Well 11 shows rapid recharge likely due to good hydraulic connection between the aquifer and base flow in Los Berros Creek. Because pumping of Well 11 likely reduces base flow in Los Berros Creek, curtailment of pumping from this well is recommended during the late summer and early fall months when creek flows are lowest. The recommended water production schedule includes curtailment of pumping from Well 11 from August through November each year to help preserve base flow in Los Berros Creek.

Well 15 is the deepest of the four wells and has the largest available drawdown between the water level attained during Phase 3 pumping and the top of screen—approximately 80 feet. Consequently, a production rate from Well 15 that results in continuing gradual drawdown is more sustainable at Well 15 than at the other wells. Accordingly, the recommended long-term viable production rate for Well 15 includes a 25 percent increase to the revised calculated sustainable pumping rate for Well 15 based on the Phase 3 production and recovery.

Table 4 summarizes the revisions to the estimated "sustainable" production rates for each of the four wells. Based on our evaluation of the hydrogeologic setting and pumping test data, including the Phase 3 recovery data, the estimated total long-term viable production rate from the four wells is 62.4 AF/Y (38.7 gpm). This is 28 percent less than the sustainable production rate estimated by CHG (July 2010) that was used for Phase 3 testing, but 35 percent more than the allocated project demand of 46.3 AF/Y.

The revised estimated viable long-term production rate of 62.4 AF/Y, which equates to 38.7 gpm, is less than the maximum daily demand (MDD) of 46 gpm. Nonetheless, based on the testing data, the capacity of the wells is more than adequate to sustain a continuous flow of 46 gpm for one month. Moreover, water in storage tanks can be used to supplement groundwater pumping during short-term high demands.

The estimates of viable long-term groundwater production rates reported herein are based on evaluation of water levels recorded in four wells for the period from October 2009 to March 2011, which included several months of pumping. However, we caution that rainfall during the testing program was 138 percent of average, and also that long-term yields of water wells producing from bedrock aquifers, which may have linear fracture systems, commonly are substantially less than short-term yields. Nonetheless, long-term groundwater production rates of 21 AF/Y reported by CHG (July 2010) for each of two irrigation wells[16] at the Project Site supports that 62 AF/Y is a viable long-term groundwater production rate for the four project wells combined.

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[16] CHG, July 2010, page 9 reports that Well 5 produced 540 AF over 26 years, and Well 9 produced 230 AF over 11 years. Each equates to approximately 21 AF/Y. Both of the wells, which are screened in the Obispo Formation fractured bedrock and their locations are shown on Figures 3 and 7.

6. REFERENCES

Ahmed, S., R. Jayakumar, A. Salih, 2008. Groundwater dynamics in hard rock aquifers: sustainable management and optimal monitoring network design, Capital Publishing Company, India; co-published by Springer.

Alley, W.M, and S.A. Leake, 2004. The journey from safe yield to sustainability, Ground Water, vol. 42, pp. 12-16.

Alley, W.M., T.E. Reilly, O.L Franke, 1999. Sustainability of Ground-Water Resources, US Geological Survey Circular 1186.

Bredehoeft, J., 1997. Safe yield and the water budget myth: Ground Water, vol. 35, no. 6, p. 929.

Bredehoeft, J., 2002. The water budget myth revisited: Why Hydrogeologists Model, Ground Water, vol. 40, no. 4, p. 340-345.

Bredehoeft, J., and T. Durbin, 2009. Ground Water Development – The Time to Full Capture Problem, Ground Water, vol. 47, no. 4, p. 506-514.

Central Coast Salmon Enhancement, March 2005. Arroyo Grande Creek Watershed.Management Plan, prepared for The Department of Fish and Game State of California. http://www.centralcoastsalmon.com/index.php?option=com_phocadownload&view=category&id=2:arroyo-grande-watershed-documents&Itemid=84

Cleath Associates, 2004. Water Supply Assessment for Laetitia Vineyard and Winery, Arroyo Grande, California, January 27.

Cleath Associates, 2005, Water Resources Studies for Laetitia Vineyard Property, Arroyo Grande, San Luis Obispo County, October 6.

Cleath Associates, 2008, Response to County Comments on Water Resources, Laetitia Agricultural Cluster EIR, Arroyo Grande, San Luis Obispo County, March 28.

Cleath Associates, 2008, Mitigation of Stream Flow Impacts, Laetitia Agricultural Cluster, Arroyo Grande, San Luis Obispo County, November 4.

Cleath Associates, 2009a. Response to hydrogeological peer review of water resources section, Laetitia agricultural cluster Draft Environmental Impact Report, June 24.

Cleath Associates, 2009b. Response to supplemental hydrogeological peer review of water resources section, Laetitia agricultural cluster Draft Environmental Impact Report, July 2.

Duffield, GM., 2007. AQTESOLV for Windows, Aquifer Testing Data Analysis Software Program. http://www.aqtesolv.com/

DWR (California Department of Water Resources), 2002. Water Resources of the Arroyo Grande-Nipomo Mesa Area, Southern District Report.

DWR (California Department of Water Resources), 2003. California's Groundwater - Bulletin 118, Update 2003; http://www.water.ca.gov/groundwater/bulletin118/bulletin118update2003.cfm

Fugro, 2009a. Hydrogeologic Review Water Resources Section of the Draft Environmental Impact Report Laetitia Agricultural Cluster Subdivision, Tentative Tract Map and Conditional Use Permit, SCH No. 2005041094, April 23.

Furgro, 2009b. Supplemental Hydrogeologic Review Water Resources Section of the Draft Environmental Impact Report Laetitia Agricultural Cluster Subdivision, Tentative Tract Map and Conditional Use Permit, SCH No. 2005041094. June 9.

Heath, R.C., 1989. Basic Ground-Water Hydrology, U.S. Geological Survey Water-Supply Paper 2220, 84 p.

Krasny, J., and J.M. Sharp, Jr., 2007. Groundwater in fractured rocks: selected papers from Groundwater in Fractured Rocks International Conference, Prague, 2003; Taylor & Francis Group, London, 2007; ISBN13: 978-0-415-41442-5

Kruseman, G.P. and N.A de Ridder, 1992. Analysis and Evaluation of Pumping Test Data, second edition, Publication 47, International Institute for Land Reclamation and Improvement, The Netherlands, 199, 377 p.

Maimone, M., 2004. Defining and Managing Sustainable Yield, Ground Water, vol. 42, pp 809-814.

Morrison-Maierle, Inc., 2002. Yield and drawdown tests, Mountain Village Well No. 7, Big Sky Water and Sewer Project, prepared for Yellowstone Development, LLC, January 2002. http://www.bigskywatersewer.com/_downloads/Well7PumpTest.pdf

Ponce, V.M, 2007. Sustainable yield of groundwater; http://gwsustainability.sdsu.edu

Robinson, Noble & Saltbush, Inc., 2004. Fractured-rock Wells in the Pacific Northwest foothills: Not your average water source; informational flyer for the Washington State Ground Water Association. www.wsgwa.org/News/FracturedRock.pdf

Singhal, B.B.S, and R.P. Gupta, 2010. Applied Hydrogeology of Fractured Rocks, second edition, Springer; ISBN 978-90-481-8798-0.

Sophocleous, M., 1997. Managing water resources systems: why “safe yield” is not sustainable: Ground Water, vol. 35, no. 4, p. 561.

Sophocleous, M., 2000. From Safe Yield to Sustainable Development of Water Resources – the Kansas Experience; Journal of Hydrology, vol 235, pp 27-43.

S.S. Papadopulos & Associates, 2004. Nipomo Mesa Groundwater Resource Capacity Study, San Luis Obispo County, California, prepared for San Luis Obispo County, March.

SWCA Morro Group, 2008. Draft Environmental Impact Report for the Laetitia Agricultural Cluster Subdivision, Tentative Tract Map and Conditional Use Permit, prepared for County of San Luis Obispo, September.

Walton, W.C., 2011. Aquifer System Response Time and Groundwater Supply Management, Ground Water, vol. 49, No 2, p. 126-12.

TABLES

Table 1
Los Berros Creek Mean Monthly Flow Data

Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

YEAR	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	1	2	3	4	5	6	7	8	9	10	11	12
1968								0.15	0.13	0.11	0.09	0.10
1969	29.42	28.69	17.52	4.37	2.07	1.00	0.31	0.28	0.15	0.36	0.47	0.48
1970	0.86	0.98	3.90	0.79	0.27	0.23	0.25	0.13	0.07	0.07	0.11	1.31
1971	2.30	1.18	0.79	0.65	0.50	0.40	0.50	0.28	0.12	0.14	0.10	0.22
1972	0.19	0.24	0.25	0.03	0.05	0.13	0.07	0.06	0.05	0.07	0.28	0.19
1973	6.68	19.16	16.68	2.79	1.15	0.34	0.20	0.08	0.06	0.04	0.06	0.70
1974	10.59	1.55	6.33	7.16	2.09	1.10	0.64	0.35	0.24	0.29	0.51	1.08
1975	0.77	2.59	2.26	1.70	1.00	0.69	0.51	0.41	0.39	0.43	0.43	0.28
1976	0.28	0.45	0.77	0.66	0.43	0.33	0.23	0.13	0.14	0.34	0.36	0.32
1977	0.38	0.39	0.40	0.34	0.40	0.22	0.12	0.08	0.02	0.00	0.00	0.08
1978	8.96	27.98	17.46	6.72	2.75	1.35	0.67	0.41	0.37			0.66
1979	1.10	2.67	4.30				0.08	0.00	0.00	0.00	0.00	0.00
1980	1.81	12.97	8.10	1.44	0.95	1.17	0.29	0.01	0.00	0.00	0.00	0.00
1981	0.06	0.36	8.38	4.06	0.46	0.25	0.07	0.00	0.00	0.00	0.00	0.00
1982	0.00	0.00	1.96	9.87	0.96	0.30	0.04	0.00	0.00	0.00	0.00	1.82
1983	9.38	30.73	36.81	12.17	9.04	4.77	2.99	2.51	1.61	1.69	2.26	4.05
1984	2.70	2.41	1.75	1.14	0.72	0.43	0.38	0.38	0.00	0.00	0.01	0.56
1985	0.82	1.90	1.11	0.85	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1986	0.00		7.23	0.94	0.34	0.05	0.00	0.00	0.00	0.00	0.00	0.00
1987	0.00	0.00	0.37	0.09	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1988	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1989	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1990	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1991	0.00	0.00	11.04	3.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1992		5.56	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1993	2.05	6.10	7.62	2.04	0.01	0.00	0.00	0.00	0.00			
1994										0.00	0.00	0.00
1995		1.82			0.72	4.35	0.79	0.00	0.00	0.00	0.00	0.00
1996	0.00	12.19	3.51	0.85	0.01	0.00	0.00	0.00	0.00	0.00		
1997						0.00	0.00	0.00	0.00	0.00	0.01	
1998		73.30	20.82	25.03	12.20	5.44	3.04			0.64	0.48	
1999		1.79	2.40			0.85	0.36	0.13			0.00	0.00
2000	0.00		4.22		0.69	0.09	0.00	0.00	0.00		0.00	
2001		2.57	25.47	2.37		0.01			0.00			
Monthly Means 68-01	**2.94**	**7.99**	**6.93**	**3.36**	**1.45**	**0.92**	**0.58**	**0.42**	**0.39**	**0.47**	**0.52**	**0.82**
Monthly Means 81-01	**1.07**	**8.16**	**7.39**	**3.96**	**1.50**	**0.83**	**0.40**	**0.17**	**0.09**	**0.14**	**0.15**	**0.43**

<u>Notes:</u>
Blank cell insufficient data for calculation of mean monthly value.
Highlighted (yellow) rows include more than one month with greater than 10% of missing data

Table 2
Wells at the Laetitia Vineyard & Winery
Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

	Well 1	**Well 2**	**Well 4**	**Well 5**	**Well 7**	**Well 8**	**Well 9**	**Well 10***	**Well 11***	**Well 12**	**Well 13**	**Well 14***	**Well 15***
	F&T #2	F.V. Wells #4	(F.V. Wells #3)	(F.V. Wells #1)	F.V. Wells #2	Enloe #1	(F&T #1)	(2004-3)	(2005-1)	(2004-2)	(2004-1)	2006-1	2006-2
Common Name or Comment	Block “o” Well	Freeway Well	Electric Well	Propane Well	Estate Well	--	Campodonico Well	Proposed Project Supply Well	Proposed Project Supply Well	**	**	Proposed Project Supply Well	Proposed Project Supply Well
Date Drilled (completed)	Nov-98	Unknown	Jul-93	1983	Jul-88	Oct-99	Nov-98	Dec-04	Jul-05	Dec-04	Nov-04	Jun-06	Jul-06
Latitude			35°05.260'	35°05.215'			35°05.678'	35°06.049'	35°05.761'	35°06.094'	35°06.145'	35°06.382'	35°06.542'
Longitude			120°31.636'	120°31.461'			120°30.528'	120°30.434'	120°30.134'	120°29.328'	120°29.278'	120°29.665'	120°29.736'
Use	Irrigation	Domestic	Irrigation	Irrigation	Domestic	Domestic	Irrigation	Proposed Development	Proposed Development			Proposed Development	Proposed Development
Casing Diameter	8-inch PVC	8-inch steel	10-inch PVC	12-inch steel	12-inch PVC	8-inch PVC	8-inch PVC	10-inch PVC	8-inch PVC	8-inch PVC	8-inch PVC	8-inch PVC	8-inch PVC
Ground Surface Elev.			372	365			460	620	410	520	600	710	830
Total Depth of Well (ft bgs)	320	129	500	392	525	65	445	330	305	510	560	530	520
Formation Screened				Obispo Tuff		alluvium	Obispo Tuff	Obispo Tuff	Obispo Tuff	Monterey Shale	Monterey Shale	Monterey Shale	Monterey Shale
Screened Interval (Perforations) (ft bgs)	250-310	N/A	250; 280-340; 360-500	Unknown	185-310; 445-520	25-65	325-425	150-240; 280-330	115-305	190-320; 370-510	220-340; 370-560	170-530	310-510
Pump Setting (ft bgs)	210	120	330	350	300	--	300	260	220	280	320	300	400
Design GPM	260	22	400	500	40	--	260						
Current Production (gpm)	320	Unknown	500	400	Unknown	--	270						
Hours Pumped per Day	6-10 per day up to 4 days, then off for 1-2 weeks	Unknown	24 for 2-3 days to pond, then off for 2-3 days	24 for 1-2 days to pond, then off for 2-3 days	Unknown	--	24 for 2-3 days to pond, then off for 2-3 days						
Distribution	Direct Irrigation	Winery	Pond	Pond	Estate & Winery	--	Pond						

* Proposed Project Well included in Test Pumping Program (also highlighted).
** Proposed Project Well that was Replaced by Well 14 & 15 due to concern about impact on Los Berros Creek
All depths are in feet.
All pumping rates in gallons per minute (gpm).
ft bgs = feet below ground surface

Table 3
Pump Testing Rates and Schedule

Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

			Allocated Project Demand:		**46.3 AF/Y**	
					28.7 gpm	
	Well 10	**Well 11**	**Well 14**	**Well 15**	**Total**	**% of project demand**
Phase 1. Oct 12 - Dec 16, 2009 ~10 wks (CHG Table 1 July 2010)						
operational Q gpm	50	45	50	35		
total pumped AF	4	3.7	4.6	3.2	15.5	
anualized AF/Y	20.8	19.2	23.9	16.6	**80.6**	**174%**
annualized gpm	12.9	11.9	14.8	10.3	50.0	
Phase 2. Jan 16 to May 10-14 ~ 4 months (CHG Table 4, July 2010)						
operational Q gpm	50	60	60	60		
total pumped AF	11.7	16.1	12.9	13.1	53.8	
annualized AF/Y	35.1	48.3	38.7	39.3	**161.4**	**191%**
annualized gpm	21.8	29.9	24.0	24.4	100.1	
Phase 3. 27 Spt - 30 Dec 2010 ~14 weeks (CHG Table 2, March 2011)						
operational Q gpm	44	55	42	44		
total pumped AF	2.8	10.3	5.2	5.5	23.8	
annualized AF/Y	10.2	38.3	19.4	20.4	**88.3**	**140%**
annualized gpm	6.3	23.7	12.0	12.6	54.7	

Notes and abbreviaions

gpm = gallons per minute
AF = acre feet
AF/Y = acre feet per year
Q = pumping rate

Table 4
Estimates of Sustainable Yields for Wells 10, 11, 14 and 15

Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

Allocated Project Demand: **46.3 AF/Y**
28.7 gpm

	Well 10	Well 11	Well 14	Well 15	Total	% of project demand
	1. CHG Est Sus Yield based on Phase 1 & 2 Testing (Table 7 July 2010 & Table 1 Mar 2011)					
AF/Y	10	38	19	20	**87.0**	**188%**
gpm	6.2	23.6	11.8	12.4	53.9	
	2. Phase 3 Testing - production schedule duration of 14 weeks (CHG Table 2 Mar 2011)					
operational Q gpm	44	55	42	44		
Total Pumped AF	2.75	10.30	5.23	5.48	23.8	
annualized AF/Y	10.2	38.3	19.4	20.4	**88.3**	**191%**
annualized gpm	6.3	23.7	12.0	12.6	54.7	
	3.1 Calculated Yield based on Phase 3 Testing					
Pumping Start - Recovery Dates	9/27-2/27	*	9/27-4/27	9/27-3/27		
Pumping Period (weeks)	14	14	14	14		
Recovery Period (weeks)	8	0	16	12		
Total Weeks	22	14	30	26		
calc sus yield from Ph3 Testing AF/Y	6.5	38.3	9.1	11.0	**64.8**	**140%**
gpm`	4.0	23.7	5.6	6.8	40.2	
	3.2 Adjustment to Protect Creek Baseflow No Q from Well 11 Aug - Nov, but 10% increase Dec - Jun					
AF/Y	6.5	28.1	9.1	15	**58.6**	**127%**
gpm	4.0	*26.1***	5.6	9.3	36.3	
	3.3 Optimized Est Sus Yield Well 11 as above and increase Q at Well 15 by 25%					
AF/Y	6.5	28.1	9.1	18.8	**62.4**	**135%**
gpm	4.0	*26.1***	5.6	11.6	38.7	
% of CHG est (1 above)	**65%**	**74%**	**48%**	**94%**	**72%**	
% decrease relative to CHG est (1 above)	35%	26%	52%	6%	28%	

Notes and abbreviaions

* No adjustment for Well 11 recovery due to influence by creek
** For version 4 and 5, operational Q for Well 11 is avg rate for 8 months,
but Q for Wells 10, 14, and 15 is avg rate for 12 months
3.1, 3.1, and 3.3 are revised calculations by Geosyntec of estimated sustainable yield
Verison 3.3, which is highlighted, is the recommended pumping
gpm = gallons per minute
AF = acre feet
AF/Y = acre feet per year
Q = pumping rate

Table 5

Estimates of Transmissivity and Hydraulic Conductivity

Review of Well Testing and Sustainable Yield Assessment

Proposed Laetitia Agricultural Cluster Subdivision, San Luis Obispo, California

Aquifer Properties Based on Detailed Type-Curve Analyses
(Hantush-Jacob Leaky Aquifer and Theis Confined Aquifer Solutions)

Well	Transmissivity*		Aquifer Thickness (ft)	Bulk K ft/day	Unit
	ft^2/day	gpd/ft			
Well 10	8.4	63	140	0.06	Resistant tuff
Well 11	107	800	190	0.56	Resistant tuff
Well 14	51	381	360	0.14	Siliceous shale
Well 15	121	905	200	0.61	Siliceous shale

* Transmissivity includes correction (decrease) to drawdown assuming 75% well efficiency

Cooper-Jacob Analyses of Simplified Aquifer Response and Averaged Pumping

	Phase 1					Phase 2					Phase 3					**T avg**	**T** avg**	screen	**Bulk K**
	Q-pmp (gpm)	T_0 (ft^2/d)	Q-prd (gpm)	T_1 (ft^2/d)	T_2 (ft^2/d)	Q-pmp (gpm)	T_0 (ft^2/d)	Q-prd (gpm)	T_1 (ft^2/d)	T_2 (ft^2/d)	Q-pmp (gpm)	T_0 (ft^2/d)	Q-prd (gpm)	T_1 (ft^2/d)	T_2 (ft^2/d)	**(ft^2/d)**	**(ft^2/d)**	(ft)	**(ft/d)**
Well-10	50		12.9	**22**	**30**	50		21.8	**16**	**16**	44	**266***	6.6	**46**		**26**	**35**	140	**0.25**
Well-11	45	**165***	11.9			60	**78**	29.9			55	**138***	24.8			**78**	**104**	190	**0.55**
Well-14	50	**76***	14.8	**16**	**29**	60		24	**18**	**28**	42	**59***	12.6	**40**	**44**	**29**	**39**	360	**0.11**
Well-15	35	**175***	10.3		**55**	60		24.4		**61**	44	**171***	13.2		**71**	**62**	**83**	200	**0.42**

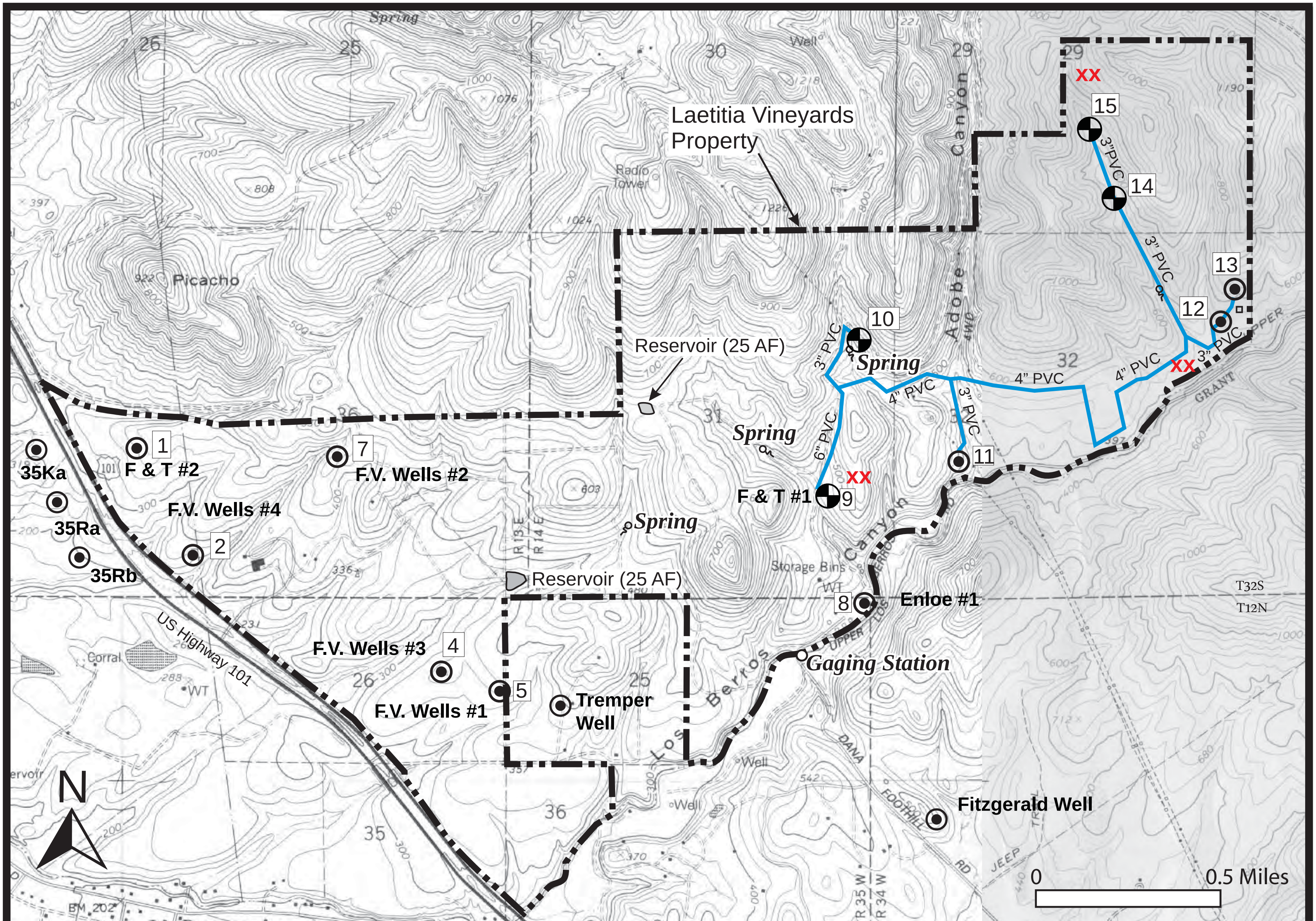
Theis Analysis of Recovery of Water Level Following Phase 1 and 2 Testing

	AF			30 wks	recovery	T	T	b	Bulk K
Well	Ph-1	Ph-2	tot	gpm	Delta S ft	ft2/d	gpd/ft	ft	ft/d
Well 10	4	11.7	15.7	16.9	34	17.4	130	140	0.12
Well 14	4.6	12.9	17.5	18.9	28	23.6	176	360	0.07
Well 15	3.2	13.1	16.3	17.6	12.5	49.2	368	200	0.25

Notes and Abbreviations: T = Transmissivity; Q –pmp = instantaneous pumping rate; Q-prod = production rate; gpd = gallons per day

* Higher transmissivity calculated from early time data likely represents most transmissive fractures near the well (not included in calculation of average transmissivity (Tavg). T**avg includes correction for assumed 75% well efficiency

FIGURES



Base map: U.S.G.S. 7.5 minute topographic, Oceano and Nipomo Quadrangles, CA

Base map scale: 1 inch = 2000 feet

Well locations approximate

Adapted from CHG memo, 4 Jan 2011

Explanation

15 ◉ Well Location and number

Well discharge piping

XX Weather recording station

Water Supply Well for Proposed Subdivision

Topographic Map of the Laetitia Site Showing Well Locations
Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

May 2011	Figure ES1	Geosyntec consultants

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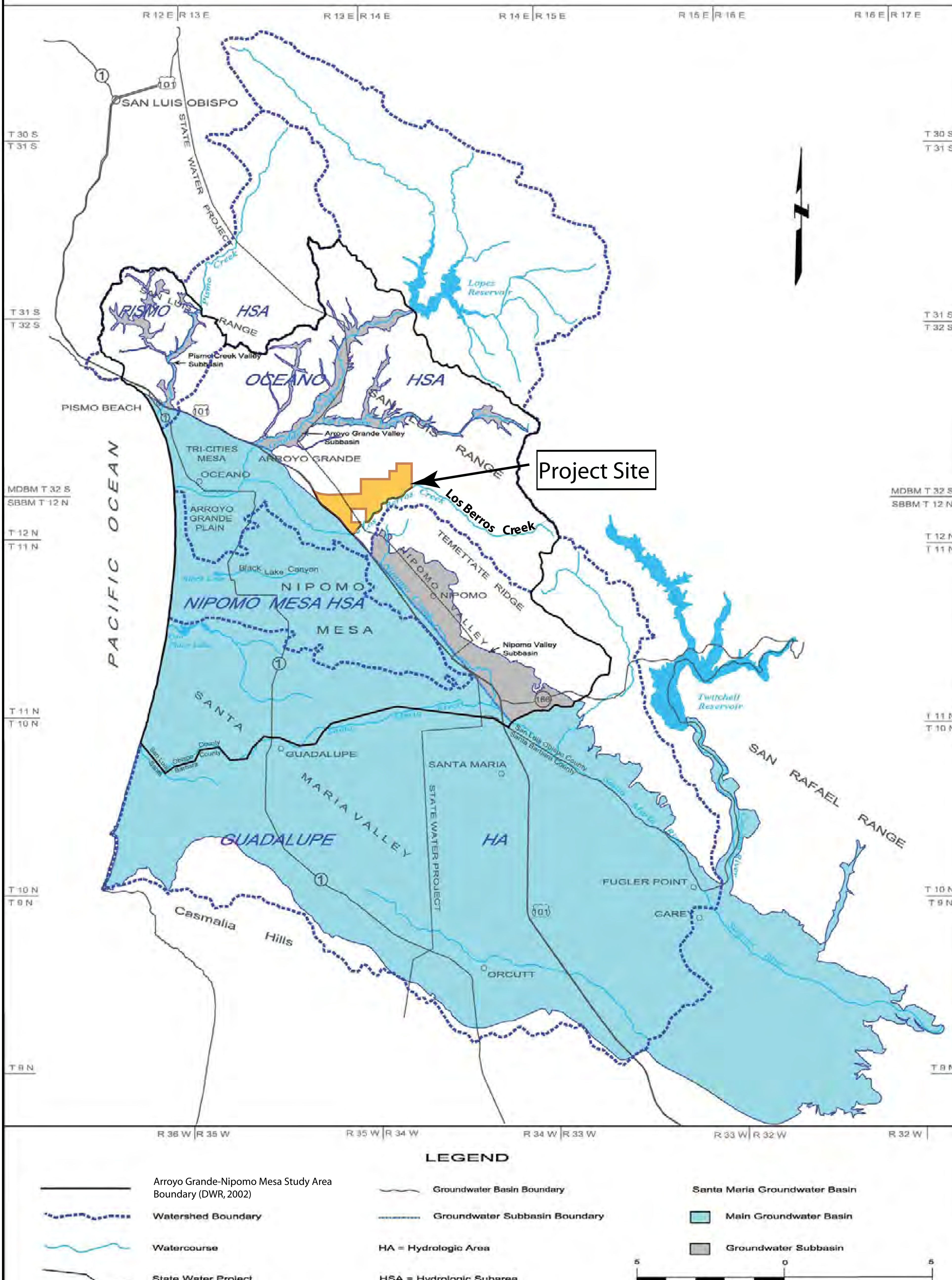
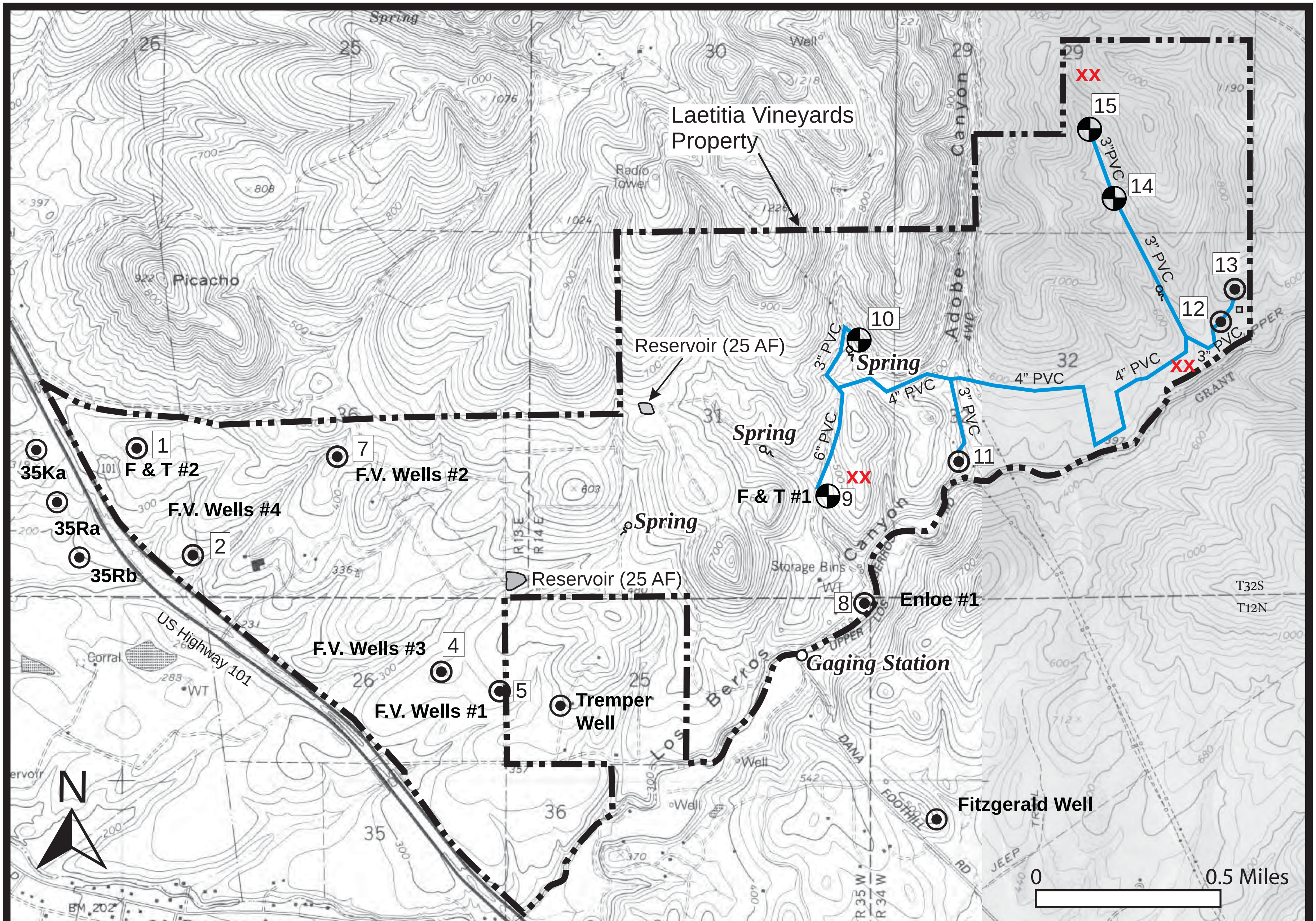


Adapted from Plate 1 of "Water Resources of the Arroyo Grande - Nipomo Mesa Area, (DWR, Southern District, 2002)

Site Location and Hydrologic Setting
Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

Geosyntec consultants
Oakland | May 2011

Figure **1**



Base map: U.S.G.S. 7.5 minute topographic, Oceano and Nipomo Quadrangles, CA

Base map scale: 1 inch = 2000 feet

Well locations approximate

Adapted from CHG memo, 4 Jan 2011

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Water Supply Well for Proposed Subdivision

Topographic Map of the Laetitia Site Showing Well Locations

Review of Well Testing and Sustainable Yield Assessment

Proposed Laetitia Agricultural Cluster Subdivision

San Luis Obispo, California

May 2011	Figure 2	Geosyntec consultants

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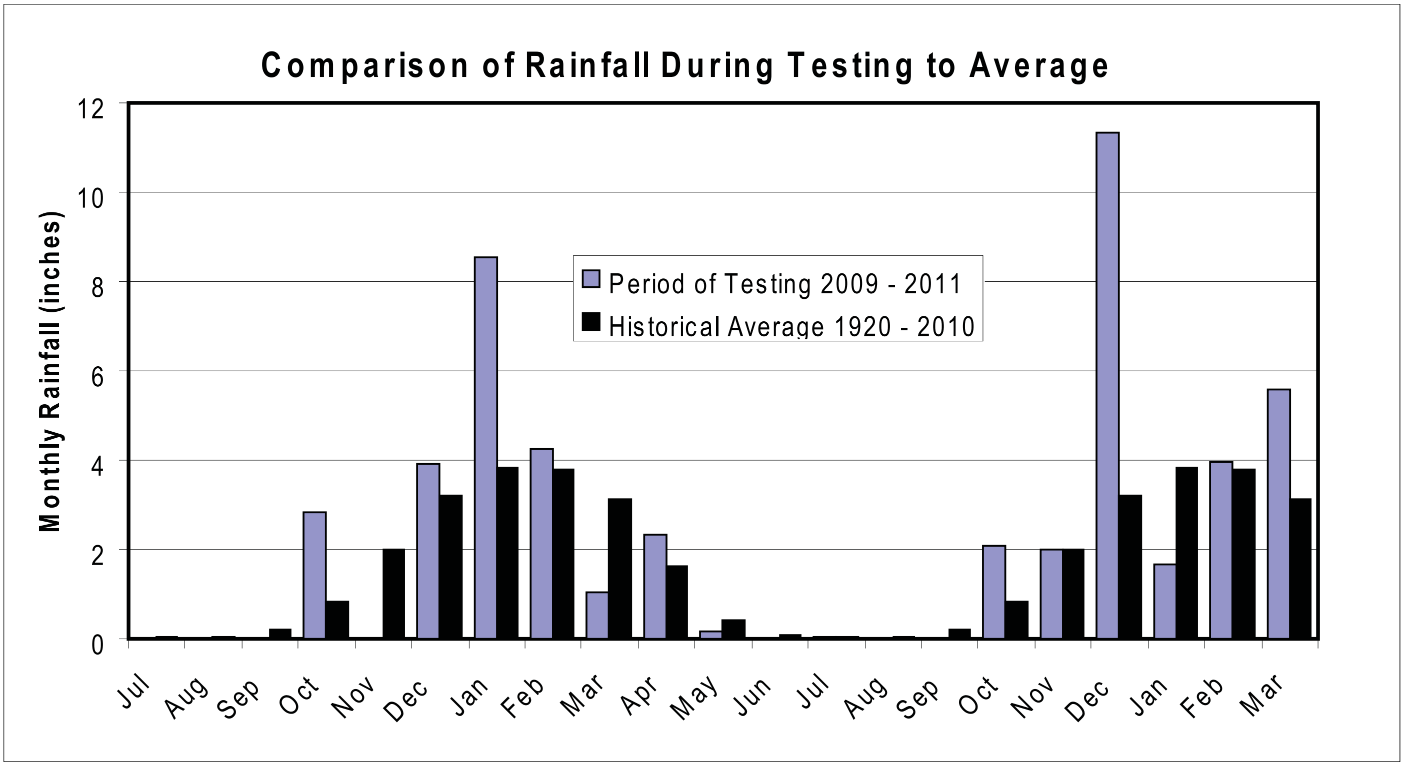
3A



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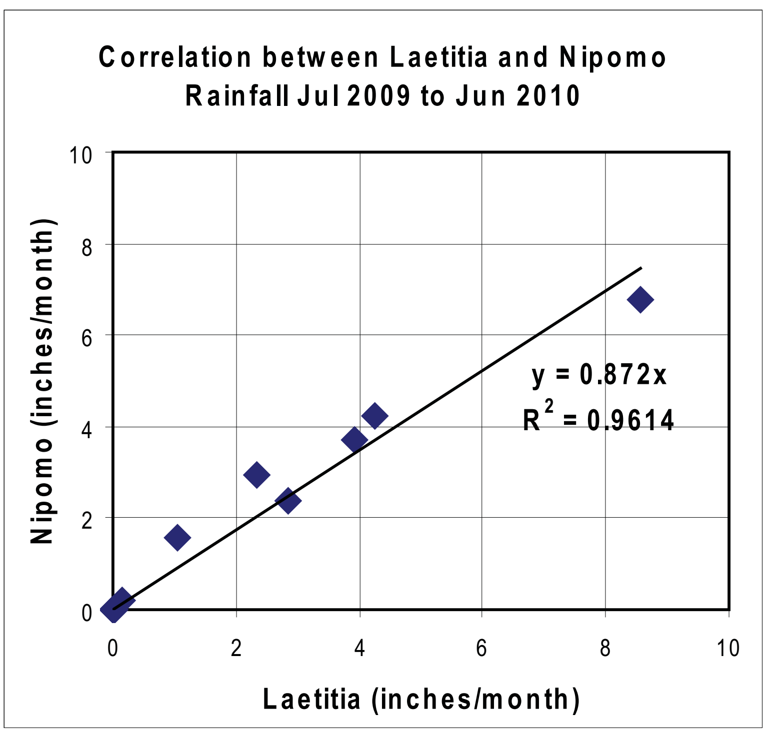
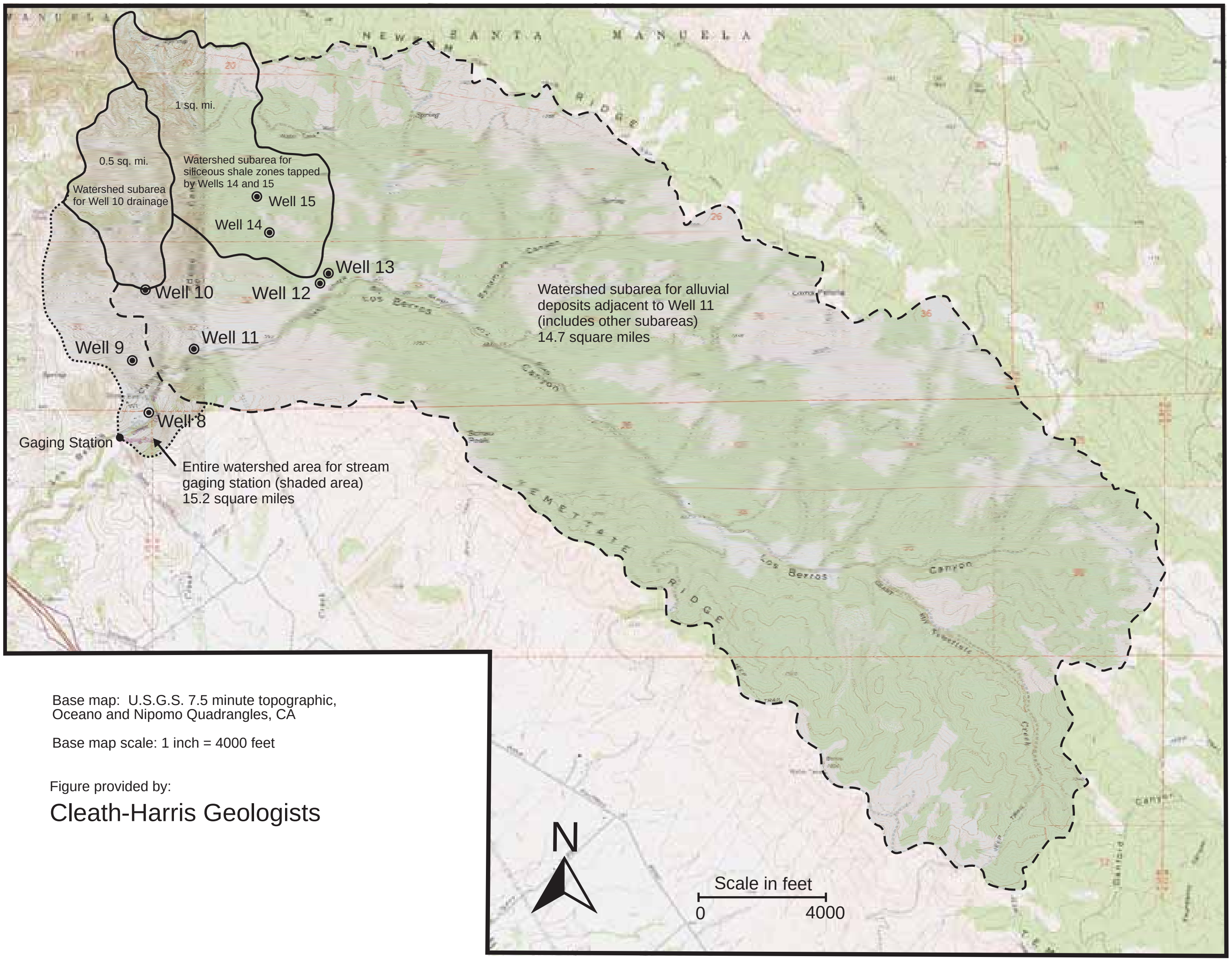


Monthly Rainfall During Testing Compared to Average Rainfall
Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

Geosyntec consultants

Oakland | May 2011

Figure 3



Base map: U.S.G.S. 7.5 minute topographic, Oceano and Nipomo Quadrangles, CA

Base map scale: 1 inch = 4000 feet

Figure provided by:

Cleath-Harris Geologists

Los Berros Canyon Watershed Laetitia Agricultural Cluster
Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

May 2011	Figure 4	Geosyntec consultants

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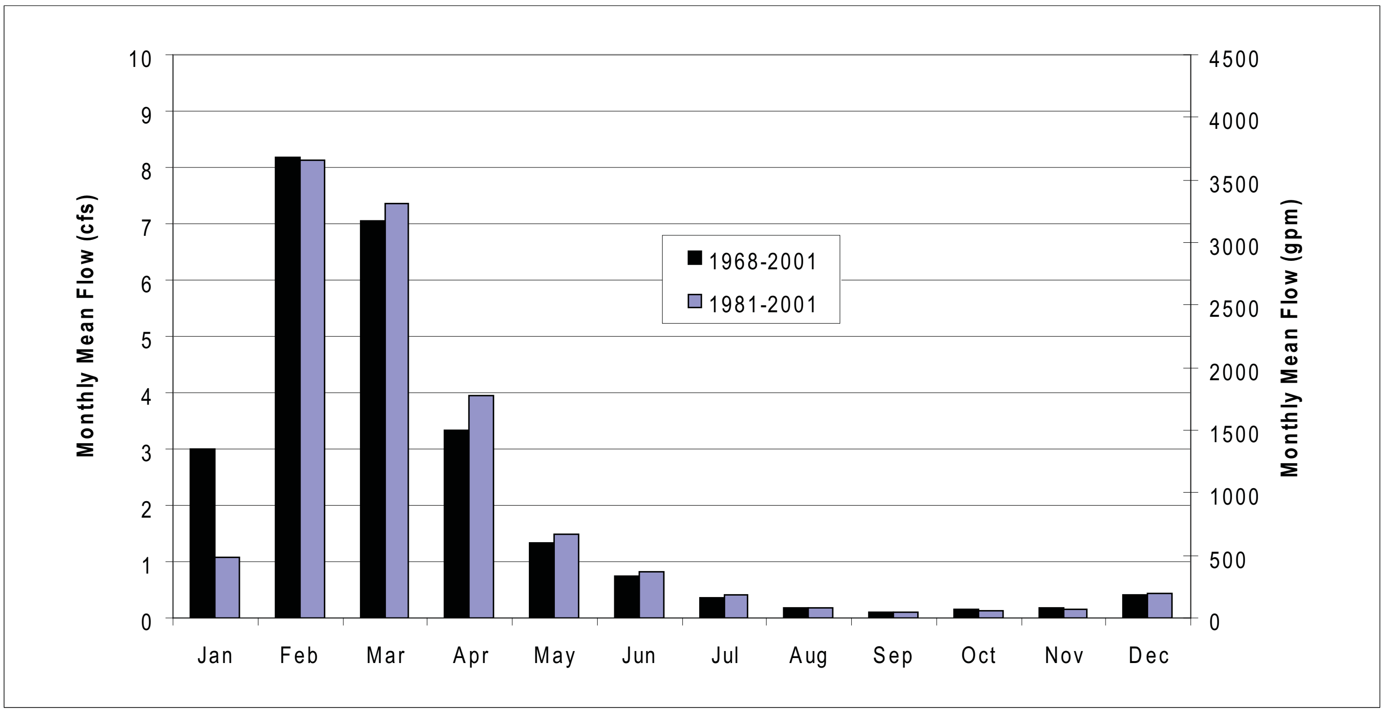

Average Monthly Flow of Los Berros Creek
Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

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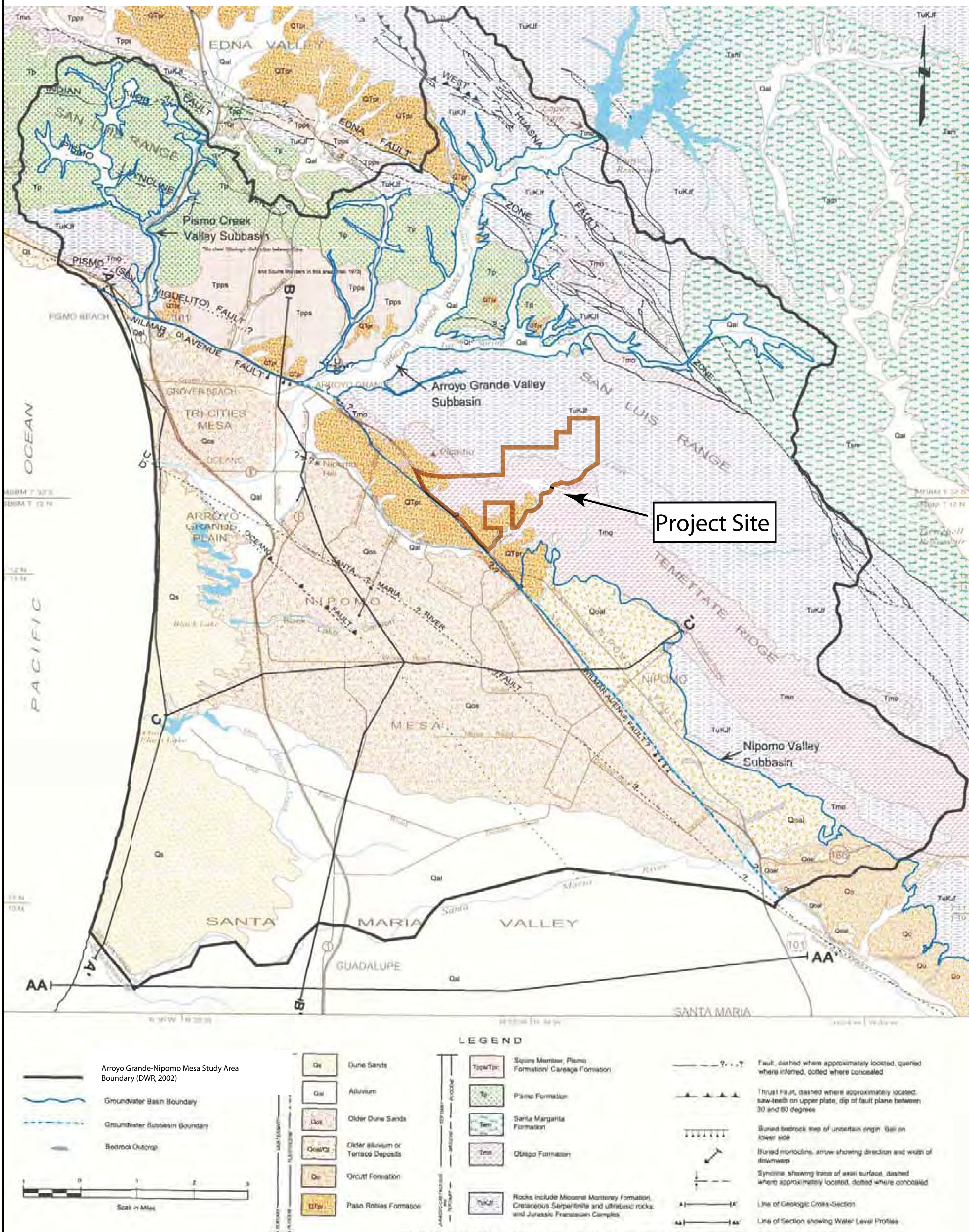
Figure **5**



Adapted from Plate 2 of "Water Resources of the Arroyo Grande - Nipomo Mesa Area, (DWR, Southern District, 2002)

Regional Geologic Setting
Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

Geosyntec consultants

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Figure 6

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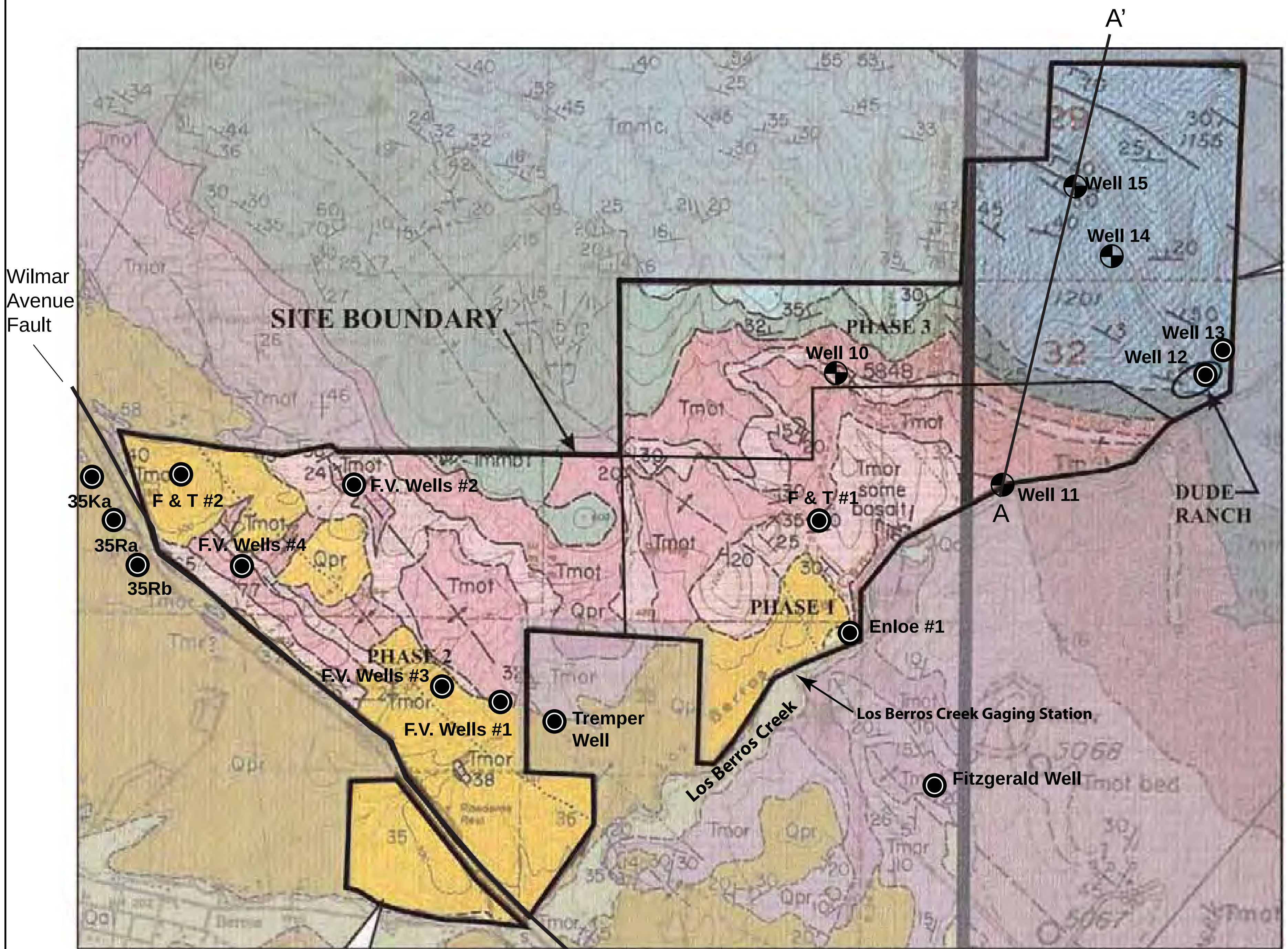

Adapted from DEIR Figure V.A.-1, Geologic Map of the Arroyo Grande Quadrangle, C.A. Hall, 1973 and Geologic Map of the Nipomo Quadrangle, Hall and Corbato, 1967

EXPLANATION

Qal	**Unconsolidated Quaternary Alluvial Deposits**
Qpr	**Paso Robles Formation** Pliocene-Pleistocene in age Unconsolidated or poorly consolidated sandsone, siltstone, and claystone
Tmmc Tmmb	**Monterey Formation** Miocene in age Siliceous shale, siltsone, chert, dolomite Tmmb - Siltstone or chert and dolomitic claystone or silt Tmmc - Opaline or cherty shale, dolomite
Tmor Tmot	**Obispo Formation** Miocene in age Volcanic tuff and some lava Tmor - Resistant cemented tuff (water-bearing) Tmot - Generally soft ashy tuff matrix
A' – A	**Location of Geologic Cross-Section (Figure 4)**
Well 10	**Water Supply Well for Proposed Subdivision**
F & T #1	**Other Water Well**

Well Locations Approximate

Local Geologic Map and Well Locations
Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
San Luis Obispo, California

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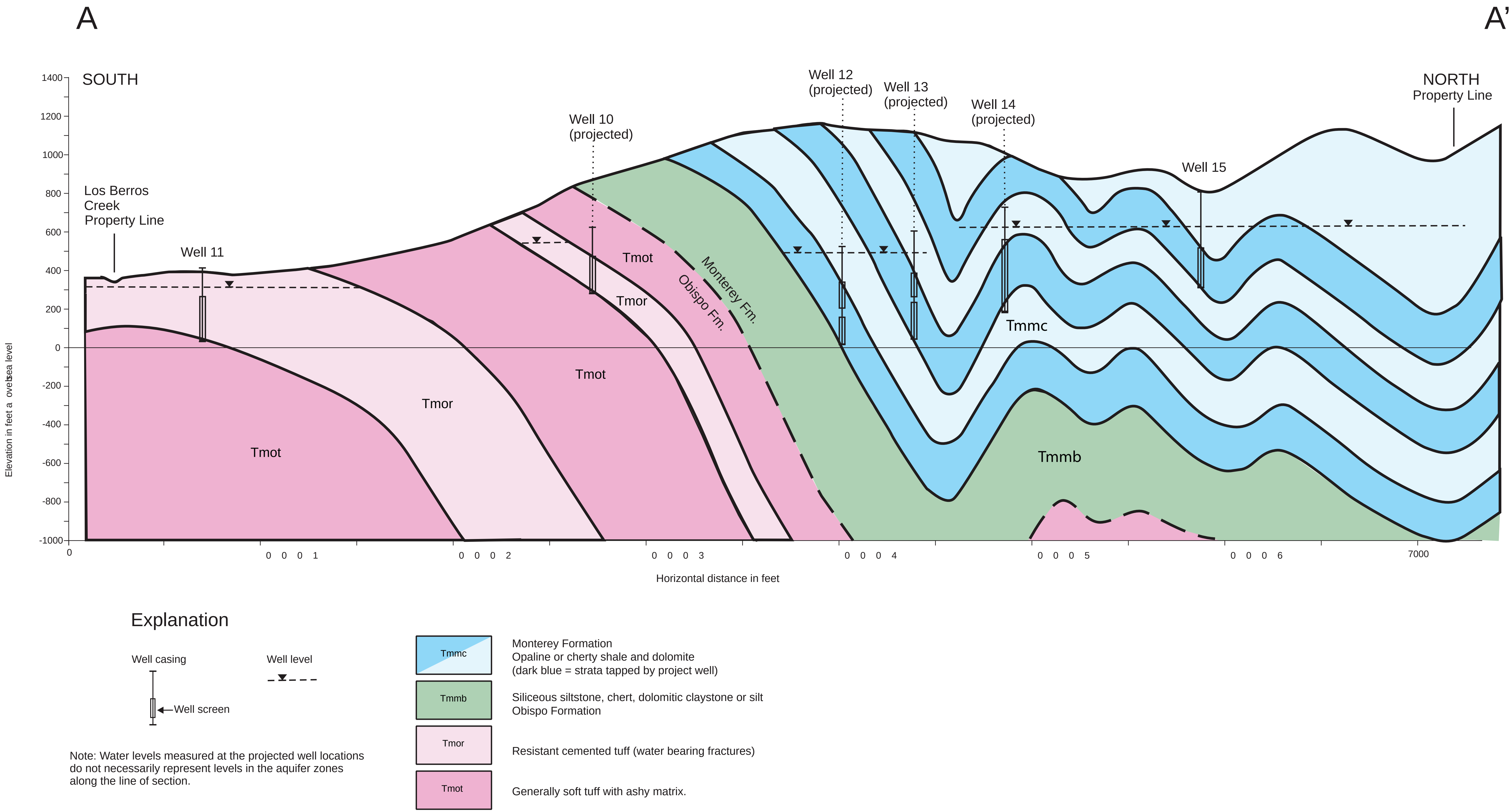
Figure 7



Adapted from Figure 3, CHG, July 2010

Geologic Cross-Section A-A'
Review of Well Testing and Sustainable Yield Assessment
Proposed Laetitia Agricultural Cluster Subdivision
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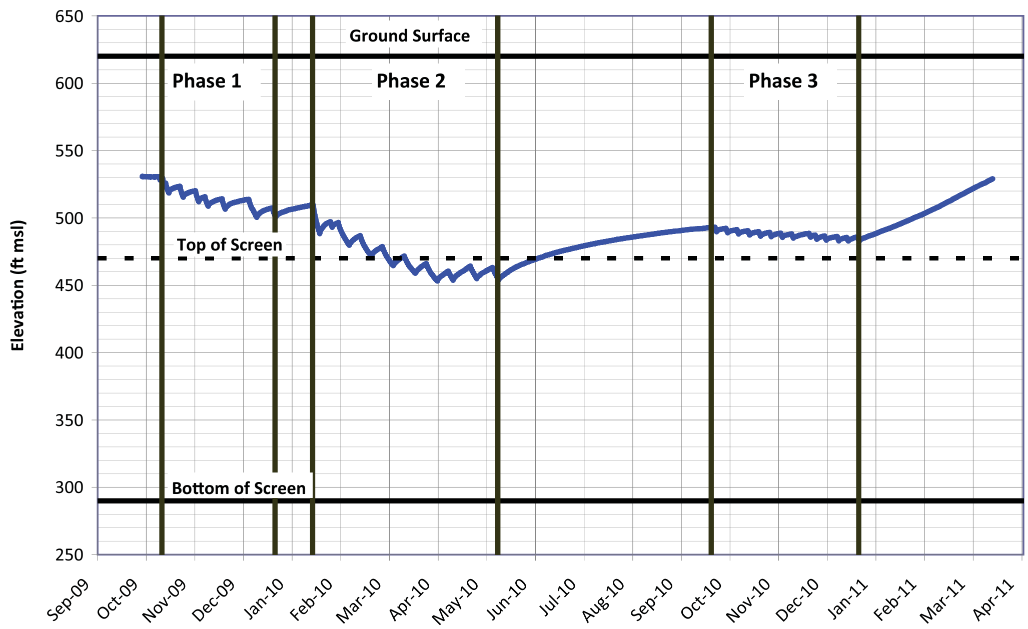
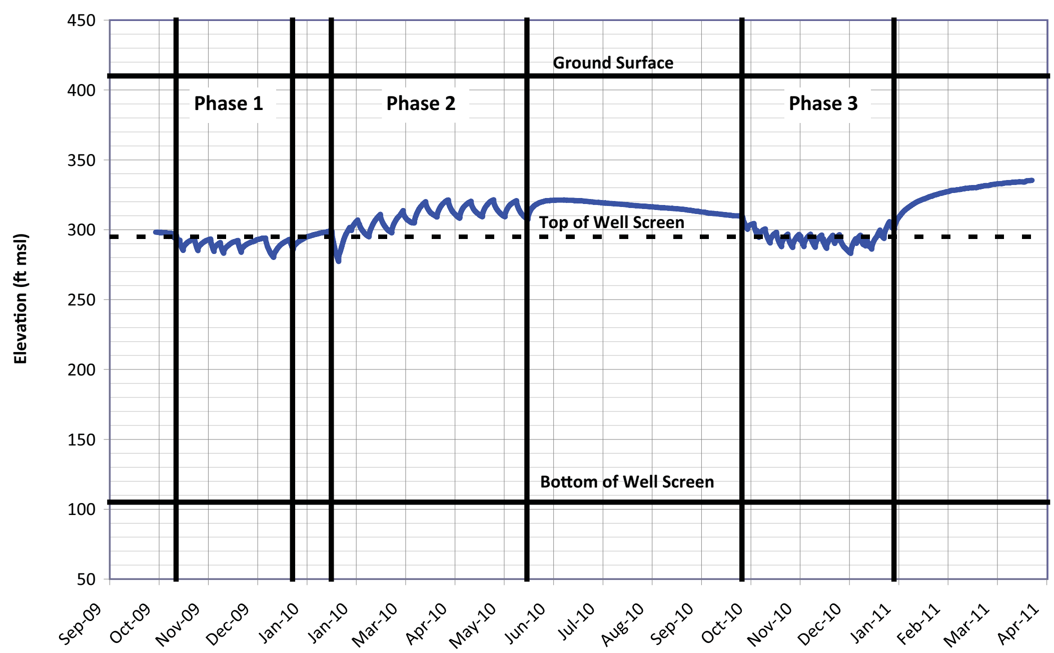
Figure 8

P:\GIS\Latetia\AI\2011Apr\CrossSectionA.ai

Hydrograph for Well 10



Hydrograph for Well 11



Hydrographs for Wells 10 and 11
Review of Well Testing and Sustainable Yield Assessment
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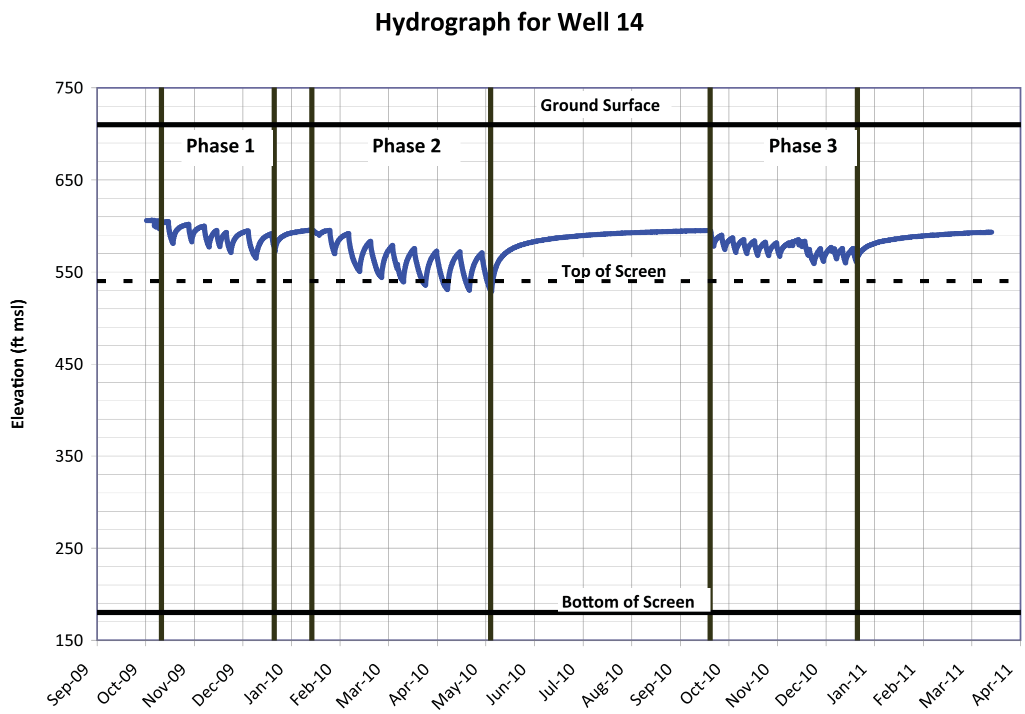
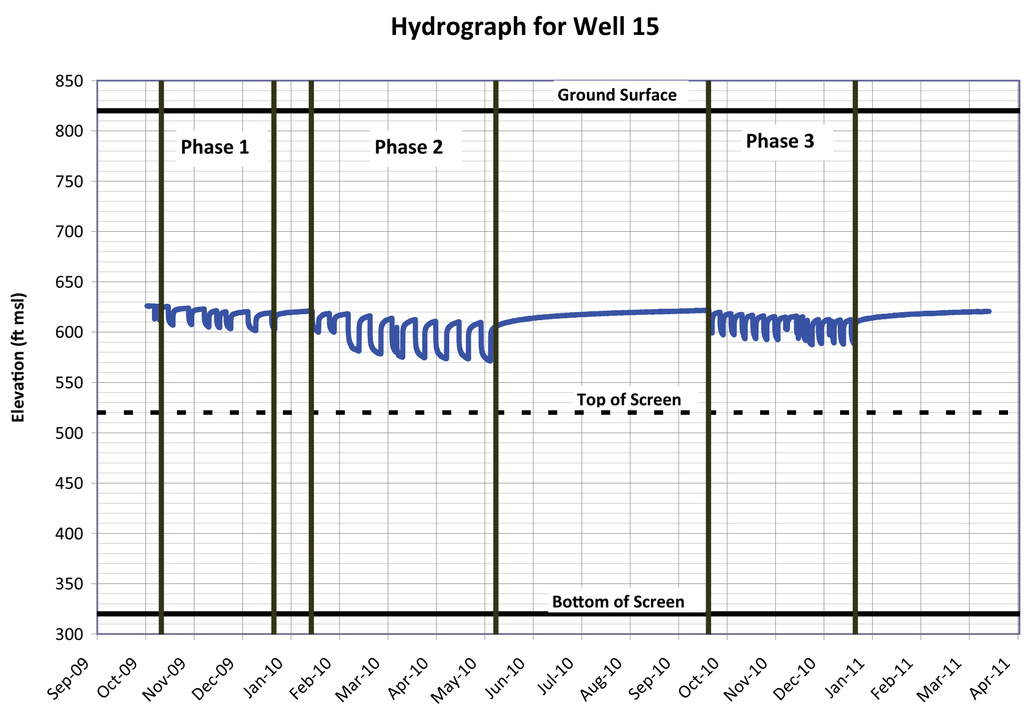
Figure 9

P:\GIS\Latetia\AI\2011Apr\Hydrographs10_11.ai





Hydrographs for Wells 14 and 15
Review of Well Testing and Sustainable Yield Assessment
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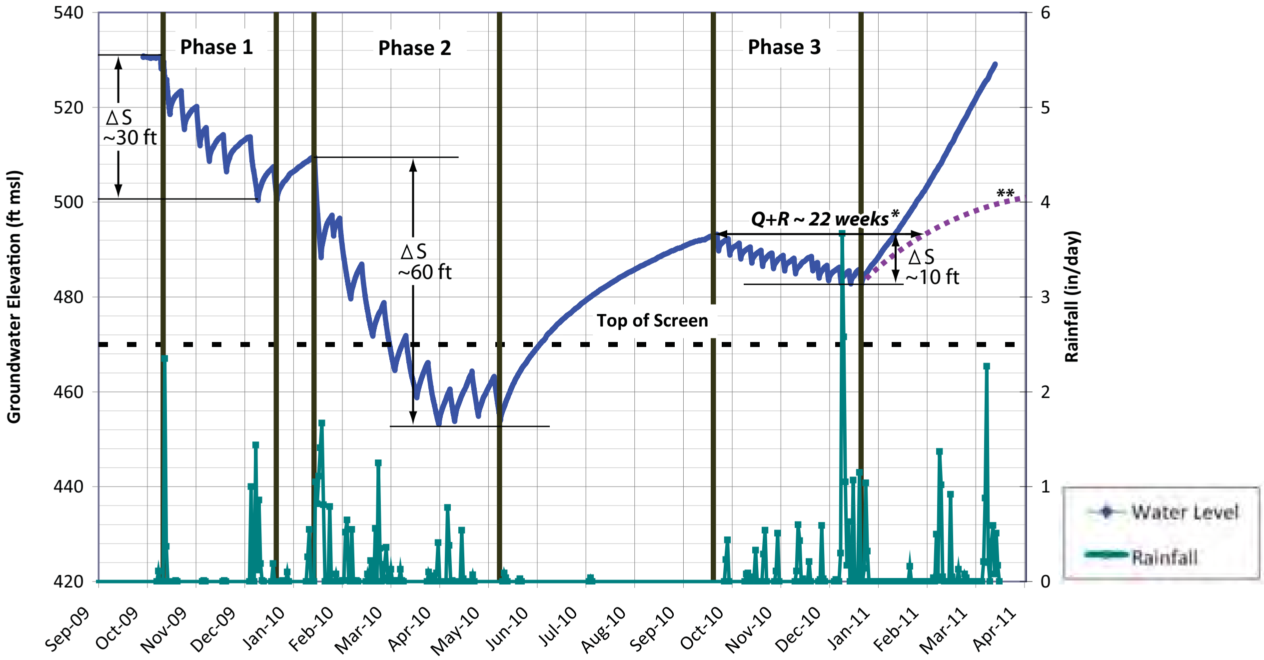
Figure **10**

P:\GIS\Latetia\AI\2011Apr\Hydrographs14_15.ai

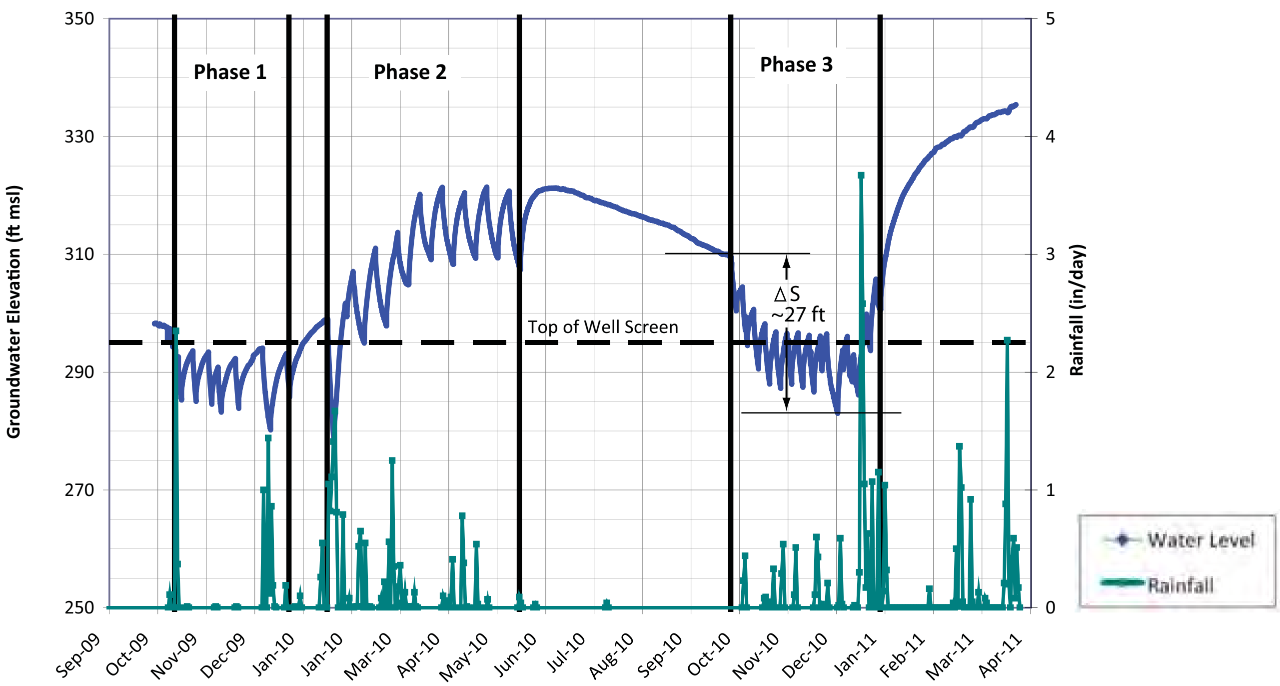
Hydrograph for Well 10



* Phase 3 Qeq = (2.75 AF/22 wks)(52 wks/yr) = 6.5 AF/Y = 4.0 gpm

** The rapid rise in water level in Well 10 after Phase 3 pumping appears related to period of abundant rainfall. Recovery after Phase 2 pumping is likely more typical. Accordingly, the sketched recovery curve after the Phase 3 pumping was used for the equilibrium pumping calculation instead of the rapid recovery.

Hydrograph for Well 11

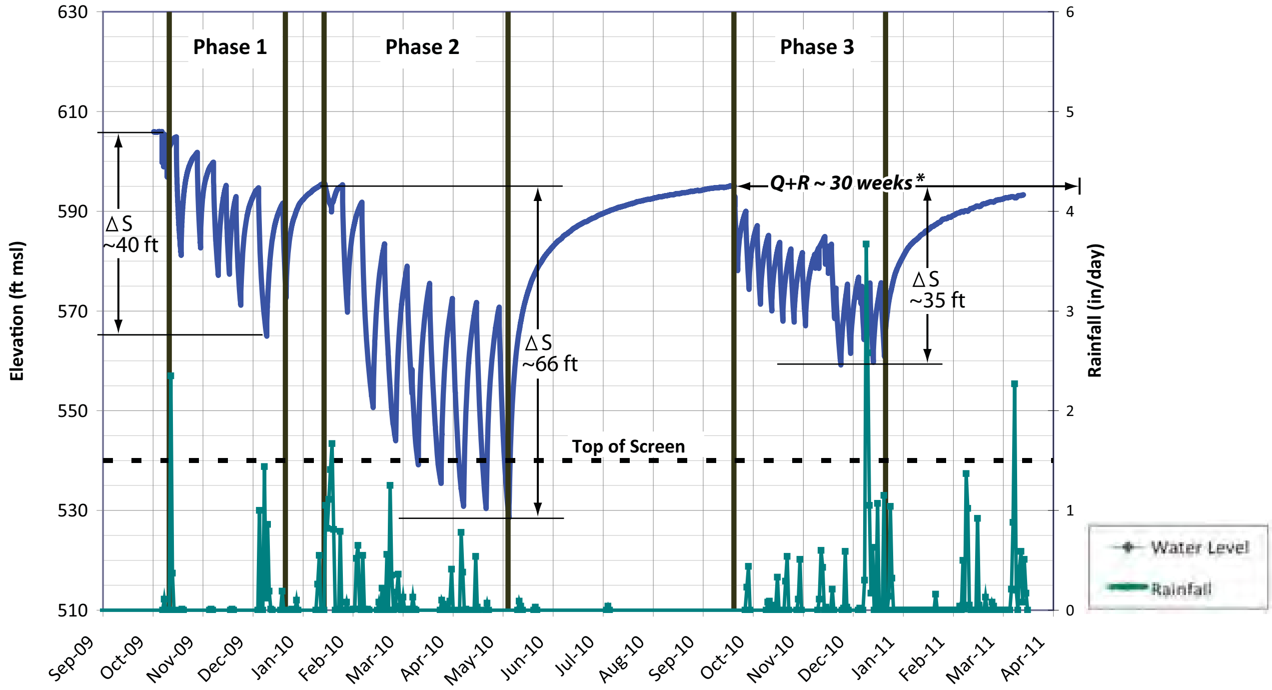


* Qeq not calculated for Well 11 because the prominent recharge that occurs at this well is independent of pumping and complicates interpretation of the aquifer response to pumping.

Detailed-Scale Hydrographs for Wells 10 and 11 Review of Well Testing and Sustainable Yield Assessment Proposed Laetitia Agricultural Cluster Subdivision San Luis Obispo, California	Geosyntec consultants Oakland — May 2011	Figure **11**

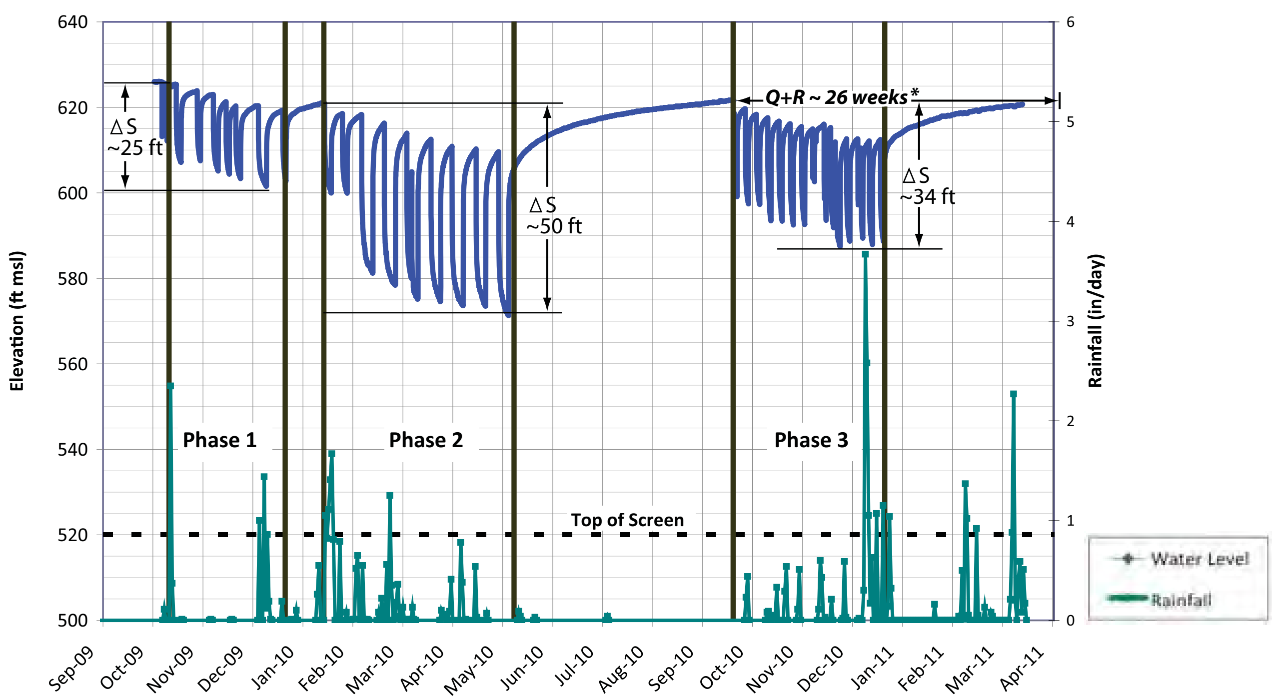
P:\GIS\Latetia\AI\2011Apr\HydroDetail10_11.ai

Hydrograph for Well 14



* Phase 3 Q_{eq} = (5.23 AF/30 wks)(52 wks/yr) = 9.1 AF/Y = 5.6 gpm

Hydrograph for Well 15



* Phase 3 Q_{eq} = (5.48 AF/26 wks)(52 wks/yr) = 11.0 AF/Y = 6.8 gpm

Detailed-Scale Hydrographs for Wells 14 and 15
Review of Well Testing and Sustainable Yield Assessment
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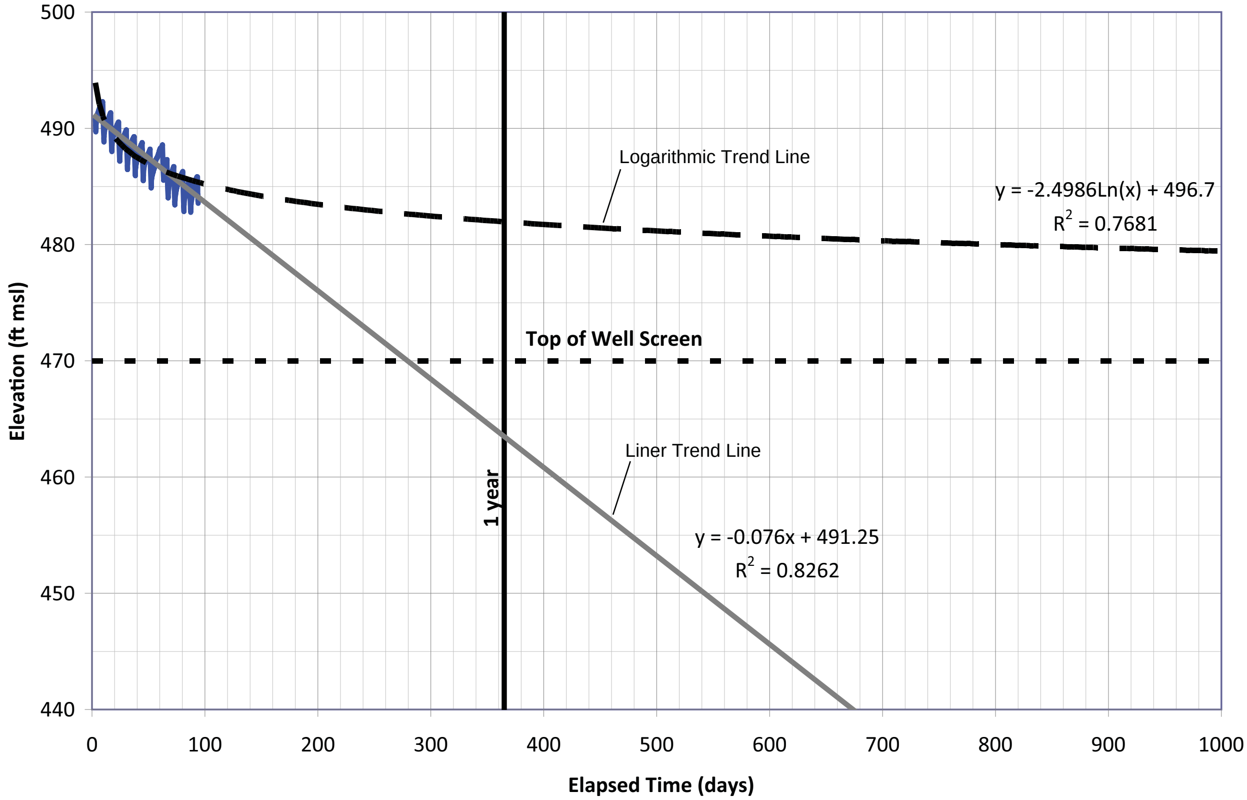
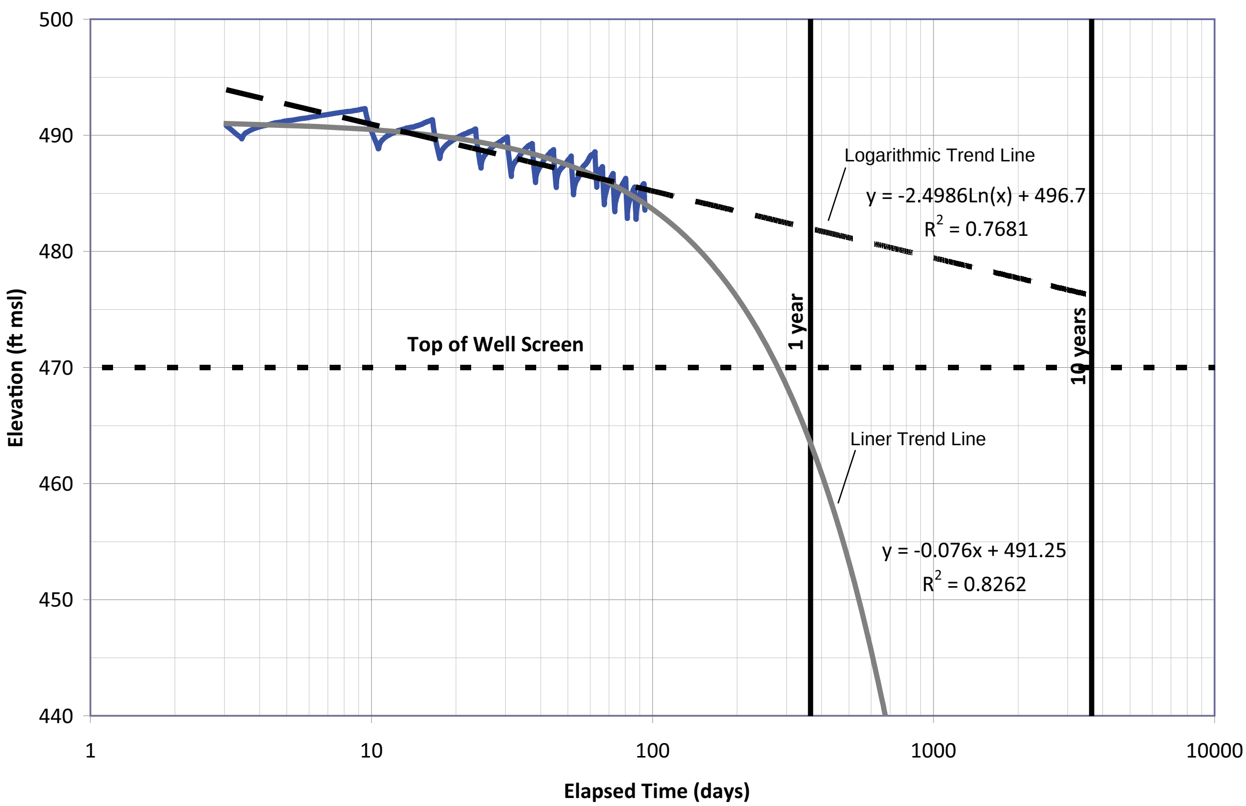
Figure 12

P:\GIS\Latetia\AI\2011Apr\HydroDetail14_15.ai





Logarithmic Trend Line   Liner Trend Line

Note: Lower graph uses logarithmic scale for elapsed time (X axis) to facilitate illustration of recorded data and projection of trends more than 10 years into the future.

Trend Analysis of Phase 3 Data and Projected Water Levels for Well 10

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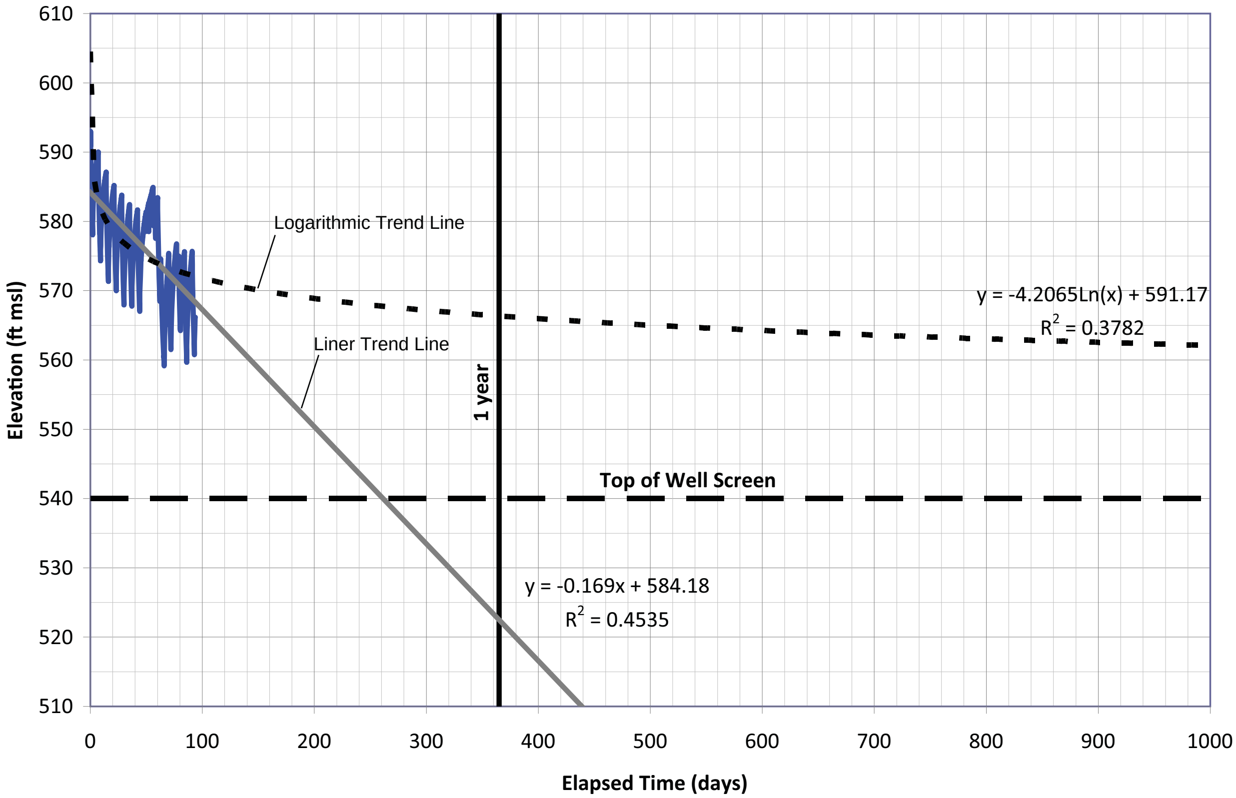
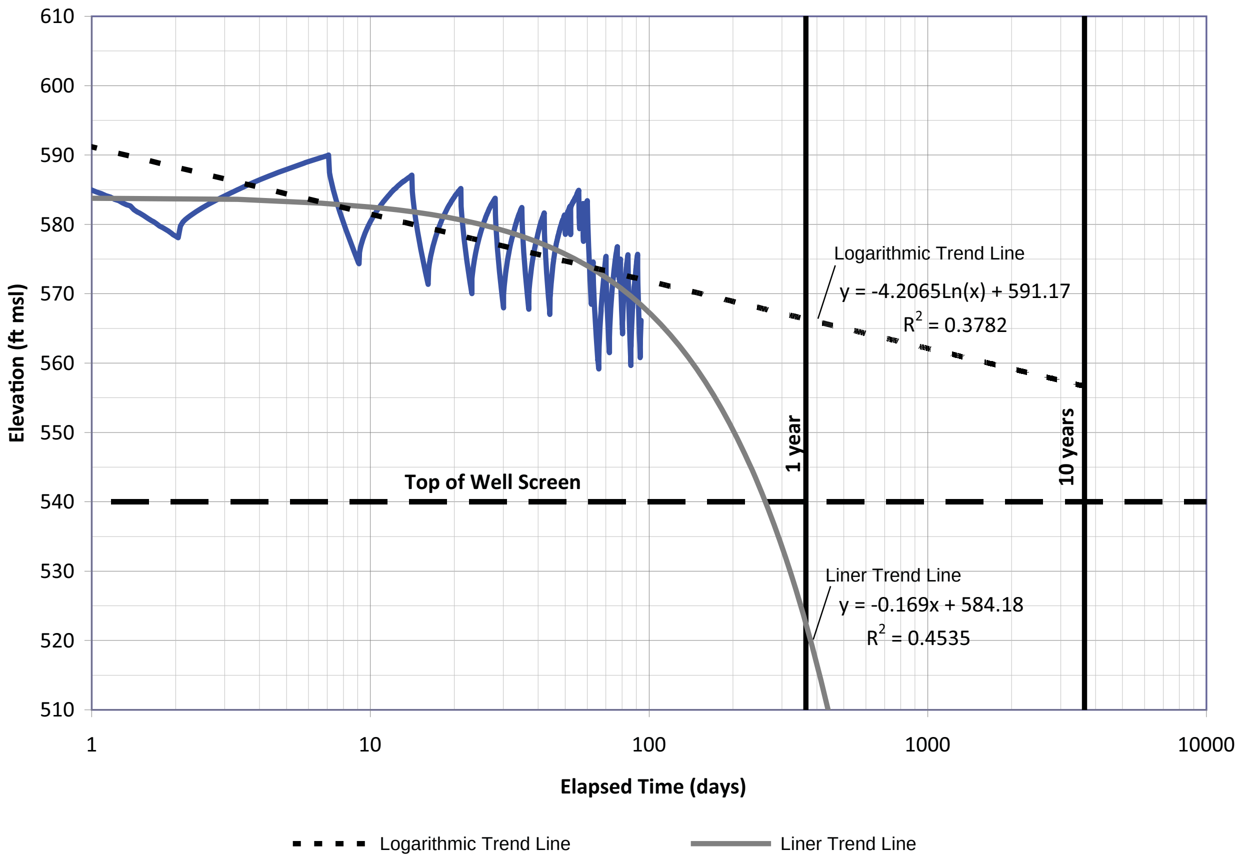
Figure **13**

P:\GIS\Latetia\AI\2011Apr\Trend10.ai





Note: Lower graph uses logarithmic scale for elapsed time (X axis) to facilitate illustration of recorded data and projection of trends more than 10 years into the future.

Trend Analysis of Phase 3 Data and Projected Water Levels for Well 14

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Proposed Laetitia Agricultural Cluster Subdivision
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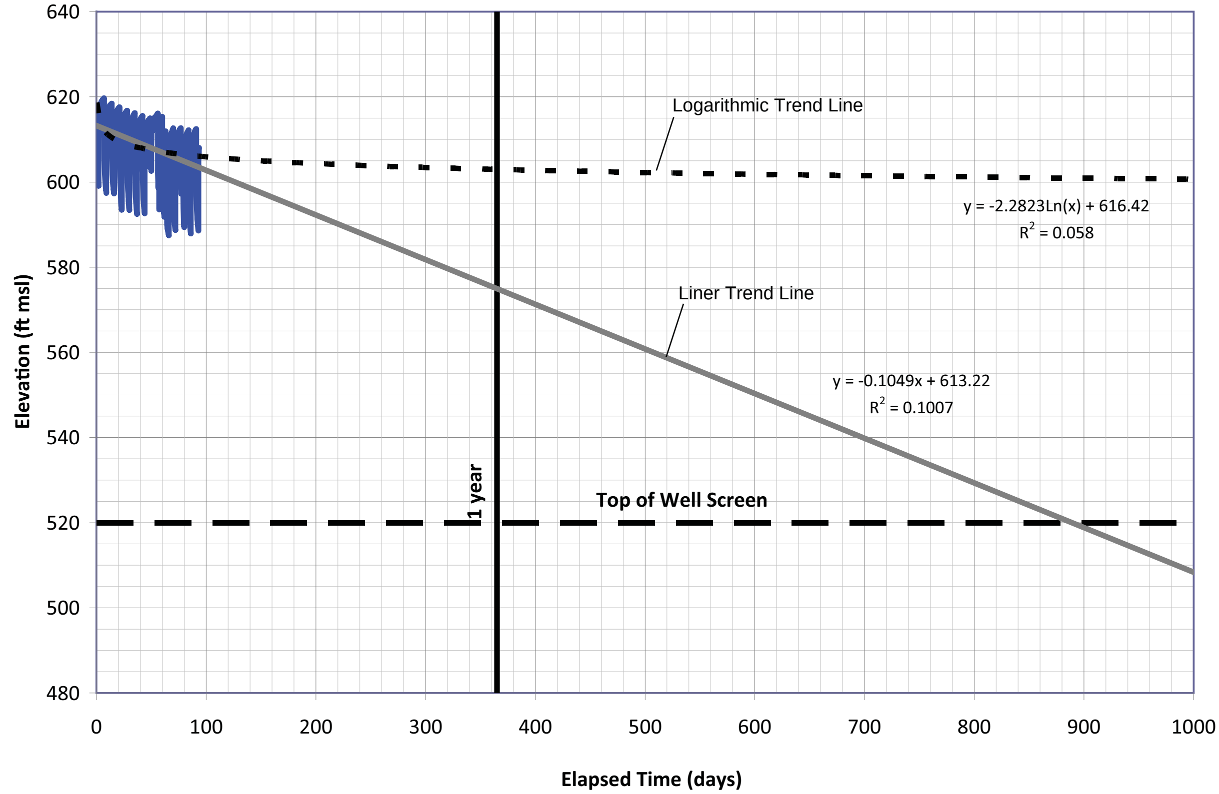
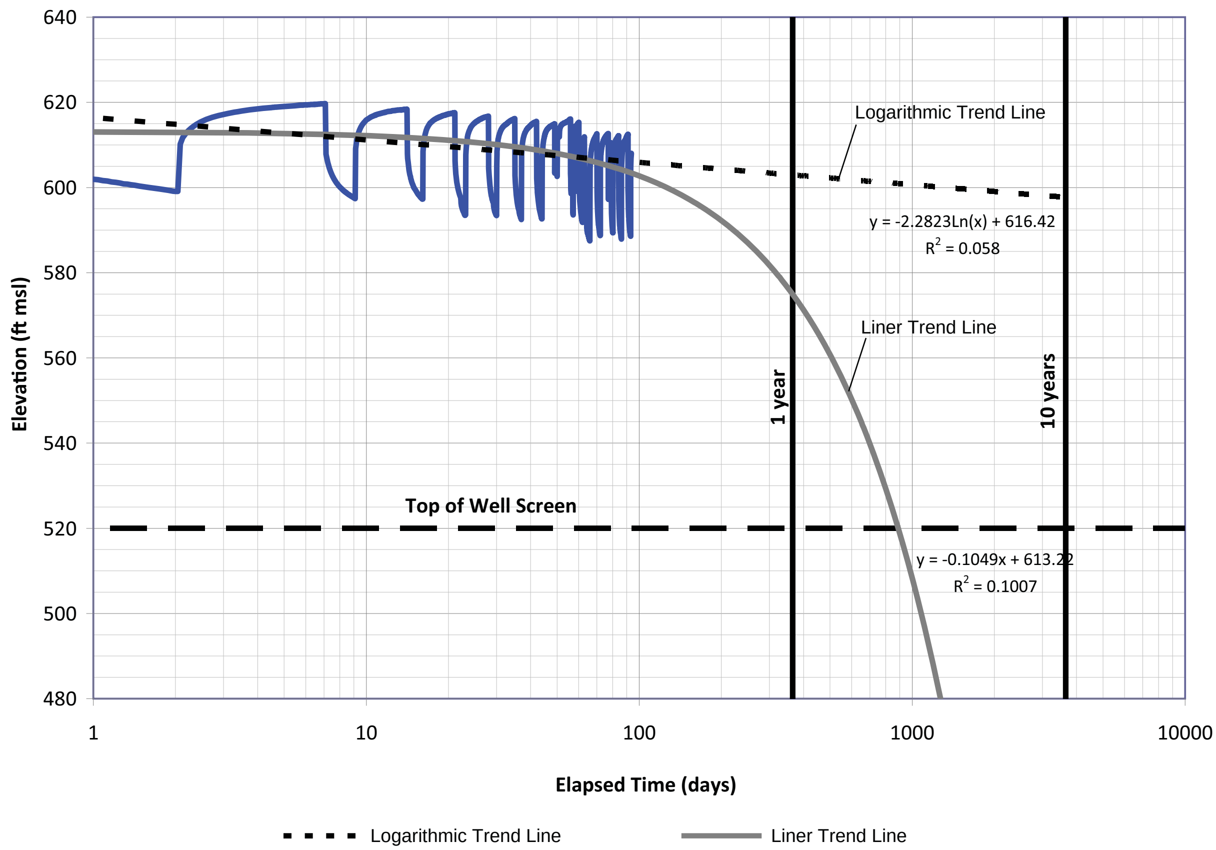
Figure 14

P:\GIS\Latetia\AI\2011Apr\Trend14.ai

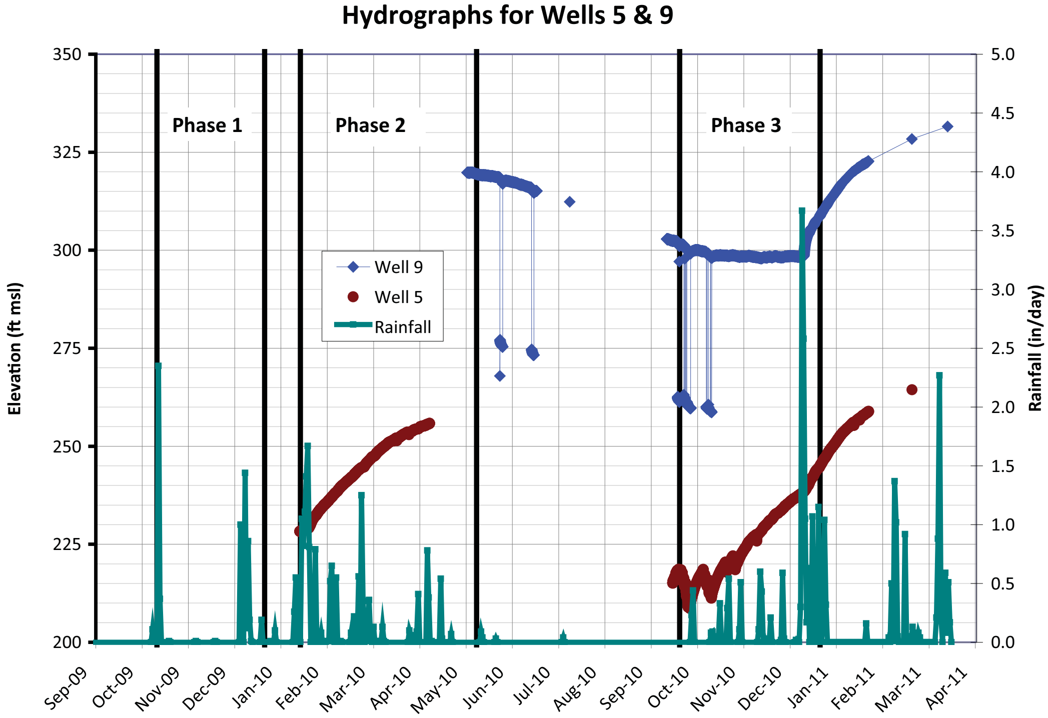


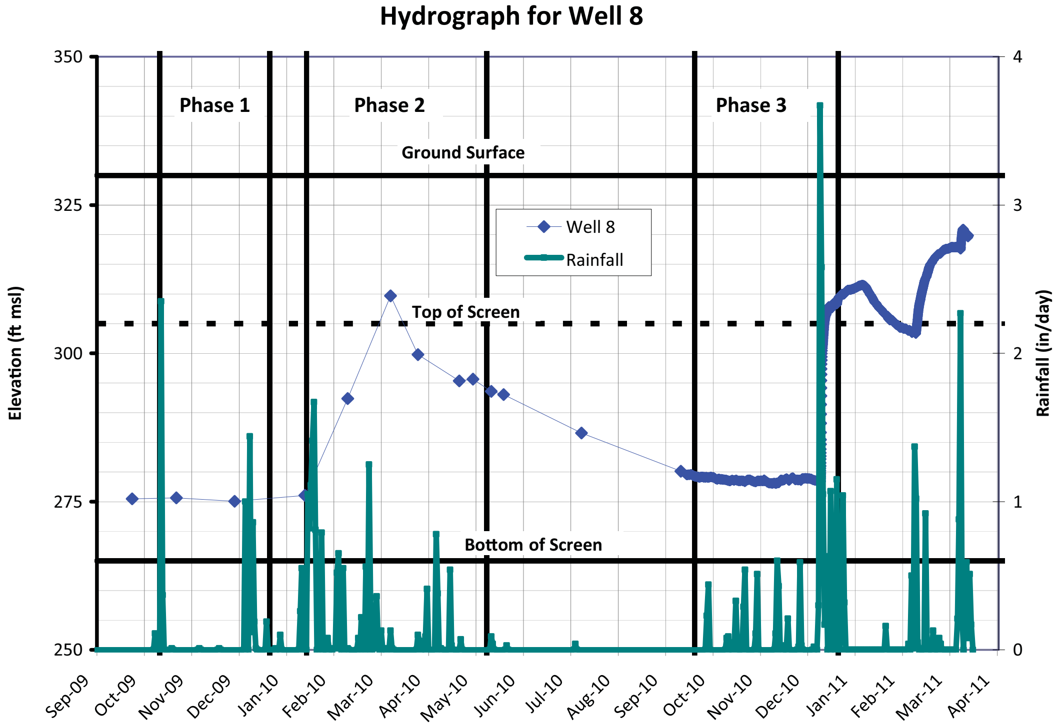


Note: Lower graph uses logarithmic scale for elapsed time (X axis) to facilitate illustration of recorded data and projection of trends more than 10 years into the future.

Trend Analysis of Phase 3 Data and Projected Water Levels for Well 15 Review of Well Testing and Sustainable Yield Assessment Proposed Laetitia Agricultural Cluster Subdivision San Luis Obispo, California	Geosyntec consultants Oakland | May 2011	Figure **15**

P:\GIS\Latetia\AI\2011Apr\Trend15.ai





Notes:
Well 5 (F.V. Wells #1) and Well 9 (F&T #1) are irrigation wells completed in the Obispo Tuff.
Well 8 (Enloe #1) is a shallow well adjacent to Los Berros Creek.
See Table 1 for additional Well Information.

Hydrographs for Wells 5, 8, and 9 Review of Well Testing and Sustainable Yield Assessment Proposed Laetitia Agricultural Cluster Subdivision San Luis Obispo, California	Geosyntec consultants		Figure **16**
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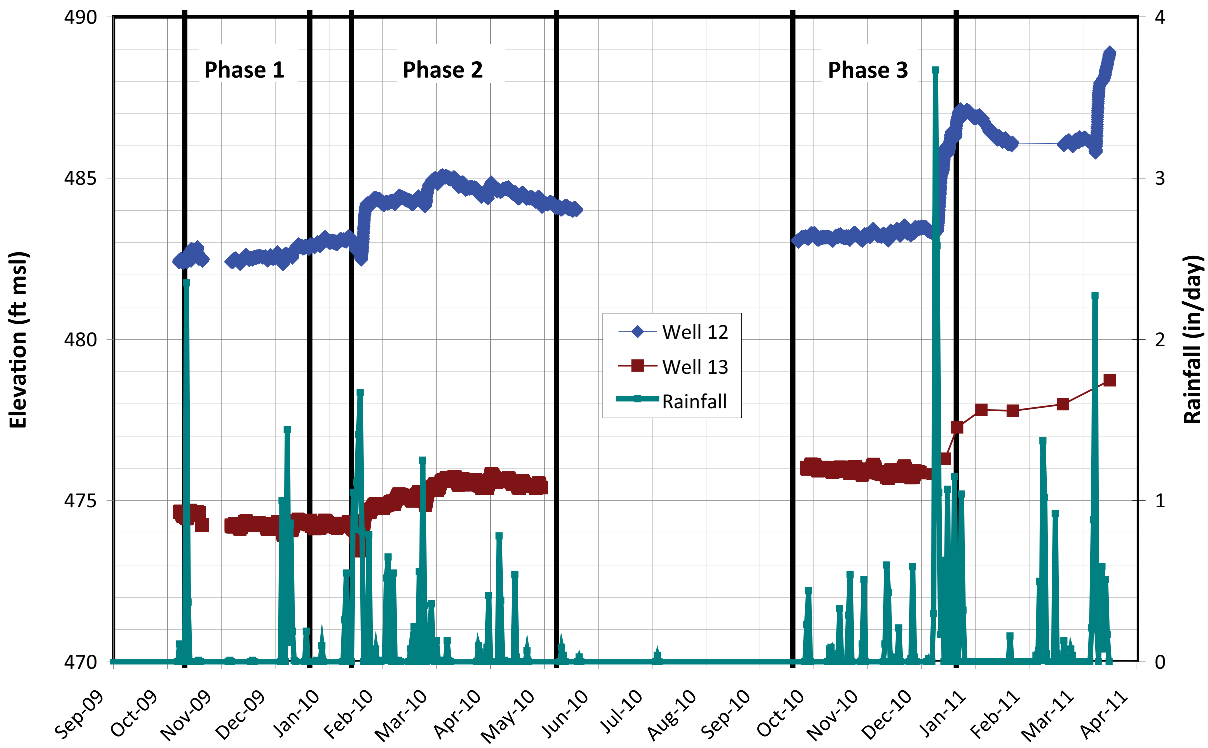
P:\GIS\Latetia\AI\2011Apr\Hydrographs5_8_9.ai



Notes:

Wells 12 and 13 are completed in the Monterey Formation close to Los Berros Creek.

Hydrographs for Wells 12 and 13

Review of Well Testing and Sustainable Yield Assessment
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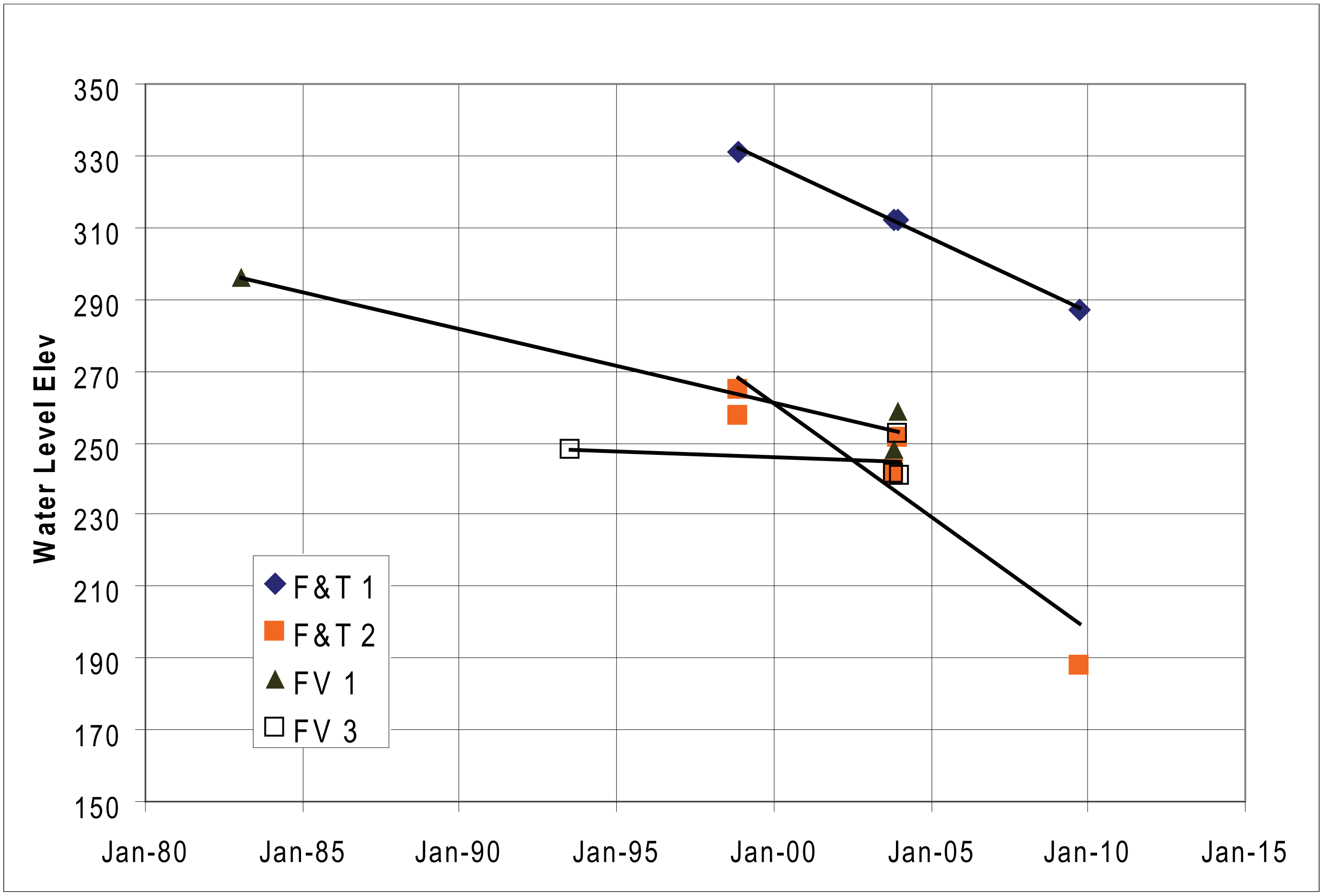
Figure **17**

P:\GIS\Latetia\AI\2011Apr\Hydrographs12_13.ai



Notes:
Data from Table 4 of C&A, Jan 2004

Groundwater Elevation Data for Four Laetitia Irrigation Wells

Review of Well Testing and Sustainable Yield Assessment
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Figure **18**

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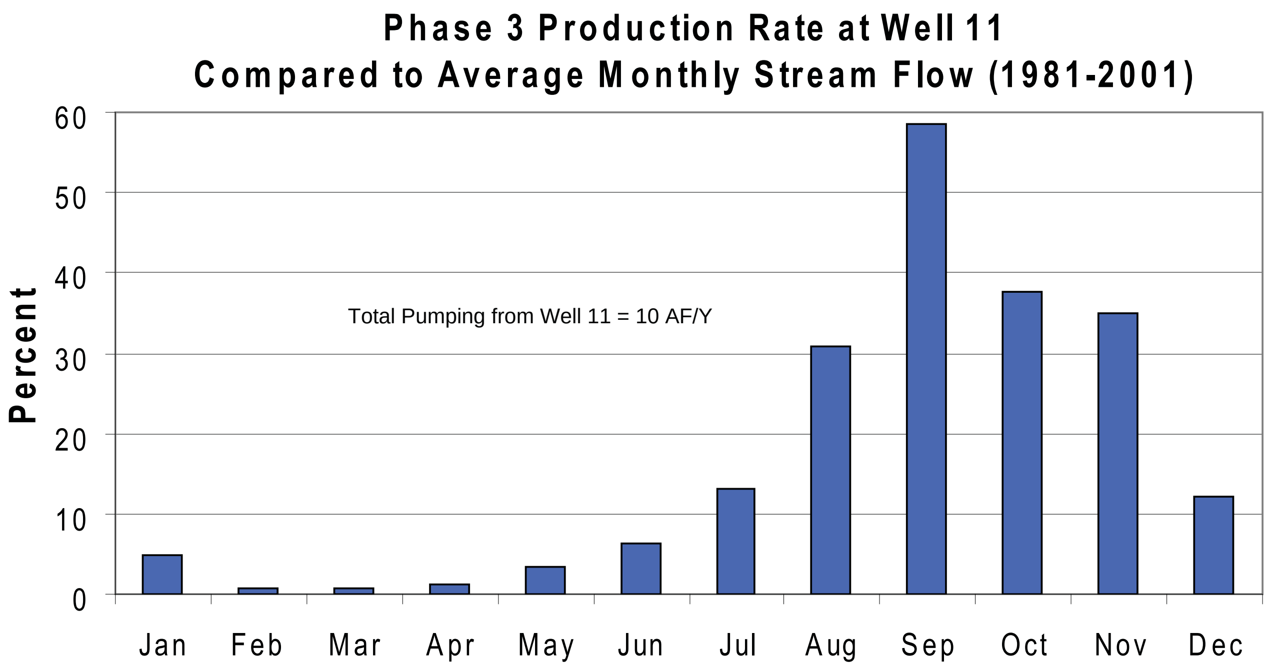
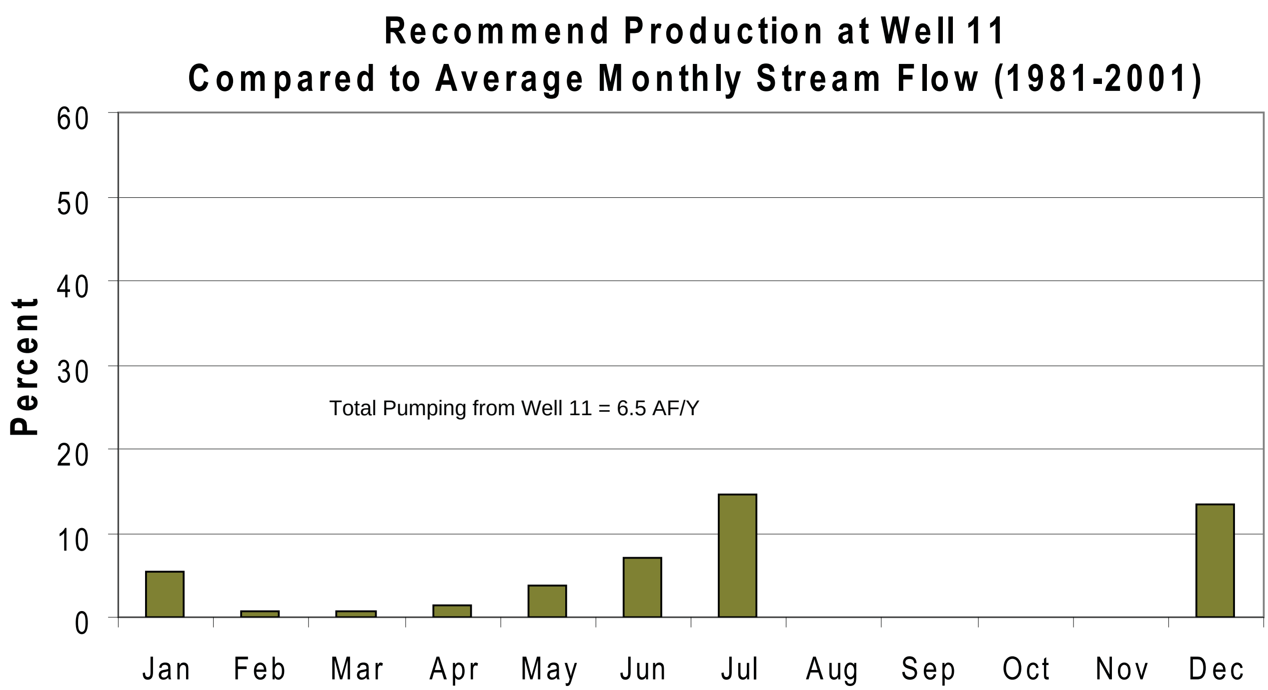
19a



19b



Notes:
Curtailment of pumping from Well 11 from August through November is recommended to help preserve base flow in Los Berros Creek.

Proposed Pumping at Well 11 Compared to Average Monthly Flow in Los Berros Creek

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Figure **19**

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