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Pilot Well Rehabilitation Study Summary Report



Prepared by the Environmental Programs Directorate

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Pilot Well Rehabilitation Study Summary Report

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EXECUTIVE SUMMARY

In 2005, Los Alamos National Laboratory conducted extensive analyses of the 33 R-wells having screens in the regional aquifer to determine which screens provided representative groundwater quality and which ones appeared to be impacted by drilling fluids. Concerns had been raised that some R-wells might not be suitable for monitoring because fluids and additives used in drilling and well construction appeared to have been incompletely removed during the development of some of the wells. These residual fluids potentially impact the ability of the wells to provide representative groundwater quality data and compromise the ability to detect reactive contaminants. As a result, the Laboratory initiated a pilot well rehabilitation study at three wells (R-20, R-16, and R-12) to investigate the effectiveness of redevelopment methods at impacted well screens. Well rehabilitation activities were conducted from June 28, 2006, to November 19, 2006. The three wells were selected because the permeabilities in their screens were high enough for redevelopment to succeed; their screens exhibited a variety of stages of geochemical reliability; the wells could be easily accessed; and they did not represent major technical challenges in redevelopment. Each is a three-screen well.

The objectives of the pilot study were as follows:

- to quantify the effectiveness of specific physical and/or chemical redevelopment techniques in removing residual drilling fluids;
- to assess whether these wells can provide representative data over time using low-volume, no-purge, multiple-screen sampling systems; and
- to provide recommendations for future rehabilitation activities at other impacted well screens.

At each of the three wells, the multiple-zone sampling system was removed, and the screens were redeveloped. Eventually, R-20 was the only well developed by means other than pumping. The development methods used included: bailing and swabbing; Hydropulsing; bailing and backwashing; pumping and backwashing; and simultaneous jetting and pumping.

Quantitative x-ray diffraction was performed on particulate samples pumped from the pilot study well screens. The results showed that R-20 screen 1 was heavily impacted by introduced materials, and screens 2 and 3 were moderately impacted by introduced materials. At R-16, screens 2 and 3 were moderately impacted, and screen 4 was heavily impacted by introduced materials. The most significant foreign component of the pumped particulate samples is talc, an indication of material derived from Pel-Plug (bentonite pellets). The amorphous component could be derived from the large amounts of Magma Fiber and N-seal glass that were used to stabilize the R-16 borehole during drilling. The abundance of foreign components may be related to the borehole slough that lies behind most of screen 4. At R-12, screen 1was moderately impacted by introduced materials; no particulates were collected from screen 2; and screen 3 was heavily impacted by introduced materials. The high quartz content (7%) in the pumped samples from screen 3 is not derived from the Miocene basalt host rock. The presence of quartz indicates that either the screen is damaged and filter pack sand is being introduced, or quartz from the overlying clay-altered dacitic pumice is being drawn into the screen.

Indicators used to determine the effectiveness of redevelopment included: specific capacity; turbidity; and dissolved oxygen, sodium, calcium, bicarbonate, carbonate alkalinity, sulfate, iron, zinc, and manganese concentrations. The results of each suite of measurements were compared to pre-redevelopment baseline values for that screen. The target value for improvement in specific capacity was an improvement of 5% over the baseline value to the measured value. Turbidity levels were also measured before redevelopment and compared to levels measured during and after redevelopment activities. The target turbidity value for successful rehabilitation was less than five nephelometric turbidity units.

Sulfate, sodium, manganese, and iron concentrations in groundwater were used as indicators of the degree to which drilling fluids affected ambient groundwater chemistry. In impacted wells, sulfate concentrations were expected to be diminished, and iron and manganese concentrations increased, because of microbial degradation of organic polymers introduced during drilling operations. Sulfate and sodium concentrations were expected to be elevated in groundwater where screened zones were impacted by the presence of bentonite introduced during drilling operations. The goal for successful rehabilitation of impacted screens was to reduce the concentrations of these constituents to background levels or below.

The Well Screen Analysis Report (WSAR) was revised in February 2007 to reflect additional tests and indicator species, to include more sampling events up to December 2006, and to use updated background groundwater chemistry values. At the three pilot-study wells, anywhere from six to 10 samples were evaluated in the WSAR, Revision 1, including post-redevelopment samples for all three wells.

The WSAR, Revision 1, ranked all three R-20 screens as "fair." As compared to Revision 0, screens 1 and 2 improved from "poor" to "fair," and screen 3 remained "fair." The primary effects of residual drilling fluids in all three R-20 screens were the presence of residual organics, iron-reducing conditions, and effects on carbonate mineral stability. In addition, however, the presence of residual inorganic species and changes in iron mineral stability were indicated at screen 3.

The WSAR, Revision 1, ranked R-16 screen 2 as "fair," screen 3 as "good," and screen 4 as "fair." As compared to Revision 0, screens 2 and 3 stayed in the same ranking category, but screen 4 improved from "poor" to "fair." Although the composite of sampling events ranked R-16 screen 2 as "good," the December sample indicated a slight degradation of conditions. The primary effects of residual drilling fluids in screen 2 were the presence of residual inorganics and manganese-reducing conditions. Although the composite of sampling events ranked R-16 screen 3 as "fair," the December sample indicated a slight improvement of conditions to "good." Screen 3 shows oxidizing conditions representative of background chemistry with mild effects of residual inorganics and changes to carbonate mineral stability. Although the composite of sampling events ranked R-16 screen 4 as "poor," the December sample indicated a slight improvement of conditions to "fair." Screen 4 shows manganese-reducing conditions, residual inorganics, and changes to carbonate mineral stability, and it is outside the background pH-alkalinity range.

The WSAR, Revision 1, ranked R-12 screen 1 as "fair," and screens 2 and 3 as "good," recognizing that screens 2 and 3 probably represent the same water chemistry. As compared to Revision 0, screen 1 improved from "poor" to "fair"; screen 2 changed from "dry" to "good"; and screen 3 improved from "fair" to "good." The primary effects of residual drilling fluids in R-12 screen 1 were the presence of residual organics and manganese-reducing conditions, effects on carbonate mineral stability, and its placement outside the pH-alkalinity range. R-12 screens 2 and 3 show oxic groundwater conditions that are representative of background but slightly outside the pH-alkalinity range for background. Screen 3 also shows some effects on carbonate mineral stability—effects similar to those in screen 1.

The pilot study execution plan called for reinstallation of the Westbay sampling system in each of the wells at the conclusion of redevelopment. To date this reinstallation has been done only at R-16, where redevelopment is considered to be complete. This report presents preliminary results, since the final measure of rehabilitation success can be determined at the earliest six months after reinstallation of the Westbay system to see whether future samples retain the chemistry of the latest development sample or have degraded to less representative conditions. Results of this pilot study will assist in determining the appropriate course of action to address remaining issues with multiple-screen wells at the Laboratory. Successful redevelopment methods are also being evaluated to determine whether they provide cost-effective means to address the impacts of residual drilling fluids on groundwater data.

The geochemisty of the water from screened intervals during and after the pilot study indicates that well rehabilitation at R-12, R-16, and R-20 was successful to varying degrees. Although several techniques were employed at R-20, much of the effort at all three wells focused on purging and pumping for extended periods. In summary, well rehabilitation results show that purging removes most of the soluble degradation products associated with residual drilling fluids and allows access and collection of representative groundwater samples.

The following can be concluded as preliminary results of redevelopment at wells R-20, R-16, and R-12:

- Geochemical results indicate that purging removed most of the soluble degradation products associated with residual drilling fluids at the three wells and allowed access and collection of representative groundwater samples.
- At R-20 it was concluded that the severe hydraulic shock induced by the Hydropuls tool had degraded the permeability of the sediments around the screens. Also, when the Hydropuls tool was removed from the well, bentonite seal material was observed on the top of the tool, and at various later times there was evidence of bentonite seal material being removed from screen 1. Apparently, the powerful action of the Hydropuls was too aggressive and either liberated seal that previously had been improperly placed adjacent to screen 1, or brought seal material down to the screened interval from above the well screen. These findings make the Hydropuls tool an unlikely candidate for redevelopment at other wells. However, the jetting operation was judged effective at R-20 and could be attempted at other wells. Groundwater accessed by screen 1 appears to be impacted by bentonite (elevated sodium and sulfate) and also has a component elevated in redox-sensitive species (iron, manganese, and zinc). This finding implies a mixture of representative formation and impacted groundwater at screen 1. Screens 2 and 3 also exhibit mixtures of representative and impacted groundwater.
- At R-16, redevelopment pumping was largely effective, but the chemistry at all three screens has failed to improve as hoped. Further monitoring using the nonpurging Westbay sampling system will provide insight into the dynamics of how the aquifer may return to prior geochemical conditions or improve to a greater degree. The rehabilitation strategy at R-16 was meant to allow a comparison of purge to nonpurge systems.
- At R-12, the data suggest that representative formation water can be accessed from all three screens by employing a sampling system capable of purging. An exception to this observation is that a large volume of water flowed from screens 1 and 2 to the regional aquifer and is thought to influence the chemistry of groundwater at screen 3. Still, R-12 shows promise, either for being maintained as a three-screen well or being converted to a dual-screen well.

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ACRONYMS

DOE	(U.S.) Department of Energy
EES-6	Hydrology, Geochemistry, and Geology Group
LANL	Los Alamos National Laboratory (the Laboratory)
NMED	New Mexico Environment Department
NTUs	nephelometric turbidity units
ORP	oxygen-reduction potential
QXRD	quantitative x-ray diffraction
WSAR	Well Screen Analysis Report
XRD	x-ray diffraction

1.0 INTRODUCTION

1.1 Purpose of the Pilot Study

In 2005, Los Alamos National Laboratory (LANL or the Laboratory) conducted extensive analyses of the 33 R-wells to determine which screens provided representative groundwater quality and which ones appeared to be impacted by drilling fluids. The "Well Screen Analysis Report (WSAR), Revision 0" (LANL 2005, 091121) results of November 2005 indicated that for 64 screens analyzed, 16 wells had screens that ranked in "fair" or "poor" condition and could not be relied upon at that time to provide completely representative data or to detect all contaminants in groundwater. As a result, the Laboratory initiated a pilot well-rehabilitation study at three wells to investigate the effectiveness of redevelopment methods at impacted well screens.

The objectives of the pilot study were as follows:

- to quantify the effectiveness of specific physical and/or chemical redevelopment techniques in removing residual drilling fluids;
- to assess whether these wells can provide representative data over time using low-volume, no-purge, multiple-screen sampling systems; and
- to provide recommendations for future rehabilitation activities at other impacted well screens.

The wells chosen for study were R-12, R-16, and R-20 (Figure 1.1-1). The redevelopment activities conducted at each well are described in Section 2.0.

1.2 Background

This section describes the rationale for selecting wells R-12, R-16, and R-20 for rehabilitation and their condition prior to the pilot study. Details of well construction and development of the three wells are described in Appendix A.

As part of the characterization program outlined by the Laboratory's "Hydrogeologic Workplan" (LANL 1998, 059599), 33 wells (called R-wells) were drilled within the Laboratory's boundary and in the surrounding area during the years from 1998 to 2005 (Figure 1.1-1). It was anticipated that eventually some of these characterization wells might become part of a groundwater monitoring network. However, concerns were raised that some R-wells might not be suitable for monitoring because fluids and additives used in drilling and well construction were not completely removed during development. These residual fluids potentially impact the ability of the wells to provide completely representative groundwater quality data and compromise the ability to detect some reactive contaminants.

Wells R-12, R-16, and R-20 were selected for the pilot study because results of the well screen analysis (LANL 2005, 091121) indicated that they were good candidates for rehabilitation studies. Aquifer tests of operable screens showed that the permeabilities in these screens were high enough, potentially, for redevelopment to succeed (LANL 2006, 092737). Furthermore, (1) their locations made them candidates for long-term environmental stewardship groundwater monitoring; (2) they were easily accessible, so a variety of tools and equipment could be brought to the site; and (3) they are neither the simplest nor the most complex wells in the program, since each one is a three-screen well.

R-12 was constructed in Sandia Canyon within Technical Area (TA) 72 in order to provide hydrogeologic and water-quality data for intermediate-perched zones and the regional aquifer near the Sandia and

Los Alamos Canyon watersheds. It also provides early warning data for water-supply well PM-1 (located approximately 0.35 miles to the east-northeast) and plays a key role in chromium source monitoring. R-12 was drilled to 886 ft below ground surface using air-rotary and casing-advance techniques. The top screened interval (screen 1) is in the vadose zone and ranked "poor" in Revision 0 of the WSAR (LANL 2005, 091121), although it seemed to be improving. Screen 2 is also in the vadose zone and was considered to be dry as of initiation of the pilot study because it was impossible to collect water samples. Screen 3 is at the top of the regional water table and ranked "fair" in Revision 0 of the WSAR.

R-16 is located south of Cañada del Buey, near Overlook Park in White Rock and immediately upstream of the White Rock sanitary sewage treatment plant. R-16 was installed to provide water-quality, geochemical, hydrologic, and geologic information for the hydrogeology in the area. In addition, data and information from R-16 contribute to the understanding of the distribution of potential contamination down-gradient of TA-54 and from Laboratory activities in the Mortandad Canyon watershed. R-16 was drilled to a depth of 1287 ft below ground surface using fluid-assisted, air-rotary, and conventional mud-rotary drilling methods. The top screened interval in the vadose zone is blocked behind drill casing that could not be removed during well construction (hence the designation of R-16 as a three-screen well). The second screen within the regional water table was ranked "fair" in the WSAR, Revision 0, while screen 3 was ranked "good," and screen 4 was ranked "poor." As of November 2005, screens 2 and 4 had stable chemistry, but screen 3 appeared to be improving.

R-20 is located east of TA-18 and south of Pajarito Road in Pajarito Canyon. R-20 provides hydrogeologic and water-quality data for the regional groundwater near potential contaminant release sites at TA-54. R-20 also assists in the characterization of the regional aquifer in the area of Pajarito Canyon. R-20 was drilled to a depth of 1365 ft below ground surface using fluid-assisted, air-rotary, and conventional mud-rotary drilling methods. All three screens are below the regional water table. Screens 1 and 2 were ranked "poor" in Revision 0 of the WSAR, and screen 3 was ranked "fair."

1.3 Scope of Activities

The "Well Rehabilitation Pilot Study Execution Plan" (LANL 2006, 092737) discussed various methods that would be implemented to improve well-screen data quality. At each of the three wells, the multiple-zone sampling system was removed and the screens were redeveloped. Prior to initiation of redevelopment activities, baseline specific capacity data were collected to evaluate the efficacy of well redevelopment.

The mechanical and chemical redevelopment techniques proposed for use in this pilot study included the following:

- pumping each screen with a Dual-Packer Isolation System to mobilize and remove some of the fines and drilling fluid residue and to measure the specific capacity of each screen before and after implementing redevelopment techniques;
- airlift pumping and jetting each screen (forcing water through the screen openings) to agitate and loosen the materials in the area immediately around the screens in order to ease redevelopment, and, immediately after jetting, swabbing the screens and bailing to remove the mobilized fines;
- utilizing the Hydropuls process to agitate the material and filter pack adjacent to the screen, and, after completion of the Hydropuls technique, cleaning each screen by swabbing, bailing, or pumping suspended particles and fines from the well; and, as a last resort,

- using chemical techniques—phosphate-free detergent to mobilize bentonite, chlorine to break down polymers, and acids to dissolve Magma Fiber—if field tests and analytical results demonstrated no improvement in water quality after the application of mechanical techniques.

The redevelopment techniques were to be applied in the order listed above, with chemical techniques used only as a last resort. (In the end, no chemical techniques were applied.) Implementation of any of the proposed techniques was to be dependent upon indicators retrieved after each application of a single technique. Geochemistry samples and field parameters were collected to evaluate in "real time" the effectiveness of each technique and to determine end points in the redevelopment effort.

Indicators used to determine the effectiveness of redevelopment included: specific capacity; turbidity; and dissolved oxygen, sodium, calcium, bicarbonate, carbonate alkalinity, sulfate, iron, zinc, and manganese concentrations. The results of each suite of measurements were compared to pre-redevelopment baseline values for that screen. The target value for improvement in specific capacity was an improvement of 5% over the baseline value to the measured value. Turbidity levels were also measured before redevelopment and compared to levels measured during and after redevelopment activities. The target turbidity value for successful rehabilitation was less than five nephelometric turbidity units (NTUs).

Section 2 of this report describes the methodologies employed at each screen in the three wells. Section 3.1 discusses results of the specific capacity tests. Section 3.2 presents results of geochemical sampling. Section 3.3 summarizes the quantitative x-ray diffraction (QXRD) analysis of particulates pumped from the pilot-well screens. Section 3.4 discusses screen rankings in the context of the well-screen analyses. Section 4 summarizes the pilot-study preliminary results and their implications for future well-rehabilitation efforts.

2.0 METHODOLOGY

The following tasks were completed at each of the pilot wells:

- use of the Westbay sampling system to collect baseline samples, which provided water chemistry data prior to its removal and the initiation of redevelopment activities;
- removal of the Westbay sampling system;
- specific capacity testing before and after redevelopment (except at R-16);
- redevelopment utilizing one or more mechanical techniques; and
- postrehabilitation and redevelopment sampling to evaluate the effectiveness of mechanical redevelopment techniques.

Numerous water quality samples were taken at each step of the process and at the end of redevelopment. Appendix B provides the parameter data for each of the wells during the pilot study. Appendix A describes the initial well characteristics (LANL 2006, 092535). Appendix C provides the complete QXRD analysis of particulates collected during redevelopment. Appendix D provides the geochemical sample data taken as baseline and at each step of the redevelopment process.

The multiple-screen Westbay sampling system was reinstalled at R-16, but as of this report, it has not been reinstalled at R-12 or R-20. Further discussion of the reinstallation process and the evaluation of results may be found in Section 4.

2.1 General Redevelopment Information

Well rehabilitation activities were conducted at regional wells R-12, R-16, and R-20 from June 28, 2006, to November 19, 2006, (Table 2.1-1). Work was performed by Kleinfelder, Inc., and its subcontractors under contract with the Department of Energy (DOE), through the U.S. Army Corps of Engineers (Kleinfelder 2006, 095044; Kleinfelder 2007, 095030.2; Pearson 2007, 095030.1). LANL provided personnel for removal and reinstallation of Westbay transducers, collection of groundwater field parameters, collection of laboratory analytical groundwater samples, and video/geophysical logging services.

All groundwater generated from redevelopment and pumping activities was containerized at each site in 21,000-gallon frac (short for fracturing) tanks. Representative samples of wastewater were collected for laboratory analysis. Upon review of the data and in accordance with the New Mexico Environment Department (NMED)-approved notice of intent Decision Tree (revised July 26, 2006), approval was given to land-apply the water.

The sections below are in chronological order of well redevelopment (i.e., R-20, R-16, and R-12). As knowledge matured, lessons learned at R-20 were applied to the subsequent well-redevelopment activities.

2.2 Summary of Field Methods at R-20

Westbay Sample System Removal. On June 1, 2006, personnel downloaded data and removed the transducer string from the Westbay casing. (Well completion details are shown in Figure 2.2-1.) From June 28 to July 2, personnel ran pressure profiles, deflated packers, and pulled the dedicated MP-55 Westbay system from the R-20 well. All components that were pulled were decontaminated by steam cleaning and rinsing with deionized water. All components were then sleeved in plastic layflat tubing and numbered for later reinstallation. All casing and ports were transported to LANL's field support facility for secure storage.

Video Logging. On July 3, personnel ran a video log in the R-20 well immediately after Westbay system removal (Table 2.2-1).

Specific Capacity Testing. Specific capacity tests were performed on each screen by utilizing a submersible pump with single and dual-packer systems with transducer (Table 2.2-2). A Grundfos pump with a 10-hp motor was used for these tests. Pumping was performed at a constant rate for approximately six hours for screen 1 and three hours each for screens 2 and 3. Field parameters (pH, temperature, conductivity, and turbidity) were collected at intervals ranging from 5 to 15 minutes (Appendix A and Figures 2.2-2 through 2.2-9). Groundwater samples were collected for laboratory analysis for select parameters and transferred from the field location under chain of custody to the LANL Hydrology, Geochemistry, and Geology Group (EES-6) laboratory for analysis. Five-gallon carboys were also collected near the beginning of each specific capacity test and submitted to EES-6 for particulate analysis (Appendix C).

Jetting. On July 9 and 10, jetting was attempted at screen 1. On the first attempt, the jetting nozzle was configured with three 3/32-inch jetting ports positioned 120 degrees apart. The system at the surface was set to deliver 18 gpm. Immediately upon startup, the ports became plugged, and the operation was halted. The tool was removed from the well, and the nozzle was reconfigured with two ¼-inch jetting ports positioned 180 degrees apart. The system at the surface was set to deliver 80 gpm. Upon startup, excessive downhole vibration at the nozzle end of the tool assembly prompted shutdown of the operation to avoid potential equipment failure and damage to the well. Jetting was not attempted at screens 2 and 3.

Swab and bail. On July 11 all three screens were swabbed and bailed.

Hydropuls. Hydropuls is a well-development tool that uses compressed nitrogen emitted in short bursts to dislodge fine-grained material from the well screen and filter pack. Nitrogen is supplied to the tool via a ½-inch, pressure-rated supply hose. After each "burst" or firing of the tool, an audible response can be heard, and air movement can be felt at the surface. These responses indirectly indicate that the tool is operating properly.

The Hydropuls tool, configured with a submersible pump located above the tool, was inserted into the well on July 12. This particular configuration allowed for pumping immediately after Hydropulsing the screened interval. The Hydropuls assembly was positioned across screen 3 and screen 2 on July 12, left suspended in the well overnight, and positioned across screen 1 on July 13. The tool was first fired in screen 3. Field notes and discussions with field personnel on site indicate that the first tool burst was detected at the surface, but subsequent firings were not.

Turbidity measurements were initially high after Hydropuls operation and pumping and declined rapidly with additional pumping. Field notes and discussions indicate the high turbidity was related to the high nitrogen levels in the groundwater off-gassing at the surface rather than to high suspended sediment load in the water. On July 13, the tool assembly was removed from the well after Hydropulsing of screen 1. When the assembly was retrieved at the surface, it was discovered that the Hydropuls tool had separated from the nitrogen supply line and had been left in the well. This event was consistent with earlier observations concerning proper tool operation. The malfunction most likely occurred at or during the initial use of the tool in screen 3. Fishing attempts began on July 13. The main body of the tool was recovered on July 14, and the remaining centralizer was recovered on July 15.

The Hydropuls tool was reconfigured to operate on a sand line without a submersible pump and was lowered back into the well on July 15. Screens 1 and 2 were both Hydropulsed, and the tool appeared to be operating properly. However, as the tool was being lowered to Hydropuls screen 3, it became stuck in the well immediately above screen 3. Attempts to pull the tool free failed. On July 16, the tool was retrieved without incident. A 2-inch-diameter joint of discharge pipe was run into the well on a sand line to check for potential obstructions. The pipe ran freely to the bottom and was retrieved to the surface without incident.

Because of the problems encountered during the two Hydropuls runs, the DOE and LANL discontinued its use and concentrated efforts on more conventional redevelopment techniques.

Swabbing, bailing, and open-hole pumping. On July 17 and 18, all three screens were swabbed and bailed. After the bailing, a straddle packer and submersible pump were lowered into the well to screen 3. Without inflating the packer, approximately 1000 gallons of water was pumped from the well. On July 19, additional open-hole pumping was performed; approximately 10,875 gallons of water was removed. Pumping rates were noted to have declined throughout the pumping period, ending at 14.5 gpm (Table 2.2-2). On July 20, an additional 9,060 gallons of water was pumped with a decline in pumping rate to 12 gpm. Cumulative open-hole pumping withdrew approximately 19,935 gallons, predominantly from screen 3 (Table 2.2-2).

Second Specific Capacity Testing. On July 22, a 10¾-hour specific capacity test was conducted on screen 3 (Table 2.2-2). That same day, attempts were made to run specific capacity tests on both screens 1 and 2; however, neither zone could sustain a minimum flow rate to conduct a test. When the pump, packers, and transducers were retrieved from the well, the presence of bentonite was reported at the top of the transducer.

Video and Gamma-Ray Logging. On July 23, personnel ran a well video (Run #2) to inspect casing and screens. As a result of the recent well activity, visibility was too poor to inspect any well features. Five hundred gallons of clean potable water were allowed to feed into the well overnight in an attempt to displace the turbid water and allow a video filming to be performed the following day. On July 24, personnel made another video log in the well (Table 2.2-3). This time visibility was improved. There were no obvious visual impacts in the well screens as a result of redevelopment to explain the recovery of bentonite on the redevelopment tools. On July 25, a gamma-ray log was run, after which logging packers were installed and inflated to isolate the well screens (Table 2.2-4). Redevelopment work was halted as the subcontractors went on days-off status.

Bail and Inject, Isolation Pumping. On August 8, a bridge plug was installed above screen 3 so efforts could be directed towards reestablishing flow from screens 1 and 2. From August 8 to 11 and on August 17, clean potable water was introduced into the well, and the upper two screens were gently backwashed and bailed in an attempt to reestablish production from each screen. From August 18 to 23, repairs were made to the Pulstar rig, and an attempt was made to reseat the Weatherford packer that had been installed above screen 3. Efforts to reseat a bridge plug above screen 3 failed, and a pump/isolation packer string was placed in the well on August 24. On August 25, the packer was set above screen 3 and both screens 1 and 2 were pumped and backwashed in combination. On August 26 and 27, screens 1 and 2 were pumped in combination. A combined flow rate of 2 gpm was established. On August 27, the packer assembly was raised in the well to isolate screen 1 from screen 2. Sustained flow was achieved from screen 1 on August 28. On August 29, the packer assembly was positioned to isolate screen 3; screen 3 was pumped on August 29, 30, and 31. Samples were collected for laboratory analysis and sent to EES-6. On August 31, isolation packers were set in the well.

Jetting and Isolation Pumping. On October 10, the isolation packer string was removed from the well and a jetting tool was tripped into the well to jet the screen 3 interval. The jetting tool was configured with a submersible pump; the nozzle was configured with four 5/64-inch ports positioned 90 degrees apart. The system was set to deliver 10 gpm and simultaneously pump 10 gpm. On October 11, screen 3 was jetted for three hours. It was then bailed. On October 12, the jetting tool was pulled from the well, and an isolation packer/pump assembly was lowered into the well. Isolation pumping was performed at screen 3 on October 13. Field parameters and samples were collected and sent to EES-6 for analysis. On October 14 and 15, the packer assembly was removed from the well and reconfigured to isolate and pump from screen 1. On October 17, screen 1 was pumped, and field parameters and samples were collected and sent to EES-6 for analysis. The pump assembly was then removed, and a dual-isolation packer string was placed in the well to provide for complete isolation of all screens. The Westbay system has not been reinstalled because decisions on future well-rehabilitation activities are pending.

2.3 Summary of Field Methods at R-16

Westbay Sample System Removal. On July 12, 2006, personnel downloaded data and removed the transducer string from the Westbay casing. (Well completion details are shown in Figure 2.3-1.) From July 31 to August 6, personnel ran pressure profiles, deflated packers, and pulled the dedicated MP-55 Westbay system. All components that were pulled were decontaminated by steam cleaning and rinsing with deionized water. All components were then sleeved in plastic layflat tubing and numbered for later reinstallation. All casing and ports were transported to LANL's field support facility for secure storage.

Video and Gamma-Ray Logging. On August 6, personnel ran a video well log (Table 2.3-1) and gamma-ray log (Table 2.3-2) immediately after Westbay system removal.

Specific Capacity Testing. Specific capacity tests were performed on each screen (2, 3 and 4) by utilizing a submersible pump dual-packer system with transducer (Table 2.3-3). A Grundfos pump with a 10-hp motor was used for these tests. Pumping was performed at a constant rate for approximately 12 hours. The specific capacity tests were lengthened to 12 hours to gather additional geochemistry data and to improve evaluation of the effects of pumping on changes in well geochemistry. Field parameters (pH, temperature, conductivity, and turbidity) were collected at intervals ranging from 5 to 15 minutes (Appendix A and Figures 2.3-2 through 2.3-4). Groundwater samples were collected for select parameters and transferred from the field location under chain of custody to the LANL EES-6 Hydrology and Geochemistry laboratory for analysis. Five-gallon carboys were also collected near the beginning of each specific capacity test and submitted to EES-6 for particulate analysis (Appendix C). At the conclusion of the specific capacity tests, a dual-packer string was installed in the well to provide for isolation of the different screen intervals.

Westbay Sampling System Reinstallation. The lack of any significant observed changes in the field parameters led DOE to make the decision to forego additional redevelopment at R-16. However, additional pumping occurred by means of longer duration specific capacity tests. The Westbay system was reinstalled in its original configuration during work carried out from August 24 to August 28.

2.4 Summary of Field Methods at R-12

Westbay Sample System Removal. On September 21, 2006, personnel downloaded data and removed the transducer string from the Westbay casing. (Well completion details are shown in Figure 2.4-1.) From September 22 to 25, personnel ran pressure profiles, deflated packers, and pulled the dedicated MP-55 Westbay system from R-12. All components that were pulled were decontaminated by steam cleaning and rinsing with deionized water. All components were then sleeved in plastic layflat tubing and numbered for later reinstallation. All casing and ports were transported to LANL's field support facility for secure storage.

The 2A measurement port (screen 2) was determined to be damaged and was replaced with a new port. The damaged port appears to be the reason for not being able to sample or measure water levels from this port during previous sampling rounds. It was also noted that the P2 packer installed at a depth of 781 ft (between screens 2 and 3) had a damaged outer skin. The packer was shipped to Westbay facilities in Vancouver, British Columbia, and was rebuilt.

Video Logging. On September 25, a video log was run immediately after Westbay system removal (Table 2.4-1). Water was observed entering screen 1 within the bottom 1 foot of the screen area. Significant flow was observed entering screen 2. The contribution of water from screen 2 was so great that visibility was impaired from 508 to 813 ft as a result of the turbulent mixing of water and air. Therefore, it was not possible to determine accurately the top depth of screen 3 or the composite static water level in the well. There were no apparent problems noted with the condition of the well casing or screens.

Specific Capacity Testing. Initial specific capacity tests were performed on each screen from September 26 to October 2, utilizing a submersible pump with single and dual-packer systems with transducer. A 3-inch Grundfos pump with a 1-hp motor was used for the initial tests. Pumping was performed at a constant rate for approximately 12 hours (Table 2.4-2). Field parameters (pH, temperature, conductivity, and turbidity) were collected at intervals ranging from 5 to 15 minutes (Appendix A and Figures 2.4-2 through 2.4-4). Groundwater samples were collected and sent to EES-6 for analysis. Five-gallon carboys were also collected near the beginning of each specific capacity test and submitted to EES-6 for

particulate analysis. At the conclusion of the specific capacity tests, a dual-packer string was installed in the well to provide for isolation of the different screen intervals.

Pump Development and Verification of Screen 1/Screen 2 Recharge Rates. A second phase of redevelopment was conducted from October 15 to October 19. It consisted of quantifying recharge/flow rates from screens 1 and 2 and pump development from screen 3. Three separate, short-duration recharge tests were conducted to determine flow contributions from the upper two screens into the open well. These tests determined that screen 1 was contributing 2.6 gpm, and screen 2 was contributing 73.6 gpm to the open wellbore. Given the large contribution of screen 2 water into the open well, three days of isolation pumping were conducted on screen 3 to determine if a representative groundwater sample could be produced (Table 2.4-2).

A single-packer string with a 4-inch Grundfos pump and 7.5-hp motor was used to perform three 10-hour specific capacity tests on screen 3. Field parameters (pH, temperature, conductivity, turbidity, and oxygen-reduction potential [ORP]) were measured and recorded at intervals ranging from 5 to 15 minutes (Appendix A). Analytical samples were collected and transferred to EES-6 for analysis.

The original work plan required rehabilitation work to be performed only on screens 1 and 3. The assumption was that screen 2 was dry, since no samples could be collected from that zone with the Westbay sampler. When the Westbay system was pulled, however, it was determined that there was a failure with the Westbay port (measurement port 2A). The well video confirmed that significant flow was present in the screen 2 interval. Therefore, screen 2 was included in the redevelopment activities.

No conventional redevelopment techniques were applied to the screens except for the additional pumping that was performed on screen 3 in an attempt to obtain a representative groundwater sample from this screen. The very short time that the screens had been open and in communication contributed an extremely large volume of screen 2 groundwater into the screen 3 interval. Therefore, all of the geochemistry samples collected during the specific capacity test of screen 3 were deemed representative of the screen 2 interval. Video observations and verification of recharge rates indicated that little benefit would have been gained with redevelopment of screen 2. Screen 1 was observed to be productive only over the bottom foot of the screened interval; therefore, because screen 1 was a low producer, no additional attempt was made to redevelop it. It is possible, however, that water entered the borehole over an even greater length and moved downward within the filter pack before entering the screen.

3.0 RESULTS

3.1 Results of Specific Capacity Tests

This section presents the results of specific capacity testing performed on wells R-12, R-16, and R-20 as part of the well-rehabilitation effort. Pumping rate, drawdown, and specific capacity data are presented along with a discussion of the development method's effect on pumping performance. The order of discussion follows that in section 2.0.

3.1.1 Specific Capacity Test Results at R-20

Numerous tests were conducted on screens 1, 2, and 3 in R-20. They consisted of baseline tests and followup tests conducted after each of several methods of development were applied. The pumping rate and drawdown results of all testing are shown in Table 2.2-2.

As indicated in the table, baseline testing produced specific capacities in screens 1, 2, and 3 of 0.011, 0.012, and 0.094 gpm/ft, respectively. The combined specific capacity of screens 1 and 2 (obtained by adding the individual values) was 0.023 gpm/ft, while that of all three screens taken together was 0.117 gpm/ft.

One observation of significance was that during the testing of screens 2 and 3, the specific capacities declined steadily throughout the pumping period, falling more than could be explained by normal expansion of the cone of depression. This observation suggested that the large drawdown imposed on the screened intervals (249 and 171 ft, respectively) was sufficient to compress the sediments around the well bore hydraulically, reducing the hydraulic conductivity. A similar effect was observed during subsequent testing of the screen 3 interval as discussed below.

3.1.1.1 Specific Capacity Effects from Bailing, Swabbing, and Hydropulsing

In mid-July, R-20 was developed by bailing and swabbing, then Hydropulsing, and finally by bailing and swabbing again. After the development work, the zones were retested. The open well was pumped for two days. Packer testing of the individual zones was then conducted. When the open well was pumped, the specific capacity was lower than before development. In addition, the specific capacity declined steadily during pumping because of the great drawdown applied to the well and the concomitant hydraulic compaction of the near-well sediments.

The first day of pumping the open well (July 19) showed a specific capacity of approximately 0.043 gpm/ft— a reduction of more than 60% from the original value of 0.117 gpm/ft. Drawdown was not measured during this test and had to be inferred from the discharge rate and the performance curve for the pump that was used in the testing; therefore, this specific capacity estimate is not precise. During the second day of pumping the open well, the specific capacity continued to decline, reaching 0.025 gpm/ft—just 21% of the original value of 0.117 gpm/ft.

On July 21, a double-packer system was used to isolate the individual zones for testing. Screen 3 production declined steadily throughout the test, reaching 0.02 gpm/ft—just 21% of the original value of 0.094 gpm/ft. Screens 1 and 2 could not sustain any production during this phase of testing.

These tests suggest that the severe hydraulic shock induced by the Hydropuls tool had degraded the permeability of the sediments around the screens. Also of note: When the Hydropuls tool was removed from the well, bentonite seal material was observed on the top of the tool. Subsequent installation and removal of pipes and pumps from the well at various times showed evidence of bentonite seal material being removed from screen 1. Apparently, the powerful action of the Hydropuls either liberated seal that previously had been improperly placed adjacent to screen 1, or brought seal material down to the screened interval from above the well screen.

3.1.1.2 Specific Capacity Effects from Bailing and Backwashing

In mid-August, backwashing and bailing the open well was performed in an attempt to restore production lost by application of the Hydropuls. A bridge plug was placed in the well to isolate the hydraulic effects of screen 3 so that screens 1 and 2 could be developed and tested. However, pumping response indicated that the plug leaked, and thus, the test results were affected by all three screen zones. As shown in Table C, the open well produced apparent specific capacities of 0.184 and 0.119 gpm/ft—both greater than the original specific capacity of 0.117 observed for the three zones combined. The water levels measured during this period were not consistent or reproducible, presumably because the bridge plug affected the hydraulic connection between screen 3 and the upper screens differently at different times.

Because of this variation, it is possible that the measured specific capacities were not representative of actual production capacity.

The bridge plug was removed, and an inflatable packer was installed to isolate screen 3 while testing was conducted on screens 1 and 2. As indicated in Table 2.2-2, by measuring the casing refill rate after brief pumpdown events, it was determined that the specific capacity of the combined screen 1 and 2 zones was 0.018 gpm/ft. This figure was 78% of the original specific capacity of 0.023 gpm/ft for screens 1 and 2 combined. Actual performance was considered less than 78% of the original, however, because the pumpdown and refill events were of shorter duration than the original specific capacity tests. Nevertheless, the significant recovery of capacity showed that backwashing and bailing were effective.

3.1.1.3 Specific Capacity Effects from Pumping and Backwashing

On August 25, pumping with backwashing was performed to further develop screens 1 and 2. This method was similar to bailing and backwashing but was more effective because pumping the well removed water much faster than bailing could. After a full day of applying this method, several tests were conducted to determine the yields of screens 1 and 2 combined; screen 1 alone; screens 1, 2 and 3 combined; and screen 3 alone.

As shown in Table 2.2-2, brief casing-refill events on screens 1 and 2 combined showed a short-term specific capacity averaging 0.031 gpm/ft, up significantly from the value of 0.018 gpm/ft observed after bailing and backwashing. Longer-term tests using the submersible pump revealed specific capacities for screens 1 and 2 combined of 0.021 and 0.018 gpm/ft. These figures were 91 and 78% of the original yield and suggested that pumping and backwashing were effective in helping to restore the production capacity.

A casing-refill test on screen 1 after extended pumping showed a specific capacity of 0.012 gpm/ft—similar to the baseline value of 0.011 gpm/ft. Subtracting this amount from the previous specific capacity of 0.018 gpm/ft for screens 1 and 2 combined implied a yield of 0.006 gpm/ft for screen 2— about half of its baseline yield.

A test on the open well indicated a combined specific capacity for screens 1, 2, and 3 of 0.083 gpm/ft—71% of the baseline value of 0.117 gpm/ft. The actual performance was considered less than 71%, however, because the discharge rate was significantly less than that used in the baseline testing (2.54 gpm versus a combined 19.9 gpm originally). The lower discharge rate reduces turbulent flow, thus increasing the specific capacity.

Finally, as shown in Table 2.2-2, testing of screen 3 alone yielded specific capacities of 0.071 and 0.069 gpm/ft—about 74% of the baseline yield of 0.094 gpm/ft. Again, the actual performance was judged to be less than 74% because of the lower discharge rate of 2.43 gpm compared to the original rate of 16.1 gpm.

3.1.1.4 Specific Capacity Effects from Simultaneous Jetting and Pumping

On October 11, screen 3 was developed by high-velocity jetting while pumping from the open well proceeded simultaneously. During the development, the measured specific capacity was approximately 0.102 gpm/ft, 87% of the original yield of 0.117 gpm for screens 1, 2 and 3 combined.

Subsequent packer testing of screen 3 showed a steady decline in specific capacity during the test, as hydraulic compaction of the sediments around the well occurred. The final specific capacity was 0.061 gpm/ft at a pumping rate of 7.9 gpm. This figure was less than the average value of 0.070 gpm/ft

measured at a discharge rate of 2.43 gpm prior to jetting. However, the specific capacity was biased by the greater pumping rate and the additional aquifer compaction that occurred during the test. Thus, on balance, the jetting operation was judged effective.

3.1.1.5 Specific Capacity during Final Groundwater Sampling of Screen 1

On October 17, water sampling was performed on the screen 1 interval, providing an additional opportunity to measure the specific capacity. The result was a specific capacity of 0.0105 gpm/ft, about 95% of the original yield.

3.1.2 Specific Capacity Test Results at R-16

The only development work at R-16 consisted of pumping screens 2, 3, and 4 for 12 hours each. The data from these baseline tests are shown in Table 2.3-3. As indicated, the specific capacities of screens 2, 3, and 4 were 0.084, 0.050, and 0.022 gpm/ft, respectively.

3.1.3 Specific Capacity Test Results at R-12

The only development performed on R-12 consisted of the baseline specific capacity testing (simple pumping) on all three screens and three days of extended pumping of screen 3. Screens 1, 2, and 3 were pumped initially for 12 hours. Subsequently, three days of pumping at 10 hours per day were carried out on screen 3. Table 2.4-2 summarizes the pumping rate and drawdown results. As indicated, initial specific capacity readings for screens 1, 2, and 3 were 0.09, 0.97, and 9.52 gpm/ft, respectively.

The three-day purging of screen 3 produced lower specific capacities than obtained originally. The reason for this fact was that the three-day purge was performed at a greater discharge rate, and most of the head loss was attributable to turbulent flow, characteristic of fracture flow. Screen 3 penetrates Miocene basalts and, presumably, derives its production from fractures and/or openings in the rock. Such flow can have a large turbulent component, making the specific capacity roughly inversely proportional to the discharge rate. The three-day purge rates of 19.2 and 19.3 gpm were nearly an order of magnitude greater than the baseline rate of 2.0 gpm, and, thus, observing a sharply lower specific capacity was not unusual.

Purging screen 3 at a high rate for three days improved its yield continuously throughout the testing (Table 2.4-2). For example, after just 10 minutes of pumping on the first day, the specific capacity was 2.53 gpm/ft, but it increased steadily to 3.43 gpm/ft by the end of the shift. Shutting down the pump at the end of the first day and restarting it on the second day resulted in an immediate increase in specific capacity, which reached 4.47 gpm/ft after 165 minutes. At that time, the pump was shut down for 10 minutes and restarted. The result was an immediate increase in specific capacity and a final value at day's end of 4.68 gpm/ft. The third day of purging showed a specific capacity of 4.95 gpm/ft.

It is unusual for simple pumping to cause such improvement in specific capacity in an existing well. One explanation for this phenomenon could be that the specific capacity testing and purging program might have been the first time that screen 3 had ever been pumped. There is a strong downward flux of about 76 gpm from screens 1 and 2 into screen 3 whenever the well stands open. Video logging has shown that the cascading water entrains significant quantities of air, probably forcing air into the aquifer and reducing its hydraulic conductivity via air locking. Initial well-development records indicate that the well was pumped at just 10 gpm after it was drilled. The records do not specify whether isolation packers were used. If this pumping occurred without a packer installed to isolate screen 3, then all of the water produced from the well would have come from screens 1 and 2, and excess screen-1 and screen-2 water would have continued infiltrating into screen 3 throughout the development process. Finally, reversing the

flow direction and removing water and trapped air from screen 3 during the packer testing effort resulted in steadily increasing performance.

3.1.4 Well Redevelopment Summary

R-20 was the only well developed by means other than pumping. The development methods used included: bailing and swabbing; Hydropulsing; bailing and backwashing; pumping and backwashing; and simultaneous jetting and pumping.

3.1.4.1 Bailing and Swabbing

There were no postdevelopment measurements of specific capacity that could be used to evaluate bailing and swabbing because Hydropulsing was performed in conjunction with this method. However, this procedure produced a good amount of sediment from the well during the bailing phase and, therefore, was probably reasonably effective.

3.1.4.2 Hydropulsing

It appeared that Hydropulsing the R-20 well destroyed the permeability of the sediments around the well screens, reducing the yields of screens 1 and 2 to near zero and that of screen 3 to less than its original capacity. Also, annular bentonite seal material entered the well, apparently as a direct result of Hydropulsing.

3.1.4.3 Bailing and Backwashing

This method restored a significant portion of the yield lost by Hydropulsing and was considered to be reasonably effective.

3.1.4.4 Pumping and Backwashing

Further gains in yield were obtained with this procedure, implying that it was effective.

3.1.4.5 Simultaneous Jetting and Pumping

The yield from screen 3 after jetting and pumping was maintained near its previous measured level despite being measured at a three-fold increase in discharge rate and despite further hydraulic compaction of the aquifer caused by the large drawdown stress during testing. Thus, this method was judged to be effective.

3.2 Geochemical Sampling Results

Sulfate, sodium, manganese, and iron concentrations in groundwater were used as indicators of the degree to which drilling fluids affected ambient groundwater chemistry. In impacted wells, sulfate concentrations were expected to be diminished and iron and manganese concentrations increased because of microbial degradation of organic polymers introduced during drilling operations. Sulfate and sodium concentrations were expected to be elevated in groundwater where screened zones were impacted by the presence of bentonite introduced during drilling operations. The goal for successful rehabilitation of impacted screens was to reduce the concentrations of these constituents to a level at or below background levels.

Water-quality parameters and indicators were measured in the field via a flow-through cell, and water samples were collected for both on- and off-site analyses. Water chemistry data—including pH, temperature, conductivity, ORP, and dissolved oxygen—were also measured in the field in support of data analyses.

3.2.1 Data Quality Objectives

Groundwater samples were collected and analyzed before, during, and after rehabilitation to measure performance of well-screen redevelopment. Data-quality objectives for each type of sampling are presented below.

- Baseline. Groundwater samples were collected before well redevelopment to determine a geochemical baseline from which to measure success of the redevelopment effort and performance after completion of field activities. Baseline samples were comprised of full analytical suites of organic, inorganic, and radiological constituents and were sent to an external laboratory for analysis.
- Sequential samples. Sequential groundwater samples were collected during specific capacity tests to help determine the success of redevelopment as large volumes of water are removed. Samples were analyzed by EES-6 for indicator constituents that are sensitive to the effects of residual drilling fluids and well construction.
- Performance monitoring. Groundwater samples continue to be collected after redevelopment to monitor the performance, or success, of well redevelopment. This phase of monitoring is ongoing at R-16 but has not yet begun at R-12 or R-20. Both indicator and full analytical suites are being collected as part of the performance monitoring phase.

Groundwater geochemical results from wells R-12, R-16, and R-20 are presented in Appendix D. Data are sorted with respect to location, screen depth, sample collection date and time, and analyte description.

3.2.2 R-20 Geochemical Sample Results

Baseline samples were collected from R-20 screens 1, 2, and 3 on June 6, 7, and 8, respectively, before removal of the Westbay sampling system. Sequential samples were collected during specific capacity tests using an isolation straddle-packer sampling system from screen 1 on July 6, screen 3 on July 7, and screen 2 on July 8. An additional specific capacity test was performed at screen 3, and samples were collected. On August 26 and 30, isolation pumping was performed on combined screens 1 and 2 and on screen 3, respectively. Samples were collected during this time but were not filtered or preserved until the following week and are considered compromised and nonrepresentative of aquifer conditions. These data are not included in this analysis. Additional pumping and sample collection took place on October 13 (screen 3) and October 17 (screen 1). These data are considered representative and are included in this analysis. Plots of key constituents are provided in Figures 3.2-1 through 3.2-3. Results are provided in Appendix D.

3.2.2.1 R-20 Screen 1

Major ions calcium and sulfate show a dramatic increase, and sodium exhibits a decrease in concentrations from baseline conditions to conditions imposed by the specific capacity tests (Figure 3.2-1). Bicarbonate/carbonate alkalinity and pH both show a decrease but soon become stable during initial pumping. Turbidity values are elevated initially and decrease to just below 5 NTU during the

latter half of the test, suggesting the presence of low concentrations of suspended solids throughout pumping. Iron, manganese, and zinc also show a dramatic initial rise in concentrations from baseline values during the initial phase of pumping. Zinc exhibits a declining trend and never appears to stabilize. Iron and manganese concentrations stabilize toward the end of the specific capacity test but remain higher than baseline values. Dissolved oxygen concentrations never rise above 1.5 mg/L, suggesting that reducing conditions are present in the aquifer adjacent to the screen. The combination of elevated zinc and iron and low concentrations of free oxygen during pumping indicates reducing waters related to residual drilling fluids are impacting formation water. In addition, concentrations of calcium, sodium, and sulfate are elevated, suggesting some impact from drilling mud (bentonite) or annular fill. The presence of high concentrations of zinc (1192 ug/L) appears to be related to reducing conditions in the aquifer, indicating that a significant component of impacted formation water was accessed throughout aquifer testing. Additional performance monitoring will test this observation.

3.2.2.2 R-20 Screen 2

Bicarbonate/carbonate alkalinity and major ions of sodium and calcium show a dramatic decrease in concentrations from baseline to pumping conditions but become linear throughout the specific capacity test (Figure 3.2-2a). Sulfate concentrations increase five-fold and become linear throughout the duration of the test. Turbidity quickly stabilizes and exhibits low values and a linear trend indicating low concentrations of suspended solids. Iron and manganese exhibit a decreasing trend during initial pumping and stabilize throughout the remainder of the test. Zinc concentrations increase seven-fold then quickly become linear throughout the remainder of pumping (Figure 3.2-2b). Dissolved oxygen concentrations remain above 4 mg/L throughout the latter half of pumping, a finding suggesting that oxygenated formation water is entering the screen. The presence of free oxygen above 4 mg/L along with redox-sensitive iron, manganese, and zinc suggests that a mixture of representative and drilling-fluid-impacted formation water was accessed throughout the specific capacity test. Additional monitoring will test this observation.

3.2.2.3 R-20 Screen 3

Major ions sodium and sulfate show an initial increase followed by a linear trend from baseline to aquifer pumping conditions. Bicarbonate/carbonate alkalinity and calcium both show decreasing trends and transition to linear trends early during the test (Figure 3.2-3a). Turbidity decreases dramatically and remains below 2 NTU, indicating low concentrations of suspended solids. Iron and manganese show similar trends, first decreasing and then slowly increasing to a linear trend. Zinc concentrations, on the other hand, increase 30-fold from baseline values during the initial phase of pumping, showing linear behavior throughout the tests. Dissolved oxygen concentrations are initially low (< 1 mg/L), then increase to between 2 and 3 mg/L at the inflection point of linearity. Low concentrations of free oxygen and elevated iron, manganese, and zinc suggest that reducing conditions are affecting the formation in the vicinity of screen 3. In addition, the October performance monitoring results (last point in Figure 3.2-3b), suggest that groundwater accessed by screen 3 may be rebounding to pre-redevelopment conditions (i.e., reduced concentrations of oxygen and sulfate and an increase in concentrations of iron, manganese, and zinc). Performance monitoring will continue to evaluate the effect of redevelopment.

3.2.3 R-16 Geochemical Sample Results

Baseline samples were collected from R-16 screens 2, 3, and 4 on July 12 and 13, 2006, and from screens 2 and 4 on July 20 before removal of the Westbay sampling system. Sequential samples were collected (using an isolation straddle-packer sampling system) from screen 4 on August 9, from screen 3

on August 10, and from screen 2 on August 11 during the specific capacity test. Performance monitoring at all three screens was conducted in mid-October after the Westbay sampling system was reinstalled. The resulting data are included in this evaluation. Plots of key constituents are provided in Figures 3.2-4 through 3.2-6; results are provided in Appendix D.

3.2.3.1 R-16 Screen 2

Major ions sodium and sulfate show a decrease, and bicarbonate/carbonate alkalinity and calcium show an increase in concentrations from baseline conditions to conditions imposed by the specific capacity test (Figure 3.2-4a). With the exception of a few results, turbidity values were below 1 NTU throughout much of the test, indicating low concentrations of suspended solids. Iron, manganese, and zinc show an initial rise in concentrations from baseline values during the initial phase of the specific capacity test, then slowly decline and stabilize to a linear trend after two hours of pumping (Figure 3.2-4b). Dissolved oxygen concentrations are initially between 2 and 3 mg/L, then stabilize just above 5 mg/L shortly into the specific capacity test. The combination of elevated zinc and iron in the presence of free oxygen during pumping indicates that some reducing waters related to residual drilling fluids are mixing with oxygenated representative formation water. However, concentrations of manganese and major ions considered are within background values, indicating that continuous purging is, for the most part, accessing representative formation water. Finally, the October performance-monitoring results (manganese, iron, and zinc; last points in Figure 3.2-4b) indicate that screen 2 may be returning to pre-redevelopment conditions. Additional performance monitoring will test this observation.

3.2.3.2 R-16 Screen 3

Major ions sodium, calcium, sulfate, and bicarbonate/carbonate alkalinity show a slight deviation from baseline to pumping conditions but become linear throughout the specific capacity test (Figure 3.2-5a). Turbidity is very low throughout the test, indicating low concentrations of suspended solids. Trace elements iron, manganese, and zinc show an initial rise in concentrations from baseline values during the initial phase of pumping, with iron and manganese quickly becoming linear and zinc showing a declining trend throughout the test (Figure 3.2-5b). Dissolved oxygen concentrations are consistently between 2 and 3 mg/L and appear to be stable throughout pumping. Redox-sensitive iron and manganese remain relatively low throughout pumping, and zinc appears to be anomalously high, especially in the initial phase of pumping. Along with free oxygen above 2 mg/L and background concentrations of sodium, calcium, and sulfate, this finding suggests that representative formation water was accessed throughout aquifer testing. Initial iron, manganese, and zinc results from performance monitoring indicate that conditions may be returning to pre-redevelopment conditions. Additional monitoring will test this observation.

3.2.3.3 R-16 Screen 4

The major ions sodium, calcium, and sulfate and bicarbonate/carbonate alkalinity show a decrease from baseline to pumping conditions. These constituents quickly become and remain linear during the initial phase of the specific capacity test (Figure 3.2-6a). With the exception of one anomalous value, turbidity is very low throughout the test, indicating low concentrations of suspended solids. Iron, manganese, and zinc show an abrupt rise in concentrations from baseline values during the initial phase of pumping; zinc exhibits the most dramatic trend. Iron and manganese become linear; zinc shows a declining trend throughout the test (Figure 3.2-6b). Dissolved oxygen concentrations are relatively low initially and incrementally increase to just above 2 mg/L toward the terminus of the test. Of the three screens at R-16, screen 4 shows the highest concentration of redox-sensitive iron, manganese, and zinc. Considering the

relatively low free oxygen throughout the aquifer test, it appears that groundwater pumped from screen 4 contained a greater component of reducing groundwater than either screen 2 or 3. In addition, results from the October performance monitoring (last point in Figure 3.2-6b) suggest that the aquifer directly adjacent to screen 4 may be rebounding to pre-redevelopment conditions. Performance monitoring will continue to evaluate the effect of redevelopment.

3.2.4 R-12 Geochemical Sample Results

Baseline samples were collected on July 11 and 12, 2006, before the Westbay sampling system was removed. Sequential samples were collected (using an isolation straddle-packer sampling system) from screen 3 on September 27, screen 1 on September 29, and screen 2 on October 1 during the specific capacity test. Plots of key constituents are provided in Figures 3.2-7 through 3.2-9; results are provided in Appendix D. An additional set of samples was collected at screen 3 on October 18 after a long specific capacity test.

3.2.4.1 R-12 Screen 1

Major ions sodium, calcium, and sulfate and carbonate alkalinity show an increase in concentrations, and pH shows a slight increase from baseline conditions to conditions imposed by the specific capacity test (Figure 3.2-7a). Turbidity quickly decreases initially from 1000 to 1.78 NTUs, indicating low concentrations of suspended solids. The trace elements iron, manganese, and zinc show an initial rise in concentrations from baseline values during the initial phase of the specific capacity test, then slowly decline and stabilize to a linear trend (Figure 3.2-7b). Dissolved oxygen concentrations are initially below 2 mg/L and stabilize between three and four mg/L at the end of the specific capacity test. Low sulfate and the initial spike in manganese and iron concentrations indicate reducing conditions in initial purge water with a transition to oxygenated formation water within the first two hours of pumping. The linear trend of parameters throughout much of the specific capacity test indicates that continuous purging is accessing representative formation water with no apparent impact from residual drilling fluids. Performance monitoring will test this observation.

3.2.4.2 R-12 Screen 2

Groundwater samples were collected at the end of specific capacity test pumping and are compared to baseline results in Figures 3.2-8a and 3.2-8b. Sulfate and bicarbonate/carbonate alkalinity show a slight increase in concentrations, and sodium and calcium show little to no change from baseline conditions to the terminus of the test. Turbidity remains well below 5 NTU throughout pumping, and pH values initially decline slightly and remain linear throughout the test. Iron and zinc increase, and manganese shows a decrease in concentration. Dissolved oxygen is initially above 3 mg/L and increases with the evolution of the test. Low iron and manganese and oxic aquifer conditions in the region of screen 2 from the baseline results indicate little impact from organic drilling fluids with conditions improving by the end of specific capacity test pumping.

3.2.4.3 R-12 Screen 3

Screen 3 results show a dramatic reduction in bicarbonate/carbonate alkalinity, sodium, and turbidity; a slight reduction in calcium and pH; and an initial increase in sulfate concentrations from baseline to specific capacity test pumping (Figure 3.2-9a and 3.2-9b). The redox-sensitive trace elements iron and manganese both exhibit an initial decrease, with iron systematically increasing and manganese decreasing, then becoming linear as pumping continues. Concentrations of both iron and manganese

decrease during the second test. Zinc exhibits a slight increase in concentrations, then quickly becomes linear throughout pumping. Groundwater appears to be oxic and shows increasing trends throughout the test. With the exception of iron concentrations, groundwater geochemistry shows little variability during the test. However, results from the second test show deviations from the initial test results, an indication of the effect of about 600,000 gallons of water, along with ample quantities of air, flowing from screens 1 and 2 into screen 3 while packers were removed from the well during redevelopment.

3.2.5 Summary of Geochemical Results

The geochemisty discussed above indicates that well redevelopment at R-12, R-16, and R-20 was successful to varying degrees. Although several techniques were employed at R-20, much of the effort at all three wells focused on purging and pumping for extended periods. A summary is presented below.

- The results of the R-20 redevelopment effort were a mixed success. Groundwater accessed by screen 1 appears to be impacted by bentonite (elevated sodium and sulfate) and also has a component elevated in redox-sensitive species (iron, manganese, and zinc). This finding implies impacted groundwater at screen 1. Screens 2 and 3 exhibit mixtures of representative and impacted groundwater. However, free oxygen was measured in screen 2 above 4 mg/L in the presence of dissolved iron, suggesting that distal groundwater is flowing to the screen via a fast path. This finding implies that select contaminants may not be appreciably affected by conditions adjacent to the screen during purging.
- Trends and concentrations of constituents at the three screens at R-16 imply that, again, purging and pumping remove groundwater adjacent to the screen, allowing access to representative formation water. Further monitoring using the nonpurging Westbay sampling system will provide insight into the dynamics of how the aquifer may return to prior geochemical conditions. The rehabilitation strategy at R-16 was meant to allow a comparison of purge to nonpurge systems.
- The data at R-12 suggest that representative formation water can be accessed from all three screens by employing a sampling system capable of purging. An exception to this observation is that a large volume of water flowed from screens 1 and 2 to the regional aquifer and is thought to influence the chemistry of groundwater accessed from screen 3.

In summary, well-redevelopment results show that purging allows access and collection of representative groundwater samples.

3.3. Particulate Results

This section summarizes the QXRD analysis of particulates pumped from the pilot-well screens. A full discussion is presented in Appendix C. The term "introduced materials" in this section is defined to include materials introduced during well drilling and development as well as annular fill that is foreign to the host rock next to the screen.

3.3.1 Particulate Results at R-20

The stratigraphy at R-20 is varied. Screen 1 is located at 904.6 to 912.1 ft, within a trachyandesite scoria sequence. Screen 2 is at 1147.1 to 1154.7 ft, within pumiceous sediments with pumice deposits that are Peralta Tuff equivalents. Screen 3 is at 1328.8 to 1336.5 ft, within stream gravels with a high content of volcaniclastic material; abundant tridymite and cristobalite in the host rock along with quartz indicate Santa Fe Group sediments derived from mixed Precambrian and volcanic source rocks. Lack of calcite

cement (although dolomite is present) and the presence of amorphous volcanic glass in the host rock make this horizon unusual among the more typical Santa Fe units.

3.3.1.1 Screen 1: Heavily Impacted by Introduced Materials

Screen 1 is located within trachyandesite scoria, characterized by mafic mineralogy (e.g., very little quartz, high plagioclase content, and the presence of augite and magnetite). At screen 1, the pumped particulates have anomalously high quartz content (~23-24% vs. <1% in the host rock). Conversely, the pumped particulates lack several of the prominent constituents of the host rock, particularly augite and amorphous volcanic glass. These results suggest that the pumped particulates are heavily impacted by introduced material, although the nature of the introduced material is different from that at the lower screens, 2 and 3. Particulates at screen 1 lack the talc that is a tracer mineral specific to Pel-Plug (bentonite pellets). The high quartz abundance in the screen 1 particulates is of uncertain origin; it could be mobilized fines from the transition sand at screen 1, or it could have been introduced from another horizon when the interval from 765 to 933 ft was reamed after cement was set to 785 ft depth. (A sample from the screened interval collected after this procedure contains traces of cementitious materials.)

3.3.1.2 Screen 2: Moderately Impacted by Introduced Materials

Screen 2 is located within pumiceous sediments, characterized by abundant rhyolitic pumice with amorphous glass plus intermediate-composition lava clasts with complex silica polymorph assemblages (cristobalite, tridymite, and quartz) and volcanic glass. The pumped particulates contain all of these silica polymorphs plus the glass; since tridymite and volcanic glass do not occur in any of the drilling additives or construction materials, a significant contribution of fine particles from the host rock is evident. However, the pumped particulates also contain significant amounts of talc (~4-5%) along with elevated calcite (~2-4%). These components are present in Pel-Plug coatings, and the talc, in particular, is not found in any of the host rocks at the Laboratory. The presence of talc is a definitive indication that annular fill materials have been drawn into screen 2, albeit mixed with native formation particulates.

3.3.1.3 Screen 3: Moderately Impacted by Introduced Materials

Screen 3 is located within stream gravels and sands with a high content of volcaniclastic detritus. As with screen 2, the silica polymorph assemblage is complex (with cristobalite, tridymite, and quartz all present), and volcanic glass is also present. Again, as in screen 2, the pumped particulates contain all of these silica polymorphs plus glass, and since tridymite does not occur in any of the drilling additives or construction materials, a significant contribution of fine particles from the host rock is evident. However, the pumped particulates again contain significant amounts of talc (~1-4%) along with calcite (~1-2%), and talc is a specific tracer for Pel-Plug coatings. As with screen 2, the presence of talc is a definitive indication that annular fill materials have been drawn into screen 3. The markers of native formation material are similar to screen 2 (tridymite and volcanic glass, in particular), but at screen 3 it was noted that the first sample contained a significant amount of organic material. The organic matter will produce an amorphous diffraction pattern similar to glass, and the ~23% of "glass" listed for this sample (Appendix C, Table C-4) may represent amorphous glass from the host rock along with organic material and possible glassy drilling additives (Magma Fiber and N-seal).

3.3.2 Particulate Results at R-16

Screen 1 at R-16 is sealed off by casing lost in the drill hole during well construction; pumped particulates were obtained only from screens 2, 3, and 4.

3.3.2.1 Screen 2: Moderately Impacted by Introduced Materials

Screen 2 is located within Santa Fe Group sands. The host rock has a very high quartz content and low cristobalite/tridymite content typical of Santa Fe Group lithosomes derived from Precambrian source rocks. Calcite is present as a cementing matrix material, typical of the Santa Fe Group sands. The most significant foreign component of both pumped particulate samples is talc, an indication of material derived from Pel-Plug.

3.3.2.2 Screen 3: Moderately Impacted by Introduced Materials

Screen 3 is located within Santa Fe Group sands. The host rock has a significant cristobalite and variable tridymite content typical of Santa Fe Group lithosomes derived from mixed Precambrian and volcanic source rocks. Calcite is present as a cementing matrix material, typical of all Santa Fe Group sands. As at screen 2, the most significant foreign component of both pumped particulate samples is talc, an indication of material derived from Pel-Plug.

3.3.2.3 Screen 4: Heavily Impacted by Introduced Materials

Screen 4 is located within Santa Fe Group sands. The host rock has a significant cristobalite content typical of Santa Fe Group lithosomes derived from mixed Precambrian and volcanic source rocks. As at screens 2 and 3, calcite is present as a cementing matrix material, typical of all Santa Fe Group sands. At screen 4, there are two components of the pumped particulates, talc and amorphous material, that are foreign to the host rock. The talc indicates particulates derived from Pel-Plug; the amorphous component could be derived from the large amounts of Magma Fiber and N-seal glass that were used to stabilize the hole during drilling. Further analysis would be necessary to confirm this hypothesis. Together, the talc and amorphous material account for 15% to 27% of the pumped particulates, a larger fraction of definitively foreign material than at screens 2 and 3. The abundance of foreign components may be related to the borehole slough that lies behind most of screen 4. That is, amorphous glass from the N-seal and Magma Fiber may have become trapped against the screen when the borehole collapsed.

3.3.3 Particulate Results at R-12

3.3.3.1 Screen 1: Moderately Impacted by Introduced Materials

Screen 1 at R-12 is located within the lower alkalic lava series of the Cerros del Rio basalts at this site. This screen is within a perched zone that includes fractured lavas and interflow zones above basal basaltic tephra and overlying gravels. Quantitative XRD data are not available for the screen horizon, but petrographic analysis of the host basalts shows that they contain feldspar, augite, olivine, magnetite, ilmenite, and some groundmass basaltic glass; clay is minor but can be found in some vesicles and fractures. The pumped particulates at screen 1 contain 1.4 to 1.6% talc, indicating that some of the particulates are derived from Pel-Plug coatings; the elevated calcite content (2.6 to 5%) may also be derived from Pel-Plug coatings, although no gypsum was detected. The high clay content (52 to 29% smectite and 1.5 to 2.5% kaolinite) suggests that some annular fill bentonite may be present, although local clay alteration in the basalt could be concentrated as fines. There is a notable difference between the first pumped sample (1/4) and the last (4/4) in amorphous material, which is absent during initial pumping but rises to 27% in the last sample. Further analysis of this sample would be required to determine what this amorphous material is. Note, however, that mafic glass is abundant (26.6%) in the trachyandesite scoria at R-20. (See the R-20 host rock sample at 895 to 900 ft depth, Table C-4.) Similar mafic glass abundance could occur in the Cerros del Rio basalts at R-12.

3.3.3.2 Screen 3: Heavily Impacted by Introduced Materials

Screen 3 at R-12 is located in partially altered Miocene basalt. Quantitative XRD data are not available for the screen horizon, but petrographic analysis of the host basalt shows that it contains feldspar, augite, largely altered olivine, magnetite and ilmenite largely altered to hematite, and groundmass altered to clay and carbonate minerals. Particulates in the two pumped samples from this screen are similar; there is only minor talc in one, indicating that Pel-Plug contamination is minimal. The high smectite content (72 to 77%) may include annular fill clays, but clay alteration of the Miocene basalt is much more extensive than in the Cerros del Rio lavas at Screen 1; moreover, the clay-altered dacitic pumice above Screen 3 and within 1 ft of the filter pack is heavily clay-altered (Broxton et al. 2001, 071252). Much of the clay at Screen 3 may be from these local host rock sources. More significant is the high quartz content (7%) in both of the pumped samples. Quartz is not found in the Miocene basalt host rock. The presence of quartz indicates that either the screen is damaged and filter pack sand is being introduced, or quartz from the overlying clay-altered dacitic pumice is being drawn into the screen.

3.4 Comparison to WSAR

The WSAR was revised (LANL 2007, 095043) to reflect additional tests and indicator species and to include more sampling events than were available for Revision 0. Furthermore, Revision 1 used updated background values from Revision 2 of the "Groundwater Background Investigation Report" (LANL 2007, 094856).

3.4.1 Geochemical Trends at R-20

The ranking of screens at R-20 as of December 2006 is shown in Figure 3.4-1. As the figure indicates, the WSAR, Revision 1, ranked all three screens as "fair." Comparison of these results to the results in the WSAR, Revision 0, shows that screens 1 and 2 improved from "poor" to "fair," and screen 3 remained as "fair."

3.4.1.1 R-20 Screen 1

Seven sampling events were evaluated in the WSAR, Revision 1, including post-redevelopment samples. The primary effects of residual drilling fluids in screen 1 were the presence of residual organics, iron-reducing conditions, and effects on carbonate mineral stability.

3.4.1.2 R-20 Screen 2

Five sampling events were evaluated in the WSAR, Revision 1, the most recent being in July 2006. The primary effects of residual drilling fluids in screen 2 were the presence of residual organics, iron-reducing conditions, and effects on carbonate mineral stability, just as in screen 1.

3.4.1.3 R-20 Screen 3

Six sampling events were evaluated in the WSAR, Revision 1, the most recent being in October 2006. The primary effects of residual drilling fluids in screen 3 were the presence of residual organics, iron-reducing conditions, and effects on carbonate mineral stability, just as in screen 1. In addition, however, the presence of residual inorganic species and changes in iron mineral stability were indicated at screen 3.

3.4.2 Geochemical Trends at R-16

The ranking of screens at R-16 as of December 2006 is shown in Figure 3.4-2. As the figure indicates, the WSAR, Revision 1, ranked screen 2 as "fair," screen 3 as "good," and screen 4 as "fair." As compared to the rankings in the WSAR, Revision 0, screens 2 and 3 stayed in the same ranking category, but screen 4 improved from "poor" to "fair."

3.4.2.1 R-16 Screen 2

Ten sampling events were evaluated in the WSAR, Revision 1, the most recent being post-redevelopment in December 2006. Although the composite of sampling events ranked screen 2 as "good," the December sample indicated a slight degradation of conditions. The primary effects of residual drilling fluids in screen 2 were the presence of residual inorganics and manganese-reducing conditions.

3.4.2.2 R-16 Screen 3

Ten sampling events were evaluated in the WSAR, Revision 1, the most recent being post-redevelopment in December 2006. Although the composite of sampling events ranked screen 3 as "good," the December sample indicated a slight improvement. Screen 3 shows oxidizing conditions representative of background chemistry with mild effects of residual inorganics and changes to carbonate mineral stability.

3.4.2.3 R-16 Screen 4

Nine sampling events were evaluated in the WSAR, Revision 1, the most recent being post-redevelopment in December 2006. Although the composite of sampling events ranked screen 4 as "poor," the December sample indicated a slight improvement of conditions to "fair." Screen 4 shows manganese-reducing conditions, residual inorganics, and changes to carbonate mineral stability, and it is outside the background pH-alkalinity range.

3.4.3 Geochemical Trends at R-12

The ranking of screens at R-12 as of December 2006 is shown in Figure 3.4-3. As the figure indicates, the WSAR, Revision 1, ranked screen 1 as "fair," and screens 2 and 3 as "good," recognizing that screens 2 and 3 probably represent the same water chemistry. Comparison to WSAR, Revision 0, shows that screen 1 improved from "poor" to "fair"; screen 2 changed from "dry" to "good"; and screen 3 improved from "fair" to "good."

3.4.3.1 R-12 Screen 1

Six samples were evaluated in the WSAR, Revision 1, the most recent being in September 2006. The primary effects of residual drilling fluids in screen 1 were the presence of residual organics, the presence of manganese-reducing conditions, effects on carbonate mineral stability, and the condition of being outside the pH-alkalinity range.

3.4.3.2 R-12 Screen 2

Six samples were evaluated in the WSAR, Revision 1, the most recent being in October 2006. Screen 2 shows oxic groundwater conditions that are representative of background but slightly outside the pH-alkalinity range for background.

3.4.3.3 R-12 Screen 3

Seven samples were evaluated in the WSAR, Revision 1, the most recent being in October 2006. Screen 3 shows oxic groundwater conditions that are representative of background but slightly outside the pH-alkalinity range for background. Screen 3 also shows some effects on carbonate mineral stability, effects similar to screen 1.

4.0 SUMMARY AND CONCLUSIONS

4.1 Summary

During the summer and autumn of 2006, well-redevelopment activities were conducted in a pilot study at wells R-20, R-16, and R-12. These wells were selected because their screens exhibited a variety of stages of geochemical reliability; they could be accessed easily; and they did not represent major technical challenges in redevelopment.

The "Well Rehabilitation Pilot Study Execution Plan" (LANL 2006, 092737) called for reinstallation of the Westbay sampling system in each of the wells at the conclusion of redevelopment. To date, reinstallation has been carried out only at R-16, where redevelopment is complete. It was acknowledged in the "Workplan for R-Well Rehabilitation and Replacement" (LANL 2006, 092535) that the final measure of rehabilitation success could only be determined at least six months after reinstallation of the Westbay system to see whether future performance water samples retained the chemistry of the latest development sample or had degraded to less representative conditions. The pilot study execution plan also stated that the summary report on the pilot study results would be submitted 60 days after the last six-months-after sample is taken. Therefore, this report must be considered preliminary.

Results of this pilot study will assist in determining the appropriate course of action to address remaining issues with multiple-screen wells at the Laboratory. Successful redevelopment methods are also being evaluated to determine if they provide cost-effective means to address the impacts of residual drilling fluids on groundwater data. Future geochemical results will be reported in the 2007 update of the "Workplan for R-Well Rehabilitation and Replacement." The update of that document will also discuss redevelopment completion activities proposed or accomplished at R-20 and R-12 (e.g., reinstallation of the Westbay system or conversion to single-screen or dual-screen wells with a different sampling system).

4.2 Conclusions

- R-wells can be effectively redeveloped using conventional mechanical techniques. The degree of success must be evaluated on a screen-by-screen basis. Overly aggressive techniques can be detrimental to hydraulic conductivity and filter pack stability by introducing annular seal materials into the well screen or exacerbating an existing problem or weakness of the well.
- As indicated by the geochemical results discussed in section 3.2, purging allowed access and collection of representative groundwater samples at the three wells. Performance monitoring will provide data that may allow evaluation of the extent to which redevelopment has permanently removed the residual drilling fluids and degradation products. Purging prior to sample collection may present an acceptable solution to the collection of representative groundwater quality samples. The need for purging questions the appropriateness of the use of the Westbay sampling system in R-wells.

- At R-20, it was concluded that the severe hydraulic shock induced by the Hydropuls tool had degraded the permeability of the sediments around the screens. In addition, when the Hydropuls tool was removed from the well, bentonite seal material was observed on the top of the tool. Subsequent installation and removal of pipes and pumps from the well at various times showed evidence of bentonite seal material being removed from screen 1. Apparently, the powerful action of the Hydropuls was too aggressive and either mobilized a portion of the seal that previously had been improperly placed adjacent to screen 1 or brought seal material down to the screened interval from above the well screen. This finding makes the Hydropuls tool an unlikely candidate for redevelopment at other R-wells. However, the jetting operation was judged effective at R-20 and could be attempted at other wells. As shown at R-20, operating wells with extremely large drawdowns compresses the near-well sediments and reduces the specific capacities.
- At R-20, screen 1 water samples showed chemical evidence of bentonite, consistent with the observation of bentonite seal material on tools removed from the well after they had passed through screen 1. Furthermore, screen 1 may have been impacted by bentonite even before the sampling system was removed. Screen 2 and screen 3 samples included both impacted and nonimpacted water.
- At R-16, although some impacted water was produced, high-rate purging appeared to draw mostly nonimpacted water into all three screens. Although redevelopment pumping was largely effective, the chemistry of the three screens has not improved to the degree hoped.
- At R-12, all three screens improved geochemically from redevelopment high-rate pumping, producing primarily nonimpacted water samples from all screens, but the results at screen 3 are compromised by the mixture of waters from screens 1 and 2 flowing into screen 3, leading to the question of whether representative groundwater quality has ever been detected at screen 3. Still, R-12 shows promise either for being maintained as a 3-screen well or being converted to a dual-screen well.

5.0 REFERENCES

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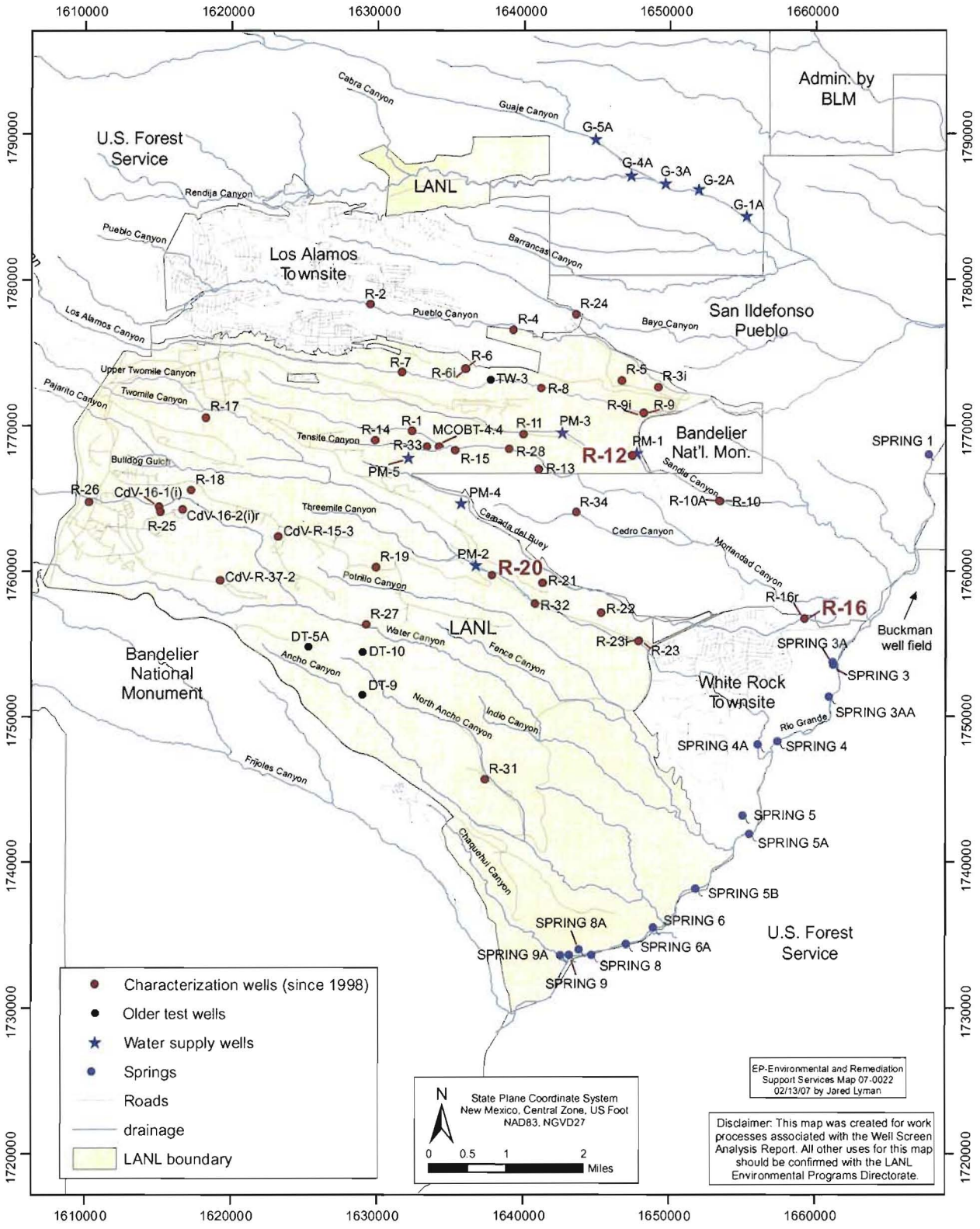


Figure 1.1-1. The Location of Pilot Study Wells R-12, R-16, and R-20 With Reference to Surrounding Wells and Springs

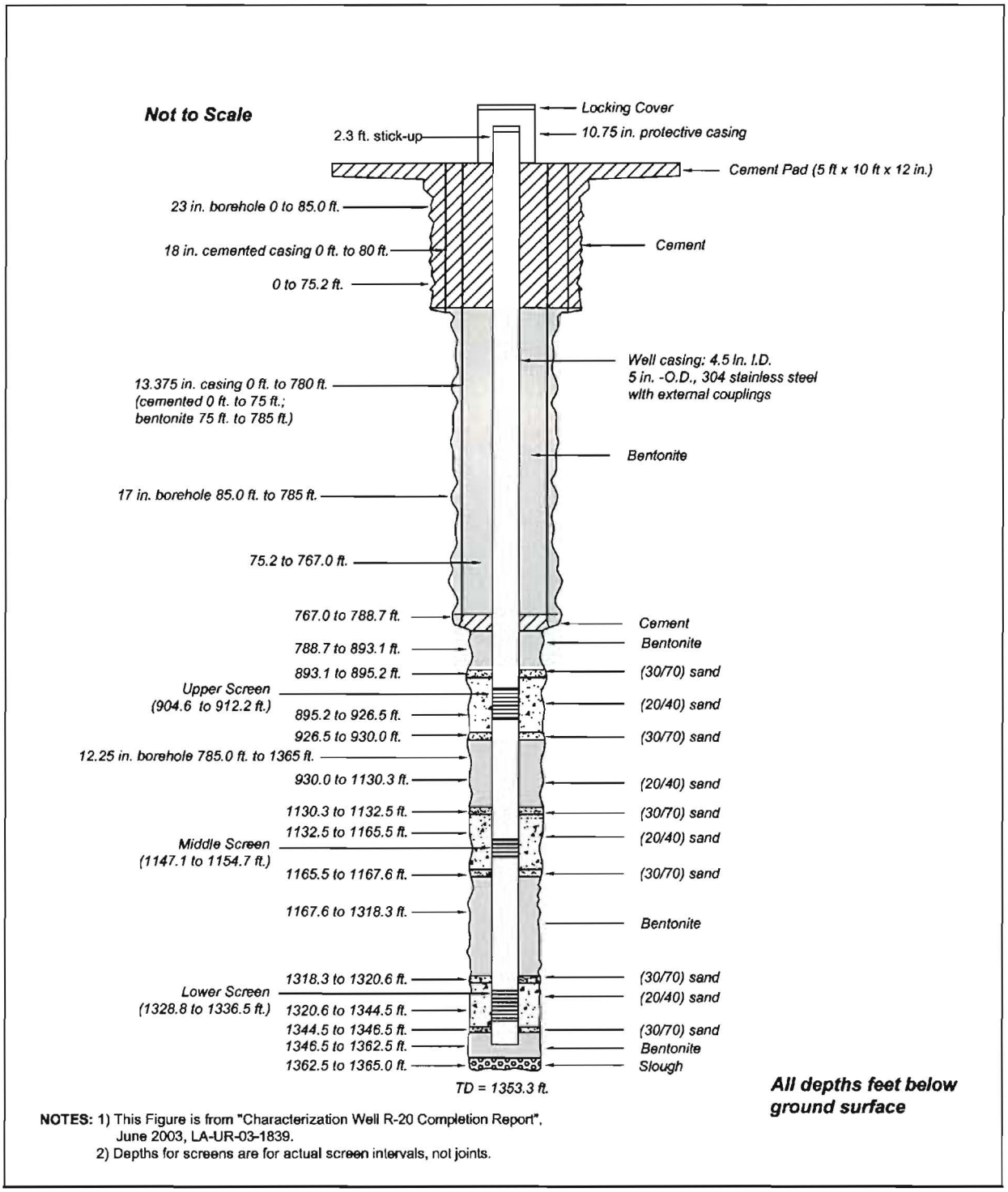
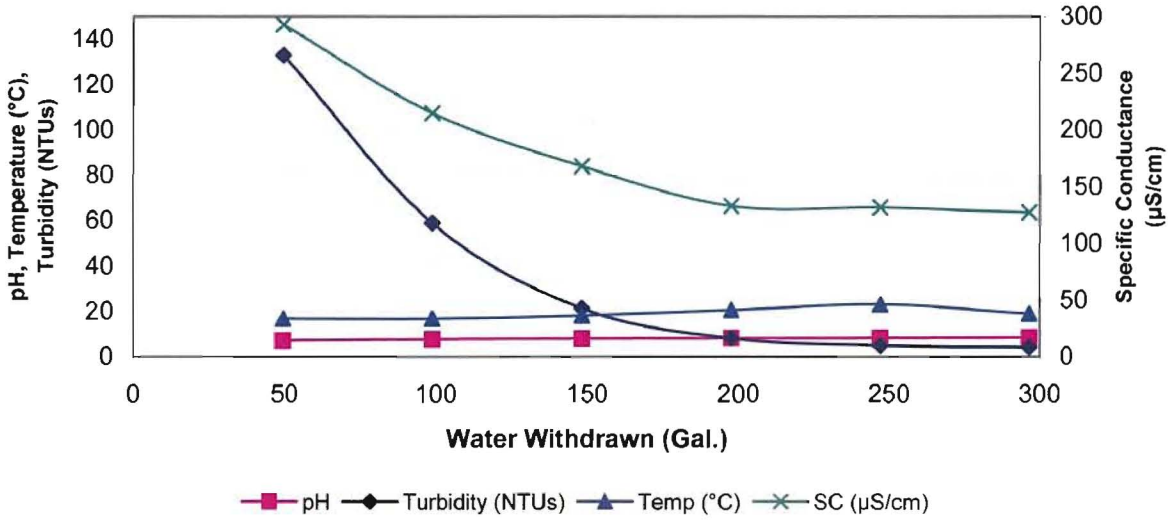
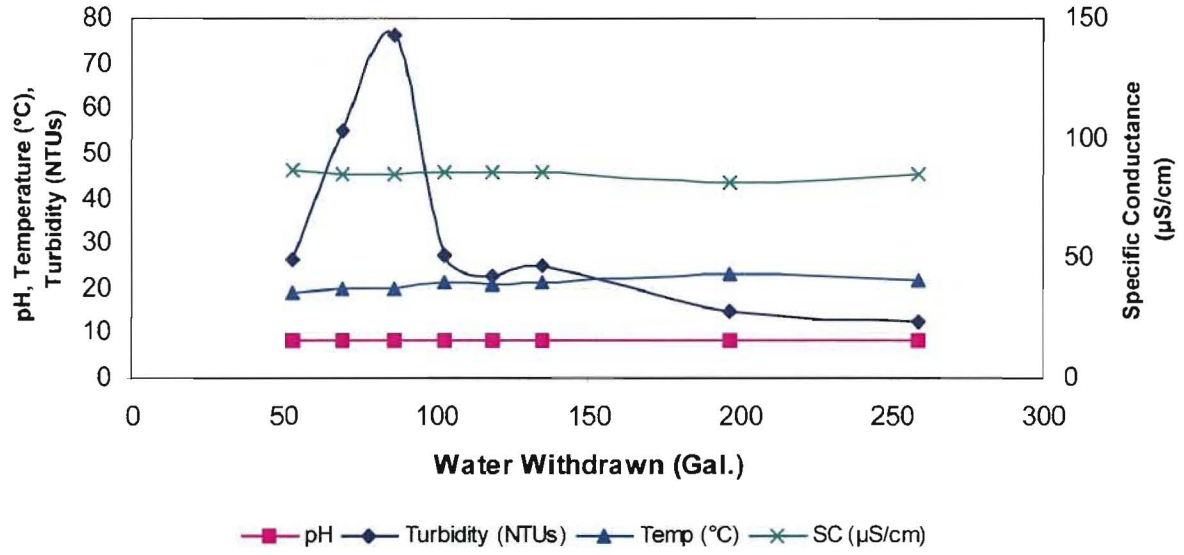


Figure 2.2-1. R-20 Well Construction Diagram



(Note: Parameters were recorded after the calculated drop pipe water volume was discharged)

Figure 2.2-2. Water Quality Parameters – R-20 Initial Upper Screen Test, July 6, 2006



(Note: Parameters from three short-duration pumping tests were combined in this graph)

Figure 2.2-3. Water Quality Parameters – R-20 Final Upper Screen Test, August 28, 2006

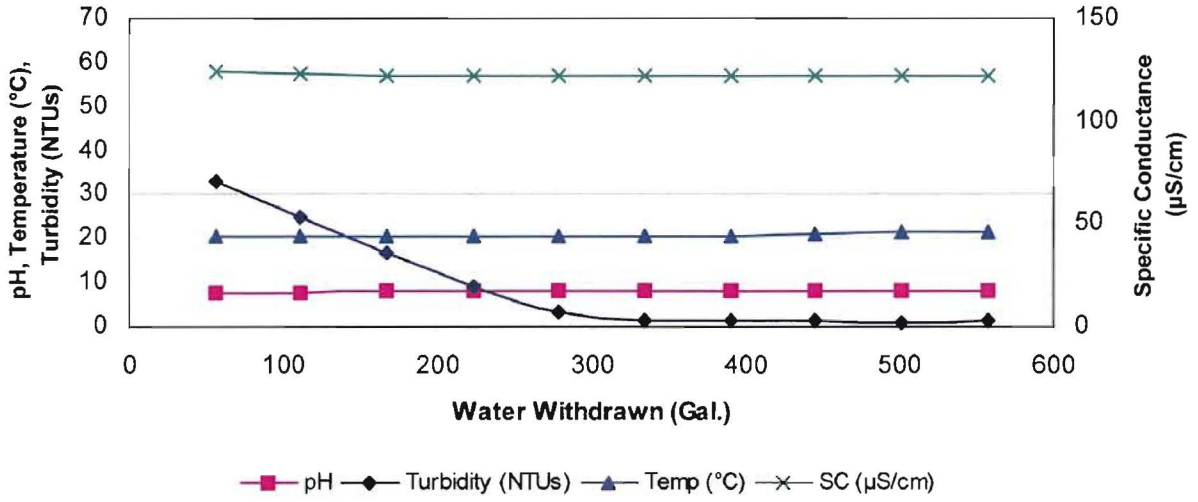
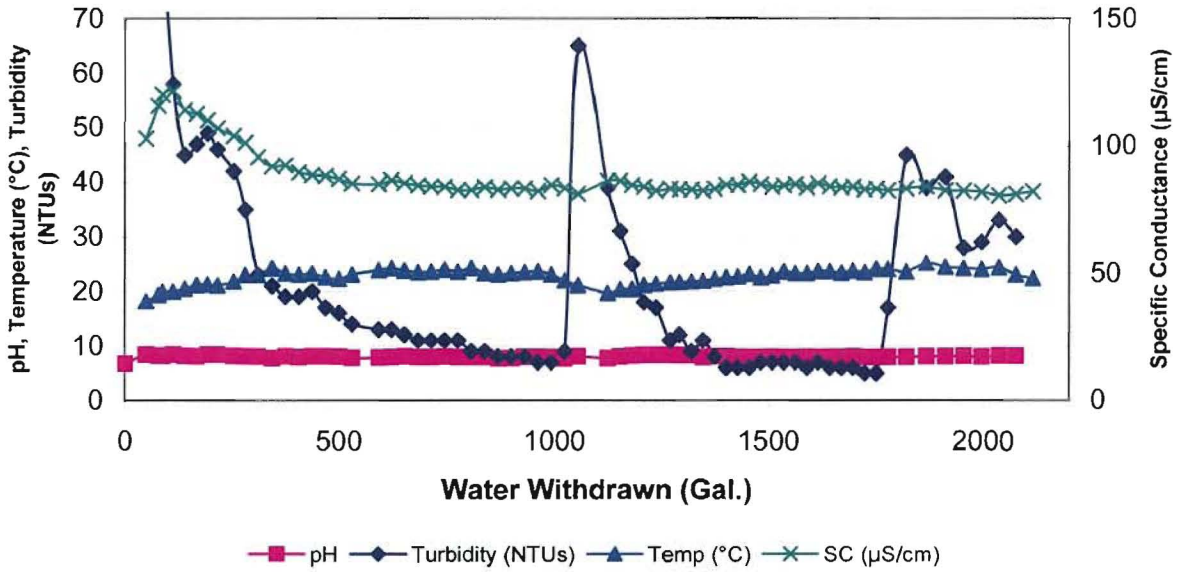


Figure 2.2-4. Water Quality Parameters – R-20 Initial Middle Screen Test, July 8, 2006



(Note: Two long-duration tests are plotted together. The turbidity peak in the middle of the chart represents the start of the second test. The turbidity peaks at approximately 1,800 gal. occurred after the valve was opened to increase the flow rate; field notes indicate the turbidity increased before the calculated arrival time of water from the middle screen and was due to rust in the pump drop pipe.)

Figure 2.2-5. Water Quality Parameters – R-20 Combined Upper and Middle Screen Tests, August 26 and 27, 2006

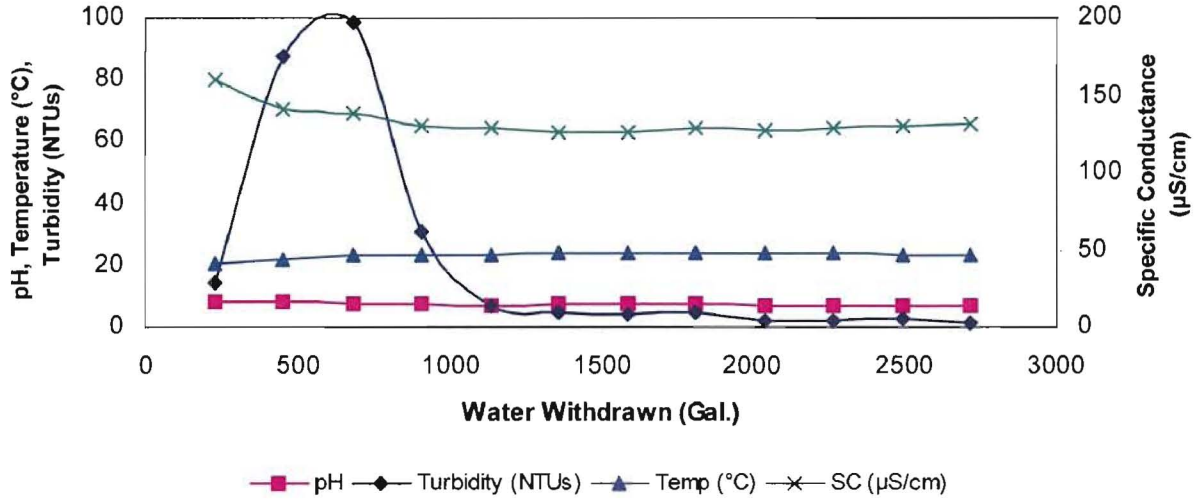


Figure 2.2-6. Water Quality Parameters – R-20 Initial Lower Screen Test, July 7, 2006

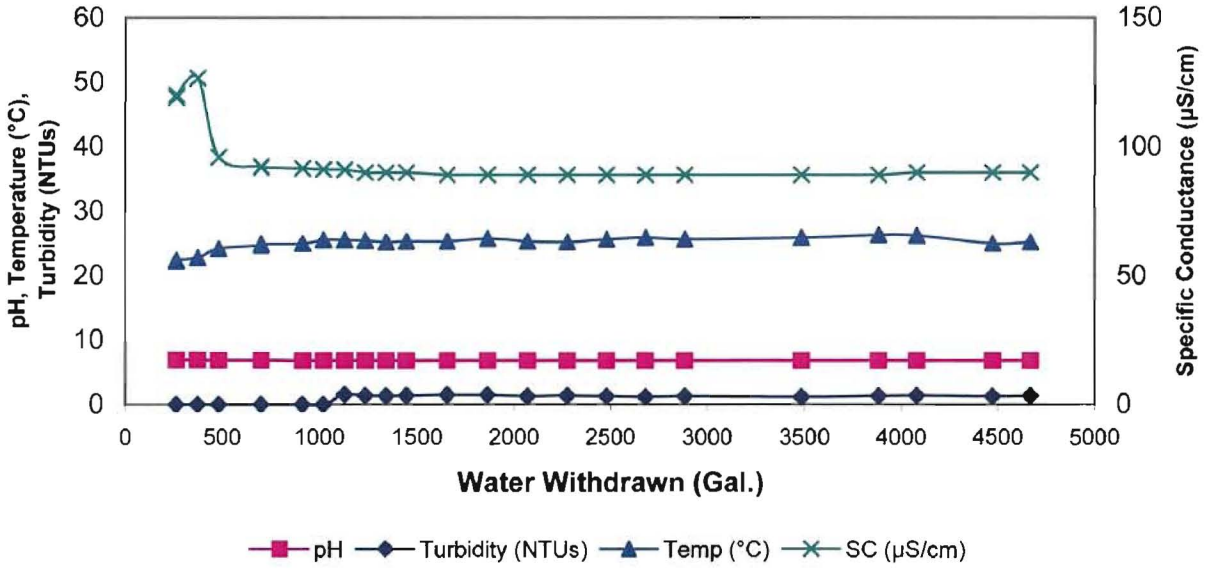
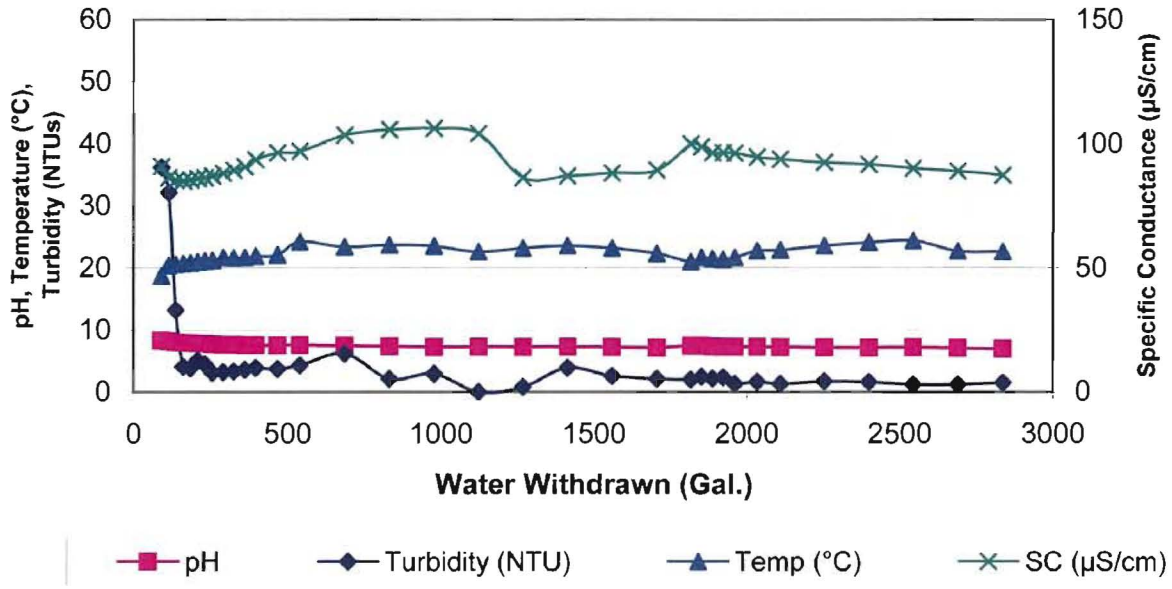


Figure 2.2-7. Water Quality Parameters – R-20 Initial Lower Screen Test, July 21, 2006



(Note: Two long-duration tests are plotted together.)

Figure 2.2-8. Water Quality Parameters – R-20 Lower Screen Tests, August 30 and 31, 2006

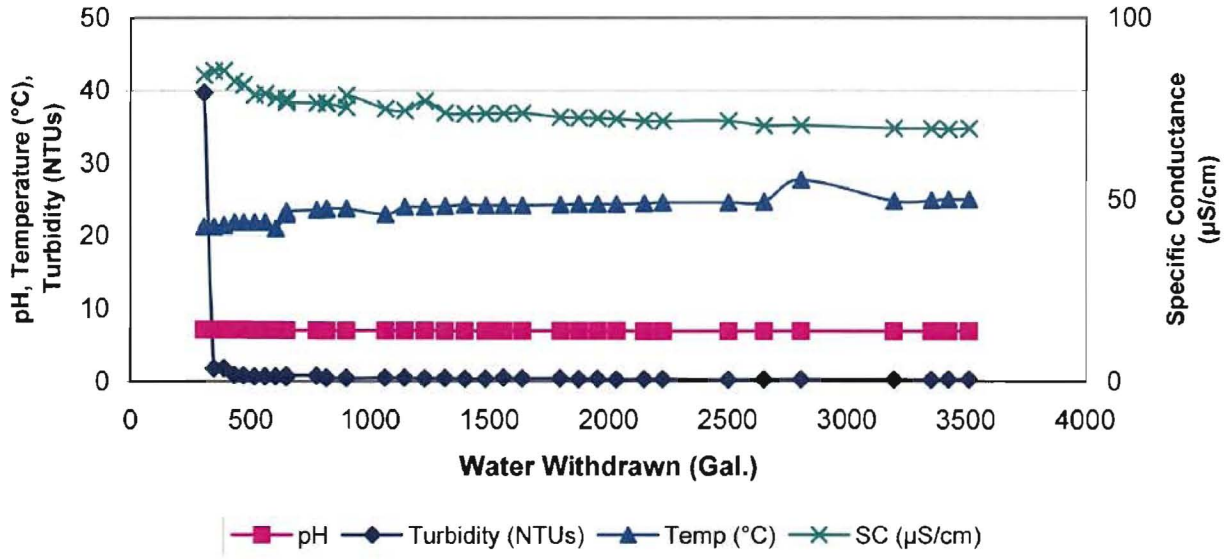


Figure 2.2-9. Water Quality Parameters – R-20 Final Lower Screen Test, October 13, 2006

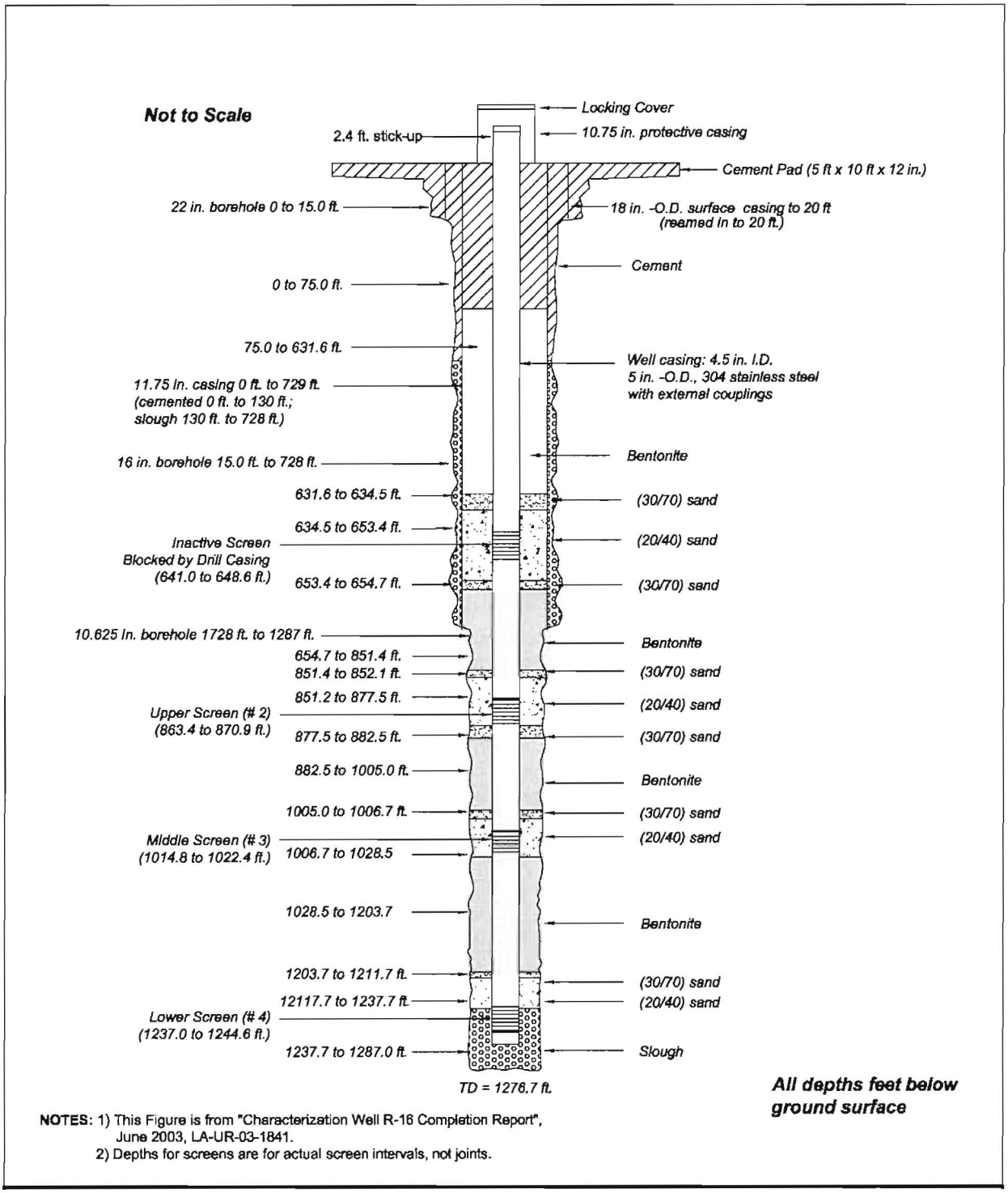


Figure 2.3-1. R-16 Well Construction Diagram

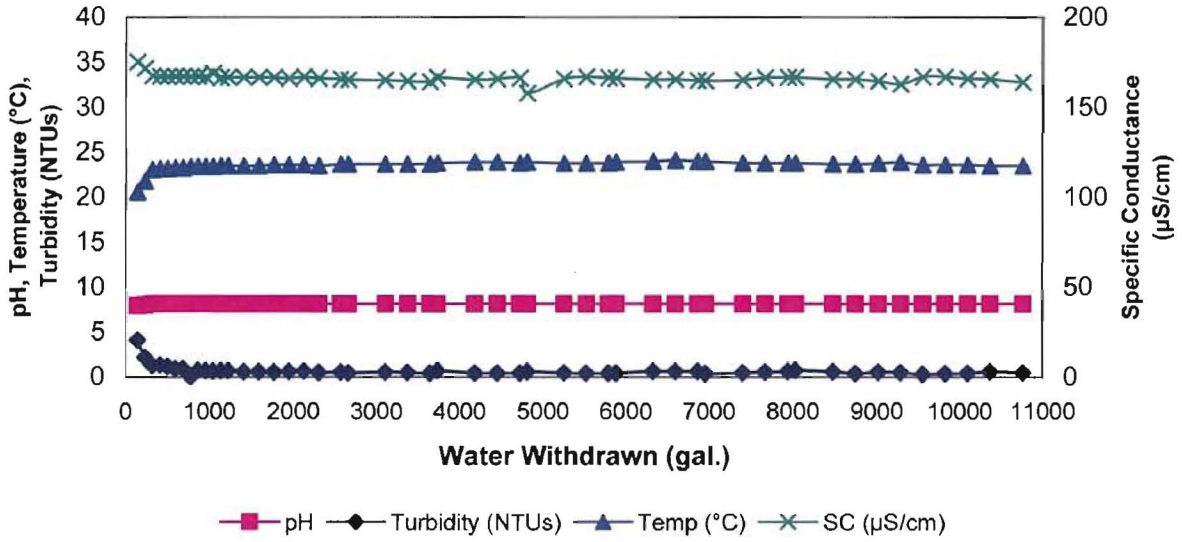


Figure 2.3-2. Water Quality Parameters – R-16 Upper Screen Test, August 11, 2006

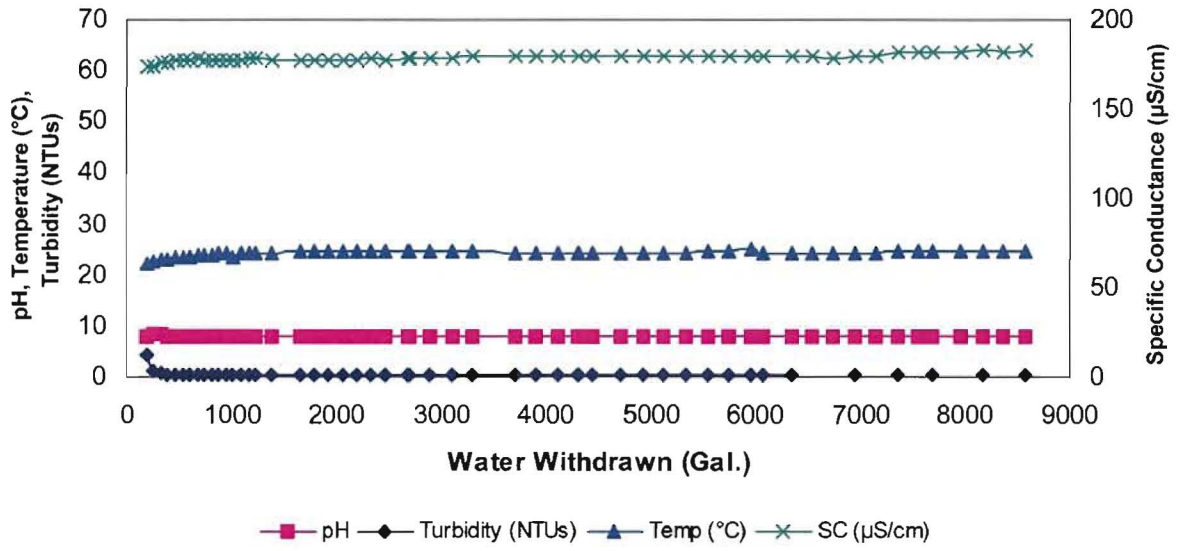


Figure 2.3-3. Water Quality Parameters – R-16 Middle Screen Test, August 10, 2006

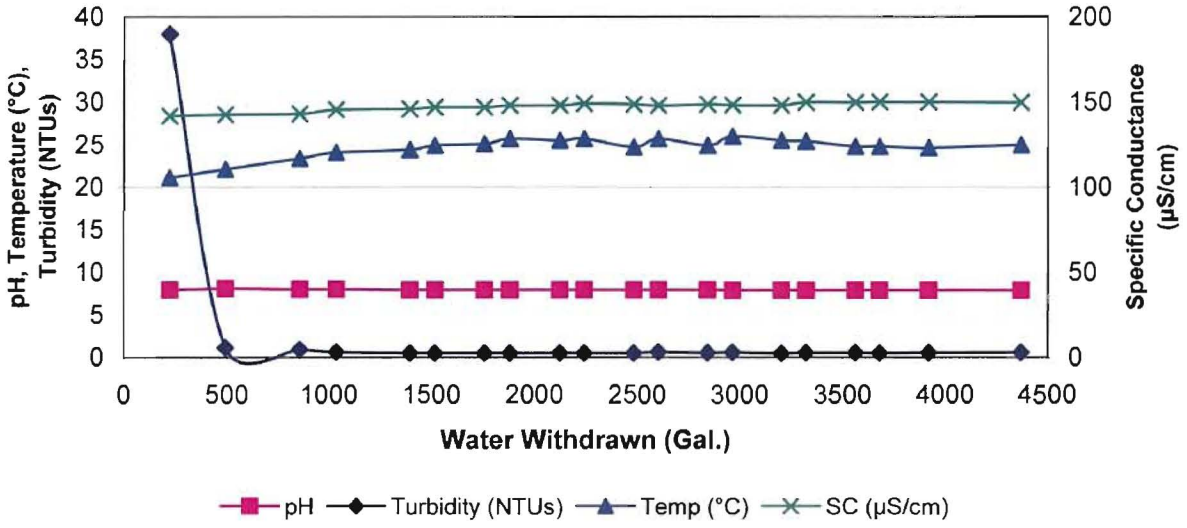


Figure 2.3-4. Water Quality Parameters – R-16 Lower Screen Test, August 9, 2006

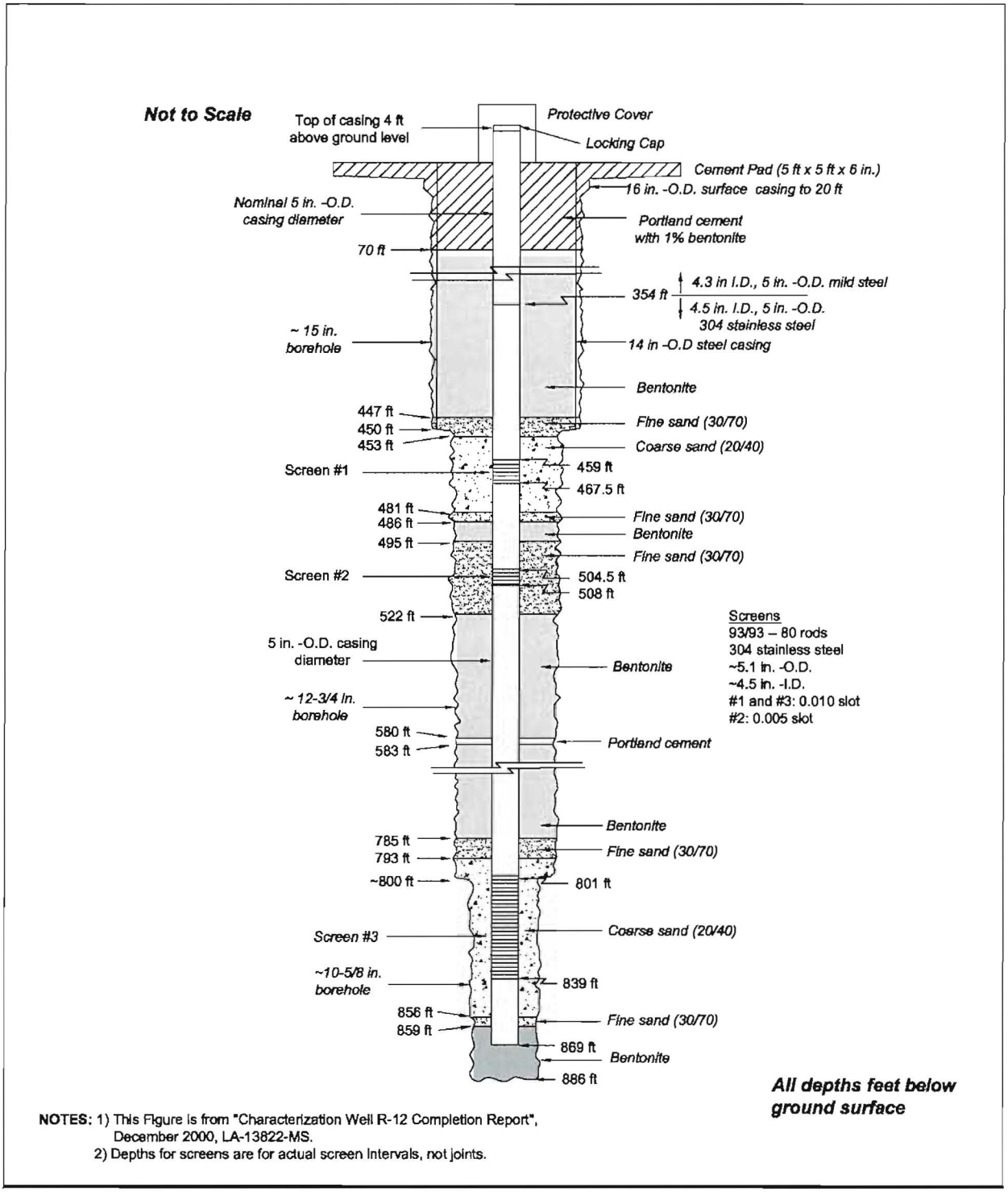


Figure 2.4-1. R-12 Well Construction

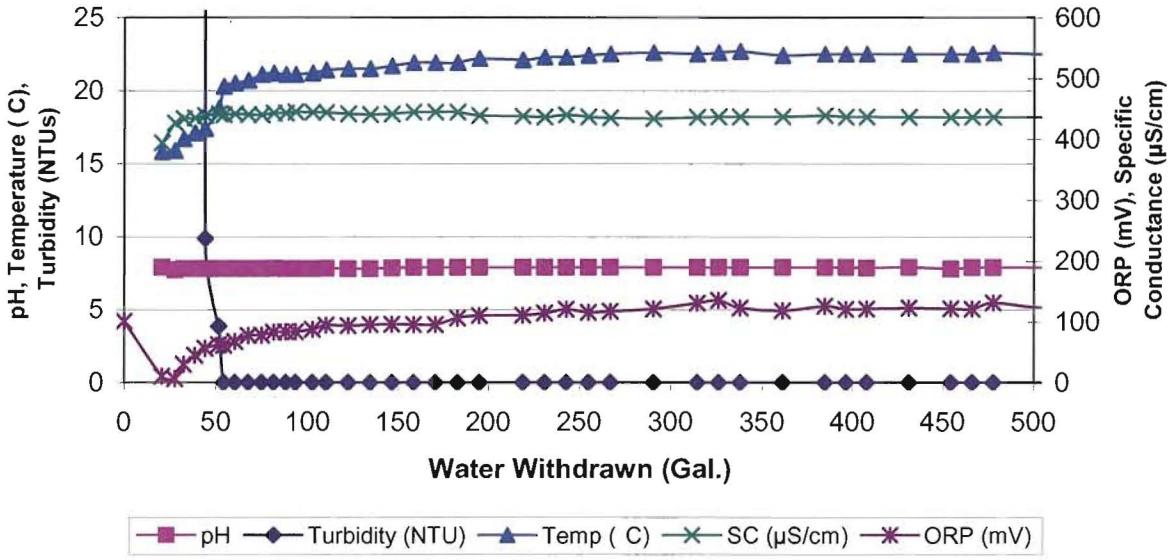


Figure 2.4-2. Water Quality Parameters – R-12 Upper Screened Interval Test

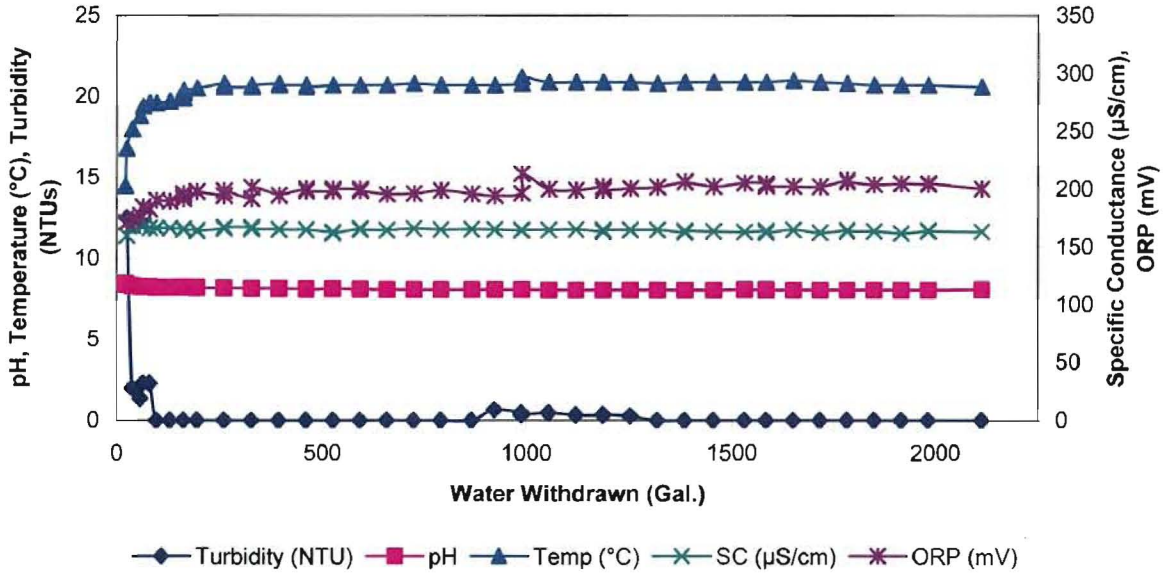


Figure 2.4-3. Water Quality Parameters – R-12 Middle Screened Interval Test

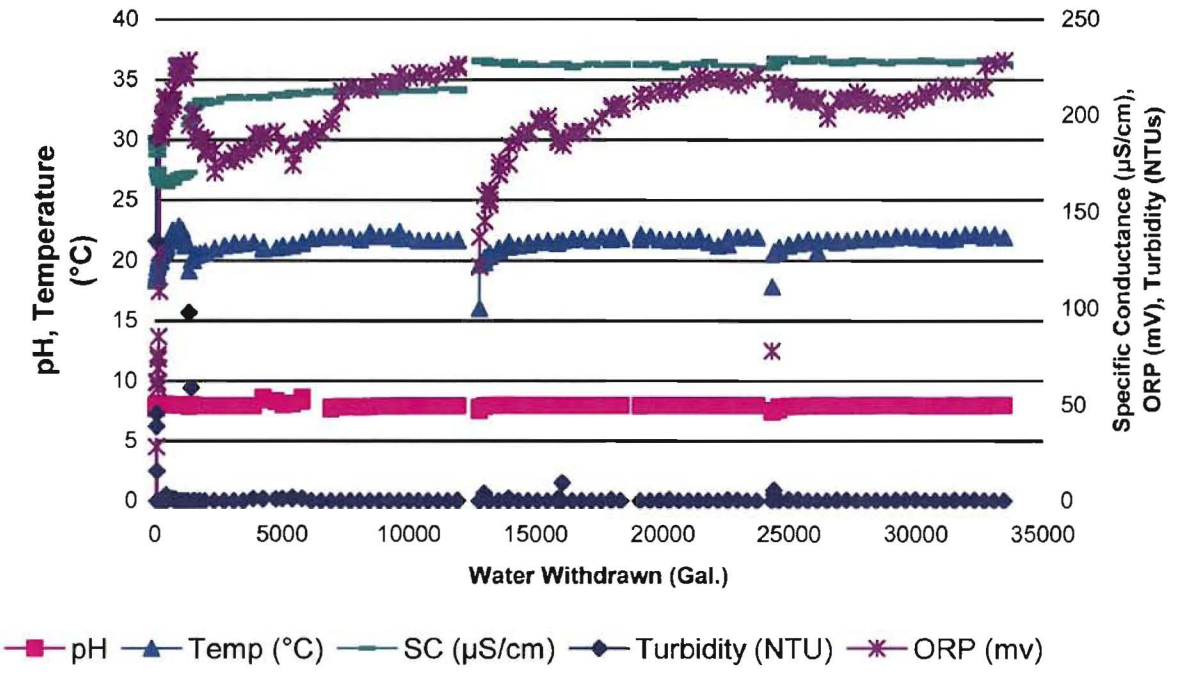


Figure 2.4-4. Water Quality Parameters – R-12 Lower Screened Interval Tests

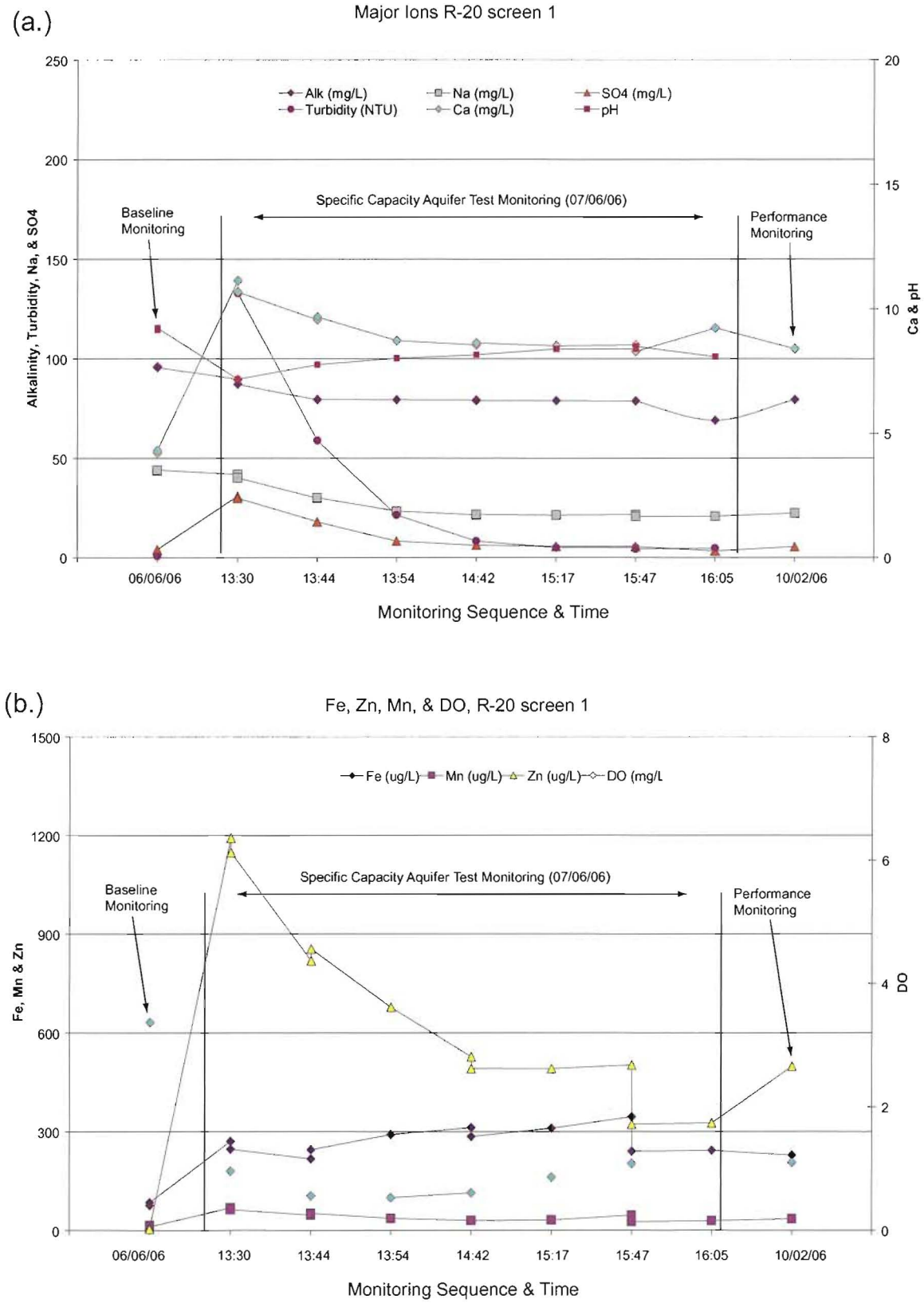


Figure 3.2-1. Geochemical Parameters at R-20 Screen 1

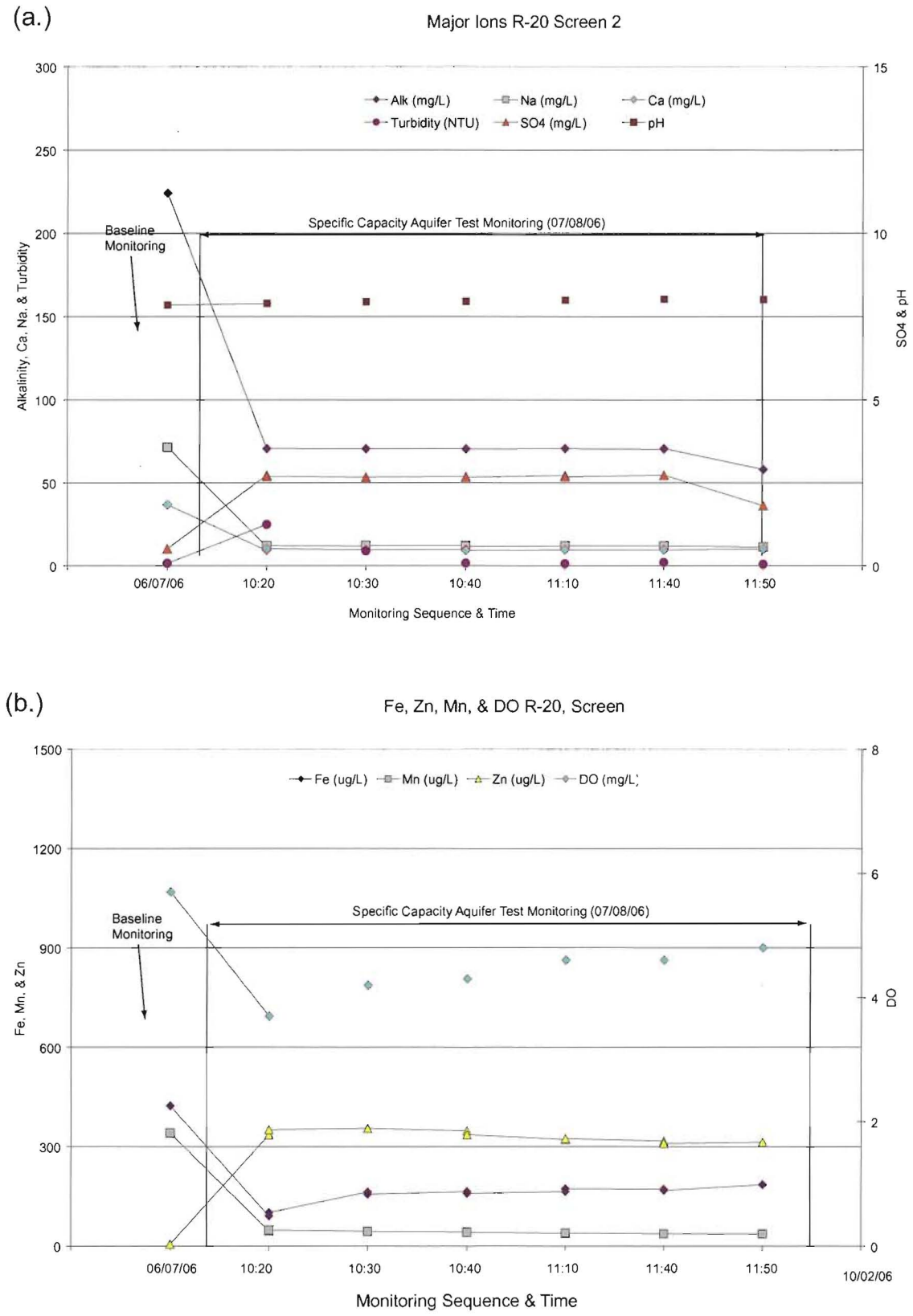


Figure 3.2-2. Geochemical Parameters at R-20 Screen 2

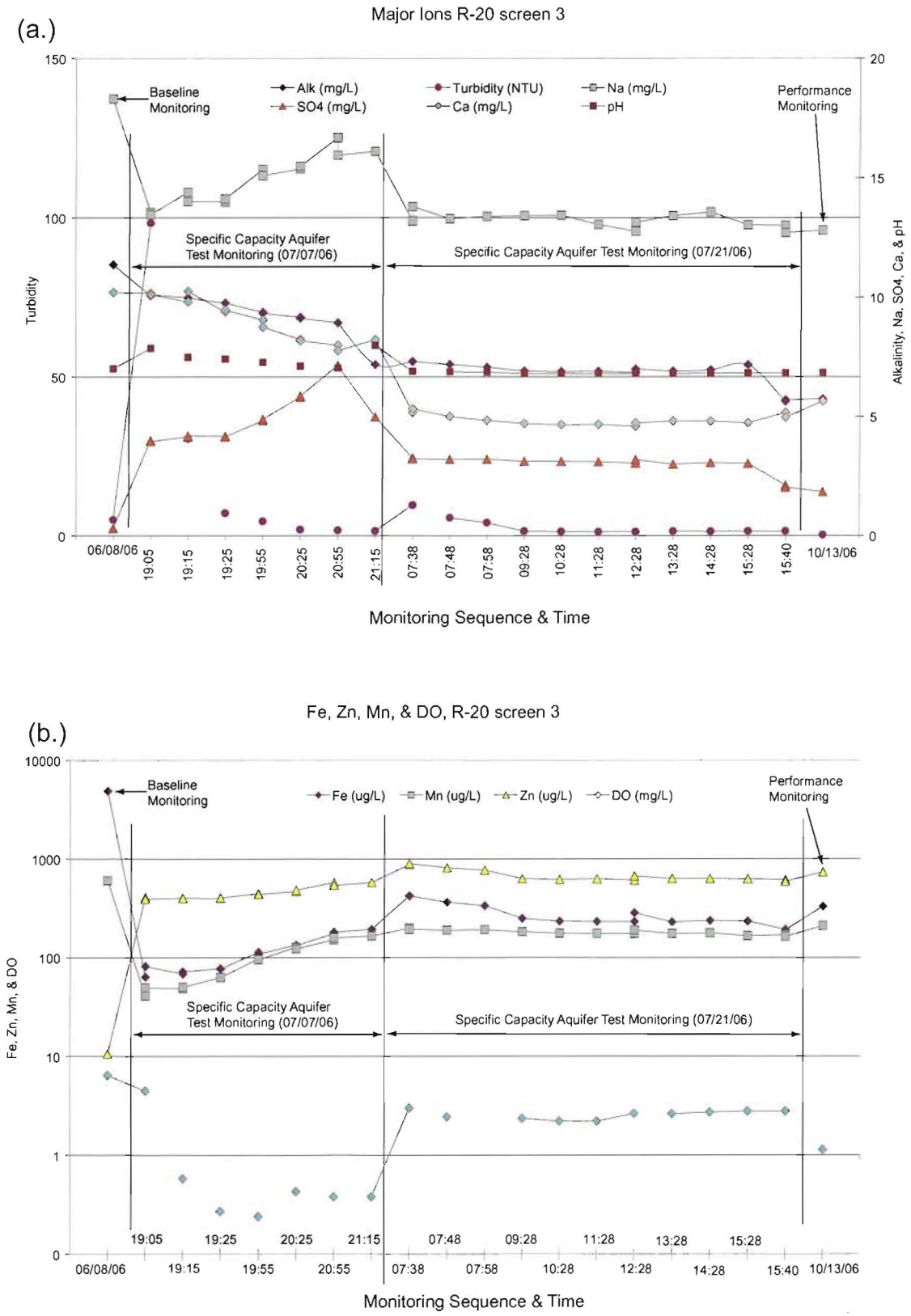


Figure 3.2-3. Geochemical Parameters at R-20 Screen 3

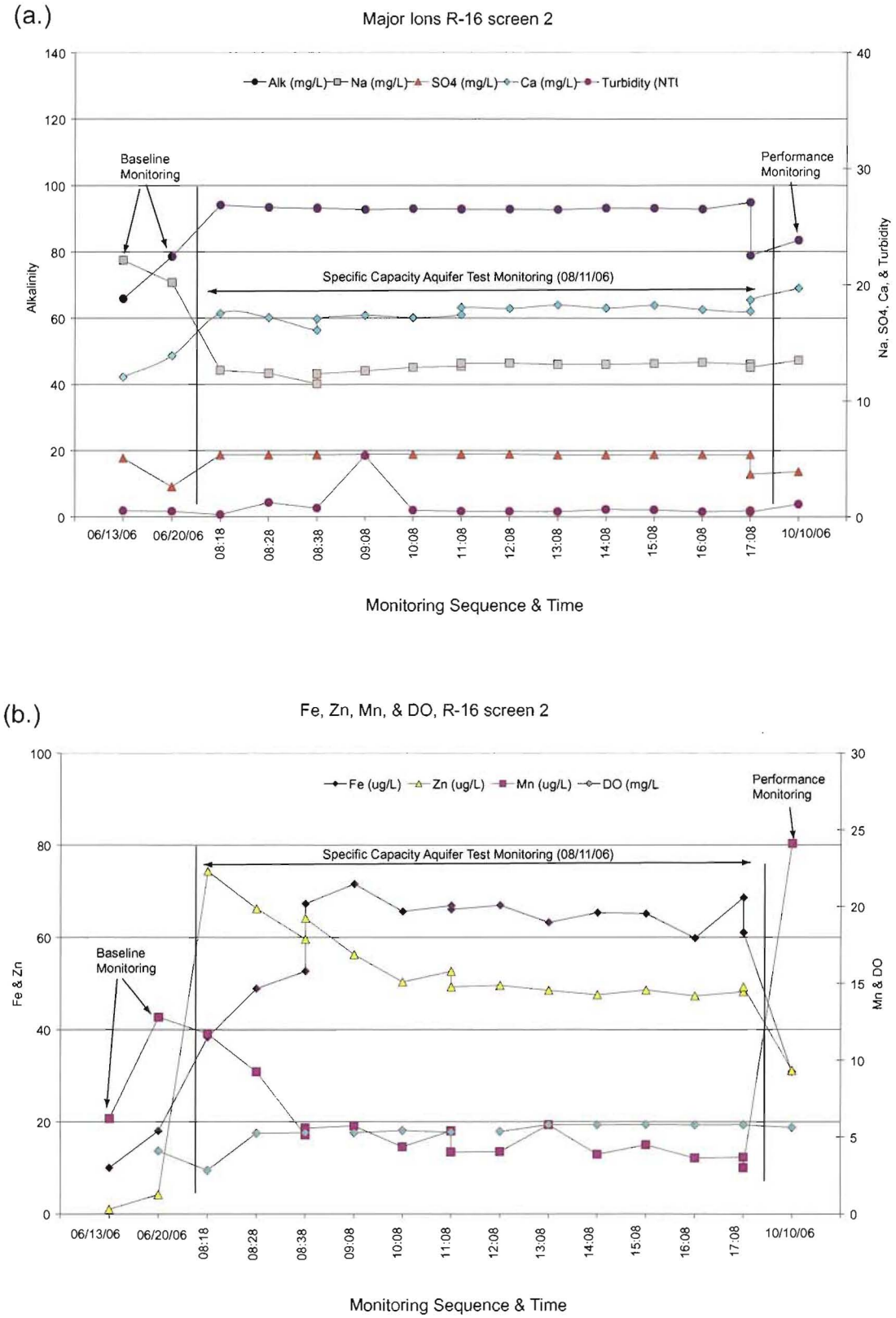
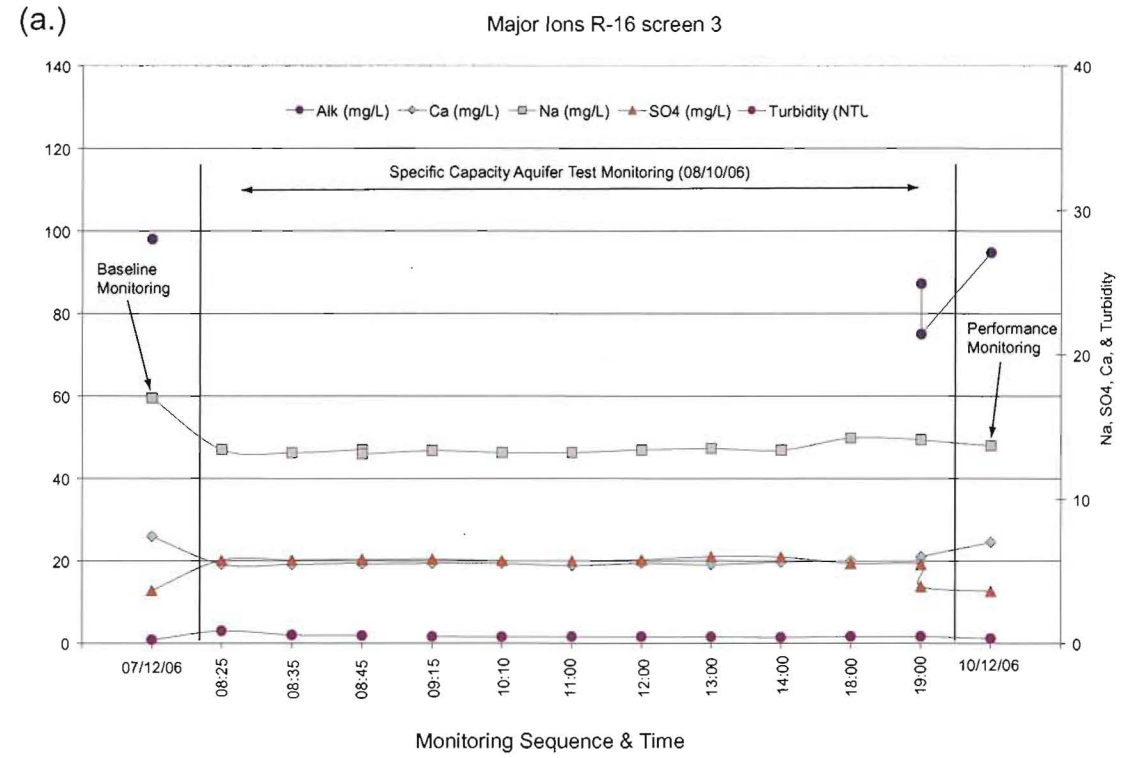


Figure 3.2-4. Geochemical Parameters at R-16 Screen 2



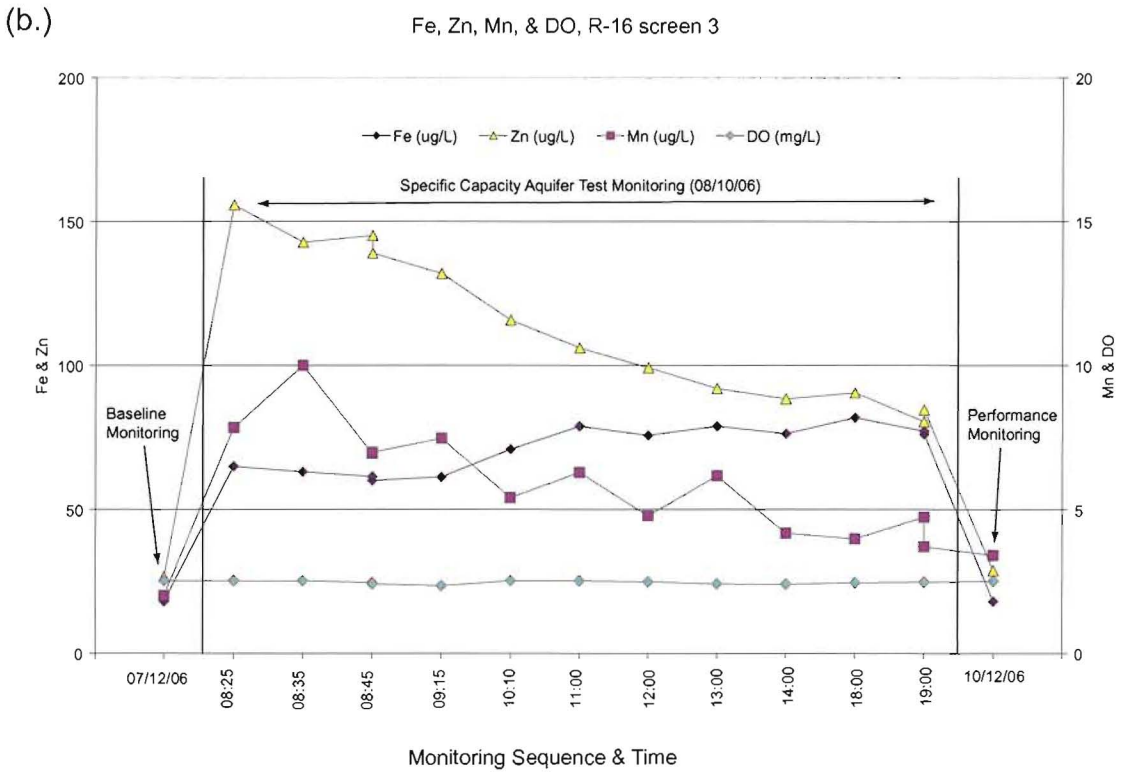


Figure 3.2-5. Geochemical Parameters at R-16 Screen 3

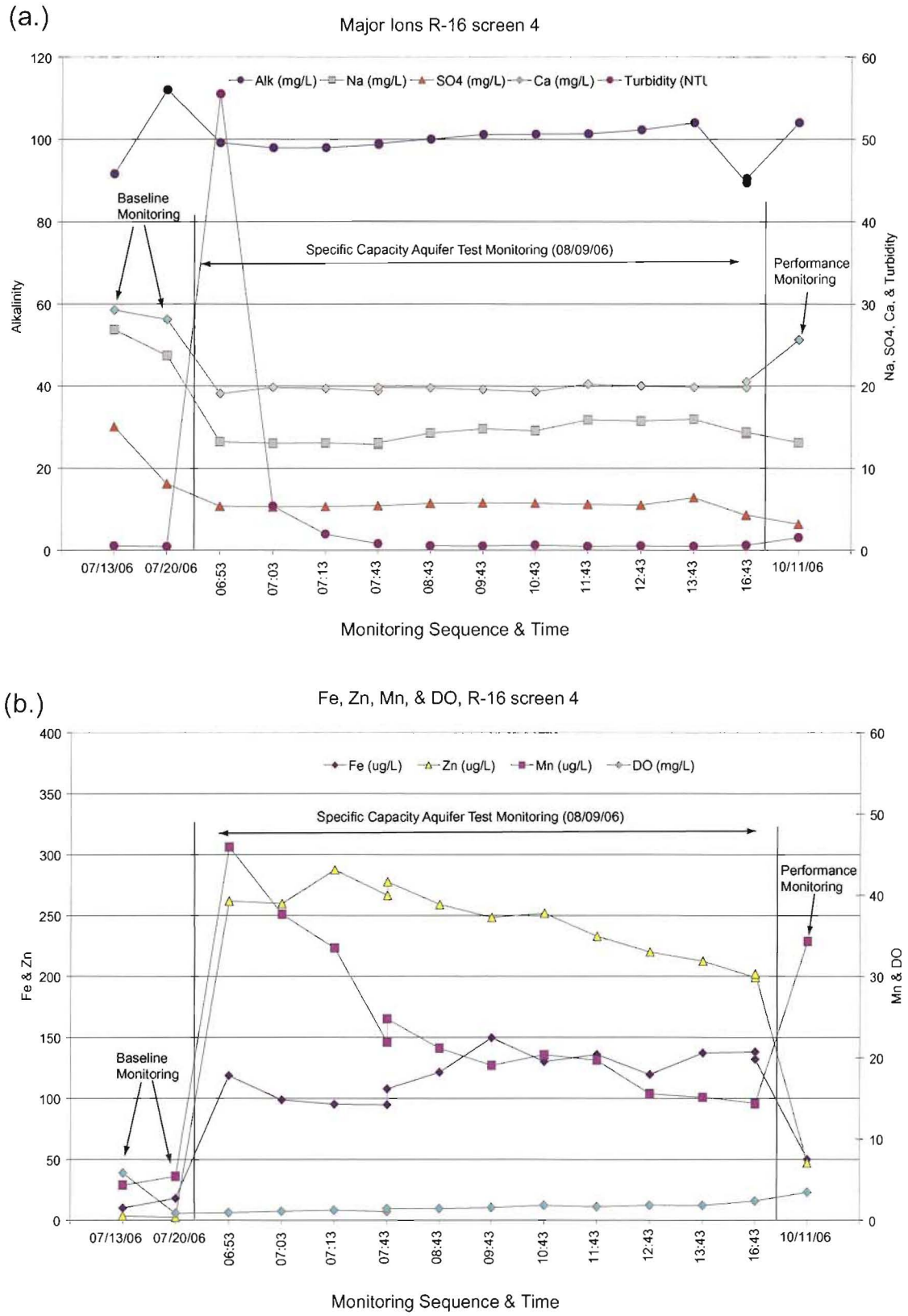


Figure 3.2-6. Geochemical Parameters at R-16 Screen 4

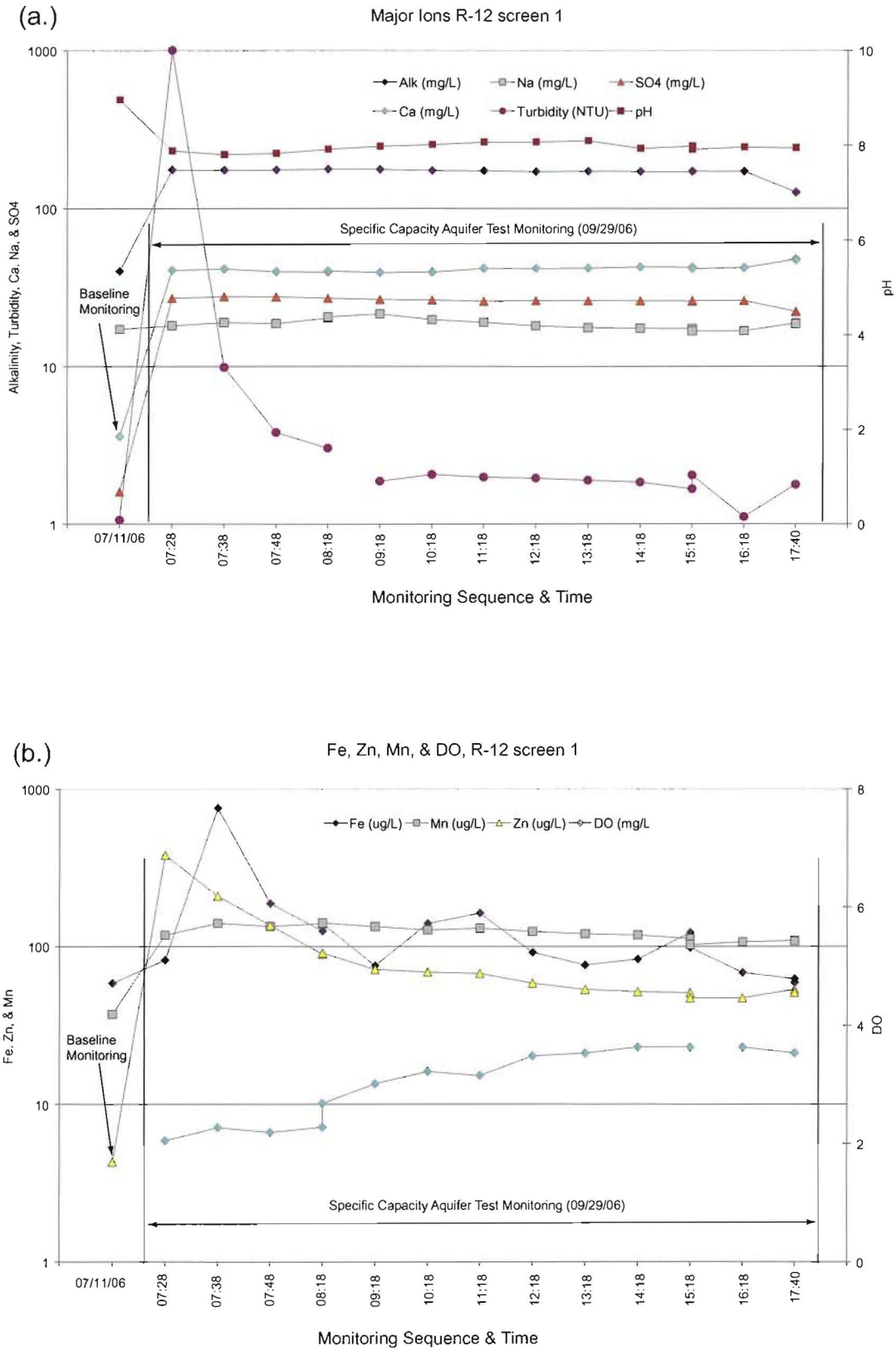


Figure 3.2-7. Geochemical Parameters at R-12 Screen 1

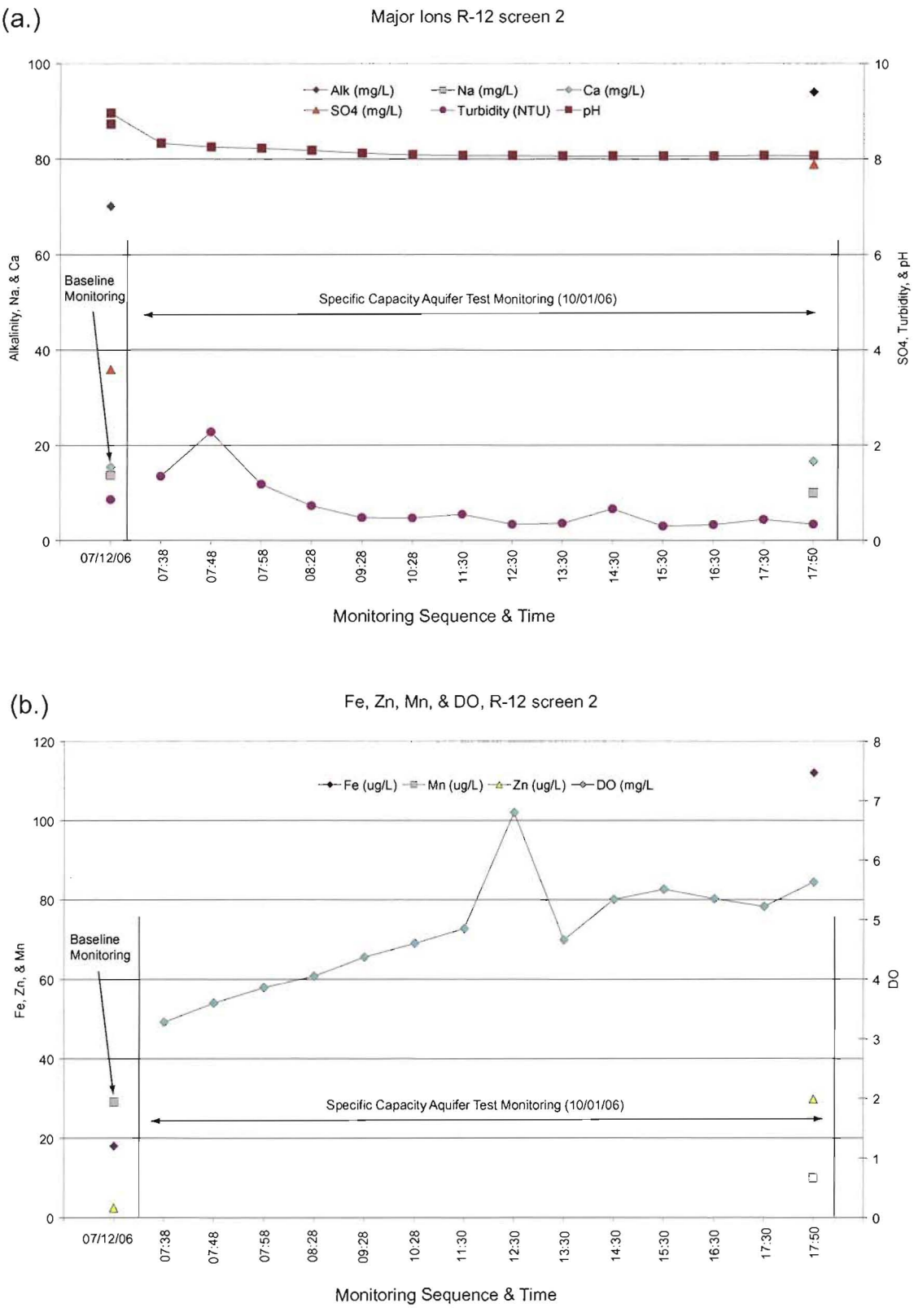


Figure 3.2-8. Geochemical Parameters at R-12 Screen 2

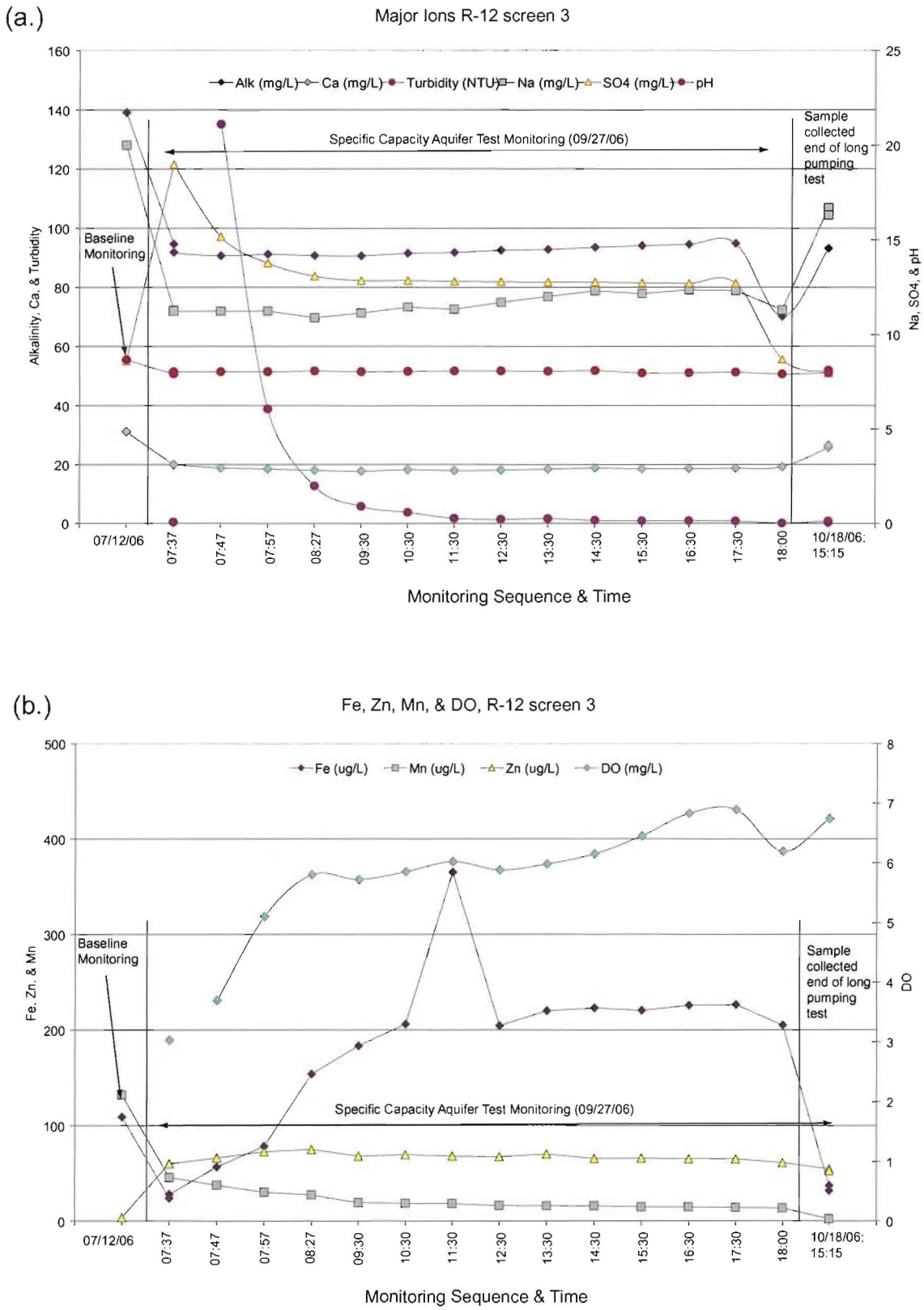


Figure 3.2-9. Geochemical Parameters at R-12 Screen 3

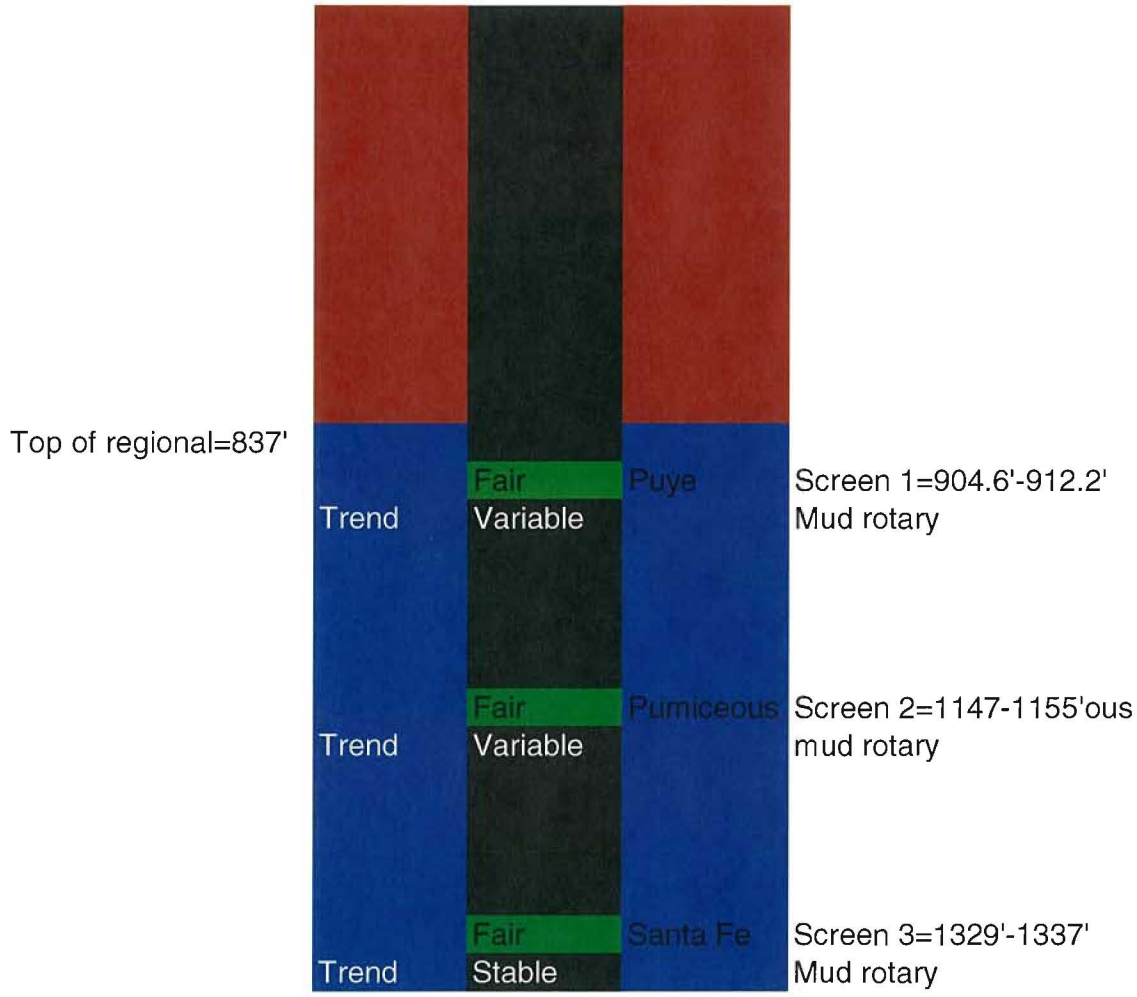


Figure 3.4-1. Well Screen Rankings at R-20 as of December 2006

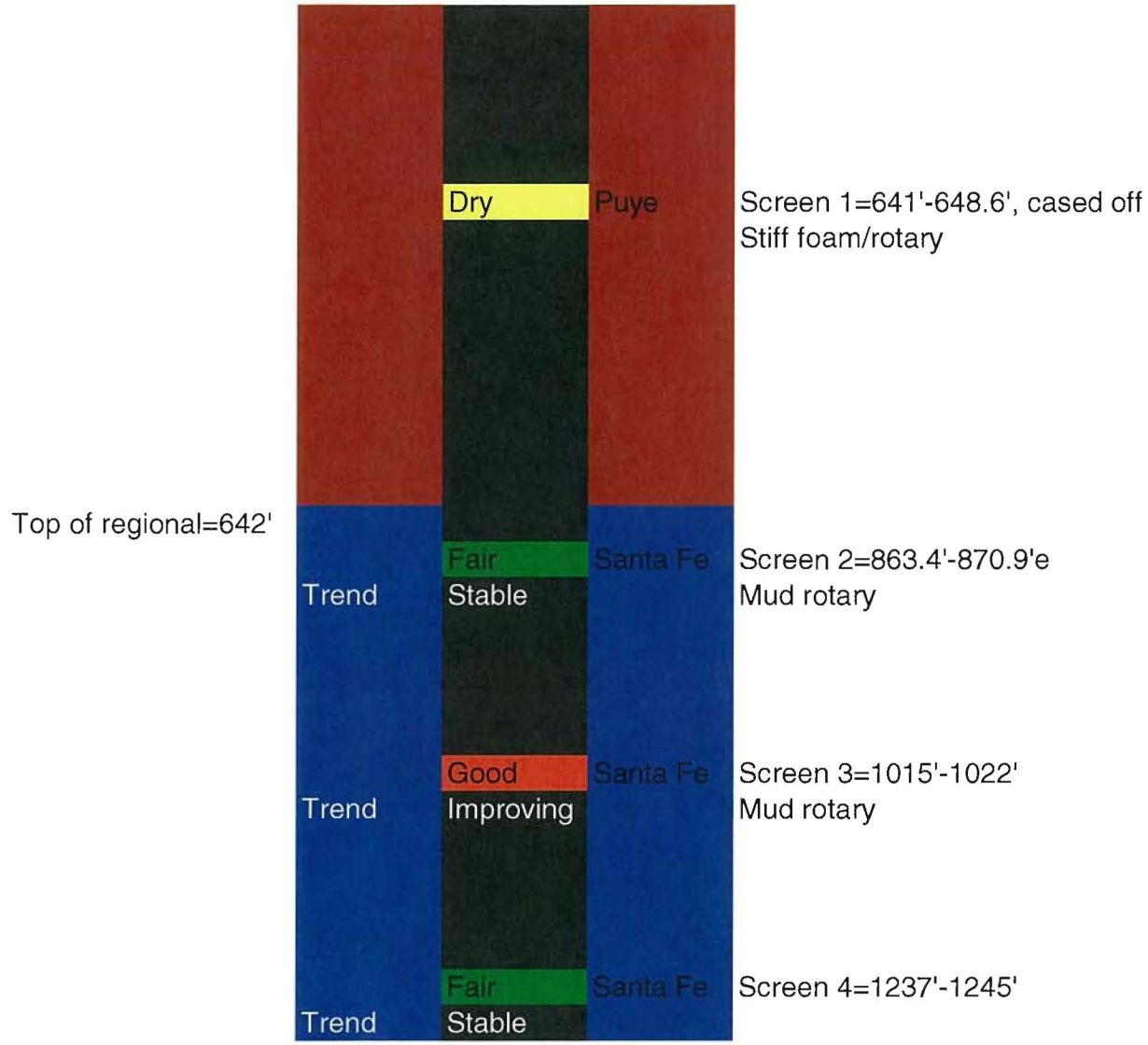


Figure 3.4-2. Well Screen Rankings at R-16 as of December 2006

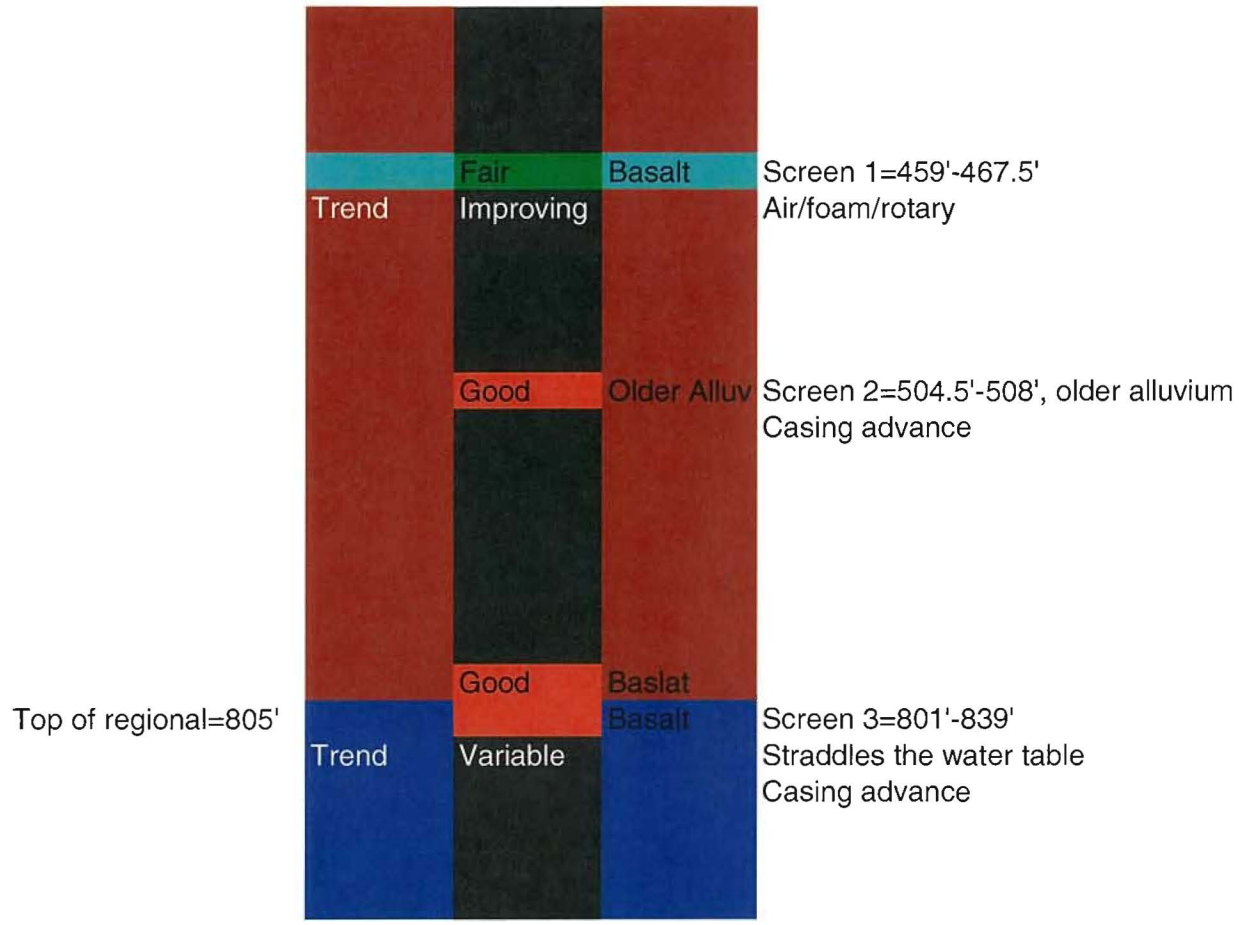


Figure 3.4-3. Well Screen Rankings at R-12 as of December 2006

Table 2.1-1
Fieldwork at Pilot Study Wells

Regional Well #	Fieldwork Dates
R-12	9-22-06 to 11-19-06
R-16	7-31-06 to 8-28-06
R-20	6-28-06 to 10-17-06

Table 2.2-1
R-20 Video Well Log, 0' to 1349'5"

	Observed Depths
Composite Static Water Level	835' 5"
Screen #1	903' 2" to 912' 2"
Screen #2	1145' 3" to 1152' 4"
Screen #3	1326' 4" to 1334' 5"
Total depth	1349' 5"

Datum—camera zeroed at ground surface.

Table 2.2-2
R-20 Specific Capacity Tests

Date	Screen	Pumping Time (minutes)	Pumping Rate (gpm)	Volume Pumped (gals)	Drawdown (ft)	Specific Capacity (gpm/ft)	Comments
7/06/06	1	350	0.8	296	75	0.011	Baseline—Q/s for screens 2 and 3 declined throughout test
7/07/06	3	180	16.1	2,717	171	0.094	
7/08/06	2	180	3.0	557	249	0.012	
	1,2					0.023	Sum of baseline results
	1,2,3					0.117	Sum of baseline results
7/10/06 to 7/18/06— bail and swab; Hydropuls; bail and swab							
7/19/06	1,2,3	720	14.5		340*	0.043	Q/s declined steadily
7/20/06	1,2,3	720	12.0		474	0.025	Q/s declined steadily
7/21/06	3	634	9.4	6380	474	0.020	Q/s declined steadily
7/21/06	2					0	Could not sustain pumping
7/21/06	1					0	Could not sustain pumping
8/8/06 to 8/11/06 and 8/17/06— backwash and bail open well							
8/20/06	1,2,3	129	3.0		16.3	0.184	Bridge plug leaking, so levels may be unreliable
8/21/06	1,2,3	30	3.0		25.3	0.119	
8/25/06	1,2					0.018	Casing refill events
8/25/06—pump and backwash, screens 1 and 2 combined							
8/25/06	1,2	variable				0.031	Casing refill events
8/26/06	1,2	687	1.55		73.2	0.021	
8/27/06	1,2	531	1.35		74.2	0.018	
8/28/06	1	160				0.012	Casing refill events
8/28/06	1,2,3	122	2.54		30.7	0.083	
8/30/06	3	720	2.43		34.3	0.071	
8/31/06	3	480	2.43		35.1	0.069	
10/11/06— jet screen 3 while pumping from open well							
10/11/06	1,2,3		10		98.4	0.102	Estimated Q/s while jetting
10/13/06	3	480	7.9		129.9	0.061	Q/s declined steadily
10/17/06	1	368	0.65		62.2	0.0105	Casing refill event

* Not measured—rough estimate inferred from pump performance curve.

Table 2.2-3
R-20 Video Well Log, Run #3

	Observed Depths
Composite Static Water Level	851'
Screen #1	901' 9" to 909' 1"
Screen #2	1143' 10" to 1151'
Screen #3	1325' to ? (too turbid near well bottom)
Total depth	1347' 11"

Datum— camera zeroed at ground surface.

Table 2.2-4
R-20 Gamma-Ray Log

Run No.	Depth
Run #1	0'-1353', down log at 30'/min.
Run #2	1353'—0', up log at 15'/min.

Table 2.3-1
R-16 Video Well Log, 0' to 1272'

	Observed Depths
Composite Static Water Level	644' 6"
Screen #1	641' 5" to 648' 6"
Screen #2	863' 4" to 870' 5"
Screen #3	1014' 4" to 1021' 6"
Screen #4	1236' 1" to 1243' 4"

Datum at ground surface.

Table 2.3-2
R-16 Gamma-Ray Log

Run No.	Depth
Run #1	0'-1265', down log at 30'/min.
Run #2	1260'—1185', up log across screen 4 at 15'/min.
Run #3	1045'—980', up log across screen 3 at 15'/min.
Run #4	895'—840', up log across screen 2 at 15'/min.
Run #5	895'—840', up log, duplicate run across screen 2, at 15'/min.
Run #6	675'—605', up log across screen 1 at 15'/min.

Table 2.3-3
R-16 Specific-Capacity Test Field Data

Date	Screen	Pumping Time (minutes)	Pumping Rate (gpm)	Volume Pumped (gals.)	Drawdown (ft)	Specific Capacity (gpm/ft)	Comments
08/09/06	4	720	6.0	4,368	276	0.022	Baseline
08/10/06	3	720	13.6	9,785	272	0.050	
08/11/06	2	720	18.0	12,926	214	0.084	

Table 2.4-1
R-12 Video Well Log, 0' to 869' 5"

	Observed Depths
Screen #1	462' 5" to 470' 11"
Screen #2	507' 2" to 510' 11"
Screen #3	803' (estimated) to 841'
Composite Static Water Level	Well turbulence too great to estimate

Datum at top of well casing; stick-up is 1' 5".

Table 2.4-2
R-12 Specific-Capacity Tests

Date	Screen	Pumping Time (minutes)	Pumping Rate (gpm)	Volume Pumped (gals.)	Drawdown (ft)	Specific Capacity (gpm/ft)	Comments
09/27/06	3	720	2.0	1,448	0.21	9.52	Baseline
09/29/06	1	720	1.2	860	12.8	0.09	
10/01/06	2	720	3.3	2,376	3.4	0.97	
10/16/06	3	10	19.2	11,393	7.6	2.53	Day 1 purge
10/16/06	3	600	19.2		5.6	3.43	Q/s increased during test
10/17/06	3	165	19.2	11,513	4.3	4.47	Day 2 purge— pump shutdown at 165 minutes
10/17/06	3	600	19.2		4.1	4.68	
10/18/06	3	600	19.3	11,591	3.9	4.95	Day 3 purge— continued increase in Q/s

Appendix A

Tables of Well Conditions Prior to Rehabilitation and Redevelopment

R-20, Geology and Geophysics of Screened Interval

R-20 Screen (Sand interval ft bgs)	Lithology at Screen Interval	Geophysical Logging Summary (depths in ft bgs)	Geophysical Indication of Screened Interval (depths in ft bgs)
Screen 1 (895.2–926.5)	Cerros del Rio Basalt (Tb4) Scoria/sediments, scoria (altered and bleached). 915–920: No recovery.	A significant shift in water saturation occurs at 755 ft; the location of the borehole fluid level at the time of the logging. However, another large shift in the water content occurs at 827 ft, decreasing from 15 to 50% below to 5%–15% above, with a corresponding equivalent decrease in total porosity associated with a significant lithology change. The low porosity formation above 827 ft has low hydraulic conductivity and, thus, is not an aquifer. These processed geophysical log results, interpreted by themselves, suggest that the top of the regional groundwater aquifer likely is 827 ft, with the tight bed above acting as a confining layer. It is possible the confining layer is saturated up to the depth of 755 ft. The measured near wellbore water-filled porosity is greater than 20% of total formation volume through most of the interval 828–1365 ft and is less than 20% and predominantly below 10% through most of the interval 46–828 ft. In the upper interval there are two major zones where the water content is elevated compared with surrounding zones: 132–286 and 398–546 ft, reaching 20% and 30% total rock volume fraction (matrix plus pore space), respectively. The highest water-filled porosities (greater than 30%) occur in the major zones 858–877 ft, 1086–1089 ft, and 1136–1244 ft. Effective water-filled porosity (moveable water) is generally 5% or less through most of the logged section, ranging from a low of 0% to a high of 26%. Correspondingly, the estimated hydraulic conductivity is generally low. The highest effective water-filled porosities (greater than 10%) occur in the zones 1086–1090 and 1127–1240 ft, with a peak of 26% of total volume at 1194 ft. The integrated log analysis shows a mafic-mineral-rich and quartz/silica-glass deficient interval from 393 to 924 ft that likely corresponds to a basalt lava flow sequence. The interval 397–630 ft has very high matrix grain density (2.8–3.1 g/cc) and significant heavy mafic mineral content (10–22% dry weight fraction), but widely varying total (air and water-filled) porosity ranging from 11% to 55% volume fraction. The high-porosity zones must be highly fractured and broken up (e.g., volcanic breccias), highly vesicular, or of .aa-texture. The remaining sections of the logged section contain a significant amount of quartz/silica glass. A volcanic tuff sequence (likely the Bandelier Tuff) in the upper half of the logged interval (54–390 ft) is clearly distinguished by the logs and is characterized by • very high total porosity (60%) in the bottom 15 ft (275–390 ft), which likely corresponds to the Guaje Pumice Bed; • lower, but still high, porosity (50%–55%) in the uphole direction from 172–275 ft; • a distinct drop in the gross gamma log and bulk density across the zone 158–172 ft, for which the integrated log analysis shows decreased total porosity (average 35%) and increased amounts of clay, likely corresponding to a formation/lithology change; and • very high total porosity (48%–60%) across the interval 54–158 ft.	These processed geophysical log results suggest that the top of the regional groundwater aquifer intersected by R-20 likely is 827 ft, with the tight bed above acting as a confining layer. It is possible the confining layer is saturated up to the depth of 755 ft or that 755 ft is the potentiometric head of the regional aquifer (the static water level in the well). Zones with apparent water content of 30% or greater by volume occur at 884–886 ft and 983–987 ft. The measured near-wellbore water-filled porosity is greater than 20% of total formation volume through most of the interval 828–1365 ft. The highest water-filled porosities (greater than 30%) occur in the major zones 858–877 ft, 1086–1089 ft, and 1136–1244 ft. Effective water-filled porosity (moveable water) is generally 5% or less through most of the logged section, ranging from a low of 0% to a high of 26%. Correspondingly, the estimated hydraulic conductivity is generally low. Pe is consistently above 3 from 392 to 924 ft and mostly above 4 (often 5 or above) from 400 to 830 ft. The dense upper section 397–630 ft is probably basalt lava flow material. The lower interval, 630–924 ft, is also likely comprised of basaltic rock, although with a lower heavy mafic mineral content. The ELAN analysis predicts variable amounts of clay/montmorillonite throughout most of the logged section. Above 975 ft there are a few zones with clay content above 20%, but most of the logged interval contains 15% or less, with many zones containing no clay.

R-20, Geology and Geophysics of Screened Interval (continued)

R-20 Screen (Sand interval ft bgs)	Lithology at Screen Interval	Geophysical Logging Summary (depths in ft bgs)	Geophysical Indication of Screened Interval (depths in ft bgs)
Screen 2 (1132.5–1165.5)	Top of pumiceous Puye Formation (Tpp). Fanglomerate. volcaniclastic sediments, mainly clayey sand (SC) with gravel and clayey sand (SC).	The integrated log analysis predicts significant, but highly variable, amounts of clay/montmorillonite below 975 ft, on average mostly above 10% dry rock matrix volume, frequently above 20%, and with a peak value of 62%. Above 975 ft there are a few zones with clay content above 20%, but most of the logged interval contains 15% or less, with many zones containing no clay. Interpreted bed boundaries across the imaged interval 777–1370 ft have dip azimuths (direction beds are dipping to) predominantly in the sector 180–260 degrees, with the highest concentration falling in the 10-degree range 210–220 degrees. The mean dip azimuth across this interval is 226 degrees. The interpreted bed boundaries have a wide range of dip angles (degrees of dip) from zero to 60 degrees, although more than 90% have dip angles less than 20 degrees and the mean dip angle is 6 degrees. A number of fractures were discernible across this interval, having dip azimuths mostly in the sector 170–220 degrees and a mean dip azimuth of 192 degrees. The fracture dip angles ranged 20–90 degrees, with a mean of 47 degrees. Across much of the imaged interval (928–1370 ft) the electrical resistivity image shows a well-bedded, thinly bedded alternating gravel-sand-silt-clay stratigraphy. Above this, the image exhibits much more massive bedding, likely corresponding to basalt lavas. A significant portion of the borehole was washed out in the top half of the log interval (46–775 ft), the diameter ranging from 17 in. (the bit size) to 25 in. The bottom half of the logged interval (775–1370 ft) contains only one interval of significant washouts (826–876 ft). Some of the washouts are abrupt, possibly cavities. The shallow-reading log measurements, predominantly the porosity reading ones, were adversely affected in a relatively few zones that contained abrupt washouts and/or high hole rugosity. The maximum deviation of the borehole across the log interval measured (777–1370 ft) is 3.5 degrees; the azimuth of deviation is to the north-northeast.	The measured near wellbore water-filled porosity is greater than 20% of total formation volume through most of the interval 828–1365 ft. The highest effective (moveable) water-filled porosities (greater than 10%) occur in the zones 1086–1090 and 1127–1240 ft, with a peak of 26% of total volume at 1194 ft. The ELAN log analysis predicts significant, but highly variable, amounts of clay/montmorillonite below 975 ft, on average mostly above 10% dry rock matrix volume, frequently above 20%, and with a peak value of 62%.
Screen 3 (1320.6–1344.5)	Santa Fe Group (Tsf) Volcaniclastic sediments, sand (SW) with clay.		The measured near-wellbore water-filled porosity is greater than 20% of total formation volume through most of the interval 828–1365 ft. The ELAN log analysis predicts significant, but highly variable, amounts of clay/montmorillonite below 975 ft, on average mostly above 10% dry rock matrix volume, frequently above 20%, and with a peak value of 62%.

Note: The data shown in this table were taken from LANL 2003 (079600). Also see LANL 2005 (091121).

ELAN = elemental log analysis program, ft bgs = feet below ground surface, Pe = photoelectric effect (a measure of porosity)

R-20, Data Quality Objectives

This well was installed east of TA-18, on the south side of Pajarito Road in Pajarito Canyon to

- provide hydrogeologic and water-quality data for regional groundwater near potential contaminant release sites at TA-54,
- function primarily as a monitoring well between MDA L at TA-54 and supply well PM-2,
- provide data for the Laboratory hydrologic and geologic conceptual models, and
- contribute to implementing a Laboratory-wide groundwater monitoring system.

Screen 1 was designed to monitor near the top of the regional aquifer in cinder beds of the Cerros del Rio lavas. Screen 2 was designed to monitor within the regional aquifer in pumiceous Puye Formation fanglomerate. Screen 3 was designed to monitor within the regional aquifer in the Santa Fe Group sediments.

Effective Screen Interval[a] (ft)	Drilling Fluids and Method(s) Used	Additives (i.e., solids, LCM)	Well Installation Fluids	Well Development Methods and Volumes Added/Removed[b]	Time Screen/Zones in Communication[c]
Screen 1 (895.2–926.5)	(Below 780 ft bgs) Mud rotary Water, Quick-Gel, Liqui-Trol	Pac-L, N-Seal, magma fiber	Water for filter pack, water and EZ-MUD for bentonite (Benseal, Pelplug) seals. Approx. 41,400 gal. of municipal water used for installation.	Brushing/swabbing/surging/bailing, PFD added, surging/bailing, acid treatment, surging/bailing, pumping, brushing/bailing, pumping, pumping with packer isolation. 616 gal. of PFD and MGA+AE solutions added. 24,018 gal. removed.	27 days (Dec. 22 to Jan. 18, 2003)
Screen 2 (1132.5–1165.5)				Brushing/swabbing/surging/bailing, PFD added, surging/bailing, acid treatment, surging/bailing, pumping, brushing/bailing, pumping, pumping with packer isolation. 616 gal. of PFD and MGA+AE solutions added. 29,160 gal. removed.	
Screen 3 (1320.6–1344.5)				Brushing/swabbing/surging/bailing, PFD added, surging/bailing, acid treatment, surging/bailing, pumping, brushing/bailing, pumping, pumping with packer isolation. 616 gal. of PFD and MGA+AE solutions added. 35,680 gal. removed.	

Note: The data shown in this table were taken from LANL 2003 (079600). Also see LANL 2005 (091121).

[a] Effective screen interval is sand pack installed across the well screen; does not include transitional sand pack adjacent to sealing materials.

[b] Chemical treatments involved PFD, MGA, and AE solutions.

[c] From completion of well development to completion of Westbay installation.

AE = acid enhancer, LCM = lost circulation material(s), MDA = material disposal area, MGA = modified granular acid, PFD = phosphate-free dispersant

R-16, Geology and Geophysics of Screened Interval

R-16 Well Screens (Sand interval ft bgs)	Lithology at Screen Interval	General Geophysical Interpretation (depths in ft bgs)	Geophysical Indication of Screened Intervals (depths in ft bgs)
Screen 1 (634.5–653.4)	NA	The estimated water saturation (fraction of pore space filled with water) remains high through most of the logged section, never dropping below 50% of total pore volume. These processed log results, interpreted by themselves, suggest that the entire interval from 311 to 1285 ft may lie within the regional aquifer, below the water table, although the results could be an artifact of borehole conditions behind the casing within the cased hole section. No information about the water content or the water table above the well water level can be inferred from the geophysical logs; it is possible the well water level at the time of the logging (311 ft) corresponds to the water table. In the open-hole log interval (731–1285 ft) water content and total porosity averages around 32% of total volume, varying between 20% and 70%; the highest water content and total porosity occurring just below the bottom of the casing from 731 to 788 ft bgs, ranging predominantly 40%–70%, but the measured porosity could be elevated due to significant washouts in this interval. In the cased hole log interval (146–731 ft) there are many zones with unrealistically high estimated water content and total porosity (greater than 50%), likely due to washouts behind casing. The integrated log analysis indicates highly heterogeneous mineralogy across the open-hole log interval (731–1285 ft), but an overall high silica content (quartz and silica glass) as high as 70% dry weight fraction. The inferred mineralogy includes significant, highly variable amounts of montmorillonite clay (0%–70% by volume) throughout this interval. The processed logs indicate the geologic formation across this interval consists of a thinly bedded sequence of silica-clastic sediments with highly variably grain size (alternating clay to sand/gravel beds). In the cased hole log interval an accurate estimate of the mineralogy from the processed logs is not possible due to the limited number of valid log measurements. Interpreted bed boundaries across the imaged interval 768–1290 ft have dip azimuths (direction beds are dipping to) predominantly in the sector 230–330 degrees, with the highest concentration falling in the 10 degree range 290–300 degrees. The mean dip azimuth across this interval is 278 degrees. The interpreted bed boundaries have a wide range of dip angles (degrees of dip) from zero to 60 degrees, although more than 80% have dip angles less than 20 degrees and the average dip angle is 6 degrees. No fractures were discernible across this interval. Throughout this interval the electrical resistivity image shows a well-bedded, thinly bedded alternating sand-silt-clay stratigraphy. The borehole was enlarged and/or washed out in the top half of the open-hole log interval (731–975 ft), but it appears only the severe washouts (as large as 19-in. borehole diameter) just below the casing (731–804 ft) caused any possible impact on geophysical log quality. However, washouts were likely present in a number of zones within the cased hole log interval (145–731 ft), causing the log measurements to be heavily influenced by the annular space between the casing and formation. Borehole deviation is measured with the GPIT, run as part of the FMI across the interval 790–1290 ft. The maximum deviation of the borehole across the log interval it was measured (790–1290 ft) is only 2.5 degrees; the azimuth of deviation is to the southeast.	NA. Screen 1 isolated behind drive casing.
Screen 2 (852.1–877.5)	Santa Fe Group (Tsf) 852–857: Clayey sand (SC) with gravel. 857–862: No recovery. 862–867: Sand (SW) with clay. 867–1047: No recovery, lost circulation.		Below the bottom of the free-standing casing (731 ft) the processed log results clearly indicate fully saturated conditions throughout most of the open-hole interval. In the open-hole log interval (731–1285 ft) water content and total porosity averages around 32%, varying between 20% and 70%. The processed logs indicate the geologic formation across this interval consists of a thinly bedded sequence of silica-clastic sediments with highly variably grain size (clay to sand/gravel beds) and bed dip magnitudes.
Screen 3 (1006.7–1028.5)	Santa Fe Group (Tsf) 867–1047: No recovery, lost circulation.		
Screen 4 (1211.7–1287)	Santa Fe Group (Tsf) 1207–1287: Clastic sediments, sand (SW) with clay and gravel, clayey sands (SC), gravel (GW) with clay and sand near TD.		

Note: The data shown in this table were taken from LANL 2003 (076061). Also see LANL 2005 (091121).

ft bgs = feet below ground surface, GPIT = general purpose inclinometry tool, NA = not applicable, TD = total depth

R-16, Data Quality Objectives

This well was installed in Cañada del Buey as part of the Hydrogeologic Workplan to

- determine the water table and vertical gradient for the regional aquifer near the Rio Grande,
- act as a monitoring point between TA-54 and the Rio Grand,;
- determine the relationship between the regional water table and springs in White Rock Canyon, and
- contribute to understanding flow paths between Mortandad Canyon and springs in White Rock Canyon.

The screen intervals were selected to monitor the top of regional aquifer (Screen 1) and deeper more productive zones within the regional aquifer (Screens 2–4).

Effective Screen Interval[a] (ft)	Drilling Method(s) Used	Drilling Fluids and Additives (i.e., solids, LCM)	Well Installation Fluids	Well Development Methods and Volumes Added/Removed	Time Screen/Zones in Communication[b]
Screen 1 634.5–653.4	Interval isolated behind abandoned drive casing.	NA	NA	NA	NA
Screen 2 852.1–877.5	Mud rotary for this interval.	Water, Quick-Gel, EZ-MUD, Liqui-Trol, magma fiber, Pac-L, N-Seal, soda ash	Water for filter pack. Water plus EZ-MUD for pellet seals.	Wire brushing, swabbing and surging, bailing (screens not isolated). Acid and dispersant added. Pumping with packer isolation. 4301 gal. removed.	6 days (Dec. 4 to Dec. 10, 2002)
Screen 3 1006.7–1028.5	Mud rotary for this interval.	Water, Quick-Gel, EZ-MUD, Liqui-Trol, magma fiber, Pac-L, N-Seal, soda ash	Water for filter pack. Water plus EZ-MUD for pellet seals.	Wire brushing, swabbing and surging, bailing (screens not isolated). Acid and dispersant added. Pumping with packer isolation. 8621 gal. removed.	
Screen 4 1211.7–1287	Mud rotary for this interval.	Water, Quick-Gel, EZ-MUD, Liqui-Trol, magma fiber, Pac-L, N-Seal, soda ash	Water for filter pack. Water plus EZ-MUD for pellet seals.	Wire brushing, swabbing and surging, bailing (screens not isolated) and jetting. Acid and dispersant added. Pumping with/without packer isolation. 65,126 gal. removed.	

Note: The data shown in this table were taken from LANL 2003 (076061). Also see LANL 2005 (091121).

[a] Effective screen interval is sand pack installed across the well screen; does not include transitional sand pack adjacent to sealing materials.

[b] From completion of well development to completion of Westbay installation.

LCM = lost circulation material(s), NA = not applicable

R-12, Geology and Geophysics of Screened Interval

R-12 Screen (Sand Interval ft bgs)	Lithology of Interval	Geophysical Logging Summary (depths in ft bgs)	Geophysical Indication of Screened Interval (depths in ft bgs)
Screen 1 453–481	Lower alkalic basalt of the Cerros del Rio Volcanic Field 450–488.2: Saturated, massive basalt. Slightly vesicular near base, with some calcite infilling. Fractured, based on drilling performance. Water encountered at 443, static at 424. Probably in hydraulic communication with groundwater in underlying perched zone.	Note: This well was logged using a color video camera, natural gamma radiation (NGR) and caliper tools. The Cerros del Rio basalt has a significantly lower NGR than the overlying Otowi Member (102–112 ft). The NGR for the basalt from 136 to 280 ft was uniform at 15 cps. The NGR remains low and uniform throughout the thickness of the basalt. Below the basalt, the NGR count rate gradually increases from 15 cps in the old alluvium (at 492 ft) to values of 74 cps at depths of 600–670 ft in the Puye Formation. Caliper measurements were made on the inside of the drill casing to inspect for the presence of clay-rich cutting buildup, which might cause anomalous NGR readings. The caliper shows that a buildup only occurred at a depth greater than 645 ft and any impact on the NGR was limited to 645–660 ft.	Only video, natural gamma, and caliper measurements made.
Screen 2 495–522	Older alluvium 495–509: Sandy gravel. 509–519.1: Fine- to medium sand; silt and clay rich. 519.1–535.5: Micaceous claystone. Dry below 520 ft. Some zones contain fine sand. 519: Claystone subunit of old alluvium forms perching layer. Probably in hydraulic communication with groundwater in overlying basalts.		Only video, natural gamma, and caliper measurements made.
Screen 3 793–856	Santa Fe Group basalt 784–803: Slightly scoriaceous, coarse-grained basalt with very irregular vesicles to 1 mm. Saturated zone encountered at 804 ft. 830–866: Slightly vesicular, coarse-grained basalt with round to slightly elongate vesicles to 6 mm, some with white clay coatings.		Only video, natural gamma, and caliper measurements made.

Note: The data shown in this table were taken from LANL 2001 (071252). Also see LANL 2005 (091121).
ft bgs = feet below ground surface, NGR = natural gamma radiation.

R-12, Data Quality Objectives

This well was installed in Sandia Canyon near the eastern boundary of the Laboratory as part of the Hydrogeologic Workplan to

- provide information about the quality of groundwater at the eastern boundary of the Laboratory;
- provide early warning of contaminants reaching the upper part of the regional aquifer near water-supply well PM-1;
- gather water-quality and water-level data for the potential intermediate-depth perched zones and from the regional aquifer downgradient of numerous contaminant source areas in upper Los Alamos, Sandia, and Mortandad Canyons (Aggregates 1 and 7 in the Hydrogeologic Workplan);
- support a completion strategy for BH R-9;
- possibly be incorporated into the Laboratory-wide groundwater-monitoring program;
- monitor the upper part of the perched groundwater zone within the Cerros del Rio basalt (Screen 1);
- monitor the lower part of the perched groundwater zone within the old alluvium sediments (Screen 2); and
- monitor the top of the regional zone of saturation (Screen 3).

Effective Screen Interval[a] (ft)	Drilling Fluids and Method(s) Used	Additives (i.e., solids, LCM)	Well Installation Fluids[b]	Well Development Methods and Volumes Added/Removed[c]	Time Screen/Zones in Communication[d]
Screen 1 453–481	Mainly casing advancement, some open-BH RC or DHH drilling in basalt Water and EZ-MUD, some foam	None mentioned	NL	Jetting, pumping (screens not isolated). 666 gal. of water added during jetting. 538 gal. removed by pumping.	41 days (Feb. 6 to Mar. 19, 2000)
Screen 2 495–522	Casing advancement Water and EZ-MUD, some foam	None mentioned	NL	Jetting, pumping (screens not isolated). 666 gal. of water added during jetting. 538 gal. removed by pumping.	
Screen 3 793–856	Casing advancement Water and EZ-MUD, some foam	None mentioned	NL	Jetting, pumping (screens not isolated). 666 gal. of water added during jetting. 538 gal. removed by pumping.	

Note: The data shown in this table were taken from LANL 2001 (071252). Also see LANL 2005 (091121).

[a] Effective screen interval is sand pack installed across the well screen; does not include transitional sand pack adjacent to sealing materials.

[b] Not listed in well completion report (LANL 2001, 071252).

[c] Assumes the amounts added/removed are equal for each screened interval.

[d] From completion of well development to completion of Westbay installation.

BH = borehole, DHH = downhole hammer, LCM = lost circulation material(s), NL = not listed

Appendix B

Parameters Measured
During the Pilot Study

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-12 Upper**
Location: **Sandia Canyon**
Lead Company: **Kleinfelder Inc.**
Supporting Company: **WDC/DS&A**

Project No.: **73885.4.2**
Document Originator: **Steven W. Baur**
Document Reviewer: **B. Lucero**
Review Complete:

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 869 **ft bgs** **Screened Interval:** 459 **ft bgs** **to** 467 **ft bgs**

Total Volume Withdrawn (Bailing): None **gals.** **Total Volume Withdrawn (Pumping):** 859.85 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 1 hp 5 gpm	**Used From**	9/29/2006	**to**	9/29/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
9/29/2006	7:10	pump	216335.7	0	0	N/A	N/A	N/A	N/A	461.7	ORP/mv
9/29/2006	7:18	pump	216356.4	20.7	20.7	7.9	15.8	394	>1000	461.7	100.3
9/29/2006	7:23	pump	216363.3	6.9	27.6	7.7	15.9	427	>1000	461.7	10.4
9/29/2006	7:28	pump	216368.2	4.9	32.5	7.8	16.7	434	>1000	461.7	6.5
9/29/2006	7:33	pump	216374.35	6.15	38.65	7.8	17.1	435	>1000	461.7	29.6
9/29/2006	7:38	pump	216379.75	5.4	44.05	7.8	17.4	439	9.86	461.7	44.7
9/29/2006	7:43	pump	216387.3	7.55	51.6	7.8	18.8	442	3.85	461.7	56

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Upper** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Steven W. Baur**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 1 hp 5 gpm	**Used From**	9/29/2006	**to**	9/29/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
9/29/2006	7:48	pump	216389.85	2.55	54.15	7.8	20.3	440.0	3.81	461.7	62.2
9/29/2006	7:53	pump	216396.1	6.25	60.4	7.8	20.5	442.0	3.81	461.7	61.2
9/29/2006	7:58	pump	216403.3	7.2	67.6	7.8	20.7	441.0	3.17	461.7	67.4
9/29/2006	8:03	pump	216410.5	7.2	74.8	7.8	21.1	440.0	3.17	461.7	76.9
9/29/2006	8:08	pump	N/A	N/A	N/A	7.8	21.2	443.0	2.99	461.7	77.4
9/29/2006	8:13	pump	216423.7	13.2	88	7.8	21.1	443.0	2.63	461.7	82.6
9/29/2006	8:18	pump	N/A	N/A	N/A	7.8	21.1	445.0	3.03	461.7	83.5
9/29/2006	8:23	pump	216438.4	14.7	102.7	7.8	21.2	444.0	3.03	461.7	83.2
9/29/2006	8:33	pump	216445.9	7.5	110.2	7.8	21.4	444.0	2.55	461.7	87.6
9/29/2006	8:43	pump	216458.1	12.2	122.4	7.8	21.5	442.0	3.12	461.7	94.3
9/29/2006	8:53	pump	216470.1	12	134.4	7.8	21.5	441.0	3.21	461.7	93.8
9/29/2006	9:03	pump	216482.1	12	146.4	7.8	21.7	442.0	2.91	461.7	95.4

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Upper** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Steven W. Baur**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 1 hp 5 gpm	**Used From**	9/29/2006	**to**	9/29/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
9/29/2006	9:13	pump	N/A	N/A	N/A	7.9	21.9	445.0	2.18	461.7	95.7
9/29/2006	9:18	pump	216506.2	24.1	170.5	7.9	21.9	445.0	1.87	461.7	95.6
9/29/2006	9:28	pump	N/A	N/A	N/A	7.9	21.9	445.0	2.25	461.7	95.5
9/29/2006	9:48	pump	216530.6	24.4	194.9	7.9	22.2	439.0	2.15	461.7	105.9
9/29/2006	9:58	pump	216554.4	23.8	218.7	7.9	22.1	438.0	1.85	461.7	109.9
9/29/2006	10:08	pump	N/A	N/A	N/A	7.9	22.3	436.0	2.06	461.7	111
9/29/2006	10:18	pump	216578.3	23.9	242.6	7.9	22.3	440.0	2.06	461.7	114.3
9/29/2006	10:33	pump	N/A	N/A	N/A	7.9	22.4	437.0	2.02	461.7	120.3
9/29/2006	10:48	pump	216602.5	24.2	266.8	7.9	22.5	435.0	2.12	461.7	115.6
9/29/2006	11:03	pump	216626.1	23.6	290.4	7.9	22.6	434.0	2.04	461.7	117
9/29/2006	11:18	pump	216650	23.9	314.3	7.9	22.5	436.0	1.98	461.7	120.9
9/29/2006	11:33	pump	N/A	N/A	N/A	7.9	22.6	437.0	1.87	461.7	130.5

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Upper** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Steven W. Baur**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundos 1 hp 5 gpm	**Used From**	9/29/2006	**to**	9/29/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
9/29/2006	11:48	pump	216673.55	23.55	337.85	7.9	22.7	437.0	1.73	461.7	135.4
9/29/2006	12:03	pump	216696.9	23.35	361.2	7.9	22.4	437.0	2.07	461.7	122.8
9/29/2006	12:18	pump	216720.2	23.3	384.5	7.9	22.5	439.0	1.95	461.7	118.1
9/29/2006	12:33	pump	N/A	N/A	N/A	7.9	22.5	437.0	2.27	461.7	125.4
9/29/2006	12:48	pump	216743.3	23.1	407.6	7.9	22.5	437.0	2.04	461.7	120.3
9/29/2006	13:03	pump	216766.6	23.3	430.9	7.9	22.5	436.0	1.92	461.7	120.8
9/29/2006	13:18	pump	216789.9	23.3	454.2	7.8	22.5	436.0	1.89	461.7	122.6
9/29/2006	13:33	pump	N/A	N/A	N/A	7.9	22.5	437.0	2.18	461.7	121.6
9/29/2006	13:48	pump	216813.35	23.45	477.65	7.9	22.6	437.0	2.07	461.7	121.3
9/29/2006	14:03	pump	216836.6	23.25	500.9	7.9	22.5	436.0	1.81	461.7	131.2
9/29/2006	14:18	pump	216860.05	23.45	524.35	7.9	22.6	437.0	1.84	461.7	123.9
9/29/2006	14:33	pump	N/A	N/A	N/A	7.9	22.6	437.0	1.89	461.7	126.8

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Upper** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Steven W. Baur**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 1 hp 5 gpm	**Used From**	9/29/2006	**to**	9/29/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
9/29/2006	14:48	pump	216883.5	23.45	547.8	7.9	22.6	435.0	2.0	461.7	131.9
9/29/2006	15:03	pump	216908	24.5	572.3	7.9	22.6	434.0	1.74	461.7	123.4
9/29/2006	15:18	pump	216929.8	21.8	594.1	7.9	22.5	436.0	2.04	461.7	114
9/29/2006	15:33	pump	N/A	N/A	N/A	7.9	22.8	436.0	2.58	461.7	132.4
9/29/2006	15:48	pump	216952.5	22.7	616.8	7.9	22.9	436.0	1.92	461.7	131.4
9/29/2006	16:03	pump	216975.6	23.1	639.9	7.9	22.8	436.0	2.06	461.7	123.9
9/29/2006	16:18	pump	216998.6	23	662.9	7.9	22.7	437.0	1.68	461.7	124.8
9/29/2006	16:33	pump	N/A	N/A	N/A	7.9	22.7	438.0	1.11	461.7	132
9/29/2006	16:48	pump	217021.6	23	685.9	7.9	22.7	435.0	1.63	461.7	129.3
9/29/2006	17:03	pump	217044.5	22.9	708.8	7.9	22.7	435.0	1.78	461.7	128.7
9/29/2006	17:18	pump	217067.45	22.95	731.75	7.9	22.7	438.0	1.67	461.7	129.5
9/29/2006	17:40	pump	217090.9	23.45	755.2	7.9	22.4	435.0	1.78	461.7	134

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-12 Middle**
Location: **Sandia Canyon**
Lead Company: **Kleinfelder Inc.**
Supporting Company: **WDC/DS&A**

Project No.: **73885**
Document Originator: **Steven W. Baur**
Document Reviewer: **B. Lucero**
Review Complete: **10/21/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 869 **ft bgs** **Screened Interval:** 504.5 **ft bgs** **to** 508 **ft bgs**

Total Volume Withdrawn (Bailing): None **gals.** **Total Volume Withdrawn (Pumping):** 2376.1 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 1 hp	**Used From**	10/1/2006	**to**	10/1/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/1/2006	7:20	pump	217299.7	0	0	N/A	N/A	N/A	N/A	503.8	ORP/mv
10/1/2006	7:27	pump	217320.7	21	21	8.5	14.5	N/A	N/A	503.8	N/A
10/1/2006	7:28	pump	217324	3.3	24.3	8.4	16.8	159.6	12.5	503.8	171
10/1/2006	7:33	pump	217337.1	13.1	37.4	8.3	18	168.5	2	503.8	174
10/1/2006	7:38	pump	217356.9	19.8	57.2	8.3	18.8	168.7	1.35	503.8	177.3
10/1/2006	7:43	pump	217363.5	6.6	63.8	8.3	19.4	168	2.28	503.8	184.4
10/1/2006	7:48	pump	217379.9	16.4	80.2	8.2	19.6	166.5	2.28	503.8	182.3

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Middle** Project No.: **73885**

Location: **Sandia Canyon** Document Originator: **Steven W. Baur**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 1 hp	**Used From**	10/1/2006	**to**	10/1/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/1/2006	7:53	pump	217396.3	16.4	96.6	8.2	19.6	166.1	1.09	503.8	190.2
10/1/2006	7:58	pump	217429	32.7	129.3	8.2	19.7	166.1	1.18	503.8	189.1
10/1/2006	8:03	pump	217461.8	32.8	162.1	8.2	19.9	165.6	1.42	503.8	194.9
10/1/2006	8:08	pump	N/A	N/A	N/A	8.2	20.2	165.3	2.16	503.8	192.2
10/1/2006	8:13	pump	N/A	N/A	N/A	8.2	20.3	164.9	1.07	503.8	196
10/1/2006	8:18	pump	N/A	N/A	N/A	8.2	20.4	164.9	0.80	503.8	191.7
10/1/2006	8:23	pump	217494.6	32.8	194.9	8.2	20.5	164.3	0.73	503.8	197.7
10/1/2006	8:28	pump	N/A	N/A	N/A	8.2	20.5	163.7	0.73	503.8	197.4
10/1/2006	8:38	pump	217560.5	65.9	260.8	8.2	20.8	165.7	0.73	503.8	194.4
10/1/2006	8:48	pump	N/A	N/A	N/A	8.2	20.6	166.9	0.47	503.8	198.4
10/1/2006	8:58	pump	217626.5	66	326.8	8.1	20.6	166.9	0.54	503.8	191.7
10/1/2006	9:08	pump	N/A	N/A	N/A	8.1	20.7	165.4	0.58	503.8	201.3

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Middle** Project No.: **73885**

Location: **Sandia Canyon** Document Originator: **Steven W. Baur**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 1 hp	**Used From**	10/1/2006	**to**	10/1/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/1/2006	9:18	pump	217693	66.5	393.3	8.1	20.8	165.2	0.62	503.8	194.6
10/1/2006	9:28	pump	N/A	N/A	N/A	8.1	20.7	164.8	0.48	503.8	194.6
10/1/2006	9:38	pump	217759	66	459.3	8.1	20.7	164.8	0.43	503.8	200.1
10/1/2006	9:48	pump	N/A	N/A	N/A	8.1	20.6	164.7	0.48	503.8	198.1
10/1/2006	9:58	pump	217824.6	65.6	524.9	8.1	20.7	162.8	0.41	503.8	198.2
10/1/2006	10:08	pump	N/A	N/A	N/A	8.1	20.7	161.8	0.48	503.8	199.8
10/1/2006	10:18	pump	217890.9	66.3	591.2	8.1	20.7	165.7	0.41	503.8	199.9
10/1/2006	10:28	pump	N/A	N/A	N/A	8.1	20.7	164.8	0.47	503.8	198.5
10/1/2006	10:45	pump	217956.9	66	657.2	8.1	20.7	164.4	0.35	503.8	195.5
10/1/2006	11:00	pump	218022.9	66	723.2	8.1	20.8	165.7	0.32	503.8	196
10/1/2006	11:30	pump	218089.1	66.2	789.4	8.1	20.7	165.0	0.54	503.8	198.8
10/1/2006	11:45	pump	218164.9	75.8	865.2	8.1	20.7	165.1	0.55	503.8	195.8

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Middle** Project No.: **73885**

Location: **Sandia Canyon** Document Originator: **Steven W. Baur**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 1 hp	**Used From**	10/1/2006	**to**	10/1/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/1/2006	12:00	pump	218221.05	56.15	921.35	8.1	20.7	164.8	0.7	503.8	194.4
10/1/2006	12:15	pump	218287	65.95	987.3	8.1	20.8	164.0	0.5	503.8	196.5
10/1/2006	12:30	pump	N/A	N/A	N/A	8.1	21.2	164.6	0.3	503.8	213.2
10/1/2006	12:45	pump	218353.2	66.2	1053.5	8.1	20.9	164.7	0.5	503.8	199.8
10/1/2006	13:00	pump	218419.6	66.4	1119.9	8.1	20.9	165.0	0.3	503.8	198.9
10/1/2006	13:15	pump	218485.8	66.2	1186.1	8.1	20.9	163.2	0.3	503.8	202
10/1/2006	13:30	pump	N/A	N/A	N/A	8.1	20.9	164.7	0.4	503.8	199
10/1/2006	13:45	pump	218552.1	66.3	1252.4	8.1	20.9	164.6	0.3	503.8	200.6
10/1/2006	14:00	pump	218618.2	66.1	1318.5	8.1	20.8	164.7	0.42	503.8	201.6
10/1/2006	14:15	pump	218684.4	66.2	1384.7	8.1	20.9	162.6	0.69	503.8	206.3
10/1/2006	14:30	pump	N/A	N/A	N/A	8.1	20.9	163.7	0.66	503.8	206.1
10/1/2006	14:45	pump	218753.7	69.3	1454	8.1	20.9	163.4	0.54	503.8	202.3

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Middle** Project No.: **73885**

Location: **Sandia Canyon** Document Originator: **Steven W. Baur**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 1 hp	**Used From**	10/1/2006	**to**	10/1/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/1/2006	15:00	pump	218829.7	76	1530	8.1	20.9	162.7	0.52	503.8	205.4
10/1/2006	15:15	pump	218882.5	52.8	1582.8	8.1	20.9	163.8	0.47	503.8	205
10/1/2006	15:30	pump	N/A	N/A	N/A	8.1	20.9	162.1	0.30	503.8	202.5
10/1/2006	15:45	pump	218948.7	66.2	1649	8.1	21.0	164.6	0.49	503.8	202.3
10/1/2006	16:00	pump	219014.8	66.1	1715.1	8.1	20.9	162.2	0.51	503.8	202.1
10/1/2006	16:15	pump	219081	66.2	1781.3	8.1	20.8	164.4	0.50	503.8	207.5
10/1/2006	16:30	pump	N/A	N/A	N/A	8.1	20.8	163.3	0.33	503.8	206.1
10/1/2006	16:45	pump	219147.2	66.2	1847.5	8.1	20.7	163.5	0.37	503.8	203.8
10/1/2006	17:00	pump	219213.4	66.2	1913.7	8.1	20.7	161.7	0.67	503.8	204.8
10/1/2006	17:15	pump	219279.6	66.2	1979.9	8.1	20.7	163.9	0.51	503.8	204.1
10/1/2006	17:30	pump	N/A	N/A	N/A	8.1	20.7	163.4	0.44	503.8	205
10/1/2006	17:50	pump	219411.85	132.25	2112.15	8.1	20.6	163.2	0.34	503.8	200.1

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-12 Lower Screen**
Location: **Sandia Canyon**
Lead Company: **Kleinfelder Inc.**
Supporting Company: **TPMC/DS&A**

Project No.: **73885.4.2**
Document Originator: **Jordan Vaughn**
Document Reviewer: **C. Goetz**
Review Complete: **10/23/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 869 **ft bgs** **Screened Interval:** 801 **ft bgs** **to** 839 **ft bgs**

Total Volume Withdrawn (Bailing): None **gals.** **Total Volume Withdrawn (Pumping):** 1447.9 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 2 hp	**Used From**	9/27/2006	**to**	9/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
9/27/2006	7:10	pump	214827.5	0	0	N/A	N/A	N/A	N/A	835.1	N/A
9/27/2006	7:27	pump	N/A	N/A	N/A	7.64	18.1	189.8	>1000	835.1	152.0
9/27/2006	7:30	pump	214870.4	42.9	42.9	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	7:32	pump	N/A	N/A	N/A	7.70	18.3	188.9	188	835.1	-23.8
9/27/2006	7:37	pump	N/A	N/A	N/A	7.79	18.5	185.6	135	835.1	-37.0
9/27/2006	7:40	pump	214891.3	20.9	63.8	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	7:42	pump	N/A	N/A	N/A	7.93	18.8	182.8	45.5	835.1	-31.8
9/27/2006	7:47	pump	N/A	N/A	N/A	8.02	19.0	179.8	38.8	835.1	28.1
9/27/2006	7:50	pump	214911.2	19.9	83.7	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	7:52	pump	N/A	N/A	N/A	8.07	19.4	172.4	15.6	835.1	61.2

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 2 hp	**Used From**	9/27/2006	**to**	9/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
9/27/2006	7:57	pump	N/A	N/A	N/A	8.09	19.4	169.7	12.7	835.1	62.1
9/27/2006	8:01	pump	214932	20.8	104.5	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	8:02	pump	N/A	N/A	N/A	8.09	19.6	168.5	23.7	835.1	74.1
9/27/2006	8:07	pump	N/A	N/A	N/A	8.10	19.8	167.9	7.46	835.1	76.0
9/27/2006	8:10	pump	214948.8	16.8	121.3	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	8:12	pump	N/A	N/A	N/A	8.09	19.9	167.3	5.93	835.1	73.8
9/27/2006	8:17	pump	N/A	N/A	N/A	8.09	20.1	166.7	6.14	835.1	58.6
9/27/2006	8:20	pump	214967.5	18.7	140	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	8:22	pump	N/A	N/A	N/A	8.09	20.2	166.3	6.09	835.1	85.4
9/27/2006	8:27	pump	N/A	N/A	N/A	8.08	19.9	166.5	5.77	835.1	69.0
9/27/2006	8:31	pump	214988.2	20.7	160.7	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	8:32	pump	N/A	N/A	N/A	8.08	19.9	166.2	3.31	835.1	109.0
9/27/2006	8:42	pump	N/A	N/A	N/A	8.08	20.0	165.4	3.03	835.1	128.9
9/27/2006	8:52	pump	N/A	N/A	N/A	8.08	19.9	165.0	3.43	835.1	191.1
9/27/2006	9:00	pump	215042.2	54	214.7	8.08	19.9	165.1	3.45	835.1	190.1
9/27/2006	9:10	pump	N/A	N/A	N/A	8.07	20.0	164.8	2.79	835.1	188.5

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 2 hp	**Used From**	9/27/2006	**to**	9/27/2006
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
9/27/2006	9:20	pump	215080.2	N/A	N/A	8.06	20.4	165.1	2.70	835.1	193.6
9/27/2006	9:30	pump	215099.4	N/A	N/A	8.07	20.5	164.9	3.76	835.1	198.7
9/27/2006	9:40	pump	215118.7	N/A	N/A	8.06	20.6	164.7	2.45	835.1	200.9
9/27/2006	9:50	pump	215138.1	N/A	N/A	8.06	20.7	164.4	1.69	835.1	199.7
9/27/2006	10:00	pump	215157.5	N/A	N/A	8.05	20.9	163.9	2.48	835.1	197.2
9/27/2006	10:10	pump	215176.8	N/A	N/A	8.05	20.9	164.2	1.69	835.1	200.1
9/27/2006	10:20	pump	215196.1	N/A	N/A	8.05	20.8	164.0	1.67	835.1	208.9
9/27/2006	10:30	pump	215215.5	N/A	N/A	8.05	20.9	164.2	1.72	835.1	209.8
9/27/2006	10:45	pump	N/A	N/A	N/A	8.04	21.1	163.7	1.48	835.1	206.4
9/27/2006	11:00	pump	215273.7	N/A	N/A	8.04	21.1	163.4	1.43	835.1	206.3
9/27/2006	11:15	pump	N/A	N/A	N/A	8.04	21.3	165.1	1.40	835.1	206.9
9/27/2006	11:30	pump	N/A	N/A	N/A	8.03	21.5	165.1	1.40	835.1	201.8

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 2 hp	**Used From**	9/27/2006	**to**	9/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
9/27/2006	11:45	pump	N/A	N/A	N/A	8.02	21.5	164.9	3.10	835.1	201.9
9/27/2006	12:00	pump	215392	N/A	N/A	8.01	21.7	165.7	1.12	835.1	203.6
9/27/2006	12:15	pump	N/A	N/A	N/A	8.01	21.8	166.2	1.89	835.1	208.1
9/27/2006	12:30	pump	N/A	N/A	N/A	8.01	21.7	166.1	1.62	835.1	207.0
9/27/2006	12:45	pump	N/A	N/A	N/A	8.01	22.0	165.8	1.61	835.1	205.5
9/27/2006	13:00	pump	215514	N/A	N/A	8.00	22.1	165.0	1.11	835.1	205.1
9/27/2006	13:15	pump	N/A	N/A	N/A	7.99	22.2	167.0	1.13	835.1	208.5
9/27/2006	13:30	pump	N/A	N/A	N/A	7.99	22.5	166.9	1.04	835.1	207.8
9/27/2006	13:45	pump	N/A	N/A	N/A	7.99	22.2	168.2	1.31	835.1	213.0
9/27/2006	14:00	pump	215636.3	N/A	N/A	7.99	21.8	168.0	0.79	835.1	220.8
9/27/2006	14:15	pump	N/A	N/A	N/A	8.00	21.7	167.5	0.87	835.1	224.8
9/27/2006	14:30	pump	N/A	N/A	N/A	8.00	21.6	168.4	0.86	835.1	225.6

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 2 hp	**Used From**	9/27/2006	**to**	9/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
9/27/2006	14:45	pump	N/A	N/A	N/A	7.99	22.3	167.6	0.88	835.1	224.5
9/27/2006	15:00	pump	215759.2	N/A	N/A	7.98	22.3	167.8	0.89	835.1	226.1
9/27/2006	15:15	pump	N/A	N/A	N/A	7.98	22.8	167.7	2.12	835.1	222.0
9/27/2006	15:30	pump	N/A	N/A	N/A	7.98	22.6	169.3	0.93	835.1	222.8
9/27/2006	15:45	pump	N/A	N/A	N/A	7.97	22.5	169.1	0.88	835.1	224.6
9/27/2006	16:00	pump	215881.9	N/A	N/A	7.97	22.5	168.7	1.37	835.1	225.5
9/27/2006	16:15	pump	N/A	N/A	N/A	7.98	22.5	168.4	1.14	835.1	223.6
9/27/2006	16:30	pump	N/A	N/A	N/A	7.98	22.3	168.0	0.81	835.1	225.8
9/27/2006	16:45	pump	N/A	N/A	N/A	7.98	22.1	169.9	0.69	835.1	223.7
9/27/2006	17:00	pump	216004	N/A	N/A	7.98	21.3	169.1	0.74	835.1	219.9
9/27/2006	17:15	pump	N/A	N/A	N/A	7.98	21.3	168.9	0.41	835.1	219.7
9/27/2006	17:30	pump	N/A	N/A	N/A	7.98	21.3	169.1	0.14	835.1	222.0

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 2 hp	**Used From**	9/27/2006	**to**	9/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
9/27/2006	17:45	pump	N/A	N/A	N/A	7.99	21.2	169.0	0.69	835.1	225.9
9/27/2006	18:00	pump	216127	N/A	N/A	7.99	21.2	170.4	0.77	835.1	228.5
9/27/2006	18:20	pump	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	18:40	pump	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	19:00	pump	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
9/27/2006	19:10	pump	216275.4	N/A	1447.9	N/A	N/A	N/A	N/A	N/A	Pump Off

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-12 Lower Screen**
Location: **Sandia Canyon**
Lead Company: **Kleinfelder Inc.**
Supporting Company: **TPMC/DS&A**

Project No.: **73885.4.2**
Document Originator: **Jordan Vaughn**
Document Reviewer: **C. Goetz**
Review Complete: **10/21/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 869 **ft bgs** **Screened Interval:** 801 **ft bgs** **to** 839 **ft bgs**

Total Volume Withdrawn (Bailing): None **gals.** **Total Volume Withdrawn (Pumping):** 34,497.50 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/16/2006	7:40	pump	219338	0	0	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	7:46	pump	219348	10	10	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	7:47	pump	219366.8	18.8	28.8	7.85	19.1	195.3	97.8	832.94	195.1
10/16/2006	7:48	pump	219386	19.2	48	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	7:50	pump	219424.2	38.2	86.2	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	7:52	pump	219462	37.8	124	8.01	20.0	199.3	58.9	832.94	200.0
10/16/2006	7:54	pump	219500	38	162	N/A	N/A	N/A	N/A	832.94	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/16/2006	7:56	pump	219538	38	200	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	7:57	pump	N/A	N/A	N/A	7.93	20.0	204.0	7.79	832.94	201.3
10/16/2006	7:58	pump	219576.2	38.2	238.2	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	8:00	pump	219614.2	38	276.2	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	8:02	pump	N/A	N/A	N/A	7.92	20.4	205.0	3.96	832.94	191.0
10/16/2006	8:07	pump	N/A	N/A	N/A	7.92	20.5	206.0	4.76	832.94	187.6
10/16/2006	8:10	pump	219804.6	190.4	466.6	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	8:12	pump	N/A	N/A	N/A	7.91	20.6	208.0	3.65	832.94	188.4
10/16/2006	8:17	pump	N/A	N/A	N/A	7.90	20.5	208.0	3.52	832.94	187.0
10/16/2006	8:20	pump	219994.8	190.2	656.8	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	8:22	pump	N/A	N/A	N/A	7.90	20.7	208.0	3.09	832.94	187.4
10/16/2006	8:27	pump	N/A	N/A	N/A	7.91	20.6	207.0	1.67	832.94	181.3

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/16/2006	8:32	pump	N/A	N/A	N/A	7.90	20.7	206.0	3.54	832.94	182.1
10/16/2006	8:37	pump	N/A	N/A	N/A	7.90	20.7	208.0	1.67	832.94	180.0
10/16/2006	8:40	pump	220376.2	381.4	1038.2	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	8:42	pump	N/A	N/A	N/A	7.90	20.9	207.0	1.72	832.94	182.2
10/16/2006	8:47	pump	N/A	N/A	N/A	7.90	20.9	207.0	1.71	832.94	175.1
10/16/2006	8:57	pump	N/A	N/A	N/A	7.90	21.0	207.0	1.54	832.94	170.5
10/16/2006	9:00	pump	220759	382.8	1421	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	9:07	pump	N/A	N/A	N/A	7.90	21.2	209.0	1.82	832.94	177.4
10/16/2006	9:20	pump	221140.5	381.5	1802.5	7.89	21.3	209.0	1.9	832.94	176.3
10/16/2006	9:30	pump	N/A	N/A	N/A	7.90	21.4	210.0	2.91	832.94	180.7
10/16/2006	9:40	pump	221523.3	382.8	2185.3	7.89	21.4	209.0	1.77	832.94	179.6
10/16/2006	9:50	pump	N/A	N/A	N/A	7.89	21.4	209.0	1.35	832.94	182.7

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/16/2006	10:00	pump	221906	382.7	2568	7.89	21.5	210.0	1.34	832.94	182.6
10/16/2006	10:10	pump	N/A	N/A	N/A	7.91	21.5	210.0	1.19	832.94	190.7
10/16/2006	10:20	pump	222289	383	2951	8.41	21.1	209.0	1.07	832.94	188.6
10/16/2006	10:30	pump	N/A	N/A	N/A	8.61	20.9	210.0	1.35	832.94	190.9
10/16/2006	10:40	pump	N/A	N/A	N/A	8.51	21.0	209.0	1.05	832.94	185.7
10/16/2006	10:46	pump	222786.2	497.2	3448.2	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	10:50	pump	N/A	N/A	N/A	8.28	21.0	211.0	1.08	832.94	191.8
10/16/2006	11:00	pump	223055	268.8	3717	8.04	21.1	210.0	1.22	832.94	184.3
10/16/2006	11:10	pump	N/A	N/A	N/A	7.99	21.2	211.0	1.19	832.94	185.5
10/16/2006	11:20	pump	223435.6	380.6	4097.6	8.08	21.2	212.0	1.02	832.94	180.0
10/16/2006	11:30	pump	N/A	N/A	N/A	8.11	21.3	211.0	1.96	832.94	174.3
10/16/2006	11:40	pump	223818.5	382.9	4480.5	8.30	21.4	211.0	1.41	832.94	185.4
10/16/2006	11:50	pump	N/A	N/A	N/A	8.60	21.5	211.0	1.25	832.94	186.9

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/16/2006	12:00	pump	224201.5	383	4863.5	nm	21.8	212.0	1.2	832.94	187.4
10/16/2006	12:10	pump	N/A	N/A	N/A	nm	21.8	213.0	1.9	832.94	193.2
10/16/2006	12:20	pump	224584.5	383	5246.5	nm	21.9	212.0	.95	832.94	191.6
10/16/2006	12:30	pump	N/A	N/A	N/A	nm	22.0	212.0	.62	832.94	191.1
10/16/2006	12:40	pump	224968.2	383.7	5630.2	7.67	21.9	212.0	1.21	832.94	195.9
10/16/2006	12:50	pump	N/A	N/A	N/A	7.77	21.9	213.0	.64	832.94	198.8
10/16/2006	13:00	pump	225352.7	384.5	6014.7	7.78	22.0	213.0	.78	832.94	207.0
10/16/2006	13:15	pump	N/A	N/A	N/A	7.80	22.0	214.0	.74	832.94	212.7
10/16/2006	13:20	pump	225737	384.3	6399	N/A	N/A	N/A	N/A	N/A	N/A
10/16/2006	13:30	pump	N/A	N/A	N/A	7.81	21.9	213.0	.81	832.94	215.3
10/16/2006	13:40	pump	226121.2	384.2	6783.2	N/A	N/A	N/A	N/A	N/A	N/A
10/16/2006	13:45	pump	N/A	N/A	N/A	7.78	21.7	214.0	.68	832.94	213.5
10/16/2006	14:00	pump	226505.6	384.4	7167.6	7.82	22.3	213.0	.72	832.94	215.2

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/16/2006	14:15	pump	N/A	N/A	N/A	7.85	22.0	213.0	.61	832.94	213.4
10/16/2006	14:20	pump	226889	383.4	7551	N/A	N/A	N/A	N/A	N/A	N/A
10/16/2006	14:30	pump	N/A	N/A	N/A	7.86	22.0	212.0	2.9	832.94	217.7
10/16/2006	14:40	pump	227273.5	384.5	7935.5	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	14:45	pump	N/A	N/A	N/A	7.86	22.0	212.0	1.09	832.94	217.3
10/16/2006	15:00	pump	227658.5	385	8320.5	7.87	22.4	213.0	.77	832.94	217.4
10/16/2006	15:15	pump	N/A	N/A	N/A	7.89	21.8	214.0	.68	832.94	222
10/16/2006	15:20	pump	228042.5	384	8704.5	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	15:30	pump	N/A	N/A	N/A	7.89	21.8	213.0	.77	832.94	219.7
10/16/2006	15:40	pump	228428	385.5	9090	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	15:45	pump	N/A	N/A	N/A	7.89	21.6	213.0	.61	832.94	222.4
10/16/2006	16:00	pump	228811.6	383.6	9473.6	7.89	21.6	213.0	.75	832.94	219.9
10/16/2006	16:15	pump	N/A	N/A	N/A	7.90	21.6	213.0	.58	832.94	220.8

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/16/2006	16:20	pump	229196	384.4	9858	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	16:30	pump	N/A	N/A	N/A	7.90	21.6	214.0	.59	832.94	221.4
10/16/2006	16:40	pump	229579	383	10241	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	16:45	pump	N/A	N/A	N/A	7.90	21.6	214.0	.54	832.94	223.3
10/16/2006	16:50	pump	229770	191	10432	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	17:00	pump	229962.5	192.5	10624.5	7.91	21.6	214.0	.48	832.94	224.7
10/16/2006	17:15	pump	N/A	N/A	N/A	7.91	21.7	213.0	0.41	832.94	226.5
10/16/2006	17:20	pump	230346	383.5	11008	N/A	N/A	N/A	N/A	832.94	N/A
10/16/2006	18:00	pump	230730.8	384.8	11392.8	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	7:15	pump	230730.8	0	11392.8	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	7:16	pump	230748.8	18	11410.8	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	7:17	pump	230767.2	18.4	11429.2	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	7:20	pump	230824	56.8	11486	N/A	N/A	N/A	N/A	832.94	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/17/2006	7:21	pump	N/A	N/A	N/A	7.52	16.0	229.0	30.9	832.94	121.7
10/17/2006	7:26	pump	N/A	N/A	N/A	7.76	19.6	228.0	18.4	832.94	137.1
10/17/2006	7:30	pump	231014.6	190.6	11676.6	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	7:31	pump	N/A	N/A	N/A	7.83	19.8	229.0	4.06	832.94	145.3
10/17/2006	7:36	pump	N/A	N/A	N/A	7.90	20.2	228.0	3.12	832.94	158.6
10/17/2006	7:40	pump	231206	191.4	11868	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	7:41	pump	N/A	N/A	N/A	7.92	20.3	227.0	2.08	832.94	153.9
10/17/2006	7:46	pump	N/A	N/A	N/A	7.93	20.4	227.0	1.96	832.94	156.4
10/17/2006	7:51	pump	N/A	N/A	N/A	7.94	20.5	228.0	1.85	832.94	161.3
10/17/2006	7:56	pump	N/A	N/A	N/A	7.94	20.6	228.0	1.38	832.94	159.3
10/17/2006	8:00	pump	231589.3	383.3	12251.3	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	8:01	pump	N/A	N/A	N/A	7.94	20.8	227.0	1.6	832.94	169.4

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/17/2006	8:06	pump	N/A	N/A	N/A	7.95	20.9	227.0	1.66	832.94	173.1
10/17/2006	8:11	pump	N/A	N/A	N/A	7.95	21.0	227.0	1.48	832.94	169.5
10/17/2006	8:16	pump	N/A	N/A	N/A	7.95	21.0	227.0	1.16	832.94	176
10/17/2006	8:20	pump	231973.5	384.2	12635.5	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	8:21	pump	N/A	N/A	N/A	7.95	21.1	228.0	1.38	832.94	174.9
10/17/2006	8:30	pump	N/A	N/A	N/A	7.95	21.5	226.0	1.34	832.94	184.5
10/17/2006	8:40	pump	232356.3	382.8	13018.3	7.94	21.2	226.0	.93	832.94	186.1
10/17/2006	8:50	pump	N/A	N/A	N/A	7.94	21.2	226.0	.83	832.94	190
10/17/2006	9:00	pump	232739.8	383.5	13401.8	7.94	21.3	227.0	.82	832.94	190.6
10/17/2006	9:10	pump	N/A	N/A	N/A	7.94	21.4	226.0	.75	832.94	192.1
10/17/2006	9:20	pump	233118.9	379.1	13780.9	7.94	21.5	226.0	.91	832.94	196.6
10/17/2006	9:30	pump	N/A	N/A	N/A	7.93	21.5	226.0	.87	832.94	198.3

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/17/2006	9:40	pump	233506.8	387.9	14168.8	7.93	21.5	226.0	.89	832.94	199.8
10/17/2006	9:50	pump	N/A	N/A	N/A	7.94	21.6	226.0	.99	832.94	196.7
10/17/2006	10:00	pump	233890.7	383.9	14552.7	7.93	21.5	227.0	.89	832.94	188
10/17/2006	10:10	pump	N/A	N/A	N/A	7.93	21.4	227.0	0.87	832.94	186.2
10/17/2006	10:20	pump	234081	190.3	14743	7.94	21.6	227.0	9.47	832.94	184.5
10/17/2006	10:30	pump	N/A	N/A	N/A	7.93	21.6	226.0	4.69	832.94	188.0
10/17/2006	10:40	pump	234468.2	387.2	15130.2	7.93	21.7	225.0	2.84	832.94	190.6
10/17/2006	10:50	pump	N/A	N/A	N/A	7.94	21.8	226.0	1.71	832.94	191.7
10/17/2006	11:00	pump	234846.9	378.7	15508.9	7.93	21.8	226.0	1.33	832.94	191.5
10/17/2006	11:15	pump	N/A	N/A	N/A	7.93	21.8	226.0	1.29	832.94	191.3
10/17/2006	11:20	pump	235228.5	381.6	15890.5	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	11:30	pump	N/A	N/A	N/A	7.92	21.6	227.0	1.15	832.94	194.8

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/17/2006	11:40	pump	235611	382.5	16273	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	11:45	pump	N/A	N/A	N/A	7.93	21.9	226.0	.87	832.94	198.9
10/17/2006	12:00	pump	235994.8	383.8	16656.8	7.93	22.0	226.0	.99	832.94	203.4
10/17/2006	12:15	pump	N/A	N/A	N/A	7.93	21.7	227.0	0.74	832.94	205.2
10/17/2006	12:20	pump	236378.3	383.5	17040.3	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	12:30	pump	N/A	N/A	N/A	7.93	21.9	226.0	.72	832.94	203.5
10/17/2006	12:45	pump	N/A	N/A	N/A	7.93	21.8	227.0	.7	832.94	206.3
10/17/2006	12:47	pump	236896	517.7	17558	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	13:00	pump	237145.5	249.5	17807.5	7.92	21.7	227.0	.66	832.94	207.6
10/17/2006	13:15	pump	N/A	N/A	N/A	7.91	22.1	226.0	.87	832.94	211.2
10/17/2006	13:20	pump	237529.3	383.8	18191.3	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	13:30	pump	N/A	N/A	N/A	7.94	22.0	226.0	.64	832.94	210.9

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/17/2006	13:40	pump	237913	383.7	18575	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	13:45	pump	N/A	N/A	N/A	7.94	21.7	227.0	.7	832.94	213
10/17/2006	14:00	pump	238296.8	383.8	18958.8	7.93	21.6	225.0	.85	832.94	212.8
10/17/2006	14:15	pump	N/A	N/A	N/A	7.93	21.7	226.0	0.67	832.94	211.6
10/17/2006	14:20	pump	238682	385.2	19344	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	14:30	pump	N/A	N/A	N/A	7.93	21.7	226.0	.58	832.94	213.4
10/17/2006	14:40	pump	239067.3	385.3	19729.3	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	14:45	pump	N/A	N/A	N/A	7.93	21.6	227.0	.54	832.94	216.5
10/17/2006	15:00	pump	239452.2	384.9	20114.2	7.93	21.7	226.0	.55	832.94	217.4
10/17/2006	15:15	pump	N/A	N/A	N/A	7.94	22.0	227.0	.71	832.94	220.5
10/17/2006	15:20	pump	239838	385.8	20500	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	15:30	pump	N/A	N/A	N/A	7.92	21.5	228.0	.64	832.94	219

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/17/2006	15:40	pump	240223	385	20885	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	15:45	pump	N/A	N/A	N/A	7.92	21.2	226.0	.6	832.94	219.2
10/17/2006	16:00	pump	240607	384	21269	7.92	21.3	226.0	.55	832.94	220
10/17/2006	16:15	pump	N/A	N/A	N/A	7.93	21.9	226.0	0.46	832.94	217.9
10/17/2006	16:20	pump	240993	386	21655	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	16:30	pump	N/A	N/A	N/A	7.93	21.9	226.0	0.42	832.94	216.0
10/17/2006	16:40	pump	241377	384	22039	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	16:45	pump	N/A	N/A	N/A	7.93	22.0	226.0	.55	832.94	218.6
10/17/2006	17:00	pump	241762.4	385.4	22424.4	7.94	21.9	225.0	.58	832.94	221.4
10/17/2006	17:20	pump	242147.5	385.1	22809.5	N/A	N/A	N/A	N/A	832.94	N/A
10/17/2006	17:25	pump	242244.1	96.6	22906.1	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	7:10	pump	242244.1	0	22906.1	N/A	N/A	N/A	N/A	832.94	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to** 10/18/2006
Tool:		**Description:**		**Used From**		**to**
Tool:		**Description:**		**Used From**		**to**
Tool:		**Description:**		**Used From**		**to**

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/18/2006	7:11	pump	242262.2	18.1	22924.2	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	7:12	pump	242280.8	18.6	22942.8	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	7:16	pump	242357.4	76.6	23019.4	7.40	17.8	225.0	40.1	832.94	77.8
10/18/2006	7:20	pump	242434.2	76.8	23096.2	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	7:21	pump	N/A	N/A	N/A	7.52	20.5	230.0	5.54	832.94	211.6
10/18/2006	7:26	pump	N/A	N/A	N/A	7.54	20.7	227.0	3.41	832.94	217.1
10/18/2006	7:30	pump	242627	192.8	23289	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	7:31	pump	N/A	N/A	N/A	7.62	20.8	228.0	2.26	832.94	216
10/18/2006	7:36	pump	N/A	N/A	N/A	7.72	21.0	230.0	1.16	832.94	214.4
10/18/2006	7:41	pump	N/A	N/A	N/A	7.77	21.1	230.0	.94	832.94	213.5
10/18/2006	7:46	pump	N/A	N/A	N/A	7.81	21.1	229.0	.68	832.94	213.9
10/18/2006	7:50	pump	243011.2	384.2	23673.2	N/A	N/A	N/A	N/A	832.94	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/18/2006	7:51	pump	N/A	N/A	N/A	7.83	21.2	230.0	.71	832.94	211.9
10/18/2006	7:56	pump	N/A	N/A	N/A	7.85	21.2	230.0	.35	832.94	213.1
10/18/2006	8:01	pump	N/A	N/A	N/A	7.86	21.3	230.0	.67	832.94	214.2
10/18/2006	8:06	pump	N/A	N/A	N/A	7.87	21.3	230.0	0.75	832.94	215.4
10/18/2006	8:10	pump	243396	384.8	24058	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	8:11	pump	N/A	N/A	N/A	7.87	21.4	229.0	0.61	832.94	210.3
10/18/2006	8:16	pump	N/A	N/A	N/A	7.88	21.5	228.0	.44	832.94	209.1
10/18/2006	8:21	pump	N/A	N/A	N/A	7.89	21.5	228.0	.58	832.94	208.1
10/18/2006	8:30	pump	243781.2	385.2	24443.2	7.89	21.7	229.0	.44	832.94	207.4
10/18/2006	8:40	pump	N/A	N/A	N/A	7.90	21.5	228.0	.49	832.94	209
10/18/2006	8:50	pump	244167	385.8	24829	7.90	21.6	229.0	.53	832.94	208.9
10/18/2006	9:00	pump	N/A	N/A	N/A	7.92	20.7	230.0	.51	832.94	207.1

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/18/2006	9:10	pump	244552.5	385.5	25214.5	7.91	21.7	228.0	.47	832.94	202.8
10/18/2006	9:20	pump	N/A	N/A	N/A	7.92	21.6	228.0	.41	832.94	198.6
10/18/2006	9:30	pump	244938	385.5	25600	7.91	21.6	227.0	.44	832.94	208
10/18/2006	9:40	pump	N/A	N/A	N/A	7.91	21.5	228.0	0.43	832.94	208.1
10/18/2006	9:50	pump	245324	386	25986	7.91	21.6	228.0	0.42	832.94	207.5
10/18/2006	10:00	pump	N/A	N/A	N/A	7.91	21.6	227.0	0.39	832.94	209.4
10/18/2006	10:10	pump	245710.5	386.5	26372.5	7.92	21.7	228.0	.47	832.94	208.6
10/18/2006	10:20	pump	N/A	N/A	N/A	7.92	21.7	229.0	.41	832.94	212.2
10/18/2006	10:30	pump	246096.3	385.8	26758.3	7.91	21.7	228.0	.35	832.94	209.3
10/18/2006	10:45	pump	N/A	N/A	N/A	7.92	21.8	228.0	.44	832.94	205.9
10/18/2006	10:50	pump	246483	386.7	27145	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	11:00	pump	N/A	N/A	N/A	7.92	21.8	228.0	.47	832.94	206.6

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/18/2006	11:10	pump	246869.8	386.8	27531.8	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	11:15	pump	N/A	N/A	N/A	7.92	21.8	227.0	.34	832.94	205.6
10/18/2006	11:30	pump	247256.3	386.5	27918.3	7.92	21.9	228.0	.43	832.94	203
10/18/2006	11:45	pump	N/A	N/A	N/A	7.92	22	228.0	0.38	832.94	206.1
10/18/2006	11:50	pump	247643	386.7	28305	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	12:00	pump	N/A	N/A	N/A	7.92	22.0	228.0	0.4	832.94	207.3
10/18/2006	12:10	pump	248029.8	386.8	28691.8	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	12:15	pump	N/A	N/A	N/A	7.91	21.90	228.0	0.500	832.94	208.2
10/18/2006	12:30	pump	248416	386.2	29078	7.91	22.0	229.0	.36	832.94	209.7
10/18/2006	12:45	pump	N/A	N/A	N/A	7.91	21.8	228.0	.34	832.94	211.6
10/18/2006	12:50	pump	248803	387	29465	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	13:00	pump	N/A	N/A	N/A	7.91	21.8	228.0	.39	832.94	213

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to** 10/18/2006
Tool:		**Description:**		**Used From**		**to**
Tool:		**Description:**		**Used From**		**to**
Tool:		**Description:**		**Used From**		**to**

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/18/2006	13:10	pump	249189.8	386.8	29851.8	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	13:15	pump	N/A	N/A	N/A	7.91	21.7	228.0	.38	832.94	215.5
10/18/2006	13:30	pump	249576.8	387	30238.8	7.92	21.8	227.0	.45	832.94	213.1
10/18/2006	13:45	pump	N/A	N/A	N/A	7.91	22	228.0	0.29	832.94	212.1
10/18/2006	13:50	pump	249969.9	393.1	30631.9	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	14:00	pump	N/A	N/A	N/A	7.91	22.1	228.0	0.36	832.94	215.5
10/18/2006	14:10	pump	250351	381.1	31013	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	14:15	pump	N/A	N/A	N/A	7.91	22.10	228.0	0.300	832.94	213.3
10/18/2006	14:30	pump	250738	387	31400	7.92	21.9	229.0	.29	832.94	214.6
10/18/2006	14:45	pump	N/A	N/A	N/A	7.91	22.1	228.0	.34	832.94	225.6
10/18/2006	14:50	pump	251125	387	31787	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	15:00	pump	N/A	N/A	N/A	7.92	22.1	228.0	.35	832.94	226.9

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-12 Lower Screen** Project No.: **73885.4.2**

Location: **Sandia Canyon** Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 7.5 hp	**Used From**	10/16/2006	**to**	10/18/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	ORP (mv)
10/18/2006	15:10	pump	251511.4	386.4	32173.4	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	15:15	pump	N/A	N/A	N/A	7.92	21.9	227.0	.34	832.94	228.6
10/18/2006	15:30	pump	251898.2	386.8	32560.2	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	15:50	pump	252285.5	387.3	32947.5	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	16:10	pump	252672.8	387.3	33334.8	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	16:30	pump	253060	387.2	33722	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	16:50	pump	253447.6	387.6	34109.6	N/A	N/A	N/A	N/A	832.94	N/A
10/18/2006	17:10	pump	253835.5	387.9	34497.5	N/A	N/A	N/A	N/A	832.94	N/A

WELL DEVELOPMENT (Cover Page)

Site/Screen Name:	**R-20 Lower**	Project No.:	**68402**
Location:	**Pajarito Canyon**	Document Originator:	**Jordan Vaughn**
Lead Company:	**KA**	Document Reviewer:	**Lee Dalton**
Supporting Company:	**DS&A**	Review Complete:	**12/15/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353 **ft bgs** 1328.8 **ft bgs** **to** 1336.5 **ft bgs**

Total Volume Withdrawn (Bailing): **Total Volume Withdraw** 3,836.00 **gals.**

DEVELOPMENT TOOLS

Tool:	pump	**Desc.**	Grundfos (7.5HP)	**Used From**	10/13/2006	**to**	10/13/2006
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	e Volume Withdraw n (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/13/2006	8:20	Pump	221459.9	N/A	N/A	N/A	N/A	N/A	N/A	1211.95	Pump on
10/13/2006	8:21	Pump	221466.6	6.7	6.7	N/A	N/A	N/A	N/A	1211.95	6.7 gpm
10/13/2006	8:22	Pump	221474.9	8.3	15.0	N/A	N/A	N/A	N/A	1211.95	8.3 gpm
10/13/2006	8:22:30	Pump	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1211.95	Pump off
10/13/2006	8:23:35	Pump	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1211.95	Pump on
10/13/2006	8:24	Pump	221483.2	8.3	23.3	N/A	N/A	N/A	N/A	1211.95	N/A
10/13/2006	8:25	Pump	221491.6	8.4	31.7	N/A	N/A	N/A	N/A	1211.95	8.4 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 Lower** Project No.: **68402**

Location: Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	pump	**Desc.**	Grundfos (7.5HP)	**Used From**	10/13/2006	**to**	10/13/2006
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/13/2006	8:26	Pump	221500.1	8.5	40.2	N/A	N/A	N/A	N/A	1211.95	8.5 gpm
10/13/2006	8:27	Pump	221508.4	8.3	48.5	N/A	N/A	N/A	N/A	1211.95	8.3 gpm
10/13/2006	8:28	Pump	221516.7	8.3	56.8	N/A	N/A	N/A	N/A	1211.95	8.3 gpm
10/13/2006	8:30	Pump	221532.8	16.1	72.9	N/A	N/A	N/A	N/A	1211.95	8.05 gpm
10/13/2006	8:32	Pump	221548.7	15.9	88.8	N/A	N/A	N/A	N/A	1211.95	7.95 gpm
10/13/2006	8:34	Pump	221564.7	16.0	104.8	N/A	N/A	N/A	N/A	1211.95	8.00 gpm
10/13/2006	8:36	Pump	221580.1	15.4	120.2	N/A	N/A	N/A	N/A	1211.95	7.70 gpm
10/13/2006	8:38	Pump	221595.8	15.7	135.9	N/A	N/A	N/A	N/A	1211.95	7.85 gpm
10/13/2006	8:40	Pump	221610.1	14.3	150.2	N/A	N/A	N/A	N/A	1211.95	7.15 gpm
10/13/2006	8:45	Pump	221647.9	37.8	188.0	N/A	N/A	N/A	N/A	1211.95	7.56 gpm
10/13/2006	8:52	Pump	221700.8	52.9	240.9	N/A	N/A	N/A	N/A	1211.95	7.56 gpm
10/13/2006	9:00	Pump	221764.0	63.2	304.1	7.08	21.3	84.3	39.70	1211.95	DO=0.80mg/L ORP=315.9 7.90 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 Lower** Project No.: **68402**

Location: Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	pump	**Desc.**	Grundfos (7.5HP)	**Used From**	10/13/2006	**to**	10/13/2006
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/13/2006	9:05	Pump	221806.0	42.0	346.1	7.10	21.3	85.4	1.80	1211.95	DO=0.58mg/L ORP=310.9 8.40 gpm
10/13/2006	9:10	Pump	221847.8	41.8	387.9	7.10	21.5	85.5	1.83	1211.95	DO=0.73mg/L ORP=301.6mv 8.36 gpm
10/13/2006	9:15	Pump	221890.6	42.8	430.7	7.10	21.9	82.5	0.91	1211.95	DO=0.62mg/L ORP= 8.56 gpm
10/13/2006	9:20	Pump	N/A	N/A		7.08	21.9	81.6	0.83	1211.95	DO=0.55mg/L ORP=
10/13/2006	9:25	Pump	221976.3	85.7	516.4	7.07	21.9	78.8	0.71	1211.95	DO=0.30mg/L ORP= 8.57 gpm
10/13/2006	9:30	Pump	222020.1	43.8	560.2	7.07	21.9	79.1	0.71	1211.95	DO=0.31mg/L ORP= 8.76 gpm
10/13/2006	9:35	Pump	222063.7	43.6	603.8	7.07	21.0	78.0	0.69	1211.95	DO=0.31mg/L ORP= 8.72 gpm
10/13/2006	9:40	Pump	222107.0	43.3	647.1	7.00	23.1	77.8	0.57	1211.95	DO=0.38mg/L ORP= 8.66 gpm
10/13/2006	9:45	Pump	N/A	N/A	N/A	7.00	23.0	77.4	0.57	1211.95	DO=0.37mg/L ORP=29.6mv
10/13/2006	9:50	Pump	N/A	N/A	N/A	6.98	23.4	76.8	0.83	1211.95	DO=0.35mg/L ORP=19.6mv

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 Lower** Project No.: **68402**

Location: Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	pump	**Desc.**	Grundfos (7.5HP)	**Used From**	10/13/2006	**to**	10/13/2006
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/13/2006	9:55	Pump	222233.5	126.5	773.6	6.98	23.6	76.6	0.79	1211.95	DO=0.37mg/L ORP=20.4mv 8.43 gpm
10/13/2006	10:00	Pump	222275.6	42.1	815.7	6.97	23.7	76.4	0.54	1211.95	DO=0.35mg/L ORP=26.7mv 8.42 gpm
10/13/2006	10:05	Pump	N/A	N/A		6.97	23.8	76.7	0.44	1211.95	DO=0.38mg/L ORP=21.5mv
10/13/2006	10:10	Pump	222358.4	82.8	898.5	6.95	23.8	75.4	0.50	1211.95	DO=0.38mg/L ORP=25.2mv 8.28 gpm
10/13/2006	10:20	Pump	N/A	N/A		6.95	23.8	78.7	0.45	1211.95	DO=0.43mg/L ORP=25.0mv
10/13/2006	10:25	Pump	222480.4	122.0	1020.5	N/A	N/A	N/A	N/A	1211.95	8.13 gpm
10/13/2006	10:30	Pump	222520.0	39.6	1060.1	6.94	23.0	75.0	0.50	1211.95	DO=0.47mg/L ORP=29.4mv 7.92 gpm
10/13/2006	10:40	Pump	222602.4	82.4	1142.5	6.93	24.0	74.5	0.52	1211.95	DO=0.48mg/L ORP=32.2mv 8.04 gpm
10/13/2006	10:50	Pump	222686.3	83.9	1226.4	6.93	24.0	77.2	0.41	1211.95	DO=0.52mg/L ORP=35.5mv 8.39 gpm
10/13/2006	11:00	Pump	222770.3	84.0	1310.4	6.92	24.1	73.9	0.45	1211.95	DO=0.54mg/L ORP=37.6mv 8.40 gpm
10/13/2006	11:10	Pump	222855.6	85.3	1395.7	6.91	24.3	73.6	0.36	1211.95	DO=0.59mg/L ORP=40.7mv 8.53 gpm
10/13/2006	11:20	Pump	222941.2	85.6	1481.3	6.91	24.2	73.7	0.33	1211.95	DO=0.61mg/L ORP=42.2mv 8.56 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 Lower** Project No.: **68402**

Location: Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	pump	**Desc.**	Grundfos (7.5HP)	**Used From**	10/13/2006	**to**	10/13/2006
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/13/2006	11:24	Pump	222974.3	33.1	1514.4	N/A	N/A	N/A	N/A	1211.95	8.28 gpm
10/13/2006	11:25:30	Pump	222984.3	10.0	1524.4	N/A	N/A	N/A	N/A	1211.95	6.67 gpm
10/13/2006	11:26	Pump	222987.6	3.3	1527.7	N/A	N/A	N/A	N/A	1211.95	6.60 gpm
10/13/2006	11:26:30	Pump	222991.1	3.5	1531.2	N/A	N/A	N/A	N/A	1211.95	7.00 gpm
10/13/2006	11:27	Pump	222994.4	3.3	1534.5	N/A	N/A	N/A	N/A	1211.95	6.60 gpm
10/13/2006	11:27:30	Pump	222998.0	3.6	1538.1	N/A	N/A	N/A	N/A	1211.95	7.20 gpm
10/13/2006	11:28	Pump	223001.8	3.8	1541.9	N/A	N/A	N/A	N/A	1211.95	7.60 gpm
10/13/2006	11:28:30	Pump	223005.6	3.8	1545.7	N/A	N/A	N/A	N/A	1211.95	7.60 gpm
10/13/2006	11:29	Pump	223009.3	3.7	1549.4	N/A	N/A	N/A	N/A	1211.95	7.40 gpm
10/13/2006	11:29:30	Pump	223013.3	4.0	1553.4	N/A	N/A	N/A	N/A	1211.95	8.00 gpm
10/13/2006	11:30	Pump	223017.3	4.0	1557.4	6.91	24.2	73.7	0.51	1211.95	DO=0.65mg/L ORP=44.6mv 8.00 gpm
10/13/2006	11:31	Pump	223025.3	8.0	1565.4	N/A	N/A	N/A	N/A	1211.95	8.00 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 Lower** Project No.: **68402**

Location: Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	pump	**Desc.**	Grundfos (7.5HP)	**Used From**	10/13/2006	**to**	10/13/2006
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/13/2006	11:32	Pump	223033.3	8.0	1573.4	N/A	N/A	N/A	N/A	1211.95	8.00 gpm
10/13/2006	11:33	Pump	223041.3	8.0	1581.4	N/A	N/A	N/A	N/A	1211.95	8.00 gpm
10/13/2006	11:35	Pump	223057.1	15.8	1597.2	N/A	N/A	N/A	N/A	1211.95	7.90 gpm
10/13/2006	11:40	Pump	223096.5	39.4	1636.6	6.90	24.2	73.8	0.41	1211.95	DO=0.60mg/L ORP=45.7mv 7.88 gpm
10/13/2006	11:45	Pump	223136.1	39.6	1676.2	N/A	N/A	N/A	N/A	1211.95	7.92 gpm
10/13/2006	11:50	Pump	223175.5	39.4	1715.6	6.90	24.2	72.8	0.44	1211.95	DO=0.71mg/L ORP= 7.88 gpm
10/13/2006	11:55	Pump	223215.0	39.5	1755.1	N/A	N/A	N/A	N/A	1211.95	7.90 gpm
10/13/2006	12:00	Pump	223254.4	39.4	1794.5	6.90	24.3	72.7	0.41	1211.95	DO=0.77mg/L ORP= 7.88 gpm
10/13/2006	12:10	Pump	223333.1	78.7	1873.2	6.89	24.4	72.5	0.29	1211.95	DO=0.73mg/L ORP= 7.87 gpm
10/13/2006	12:20	Pump	223411.9	78.8	1952.0	6.89	24.4	72.4	0.35	1211.95	DO=0.78mg/L ORP= 7.88 gpm
10/13/2006	12:30	Pump	223490.5	78.6	2030.6	6.88	24.4	72.2	0.27	1211.95	DO=0.82mg/L ORP= 7.86 gpm
10/13/2006	12:40	Pump	N/A	N/A		6.88	24.4	72.1	0.23	1211.95	DO=0.84mg/L ORP=

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 Lower** Project No.: **68402**

Location: Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	pump	**Desc.**	Grundfos (7.5HP)	**Used From**	10/13/2006	**to**	10/13/2006
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/13/2006	12:45	Pump	223608.2	117.7	2148.3	N/A	N/A	N/A	N/A	1211.95	7.85 gpm
10/13/2006	12:50	Pump	N/A	N/A	N/A	6.88	24.4	71.8	0.31	1211.95	DO=0.87mg/L ORP=
10/13/2006	13:00	Pump	223725.1	116.9	2265.2	6.87	24.5	71.6	0.30	1211.95	DO=0.96mg/L ORP= 7.79 gpm
10/13/2006	13:15	Pump	N/A	N/A	N/A	6.87	24.6	71.6	0.29	1211.95	DO=0.99mg/L ORP=
10/13/2006	13:20	Pump	223881.8	156.7	2421.9	N/A	N/A	N/A	N/A	1211.95	7.84 gpm
10/13/2006	13:30	Pump	N/A	N/A	N/A	6.87	24.6	71.6	0.22	1211.95	DO=1.01mg/L ORP=
10/13/2006	13:40	Pump	224037.3	155.5	2577.4	N/A	N/A	N/A	N/A	1211.95	7.78 gpm
10/13/2006	13:45	Pump	N/A	N/A	N/A	6.86	24.7	70.3	0.27	1211.95	DO=1.04mg/L ORP=
10/13/2006	14:00	Pump	224192.7	155.4	2732.8	6.86	27.7	70.4	0.23	1211.95	DO=1.06mg/L ORP= 7.78 gpm
10/13/2006	14:15	Pump	N/A	N/A	N/A	6.85	24.9	69.9	0.25	1211.95	DO=1.12mg/L ORP=
10/13/2006	14:20	Pump	224349.0	156.3	2889.1	N/A	N/A	N/A	N/A	1211.95	7.82 gpm
10/13/2006	14:30	Pump	N/A	N/A	N/A	6.84	24.8	69.8	0.32	1211.95	DO=1.16mg/L ORP=

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 Lower** Project No.: **68402**

Location: Document Originator: **Jordan Vaughn**

DEVELOPMENT TOOLS

Tool:	pump	**Desc.**	Grundfos (7.5HP)	**Used From**	10/13/2006	**to**	10/13/2006
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	
Tool:		**Desc.**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
10/13/2006	14:40	Pump	224505.8	156.8	3045.9	N/A	N/A	N/A	N/A	1211.95	7.84 gpm
10/13/2006	14:45	Pump	N/A	N/A	N/A	6.84	24.8	69.6	0.23	1211.95	DO=1.20mg/L ORP=
10/13/2006	15:00	Pump	224663.5	157.7	3203.6	6.83	24.9	69.5	0.22	1211.95	DO=1.09mg/L ORP= 7.86 gpm
10/13/2006	15:15	Pump	N/A	N/A	N/A	6.83	25.0	69.3	0.26	1211.95	DO=1.14mg/L ORP=
10/13/2006	15:20	Pump	224821.9	158.4	3362.0	N/A	N/A	N/A	N/A	1211.95	7.92 gpm
10/13/2006	15:30	Pump	N/A	N/A	N/A	6.83	25.0	69.5	0.25	1211.95	DO=1.14mg/L ORP=
10/13/2006	15:40	Pump	224980.0	158.1	3520.1	N/A	N/A	N/A	N/A	1211.95	7.92 gpm
10/13/2006	16:00	Pump	225137.9	157.9	3678.0	N/A	N/A	N/A	N/A	1211.95	7.90 gpm
10/13/2006	16:20	Pump	225295.9	158.0	3836.0	N/A	N/A	N/A	N/A	1211.95	7.90 gpm Pump off

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-20/Lower**
Location: **Pajarito Canyon**
Lead Company: **KA**
Supporting Company: **DS&A**

Project No.: **68402.3**
Document Originator: **Brian Lucero**
Document Reviewer: **Brain Lucero**
Review Complete: **11/7/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353 **ft bgs** 1329 **ft bgs** **to** 1337 **ft bgs**

Total Volume Withdrawn (Bailing): _____ **Total Volume Withdrawn (Pumping):** 1734.6 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**cription:**	Grundfos 10 hp	**Used From**	8/30/2006	**to**	8/30/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	e Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/30/2006	7:12	pump	211879.7	0	0	N/A	N/A	N/A	N/A	1307	pump on
8/30/2006	7:50	pump	211969.7	90	90	8.28	18.7	90.9	36.2	1307	DO=0.24 mg/l
8/30/2006	8:00	pump	211993	23.3	113.3	8.15	20.4	86.3	32.1	1307	DO=0.09 mg/l
8/30/2006	8:10	pump	212016.3	23.3	136.6	7.98	20.6	85.3	13.2	1307	DO=0.13 mg/l
8/30/2006	8:20	pump	212039.8	23.5	160.1	7.91	20.7	85	4.09	1307	DO=0.06 mg/l
8/30/2006	8:30	pump	212063.4	23.6	183.7	7.88	20.8	85.5	3.86	1307	DO=0.06 mg/l
8/30/2006	8:45	pump	212086.9	23.5	207.2	7.82	21	86.1	5.13	1307	DO=0.06 mg/l

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20/Lower** Project No.: **68402.3**

Location: **Pajarito Canyon** Document Originator: **Brian Lucero**

DEVELOPMENT TOOLS

Tool:	Pump	**cription:**	Grundfos 10 hp	**Used From**	8/30/2006	**to**	8/30/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/30/2006	8:50	pump	212110.4	23.5	230.7	7.78	21.1	86.300	4.48	1307	DO=0.06 mg/l
8/30/2006	9:00	pump	212133.9	23.5	254.2	7.71	21.2	87.100	3.12	1307	DO=0.05 mg/l
8/30/2006	9:15	pump	212169.2	35.3	289.5	7.65	21.7	88.200	3.17	1307	DO=0.05 mg/l
8/30/2006	9:30	pump	212204.4	35.2	324.7	7.62	21.6	89.400	3.32	1307	ORP=-123.0mv;DO=0.05mg/l
8/30/2006	9:45	pump	212239.7	35.3	360	7.56	21.7	90.800	3.58	1307	ORP=-123.7mv;DO=0.05mg/l
8/30/2006	10:00	pump	212274.9	35.2	395.2	7.57	21.9	93.600	3.94	1307	ORP=-117.1mv;DO=0.05mg/l
8/30/2006	10:30	pump	212346.3	71.4	466.6	7.49	22.1	96.400	3.68	1307	ORP=-109.3mv;DO=0.06mg/l
8/30/2006	11:00	pump	21419.2	72.9	539.5	7.55	24.2	97.000	4.34	1307	ORP=-107.5mv;DO=0.06mg/l
8/30/2006	12:00	pump	21564.8	145.6	685.1	7.47	23.4	103.600	6.21	1307	ORP=-102.3.0mv;DO=0.10mg/l
8/30/2006	13:00	pump	21710.5	145.7	830.8	7.36	23.7	105.700	2.13	1307	ORP=-105.7mv;DO=0.09mg/l
8/30/2006	14:00	pump	21856	145.5	976.3	7.24	23.5	106.200	2.86	1307	ORP=-105.8mv;DO=0.12mg/l
8/30/2006	15:00	pump	213002	146	1122.3	7.26	22.6	104.100	1.8	1307	ORP=-114.0mv;DO=0.12mg/l

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20/Lower** Project No.: **68402.3**

Location: **Pajarito Canyon** Document Originator: **Brian Lucero**

DEVELOPMENT TOOLS

Tool:	Pump	**cription:**	Grundfos 10 hp	**Used From**	8/30/2006	**to**	8/30/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/30/2006	16:00	pump	213147.7	145.7	1268	7.25	23.2	86.300	.81	1307	ORP=-116.0mv;DO=0.14mg/l
8/30/2006	17:00	pump	213293.4	145.7	1413.7	7.28	23.6	87.100	3.88	1307	ORP=-113.1mv;DO=0.14mg/l
8/30/2006	18:00	pump	213438.9	145.5	1559.2	7.23	23.2	88.200	2.62	1307	ORP=-120.9mv;DO=0.11mg/l
8/30/2006	19:00	pump	21585.3	146.4	1705.6	7.10	22.3	89.400	2.09	1307	ORP=-114.0mv;DO=0.11mg/l
8/30/2006	19:12	pump	21614.3	29	1734.6	N/A	N/A	N/A	N/A	1307	Pump off

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-20 (Lower Scre**
Location: **Pajarito Canyon**
Lead Company: **Kleinfelder, Inc.**
Supporting Company: **WDC Exploration**

Project No.: **68402 3.L**
Document Originator: **Lucero, Brian**
Document Reviewer: **Lucero, Brian**
Review Complete: **11/7/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353.3 **ft bgs** 1329 **to** 1337 **ft bgs**

Total Volume Withdrawn (Bailing): n/a **Total Volume Withdrawn (Pumping):** 1164.5 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	dfos 3 gpm subme	**Used From**	8/31/2006	**to**	8/31/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	e Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/31/2006	7:00	Pump	213644.3	N/A	N/A	N/A	N/A	N/A	N/A	1307	Pump On
8/31/2006	7:45	Pump	213724.4	110.1	110.1	7.44	21	100	2.01	1307	N/A
8/31/2006	8:00	Pump	213760.1	35.7	145.8	7.44	21.7	98.8	2.45	1307	N/A
8/31/2006	8:15	Pump	213795.7	35.6	181.4	7.32	21.5	96.4	2.2	1307	N/A
8/31/2006	8:30	Pump	213830.9	35.2	216.6	7.31	21.4	96.4	2.36	1307	N/A
8/31/2006	8:45	Pump	213869	38.1	254.7	7.3	21.7	96.2	1.32	1307	N/A
8/31/2006	9:15	Pump	213942.5	73.5	328.2	7.28	22.8	94.6	1.68	1307	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (Lower Scre** Project No.: **68402 3.L**

Location: **Pajarito Canyon** Document Originator: **Lucero, Brian**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	dfos 3 gpm subme	**Used From**	8/31/2006	**to**	8/31/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/31/2006	9:45	Pump	214018.2	75.7	403.9	7.23	22.9	93.8	1.28	1307	N/A
8/31/2006	10:45	Pump	214161.3	143.1	547	7.16	23.6	92.5	1.66	1307	N/A
8/31/2006	11:45	Pump	214307.2	145.7	692.7	7.10	24.1	91.7	1.60	1307	N/A
8/31/2006	12:45	Pump	214453	145.8	838.5	7.17	24.4	90.1	1.23	1307	N/A
8/31/2006	13:45	Pump	214600.5	146.5	985	7.07	22.7	88.9	1.15	1307	N/A
8/31/2006	14:45	Pump	214746.6	146.1	1131.1	6.94	22.6	87.4	1.45	1307	N/A
8/31/2006	15:00	Pump	214780	33.4	1164.5	N/A	N/A	N/A	N/A	1307	Pump Off

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-20 (Upper and Middle)**
Location: **Pajarito Canyon**
Lead Company: **Kleinfelder, Inc.**
Supporting Company: **WDC Exploration/**

Project No.: **68402 3.L**
Document Originator: **C. Vallejo**
Document Reviewer: **Lucero, Brian**
Review Complete: **11/7/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353.3 **ft bgs** 904.6 - 912.2 **ft bgs** **and** 1147.1 - 1154.7 **ft bgs**

Total Volume Withdrawn (Bailing): n/a **Total Volume Withdrawn (Pumping):** 1084.8 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5hp	**Used From**	8/26/2006	**to**	8/26/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/26/2006	7:33	Pump	209105	N/A	N/A	N/A	N/A	N/A	N/A	1161	Pump On
8/26/2006	7:51	Pump	209154.5	49.5	49.5	6.83	18.2	102.9	314	1161	N/A
8/26/2006	7:57	Pump	209183.4	28.9	78.4	8.35	19.3	115.8	153	1161	N/A
8/26/2006	8:14	Pump	209192.5	9.1	87.5	8.2	19.9	120.2	104	1161	N/A
8/26/2006	8:30	Pump	209217	24.5	112	8.15	20	121.6	85.4	1161	N/A
8/26/2006	8:47	Pump	209244.7	27.7	139.7	8.37	20.5	114.1	58.4	1161	N/A
8/26/2006	9:04	Pump	209272.2	27.5	167.2	8.11	21.2	112.7	45.2	1161	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (Upper and Middle)** Project No.: **68402 3.L**

Location: **Pajarito Canyon** Document Originator: **C. Vallejo**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5hp	**Used From**	8/26/2006	**to**	8/26/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/26/2006	9:20	Pump	209297.7	25.5	192.7	8.08	21.3	110	47.2	1161	N/A
8/26/2006	9:35	Pump	209321.3	23.6	216.3	8.40	21.1	106.9	48.8	1161	N/A
8/26/2006	10:00	Pump	209359	37.7	254	8.39	21.8	103.9	46.3	1161	N/A
8/26/2006	10:20	Pump	209386.2	27.2	281.2	8.14	23.0	101.2	42.2	1161	N/A
8/26/2006	10:40	Pump	209416.4	30.2	311.4	8.09	23.0	95.6	34.8	1161	N/A
8/26/2006	11:00	Pump	209448.6	32.2	343.6	8.01	24.2	92	22.6	1161	N/A
8/26/2006	11:20	Pump	209479.9	31.3	374.9	7.71	23.3	92.4	21.1	1161	N/A
8/26/2006	11:40	Pump	209511.5	31.6	406.5	8.08	23.1	89.7	18.8	1161	N/A
8/26/2006	12:00	Pump	209542.9	31.4	437.9	7.91	23.3	88.6	19.2	1161	N/A
8/26/2006	12:20	Pump	209574	31.1	469	8.07	22.6	88.2	19.8	1161	N/A
8/26/2006	12:40	Pump	209605	31	500	8.05	22.3	87	17.4	1161	N/A
8/26/2006	13:00	Pump	209635.7	30.7	530.7	8.00	23.1	85.2	16.1	1161	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (Upper and Middle)** Project No.: **68402 3.L**

Location: **Pajarito Canyon** Document Originator: **C. Vallejo**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5hp	**Used From**	8/27/2006	**to**	8/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/26/2006	13:40	Pump	209697.1	61.4	592.1	7.78	23.9	84.9	14.1	1161	NA
8/26/2006	14:00	Pump	209726.7	29.6	621.7	7.85	24.3	86.5	12.7	1161	NA
8/26/2006	14:20	Pump	209757	30.3	652	7.88	23.8	85.3	13.0	1161	NA
8/26/2006	14:40	Pump	209788.4	31.4	683.4	8.05	23.5	84.4	11.9	1161	NA
8/26/2006	15:00	Pump	209818.9	30.5	713.9	7.89	23.6	84	10.7	1161	NA
8/26/2006	15:20	Pump	209849.9	31	744.9	7.87	24.0	83.9	11.0	1161	NA
8/26/2006	15:40	Pump	209881	31.1	776	7.99	23.6	82.6	11.4	1161	NA
8/26/2006	16:00	Pump	209912	31	807	7.92	24.3	82.6	11.1	1161	NA
8/26/2006	16:20	Pump	209942.9	30.9	837.9	7.89	23.3	83.8	9.17	1161	NA
8/26/2006	16:40	Pump	209973.6	30.7	868.6	7.88	23.1	82.8	8.50	1161	NA
8/26/2006	17:00	Pump	210004.3	30.7	899.3	7.62	23.3	83.3	7.55	1161	NA
8/26/2006	17:20	Pump	210035.1	30.8	930.1	7.72	23.5	83.3	7.58	1161	NA

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (Upper and Middle)** Project No.: **68402 3.L**

Location: **Pajarito Canyon** Document Originator: **C. Vallejo**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5hp	**Used From**	8/27/2006	**to**	8/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/26/2006	17:40	Pump	210035.8	30.7	960.8	7.95	23.6	82.2	7.63	1161	N/A
8/26/2006	18:00	Pump	210097.1	31.3	992.1	7.96	23.1	84.5	7.03	1161	N/A
8/26/2006	18:20	Pump	210127.9	30.8	1022.9	7.89	22.0	83.4	6.65	1161	N/A
8/26/2006	18:40	Pump	210158.9	31	1053.9	7.66	21.1	81.2	9.03	1161	N/A
8/26/2006	19:00	Pump	210189.8	30.9	1084.8	N/A	N/A	N/A	N/A	1161	Pump Off

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-20 (Upper and Middle)**
Location: **Pajarito Canyon**
Lead Company: **Kleinfelder, Inc.**
Supporting Company: **WDC Exploration**

Project No.: **68402 3.L**
Document Originator: **C. Vallejo**
Document Reviewer: **Lucero, Brian**
Review Complete: **11/7/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353.3 **ft bgs** 904.6 - 912.2 **ft bgs** **and** 1147.1 - 1154.7 **ft bgs**

Total Volume Withdrawn (Bailing): n/a **Total Volume Withdrawn (Pumping):** 1071.4 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5 hp	**Used From**	8/27/2006	**to**	8/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	e Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/27/2006	7:15	Pump	210189.8	N/A	N/A	N/A	N/A	N/A	N/A	1161	Pump On
8/27/2006	8:00	Pump	210259.9	70.1	70.1	8.09	19.7	86.3	65	1161	N/A
8/27/2006	8:20	Pump	210288.7	28.8	98.9	7.69	20.4	86.2	38.7	1161	N/A
8/27/2006	8:40	Pump	210317	28.3	127.2	8.04	20.4	84.6	30.8	1161	N/A
8/27/2006	9:00	Pump	210345	28	155.2	8.19	21.2	83.9	25.1	1161	N/A
8/27/2006	9:20	Pump	210372.7	27.7	182.9	8.3	21.4	82.3	18	1161	N/A
8/27/2006	9:44	Pump	210405.6	32.9	215.8	8.3	21.6	83.1	17	1161	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (Upper and Middle)** Project No.: **68402 3.L**

Location: **Pajarito Canyon** Document Originator: **C. Vallejo**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5 hp	**Used From**	8/26/2006	**to**	8/26/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/27/2006	10:00	Pump	210427.6	22	237.8	8.31	21.7	82.9	11.3	1161	N/A
8/27/2006	10:20	Pump	210455.1	27.5	265.3	8.24	21.8	82.7	11.7	1161	N/A
8/27/2006	10:40	Pump	210482.3	27.2	292.5	8.24	21.9	82.4	8.99	1161	N/A
8/27/2006	11:00	Pump	210509.5	27.2	319.7	7.92	22.3	83.1	10.9	1161	N/A
8/27/2006	11:20	Pump	210536.7	27.2	346.9	8.08	22.5	84.7	8.45	1161	N/A
8/27/2006	11:40	Pump	210563.9	27.2	374.1	8.10	22.7	84.6	6.15	1161	N/A
8/27/2006	12:00	Pump	210590.9	27	401.1	7.96	23.2	85.9	5.93	1161	N/A
8/27/2006	12:20	Pump	210617.8	26.9	428	7.91	22.5	84.9	6.44	1161	N/A
8/27/2006	12:40	Pump	210644.7	26.9	454.9	7.90	22.9	83.9	6.96	1161	N/A
8/27/2006	13:00	Pump	210671.6	26.9	481.8	7.95	23.6	84.4	6.96	1161	N/A
8/27/2006	13:20	Pump	210698.5	26.9	508.7	7.90	23.3	84.9	6.76	1161	N/A
8/27/2006	13:40	Pump	210725.4	26.9	535.6	7.92	23.3	83.7	6.7	1161	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (Upper and Middle)** Project No.: **68402 3.L**

Location: **Pajarito Canyon** Document Originator: **C. Vallejo**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5 hp	**Used From**	8/27/2006	**to**	8/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/27/2006	14:00	Pump	210752.4	27	562.6	7.98	23.7	85.2	6.35	1161	N/A
8/27/2006	14:20	Pump	210779.4	27	589.6	7.92	23.7	84	6.64	1161	N/A
8/27/2006	14:40	Pump	210806.4	27	616.6	7.93	23.4	83.7	5.87	1161	N/A
8/27/2006	15:00	Pump	210833.4	27	643.6	7.94	23.8	83.9	5.76	1161	N/A
8/27/2006	15:20	Pump	210860.5	27.1	670.7	8.01	23.5	82.9	5.66	1161	N/A
8/27/2006	15:40	Pump	210887.4	26.9	697.6	7.92	24.1	83.1	4.94	1161	turbidity below 5 NTU
8/27/2006	16:00	Pump	210914.4	27	724.6	7.90	24.1	82.5	4.84	1161	N/A
8/27/2006	16:20	Pump	210957.4	43	767.6	7.93	23.6	83.3	17.4	1161	Increased flowrate at 1606
8/27/2006	16:40	Pump	211004	46.6	814.2	7.94	25.2	84.1	45	1161	N/A
8/27/2006	17:00	Pump	211047.9	43.9	858.1	8.06	24.5	82.5	39.2	1161	N/A
8/27/2006	17:20	Pump	211090.6	42.7	900.8	8.10	24.3	82.3	40.6	1161	N/A
8/27/2006	17:40	Pump	211131.9	41.3	942.1	8.11	24.1	81.8	27.9	1161	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (Upper and Middle)** Project No.: **68402 3.L**

Location: **Pajarito Canyon** Document Originator: **C. Vallejo**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5 hp	**Used From**	8/27/2006	**to**	8/27/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/27/2006	18:00	Pump	211172.3	40.4	982.5	8.00	24.4	80.5	29.0	1161	N/A
8/27/2006	18:20	Pump	211212	39.7	1022.2	8.17	23.1	81.1	33.1	1161	N/A
8/27/2006	18:40	Pump	211251.4	39.4	1061.6	8.12	22.4	82.1	29.8	1161	N/A
8/27/2006	18:45	Pump	211261.2	9.8	1071.4	n/a	n/a	n/a	n/a	1161	Pump Off

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-20 (Upper Screen)**
Location: **Pajarito Canyon**
Lead Company: **Kleinfelder, Inc.**
Supporting Company: **WDC Exploration**

Project No.: **68402 3.L**
Document Originator: **C. Vallejo**
Document Reviewer: **Lucero, Brian**
Review Complete: **11/7/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353.3 **ft bgs** 904.6 **ft bgs** **to** 912.2 **ft bgs**

Total Volume Withdrawn (Bailing): n/a **Total Volume Withdrawn (Pumping):** 264.2 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5 hp	**Used From**	8/28/2006	**to**	8/28/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	e Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/28/2006	7:50	Pump	211261.2	N/A	N/A	N/A	N/A	N/A	N/A	929	Pump On
8/28/2006	8:43	Pump	211314.2	53	53	8.36	18.8	87.1	26.4	929	N/A
8/28/2006	9:00	Pump	211330.4	16.2	69.2	8.46	20	85.4	54.8	929	N/A
8/28/2006	9:20	Pump	211347.3	16.9	86.1	8.42	20	85.4	76.4	929	N/A
8/28/2006	9:40	Pump	211363.6	16.3	102.4	8.29	21.1	85.5	27.2	929	N/A
8/28/2006	10:00	Pump	211379.8	16.2	118.6	8.3	20.8	85.9	22.7	929	N/A
8/28/2006	10:20	Pump	211396.2	16.4	135	8.33	21.3	85.9	25	929	N/A

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (Upper Screen)** Project No.: **68402 3.L**

Location: **Pajarito Canyon** Document Originator: **C. Vallejo**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 5 hp	**Used From**	8/28/2006	**to**	8/28/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/28/2006	12:15	Pump	211458	61.8	196.8	8.16	22.9	81.100	15.0	929	N/A
8/28/2006	14:45	Pump	211519.8	61.8	258.6	8.21	21.7	85.400	12.6	929	N/A
8/28/2006	14:50	Pump	211525.4	5.6	264.2	N/A	N/A	N/A	N/A	929	Pump Off

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-16 Sc 2**
Location: **Canada del Buey**
Lead Company: **KA**
Supporting Company: **DS&A**

Project No.: **68402**
Document Originator: **Lee Dalton**
Document Reviewer: **C. Goetz**
Review Complete: **11/13/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1276.7 **ft bgs** 863.4 **ft bgs** **to** 870.9 **ft bgs**

Total Volume Withdrawn (Bailing): _____ **Total Volume Withdrawn (Pumping):** 12926.4 **gals.**

DEVELOPMENT TOOLS

Tool: Submersible Pump	**cription:** Grundfos 10 hp/16 gpm	**Used From** 8/11/2006	**to**	8/11/2006
Tool:	**cription:**	**Used From**	**to**	
Tool:	**cription:**	**Used From**	**to**	
Tool:	**cription:**	**Used From**	**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/11/2006	8:00	pump	194598.4	0	0	7.9	19.1	183	11.1	857.5	Start capacity test ORP = 31.0
8/11/2006	8:08	pump	194740.7	142.3	142.3	7.9	20.6	175	4.15	857.5	flow rate: 17.9 gpm ORP = 36.0
8/11/2006	8:12	pump	194810.8	70.1	212.4	N/A	N/A	N/A	N/A	857.5	flow rate: 17.5 gpm
8/11/2006	8:13	pump	used flow rate x time	17.3	229.7	8.0	21.8	172	2.2	857.5	ORP = 68.5
8/11/2006	8:14	pump	194845.4	17.3	247.0	N/A	N/A	N/A	N/A	857.5	flow rate: 17.3 gpm
8/11/2006	8:18	pump	194916.5	71.1	318.1	8.2	23.1	167	1.3	857.5	flow rate: 17.95 gpm ORP = 110.9
8/11/2006	8:22	pump	194988.7	72.2	390.3	N/A	N/A	N/A	N/A	857.5	flow rate: 18.0 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: _____ Project No.: **68402**

Location: _____ Document Originator: **Lee Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**cription:**	Grundfos 10 hp/16 gpm	**Used From**	8/11/2006	**to**	8/11/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/11/2006	8:23	pump	used flow rate x time	18.1	408.4	8.2	23.2	167	1.4	857.5	ORP = 115.5
8/11/2006	8:24	pump	195024.9	18.1	426.5	N/A	N/A	N/A	N/A	857.5	flow rate: 18.1 gpm
8/11/2006	8:28	pump	195097.4	72.5	499.0	8.2	23.2	167	1.2	857.5	flow rate: 18.1 gpm ORP = 121.6
8/11/2006	8:30	pump	195133.7	36.3	535.3	N/A	N/A	N/A	N/A	857.5	flow rate: 18.2 gpm
8/11/2006	8:33	pump	used flow rate x time	54.9	590.2	8.2	23.3	167	1.0	857.5	ORP = 126.6
8/11/2006	8:35	pump	195225.0	36.4	626.6	N/A	N/A	N/A	N/A	857.5	flow rate: 18.3 gpm
8/11/2006	8:38	pump	used flow rate x time	54.6	681.2	8.2	23.3	167	1.0	857.5	ORP = 126.6
8/11/2006	8:40	pump	195316.1	36.5	717.7	N/A	N/A	N/A	N/A	857.5	flow rate: 18.2 gpm
8/11/2006	8:43	pump	used flow rate x time	54.6	772.3	8.2	23.4	167	0.1	857.5	ORP = 131.0
8/11/2006	8:48	pump	used flow rate x time	90.5	862.8	8.2	23.4	167	0.8	857.5	ORP =131.8
8/11/2006	8:50	pump	195497.5	36.3	899.1	N/A	N/A	N/A	N/A	857.5	flow rate: 18.1 gpm
8/11/2006	8:53	pump	used flow rate x time	54.0	953.1	8.2	23.4	167	0.7	857.5	ORP = 134.7

WELL DEVELOPMENT (Continued)

Site/Screen Name: _____ Project No.: **68402**

Location: _____ Document Originator: **Lee Dalton**

DEVELOPMENT TOOLS

Tool: Submersible Pump	**cription:** Grundfos 10 hp/16 gpm	**Used From** 8/11/2006	**to** 8/11/2006
Tool: _____	**cription:** _____	**Used From** _____	**to** _____
Tool: _____	**cription:** _____	**Used From** _____	**to** _____
Tool: _____	**cription:** _____	**Used From** _____	**to** _____

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/11/2006	8:55	pump	195587.5	36.0	989.1	N/A	N/A	N/A	N/A	857.5	flow rate: 18.0 gpm
8/11/2006	8:58	pump	used flow rate x time	54.0	1043.1	8.2	23.4	169	0.7	857.5	ORP = 135.9
8/11/2006	9:00	pump	195677.2	35.7	1078.8	N/A	N/A	N/A	N/A	857.5	flow rate: 18.0 gpm
8/11/2006	9:03	pump	used flow rate x time	54.0	1132.8	8.2	23.5	167	0.7	857.5	ORP = 137.1
8/11/2006	9:08	pump	used flow rate x time	90.8	1223.6	8.2	23.5	167	0.8	857.5	ORP = 139.9
8/11/2006	9:10	pump	195858.7	36.7	1260.3	N/A	N/A	N/A	N/A	857.5	flow rate: 18.15 gpm
8/11/2006	9:18	pump	used flow rate x time	144.8	1405.1	8.2	23.5	167	0.6	857.5	ORP = 145.3
8/11/2006	9:20	pump	196039.8	36.3	1441.4	N/A	N/A	N/A	N/A	857.5	flow rate: 18.1 gpm
8/11/2006	9:28	pump	used flow rate x time	144.8	1586.2	8.2	23.5	167	0.6	857.5	ORP = 145.4
8/11/2006	9:30	pump	196220.7	36.1	1622.3	N/A	N/A	N/A	N/A	857.5	flow rate: 18.1 gpm
8/11/2006	9:38	pump	used flow rate x time	144.8	1767.1	8.2	23.6	167	0.6	857.5	ORP = 145.9
8/11/2006	9:40	pump	196401.2	35.7	1802.8	N/A	N/A	N/A	N/A	857.5	flow rate: 18.05 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: _____ Project No.: **68402**

Location: _____ Document Originator: **Lee Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**cription:**	Grundfos 10 hp/16 gpm	**Used From**	8/11/2006	**to**	8/11/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/11/2006	9:48	pump	used flow rate x time	144.4	1947.2	8.2	23.6	166	0.7	857.5	ORP=149.0;DO=5.34
8/11/2006	9:50	pump	196580.7	35.1	1982.3	N/A	N/A	N/A	N/A	857.5	flow rate= 17.95 gpm
8/11/2006	9:58	pump	used flow rate x time	143.6	2125.9	8.2	23.6	167	0.7	857.5	ORP=147.3;DO=5.51
8/11/2006	10:00	pump	196761.0	36.7	2162.6	N/A	N/A	N/A	N/A	857.5	flow rate= 18.03 gpm
8/11/2006	10:08	pump	used flow rate x time	144.24	2306.8	8.2	23.5	166	0.5	857.5	ORP=142.7; DO=5.54
8/11/2006	10:10	pump	196939	33.8	2340.6	N/A	N/A	N/A	N/A	857.5	flow rate= 17.80 gpm
8/11/2006	10:20	pump	197116.5	177.5	2518.1	N/A	N/A	N/A	N/A	857.5	flow rate= 17.75 gpm
8/11/2006	10:23	pump	used flow rate x time	53.3	2571.4	8.2	23.7	166	0.6	857.5	ORP=142.9; DO=5.43
8/11/2006	10:38	pump	used flow rate x time	88.75	2660.1	8.2	23.7	165	0.5	857.5	ORP=144.4; DO=5.43
8/11/2006	10:40	pump	197472.2	213.65	2873.8	N/A	N/A	N/A	N/A	857.5	flow rate= 17.78 gpm
8/11/2006	10:53	pump	used flow rate x time	231.1	3104.9	8.2	23.7	165	0.6	857.5	ORP=142.3; DO=5.42
8/11/2006	11:00	pump	197830.5	127.2	3232.1	N/A	N/A	N/A	N/A	857.5	flow rate= 17.91 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: _____ Project No.: **68402**

Location: _____ Document Originator: **Lee Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**cription:**	Grundfos 10 hp/16 gpm	**Used From**	8/11/2006	**to**	8/11/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/11/2006	11:08	pump	used flow rate x time	143.3	3375.4	8.2	23.7	165	0.6	857.5	ORP=145.5; DO=5.3
8/11/2006	11:20	pump	198188.7	214.9	3590.3	N/A	N/A	N/A	N/A	857.5	flow rate= 17.91 gpm
8/11/2006	11:23	pump	used flow rate x time	53.7	3644.0	8.2	23.7	164	0.5	857.5	ORP=146.2; DO=5.32
8/11/2006	11:38	pump	used flow rate x time	89.5	3733.5	8.2	23.8	166	0.8	857.5	ORP=145.3; DO=5.34
8/11/2006	11:40	pump	198547.4	215.5	3949.0	N/A	N/A	N/A	N/A	857.5	flow rate= 17.93 gpm
8/11/2006	11:53	pump	used flow rate x time	232.3	4181.3	8.1	23.9	165	0.5	857.5	ORP=145.4; DO=5.36
8/11/2006	12:00	pump	198904.8	125.1	4306.4	N/A	N/A	N/A	N/A	857.5	flow rate= 17.87 gpm
8/11/2006	12:08	pump	used flow rate x time	143.0	4449.4	8.1	23.9	166	0.5	857.5	ORP=145.1; DO=5.36
8/11/2006	12:20	pump	199264.2	216.4	4665.8	N/A	N/A	N/A	N/A	857.5	flow rate= 17.97 gpm
8/11/2006	12:23	pump	used flow rate x time	53.9	4719.7	8.1	23.8	166	0.5	857.5	ORP=146.3; DO=5.72
8/11/2006	12:38	pump	used flow rate x time	89.9	4809.6	8.1	23.9	158	0.6	857.5	ORP=157.8; DO=5.80
8/11/2006	12:40	pump	199621.3	213.3	5022.8	N/A	N/A	N/A	N/A	857.5	flow rate= 17.85 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: _____ Project No.: **68402**

Location: _____ Document Originator: **Lee Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**cription:**	Grundfos 10 hp/16 gpm	**Used From**	8/11/2006	**to**	8/11/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/11/2006	12:53	pump	used flow rate x time	232.1	5254.9	8.2	23.8	166	0.5	857.5	ORP=155.3; DO=5.80
8/11/2006	13:00	pump	199977.1	123.7	5378.6	N/A	N/A	N/A	N/A	857.5	flow rate= 17.79 gpm
8/11/2006	13:08	pump	used flow rate x time	142.3	5520.9	8.1	23.8	167	0.5	857.5	ORP=157; DO=5.80
8/11/2006	13:20	pump	200333.2	213.8	5734.7	N/A	N/A	N/A	N/A	857.5	flow rate= 17.80 gpm
8/11/2006	13:23	pump	used flow rate x time	53.6	5788.3	8.2	23.8	166	0.5	857.5	ORP=157.5; DO=5.80
8/11/2006	13:38	pump	used flow rate x time	89.3	5877.5	8.2	23.9	166	0.5	857.5	ORP=158; DO=5.79
8/11/2006	13:40	pump	200690.2	214.1	6091.8	N/A	N/A	N/A	N/A	857.5	flow rate= 17.85 gpm
8/11/2006	13:53	pump	used flow rate x time	232.7	6324.5	8.1	24.0	165	0.7	857.5	ORP=156.1; DO=5.79
8/11/2006	14:00	pump	201048.3	125.4	6449.9	N/A	N/A	N/A	N/A	857.5	flow rate= 17.90 gpm
8/11/2006	14:08	pump	used flow rate x time	143.2	6593.1	8.1	24.1	166	0.6	857.5	ORP=156.5; DO=5.79
8/11/2006	14:20	pump	201406.9	215.4	6808.5	N/A	N/A	N/A	N/A	857.5	flow rate= 17.93 gpm
8/11/2006	14:23	pump	used flow rate x time	53.8	6862.3	8.1	24.0	165	0.7	857.5	ORP=154.3; DO=5.79

WELL DEVELOPMENT (Continued)

Site/Screen Name: _____ Project No.: **68402**

Location: _____ Document Originator: **Lee Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**cription:**	Grundfos 10 hp/16 gpm	**Used From**	8/11/2006	**to**	8/11/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/11/2006	14:38	pump	used flow rate x time	89.5	6951.8	8.1	24.0	165	0.4	857.5	ORP=155.1; DO=5.78
8/11/2006	14:40	pump	201765	214.8	7166.6	N/A	N/A	N/A	N/A	857.5	flow rate= 17.905 gpm
8/11/2006	14:53	pump	used flow rate x time	232.7	7399.3	8.1	23.8	165	0.5	857.5	ORP=155.6; DO=5.80
8/11/2006	15:00	pump	202123.4	125.7	7525.0	N/A	N/A	N/A	N/A	857.5	flow rate= 17.92 gpm
8/11/2006	15:08	pump	used flow rate x time	143.8	7668.8	8.1	23.8	167	0.6	857.5	ORP=157.9; DO=5.81
8/11/2006	15:20	pump	202483	215.8	7884.6	N/A	N/A	N/A	N/A	857.5	flow rate= 17.98 gpm
8/11/2006	15:23	pump	used flow rate x time	54.0	7938.6	8.1	2.8	167	0.7	857.5	ORP=161.8; DO=5.80
8/11/2006	15:38	pump	used flow rate x time	90.0	8028.6	8.1	23.8	167	0.8	857.5	ORP=162.6; DO=5.74
8/11/2006	15:40	pump	202842.7	215.7	8244.3	N/A	N/A	N/A	N/A	857.5	flow rate= 17.985 gpm
8/11/2006	15:53	pump	used flow rate x time	232.7	8477.0	8.1	23.7	166	0.6	857.5	ORP=171.2; DO=5.78
8/11/2006	16:00	pump	203201.0	125.6	8602.6	N/A	N/A	N/A	N/A	857.5	flow rate= 17.915 gpm
8/11/2006	16:08	pump	used flow rate x time	143.2	8745.8	8.1	23.7	166	0.4	857.5	ORP=170.1; DO=5.79

WELL DEVELOPMENT (Continued)

Site/Screen Name: _____ Project No.: **68402**

Location: _____ Document Originator: **Lee Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**cription:**	Grundfos 10 hp/16 gpm	**Used From**	8/11/2006	**to**	8/11/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/11/2006	16:20	pump	203559.7	215.5	8961.3	N/A	N/A	N/A	N/A	857.5	flow rate= 17.93 gpm
8/11/2006	16:23	pump	used flow rate x time	53.8	9015.1	8.2	23.8	165	0.6	857.5	ORP=170.9; DO=5.77
8/11/2006	16:38	pump	used flow rate x time	269.0	9284.1	8.2	23.9	163	0.6	857.5	ORP=169.8; DO=5.76
8/11/2006	16:40	pump	203918.8	36.3	9320.4	N/A	N/A	N/A	N/A	857.5	flow rate= 17.95 gpm
8/11/2006	16:53	pump	used flow rate x time	233.4	9553.8	8.2	23.6	167	0.4	857.5	ORP=175.8; DO=5.88
8/11/2006	17:00	pump	204277.9	125.7	9679.5	N/A	N/A	N/A	N/A	857.5	flow rate= 17.95 gpm
8/11/2006	17:08	pump	used flow rate x time	144.0	9823.5	8.2	23.6	167	0.4	857.5	ORP=176; DO=5.79
8/11/2006	17:20	pump	204638.6	216.7	10040.2	N/A	N/A	N/A	N/A	857.5	flow rate= 18.03 gpm
8/11/2006	17:23	pump	used flow rate x time	54	10094.2	8.1	23.6	166	0.5	857.5	ORP=177.6; DO=5.79
8/11/2006	17:38	pump	used flow rate x time	270	10364.2	8.1	23.5	166	0.6	857.5	ORP=175.6; DO=5.79
8/11/2006	17:40	pump	204999.8	37.2	10401.4	N/A	N/A	N/A	N/A	857.5	flow rate= 18.06 gpm
8/11/2006	18:00	pump	205361.4	361.6	10763.0	8.2	23.5	164	0.5	857.5	flow rate= 18.08; ORP=177.2; DO=5.80

WELL DEVELOPMENT (Continued)

Site/Screen Name: _____ Project No.: **68402**

Location: _____ Document Originator: **Lee Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**cription:**	Grundfos 10 hp/16 gpm	**Used From**	8/11/2006	**to**	8/11/2006
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	
Tool:		**cription:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/11/2006	18:20	pump	205721.3	359.9	11122.9	N/A	N/A	N/A	N/A	857.5	flow rate= 17.99 gpm
8/11/2006	18:42	pump	206117	395.7	11518.6	N/A	N/A	N/A	N/A	857.5	flow rate= 17.986 gpm
8/11/2006	19:02	pump	206477.0	360.0	11878.6	N/A	N/A	N/A	N/A	857.5	flow rate= 18 gpm
8/11/2006	19:20	pump	206801.4	324.4	12203.0	N/A	N/A	N/A	N/A	857.5	flow rate= 18.02 gpm
8/11/2006	19:40	pump	207162.5	361.1	12564.1	N/A	N/A	N/A	N/A	857.5	flow rate= 18.055 gpm
8/11/2006	20:00	pump	207524.8	362.3	12926.4	N/A	N/A	N/A	N/A	857.5	flow rate= 18.115 gpm; pump off

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-16 Screen 3**
Location: **White Rock Overlook Park**
Lead Company: **Kleinfelder**
Supporting Company: **WDC**

Project No.: **68402**
Document Originator: **L.Dalton**
Document Reviewer: **C. Goetz**
Review Complete: **11/13/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1276.7 **ft bgs** **Screened Interval:** 1014.8 **ft bgs** **to** 1022.4 **ft bgs**

Total Volume Withdrawn (Bailing): 0 **gals.** **Total Volume Withdrawn (Pumping):** 9785.5 **gals.**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/10/2006	**to**	8/10/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/10/2006	8:02:30	pump	184812.6	0	0	N/A	N/A	N/A	N/A	1014.9	Start capacity test
8/10/2006	8:15	pump	185003.0	190.4	190.4	8.1	22.4	174	4.2	1014.9	flow rate: 13.7 gpm ORP = 48.8
8/10/2006	8:20	pump	185071.7	68.7	259.1	8.2	22.8	174	1.3	1014.9	flow rate: 13.8 gpm ORP = 50.2
8/10/2006	8:25	pump	used flow rate x time	69	328.1	8.2	23	176	0.8	1014.9	ORP = 56.4
8/10/2006	8:26	pump	185154.3	13.6	341.7	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.8 gpm
8/10/2006	8:30	pump	185209.5	55.2	396.9	8.2	23.2	176	0.6	1014.9	flow rate: 13.8 gpm ORP = 57.3
8/10/2006	8:35	pump	185278.4	68.9	465.8	8.2	23.4	177	0.6	1014.9	flow rate: 13.8 gpm ORP = 58.4

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-16 Screen 3** Project No.: **68402**

Location: **White Rock Overlook Park** Document Originator: **L.Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/10/2006	**to**	8/10/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/10/2006	8:40	pump	185347.4	69.0	534.8	8.1	23.5	178	0.6	1014.9	flow rate: 13.8 gpm ORP = 59.2
8/10/2006	8:45	pump	185416.4	69.0	603.8	8.1	23.6	177	0.5	1014.9	flow rate: 13.8 gpm ORP = 59.5
8/10/2006	8:50	pump	185485.1	68.7	672.5	8.1	23.9	178	0.5	1014.9	flow rate: 13.7 gpm ORP = 59.3
8/10/2006	8:55	pump	185553.8	68.7	741.2	8.1	24.0	177	0.5	1014.9	flow rate: 13.7 gpm ORP = 59.6
8/10/2006	9:00	pump	185622.6	68.8	810.0	8.1	24.0	177	0.4	1014.9	flow rate: 13.8 gpm ORP = 35.4
8/10/2006	9:05	pump	used flow rate x time	69	879.0	8.1	24.1	177	0.5	1014.9	ORP = 35.8
8/10/2006	9:10	pump	185760.2	68.6	947.6	8.1	24.2	177	0.4	1014.9	flow rate: 13.8 gpm ORP = 35.3
8/10/2006	9:15	pump	used flow rate x time	68.9	1016.5	8.1	23.3	177	0.5	1014.9	ORP = 47.8
8/10/2006	9:20	pump	185898.0	68.9	1085.4	8.1	24.2	177	0.4	1014.9	flow rate: 13.8 gpm ORP = 55.7
8/10/2006	9:25	pump	used flow rate x time	69.2	1154.5	8.1	24.2	178	0.4	1014.9	ORP = 52.4
8/10/2006	9:30	pump	186036.7	69.6	1224.1	8.1	24.2	178	0.4	1014.9	flow rate: 13.9 gpm ORP = 49.2
8/10/2006	9:40	pump	186180.5	143.8	1367.9	8.1	24.4	178	0.4	1014.9	flow rate: 14.4 gpm ORP = 40.9

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-16 Screen 3** Project No.: **68402**

Location: **White Rock Overlook Park** Document Originator: **L.Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/10/2006	**to**	8/10/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/10/2006	9:50	pump	186325.7	145.2	1513.1	8.1	24.5	178	0.4	1014.9	flow rate: 14.5 gpm ORP = 39.3
8/10/2006	10:00	pump	186454.4	128.7	1641.8	8.1	24.6	178	0.5	1014.9	flow rate: 12.9 gpm ORP = 45.3
8/10/2006	10:10	pump	186592.9	138.5	1780.3	8.1	24.6	178	0.4	1014.9	flow rate: 13.9 gpm ORP = 48.7
8/10/2006	10:20	pump	186731.1	138.2	1918.5	8.1	24.7	177	0.4	1014.9	flow rate: 13.8 gpm ORP = 6.10
8/10/2006	10:30	pump	186869.1	138	2056.5	8.1	24.6	177	0.4	1014.9	flow rate: 13.8 gpm ORP = 54.6
8/10/2006	10:40	pump	187007.3	138.2	2194.7	8.0	24.6	178	0.4	1014.9	flow rate: 13.8 gpm ORP = 59.2
8/10/2006	10:50	pump	187143.9	136.6	2331.3	8.0	24.7	178	0.4	1014.9	flow rate: 13.7 gpm ORP = 55.7
8/10/2006	11:00	pump	187281.2	137.3	2468.6	8.0	24.6	178	0.5	1014.9	flow rate: 13.7 gpm ORP = 55.6
8/10/2006	11:10	pump	187418.6	137.4	2606.0	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.7 gpm
8/10/2006	11:15	pump	used flow rate x time	68.8	2674.8	8.0	24.6	178	0.4	1014.9	ORP = 62.7
8/10/2006	11:20	pump	187556.3	68.9	2553.3	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.8 gpm
8/10/2006	11:30	pump	187693	136.7	2690.0	8.0	24.7	178	0.4	1014.9	flow rate: 13.7 gpm ORP = 68.9

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-16 Screen 3** Project No.: **68402**

Location: **White Rock Overlook Park** Document Originator: **L.Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/10/2006	**to**	8/10/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/10/2006	11:40	pump	187829.7	136.7	2826.7	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.7 gpm
8/10/2006	11:45	pump	used flow rate x time	68.1	2894.8	8.0	24.7	179	0.4	1014.9	ORP = 66.0
8/10/2006	11:50	pump	187965.4	67.6	2962.4	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.6 gpm
8/10/2006	12:00	pump	188100.9	135.5	3097.9	8.0	24.5	179	0.5	1014.9	flow rate: 13.6 gpm ORP = 62.6
8/10/2006	12:10	pump	188247.1	146.2	3244.1	N/A	N/A	N/A	N/A	1014.9	flow rate: 14.6 gpm
8/10/2006	12:15	pump	used flow rate x time	63.0	3307.1	8.0	24.7	179	0.4	1014.9	ORP = 61.8
8/10/2006	12:20	pump	188373.1	63.0	3560.5	N/A	N/A	N/A	N/A	1014.9	flow rate: 12.6 gpm
8/10/2006	12:30	pump	used flow rate x time	136.0	3696.5	8.0	24.3	179	0.4	1014.9	ORP = 65.6
8/10/2006	12:40	pump	188645.7	136.6	3833.1	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.6 gpm
8/10/2006	12:45	pump	used flow rate x time	68	3901.1	8.0	24.1	179	0.4	1014.9	ORP = 67.3
8/10/2006	13:00	pump	188918.0	204.3	4105.4	8.0	24.1	179	0.4	1014.9	flow rate: 13.6 gpm ORP = 66.8
8/10/2006	13:15	pump	used flow rate x time	204.0	4309.4	8.0	24.1	180	0.4	1014.9	ORP = 65.7

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-16 Screen 3** Project No.: **68402**

Location: **White Rock Overlook Park** Document Originator: **L.Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/10/2006	**to**	8/10/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/10/2006	13:20	pump	189190.6	68.6	4378.0	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.6 gpm
8/10/2006	13:30	pump	used flow rate x time	68.1	4446.1	8.0	24.1	180	0.4	1014.9	ORP = 64.0
8/10/2006	13:40	pump	189462.7	204.0	4650.1	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.6 gpm
8/10/2006	13:45	pump	used flow rate x time	68	4718.1	8.0	24.1	180	0.4	1014.9	ORP = 69.7
8/10/2006	14:00	pump	189735.1	204.4	4922.5	8.0	24.2	180	0.4	1014.9	flow rate: 13.6 gpm ORP = 62.4
8/10/2006	14:15	pump	used flow rate x time	204.3	5126.8	8.0	24.4	180	0.4	1014.9	ORP = 62.9
8/10/2006	14:20	pump	190007.5	68.1	5194.9	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.6 gpm
8/10/2006	14:30	pump	used flow rate x time	141.0	5335.9	8.0	24.4	180	0.4	1014.9	ORP = 62.7
8/10/2006	14:40	pump	190289.3	140.8	5476.7	N/A	N/A	N/A	N/A	1014.9	flow rate: 14.1 gpm
8/10/2006	14:45	pump	used flow rate x time	67	5543.7	8.0	24.5	180	0.4	1014.9	ORP = 64.3
8/10/2006	15:00	pump	190557.4	201.1	5744.8	8.0	24.6	180	0.4	1014.9	flow rate: 13.4 gpm ORP = 65.0
8/10/2006	15:15	pump	used flow rate x time	202.5	5947.3	8.0	25.0	179	0.5	1014.9	ORP = 63.0

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-16 Screen 3** Project No.: **68402**

Location: **White Rock Overlook Park** Document Originator: **L.Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/10/2006	**to**	8/10/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/10/2006	15:20	pump	190826	66.1	6013.4	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.5 gpm
8/10/2006	15:30	pump	used flow rate x time	64.5	6077.9	8.0	24.4	179	0.5	1014.9	ORP = 63.4
8/10/2006	15:40	pump	191084.3	193.8	6271.7	N/A	N/A	N/A	N/A	1014.9	flow rate: 12.9 gpm
8/10/2006	15:45	pump	used flow rate x time	65	6336.7	8.0	24.2	179	0.4	1014.9	ORP = 62.0
8/10/2006	16:00	pump	191353	203.7	6540.4	8.0	24.2	179	N/A	1014.9	flow rate: 13.4 gpm ORP = 72.8
8/10/2006	16:15	pump	used flow rate x time	199.5	6739.9	8.0	24.4	179	N/A	1014.9	ORP = 73
8/10/2006	16:20	pump	191619.3	66.8	6806.7	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.3 gpm
8/10/2006	16:30	pump	used flow rate x time	135.0	6941.7	8.0	24.4	179	N/A	1014.9	ORP = 73.5
8/10/2006	16:40	pump	191889.5	135.2	7076.9	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.5 gpm
8/10/2006	16:45	pump	used flow rate x time	67.5	7144.4	8.0	24.4	179	N/A	1014.9	ORP = 70.3
8/10/2006	17:00	pump	192158.7	201.7	7346.1	8.0	24.5	182	N/A	1014.9	flow rate: 13.5 gpm ORP = 57.1
8/10/2006	17:15	pump	used flow rate x time	202.5	7548.6	8.0	24.8	182	N/A	1014.9	ORP = 57.1

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-16 Screen 3** Project No.: **68402**

Location: **White Rock Overlook Park** Document Originator: **L.Dalton**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/10/2006	**to**	8/10/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/10/2006	17:20	pump	192429	67.8	7616.4	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.5 gpm
8/10/2006	17:30	pump	used flow rate x time	64.5	7680.9	8.0	24.6	182	N/A	1014.9	ORP = 58.6
8/10/2006	17:40	pump	192699.2	205.7	7886.6	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.5 gpm
8/10/2006	17:45	pump	used flow rate x time	67.5	7954.1	8.0	24.6	182	N/A	1014.9	ORP = 71.2
8/10/2006	18:00	pump	192969.1	202.4	8156.5	8.0	24.8	182	N/A	1014.9	flow rate: 13.5 gpm ORP = 71.8
8/10/2006	18:15	pump	used flow rate x time	204.0	8360.5	8.0	24.8	182	N/A	1014.9	ORP = 72.0
8/10/2006	18:20	pump	193241.5	68.4	8428.9	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.6 gpm
8/10/2006	18:30	pump	used flow rate x time	135.0	8563.9	8.0	24.7	183	N/A	1014.9	ORP = 67.8
8/10/2006	18:42	pump	193538.8	162.3	8726.2	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.5 gpm
8/10/2006	20:00	pump	194598.1	1059.3	9785.5	N/A	N/A	N/A	N/A	1014.9	flow rate: 13.6 gpm Pump Turned Off
Pump Turned Off At 20:00											

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-16 Screen 4**
Location: **White Rock Overlook Park**
Lead Company: **Kleinfelder**
Supporting Company: **WDC**

Project No.: **68402**
Document Originator: **J. Hiller**
Document Reviewer: **C. Goetz**
Review Complete: **11/13/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1276.7 **ft bgs** 1237.0 **ft bgs** **to** 1244.6 **ft bgs**

Total Volume Withdrawn (Bailing): 0 **gals.** **Total Volume Withdrawn (Pumping):** 4368.3 **gals.**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/9/2006	**to**	8/9/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	e Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/9/2006	06:15	pump	180443.9	0	0	N/A	N/A	N/A	N/A	1183.3	Start capacity test
8/9/2006	06:40	pump	180631.5	187.6	187.6	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.65 gpm
8/9/2006	06:43	pump	N/A	N/A		7.9	21.1	142	38.0	1183.3	est. volume 205 gal
8/9/2006	06:45	pump	180665.5	34	221.6	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.8 gpm
8/9/2006	07:28	pump	N/A	N/A		8.1	22.1	143	1.1	1183.3	est. volume 481 gal
8/9/2006	07:30	pump	180936.9	271.4	493.0	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	08:00	pump	181117.6	180.7	673.7	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.1 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-16 Screen 4** Project No.: **68402**

Location: **White Rock Overlook Park** Document Originator: **J. Hiller**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/9/2006	**to**	8/9/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/9/2006	08:03	pump	N/A	N/A	N/A	8.0	23.4	143	0.9	1183.3	est. volume 692 gal
8/9/2006	08:30	pump	181298.1	180.5	854.2	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	08:33	pump	N/A	N/A	N/A	8.0	24.1	146	0.6	1183.3	est. volume 872 gal
8/9/2006	09:00	pump	181477.2	179.1	1033.3	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	09:03	pump	N/A	N/A	N/A	7.9	24.4	146	0.5	1183.3	est. volume 1051 gal
8/9/2006	09:58	pump	N/A	N/A	N/A	7.9	24.9	147	0.5	1183.3	est. volume 1382 gal
8/9/2006	10:00	pump	181838.2	361.0	1394.3	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.1 gpm
8/9/2006	10:20	pump	181958.8	120.6	1514.9	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	10:28	pump	N/A	N/A	N/A	7.9	25.1	147	0.5	1183.3	est. volume 1563 gal
8/9/2006	10:58	pump	N/A	N/A	N/A	7.9	25.7	148	0.5	1183.3	est. volume 1744 gal
8/9/2006	11:00	pump	182199.9	241.1	1756.0	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.1 gpm
8/9/2006	11:20	pump	182322.0	122.1	1878.1	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.1 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-16 Screen 4** Project No.: **68402**

Location: **White Rock Overlook Park** Document Originator: **J. Hiller**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/9/2006	**to**	8/9/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/9/2006	11:28	pump	N/A	N/A	N/A	7.9	25.5	148	0.5	1183.3	est. volume 1927 gal
8/9/2006	11:58	pump	N/A	N/A	N/A	7.9	25.7	149	0.5	1183.3	est. volume 2109 gal
8/9/2006	12:00	pump	182564.4	242.4	2120.5	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	12:20	pump	182683.5	119.1	2239.6	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	12:28	pump	N/A	N/A	N/A	7.9	24.7	149	0.5	1183.3	est. volume 2288 gal
8/9/2006	12:58	pump	N/A	N/A	N/A	7.9	25.7	148	0.6	1183.3	est. volume 2467 gal
8/9/2006	13:00	pump	182922.8	239.3	2478.9	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	13:20	pump	183043.8	121.0	2599.9	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	13:28	pump	N/A	N/A	N/A	7.9	24.9	149	0.5	1183.3	est. volume 2648 gal
8/9/2006	13:58	pump	N/A	N/A	N/A	7.9	26.0	148	0.6	1183.3	est. volume 2830 gal
8/9/2006	14:00	pump	183285.4	241.6	2841.5	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	14:20	pump	183406.0	120.6	2962.1	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-16 Screen 4** Project No.: **68402**

Location: **White Rock Overlook Park** Document Originator: **J. Hiller**

DEVELOPMENT TOOLS

Tool:	Submersible Pump	**Description:**	Grundfos 10 hp - 16 gpm	**Used From**	8/9/2006	**to**	8/9/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
8/9/2006	14:28	pump	N/A	N/A	N/A	7.9	25.5	148	0.5	1183.3	est. volume 2980 gal
8/9/2006	14:58	pump	N/A	N/A	N/A	7.9	25.4	150	0.5	1183.3	est. volume 3189 gal
8/9/2006	15:00	pump	183645.1	239.1	3201.2	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	15:20	pump	183764.7	119.6	3320.8	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	15:28	pump	N/A	N/A	N/A	7.9	24.8	150	0.5	1183.3	est. volume 3369 gal
8/9/2006	15:58	pump	N/A	N/A	N/A	7.9	24.8	150	0.5	1183.3	est. volume 3547 gal
8/9/2006	16:00	pump	184002.8	238.1	3558.9	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm
8/9/2006	16:20	pump	184121.4	118.6	3677.5	N/A	N/A	N/A	N/A	1183.3	flow rate: 5.9 gpm
8/9/2006	16:28	pump	N/A	N/A	N/A	7.9	24.6	150	0.5	1183.3	est. volume 3725 gal
8/9/2006	16:58	pump	N/A	N/A	N/A	7.9	25.0	150	0.6	1183.3	est. volume 3905 gal
8/9/2006	17:00	pump	184361.0	239.6	3917.1	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.1 gpm
8/9/2006	18:15	pump	184812.2	451.2	4368.3	N/A	N/A	N/A	N/A	1183.3	flow rate: 6.0 gpm

NOTE: Pump stop at 18:15 on 8/9/2006

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-20/Lower Specific Capacity Test**
Location: **Pajarito Canyon**
Lead Company: **Kleinfelder, Inc**
Supporting Company: **WDC Exploration/DS&A**

Project No.: **68402 3.L**
Document Originator: **Lucero, Brian**
Document Reviewer: **Lucero, Brian**
Review Complete: **11/6/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353 **ft bgs** **Screened Interval:** 1328.8 **ft bgs** **to** 1336.5 **ft bgs**

Total Volume Withdrawn (Bailing): n/a **gals.** **Total Volume Withdrawn (Pumping):** 2716.8 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 10 horsepower	**Used From**	7/7/2006	**to**	7/7/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/7/2006	18:40	Pump	160891.7	0	N/A	N/A	N/A	N/A	N/A	N/A	Pump on
7/7/2006	18:55	Pump	See Note Below *	See Note Below *	See Note Below *	8.36	20.5	160.8	14.5	1309	= 4.02 mg/L ORP = 60.8
7/7/2006		Pump	See Note Below *	See Note Below *	See Note Below *	8.16	21.6	140.9	87.8	1309	DO = 4.39
7/7/2006		Pump	See Note Below *	See Note Below *	See Note Below *	7.86	23	138.4	98.3	1309	DO = 4.48
7/7/2006		Pump	See Note Below *	See Note Below *	See Note Below *	7.48	23.3	129.7	30.5	1309	DO = 0.58 ORP = 67.5
7/7/2006		Pump	See Note Below *	See Note Below *	See Note Below *	7.08	23.6	128.5	7.08	1309	DO = 0.27 ORP = 36.9
7/7/2006		Pump	See Note Below *	See Note Below *	See Note Below *	7.36	23.9	126.6	4.79	1309	DO = 0.26 ORP = 33.7
7/7/2006		Pump	See Note Below *	See Note Below *	See Note Below *	7.31	24.1	126.7	4.19	1309	DO = 0.33 ORP = 24.4

*** LANL water quality parameters were not recorded with a corresponding flowmeter reading. Pumped total of 2716.8 gal btwn 1840 and 2130.**

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (Lower SC Test)**
Location: **Pajarito Canyon**
Project No.: **68402 3.L**
Document Originator: **Lucero, Brian**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 10 horsepower	**Used From**	7/7/2006	**to**	7/7/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/7/2006	19:50	Pump	See Note p. 1 *	See Note p. 1 *	See Note p. 1 *	7.27	23.9	129.1	4.51	1309	DO = 0.24 ORP = 10.3
7/7/2006	20:10	Pump	See Note p. 1 *	See Note p. 1 *	See Note p. 1 *	7.17	23.9	127	1.80	1309	DO = 0.32 ORP = 34.7
7/7/2006	20:20	Pump	See Note p. 1 *	See Note p. 1 *	See Note p. 1 *	7.11	23.7	128.3	1.93	1309	DO = 0.43 ORP = 36.2
7/7/2006	20:30	Pump	See Note p. 1 *	See Note p. 1 *	See Note p. 1 *	7.05	23.2	129.6	2.55	1309	DO = 0.42 ORP = 33.8
7/7/2006	20:40	Pump	See Note p. 1 *	See Note p. 1 *	See Note p. 1 *	6.98	23.0	132.1	1.42	1309	DO = 0.38 ORP = 14.2
7/7/2006	21:00	Pump	See Note p. 1 *	See Note p. 1 *	See Note p. 1 *	N/A	N/A	N/A	N/A	1309	N/A
7/7/2006	21:30	Pump	163608.5	See Note p. 1 *	2716.8	N/A	N/A	N/A	N/A	N/A	Pump off

* See page 1 of 2.

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-20/Lower Screen**
Location: **Pajarito Canyon**
Lead Company: **Kleinfelder**
Supporting Company: **WDC**

Project No.: **68402**
Document Originator: **Brian Lucero**
Document Reviewer: **Lee Dalton**
Review Complete: **1/10/2007**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353 **ft bgs** **Screened Interval:** 1328.8 **ft bgs** **to** 1336.5 **ft bgs**

Total Volume Withdrawn (Bailing): N/A **gals.** **Total Volume Withdrawn (Pumping):** 6383.3 **gals.**

DEVELOPMENT TOOLS

Tool:	pump	**Description:**	Grundfos submersible (10 HP)	**Used From**	7/21/2006	**to**	7/21/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/21/2006	7:06	pump	173226.6	N/A	N/A	N/A	N/A	N/A	N/A	1309	N/A
7/21/2006	7:07	pump	173238.7	12.1	12.1	N/A	N/A	N/A	N/A	1309	12.10 gpm
7/21/2006	7:08	pump	173250.3	11.6	23.7	N/A	N/A	N/A	N/A	1309	11.60 gpm
7/21/2006	7:09	pump	173261.2	10.9	34.6	N/A	N/A	N/A	N/A	1309	10.90 gpm
7/21/2006	7:10	pump	173272.2	11.0	45.6	N/A	N/A	N/A	N/A	1309	11.00 gpm
7/21/2006	7:11	pump	173283.1	10.9	56.5	N/A	N/A	N/A	N/A	1309	10.90 gpm
7/21/2006	7:12	pump	173294.0	10.9	67.4	N/A	N/A	N/A	N/A	1309	10.90 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20** Project No.: **68402**

Location: **Pajarito Canyon** Document Originator: **Brian Lucero**

DEVELOPMENT TOOLS

Tool:	pump	**Description:**	Grundfos submersible (10 HP)	**Used From**	7/21/2006	**to**	7/21/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/21/2006	7:13	pump	173304.9	10.9	78.3	N/A	N/A	N/A	N/A	1309	10.90 gpm
7/21/2006	7:14	pump	173315.9	11.0	89.3	N/A	N/A	N/A	N/A	1309	11.00 gpm
7/21/2006	7:15	pump	173327.0	11.1	100.4	N/A	N/A	N/A	N/A	1309	11.10 gpm
7/21/2006	7:17	pump	173348.8	21.8	122.2	N/A	N/A	N/A	N/A	1309	10.90 gpm
7/21/2006	7:20	pump	173381.8	33.0	155.2	N/A	N/A	N/A	N/A	1309	11.00 gpm
7/21/2006	7:25	pump	173436.8	55.0	210.2	N/A	N/A	N/A	N/A	1309	11.00 gpm
7/21/2006	7:27	pump	N/A	N/A	N/A	6.89	22.2	119.0	32.50	1309	DO=3.30% ORP=34.8mv
7/21/2006	7:30	pump	173491.6	54.8	265.0	N/A	N/A	N/A	N/A	1309	10.96 gpm
7/21/2006	7:32	pump	N/A	N/A	N/A	6.91	22.4	120.1	18.50	1309	DO=3.10% ORP=36.1mv
7/21/2006	7:35	pump	173546.3	54.7	319.7	N/A	N/A	N/A	N/A	1309	10.94 gpm
7/21/2006	7:37	pump	N/A	N/A	N/A	6.89	22.8	126.6	9.59	1309	DO=2.99% ORP=35.9mv
7/21/2006	7:40	pump	173600.9	54.6	374.3	N/A	N/A	N/A	N/A	1309	10.92 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20** Project No.: **68402**

Location: **Pajarito Canyon** Document Originator: **Brian Lucero**

DEVELOPMENT TOOLS

Tool:	pump	**Description:**	Grundfos submersible (10 HP)	**Used From**	7/21/2006	**to**	7/21/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/21/2006	7:42	pump	N/A	N/A	N/A	6.89	23.4	106.4	7.00	1309	DO=2.50% ORP48.9=mv
7/21/2006	7:47	pump	N/A	N/A	N/A	6.87	23.8	100.4	5.57	1309	DO=2.44% ORP=57.0mv
7/21/2006	7:50	pump	173710.0	109.1	483.4	N/A	N/A	N/A	N/A	1309	10.91 gpm
7/21/2006	7:52	pump	N/A	N/A	N/A	6.86	24.2	95.9	3.16	1309	DO=2.37% ORP=65.1mv
7/21/2006	7:57	pump	N/A	N/A	N/A	6.85	24.3	94.2	4.03	1309	DO=2.35% ORP=71.6mv
7/21/2006	8:00	pump	173819.0	109	592.4	N/A	N/A	N/A	N/A	1309	10.90 gpm
7/21/2006	8:07	pump	N/A	N/A	N/A	6.84	24.7	92.3	2.33	1309	DO=2.24% ORP=99.8mv
7/21/2006	8:10	pump	173927.5	108.5	700.9	N/A	N/A	N/A	N/A	1309	10.85 gpm
7/21/2006	8:17	pump	N/A	N/A	N/A	6.83	24.9	92.0	2.16	1309	DO=2.19% ORP=92.1mv
7/21/2006	8:20	pump	174034.5	107	807.9	N/A	N/A	N/A	N/A	1309	10.70 gpm
7/21/2006	8:27	pump	N/A	N/A	N/A	6.82	25.0	91.6	1.99	1309	DO=2.06% ORP=105.3mv
7/21/2006	8:30	pump	174141.2	106.7	914.6	N/A	N/A	N/A	N/A	1309	10.67 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20** Project No.: **68402**

Location: **Pajarito Canyon** Document Originator: **Brian Lucero**

DEVELOPMENT TOOLS

Tool:	pump	**Description:**	Grundfos submersible (10 HP)	**Used From**	7/21/2006	**to**	7/21/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/21/2006	8:37	pump	N/A	N/A	N/A	6.81	25.5	91.0	1.57	1309	DO=1.97% ORP=107.9mv
7/21/2006	8:40	pump	174247.7	106.5	1021.1	N/A	N/A	N/A	N/A	1309	10.65 gpm
7/21/2006	8:47	pump	N/A	N/A	N/A	6.80	25.5	91.2	1.56	1309	DO=1.96% ORP=106.4mv
7/21/2006	8:50	pump	174354.2	106.5	1127.6	N/A	N/A	N/A	N/A	1309	10.65 gpm
7/21/2006	8:57	pump	N/A	N/A	N/A	6.80	25.5	90.7	1.53	1309	DO=2.20% ORP=93.6mv
7/21/2006	9:00	pump	174460.0	105.8	1233.4	N/A	N/A	N/A	N/A	1309	10.58 gpm
7/21/2006	9:07	pump	N/A	N/A	N/A	6.80	25.4	90.1	1.40	1309	DO=2.08% ORP=85.9mv
7/21/2006	9:10	pump	174565.5	105.5	1338.9	N/A	N/A	N/A	N/A	1309	10.55 gpm
7/21/2006	9:17	pump	N/A	N/A	N/A	6.80	25.2	90.2	1.33	1309	DO=2.09% ORP=84.7mv
7/21/2006	9:20	pump	174670.7	105.2	1444.1	N/A	N/A	N/A	N/A	1309	10.52 gpm
7/21/2006	9:27	pump	N/A	N/A	N/A	6.80	25.3	90.1	1.37	1309	DO=2.15% ORP=95.0mv
7/21/2006	9:30	pump	174775.5	104.8	1548.9	N/A	N/A	N/A	N/A	1309	10.48 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20** Project No.: **68402**

Location: **Pajarito Canyon** Document Originator: **Brian Lucero**

DEVELOPMENT TOOLS

Tool:	pump	**Description:**	Grundfos submersible (10 HP)	**Used From**	7/21/2006	**to**	7/21/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/21/2006	9:40	pump	174880.0	104.5	1653.4	N/A	N/A	N/A	N/A	1309	10.45 gpm
7/21/2006	9:47	pump	N/A	N/A	N/A	6.80	25.3	89.4	1.48	1309	DO=2.23% ORP=100.5mv
7/21/2006	9:50	pump	174984.2	104.2	1757.6	N/A	N/A	N/A	N/A	1309	10.42 gpm
7/21/2006	10:00	pump	175087.7	103.5	1861.1	N/A	N/A	N/A	N/A	1309	10.35 gpm
7/21/2006	10:07	pump	N/A	N/A	N/A	6.79	25.7	89.2	1.50	1309	DO=2.36% ORP=114.3mv
7/21/2006	10:10	pump	175191.5	103.8	1964.9	N/A	N/A	N/A	N/A	1309	10.38 gpm
7/21/2006	10:20	pump	175294.8	103.3	2068.2	N/A	N/A	N/A	N/A	1309	10.33 gpm
7/21/2006	10:27	pump	N/A	N/A	N/A	6.79	25.3	89.3	1.28	1309	DO=2.21% ORP=112.9mv
7/21/2006	10:30	pump	175397.8	103	2171.2	N/A	N/A	N/A	N/A	1309	10.30 gpm
7/21/2006	10:40	pump	175500.5	102.7	2273.9	N/A	N/A	N/A	N/A	1309	10.27 gpm
7/21/2006	10:47	pump	N/A	N/A	N/A	6.79	25.2	88.8	1.40	1309	DO=2.42% ORP=108.4mv
7/21/2006	10:50	pump	175603.5	103	2376.9	N/A	N/A	N/A	N/A	1309	10.30 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20** Project No.: **68402**

Location: **Pajarito Canyon** Document Originator: **Brian Lucero**

DEVELOPMENT TOOLS

Tool:	pump	**Description:**	Grundfos submersible (10 HP)	**Used From**	7/21/2006	**to**	7/21/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/21/2006	11:00	pump	175705.4	101.9	2478.8	N/A	N/A	N/A	N/A	1309	10.19 gpm
7/21/2006	11:07	pump	N/A	N/A	N/A	6.79	25.6	88.5	1.30	1309	DO=2.19% ORP=137.3mv
7/21/2006	11:10	pump	175807.2	101.8	2580.6	N/A	N/A	N/A	N/A	1309	10.18 gpm
7/21/2006	11:20	pump	175908.0	100.8	2681.4	N/A	N/A	N/A	N/A	1309	10.08 gpm
7/21/2006	11:27	pump	N/A	N/A	N/A	6.80	25.9	88.8	1.18	1309	DO=2.20% ORP=134.9mv
7/21/2006	11:40	pump	176110.4	202.4	2883.8	N/A	N/A	N/A	N/A	1309	10.12 gpm
7/21/2006	11:57	pump	N/A	N/A	N/A	6.80	25.6	88.9	1.30	1309	DO=2.67% ORP=129.6mv
7/21/2006	12:00	pump	176311.8	201.4	3085.2	N/A	N/A	N/A	N/A	1309	10.07 gpm
7/21/2006	12:20	pump	176512.0	200.2	3285.4	N/A	N/A	N/A	N/A	1309	10.01 gpm
7/21/2006	12:27	pump	N/A	N/A	N/A	6.79	25.8	89.4	1.20	1309	DO=2.64% ORP=130.3mv
7/21/2006	12:40	pump	176711.5	199.5	3484.9	N/A	N/A	N/A	N/A	1309	9.98 gpm
7/21/2006	12:57	pump	N/A	N/A	N/A	6.79	25.9	89.3	1.15	1309	DO=2.45% ORP=171.8mv

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20** Project No.: **68402**

Location: **Pajarito Canyon** Document Originator: **Brian Lucero**

DEVELOPMENT TOOLS

Tool:	pump	**Description:**	Grundfos submersible (10 HP)	**Used From**	7/21/2006	**to**	7/21/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/21/2006	13:00	pump	176910.2	198.7	3683.6	N/A	N/A	N/A	N/A	1309	9.94 gpm
7/21/2006	13:20	pump	177108.0	197.8	3881.4	N/A	N/A	N/A	N/A	1309	9.89 gpm
7/21/2006	13:27	pump	N/A	N/A	N/A	6.79	26.3	89.0	1.33	1309	DO=2.62% ORP=173.4mv
7/21/2006	13:40	pump	177305.3	197.3	4078.7	N/A	N/A	N/A	N/A	1309	9.87 gpm
7/21/2006	13:57	pump	N/A	N/A	N/A	6.80	26.2	89.6	1.37	1309	DO=2.64% ORP=179.0mv
7/21/2006	14:00	pump	177502.0	196.7	4275.4	N/A	N/A	N/A	N/A	1309	9.84 gpm
7/21/2006	14:20	pump	177697.7	195.7	4471.1	N/A	N/A	N/A	N/A	1309	9.79 gpm
7/21/2006	14:27	pump	N/A	N/A	N/A	6.81	25.0	90.0	1.29	1309	DO=2.73% ORP=170.0mv
7/21/2006	14:40	pump	177892.2	194.5	4665.6	N/A	N/A	N/A	N/A	1309	9.73 gpm
7/21/2006	14:57	pump	N/A	N/A	N/A	6.82	25.2	90.1	1.38	1309	DO=2.99% ORP=180.1mv
7/21/2006	15:00	pump	178085.6	193.4	4859	N/A	N/A	N/A	N/A	1309	9.67 gpm
7/21/2006	15:20	pump	178279.5	193.9	5052.9	N/A	N/A	N/A	N/A	1309	9.70 gpm

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20** Project No.: **68402**

Location: **Pajarito Canyon** Document Originator: **Brian Lucero**

DEVELOPMENT TOOLS

Tool:	pump	**Description:**	Grundfos submersible (10 HP)	**Used From**	7/21/2006	**to**	7/21/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/21/2006	15:27	pump	N/A	N/A	N/A	6.82	25.2	90.0	1.38	1309	DO=2.79% ORP=175.3mv
7/21/2006	15:40	pump	178471.9	192.4	5245.3	N/A	N/A	N/A	N/A	1309	9.62 gpm
7/21/2006	16:00	pump	178663.5	191.6	5436.9	N/A	N/A	N/A	N/A	1309	9.58 gpm
7/21/2006	16:20	pump	178854.5	191	5627.9	N/A	N/A	N/A	N/A	1309	9.55 gpm
7/21/2006	16:40	pump	179044.2	189.7	5817.6	N/A	N/A	N/A	N/A	1309	9.49 gpm
7/21/2006	17:00	pump	179233.4	189.2	6006.8	N/A	N/A	N/A	N/A	1309	9.46 gpm
7/21/2006	17:20	pump	179421.8	188.4	6195.2	N/A	N/A	N/A	N/A	1309	9.42 gpm
7/21/2006	17:40	pump	179609.9	188.1	6383.3	N/A	N/A	N/A	N/A	1309	9.41 gpm

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-20/Middle Specific Capacity Test**
Location: **Pajarito Canyon**
Lead Company: **Kleinfelder, Inc.**
Supporting Company: **WDC Exploration**

Project No.: **68402 3.L**
Document Originator: **Lucero, Brian**
Document Reviewer: **Lucero, Brian**
Review Complete: **11/6/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353 **ft bgs** **Screened Interval:** 1147.1 **ft bgs** **to** 1154.7 **ft bgs**

Total Volume Withdrawn (Bailing): n/a **gals.** **Total Volume Withdrawn (Pumping):** 557.2 **gals.**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos 10 horsepower	**Used From**	7/8/2006	**to**	7/8/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/8/2006	9:00	Pump	163608.7	N/A	0	N/A	N/A	N/A	N/A	N/A	Pump on
7/8/2006	10:14	Pump	See Note Below*	See Note Below*	See Note Below*	7.84	20.5	124	33	1141	DO=39.5 mg/L ORP=3.68mV
7/8/2006	10:19	Pump	See Note Below*	See Note Below*	See Note Below*	7.89	20.5	123.3	24.9	1141	DO=37.6 ORP=3.46
7/8/2006	10:24	Pump	See Note Below*	See Note Below*	See Note Below*	7.92	20.6	122.5	16.6	1141	DO=40.9 ORP=3.44
7/8/2006	10:29	Pump	See Note Below*	See Note Below*	See Note Below*	7.94	20.6	122.1	8.95	1141	DO=42.7 ORP=3.36
7/8/2006	10:34	Pump	See Note Below*	See Note Below*	See Note Below*	7.95	20.6	122.4	3.39	1141	DO=42.3 ORP=3.30
7/8/2006	10:39	Pump	See Note Below*	See Note Below*	See Note Below*	7.95	20.6	122.5	1.53	1141	DO=43.2 ORP=3.28
7/8/2006	10:44	Pump	See Note Below*	See Note Below*	See Note Below*	7.96	20.7	122.5	1.65	1141	DO=40.4 ORP=3.23

*** LANL water quality parameters were not recorded w/ totalizer readings. Pumped a total of 557.2 gal btwn 0900 and 1200.**

WELL DEVELOPMENT (Continued)

Site/Screen Name: **R-20 (middle screen)** Project No.: **68402 3.L**

Location: **Pajarito Canyon** Document Originator: **Lucero, Brian**

DEVELOPMENT TOOLS

Tool:	Pump	**Description:**	Grundfos isolated @ middle screen	**Used From**	7/8/2006	**to**	7/8/2006
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	
Tool:		**Description:**		**Used From**		**to**	

WELL DEVELOPMENT DATA (Continued)

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/8/2006	10:54	Pump	See Note on p. 1*	See Note on p. 1*	See Note Below*	7.98	21.0	122.3	1.42	1141	DO=43.5 ORP=3.37
7/8/2006	11:09	Pump	See Note on p. 1*	See Note on p. 1*	See Note Below*	7.99	21.4	122.2	1.14	1141	DO=44.5 ORP=3.43
7/8/2006	11:19	Pump	See Note on p. 1*	See Note on p. 1*	See Note Below*	8.00	21.5	122.2	1.41	1141	DO=49.8 ORP=3.52
7/8/2006	12:00	Pump	164165.9	See Note on p. 1*	557.2	N/A	N/A	N/A	N/A	N/A	Pump off

* see page 1 of 2

WELL DEVELOPMENT (Cover Page)

Site/Screen Name: **R-20/Upper Sepcific Capacity Test**
Location: **Pajarito Canyon**
Lead Company: **Kleinfelder, Inc**
Supporting Company: **WDC Exploration**

Project No.: **68402 3.L**
Document Originator: **Lucero, Brian**
Document Reviewer: **Lucero, Brian**
Review Complete: **11/6/2006**

FINAL WELL DEVELOPMENT PARAMETERS

Well Total Depth: 1353 **ft bgs** **Screened Interval:** 904 **ft bgs** **to** 912 **ft bgs**

Total Volume Withdrawn (Bailing): n/a **gals.** **Total Volume Withdrawn (Pumping):** 296.5 **gals.**

DEVELOPMENT TOOLS

Tool: Pump **Description:** Grundfos 5 hp **Used From** 7/6/2006 **to** 7/6/2006

Tool: **Description:** **Used From** **to**

WELL DEVELOPMENT DATA

Date	Time	Tool	Totalizer Reading	Volume Withdrawn (gal.)	Cumulative Volume Withdrawn (gal.)	pH	Temp (°C)	SC (µS/cm)	Turbidity (NTU)	Pump Intake (ft. bgs.)	Comments
7/6/2006	11:10	Pump	Not available	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Pump on
7/6/2006	13:33	Pump	160747.81	See Note Below *	See Note Below *	7.18	16.8	293	133	888	DO = 0.96 mg/L ORP = 10.3 mV
7/6/2006	13:43	Pump	See Below *	See Note Below *	See Note Below *	7.76	16.8	215	58.9	888	DO = 0.56 ORP = -26.0
7/6/2006	13:53	Pump	See Below *	See Note Below *	See Note Below *	8.02	18.2	168	21.4	888	DO = 0.53 ORP = -37.3
7/6/2006	14:40	Pump	See Below *	See Note Below *	See Note Below *	8.16	20.7	132.7	8.24	888	DO = 0.61 ORP = -5.0
7/6/2006	15:15	Pump	See Below *	See Note Below *	See Note Below *	8.39	23.2	131.6	4.98	888	DO = 0.86 ORP = -2.9
7/6/2006	15:46	Pump	See Below *	See Note Below *	See Note Below *	8.49	19.1	127.3	4.24	888	DO = 1.08 ORP = -17.2
7/6/2006	17:00	Pump	See Below *	See Note Below *	296.5	N/A	N/A	N/A	N/A	N/A	Pump off

*** Cannot accurately read flowmeter during time that J. Jordan (TerranearPMC) is sampling because samples are withdrawn before the flowmeter, affecting its reading. Pumped a total of 296.5 gal today, 150.9 gal. based on totalizer + 145.6 gal. that filled the drop pipe.**

Appendix C

Results of Analysis of Bentonite-Based Drilling Additives and Annular Filling Materials as Compared with Formation Materials and Pumped Particulates at Wells R-12, R-16, and R-20

C-1.0 BENTONITE-BASED DRILLING ADDITIVES AND ANNULAR FILLING MATERIALS

Bentonite-based drilling additives and annular filling materials commonly used during drilling (Gold Seal and QUIK-GEL) and as annular fill (Pel Plug and bentonite chips; also Benseal and QUICK-GROUT) were analyzed by quantitative X-ray diffraction (QXRD); results are shown in Table C-1. These data provide a mineralogic basis for evaluating which of the particulates are derived from the host rock and which are derived from drilling and well construction materials. Precise quantification of the ratio of introduced to native mineral particulates is not possible at this time, but a qualitative assessment of whether each screen is moderately or heavily impacted by introduced materials is possible.

Figure 1 summarizes the stratigraphy and well construction at R-12, R-20, and R-16. This figure provides a basis for comparison between the wells at each of these holes. The screens from which pumped particulates were collected and analyzed are shown as red in Figure 1.

C-1.1 Drilling Additives

The bentonite-based drilling additives Gold Seal and QUIK-GEL have very high smectite content (>80 wt%)and essentially no other clay minerals (e.g., no kaolinite; Table C-1). They do however have a significant salt component of ~2 wt% gypsum, which is absent in all of the annular fill bentonite materials except Pel Plug. They lack carbonate minerals and zeolites.

C-1.2 Annular Fills

The bentonite chips examined were splits of those reserved from well construction at R-34, and represent the 3/8 inch and 1/2 inch commercial chips (Table C-1). These materials have moderate smectite content (~40-60 wt%), generally associated with traces of kaolinite. Silica phases comprise ~20-40% of both chip sizes, although in the coarser chips quartz predominates and in the finer chips the more soluble phases opal-CT and cristobalite predominate. All of the bentonite chips contain a few percent of zeolite as well, but salts are not present.

Pel Plug differs considerably from the bentonite chips. Analyses by QXRD (Table C-1) and direct XRD analysis of unground pellet surfaces show that Pel Plug is coated with a mixture of calcite (with minor dolomite), gypsum, and talc. The presence of talc is a particularly significant feature, because it is a mineral that has not been found to date in any of the host lithologies beneath the Laboratory. Talc is thus a useful tracer of annular fill material wherever Pel Plug was used.

Filter packs for the screens are composed of quartz-rich sand in one of several size ranges. Nominally, the sand dimensions are listed as a range between coarse and fine sieve sizes (e.g., 20/40 sand passes a 20-mesh sieve but not a 40-mesh sieve, where 20-mesh has an opening of 841 µm and 40-mesh an opening of 420 µm). Particles of quartz have appeared in pumping from some screens where the host rock lacks quartz (e.g., screen 3 at R-12 and screen 1 at R-20, so we sieved and weighed two of the common construction sands to determine the actual size distribution. These results are shown in Table C-1-1.

Table C-1-1
Size Distribution of Two Construction Sands

	nominal max	nominal min	wt% >425 µm	wt% 425-250 µm	wt% 250-150 µm
10/20 sand	1.68 mm	841 µm	99.7%	0.33%	0
20/40 sand	841 µm	420 µm	92.6%	7.33%	0.03%

Ideally, neither the 10/20 nor the 20/40 sand should have particles finer than 420 µm, but the 20/40 sand has >7% finer material and even the 10/20 sand has traces in this size range. However, most of the screens used in these wells have 0.010 slot size (254 µm), so few if any of the quartz particles from the filter pack should be showing up as pumped particulates unless (1) the filter pack sand was abraded during shipping and handling or (2) the screen is damaged.

C-1.3 Additives and Annular Fills Used

Typical additives used during drilling include polymers, bentonite products, glass fibers, petroleum derivatives, and soda ash. Of these, the bentonite products are mineral mixtures that produce characteristic X-ray diffraction patterns; the others are expected to produce only amorphous diffraction in their end states after application.

Typical annular fill materials include bentonite products, quartz-rich sand, and cement. All of these contain natural or synthetic minerals that have characteristic X-ray diffraction properties.

At R-12: A complete inventory of drilling additives and annular fill materials is not available. However, bentonite-based drilling mud was used behind the casing during drilling, along with TORKease polymer, QUIKFOAM (alcohol ethoxy sulfates), and EZ-MUD (polymer). Although the inventory of bentonite types used as annular fill is not available, presence of talc as a pumped particulate indicates that at least some Pel Plug was used.

At R-16: The following drilling additives were used in the interval below 729 ft depth (Screen 1, above this depth, is sealed off behind lost casing):

- QUIK-GEL 31,100 lb bentonite product
- EZ-MUD 25.5 gal polymer
- Liqui-Trol 5 gal petroleum distillate
- Magma Fiber 800 lb slag/basalt glass fiber, surfactant coated
- Pac-L 50 lb polymer
- N-Seal 800 lb glass fiber
- Soda ash 100 lb Na_2CO_3

The following were used in annular fill –

- 20/40 sand 82 bags
- 30/70 sand 25 bags
- Benseal 2 bags bentonite product
- Pel Plug 790 buckets coated bentonite product
- Cement 70 bags (only used in upper 100 ft – not relevant to screens)

At R-20: The following drilling additives were used below 780 ft depth (there are no screens above this depth) –

- QUIK-GEL 7,000 lb bentonite product
- Liqui-Trol 87 gal cellulose polymer

- Magma Fiber 620 lb slag/basalt glass fiber, surfactant coated
- Pac-L 200 lb polymer
- N-Seal 100 lb glass fiber

The following were used in annular fill –

- 20/40 sand 115 bags
- 30/70 sand 27 bags
- Benseal 5.5 bags bentonite product
- QUICK-GROUT 125 bags bentonite product
- Pel Plug 354 buckets coated bentonite product
- Cement 48 bags (only used in upper 130 ft – not relevant to screens)

C-2.0 BACKGROUND TO DATA ON PUMPED PARTICULATES

Tables C-2 through C-4 summarize the QXRD data for pumped particulates at R-12, R-16, and R-20. As noted above, Figure 1 shows the stratigraphy of these three wells along with the distribution of well screens; those screens for which pumped particulates were analyzed are shown in red. Water samples were collected in 5 gal carboys during pumping tests at each well. Representative carboys with moderate to high particulate content were allowed to settle for several days to weeks before the clear supernatant was decanted and settled particulates were washed from the bottoms of the carboys with DI water. In most instances the bulk settled material was analyzed directly by QXRD; in a few instances cloudy supernatant was dried and the finer material (noted as "fines" in Tables C-3 and C-4) was analyzed by QXRD as well. In tables C-2 through C-4 each analysis of pumped particulates is identified by the screen number, the carboy sequence number (e.g., 1/4 identifies the first carboy in a sequence of four collected for a particular test), and by the date of the pump test. All of the mineral abundance vales in the tables are in weight percent. The same sequence of minerals is used in a uniform set of columns for each table; if no numbers is listed in a column the mineral was not detected in that sample.

In tables C-3 and C-4, analysis of host rock cuttings was possible at or near each screen. These analyses are listed with a gray background. For each of these analyses the depth interval of the cuttings sample is indicated (e.g., R-16 862/867 indicates cuttings from R-16 at the depth interval of 862 to 867 ft below ground surface). Cuttings samples represent the 2-4 mm cuttings size fraction unless otherwise indicated.

In addition to abundances of crystalline minerals, one column lists the abundance of amorphous material. For all of the host rock cuttings samples this represents volcanic glass, of mafic to silicic composition depending on the host unit. For the pumped particulates some amorphous material likely also glass from the host rock, where the rock is basaltic, but another possibility could be amorphous opal (opal-A) if local silica dissolution and precipitation has occurred. None of the bentonite-based drilling additives or annular fill materials contain an amorphous constituent, but additives based on spun glass (Magma Fiber and N-seal) show up in XRD as amorphous materials.

C-2.1 Pumped Particulates at R-12

Pumped particulates were collected and analyzed by QXRD from screens 1 and 3 at R-12 (Table C-2). Figure 1 summarizes the screen locations at R-12 relative to host-rock stratigraphy. Both of these screens

are located within basaltic units. Screen 1 is within a perched zone in fractured basalts of the lower alkalic sequence of Cerros del Rio lavas. Screen 3 is at the top of the regional aquifer, within Miocene basalt. Petrographic analysis shows that the Miocene basalt is considerably more altered than the Cerros del Rio, containing more clay and calcite (Broxton et al. 2001, 071252), although XRD data are not available for either lava type at R-12.

Screen slots at R-12 are of the following sizes:

- Screen 1 = 0.010 in (254 µm); filter pack = 20/40 sand
- Screen 2 = 0.005 in. (127 µm); filter pack = 30/70 sand
- Screen 3 = 0.010 in (254 µm); filter pack = 20/40 sand

***Screen 1: moderately impacted by introduced materials*.** Screen 1 at R-12 is located within the lower alkalic lava series of the Cerros del Rio basalts at this site. This screen is within a perched zone that includes fractured lavas and interflow zones above basal basaltic tephra and overlying gravels. Quantitaive XRD data are not available for the screen horizon, but petrographic analysis of the host basalts shows that they contain feldspar, augite, olivine, magnetite, ilmenite, and some groundmass basaltic glass; clay is minor but can be found in some vesicles and fractures. The pumped particulates at screen 1 contain 1.4-1.6% talc, indicating that some of the particulates are derived from Pel Plug coatings; the elevated calcite content (2.6-5%) may also be derived from Pel Plug coatings, although no gypsum was detected. The high clay content (52-29% smectite and 1.5-2.5% kaolinite) suggests that some annular fill bentonite may be present, although local clay alteration in the basalt could be concentrated as fines. There is a notable difference between the first pumped sample (1/4) and the last (4/4) in amorphous material, which is absent during initial pumping but rises to 27% in the last sample. Further analysis of this sample would be required to determine what this amorphous material is, whether derived from amorphous (organic or spun glass?) drilling additives or from basaltic glass. Note however that mafic glass is abundant (26.6%) in the trachyandesite scoria at R-20 (see the R-20 host rock sample at 895-900 ft depth, Table C-4); similar mafic glass abundance could occur in the Cerros del Rio basalts at R-12.

***Screen 3: heavily impacted by introduced materials*.** Screen 3 at R-12 is located in partially altered Miocene basalt. Quantitaive XRD data are not available for the screen horizon, but petrographic analysis of the host basalt shows that it contains feldspar, augite, largely altered olivine, magnetite and ilmenite largely altered to hematite, and groundmass altered to clay and carbonate minerals. Particulates in the two pumped samples from this screen are similar; there is only minor talc in one, indicating that Pel Plug contamination is minimal. The high smectite content (72-77%) may include annular fill clays, but clay alteration of the Miocene basalt is much more extensive than in the Cerros del Rio lavas at Screen 1; moreover, the clay-altered dacitic pumice above Screen 3 and within 1 ft of the filter pack is heavily clay-altered (Broxton et al. 2001, 071252). Much of the clay at Screen 3 may be from these local host rock sources. More significant is the high quartz content (7%) in both of the pumped samples. Quartz is not found in the Miocene basalt host rock. The presence of quartz indicates that either the screen is damaged and filter pack sand is being introduced, or quartz from the overlying clay-altered dacitic pumice is being drawn into the screen.

C-2.2 Pumped Particulates at R-16

Screen 1 at R-16 is sealed off by casing lost in the drill hole during well construction; pumped particulates were obtained only from screens 2, 3, and 4. All screen slots at R-16 have 0.010 in aperture and all were

designed to have 20/40 sand at the screen interval; however, screen 4 is almost entirely covered by slough at the bottom of the well (Figure 1).

Screen 2: moderately impacted by introduced materials. Screen 2 is located within Santa Fe Group sands. The host rock has a very high quartz content and low cristobalite/tridymite content typical of Santa Fe Group lithosomes derived from Precambrian source rocks. Calcite is present as a cementing matrix material, typical of the Santa Fe Group sands. The most significant foreign component of both pumped particulate samples is talc, an indication of material derived from Pel Plug.

Screen 3: moderately impacted by introduced materials. Screen 3 is located within Santa Fe Group sands. The host rock has a significant cristobalite and variable tridymite content typical of Santa Fe Group lithosomes derived from mixed Precambrian and volcanic source rocks. Calcite is present as a cementing matrix material, typical of all Santa Fe Group sands. As at screen 2, the most significant foreign component of both pumped particulate samples is talc, an indication of material derived from Pel Plug.

Screen 4: heavily impacted by introduced materials. Screen 4 is located within Santa Fe Group sands. The host rock has a significant cristobalite content typical of Santa Fe Group lithosomes derived from mixed Precambrian and volcanic source rocks. As at screens 2 and 3, calcite is present as a cementing matrix material, typical of all Santa Fe Group sands. At screen 4 there are two components of the pumped particulates, talc and amorphous material, that are foreign to the host rock. The talc indicates particulates derived form Pel Plug; the amorphous component could be derived from the large amounts of Magma Fiber and N-seal glass that were used to stabilize the hole during drilling. Further analysis would be necessary to confirm this. Together, the talc and amorphous material account for 15% to 27% of the pumped particulates, a larger fraction of definitively foreign material than at screens 2 and 3. The abundance of foreign components may be related to the borehole slough that lies behind most of screen 4 (Figure 1).

C-2.3 Pumped Particulates at R-20

All screen slots at R-20 have 0.010 in aperture and all were designed to have 20/40 sand at the screen interval.

The QXRD results for R-20 particulates are listed in Table C-4, along with representative QXRD data for the host rock at each of the three screens. The stratigraphy at R-20 is varied. Screen 1 is located at 904.6-912.1 ft, within a trachyandesite scoria sequence. Screen 2 is at 1147.1-1154.7 ft, within pumiceous sediments with pumice deposits that are Peralta Tuff equivalents. Screen 3 is at 1328.8-1336.5 ft, within stream gravels with a high content of volcaniclastic material; abundant tridymite and cristobalite in the host rock along with quartz indicate Santa Fe Group sediments derived from mixed Precambrian and volcanic source rocks. Lack of calcite cement (although dolomite is present) and presence of amorphous volcanic glass in the host rock make this horizon unusual among the more typical Santa Fe units.

Screen 1: heavily impacted by introduced materials. Screen 1 is located within trachyandesite scoria, characterized by mafic mineralogy (e.g., very little quartz, high plagioclase content, and presence of augite and magnetite). At screen 1 the pumped particulates have anomalously high quartz content (~23-24% vs. <1% in the host rock). Conversely, the pumped particulates lack several of the prominent constituents of the host rock, particularly augite and amorphous volcanic glass. These results suggest that the pumped particulates are heavily impacted by introduced material, although the nature of the introduced material is different from that at the lower screens, 2 and 3. Particulates at screen 1 lack the talc that is a tracer mineral specific to Pel Plug. The high quartz abundance in the screen 1 particulates is of uncertain origin; it could be mobilized fines from the transition sand at screen 1 or it could have been

introduced from another horizon when the interval from 765 to 933 ft was reamed after cement was set to 785 ft depth (a sample from the screened interval collected after this procedure contains traces of cementitious materials).

Screen 2: moderately impacted by introduced materials. Screen 2 is located within pumiceous sediments, characterized by abundant rhyolitic pumice with amorphous glass plus intermediate-composition lava clasts with complex silica polymorph assemblages (cristobalite, tridymite, and quartz are all present) and volcanic glass. The pumped particulates contain all of these silica polymorphs plus the glass; since tridymite and volcanic glass do not occur in any of the drilling additives or construction materials, a significant contribution of fine particles from the host rock is evident. However, the pumped particulates also contain significant amounts of talc (~4-5%) along with elevated calcite (~2-4%); these components are present in Pel Plug coatings and the talc in particular is not found in any of the host rocks at the LANL site. Presence of talc is definitive indication that annular fill materials have been drawn into screen 2, albeit mixed with native formation particulates.

***Screen 3: moderately impacted by introduced materials*.** Screen 3 is located within stream gravels and sands with a high content of volcaniclastic detritus. As with screen 2, the silica polymorph assemblage is complex (cristobalite, tridymite, and quartz are all present) and volcanic glass is present. Again similar to screen 2, the pumped particulates contain all of these silica polymorphs plus glass, and since tridymite does not occur in any of the drilling additives or construction materials, a significant contribution of fine particles from the host rock is evident. However, the pumped particulates again contain significant amounts of talc (~1-4%) along with calcite (~1-2%), with talc a specific tracer for Pel Plug coatings. As with screen 2, the presence of talc is definitive indication that annular fill materials have been drawn into screen 3. The markers of native formation material are similar to screen 2 (tridymite and volcanic glass in particular), but at screen 3 it was noted that the first sample contained a significant amount of organic material. The organic matter will produce an amorphous diffraction pattern similar to glass, and the ~23% of “glass” listed for this sample (Table C-4) may represent amorphous glass from the host rock along with organic material and possible glassy drilling additives (Magma Fiber and N-seal).

C-3.0 REFERENCE

Broxton, D., R. Warren, A. Crowder, M. Everett, R. Gilkeson, P. Longmire, and J. Marin, May 2001. “Characterization Well R-12 Completion Report,” Los Alamos National Laboratory report LA-13822-MS, Los Alamos, New Mexico. (Broxton et al. 2001, 071252)

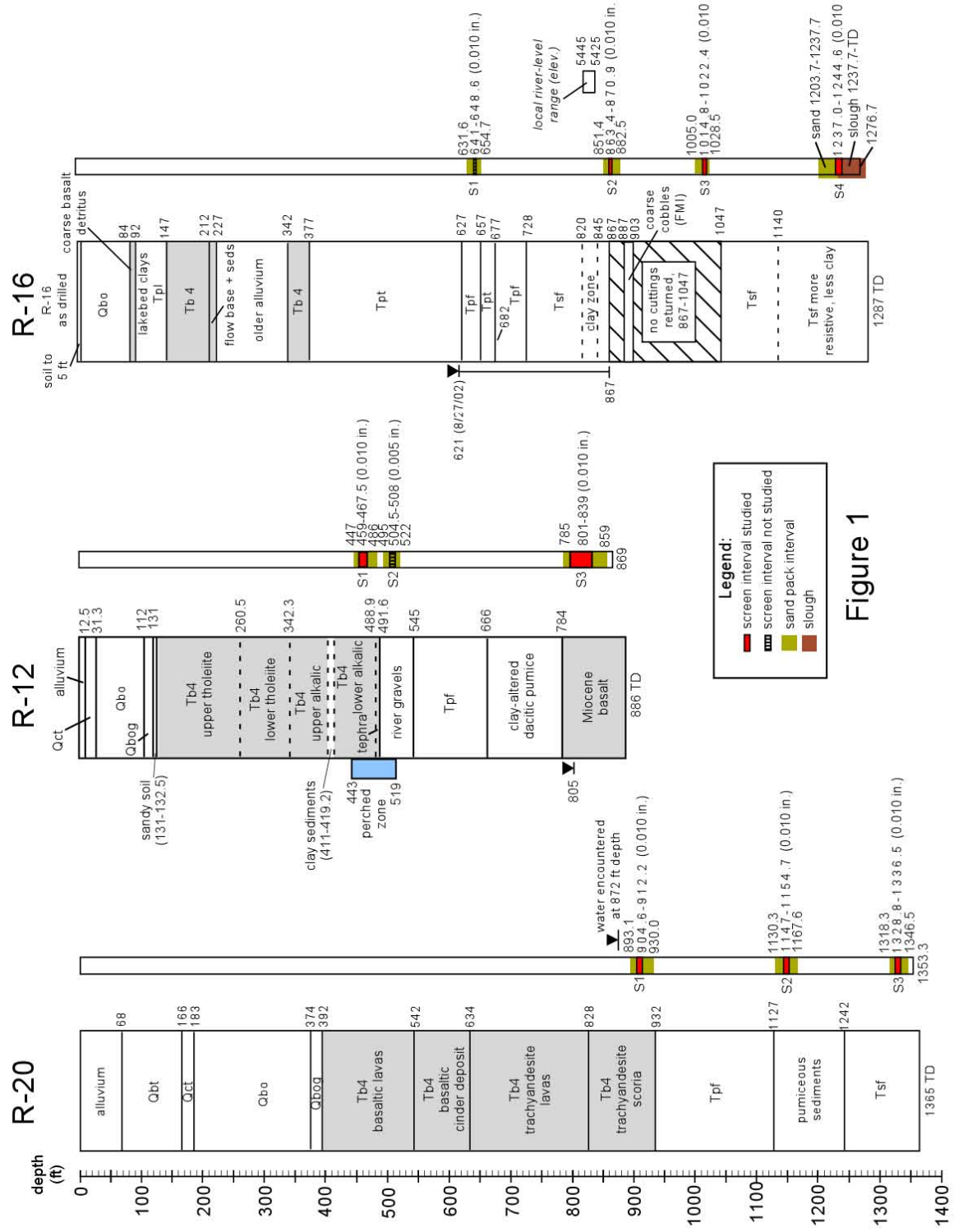

R-16
R-16
as drilled
soil to
5 ft
coarse basalt
detritus
Qbo
84
92
lakebed clays
Tpl
147
Tb 4
212
227
flow base + seds
older alluvium
342
377
Tb 4
Tpt
627
657
677
Tpf
Tpt
682
Tpf
728
Tsf
820
845
clay zone
867
887
903
coarse
cobbles
(FMI)
no cuttings
returned,
867-1047
1047
Tsf
1140
Tsf more
resistive, less clay
1287 TD
621 (8/27/02)
867
631.6
641-648.6 (0.010 in.)
654.7
S1
local river-level
range (elev.)
5445
5425
851.4
863.4-870.9 (0.010 in.
882.5
S2
1005.0
1014.8-1022.4 (0.010
1028.5
S3
sand 1203.7-1237.7
1237.0-1244.6 (0.010
slough 1237.7-TD
1276.7
S4
R-12
Qct
alluvium
Qbo
Qbog
12.5
31.3
112
131
sandy soil
(131-132.5)
Tb4
upper tholeiite
260.5
Tb4
lower tholeiite
342.3
Tb4
upper alkalic
clay sediments
(411-419.2)
Tb4
lower alkalic
tephra
443
perched
zone
519
488.9
491.6
river gravels
545
Tpf
666
clay-altered
dacitic pumice
784
Miocene
basalt
886 TD
805
447
459-467.5 (0.010 in.)
486
495
504.5-508 (0.005 in.)
522
S1
S2
785
801-839 (0.010 in.)
859
869
S3
water encountered
at 872 ft depth
893.1
904.6-912.2 (0.010 in.)
930.0
S1
1130.3
1147-1154.7 (0.010 in.)
1167.6
S2
1318.3
1328.8-1336.5 (0.010 in.)
1346.5
1353.3
S3
Legend:
screen interval studied
screen interval not studied
sand pack interval
slough
R-20
depth
(ft)
alluvium
68
Qbt
166
183
Qct
Qbo
374
392
Qbog
Tb4
basaltic lavas
542
Tb4
basaltic
cinder deposit
634
Tb4
trachyandesite
lavas
828
Tb4
trachyandesite
scoria
932
Tpf
1127
pumiceous
sediments
1242
Tsf
1365 TD
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400

Figure 1

Table C-1
QXRD data for Drilling Additives and Annular Fill Materials

	smectite	kaolinite	halloysite	talc	chlorite	mica	quartz	tridymite	cristobalite	opal-CT	K feldspar	plagioclase	hornblende	biotite	augite	amorphous	hematite	magnetite	zeolite	calcite	dolomite	apatite	gypsum	halite
Drilling additives																								
Aqua Gold Seal	84.7					1.2	3.5				3.8	8.6											1.8	
QUIK-GEL	90.6					1.9	2.6				2.3	3.9					0.1						1.9	
Annular fill																								
Pel Plug 1/4"	48.4	0.5		2.9			22.5				5.7	7.9					0.1			8.4	0.5		2.1	
R-34 3/8" chips	40.9					7.7	2.7		10.6	25.8	2.2	5.5							4.5					
R-34 1/2" upper chips	60.8	0.7				5	21.9			0.3	3.1	6.6							1.4					
R-34 1/2" lower chips	60.2	0.6				3.7	23.9				3.3	6							2.2					

Table C-2
QXRD data for R-12 Host Rock and Pumped Particulates (wt%)*

	smectite	kaolinite	halloysite	talc	chlorite	mica	quartz	tridymite	cristobalite	K feldspar	plagioclase	hornblende	biotite	augite	amorphous	hematite	magnetite	zeolite	calcite	dolomite	apatite	gypsum	halite
Screen 1, 1/4 9/29/06	52	1.5		1.6		8.1				5	15	0.2				0.5			2.6	1			
Screen 1, 4/4 9/29/06	29	2.5		1.4		14				3.5	6.5	0.2			27				5	2.5			
Screen 3, 1/4 10/16/06	77	3.5				0.8	7			5	6.5					0.3							
Screen 3, 4/4 10/16/06	72	2.9		0.4		3.1	7			4.5	9					0.3			0.5				

* Host rock analyses list depth range in feet and if applicable, the size range of cuttings analyzed. Pumped particulates (text in italics) are listed by screen number and time/date of pumping.

Table C-3

QXRD data for R-16 Host Rock and Pumped Particulates (wt%)*

	smectite	kaolinite	halloysite	talc	chlorite	mica	quartz	tridymite	cristobalite	K feldspar	plagioclase	hornblende	biotite	augite	amorphous	hematite	magnetite	zeolite	calcite	dolomite	apatite	gypsum	halite
R-16 862/867	12.1	0.4				3.6	23.2		0.5	13.6	36.9					0.4		1.6	4.1				
Screen 2, 1/4 8/11/06	68	1.4		1.7		2.2	9.8		0.2	3.2	5.8					0.1		3.7	3.6	0.2			
Screen 2, 4/4 8/11/06	55	2.0		2.4		4.3	9.3		0.1	6.1	11.3					0.3		4.9	3.8	0.5			
R-16 1097/1102 1-2 mm	11.7	0.2				2.2	16.7		5.7	19.2	34.9	0.2				0.6		1.3	4.4				
R-16 1097/1102 2-4 mm	16.5	0.2				2.3	11.6	1.5	7.3	19.7	33.7	0.1				0.7		1.0	2.8				
Screen 3, 1/4 8/10/06	73	1.7		1.8		3.7	6.4			3.1	7.0					0.2		4.8	1.2				
Screen 3, 4/4 8/10/06	74	2.4		2.1		4.8	1.6			2.4	6.1	0.2											
R-16 1237/1242	12.6	0.2				3.3	12.8		7.8	21.8	36.5	0.1				0.9		0.5	1.3				
Screen 4, 1/4 8/9/06	49	1.1		2.0		3.8	4.8			2.4	4.3				25	0.1		2.6	4.5	0.3			
Screen 4, 4/4 8/9/06	63	0.8		0.6		1.7	5.6		0.2	4.8	7.3				14	0.4		1.8	0.2	0.2			
Screen 4, 4/4 8/9/06 fines	55	0.3					0.4		0.2	1.2	1.3				28				6.9				0.4

* Host rock analyses list depth range in feet and if applicable, the size range of cuttings analyzed. Pumped particulates (text in italics) are listed by screen number and time/date of pumping.

Table C-4
QXRD data for R-20 Host Rock and Pumped Particulates (wt%)*

	smectite	kaolinite	halloysite	talc	chlorite	mica	quartz	tridymite	cristobalite	K feldspar	plagioclase	hornblende	biotite	augite	amorphous	hematite	magnetite	zeolite	calcite	dolomite	apatite	gypsum	halite
R-20 895/900	2.5						0.5	1.8	3.3	7.4	44.8	0.3	0.4	8.2	26.6		2.6				1.5		
Screen 1, 1/4 7/6/06	57.2	2			0.2	5.2	23.9		0.1	3.7	6.6					0.1		0.3			0.7		
Screen 1, 4/4 7/6/06	59.1	1.5				3.7	22.5		0.3	4.4	7.4					0.4					0.6		
R-20 1205/1210 1-2 mm	12.8						8.7	1.5	3.1	7.4	24.9				40.8	0.3				0.4			
R-20 1205/1210 2-4 mm	14.6					0.8	5.3	3.2	3.0	10.6	28.5				32.2	0.6				0.5			
Screen 2, 1/4 7/8/06	57	1.4		3.7		2.4	17	0.1	0.3	3.3	5	0.1			6	0.1			3.5				
Screen 2, 4/4 7/8/06	53.3	0.4	3.3	4.8		2.7	11.4	1	0.4	4.2	11.5	0.1			4.6	0.3			2				
R-20 1325/1335 1-2 mm	8.4					3.8	17.5	1.8	5	17	34.6	0.1			6.4	0.6				0.5			
R-20 1325/1335 2-4 mm	7.9					3.1	13.9	2.1	5.9	18.3	36.9	0.1			7.1	0.7		0.5		0.6			
Screen 3, 1/4 7/7/06	46.7	1.1	1.1	0.9		1.8	10.2	0.8	0.3	2.8	8.7	0.1			22.5	0.2		0.8	1.2	0.8			
Screen 3, 1/7 7/12/06	35.5	0.6	0.7	2.4		3.2	22.9	0.7	0.5	3.8	8	0.1			18.8	0.2			2.4	0.2			
Screen 3, 1/7 7/12/06 fines	58.8	0.4					0.3			0.3	1.8				28.6				9.3				0.4
Screen 3, 7/7 7/12/06	30.4	1	0.7	4.3		5.3	20.7	0.7	0.3	3.5	11.9	0.3			18.7	0.1			1.7	0.4			
Screen 3, 1/4 10/13/06	61	5		1.5		2.2	10	0.1	0.9	5	11					0.6			0.7				
Screen 3, 4/4 10/13/06	7	1		0.5		2.3	10	0.5		7	17				51	1.0			2.3				

* Host rock analyses list depth range in feet and if applicable, the size range of cuttings analyzed. Pumped particulates (text in italics) are listed by screen number and time/date of pumping.

Appendix D

Tables of Geochemical Data and Indicators from R-Wells R-20, R-16, and R-12 Pilot Well Rehabilitation (on CD included with this report)