2007 ADDENDUM TO HYDROGEOLOGIC INVESTIGATION AND CONCEPTUAL SITE MODEL WITHIN THE LOWER REACH OF THE BIG SUR RIVER

El Sur Ranch
Big Sur, California

01-ESR-004

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1.0 INTRODUCTION

1.1 Purpose and Goals

The purpose of this report (2007 Report) is to further expand on the understanding of the relationship between the pumping of the two El Sur Ranch (ESR) irrigation wells and the effects that pumping has on both the volume of flow in the Big Sur River (River) and the quality of the water in the River. Information regarding the Big Sur River Valley setting, geology, and hydrogeology, along with a refined hydrogeologic conceptual model can be found in The Source Group, Inc. (SGI) report titled *Hydrogeologic Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River* (2004 Report), May 2005. Specific information regarding the pumping area of influence, streambed hydraulic conductivity, River responses to pumping, saline wedge movement, and detailed water availability analysis and water quality analysis can be found in the SGI report titled *Addendum to Hydrogeologic Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River* (2006 Report), March 2007. This report does not specifically provide a synopsis of the information contained in the 2004 Report and 2006 Report, and thus should only be read with the knowledge of the previous reports in hand.

The nature of the relationship between irrigation well pumping and aspects of River water quality and flow is most important during a year experiencing 'critically dry' River flow conditions (see Appendix A for an explanation of the various River flow conditions). River conditions are presumed to be most vulnerable during 'critically dry' flow conditions due to the expected low River flow volumes and are thus are more likely to be affected by irrigation well pumping. Based on the results detailed in the 2004 Report and the 2006 Report, several hypotheses were formed regarding the nature of the relationship between irrigation well pumping and aspects of River water quality and flow during a year with 'critically dry' River flow. These hypotheses include:

Hypothesis 1:

The stretch of River that can be influenced by irrigation well pumping was identified and defined during the 2006 Study. When compared to the upstream inflow volume entering this stretch, the downstream outflow volume was greater during the absence of pumping. This is due to the upwelling of groundwater within the influent stretch adding to the overall flow volume of the River. Irrigation well pumping (New Well in particular) has the effect of reducing the amount of flow gained by the River, primarily by intercepting groundwater that would have otherwise upwelled into the River, but does not reduce the flow to the point such that the downstream outflow volume is less than the upstream inflow volume.

Hypothesis 2:

The temperature of the water flowing in the River is generally higher than groundwater temperature. Pumping intercepts some of the colder groundwater before it can mix with the water in the River. Thus, irrigation well pumping can reduce the cooling effect groundwater has on River water temperatures within the zone of influence.

Hypothesis 3:

The water flowing in the River is relatively high in dissolved oxygen content while groundwater is relatively low in dissolved oxygen. Pumping has the effect of intercepting low dissolved oxygen groundwater before it can mix with the water in the River. Thus, irrigation well pumping may help maintain higher levels of dissolved oxygen in the River.

As River flow conditions during the 2007 Study were considered 'critically dry', the validity of each of the hypotheses could be determined though data collected and subsequent analysis. The analytical results are detailed within this 2007 Report and the validity of each hypothesis is addressed.

This report also expands on the water availability analysis outlined in the 2006 Report. The data to complete the analysis were taken from a 'wet' River flow condition year (2006) and a 'dry' River flow condition year (2004). The data collected for this study cover River flow conditions that occured during a year with 'critically dry' River flow conditions, and thus expands the previous water availability analysis to provide coverage for three different River flow types.

The work performed for the 2007 Report (2007 Study) was based upon the June 20, 2007 Technical Memorandum titled *El Sur Ranch - Hydrogeologic Workplan Elements for Proposed 2007 Data Collection Program* (2007 Data Collection Program) (Appendix B). The 2007 Study was carried out in cooperation with the biological consulting firm Hanson Environmental (Hanson).

1.2 Previous Work

Much of the general information regarding the ESR Study Area, including climate, regional geology and hydrogeology, details of local geology, aquifer characteristics, general River hydrology, and previous site investigations were covered in detail within the 2004 Report. The 2004 Report described the methods, results and conclusions of the 2004 investigation of the Big Sur River Study Area (2004 Study). The 2006 Report covered specific information regarding the stretch of River nearest to the ESR pumping wells, including pumping stabilization, pumping effects on the exchange of water between the River and the underlying aquifer, pumping effects on water quality, pumping effects on saltwater intrusion and pumping effects on Creamery Meadow. The 2006 Report described the methods, results, and conclusions derived from the 2006 investigation of the Big Sur River Study Area (2006 Study). This 2007

Report expands on the work and studies reported in the 2004 Report and the 2006 Report. However, it is also an independent report and some of its findings and conclusions are different than the results and conclusions reached in previous reports.

1.3 Study Area

During the 2004 Study, the Study Area (2004 Study Area) was defined as an approximately one-mile stretch of the Big Sur River terminating at the Pacific Ocean and includes the land area that contributes groundwater and surface water flow into and out of that stretch of River (Figure 1-1). For the 2006 Study, the majority of the work was focused around a 2,000-foot stretch of the lower Big Sur River bounded downstream by the upper lagoon and upstream by the 'deep pool' area (former location of the 2004 Study's 'Temperature Logger #3' data collection point). It is along this section that the alignment of the River changes from running approximately parallel to the direction of Creamery Meadow groundwater flow to approximately perpendicular to the Creamery Meadow groundwater flow direction. This 2,000-foot stretch of the River constitutes both the 2006 Study Area and the 2007 Study Area. See Figure 1-2 for details of the 2007 Study Area.

1.4 Methods of Investigation

This section summarizes the activities that were conducted as part of the 2007 Study. The entire field portion of the project, including equipment installation, data collection and equipment removal occurred between August 27 and October 17, 2007. Further information regarding details and methodologies used to complete the activities summarized below are provided in Section 2.0.

The methods of investigation included a combination of direct field measurements from within the 2007 Study Area and acquisition of data generated by the United States Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA). A renewal of the Permit to Conduct Biological, Geological, or Soil Investigation/Collections for this work was approved by the Department of Parks and Recreation and can be found in Appendix C. Investigation activities included the following:

- Ten pairs of piezometers were installed in the bed of the River at seven locations within the Study Area. Each pair consisted of a deep and shallow piezometer equipped with a data logging transducer that allowed continuous recording of water pressure (which is translated into water level elevation) and temperature data. The water level elevation difference between each piezometer pair specified the magnitude of the groundwater flow gradient into or out of the River at the piezometer pair location.
- Three temporary gauging stations were established on the River for the 2007 Study. The first, VT1, was established on the River up-gradient from the 2007 Study Area to periodically measure River water velocity and overall flow. The second, VT2, was established at the downstream end

of what was identified in the 2006 Report as 'Zone 2' (coincident with passage transect 4). The third, VT3, was established at the upstream end of what was identified in the 2006 Report as 'Zone 4' (coincident with passage transect 9). Data from these gauging stations were correlated with continuously recording water level data from an adjacent stilling well or piezometer to achieve a continuous record of River flow both entering the Study Area and within the Study Area.

- Continuous monitoring and recording of River water dissolved oxygen (DO) content was established at eight locations within the 2007 Study Area. Specifically, DO sensors were installed within eight of the ten shallow piezometer locations described above, including P2, P3, P4, P4u, and P5. The data were used to assess interactions between surface water and groundwater.
- Continuous groundwater elevation and temperature data were monitored and recorded from nine groundwater monitoring wells within the Study Area. The data were used to assess water level fluctuations, diurnal events and degree of connection between groundwater and surface water.
- Contemporaneous manual water level measurements were routinely collected from eleven wells within the 2007 Study Area.
- Water quality parameter data, including DO, temperature, and electroconductivity (EC) were collected using handheld field instruments from both groundwater and River water periodically during this investigation. These data were used to describe the general water quality and to characterize significant conductivity and temperature differences between groundwater, surface water and ocean water.
- All of the monitoring wells, piezometer locations, velocity transects, and the stilling well used for data collection were surveyed by a licensed surveyor. The survey data were used in the construction of the potentiometric surface maps and for accurately placing the measurement locations on a base map.
- Relevant public domain data was acquired from other entities.

2.0 WORK PERFORMED

2.1 Field Reconnaissance

On August 2, 2007, a detailed field reconnaissance was conducted along the 2,000-foot section of the lower Big Sur River bounded downstream by the upper lagoon and upstream by the 'deep pool' area (i.e., the 2007 Study Area). The survey was conducted by walking and inspecting this stretch of the River, which allowed for the accurate location of transects, piezometers, sensors, and other equipment as outlined in the 2007 Data Collection Program.

2.2 Monitoring Station Installation

The installation of monitoring equipment at various locations was conducted over the period of August 27 to August 31 based on the requirements of the 2007 Data Collection Program. The surveyed locations of all monitoring stations are depicted on Figure 2-1. See Appendix D for photos of select installed equipment. Note that all station identification information assumes a frame of reference looking upstream (i.e., station identification numbers count upward going upstream and reference a river bank (left or right) relative to looking upstream). The following sections present the details of station installations.

2.2.1 Monitoring Well Water Level Transducers

During the 2007 Study, Global Water™ model WL16 data logging pressure/temperature transducers were installed in nine groundwater wells located within the Study Area, recording both water temperature and groundwater elevation (water pressure) on an hourly basis. Each transducer was factory calibrated prior to installation. The nine wells fitted with WL16 transducers included ESR-01, ESR-02, ESR-03, JSA-03, JSA-04, the Original Old Well, and the triple nested well cluster ESR-10A, ESR-10B, and ESR-10C. The locations of the groundwater wells are shown on Figure 2-1.

2.2.2 Passage Transects

Eleven passage transects were installed along the River within the 2007 Study Area as part of Hanson Environmental's scope of work. They were labeled Passage Transect 1 through 11 (PT1 – PT11) starting at the downstream end of the 2007 Study Area and working upstream (Figure 2-1). Aside from minor variations, each passage transect was coincident with the eleven passage transects used in the 2006 Study. Each passage transect consisted of a pair of rebar markers installed on opposite banks of the River. On a weekly basis, the depth profile was measured at each passage transect by recording the depth of the River from bank to bank in half-foot increments. This was accomplished by stretching a measuring tape across the River between each pair of rebar markers. At every half-foot interval between the markers, the depth of the River was measured using a graduated pole. From the resulting data, the cross-sectional area of River surface water flow at each location was calculated. The locations of the 11 passage transects are shown on Figure 2-1

2.2.3 Gauging Stations

Three temporary gauging stations were set up to monitor the flow of the River both upstream from and within the 2007 Study Area. The first gauging station was set up several hundred feet downstream of the Andrew Molera State Park parking lot, at the same location as the upstream velocity gauging station that was installed during the 2004 Study (identified as Velocity Transect 1) and 2006 Study (identified as VT1). For the purposes of this report, the temporary gauging station will continue to be identified as Velocity Transect 1 (VT1). The second gauging station, identified as VT2, was installed coincident with passage transect 4. This location was chosen as it was identified in the 2006 Study as the downstream end of the section of River affected by the pumping of the ESR irrigation wells. The third gauging station, VT3, was installed coincident with passage transect 9. This location was identified in the 2006 Study as near the upstream end of the section of River influenced by the pumping of the ESR irrigation wells. See Figure 2-1 for the locations of the three gauging stations.

Each gauging station consisted of two rebar markers located on opposite banks of the river. To measure River flow, a measuring tape was attached to the rebar markers and stretched across the River. Along this tape, water velocity was measured and recorded at half-foot increments using a portable flow meter. Using the aggregate results of all the water velocity measurements, overall River flow was calculated.

2.2.4 Stilling Well

At the VT1 gauging station location, a stilling well equipped with a pressure/temperature data logging transducer was installed to monitor and record River water level (pressure) and temperature. When correlated with the measured River flow data, the water level data provided an hourly record of River flow throughout the 2007 Study.

The stilling well near the VT1 was constructed using 3-feet of 2-inch inside diameter Schedule 40 PVC well casing connected to 5-feet of 0.020-inch machine slotted flush threaded Schedule 40 PVC well screen. The angle of the joint between the casing and the screen was 90-degrees. The well casing was oriented vertically and buried in the right bank of the River. The slotted section of the well was embedded several inches into the River bed, oriented parallel to the River surface approximately 1-foot underwater. An In-Situ Level Troll 500 pressure/temperature data logging transducer was installed in the stilling well which measured and recorded water elevation (pressure) and water temperature hourly. See Figure 2-1 for the location of the VT1 stilling well and Figure 2-2 for a cut-away view of the VT1 stilling well.

2.2.5 Piezometer Well Pairs

A total of ten piezometer well pairs were installed at seven different locations within the 2007 Study Area as shown on Figure 2-1. Each pair consisted of a shallow piezometer (installed in the River with little to no penetration into the riverbed) and a deep piezometer (installed 36-inches into the riverbed). The piezometers are identified by which of the seven locations they were installed at (P1 through P4, P4u, P5, and P6), which bank of the River they were closest to (left [L] or right [R]), and if they were installed shallow or deep (S or D) (e.g., the deep piezometer located near the right bank of the River at the P3 location is identified as P3RD). Each piezometer was equipped with an In-Situ™ Level Troll 500 which measured and recorded water level elevation (pressure) and temperature every hour.

Data from each piezometer pair was designed to yield a continuous record of the vertical hydraulic gradient at each of the ten locations throughout the 2007 Study. Vertical hydraulic gradient is the difference in water levels over the vertical distance between the measurement points. The piezometers were installed specifically to measure the vertical hydraulic gradient across the upper 3-feet of the bed of the River, the maximum depth to which vertical hydraulic conductivity (K) was likely to be significantly altered by the effects of River water flow. This depth was thought to be conservative as most processes effecting shallow streambed vertical hydraulic conductivity generally take place in the upper 0.82-foot (0.25-meter). The deep piezometers were installed 3-feet into streambed while the shallow piezometers were installed in such a manner as to effectively make them River stilling wells.

The shallow piezometers were each constructed of a PVC transducer housing measuring 4-inches in diameter by approximately 48-inches long, the bottom most 4-inches of casing were radially perforated to allow for the through flow of River water. Each was installed by securing the casing to the River bed, leaving the transducer housing projecting up from the bed of the River and the top end exposed above the surface of the water. The shallow piezometers were secured by strapping each to two adjacent pieces of rebar which had been driven approximately 18-inches into the riverbed. The method of installation effectively made each shallow piezometer a River stilling well.

Each deep piezometer was constructed of a 6-inch long by ¾-inch diameter stainless steel screen drive point attached to a 30-inch long by ¾-inch diameter stainless steel drive pipe which in turn was connected to a PVC transducer housing measuring 1.5-inches in diameter by approximately 40-inches long. The drive points used were Solinst™ Model 615, composed of a stainless steel cylindrical filter screen protected within a ¾-inch stainless steel body. The drive point was threaded into one end of the drive pipe and hand driven approximately 36-inches into the bed of the River until only the threaded tip of the drive pipe was visible above the riverbed. The housing was attached to the drive pipe with the top end exposed above the surface of the River.

Every deep piezometer and the shallow piezometers at the P1 and P6 locations were equipped with an In-Situ™ Level Troll 500 pressure/temperature data logging transducer. The transducer cable was securely attached to a cap covering the top of the transducer housing, allowing the transducer to hang free within. The other end of the transducer cable contained the data uplink connector, which was routed through the housing and attached to the outside, enabling easy access for routine data downloading.

Eight of the ten shallow piezometers were equipped with a transducer capable of measuring and logging dissolved oxygen content, along with temperature and water elevation. These transducers were installed such that they rested on a lip within the PVC transducer housing, as opposed to hanging like the Level Troll 500s. See Section 2.2.6 for details on the dissolved oxygen transducers.

Figure 2-1 shows the locations of the piezometer pairs and Figure 2-3 shows an idealized cross section of a piezometer well pair installation.

2.2.6 Dissolved Oxygen Transducers

In-Situ™ Model 9500 data logging transducers capable of measuring the dissolved oxygen (DO) content of the River water were installed in eight of the ten shallow piezometers within the 2007 Study Area. The eight locations include both shallow piezometers at stations P2, P3 and P4, and the single shallow piezometers at stations P4u and P5. The transducers measured and recorded the concentration of DO in the River water on an hourly basis, along with temperature and water depth. Figure 2-1 shows the locations of the piezometer pairs equipped with dissolved oxygen transducers.

2.3 Elevation/Location Surveying

In April 2003 and September 2004, Rasmussen Surveyors developed a benchmark at the location of the Old Well and surveyed wellhead and ground surface elevations for all accessible wells including Old Well, New Well, ESR-01, ESR-02, ESR-03, JSA-03, JSA-04, ESR-10A, ESR-10B, ESR-10C, ESR-11 and ESR-12. In September 2007, Rasmussen Surveyors surveyed in the locations of all of the transect rebar markers (PT1 through PT11, and VT1 through VT3), all ten piezometer pairs, and the stilling well at VT1. A copy of the survey data is provided in Appendix E.

2.4 Monitoring Program

The collection of field measurements and monitoring of equipment was conducted on a regular basis during the course of the 2007 Study. These activities included:

- The collection of groundwater levels from nine monitoring wells, ten piezometer pairs and a stilling well (once weekly).
- The measurement of River flow velocity and stage from three temporary gauging stations (twice weekly).

- The collection of water quality parameter data from nine monitoring wells (weekly).
- The download of data from all accessible deployed transducers (weekly).

2.4.1 Groundwater Levels

Global Water™ model WL16 data logging transducers were used to collect and record temperature and groundwater elevation (pressure) measurements from monitoring wells within the Study Area. See Figure 2-1 for the location of each transducer equipped well. The data recorded by the transducers were downloaded to a handheld computer (PDA) on a weekly basis. Each transducer was factory calibrated prior to deployment. According to the manufacturer, the accuracy of the pressure transducers is ± 0.2% of the full pressure range between 35 degrees Fahrenheit (°F) to 70 °F. This equates to an accuracy of ± 0.03-foot (± 0.36 inch) for the pressure transducers (15-feet pressure range). The pressure transducers used are known as "differential water level monitors", meaning that they automatically compensate for changes in atmospheric pressure and that no post data retrieval corrections are required.

In-Situ™ Level Troll 500 data logging transducers were used to collect and record temperature and surface water head (amount of water above the sensor) measurements from the piezometers and stilling wells within the Study Area. See Figure 2-1 for the location of each transducer equipped well. The data recorded by the transducers were downloaded to a handheld computer (PDA) on a weekly basis. Each transducer was factory calibrated prior to deployment. According to the manufacturer, the accuracy of the pressure transducers is ± 0.05% of full scale at 60 °F. This equates to an accuracy of ± 0.006-foot (± 0.07 inch) as full scale for these transducers is 11.5-feet. The pressure transducers are also "differential water level monitors", meaning that they automatically compensate for changes in atmospheric pressure and that no post data retrieval corrections are required.

On a weekly basis, depth to groundwater was measured manually in each well, stilling well and piezometer. A Heron™ "Little Dipper" water level meter was used to assess depth to water. According to the manufacturer, the instrument conforms to the upcoming American Society for Mechanical Engineers (ASME) performance standard for steel measuring tapes (reference B89.1.7).

2.4.2 River Stage and Flow

River stage and flow at each velocity transect (VT1 through VT3) was measured manually on a twice weekly basis. Data from the VT1 stilling well pressure and temperature transducer was downloaded to a handheld computer (PDA) concurrent with the stage and flow readings (see Section 2.4.1 for specification for the In-Situ™ Level Troll 500 data logging pressure/temperature transducer used in the stilling well).

On a twice weekly basis, the volume of flow in the River was measured at each location. The survey was accomplished by first stretching a measuring tape across the stream channel between two rebar markers. Note that the markers were fixed in place for the duration of the 2007 Study and surveyed for exact location. Water velocity and water depth was measured at 0.5-foot (0.15-meter) intervals across the channel. Water depth was measured using a top-setting depth measuring rod and recorded to 0.05-foot accuracy. Water velocity was measured for each half-foot interval using a Marsh-McBirney Model 2000 Flo-Mate portable electromagnetic velocity meter measuring water flow in cubic feet per second (cfs) on a 15 second averaging system. According to the manufacturer's specifications, the meter can record velocities in the range of -0.5 foot per second (ft/sec) to +20 ft/sec, with an accuracy of ± 2% of the reading. This allows for a maximum error of ± 0.2 ft/sec at maximum velocity. The sensor was calibrated by placing it in a pan of standing water and 'zeroing' the unit. Periodic maintenance was confined to simply cleaning the sensor and checking the strength of the batteries.

Total River flow volume was calculated based on the cross-sectional area of each 0.5-foot (0.15-meter) wide cell (i.e., measured River depth multiplied by the 0.5-foot cell width) and the corresponding water velocity (feet per second) measured for each cell. The sum of all of the cells yields the total flow of the River through the cross-section defined by the rebar posts. Figure 2-4 illustrates how the aggregate measurement from each cell is combined to determine total River flow volume. Each point represents data from each half-foot spacing across the River. The total area under the River flow velocity curve represents overall River flow.

At each velocity transect location, there was a stilling well or a piezometer containing a transducer that measured the elevation of the water in the River hourly (see Section 2.4.1) for the duration of the 2007 Study. Each flow volume measurement was compared to the contemporaneous transducer measurement of River elevation. A regression line was fit to the set of contemporaneous data points (River elevation against flow volume). The regression line equation allows the translation of hourly River elevation data from the stilling well to be translated directly to River flow volume. Thus, hourly flow volume was calculated for each of the three locations for the duration of the 2007 Study. Figure 2-5 shows the regression line fit to the data set which correlates measured River flow at VT2 and the corresponding River elevation data. Once the data from the 2007 Study was collected, correlating the weekly velocity measurements with the continuously recorded measurements of River stage height yielded a continuous record of River flow at all three locations.

2.4.3 River and Groundwater Water Quality

Groundwater temperatures were monitored via Global Water™ model WL16 data logging temperature transducers installed in the Study Area groundwater wells, with an accuracy of ± 1.0 °F. The data recorded by the transducers were downloaded to a handheld computer (PDA) on a weekly basis. When practical, temperature, conductivity and dissolved oxygen were measured manually in monitoring wells with suitable accessibility using an YSI™ 556 water quality meter. The temperature sensor has an accuracy of ± 0.15 degrees Celsius (°C) (± 0.27 °F) and does not require periodic calibration. The electrical conductivity sensor has an accuracy of ± 0.5% of reading + 1.0 micro-Siemens per centimeter (µS/cm) (example: a reading of 250 µS/cm would result in an accuracy of ± 2.25 µS/cm) and requires periodic calibration. The dissolved oxygen sensor has an accuracy of ± 2% of reading or 0.2 milligram per liter (mg/L), whichever is greater (example: a reading of 12 mg/L would result in an accuracy of ± 0.24 mg/L) and requires periodic calibration and sensor maintenance. The YSI™ 556 was calibrated by a manufacturer certified facility prior to field deployment, then on a frequency of every two weeks during the study period. At each calibration, the conductivity meter was calibrated to a 1,000 µS/cm standard solution and the dissolved oxygen sensor was calibrated using a water saturated environment, all following YSI™ published procedures. In addition, the dissolved oxygen sensor permeable membrane was replaced at each calibration as recommended by the manufacturer.

River water temperatures were additionally monitored via the In-Situ™ Level Logger 500 and Troll 9500 data logging transducers installed in the Study Area and piezometers and the VT1 stilling well with an accuracy of ± 0.1 °C. The data recorded by the transducers were downloaded to a handheld computer (PDA) on a weekly basis.

2.4.3.1 River Dissolved Oxygen

In-Situ™ Model 9500 data logging transducers were used to measure and record hourly the concentration of DO in the River at eight locations within the Study Area. The In-Situ™ Model 9500 was equipped with an optical DO sensor which can measure DO concentrations with an accuracy of ± 0.2 mg/L. Each transducer was factory calibrated prior to deployment. Data from each of the transducers were downloaded on a weekly basis. See Figure 2-1 for the locations of the eight DO transducers.

2.4.4 Public Domain Data Acquisition

Some of the data needed for the study was being collected by other entities and was available via internet download. The following data was collected:

2.4.4.1 Big Sur River Gauge Flows

United States Geological Survey (USGS) stream gauge #11143000 is located on the Big Sur River above the Study Area. This gauge records stage height and stream flow of the Big Sur River every fifteen minutes. The data was obtained from the following USGS web page: http://waterdata.usgs.gov/ca/nwis/.

2.4.4.2 Tidal Conditions

NOAA tidal station #9413450 is located in Monterey Harbor within Monterey Bay. This station records tidal changes every six minutes. Data from this station is collected and maintained by the Center for Operational and Oceanographic Products and Services (CO-OPS). The data were obtained from the following web page: http://tidesandcurrents.noaa.gov/.

3.0 DATA ANALYSIS AND STUDY RESULTS

3.1 Groundwater Pumping

In order to facilitate the monitoring of a stabilized groundwater system, ESR did not run either of their two irrigation wells for the five days preceding the August 31 start of the 2007 Study. Monitoring equipment was installed between August 27 and August 31. Beginning on August 31, the active portion of the 2007 Study was initiated, including three discrete periods of irrigation well pumping following this schedule:

1. Both Old Well and New Well were actively pumped at the maximum rate achievable starting on August 31. Due to the elevated conductivity of Old Well water as a result of high tide conditions, it was shut down on September 2. The test was continued as a New Well only test through September 7. The average pumping rate of the New Well was 2.37 cfs.
2. Old Well alone was pumped at the maximum rate possible starting on September 14 and ending on September 21. The average pumping rate of the Old Well was 2.26 cfs.
3. Both wells were actively pumped at the maximum rate achievable starting on September 28. Five days into the test, the Old Well was again shut down due to high conductivity levels. New Well continued to pump through October 5. The average pumping rate while both wells were running was 5.02 cfs.

During the 2007 Study, the goal was to run the irrigation pumps at the 'maximum rate possible', but within the constraints of day to day El Sur Ranch operations. The first constraint was that pumping to the same field(s) for six straight days would lead to over-watering, significant water runoff and possibly erosion. Surface water runoff and potential erosion concerns were voiced by the Department of Parks and Recreation in 2004 and 2005. Three separate field inspection events were conducted in 2005 to evaluate concerns over potential irrigation water runoff issues to park lands which were documented in Appendix D of the 2006 Report. To ensure that the pumping tests conducted in 2007 did not create conditions of irrigation water runoff, the fields being irrigated had to be switched periodically mid-test to prevent this from occurring. The second constraint was that, during the tests, there were occasional leaks in the piping that conveyed the water from the pumps to the fields. This sometimes resulted in pumping to fields at a higher elevation in order to bypass a leak as it was being repaired. Again, not immediately bypassing the leak would have resulted in excess water runoff and possibly erosion. Keeping the two constraints in mind, every effort was made to bias pumping to fields at lower elevations in order to keep groundwater extraction rates up during the 2007 Study. Thus, the test pumping rates reflect the reality of ESR water demands during a 'critically dry' year.

3.2 Pumping Area of Influence

Data from the 2006 Study demonstrated that the hydraulic impacts of pumping were only discernable in the area of the River that curves around the pumping well field (see Figure 2-1). This included piezometer pairs P2, P3, and P4, but not P5, the data from which demonstrated that it was outside the influence of pumping (i.e., no discernable drawdown resulting from pumping was identifiable). Additionally, a distance-drawdown analysis based on groundwater drawdown data measured in the monitoring wells showed that the maximum theoretical radius of influence of the New Well was 1,000-feet up-gradient of its location. Note that the up-gradient radius of influence of both wells pumping together was no more than the New Well pumping alone. Details of the pumping area of influence are summarized in Section 3.2 of the 2006 Report.

Maximum groundwater level drawdown conditions during the 2007 Study occurred around October 4, the point in time at which both the New Well and the Old Well had been pumping together for approximately five days. Figure 3-1 depicts the maximum groundwater level drawdown recorded in each of the monitoring wells and the deep River piezometers closest to Creamery Meadow, along with groundwater drawdown contours. Hydrographs for each of the monitoring wells are presented in Appendix F.

Groundwater elevation data for piezometers P5LD, P2RD, and P4RD are presented on Figures 3-2, 3-3, and 3-4, respectively. The piezometer hydrographs mirror the River flow as demonstrated on Figure 3-2. The River flow showed the seasonal low corresponding to the Labor Day weekend when local water use hits a high. According to a California State Parks representative, Labor Day weekend is one of their busiest times of the year. Following this holiday, River flow rebounded and the first significant rainfall events of the season occurred on September 21 and October 10 as shown by peaks in flow. On October 9, a large storm event marked the real beginning of the rainy season as River flow goes off the chart.

For piezometer P5LD, no pumping induced groundwater level drawdown signal can be interpreted from the data (Figure 3-2). Prior to the initiation of the two well pumping test in late September, there was a general reduction in groundwater elevation following a rain event. This decreasing trend was not altered with the onset of pumping. Included on this figure are groundwater elevations for P5LS and River flow as measured at VT1 showing that the decreasing groundwater levels are a function of decreasing River flow. A drawdown signal can be seen in the groundwater elevation data for piezometer P2RD (Figure 3-3) when the New Well was pumping and was most apparent when both wells are pumping, though superimposed on that signal was the general decreasing trend in groundwater elevation brought about by a slow decrease in River flow. Note that in the period leading up to and during the two well pumping test, there were sporadically high groundwater measurements resulting from tidal influence. The drawdown signal resulting from pumping can also be seen in the data for piezometer P4RD (Figure 3-4). Figure 3-1 shows the theoretical maximum radii of influence of both the New Well and the Old Well, based on data obtained from the 2006 Study. The figure demonstrates that the pumping influence on the River might extend upstream to piezometer P4u, and it does extend beyond the River into Creamery Meadow. When compared to data from the 2006 Study (see Figure 3-9 of the 2006 Report), there was not an appreciable change in pumping influence between 'wet' year conditions of 2006 and 'critically dry' year conditions of the 2007 Study.

3.2.1 Creamery Meadow Pumping Influence

The results of the 2006 Study demonstrated that groundwater moves down the El Sur River valley from Creamery Meadow toward the River and that pumping could induce a maximum groundwater drawdown at the River of 0.2-foot (2.4-inches), as seen in River piezometer P2RD. Thus, any groundwater drawdown under Creamery Meadow resulting from pumping must be less than 0.2-foot (2.4-inches). It was also demonstrated during the 2006 Study that the maximum theoretical radius of pumping influence of the New Well (which also includes the scenario when both wells were pumping together) was 1,000-feet up-gradient of the New Well, which is approximately 500-feet into Creamery Meadow. It should be noted that this is a conservative estimate as it does not take into account the River as a source of water for the pumping wells. Details of the pumping effects on Creamery Meadow based on the 2006 data can be found in Section 3.2.1 of the 2006 Report.

The maximum pumping-induced groundwater drawdown recorded in the River during the 2007 Study, 0.17-foot (2.0 inches), was nearly identical to the 0.20-foot (2.4-inches) observed in 2006. Groundwater drawdown effects throughout Creamery Meadow resulting from the pumping of the ESR irrigation wells cannot exceed those experienced at the River. Specifically, groundwater drawdown cannot increase farther away from the source of pumping. Thus, any piezometer or groundwater well installed in Creamery Meadow would have experienced a maximum groundwater drawdown resulting from pumping of less than 0.17-foot (2.0 inches) during the 2007 Study. This also demonstrated that groundwater drawdown in Creamery Meadow resulting from ESR irrigation well pumping were of the same magnitude in both 'wet' and 'critically dry' River flow conditions.

3.3 River/Aquifer Interactions and Response to Pumping

The data collected during the 2007 Study from River piezometers at stations P1 through P6 demonstrated the direction and relative magnitude of the vertical hydraulic gradients across the upper 3-feet of the streambed. The data demonstrated the relative gains and losses to the River by comparing measured vertical hydraulic gradients and identified pumping effects. Section 3.4 will explore the actual volume of water gained and lost in the River. Appendix G contains hydrographs of all the River piezometers including graphs of head differentials and calculated vertical gradients across the streambed at each piezometer pair location.

At around noon on September 3, 2007, a storm surge affected the closure of the Lagoon outlet to the Ocean via the deposition of beach sand. The Lagoon remained blocked until the early morning of September 12, 2007, when the River renewed the channel through the sand to the Pacific Ocean

(Ocean). The intervening period saw the backup of both surface water and groundwater, which had an impact on the hydrogeology of the Study Area during the 2007 Study.

Stations P5 and P6 were located more than 1,000-feet up-gradient of the New Well (Figure 2-1). Data from both locations showed no discernable response to pumping (Figure 3-5), supporting the area of influence calculations discussed in Section 3.2. The vertical hydraulic gradient between the deep and the shallow piezometers remained negative (i.e., water was flowing out of the River into the underlying aquifer) throughout the 2007 Study with minor fluctuations related to changes in River flow entering the Study Area. The changes can be seen in the flow conditions observed at VT1 (Figure 3-5). The hydraulic gradients were steadily negative at both the P5 and P6 locations illustrating that the natural condition was to lose water to the aquifer. The P5 location also revealed a losing condition when measured during the 2006 Study.

Station P4u was added to the 2007 Study to determine gradient conditions between P5, which the 2006 Study showed to be steadily negative, and P4, which the 2006 Study showed to be positive. P4u data showed that the River was neither gaining nor losing during the 2007 Study (Figure 3-6). However, the nearly flatlined nature of the gradient suggests that the deep piezometer casing might have leaked, in which case it would read identically with the shallow piezometer and yield a totally flat gradient. Due to the uncertainty of the data, it was discounted. The water elevation data from the shallow piezometer did not show any influence from groundwater pumping and generally tracked with changes in River flow (see hydrograph in Appendix G).

Piezometer station P4 was located up-gradient of the New Well within the section of River that runs perpendicular to the general direction of groundwater flow within the underlying aquifer. The vertical hydraulic gradient near the left and right bank of the River generally remained positive (i.e., groundwater was flowing into the River from the underlying aquifer) during the 2007 Study (Figure 3-7). As seen in 2006, the magnitude of the vertical gradient was higher on the right side of the River, due to the River flowing perpendicular to the flow of groundwater at this location. Higher hydraulic pressures were generated on the up-gradient side of the River (i.e., the right side or the 'up hill' side of the River) relative to the down-gradient side of the River (i.e., the left side or the 'down hill' side of the River). The higher hydraulic pressures on the right side were responsible for the increased vertical gradient. The effects of the two pumping periods that included the New Well are clearly discernible in the P4 vertical hydraulic gradient graph (Figure 3-7). The effect of pumping was to reduce the magnitude of the positive vertical gradients in this area. In fact, the vertical gradient went temporarily negative along the left bank during the New Well only test. This effect served to reduce the amount of groundwater in-flow from the aquifer to the River during times of pumping. The pumping of Old Well alone did not have an appreciable effect on the vertical gradient.

Like station P4, piezometer station P3 was also located up-gradient of the New Well within the section of River that runs perpendicular to the general direction of groundwater flow. The vertical gradient on the right bank of the River was generally gaining with the exception of some periods of pumping, while the left bank of the River was close to neutral or losing (Figure 3-8). The fact that the right bank was more positive than the left was again due to the greater hydraulic pressures generated on the up-gradient side of the River, which increased the vertical gradient. The effects of the two pumping periods that included the New Well are clearly discernible in the P3 vertical hydraulic gradient graph. The effect of pumping near the right bank was to reduce the magnitude of the positive vertical gradients in this area, turning them negative during the test with both wells pumping. On the left bank, pumping generally turned the gradient negative, including when Old Well alone was pumping. This effect served to reduce the amount of groundwater in-flow from the aquifer to the River during times of pumping.

Piezometer station P2 was located 550-feet southeast of the New Well within the section of River that cuts across the direction of groundwater flow, just before the River turns to the northwest (Figure 2-1). The vertical hydraulic gradients on both sides of the River were negative for the duration of the 2007 Study with the exception of the period when the River outlet from the Lagoon was closed (Figure 3-9). In contrast to P3 and P4, the area near the right bank of the River had a slightly more negative gradient than near the left bank of the River. It can be seen in both vertical gradient graphs that pumping has the effect of making both sides of the River more losing. The effects of pumping on the vertical gradient across the riverbed were most noticeable at the P2 location.

Piezometer station P1 was located within the lagoon area of the River, approximately 450 feet south of New Well. The P1 station consisted of a single pair of piezometers placed just north of the mid-channel point of the lagoon (i.e., located closer to the pumping well side of the lagoon). The vertical hydraulic gradient was generally neutral or positive during the 2007 Study (Figure 3-10). The effects of pumping were not enough to cause a significant change in gradient conditions.

In summary, the River was losing water to the underlying aquifer at station P6 and P5, and neutral at P4u. In all three locations, there were no discernable effects of pumping. The River was gaining at stations P4 and the right bank at P3 and losing at the left bank of P3 and P2. The effects of pumping became more noticeable when moving downstream from P4 to P2, where the effects were greatest. The lagoon was neutral or gaining, and not significantly affected by pumping.

3.4 Gains and Losses in River Flow and the Effects of Pumping

The analyses conducted by SGI based on the data collected during the 2006 Study led to the following hypothesis regarding the loss of River flow related to ESR irrigation well pumping activities:

The stretch of River that can be influenced by irrigation well pumping was identified and defined during the 2006 Study. When compared to the upstream inflow volume entering this stretch, the downstream outflow volume was greater during the absence of pumping. This is due to the upwelling of groundwater within the influent stretch adding to the overall flow volume of the River. Irrigation well pumping (New

Well in particular) has the effect of reducing the amount of flow gained by the River, primarily by intercepting groundwater that would have otherwise upwelled into the River, but does not reduce the flow to the point such that the downstream outflow volume is less than the upstream inflow volume.

The analysis conducted by SGI based on the data collected during the 2007 Study allowed for the testing of the hypothesis under 'critically dry' River flow conditions, the results of which can be found below.

3.4.1 Velocity Transect Data

In order to focus in on the potential loss of surface flow related to pumping, temporary river flow gauging stations were installed within the Study Area. VT2 was located downstream from piezometer pair P2, near the Lagoon. VT3 was located near the piezometer pair P4 location (Figure 2-1). The stretch of River between upstream station VT3 and downstream station VT2 was shown in the 2006 Study to be the most influenced by the effects of pumping.

Figure 3-11 shows the daily average flow volume of the River at VT2 and VT3, demonstrating that the stretch of River between the two stations was predominantly gaining flow during the 2007 Study (i.e. River flow at downstream station VT2 was almost always greater than the River flow at upstream station VT3). The River reached its lowest recorded flow of approximately 0.3 cfs around September 3, as seen at the VT3 location. The flow in the River at VT2 was around 0.4 cfs during the same time period. Figure 3-12 shows the change in flow between the VT3 location and the VT2 location. A positive result illustrates the net amount of water the River gained from the underlying aquifer between the two river flow gauging stations. A negative result shows the net amount of water the River lost between the two points to the underlying aquifer. Superimposed on the hourly gain/loss data is the daily average gain/loss between the two points. The data revealed that the River generally had a net gain of water between the two measuring points during the 2007 Study. The maximum daily net gain was approximately 1.6 cfs which occurred near the end of the period when the Lagoon was closed (i.e., around September 11). The greatest daily net loss was approximately 0.4 cfs which occurred near the end of the two well pumping test (i.e., around August 4).

The data showed (Figure 3-12) that pumping does affect the amount of River flow during the 'critically dry' conditions documented in 2007. Flow volume within the stretch of River between upstream station VT3 and downstream station VT2 generally increased during the 2007 Study. However, the pumping of both wells induced an overall net loss of 0.4 cfs.

3.4.2 Piezometer Data

The direct measurement of the flux of water flowing across the bed of the River was calculated during the 2006 Study using the simple Darcy Flow equation. The same equation was applied to the data obtained during the 2007 Study. The River flow data from VT2 and VT3 was used to calibrate the results of the flux calculations. The Darcy Flow equation reads as follows:

$$Q = K * i * A$$

where:

K, or hydraulic conductivity, was measured during the 2006 Study using a permeameter and was found to be approximately 104 feet per day (see Section 3.3 of the 2006 Report for details of how hydraulic conductivity of the riverbed was determined). This value for riverbed K will continue to be used during this Study.

i, or vertical hydraulic gradient, was measured by subtracting the difference in water levels between adjacent piezometers (one deep and one shallow) and dividing by the difference in screened intervals. See Section 2.2.5 for details regarding the installation of the piezometers and Section 3.3 for the results of the vertical hydraulic gradients measured at each of the piezometer pairs and what they revealed about River/aquifer interactions.

A; the area of the riverbed across which the exchange of water between the River and the underlying aquifer takes place. For the calculations used in the 2006 Report, the area of the riverbed was divided into Zones centered on each piezometer pair location. The dividing line between each Zone was either the midpoint between piezometer pair locations or a physical feature of the River itself. This distribution of riverbed areas (Zones) was necessitated by the absence of additional calibration data. Analysis of the gradient data from 2006 demonstrated that the areas represented by Zones 2 through 4 include the stretch of River in which flow can be influenced by ESR irrigation well pumping. For the 2007 Study, the area assigned to each Zone was calibrated based on changes in surface flow along the stretch of River influenced by pumping as measured by temporary flow gauging stations VT2 and VT3.

Q, or the Darcy Flow, was the rate of water flow across the bed of the River. Details regarding the calculations of River gains and losses using the piezometers and the Darcy Flux equation for the 2006 Study can be found in Section 3.6 of the 2006 Report.

The computation of the volumes of water gained and lost focused on piezometer locations P2, P3 and P4, which corresponded to riverbed area Zone 2, Zone 3, and Zone 4, respectively. As demonstrated in Section 3.3, only piezometer pairs P2, P3 and P4 showed an appreciable response to ESR irrigation well pumping. There is likely a minor groundwater contribution associated with the area around piezometer P4u, though it will not be included in the calculation as there is reason to believe the true gradient was not captured in the data (see Section 3.3). Data from piezometer locations P1, P5 and P6 have demonstrated no impact from irrigation well pumping.

Zone 4 represents the area around piezometer P4. This area of the River experienced a steady gain of groundwater inflow during the entire 2007 Study. Figure 3-13 depicts the calculated groundwater flux through the left and right River streambed sections using the area defined in the 2006 Study. The figure also includes the combined calculated groundwater gain (shows as a positive flux on the graph) in Zone 4 of approximately 0.5 to 1.0 cfs when not influenced by pumping. Pumping reduced the magnitude of the vertical gradients across the streambed, which in turn reduced the rate of groundwater inflow from the aquifer to the River. With both irrigation wells pumping at maximum capacity, the inflow of groundwater was reduced to approximately 0.2 cfs, a reduction of between 0.3 to 0.6 cfs. At no point during the 2007 Study did the total Zone 4 groundwater flux to the River turn negative (i.e., change conditions from groundwater flowing into the River to water flowing out of the River into the underlying aquifer).

Zone 3 represents the area around piezometer P3. This area of the River was experiencing a mix of groundwater inflow and surface water outflow during the 2007 Study. Figure 3-14 depicts the calculated groundwater flux through the left and right River streambed sections. The figure also includes the combined total calculated groundwater gains (shows as a positive flux on the graph) in Zone 3 of approximately 0.1 to 0.3 cfs when not influenced by pumping or the closed Lagoon. Pumping reduced the magnitude of the vertical gradients across the streambed, which changes the flux of water from groundwater inflow to surface water outflow. With both irrigation wells pumping at maximum capacity, the maximum outflow of surface water was approximately -0.3 cfs, a reduction of around 0.4 to 0.6 cfs.

Zone 2 represents the area around piezometer P2. Figure 3-15 depicts the calculated groundwater flux through the left and right River streambed sections. The figure also includes the combined calculated groundwater losses (shows as a negative value on the graph) in Zone 2 of approximately -0.3 cfs when not influenced by pumping or the closed Lagoon. The Lagoon closure had the effect of changing the flux from surface water loss to a groundwater gain of 0.3 cfs at its peak. Pumping reduced the magnitude of the negative vertical gradients across the streambed. With both irrigation wells pumping at maximum capacity, the maximum outflow of surface water was approximately -0.5 cfs, a reduction of around 0.2 cfs.

In principal, the River flow gains and losses measured between gauging stations VT3 and VT2 (see Figure 3-12) should be a close approximation of the gains and losses calculated using the data from piezometer pairs P2, P3 and P4, coupled with the appropriate areas (Zones 2 through 4). The riverbed areas assigned to the three Zones were adjusted (Figure 3-16) until the overall piezometer gain/loss graph approximated the actual measured flow loss between upstream gauging station VT3 and downstream gauging station VT2 (Figure 3-12). The calibrated graph of calculated overall flow gain/loss across Zones 2 through 4 is illustrated on Figure 3-17. Like the data from the velocity transects, the revised piezometer data showed a maximum loss in flow during times of pumping of approximately 0.4 cfs, indicating that during 'critically dry' River flow conditions, ESR irrigation well pumping has a measurable impact on the flow of surface water in the River within the area of influence.

3.4.3 Longitudinal Profile

A longitudinal profile was completed by surveying the thalweg of the River (i.e., the deepest channel of the River) within the 2007 Study Area and around the VT1 location. Figure 3-18 shows the surveyed thalweg of the River with superimposed data showing surface water and groundwater elevations. This graphically illustrates the changing regions of River gains (i.e., groundwater upwelling into the River) and losses (i.e., surface water outflowing to the underlying aquifer) within the 2007 Study Area. Shown on the figure is the projected groundwater elevation from the P5/P6 location to the upstream VT1 location. The elevation of the groundwater surface is below the surface water elevation which indicates that the River loses water, and thus flow volume, to the underlying aquifer from the VT1 location all the way down stream to the VT6 location.

3.5 River Water Quality

The quality of the water in the River is as important to the amount of flow when determining the suitability of the River as a habitat for species such as Steelhead trout (Steelhead). Previous studies have tried to determine the natural processes that govern changes in water quality and what influence, if any, the pumping of the ESR irrigation wells may have on the water quality. Two components critical to Steelhead habitat are temperature and dissolved oxygen. According to Hanson (Hanson, 2005), River water quality is generally considered stressful to Steelhead if dissolved oxygen content is less than 6 mg/L and/or if average daily temperature is greater than 68 °F (20 °C). The following sections detail the findings from the 2007 Study.

3.5.1 Temperature

The analyses conducted by SGI based on the data collected during the 2006 Study led to the following hypothesis regarding the interaction between ESR irrigation well pumping and River water temperature:

The temperature of the water flowing in the River is generally higher than groundwater temperature. Pumping intercepts some of the colder groundwater before it can mix with the water in the River. Thus, irrigation well pumping may reduce the cooling effect groundwater has on River water temperatures.

The analysis conducted by SGI based on the data collected during the 2007 Study allowed for the testing of the hypothesis under 'critically dry' River flow conditions, the results of which can be found in the following sections.

3.5.1.1 Surface Water Temperature

There are three primary factors that govern the temperature of the water in the River within the Study Area. These include:

- The upstream temperature of the water in the River. The River water is derived from a combination of aquifer derived baseflow and overland flow from tributaries. Water contributed to River flow from the tributaries is significantly warmer than aquifer derived water. Both systems are recharged yearly during the winter rainy season.
- Solar heating can increase the temperature of the water in the River as it flows downstream. Abundant overhanging vegetation (i.e., shade) has the effect of limiting temperature increases.
- Colder groundwater can mix with the water in the River lowering its overall temperature. The greater the ratio of groundwater mixing in the River, the greater the surface water temperature decrease.

The combination of solar heating and groundwater interaction alter the initial temperature of the water in the River as it flows downstream. During the 2007 Study, River water temperature was recorded at each of the piezometer locations and at the VT1 stilling well. The maximum recorded instantaneous temperature across all surface water data locations was 69.4 °F while the overall average temperature across all surface water data locations was 59 °F.

VT1 is located just downstream from the Andrew Molera State Park parking lot (Figure 2-1). The River water at this location is not influenced by the pumping of the ESR irrigation wells. Figure 3-19 shows the daily average temperature of the water in the River at the VT1 location. At the beginning of the Study, the temperature was around 65 °F. Over the course of the 2007 Study, the contribution of water in the River from upstream tributaries decreased relative to the amount of colder baseflow, resulting in the gradual drop in temperature to around 56 °F as shown in Figure 3-19.

3.5.1.2 Groundwater Temperature

Groundwater temperature was recorded in nine monitoring wells located between the pumping wells and the River. In general, the temperature of groundwater is less than the temperature of the water in the River. Figure 3-20 shows the temperature of the groundwater as measured in well ESR-1. From the beginning of the Study to the end, the temperature remained a fairly constant 54.5 °F to 55 °F. It was assumed that the groundwater upwelling into the River from Creamery Meadow would have a nearly constant temperature of approximately 55 °F.

3.5.1.3 Study Area Temperature Results

Throughout the Study, the temperature of the River at both P6 and P5 was nearly identical to the temperature at the upstream VT1 location as illustrated on Figure 3-21. The lack of any significant deviations between the three temperature plots indicates two things; a) there is no groundwater influence as far downstream as P5 and b) thick vegetative cover prevents significant solar heating between the VT1 location and P5.

The temperature of the River at P4u was nearly identical to P5, P6, and VT1 with one exception. As can be seen on Figure 3-22, the temperature of the water at P4u was up to 2 °F lower than the temperature of the upstream stations for the first five days of the Study. This illustrates the cooling influence of groundwater mixing with River water. Also shown on Figure 3-22 is the volume of flow in the River as measured at VT3, located downstream of P4u (Figure 2-1). The period with the least amount of flow in the River, occurring during the Labor Day weekend, corresponded with the period of increased groundwater mixing which resulted in reduced surface water temperatures. Once flow volume increased, there were no significant differences between the P4u temperature trace and that of the three upstream stations. The fact that the influence of groundwater only altered surface water temperatures 2 °F and only during a period of extreme low River flows reveals that the P4u location was at the very upstream end of where groundwater upwells into the River. As the flow of water in the River was reduced, enough groundwater was able to mix with River water such that a temperature drop was recorded by the P4u transducer. As the flow increased, the minor amount of groundwater inflow was mixed with a greater amount of River water and flushed downstream before any measurable temperature drop could occur.

The temperature of the surface water at P4 was generally higher than the temperature of the water at P4u (Figure 3-23) and the other upstream stations. The greater temperature was due to solar heating of the surface water made possible by the lack of vegetative cover shielding the River from the Sun between the P4 location and the P4u location. If there was any surface water mixing with groundwater, it was masked by the increase in temperature resulting from exposure to the Sun. Note that there was not a significant variation in temperatures between the left and right banks of the River, indicating minimal groundwater influence.

At the beginning of the 2007 Study, the temperature of the River water on the right bank at P3 was lower than any of the upstream stations (Figure 3-24). This was the result of cold groundwater mixing with the water in the River and lowering the temperature. Note that there were significant differences in temperature between the left bank and the right bank of the River. The greater inflow of groundwater along the right bank was clearly shown by the lower temperatures recorded there relative to the left bank. In fact, the temperature of the water near the right bank of the River was nearly identical to the influent groundwater temperature of 55 °F, showing that the right bank piezometer transducer was measuring nearly pure groundwater yet unmixed with River water. Around September 17, the temperature along the right bank began to increase and the difference in temperature between the left and right bank started to decline in response to a spike in River flow as measured at VT3. The increase in River flow diluted the upwelling groundwater with a higher percentage of unmixed surface water from upstream, which resulted in the rise in temperatures along the right bank. It also increased the amount of mixing between the left and right banks, which reduced the difference in temperature between the two sides and slightly lowered the temperature along the left bank. Continuing differences in water temperatures between the left and right banks of the River shows that groundwater was still influencing surface water temperature through October 5, at which point the temperatures were nearly identical across the River at P3. Note that after October 5, the temperature of the River at P3 was lower than the temperatures at P4, but greater than the stations above P4, showing that upwelling groundwater after this time was not enough to overcome the effects of solar heating.

The temperature of the surface water at P2 was nearly identical between the left and right banks of the River throughout the Study period (Figure 3-25). This indicates that the water in the River was well mixed at this location, and suggests a minimal amount of groundwater was mixing with the water in the River. This is supported by vertical gradient data from the piezometers which shows the River losing water to the underlying aquifer for the majority of the Study period. Around September 17, when the volume of flow in the River increased, the temperature of the water tracked with those seen at P4u, P5 and P6 suggesting that temperature reductions resulting from upstream mixing with groundwater were largely offset by upstream temperature increases resulting from solar heating.

The temperature of the Lagoon was much more stable than that recorded at the other stations (Figure 3-26). Surface flow was the largest contributor of water to the Lagoon, as direct groundwater inputs were negligible (see Section 3.3 and Figure 3-10). The large volume of water in the Lagoon maked it resistant to fluctuations in temperature and was thus responsible for the temperature stability observed at the P1 location and shown on Figure 3-26.

3.5.1.4 Conclusions Regarding River Temperature

The working hypotheses suggests that pumping can reduce the cooling effect groundwater has on River water temperatures by limiting the amount of groundwater mixing. The data collected during 'critically dry' flow conditions present during the 2007 Study did not reveal pumping to have a measurable influence on the temperature of water in the River. No correlations were revealed between pumping events and River water temperatures at any of the piezometer stations. However, statistical studies carried out by Hanson (Hanson 2008) showed that River temperatures increased by 0.5 °F (0.3 °C) during the period when both wells were pumping compared to the period when both pumps were off. This would indicate that pumping does limit the cooling effect of groundwater mixing, but to a degree not visibly discernable in the temperature data collected at the piezometer locations.

Note that River source water temperatures during this 'critically dry' year were appreciably lower than the River source water temperatures measured during 2004 ('dry') and during 2006 ('wet'). If the source water temperatures are always this low during 'critically dry' flow conditions (i.e. between 56 °F and 65 °F), no amount of pumping would be able to alter River water temperatures such that they became stressful to Steelhead (i.e, greater than 68 °F).

3.5.2 Dissolved Oxygen

During the 2004 Study and the 2006 Study, direct DO concentration measurements of the River water along the stretch of River between passage transects (PT) 4 and 9 (see Figure 2-1) showed that dissolved oxygen content along the right bank was less than that measured along the left bank. This is an area where incoming groundwater upwells and mixes with water in the River. This stretch of River is also within the radius of influence of the two ESR irrigation wells, as shown on Figure 3-1. The analysis conducted by SGI based on the data collected during the 2004 Study and the 2006 Study led to the following hypothesis regarding the interaction between ESR irrigation well pumping and the DO content of water in the River:

The water flowing in the River is relatively high in DO content while groundwater is relatively low in DO. Pumping has the effect of intercepting low DO groundwater before it can mix with the water in the River. Thus, irrigation well pumping may help maintain higher levels of DO in the River.

2007 was a 'critically dry' year and thus experienced a much lower volume of River flow relative to 2004 or 2006. The 2007 Study was partially designed to explore the changes in DO content in the River as the groundwater mixed with a reduced amount of surface flow (i.e., reducing the ratio of surface flow to groundwater inflow). More importantly, the 2007 Study attempted to identify what impact, positive or negative, the ESR irrigation wells had on the overall DO content of the River during this 'critically dry' period.

3.5.2.1 Dissolved Oxygen Content of River Water

The DO content of the River water not mixed with groundwater is approximately 7 to 11 mg/L as measured at upstream location P5 during the 2007 Study. There are many factors that can affect the DO content of the water in the River, including:

- Turbulent flow over riffle zones within the River. The frothy nature of turbulent flow allows for greater transfer of oxygen from the atmosphere to the River (i.e., aeration) which has the effect of increasing water DO content. As River flow velocity decreases, riffle zone flow becomes more laminar and thus DO content of River water remains static or potentially decreases.
- Inflowing groundwater mixing with the water in the River will reduce the DO content of the River water due to the fact that groundwater, or 'underflow', has been depleted of oxygen. Greater volumes of inflowing groundwater will progressively lower the DO content of the water in the River.
- DO content is greatly reduced when water goes stagnant or nearly stagnant. Microbes (such as Coliform) rapidly use up the DO in the River to break down organic matter. DO replenishment via aeration is virtually nil when water is stagnant.

Eight DO data logging transducers were placed in the River during 2007 in order to observe and quantify the effect of pumping on the content of DO in River water. Piezometer locations P2, P3 and P4 were within the pumping zone of influence. At each of these locations, DO was measured and recorded near both the left and right banks of the River. Piezometer locations P4u and P5 are near the edge of the pumping zone of influence and upstream of the pumping zone of influence, respectively. At each location, DO was measured and recorded at approximately the mid channel point of the River. See Figure 2-1 for the locations of the DO transducers.

3.5.2.2 Dissolved Oxygen Content of Groundwater

Data from the 2004 Study and the 2006 Study showed that groundwater was quite low in DO content, generally around 0 to 5 mg/L as measured in groundwater wells and at groundwater seeps. The low DO content of the groundwater is due to the numerous leach fields and septic tanks located further up the Big Sur River valley creating an anoxic environment in the alluvial groundwater aquifer. See Appendix H for a detailed explanation of the sources of the depressed DO content of the alluvial groundwater.

3.5.2.3 Study Area Dissolved Oxygen Results

Baseline DO content was measured at piezometer pair P5. Data from this piezometer pair showed that the River here was losing water to the underlying aquifer and was unaffected by pumping (see Sections 3.3 and 3.4.1), thus the DO concentration was locally unaffected by mixing with groundwater. Figure 3-27 shows daily average DO content at P5. The DO concentrations were largely stable between 8.7 and 10 mg/L with the exception of an early dip that centers on September 4 (Labor Day weekend). Superimposed on Figure 3-27 is the flow of the water in the River as measured at VT1. This dip mirrors the trend of the daily average River flow at VT1, showing the River reached its point of lowest flow at the same time the water in the River was the most reduced in DO. As the flow of water in the River declined, the turbulent flow of water over the various riffles found in the River was attenuated. Without the turbulent flow, less aeration occurred and thus the DO content of the River was reduced.

Figure 3-28 shows the DO content of the River at P4u throughout the 2007 Study. Note that the data is nearly identical to that found at P5 which, along with the piezometer data and the temperature data, supports the conclusion that groundwater at this point was not affected by pumping. However, the reduction in DO that reached its maximum around September 4 was greater at P4u than seen at P5. The DO concentrations at P4u were largely stable between 8.5 and 10 mg/L with the exception of the September 4 DO reduction which dropped as low as 2 mg/L. The data from P4u mirrors the trend of the daily average River flow at VT3, located downstream from the P4u location (see Figure 3-28). The flow in the River at VT3 dropped to approximately 0.5 cfs, greatly reducing the aeration of water over the riffles found between P5 and P4u. The reason why DO dropped so low at P4u was very likely due to the influence of groundwater and/or stagnation. The P4u DO sensor was installed in a spot where the riverbed forms a deep bowl and the water was relatively slow moving. Any amount of cold water low in DO would accumulate in the deepest part of the River first, which was what likely happened when the River was slowest moving. Also, biological activity during the low flow conditions would have consumed

DO if the water around the sensor went stagnant. Once the velocity of the River increased following the minimum point reached on September 4, the water was flushed and DO concentrations increased.

The data obtained from the P4 area can be found on Figure 3-29. Unfortunately, data from piezometer P4LS is not shown as it was compromised due to algal interference. Algae would get wrapped around the transducer and form a zone around the sensor of artificially low DO which resulted in errant readings. During several of the weekly data collection visits, the algal material would be removed which would result in immediate and substantial changes in DO readings, thus, the entire data set was deemed suspect and not included. Substantial algal interference did not occur for the sensor associated with the P4RS transducer (i.e., the DO sensor located near the right bank of the River). The data from P4RS moved between 2 and 4 mg/L until sometime near the end of the test when both irrigation wells were pumping, when it increased to around 6 mg/L. The overall low DO content, relative to P4u and P5, was due to the inflow and mixing of groundwater with the water in the River. Groundwater was observed trickling into the River along the riverbank at the P4 location by field personnel. Daily average flow volume in the River was monitored at upstream station VT1 and at VT3, located adjacent to the P4 piezometers. The daily average flow data is also shown on Figure 3-29, which exhibits a strong correlation with the DO data from P4RS. No changes in DO attributable to irrigation pumping are identifiable in the data graph.

The data found at P3 reflects the DO patterns experienced during previous studies. As seen in Figure 3-30, the concentration of DO was generally higher in the sensor located near the left bank of the River (P3LS) when compared to the sensor located near the right bank of the River (P3RS) due to groundwater inflow. DO content seemed to be lowest on September 4 along both sides of the River, consistent with the extremely low flow conditions. The flow in the River had just passed its minimum point as can be seen in the average daily River flow data at VT3 (located upstream of P3) and VT2 (located downstream of P3). Based on the correlations between River flow and DO concentration observed in the data from P4, P4u, and P5, the same relationship exists at P3. There does seem to be a distinct reduction in DO content near the right bank of the River while Old Well alone was pumping, but rebounds prior to the end of the pumping test, mirroring increased River flow. There was no identifiable change in DO near either bank of the River attributable to the period when both wells were pumping, the pumping period that had the potential for the greatest effect on the River.

The DO content measured at P2 can be found in Figure 3-31. The data from P2 contrasts with the data from P3 in that there was not much separation between the DO content near the left bank and the right bank of the River. Also shown on the graph is the daily average River flow at VT2, which was located just downstream of the P2 location. The correlation between DO content and flow in the River was not as strong here as it was at the upstream locations. DO remains depressed during the period when the Lagoon was closed, rebounding significantly throughout the period when the Old Well alone was pumping following the Lagoon reopening.

During the period when both ESR irrigation wells were pumping, the DO content near the left bank of the River dropped substantially below the DO content near the right bank. This was in contrast to DO along the right bank of the River being lower than along the left bank resulting from the inflow of low DO groundwater, as seen in the data from piezometer location P3 (Figure 3-30), thus suggesting a different mechanism occurred at the P2 location. The reduction in DO near the left bank corresponded with very low flows recorded at gauging station VT2. Figure 3-32 shows hourly DO measurement near the left and right banks compared to hourly measurements of River flow volume as measured at gauging station VT2. Daily maximum DO concentrations corresponded generally with daily high water flow while lowest DO concentrations corresponded generally with daily low water flow. In several instances, the daily high DO concentrations were similar on both banks of the River. However, daily low DO concentrations were much lower along the left bank of the River. The reason DO along the left bank of the River became so much lower than the right bank was that the water along the left bank went stagnant during the periods of low River flow. Figure 3-33 is taken from Hanson (Hanson 2008) and clearly shows that the thalweg of the River (i.e. the deep, flowing channel) was near the right bank while the left bank was shallower and separated from the thalweg by a mid-channel ridge. Appreciable water flow was maintained across the right bank DO sensor while water goes stagnant around the left bank sensor during the low flow periods of the day resulting in depressed DO conditions due to microbial activity. Figure 3-34 shows the flow volume of the River as measured at gauging stations VT1, VT2, and VT3. The arrow on the figure illustrates that as the two well pumping test concluded, the flow in the River was increasing of its own accord. This suggests that low River flow conditions (naturally occurring or as a result of upstream use) combined with ESR irrigation well pumping created partial stagnant conditions along the left bank at the P2 location.

Following the two well pumping test, DO concentrations on both banks nearly achieved parity again before a substantial increase in River flow raises DO to higher concentrations. The River was experiencing losing conditions (i.e., surface water was outflowing to the underlying aquifer) on both sides of the River throughout the test. The temperature of the water on both sides of the River was nearly identical throughout the test (Section 3.5.1), indicating that mixing between surface water and groundwater had taken place at points upstream.

3.5.2.4 Conclusions Regarding River Dissolved Oxygen Content

In summary, there was no observed link between the pumping of the ESR irrigation wells and DO concentrations in the River around locations P3, P4, P4u, and P5. Fluctuations in DO concentrations are instead linked to the amount of water flowing in the River. It has been demonstrated that low DO content groundwater flows into and mixes with the water in the River around piezometer pairs P3, P4, and P4u. When the incoming flow of surface water was reduced, the ratio of groundwater mixed with River water increases and mechanical aeration was reduced to a minimum. The combination of effects led to significant depletion of oxygen in the surface water. At the P2 location, the River was generally losing water to the underlying aquifer, a condition that eliminates any local influence of groundwater. However, the data suggests that low surface flow combined with ESR irrigation well pumping led to stagnation outside of the main River channel resulting in transient low DO conditions along the left bank at this location.

During the extremely low River flows that occur during a 'critically dry' River flow year, there may not be enough flow in the River to keep DO levels in an acceptable range to maintain a viable habitat for Steelhead. What has been demonstrated is that ESR irrigation pumping does not have any substantial influence on this balance between River flow and DO content.

3.6 Effects of Pumping on River Flow

Figure 3-17 presents the calculated net River gain across Zones 2 through 4 during the entire pumping period. These calculations, detailed in Section 3.4, illustrate that the Zones 2 through 4 area of the River did show a loss of overall River flow during periods when the New Well was pumping (both with and without Old Well). During the periods when the New Well was not pumping, the River gained flow across Zones 2 through 4.

The following table (Table 3-1) presents a summary of the change in net gain in the area of influence of Zones 2 through 4 as a ratio related to average pumping rate during each of the pumping periods.

Table 3-1
Correlation Between Pumping Rate and Decrease in Groundwater Inflow to River, Zone 2 Through Zone 4

Wells Active	Total Pumping Rate (cfs)	Calculated Decrease in Groundwater Inflow (cfs)	Is There a Net Gain in River Flow?	Pumping to Groundwater Inflow Reduction Ratio (cfs per cfs)
Both	5.02	~1 to 1.2	NO	0.24
New	2.37	NA*	NO	NA*
Old	2.26	~0.2	YES	0.09

*due to overlapping hydraulic events (specifically, the closing of the Lagoon), it is not possible to calculate the decrease in overall groundwater flow with any amount of accuracy.

The 'Pumping to Groundwater Inflow Reduction Ratio' illustrates the reduction of groundwater flow into the River for every 1 cfs of groundwater pumped by the irrigation wells. The ratio for both wells pumping was measured as 0.24, which is to say that for every 1 cfs of water pumped, the amount of groundwater inflow into the River decreased by 0.24 cfs. Note the column 'Is There a Net Gain in River Flow?' The answer indicates whether, despite the indicated pumping rate, the River was still gaining water via inflow from the underlying aquifer. The River overall lost flow when New Well was pumping, as illustrated in Figure 3-17.

In summary, data collected and analyzed for the 2007 Study under 'critically dry' conditions indicate the following; 1) the River did lose flow when New Well was pumping and 2) the rate at which River flow accretes groundwater flow was reduced at a maximum rate of approximately 0.24 cfs reduction per 1 cfs of pumping. This is comparable to the ratio measured during the 2006 Study of 0.30 cfs per 1 cfs of groundwater pumped (see Section 3.9 and Table 3-5 of the 2006 Report).

3.7 Water Availability Analysis

In 2006, the California Department of Fish and Game (CDFG) requested a water balance evaluation considering 'wet', 'above normal', 'normal', 'dry', and 'critically dry' water year types segregated based on 20-40-60-80 percent non-exceedance flows. This evaluation was included in Section 3.10 of the 2006 Report. The 20% non-exceedance frequency daily flows in the River characteristic of a 'critically dry' year reach a minimum of 8 cfs during September and October. See Appendix A for an explanation of water year types and non-exceedance flows.

A detailed water availability analysis was included as part of the 2006 Report. The analysis utilized data collected during the 2004 Study and the 2006 Study to project conditions in the River during a 'critically dry' water year type. Table 3-2 shows the monthly average flow data indicative of each water year type and the corresponding data from 2004, 2006, and 2007. During 2007, the average September River flow at the USGS gauge was 7.5 cfs, while the September criteria for being 'critically dry' is an average monthly flow of less than 8 cfs.

Data collected during both the 2006 Study and the 2007 Study has served to establish that the ESR irrigation well's area of influence is focused on the stretch of the River identified as River Zones 2 through 4 (Figure 3-16). The calculation of River water gains (i.e. from the flow of groundwater into the River) and losses (i.e. the loss of water from the River to the underlying aquifer) within these areas in response to pumping and non-pumping conditions was possible from the data collected during the 2007 Study. This information, combined with earlier developed water balance data described in the 2006 Report, allowed for the calculation of a simple surface flow water balance for the ESR irrigation well area of influence. A surface flow water balance was constructed for Zones 2 through 4 of the River for September flow conditions as a tool to evaluate worst case conditions on River flow in response to pumping and a determination of water availability based on various year types.

Table 3-3 presents the surface flow water balance for September conditions across River Zones 2 through 4. This water balance includes the following input and output terms:

- The average monthly Big Sur River flow measured at USGS gauging station 11143000 for the month of September.
- The net loss in River surface flow between the Big Sur River gauging station and temporary River flow gauging station VT1. An average flow loss of 3.7 cfs was measured during the 'dry' late summer conditions of the 2004 Study as documented in Section 3.4.7 of the 2004 Report. A value of 1.5 cfs was calculated based on the 2006 Study flow data obtained at VT1 that is characteristic of a 'wet' year type. A value of 2.9 cfs was the average loss between the USGS gauge and VT1 for the month of September based on 2007 Study data and characteristic of a 'critically dry' year type.
- The net loss in flow between temporary River flow gauging station VT1 and the upstream end of River Zone 4. Based on data from the 2006 Study, this was calculated to be 1.3 cfs. For 2007, the average monthly loss between temporary River flow gauging station VT1 and temporary River flow gauging station VT3 (located at the upstream end of River Zone 4) was 3.0 cfs. The longitudinal profile shown on Figure 3-18 illustrates that the net loss is the result of losing conditions between VT1 and the upstream end of Zone 4.
- The net calculated non-pumping accretion rate of groundwater in-flow to the River (i.e. the amount of surface flow the River naturally gains from inflowing groundwater) across Zones 2 through 4 of 1.7 cfs is based on data discussed in Section 3.6 of the 2006 Report. For 2007, the average monthly gain in River flow between temporary River flow gauging station VT3 (located near the upstream end of River Zone 4) and temporary River flow gauging station VT2 (located at the downstream end of River Zone 2) during non-pumping conditions was 0.4 cfs.
- The net calculated reduction in groundwater accretion rate through Zones 2 through 4 in response to pumping. The net reduction in accretion rate is calculated by multiplying the pumping rate by the correlated reduction rate of 0.30 cfs reduction per 1 cfs of total pumping as discussed in 2006 Report (see Sections 3.6 and 3.8 and Table 3-5 of the 2006 Report). For September 2007 conditions, Section 3.6 and Table 3-1 of this report show the pumping rate correlation to be a reduction rate of 0.24 cfs for every 1 cfs of total pumping.
- The average total pumping rate condition for September.

Detailed water balance calculations are provided in Table 3-3 for the 'wet' year of 2006, 'dry' year of 2004 and the 'critically dry' year of 2007. Based on the data from 2004, 2006, and 2007, a relationship has been established between surface flow as measured at the Big Sur River Gauge and the net surface water flow within the stretch of River influenced by ESR irrigation well pumping (Zones 2 through 4) for average River conditions (including pumping influence) for the month of September. The surface water flow balance detailed on Table 3-3 has been condensed in Table 3-4 below to include only the Big Sur River Gauge data and the resulting net River flow in Zones 2 through 4:

Table 3-4
Relationship Between Big Sur River Gauge Flow and Net River Flow Across Zones 2-4 During Average September Pumping Conditions

Year	Big Sur Gauge Flow (Sept. Avg)	Net River Flow in Zones 2-4	Flow Conditions
2006	20.6 cfs	18.7 cfs	Wet
2004	12.2 cfs	8.0 cfs	Dry
2007	7.5 cfs	1.3 cfs	Critically Dry

Figure 3-35 graphically illustrates the relationship between average September flow at the Big Sur Gauge and average September net River flow in Zones 2 through 4 by plotting the two terms against each other and fitting a regression line to the resulting data points. The equation derived from the regression line allows for the estimation of average September net River flow in Zones 2 through 4 for any given average September Big Sur River gauge flow value. For example, we can calculate that a flow of approximately 6.4 cfs at the Big Sur River Gauge will yield zero net River flow across Zones 2 through 4.

In comparison, Table 3-5 shows the relationship between average September flow at the Big Sur Gauge and average September net River flow in Zones 2 through 4 without the influence of ESR irrigation well pumping (i.e., recalculating Table 3-3 by removing the 'Pumping Induced Reduction in Accretion' term). The resulting modified surface water flow balance has been condensed in Table 3-5 below to include only the Big Sur River Gauge data and the resulting net River flow in Zones 2 through 4:

Table 3-5
Relationship Between Big Sur River Gauge Flow and Net River Flow Across Zones 2-4 With No Irrigation Well Pumping

Year	Big Sur Gauge Flow (Sept. Avg)	Net River Flow in Zones 2-4	Flow Conditions
2006	20.6 cfs	19.6 cfs	Wet
2004	12.2 cfs	8.9 cfs	Dry
2007	7.5 cfs	2.0 cfs	Critically Dry

Again, Figure 3-35 graphically illustrates the non-pumping relationship between average September flow at the Big Sur Gauge and average September net River flow in Zones 2 through 4 by plotting the two terms against each other and fitting a regression line to the resulting data points. The equation derived from the regression line allows for the estimation of average September net River flow in Zones 2 through 4 for any given average September Big Sur River gauge flow value. Without the influence of pumping, we calculate that a flow of approximately 5.8 cfs at the Big Sur River Gauge will yield zero net River flow across Zones 2 through 4.

This shows that River flow measured at the Big Sur River gauge can be tied directly to surface flow within the stretch of River influenced by ESR irrigation well pumping, at least on an average monthly basis.

4.0 SUMMARY AND CONCLUSIONS

SGI's 2004 and 2006 Hydrogeologic Reports provided a site conceptual model based upon recorded monitoring of Big Sur River flows and water quality parameters. The reports provided a better understanding of the potential for impacts to the relevant reach of the Big Sur River assignable to ESR pumping and/or irrigation practices. The purpose of this 2007 Report is to provide greater understanding of conditions during a "critically dry" year. Consistent with past data collections, the effects of pumping upon River flow and water quality were tested across a spectrum of pumping conditions: New Well pumping alone, Old Well pumping alone, and both wells pumping together. After review and analysis of this data the 2007 Study concludes the following:

4.1 Observations of the 2007 Study

- 2007 was a 'critically dry' year, as measured at the USGS Gauge.
    - The average daily River flow at the USGS Gauge for the month of September was 7.5 cfs (the September criteria for 'critically dry' is a monthly average River flow of less than 8 cfs).
    - The average daily River flow at the USGS Gauge for the entire Study Period (August 27 through October 17) was 8.4 cfs.
    - The lowest reported average daily River flow at the USGS Gauge was 6.3 cfs, occurring between September 2 and September 4.
- The effects of pumping upon the Study Area, including effects of pumping on conditions within Creamery Meadow, were nearly identical to the effects seen during the 'wet' year conditions described in the 2006 Study.
    - In 2007, the maximum measured drawdown of the River surface waters was 0.17-foot (2.0 inches), and the maximum radius of influence of pumping extends upriver approximately 1,000-feet from the New Well to a point between piezometer location P4 and P5.
- The average daily River flow measured within the Study Area was approximately 2.1 cfs at temporary gauging station VT3 (near the upstream end of the stretch of River influenced by ESR irrigation well pumping) and 2.3 cfs at temporary gauging station VT2 (near the downstream end of the stretch of River influenced by ESR irrigation well pumping).
    - The lowest reported average daily River flow at upstream gauging station VT3 was 0.3 cfs which occurred on September 3 and September 4.

  - The lowest reported average daily River flow at downstream gauging station VT2 was 0.4 cfs which occurred on September 2.

- Changes in water quality (temperature and dissolved oxygen) bear a direct correlation to increases or decreases in the amount of flow in the surface waters and the relative amount of mixing of surface flows with upwelling groundwater.
- Pumping of the ESR irrigation wells did not have a discernable effect on River water quality (temperature or DO content).
- During maximum pumping tests under the 'critically dry' conditions of the 2007 Study, the River lost a maximum of 0.4 cfs of flow in response to pumping both ESR irrigation wells simultaneously.
  - Changes in River flow within the area of pumping influence were directly measured using temporary River gauging stations (VT2 and VT3). Additionally, localized River gains and losses to and from the underlying aquifer were calculated using the Darcy Flow calculation combining vertical hydraulic gradients measured at piezometer pair locations, riverbed hydraulic conductivity (measured during the 2006 Study) and riverbed areas. The aggregate gains and losses calculated were compared to those measured by the temporary gauging stations.
- The data collected during the 2007 Study confirms the dynamics of River-aquifer interaction measured and described in previous studies.
- Hydrologic data collection and analysis have verified the River-aquifer dynamic for three varying water year types, namely 'wet' (2006), 'dry' (2004), and 'critically dry' (2007).

4.2 Conclusions Regarding Critically Dry Year Hypotheses

SGI framed three working hypotheses that serve as the basis for 2007 analysis (outlined in Section 1.1). These hypotheses were framed to obtain a more informed understanding of the relationship between irrigation well pumping and aspects of River water quality and flow during a year with 'critically dry' River flow. ESR sought to take advantage of the unusual flow conditions presented by 2007 weather conditions to test the hypotheses presented. In summary, a conclusion for each hypotheses is presented hereafter:

Hypothesis 1:

The stretch of River that can be influenced by irrigation well pumping was identified and defined during the 2006 Study. When compared to the upstream inflow volume entering this stretch, the downstream outflow volume was greater during the absence of pumping. This increase in outflow volume is due to the upwelling of groundwater within the influent stretch adding to the overall flow volume of the River. Irrigation well pumping (New Well in particular) has the effect of reducing the amount of flow gained by *the River, primarily by intercepting groundwater that would have otherwise upwelled into the River, but does not reduce the River flow to the point such that the downstream outflow volume is less than the upstream inflow volume.*

Conclusion:

During actual 'critically dry' River flow conditions of the 2007 Study, simultaneous pumping from both wells did reduce flow in the stretch of River that can be influenced by pumping such that the downstream outflow volume was less than the upstream inflow volume. The observed maximum deficit resulting from the use of both ESR irrigation wells simultaneously (i.e. maximum pumping conditions) was approximately 0.4 cfs. Thus, maximum pumping of the irrigation wells can reduce overall surface water flow within the area of influence during 'critically dry' River flow conditions. This is explored in detail in Section 3.4.

Hypothesis 2:

The temperature of the water flowing in the River is generally higher than groundwater temperature. Pumping intercepts some of the colder groundwater before it can mix with the water in the River. Thus, irrigation well pumping may reduce the cooling effect groundwater has on River water temperatures within the zone of influence.

Conclusion:

This hypothesis suggests that pumping can reduce the cooling effect groundwater has on River water temperatures by limiting the amount of groundwater mixing. The data collected during 'critically dry' flow conditions present during the 2007 Study do not reveal pumping to have a measurable influence on the temperature of water in the River. No correlations between pumping events and River water temperatures were identified at any of the piezometer stations. This is explored in detail in Section 3.5.1.

Hypothesis 3:

The water flowing in the River is relatively high in DO content while groundwater is relatively low in DO. Pumping has the effect of intercepting low DO groundwater before it can mix with the water in the River. Thus, irrigation well pumping may help maintain higher levels of DO in the River.

Conclusion:

There was no observed link between the pumping of the ESR irrigation wells and DO concentrations in the River around locations P3, P4, P4u, and P5. Fluctuations in DO concentrations are instead linked to the amount of water flowing in the River. It has been demonstrated that low DO content groundwater flows into and mixes with the water in the River around piezometer pairs P3, P4, and P4u. When the incoming flow of surface water is reduced, the ratio of groundwater mixed with River water increases and mechanical aeration is reduced to a minimum. The combination of effects leads to significant depletion of oxygen in the surface water. At the P2 location, the River is generally losing water to the underlying aquifer, a condition that eliminates any local influence of groundwater. However, it has been demonstrated that low flow conditions can lead to localized areas of River flow stagnation resulting in a reduction in DO content. This is explored in detail in Section 3.5.2.

4.3 Effects of ESR Irrigation Well Pumping on the Big Sur River

The result of a synthesized analysis of the 2007 'critically dry' year data with previous studies has generated a significant conclusion regarding the relationship between the pumping of the two ESR irrigation wells and the effects that pumping has on both the volume of flow in the River and the quality of the water in the River. The conclusion, simply stated, is that River conditions related to critical Steelhead habitat factors of passage and water quality are controlled by two factors: 1) River flow volume and 2) the quality of upwelling groundwater.

The amount of surface flow entering the stretch of the Big Sur River within the influence of ESR irrigation well pumping is largely a function of rainfall. River flow during the late summer and early fall is directly proportional to the amount of rainfall the Big Sur River watershed received the previous winter (i.e., a below average amount of winter rainfall will yield lower flows in the River). The dry winter of 2006-2007 resulted in 'critically dry' River flow conditions (as measured at the USGS gauge) during the 2007 Study. In addition, there is some surface flow depletion from the upstream use of the River and the underlying aquifer as a water source for human related activities. The higher than usual number of vacationers that populate the upstream hotels and campgrounds during certain time periods, such as holidays, adds to the amount of human related water use. This use was observed as a reduction in the measured River flow conditions over the Labor Day weekend in 2007. The combination of 'critically dry' River flow conditions and upstream water use had the effect of reducing River surface flow rates within the Study Area to less than 0.5 cfs.

The ongoing upstream discharge of sewage through the use of septic tanks and leach fields installed directly into the alluvial aquifer has the effect of greatly reducing the DO content of Big Sur River Valley groundwater (underflow). This groundwater perpetually moves down the Valley, into Creamery Meadow and ultimately either upwells into the River within the Study Area or is discharged to the Ocean. This underflow upwelling process occurs naturally along the stretch of River that is aligned approximately perpendicular to the flow of Creamery Meadow underflow. This stretch is also within the ESR irrigation well pumping area of influence. In the absence of pumping, this naturally upwelling groundwater reduces the DO content of the water in the River. The amount of surface water DO content reduction is dependant on the amount of surface flow in the River. When surface flows in the River are reduced to levels observed during the 2007 Study, there is not enough surface water to raise the DO content of the upwelling groundwater to levels conducive to Steelhead habitat.

It is the combination of River water use during a 'critically dry' year and the depletion of DO in groundwater in areas far upstream from the ESR irrigation well area of pumping influence that has the dominant effect on Study Area Steelhead habitat conditions. Our studies have shown that active ESR irrigation well pumping does not affect either the temperature of the River or the DO content of the River. Fish passage is compromised by low River flow conditions that occur upstream of the pumping area of influence and are thus unchanged by pumping.

5.0 REFERENCES

Hanson Environmental (Hanson). Assessment of Habitat Quality and Availability Within the Lower Big Sur River: April-October 2004, March 2005.

Hanson Environmental (Hanson). Evaluation of the Potential Relationship Between El Sur Ranch Well Operations and Fish and Wildlife Habitat Associated with the Big Sur River During Late Summer and Early Fall, 2006, July 2006.

Hanson Environmental (Hanson). Assessment of the Potential Effects of El Sur Ranch Well Operations on Aquatic Habitat Within the Big Sur River and Swiss Canyon During Late Summer and Early Fall, 2007, April 2008.

The Source Group, Inc. (SGI). Pumping Test Report, El Sur Ranch, Point Sur, California, March 2004.

The Source Group, Inc. (SGI). Hydrogeological Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River, May 2005.

The Source Group, Inc. (SGI). Hydrogeologic Workplan Elements for Proposed 2006 Data Collection Program, August 2006.

The Source Group, Inc. (SGI). Addendum to Hydrogeological Investigation and Conceptual Site Model Within the Lower Reach of the Big Sur River, March 2007.

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6.0 ACRONYMS AND GLOSSARY

Acronyms

μS/cm	Micro-siemens per centimeter
amsl	Above mean sea level
ASME	American Society for Mechanical Engineers
CDFG	California Department of Fish and Game
CDWR	California Department of Water Resources
cfs	Cubic feet per second
DO	Dissolved oxygen
DPR	Department of Parks and Recreation
EC	Electroconductivity
ESR	El Sur Ranch
gpm	Gallons per minute
K	Hydraulic conductivity
mg/L	Milligrams per liter
NOAA	National Oceanic and Atmospheric Administration
PDA	Personal Data Assistant
PVC	Polyvinyl chloride
SGI	The Source Group, Inc.
USGS	United States Geological Survey
VT	Velocity transect

Glossary

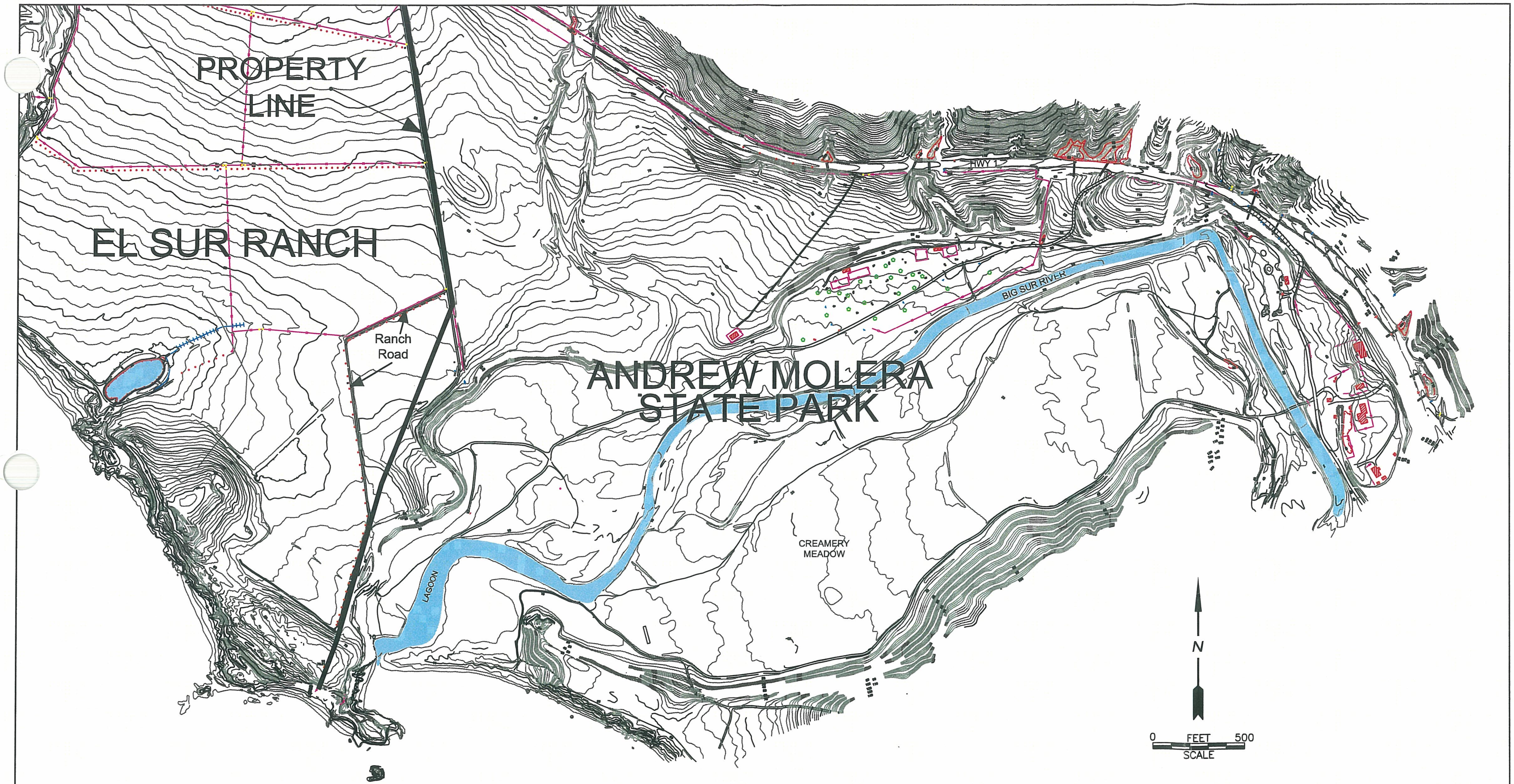
Aquifer test	A test to determine hydrologic properties of an aquifer, involving the withdrawal of measured quantities of water from, or the addition of water to, a well and the measurement of resulting changes in head in the aquifer both during and after the period of discharge or addition (recharge).
Cubic feet per second (cfs)	A unit expressing rate of discharge, typically used in measuring streamflow. One cubic foot per second is equal to the discharge of a stream having a cross section of 1 square foot and flowing at an average velocity of 1 foot per second. It also equals a rate of approximately 7.48 gallons per second, 449 gallons per minute, 1.98 acre-feet per day, or 724 acre-feet per year.
Data logger	A data logger is an electronic instrument that records data over time or in relation to location. Increasingly, but not necessarily, they are based on a digital processor (or computer). They may be small, battery powered and portable and vary between general purpose types for a range of measurement applications to very specific devices for measuring in one environment only.
Data logging	(Data acquisition) Storing a series of measurements over time, usually from a sensor that converts a physical quantity such as temperature or pressure, into a voltage that is then converted by a digital to analog converter (DAC) into a binary number. This number is stored electronically pending retrieval via portable computer or similar device.
Discharge	To pour forth, emit, or release contents.
Dissolved oxygen	The amount of free (not chemically combined) oxygen dissolved in water, wastewater, or other liquid, usually expressed in milligrams per liter, parts per million, or percent of saturation.
Diurnal	Having a 24-hour period or cycle; daily.
Diurnal events	Events that reoccur on a 24-hour period or cycle; daily
Drawdown Stabilization	In subsurface hydrogeology, drawdown is the change in hydraulic head observed at a well in an aquifer, typically due to pumping a well as part of an aquifer test or well test. Stabilization is the point that occurs when continued pumping does not result in further changes in hydraulic head.
Electroconductivity	A measure of the ability of a solution or media to carry an electrical current.
Electromagnetic velocity meter	Electromagnetic meters produce voltage proportional to the velocity of water flow across the sensor. The working principle of these meters is the same as the pipeline electromagnetic flow meter.
Field measurements	Data manually collected by field personnel within a specified Study Area.

Flow gauging	Measuring the rate of water discharged from a source given in volume with respect to time.
Fluctuations	To vary irregularly.
Gallons per minute (GPM)	A unit expressing rate of discharge, used in measuring well capacity. Typically used for rates of flow less than a few cubic feet per second (CFS)
Gradient	Degree of incline; slope of a stream bed. The vertical distance that water falls while traveling a horizontal distance downstream or through an aquifer.
Groundwater	(1) Generally, all subsurface water as distinct from *Surface Water*, specifically, the part that is in the saturated zone of a defined aquifer. (2) Water that flows or seeps downward and saturates soil or rock, supplying springs and wells. The upper level of the saturated zone is called the Water Table. (3) Water stored underground in rock crevices and in the pores of geologic materials that make up the earth's crust. Ground water lies under the surface in the ground's *Zone of Saturation*, and is also referred to as *Phreatic Water*.
Groundwater flux	(1) Water that moves through the subsurface soil and rocks. (2) The movement of water through openings in sediment and rock that occurs in the *Zone of Saturation*.
Groundwater gradient	The gradient or slope of a water table or *Piezometric Surface* in the direction of the greatest slope, generally expressed in feet per mile or feet per feet. Specifically, the change in static head per unit of distance in a given direction, generally the direction of the maximum rate of decrease in head. The difference in hydraulic heads (h1 – h2), divided by the distance (L) along the flowpath, or, expressed in percentage terms: $I = (h1 - h2) / L \times 100$. A hydraulic gradient of 100 percent means a one foot drop in head in one foot of flow distance.
Hydraulic conductivity	Simply, a coefficient of proportionality describing the rate at which water can move through an aquifer or other permeable medium. The density and kinematic viscosity of the water must be considered in determining hydraulic conductivity. More specifically, the volume of water at the existing kinematic viscosity that will move, in unit time, under a unit *Hydraulic Gradient* through a unit area measured at right angles to the direction of flow, assuming the medium is isotropic and the fluid is homogeneous. In the Standard International System, the units are cubic meters per day per square meter of medium (m3/day/m2) or m/day (for unit measures).
Hydraulic head	(1) The height of the free surface of a body of water above a given point beneath the surface. (2) The height of the water level at the headworks or an upstream point of a waterway, and the water surface at a given point downstream.
Hydrogeology	The part of geology concerned with the functions of water in modifying the earth, especially by erosion and deposition; geology of ground water, with particular emphasis on the chemistry and movement of water.

Hydrograph	(1) A graphic representation or plot of changes in the flow of water or in the elevation of water level plotted against time. (2) The trace of stage (height) or discharge of a stream over time, sometimes restricted to the short period during storm flow.
Hydrologic	Of or pertaining to hydrology, that is the science dealing with water, its properties, phenomena, and distribution over the earth's surface.
Monitoring well	A well used to obtain water quality samples or measure groundwater levels.
Monitoring well cluster	A collection of monitoring wells drilled to varying depths located in close proximity to one another. This arrangement is generally used to determine vertical groundwater gradients.
Passage Transect	A cross-section of the River measured to determine if there is enough water for fish to pass. Each passage transect was identified by rebar markers located on opposite sides of the River. On a twice weekly basis, the depth profile was measured at each passage transect by recording the depth of the River from bank to bank in half-foot increments
Permeameter	A device used to determine the vertical hydraulic conductivity of a streambed.
Piezometer	Small diameter well used to measure the elevation (hydraulic head) of groundwater in aquifers.
Potentiometric surface	A surface which represents the static head of ground water in tightly cased wells that tap a water-bearing rock unit (i.e., aquifer). In relation to an aquifer, the potentiometric surface is defined by the levels to which water will rise in tightly cased wells. If the head varies significantly with depth in the aquifer, then there may be more than one potentiometric surface. The *Water Table* is a particular potentiometric surface for an *Unconfined Aquifer*.
Pressure transducers	A data logger that measures and records water pressure (head of water over the sensor). See data logging.
Pumping test	See aquifer testing.
Riffle Zone	Shallow turbulent water passing over a sand or gravel bar
River stage	The elevation of the water surface at a specified station above some arbitrary zero datum (level).
River transect	A surveyed line (generally constructed with two surveyed posts connected by a string) emplaced perpendicular to river flow across which river velocity data is collected

Saltwater intrusion	The invasion of a body of fresh water by a body of salt water, due to its greater density. It can occur either in surface or ground-water bodies. The term is applied to the flooding of freshwater marshes by seawater, the migration of seawater up rivers and navigation channels, and the movement of seawater into freshwater aquifers along coastal regions.
Saltwater wedge	The wedge shaped body of saltier water that underlies fresher water in poorly mixed estuaries, or underlies fresher groundwater in coastal or estuary situations where the fresher groundwater is discharging to the ocean or estuary over and through a fresh/salt water interface.
Site	Generally refers to the Study Area and may refer specifically to areas of data collection within the Study Area.
Spring tide	The exceptionally high and low tides that occur at the time of the new moon or the full moon when the sun, moon, and earth are approximately aligned.
Stage height	The height of a water surface above some established reference point or *Datum* (not the bottom) at a given location. Also referred to as *Gage Height.*
Stilling well	A device used to allow monitoring of water levels in turbulent flow.
Study Area	The Study Area includes the portion of Andrew Molera State Park from the parking lot to the ocean and a portion of the adjacent El Sur Ranch property to the north.
2007 Study Area	Includes the area from the Lagoon upstream to the 'Deep Pool' Area. See Figure 1-2 of this report. 2006 Study Area is similar.
2007 Study Period	The period of field data collection for this report that is inclusive of the time between August 27 and October 17, 2007.
Thalweg	The line connecting the lowest points of a riverbed. The deepest or best navigable channel.
Transducer	A substance or device, such as a piezoelectric crystal, microphone, or photoelectric cell that converts input energy of one form into output energy of another. See data logging.
Velocity transect	see river transect
Water balance	An accounting of the inflows to, the outflows from, and the storage changes of water in a hydrologic unit or system.
Water table	The surface of a groundwater body at which the water is at atmospheric pressure; the upper surface of the ground water reservoir.

FIGURES



Map Source File by Rasmussen Land Surveying, Inc.
File Name: APS_Contours_Planimetric.dwg

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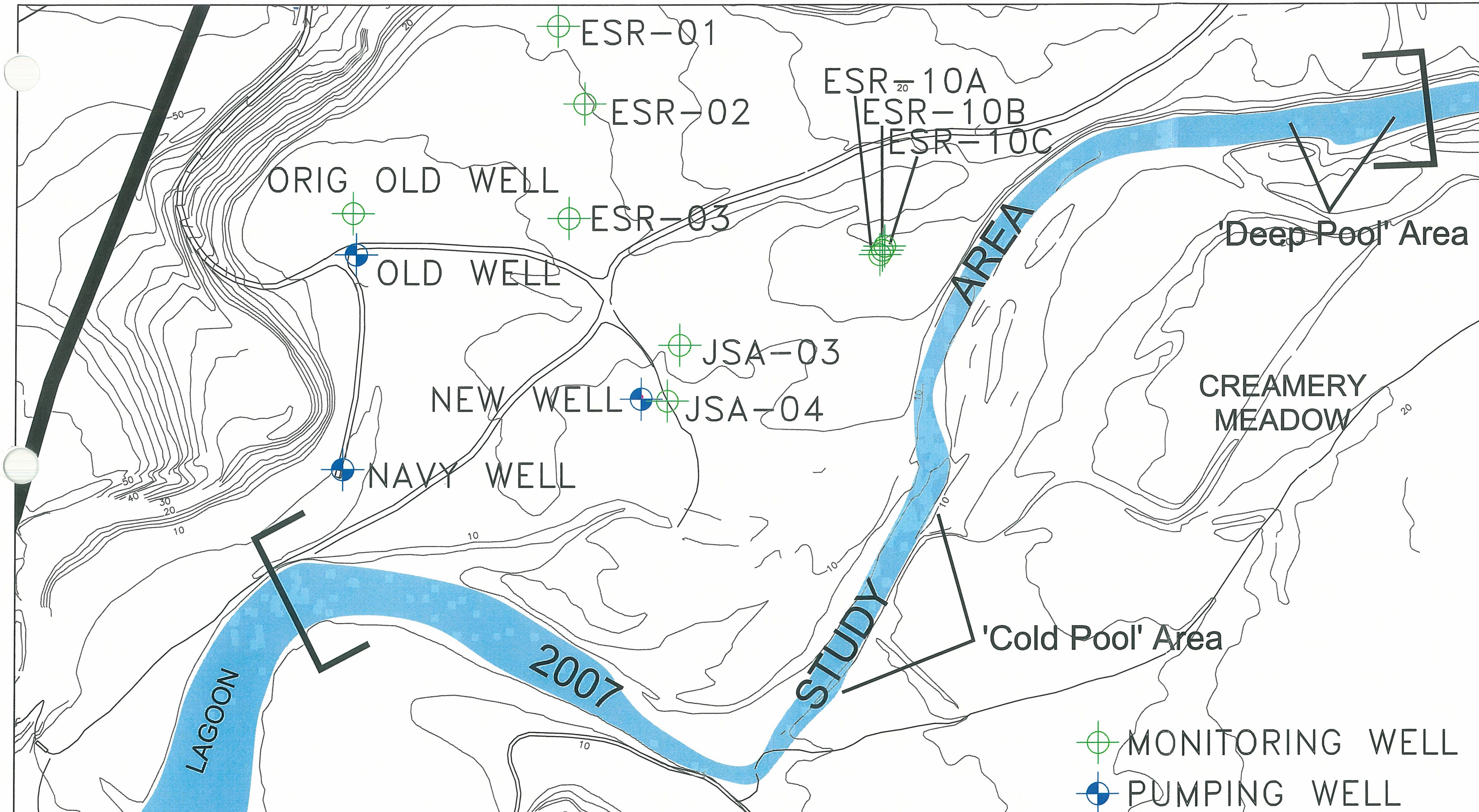
EL SUR RANCH BIG SUR, CALIFORNIA				FIGURE 1-1 STUDY AREA BASE MAP
PROJECT NO. 01-ESR-004	DATE 1/15/08	DR. BY ML/jp	APP. BY PH	



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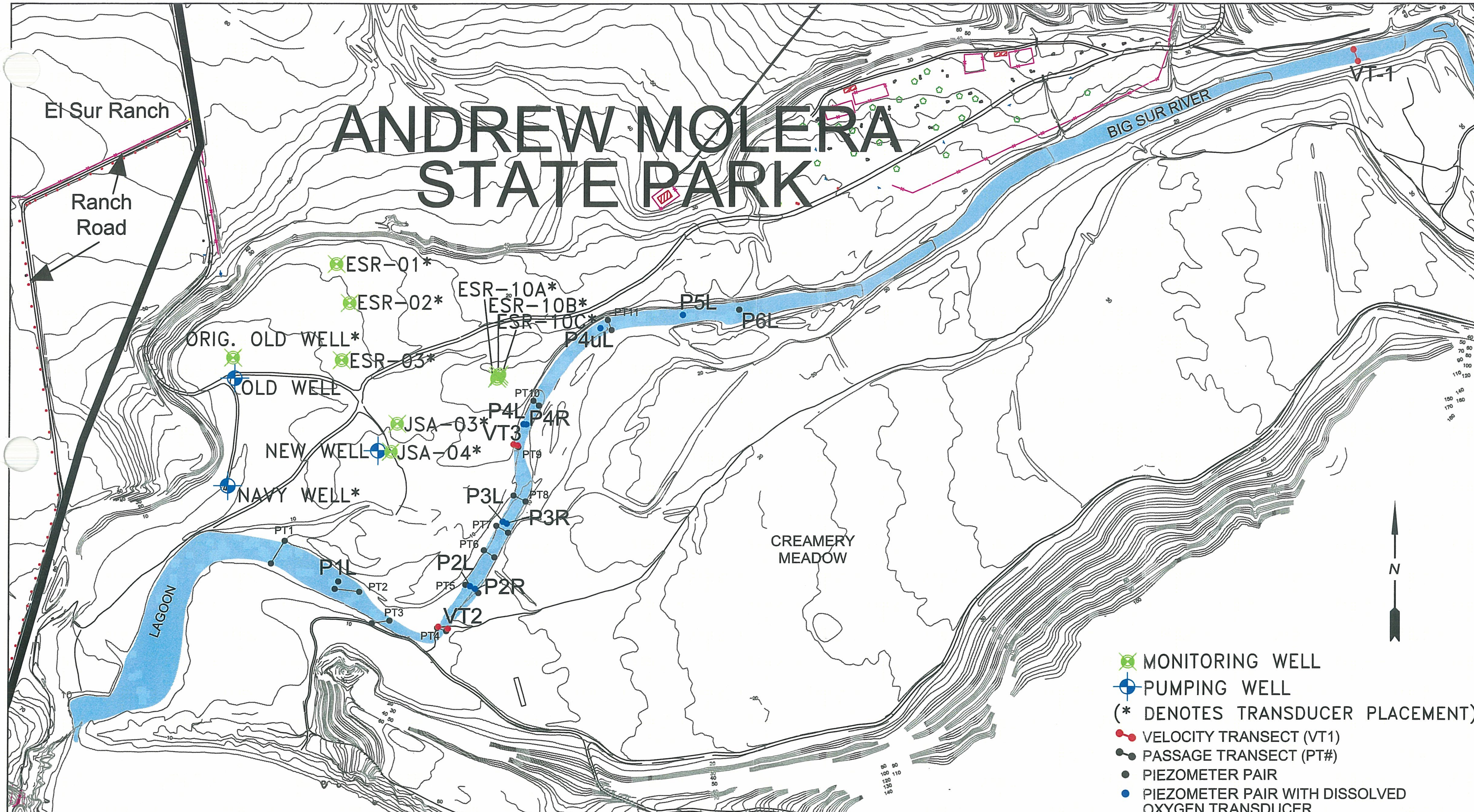
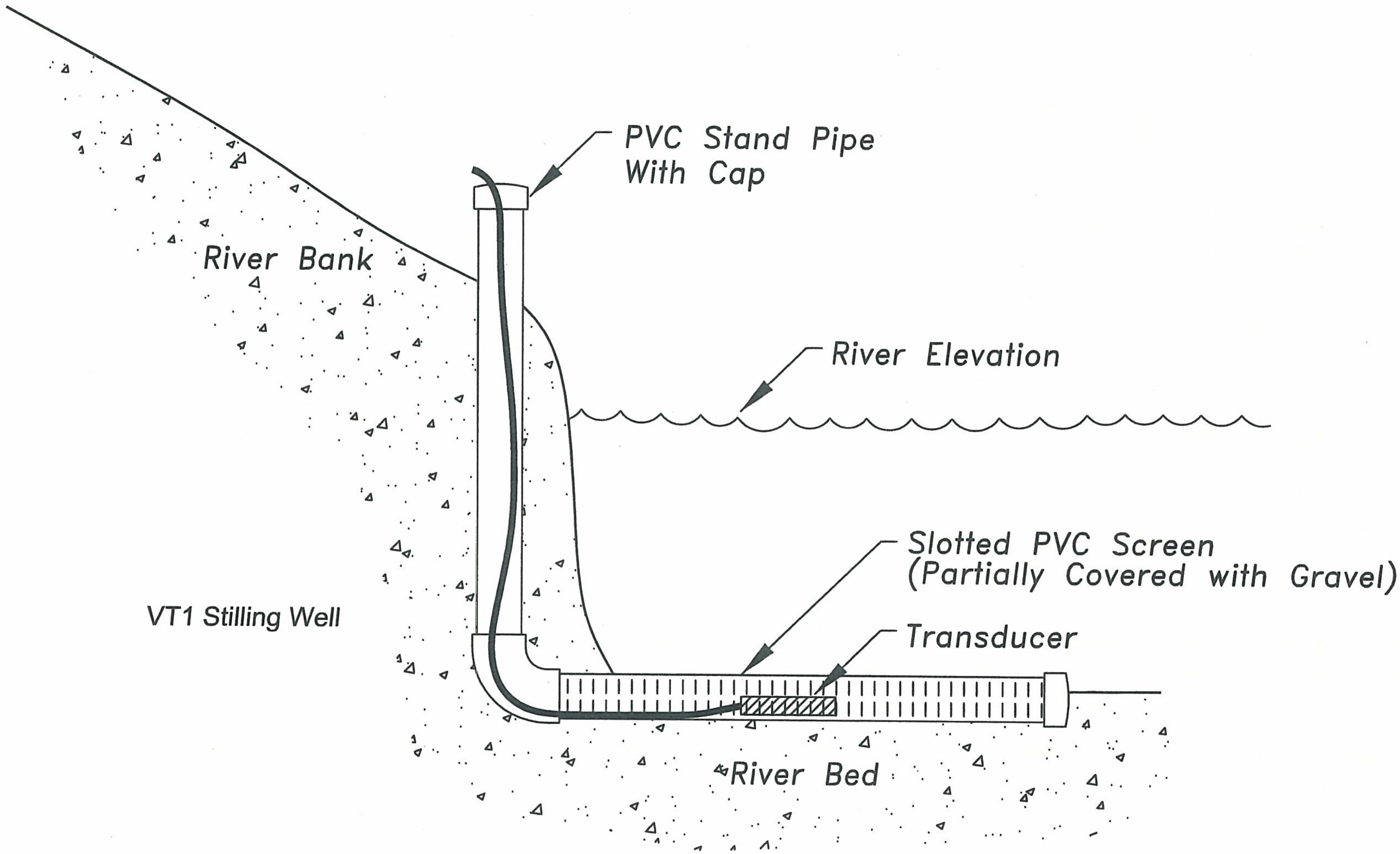
EL SUR RANCH BIG SUR, CALIFORNIA		SCALE 0 150 300 SCALE IN FEET		FIGURE 1-2 2007 STUDY AREA MAP
PROJECT NO. 01-ESR-004	DATE 1/15/08	DR. BY ML/jp	APP. BY PH	



SGI environmental THE SOURCE GROUP, INC.	EL SUR RANCH BIG SUR, CALIFORNIA	SCALE 0 300 600 SCALE IN FEET	FIGURE 2-1 2007 STUDY AREA MONITORING STATION AND SENSOR LOCATION MAP
	PROJECT NO. 01-ESR-004 / DATE 1/15/08	DR. BY NC/jp / APP. BY PH	

ESR-6



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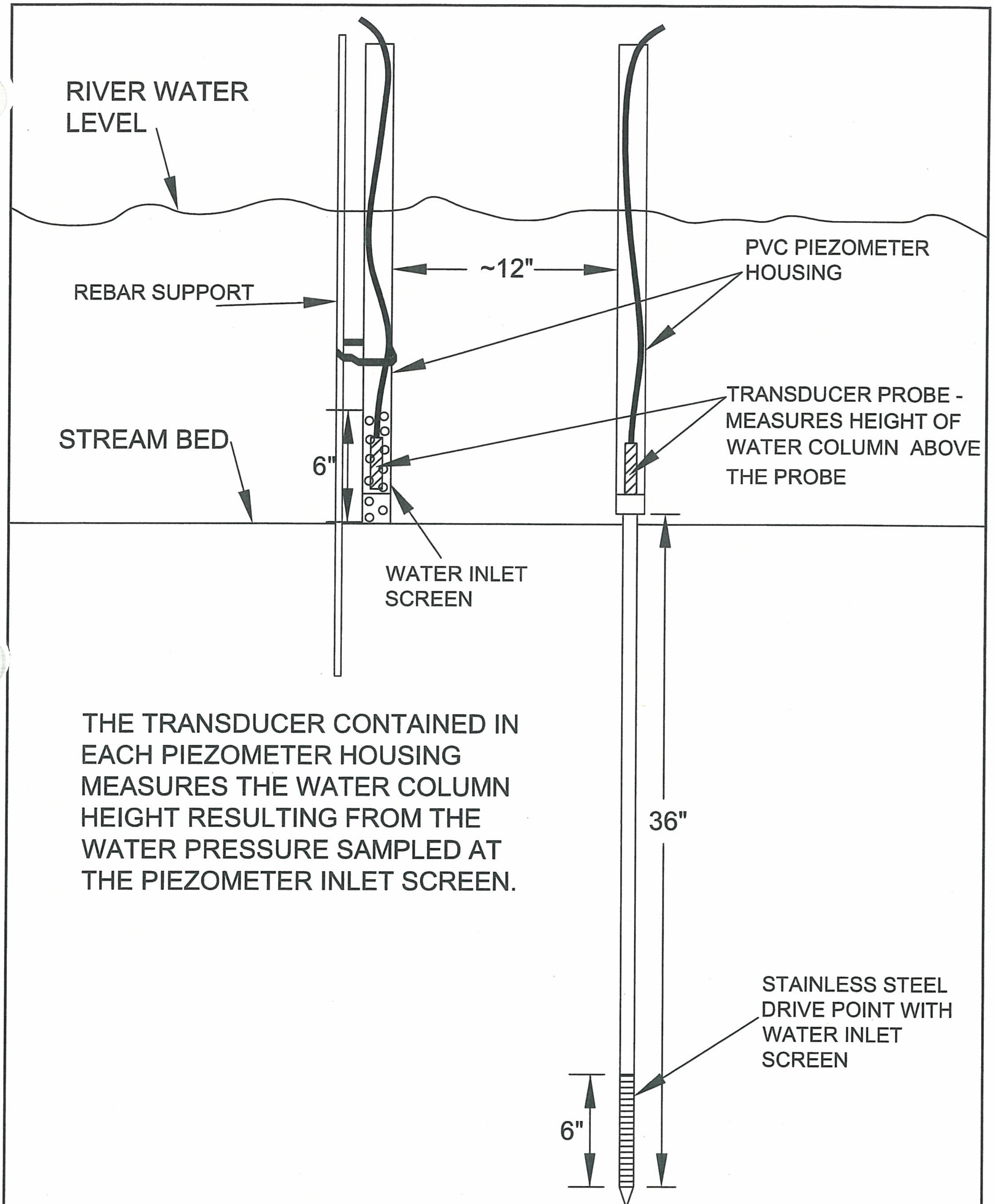
SGI environmental

EL SUR RANCH
BIG SUR, CALIFORNIA

FIGURE 2-2
SIMPLIFIED STILLING WELL DIAGRAM

FILE NAME	PROJECT NO.	DATE	DR. BY	APP. BY
FIGURE 2-2	01-ESR-004	1/15/08	ML	JP



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EL SUR RANCH
BIG SUR, CALIFORNIA

PROJECT NO.:	DATE:	DR. BY:	APP. BY:
01-ESR-004	1/15/08	NC	JP

FIGURE 2-3

PIEZOMETER WELL PAIR INSTALLATION SCHEMATIC

Figure 2-4
Measurement of River Flow at VT2
El Sur Ranch
Big Sur, California

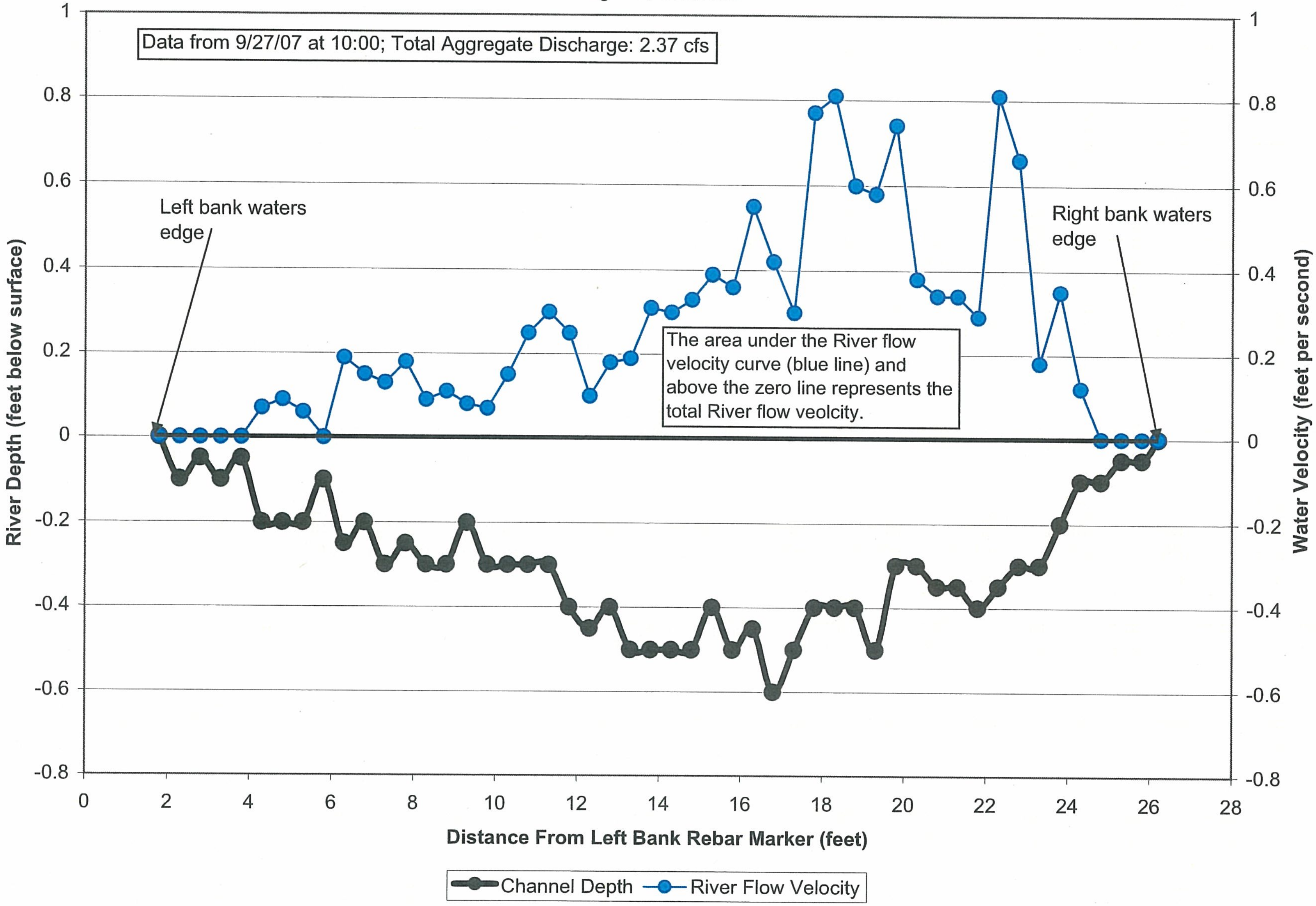

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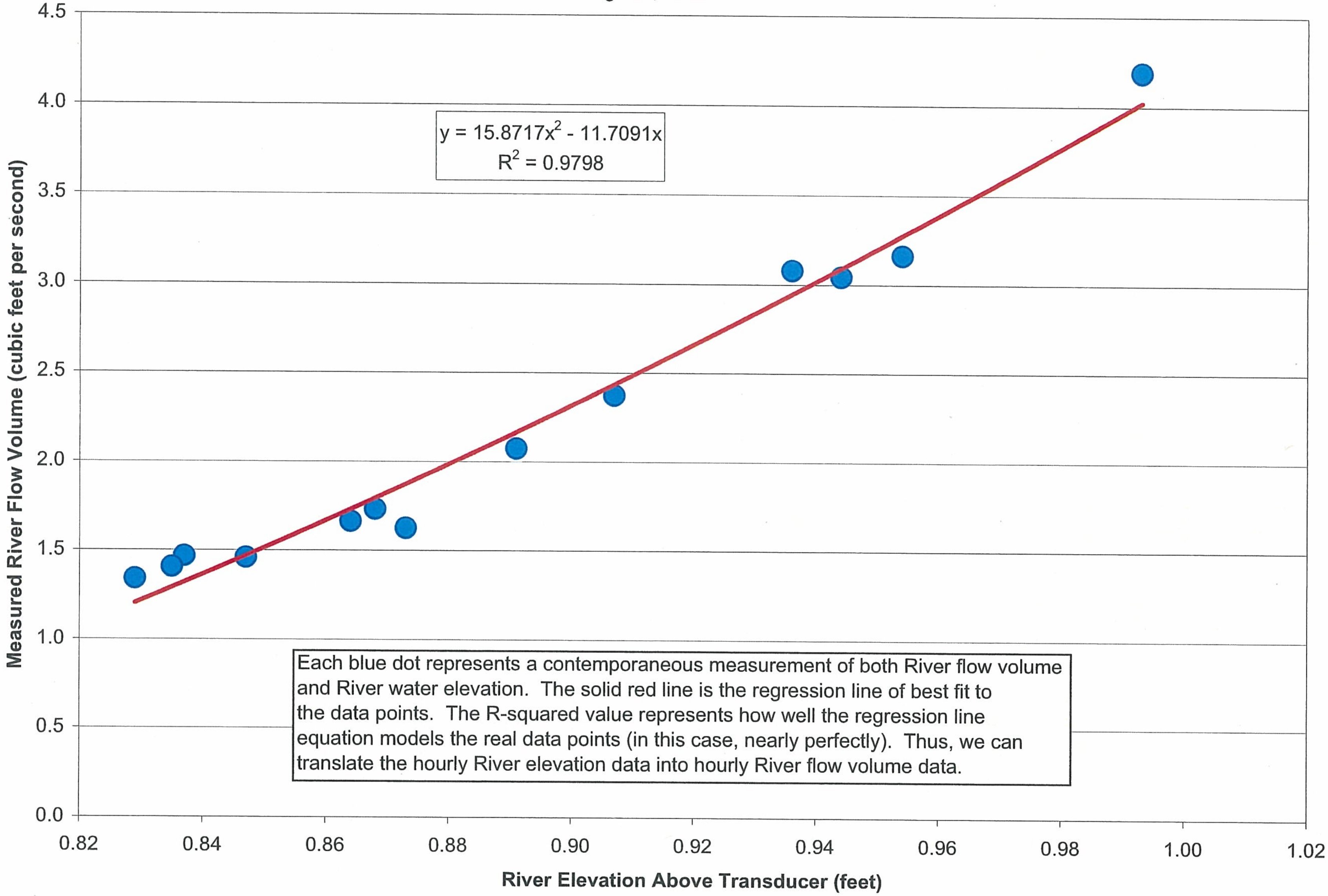
Figure 2-5
Regression Line Fit to VT2 River Flow Data and River Elevation at P2RS
El Sur Ranch
Big Sur, California



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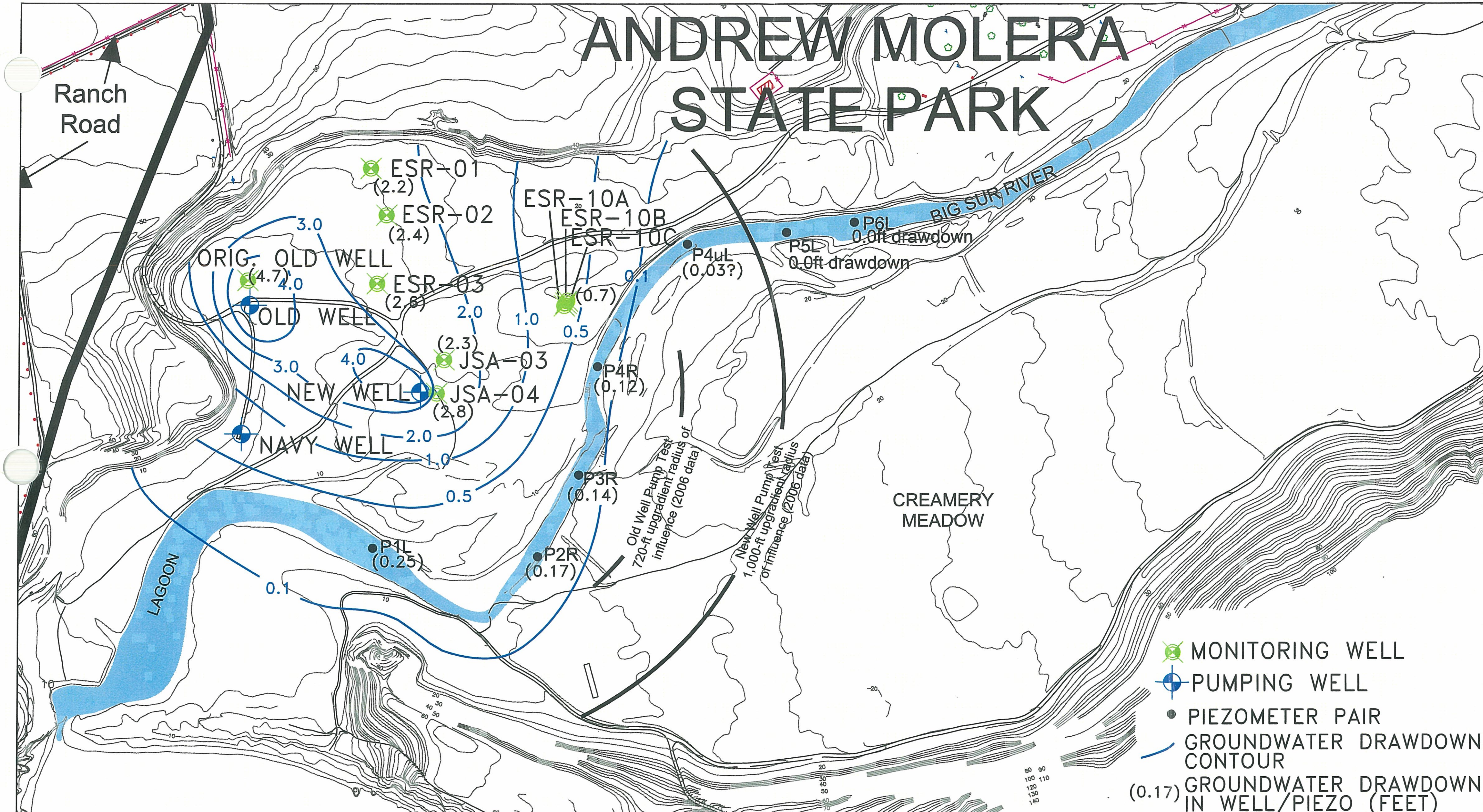

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EL SUR RANCH
BIG SUR, CALIFORNIA

SCALE
0 250 500
SCALE IN FEET

PROJECT NO.	DATE	DR. BY	APP. BY
01-ESR-004	11/16/07	ML/jp	PH

FIGURE 3-1
IRRIGATION WELL RADIUS OF INFLUENCE AND CONCEPTUAL GROUNDWATER DRAWDOWN MAP (2007 MAXIMUM PUMPING CONDITIONS DEPICTED)

Figure 3-2
Drawdown at P5LD
El Sur Ranch
Big Sur, California

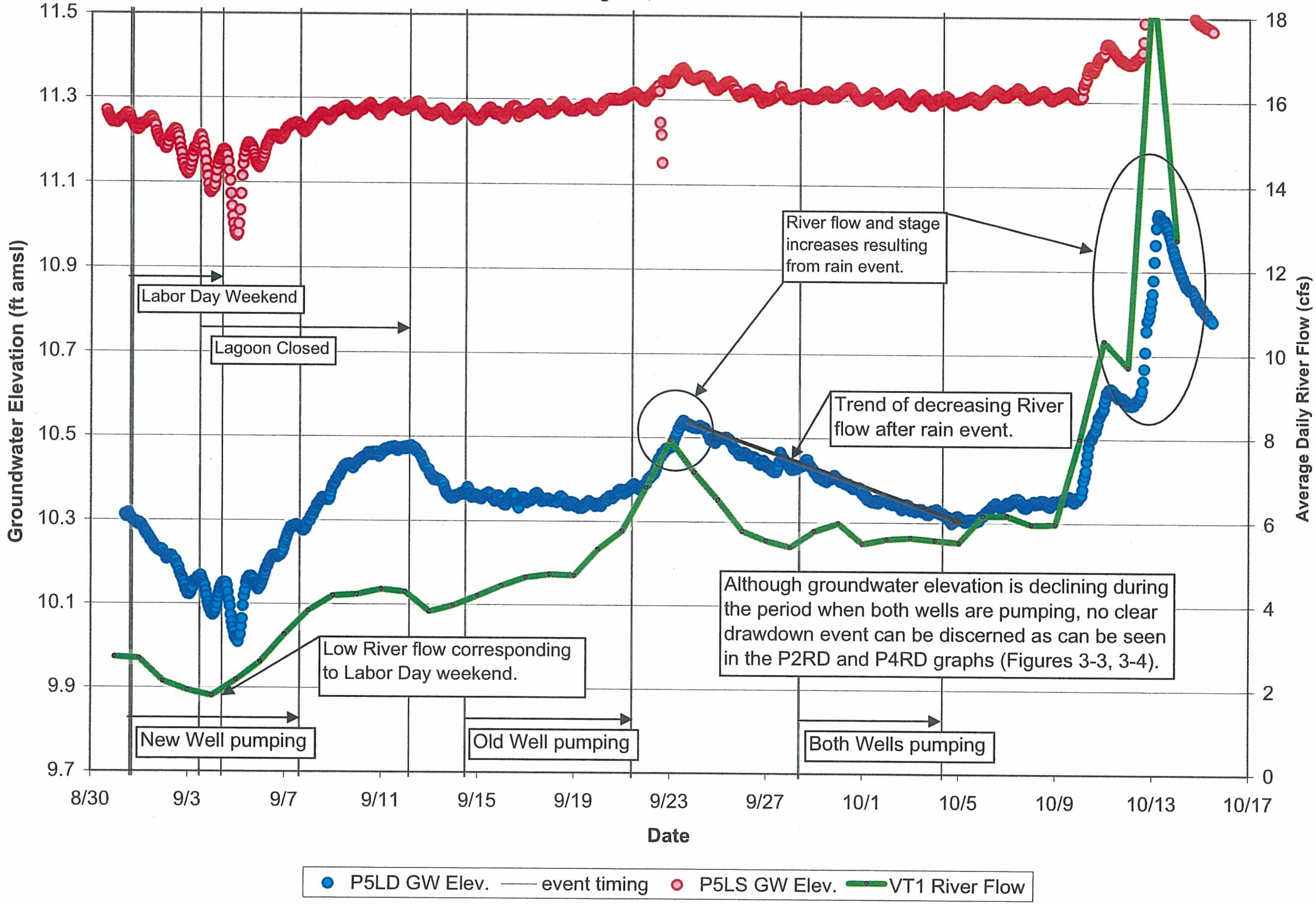

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Figure 3-3
Drawdown at P2RD
El Sur Ranch
Big Sur, California

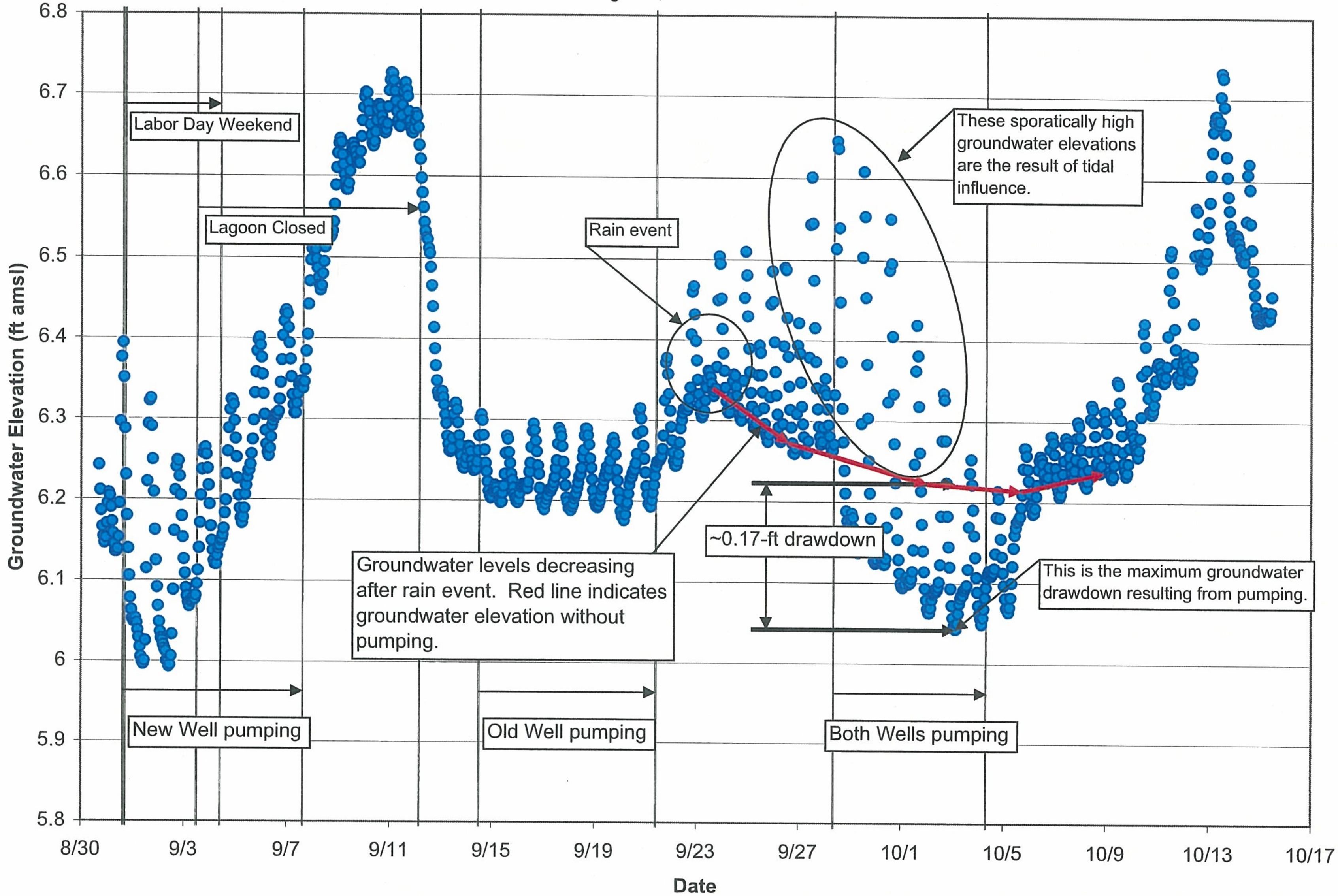

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Figure 3-4
Drawdown at P4RD
El Sur Ranch
Big Sur, California

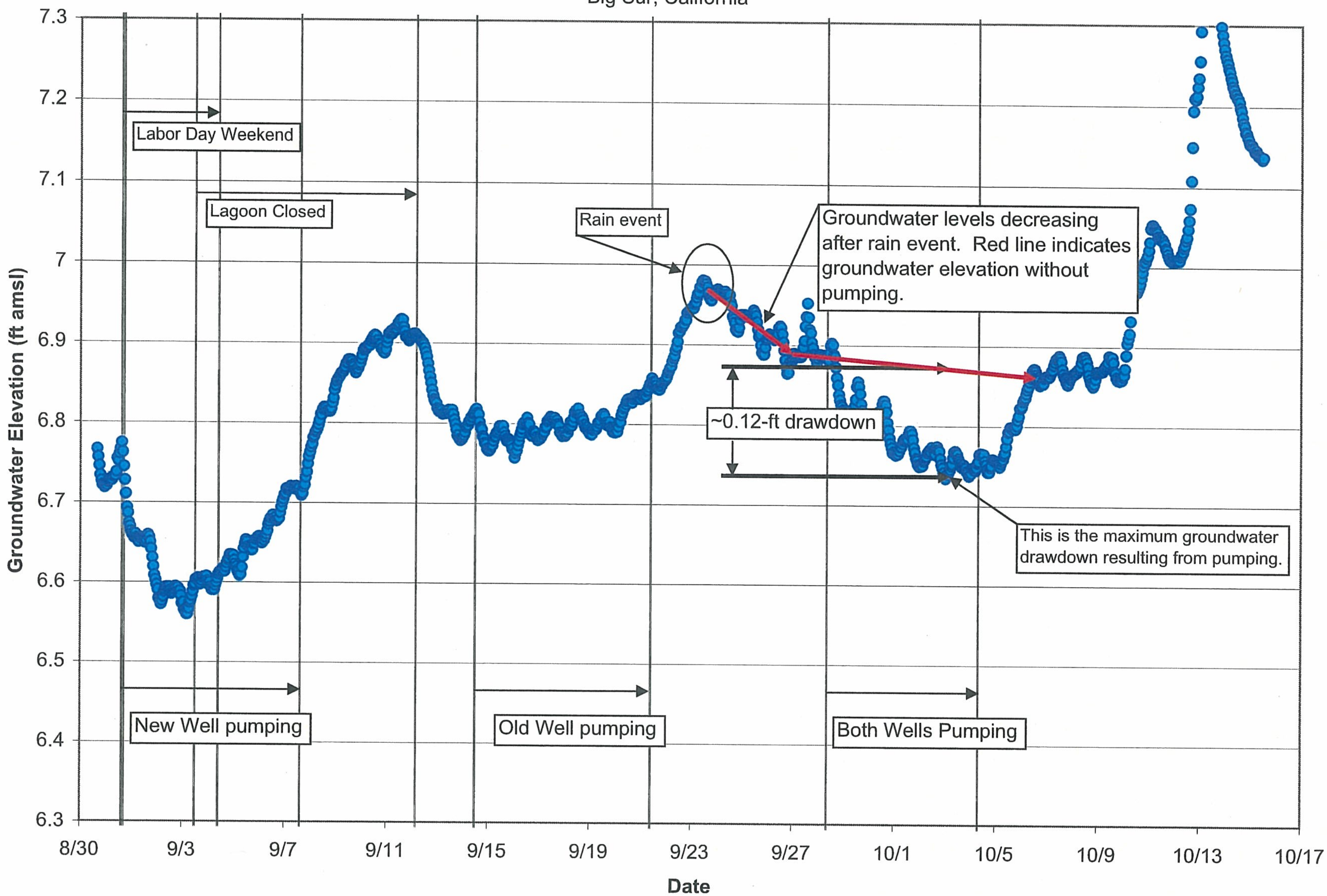

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Figure 3-5
P6L and P5L Vertical Gradient Across Riverbed
El Sur Ranch
Big Sur, California

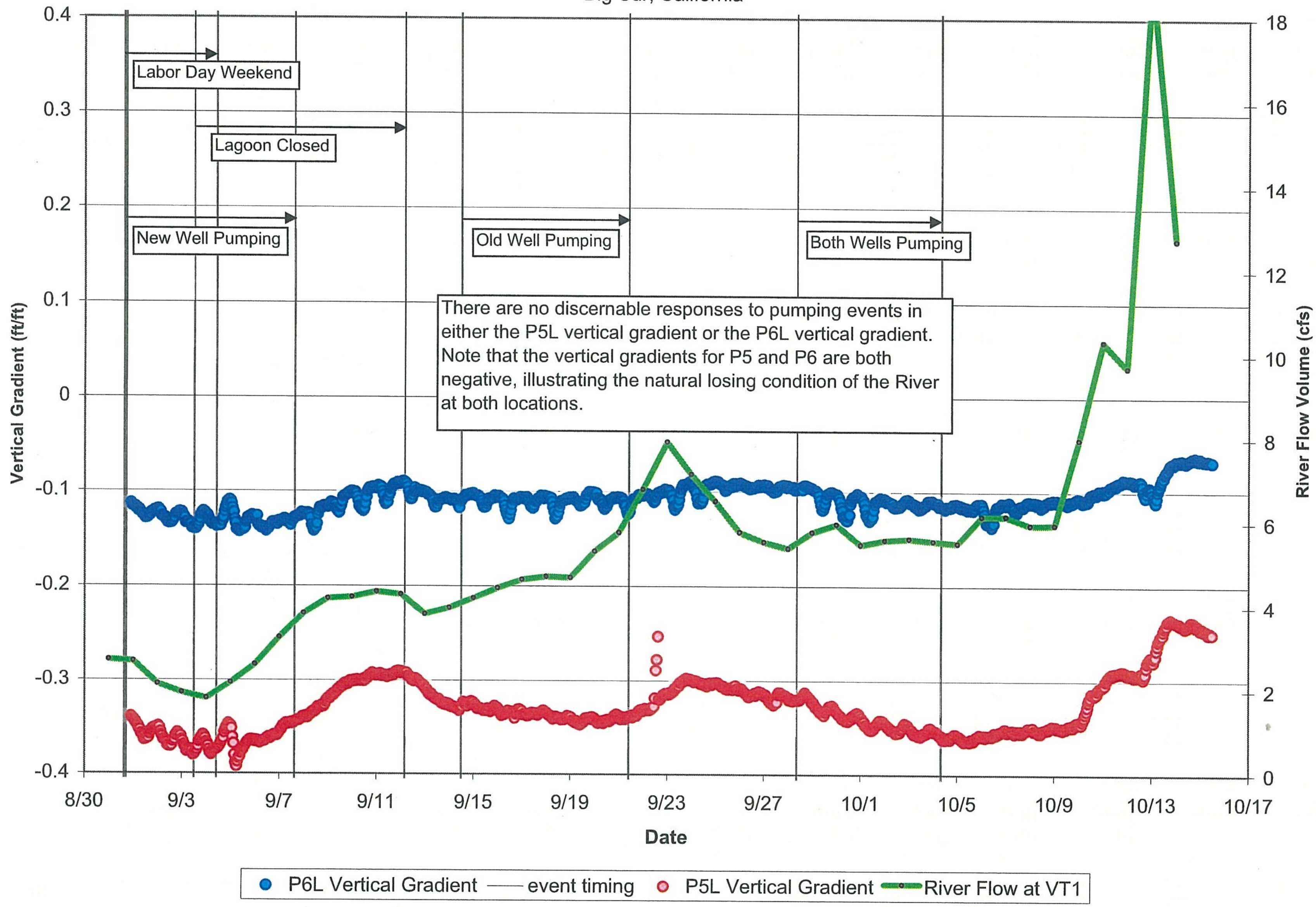

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Figure 3-6
P4uL Vertical Gradient Across Riverbed
El Sur Ranch
Big Sur, California

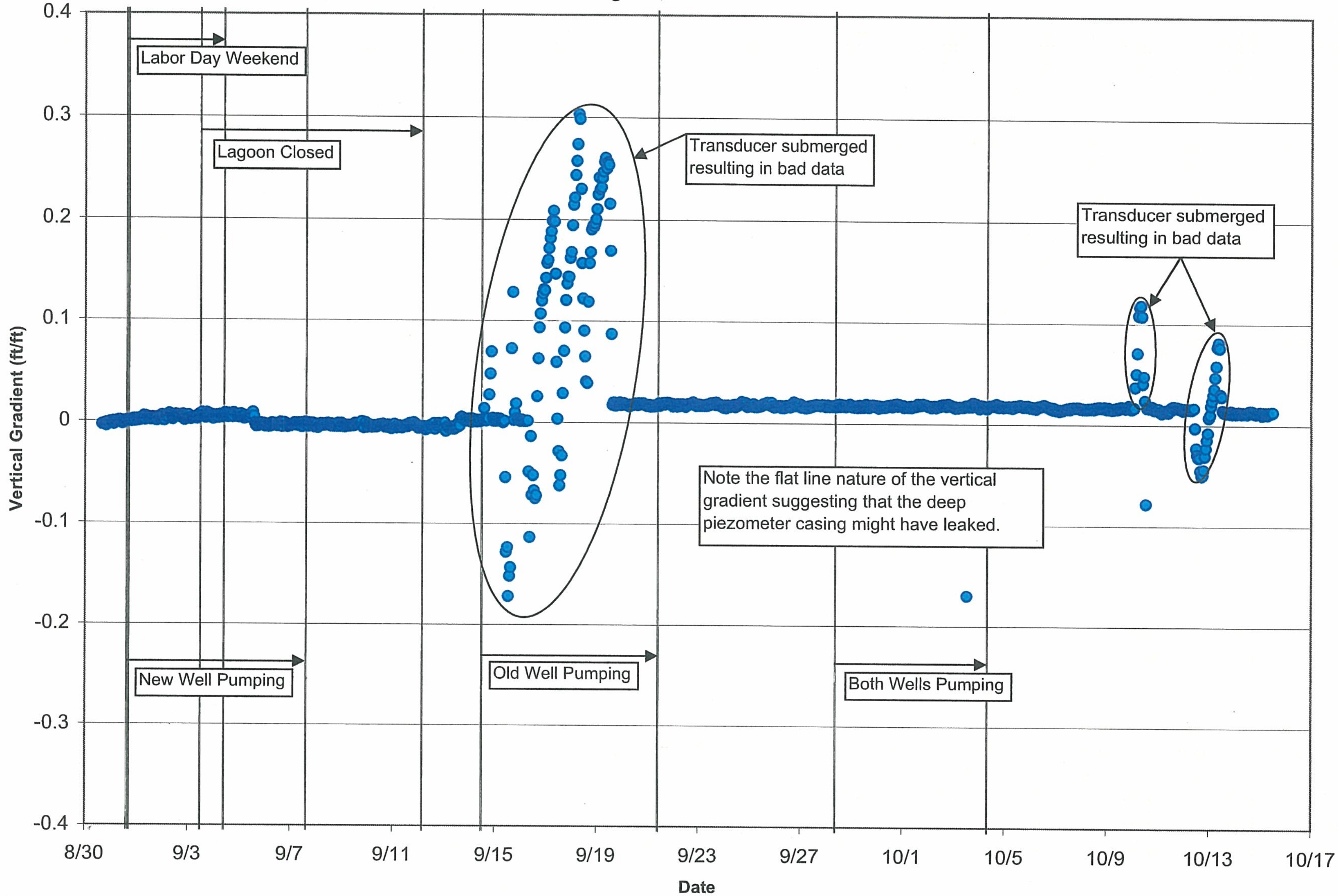

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Figure 3-7
P4L (Left Bank) and P4R (Right Bank) Vertical Gradient Across Riverbed
El Sur Ranch
Big Sur, California

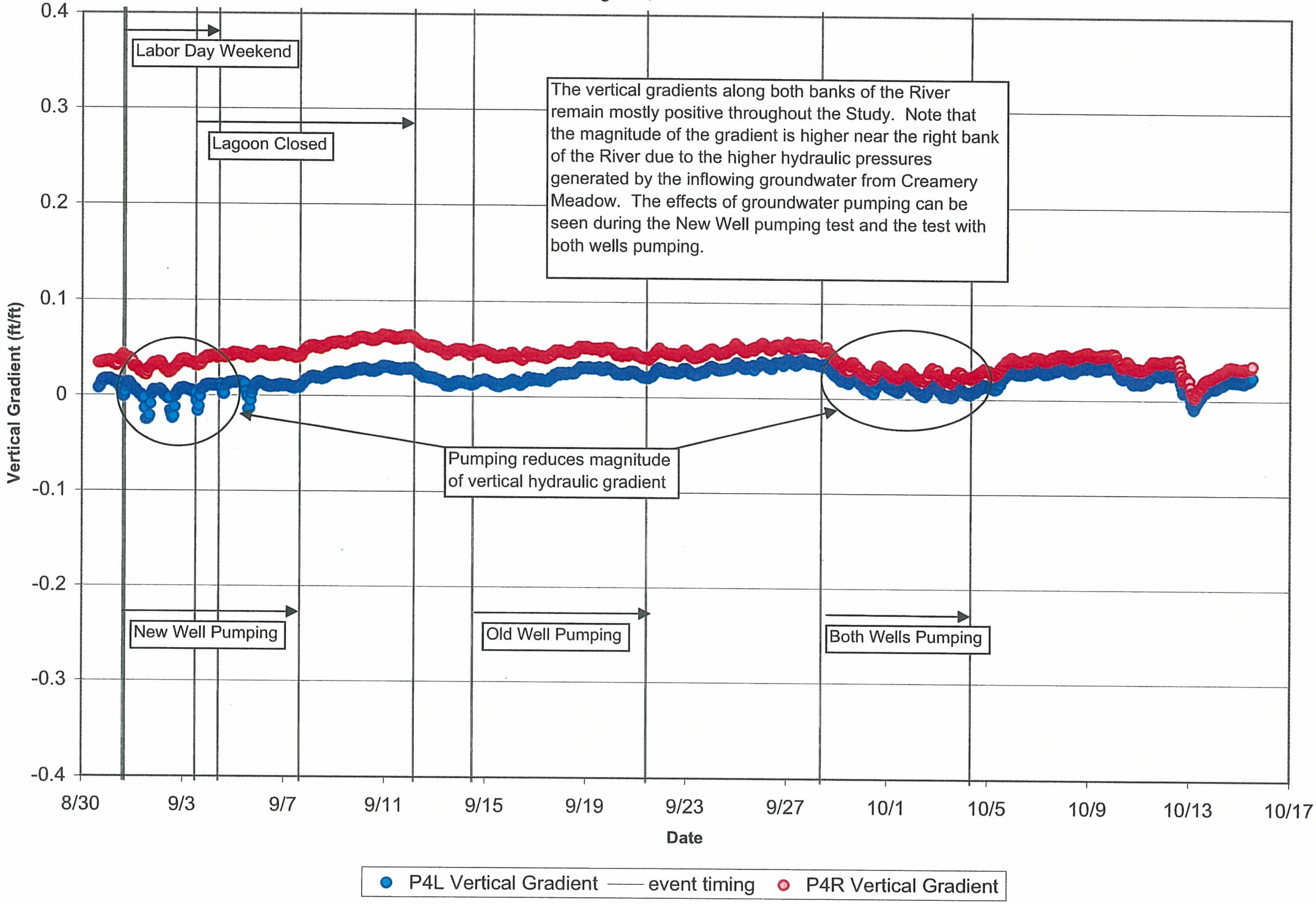

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Figure 3-8
P3L (Left Bank) and P3R (Right Bank) Vertical Gradient Across Riverbed
El Sur Ranch
Big Sur, California

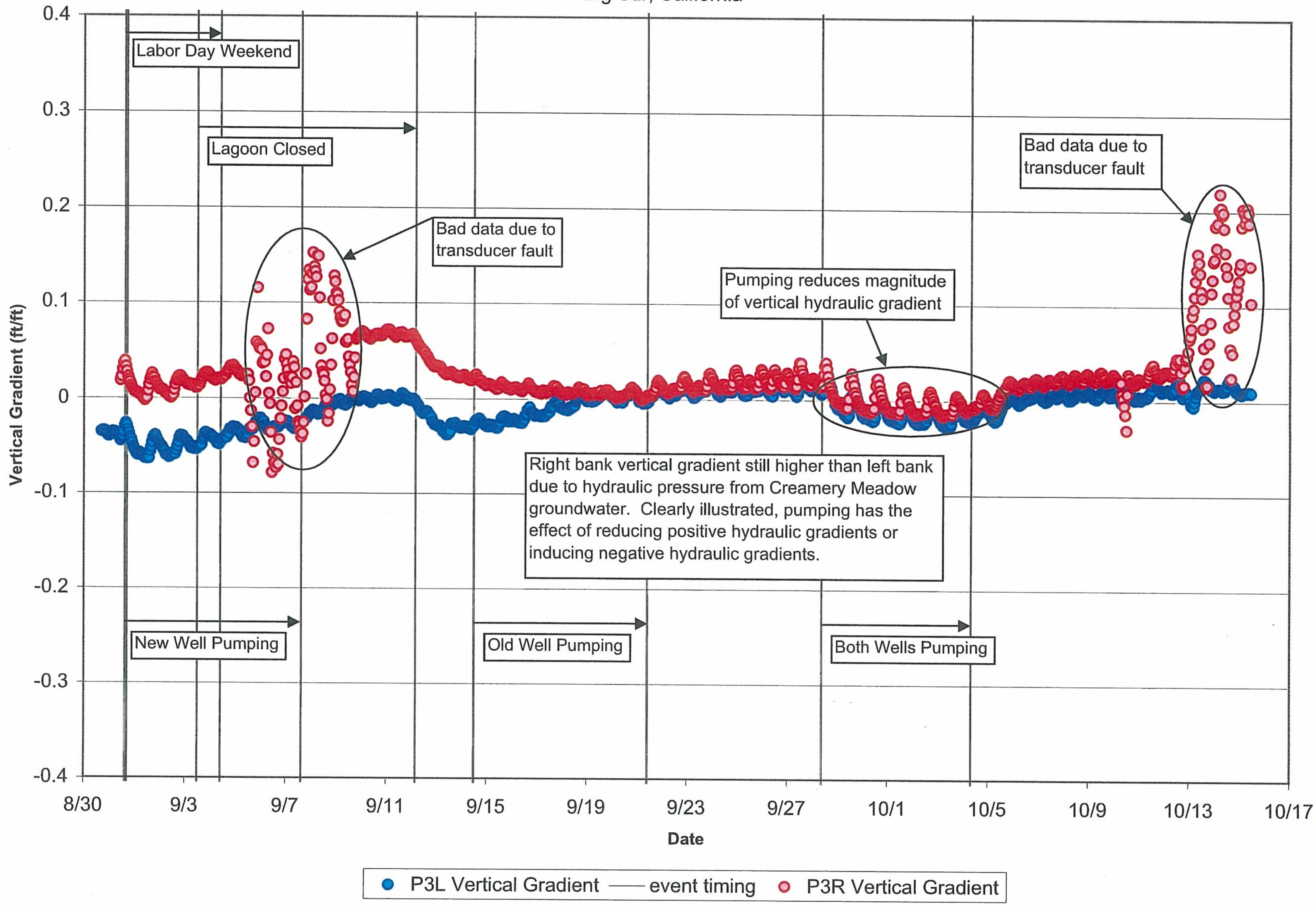

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Figure 3-9
P2L (Left Bank) and P2R (Right Bank) Vertical Gradient Across Riverbed
El Sur Ranch
Big Sur, California

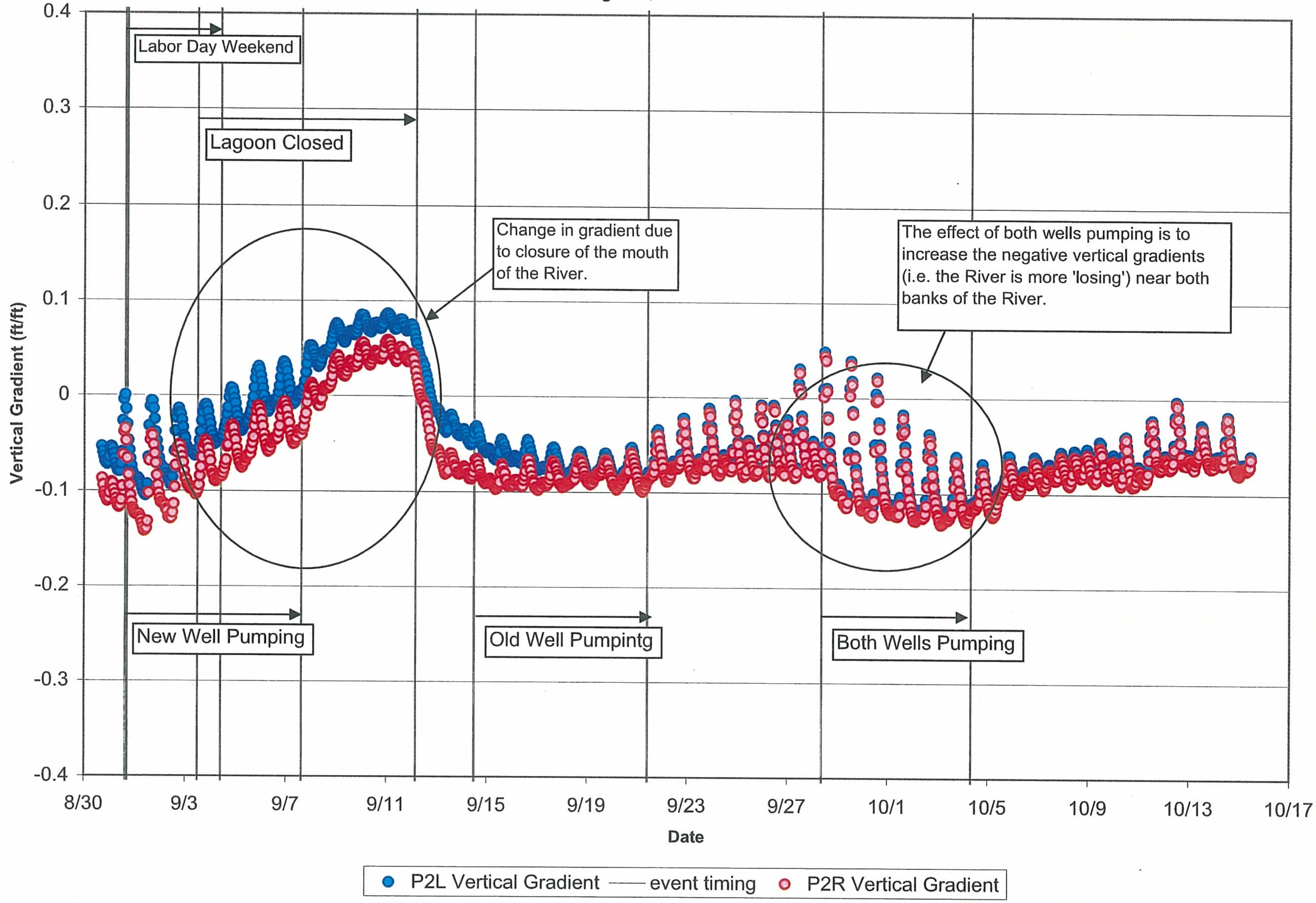

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Figure 3-10
P1L Vertical Gradient Across Riverbed
El Sur Ranch
Big Sur, California

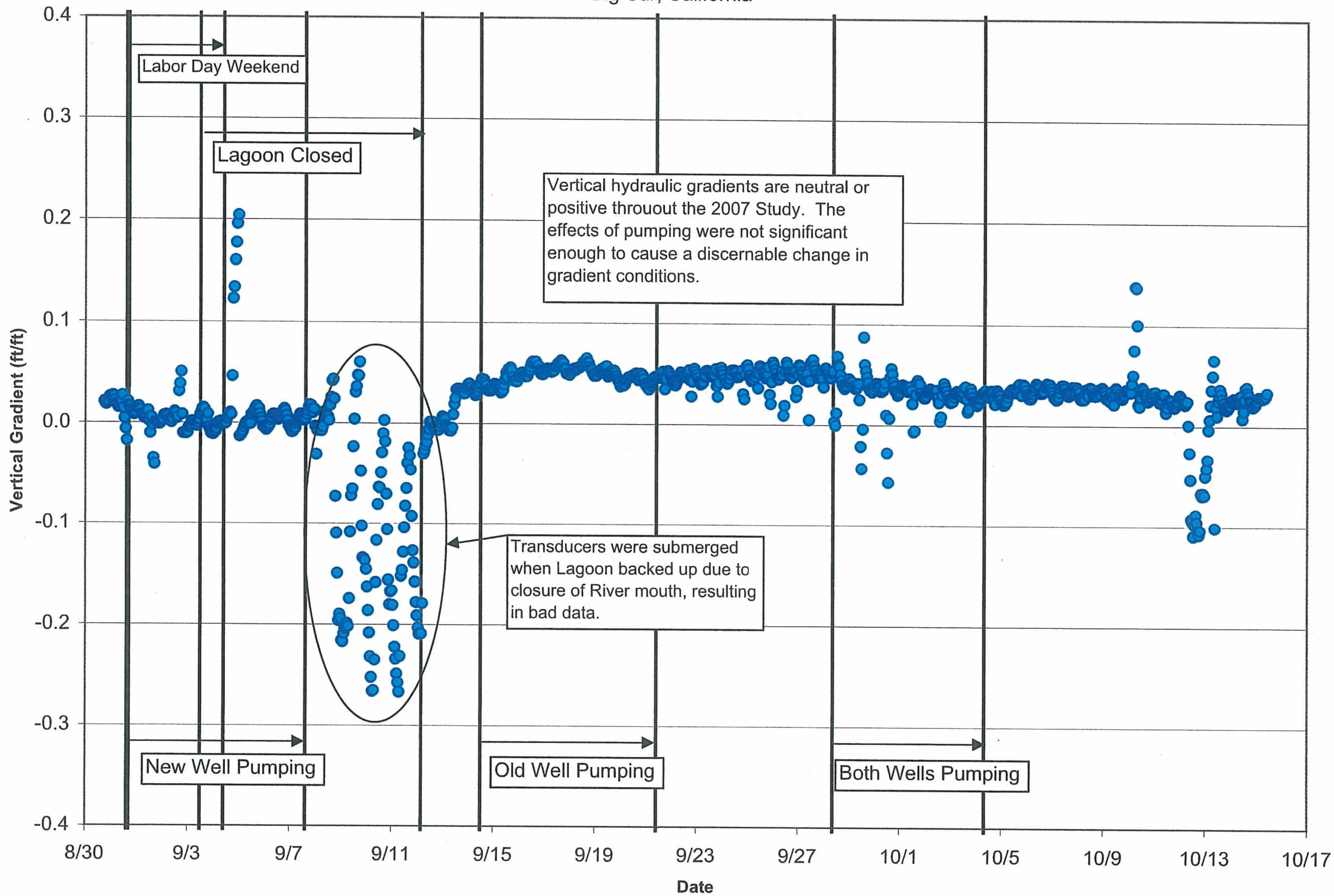

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Figure 3-11
Average Daily Flow Volume at VT2 and VT3
El Sur Ranch
Big Sur, California

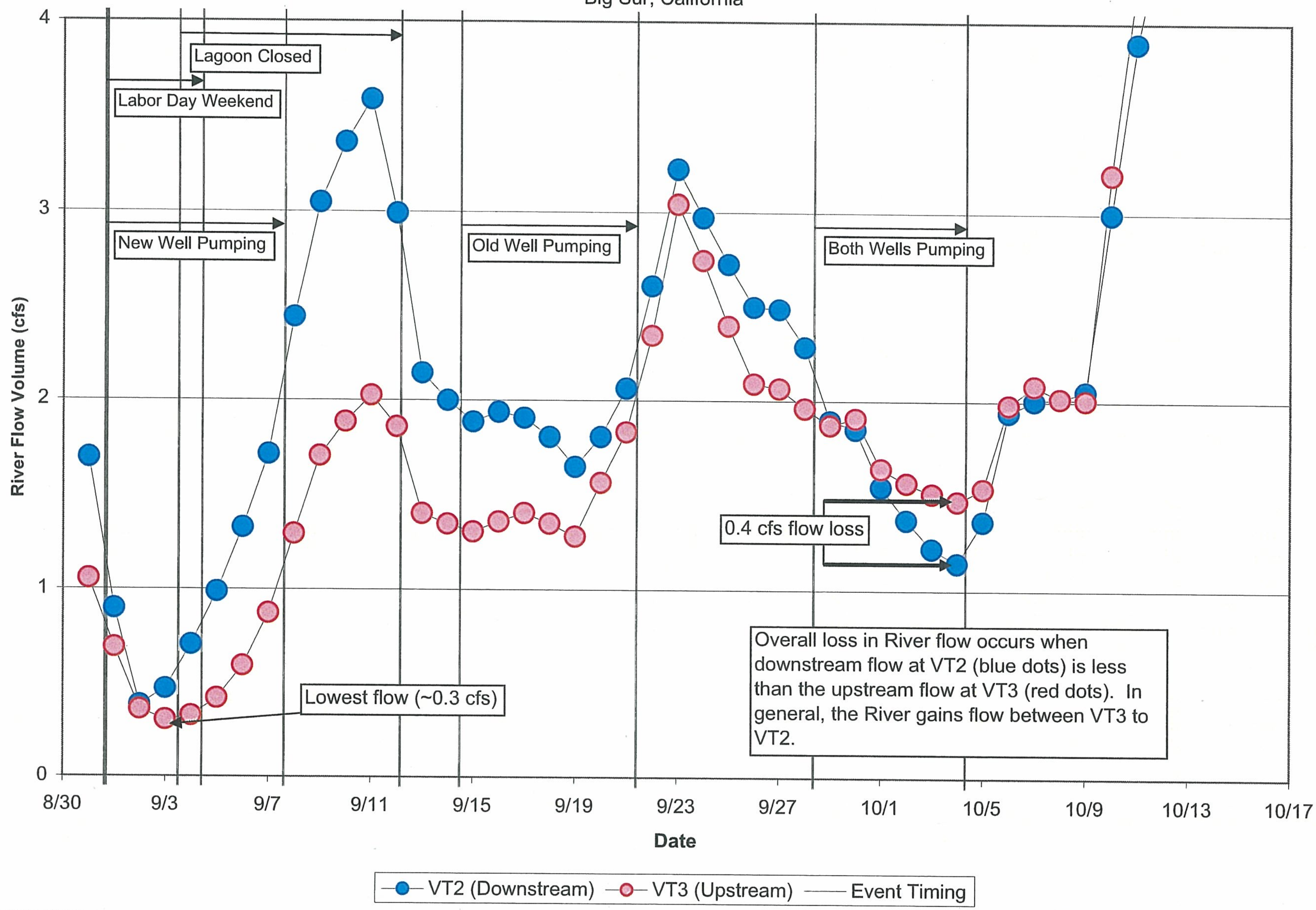

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Figure 3-12
Change in Flow Between VT3 and VT2
El Sur Ranch
Big Sur, California

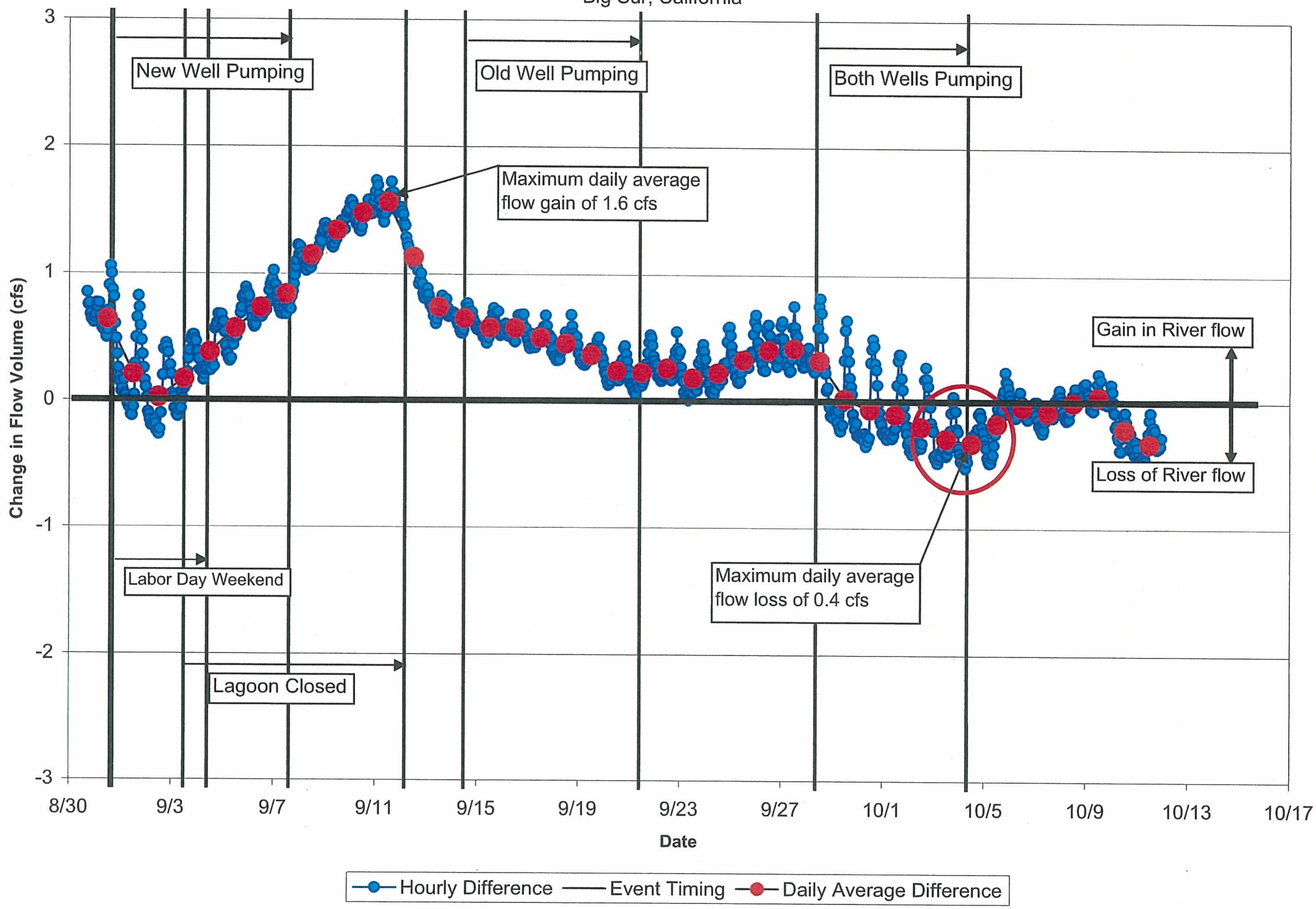

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Figure 3-13
River Flow Gain Loss - Zone 4
El Sur Ranch
Big Sur, California

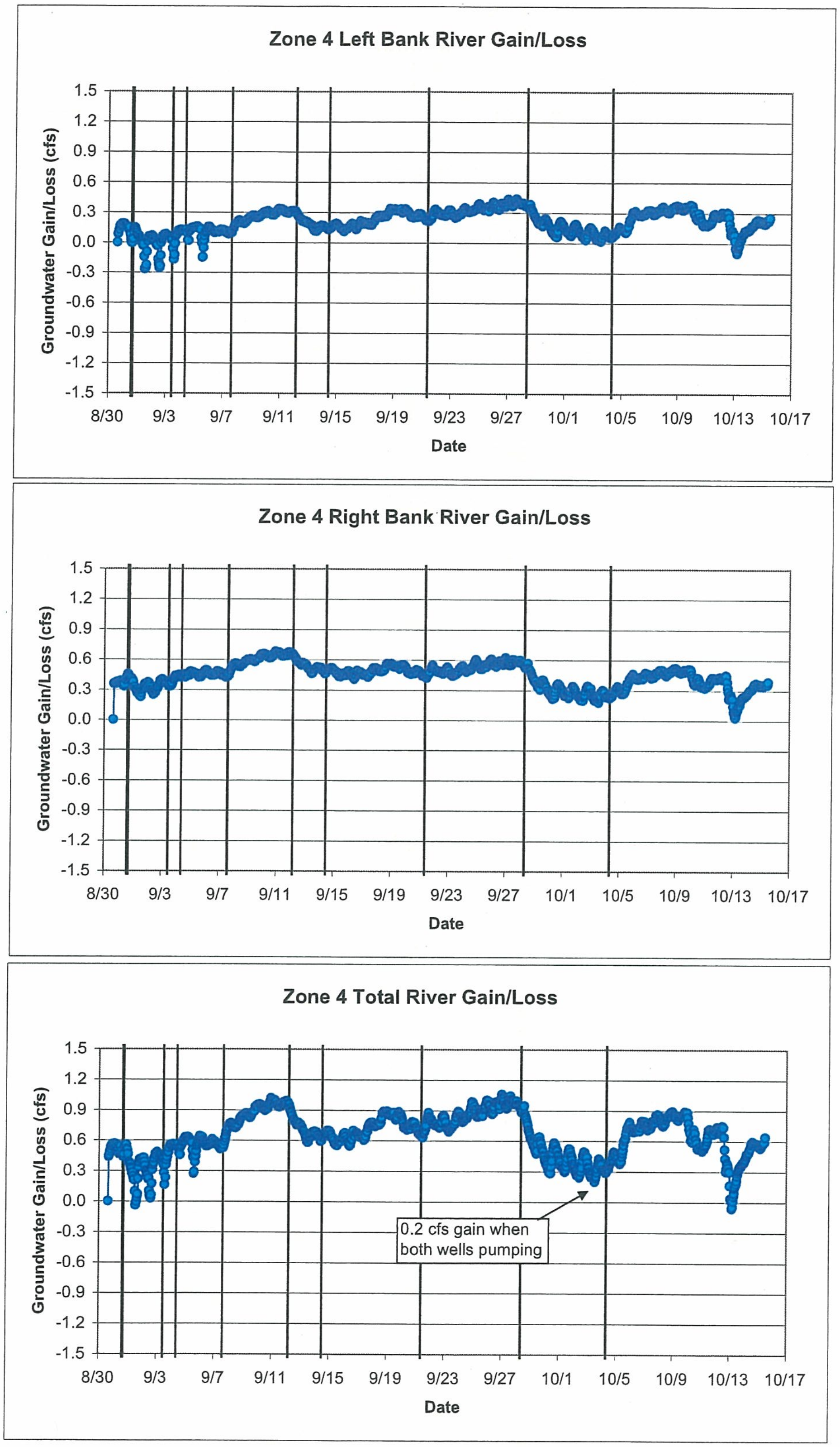

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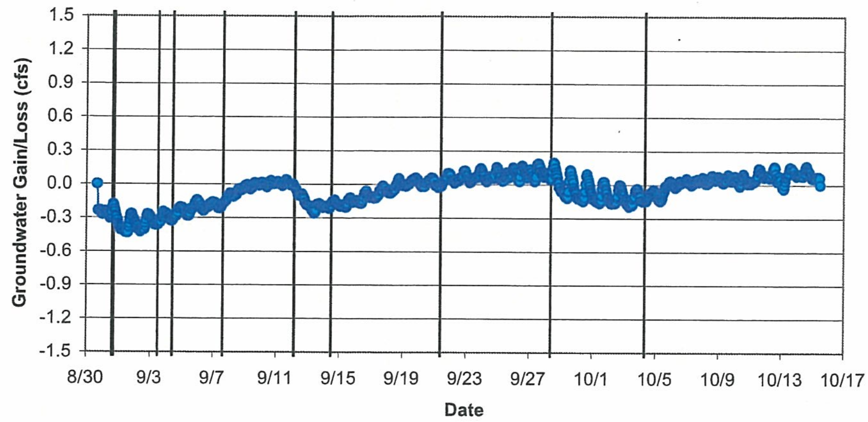
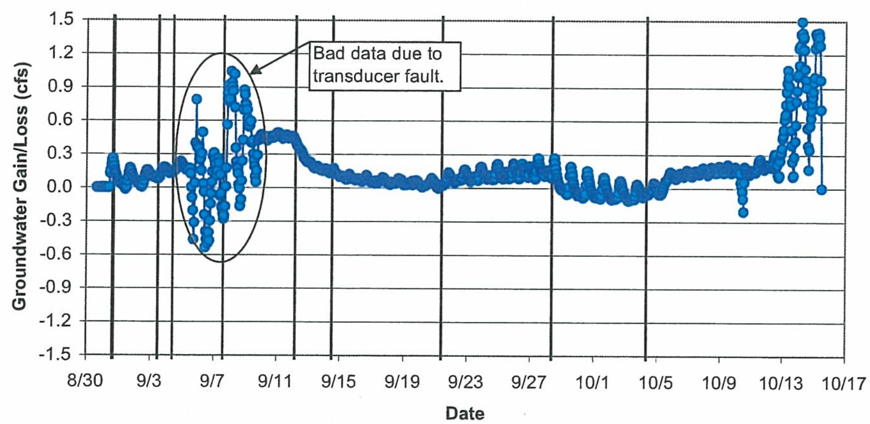
Figure 3-14
River Flow Gain Loss - Zone 3
El Sur Ranch
Big Sur, California

Zone 3 Left Bank River Gain/Loss



Zone 3 Right Bank River Gain/Loss



Zone 3 Total River Gain/Loss

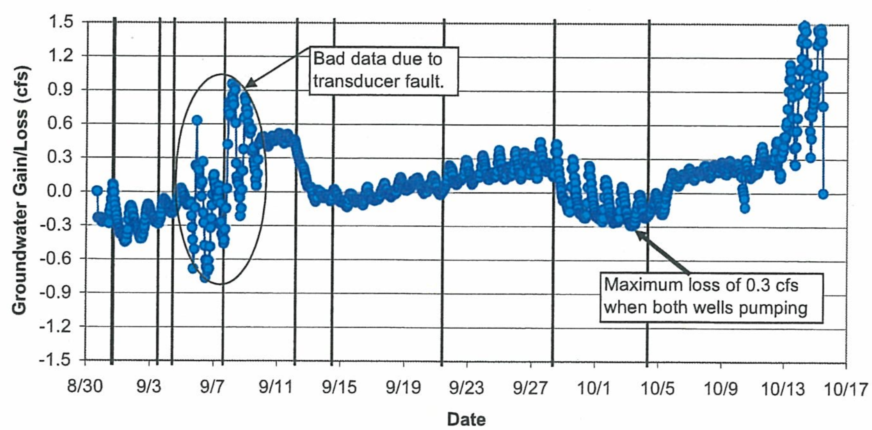
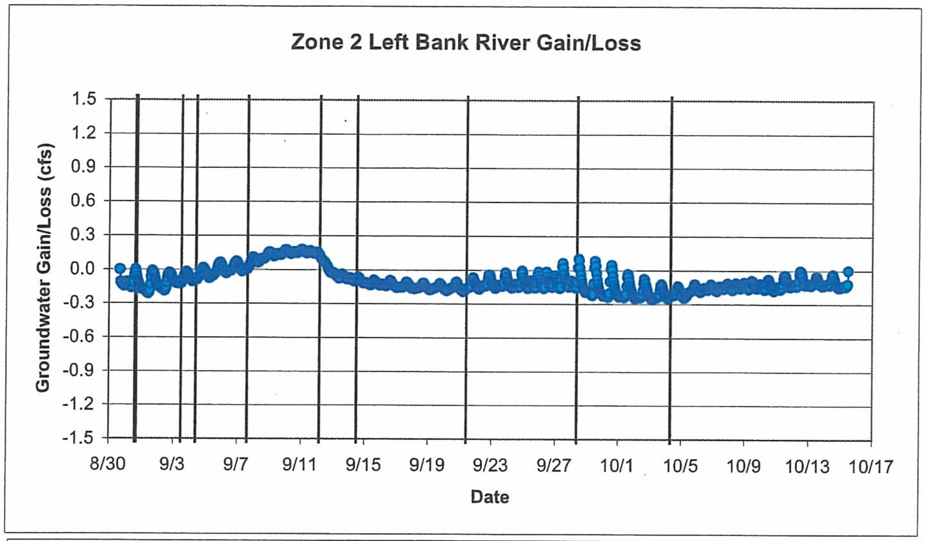
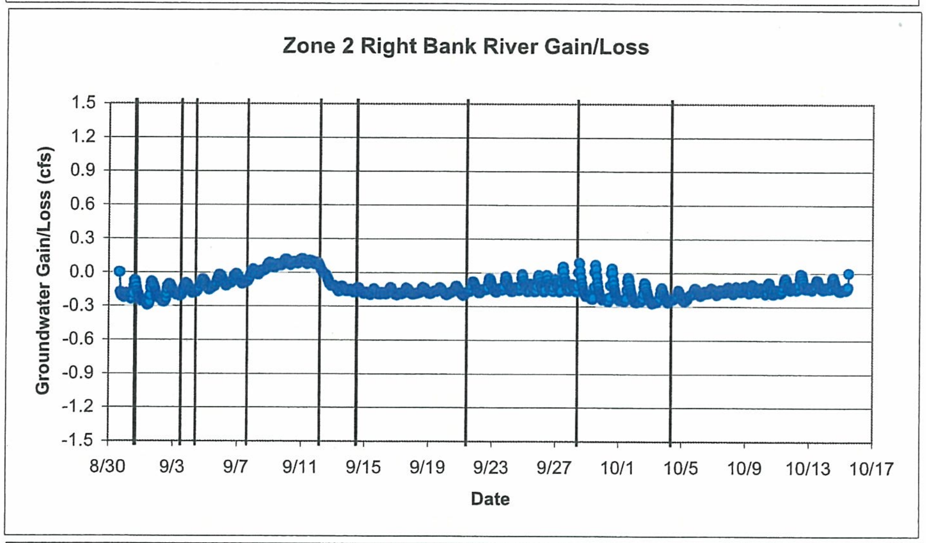
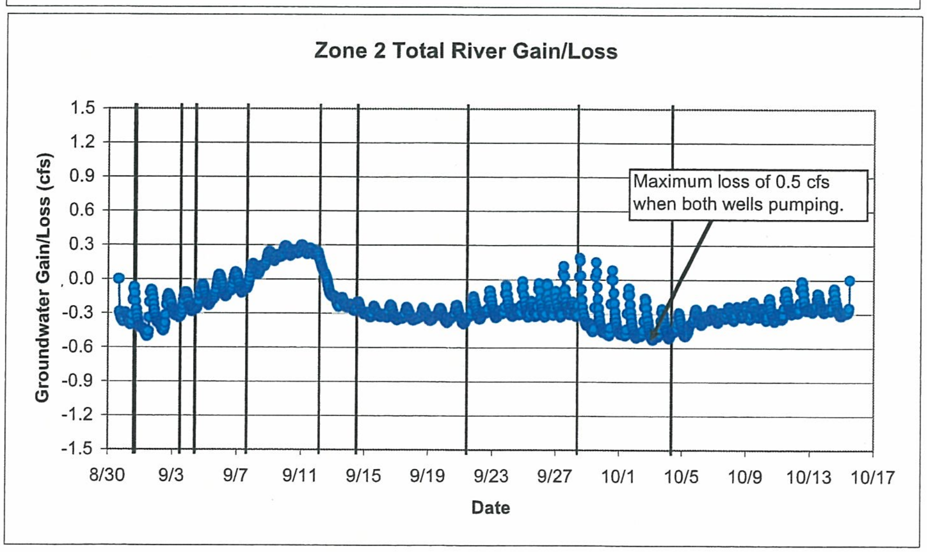


Figure 3-15
River Flow Gain Loss - Zone 2
El Sur Ranch
Big Sur, California







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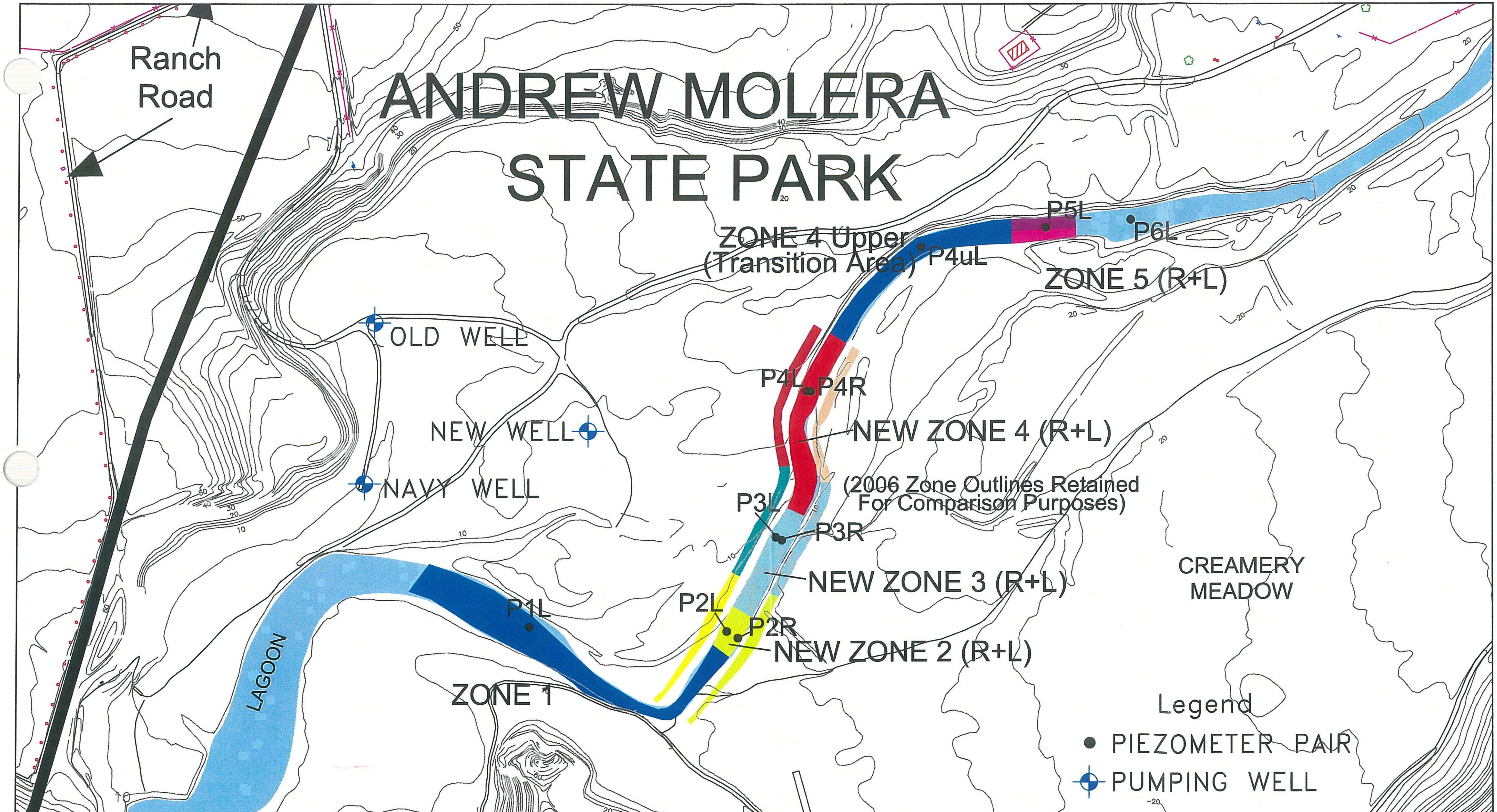

THE SOURCE GROUP, INC. SGI environmental	EL SUR RANCH BIG SUR, CALIFORNIA	SCALE 0 200 400 SCALE IN FEET	FIGURE 3-16 2007 INTERPRETED STREAMBED ZONES

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Figure 3-17
Total River Flow Gain/Loss Across Zones 2-4 Using Calibrated Areas
El Sur Ranch
Big Sur, California

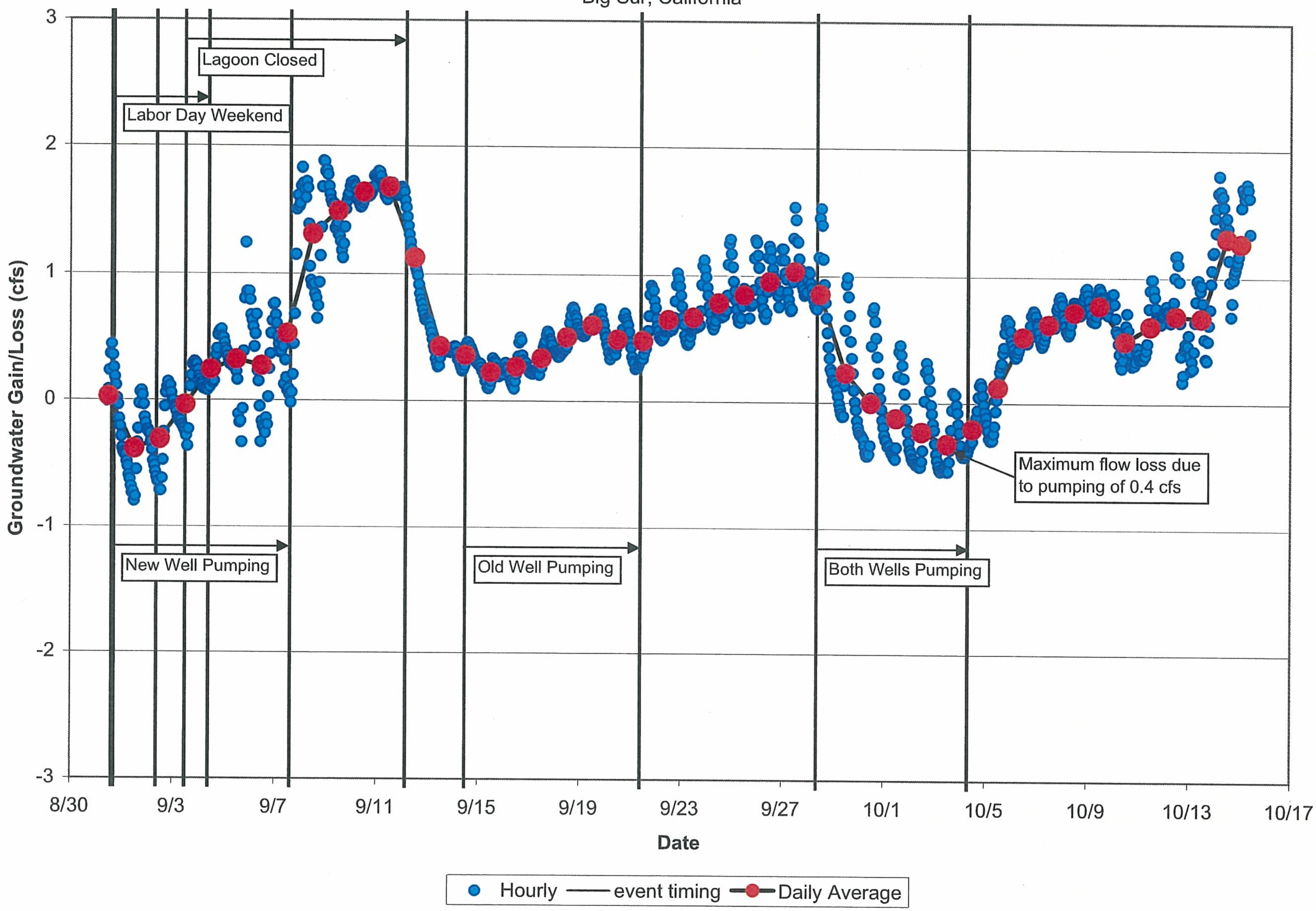

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Figure 3-18
Longitudinal Profile
El Sur Ranch
Big Sur, California

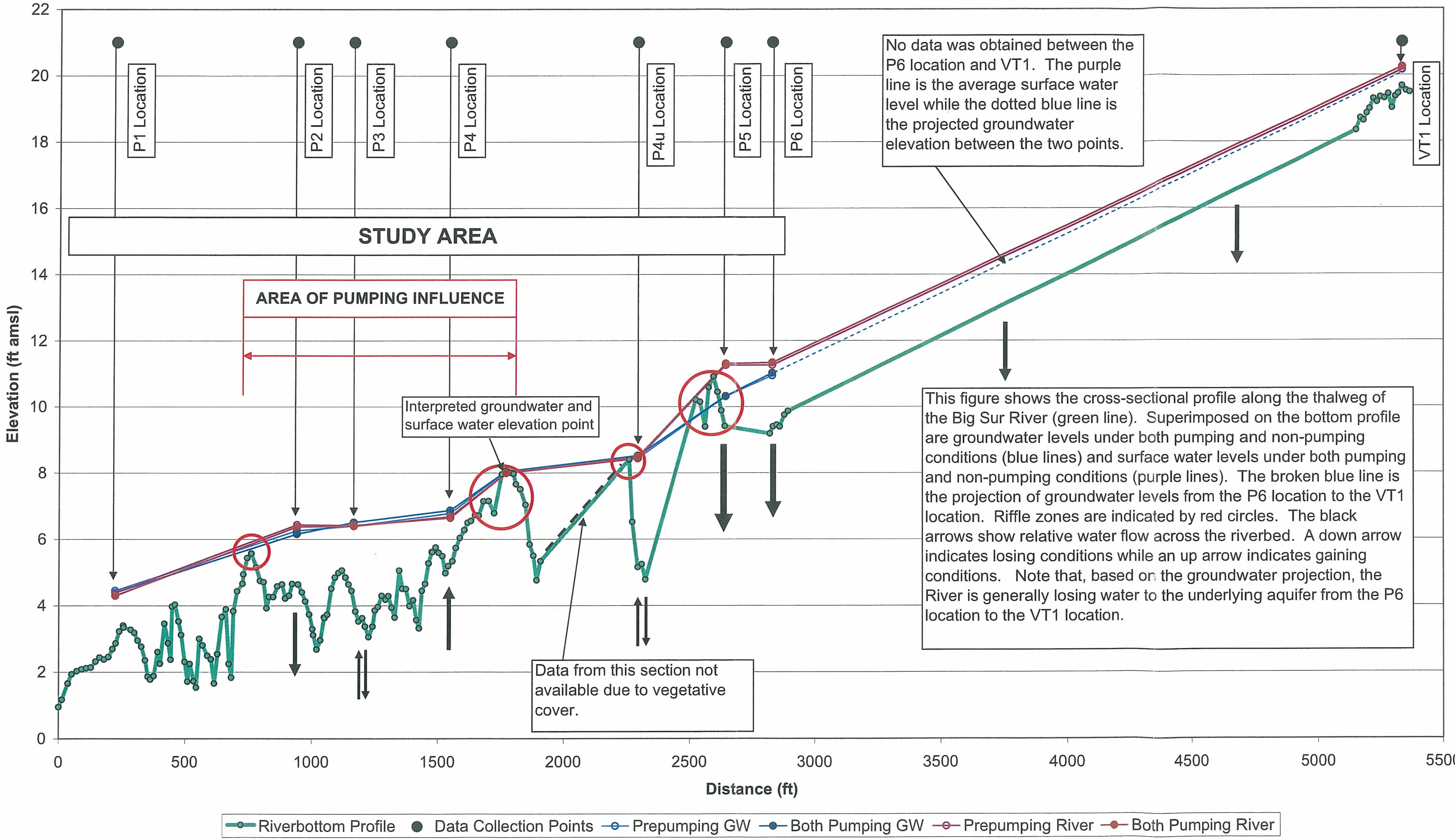

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Figure 3-19
Average Daily River Water Temperature Measured at VT1
El Sur Ranch
Big Sur, California

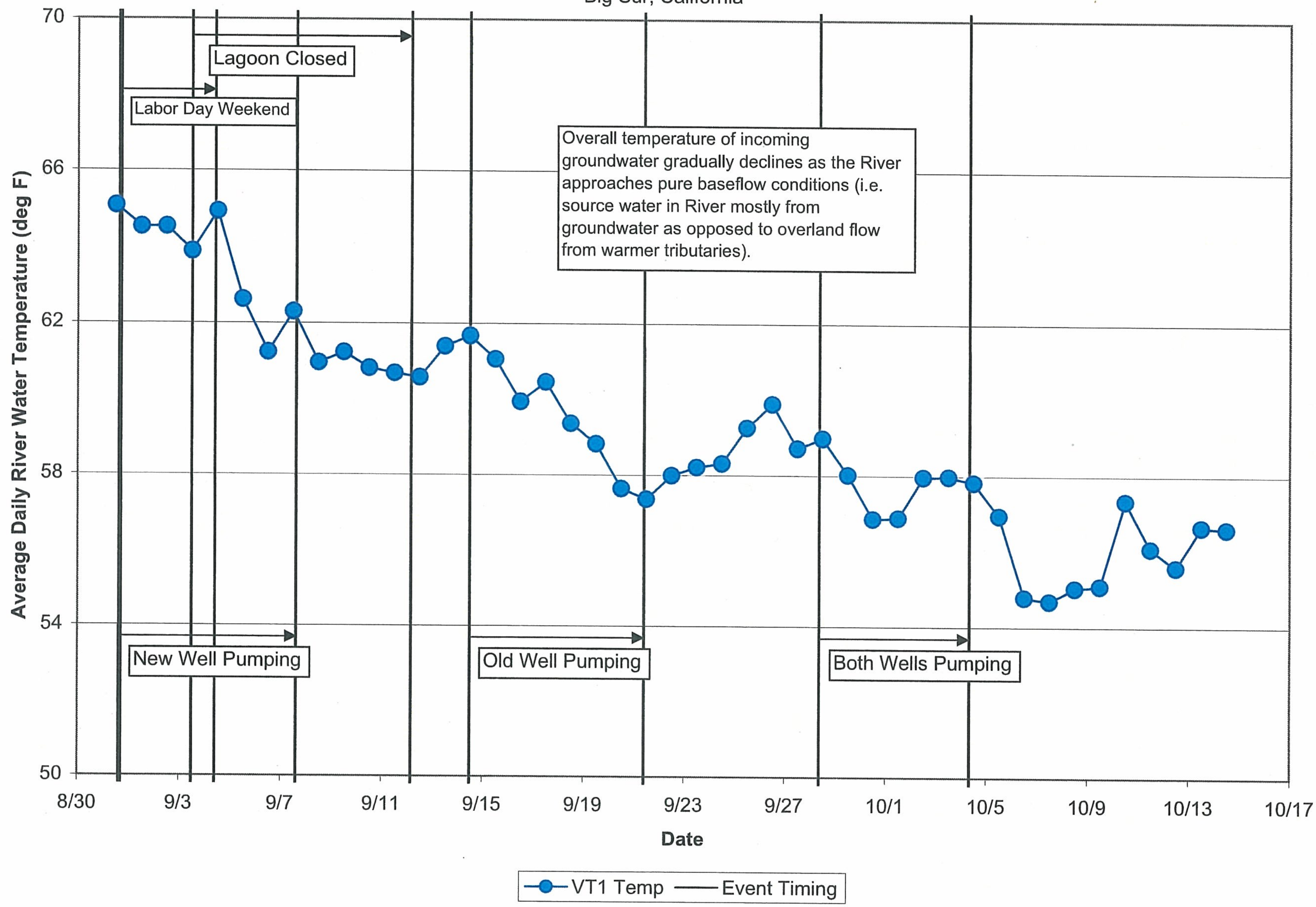

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Figure 3-20
Groundwater Temperature Measured at Monitoring Well ESR-1
El Sur Ranch
Big Sur, California

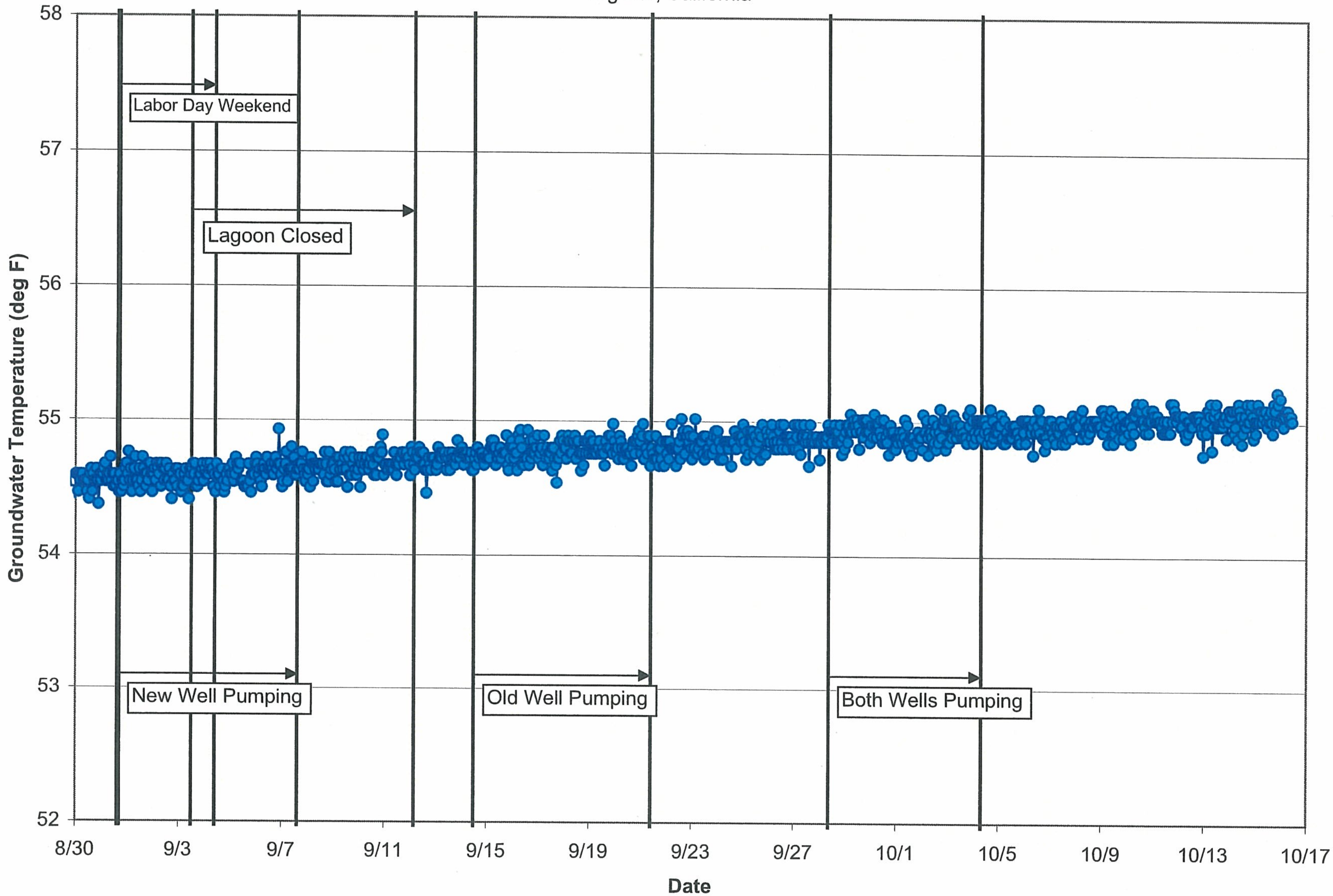

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Figure 3-21

Average Daily River Water Temperature Comparison Between Locations P5, P6 and VT1

El Sur Ranch

Big Sur, California

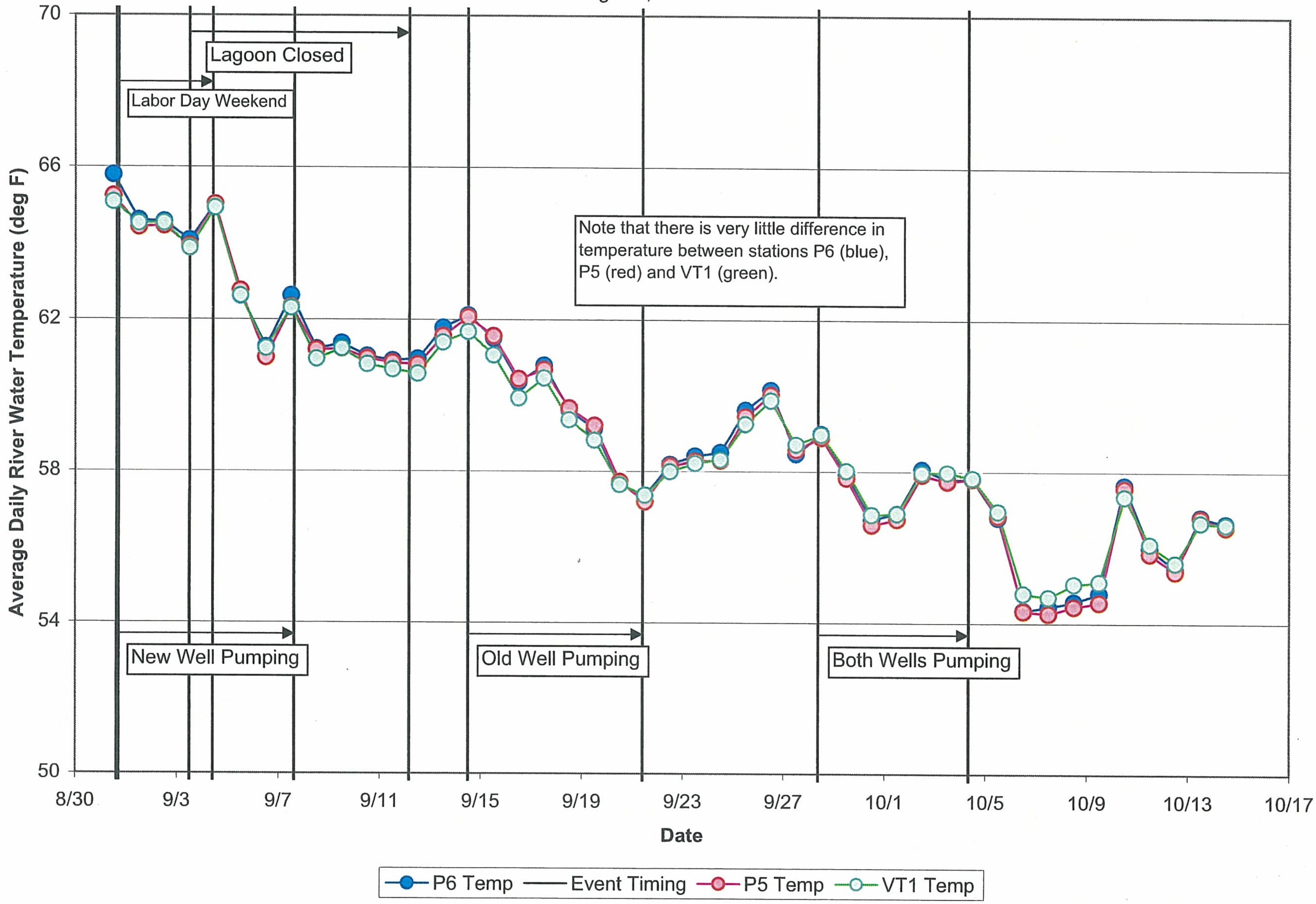

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Figure 3-22
Average Daily River Water Temperature Measured at P4u
El Sur Ranch
Big Sur, California

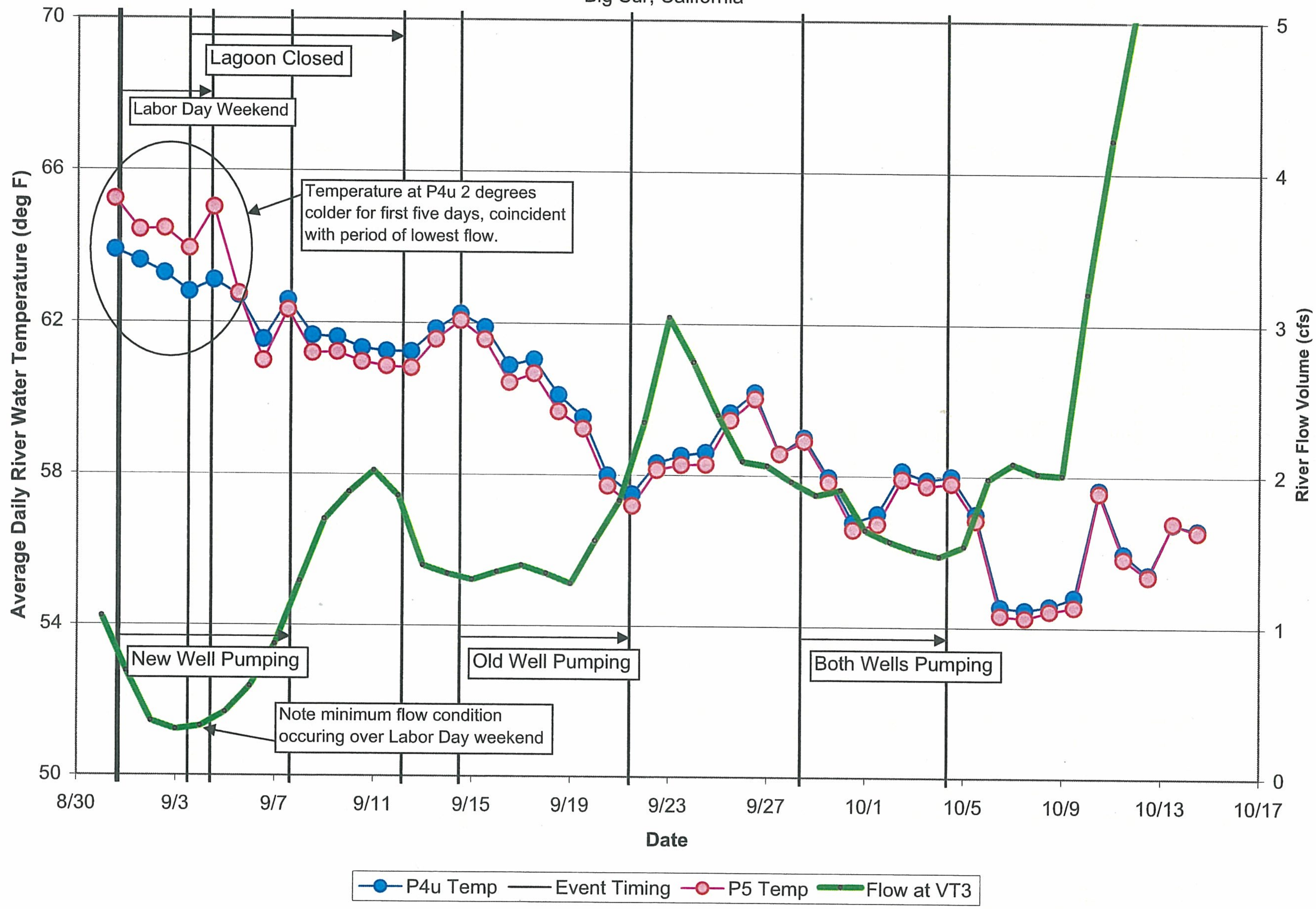

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Figure 3-23
Average Daily River Water Temperature Measured at P4
El Sur Ranch
Big Sur, California

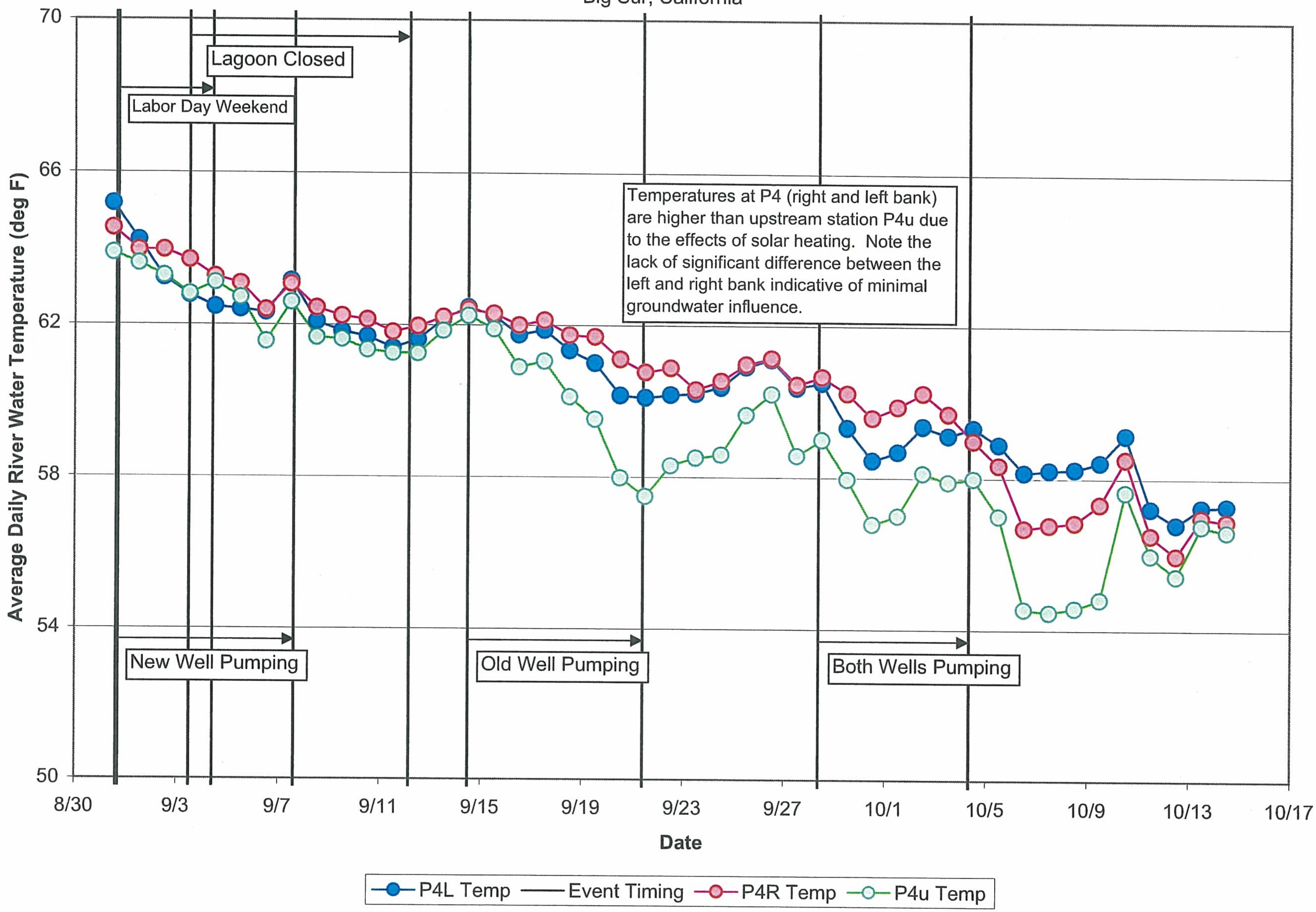

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Figure 3-24
Average Daily River Water Temperature Measured at P3
El Sur Ranch
Big Sur, California

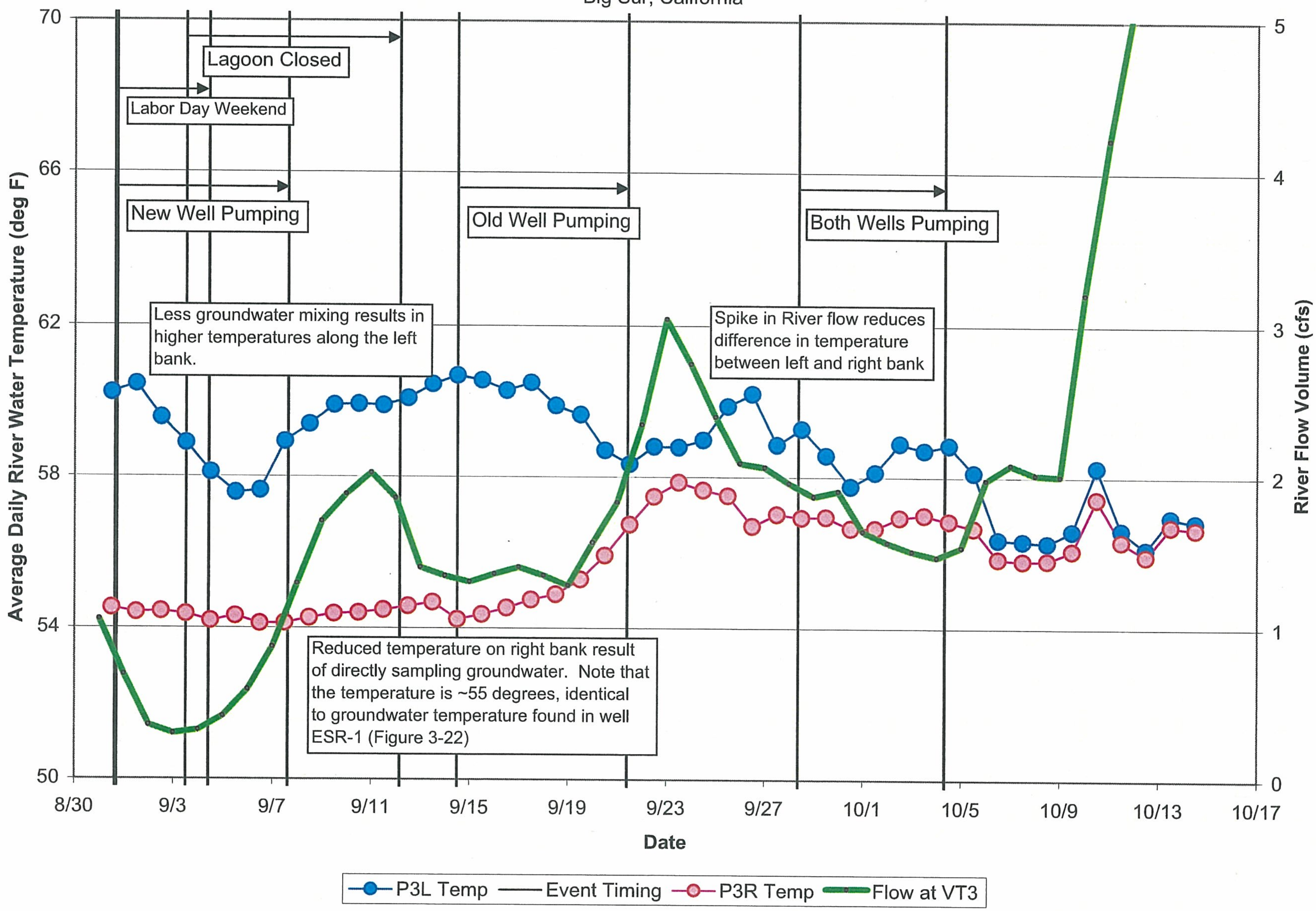

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Figure 3-25
Average Daily River Water Temperature Measured at P2
El Sur Ranch
Big Sur, California

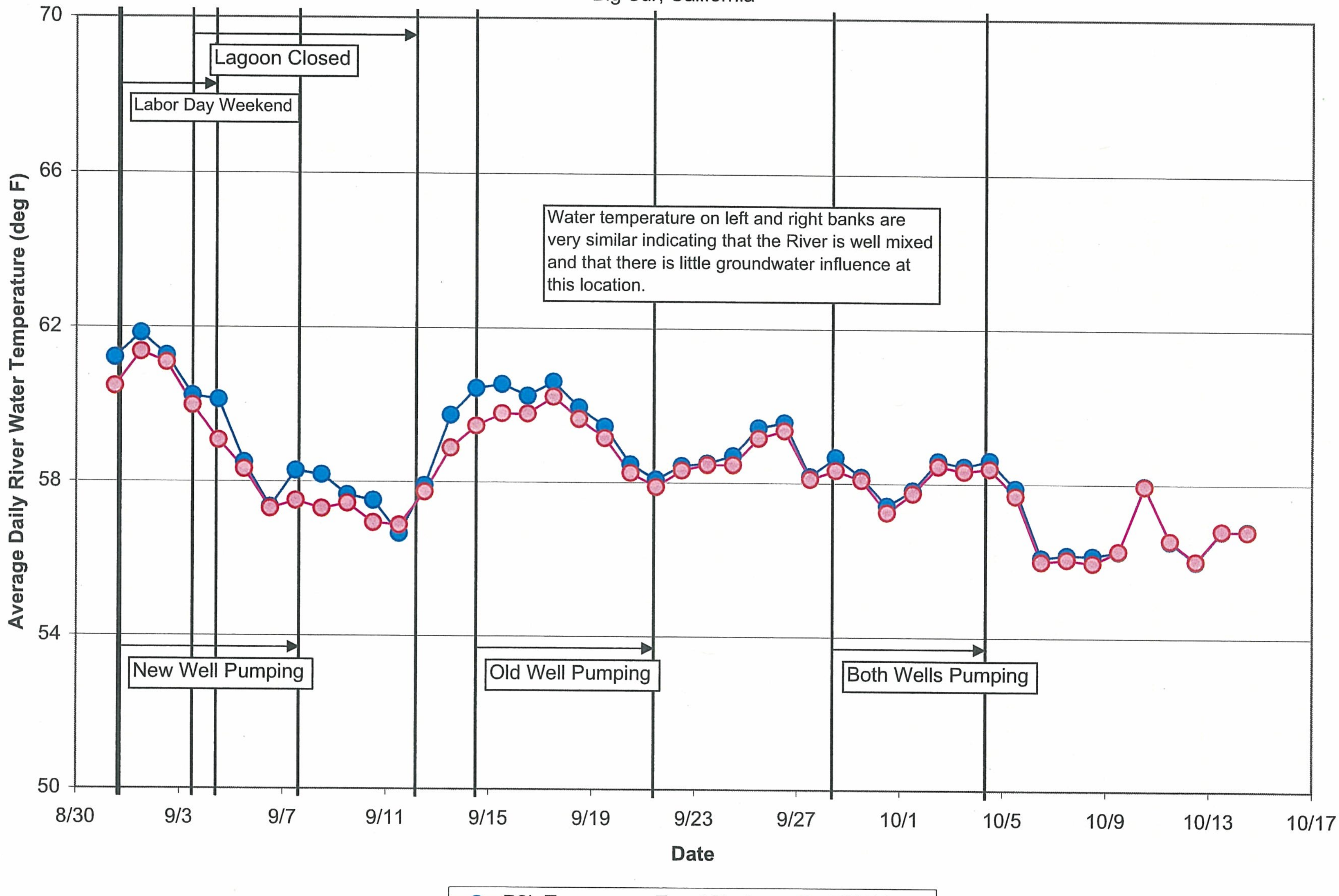

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Figure 3-26
Average Daily River Water Temperature Measured at P1 (Lagoon)
El Sur Ranch
Big Sur, California

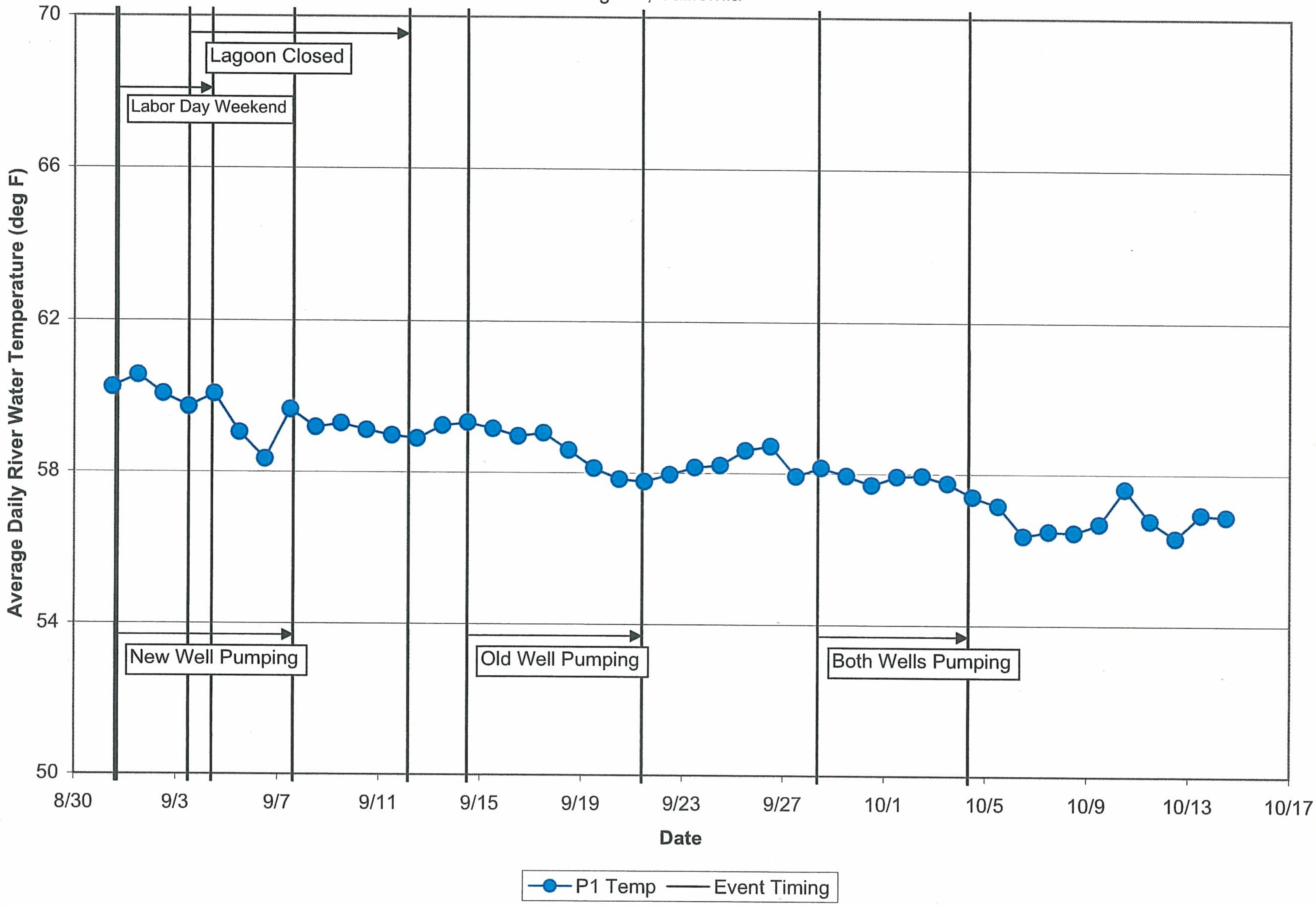

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Figure 3-27
Daily Average Dissolved Oxygen Content in River Water at P5
El Sur Ranch
Big Sur, California

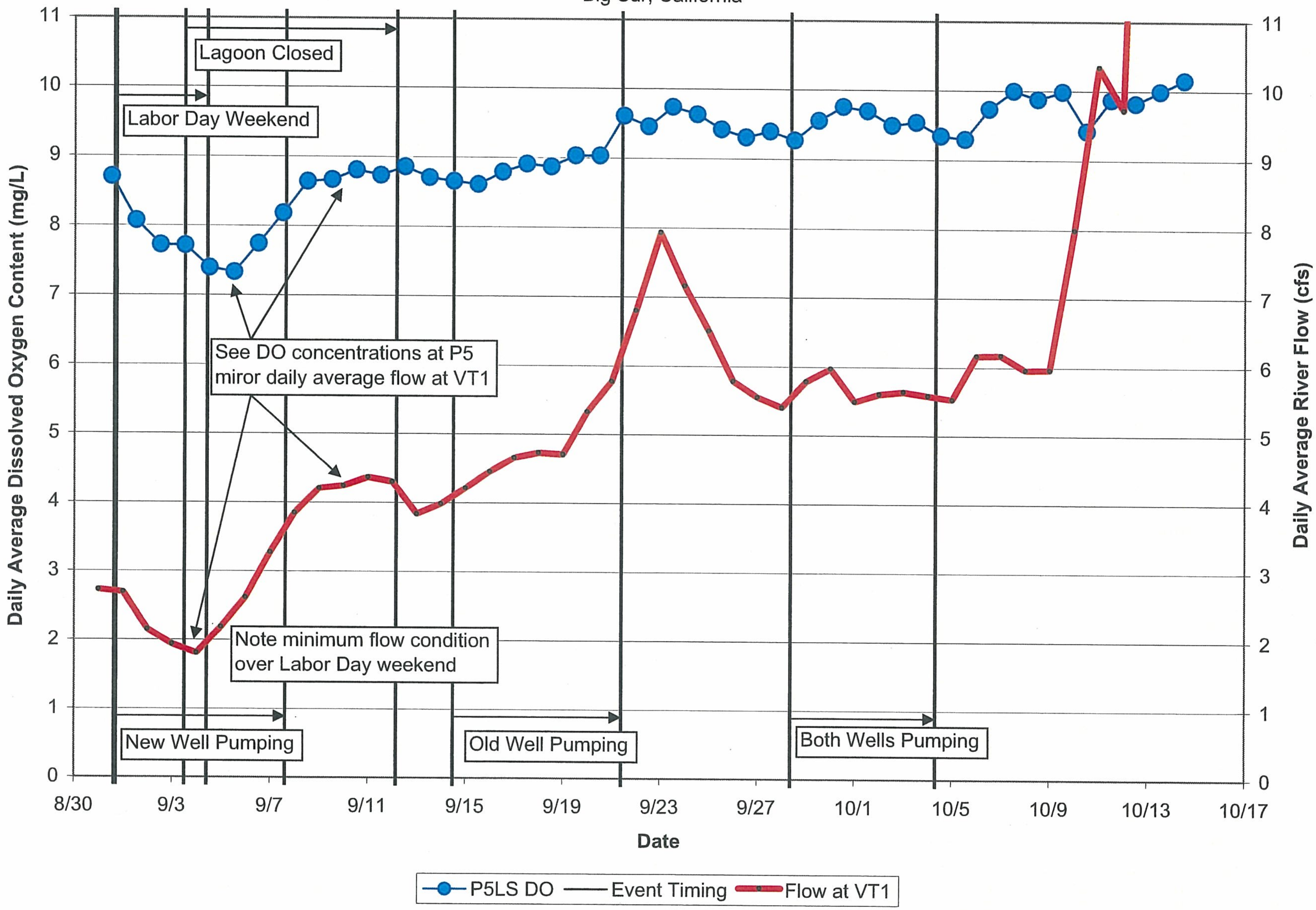

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Figure 3-28
Daily Average Dissolved Oxygen Content in River Water at P4u
El Sur Ranch
Big Sur, California

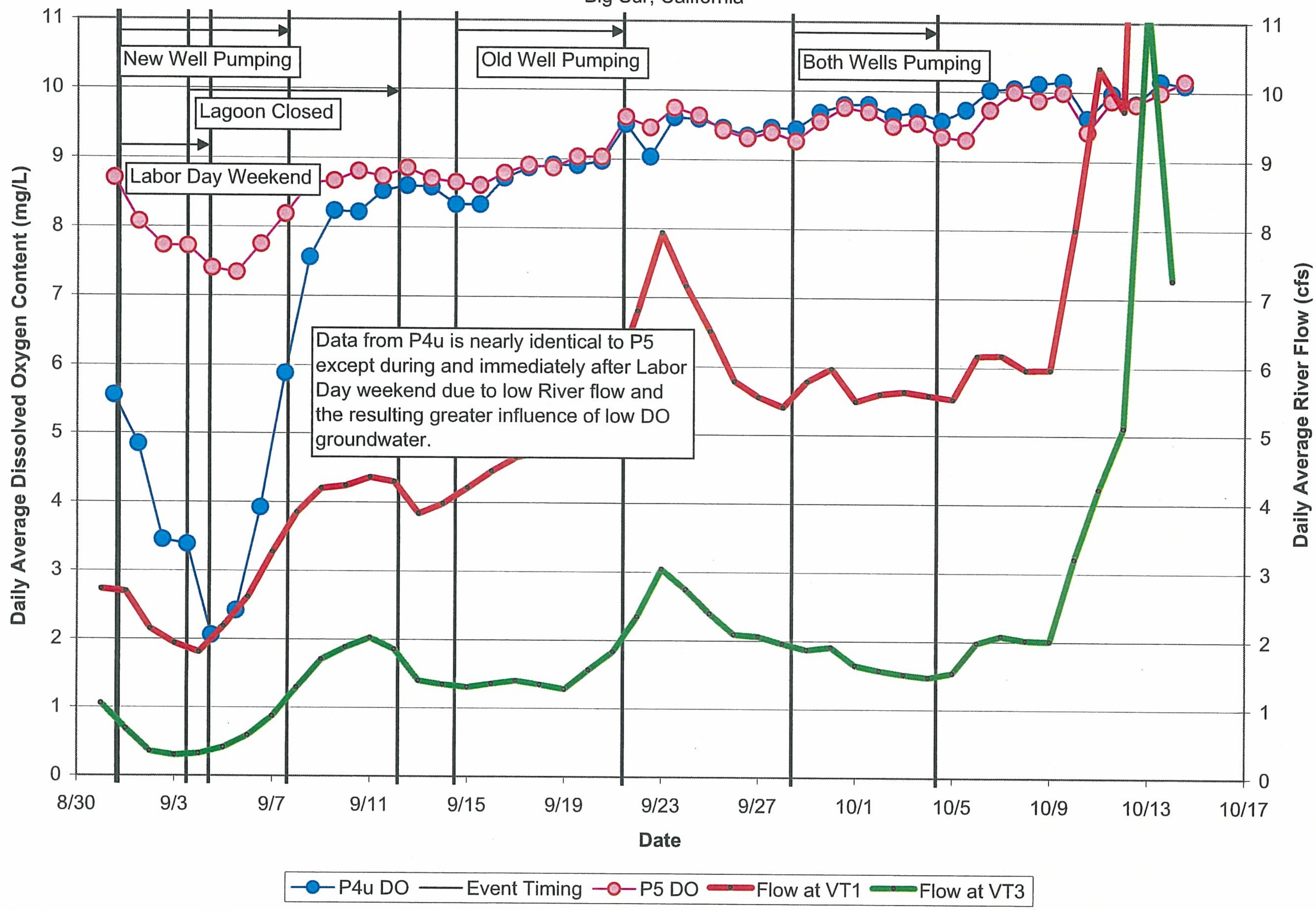

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Figure 3-29
Daily Average Dissolved Oxygen Content in River Water at P4
El Sur Ranch
Big Sur, California

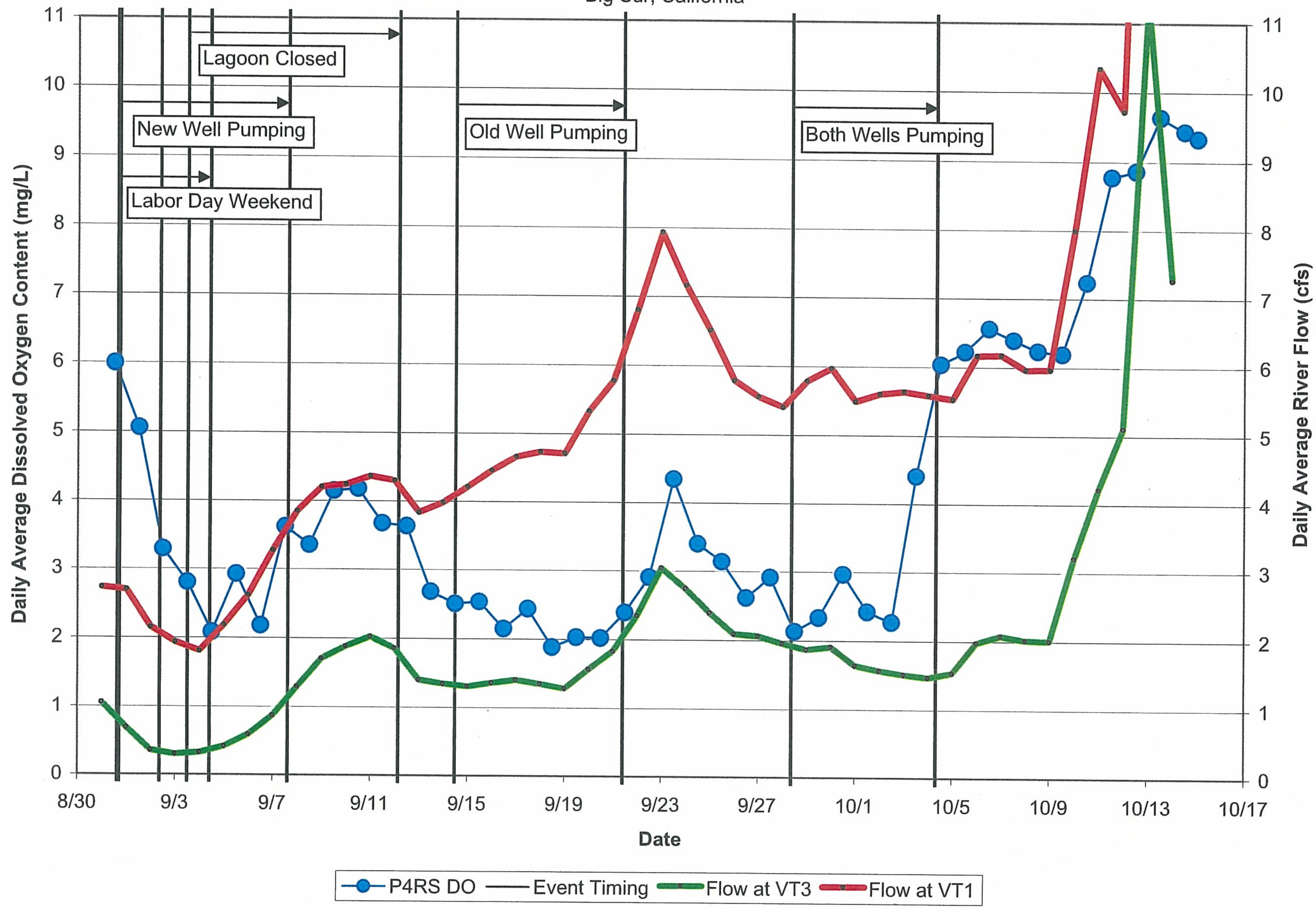

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Figure 3-30
Daily Dissolved Oxygen Content in River Water at P3
El Sur Ranch
Big Sur, California

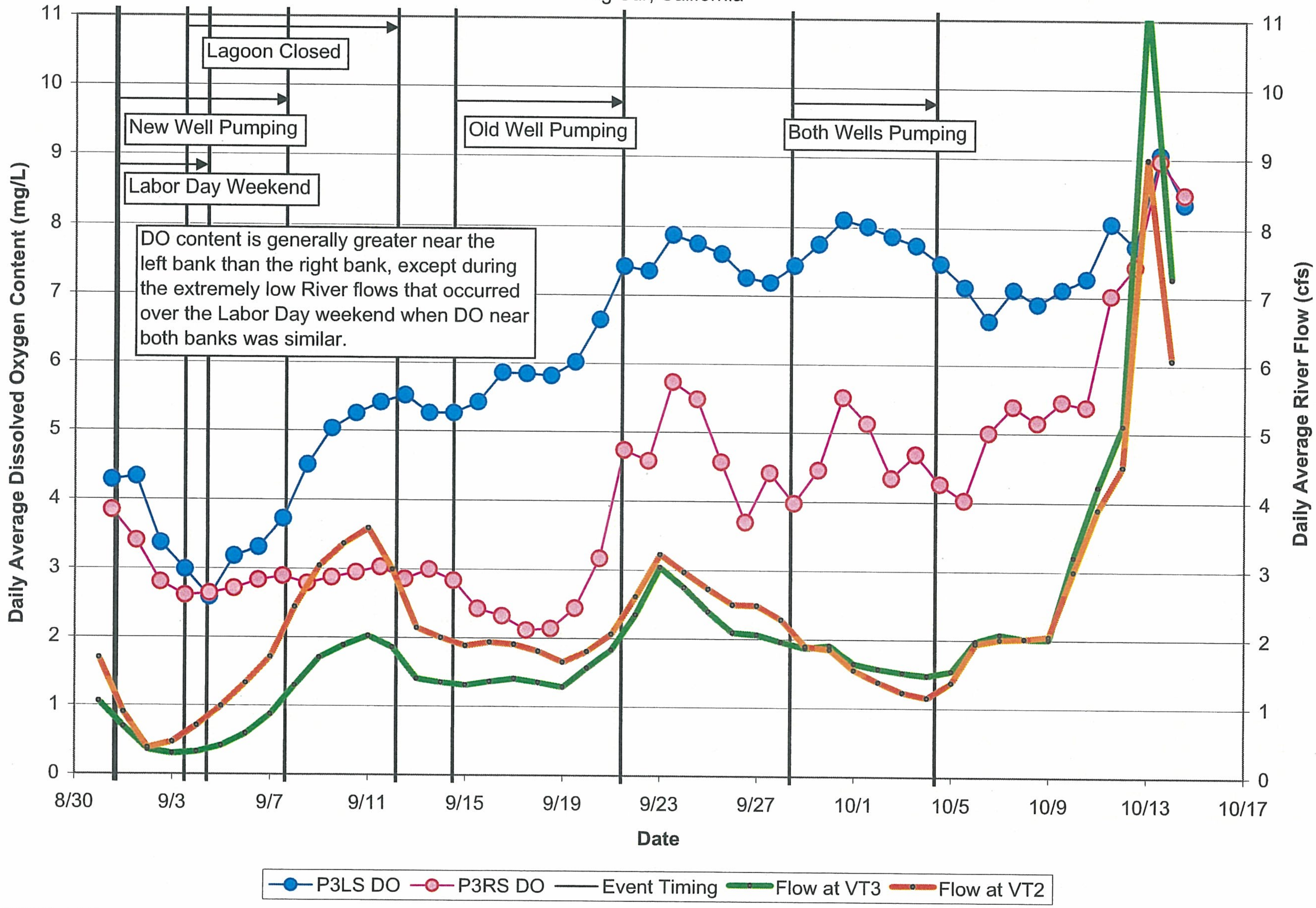

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Figure 3-31
Daily Average Dissolved Oxygen Content in River Water at P2
El Sur Ranch
Big Sur, California

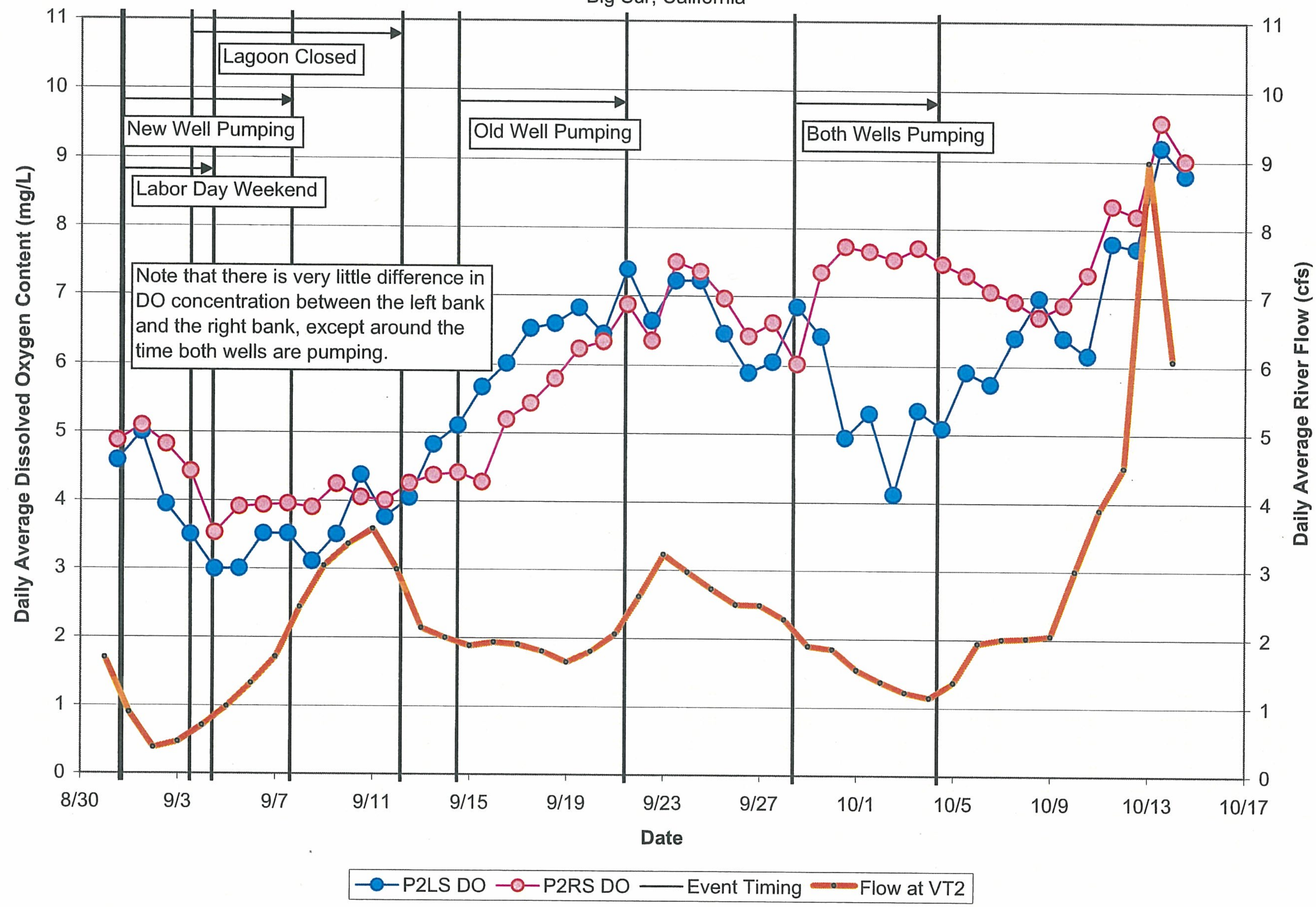

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Figure 3-32
Hourly Average Dissolved Oxygen Content in River Water at P2 vs. River Flow at VT2
El Sur Ranch
Big Sur, California

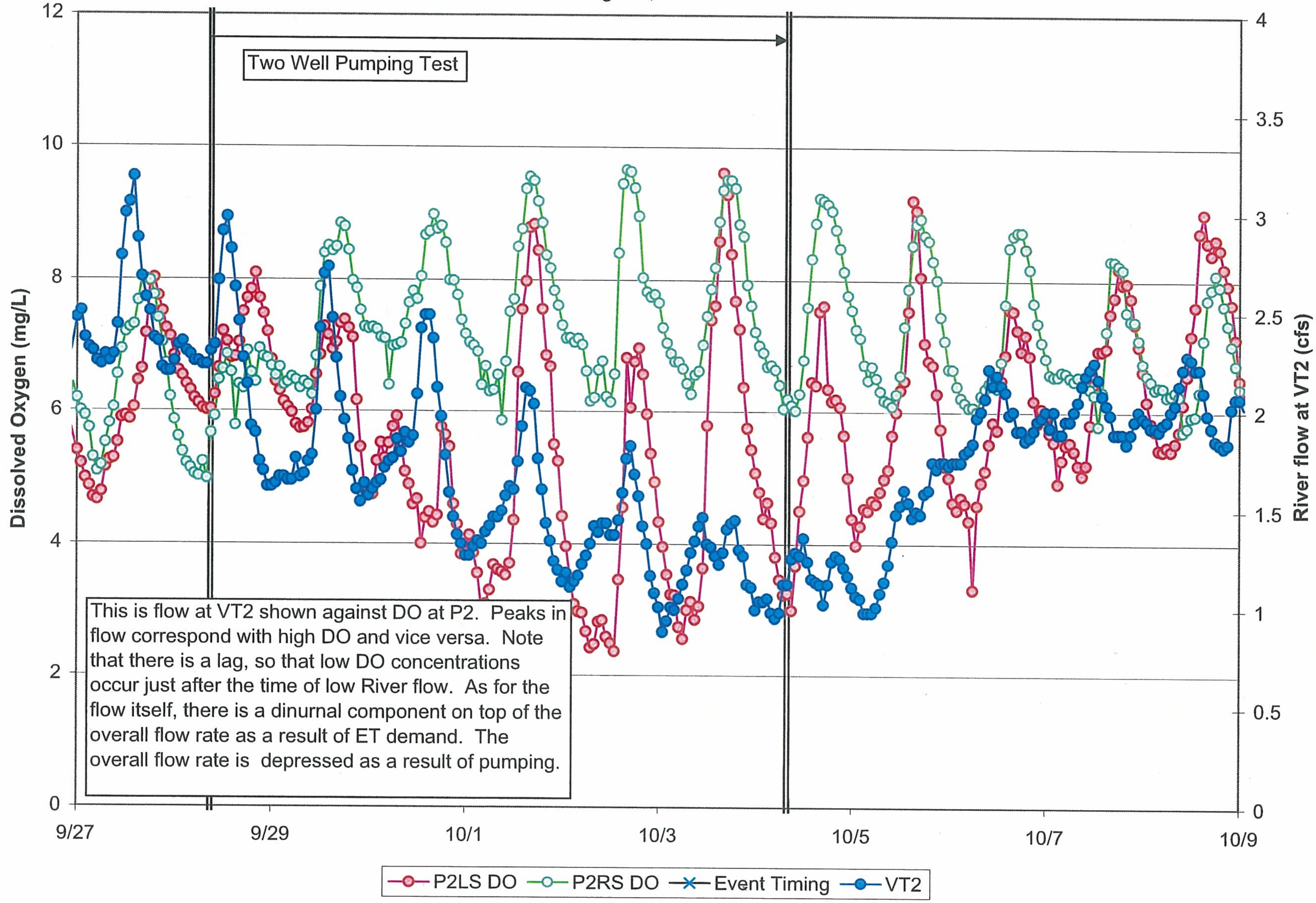

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Figure 3-33
River Bottom Profile at P2 Location
El Sur Ranch
Big Sur, California

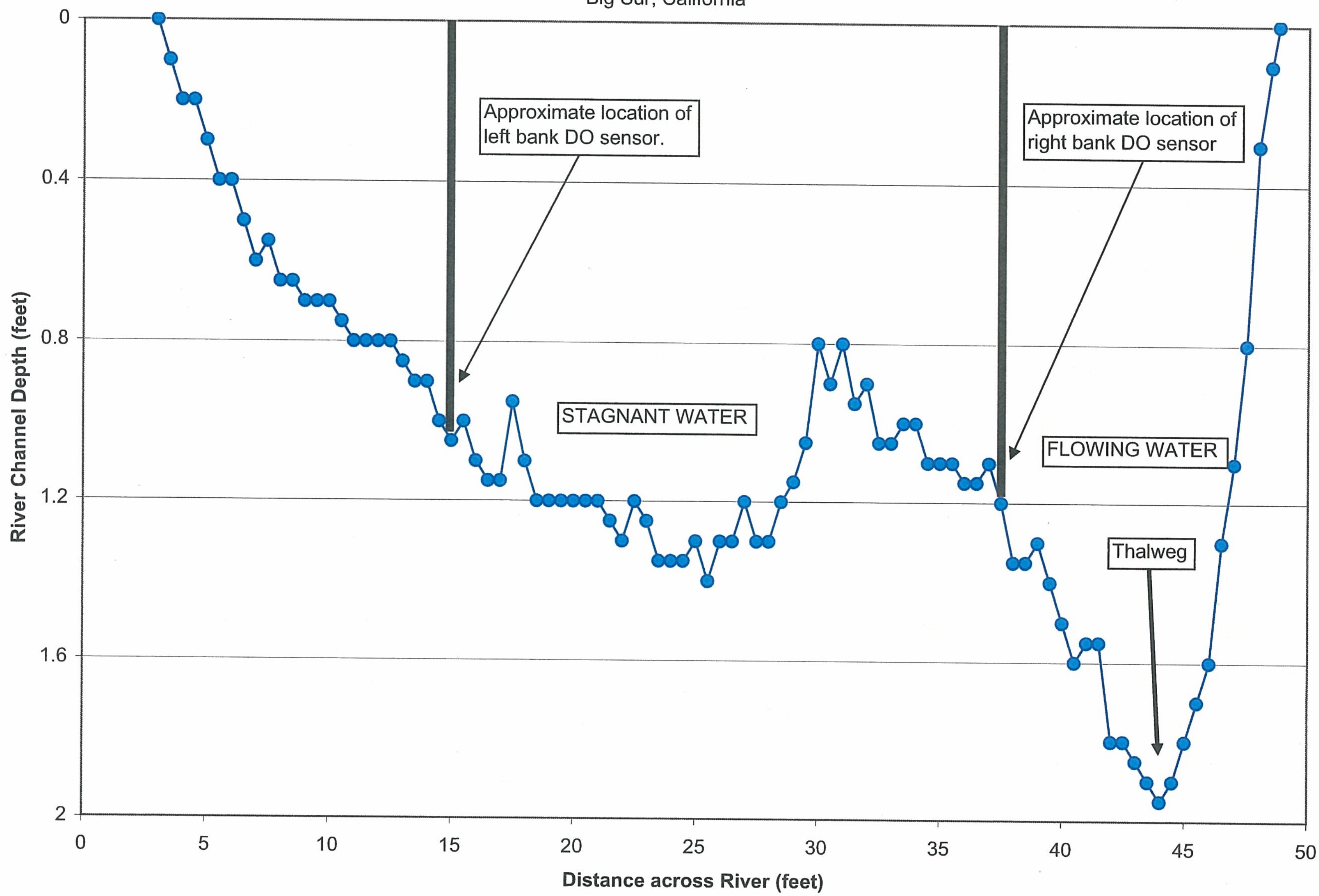

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Figure 3-34
Hourly Average River Flow Rates at VT1, VT2 and VT3
El Sur Ranch
Big Sur, California

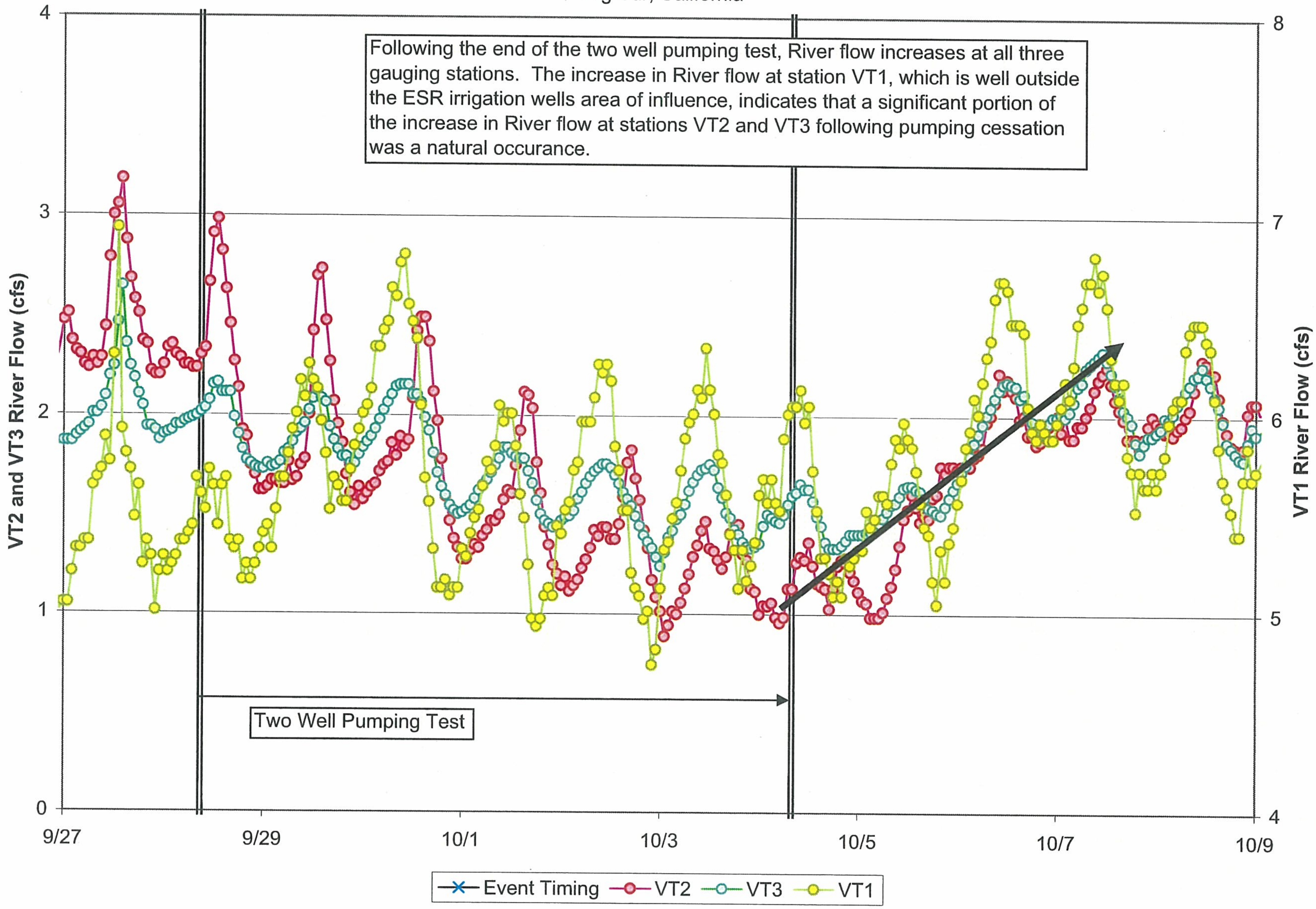

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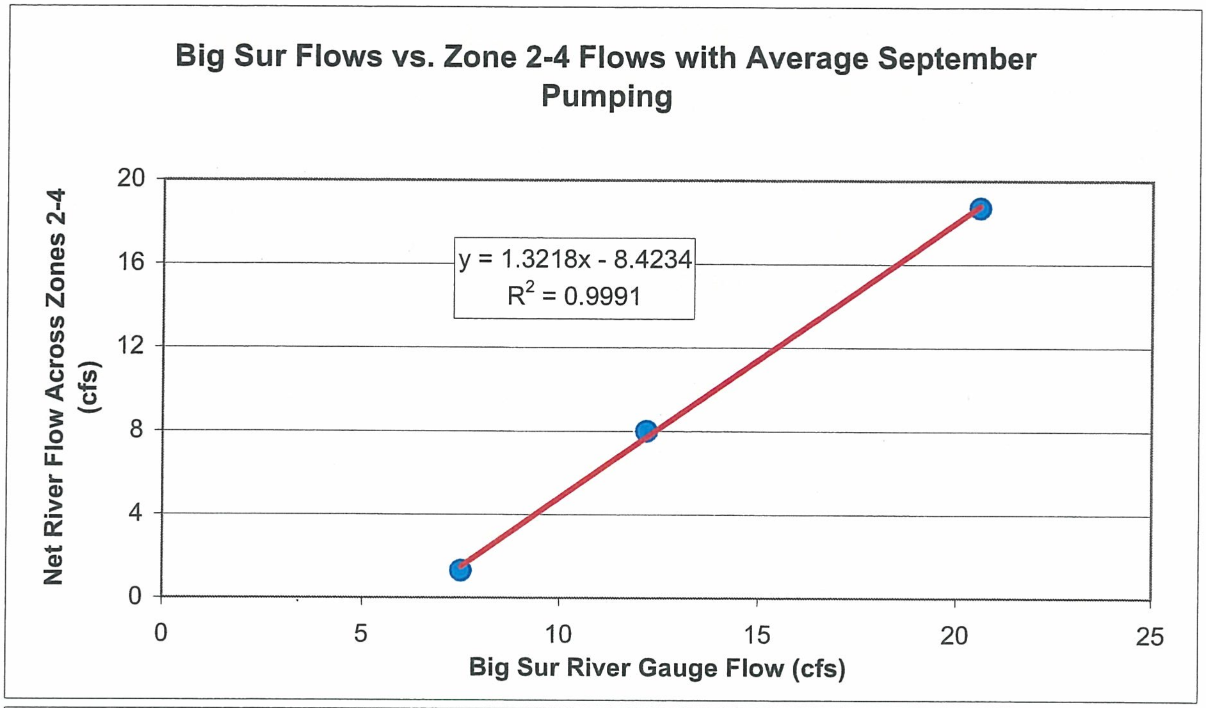
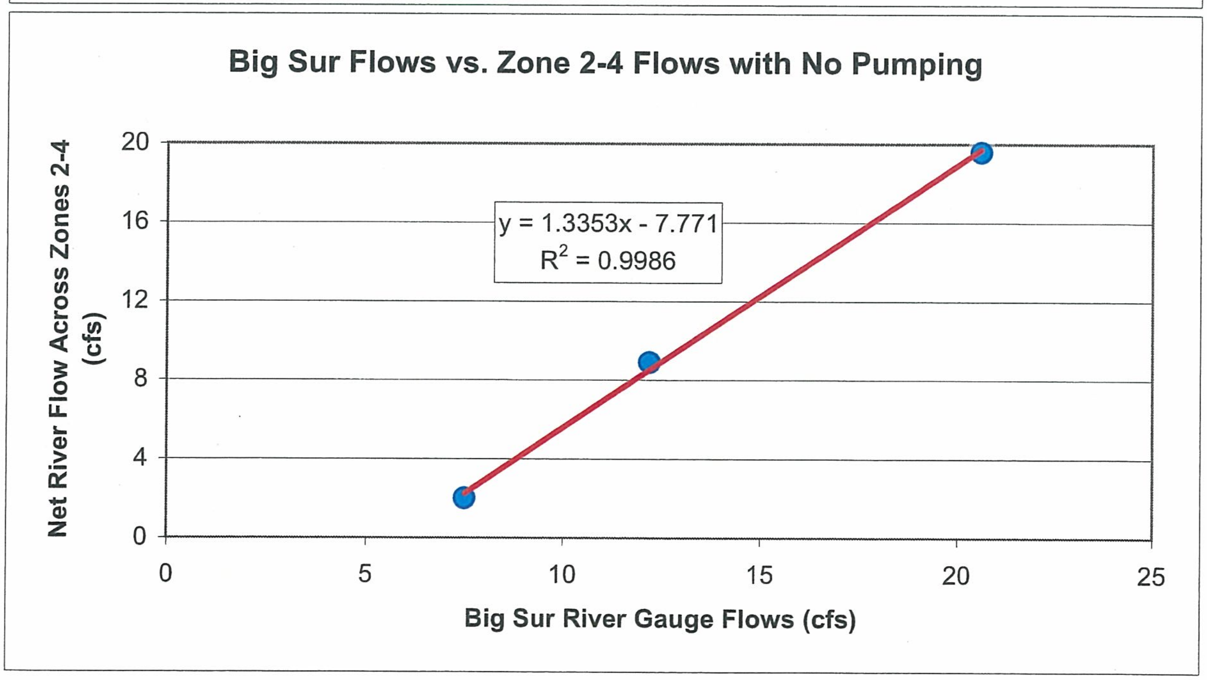
Figure 3-35
Big Sur Flows vs. Zone 2-4 Flows Regression Analysis
El Sur Ranch
Big Sur, California





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TABLES

Table 3-1
Correlation Between Pumping Rate and Decrease in Groundwater Inflow to River, Zone 2 Through Zone 4
El Sur Ranch
Big Sur, California

Wells Active	Total Pumping Rate (cfs)	Calculated Decrease in Groundwater Inflow (cfs)	Is There a Net Gain in River Flow?	Pumping to Groundwater Inflow Reduction Ratio (cfs per cfs)
Both	5.02	~1 to 1.2	NO	0.24
New	2.37	NA*	NO	NA*
Old	2.26	~0.2	YES	0.09

*due to overlapping hydraulic events (specifically, the closing of the Lagoon), it is not possible to calculate the decrease in overall groundwater flow with any amount of accuracy.

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Table 3-2
Big Sur River Gauge Non-Exceedance Flow Criteria Values
El Sur Ranch
Big Sur, California

	Average Monthly Non-Exceedance Flow Value (CFS)					Study Period Avg. Flows		
Year Type	Critically Dry (<.20)	Dry (.20-.40)	Normal (.40-.60)	Above Normal (.60-.80)	Wet (>.80)	2004	2006	2007
Exceedance %	80%	60%	40%	20%	0%	Dry	Wet	Crit. Dry
April	37	64	81	110	184	50.4	751.2	24.4
May	26	40	54	67	92	33.7	158.2	15.8
June	14	22	28	34	45	23.4	72.6	11.7
July	11	17	22	26	35	14.6	40.5	8.6
August	9	13	16	19	25	12.3	26.9	7.6
September	8	12	14	16	20	12.2	20.6	7.5
October	9	14	15	17	21	13.7	20.5	9.8

Notes:
CFS = Cubic Feet Per Second

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Table 3-3
Surface Flow Water Balance
September Conditions - River Zone 2-4
El Sur Ranch
Big Sur, California

Flow Term (All Values in CFS)	**2006 (Wet)**	**2004 (Dry)**	**2007 (Critically Dry)**
Big Sur Gauge Flow (Avg. Monthly)	20.6	12.2	7.5
Net Loss - Big Sur Gauge to VT1 (note 1)	-1.5	-3.7	-2.9
Net Loss - VT1 Through Zone 5 (note 2)	-1.3	-1.3	-3.0
Flow of River Entering Zone 4	17.8	7.2	1.6
Net Accretion - Zones 2-4	1.7	1.7	0.4
Pumping Induced Reduction in Accretion (note 3) (0.30 cfs reduction for every 1 cfs pumped - 2004 and 2006). (0.24 cfs reduction for every 1 cfs pumped - 2007)	-0.9	-0.9	-0.7
Reduction Based on ESR Irrigation Well Pumping Rate (note 4)	(2.9)	(3.0)	(2.7)
Net River Flow in Zones 2-4	**18.7**	**8.0**	**1.3**

Notes:
1. Net loss of -3.7 based on data reported in 2004 for Dry Year; -1.5 based on 2006, Wet Year; -2.9 based on 2007, Critically Dry Year
2. Net loss of -1.3 based on calculations of losses from zone 5 in section 3.6 of 2006 Report; -3 based on difference between VT1 and VT3, 2007
3. Net reduction in gain based on calculations in section 3.6 and as shown on Figure 3-37
4. 2.7 cfs is avg. September pumping for period of record, 3.0 and 2.9 cfs are average for September in 2004 and 2006
5. CFS = Cubic Feet per Second

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Table 3-4
Relationship Between Big Sur River Gauge Flow and Net River Flow Across Zones 2-4
During Average September Pumping Conditions
El Sur Ranch
Big Sur, California

Year	Big Sur Gauge Flow (Sept. Avg)	Net River Flow in Zones 2-4	Flow Conditions
2006	20.6 cfs	18.7 cfs	Wet
2004	12.2 cfs	8.0 cfs	Dry
2007	7.5 cfs	1.3 cfs	Critically Dry

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Table 3-5
Relationship Between Big Sur River Gauge Flow and Net River Flow
Across Zones 2-4 With No Irrigation Well Pumping
El Sur Ranch
Big Sur, California

Year	Big Sur Gauge Flow (Sept. Avg)	Net River Flow in Zones 2-4	Flow Conditions
2006	20.6 cfs	19.6 cfs	Wet
2004	12.2 cfs	8.9 cfs	Dry
2007	7.5 cfs	2.0 cfs	Critically Dry

APPENDIX A

RIVER FLOW CONDITIONS DEFINED

APPENDIX A – RIVER FLOW CONDITION DEFINED

In order to put current River flow conditions at the USGS gauge located on the Big Sur River into context, they are compared to 54 years of daily average flow data. Using the Weibull plotting position formula, the historical data can be segregated into non-exceedance flow percentages for each day of the year. For any given day, a percentage of historical flows do not exceed a specified flow rate. For example, 20% of the historical flows do not exceed 10 cfs on July 22, while 80% of them do (Figure A-1).

The California Department of Fish and Game (CDFG) wanted to identify the water year types of 'critically dry', 'dry', 'average', 'above normal' and 'wet' as conforming to 20%, 40%, 60%, 80% and 100% historical non-exceedance flows, respectively. If current River flow is less than (i.e., does not exceed) 20% of the historical flows on that specific day, conditions are considered to be 'critically dry'. If current River flow is less than 60% of historical flows but not less than 40%, conditions are considered to be 'average', and so on.

Figure A-1 shows the distribution of non-exceedance flow percentages for the entire year. Current flow conditions are indicated by what line they lie beneath. Current flow conditions are 'wet' if they lie above the 'above normal' flow line. Figure A-2 presents the distribution of non-exceedance flow percentages for the months of July through October, the driest months of the year and the focus of each of the three Studies.

Figure A-1
54 Year Non-Exceedance Flow Criteria - Data from USGS
Gauging Station #11143000, Big Sur River, near Big Sur, California
El Sur Ranch
Big Sur, California

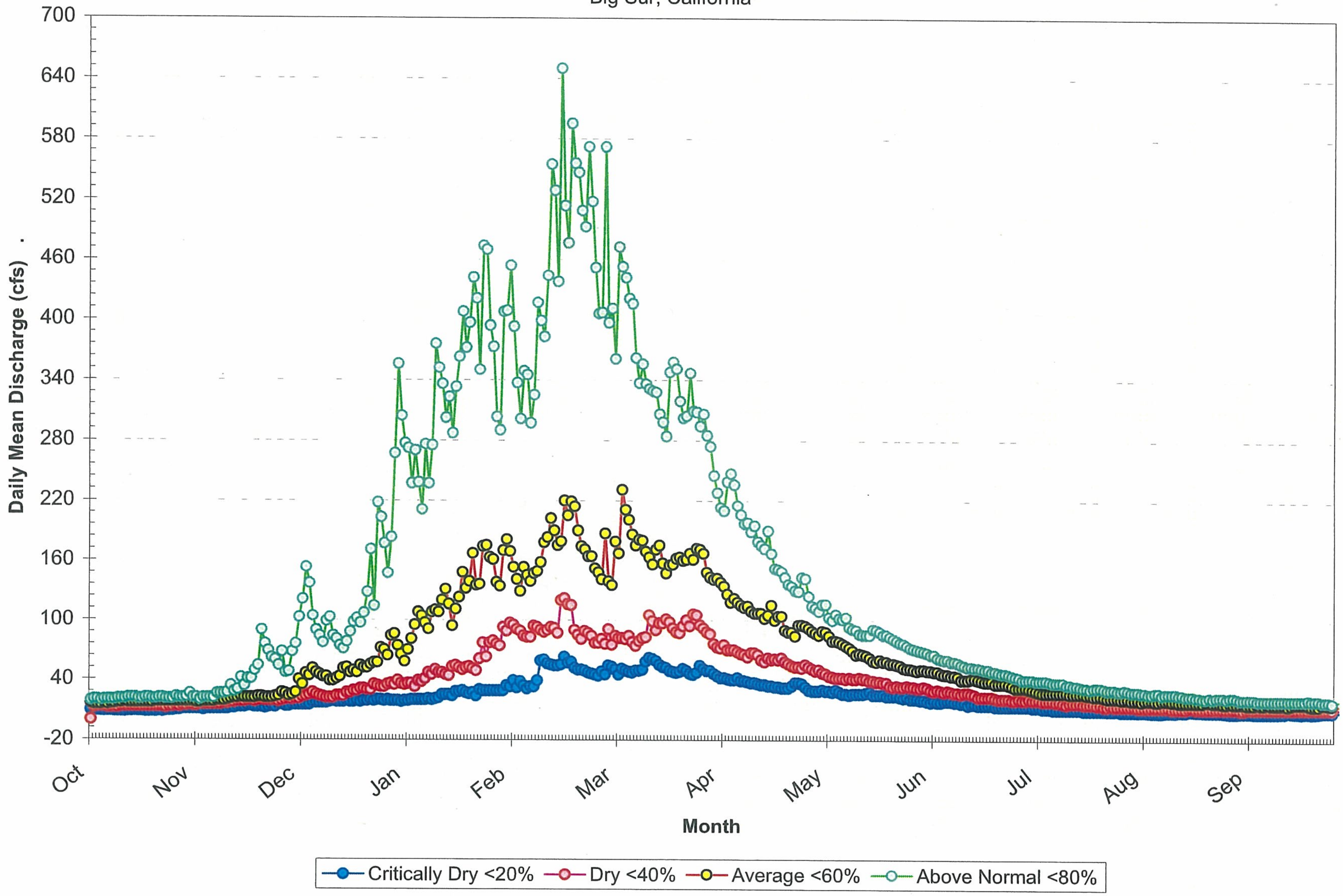

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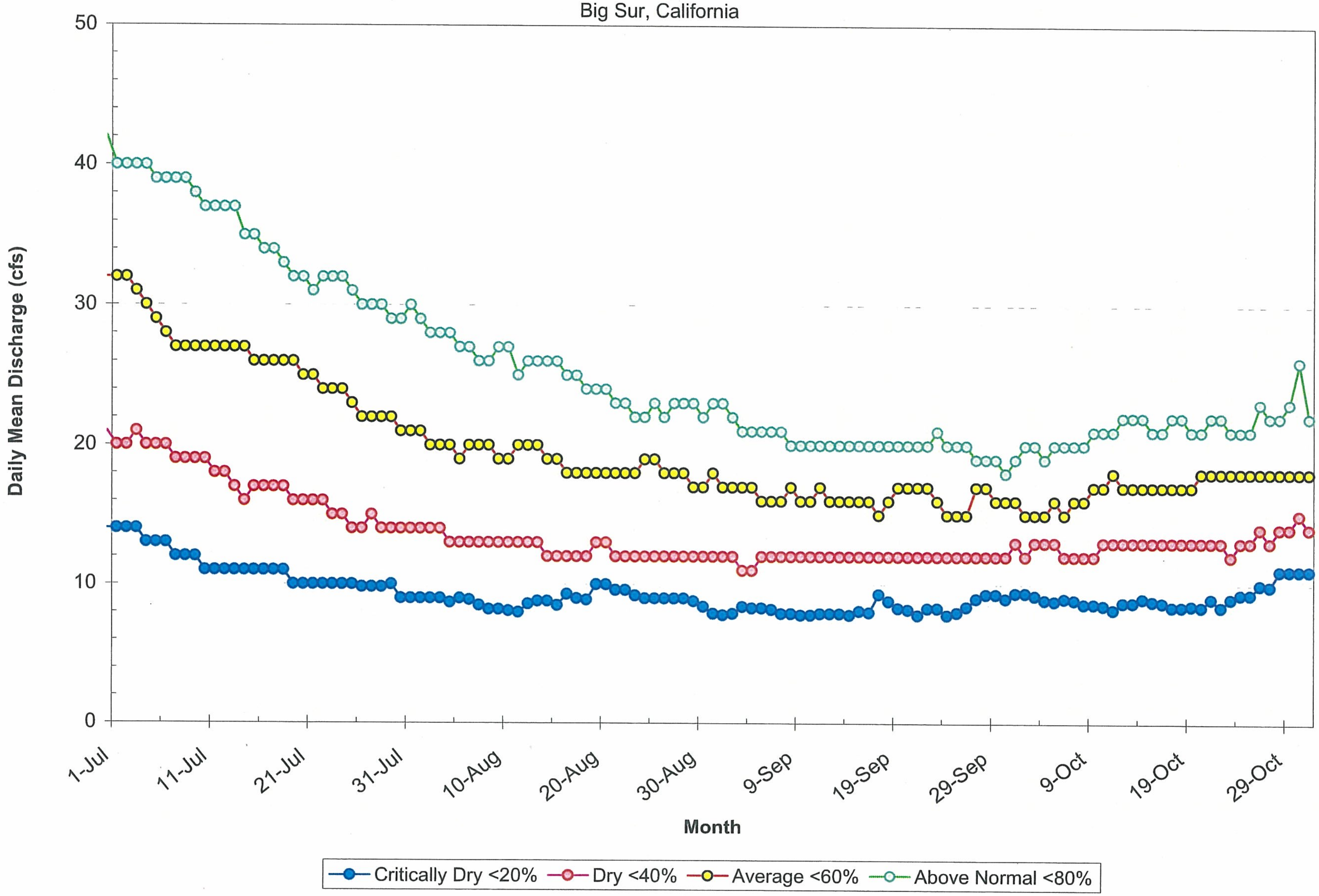
Figure A-2
54 Year Based Non-Exceedance (July-October) - Data from USGS Gauging Station #11143000, Big Sur River, near Big Sur, California
El Sur Ranch
Big Sur, California



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APPENDIX B

HYDROGEOLOGIC WORKPLAN ELEMENTS FOR PROPOSED 2007 DATA COLLECTION PROGRAM

SGI environmental THE SOURCE GROUP, INC.

Technical Memorandum

From: Paul D. Horton, P.G., C.HG.
Jon R. Philipp, P.G., C.HG.

Date: 6-20-07

Re: **El Sur Ranch – Hydrogeologic Workplan Elements for Proposed 2007 Data Collection Program**

As the 2007 water season is shaping up to be an extremely dry year, we have developed the following specific work scope items for a six week study of the El Sur River. The results of this proposed 2007 Study will be directly comparable to data obtained during the 2006 Study and will greatly enhance our understanding of the relationship between ESR irrigation pumping, River hydrology, and Steelhead habitat quality within the context of an extremely dry year. Flows are currently at 9.5 cfs already this year.

Goal of Hydrogeologic Elements of the Monitoring Plan.

The goal of the hydrogeologic portion of the 2006 Study was to develop a correlation between ESR irrigation well pumping rates and the gain/loss of flow within the Big Sur River. The proposed 2007 Study will refine that correlation be gathering data during an extremely dry year as 2007 is predicted to be. The correlation was initially conceived to be used to set permit terms based on flows gauged as they enter the study area at the transect 1 location (just down river of Andrew Molera parking lot). Data collected during this upcoming dry year will refine the ability to set permit conditions during low flow years.

The ability of the pumping to create drawdown impacts within the ESR irrigation wells radius of influence (established in 2006 Study) will be further evaluated through the data collected as part of the 2007 Study.

Thirdly, the movement of the saline wedge inland via tracking concentrations in the Navy Well will again be conducted to further address concerns over potential saline wedge impacts to lagoon and riparian zones during an extremely dry year.

Proposed Hydrogeologic Work Scope:

1. Install a series of 10 piezometer well nests within the River to measure vertical gradient between river bed and underflow (See attached map for locations). Each well nest will be composed of two piezometers with screens set at 0.25 and 3 feet below streambed surface. These piezometers will be constructed of 1.75 inch steel screen and pipe with 6 inches of open screen at the base. The piezometers will be installed by hand and will be driven in place to completion depth. Each of these piezometers will be fitted with data transducers that record water level and water temperature. In 8 of the piezometer locations, the data transducer in the shallow piezometer will additionally measure dissolved oxygen (DO). Readings will be logged and recorded at one hour intervals for the duration of testing. At a minimum, each of the piezometer well nests will be surveyed for relative elevation to allow calculation of head drop between piezometers.

2. A stream-flow gauging station will be re-established near the location of Transect 1 from the 2004 study. The Stream flow station will include a stilling well and a water level transducer set to record level and temperature at one hour intervals for the duration of the study. The ultimate intent is to establish a permanent monitoring station at or near the Transect 1 location, but will be refined based on field inspection of current conditions at the River. Two additional stream-flow gauging

stations (with datalogging transducer equipped stilling wells) will be installed with the 2006 Study Area. The first will be located at the upstream end of Zone 4, while the second will be at the downstream end of Zone 2. These gauging stations will work in concert with the piezometers to measure changes in River flow in response to ESR irrigation well pumping and to further our understanding of the surface flow, underflow and pumping interaction. These gauging stations will be measured at least twice during a two day period.

3 Water level monitoring will be conducted in the groundwater surrounding the pumping wells via installation of pressure transducers in existing wells. These transducers will record water level and temperature at one hour intervals for the duration of testing. Wells to be fitted include JSA-3, JSA-4, ESR-10A, B, and C, ESR 1, ESR2, ESR3, and the Original Old Well.

4 Installation of a conductivity meter and/or scheduling of conductivity readings from the Navy Well in addition to daily temperature and conductivity readings from the Old and New Wells.

5 Collect physical evidence from the River when certain flow benchmarks are achieved. These bench marks include approximately 6 cfs, 5 cfs and 4 cfs as measured by the USGS gauge. The physical evidence will be collected within the 2006 Study Area reach and will include measuring River flow with a velocity meter, collecting fish passage data along the reach and collecting water quality data using a handheld meter (YSI 556 or equivalent).

Study Implementation Schedule

Monitoring of the stations and transducers installed as above will be continuous during the duration of the proposed pumping cycles of the month of September and early October (2007 Study period). The pumping schedule is based on a complete week for each pumping scenario. Data collected in the 2006 Study indicates that recovery times of the groundwater system to pumping are on the order of four days. A 7-day period is selected for each step to ensure that data collected for each pumping scenario is representative of a stabilized hydraulic condition in response to the pumping condition. The pumping schedule include pumping both wells together for a week, and each well individually for a week with week long periods of no pumping in between. Measurements of streambed width and depth profile will be also taken at the location of each piezometer well nest. Stream flow measurements will also be collected several times over a two day period from the Transect 1 station and the proposed transects above Zone 4 and below Zone 2. Each of these measurements will be conducted at the same time of day each time they are taken. Field measurements of conductivity, temperature and dissolved oxygen will be measured daily from the Old Well, New Well and Navy Well. During the 2007 Study period, all transducers collecting data will be downloaded weekly to ensure that major data loss does not occur. This data will be immediately backed up to a second laptop that is then backed up on disc and servers back at the SGI office. The following table details the proposed study schedule:

Week of	Tasks
Aug 26-Sep 1	Install equipment, including piezometers, gauging stations, stilling wells, and transducers. Ideally, El Sur Ranch wells should be **OFF** for this week. Both wells should be turned **ON** Saturday, September 1.
Sep 2-Sep 8	Two day site visit to measure River flow and retrieve data from transducers. Ideally, both El Sur Ranch wells should be **OFF** starting Saturday, September 8.
Sep 9-Sep 15	Two day site visit to measure River flow and retrieve data from transducers. Ideally, the El Sur Ranch Old Well should be **ON** starting Saturday, September 15.
Sep 16-Sep 22	Two day site visit to measure River flow and retrieve data from transducers. Ideally, both El Sur Ranch wells should be **OFF** starting Saturday, September 22.
Sep 23-Sep 29	Two day site visit to measure River flow and retrieve data from transducers. Ideally, the El Sur Ranch New Well should be **ON** starting Saturday, September 29.

Sep 30-Oct 6	Two day site visit to measure River flow and retrieve data from transducers. Ideally, both El Sur Ranch wells should be **OFF** starting Saturday, October 6.
Oct 7-Oct 13	Two day site visit to measure River flow and retrieve data from transducers. El Sur Ranch wells can resume normal schedule starting Saturday, October 13.
Oct 14-Oct 20	Remove all equipment.

Data Analysis and Development of Correlations

Data collected from steps 1 and 2 above will be used to calculate total loss of river flow through its bed during each study period. Losses will be calculated using Darcy's Law. Water level from the piezometer well pairs will be used to calculate the vertical hydraulic gradient at each location. This value will then be multiplied by the weighted average surface area of the streambed between measurement areas. The streambed areas will be calculated based on the streambed measurements taken at each location. This value will then be multiplied by the streambed hydraulic conductivity as determined from the field tests carried out during the 2006 Study. The result will be an area averaged calculation of stream loss or gain along the study area section of River. These values will then be correlated to the pumping condition occurring and to the stream flow entering the study area as determined from flow measurements at Transect 1. Additionally, the data can be directly compared to the difference in flows measures at the proposed Zone 4 station and the proposed Zone 2 station (the difference should be total gain/loss resulting from the effects of underflow and pumping). The correlation factor relating pumping to loss referenced to the stream flow gauge developed during the 2006 Study will be greatly enhanced with data obtained during this low flow year.

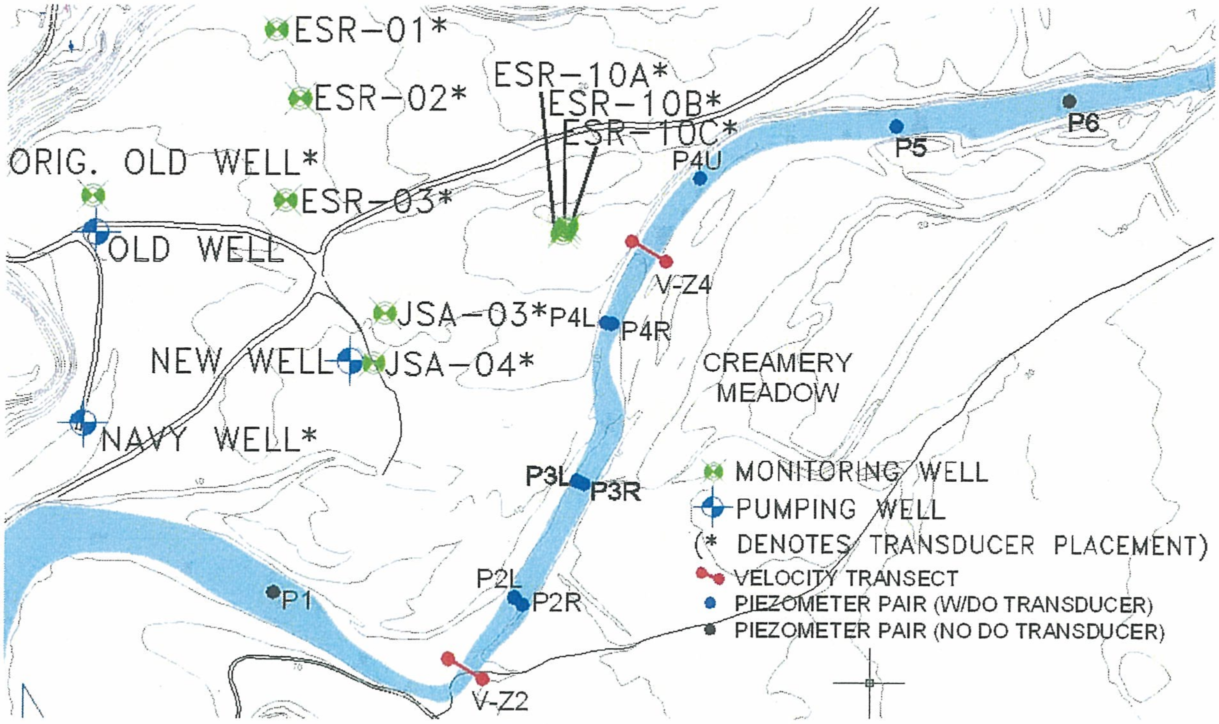
Eight of the piezometer transducers will be equipped with dissolved oxygen transducers which will allow for continuous DO measurement at multiple locations both within the zone of influence (as established during the 2006 Study) and above the zone of influence (i.e. background). This should remove any remaining uncertainty surrounding the relationship between pumping and DO concentrations in the River.

This analysis will be supplemented via evaluation of transducer data from the monitoring wells as detailed in Task 3. Water elevation data from the monitoring wells will be evaluated to estimate gradients during the differing pumping conditions and their relationship to the calculated stream losses. This data will be used to qualify and inform the analysis of stream loss discussed above. Water level monitoring data will also be utilized to provide a calibration data set for the calculation of the radius-of-influence of the pumping wells on the groundwater system for a dry year to complement the wet year data set collection during the 2006 Study. These calculations are specifically focused on estimating the potential for drawdown impacts up-river from the pumping wells.

Monitoring data collected from Task 4 will be evaluated to determine if any saline wedge mixing zone impacts can be detected during this dry year, and if they are increased as a result of pumping conditions. This will be evaluated by comparing conductivity data specifically during and following high tide events, when it is most likely to occur. Comparisons will be made between the differing pumping conditions and non-pumping conditions. The data will be compared to data obtained during the 2006 Study.

Finally, data collected during this period (stream flow and stream loss data) will be considered along with all available historical data to prepare a refined water availability analysis. This analysis will be conducted to evaluate a monthly based water budget for various water year types, specifically focused on the later summer months when pumping has the most potential to cause an impact.

Figure Showing Proposed Hardware Locations



APPENDIX C

PERMITS

DEPARTMENT OF FISH AND GAME
http://www.dfg.ca.gov
Central Region
1234 East Shaw Avenue
Fresno, CA 93710
(559) 243-4005

August 24, 2007

Pamela Silkwood, Esq.
Law Offices of Horan, Lloyd, Karachale, Dyer,
Schwartz, Law and Cook, Inc.
499 Van Buren Street
Monterey, California 93940

Dear Ms. Silkwood:

Determination on Stream Alteration Notification No. 2007-0197-R4
Big Sur River Mouth Stilling Wells – Big Sur River – Monterey County

This is in response to the notification package that you submitted to the Department of Fish and Game (Department). The location of your proposed project activity, as stated in your Notification, will be within or adjacent to a reach of the Big Sur River, in Andrew Molera State Park, just upstream of the confluence of the Big Sur River with the Pacific Ocean, in Monterey County (Township 19 South, Range 1 East, MBD&M). Your proposed Project activity, as described in your Notification, will consist of the installation of three stilling wells at three locations in the river. The Project is proposed to gather data to be utilized by the State Water Resources Control Board (SWRCB) in the preparation of an Environmental Impact Report (EIR) for pending Water Rights Application No. 30166. Installation of each stilling well will require a hand dug trench, starting approximately two to three feet from the bank of the water course, and continuing into the bed the minimal distance required for each transect, or approximately 3 to 6 feet. The dimensions of stilling well trench will be approximately six inches deep and six inches wide. A stilling well (2 inch perforated pipe) will be placed within each hand dug trench and covered with native streambed materials originating from the trench work. Upon completion of data collection, the stilling wells will be removed and the streambed and bank restored. Installation of the housing casings will occur between August 26 and September 1 in 2007 and removal shall occur between the dates of October 14 and October 20 in 2007. Installation and removal will not require access by vehicle, the use of heavy equipment, or the use of cement in flowing waters.

Based on the Department's review of the information you submitted, consultation with you regarding the scope of your proposed work activity, and our knowledge of the Project site, we have determined that there is no existing fish or wildlife resource that will be substantially adversely affected by your Project, if it is constructed in the manner described in your notification. A Stream Alteration Agreement will not be required for you to perform your proposed Project. We have no Project modifications or recommendations for protective measures to propose at this time.

You are responsible for complying with all applicable local, state, and federal laws in completing your Project or activity. This letter is valid for the Project described above for one (1) year from the date of this letter. If your Project will extend beyond that date, a new Notification shall be submitted or a renewal shall be requested. If your Project is changed from the one proposed in your notification, you shall submit a separate notification regarding the new project.

You may proceed with your Project if you have obtained all other permits required by local, state and federal agencies, and have fulfilled the California Environmental Quality Act (CEQA) requirements. A copy of this letter shall be available at the work site during all periods of active work and shall be presented to Department personnel upon demand.

If you have any questions regarding this matter, please contact Julie Means, Senior Environmental Scientist, at the above letterhead address or by telephone at (559) 243-4014, extension 240. Thank you for your cooperation.

Sincerely,

Julie Means
For/W. E. Loudermilk
Regional Manager

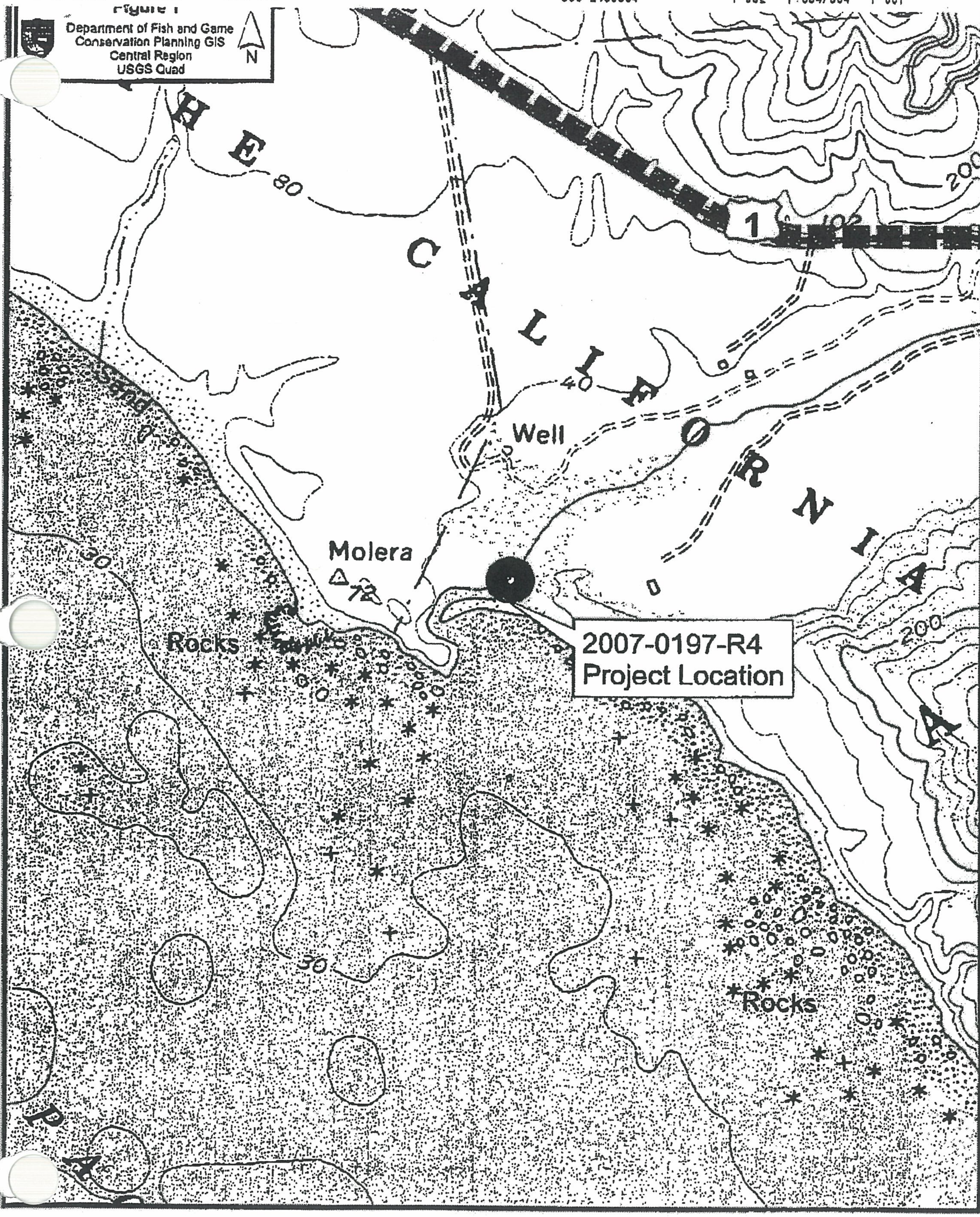


Figure 1
Department of Fish and Game
Conservation Planning GIS
Central Region
USGS Quad
N
THE CALIFORNIA
1
200
80
40
Well
Sand
Molera
72
30
Rocks
2007-0197-R4
Project Location
200
Rocks
PA

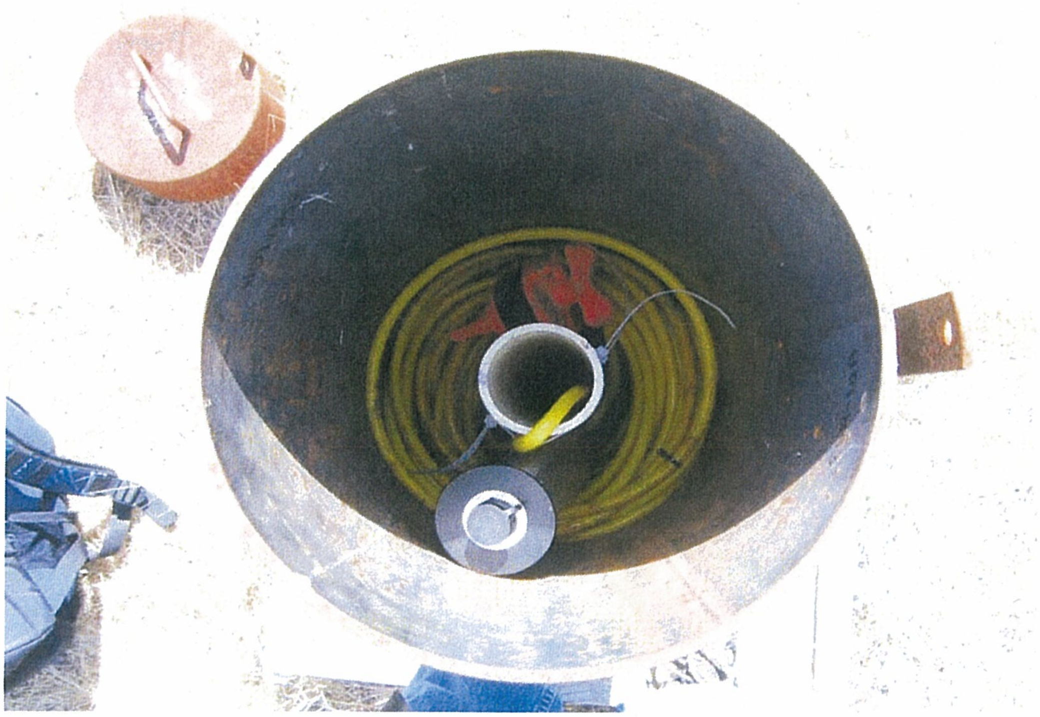
APPENDIX D

PHOTOS OF EQUIPMENT

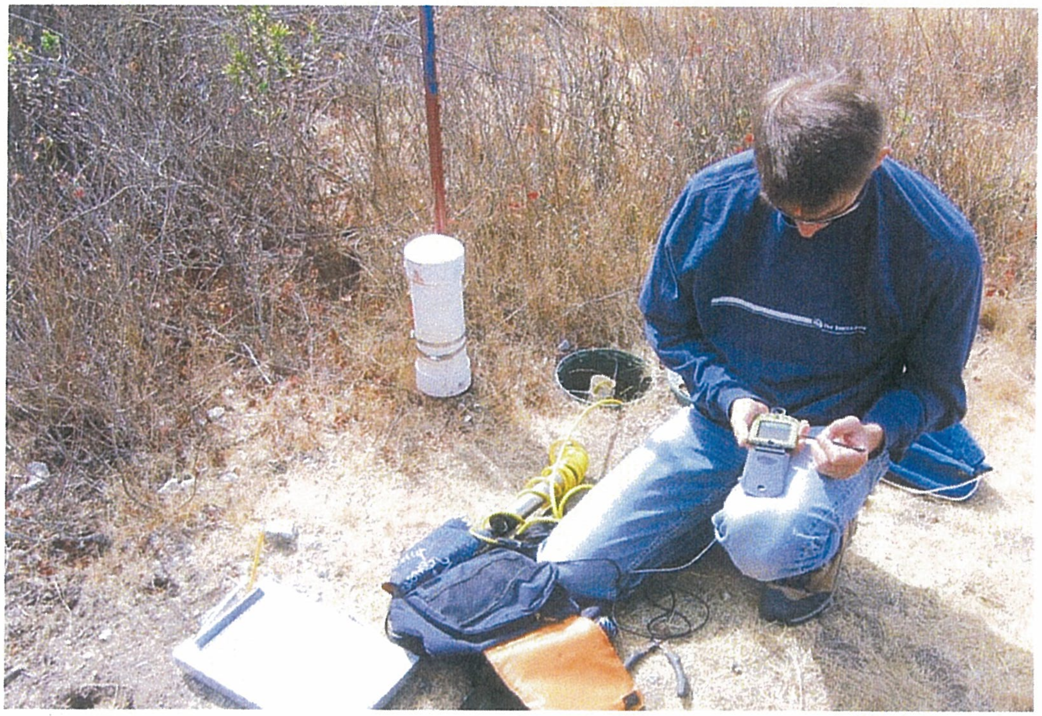
Photograph 1: *Monitoring Well ESR-01*

Photograph 2: *Monitoring Well ESR-02*

Photograph 3: *Monitoring Well ESR-03*

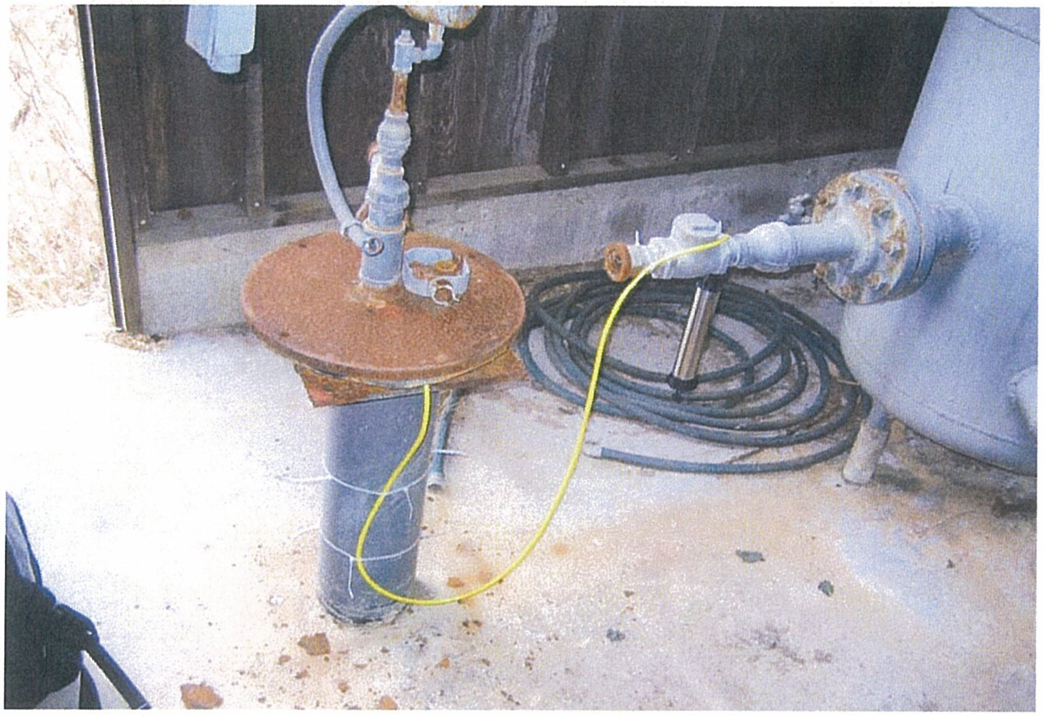


Photograph 4: *Monitoring Well ESR-10A (ESR-10B and ESR-10C similar)*



Photograph 5: *Monitoring Well JSA-03*

Photograph 6: *Monitoring Well JSA-04 (near New Well irrigation well)*



Photograph 7: *Original Old Well (near Old Well irrigation well)*

Photograph 8: *Piezometer Pair P1 (located in Big Sur River Lagoon)*

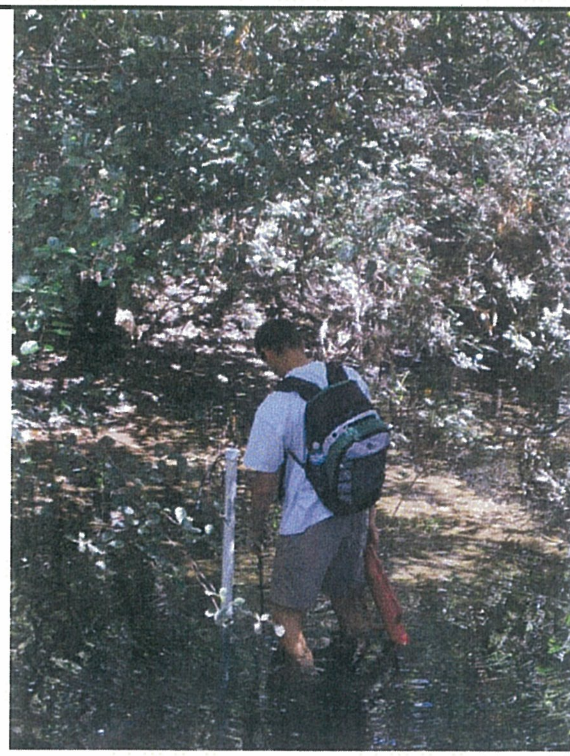
Photograph 9: *Piezometer Pair P2(located near Passage Transect 5)*

Photograph 10: *Piezometer Pair P3 (located near Passage Transect 7)*

Photograph 11: *Piezometer Pair P4 (located near Passage Transect 9)*

Photograph 12: *Piezometer Pair P4U (located near Passage Transect 11)*

Photograph 13: *Piezometer Pair P5 (located upstream of Passage Transect 11)*



Photograph 14: *Piezometer Pair P6 (located upstream of Passage Transect 11)*

Photograph 15: *Piezometer Pair (left is shallow, right is deep)*

Photograph 16: *Piezometer Pair (front is shallow, rear is deep)*

Photograph 17: *Passage Transect 1 (Big Sur River Lagoon)*

Photograph 18: *Passage Transect 2 (Big Sur River Lagoon)*

Photograph 19: *Passage Transect 3 (Big Sur River Lagoon)*

Photograph 20: *Passage Transect 4 (in riffle zone)*

Photograph 21: *Passage Transect 5*

Photograph 22: *Passage Transect 6 (lower Cold Pool)*

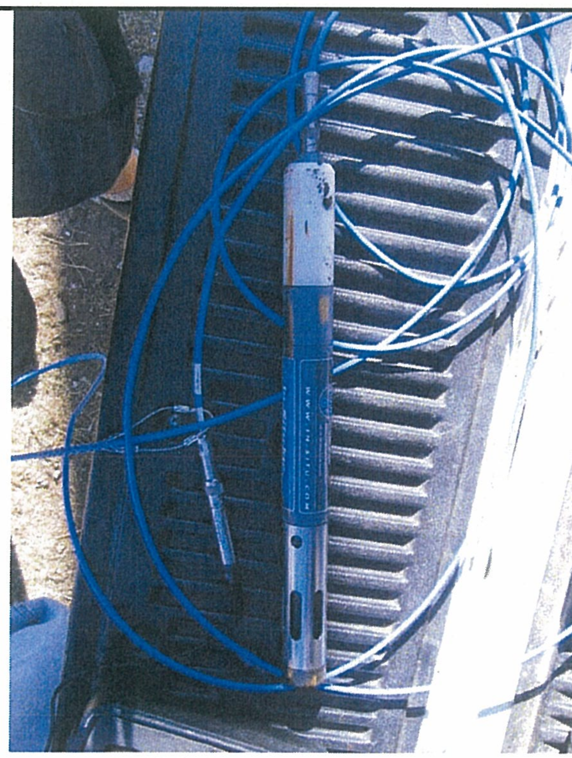
Photograph 23: *Passage Transect 7 (upper Cold Pool)*

Photograph 24: *Passage Transect 8*

Photograph 25: *Passage Transect 9 (in riffle zone)*

Photograph 26: *Passage Transect 10 (in riffle zone)*

Photograph 27: *Passage Transect 11 (in riffle zone)*



Photograph 28: *Dissolved Oxygen Transducer*

Photograph 29: *Velocity Transect 1*

Photograph 30: *Stilling Well at Velocity Transect1*

APPENDIX E

SURVEY DATA

APPENDIX E

Surveyed Equipment Points

Point #	Northing*	Easting*	Elevation	Name
1060	358172.6	1158117	5.9979	PT1-R
1061	358247	1158161	5.609	PT1-L
1075	358113.6	1158335	6.4119	P1LS
1076	358114.7	1158336	6.6845	P1LD
1077	358089.3	1158324	4.3639	PT2-R
1085	358079.9	1158404	6.0327	PT2-L
1099	357985.3	1158503	5.7386	PT3-L
1100	357976.4	1158445	8.6239	PT3-R
1121	357961.5	1158660	6.4257	PT4-L
1122	357951	1158691	7.0516	PT4-R
1123	357964.9	1158664	6.2786	VT2-L
1124	357958.6	1158696	6.9823	VT2-R
1138	358098.5	1158768	9.3313	P2LS
1139	358086.2	1158786	9.2557	P2RS
1140	358098	1158770	8.7424	P2LD
1141	358086.7	1158784	8.9679	P2RD
1142	358076.4	1158795	7.2268	PT5-R
1143	358103.1	1158753	6.5692	PT5-L
1156	358193.9	1158847	7.0694	PT6-R
1157	358216.7	1158813	6.6492	PT6-L
1166	358297.4	1158853	8.2723	PT7-L
1167	358274.9	1158892	7.6902	PT7-R
1168	358303.4	1158888	7.478	P3RD
1169	358304.1	1158887	8.2674	P3RS
1170	358308.8	1158875	9.1025	P3LS
1171	358310.4	1158874	8.4764	P3LD
1181	358397	1158909	7.4637	PT8-L
1182	358377.5	1158948	7.7435	PT8-R
1202	358558.5	1158904	7.1715	PT9-L
1203	358556.8	1158925	7.3479	PT9-R
1204	358564.8	1158908	6.7178	VT3L
1205	358561.6	1158922	6.7277	VT3R
1212	358629.6	1158950	9.3226	P4RD
1213	358631.7	1158941	8.769	P4LD
1214	358631	1158950	9.7955	P4RS
1215	358633	1158941	9.369	P4LS
1234	358709	1158973	7.2337	PT10L
1235	358693.2	1158991	7.1411	PT10R
1257	358947.9	1159190	9.6284	P4uLS
1258	358949.1	1159190	8.775	P4uLD
1259	358974.6	1159215	10.1352	PT11L
1260	358941.6	1159228	10.1142	PT11R
1269	358989.5	1159463	13.6452	P5LS
1270	358990.9	1159462	13.2049	P5LD
1273	359008.5	1159647	13.6251	P6LD
1274	359007.7	1159648	13.155	P6LS
1282	359822	1161671	21.4377	INK MARK
1283	359822.8	1161675	20.2491	RBR VT-1 R
1284	359860.6	1161661	20.6732	RBR VT-1 L

* California State Plane Coordinates

APPENDIX E

Surveyed Longitudinal Profile Points

Point #	Northing*	Easting*	Elevation	Name
1062	358230.1	1158152	0.95	FL RIV
1063	358221.7	1158162	1.172	FL RIV
1064	358211.2	1158183	1.6552	FL RIV
1065	358210.4	1158198	1.9324	FL RIV
1066	358198	1158214	2.0328	FL RIV
1067	358188.5	1158231	2.0838	FL RIV
1068	358179.3	1158247	2.1195	FL RIV
1069	358167	1158260	2.1352	FL RIV
1070	358157.7	1158276	2.3159	FL RIV
1071	358152.6	1158291	2.4372	FL RIV
1072	358144.8	1158306	2.3802	FL RIV
1073	358135.4	1158321	2.4539	FL RIV
1074	358123	1158331	2.6929	FL RIV
1078	358112.9	1158338	2.8633	FL RIV
1079	358101	1158346	3.221	FL RIV
1080	358093.7	1158360	3.4034	FL RIV
1081	358094.8	1158361	3.3417	FL RIV
1082	358066.5	1158363	3.273	FL RIV
1083	358058.4	1158374	3.1821	FL RIV
1084	358049.5	1158385	2.9464	FL RIV
1086	358041.5	1158396	2.7605	FL RIV
1087	358032.5	1158408	2.3544	FL RIV
1088	358025.5	1158417	1.8612	FL RIV
1089	358019.7	1158424	1.7775	FL RIV
1090	358009.4	1158433	1.8792	FL RIV
1091	357999.8	1158445	2.6022	FL RIV
1092	357991.7	1158450	2.254	FL RIV
1093	358003.4	1158462	3.454	FL RIV
1094	357993.7	1158475	2.8705	FL RIV
1095	357988.4	1158483	2.3752	FL RIV
1096	357984.2	1158485	3.9682	FL RIV
1097	357972.9	1158483	4.0272	FL RIV
1098	357962	1158494	3.5217	FL RIV
1101	357955	1158501	3.1136	FL RIV
1102	357944	1158510	2.3063	FL RIV
1103	357934.6	1158516	1.7135	FL RIV
1104	357927.4	1158522	2.2433	FL RIV
1105	357914.5	1158531	1.7266	FL RIV
1106	357908.2	1158538	1.5371	FL RIV
1107	357908.9	1158551	2.9978	FL RIV
1108	357907.1	1158564	2.8009	FL RIV
1109	357895.8	1158580	2.4911	FL RIV
1110	357884.8	1158588	2.3855	FL RIV
1111	357879.1	1158600	1.6577	FL RIV
1112	357876.3	1158612	2.539	FL RIV
1113	357879.9	1158629	3.6568	FL RIV
1114	357889	1158643	3.8861	FL RIV
1115	357897.4	1158651	2.2449	FL RIV
1116	357905.3	1158656	1.833	FL RIV

APPENDIX E

Surveyed Longitudinal Profile Points

Point #	Northing*	Easting*	Elevation	Name
1117	357903.8	1158664	3.8265	FL RIV
1118	357916.4	1158671	4.4308	FL RIV
1119	357936.9	1158674	4.6558	FL RIV
1125	357940.1	1158675	4.9396	FL RIV
1126	357955	1158680	5.4335	FL RIV
1127	357969.4	1158687	5.5677	FL RIV
1128	357982.3	1158701	5.1487	FL RIV
1129	357992.7	1158712	4.7459	FL RIV
1130	358004.5	1158718	4.704	FL RIV
1131	358013.3	1158726	3.9209	FL RIV
1132	358021.7	1158732	4.2608	FL RIV
1133	358033.4	1158743	4.2573	FL RIV
1134	358041.7	1158757	4.5785	FL RIV
1135	358053.5	1158772	4.6383	FL RIV
1136	358062.9	1158781	4.2166	FL RIV
1137	358075.7	1158788	4.2977	FL RIV
1144	358087.6	1158792	4.6542	FL RIV
1145	358109.1	1158785	4.6352	FL RIV
1146	358122.9	1158792	4.4005	FL RIV
1147	358134.5	1158799	4.1296	FL RIV
1148	358148.9	1158805	3.7306	FL RIV
1149	358159.8	1158813	3.2916	FL RIV
1151	358162.4	1158813	3.1123	FL RIV
1152	358175.5	1158816	2.6787	FL RIV
1153	358189	1158822	2.9565	FL RIV
1154	358202.5	1158828	3.6463	FL RIV
1158	358204.8	1158828	3.6269	FL RIV
1159	358215.3	1158830	3.7253	FL RIV
1160	358228.9	1158838	4.5098	FL RIV
1161	358242.7	1158841	4.8441	FL RIV
1162	358255.1	1158848	4.9865	FL RIV
1163	358266.5	1158855	5.0597	FL RIV
1164	358278.2	1158863	4.8463	FL RIV
1172	358286.2	1158872	4.6378	FL RIV
1173	358296.7	1158878	4.4451	FL RIV
1174	358305.8	1158891	3.8221	FL RIV
1175	358315.7	1158897	3.5231	FL RIV
1176	358329.3	1158904	3.6205	FL RIV
1177	358338.6	1158911	3.3656	FL RIV
1178	358347.7	1158920	3.0511	FL RIV
1179	358363.7	1158924	3.3667	FL RIV
1183	358371.1	1158929	3.8535	FL RIV
1184	358383.4	1158929	3.958	FL RIV
1185	358397.4	1158932	4.2953	FL RIV
1186	358407.1	1158944	4.1755	FL RIV
1188	358417.9	1158949	4.2853	FL RIV
1189	358427.4	1158958	3.9327	FL RIV
1190	358437.9	1158963	3.6408	FL RIV
1191	358455.1	1158963	5.0524	FL RIV

APPENDIX E

Surveyed Longitudinal Profile Points

Point #	Northing*	Easting*	Elevation	Name
1192	358465	1158955	4.5044	FL RIV
1193	358476.5	1158947	4.4991	FL RIV
1194	358490.1	1158941	3.9832	FL RIV
1195	358503.2	1158936	4.1556	FL RIV
1196	358512.1	1158927	3.5634	FL RIV
1197	358517.7	1158919	3.3131	FL RIV
1198	358528.3	1158914	4.4439	FL RIV
1199	358540.8	1158910	4.6508	FL RIV
1200	358554.5	1158909	5.2741	FL RIV
1201	358565.4	1158915	5.6146	FL RIV
1206	358567.5	1158917	5.6119	FL RIV
1207	358579.1	1158922	5.7526	FL RIV
1208	358590.8	1158925	5.5938	FL RIV
1209	358604.3	1158931	5.4901	FL RIV
1210	358615.2	1158936	4.9746	FL RIV
1211	358625.6	1158940	5.1922	FL RIV
1217	358639.3	1158949	5.3371	FL RIV
1218	358651.3	1158955	5.7377	FL RIV
1219	358663.6	1158966	6.0357	FL RIV
1220	358679.2	1158974	6.2761	FL RIV
1221	358689.5	1158982	6.498	FL RIV
1222	358702.9	1158983	6.5527	FL RIV
1223	358718.6	1158988	6.7308	FL RIV
1224	358732.2	1158991	6.7132	FL RIV
1226	358750.3	1158999	7.1426	FL RIV
1227	358766.7	1159010	7.1519	FL RIV
1228	358787.4	1159019	6.7834	FL RIV
1229	358801.8	1159046	7.9578	FL RIV
1230	358813.5	1159057	8.0104	FL RIV
1231	358825.4	1159067	8.0082	FL RIV
1232	358837.3	1159075	7.9721	FL RIV
1236	358842.1	1159083	7.6597	FL RIV
1237	358851.7	1159097	7.5071	FL RIV
1238	358873	1159098	7.0384	FL RIV
1239	358885.5	1159110	5.8396	FL RIV
1240	358895	1159120	5.4993	FL RIV
1241	358904.9	1159129	4.7568	FL RIV
1242	358914.9	1159141	5.3339	FL RIV
1243	358945.2	1159349	10.5125	FL RIV
1244	358946.6	1159332	10.5947	FL RIV
1245	358948.3	1159316	10.499	FL RIV
1246	358948.3	1159300	10.32	FL RIV
1247	358948.9	1159286	10.0783	FL RIV
1248	358953.2	1159271	10.0618	FL RIV
1249	358956.2	1159256	9.9608	FL RIV
1250	358962.9	1159241	9.4887	FL RIV
1251	358970.8	1159226	8.9112	FL RIV
1252	358969.1	1159213	8.4035	FL RIV
1253	358966.7	1159201	6.5186	FL RIV

APPENDIX E

Surveyed Longitudinal Profile Points

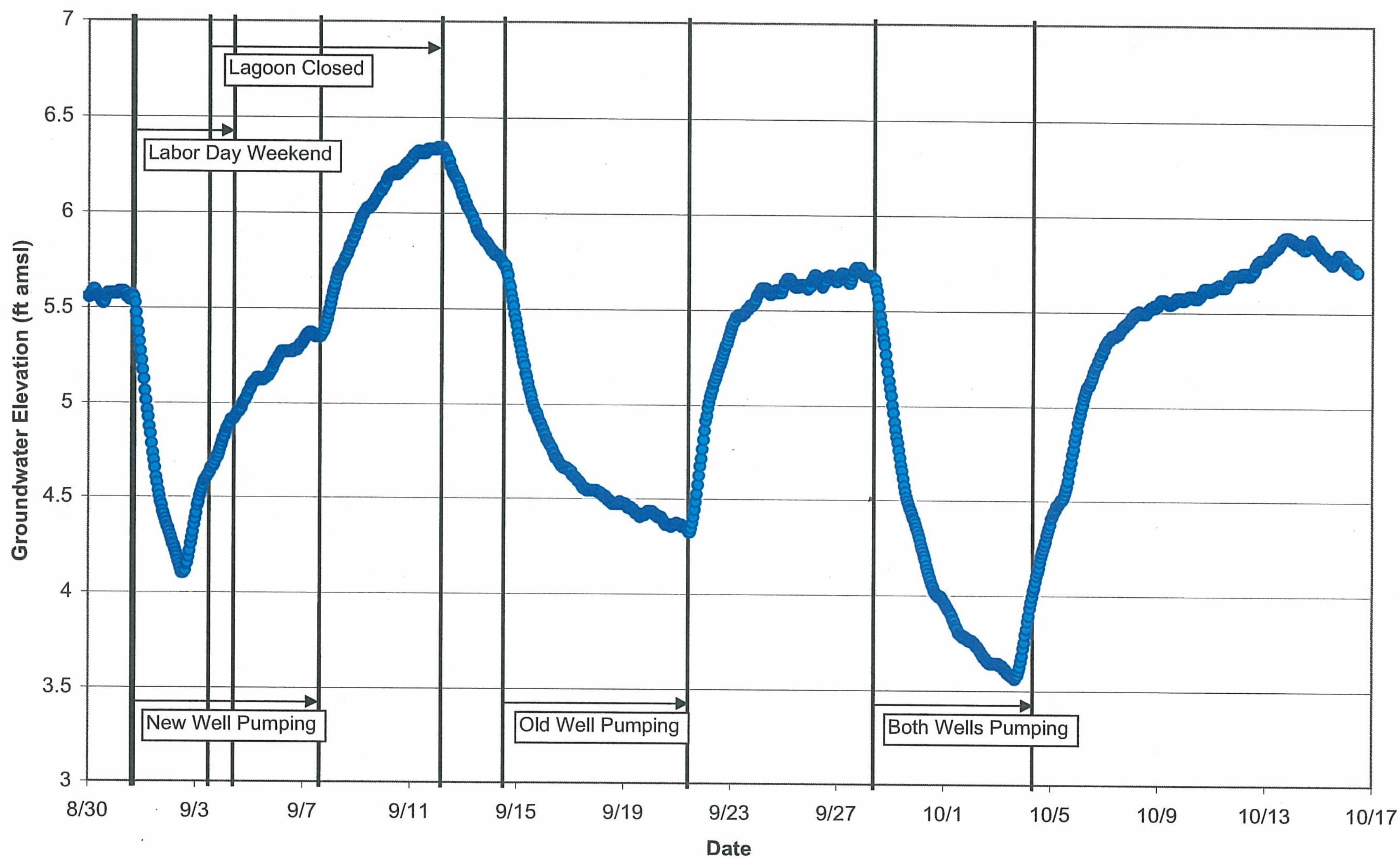
Point #	Northing*	Easting*	Elevation	Name
1254	358949.3	1159188	5.1542	FL RIV
1255	358940.9	1159174	5.2436	FL RIV
1256	358934.1	1159162	4.7819	FL RIV
1261	358943	1159362	10.2125	FL RIV
1262	358947.7	1159378	10.1453	FL RIV
1263	358949.8	1159398	9.3984	FL RIV
1264	358955.6	1159411	10.5828	FL RIV
1265	358970.7	1159423	10.911	FL RIV
1266	358976.4	1159438	10.4432	FL RIV
1267	358983.1	1159451	9.8832	FL RIV
1268	358986.4	1159465	9.413	FL RIV
1275	359003.6	1159644	9.1863	FL RIV
1276	359006.8	1159631	9.401	FL RIV
1277	359008.5	1159617	9.4516	FL RIV
1278	359008.1	1159605	9.3971	FL RIV
1279	359010	1159586	9.7485	FL RIV
1280	359013.7	1159572	9.8666	FL RIV
1286	359844.9	1161671	18.3389	FL RIV
1287	359838.1	1161655	18.6998	FL RIV
1288	359834.5	1161643	18.6289	FL RIV
1289	359830.5	1161631	18.8431	FL RIV
1290	359829.1	1161619	18.9802	FL RIV
1291	359822	1161606	19.2837	FL RIV
1292	359813	1161595	19.1918	FL RIV
1293	359810.1	1161582	19.3339	FL RIV
1294	359808.4	1161566	19.2989	FL RIV
1295	359804.9	1161551	19.4253	FL RIV
1296	359798.7	1161537	19.0078	FL RIV
1297	359798.5	1161524	19.3557	FL RIV
1298	359797.7	1161513	19.4353	FL RIV
1299	359789.8	1161499	19.6669	FL RIV
1300	359789.3	1161484	19.531	FL RIV
1301	359785.5	1161470	19.4831	FL RIV

* California State Plane Coordinates

APPENDIX F

MONITORING WELL HYDROGRAPHS

Appendix F - ESR-1 Groundwater Elevation - 2007



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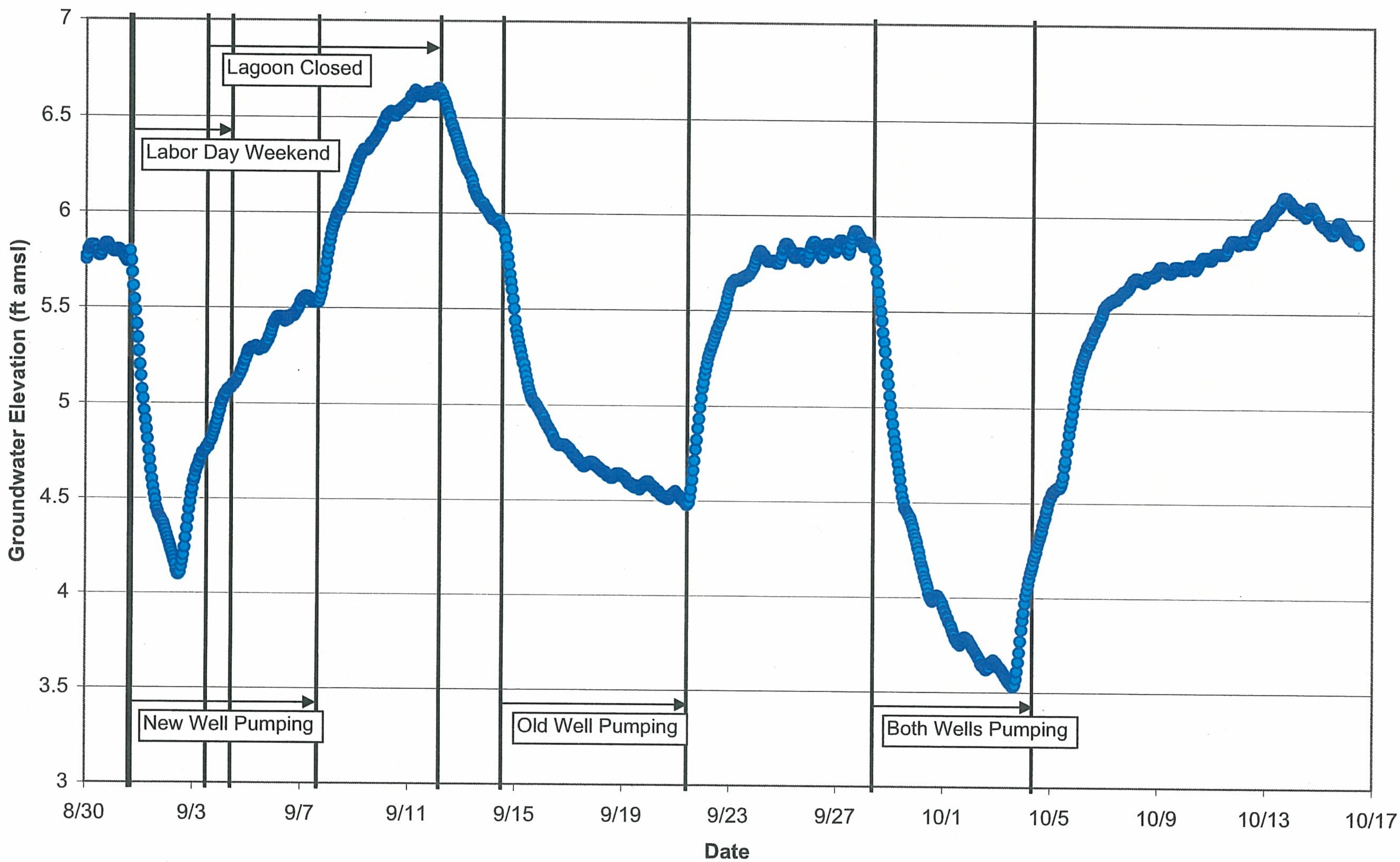
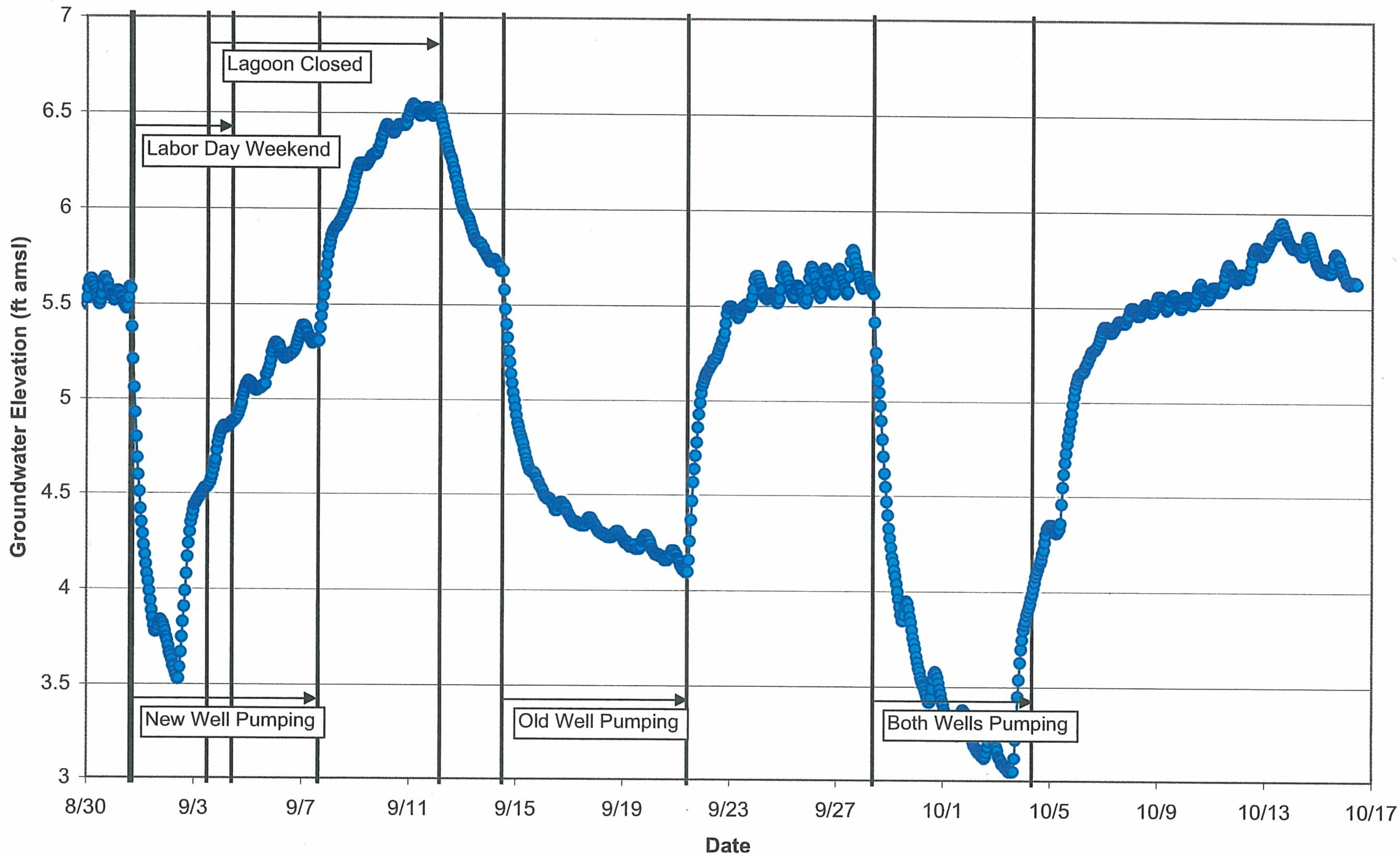
Appendix F - ESR-2 Groundwater Elevation - 2007



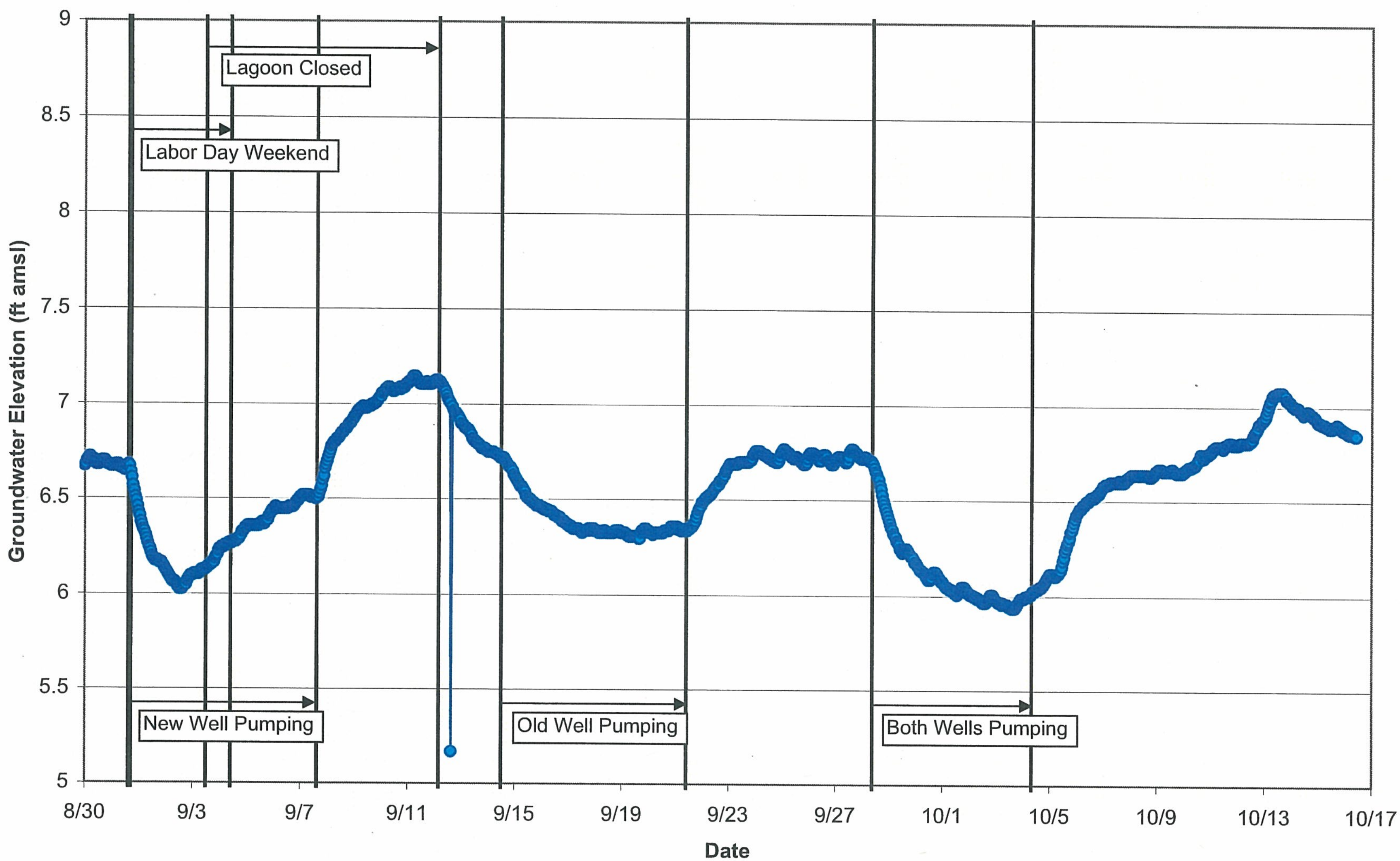
THE SOURCE GROUP, INC.

Appendix F - ESR-3 Groundwater Elevation - 2007



SGI environmental THE SOURCE GROUP, INC.

Appendix F - ESR-10A Groundwater Elevation - 2007



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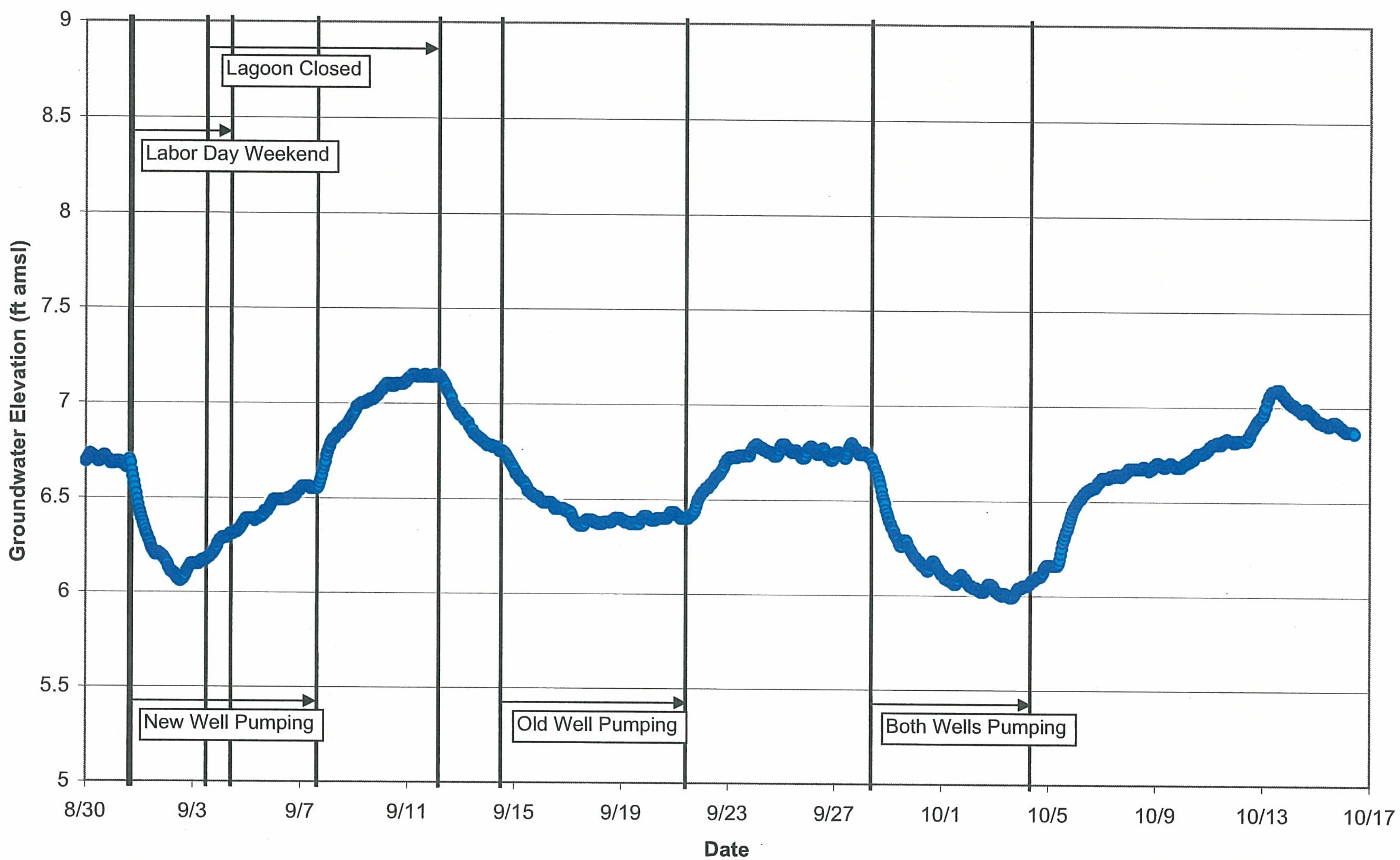
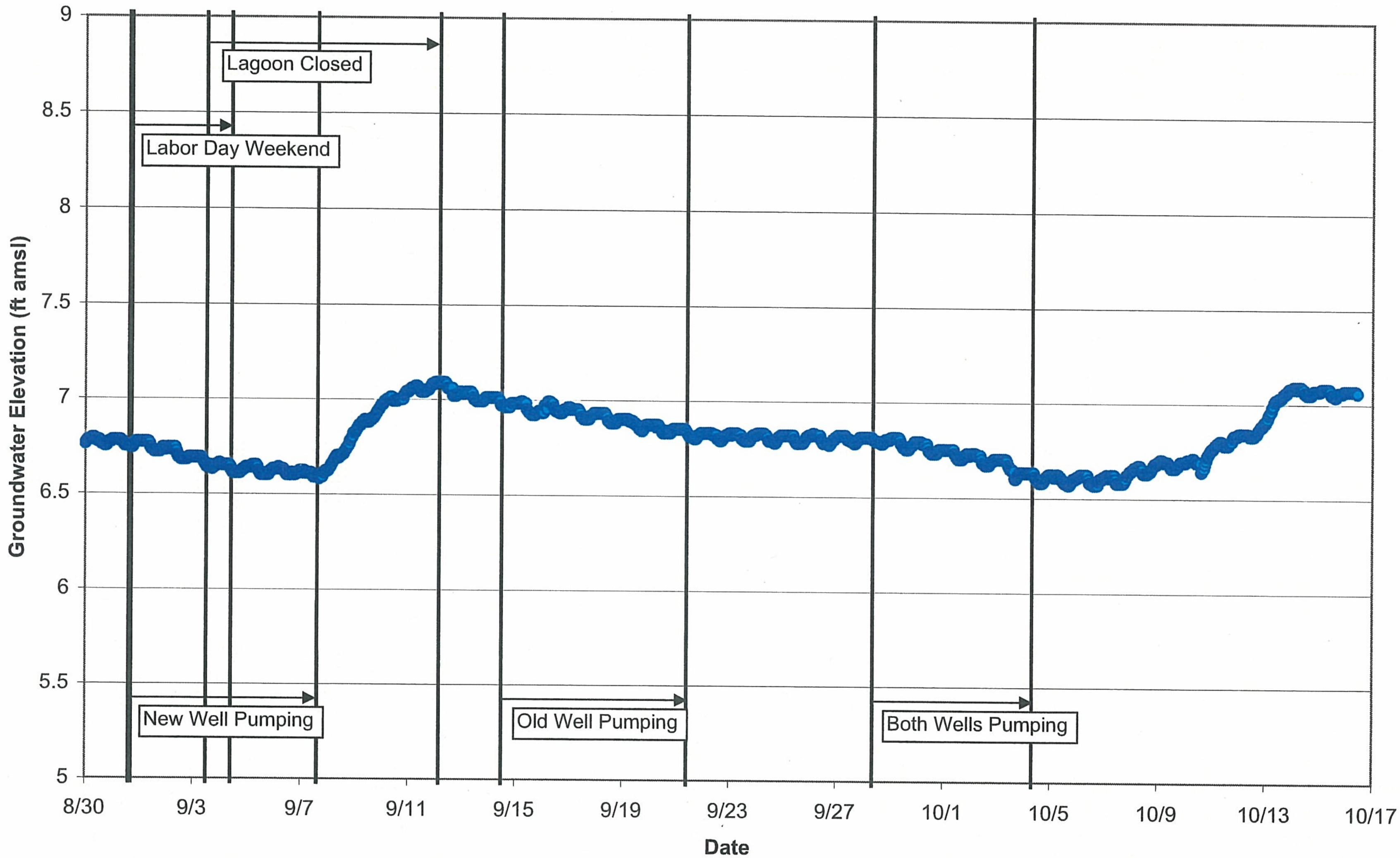
Appendix F - ESR-10B Groundwater Elevation - 2007



SGI environmental THE SOURCE GROUP, INC.

Appendix F - ESR-10C Groundwater Elevation - 2007



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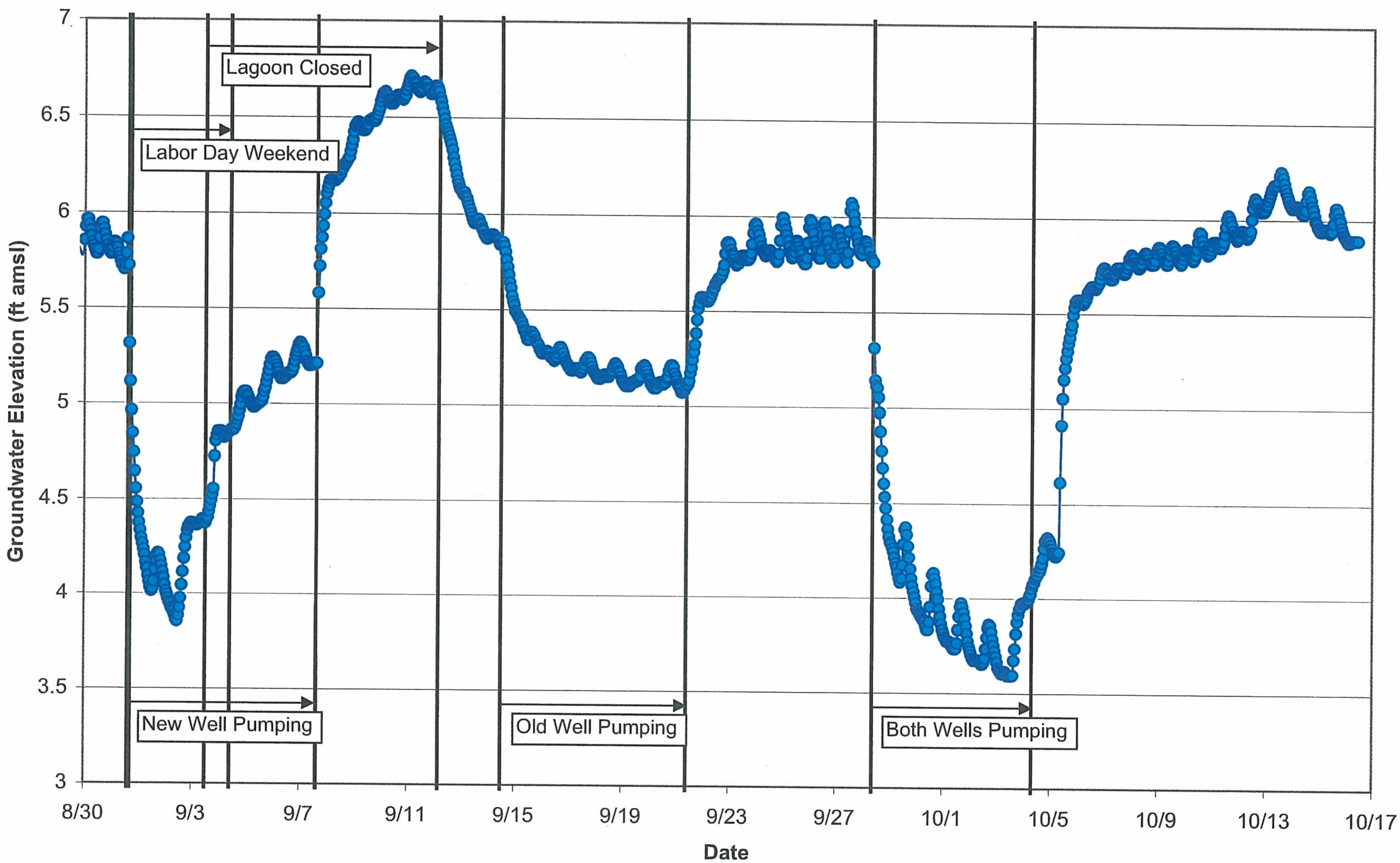
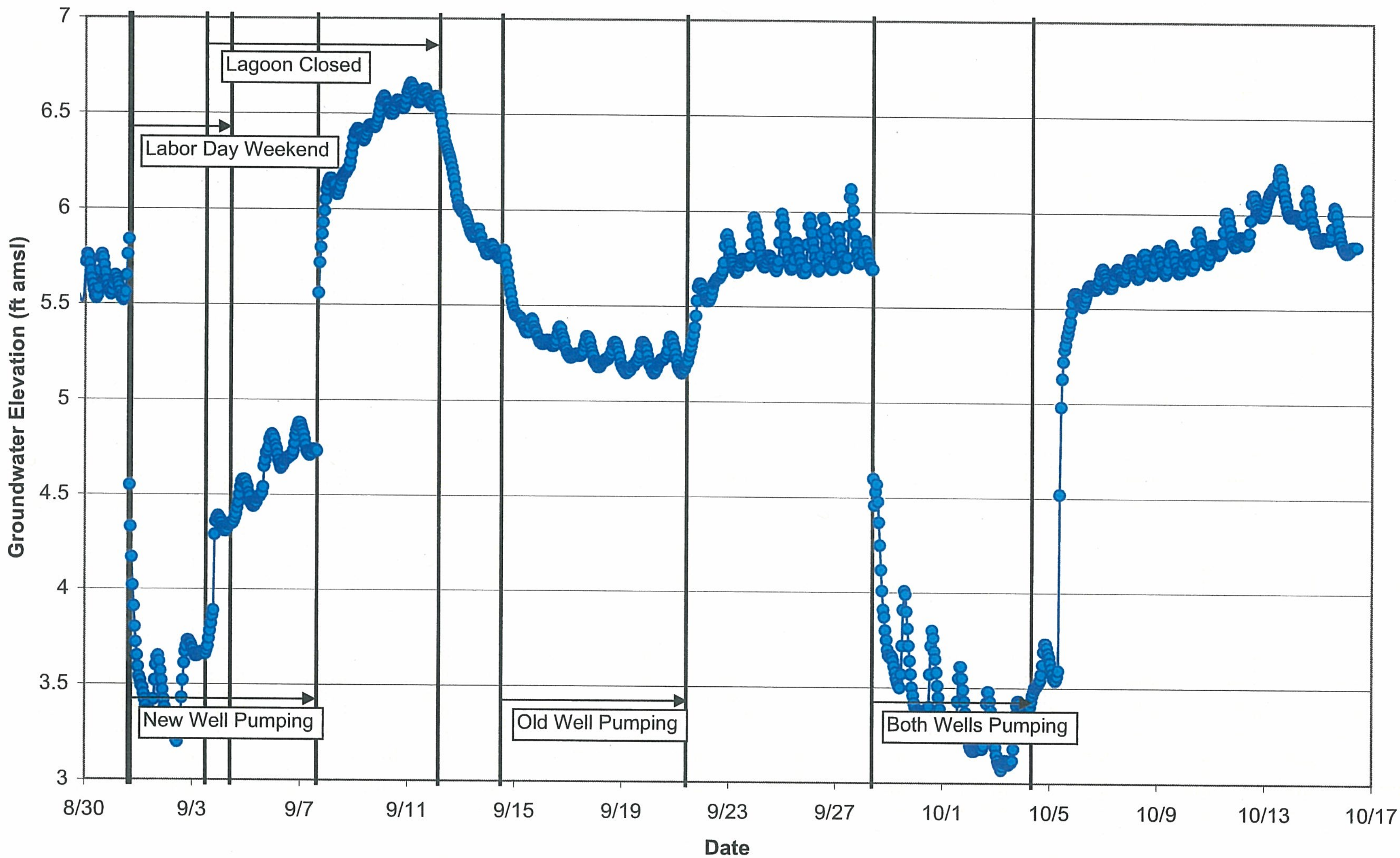
Appendix F - JSA-3 Groundwater Elevation - 2007



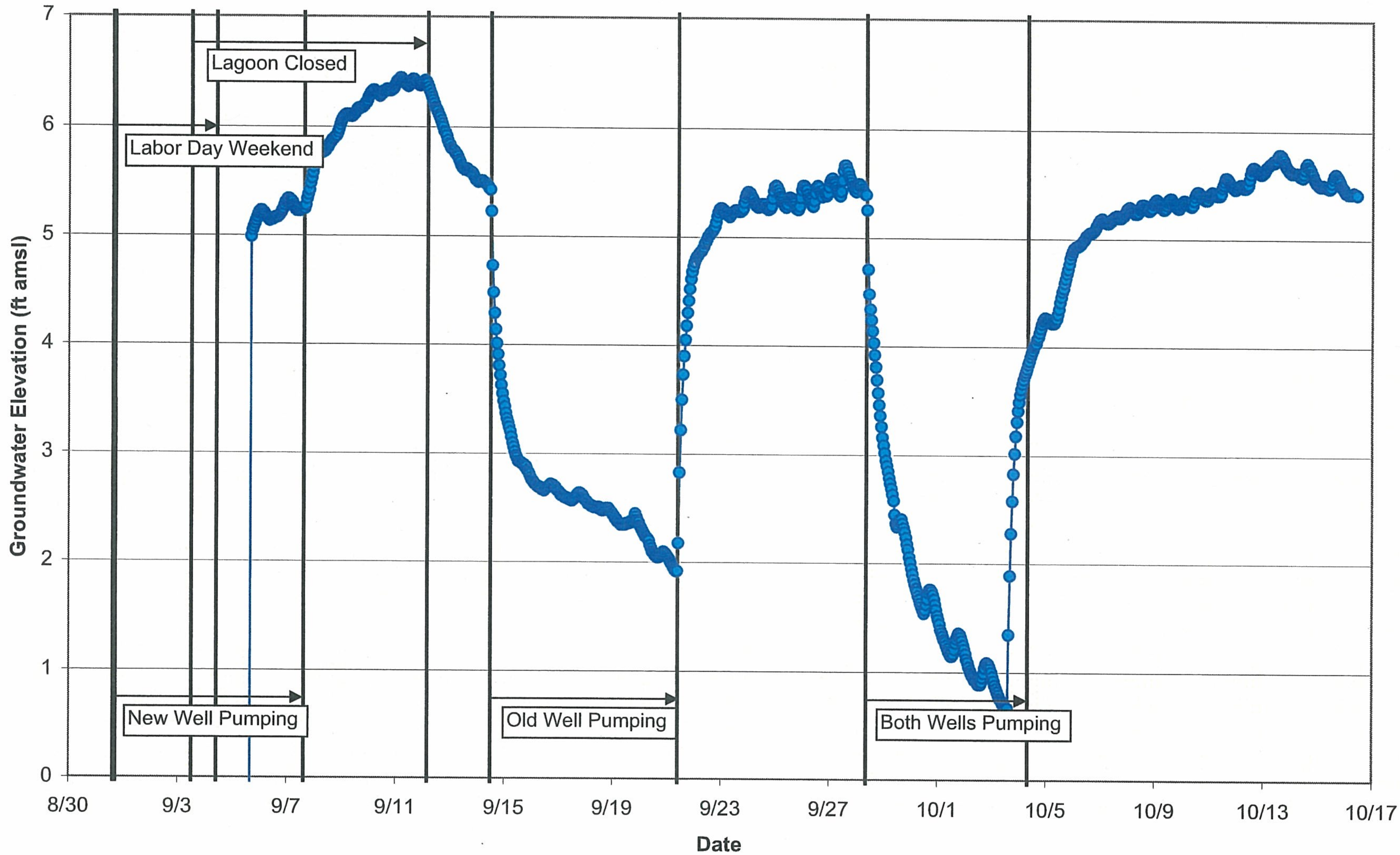
SGI environmental THE SOURCE GROUP, INC.

Appendix F - JSA-4 Groundwater Elevation - 2007



SGI environmental THE SOURCE GROUP, INC.

Appendix F - Original Old Well Groundwater Elevation - 2007



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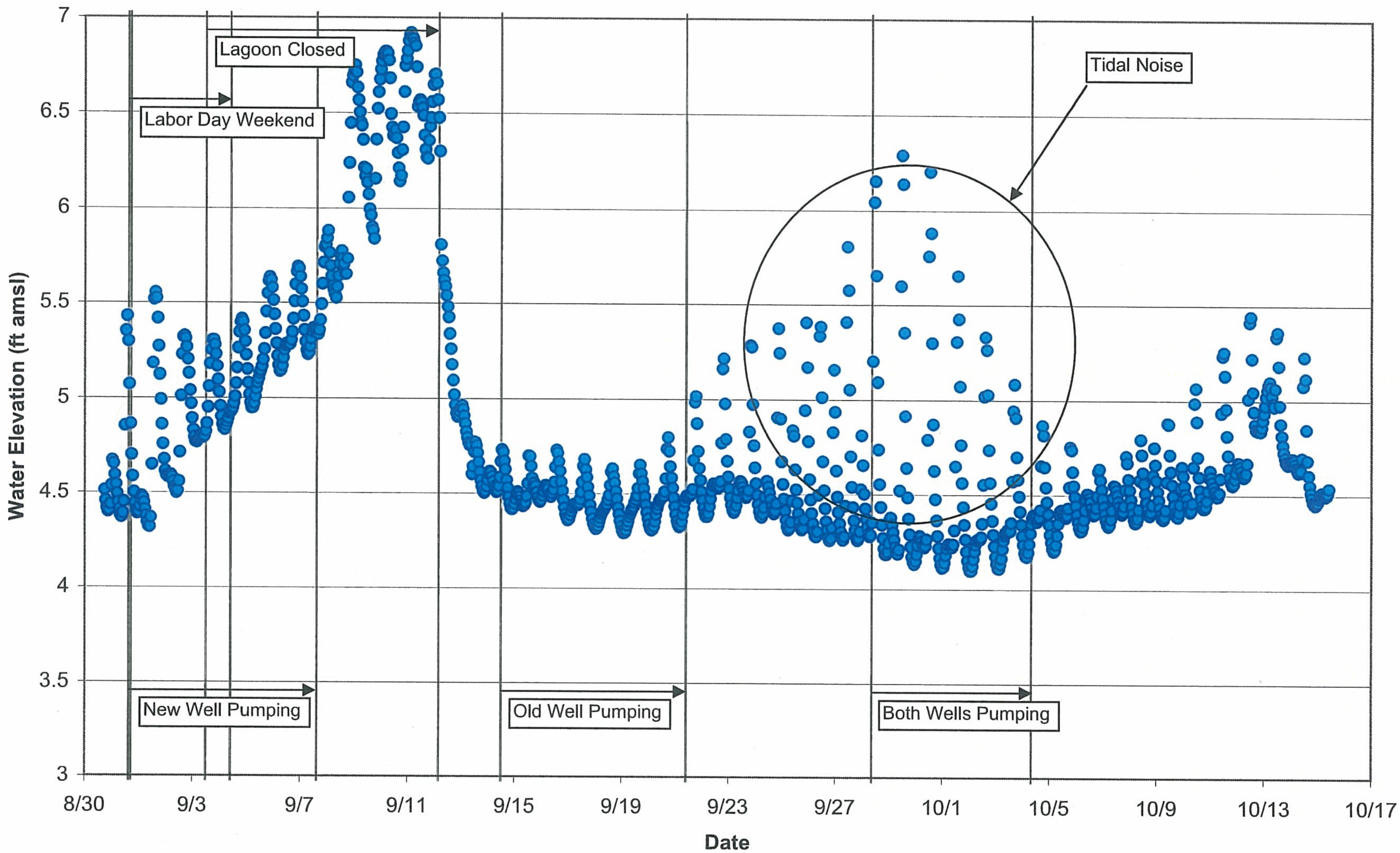
APPENDIX G

RIVER PIEZOMETER HYDROGRAPHS

Appendix G - P1LS Hydrograph - 2007



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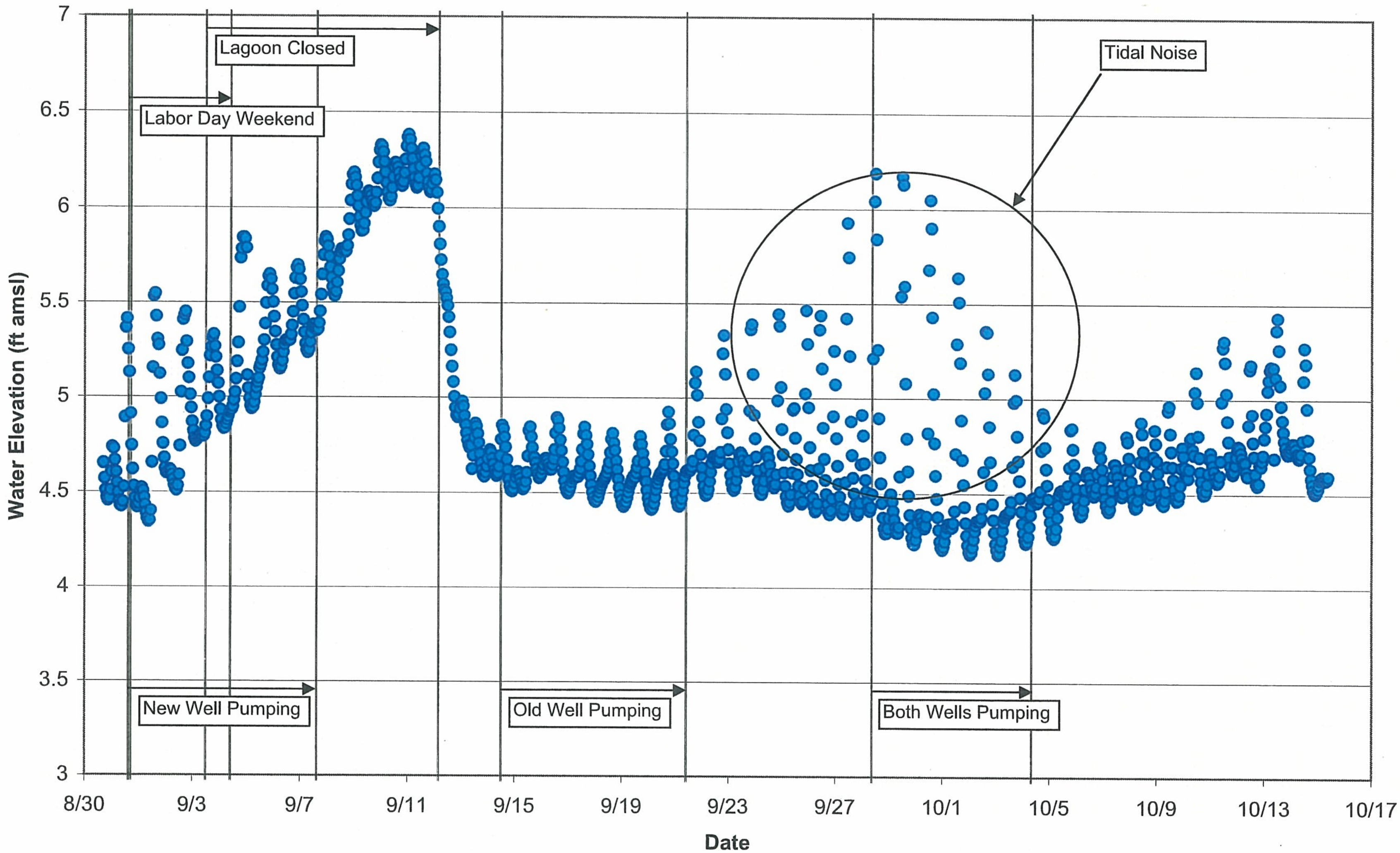
Appendix G - P1LD Hydrograph - 2007



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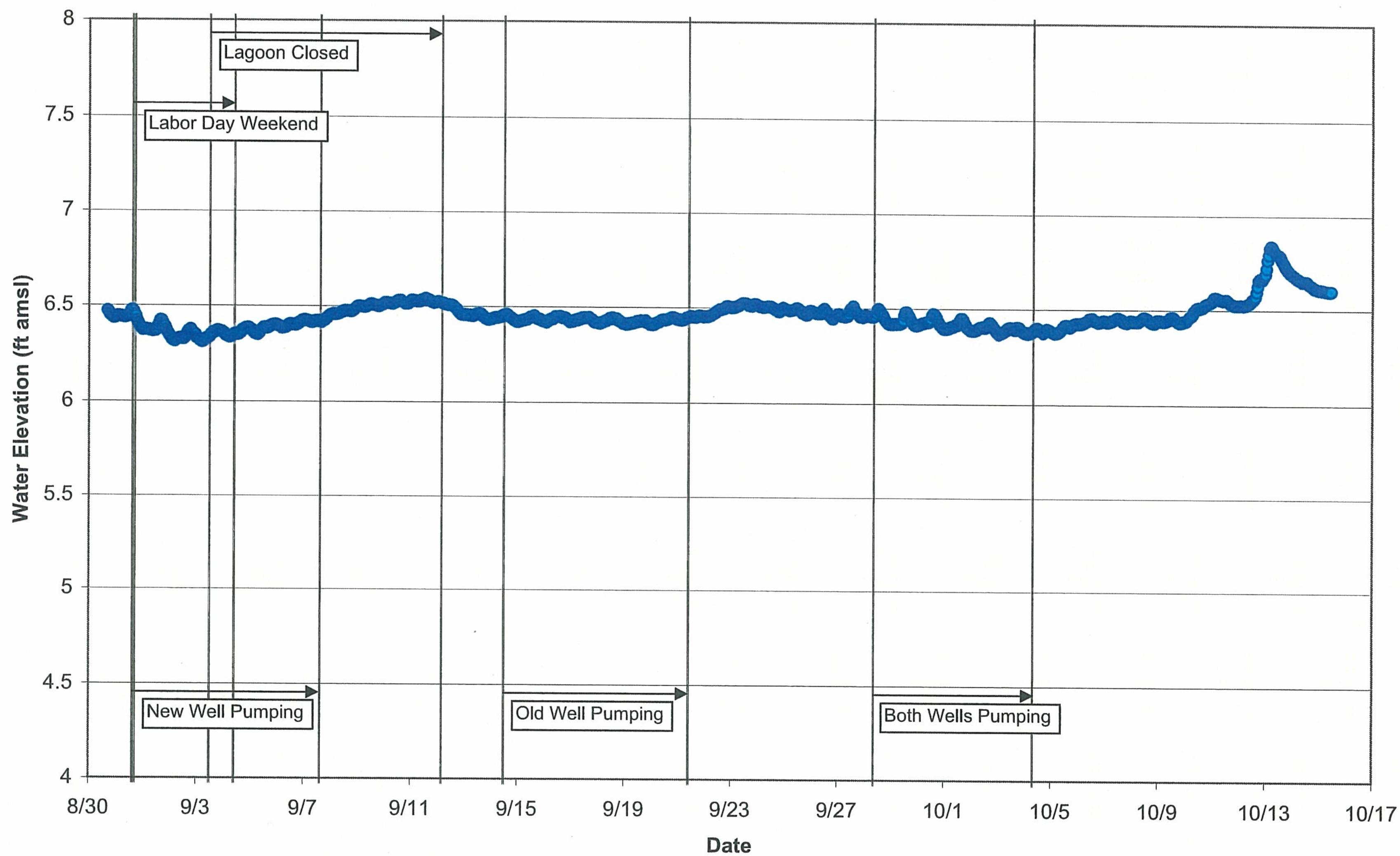
Appendix G - P2LS Hydrograph - 2007



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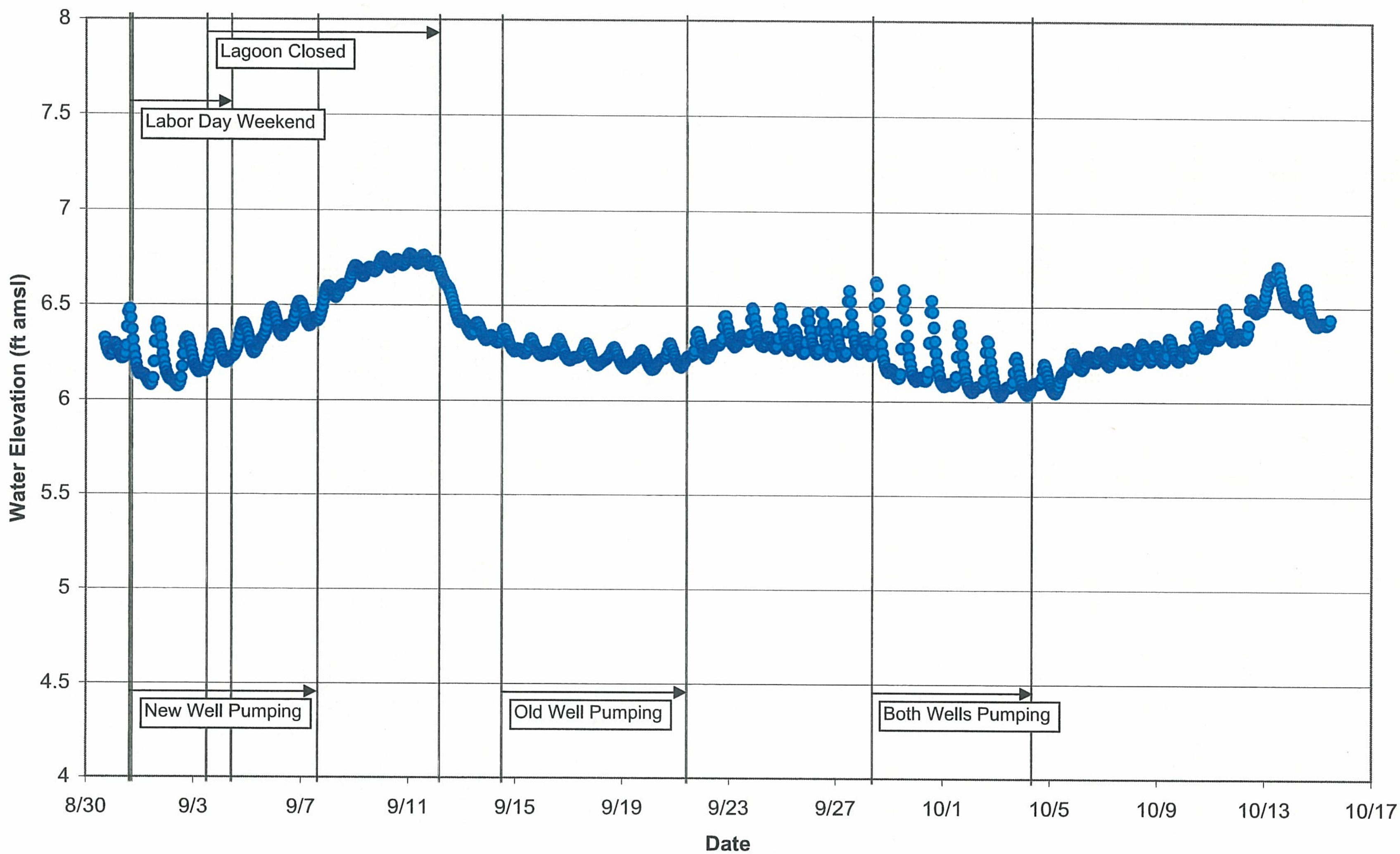
Appendix G - P2LD Hydrograph - 2007



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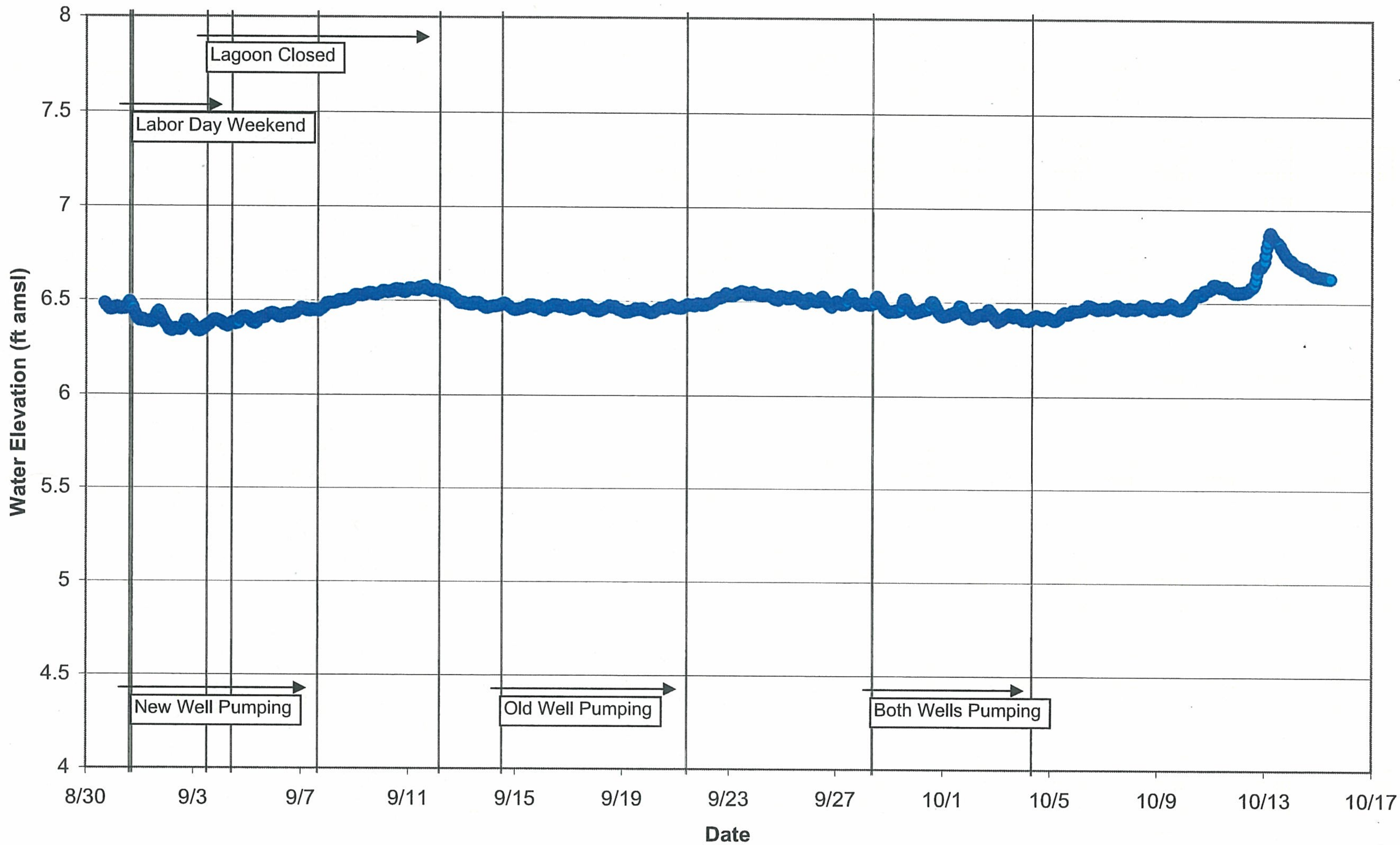
Appendix G - P2RS Hydrograph - 2007



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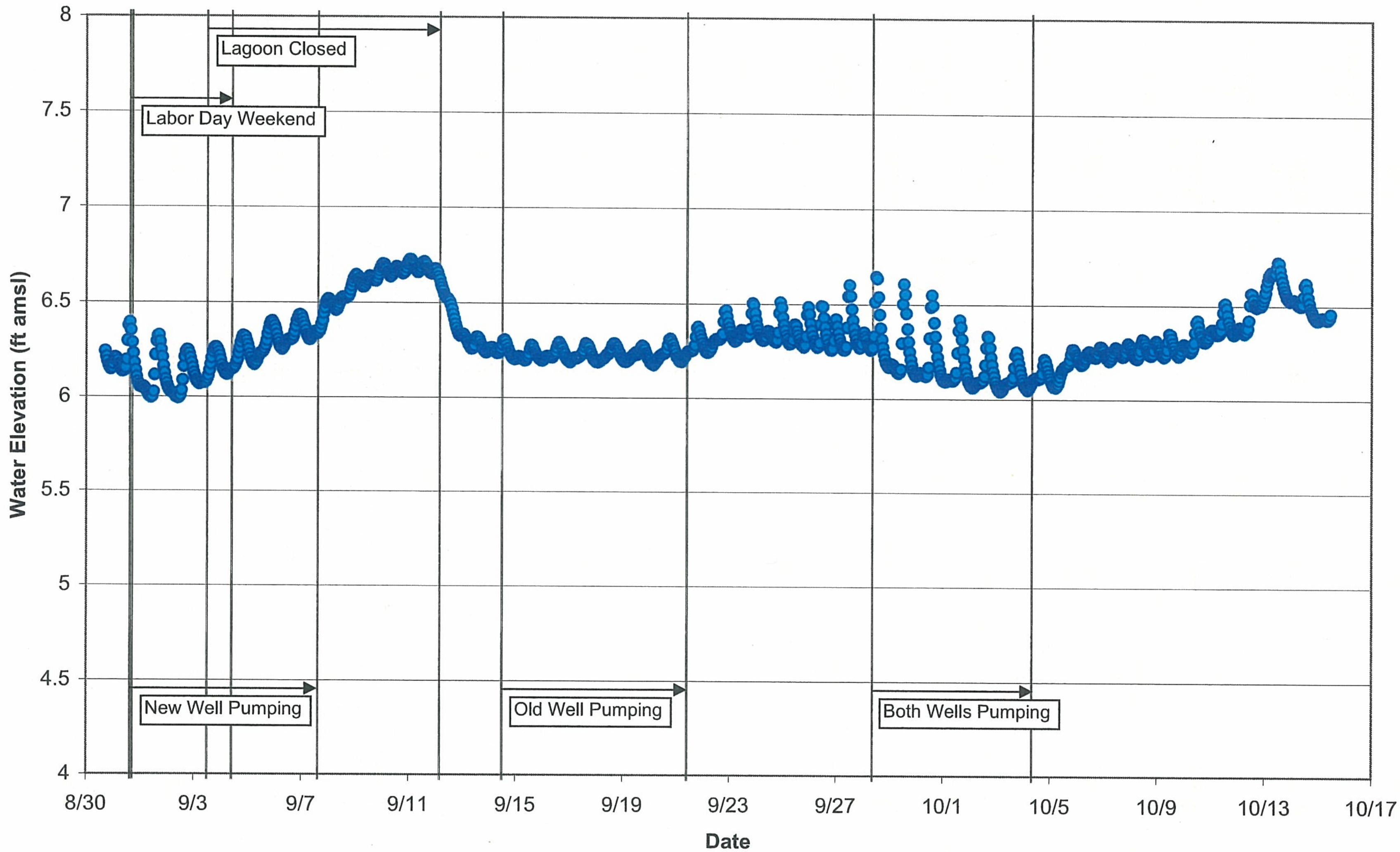
Appendix G - P2RD Hydrograph - 2007



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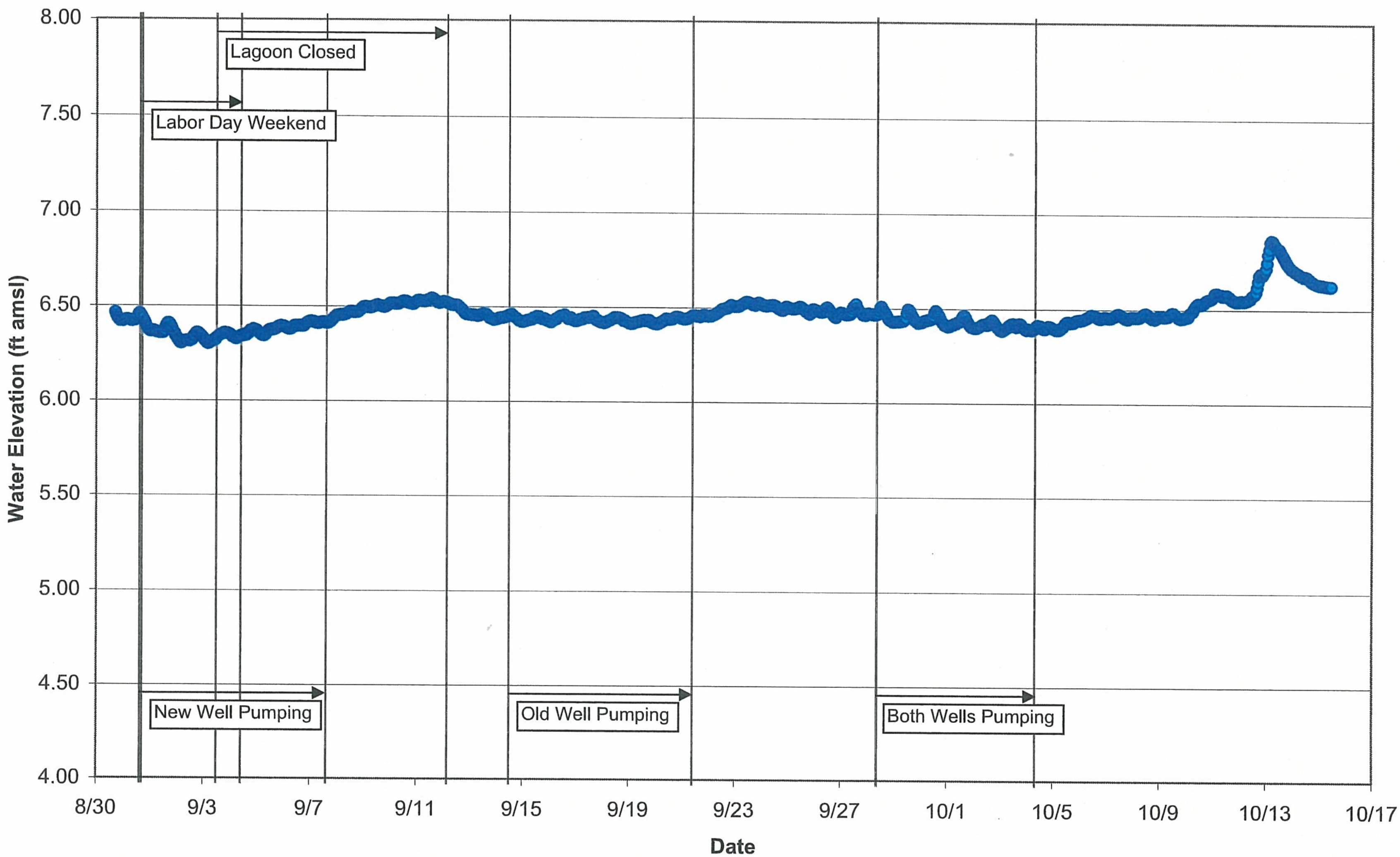
Appendix G - P3LS Hydrograph - 2007



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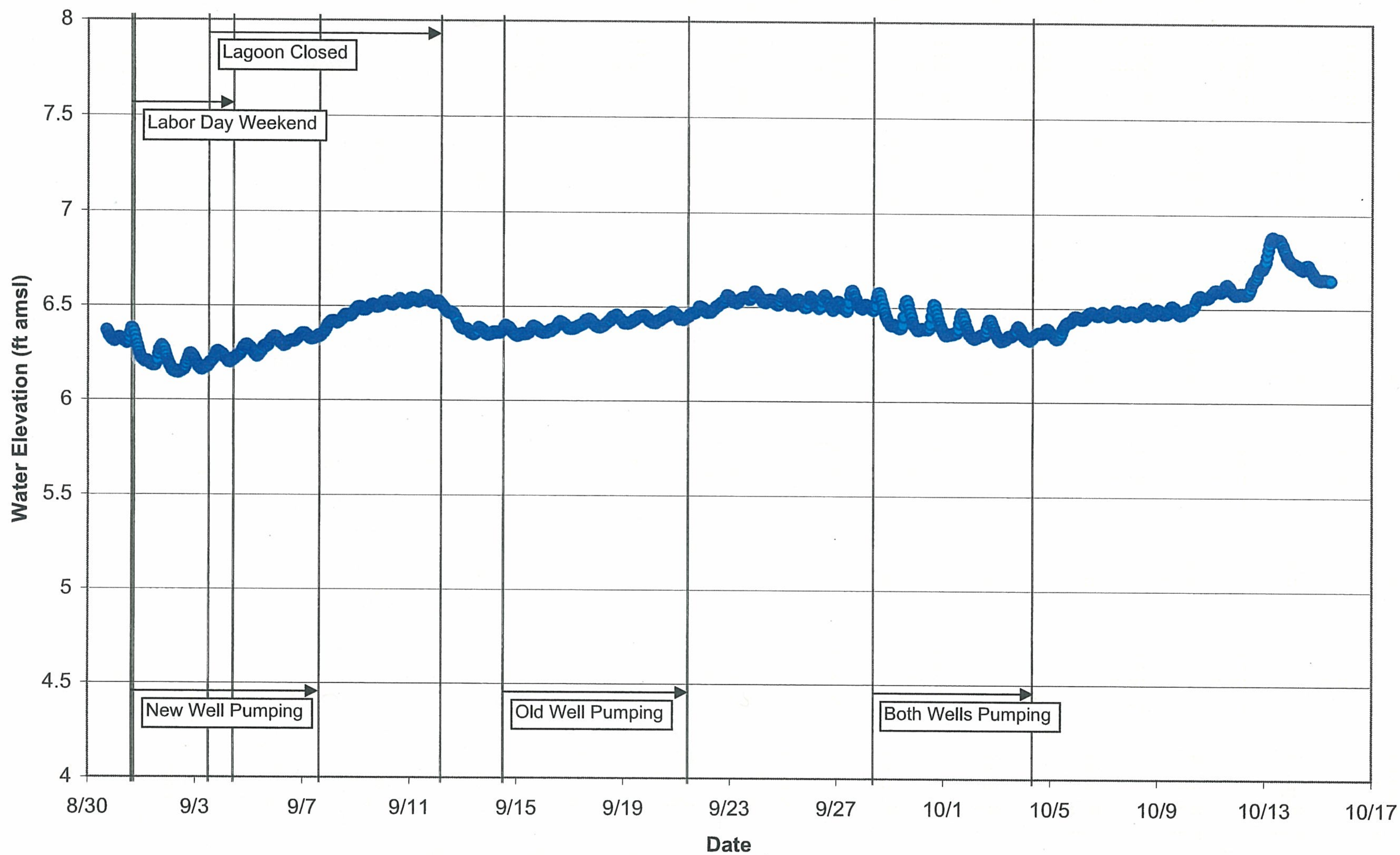
Appendix G - P3LD Hydrograph - 2007



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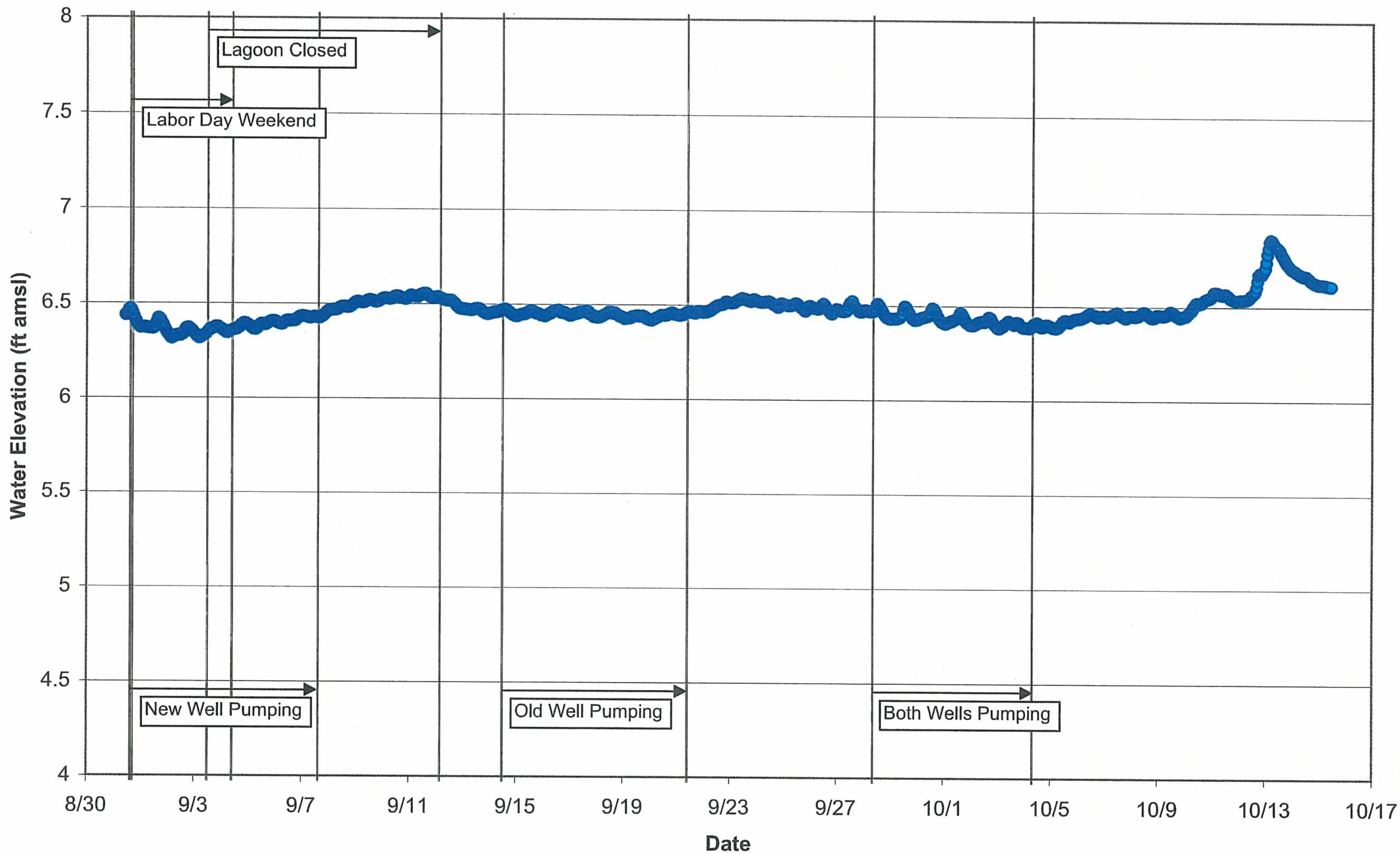
Appendix G - P3RS Hydrograph - 2007



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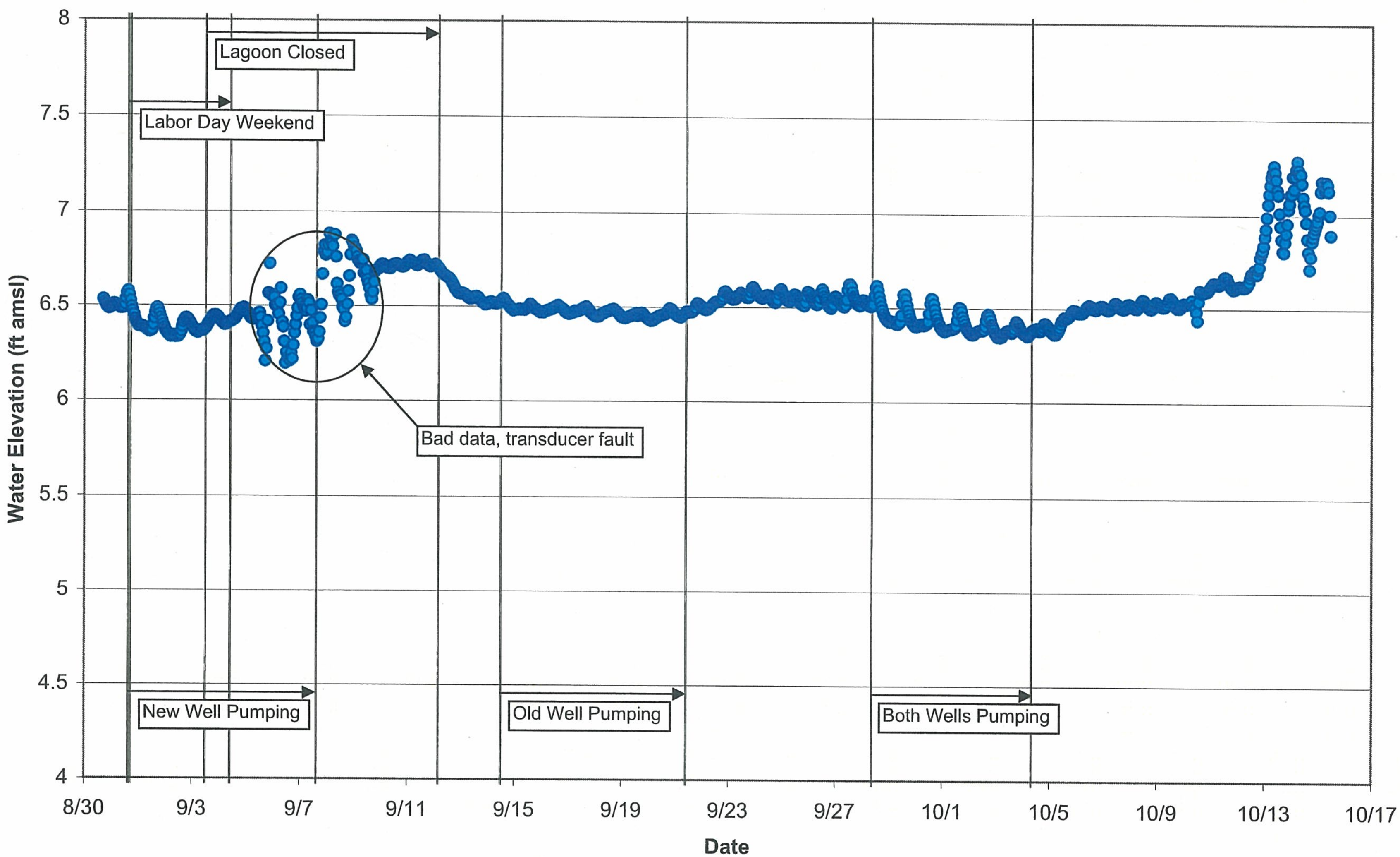
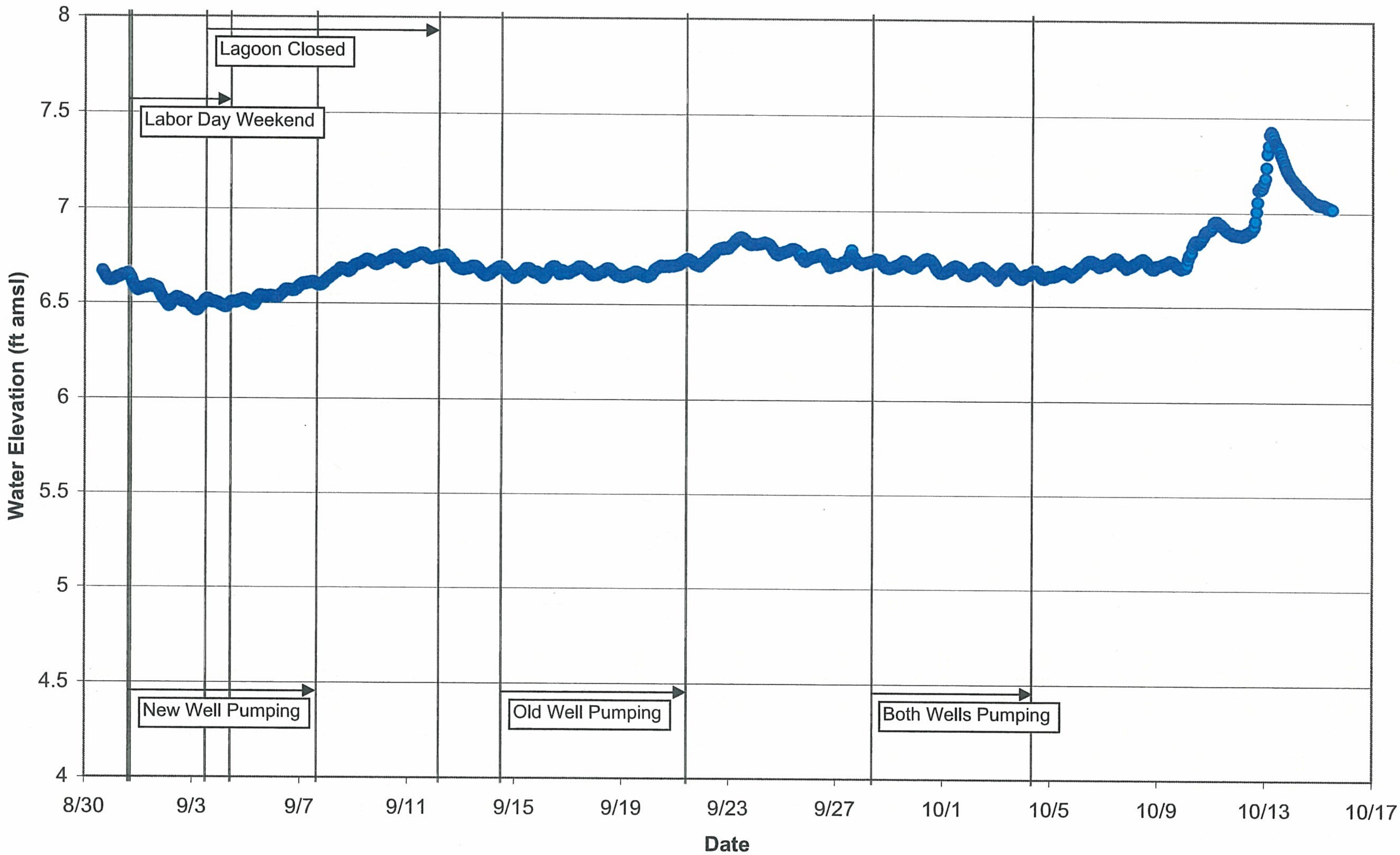
Appendix G - P3RD Hydrograph - 2007



Appendix G - P4LS Hydrograph - 2007



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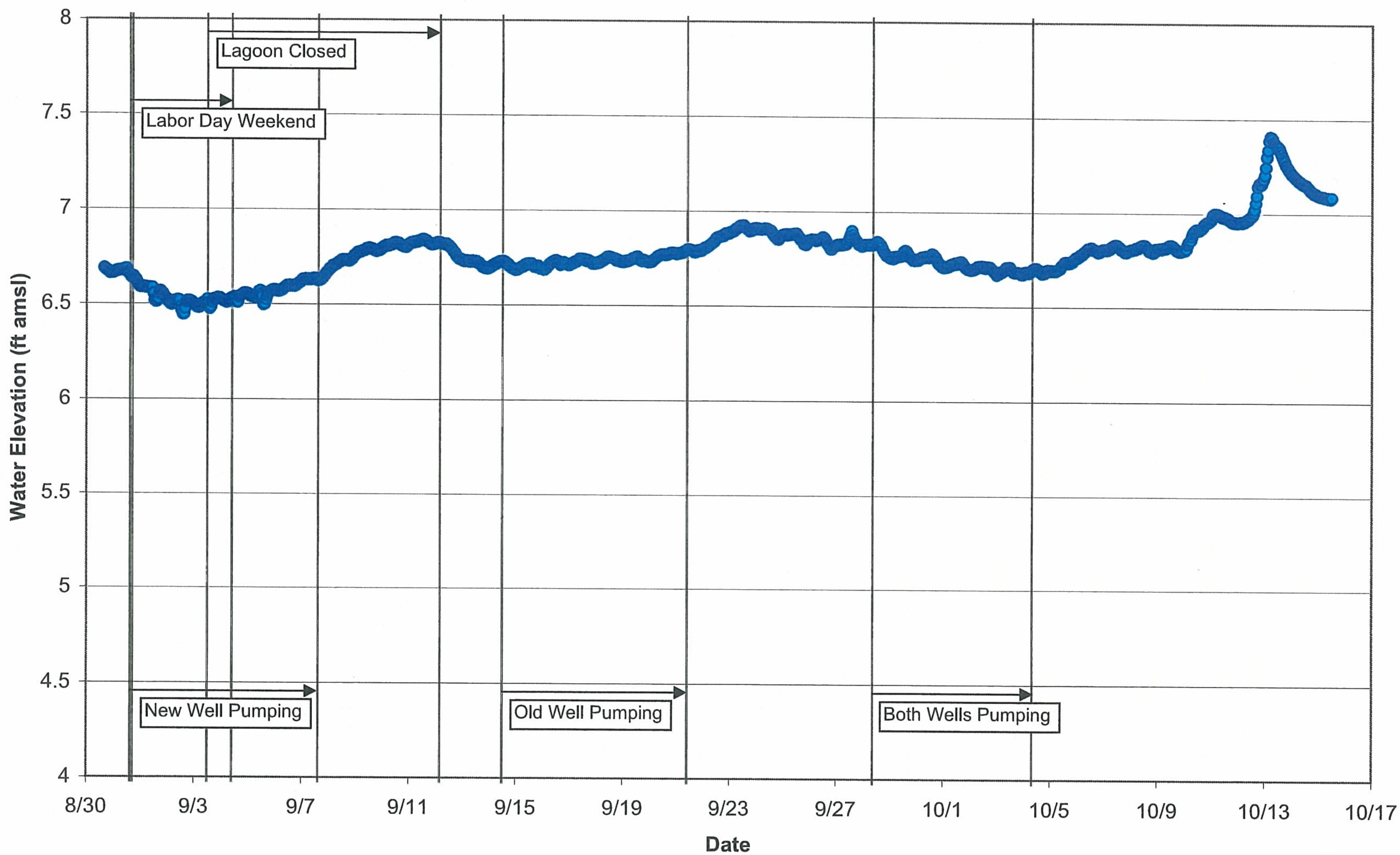
Appendix G - P4LD Hydrograph - 2007



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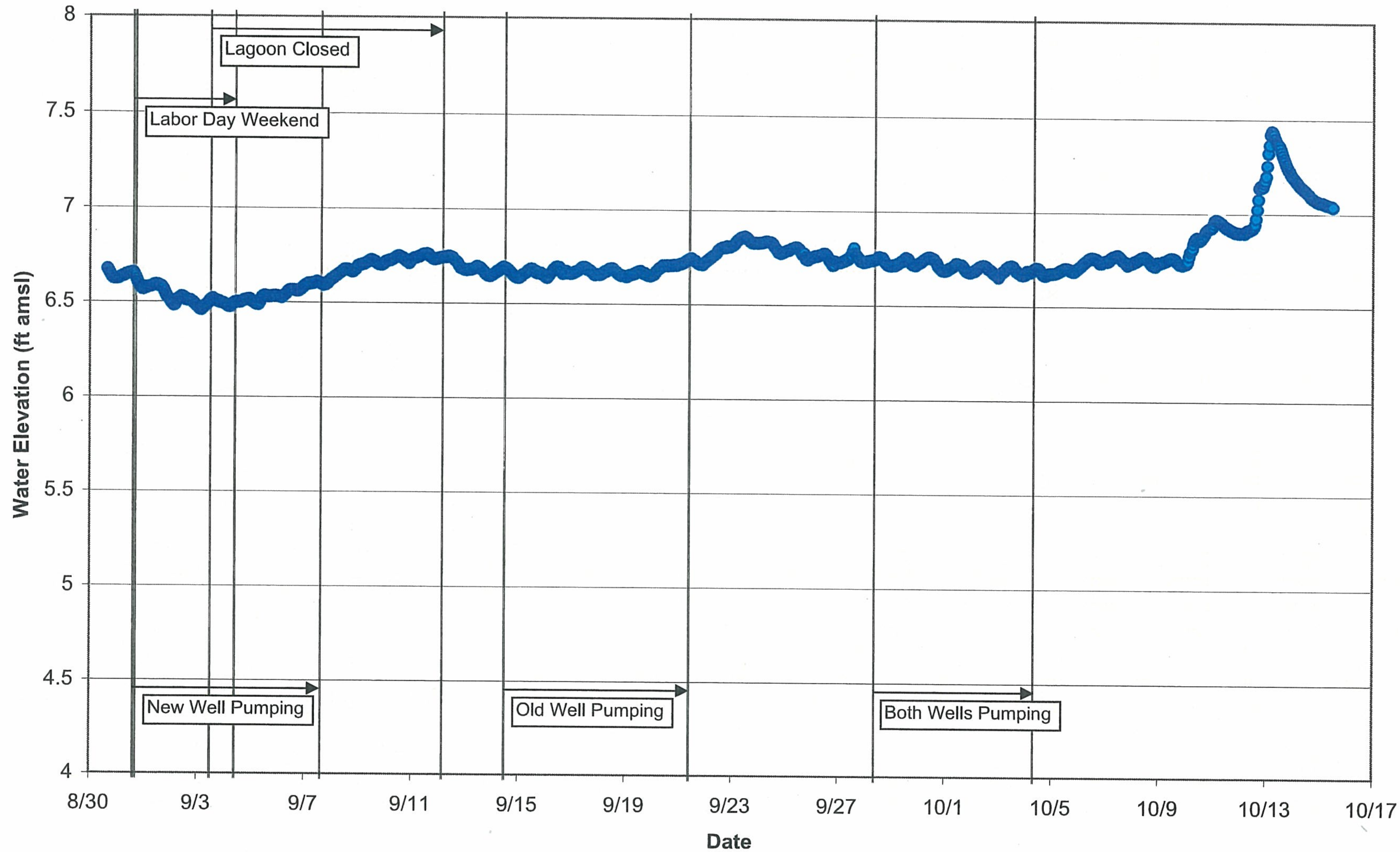
Appendix G - P4RS Hydrograph - 2007



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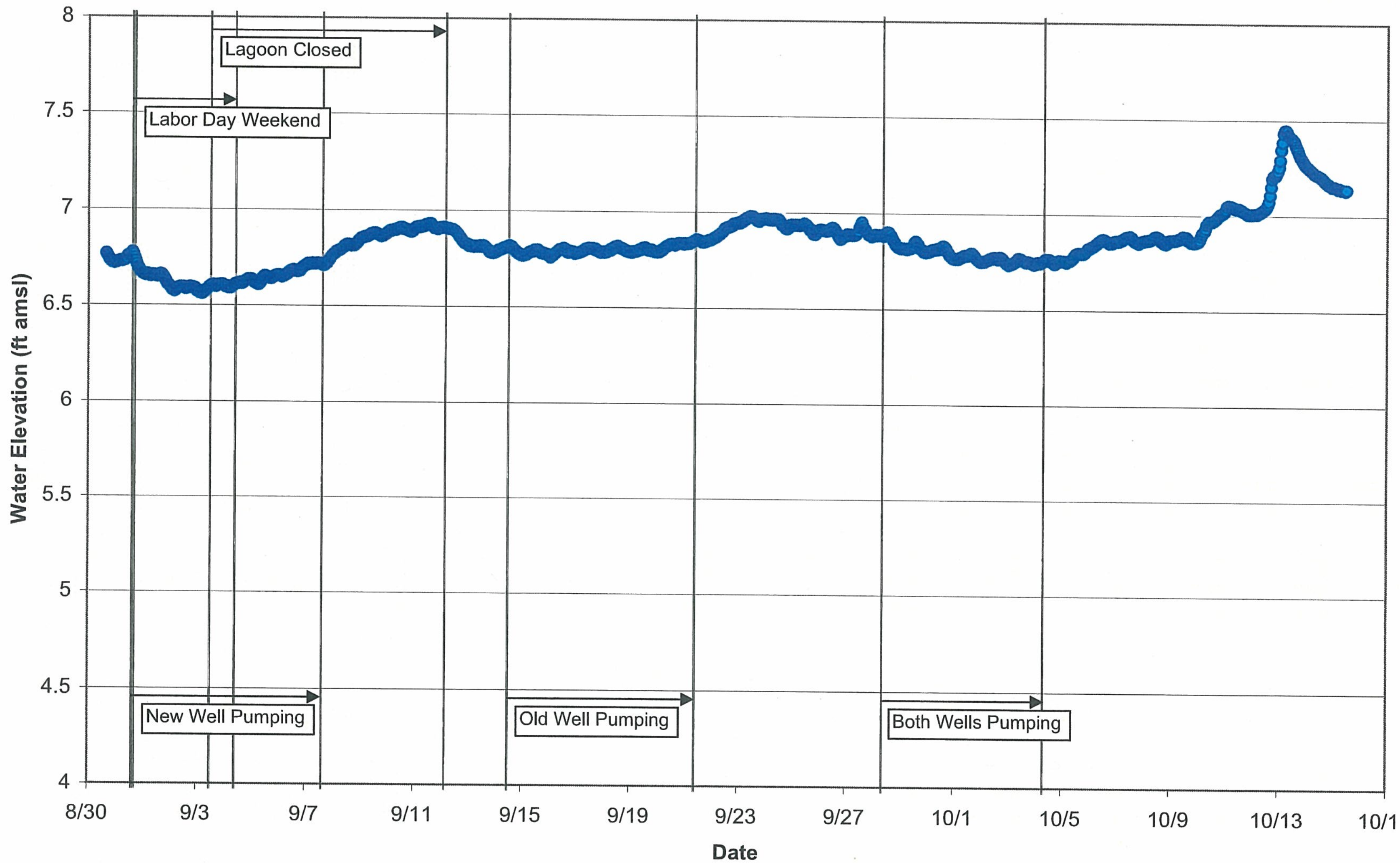
Appendix G - P4RD Hydrograph - 2007



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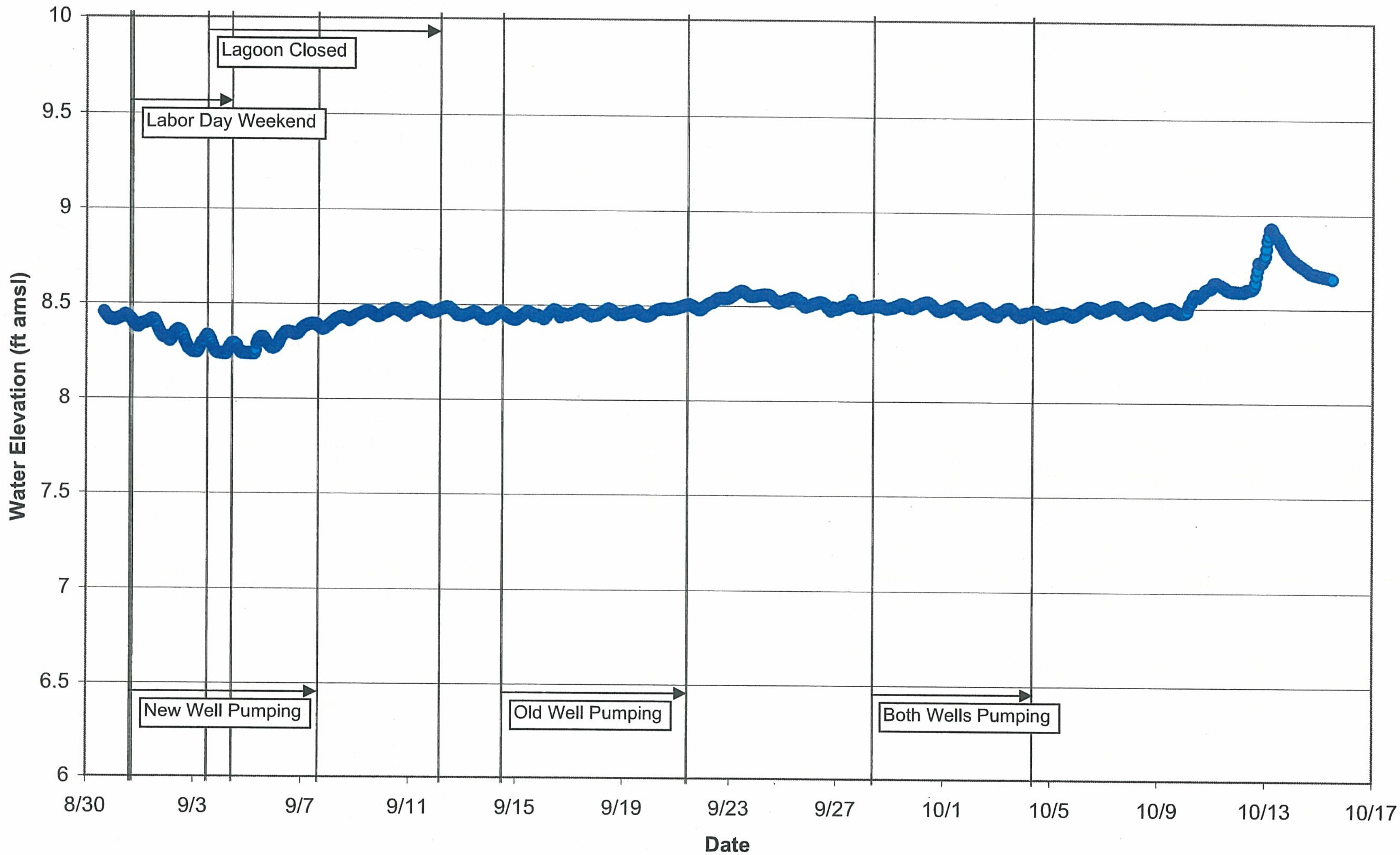
Appendix G - P4uLS Hydrograph - 2007



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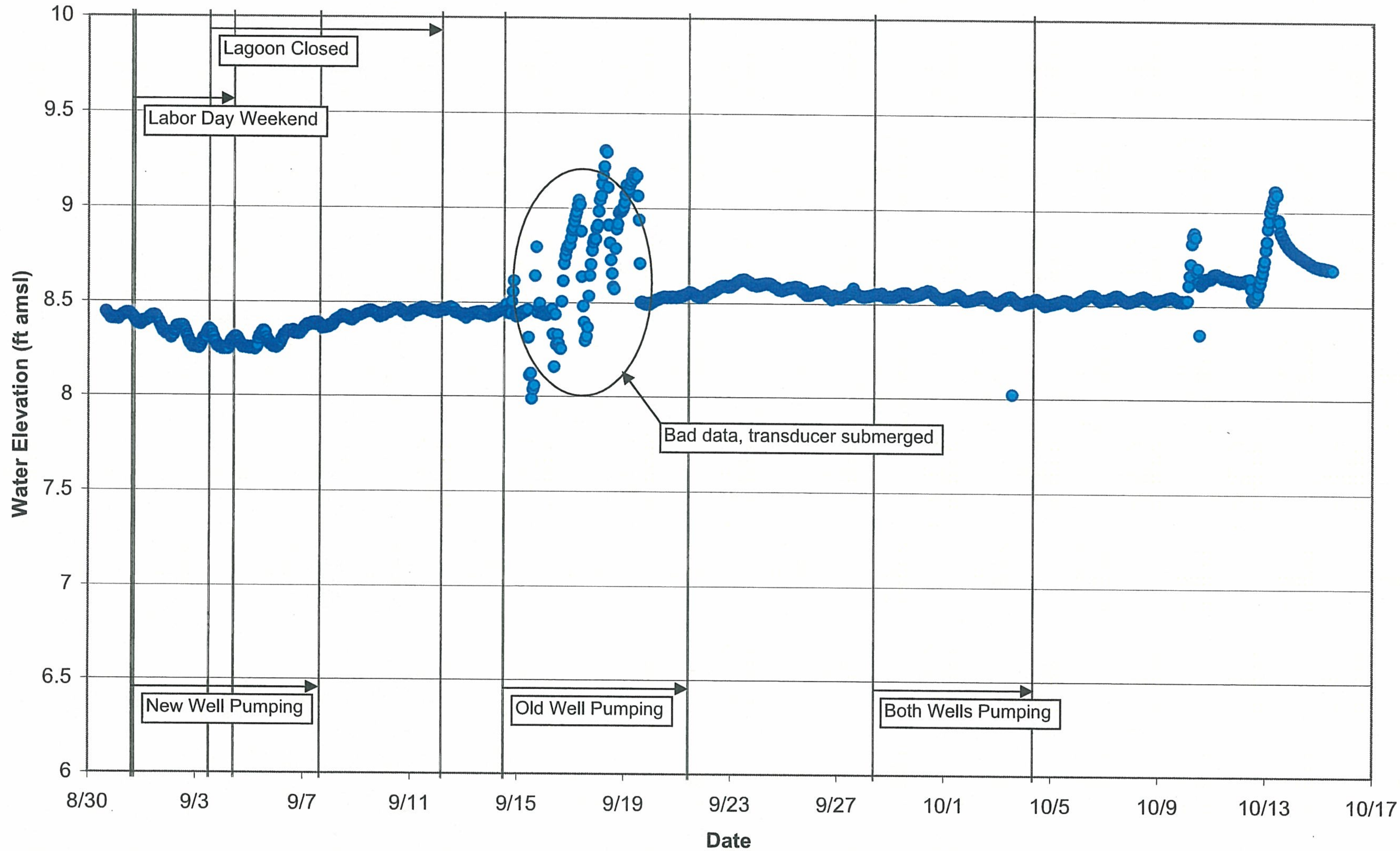
ESR--6

Appendix G - P4uLD Hydrograph - 2007



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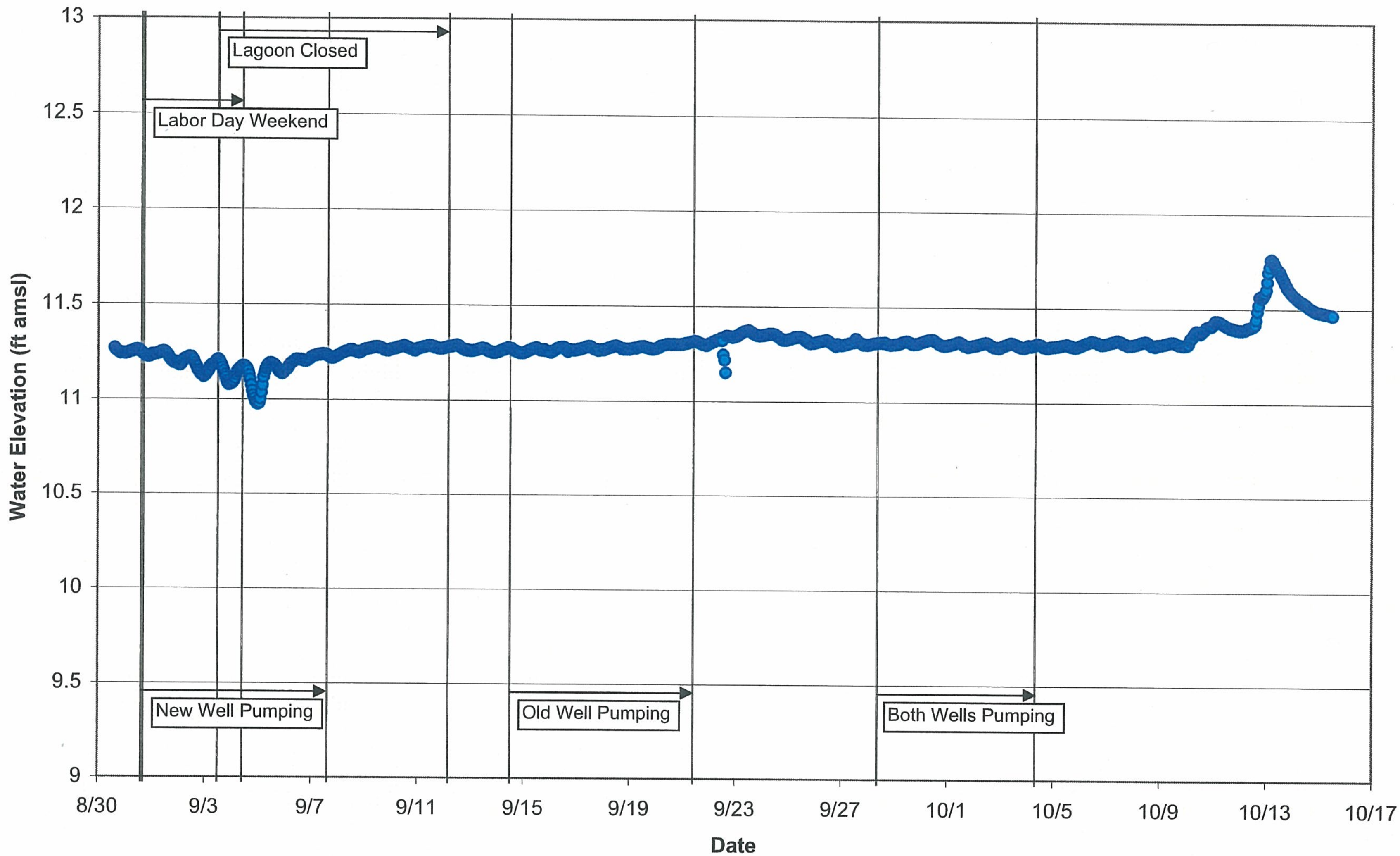
Appendix G - P5LS Hydrograph - 2007



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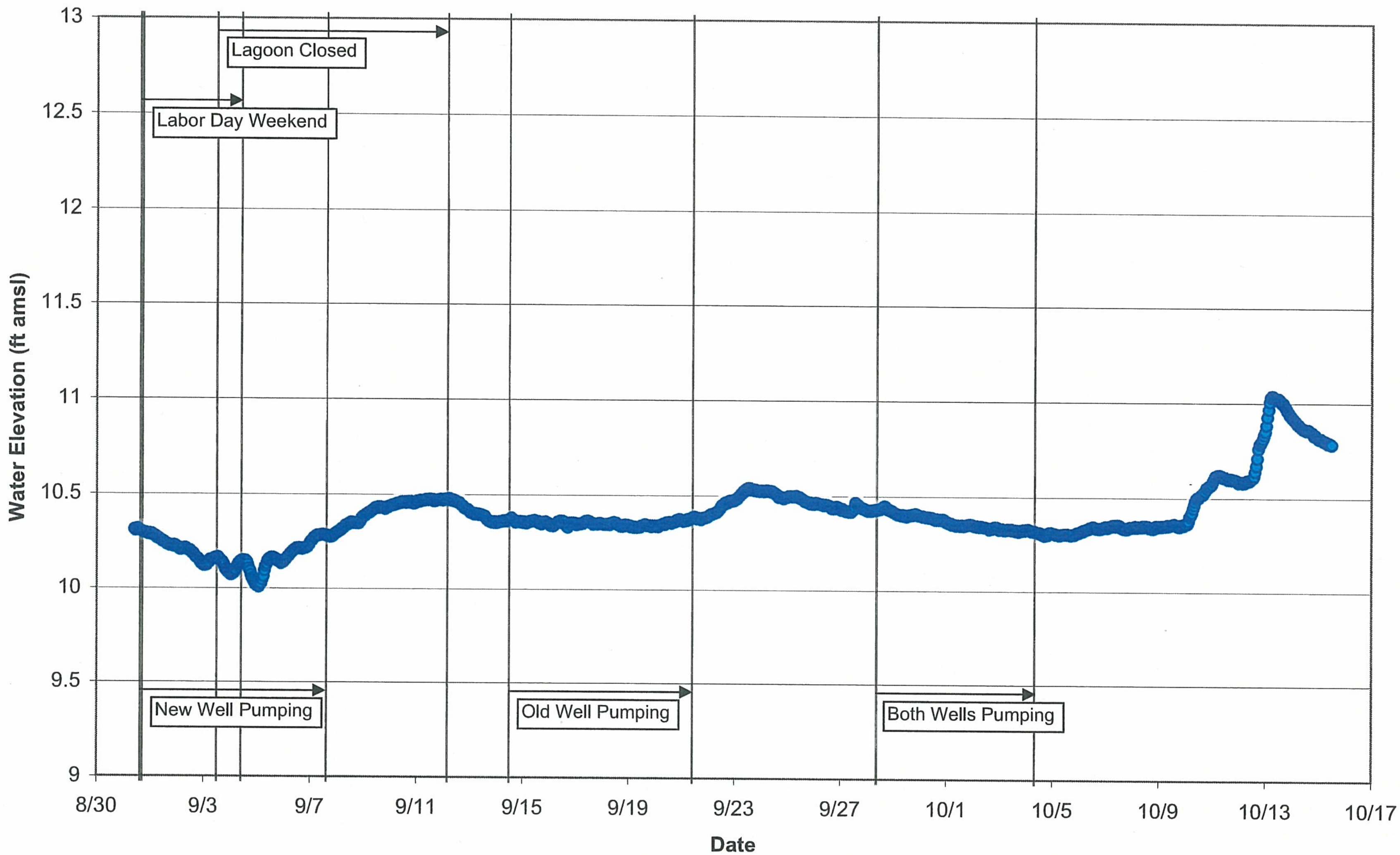
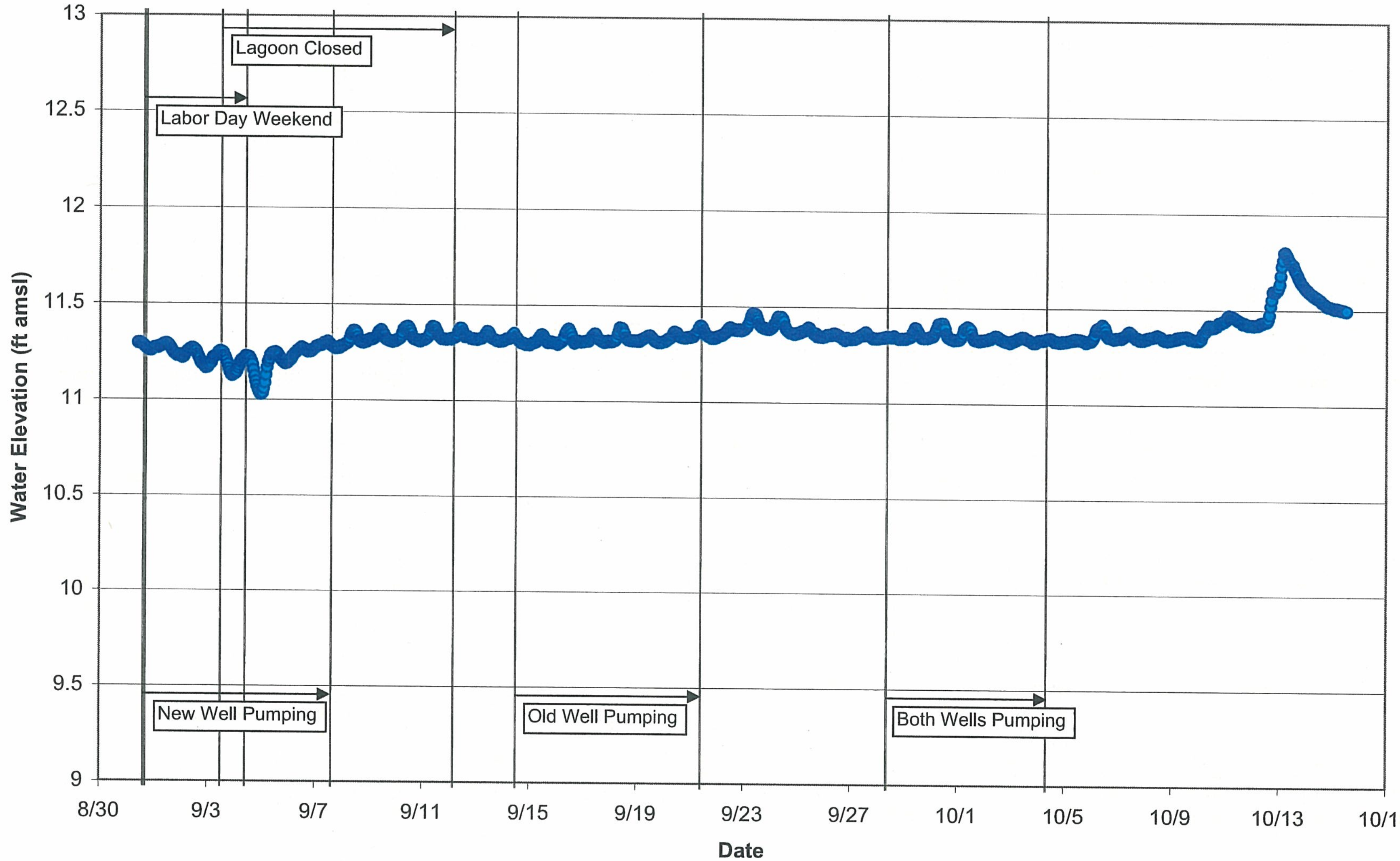
Appendix G - P5LD Hydrograph - 2007



ESR--6

Appendix G - P6LS Hydrograph - 2007



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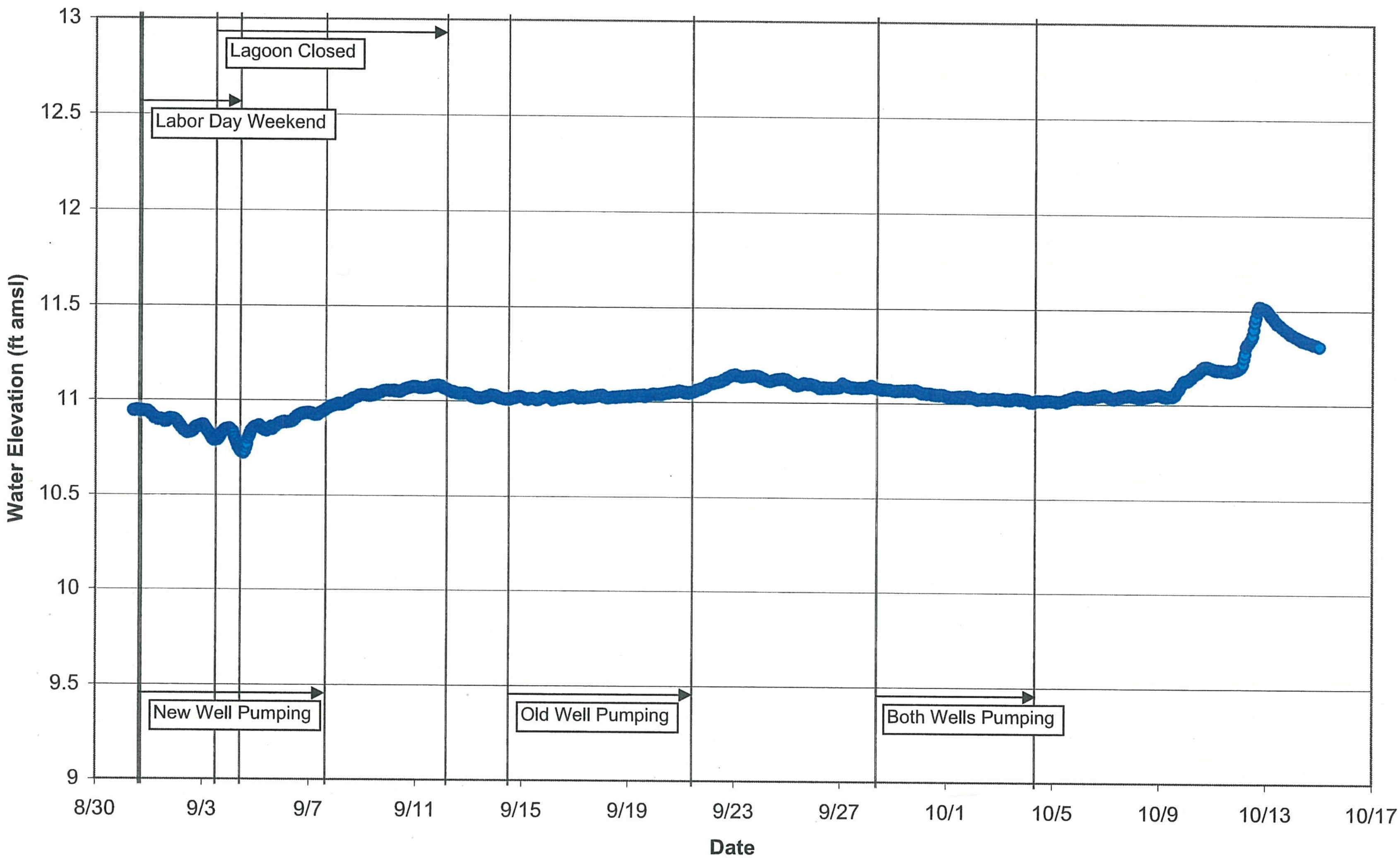
Appendix G - P6LD Hydrograph - 2007



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APPENDIX H

ALLUVIAL GROUNDWATER DISSOLVED OXYGEN CONTENT ANALYSIS

May 31, 2006

Ms. Janet Goldsmith
Kronick, Moskovitz, Tiedeman & Girard
400 Capitol Mall, 27th Floor
Sacramento, CA 95814

Subject: Draft Report of Findings to Investigate the Source of Depressed Dissolved Oxygen Concentrations in Big Sur River Underflow El Sur Ranch, Big Sur, California

Dear Mrs. Goldsmith:

Monitoring of the Big Sur River (the River) and associated underflow during the 2004 Hydrogeologic Investigation conducted by The Source Group (SGI) revealed much lower concentrations of dissolved oxygen (DO) in the underflow when compared to concentrations found in the River itself. DO concentrations in the River ranged from a recorded maximum concentration of 12.75 milligrams per liter (mg/L) to a recorded minimum concentration of 3.27 mg/L, while the maximum and minimum recorded DO concentrations in the underflow ranged from 4.79 mg/L to 0.1 mg/L, respectively.

In order to better understand the relationship between the surface flow and the underflow, it is important to understand why DO levels in the underflow are lower than expected. This report has been prepared to document the possible cause of low concentrations of DO in the Big Sur River underflow.

1.0 METHODS OF INVESTIGATION

This section summarizes activities that were conducted as part of this investigation. Further information regarding details and results of the activities summarized below are provided in the subsequent sections.

Investigation activities included the following:

1) Literature Search – A literature search was conducted and focused on naturally occurring and manmade mechanisms that could be responsible for the depressed DO levels in the underflow. In addition, the literature search focused on isolated riverine environments such as the Big Sur River basin. A bibliography of the literature obtained and reviewed in support of this report is provided in Attachment A.

2) File Review – File reviews were conducted at the Monterey County Water Resources Agency and the Monterey County Environmental Health Division by Sandra L. Ross of SLR Consulting. During the file reviews, information was obtained regarding wells, septic systems, leach fields, and water treatment plants in the area along Highway 1 between Andrew Molera

State Park and Pfeiffer Big Sur State Park. The Monterey County Water Resources Agency provided a list of water wells and their permitted use. Table 1 summarizes the wells by facility. The Monterey County Environmental Health Division was provided with a list of 137 parcel numbers located in the area of investigation. Due to County limitations, the County was only able to provide data regarding permitted septic systems for approximately 30 parcel numbers. Table 2 summarizes the data available for these parcel numbers.

3) Data Analyses – Based on a review of available literature, there are water quality parameters that can impact DO concentrations in both groundwater and surface water. However, limited water quality data were available for existing wells (both public and private) within the Big Sur River basin. Available data are described in Section 5.0 of this report.

4) Reporting – This report provides a preliminary report of the findings and provides a hypothesis for depressed DO concentrations in the underflow and how it fits within the overall Big Sur River basin environment.

2.0 DESCRIPTION OF LOWER BIG SUR WATERSHED

The Big Sur River (the River) is located in Monterey County and flows to the Pacific Ocean at Andrew Molera State Park on the Big Sur Coast. The watershed has a drainage area of approximately 37,392 acres. Recreation is the primary land use. Other land use in the lower reaches of the River includes rural residential, rangeland, and urban.

Along the Big Sur River, lie businesses, residences, and campgrounds. An evaluation of parcels immediately adjacent to the River from Andrew Molera State Park towards Pfeiffer Big Sur State Park was conducted at the Monterey County Environmental Health Division. Based on the information obtained for approximately 30 parcels, generally the occupants of the property adjacent to the River maintain septic systems. The average size is approximately 1,000 gallon capacity with leach fields. One of the businesses, the River Inn, has a 6,000 gallon capacity. At Andrew Molera State Park, three septic tanks and a leach field were installed in 2001. Prior to 2001, they had concrete pit toilets for the general public. It is unknown if there was a septic system that supported the Department of Parks and Recreation housing facilities. One septic tank is close to the River, so it has a pump station to bring the waste up to the leach field. Due to limitations by the County, information was provided for approximately 30 parcels, a subset of the parcels immediately adjacent to the River from Andrew Molera State Park to Pfeiffer Big Sur State Park.

According to an engineer with the State of California Department of Parks and Recreation, the waste and wastewater from Pfeiffer Big Sur State Park is piped to a treatment plant and then discharged via a leach field. The treatment system consists of an activated sludge extended aeration system with a total capacity of 100,000 gallons per day (CRWQCB, 1998). The treated effluent water is discharged to a subsurface disposal area consisting of 2 acres of sandy alluvial soils to a depth of 9 feet, on level topography (CRWQCB, 1998 and DPR, 1997). Depth to groundwater is from 8 to 10 feet below ground surface (bgs). The Big Sur River is located along the western edge of the subsurface disposal area for the treatment plant effluent (CRWQCB, 1998). As recommended in the Big Sur River, Protected Waterway Management Plan (MCPD, 1986), one of the provisions to consider in the construction of new septic tanks and leach fields in the Lower Big Sur River Basin is “septic systems should be prohibited in areas with groundwater within 10 feet of the bottom of the proposed leaching device”. With groundwater at a depth of 8- 10 feet below ground surface (bgs), it is unlikely that any currently installed septic system or leach field in the Lower Big Sur River Basin is consistent with this recommended provision. Other recommended provisions for the construction of new septic tanks and leach fields in the Lower Big Sur River Basin include the following (MCPD, 1986):

- New septic systems should not be allowed within 100 feet of the river or any perennial tributary.
- Septic systems for new development should be prohibited on slopes greater than 30 percent and on landslides.
- Required watertable determinations and percolation tests shall be conducted only during the wet weather months.
- A minimum parcel size of one acre should be required for all new development requiring septic systems.

The primary means of human waste disposal in the Lower Big Sur River Basin is through the use of septic tanks. According to the Big Sur River, Protected Waterway Management Plan (MCPD, 1986), a majority of the leach fields serving the recreation and visitor-serving facilities in the Big Sur Valley are in the quaternary alluvium; gravel and sands which form the floodplain on either side of the River. As mentioned previously, the leach field for the Pfeiffer Big Sur State Park treatment plant is also in the alluvial floodplain meadow between Highway One and the River. Figure 1 illustrates the estimated location of the Pfeiffer Big Sur State Park treatment plant and leach field.

Based on information provided by the California Regional Water Quality Control Board (CRWQCB) and the CRWQCBs GeoTracker database, there are three Leaking Underground Storage Tank (LUST) sites and one Spills, Leaks, Investigations, and Cleanups (SLIC) site in the Big Sur area. All three LUST sites, River Inn, Ventana Inn, and Fernwood are closed cases. According to the CRWQCB, there is only one SLIC site in the Big Sur area, Burns Creek Bridge, which is located south of Big Sur. At the Burns Creek Bridge, lead deposits (from sand blasting the Highway 1 bridge) were found during construction of a new bridge. Undisturbed material was left in place and disturbed deposits were hauled offsite for proper disposal. The case for this site is open. Lead is unlikely to have any effect on dissolved oxygen levels in the River.

3.0 DESCRIPTION OF WATER QUALITY PROBLEM

3.1 SURFACE WATER

It is important for the River to be a suitable habitat that provides food, water, shelter, and reproduction conditions for freshwater organisms like fish. Freshwater fish need cool, clean, oxygen-rich water. In general, water temperatures exceeding 64 degrees Fahrenheit (18 degrees Celsius) may cause fish to become sluggish and more susceptible to disease and predators. Temperatures in the 74 to 78 degrees Fahrenheit (23 to 26 degrees Celsius) range may be lethal. In addition, the water needs to be rich in oxygen. Water becomes more oxygenated as it bubbles over rocks and boulders and is able to hold the oxygen better at lower temperatures. It is important for the water to be free of harmful contaminants contained in stormwater runoff, sewage, and industrial wastewater. While nutrients (i.e., nitrogen and phosphorous) are important, elevated concentrations of nutrients can encourage excess algae to grow in the water. Once the algae begin to die, the decomposition process begins. This process depletes the DO in the w ater. (UC Regents, 2006)

3.2 GROUNDWATER (UNDERFLOW)

Effluent from septic systems and wastewater treatment plants can introduce nutrients (nitrate, and phosphate) and organic wastes, which encourage the growth of bacteria. Generally, groundwater contains low concentrations of nutrients, thereby limiting biological growth. The introduction of sewage into groundwater results in elevated levels of nutrients and biological activity. Due to the presence of organic matter in sewage effluent, there is an increase in the growth rate of bacteria that consume the organic matter. The more organic matter that is available, the more bacteria will grow and use oxygen, resulting in decreased DO concentrations. The degree and extent of the decrease in DO depends on the Biological Oxygen Demand (BOD) of the effluent (how much oxygen the effluent can consum e).

In the past, DO levels in portions of the River have dropped below 7 mg/L, which is the threshold for maintaining a healthy fishery. Therefore, it is important to evaluate the water quality parameters in both surface water and groundwater that may be impacting DO to levels below water quality objectives for maintaining a healthy fishery.

4.0 DESCRIPTION OF APPLICABLE WATER QUALITY STANDARDS

4.1 SURFACE WATER

According to the Central Coast Regional Water Quality Control Board (RWQCB) Central Coast Basin Plan, "water quality objectives are considered to be necessary to protect those present and probably future beneficial uses....and to protect existing high quality water of the State." There are several water quality objectives included in the Central Coast Basin Plan, including objectives for all inland surface waters, enclosed bays, and estuaries. Within this category of objectives, there are general water quality objectives and objectives based on beneficial uses (i.e., municipal and domestic supply, water contact recreation, non-contact water recreation, cold freshwater habitat, warm freshwater habitat, fish spawning, marine habitat, and shellfish harvesting). The Big Sur River is considered a cold freshwater habitat with possible water contact recreation. For the purposes of evaluating water quality data in the Big Sur River, the other water quality objectives were included in this analysis if "cold freshwater habitat" or "water contact recreation" water quality objectives were not available. In addition to the RWQCB's Central Coast Basin Plan, water quality objectives are available from the California Ocean Plan, Water Body Objectives for Big Sur River, U.S. Environmental Protection Agency's (USEPA) maximum contaminant level, and Central Coast Ambient Monitoring Program (CCAMP). As presented by CCAMP (2006), the water quality objectives used in this report are summarized in Table 3. Section 5.1 compares data from the Big Sur River basin to appropriate surface water quality objectives.

4.2 GROUNDWATER (UNDERFLOW)

According to the Central Coast RWQCB Central Coast Basin Plan, groundwater quality objectives for organic chemicals and chemical constituents shall not exceed the maximum contaminant levels (MCLs) specified in the California Code of Regulations, Title 22, Chapter 15. MCLs, maximum contaminant levels, are health-protective drinking water standards to be met by public water systems. MCLs take into account not only chemicals' health risks but also factors such as their detectability and treatability, as well as the costs of treatment. MCLs are enforceable standards. In addition, there are secondary MCLs. These are non-enforceable standards regarding aesthetic effects (i.e., taste, odor, and color) of drinking water. For bacteria, the median concentration of coliform organisms over any seven-day period should not exceed 2.2 most probable number (MPN)/100 mL. The groundwater quality objectives used in this report are summarized in Table 3. Section 5.2 compares groundwater well data from the Big Sur River basin to appropriate groundwater quality objectives.

5.0 WATER QUALITY DATA

5.1 BIG SUR RIVER

Several factors can affect DO levels. These water quality parameters are evaluated in this report, as well as their importance to the aquatic ecosystem and their potential impact on DO concentrations. Much of the information regarding the water quality parameters was derived from information prepared by the Boulder Area Sustainability Information Network (BASIN), which is a local community service network offering public access to environmental information. BASIN focus is on water in Boulder County, Colorado, but they provide general information on several key water quality parameters which are applicable to all waters. In the CCAMP database, surface water data were available for the following two sites along the Big Sur River: Big Sur River at Andrew Molera and Big Sur River at Pfeiffer, Weyland Camp. The comparison of the water quality data from these two sites and the surface water quality objectives is provided below.

<u>Dissolved Oxygen</u>

All aquatic species require DO. The concentration of DO in the water column affects a wide range of behaviors (i.e., feeding, spawning, and incubation). Lowered DO is mainly a result of excessive nutrients which promote bacterial growth. In the process of breaking down plant matter, organisms deplete available oxygen through respiration.

The Basin Plan Objective for Cold Water Fish for DO is not less than 7 mg/L or greater than 12 mg/L. The average DO concentration for CCAMP monitoring locations along the Big Sur River at Pfeiffer and Andrew Molera were 9.1 mg/L and 9.3 mg/L, respectively.

<u>Water Temperature</u>

Water temperature is an important environmental factor for aquatic life, because many species need specific temperatures to survive and reproduce. Temperature affects the concentration of DO in the water column and the rate of photosynthesis for aquatic plants. Human activities such as water diversions that decrease flows or removal of streamside vegetation that shades the water, can lead to elevated water temperatures.

Climate can affect the water temperature and DO levels. During the winter, low temperatures in the River allow more oxygen to be dissolved in the water. In addition to cooler temperatures in the winter, rain can interact with oxygen in the air as it falls and increase DO levels in the River. During the summer, DO levels are generally lower for several reasons (i.e., decreased river flow, sunlight induced photosynthesis, and warmer temperatures). During the summer, there is a possibility of reduced water levels and flow rates. The slower the water flows, the less mixing with air, and DO levels decrease. Spring and summer will generally bring increased plant and animal activity, especially in the presence of elevated nutrient levels. While the process of photosynthesis during the day releases oxygen into the water, respiration during the night removes oxygen from the water. In addition, the decomposition of these plants by organisms can reduce the DO levels available in the River.

The Basin Plan Objective for Cold Water Fish is water temperature less than 22 degrees Celsius (22°C [72°F]). Temperatures above 22°C can be stressful for fish and other aquatic organisms. The average temperature for CCAMP monitoring locations along the Big Sur River at Pfeiffer and Andrew Molera were 16.1°C and 15.8°C, respectively.

<u>Nutrients</u>

Nitrate and orthophosphate are nutrients that occur naturally in water bodies and promote aquatic plant growth. Runoff containing sewage discharge, fertilizer runoff, and leakage from septic systems, and detergents contributes to elevated nutrient levels. Excessive nutrient levels can lead to excessive algal and aquatic weed growth. When these algae die, they are decomposed by bacteria in a process called eutrophication. During this process, the available oxygen in the water column is depleted.

Nitrate as NO_3

The Basin Plan Objective for Municipal and Domestic Supply is less than 45 mg/L of nitrate. The average nitrate (as NO_3) concentration for CCAMP monitoring locations along the Big Sur River at Pfeiffer and Andrew Molera were 0.073 mg/L and 0.072 mg/L, respectively.

Orthophosphate

The General Basin Plan Objective is less than 0.12 mg/L. The average orthophosphate (as P) concentration for CCAMP monitoring locations along the Big Sur River at Pfeiffer and Andrew Molera were 0.011 mg/L and 0.008 mg/L, respectively.

<u>Coliform</u>

Total coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm- and cold-blooded animals. They aid in the digestion of food. A specific subgroup of this collection is the fecal coliform bacteria, the most common member being *Escherichia coli* (*E. Coli*). These organisms may be separated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm-blooded animals. The presence of fecal coliform bacteria in aquatic environments indicates the presence of human sewage or wildlife contamination, as well as feces-born organisms that can cause diseases such as hepatitis A, bacterial meningitis, and encephalitis. Excessive coliform counts pose potential problems for both aquatic and human health.

The Basin Plan Objective for Marine Water Contact Recreation for total coliform is less than 10,000 MPN/100 mL. The average total coliform concentration for CCAMP monitoring locations along the Big Sur River at Pfeiffer and Andrew Molera were 1,071 MPN/100 mL and 1,047 MPN/100 mL, respectively.

The Basin Plan Objective for Water Body Contact Recreation for fecal coliform is less than 400 MPN/100 mL. The average fecal coliform concentration for CCAMP monitoring locations along the Big Sur River at Pfeiffer and Andrew Molera were 20.1 MPN/100 mL and 183 MPN/100 mL, respectively. During the one year monitoring period (January 1, 2002 through March 1, 2003), 14 samples were collected at the CCAMP monitoring location along the Big Sur River at Pfeiffer. At this location, the maximum fecal coliform concentration was 80 MPN/100 mL. During the 3.5 year monitoring period (April 1, 2001 through September 1, 2004), 29 samples were collected at the CCAMP monitoring location along the Big Sur River at Andrew Molera. At this location, the maximum fecal coliform concentration was 2,400 MPN/100 mL, which is well above the water quality objective of 400 MPN/100 mL. Based on the data provided by CCAMP (2006), it is not clear how many samples within the dataset exceeded the water quality objective. Concentrations of fecal coliform in the River appear to increase between Pfeiffer and Andrew Molera, as expected given the abundance of septic systems in the Big Sur River Valley.

5.2 GROUNDWATER (UNDERFLOW)

From August 2004 through October 2004, groundwater data were collected from 10 groundwater monitoring wells as part of the El Sur Ranch groundwater monitoring program. Two of the groundwater monitoring wells (ESR-11 and ESR-12) are located on El Sur Ranch. The remaining 8 groundwater monitoring wells (ESR-01, ESR-02, ESR-03, ESR-10A,B,C, JSA-03, and JSA-04) are located at the Andrew Molera State Park. The data from the 10 groundwater monitoring wells were used to characterize groundwater quality at or near El Sur Ranch. These wells are hereafter referred to as El Sur Ranch wells. In December 2005, a well search report was prepared by Environmental Data Resources, Inc. (EDR; Attachment 2). This EDR report identified 8 wells from Andrew Molera State Park to Pfeiffer Big Sur State Park. Water quality data were only available from 3 of the 8 wells. The comparison of the water quality data from the El Sur Ranch wells and the 3 wells identified in the EDR well search report and the groundwater quality objectives is provided below.

<u>Dissolved Oxygen</u>

There is no California MCL for DO. The DO concentrations in groundwater at the El Sur Ranch wells ranged from 0.10 to 4.79 mg/L, with an average of 2.22 mg/L. These DO concentrations are significantly lower than the DO concentrations in the River. DO was not reported for the wells identified in the EDR Well Search Report.

Water Temperature

As mentioned previously, groundwater typically has lower concentrations of DO and it is colder in temperature than river water. There is no groundwater quality standard for temperature. The temperature of groundwater at the El Sur Ranch wells ranged from 13 to 19°C, with an average of 16°C. This average groundwater temperature is consistent with the water temperature along the Big Sur River. Water temperature was not reported for the wells identified in the EDR Well Search Report.

Nutrients

Nitrate as NO_3

The Basin Plan Objective for Municipal and Domestic Supply and California MCL for nitrate as NO_3 is 45 mg/L. According to the Monterey County Flood Control and Water Conservation District (1988), nitrates may occur naturally in groundwater due to biologic activity or decomposition of geologic deposits, but rarely will these concentrations exceed 10 mg/L. Nitrate (as NO_3) concentrations range from 2.1 mg/L to 7.5 mg/L in the wells identified in the EDR Well Search Report. Nitrates were not tested for in the El Sur Ranch wells.

Orthophosphate

There is no California MCL for orthophosphate (as P). Orthophosphate (as P) was not tested for in the El Sur Ranch wells and not reported for the wells identified in the EDR Well Search Report.

Coliform

The Basin Plan Objective for Municipal and Domestic Supply states the median concentration of coliform organisms over any seven-day period should not exceed 2.2 MPN/100 mL. The federal MCL states that no more than 5-percent of samples can be positive for total coliform in one month. For water systems that collect fewer than 40 routine samples per month, no more than one sample can be positive for total coliform in one month. Every sample that is positive for total coliform must be analyzed for either fecal coliform or E. coli. If two consecutive samples are positive for total coliform and one of those is positive for either fecal coliform or E. coli , then the system has an acute MCL violation. Coliform was not tested for in the El Sur Ranch wells and not reported for the wells identified in the EDR Well Search Report.

6.0 REASONS FOR DEPRESSED DO CONCENTRATIONS WITHIN THE BIG SUR RIVER BASIN ENVIRONMENT

The Big Sur River Basin environment consists of recreational, rural residential, agriculture, and rangeland land uses. The primary means of human waste disposal in the Big Sur River Basin is through the use of septic tanks and leach fields, which are located within the alluvial floodplain.

The 2-acre leachfield associated with Pfeiffer Big Sur State Park treatment plant discharge is bordered on the western edge by the Big Sur River. Based on coliform detections in the Big Sur River, it is apparent that coliform concentrations increase from Pfeiffer Big Sur State Park to Andrew Molera State Park. It is likely that the coliform is a result of sewage discharge and fertilizer runoff into the River and leakage from septic systems and leachfields along the Big Sur River into groundwater entering the River via underflow. As a result, nutrients (i.e., nitrate and phosphate) and coliform (i.e., organic matter) are introduced into the aquatic system. The nutrients and organic wastes encourage bacteria growth. As the bacteria consume organic matter, they deplete oxygen resulting in low DO in the aquatic system. As underflow with low DO enters the River, the DO of the River is reduced as well.

7.0 REFERENCES

California Regional Water Quality Control Board (CRWQCB). 1998. Waste Discharge Requirements Order Number 98-62, for Pfeiffer Big Sur State Park. Central Coast Region. September 11.

Central Coast Ambient Monitoring Program (CCAMP). 2006. Water Quality Data Available Online. http://www.ccamp.org/ca0/3/3.htm

Department of Parks and Recreation (DPR). 1997. Discharge Self-Monitoring Annual Report for 1997, Pfeiffer Big Sur State Park.

Monterey County Planning Commission (MCPD). 1986. Big Sur River, Protected Waterway Management Plan. Prepared by John T. Stanley Jr., consultant to MCPD. Adopted by the Monterey County Planning Commission October 26, 1983, Monterey County Board of Supervisors November 5, 1985, Certification Acknowledged by the California Coastal Commission April 9, 1986.

University of California Regents (UC Regents). 2006. Online Curriculum for Salmon and Steelhead. http://groups.ucanr.org/sns/Unit_Overview/Background_Information.htm

If you have any questions, please don't hesitate to contact me at 925-944-2856 x318.

Sincerely,

The Source Group, Inc.

Ivy Inouye
Senior Toxicologist

Steven M. McCabe, P.G., C.HG
Senior Hydrogeologist

cc: ESR Technical Team

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TABLES

Table 1 DRAFT

Groundwater Wells, Hwy 1 between Andrew Molera State Park and Pfeiffer Big Sur State Park

El Sur Ranch

Big Sur, California

Facility	Facility Status	Well Use	Construction Date	Depth (ft.)	Pert. Start Depth (ft.)	Perf. Stop Depth (ft.)
19S/01E-26T50	UNKNOWN	IRRIGATION	1/7/50	75	33	54
19S/01E-31J50	UNKNOWN	DOMESTIC USE	4/28/90	605	200	600
19S/01E-36A50	UNKNOWN	DOMESTIC USE	11/5/85	135	60	120
19S/01E-36D50	UNKNOWN	DOMESTIC USE	6/3/91	265	75	265
19S/01E-36D51	ACTIVE	DOMESTIC USE	4/26/91	460	60	80
					200	260
					300	360
					380	440
19S/01E-36M50	UNKNOWN	DOMESTIC USE	4/13/89	460	160	460
19S/01E-36T50	UNKNOWN	DOMESTIC USE	9/12/77	310	100	300
19S/01E-36T51	UNKNOWN	DOMESTIC USE	11/25/74	68	40	68
19S/01E-36T52	UNKNOWN	DOMESTIC USE	6/25/80	220	60	220
19S/01E-36T53	UNKNOWN	DOMESTIC USE	11/20/74	64	15	60
20S/02E-05A50	UNKNOWN	DOMESTIC USE	12/8/83	410	100	410
20S/02E-05B50	UNKNOWN	DOMESTIC USE	3/26/85	276	55	170
20S/02E-05B51	UNKNOWN	DOMESTIC USE	6/24/91	220	120	180
					200	220
20S/02E-05C50	UNKNOWN	DOMESTIC USE	8/16/85	225	140	220
20S/02E-05C51	UNKNOWN	DOMESTIC USE	10/10/92	440	80	100
					120	140
					160	200
					220	240
					280	300
					340	360

Notes:

Data Source: MCWRA

3/13/2006

Table 2
Select Septic Systems, Highway 1 between Andrew Molera State Park and Pfeiffer Big Sur State Park
El Sur Ranch
Big Sur, California

Parcel No.	Owner	Address	Septic System
419-201-01 Apple Pie Ridge	Chad Lincoln	27538 Schultz Road Carmel, Ca	1,000 -gallons? Drain Field 1,000 ft2 50' x 10' x 18"
419-031-25	Paul Witt	Coast Ridge Road	1,000 - gallons 50' x 10' x 18"
419-031-17	Robert Thompson	Coast Ridge Road	1,000 - gallons 50' x 10' x 18"
419-201-11	River Inn - Big Sur Victor Smolen 68 employees	Hwy 1	2,000 - gallons - This system was repaired in 1998 to prevent overflow 80' x 12' deep X 18" wide 1,500 - gallon (redwood tank) - removed and replaced with tanks listed below L 40' x W 18" X 12' deep , 1968 6,000 - gallons - (1,500 & 4,500 - gallons) Installed in 2003 Fiberglass and Concrete 65' x 18" x 12' - Leach lines under parking area 1984 - Letter from Monterey County "according to our research, the system had periods of failure probably due to detergents and the quantity of wastewater production. The system will need expansion and use of only biodegradable soaps.
419-201-11 and 12		Hwy 1	There are spectic tanks for the River Inn on both sides of Hwy 1
419-201-016	Carolyn Motzel	Butch Creek	1,000 -gallon main house 1997 1,000 - gallon quest house 75' x 18" x 10'
419-201-017	Ken and Laverne Mc Leod	Cedar Ridge Road	1,000 - gallon 1998 50' x 18" x 10'
419-201-018	Hal Latta and Sharon Carey	45950 Clear Ridge Rd	1,500 - gallon 2003 50' x 18" x 10'

ESR--6

Table 2

Select Septic Systems, Highway 1 between Andrew Molera State Park and Pfeiffer Big Sur State Park

El Sur Ranch

Big Sur, California

419-201-022	All Saints Episcopal Church and Health Center On a water well	#1 Pfeiffer Ridge Hwy 1	1,500 - gallon 64 x 18" x 10'	2003 Septic Tank Repair	
419-201-20	fence construction permit - no septic noted				
419-201-23	Don and Mieke Mcqueen	Big Sur Camp Ground and Cabins	(2) 1,500 -gallon 1,000 - gallon 50 x 18 x 10		
419-211-03 and 04	Barbara Pfieffer Subdivision Gordon Clemens Private well	Residential permit Cabins and Camp sites	1,000 - gallons 60 x 18 x 10	Concrete	1974
419-211-05	Ripplewood Resort Theodore Hartman	Motel Water well	1,000 -gallons 40 x 18 x 10	Concrete	1973
419-211-24	Ken Daughter		1,000 -gallon 100' x 3' w x 3.5 d	Fiberglass	1985
419-211-10	Big Sur Grange San Juan Creek		1250 - gallons 60 x 18 x 10	Concrete	1990
419-211-21&22	Fernwood Greg Davies	Hwy 1 Residential Mobile Home	55 x 10 deep 1,000 - gallons		
419-211-29	Mike Tucker	Pfieffer Ridge Road	1,500 - gallons 50 x 18 x 13	Poly	1991
419-211-032	Bill Johnston	Pfieffer Ridge Road	(2) 1,000 - gallon 50 x 18 x 10	Concrete	1994
419-211-33	Emil Norman	Pfieffer Ridge Road	1,000 - gallon 50 x 18 x 10	Concrete	1975

Table 3
Water Quality Objectives
El Sur Ranch
Big Sur, California

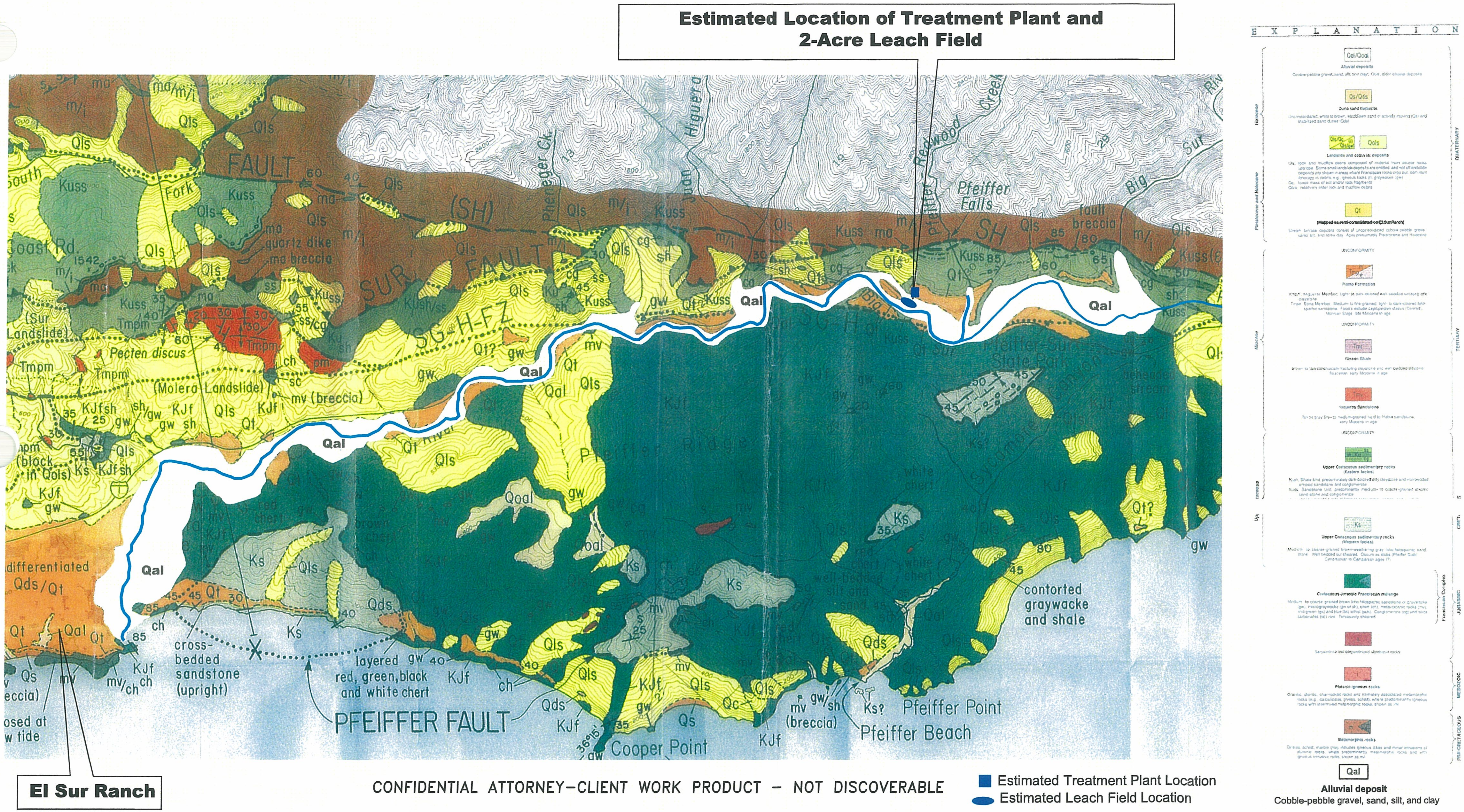
Water Quality Parameter	Unit	Surface Water Quality Objectives		Groundwater Quality Objectives	
		Value	Source	Value	Source
Ammonia as Nitrogen, Total	mg/L	2.4	California Ocean Plan Daily Maximum	- -	- -
Coliform, Fecal	MPN/100 mL	400	Basin Plan Water Body Contact Recreation	- -	- -
Coliform, Total	MPN/100 mL	10000	Basin Plan Marine Water Contact Recreation	2.2[1] 5%[2]	Basin Plan Municipal and Domestic Supply Federal MCL
Dissolved Solids, Total	mg/L	200	Waterbody Objective for Big Sur River	500	California Secondary MCL
Nitrate as N	mg/L	10	Basin Plan Municipal and Domestic Supply	10	California MCL
Nitrate as NO_3	mg/L	45	Basin Plan Municipal and Domestic Supply	45	California MCL
Nitrite as N	mg/L	1	EPA Primary Max. Contaminant Level	1	California MCL
OrthoPhosphate as P	mg/L	0.12	Central Coast Ambient Water Program	- -	- -
Oxygen, Dissolved	mg/L	7-12	Basin Plan Cold Water Fish Habitat	- -	- -
Oxygen, Saturation	mg/L	85	Basin Plan General	- -	- -
pH	unitless	6.5-8.5	Basin Plan Cold Water Fish Habitat	6.5-8.5	Federal Secondary MCL
Sulfate	mg/L	20	Waterbody Objective for Big Sur River	250	California Secondary MCL
Water Temperature	°C	- -	- -	- -	- -

Notes:

[1] The median concentration of coliform organisms over any seven-day period should not exceed 2.2 MPN/100 mL.

[2] No more than 5% samples total coliform-positive in one month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliform or E.coli if two consecutive total coliform wamples, and one is also postive for E. coli fecal coliforms, system has an acute MCL violation.

FIGURES



CONFIDENTIAL ATTORNEY–CLIENT WORK PRODUCT – NOT DISCOVERABLE

SGI environmental — **THE SOURCE GROUP, INC.**

EL SUR RANCH BIG SUR, CALIFORNIA				FIGURE 1 – DRAFT Pfeiffer Big Sure State Park Treatment Plant Location Map (Excerpted from Hall, 1991)
PROJECT NO.	DATE	DR. BY	APP. BY	
01–ESR–002	5/31/06	SB	PH	

ATTACHMENT 1

Bibliography of Literature

Abrams, R.H., Loague, K., and Kent, D. 1998. Development and Testing of a Compartmentalized Reaction Network Model for Redox Zones in Contaminated Aquifers. Water Resources Research, Vol. 34, No. 6, pp. 1531-1541. June.

Corwin, D.L., Loague, K., Ellsworth, T.R. Assessment of Non-Point Source Pollution in the Vadose Zone. Geophysical Monograph 108.

H. Esmaili & Associates, Inc. 1977. An Investigation of Nonpoint Sources of Groundwater Pollution in the Santa Cruz and Monterey Counties. Volume I, Preliminary Draft. November.

H. Esmaili & Associates, Inc. 1977. An Investigation of Nonpoint Sources of Groundwater Pollution in the Santa Cruz and Monterey Counties. Volume II, Preliminary Draft. November.

Kapple, G.W., Mitten, H.T., Durbin, T.J., and Johnson, M.J. 1984. Analysis of the Carmel Valley Alluvial Ground-Water Basin, Monterey County, California. U.S. Geological Survey, Water Resources Investigation Report 83-4280. June.

Kondolf, G.M., Maloney, L.M., and Williams, J.G. 1987. Effects of Bank Storage and Well Pumping on Base Flow, Carmel River, Monterey County, California. Journal of Hydrology, 91, pp. 351-369.

LeBlanc, Dennis R. 1984. Sewage Plume in a Sand and Gravel Aquifer, Cape Cod, Massachusetts. U.S. Geological Survey Water- Supply Paper 2218. Prepared in cooperation with the Massachusetts Department of Environmental Quality Engineering Division of Water Pollution Control.

Masterson, J.P., Walter, D.A., and Savoie, J. 1996. Use of Particle Tracking to Improve Numerical Model Calibration and to Analyze Groundwater Flow and Contaminant Migration, Massachusetts Military Reservation, Western Cape Cod, Massachusetts. U.S. Geological Survey, Open-File Report 96-214.

Zidar, M. and Thomasberg, K. 1995. Nitrates in Ground Water, 1987-1993 Salinas Valley, California. Monterey County Water Resources Agency. August.

Muir, K.S. 1972. Geology and Ground Water of the Pajaro Valley Area, Santa Cruz and Monterey Counties, California. U.S. Department of the Interior Geological Survey, Water Resources Division. June 27.

Nolan, B.T., Hitt, K.J., and Ruddy, B.C. 2002. Probability of Nitrate Contamination of Recently Recharged Groundwaters in the Conterminous United States. Environmental Science & Technology, Vol. 36, No. 10, pp 2138-2145.

Savoie, J. and LeBlanc, D.R. 1998. Water-Quality Data and Methods of Analysis for Samples Collected Near a Plume of Sewage-Contaminated Ground Water, Ashumet Valley, Cape Cod, Massachusetts, 1993-94. U.S. Geological Survey Water-Resources Investigations Report 97-4269.

Smith, R.L. and Duff, J.H. 1988. Denitrification in a Sand and Gravel Aquifer. Applied and Environmental Microbiology, Vol. 54, No. 5, pp 1071-1078. May.

Smith, R.L., Harvey, R.W., and LeBlanc, D.R. 1991. Importance of Closely Spaced Vertical Sampling in Delineating Chemical and Microbiological Gradients in Groundwater Studies. Journal of Contaminant Hydrology, 7, pp. 285-300.

Smith, R.L., Howes, B.L., and Duff, J.H. 1991. Denitrification in Nitrate-Contaminated Groundwater: Occurrence in Steep Vertical Geochemical Gradients. Geochimica es Cosmochimica Acta, Vol. 55, pp. 1815-1825.

Snow, J., Mills, T., and Zidar, M. 1988. Nitrates in Ground Water, Salinas Valley, California. Monterey County Flood Control & Water Conservation District. June.

Stanley, J.T. Jr. 1983. Big Sur River Protected Waterway Management Plan. Local Coastal Program, Monterey County, California. Monterey County Planning Department. October.

Templin, W.E., Smith, P.E., DeBortoli, M.L., and Schluter, R.C. 1996. Water Resources Data Network Evaluation for Monterey County, California, Phase 2: Northern and Coastal Areas of Monterey County. U.S. Geological Survey, Water Resources Investigations Report 95-4210.

Walter, D.A., Rea, B.A., Stollenwerk, K.G., and Savoie, J. 1996. Geochemical and Hydrologic Controls on Phosphorus Transport in a Sewage-Contaminated Sand and Gravel Aquifer Near Ashumet Pond, Cape Cod, Massachusetts. U.S. Geological Survey Water-Supply Paper 2463.

ATTACHMENT 2

EDR Data Map, EDR Well Search Report

EDR DataMap™
EDR Well Search Report

El Sur
Big Sur, CA 93920

December 08, 2005

Inquiry number 01569299.1r

EDR® Environmental Data Resources Inc

The Standard in Environmental Risk Management Information

440 Wheelers Farms Road
Milford, Connecticut 06461

Nationwide Customer Service

Telephone: 1-800-352-0050
Fax: 1-800-231-6802
Internet: www.edrnet.com

AREA RADON INFORMATION

Federal Area Radon Information for MONTEREY COUNTY, CA

Number of sites tested: 16

Area	Average Activity	% <4 pCi/L	% 4-20 pCi/L	% >20 pCi/L
Living Area - 1st Floor	0.788 pCi/L	94%	6%	0%
Living Area - 2nd Floor	Not Reported	Not Reported	Not Reported	Not Reported
Basement	2.133 pCi/L	67%	33%	0%

Sample Collected:	03/21/1989	Findings:	130.000 MG/L
Chemical:	TOTAL HARDNESS (AS CACO3)		
Sample Collected:	03/21/1989	Findings:	40.000 MG/L
Chemical:	CALCIUM		
Sample Collected:	03/21/1989	Findings:	8.400 MG/L
Chemical:	MAGNESIUM		
Sample Collected:	03/21/1989	Findings:	15.000 MG/L
Chemical:	SODIUM		
Sample Collected:	03/21/1989	Findings:	1.400 MG/L
Chemical:	POTASSIUM		
Sample Collected:	03/21/1989	Findings:	12.000 MG/L
Chemical:	CHLORIDE		
Sample Collected:	03/21/1989	Findings:	.200 MG/L
Chemical:	FLUORIDE (TEMPERATURE DEPENDENT)		
Sample Collected:	03/21/1989	Findings:	160.000 UG/L
Chemical:	BORON		
Sample Collected:	03/21/1989	Findings:	240.000 MG/L
Chemical:	TOTAL DISSOLVED SOLIDS		
Sample Collected:	03/21/1989	Findings:	2.100 MG/L
Chemical:	NITRATE (AS NO3)		
Sample Collected:	03/21/1989	Findings:	.140 NTU
Chemical:	TURBIDITY (LAB)		

Water System Information:

Map ID:	3	Info Source:	State Water Wells Database
Prime Station Code:	19S/01E-16E01 M	User ID:	HEN
FRDS Number Number:	2710700001	County:	Monterey
District Number:	05	Station Type:	WELL/AMBNT/MUN/INTAKE
Water Type:	Well/Groundwater	Well Status:	Inactive Raw
Source Lat/Long:	361701.0 1215128.0	Precision:	100 Feet (one Second)
Source Name:	WELL 01 - INACTIVE		
System Number:	2710700		
System Name:	NAVAL FACILITY POINT SUR		
Organization That Operates System:			
	P.O. BOX 8717 MONTEREY, CA 93943-5000		
Pop Served:	9	Connections:	6
Area Served:	NAVAL FACILITY POINT SUR		

Sample Information: * Only Findings Above Detection Level Are Listed

Sample Collected:	11/23/1987	Findings:	11.000 UG/L
Chemical:	BROMODICHLORMETHANE (THM)		
Sample Collected:	11/23/1987	Findings:	3.700 UG/L
Chemical:	BROMOFORM (THM)		
Sample Collected:	11/23/1987	Findings:	14.000 UG/L
Chemical:	DIBROMOCHLOROMETHANE (THM)		
Sample Collected:	11/23/1987	Findings:	6.800 UG/L
Chemical:	CHLOROFORM (THM)		

Sample Information: * Only Findings Above Detection Level Are Listed

Sample Collected:	09/12/1985	Findings:	8.300
Chemical:	PH (LABORATORY)		
Sample Collected:	09/12/1985	Findings:	175.000 MG/L
Chemical:	TOTAL ALKALINITY (AS CACO3)		
Sample Collected:	09/12/1985	Findings:	105.000 MG/L
Chemical:	BICARBONATE ALKALINITY		
Sample Collected:	09/12/1985	Findings:	181.000 MG/L
Chemical:	TOTAL HARDNESS (AS CACO3)		
Sample Collected:	09/12/1985	Findings:	8.600 MG/L
Chemical:	MAGNESIUM		
Sample Collected:	09/12/1985	Findings:	13.400 MG/L
Chemical:	SODIUM		
Sample Collected:	09/12/1985	Findings:	17.000 MG/L
Chemical:	CHLORIDE		
Sample Collected:	09/12/1985	Findings:	.220 MG/L
Chemical:	FLUORIDE (TEMPERATURE DEPENDENT)		
Sample Collected:	09/12/1985	Findings:	225.000 MG/L
Chemical:	TOTAL DISSOLVED SOLIDS		
Sample Collected:	09/12/1985	Findings:	4.000 MG/L
Chemical:	NITRATE (AS NO3)		
Sample Collected:	09/12/1985	Findings:	1.200 UG/L
Chemical:	MERCURY		
Sample Collected:	03/14/1989	Findings:	360.000 UMHO
Chemical:	SPECIFIC CONDUCTANCE		
Sample Collected:	03/14/1989	Findings:	7.100
Chemical:	PH (LABORATORY)		
Sample Collected:	03/14/1989	Findings:	120.000 MG/L
Chemical:	TOTAL ALKALINITY (AS CACO3)		
Sample Collected:	03/14/1989	Findings:	120.000 MG/L
Chemical:	BICARBONATE ALKALINITY		
Sample Collected:	03/14/1989	Findings:	120.000 MG/L
Chemical:	TOTAL HARDNESS (AS CACO3)		
Sample Collected:	03/14/1989	Findings:	35.000 MG/L
Chemical:	CALCIUM		
Sample Collected:	03/14/1989	Findings:	8.100 MG/L
Chemical:	MAGNESIUM		
Sample Collected:	03/14/1989	Findings:	9.500 MG/L
Chemical:	SODIUM		
Sample Collected:	03/14/1989	Findings:	1.200 MG/L
Chemical:	POTASSIUM		
Sample Collected:	03/14/1989	Findings:	10.000 MG/L
Chemical:	CHLORIDE		
Sample Collected:	03/14/1989	Findings:	.190 MG/L
Chemical:	FLUORIDE (TEMPERATURE DEPENDENT)		
Sample Collected:	03/14/1989	Findings:	240.000 UG/L
Chemical:	BORON		

Sample Collected:	03/14/1989	Findings:	310.000 UMHO
Chemical:	SPECIFIC CONDUCTANCE		
Sample Collected:	03/14/1989	Findings:	7.300
Chemical:	PH (LABORATORY)		
Sample Collected:	03/14/1989	Findings:	110.000 MG/L
Chemical:	TOTAL ALKALINITY (AS CACO3)		
Sample Collected:	03/14/1989	Findings:	110.000 MG/L
Chemical:	BICARBONATE ALKALINITY		
Sample Collected:	03/14/1989	Findings:	110.000 MG/L
Chemical:	TOTAL HARDNESS (AS CACO3)		
Sample Collected:	03/14/1989	Findings:	34.000 MG/L
Chemical:	CALCIUM		
Sample Collected:	03/14/1989	Findings:	7.200 MG/L
Chemical:	MAGNESIUM		
Sample Collected:	03/14/1989	Findings:	8.600 MG/L
Chemical:	SODIUM		
Sample Collected:	03/14/1989	Findings:	1.100 MG/L
Chemical:	POTASSIUM		
Sample Collected:	03/14/1989	Findings:	8.000 MG/L
Chemical:	CHLORIDE		
Sample Collected:	03/14/1989	Findings:	.210 MG/L
Chemical:	FLUORIDE (TEMPERATURE DEPENDENT)		
Sample Collected:	03/14/1989	Findings:	200.000 UG/L
Chemical:	BORON		
Sample Collected:	03/14/1989	Findings:	.080 UG/L
Chemical:	FOAMING AGENTS (MBAS)		
Sample Collected:	03/14/1989	Findings:	200.000 MG/L
Chemical:	TOTAL DISSOLVED SOLIDS		
Sample Collected:	03/14/1989	Findings:	.300 NTU
Chemical:	TURBIDITY (LAB)		

PWS SUMMARY:

ENFORCEMENT INFORMATION:

System Name:	CSP - PFEIFFER BIG SUR		
Violation Type:	MCL, Monthly (TCR)		
Contaminant:	COLIFORM (TCR)		
Compliance Period:	1995-03-01 - 1995-03-31	Analytical Value:	00000000.00
Violation ID:	9505001	Enforcement ID:	9505003
Enforcement Date:	1995-06-07	Enf. Action:	State Violation/Reminder Notice

Thank you for your business.
Please contact EDR at 1-800-352-0050
with any questions or comments.

HUNTER◂▸RUIZ
Research, Strategies & Advocacy

22 April 2008

Paul Murphey, Geologist
Hearings Unit
Division of Water Rights
State Water Resources Control Board
1101 11th Street, 14th Floor
Sacramento, California 95814

Re: Transmittal of Additional Data Collection and Analysis of the Big Sur River Hydrology and Biology -- Low Flow Conditions 2007
Water Right Application #30166

Dear Mr. Murphey:

Attached please find three copies of "Additional Technical Data Collection and analysis of The Big Sur River Hydrology and Biology - Low Flow Conditions 2007". The Hydrology report was prepared by SGI and the Biologic Report was prepared by Hanson Environmental. Also, within the pocket front of each binder is a summary table of all reports prepared by SGI and Hanson Environmental for 2004, 2006 and 2007.

In light of the fact that these new reports are addendums to previously reviewed reports it should not require more than a review by your consultant. The previously provided estimate for review ($10,000) provided by your CEQA consultant did not have the benefit of these reports. Therefore, if there is a contractual basis for your consultant to charge additional amounts for the review of these reports under your consulting agreement, and these charges can be passed on to the applicant under its MOU with the state board, ESR respectfully requests a new and amended estimate for review of these materials by EIP/PBS&J. Please be reminded that according to our records that the consultant has already estimated amounts in excess of $200,000. and has expended some $55,000.

COPY

Should you require any further explanation of the contents of these reports or have any question at all, do not hesitate to contact Janet Goldsmith or the undersigned.

Sincerely,

/s/

Darlene E. Ruiz

cc: DFG
DPR
NOAA
Cal SPA
J. Hill
M. Blum
J. Goldsmith

MAY 02 2008

1017 L Street, #599 Sacramento, California 95814 Telephone 916.552.6700 Fax 916.458.4864

SUMMARY OF EL SUR RANCH 2004 THR GH 2007 HYDROLOGIC, WATER QUALITY D BIOLOGIC STUDIES

Hydrologic Studies River Flow Conditions	**SGI 2004 Study** Moderately Low Flow	**SGI 2006 Study** Moderately High Flow	**SGI 2007 Study** Critical Low Flow
Availability Flow-volumes and conditions	Developed site conceptual model reflecting relationship between underflow, surface flow, spring tides and coastal saline wedge. Study Area water balance and water availability was calculated from available data.	Diversions had effect of reducing the rate of underflow upwelling w/n study area by approximately 4.1% (48af) of the estimated 1,166 af flowing to the ocean in September. The river continued to gain underflow across the study area throughout 2006 Study period. Described geographic extent of pumping influence as 1,000-foot radius, up-gradient from a pumping New Well.	At no time during study of 'critical low' flow condition was surface flow continuity compromised. Simultaneous diversion from 2 wells during 2007 resulted in maximum reduction of surface flow w/n study area of 0.4 cfs. The maximum recorded River surface water drawdown in response to both wells pumping was 0.17-feet.
Conditions of the coastal saline wedge	Identified subterranean ancestral, alluvial filled canyon that serves as preferential pathway for saline water wedge inland migration. Identified correlation between spring tides and elevated EC measured in Old Well. Found no correlation between diversions and EC levels.	Monitoring of Navy Well further confirmed finding that diversions have no effect upon the inland movement of the coastal saline wedge.	
Relationship of diversions to increases in temperature			Diversions during 'critically dry' flow conditions did not have a measurable effect upon temperature w/n the study area.

ESR--6

Conditions beneath Creamery Meadow	Diversions had no effect upon conditions within Creamery Meadow.	During periods of maximum diversion effect upon Creamery Meadow was limited to 0.2-foot of drawdown at River's edge, opposite the pumps, diminishing to zero drawdown w/n several hundred feet into Creamery Meadow.	Maximum drawdown of groundwater along the Creamery Meadow edge of the river was 0.17 foot of drawdown at River's edge, opposite the pumps, diminishing to zero drawdown w/n several hundred feet into Creamery Meadow.
Relationship of pumping to reduced amounts of dissolved oxygen within the river	Variations in water quality allowed for the identification of River stretch where groundwater was inflowing. Dissolved Oxygen changes were not correlated with pumping.	Confirmed groundwater inflow based on lower right bank River DO concentrations at specific locations. No actual correlation between diversions and River DO noted. Theoretical effects on DO resulting from pumping were explored based on surface water and groundwater mixing model.	No discernable correlation between diversions and dissolved oxygen levels within the study area except an influence from both wells operating appears to have occurred near the right bank of Location 4 where dissolved oxygen levels may have reduced by 2 mg/l. Thus, fluctuations in DO concentrations are linked to variations in the amount of River surface water flowing into the Study Area.
Biologic Studies <u>River Flow Conditions</u>	**Hanson 2004 Study** Moderately Low Flow	**Hanson 2006 Study** Moderately High Flow	**Hanson 2007 Study** Critical Low Flow
Water availability Flow-volume and conditions	River conditions were found to be protective of indicator species with well-developed	Surface flows available and consistent to provide for habitat and juvenile steelhead	Variation in water depth w/n the study area regardless of diversion status was small. Other factors affecting water depth include: upstream

ESR--6

	riparian vegetation, refugia, and other habitat features within protective parameters. Only barrier to migration but a possible benefit to juvenile rearing habitat was the observed formation of a sand bar temporarily closing the lagoon mouth.	rearing.	river flow, tidal influence in the lagoon and closure of sand bar. Effect of diversions on average cross-channel water depth was approximately 0.17 foot. Tidal height within the lagoon, and the associated backwater effect in the river immediately upstream of the lagoon, was found to be a major factor affecting river stage and channel wetted width at two of the passage transects (PT2 and PT3).
Habitat connectivity and passage opportunity	Observed riffles, connectivity, pool depth, and runs were w/n accepted parameters for protection of habitat, rearing and migration. Snorkel surveys corroborate same.	Found flows, depth, width and riffles supportive of passage and habitat. No barrier impediments identified.	Visual observations confirmed surface water connectivity throughout 2007 study. Naturally low river flows in late summer resulted in shallow water depths at several of the passage transects located upstream of Creamery Meadow.
Conditions in Swiss Canyon		Identified red-legged frog, a federally threatened specie w/n canyon (Miriam Green). Amphibians were observed inhabiting the stream running through Swiss Canyon. There were no differences observed during periods when wells were on or off.	Lower reaches continued to support aquatic habitat for amphibians and other species. Surface water was absent throughout the study period at the upper two monitoring sites. Water depths at the lower site were independent of well operations.
Temperature Changes due to Pumping?	Water temperatures at all measurement locations were within the range to be considered to be suitable of juvenile steelhead rearing. A cold water zone was detected in the river near	Diversions do not raise temperatures above naturally occurring levels that are well within accepted range protective of habitat and juvenile rearing.	Water temperatures were within the range considered to be suitable for juvenile steelhead rearing at all sites. A statistical significant increase in water temperature averaging 0.3 C (0.5 F) was detected near Creamery Meadow when both wells were operating but river temperatures did not exceed criteria for suitable

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	Creamery Meadow associated with groundwater upwelling.		habitat despite critical low river flows.
Impact of temperature change upon biologic receptors/habitat?	No monitored or observed changes in temperature due to diversions therefore no ability to monitor for potential impacts to biologic receptors or habitat.	Recorded temperature differences during diversions are well below temperature range protective of habitat and juvenile rearing.	Water temperatures were consistently w/n a range considered suitable habitat for juvenile steelhead rearing regardless of pumping status.
Dissolved Oxygen impacts upon habitat quality and steelhead rearing w/n study area	Depressed levels of DO due to upstream sources are within a range that poses a threat to habitat and receptors. No observed impacts were observed.	Depressed DO levels are neither exacerbated nor improved by ESR diversions and as such the diversions cannot adversely impact habitat or juvenile rearing.	Depressed dissolved oxygen levels affect habitat quality and availability for steelhead rearing w/n the lower reach. Reduced dissolved oxygen levels near Creamery Meadow were associated with groundwater upwelling into the river channel. Reductions in dissolved oxygen levels are unrelated to ESR diversions. Effects of groundwater upwelling on localized dissolved oxygen concentrations within the river were more apparent under critically low river flow conditions when compared to 2004 or 2006.
Impacts of electrical conductivity on habitat	No evidence of variability in EC in surface water due to diversions. No observed effects to biologic receptors were observed.	EC levels w/n surface flows are within a range that does not impact habitat or biologic receptors.	Electrical conductivity w/n study area remained constant and was independent of ESR diversions. EC was increased in the lagoon in response to tidal and wave inflows. No change in EC within the river was detected during periods when the wells were in operation and when no wells were operating.
Juvenile steelhead rearing	Juvenile steelhead were observed rearing within the lower river. Over summering survival appear to be good, fish appeared to be healthy and in good		Juvenile steelhead were observed in the lower river. The fish appeared to be healthy and in good condition, showing signs of smolting within the lagoon. Juvenile steelhead were most abundant in the lagoon and lower reaches of the river, and appeared to select deeper

ESR--6

	condition all locations, and summer growth rates were comparable to, or greater than, juvenile growth reported for other California rivers. Juveniles showing signs of smolting were observed in the lower river reaches and lagoon.		habitats with overhead cover.

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