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# Completion Report for Regional Aquifer Well R-37

Los Alamos
NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

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September 2009

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## EXECUTIVE SUMMARY

The primary purpose of well R-37 is to provide detection monitoring for potential releases of hazardous or radioactive chemicals from Material Disposal Areas H and J at Technical Area 54.

The “Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54” states that “R-37 shall be drilled 100 ft into the regional aquifer, and [a] single completion well will be installed in the uppermost transmissive zone that is identified as optimal based on variations in production and on stratigraphic considerations within either the Puye Formation or Cerros del Rio basalt.” A total of three boreholes were required to install well R-37 to the required depth. The first and second attempts encountered multiple drilling problems, including stuck tools in fractured basalt, failed to reach the required depth, and were abandoned. The third borehole achieved the required depth.

Based on the regional stratigraphy projected from surrounding wells, the R-37 borehole was expected to terminate in Cerros del Rio basalt but actually ended in the Puye Formation. Regional groundwater saturation was expected to be at approximately 1000 ft below ground surface (bgs) in Cerros del Rio basalt but actually stabilized at 1009 ft bgs in the Puye Formation.

The first borehole for well R-37 was drilled from July 26 to September 26, 2008, using the air-rotary casing hammer drilling technique. It was drilled essentially dry, encountered significant perched groundwater at 925 ft, failed to reach the required depth to install the well into the regional aquifer, and was abandoned from October 13 to 21, 2008. The second borehole was located 43 ft north from the first borehole and was drilled from October 24, 2008, to January 28, 2009. It was also drilled using the air-rotary casing hammer drilling technique but with liquid-based foam drilling fluid. The second borehole also failed to reach the required depth and was abandoned on February 5, 2009.

The third borehole was located 225 ft west-northwest from the first borehole and was drilled using the dual-rotary casing advance drilling method. This borehole was drilled from April 17 to May 27, 2009, to a total depth (TD) of 1100 ft bgs. The borehole TD was approximately 100 ft deeper than the projected top of regional saturation. The LANL Water Stewardship Program designed a two-screen well and submitted the design to the New Mexico Environment Department for approval. Well R-37 screen 1 is 20.7 ft long and is positioned from 929.3 to 950.0 ft bgs in perched groundwater. Well R-37 screen 2 is 20.6 ft long and positioned from 1026 to 1046.6 ft bgs in the regional aquifer. The two aquifers are separated by a well-defined perching horizon of claystone from 956 to 991 ft bgs.

This well completion report describes site preparation, drilling, sampling, well installation, well completion, well development, aquifer testing, surface completion, geodetic survey, and permanent pump and sampling system installation. Ongoing activities scheduled for fall 2009 include permanent pump and sampling system installation, waste management, and site restoration.

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## 1.0 INTRODUCTION

Well R-37 is one of several regional aquifer wells installed at Technical Area 54 (TA-54) for groundwater monitoring to comply with the Resource Conservation Recovery Act (RCRA) permit. The purpose of well R-37 is to provide detection monitoring for potential releases of hazardous or radioactive chemicals from Material Disposal Areas (MDAs) H and J (Figure 1.0-1). Well R-37 is located approximately 0.25 mi east of MDA J, 0.4 mi east of MDA H and 0.8 mi northwest of MDA L (Figure 1.0-2).

Well R-37 was proposed in the “Technical Area 54 Well Evaluation and Network Recommendations, Revision 1” (LANL 2007, 098548) and “Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54” (LANL 2007, 099662). The New Mexico Environment Department (NMED) approved these documents in 2007 (NMED 2007, 099257). This completion report summarizes the site preparation, drilling and sampling, well installation, and well completion activities for well R-37, in accordance with the requirements in Section IV.A.3.e.iv of the March 1, 2005, Compliance Order on Consent (the Consent Order). Information on radioactive materials and radionuclides, including the results of sampling and analysis of radioactive constituents, is voluntarily provided to the New Mexico Environment Department (NMED) in accordance with U.S. Department of Energy policy.

### 1.1 Overview of Well R-37 Completion Report

The information presented in this report is compiled from field reports and daily activity summaries. Records, including field reports, field logs, and survey information, are on file at the Laboratory’s Records Processing Facility (RPF). This report contains brief descriptions of all activities associated with the well R-37 project, as well as supporting figures, tables, and appendixes.

Section 1 of this completion report describes the site, purposes of well R-37, and an overview of the installation activities. Section 2 presents the scope of activities for site preparation, drilling, and sampling. Section 3 presents the results of field investigations. Well R-37 installation and completion activities are described in Sections 4 and 5, respectively. Section 6 explains deviations from planned activities. References and map data sources are provided in Section 7.

Appendixes include acronyms and abbreviations, a metric conversion table, and definitions of the data qualifiers used in this report (Appendix A); lithologic log (Appendix B); groundwater analytical results (Appendix C); geophysical logging results (Appendix D, on CD); aquifer testing report (Appendix E); and borehole abandonment information forms (Appendix F).

### 1.2 Overview of Regional Aquifer Well R-37

The purpose of well R-37 is to provide detection monitoring for potential releases of hazardous or radioactive chemicals from MDAs H and J (Figure 1.0-1).

At the R-37 location, LANL Water Stewardship Program (LWSP) had predicted the regional groundwater at 1000 ft below ground surface (bgs). A multiple screened well was designed, and well installation activities were completed on May 27 and June 6, 2009.

Well R-37 screen 1 is 20.7 ft long, positioned from 829.3 to 950.0 ft bgs in perched groundwater. Well R-37 screen 2 is 20.6 ft long and positioned from 1026.0 to 1047.6 ft bgs in the regional aquifer. Annular backfill materials were installed from May 29 to June 6, 2009, as the 12-in. welded casing was withdrawn from the R-37 borehole. As stipulated by the Consent Order, the R-37 borehole was drilled, and the well was installed, causing minimal impact to the in situ characteristics of the perched and regional groundwater.

On June 10, 2009, well development activities were initiated on screen 2, and a 24-h aquifer test was conducted from June 21 to June 22, 2009. The flow rate was approximately 12.5 gpm. On June 29, 2009, a TAM packer was installed above screen 2 to isolate screen 1. Development activities were initiated on screen 1, and a 24-h aquifer test was conducted from July 12 to July 13, 2009. The flow rate was 0.8 gpm.

In August 2009, well development pumping of well R-37 screen 1 was continued to meet the total organic carbon (TOC) target water-quality parameter. The TAM packer will remain in place until the final sampling system is installed.

## 2.0 SCOPE OF ACTIVITIES

### 2.1 Preliminary Activities

Preliminary activities included preparing administrative planning documents, receiving contractual notice to proceed with field activities, and constructing the drill pad and access road.

### 2.1.1 Administrative Preparation

The following documents were prepared to support the implementation of the scope of work: “LSRS TA-54 Wells IWD” (Work Document # 327703-01); “R-37, R-39, and R-40 Construction Project Storm Water Pollution Prevention Plan Addendum” (LANL 2008); and “Waste Characterization Strategy Form (WCSF) for Drilling and Installation of Wells at TA-54 R-37, R-39 and R-40 (EP2008-0306).

### 2.1.2 Site Preparation

Site preparation activities were performed between June 17 and July 18, 2008, and involved constructing a drill pad and a 0.5-mi access road on the north side of the mesa overlooking Cañada del Buey (Figure 1.0-2); excavating and lining the first cuttings containment pit; and installing straw waddles to limit stormwater flow and prevent erosion. The second and third R-37 boreholes required the construction of new lined containment pits, and the third R-37 borehole required the enlargement of the pad. The final drill pad was approximately 30,000 $ft^2$ and elongated because of its location between the mesa edge and an archeological buffer area atop the mesa. Except for the pits, the pad area and road were surfaced with base-coarse gravel. Radiation control technicians from the Laboratory’s Radiation Protection Group (RP-1) performed radiological screening of the site before pad and road construction and of samples and equipment before transport from the site, as needed.

The Los Alamos National Laboratory (the Laboratory) subcontractor for well installation, LATA-SHARP Remediation Service, LLC (LSRS), set up an office trailer and generator, and the LSRS drilling contractor, WDC Exploration & Wells (WDC), started mobilizing drilling equipment on July 21, 2008. Municipal water for construction and drilling activities was obtained from a fire hydrant located at TA-18. A safety fence was installed around the second and third containment pits (due to their depths), and signs were posted at the entrance to the site to limit access to authorized personnel.

## 2.2 Drilling Activities

This section describes the drilling strategy and provides a chronology of drilling activities conducted at R-37.

### 2.2.1 Drilling Strategy

The first two R-37 boreholes were drilled using a Speedstar 50K air-rotary drilling rig manufactured by George E. Failing & Co. The field crew typically worked one 10-h shift per day, 10 d on and 4 d off. However, night shift activities were conducted intermittently while drilling the first R-37 borehole.

The first R-37 borehole was drilled essentially dry from July 11 to September 23, 2008, using the air-rotary casing hammer drilling method in an open and cased borehole. A minimal amount of municipal water was injected to control dust emissions, and AQF-2 foam was used only once to regain lost cuttings circulation. Below the 16-in. surface conductor casing set at 40 ft, the R-37 borehole was drilled “open-hole” to a depth of 350 ft using a 13-in. tricone bit. From 350 to 822 ft, 12.75-in. threaded drive casing was advanced using a downhole hammer and Stratex underreamer bit. From 822 to 1080 ft, the R-37 borehole was drilled open using 9.875-in. hammer and tricone bits.

On August 20, 2008, significant perched groundwater was encountered, and a screening sample was air-lifted from 925 ft bgs. The open R-37 borehole was advanced to 985 ft in saturated fine sand and siltstone to 1000 ft in dryer silt stone and to 1080 ft in saturated Puye Formation dacitic sedimentary deposits. The borehole was unstable and caved below 1060 ft. Schlumberger, Inc., was called on-site to perform open borehole geophysical logging to define the perching horizon; however, repeated logging attempts could not go deeper than 940 ft.

LWSP required deeper drilling to ensure that well R-37 was placed into the regional aquifer. The attempt to advance the 12.75-in. casing beyond 822 ft encountered multiple drilling problems, including broken casing and stuck tools in fractured basalt, and was abandoned without achieving an open or cased borehole to the target depth of 1100 ft. An abandonment form for the first R-37 borehole is included in Appendix F.

The second R-37 borehole was located 43 ft north from the first borehole and drilled from October 24, 2008, to January 28, 2009. It was drilled using a different Speedstar 50K drilling rig and the air-rotary casing hammer drilling method in an open and cased borehole. The second R-37 borehole was drilled using a mixture of municipal water and Baroid AQF-2 foaming agent. Below the 16-in. surface conductor casing set at 40 ft, the R-37 borehole was drilled open using stabilizers and a 14.75-in. tricone bit through the Bandelier Tuff. and a 14.75-in. hammer bit to 840 ft in basalt. On November 9, 2008, the R-37 borehole was backfilled with sand and 12.75-in. threaded casing was lowered to the backfill. Casing jacks were positioned below the rig to help hold the casing during advancement, and a casing-jack slip was inadvertently dropped down the casing. The lost tool caused a 1-mo delay in drilling production.

On December 12, 2008, the slip had been recovered, and the casing finally reached the previous depth of 840 ft using the Stratex underreamer bit. From December 13 to 19, 2008, the casing was advanced to 890 ft and wedged in fractured basalt. After the holiday break, the casing was freed and pulled back to 884 ft; however, the Stratex bit and drill string were immediately stuck when drilling resumed. Downhole camera video logs performed while fishing for the stuck tools revealed that the lead casing joint and shoe had broken. A subject matter expert was mobilized and performed specialized fishing activities. On January 22, 2009, the Stratex bit was retrieved. Because of the multiple drilling problems, including lost and stuck tools, broken casing, and fractured basalt, the second R-37 borehole was also abandoned without achieving the target depth of 1100 ft. An abandonment form for the second R-37 borehole is included in Appendix F.

From April 17 to May 27, 2009, the third and final R-37 borehole was drilled using a dual rotary- (DR-) 24 drilling rig manufactured by Foremost. The number 24 signifies the maximum diameter of casing in inches that the rig can handle. The DR drilling method advanced welded steel casing and required significantly more circulation fluid than the air-rotary casing hammer drilling method.

The third R-37 borehole was located 225 ft west-northwest from the first borehole to miss the fractured basalt encountered in the first two boreholes. A mixture of Baroid AQF-2 foaming agent and approximately 206,000 gal. of municipal water were added from below the surface casing to the bottom of the basalt at 933 ft. From 933 to 1100 ft bgs, no foam and 32,900 gal. of municipal water was injected to complete well R-37 in the saturated portion of the regional aquifer without using drilling mud or additives. Table 2.2-1 presents the estimated cumulative total of liquid drilling fluids introduced to and recovered from the third R-37 borehole above the base of the basalt, below the basalt, and during well construction. Of the total volume of municipal water introduced (302,680 gal.), 32,900 gal. was injected while drilling below the basalt, and 63,800 gal. was injected during well R-37 construction (Table 2.2-1).

In the third R-37 borehole, 24-in. surface conductor casing was installed to 20 ft, 16-in. welded casing was advanced to 565 ft and landed in the basalt, and 12-in. welded casing was advanced to 1080 ft to complete well R37. Because of the injection of municipal water and foaming agent in the third R-37 borehole, the perched groundwater encountered at 920 ft bgs in the first borehole was obscured. However, the third R-37 borehole recovered significant clay and shale cuttings, and the drilling pressure rose from 956 to 991 ft bgs. This finding established the horizon perching the upper aquifer encountered in the first borehole.

During drilling with the casing at 1040 ft and the R-37 borehole at 1060 ft, groundwater was first measured in the third borehole using a depth to water (DTW) meter at 1012 ft bgs on May 22, 2009. From May 23 to May 27, 2009, the R-37 borehole was drilled to 1100 ft, and the casing advanced to 1080 ft in unstable Puye Formation gravel and boulders.

### 2.2.2 Chronological Drilling Activities

#### First Borehole

On July 26, 2008, the LSRS team performed site setup activities and installed 40 ft of 16-in. surface casing that was sealed using cement and bentonite chips.

On July 27, 2008, the LSRS team drilled a 13-in. dry open borehole to 192 ft during the day shift and 292 ft during the night shift.

On July 28, 2008, the LSRS team drilled the 13-in. borehole to 350 ft, pulled out 40 ft, tripped back in, and determined that the borehole was stable.

From July 29, 2008 to August 4, 2008, drilling activities were suspended for a 6-d break.

On August 5, 2008, the LSRS team mobilized and prepared to install 12.75-in. threaded casing.

On August 6, 2008, the LSRS team installed 12.75-in. threaded casing to 352 ft inside the open borehole.

On August 7, 2008, the LSRS team tripped in a hammer and 11.75-in. underreamer Stratex bit inside the 12.75-in. casing, started drilling, and advanced the casing to 375 ft. Compressed air was injected as the drilling fluid.

On August 8, 2008, the LSRS team advanced the casing to 485 ft and began adding a trickle of municipal water to control dust emissions. The Cerros del Rio basalt was encountered at 485 ft (borehole 1, Figure 2.2-1). During the night shift from August 8 to 9, 2008, the LSRS team stuck the casing and hammer at 485 ft, freed and tripped out the hammer, and determined that the hammer was not firing.

On August 9, 2008, the LSRS team worked on the hammer, tripped in, encountered difficulty tripping in, and tripped out.

On August 10, 2008, the LSRS team tripped in, started drilling, lost air return at 525 ft, injected 35 gal. municipal water and 2.5 gal. AQF-2 foam, closed the Stratex bit and determined that it was free and tripped out, and determined that lost circulation must be caused by a void or fracture zone in the basalt.

On August 11, 2008, the LSRS team tripped in the 11.75-in. Stratex bit and hammer, drilled from 525 ft, restored cuttings circulation at 550 ft, and advanced the casing to 585 ft at the end of the shift. A trickle of municipal water was injected to control dust emissions.

On August 11 to 12, 2008, night shift, the LSRS team drilled to 685 ft at the end of the shift. A trickle of municipal water was injected to control dust emissions.

On August 12, 2008, the LSRS team started drilling from 685 ft and recovered muddy cuttings at 704 ft. Water was measured at 692 ft bgs (10:28 a.m.), 693 ft bgs (10:30 and 10:50 a.m.), and 693 ft bgs (1:10 p.m.). By using a bailer with the tools in, the LSRS team attempted to collect a water sample but was unsuccessful, removed the tools, determined that the Stratex bit was missing one of two bearing plugs, and disassembled the bit. With the tools removed, water was measured at 697 ft bgs. The casing depth at the end of the day was 705 ft. Note: No groundwater was detected in either of the other boreholes at this interval. This observation, along with the fact that water levels dropped through time, suggests that this was introduced water and not groundwater.

During the night shift from August 12 to 13, 2008, the LSRS team repaired the Stratex bit, advanced the casing from 705 to 735 ft, tripped out the tools to evaluate and repair the hammer, and started to trip in the tools. A trickle of municipal water was injected to control dust emissions.

On August 13, 2008, the LSRS team finished tripping in the tools and advanced the casing from 735 to 790 ft. A trickle of municipal water was injected to control dust emissions.

On August 13 to 14, 2008, night shift, the LSRS team advanced the casing from 790 to 822 ft, noted the casing was very tight, and stuck the bit at 822 ft. A trickle of municipal water was injected to control dust emissions.

On August 14, 2008, the LSRS team installed casing jacks to loosen the 12.75-in. casing and tools, freed and pulled back 40 ft of casing, tripped out and disassembled the tools. Upon inspection of the Stratex bit, the worn character of the lip that rests on the casing shoe during casing-advance drilling indicated that the casing shoe was likely worn out and could go no farther.

From August 15, 2008 to August 18, 2008, drilling activities were suspended for a 4-d break.

On August 19, 2008, the LSRS team changed to open borehole drilling using a 9.875-in. hammer bit, drilled from 822 to 908 ft, and noted water in the borehole at the end of the day.

On August 20, 2008, the LSRS team continued drilling from 908 ft to determine whether the observed water was injected or in situ, exited the base of the basaltic lava flow at 920 ft (Figure 2.2-1), encountered significant formation water in basaltic gravel, air-lifted a groundwater-screening sample from 925 ft, and drilled to 985 ft in siltstone and fine sand with significant groundwater production. LWSP technical personnel were notified and well installation activities were planned.

From August 20 to 21, 2008, night shift, the LSRS team noted that the borehole had collapsed from 985 to 972 ft and tripped out the tools to prepare for Laboratory geophysical logging.

On August 21, 2008, the LSRS team transferred well materials from the Pajarito lay-down yard and decontaminated the well casing and couplings. The Laboratory performed natural gamma logging of the open borehole from 822 to 972 ft. The groundwater was measured at 893.4 ft bgs using a DTW meter. LWSP directed that drilling continue to 1100 ft using a tricone bit to ensure that the regional aquifer was penetrated.

On August 21 to 22, 2008, night shift, the LSRS team tripped out to change bits, noted that the borehole had collapsed from 972 to 960 ft, started drilling using a 9.875-in. tricone bit, recovered dry cuttings at 993 ft, added a small amount of municipal water at 998 ft to facilitate cuttings recovery, conditioned the borehole repeatedly between 980 and 1000 ft to ensure stability, encountered Puye Formation dacitic sediments at 1000 ft, and drilled to 1060 ft at the end of the day.

On August 22, 2008, the LSRS team continued drilling from 1060 ft, air-lifted a groundwater-screening sample from 1070 ft, noted repeated borehole collapse at 1080 ft, tripped out the tools, and measured the bottom of the borehole at 1062 ft and the depth to groundwater at 963 ft bgs.

On August 23, 2008, the DTW was measured at 895 and 895.6 ft bgs. At the end of the shift, Schlumberger, Inc., arrived on-site to perform open borehole geophysical logging.

On August 23 to 24, 2008, night shift, Schlumberger's geophysical logging tool could not go deeper than 940 ft, although the borehole appeared to be open to 1062 ft. The LSRS team tripped in drilling tools to clean out the borehole, noted resistance from 955 to 957 ft and determined that the borehole collapsed at 970 ft, injected air and cleaned out the borehole to 1030 ft with cuttings recovery, advanced the bit to 1050 ft with no recovery, and tripped out to evaluate the drill rods and bit.

On August 24, 2008, the LSRS team finished tripping out the tools and using a borehole tagger and determined that the borehole was open to 1050 ft. Schlumberger attempted to log the open borehole but again failed to get its geophysical tools past 940 ft. This process continued throughout the day until Schlumberger demobilized. LWSP, LSRS, and the LSRS team discussed advancing the 12.75-in. casing to hold back the formation, which would involve replacing the casing shoe at 782 ft or attempting alternative methods to open the borehole for geophysical logging.

On August 24 to 25, 2008, night shift, the LSRS team tagged the open borehole at 1060 ft and delivered reaming tools to the site. The DTW was measured at 894.3 ft bgs using the DTW meter. The LSRS team installed the reaming tool, reamed to 890 ft until tight, and pulled back 20 ft. The reaming tools became stuck at 870 ft. While attempting to free the stuck reaming tool, a main cable broke on the drill rig.

On August 25, 2008, drilling activities were suspended, pending resolution of the cable break incident.

On August 25 to 26, 2008, night shift, cable repair activities were authorized but suspended because of inadequate lighting.

On August 26, 2008, drilling activities were suspended until a rig inspection at R-37 was performed.

On September 7, 2008, the LSRS team performed cable and other repairs, pursuant to an LWSP-approved restart plan.

On September 8, 2008, the LSRS team completed the repairs, freed the stuck reaming tool, and tripped out and tagged the open borehole at 927 ft.

On September 9, 2008, LWSP authorized drilling activities to restart. The LSRS team tripped in a Stratex bit to 780 ft.

On September 10, 2008, the LSRS team advanced the 12.75-in. casing from 782 ft, encountered resistance at 810 ft, and was barely able to close the Stratex bit at 863 ft.

On September 11, 2008, the LSRS team advanced the 12.75-in. casing from 863 to 870 ft, tripped out to evaluate the Stratex bit, tripped in a new bit, and failed to advance the casing deeper than 870 ft.

From September 12 to 15, 2008, drilling activities were suspended because of a 4-d break and ordered a replacement Stratex bit.

On September 16, 2008, the LSRS team tripped in a rebuilt Stratex bit, failed to advance the 12.75-in. casing from 870 ft, and tripped out and determined that the bit was damaged beyond repair.

From September 15 to 22, 2008, drilling activities were suspended while waiting for a new Stratex bit.

On September 23, 2008, the LSRS team removed the 12.75-in. casing from 870 to 550 ft.

On September 24, 2008, the LSRS team finished pulling the 12.75-in. casing, replaced the casing shoe, and added sand backfill to 520 ft.

On September 25, 2008, the LSRS team added more sand backfill to 500 ft, tripped in 12.75-in. casing and a new Stratex bit to 518 ft, and advanced the casing in the sand backfill to 640 ft.

On September 26, 2008, the LSRS team advanced the 12.75-in. casing to 850 ft and noted a potential casing shoe failure at the end of the day.

On September 27, 2008, the LSRS team removed the drill string from inside the 12.75-in. casing and the Laboratory performed video logging. The video log revealed the casing was intact from the surface to 815 ft; however, the lead casing, including the shoe, had broken off and was lodged from 830 to 848 ft.

On September 28, 2008, the LSRS team pulled 20 ft of casing and tripped in the 9.875-in. tricone bit to clean out the borehole.

On September 29, 2008, the LSRS team cleaned out the borehole to 1010 ft, pulled back the drill string to 920 ft, and filled the borehole with municipal water.

On September 30, 2008, the LSRS team tripped in the 9.875-in. tricone bit, determined that the borehole had collapsed from 1010 to 985 ft overnight, and pulled back the drill string to 920 ft.

From October 1 to 9, 2008, drilling activities were suspended, awaiting a borehole completion strategy. The rig was demobilized for maintenance. LWSP decided to abandon the first borehole.

On October 10, 2008, the Speedstar 50K rig reoccupied the borehole, and the LSRS team prepared to clean out the borehole for abandonment.

From October 11 to 12, 2008, the LSRS team cleaned the borehole to 1020 ft and tripped out the drill string.

On October 13, 2008, the LSRS team installed a 2-in.-diameter tremie pipe, mixed Volclay bentonite gel with municipal water, tremied the bentonite gel to 920 ft and 0.375-in. bentonite chips and municipal water to 870 ft.

On October 14, 2008, the LSRS team removed the tremie pipe, installed a larger set of casing jacks, pulled back the casing 20 ft, and poured bentonite chips. The Laboratory performed video logging that revealed the casing had broken at 645 ft, leaving casing from 645 to 805 ft. The borehole backfill was tagged at 675 ft.

On October 15, 2008, the LSRS team alternatively pulled casing and poured bentonite chips. At the end of the day, the borehole backfill was tagged at 450 ft.

On October 16, 2008, the LSRS team reinstalled the tremie pipe to 420 ft; KSL spread base-coarse gravel as preparation for digging a new pit on-site.

From October 17 to 20, activities were suspended for a 4-d break; KSL worked on the new pit.

On October 21, 2008, the LSRS team backfilled the remaining borehole with cement and left 360 ft of tremie pipe stuck in the cement.

Total volume of water introduced during drilling of borehole 1 was approximately 450 gal. and the total AQF-2 foam used was 2.5 gal.

### Second Borehole

On October 23, 2008, a new borehole location was chosen 43 ft north from the abandoned borehole.

On October 24, 2008, the LSRS team performed site setup activities, mobilized a Speedstar 50K rig, drilled and reamed a 22-in.-diameter borehole to 40 ft, installed 16-in. casing to 40 ft, and poured a concrete seal to set the surface casing.

On October 25, 2008, the LSRS team advanced an open borehole using a 14.75-in. tricone bit and stabilizers from 40 to 144 ft and used 15 gal. of AQF-2 foam and 750 gal. municipal water.

On October 26, 2008, the LSRS team advanced the open borehole from 144 to 490 ft and used 50 gal. of AQF-2 foam and 1500 gal. of municipal water. The basalt was encountered at 490 ft.

On October 27, 2008, the LSRS team advanced the open borehole from 490 to 504 ft in Cerros del Rio basalt and used 17 gal. of AQF-2 foam and 1500 gal. of municipal water.

On October 28, 2008, the LSRS team advanced the open borehole from 504 to 519 ft in Cerros del Rio basalt and used 20 gal. of AQF-2 foam and 1500 gal. of municipal water.

On October 29, 2008, the LSRS team advanced the open borehole from 519 to 529 ft in Cerros del Rio basalt and used 22 gal. of AQF-2 foam and 1500 gal. of municipal water.

On October 30, 2008, the LSRS team advanced the open borehole from 529 to 534 ft in Cerros del Rio basalt and used 20 gal. of AQF-2 foam and 1600 gal. of municipal water.

From October 31 to November 3, 2008, drilling activities were suspended for a 4-d break.

On November 4, 2008, the LSRS team replaced the 14.75-in. tricone bit with a 14.75-in. hammer bit, advanced the open borehole from 534 to 570 ft in Cerros del Rio basalt, and used 25 gal. of AQF-2 foam and 1000 gal. of municipal water.

On November 5, 2008, the LSRS team advanced the open borehole from 570 to 670 ft in Cerros del Rio basalt and used 30 gal. AQF-2 foam and 3000 gal. of municipal water.

On November 6, 2008, the LSRS team advanced the open borehole from 670 to 770 ft in Cerros del Rio basalt and used 20 gal. of AQF-2 foam and 3000 gal. of municipal water.

On November 7, 2008, the LSRS team advanced the open borehole from 770 to 810 ft in Cerros del Rio basalt and used 20 gal. of AQF-2 foam and 2500 gal. of municipal water.

On November 8, 2008, the LSRS team advanced the open borehole from 810 to 840 ft in Cerros del Rio basalt, used no foam and 1700 gal. of municipal water, and started tripping out the drill string as preparation to lower 12.75-in. threaded casing.

On November 9, 2008, the LSRS team finished tripping out the drill string, backfilled sand to 695 ft (to support the weight of the 12.75-in casing), and installed casing to 232 ft.

On November 10, 2008, the LSRS team removed the casing from 232 ft, repositioned the drill rig for greater stability, dropped a casing slip down the borehole, and reinstalled the casing to 232 ft.

On November 11, 2008, the LSRS team installed the casing to 670 ft. The Laboratory performed video logging that revealed the casing-jack slip atop the sand backfill at 695 ft. A downhole magnet was ordered from Farmington, New Mexico.

From November 12 to 13, 2008, the LSRS team fished for but did not recover the casing-jack slip.

From November 14 to 18, 2008, drilling activities were suspended for a 5-d break.

On November 19, 2008, the LSRS team continued fishing for the casing-jack slip and pulled back the casing to 615 ft.

On November 20, 2008, the LSRS team removed the remaining the casing, deployed a camera, and tripped casing back in to 180 ft.

On November 21, 2008, the LSRS team reinstalled the casing back to 700 ft and tripped in an 8.5-in. drag bit to attempt to push the slip aside.

On November 22, 2008, the LSRS team lowered the casing to 705 ft, drilled the drag bit to 705 ft, and drilled a 9.875-in. tricone bit to 785 ft.

On November 23, 2008, the LSRS team advanced the tricone bit but failed to penetrate deeper than at 808 ft, tripped out the drill string, deployed their camera that lost visibility below 700 ft, and tripped in the drill string to 810 ft to provide a clean and dry route for the camera.

On November 24, 2008, the LSRS team cleaned out the drill string and borehole using municipal water and air, deployed their camera, observed water at 803 ft, and pulled back the drill string to 530 ft.

On November 25, 2008, the LSRS team finished removing the drill string, pulled the casing back 20 ft, deployed their camera, and observed the slip wedged in the casing bottom.

From November 26 to 30, 2008, drilling activities were suspended for a 5-d break.

On December 1, 2008, the LSRS team removed 220 ft of casing to recover the lodged slip from the borehole.

On December 2, 2008, the LSRS team removed the remaining casing, recovered the slip, backfilled sand into the borehole to 675 ft, and replaced the casing shoe.

On December 3, 2008, the LSRS team reinstalled 12.75-in. casing to 678 ft.

On December 4, 2008, the LSRS team reinstalled the drill string and button bit to blow out the sand.

On December 5, 2008, the LSRS team advanced the casing in the sand backfill to 792 ft.

On December 6, 2008, the LSRS team advanced the casing in the sand backfill to 832 ft.

On December 7, 2008, the LSRS team tripped out the drill string, replaced the tricone bit with the Stratex bit, immediately plugged the bit in the sand backfill, and were unable to clean the bit using municipal water.

On December 8, 2008, the LSRS team tripped in a tremie pipe and tagged an obstruction at 790.5 ft, 41 ft above the Stratex bit.

On December 9, 2008, the LSRS team injected air into the tremie pipe, discharged sand and large fragments of basalt, freed and tripped out the Stratex bit, and tripped in the tricone bit to 812 ft.

On December 10, 2008, the LSRS team disassembled the Stratex bit and advanced the button bit to 832 ft.

On December 11, 2008, the LSRS team replaced the tricone bit with the Stratex bit, advanced the casing from 837 to 839 ft at 0.25 ft/h, and used no foam and 1000 gal. of municipal water.

On December 12, 2008, the LSRS team advanced the casing from 839 to 846 ft at 0.5 ft/h and used no foam and 2000 gal. of municipal water.

On December 13, 2008, the LSRS team advanced the casing from 846 to 850 ft at 0.5 ft/h and used no foam and 1000 gal. of municipal water.

On December 14, 2008, the LSRS team advanced the casing from 850 to 855 ft at 0.5 ft/h and used no foam and 1000 gal. of municipal water.

On December 15, 2008, the LSRS team advanced the casing from 855 to 870 ft at 3.75 ft/h and used no foam and 1000 gal. of municipal water. At midday, drilling activities were suspended because of adverse weather conditions.

On December 16, 2008, all drilling activities were suspended by LWSP due to adverse weather conditions.

On December 17, 2008, the LSRS team advanced the casing from 870 to 876 ft at 0.5 ft/h and used no foam and 1000 gal. of municipal water.

On December 18, 2008, the LSRS team advanced the casing from 876 to 887 ft at 1 ft/h and used no foam and 2000 gal. of municipal water.

On December 19, 2008, the LSRS team advanced the casing from 887 to 890 ft at 0.33 ft/h and used no foam and 1500 gal. of municipal water.

On December 20, 2008, the LSRS team performed rig maintenance and tripped out 260 ft of the drill string to evaluate the Stratex bit.

On December 21, 2008, the LSRS team removed and repaired the Stratex bit and mobilized and repaired stronger casing jacks from R-40.

On December 22, 2008, the LSRS team positioned the stronger casing jacks over the borehole and casing.

On December 23, 2008, the Laboratory suspended drilling activities due to adverse weather conditions.

From December 24, 2008 to January 4, 2009, drilling activities were suspended for the holiday break.

On January 5, 2009, the LSRS team positioned the stronger casing jacks over the borehole and casing, pulled the casing back 5 ft, and freed and reinstalled the casing to 884 ft.

On January 6, 2009, the LSRS team tripped in the Stratex bit to 884 ft and stuck the bit.

On January 7, 2009, the LSRS team was unable to free the stuck bit.

On January 8, 2009, activities were suspended until a drill-rod extractor operated by the casing jacks could be mobilized to the site.

On January 9, 2009, the LSRS team installed the drill-rod extractor atop the casing jacks, moved the extractor 2 in., and stopped before the drill string failed. LWSP approved injecting a minimal amount of foam to free the bit.

On January 10, 2009, the drill-rod extractor was removed from the casing jacks but remained on-site. The LSRS team mixed and injected 2 gal. AQF-2 foam with 300 gal. of municipal water, discharged some cuttings but no foam, repositioned the extractor atop the casing, pulled the drill string back another 2 in., and pulled and applied tension to the drill string overnight.

On January 11, 2009, the LSRS team worked the stuck drill string using the extractor. At midday, the extractor was removed and the casing was pulled back 15 ft. The LSRS team deployed their camera and determined that the bottom casing joint containing the Stratex shoe and bit had broken.

On January 12, 2009, activities were halted pending a strategy discussion about fishing for the lost bit and broken casing.

On January 13, 2009, fishing activities were on hold, pending arrival of a subject matter expert.

On January 14, 2009, the LSRS team contracted Weatherford Completion & Oilfield Services (Weatherford) from Farmington, New Mexico, to retrieve the stuck tools.

On January 15, 2009, Weatherford prepared downhole tools to jar the stuck tools. The LSRS team mixed and injected 7 gal. AQF-2 foam and 400 gal. municipal water, discharged angular basalt fragments, pulled back, freed and tripped out the hammer and stabilizers but left the Stratex bit lodged in the casing shoe.

From January 16 to 19, 2009, all drilling activities were suspended for a 4-d break.

On January 20, 2009, Weatherford prepared a downhole overshot tool to fish. The LSRS team tripped in, ran their camera, and determined that the bit was not secured by the overshot tool.

On January 21, 2009, the LSRS team continued fishing, monitored the downhole situation with the camera, determined that the drive chuck on the bit prevented the overshot tool from grabbing the bit, and tripped in a hammer to loosen the drive chuck.

On January 22, 2009, the LSRS team ran the camera and determined that the drive chuck was secured, tripped out the drill string and chuck, tripped in the grapple and jarring tools, and grabbed onto something. The LSRS team ran the camera, determined that the bit was secured, withdrew the camera, tripped out the drill string, and recovered the Stratex bit. The lead casing joint and shoe remained stuck from 870 to 890 ft.

On January 23, 2009, the LSRS team ran the camera to assess the broken casing at 884 ft, noted water in the borehole, attempted but failed to bail a water sample, injected 500 gal. municipal water (no foam), and blew water and air to clean out borehole.

On January 24, 2009, the LSRS team continued to clean the borehole and assess using the camera; performed maintenance on the access road.

On January 25, 2009, crews maintained stormwater best management practices, conducted housekeeping, and swept mud off Pajarito Road.

On January 26, 2009, the LSRS team delivered new roller reamers and more AQF-2 foam. On January 27, 2009, activities were on hold, pending fiscal approval to continue work.

On January 28, 2009, the LSRS team contracted Jet West from Farmington, New Mexico, to run a gyro-based deviation tool that could not get past 884 ft. The deviation survey determined that from the surface to 800 ft, the 12.75-in. casing deviated only 1 degree. Below 800 ft, the survey was inconclusive because of airflow in the basalt.

From January 29 to February 2, 2009, all drilling activities were suspended for a 5-d break.

On February 3, 2009, LWSP decided to abandon the second borehole, and the LSRS team removed half of the 12.75-in. casing.

On February 4, 2009, the LSRS team removed the remainder of the 12.75-in. casing and moved the drill rig off the borehole. RP-1 was notified to start screening equipment for demobilization.

On February 5, 2009, the LSRS team poured four truckloads of cement to abandon the borehole and began demobilizing casing and drilling equipment from the site.

From February 5 to 6, 2009, the LSRS team demobilized casing and drilling equipment from the site.

From February 7 to 8, 2009, activities were suspended for the weekend.

From February 9 to 10, 2009, the LSRS team demobilized support equipment and cleaned up trash from the site.

From February 11 to 13, 2009, the LSRS team demobilized casing and equipment from the Pajarito lay-down yard.

Total volume of water introduced during drilling of borehole 2 was approximately 31,250 gal. and the total volume of AQF-2 foam used was 237 gal.

### Third Borehole

From February 14 to March 13, 2009, drilling activities were suspended while discussions continued between LWSP and LSRS regarding a third borehole to complete the R-37 well. During this period, LSRS periodically conducted waste and stormwater management activities on-site. KSL enlarged the drill pad and built a new pit for the third borehole. LSRS prepared a new drilling plan for LWSP approval.

On April 13, 2009, the LSRS team delivered drilling tools and a water truck to the site.

On April 14, 2009, LSRS inspected a Foremost DR-24 drilling rig that would be used for the third borehole.

On April 16, 2009, the LSRS team mobilized the DR-24 drilling rig and support equipment to the site. LWSP inspected and approved the DR-24 rig; the crew set up the site.

On April 17, 2009, the LSRS team drilled a 20 ft open borehole for the surface casing.

On April 18, 2009, the LSRS team set 20 ft of 24-in.-diameter surface casing, set up discharge from the 24-in. surface casing to the pit, drilled a 22-in. roller bit to 56 ft, installed and centralized 16-in. casing to 56 ft, and injected 1.5 gal. of AQF-2 foam and 180 gal. of municipal water.

On April 19, 2009, the LSRS team advanced 12-in. casing from 56 to 300 ft; injected 7 gal. of AQF-2 foam and 16,000 gal. of municipal water.

On April 20, 2009, the LSRS team advanced 12-in. casing from 300 to 420 ft, tripped out and replaced the bit, and injected 25 gal. of AQF-2 foam and 25,000 gal. of municipal water.

On April 21, 2009, the LSRS team advanced 12-in. casing from 420 to 500 ft, injected 20 gal. of AQF-2 foam and 15,400 gal. of municipal water.

On April 22, 2009, the LSRS team advanced 12-in. casing from 500 to 520 ft; injected 2 gal. of AQF-2 foam and 1500 gal. of municipal water. The Cerros del Rio basalt was encountered at 501 ft.

On April 23, 2009, the LSRS team advanced 12-in. casing from 520 to 560 ft, injected 9 gal. of AQF-2 foam and 13,400 gal. of municipal water, and determined that the bit and discharge from behind the casing had plugged.

On April 24, 2009, the LSRS team encountered velocity problems due to air loss behind the casing, removed 60 ft of 12-in. casing, tripped out the bit, installed a tricone bit to clean out the borehole, and injected 6 gal. of AQF-2 foam and 8800 gal. of municipal water.

On April 25, 2009, the LSRS team decided to run 16-in. casing to the basalt.

From April 26 to April 30, 2009, drilling activities were on hold, pending arrival of 16-in. casing.

On May 1, 2009, the LSRS team mobilized 500 ft of 16-in. casing.

On May 2, 2009, the LSRS team removed the 16-in. casing in the borehole (56 ft), welded a drilling shoe on the lead joint, tripped the casing back in to 56 ft, installed the bit and drill string, advanced and welded the 16-in. casing to 100 ft, and injected 0.5 gal. of AQF-2 foam and 5000 gal. of municipal water.

On May 3, 2009, the LSRS team advanced the 16-in. casing to 510 ft and injected 0.5 gal. of AQF-2 foam and 5000 gal. of municipal water.

On May 4, 2009, the LSRS team advanced the 16-in. casing to 560 ft and injected 3 gal. of AQF-2 foam and 32,000 gal. of municipal water.

On May 5, 2009, the LSRS team advanced the 16-in. casing to 565 ft, and injected 3 gal. of AQF-2 foam and 8400 gal. of municipal water.

On May 6, 2009, the LSRS team cleaned out the 16-in. casing, tripped out the drill string and bit, and injected 4 gal. of AQF-2 foam and 1000 gal. of municipal water.

On May 7, 2009, the LSRS team advanced 12-in. casing to 220 ft. No foam or water was used.

On May 8, 2009, advanced 12-in. casing to 560 ft. No foam or water was used.

On May 9, 2009, the LSRS team mobilized an auxiliary air booster to the site, advanced 12-in. casing in Cerros del Rio basalt to 650 ft, and injected 75 gal. of AQF-2 foam and 15,400 gal. of municipal water.

On May 10, 2009, the LSRS team advanced 12-in. casing to 750 ft in Cerros del Rio basalt and injected 75 gal. of AQF-2 foam and 15,400 gal. of municipal water.

On May 11, 2009, the LSRS team advanced 12-in. casing to 850 ft in Cerros del Rio basalt and injected 30 gal. of AQF-2 foam and 22,000 gal. of municipal water.

On May 12, 2009, the LSRS team advanced 12-in. casing to 880 ft in Cerros del Rio basalt, injected 10 gal. of AQF-2 foam and 16,000 gal. of municipal water, tripped out the bit for evaluation, and determined that the bit needed new cutting wings.

From May 13 to May 18, 2009, crews were off-site for a break.

On May 19, 2009, the LSRS team observed no standing water in the borehole, advanced 12-in. casing to 930 ft in Cerros del Rio basalt, and injected 20 gal. of AQF-2 foam and 16,000 gal. of municipal water.

On May 20, 2009, the advancing 12-in. casing penetrated the base of the basalt at 933 ft. Use of AQF-2 foam was discontinued at 933 ft. Advanced and welded 12-in. casing to 1000 ft in Puye Formation sedimentary deposits and injected 2 gal. of AQF-2 foam before stopping its use and 7000 gal. total of municipal water. The drilling pressure increased from 956 to 991 ft, and cuttings indicated the presence of claystone and shale. Below 991 ft, borehole stability was hindered because foam was not injected. To keep advancing the casing, extensive cleaning and reaming were required to keep the 12-in. casing from getting stuck.

On May 21, 2009, to facilitate recovery, the drill bit was advanced 20 ft in front of the 12-in. casing. The casing was advanced to 1040 ft and the borehole to 1060 ft in Puye Formation dacitic sedimentary deposits. No foam was used and 12,600 gal. of municipal water was injected.

On May 22, 2009, the LSRS team tripped out the hammer bit and drill string, measured the depth to groundwater at 1012 ft bgs using the DTW meter, removed the hammer bit and tripped in a tricone bit, air-lifted a groundwater-screening sample from 1052 ft, blew air for 2 h, tripped out the tricone bit and drill string, and immediately measured the DTW at 1012 ft bgs and twice at 1011.8 ft bgs (at 0.5-h and 1-h intervals).

On May 23, 2009, the LSRS team measured the depth to groundwater at 1010.8 ft bgs using the DTW meter. Drilling activities were suspended because of heavy rain.

On May 24, 2009, the LSRS team measured the depth to groundwater at 1010.8 ft bgs using the DTW meter, tripped in the hammer and drill string, advanced the drill bit 20 ft in front of the 12-in. casing, and used 2200 gal. of municipal water. The casing was advanced to 1080 ft and the borehole to 1100 ft in Puye Formation dacitic sedimentary deposits.

On May 25, 2009, the LSRS team advanced the 12-in. casing to 1090 ft and used 9900 gal. of municipal water.

On May 26, 2009, the LSRS team tagged the gravel inside the 12-in. casing at 1077 ft, continued cleaning the borehole to keep the 12-in. casing free, and tripped out the drill string to prepare for geophysical logging. The Laboratory performed natural gamma logging of the cased borehole. The LSRS team tripped in the bit and drill string to keep the 12-in. casing free.

On May 27, 2009, the LSRS team tagged the gravel inside the 12-in. casing at 1077 ft, removed 20 ft of casing to 1070 ft, continued cleaning the borehole to keep the 12-in. casing free, injected no foam and 600 gal. of municipal water, tagged the borehole bottom at 1080 ft, and reported that the casing at 1070 ft was “very free.” LWSP sent LSRS an NMED-approved well design and designated May 27, 2009, as the borehole completion date. The TD of the third R-37 borehole was 1100 ft.

## 2.3 Sampling Activities

The following sampling activities were performed at R-37.

From the first borehole, drill cuttings were collected at 2- to 5-ft intervals from the cuttings discharged into the lined cuttings containment pits. From the second borehole, confirmation cuttings were to be collected starting at 900 ft; however, since the second borehole never reached this depth, no cuttings were collected. From the third borehole, cuttings were collected from 800 to 1100 ft (TD) and provided reliable evidence of the perching horizon. The cuttings were sieved, collected in chip trays, and examined to characterize the lithology and stratigraphy of the R-37 borehole and to generate the lithologic log in Appendix B.

In the first borehole, borehole-screening groundwater samples were air-lifted from the perched zone at 925 ft and from the regional aquifer at 1070 ft bgs and analyzed for volatile organic compounds, high explosives, and low-level tritium at off-site laboratories and for dissolved cations/metals and anions at the Laboratory’s Earth and Environmental Science Division (Group EES-14) chemistry laboratory.

No screening samples were collected from the second borehole.

From the third borehole, screening samples were air-lifted from within the regional aquifer at 1020, 1040, and 1052 ft bgs and were a composite of injected municipal water and groundwater. They were analyzed for dissolved cations/metals and anions at the EES-14 chemistry laboratory.

After well installation, screen 2 development groundwater was sampled and measured for the following water-quality parameters: pH, specific conductivity, temperature, turbidity, dissolved oxygen (DO), and salinity. In addition, some samples were also submitted for TOC analysis at the EES-14 chemistry laboratory. On June 22, 2009, at the conclusion of the 24-h pumping test on screen 2, LWSP collected a full-suite groundwater sample.

From screen 1, development water was sampled and measured for the same water-quality parameters as screen 2: pH, specific conductivity, temperature, turbidity, dissolved oxygen, and salinity. Also, samples were submitted for TOC analysis at the EES-14 chemistry laboratory. On July 13, 2009, at the conclusion of the 24-h pumping test on screen 1, LWSP collected a full-suite groundwater sample.

In August 2009, additional samples were collected from continued development pumping from R-37 screen 1. These additional development samples were analyzed for TOC to confirm that development was complete.

Waste characterization samples were collected of dry cuttings in rolloff containers, wet cuttings and drilling water were discharged into the lined cuttings containment pit, and well development water was contained in aboveground storage tanks.

Sampling documentation and containers were provided by the Laboratory and processed through the Laboratory's Sample Management Office. Groundwater analytical results and details of groundwater chemistry at R-37 are presented in Appendix C. Table 2.3-1 presents a summary of groundwater samples collected during drilling, well development, and aquifer testing at well R-37.

### 2.4 Geophysical Testing

In the first borehole on August 21, 2008, the Laboratory performed natural gamma logging of the open borehole from 822 to 972 ft. Schlumberger, Inc., was mobilized but was unable to get past 940 ft. Therefore, Schlumberger did not collect any borehole logs.

In the second borehole, no geophysical logging was conducted.

In the third borehole on May 26, 2009, the Laboratory performed natural gamma logging of the cased borehole to 1090 ft.

The results of the geophysical logging are included in Appendix D (on CD) and were used to further define lithologic contacts (Appendix B) and design the R-37 well.

## 3.0 FIELD INVESTIGATION RESULTS

### 3.1 Geology and Hydrogeology

A brief description of the geologic and hydrogeologic features encountered at R-37 is presented here. The Laboratory's geology task leader and site geologists examined cuttings and geophysical logs to determine geologic contacts. Drilling observations, video logging, water-level measurements, and geophysical logs were used to characterize the perched and regional groundwater encountered at R-37.

#### 3.1.1 Stratigraphy

The stratigraphy for the R-37 boreholes is presented in order of youngest to oldest geologic units, and depths listed are from the third borehole in which the well was installed. Lithologic descriptions are based on samples of discharged cuttings. Cuttings and borehole geophysical logs were used to identify geologic contacts. Figure 3.1-1 illustrates the stratigraphy of the first and third borehole at R-37. A detailed lithologic log is presented in Appendix B.

Slight variations in depths to geologic contacts and water levels were noted between boreholes 1 and 3. Where significant, differences are described in the following sections and illustrated in Figure 3.1-1. Because of their proximity, boreholes 1 and 2 were stratigraphically identical; therefore, borehole 2 is not shown in Figure 3.1-1.

### Unit 2, Tshirege Member of the Bandelier Tuff, Qbt 2 (0–52 ft bgs)

Unit 2 of the Tshirege Member of the Bandelier Tuff is present at R-37 from the surface to 52 ft bgs. Unit 2 is a reddish gray, devitrified, lithic-bearing, pumiceous, moderately welded and indurated ash-flow tuff. The reddish color is from minute oxidized mafic minerals, and the pumice lapilli are characteristically flattened.

### Unit 1v, Tshirege Member of the Bandelier Tuff, Qbt 1v (52–145 ft bgs)

Unit 1v of the Tshirege Member of the Bandelier Tuff is present at R-37 from 52 to 145 ft bgs. Unit 1v is a whitish gray, devitrified, lithic-bearing, pumiceous, nonwelded, non- to weakly indurated (soft) ash-flow tuff. From 5 to 15 ft above the lower contact (the vapor-phase notch), Qbt 1v is brownish gray, moderately indurated, and typically contains chocolate-colored pumice lapilli and a higher percentage of lithics (up to 5%).

### Unit 1g, Tshirege Member of the Bandelier Tuff, Qbt 1g (145–228 ft bgs)

Unit 1g of the Tshirege Member of the Bandelier Tuff is present at R-37 from 140 to 228 ft bgs. Unit 1g is a glassy, lithic-bearing, pumiceous, poorly welded ash-flow tuff. At its upper contact, the unit is reddish gray and moderately indurated and typically transitions within 10 to 20 ft to a light pinkish gray, weakly indurated ash-flow tuff. It contains reddish gray to gray, subangular to subrounded, intermediate composition volcanic rocks (lithics) up to 15 mm in diameter. Light olive-green vitric pumice lapilli have a waxy luster and well-developed flow-tube structure. The lapilli are harder than the surrounding tuff matrix.

### Tephra and Volcaniclastic Rocks of the Cerro Toledo Interval, Qct (228–231 ft bgs)

Tephra and volcaniclastic rocks of the Cerro Toledo interval are present at R-37 from 228 to 231 ft bgs. The Cerro Toledo interval consists of tuffaceous sedimentary deposits separating the Tshirege and Otowi Members of the Bandelier Tuff. The deposits are predominantly reworked tuff with some sands, gravels, and cobbles derived from the Tshicoma dacite in the Jemez Mountains west of the Pajarito Plateau.

### Otowi Member of the Bandelier Tuff, Qbo (231–490 ft bgs)

The Otowi Member of the Bandelier Tuff is present in R-37 from 231 to 490 ft bgs. The Otowi Member is a glassy, lithic-bearing, pumiceous, poorly welded ash-flow tuff. It contains reddish gray to gray, subangular to subrounded, intermediate composition volcanic rocks up to 15 mm in diameter. Vitric pale yellow to white pumice lapilli contain conspicuous phenocrysts of quartz and sanidine.

### Guaje Pumice Bed of the Otowi Member of the Bandelier Tuff, Qbog (490–501 ft bgs)

The Guaje Pumice Bed is present from 490 to 501 ft bgs. The pumice bed contains abundant pumice fragments (up to 97%) with subordinate amounts of volcanic lithics, quartz and sanidine phenocrysts, trace mafic minerals, and fine ash.

### Cerros del Rio Basalt, Tb4 (501–933 ft bgs)

Cerros del Rio basalt, from 501 to 993 ft bgs, consists of multiple lava flows of vesicular to massive aphanitic basalt with local scoria, cinder, and maar interbeds. Basalt is typically very hard and ranges from dark to medium gray, scoria is highly vesicular oxidized basalt, cinder typically has a frothy texture and is red to reddish gray, and maar deposits contain clay and other fine-grained lake-type deposits.

### Puye Formation Fanglomerate (Tpf) (933–1000 ft bgs)

Puye Formation fanglomerate, from 933 to 1000 ft bgs, consists of a sequence of fluvial and lacustrine sedimentary deposits. Clay-rich lacustrine deposits provide a perching horizon for groundwater at R-37.

#### Basaltic Gravel (933–950 ft bgs)

In the third borehole, well-rounded basaltic gravel and cobbles were present immediately below the basalt lava flows. The basaltic gravel in this borehole was 17 ft thick from 933 to 950 ft.

In the first borehole, basaltic gravel was also present below the basalt and was 5 ft thick from 920 to 925 ft. Upon encountering this subunit in the first borehole, significant perched groundwater (possibly up to 100 gpm) was ejected from the borehole.

#### Silt and Fine-Grained Gravel (950–956 ft bgs)

In the third borehole, silts, sands, and fine-grained gravel were present from 950 to 956 ft. This subunit was 6 ft thick.

In the first borehole, this subunit was up to 60 ft thick and consisted predominantly of silts and fine-grained sand. The sand consisted mostly of well-sorted quartz grains and also contained flakes of muscovite, a metamorphic mineral signifying a contribution from Precambrian rocks.

#### Claystone (956–991 ft bgs)

In the third borehole, claystone and shale were present in the cuttings below the silt and fine-grained gravel. The drill operator noted an increase in drilling pressure from 956 to 991 ft, typical of drilling in claylike material. The combination of these observations provided conclusive proof of the perching horizon at 956 ft and a 35-ft-thick aquiclude (956 to 991 ft).

In the first borehole, evidence of this subunit did not survive the drilling circulation and was not preserved in the cuttings. However, a perching horizon was suggested by the “drying up” of the borehole at 993 ft. To define this subunit, Schlumberger, Inc., attempted open borehole geophysical logging but was unable to get deeper than 940 ft.

#### Basaltic Scoria Gravel (991–1000 ft bgs)

In the third borehole, basaltic scoria gravel was present below the claystone from 991 to 1000 ft.

This subunit was not present in the first borehole, providing evidence of lateral heterogeny in the sedimentary deposits below the basaltic lava flows.

### Puye Formation Fanglomerate (1000–1100 ft bgs)

The Puye Formation fanglomerate is present from 1000 to 1100 ft bgs and consists predominantly of porphyritic dacitic gravels, cobbles, and boulders. Basaltic fragments are absent. This lithology is typical of the Puye Formation fanglomerate.

### 3.1.2 Groundwater

On August 20, 2008, groundwater was encountered in the first borehole upon exiting the base of the basaltic lava at 920 ft bgs. By the next day, the water level had risen 26.6 ft to 893.4 ft bgs, indicating that the basaltic lava was confining the groundwater. As drilling continued in fine sand and silt, significant groundwater—estimated at up to 100 gpm—was produced by the borehole. With the borehole at 980 ft, LWSP interpreted the groundwater as perched because the measured water levels (about 893.4 ft bgs) were more than 100 ft higher than water levels predicted, based on regional water-table maps. Once this interpretation was made, plans for a multiple completion well were initiated. Drilling resumed so that the lower screen in R-37 well could be installed in the regional aquifer, believed to be greater than 1000 ft deep. Water production ceased at 993 ft but gradually resumed as drilling proceeded.

The second borehole was terminated before reaching the depth of this perched groundwater.

In the third borehole, the perched water zone was not apparent because of injecting large amounts of municipal water to aid drilling. However, claystone cuttings from the third borehole documented the existence of a perching horizon. Additional evidence for a perching horizon was also obtained from drilling; an increase in drilling pressure from 956 to 991 ft indicated that the drill bit had entered and exited fine-grained claylike material.

On May 20, 2009, the third borehole and casing drilled past 1000 ft, the depth that LWSP had predicted to be the depth to regional aquifer saturation. With the borehole at 1060 ft, regional groundwater was measured at 1012 ft bgs using a DTW meter. Additional measurements collected after the borehole was cleaned and rested were 1011.8 and 1010.8 ft bgs (Table 3.1-1).

Before well construction, the DTW was measured at 1009.9 ft and 1009.8 ft bgs. During well construction, the DTW was measured at 1011.5 ft and 993.4 ft (Table 3.1-1). These measurements were composites of perched and regional groundwater.

Before development, the two zones were separated by a packer and isolated from each other over a weekend. On June 29, 2009, the DTW of the regional groundwater was measured through an open access tube (the pipe supporting the packer) at 1009.65 ft bgs (Table 3.1-2). The DTW of the perched groundwater was measured between the access tube and the well at 906.6 ft bgs (Table 3.1-3).

## 4.0 WELL INSTALLATION

### 4.1 Well Design

The R-37 well was designed in accordance with the Consent Order, and the well design was approved by NMED before installation. R-37 was designed as a multiple completion well using two screens; the lower screen (screen 2) was designed to monitor the regional groundwater. The upper screen (screen 1) was installed to monitor perched groundwater.

## 4.2 R-37 Well Construction

R-37 well installation activities were started on May 27, 2009, and completed on June 6, 2009. The Foremost DR-24 rig was used for all well construction activities.

The R-37 well was constructed of 5.0-in.-inside diameter (I.D.)/5.563-in.-outside diameter (O.D.) type A304 stainless-steel casing fabricated to American Society for Testing and Materials (ASTM) A312 standards. External couplings (also type A304 stainless steel fabricated to ASTM A312 standards) were used to connect individual casing and screen sections. The casing and screens were factory-cleaned and steam-cleaned on-site before installation.

R-37 screen 1 was designed from 930 to 950 ft bgs and was positioned from 929.3 to 950.0 ft bgs. Screen 1 consisted of two 10-ft sections of 5.0-in.-I.D. rod-based 0.020-in. wire-wrapped screen slots. The coupled union between the threaded sections was 0.7 ft long. The bottom of screen 1 at 950.0 ft bgs was the anchor point for well construction and matched the design target; however, the top depth was slightly above the target depth due to the threaded connection between the screen sections.

R-37 screen 2 was designed from 1025 to 1045 ft bgs and was positioned from 1026.0 to 1046.6 ft bgs. Screen 2 consisted of two 10-ft sections of 5.0-in.-I.D. rod-based 0.020-in. wire-wrapped screen slots. The coupled union between threaded sections was 0.7 ft long. The bottom of screen 2 at 1046.6 ft bgs was 1.6 ft lower than the design target, and the top depth of screen 2 was 0.9 ft below the design target. The discrepancies from the designed depths were the result of casing make-up and landing the well in order to hit the anchor point. A 22.1-ft stainless-steel sump with bottom cap was placed below screen 2.

The well was assembled from the bottom up and lowered into the borehole. The bottom of the sump was positioned at 1068.8 ft bgs. Figure 4.2-1 presents an as-built schematic showing construction details for the completed well.

After the well casing was assembled and lowered into the borehole, the process of installing annular backfill materials was started. A 2.0-in.-I.D. steel tremie pipe was used to deliver the annular backfill materials under pressure; the materials were mixed with municipal water and pumped through the tremie pipe. To document that the annular materials settled to the proper position, the depth of the annular material was repeatedly measured using a depth-to-bottom tagger and recorded. As the backfilling process progressed, the tremie pipe and 12-in. casing were withdrawn from the well.

Figure 4.2-1 also illustrates the types, depths, calculated volumes, and actual volumes of annular materials used in relation to the R-37 well screens. As the sand filter pack was installed around screen 2, over two times the calculated volume was required to fill the borehole annulus in the Puye Formation (compare Figures 3.1-1 and 4.2-1). For screen 1, almost three times the calculated volume of sand filter pack was required to fill fractures and voids in the basalt. During annular material installation, the screened intervals were mechanically surged to settle the sand filter packs before installing subsequent bentonite seal above.

After filter pack material had been installed around R-37 screens 2 and 1 and a 10-ft bentonite seal was installed and hydrated above screen 1, the bentonite chip seal was brought up to 584 ft bgs as the 12-in. casing was withdrawn in 40-ft increments. The remaining 12-in. casing was removed, and the 16-in. casing (at 565 ft) was backfilled with bentonite chips to 60 ft. The outside of the 16-in. casing had sealed itself with drill cuttings during drilling. As the 24-in. surface casing was removed, cement containing IDP 381 additive was poured from the surface to 20 ft outside the 16-in. casing and from the surface to 60 ft inside the 16-in. casing.

# 5.0 WELL COMPLETION

## 5.1 Well Development

The R-37 screens were developed by mechanical means, including swabbing, bailing, and pumping. Target water-quality parameters were turbidity <5 nephelometric turbidity units (NTUs), TOC <2 ppm, and other parameters stable. A Pulstar 1200 work-over rig was used for all well development activities.

Development activities were started at screen 2 and finished at screen 1.

### 5.1.1 R-37 Screen 2

Development of screen 2 was conducted between June 10 and June 18, 2009. First, the well sump was bailed using a bailer fitted with a mechanical suction device to remove silt and sand accumulated in the sump. Next, the screen was swabbed to mobilize formation fines settled in the sand filter pack. The swabbing tool was a 5.0-in.-O.D. 1-in.-thick nylon disc attached to a steel rod, lowered by wireline and drawn repeatedly across the screened interval. Then the bailer was used to remove groundwater until the recovered water was clear.

After swabbing and bailing, a 5.0-hp, 4-in.-O.D. Grundfos submersible pump was lowered into the well to continue well development. During well development pumping, water levels were measured to ensure that the pumping did not draw down the water column in the well and expose the pump. This also helped establish a preliminary flow rate of approximately 12 gpm for screen 2. Table 3.1-2 lists water levels measured in screen 2 during development.

Also during well development pumping, groundwater was sampled and measured on-site for pH, specific conductivity, temperature, turbidity, dissolved oxygen, and salinity. The instrument used for groundwater measurements was a Horiba Water Quality Checker Model U-10. Additional groundwater samples were collected for TOC analysis. The field parameter measurements for screen 2 are tabulated in Table C-1.2-1 in Appendix C.

At the conclusion of the development pumping of screen 2, the measured water-quality parameters were turbidity at 4 NTUs and TOC at 0.7 mg/L. Both development parameters were below the respective development targets (5 NTUs and 2 mg/L).

### 5.1.2 R-37 Screen 2 Aquifer Testing

On June 18, 2009, well development pumping was halted and preparation began for aquifer testing by David Schafer and Associates. To perform the aquifer testing, an inflatable packer was positioned above a 5-hp Grundfos submersible pump and deployed into the well. Simultaneously, nonvented In-Situ Level Troll 700 transducers were positioned below the pump and above the packer. The packer was inflated to isolate screen 2 from screen 1 and minimize the effects of casing storage on the test data. Short-duration pumping tests were conducted on June 20, 2009, and a 24-h aquifer pumping test was conducted between June 21 and 22, 2009. The transducers remained in the well, collecting aquifer recovery data until they were removed on June 25, 2009. Results of the aquifer tests are described in Appendix E.

At the conclusion of the 24-h aquifer test, the turbidity had dropped to 1 NTU and the total volume of regional groundwater removed from screen 2 was 33,437.6 gal. (See Table C-1.2-1 in Appendix C).

### 5.1.3 R-37 Screen 1

As preparation for development of screen 1, a TAM packer was deployed and positioned in the well above screen 2. Municipal water under pressure was used to inflate the packer that was set from 996 to 1008 ft. The delivery pipe was detached from the TAM packer and removed from the well.

Development of screen 1 was initiated on June 30, 2009. Like screen 2, screen 1 was bailed using a bailer fitted with a mechanical suction device to remove silt and sand accumulated in the artificial sump created by the TAM packer. Next, the screen was swabbed to mobilize formation fines settled in the sand filter pack. The swabbing tool was a 5.0-in.-O.D. 1-in.-thick nylon disc attached to a steel rod, lowered by wireline, and drawn repeatedly across the screened interval. The bailer was then used to remove groundwater until the recovered water was clear.

After swabbing and bailing, a 1.5-hp, 4-in.-O.D. Grundfos submersible pump was lowered into the well to continue well development. During well development pumping, water levels were measured to ensure that the pumping did not draw down the water column in the well and expose the pump. This also helped establish a preliminary flow rate of approximately 1 gpm for screen 1. Table 3.1-3 lists water levels measured in screen 1 during development.

Also during well development pumping of screen 1, the perched groundwater was sampled and measured on-site for pH, specific conductivity, temperature, turbidity, dissolved oxygen, and salinity. The instrument used for groundwater measurements was a Horiba Water Quality Checker Model U-10. Also some groundwater samples were collected for TOC analysis. The field parameter measurements for screen 1 are tabulated in Table 5.1.-1 and included in Appendix C as Table C-1.2-1.

A curious phenomenon was observed while conducting the development pumping of screen 1. Initial TOC results were below the threshold and turbidity values and had stabilized at 0 or 1 NTU (Table 5.1-1). These results did not reflect the large amount of foam used to drill the borehole in the screen 1 interval and were actually representative of the upper portion of the screened interval. During pumping when the decreasing water level reached midscreen (approximately 940 ft bgs), the turbidity and TOC values rose above the thresholds. However, before the result of the July 7, 2009, TOC sample was received (4 ppm, Table 5.1-1), the decision had been reached to proceed with a 24-h pumping test.

### 5.1.4 R-37 Screen 1 Aquifer Testing

On June 9, 2009, well-development pumping of R-37 screen 1 was halted, and preparation began for aquifer testing by David Schafer and Associates. To perform the aquifer testing in R-37 screen 1, a nonvented In-Situ Level Troll 700 transducer was positioned below the pump. Short-duration pumping tests were conducted on June 10, 2009, and a 24-h aquifer pumping test was conducted between June 12 and 13, 2009. The transducer remained in the well collecting aquifer recovery data until it was removed on June 15 2009. Results of the aquifer tests are described in Appendix E.

At the end of the aquifer pumping testing in R-37 screen 1, water-quality parameters were turbidity at 3 NTUs and TOC at 4 mg/L. The turbidity was below the development threshold of 5 NTUs, but TOC was above the development threshold of 2 ppm (mg/L).

## 5.2 Continued Development Pumping

In August 2009, development pumping of screen 1 continued in order to meet the target well-development parameter for TOC. The top of the TAM packer remained at 996 ft bgs between screens 1 and 2. A Laboratory-owned Bennett pump was deployed and pumped starting on August 21 and continuing through September 1, 2009. At the conclusion of the development, the measured water-quality parameters were turbidity at 4 NTUs and 0.5 ppm TOC. Both development parameters were below the respective development targets (5 NTUs and 2 mg/L). At the conclusion of development pumping of screen 1, the total volume of perched groundwater removed was approximately 7010 gal. (Table 5.1-1).

### 5.3 Dedicated Sampling System Installation

In September 2009, a dedicated Baski dual completion sampling system and transducers will be installed for sampling and monitoring R-37 screens 1 and 2. The Baski system relies on a permanent packer and liquid inflation chamber to separate groundwater in screens 1 and 2. Details of the dedicated sampling system designed for R-37 are presented in Figure 5.3-1.

For screen 2, a 4.0-in.-O.D. Grundfos pump and 2-hp electric motor will be deployed into the well on a type A304 grade stainless-steel 1.0-in.-I.D. discharge pipe. The intake for the Grundfos pump will be set at 1053 ft bgs. For screen 1, a 1.8-in.-O.D. Bennett pump and associated air tubes (supply and exhaust), water-level indicator, and discharge tube will be used for sample collection. The intake for the Bennett pump will be set at 962 ft bgs. Simultaneously, two 1.0-in.-I.D. flush-threaded schedule 40 polyvinyl chloride pipes will be installed for a dedicated In-Situ Level Troll 500 vented transducer in each screened interval**.** For passing through the Baski packer and liquid inflation chamber, the screen 2 transducer access tube will be constructed of 1.0-in. type A304 grade stainless-steel pipe and adapters. The transducers must be removed to conduct manual water-level measurements.

For the R-37 well, the sampling system discharge pipes and the transducer tubes will rest on a 1-in. thick 6-in.-diameter stainless-steel landing plate positioned atop the stainless-steel well riser. Details of the dedicated sampling system installed in R-37 are presented in Figures 5.3-1 and 5.3-2.

### 5.4 Wellhead Completion

On July 24, 2009, a surface pad consisting of 4000-psi reinforced concrete, 10 ft × 10 ft × 6 in. thick, was installed at the R-37 wellhead. A 16-in.-I.D. steel protective casing with a locking lid was positioned over the stainless-steel well riser and cemented into the pad. In addition, four removable 4-in. steel bollards were installed around the pad. The pad and bollards will provide long-term structural integrity for the wellhead. A brass survey monument displaying the well name and elevation was embedded in the northwest corner of the pad. The concrete pad was slightly elevated above the ground surface and crowned to promote runoff.

A permanent electric starter box with a connection for three-phase, 480-V portable generator power for the Gundfos pump, will be mounted by the Laboratory on the pad adjacent to the protective casing. The Laboratory will connect the starter box and the power cables to the dedicated pumps in the well. During site restoration, base-coarse gravel will be graded around the edges of the pad. Details of the wellhead completion are presented in Figure 5.3-2.

### 5.5 Geodetic Survey

On July 30, 2009, geodetic survey data for the center of the well, 16-in. protective casing, brass monument, and ground surface at R-37 were collected by Precision Surveying, Inc. The survey data are presented in Table 5.5-1. Geodetic surveys were conducted using a Topcon Hiper+ global positioning system and Wild Heerbrugg NA1 level. The survey data were collected by a New Mexico licensed surveyor and conform to Laboratory Information Architecture project standards IA-CB02, “GIS Horizontal Spatial Reference System,” and IA-D802, “Geospatial Positioning Accuracy Standard for A/E/C and

Facility Management." All coordinates are expressed as New Mexico State Plane Coordinate System Central Zone (NAD 83); elevation is expressed in feet above mean sea level using the National Geodetic Vertical Datum of 1929.

## 5.6 Waste Management and Site Restoration

Wastes produced during drilling were managed in accordance with the "Waste Characterization Strategy Form for Drilling and Installation of Wells at TA-54 R-37, R-39, and R-40" (EP2008-0306). Wastes generated at the R-37 project include a small quantity of contact waste, drill cuttings, discharged drilling water, development groundwater, and New Mexico special waste (NMSW), consisting of base-coarse gravel and hydraulic oil. After the completion of drilling, waste characterization samples were collected from cuttings and drilling water in the lined retention pit, and drilling and development water was sampled in aboveground storage tanks during well development. A summary of waste characterization samples collected from the R-37 well is presented in Table 5.6-1.

On May 14, 2009, some of the dry drill cuttings were land-applied in accordance with the Land Application of Drill Cutting procedure (ENV-RCRA-QP-011.1). Final disposition is ongoing on the rest of the dry drill cuttings, the wet drill cuttings, and drilling and development water. If approved, liquid wastes will be land applied in accordance with the land application of groundwater procedure (ENV-RCRA-QP-010.1) http://www.lanl.gov/environment/all/qa/adep.shtml.

Site restoration activities will include removing drilling fluids from the pit, removing the polyethylene liner, removing the containment area berms, backfilling and regrading the containment area, as appropriate. The site will be reseeded with a Laboratory-approved seed mix consisting of Indian rice grass, mountain broam, blue stem, sand drop, and slender wheat grass seed.

# 6.0 DEVIATIONS FROM PLANNED ACTIVITIES

In general, drilling, sampling, and well construction at R-37 were performed as specified in the "Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54" (LANL 2007, 099662) and LANS subcontract 22851-009-08, Exhibit D "Scope of Work and Technical Specifications—Drilling and Installation of Wells at TA-54."

The following changes to the original work plan were implemented after approval by LWSP.

- Well Completion: R-37 was initially designed as a single completion well. However, the discovery of perched groundwater required the installation of a multiple screened well.

# 7.0 ACKNOWLEDGMENTS

WDC Exploration & Wells drilled and installed the R-37 regional aquifer monitoring well.

Patrick Longmire wrote Appendix C, Groundwater Analytical Results.

David Schafer wrote Appendix E, Aquifer Testing Report.

LATA-SHARP Remediation Service, LLC, provided oversight on all preparatory and field-related activities.

## 8.0 REFERENCES AND MAP DATA SOURCES

### 8.1 References

*The following list includes all documents cited in this report. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's RPF and are used to locate the document at the RPF and, where applicable, in the master reference set.*

*Copies of the master reference set are maintained at the NMED Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.*

LANL (Los Alamos National Laboratory), October 2007. "Technical Area 54 Well Evaluation and Network Recommendations, Revision 1," Los Alamos National Laboratory document LA-UR-07-6436, Los Alamos, New Mexico. (LANL 2007, 098548)

LANL (Los Alamos National Laboratory), November 2007. "Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54," Los Alamos National Laboratory document LA-UR-07-7578, Los Alamos, New Mexico. (LANL 2007, 099662)

NMED (New Mexico Environment Department), December 7, 2007. "Approval with Direction, Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54," New Mexico Environment Department letter to D. Gregory (DOE-LASO) and D. McInroy (LANL) from J.P. Bearzi (NMED-HWB), Santa Fe, New Mexico. (NMED 2007, 099257)

### 8.2 Map Data Sources

Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 15 October 2008. Dirt road to Regional Well R-37; Jon Marin, Los Alamos Technical Associates, Los Alamos, NM, July 2008.

Groundwater Monitoring Locations; David Rogers, Los Alamos National Laboratory, Environmental Data & Analysis Group, GIS Project File PMR07007, unpublished data, April 2007.

Hypsography, 100-, 20- & 10-Foot Contour Intervals; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program; 1991.

Location for Reigional Aquifer Well R-37; Jon Marin, Los Alamos Technical Associates, Los Alamos, NM, July 2008.

Ownership Boundaries Around LANL Area; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; June 4, 2008.

Paved Parking; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; August 12, 2002; as published 15 October 15, 2008.

Paved Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; January 6, 2004; as published October 15, 2008.

Potential Release Sites; Los Alamos National Laboratory, Waste & Environmental Services Division, Environmental Data and Analysis Group, EP2008-0623; 1:2,500 Scale Data; December 10, 2008

Primary Landscape Features; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; January 6, 2004; as published October 15, 2008.

Road Centerlines; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; December 15, 2005; as published October 15, 2008.

Security and Industrial Fences and Gates; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; January 6, 2004; as published October 15, 2008.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; January 6, 2004; as published October 15, 2008.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; June 4, 2008.

WQH Drainage_arc; Los Alamos National Laboratory, ENV Water Quality and Hydrology Group; 1:24,000 Scale Data; June 3, 2003.

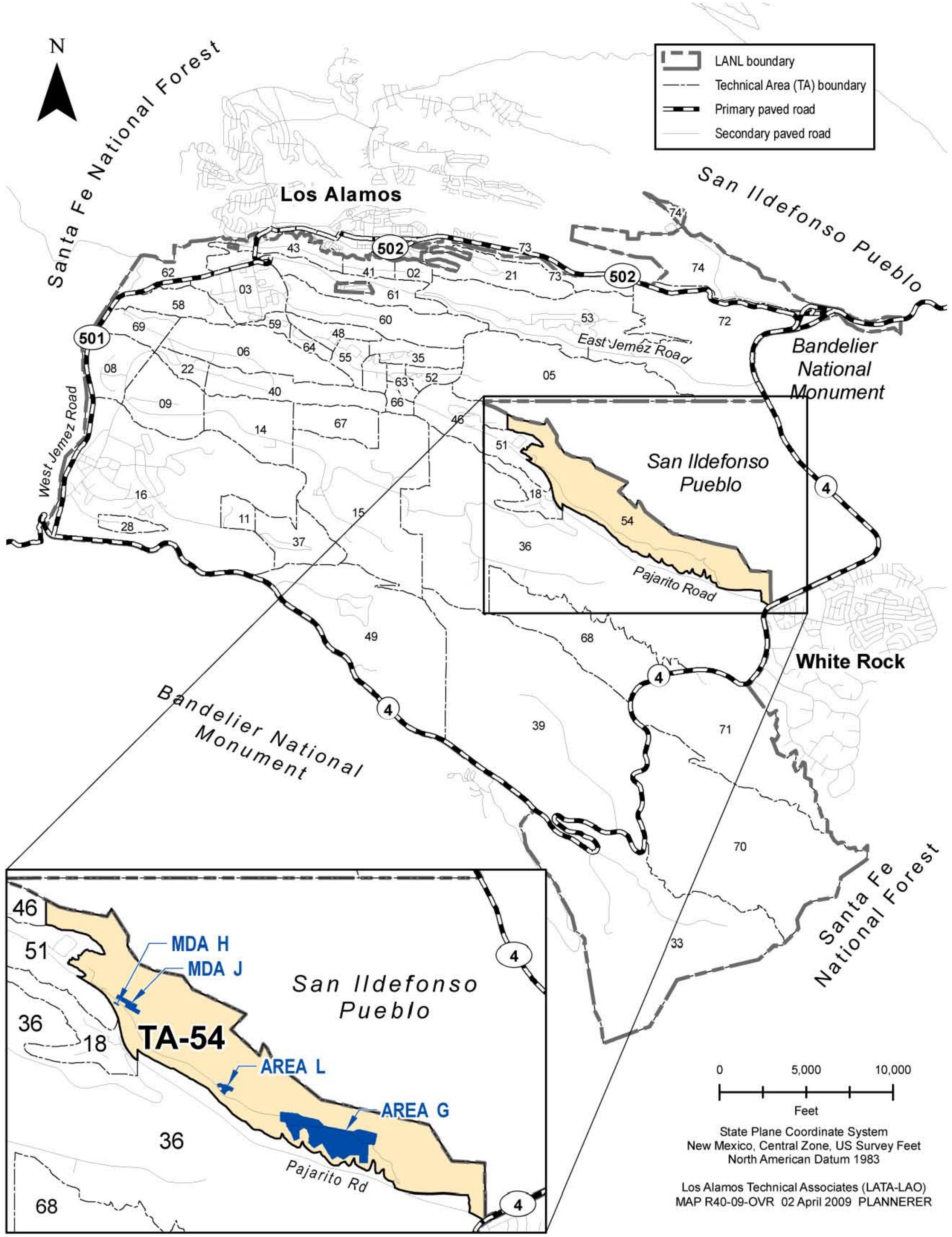


Figure 1.0-1 MDAs at TA-54 with respect to Laboratory technical areas and surrounding land holdings

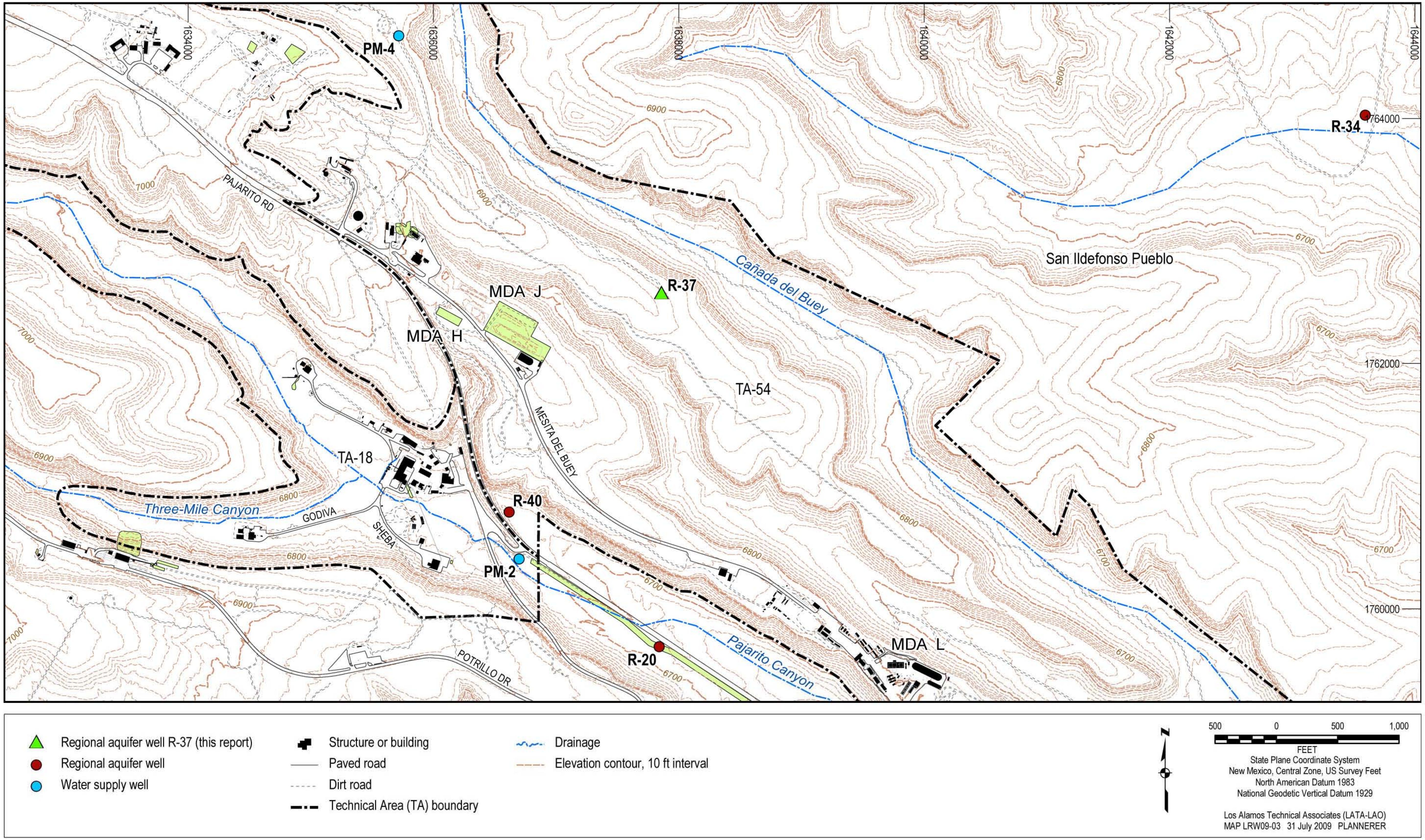
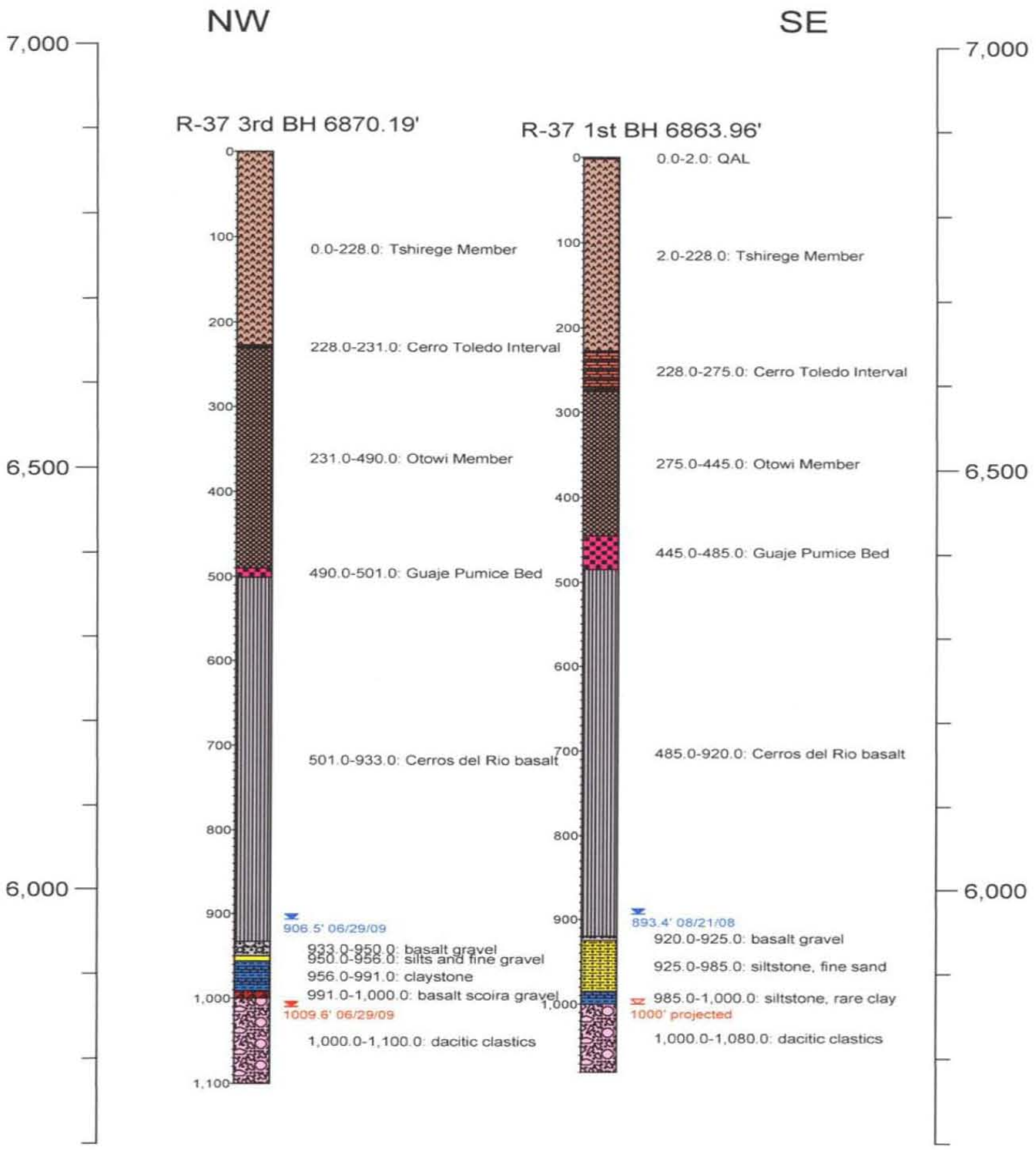


**Figure 1.0-2** Regional aquifer well R-37



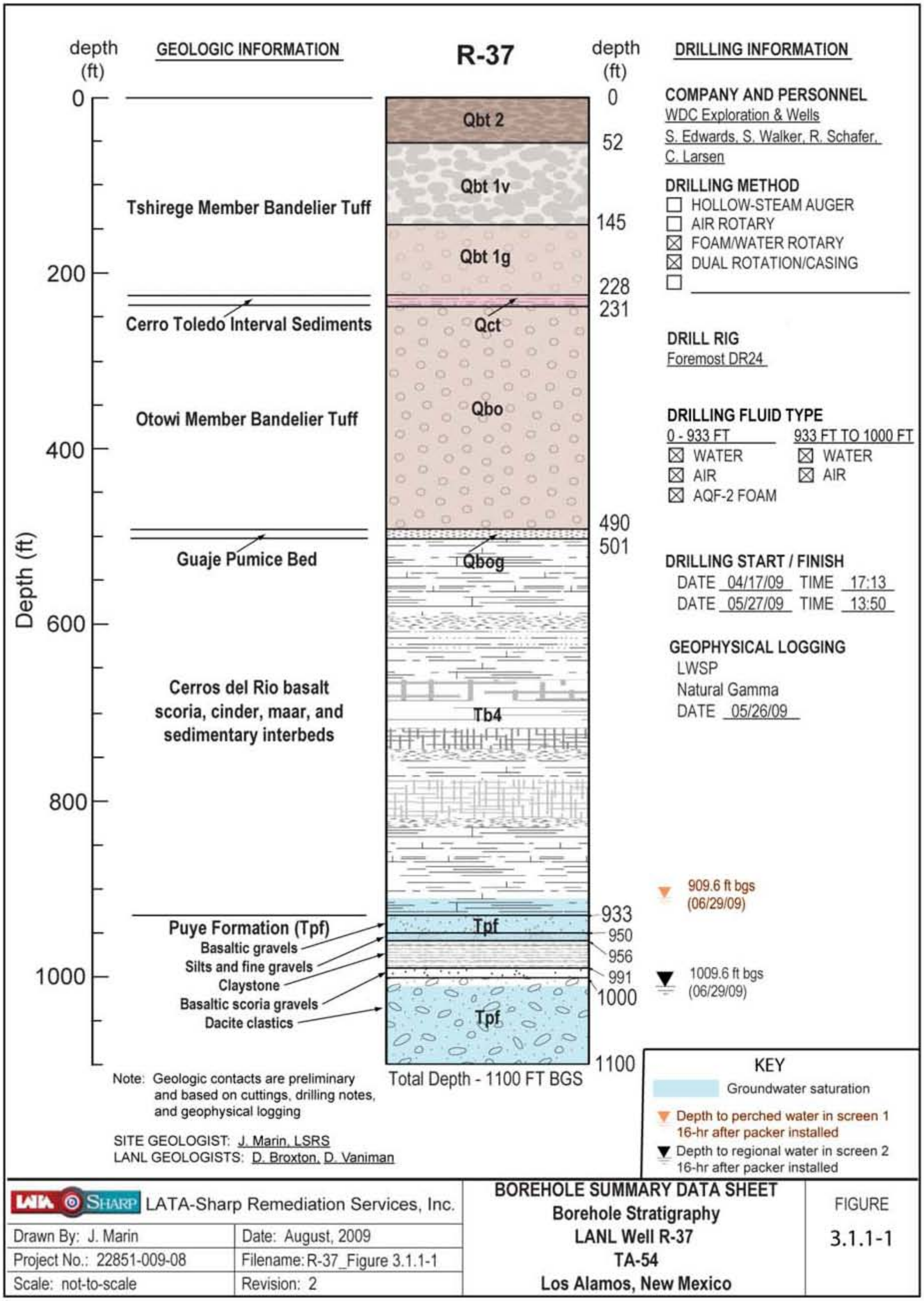
LATA-Sharp Remediation Services, Inc.

Drawn By: J. Marin
Date: August, 2009
Project No.: 22851-009-08
Filename: R-37_Figure 3.1.1-2
Scale: not-to-scale
Revision: 0

**Stratigraphy and Water Levels in Boreholes 1 and 3**
**LANL Well R-37, TA-54**
**Los Alamos, New Mexico**

FIGURE
3.1.1-2

**Figure 2.2-1 Stratigraphy and water levels in boreholes 1 and 3**



Note: Geologic contacts are preliminary and based on cuttings, drilling notes, and geophysical logging

SITE GEOLOGIST: J. Marin, LSRS
LANL GEOLOGISTS: D. Broxton, D. Vaniman

**DRILLING INFORMATION**

**COMPANY AND PERSONNEL**
WDC Exploration & Wells
S. Edwards, S. Walker, R. Schafer, C. Larsen

**DRILLING METHOD**
☐ HOLLOW-STEAM AUGER
☐ AIR ROTARY
☒ FOAM/WATER ROTARY
☒ DUAL ROTATION/CASING
☐ ______________

**DRILL RIG**
Foremost DR24

**DRILLING FLUID TYPE**

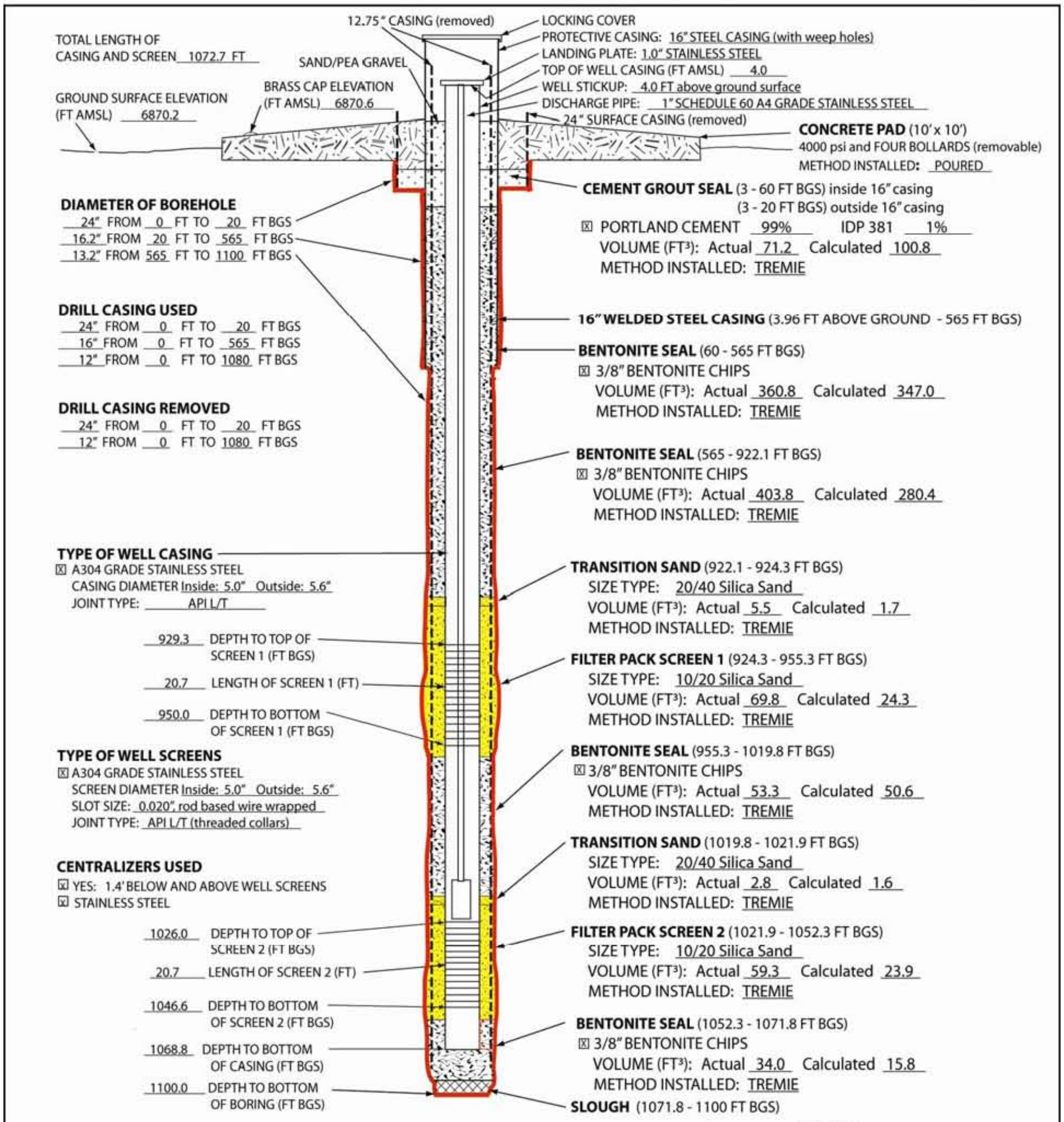
| 0 - 933 FT | 933 FT TO 1000 FT |
|---|---|
| ☒ WATER | ☒ WATER |
| ☒ AIR | ☒ AIR |
| ☒ AQF-2 FOAM | |

**DRILLING START / FINISH**
DATE 04/17/09 TIME 17:13
DATE 05/27/09 TIME 13:50

**GEOPHYSICAL LOGGING**
LWSP
Natural Gamma
DATE 05/26/09

| | | | |
|---|---|---|---|
| LATA-Sharp Remediation Services, Inc. | | BOREHOLE SUMMARY DATA SHEET<br>Borehole Stratigraphy<br>LANL Well R-37<br>TA-54<br>Los Alamos, New Mexico | FIGURE<br>3.1.1-1 |
| Drawn By: J. Marin | Date: August, 2009 | | |
| Project No.: 22851-009-08 | Filename: R-37_Figure 3.1.1-1 | | |
| Scale: not-to-scale | Revision: 2 | | |

**Figure 3.1-1 R-37 borehole summary data sheet**



TOTAL LENGTH OF CASING AND SCREEN 1072.7 FT

GROUND SURFACE ELEVATION (FT AMSL) 6870.2

BRASS CAP ELEVATION (FT AMSL) 6870.6

PROTECTIVE CASING: 16" STEEL CASING (with weep holes)
LANDING PLATE: 1.0" STAINLESS STEEL
TOP OF WELL CASING (FT AMSL) 4.0
WELL STICKUP: 4.0 FT above ground surface
DISCHARGE PIPE: 1" SCHEDULE 60 A4 GRADE STAINLESS STEEL

**CONCRETE PAD** (10' x 10')
4000 psi and FOUR BOLLARDS (removable)
METHOD INSTALLED: POURED

**DIAMETER OF BOREHOLE**
24" FROM 0 FT TO 20 FT BGS
16.2" FROM 20 FT TO 565 FT BGS
13.2" FROM 565 FT TO 1100 FT BGS

**CEMENT GROUT SEAL** (3 - 60 FT BGS) inside 16" casing
(3 - 20 FT BGS) outside 16" casing
☒ PORTLAND CEMENT 99% IDP 381 1%
VOLUME (FT³): Actual 71.2 Calculated 100.8
METHOD INSTALLED: TREMIE

**DRILL CASING USED**
24" FROM 0 FT TO 20 FT BGS
16" FROM 0 FT TO 565 FT BGS
12" FROM 0 FT TO 1080 FT BGS

**16" WELDED STEEL CASING** (3.96 FT ABOVE GROUND - 565 FT BGS)

**BENTONITE SEAL** (60 - 565 FT BGS)
☒ 3/8" BENTONITE CHIPS
VOLUME (FT³): Actual 360.8 Calculated 347.0
METHOD INSTALLED: TREMIE

**DRILL CASING REMOVED**
24" FROM 0 FT TO 20 FT BGS
12" FROM 0 FT TO 1080 FT BGS

**BENTONITE SEAL** (565 - 922.1 FT BGS)
☒ 3/8" BENTONITE CHIPS
VOLUME (FT³): Actual 403.8 Calculated 280.4
METHOD INSTALLED: TREMIE

**TYPE OF WELL CASING**
☒ A304 GRADE STAINLESS STEEL
CASING DIAMETER Inside: 5.0" Outside: 5.6"
JOINT TYPE: API L/T

**TRANSITION SAND** (922.1 - 924.3 FT BGS)
SIZE TYPE: 20/40 Silica Sand
VOLUME (FT³): Actual 5.5 Calculated 1.7
METHOD INSTALLED: TREMIE

929.3 DEPTH TO TOP OF SCREEN 1 (FT BGS)

20.7 LENGTH OF SCREEN 1 (FT)

950.0 DEPTH TO BOTTOM OF SCREEN 1 (FT BGS)

**FILTER PACK SCREEN 1** (924.3 - 955.3 FT BGS)
SIZE TYPE: 10/20 Silica Sand
VOLUME (FT³): Actual 69.8 Calculated 24.3
METHOD INSTALLED: TREMIE

**TYPE OF WELL SCREENS**
☒ A304 GRADE STAINLESS STEEL
SCREEN DIAMETER Inside: 5.0" Outside: 5.6"
SLOT SIZE: 0.020", rod based wire wrapped
JOINT TYPE: API L/T (threaded collars)

**BENTONITE SEAL** (955.3 - 1019.8 FT BGS)
☒ 3/8" BENTONITE CHIPS
VOLUME (FT³): Actual 53.3 Calculated 50.6
METHOD INSTALLED: TREMIE

**CENTRALIZERS USED**
☒ YES: 1.4' BELOW AND ABOVE WELL SCREENS
☒ STAINLESS STEEL

**TRANSITION SAND** (1019.8 - 1021.9 FT BGS)
SIZE TYPE: 20/40 Silica Sand
VOLUME (FT³): Actual 2.8 Calculated 1.6
METHOD INSTALLED: TREMIE

1026.0 DEPTH TO TOP OF SCREEN 2 (FT BGS)

20.7 LENGTH OF SCREEN 2 (FT)

1046.6 DEPTH TO BOTTOM OF SCREEN 2 (FT BGS)

**FILTER PACK SCREEN 2** (1021.9 - 1052.3 FT BGS)
SIZE TYPE: 10/20 Silica Sand
VOLUME (FT³): Actual 59.3 Calculated 23.9
METHOD INSTALLED: TREMIE

1068.8 DEPTH TO BOTTOM OF CASING (FT BGS)

1100.0 DEPTH TO BOTTOM OF BORING (FT BGS)

**BENTONITE SEAL** (1052.3 - 1071.8 FT BGS)
☒ 3/8" BENTONITE CHIPS
VOLUME (FT³): Actual 34.0 Calculated 15.8
METHOD INSTALLED: TREMIE

**SLOUGH** (1071.8 - 1100 FT BGS)

**WELL INSTALLATION**
START: 05/27/09 END: 05/28/09

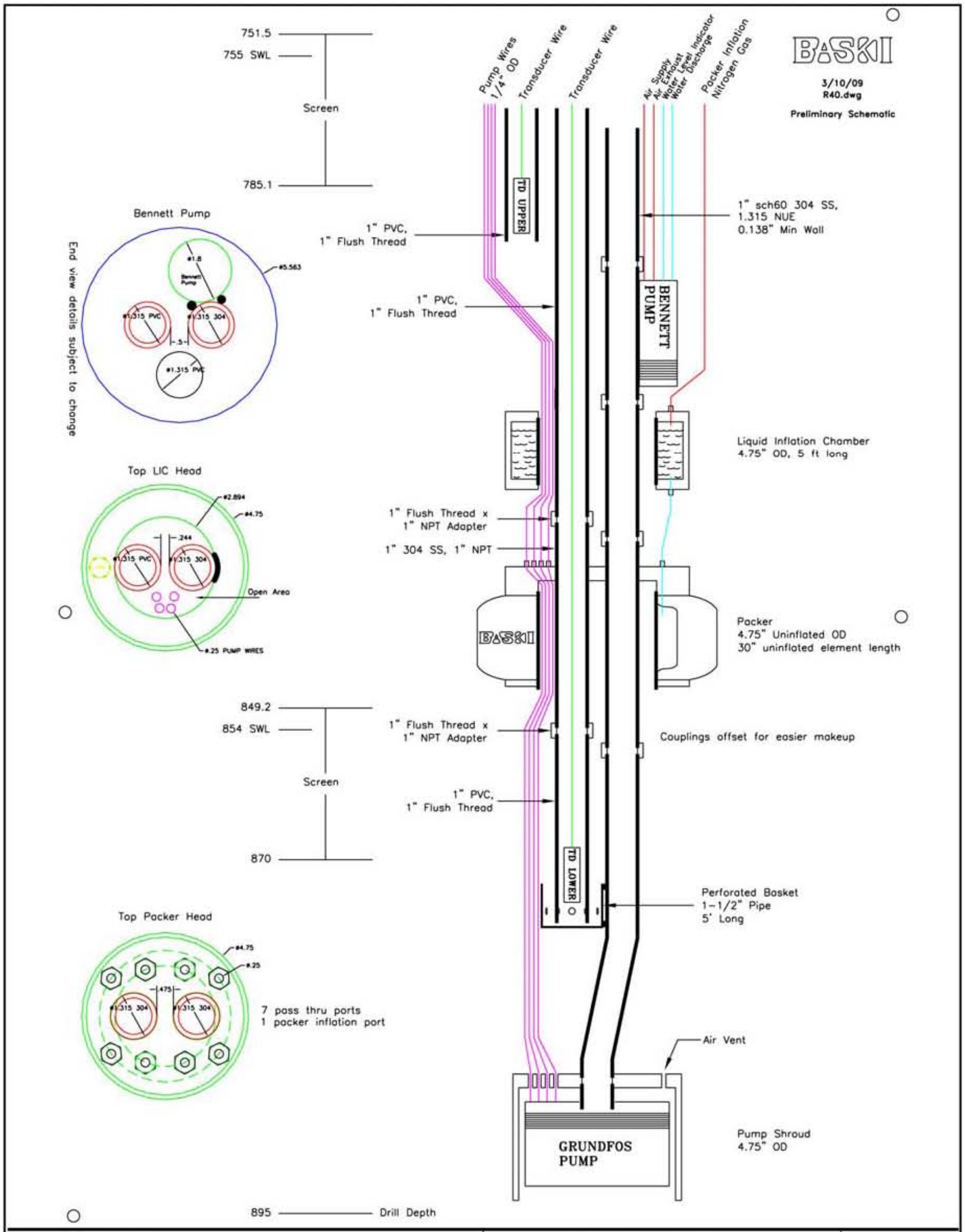
**WELL BACKFILL**
START: 05/29/09 END: 06/06/09

**SCREEN 2**
**DEVELOPED:** FROM 06/10/09 TO 06/17/09
**METHODS:** swabbing, bailing, pumping
**24-hr AQUIFER TEST:** 06/21/09 - 06/22/09
**AVERAGE FLOW RATE:** 12.5 gpm
**TOTAL VOLUME PURGED:** 33437.6 gallons
**FINAL TURBIDITY:** 1 NTU
**FINAL TOC:** 0.7 ppm
**SAMPLING SYSTEM:** BASKI

**SCREEN 1**
**DEVELOPED:** FROM 06/30/09 TO TBD
**METHODS:** swabbing, bailing, pumping
**24-hr AQUIFER TEST:** 07/12/09 - 07/13/09
**AVERAGE FLOW RATE:** 0.8 gpm
**TOTAL VOLUME PURGED:** TBD
**FINAL TURBIDITY:** TBD
**FINAL PARAMETERS:** TBD
**SAMPLING SYSTEM:** Bennett

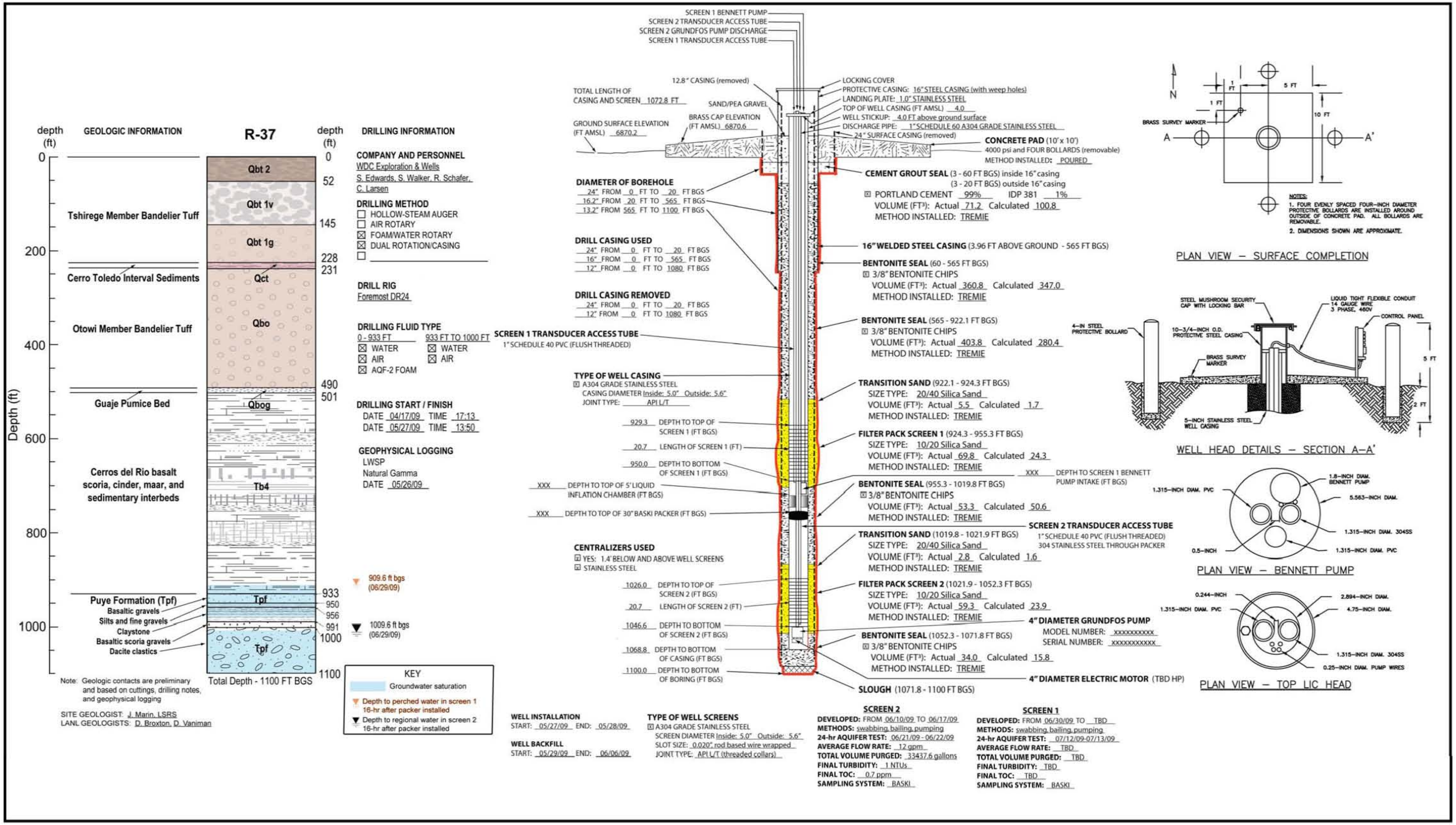
| | | | |
|---|---|---|---|
| LATA-Sharp Remediation Services, Inc. | | **AS-BUILT WELL CONSTRUCTION DIAGRAM**<br>**LANL Well R-37**<br>**TA-54**<br>**Los Alamos, New Mexico** | FIGURE<br>4.2-1 |
| Drawn By: J. Marin | Date: August, 2009 | | |
| Project No.: 22851-009-08 | Filename: R-37_Figure 4.2-1 | | |
| Scale: not-to-scale | Revision: 3 | | |

**Figure 4.2-1 As-built well construction diagram**



| | | | |
|---|---|---|---|
| LATA-Sharp Remediation Services, Inc. | | BASKI Sampling System<br>LANL Well R-37<br>TA-54<br>Los Alamos, New Mexico | FIGURE<br>5.3-1 |
| Drawn By: BASKI | Date: August, 2009 | | |
| Project No.: 22851-009-08 | Filename: R-37_Figure 5.3-1 | | |
| Scale: not-to-scale | Revision: 0 | | |

**Figure 5.3-1 As-built completion schematic for regional aquifer well R-37**



Note: Geologic contacts are preliminary and based on cuttings, drilling notes, and geophysical logging

SITE GEOLOGIST: J. Marin, LSRS
LANL GEOLOGISTS: D. Broxton, D. Vaniman

**DRILLING INFORMATION**

**COMPANY AND PERSONNEL**
WDC Exploration & Wells
S. Edwards, S. Walker, R. Schafer, C. Larsen

**DRILLING METHOD**
☐ HOLLOW-STEAM AUGER
☐ AIR ROTARY
☒ FOAM/WATER ROTARY
☒ DUAL ROTATION/CASING
☐ ____

**DRILL RIG**
Foremost DR24

**DRILLING FLUID TYPE**
0 - 933 FT: ☒ WATER ☒ AIR ☒ AQF-2 FOAM
933 FT TO 1000 FT: ☒ WATER ☒ AIR

**DRILLING START / FINISH**
DATE 04/17/09 TIME 17:13
DATE 05/27/09 TIME 13:50

**GEOPHYSICAL LOGGING**
LWSP
Natural Gamma
DATE 05/26/09

TOTAL LENGTH OF CASING AND SCREEN 1072.8 FT
GROUND SURFACE ELEVATION (FT AMSL) 6870.2
BRASS CAP ELEVATION (FT AMSL) 6870.6

**DIAMETER OF BOREHOLE**
24" FROM 0 FT TO 20 FT BGS
16.2" FROM 20 FT TO 565 FT BGS
13.2" FROM 565 FT TO 1100 FT BGS

**DRILL CASING USED**
24" FROM 0 FT TO 20 FT BGS
16" FROM 0 FT TO 565 FT BGS
12" FROM 0 FT TO 1080 FT BGS

**DRILL CASING REMOVED**
24" FROM 0 FT TO 20 FT BGS
12" FROM 0 FT TO 1080 FT BGS

**SCREEN 1 TRANSDUCER ACCESS TUBE**
1" SCHEDULE 40 PVC (FLUSH THREADED)

**TYPE OF WELL CASING**
☒ A304 GRADE STAINLESS STEEL
CASING DIAMETER Inside: 5.0" Outside: 5.6"
JOINT TYPE: API L/T

929.3 DEPTH TO TOP OF SCREEN 1 (FT BGS)
20.7 LENGTH OF SCREEN 1 (FT)
950.0 DEPTH TO BOTTOM OF SCREEN 1 (FT BGS)
XXX DEPTH TO TOP OF 5' LIQUID INFLATION CHAMBER (FT BGS)
XXX DEPTH TO TOP OF 30" BASKI PACKER (FT BGS)

**CENTRALIZERS USED**
☒ YES: 1.4' BELOW AND ABOVE WELL SCREENS
☒ STAINLESS STEEL

1026.0 DEPTH TO TOP OF SCREEN 2 (FT BGS)
20.7 LENGTH OF SCREEN 2 (FT)
1046.6 DEPTH TO BOTTOM OF SCREEN 2 (FT BGS)
1068.8 DEPTH TO BOTTOM OF CASING (FT BGS)
1100.0 DEPTH TO BOTTOM OF BORING (FT BGS)

PROTECTIVE CASING: 16" STEEL CASING (with weep holes)
LANDING PLATE: 1.0" STAINLESS STEEL
TOP OF WELL CASING (FT AMSL) 4.0
WELL STICKUP: 4.0 FT above ground surface
DISCHARGE PIPE: 1" SCHEDULE 60 A304 GRADE STAINLESS STEEL

**CONCRETE PAD** (10' x 10')
4000 psi and FOUR BOLLARDS (removable)
METHOD INSTALLED: POURED

**CEMENT GROUT SEAL** (3 - 60 FT BGS) inside 16" casing
(3 - 20 FT BGS) outside 16" casing
☒ PORTLAND CEMENT 99% IDP 381 1%
VOLUME (FT³): Actual 71.2 Calculated 100.8
METHOD INSTALLED: TREMIE

**16" WELDED STEEL CASING** (3.96 FT ABOVE GROUND - 565 FT BGS)

**BENTONITE SEAL** (60 - 565 FT BGS)
☒ 3/8" BENTONITE CHIPS
VOLUME (FT³): Actual 360.8 Calculated 347.0
METHOD INSTALLED: TREMIE

**BENTONITE SEAL** (565 - 922.1 FT BGS)
☒ 3/8" BENTONITE CHIPS
VOLUME (FT³): Actual 403.8 Calculated 280.4
METHOD INSTALLED: TREMIE

**TRANSITION SAND** (922.1 - 924.3 FT BGS)
SIZE TYPE: 20/40 Silica Sand
VOLUME (FT³): Actual 5.5 Calculated 1.7
METHOD INSTALLED: TREMIE

**FILTER PACK SCREEN 1** (924.3 - 955.3 FT BGS)
SIZE TYPE: 10/20 Silica Sand
VOLUME (FT³): Actual 69.8 Calculated 24.3
METHOD INSTALLED: TREMIE

XXX DEPTH TO SCREEN 1 BENNETT PUMP INTAKE (FT BGS)

**BENTONITE SEAL** (955.3 - 1019.8 FT BGS)
☒ 3/8" BENTONITE CHIPS
VOLUME (FT³): Actual 53.3 Calculated 50.6
METHOD INSTALLED: TREMIE

**SCREEN 2 TRANSDUCER ACCESS TUBE**
1" SCHEDULE 40 PVC (FLUSH THREADED)
304 STAINLESS STEEL THROUGH PACKER

**TRANSITION SAND** (1019.8 - 1021.9 FT BGS)
SIZE TYPE: 20/40 Silica Sand
VOLUME (FT³): Actual 2.8 Calculated 1.6
METHOD INSTALLED: TREMIE

**FILTER PACK SCREEN 2** (1021.9 - 1052.3 FT BGS)
SIZE TYPE: 10/20 Silica Sand
VOLUME (FT³): Actual 59.3 Calculated 23.9
METHOD INSTALLED: TREMIE

**4" DIAMETER GRUNDFOS PUMP**
MODEL NUMBER: xxxxxxxxxx
SERIAL NUMBER: xxxxxxxxxxx

**BENTONITE SEAL** (1052.3 - 1071.8 FT BGS)
☒ 3/8" BENTONITE CHIPS
VOLUME (FT³): Actual 34.0 Calculated 15.8
METHOD INSTALLED: TREMIE

**4" DIAMETER ELECTRIC MOTOR** (TBD HP)

**SLOUGH** (1071.8 - 1100 FT BGS)

NOTES:
1. FOUR EVENLY SPACED FOUR-INCH DIAMETER PROTECTIVE BOLLARDS ARE INSTALLED AROUND OUTSIDE OF CONCRETE PAD. ALL BOLLARDS ARE REMOVABLE.
2. DIMENSIONS SHOWN ARE APPROXIMATE.

**WELL INSTALLATION**
START: 05/27/09 END: 05/28/09

**WELL BACKFILL**
START: 05/29/09 END: 06/06/09

**TYPE OF WELL SCREENS**
☒ A304 GRADE STAINLESS STEEL
SCREEN DIAMETER Inside: 5.0" Outside: 5.6"
SLOT SIZE: 0.020" rod based wire wrapped
JOINT TYPE: API L/T (threaded collars)

**SCREEN 2**
**DEVELOPED:** FROM 06/10/09 TO 06/17/09
**METHODS:** swabbing, bailing, pumping
**24-hr AQUIFER TEST:** 06/21/09 - 06/22/09
**AVERAGE FLOW RATE:** 12 gpm
**TOTAL VOLUME PURGED:** 33437.6 gallons
**FINAL TURBIDITY:** 1 NTUs
**FINAL TOC:** 0.7 ppm
**SAMPLING SYSTEM:** BASKI

**SCREEN 1**
**DEVELOPED:** FROM 06/30/09 TO TBD
**METHODS:** swabbing, bailing, pumping
**24-hr AQUIFER TEST:** 07/12/09-07/13/09
**AVERAGE FLOW RATE:** TBD
**TOTAL VOLUME PURGED:** TBD
**FINAL TURBIDITY:** TBD
**FINAL TOC:** TBD
**SAMPLING SYSTEM:** BASKI

**Figure 5.3-2 As-built completion composite for regional aquifer well R-37**

## Table 2.2-1
## Municipal Water and AQF-2 Foam Used during Drilling of the Third Borehole and Well Construction at Well R-37

| Date | Water (gal.) | Cumulative Water (gal.) | AQF-2 Foam (gal.) | Cumulative AQF-2 Foam (gal.) | Cumulative Returns in Pit (gal.) |
|---|---|---|---|---|---|
| **Drilling (above the base of the basalt)** | | | | | |
| 04/17/09 | 0 | 0 | 0 | 0 | 0 |
| 04/18/09 | 180 | 180 | 1.5 | 1.5 | 43 |
| 04/19/09 | 16,000 | 16,180 | 7 | 8.5 | 3880 |
| 04/20/09 | 25,000 | 41,180 | 25 | 33.5 | 9900 |
| 04/21/09 | 15,400 | 56,580 | 20 | 53.5 | 13,500 |
| 04/22/09 | 1500 | 58,080 | 2 | 55.5 | 14,000 |
| 04/23/09 | 13,400 | 71,480 | 9 | 64.5 | 17,100 |
| 04/24/09 | 8800 | 80,280 | 6 | 70.5 | 19,300 |
| 04/25/09 | 4400 | 84,680 | 2 | 72.5 | 20,300 |
| 05/01/09 | 0 | 84,680 | 0 | 72.5 | 20,300 |
| 05/02/09 | 5000 | 89,680 | 0.5 | 73 | 21,500 |
| 05/03/09 | 5000 | 94,680 | 0.5 | 73.5 | 23,000 |
| 05/04/09 | 32,000 | 126,680 | 3 | 76.5 | 30,400 |
| 05/05/09 | 8400 | 135,080 | 3 | 79.5 | 32,400 |
| 05/06/09 | 1000 | 136,080 | 4 | 83.5 | 32,650 |
| 05/07/09 | 0 | 136,080 | 0 | 83.5 | 32,650 |
| 05/08/09 | 0 | 136,080 | 0 | 83.5 | 32,650 |
| 05/09/09 | 15,400 | 151,480 | 75 | 158.5 | 36,300 |
| 05/11/09 | 22,000 | 173,480 | 30 | 188.5 | 41,600 |
| 05/12/09 | 16,000 | 189,480 | 10 | 198.5 | 45,500 |
| 05/19/09 | 16,000 | 205,480 | 20 | 218.5 | 49,300 |
| 05/20/09 | 500 | 205,980 | 2 | 220.5 | 49,400 |
| **Subtotal Drilling (above the base of the basalt ) (gal.)** | **205,980** | **205,480** | **220.5** | **220.5** | **49,400** |
| **Drilling (below the basalt)** | | | | | |
| 05/20/09 | 6500 | 7000 | 0 | 0 | 1800 |
| 05/21/09 | 12,600 | 19,600 | 0 | 0 | 5100 |
| 05/22/09 | 0 | 19,600 | 0 | 0 | 5100 |
| 05/24/09 | 2200 | 21,800 | 0 | 0 | 5800 |
| 05/25/09 | 9900 | 31,700 | 0 | 0 | 8600 |
| 05/26/09 | 600 | 32,300 | 0 | 0 | 9200 |
| 05/27/09 | 600 | 32,900 | 0 | 0 | 9400 |
| **Subtotal Drilling (below the basalt) (gal.)** | **32,900** | **32,900** | **0** | **0** | **9400** |

### Table 2.2-1 (continued)

| Date | Water (gal.) | Cumulative Water (gal.) | AQF-2 Foam (gal.) | Cumulative AQF-2 Foam (gal.) | Cumulative Returns in Pit (gal.) |
|---|---|---|---|---|---|
| **Well Construction** | | | | | |
| 05/29/09 | 600 | 600 | 0 | 0 | 0 |
| 05/30/09 | 12,000 | 12,600 | 0 | 0 | 0 |
| 05/31/09 | 15,400 | 28,000 | 0 | 0 | 0 |
| 06/02/09 | 6600 | 34,600 | 0 | 0 | 0 |
| 06/03/09 | 13,200 | 47,800 | 0 | 0 | 0 |
| 06/04/09 | 12,000 | 59,800 | 0 | 0 | 0 |
| 06/05/09 | 4000 | 63,800 | 0 | 0 | 0 |
| **Subtotal Well Construction (gal.)** | **63,800** | **63,800** | **0** | **0** | **0** |
| **Total Volume (gal.)** | **302,680** | **302,680** | **220.5** | **220.5** | **58,800** |

### Table 2.3-1
### Summary of Groundwater-Screening Samples Collected during Drilling, Well Development, and Aquifer Testing of Well R-37

| Location ID | Sample ID | Date Collected | Collection Depth (ft bgs) | Sample Type |
|---|---|---|---|---|
| **Drilling** | | | | |
| R-37 (first borehole) | GW37-08-15104 | 08/20/08 | 925 | Screening |
| R-37 (first borehole) | GW37-08-15105 | 08/22/08 | 1070 | Screening |
| R-37 (third borehole) | GW37-09-9724 | 05/21/09 | 1020 | Screening |
| R-37 (third borehole) | GW37-09-9723 | 05/21/09 | 1040 | Screening |
| R-37 (third borehole) | GW37-09-9725 | 05/21/09 | 1052 | Screening |
| ***R-37 Screen 2*** | | | | |
| **Prewell Development** | | | | |
| R-37 screen 2 | GR37-09-1560 | 06/15/09 | 1044.4 | TOC |
| **Well Development** | | | | |
| R-37 screen 2 | GW37-09-1561 | 06/15/09 | 1044.4 | TOC |
| R-37 screen 2 | GW37-09-1562 | 06/16/09 | 1044.4 | TOC |
| R-37 screen 2 | GW37-09-1563 | 06/16/09 | 1044.4 | TOC |
| R-37 screen 2 | GW37-09-1564 | 06/17/09 | 1044.4 | TOC |
| ***R-37 Screen 1*** | | | | |
| **Prewell Development** | | | | |
| R-37 screen 1 | GW37-09-1566 | 06/30/09 | 906.6 | TOC |

## Table 2.3-1 (continued)

| Location ID | Sample ID | Date Collected | Collection Depth (ft bgs) | Sample Type |
|---|---|---|---|---|
| **Well Development** | | | | |
| R-37 screen 1 | GW37-09-1567 | 07/01/09 | 980 | TOC |
| R-37 screen 1 | GW37-09-1568 | 07/02/09 | 980 | TOC |
| R-37 screen 1 | GW37-09-1569 | 07/06/09 | 980 | TOC |
| R-37 screen 1 | GW37-09-1570 | 07/08/09 | 980 | TOC |
| R-37 screen 1 | GW37-09-1571 | 07/14/09 | 980 | TOC |
| R-37 screen 1 | GW37-09-1572 | 07/14/09 | 980 | TOC |
| R-37 screen 1 | GW37-09-1573 | 07/14/09 | 980 | TOC |

## Table 3.1-1
## Summary of Water-Level Measurements during Drilling and Well Construction at Well R-37

| Date | Time | DTW (ft bgs) | Source | Type | After |
|---|---|---|---|---|---|
| **Drilling (1st Borehole)** | | | | | |
| 08/12/08 | 1028 | 692 | DTW meter | Perched | Drilling |
| 08/12/08 | 1030 | 693 | DTW meter | Perched | Drilling |
| 08/12/08 | 1050 | 693 | DTW meter | Perched | Drilling |
| 08/12/08 | 1310 | 693 | DTW meter | Perched | Drilling |
| 08/12/08 | 1510 | 697 | DTW meter | Perched | Tripping out |
| 08/21/08 | 1455 | 893.4 | DTW Meter | Perched | Drilled to 985 ft |
| 08/22/08 | 1620 | 963 | DTW Meter | Perched | Drilled to 1070 ft |
| 08/23/08 | 0820 | 895 | DTW Meter | Perched | Resting |
| 08/23/08 | 0945 | 895.6 | DTW Meter | Perched | Resting |
| 08/24/08 | 2305 | 894.3 | DTW Meter | Perched | Resting |
| **Drilling (3rd Borehole)** | | | | | |
| 05/22/09 | 0921 | 1012 | DTW Meter | Regional | Tripping out |
| 05/22/09 | 1001 | 1012 | DTW Meter | Regional | Resting |
| 05/22/09 | 1020 | 1012 | DTW Meter | Regional | Resting |
| 05/22/09 | 1030 | 1012 | DTW Meter | Regional | Resting |
| 05/22/09 | 1625 | 1012 | DTW Meter | Regional | Air-lifting |
| 05/22/09 | 1700 | 1011.8 | DTW Meter | Regional | Air-lifting |
| 05/22/09 | 1738 | 1011.8 | DTW Meter | Regional | Air-lifting |
| 05/23/09 | 0640 | 1010.8 | DTW Meter | Regional | Resting |
| 05/23/09 | 0645 | 1010.8 | DTW Meter | Regional | Resting |
| **Prewell Construction** | | | | | |
| 05/28/09 | 0645 | 1009.9 | DTW Meter | Regional | Resting |
| 05/28/09 | 0854 | 1009.8 | DTW Meter | Regional | Resting |
| **Well Construction** | | | | | |
| 05/29/09 | 0705 | 1011.5 | DTW Meter | Regional | Well Construction |
| 06/04/09 | 0600 | 993.4 | DTW Meter | Composite | Backfilling |

## Table 3.1-2
## Summary of Water-Level Measurements at Well R-37 Screen 2

| Date | Time | DTW (ft bgs) | Source | Type | After |
|---|---|---|---|---|---|
| **Postwell Development and Pumping Test, before TAM Packer Set** | | | | | |
| 06/26/09 | 1133 | 1009.8 | DTW Meter | Regional | Resting |
| 06/26/09 | 1330 | 1009.61 | DTW Meter | Regional | Resting |
| 06/29/09 | 0712 | 1009.65 | DTW Meter | Regional | Resting |

## Table 3.1-3
## Summary of Water-Level Measurements at Well R-37 Screen 1

| Date | Time | Depth to Water (ft bgs) | Pumping Rate (gpm) | Source | Type | After |
|---|---|---|---|---|---|---|
| **Prewell Development (R-37 screen 1)** | | | | | | |
| 06/15/09 | 1029 | 806.18 | NA* | DTW Meter | Perched | Resting |
| 06/15/09 | 1500 | 806.13 | NA | DTW Meter | Perched | Pumping Screen 2 |
| 06/16/09 | 0710 | 806.18 | NA | DTW Meter | Perched | Resting |
| 06/16/09 | 1615 | 806.14 | NA | DTW Meter | Perched | Pumping Screen 2 |
| 06/18/09 | 0710 | 806.8 | NA | DTW Meter | Perched | Resting |
| 06/26/09 | 1230 | 944.41 | NA | DTW Meter | Perched | Draining |
| 06/26/09 | 1320 | 923.51 | NA | DTW Meter | Perched | Draining |
| 06/26/09 | 1430 | 912.67 | NA | DTW Meter | Perched | Draining |
| 06/29/09 | 0711 | 906.6 | NA | DTW Meter | Perched | Resting |
| **Well Development (R-37 screen 1)** | | | | | | |
| 06/30/09 | 0730 | 906.42 | TAM packer top at 997 ft | DTW Meter | Perched | Resting |
| 06/30/09 | 1114 | 898.41 | NA | DTW Meter | Perched | Bailing |
| 06/30/09 | 1136 | 918.04 | NA | DTW Meter | Perched | Recovery |
| 06/30/09 | 1140 | 917.04 | NA | DTW Meter | Perched | Recovery |
| 06/30/09 | 1435 | 909.4 | NA | DTW Meter | Perched | Bailing |
| 06/30/09 | 1445 | 908.4 | NA | DTW Meter | Perched | Recovery |
| 06/30/09 | 1653 | 932.46 | NA | DTW Meter | Perched | Bailing |
| 07/01/09 | 0730 | 908.35 | NA | DTW Meter | Perched | Resting |
| 07/01/09 | 1516 | 906.12 | NA | DTW Meter | Perched | Setting pump |
| 07/01/09 | 15.33 | 930.03 | 5 | DTW Meter | Perched | Pumping |
| 07/01/09 | 1626 | 925.94 | 1.5 | DTW Meter | Perched | Pumping |
| 07/01/09 | 1638 | 927.86 | 1.5 | DTW Meter | Perched | Pumping |
| 07/01/09 | 1645 | 929.04 | 1.67 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0705 | 907.35 | 1.5 | DTW Meter | Perched | Resting |
| 07/02/09 | 0723 | 915.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0726 | 916.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0730 | 917.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0733 | 918.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0736 | 919.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0740 | 920.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0744 | 921.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0748 | 922.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0758 | 924.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0804 | 925.04 | 1.5 | DTW Meter | Perched | Pumping |

## Table 3.1-3 (continued)

| Date | Time | Depth to Water (ft bgs) | Pumping Rate (gpm) | Source | Type | After |
|---|---|---|---|---|---|---|
| 07/02/09 | 809 | 926.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0815 | 927.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0822 | 928.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0829 | 929.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0837 | 930.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0848 | 931.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0904 | 932.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0918 | 933.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 0954 | 935.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1009 | 937.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1043 | 938.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1132 | 940.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1158 | 941.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1226 | 942.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1247 | 943.04 | 1.5 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1315 | 942.84 | 1.2 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1321 | 942.66 | 1.2 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1327 | 942.44 | 1.2 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1344 | 942.34 | 1.2 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1450 | 942.84 | 1.2 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1610 | 942.49 | 1.2 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1632 | 943.25 | 1.2 | DTW Meter | Perched | Pumping |
| 07/02/09 | 1643 | 943.38 | 1.2 | DTW Meter | Perched | Pumping |
| 07/06/09 | 1000 | 906.56 | NA | DTW Meter | Perched | Resting |
| 07/06/09 | 1034 | 919.79 | 1.4 | DTW Meter | Perched | Pumping |
| 07/06/09 | 1045 | 921.04 | 1.4 | DTW Meter | Perched | Pumping |
| 07/06/09 | 1050 | 922.04 | 1.4 | DTW Meter | Perched | Pumping |
| 07/06/09 | 1125 | 928.84 | 1.4 | DTW Meter | Perched | Pumping |
| 07/06/09 | 1132 | 930.04 | 1.4 | DTW Meter | Perched | Pumping |
| 07/06/09 | 1142 | 931.04 | 1.4 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0700 | 907.04 | NA | DTW Meter | Perched | Resting |
| 07/07/09 | 0753 | 919.75 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0804 | 922.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0810 | 923.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0816 | 924.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0823 | 925.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0830 | 926.04 | 1.15 | DTW Meter | Perched | Pumping |

## Table 3.1-3 (continued)

| Date | Time | Depth to Water (ft bgs) | Pumping Rate (gpm) | Source | Type | After |
|---|---|---|---|---|---|---|
| 07/07/09 | 0839 | 927.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0846 | 928.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0856 | 929.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0856 | 929.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0917 | 931.04 | 1.05 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0934 | 932.04 | 1.05 | DTW Meter | Perched | Pumping |
| 07/07/09 | 0951 | 933.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1001 | 934.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1020 | 935.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1025 | 935.14 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1034 | 935.44 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1039 | 935.54 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1055 | 936.04 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1106 | 936.44 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1117 | 936.74 | 1.13 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1121 | 936.44 | 1.13 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1148 | 936.94 | 1.13 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1300 | 943.51 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1400 | 941.49 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1500 | 942.77 | 1.15 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1600 | 943.24 | 1.05 | DTW Meter | Perched | Pumping |
| 07/07/09 | 1700 | 943.83 | 1.1 | DTW Meter | Perched | Pumping |
| 07/08/09 | 0718 | 906.75 | NA | DTW Meter | Perched | Resting |
| 07/08/09 | 1320 | 906.92 | NA | DTW Meter | Perched | Pulling pump |

*NA -= Not analyzed.

### Table 5.1-1
### Well-Development Volumes and Field Water-Quality-Parameter Measurements at Well R-37 Screen 1

| Date | Time | pH | SP[a] (µS/cm) | T[c] (°C) | Turbidity (NTU) | DO[c] (mg/L) | Salinity % | TOC Result (ppm) | Comment | End-of-Day Cumulative Purge Volume Screen 1 (gal.) |
|---|---|---|---|---|---|---|---|---|---|---|
| **Well Development** | | | | | | | | | | |
| 06/30/09 | 0908 | —[d] | — | — | — | — | — | 1.68 | Bail | 450 |
| 07/01/09 | 1520 | — | — | — | — | — | — | — | Pump on | — |
| 07/01/09 | 1527 | 7.71 | 0.321 | 28.9 | 234 | — | 0.01 | — | — | — |
| 07/01/09 | 1606 | 8.24 | 0.3 | 21.7 | 398 | 0.62 | 0.01 | — | — | — |
| 07/01/09 | 1626 | 7.9 | 0.305 | 22.3 | 240 | 0.56 | 0.01 | — | — | — |
| 07/01/09 | 1700 | 7.69 | 0.305 | 22.8 | 39 | 0.65 | 0.01 | 0.79 | Pump off | 952.7 |
| 07/02/09 | 0707 | — | — | — | — | — | — | — | Pump on | — |
| 07/02/09 | 0723 | 8.26 | 0.304 | 16.6 | 32 | 0.05 | 0.01 | — | — | — |
| 07/02/09 | 0726 | 7.75 | 0.289 | 17.2 | 38 | -0.28 | 0.01 | — | — | — |
| 07/02/09 | 0744 | 7.58 | 0.248 | 18 | 27 | — | 0.01 | — | — | — |
| 07/02/09 | 0758 | 7.44 | 0.294 | 19.2 | 10 | 0.07 | 0.01 | — | — | — |
| 07/02/09 | 0815 | 7.47 | 0.297 | 19.5 | 9 | 0.04 | 0.01 | — | — | — |
| 07/02/09 | 0822 | 7.52 | 0.302 | 19.2 | 7 | 0.04 | 0.01 | — | — | — |
| 07/02/09 | 0848 | 7.59 | 0.307 | 22.2 | 6 | 0.01 | 0.01 | — | — | — |
| 07/02/09 | 0904 | 7.57 | 0.31 | 20.6 | 5 | 0 | 0.01 | — | — | — |
| 07/02/09 | 0939 | 7.77 | 0.314 | 18.6 | 5 | 0.13 | 0.01 | — | — | — |
| 07/02/09 | 0954 | 7.78 | 0.31 | 21.7 | 7 | 0.03 | 0.01 | — | — | — |
| 07/02/09 | 1045 | 8.03 | 0.301 | 23.9 | 11 | 0.27 | 0.01 | — | — | — |
| 07/02/09 | 0954 | 7.78 | 0.31 | 21.7 | 7 | 0.03 | 0.01 | — | — | — |
| 07/02/09 | 1045 | 8.03 | 0.301 | 23.9 | 11 | 0.27 | 0.01 | — | — | — |
| 07/02/09 | 1132 | 8.15 | 0.268 | 25.4 | 36 | 0.37 | 0.01 | — | — | — |
| 07/02/09 | 1201 | 8.25 | 0.293 | 24.4 | 37 | 0.35 | 0.01 | — | — | — |
| 07/02/09 | 1239 | 8.3 | 0.294 | 24.4 | 43 | 0.43 | 0.01 | — | — | — |
| 07/02/09 | 1306 | 8.44 | 0.294 | 24.6 | 69 | 0.46 | 0.01 | — | — | — |
| 07/02/09 | 1318 | 8.44 | 0.294 | 23.1 | 50 | 0.3 | 0.01 | — | — | — |
| 07/02/09 | 1345 | 8.27 | 0.293 | 23.6 | 32 | — | 0.01 | — | — | — |
| 07/02/09 | 1354 | 8.27 | 0.29 | 23.4 | 30 | 0.27 | 0.01 | — | — | — |
| 07/02/09 | 1451 | 8.41 | 0.292 | 25.8 | 14 | 0.47 | 0.01 | — | — | — |
| 07/02/09 | 1526 | 8.51 | 0.293 | 25.1 | 9 | 0.32 | 0.01 | — | — | — |
| 07/02/09 | 1610 | 8.3 | 0.29 | 25.1 | 8 | 0.46 | 0.01 | — | — | — |
| 07/02/09 | 1630 | 8.26 | 0.291 | 20.9 | 6 | 0.51 | 0.01 | — | — | — |
| 07/02/09 | 1646 | 8.14 | 0.29 | 24.1 | 6 | 0.49 | 0.01 | 0.62 | — | — |
| 07/02/09 | 1700 | — | — | — | — | — | — | — | Pump off | 1759.2 |

## Table 5.1-1 (continued)

| Date | Time | pH | SP[a] (µS/cm)[b] | T[c] (°C) | Turbidity (NTU) | DO[d] (mg/L) | Salinity % | TOC Result (ppm) | Comment | End-of-Day Cumulative Purge Volume Screen 1 (gal.) |
|---|---|---|---|---|---|---|---|---|---|---|
| 07/06/09 | 1004 | — | — | — | — | — | — | — | Pump on | — |
| 07/06/09 | 1012 | 8.41 | 0.294 | 16.1 | 11 | -0.17 | 0.01 | — | — | — |
| 07/06/09 | 1024 | 8.29 | 0.229 | 17.5 | 36 | -0.45 | 0 | — | — | — |
| 07/06/09 | 1045 | 7.91 | 0.303 | 19 | 28 | -0.03 | 0 | — | — | — |
| 07/06/09 | 1100 | 7.62 | 0.302 | 20.6 | 9 | 0.03 | 0.01 | — | — | — |
| 07/06/09 | 1110 | 8.74 | 0.307 | 20.8 | 4 | 0.06 | 0.01 | — | — | — |
| 07/06/09 | 1152 | 8.37 | 0.318 | 23 | 1 | 0 | 0.01 | — | — | — |
| 07/06/09 | 1408 | 8.49 | 0.314 | 24.4 | 5 | 0.16 | 0.01 | — | — | — |
| 07/06/09 | 1529 | 8.78 | 0.313 | 24 | 7 | 0.23 | 0.01 | — | — | — |
| 07/06/09 | 1608 | 8.77 | 0.311 | 22.7 | 10 | 0.31 | 0.01 | — | Pump off | 2161.3 |
| 07/07/09 | 0710 | — | — | — | — | — | — | — | Pump on | — |
| 07/07/09 | 0845 | 8.29 | 0.292 | 21.8 | 0 | -0.07 | 0.01 | — | — | — |
| 07/07/09 | 0858 | 8.17 | 0.303 | 22.2 | 2 | -0.02 | 0.01 | — | — | — |
| 07/07/09 | 0903 | 8.18 | 0.303 | 22.2 | 0 | 0 | 0.01 | — | — | — |
| 07/07/09 | 0907 | 8.21 | 0.303 | 22.2 | 0 | 0 | 0.01 | — | — | — |
| 07/07/09 | 0918 | 8.25 | 0.303 | 22.4 | 0 | 0.01 | 0.01 | — | — | — |
| 07/07/09 | 0925 | 8.24 | 0.304 | 22.6 | 0 | 0 | 0.01 | — | — | — |
| 07/07/09 | 0930 | 8.21 | 0.306 | 22.8 | 0 | 0 | 0.01 | — | — | — |
| 07/07/09 | 0935 | 8.21 | 0.306 | 22.9 | 0 | -0.02 | 0.01 | — | — | — |
| 07/07/09 | 0951 | 8.25 | 0.307 | 22.9 | 0 | 0.03 | 0.01 | — | — | — |
| 07/07/09 | 0957 | 8.23 | 0.308 | 23.1 | 1 | 0.02 | 0.01 | — | — | — |
| 07/07/09 | 1001 | 8.21 | 0.308 | 23.2 | 0 | 0.02 | 0.01 | — | — | — |
| 07/07/09 | 1025 | 8.28 | 0.307 | 23.4 | 0 | 0.03 | 0.01 | — | — | — |
| 07/07/09 | 1037 | 8.29 | 0.309 | 23.3 | 1 | 0.05 | 0.01 | — | — | — |
| 07/07/09 | 1043 | 8.26 | 0.309 | 23.4 | 0 | — | 0.01 | — | — | — |
| 07/07/09 | 1046 | 8.3 | 0.309 | 23.3 | 0 | 0.1 | 0.01 | — | — | — |
| 07/07/09 | 1058 | 8.28 | 0.307 | 23.7 | 2 | 0.04 | 0.01 | — | — | — |
| 07/07/09 | 1103 | 8.29 | 0.307 | — | 1 | 0.06 | 0.01 | — | — | — |
| 07/07/09 | 1110 | 8.29 | 0.305 | 23.8 | 2 | 0.05 | 0.01 | — | — | — |
| 07/07/09 | 1119 | 8.31 | 0.304 | 23.8 | 1 | 0.08 | 0.01 | — | — | — |
| 07/07/09 | 1129 | 8.34 | 0.305 | 24 | 1 | 0.1 | 0.01 | — | — | — |
| 07/07/09 | 1150 | 8.34 | 0.299 | 24.3 | 1 | 0.09 | 0.01 | — | — | — |
| 07/07/09 | 1300 | 8.5 | 0.297 | 25.1 | 17 | 0.34 | 0 | — | — | — |
| 07/07/09 | 1400 | 8.46 | 0.292 | 26.1 | 8 | 0.55 | 0.01 | — | — | — |
| 07/07/09 | 1500 | 8.5 | 0.292 | 26.2 | 9 | 0.57 | 0.01 | — | — | — |
| 07/07/09 | 1600 | 8.62 | 0.297 | 26.7 | 6 | 0.54 | 0.01 | — | — | — |

## Table 5.1-1 (continued)

| Date | Time | pH | SP[a] (μS/cm)[b] | T[c] (°C) | Turbidity (NTU) | DO[d] (mg/L) | Salinity % | TOC Result (ppm) | Comment | End-of-Day Cumulative Purge Volume Screen 1 (gal.) |
|---|---|---|---|---|---|---|---|---|---|---|
| 07/07/09 | 1700 | 8.55 | 0.294 | 25.4 | 15 | 0.37 | 0.01 | — | — | — |
| 07/07/09 | 1705 | — | — | — | — | — | — | 4 | Pump off | 2757.1 |
| **R-37 Screen 1 Mini -Pumping Tests** | | | | | | | | | | |
| 07/10/09 | — | — | — | — | — | — | — | — | — | 2864.9 |
| **R-37 Screen 1 24-H Pumping Test** | | | | | | | | | | |
| 07/12/09 | 0700 | — | — | — | — | — | — | — | Pump on | — |
| 07/12/09 | 0715 | 8.32 | 0.302 | 16.2 | 8 | 0.12 | 0.01 | — | — | — |
| 07/12/09 | 0747 | 7.54 | 0.302 | 15.9 | 2 | -0.05 | 0.01 | — | — | — |
| 07/12/09 | 0835 | 7.83 | 0.31 | 18.4 | 4 | 0.11 | 0.01 | — | — | — |
| 07/12/09 | 0912 | 8.13 | 0.308 | 20.4 | 2 | 0.06 | 0.01 | — | — | — |
| 07/12/09 | 0955 | 8.27 | 0.308 | 22.2 | 0 | 0.33 | 0.01 | — | — | — |
| 07/12/09 | 1114 | 8.57 | 0.319 | 27.7 | 0 | 0.28 | 0.01 | — | — | — |
| 07/12/09 | 1239 | 8.52 | 0.323 | 28.8 | 0 | 0.27 | 0.01 | — | — | — |
| 07/12/09 | 1334 | 8.42 | 0.321 | 29.3 | 0 | 0.28 | 0.01 | — | — | — |
| 07/12/09 | 1404 | 8.53 | 0.316 | 27.5 | 0 | 0.32 | 0.01 | — | — | — |
| 07/12/09 | 1447 | 8.44 | 0.317 | 28.1 | 0 | 0.26 | 0.01 | — | — | — |
| 07/12/09 | 1601 | 8.62 | 0.312 | 29.3 | 0 | 0.23 | 0.01 | — | — | — |
| 07/12/09 | 1645 | 8.57 | 0.309 | 27 | 0 | 0.24 | 0.01 | — | — | — |
| 07/12/09 | 1745 | 8.53 | 0.308 | 27.7 | 0 | 0.32 | 0.01 | — | — | — |
| 07/12/09 | 1900 | 8.34 | 0.304 | 26.2 | 0 | 0.33 | 0.01 | — | — | — |
| 07/12/09 | 2000 | 8.34 | 0.301 | 24.2 | 0 | 0.26 | 0.01 | — | — | — |
| 07/12/09 | 2100 | 8.46 | 0.299 | 22 | 1 | 0.18 | 0.01 | — | — | — |
| 07/12/09 | 2200 | 8.21 | 0.299 | 21.6 | 0 | 0.19 | 0.01 | — | — | — |
| 07/12/09 | 2300 | 8.33 | 0.299 | 22 | 1 | 0.18 | 0.01 | — | — | — |
| 07/12/09 | 2400 | — | — | — | — | — | — | — | — | 3573.1 |
| 07/13/09 | 0000 | 7.88 | 0.296 | 21.7 | 0 | 0.05 | 0.01 | — | — | — |
| 07/13/09 | 0100 | 8.18 | 0.295 | 19.2 | 1 | 0.26 | 0.01 | — | — | — |
| 07/13/09 | 0200 | 8.19 | 0.245 | 18.7 | 1 | 0.19 | 0.01 | — | — | — |
| 07/13/09 | 0300 | 8.12 | 0.292 | 18.5 | 1 | 0.2 | 0.01 | — | — | — |
| 07/13/09 | 0400 | 8.07 | 0.292 | 18.5 | 1 | 0.26 | 0.01 | — | — | — |
| 07/13/09 | 0500 | 8.06 | 0.292 | 18.5 | 1 | 0.26 | 0.01 | — | — | — |
| 07/13/09 | 0600 | 8.12 | 0.246 | 19.7 | 1 | 0.45 | 0.01 | — | — | — |
| 07/13/09 | 0700 | 8.12 | 0.246 | 19.7 | 1 | 0.45 | 0.01 | — | Pump off | 4002 |

### Table 5.1-1 (continued)

| Date | Time | pH | SP[a] (µS/cm)[b] | T[c] ($^{o}$C) | Turbidity (NTU) | DO[d] (mg/L) | Salinity % | TOC Result (ppm) | Comment | End-of-Day Cumulative Purge Volume Screen 1 (gal.) |
|---|---|---|---|---|---|---|---|---|---|---|
| **R-37 Screen 1 Development Pumping (continued)** | | | | | | | | | | |
| 07/14/09 | 0820 | 8.24 | 0.289 | 24.8 | 3 | 0.8 | 0.01 | — | Pump on | — |
| 07/14/09 | 1100 | 8.35 | 0.312 | 25.8 | 3 | 0.86 | 0.01 | — | — | — |
| 07/14/09 | 1200 | 8.29 | 0.302 | 26.1 | 3 | 0.67 | 0.01 | — | — | — |
| 07/14/09 | 1230 | — | — | — | — | — | — | > 60 | — | — |
| 07/14/09 | 1300 | 8.4 | 0.314 | 25.4 | 3 | 0.74 | 0.01 | — | — | — |
| 07/14/09 | 1330 | 8.45 | 0.306 | 26.9 | 4 | 0.74 | 0.01 | > 15 | — | — |
| 07/14/09 | 1400 | 8.39 | 0.309 | 26.8 | 4 | 0.85 | 0.01 | — | — | — |
| 07/14/09 | 1500 | 8.4 | 0.305 | 26.8 | 5 | 0.75 | 0.01 | — | — | — |
| 07/14/09 | 1600 | 8.69 | 0.302 | 27.8 | 5 | 1.02 | 0.01 | — | — | — |
| 07/14/09 | 1700 | 8.64 | 0.305 | 27.4 | 3 | 1.01 | 0.01 | — | — | — |
| 07/14/09 | 0100 | 8.66 | 0.298 | 25.1 | 3 | 1.05 | 0.01 | 1.8 | Pump off | 4460.3 |
| 08/21/09 | 0700 | 9.13 | 0.328 | 15.2 | 14 | 0.49 | 0.0.1 | 0.86 | — | 5010.3 |
| 08/24/09 | 0700 | 9.11 | 0.326 | 15.2 | 14 | 0.49 | 0.01 | 0.78 | — | 5560.3 |
| 08/25/09 | 0700 | 9.12 | 0.325 | 15.3 | 14 | 0.49 | 0.01 | 0.73 | — | 6110.3 |
| 08/26/09 | 1330 | 8.25 | 0.322 | 16.5 | 10 | 0.92 | 0.01 | 0.73 | — | 6710.3 |
| 08/27/09 | 1550 | 8.72 | 0.322 | 16.5 | 19 | 0.92 | 0.01 | 1.02 | — | 6760.3 |
| 08/28/09 | 1400 | 8.52 | 0.327 | 18.1 | 5 | 0.92 | 0.01 | 0.61 | — | 6860.3 |
| 08/31/09 | 1435 | 8.74 | 0.327 | 20.9 | 10 | 0.46 | 0.01 | 0.5 | — | 6960.3 |
| 09/1/09 | 1430 | 8.51 | 0.318 | 20.0 | 4 | 0.52 | 0.01 | 0.5 | — | 7010.3 |

[a] SP = Specific conductance.

[b] T = Temperature.

[c] DO FLC = Dissolved oxygen measured by the Horiba instrument in a flow-through cell.

[d] — = Analysis not conducted.

### Table 5.5-1
### R-37 Survey Coordinates

| Identification | Northing | Easting | Elevation |
|---|---|---|---|
| 1st borehole | 1762515.66 | 1638031.1 | 6863.96 |
| 2nd borehole | 1762552.38 | 1638049.26 | 6862.86 |
| R-37 top of stainless-steel well casing | 1762611.09 | 1637828.48 | 6870.19 |
| R-37 top of 16-in. protective casing | 1762611.09 | 1637828.48 | 6873.6 |
| R-37 brass monument in cement pad | 1762616.71 | 1637828.13 | 6870.59 |
| R-37 ground surface adjacent to pad | 1762617.71 | 1637827.13 | 6870.19 |

## Table 5.6-1
## Summary of Waste Samples Collected during Drilling and Development of Well R-37

| Location ID | Sample ID | Date Collected | Description | Container | Sample Type |
|---|---|---|---|---|---|
| R-37 | GW40-08-14314 | 07/28/2008 | Dry drill cuttings | Rolloff | Solid |
| R-37 | GW37-08-15271 | 08/25/2008 | Hydraulic-oil gravel | Drum | NMSW |
| R-37 | GW37-08-15272 | 08/25/2008 | Hydraulic-oil gravel | Drum | NMSW |
| R-37 | GW37-08-15273 | 08/25/2008 | Hydraulic-oil gravel | Drum | NMSW |
| R-37 | GW37-08-15262 | 009/07/2008 | Dry drill cuttings | Rolloff | Solid |
| R-37 | GW37-08-15263 | 09/09/2008 | Dry drill cuttings | Rolloff | Solid |
| R-37 | GW37-08-15264 | 09/10/2008 | Dry drill cuttings | Rolloff | Solid |
| R-37 | GW37-08-15268 | 09/11/2008 | Hydraulic-oil gravel | Drum | NMSW |
| R-37 | GW37-08-15266 | 10/10/2008 | Dry drill cuttings | Rolloff | Solid |
| R-37 | GW40-08-15266 | 09/09/2008 | Hydraulic-oil gravel | Drum | NMSW |
| R-37 | GW40-09-515 | 11/19/2008 | Drilling water | 1st tank | Liquid |
| R-37 | GW40-08-1366 | 11/21/2008 | Dry drill cuttings | Rolloff | Solid |
| R-37 | GW37-09-1546 | 02/13/2009 | Hydraulic-oil gravel | Drum | NMSW |
| R-37 | GW37-09-1547 | 02/23/2009 | Hydraulic-oil gravel | Drum | NMSW |
| R-37 | GW37-09-1548 | 03/05/2009 | Hydraulic-oil gravel | Drum | NMSW |
| R-37 | GW37-09-6300 | 03/30/2009 | Drilling water | 1st tank, resample, cyanide only | Liquid |
| R-37 | GW37-09-1549 | 05/04/2009 | Wet drill cuttings | Containment pit # 1 | Solid |
| R-37 | GW37-09-1550 | 05/04/2009 | Wet drill cuttings | Containment pit # 2 | Solid |
| R-37 | GW37-09-6295 | 05/05/2009 | Drilling water | Containment pit # 2 | Liquid |
| R-37 | GW37-09-9755 | 05/26/2009 | Diesel fuel gravel | Drum, resample | NMSW |
| R-37 | GW37-09-9751 | 05/27/2009 | Hydraulic-oil gravel | Drum, resample | NMSW |
| R-37 | GW37-09-10457 | 06/15/2009 | Wet drill cuttings | Containment pit # 3 | Solid |
| R-37 | GW37-09-10448 | 06/16/2009 | Drilling water | Containment pit # 3 | Liquid |
| R-37 | GW37-09-10586 | 06/24/2009 | Drilling water | Containment pit # 2, resample | Liquid |
| R-37 | GW37-09-10449 | 06/30/2009 | Development water | 2nd tank | Liquid |
| R-37 | GW37-09-10450 | 07/01/2009 | Development water | 3rd tank | Liquid |
| R-37 | GW37-09-9387 | 07/22/2009 | Development water | 3rd tank | Liquid |
| R-37 | GW37-09-11581 | 08/06/2009 | Drilling water | Containment pit # 2, resample | Liquid |

# Appendix A

## *Acronyms and Abbreviations, Metric Conversion Table, and Data Qualifier Definitions*

## A-1.0 ACRONYMS AND ABBREVIATIONS

| | |
|---|---|
| μS/cm | microsiemens per centimeter |
| amsl | above mean sea level |
| ASTM | American Society for Testing and Materials |
| bgs | below ground surface |
| Consent Order | Compliance Order on Consent |
| DO | dissolved oxygen |
| DR | dual rotary |
| DTW | depth to water |
| EES-14 | Earth and Environmental Science Group |
| EPA | Environmental Protection Agency (U.S.) |
| FTC | flow-through cell |
| IC | ion chromatography |
| ICPMS | inductively coupled (argon) plasma mass spectrometry |
| ICPOES | inductively coupled (argon) plasma optical emission spectroscopy |
| I.D. | inside diameter |
| LANL | Los Alamos National Laboratory |
| LSRS | LATA-SHARP Remediation Service, LLC |
| LWSP | LANL Water Stewardship Program |
| MDA | material disposal area |
| mgC/L | milligram carbon per liter |
| NMED | New Mexico Environment Department |
| NMSW | New Mexico special waste |
| NTU | nephelometric turbidity unit |
| O.D. | outside diameter |
| ORP | oxidation-reduction potential |
| RCRA | Resource Conservation and Recovery Act |
| RP-1 | Radiation Protection 1 |
| RPF | Records Processing Facility |
| SP | specific conductance |
| T | temperature |
| TA | technical area |
| TD | total depth |
| TOC | total organic carbon |
| WDC | WDC Exploration & Wells |
| Weatherford | Weatherford Completion & Oilfield Services |

## A-2.0 METRIC CONVERSION TABLE

| Multiply SI (Metric) Unit | by | To Obtain U.S. Customary Unit |
|---|---|---|
| kilometers (km) | 0.622 | miles (mi) |
| kilometers (km) | 3281 | feet (ft) |
| meters (m) | 3.281 | feet (ft) |
| meters (m) | 39.37 | inches (in.) |
| centimeters (cm) | 0.03281 | feet (ft) |
| centimeters (cm) | 0.394 | inches (in.) |
| millimeters (mm) | 0.0394 | inches (in.) |
| micrometers or microns (µm) | 0.0000394 | inches (in.) |
| square kilometers (km$^2$) | 0.3861 | square miles (mi$^2$) |
| hectares (ha) | 2.5 | acres |
| square meters (m$^2$) | 10.764 | square feet (ft$^2$) |
| cubic meters (m$^3$) | 35.31 | cubic feet (ft$^3$) |
| kilograms (kg) | 2.2046 | pounds (lb) |
| grams (g) | 0.0353 | ounces (oz) |
| grams per cubic centimeter (g/cm$^3$) | 62.422 | pounds per cubic foot (lb/ft$^3$) |
| milligrams per kilogram (mg/kg) | 1 | parts per million (ppm) |
| micrograms per gram (µg/g) | 1 | parts per million (ppm) |
| liters (L) | 0.26 | gallons (gal.) |
| milligrams per liter (mg/L) | 1 | parts per million (ppm) |
| degrees Celsius (°C) | 9/5 + 32 | degrees Fahrenheit (°F) |

## A-3.0 DATA QUALIFIER DEFINITIONS

| Data Qualifier | Definition |
|---|---|
| U | The analyte was analyzed for but not detected. |
| J | The analyte was positively identified, and the associated numerical value is estimated to be more uncertain than would normally be expected for that analysis. |
| J+ | The analyte was positively identified, and the result is likely to be biased high. |
| J- | The analyte was positively identified, and the result is likely to be biased low. |
| UJ | The analyte was not positively identified in the sample, and the associated value is an estimate of the sample-specific detection or quantitation limit. |
| R | The data are rejected as a result of major problems with quality assurance/quality control (QA/QC) parameters. |

# Appendix B

## *Well R-37 Lithologic Log*

# LATA-Sharp Remediation Services, Inc.
# Borehole Log

**Project: TA-54 Regional Aquifer Wells** **Page 1 of 10**

**Borehole Location ID:** R-37

**Technical Area - 54**

**AOC/SWMU:** NA

**Drilling Company:** WDC Exploration and Wells

**Drilling Equipment:** Foremost DR-24

**Geologist:** Jon Marin

**Sampling Equipment:** Airlift, bail, and pump

**Date:** April 17 to May 27, 2009

**Attitude:** Vertical

**Drill Operator:** Shawn Edwards

**DTW 1st BH Perched (ft):** 893.4 08/21/08

**DTW R-37 Screen 1 Perched (ft):** 909.6 06/29/09

**DTW R-37 Screen 2 Regional (ft):** 1009.6 06/29/09

**Total Depth (ft):** 1100

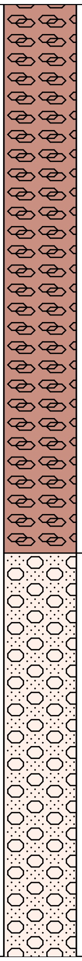
| Depth (ft) | Radiological Screening | Cuttings Sample |
|---|---|---|
| 0 | | |
| | NDA | chips |
| 10 | NDA | chips |
| | NDA | chips |
| 20 | NDA | chips |
| | NDA | chips |
| 30 | NDA | chips |
| | NDA | chips |
| 40 | NDA | chips |
| | NDA | chips |
| 50 | NDA | chips |
| | NDA | chips |
| 60 | NDA | chips |
| | NDA | chips |
| 70 | NDA | chips |
| | NDA | chips |
| 80 | NDA | chips |
| | NDA | chips |
| 90 | NDA | chips |

24" Casing (0 to 20'): casing (removed)

16" Casing (0' to 565'): 16-inch welded steel casing (abandoned in place)

12" casing (0 to 1080'): 12-inch welded steel casing (removed)

Graphic Log



**Lithology**

(0.0, 52.0)
Qbt2: Cooling Unit 2, Tshirege Member, Bandelier Tuff. Reddish gray 10R5/1 to light gray 10R7/1, devitrified, lithic-bearing, pumiceous, moderately welded and indurated ash-flow tuff.

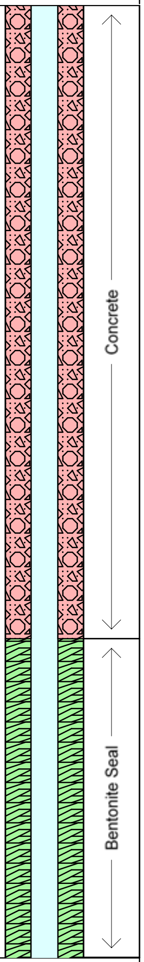
(52.0, 145.0)
Qbt1v: Cooling Unit 1v, Tshirege Member, Bandelier Tuff. Pinkish gray 5YR6/2 to whitish gray, devitrified, lithic-bearing, pumiceous, non-welded, non- to weakly-indurated (soft) ash-flow tuff.

**Notes**

R-37 is located in TA-54 approximately 0.25 mi east of MDA J, 0.4 mi. east of MDA H, and 0.8 mi northwest of MDA L.

All depths are in feet below ground surface (ft bgs).

R-37 Well Construction / Annular Backfill Material



bgs = below ground surface; DTW = Depth to Water (ft bgs); NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Radiological Screening peformed on cuttings for curation; SAA = same as above; SS = A304 stainless steel; TD = Total Depth;

## LATA-Sharp Remediation Services, Inc.
## Borehole Log

**TA-54 Regional Aquifer Wells**

**Well Location ID:** R-37

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| Depth (ft) | Radiological Screening | 24" Casing (0 to 20') | 16" Casing (0' to 565') | 12" casing (0 to 1080') | Cuttings Sample | Graphic Log | Lithology | Notes | R-37 Well Construction | Annular Backfill Material |
|---|---|---|---|---|---|---|---|---|---|---|
| 90 | | | 16-inch welded steel casing (abandoned in place) | 12-inch welded steel casing (removed) | | | Qbt1v continued. Pinkish gray 5YR6/2 to whitish gray, devitrified, lithic-bearing, pumiceous, non-welded, non- to weakly-indurated (soft) ash-flow tuff. | | | Bentonite Seal |
| | NDA | | | | chips | | | | | |
| 100 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 110 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 120 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 130 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | From 135 to 145 ft, same as above (SAA) except brownish gray, moderately indurated, with lithics up to 5 %. | | | |
| 140 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | (145.0, 228.0)<br>Qbt1g: Cooling Unit 1g, Tshirege Member, Bandelier Tuff. Pinkish gray 5YR6/2 vitric, weakly indurated, ash flow tuff; vitric pumice fragments have well defined tube structures, phenocrysts are quartz and sanidine, lithics are mostly dacite, slightly magnetic from minute magnetite crystals. | Vapor Phase Notch | | |
| 150 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 160 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 170 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 180 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 190 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 200 | NDA | | | | chips | | | | | |

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# LATA-Sharp Remediation Services, Inc.
# Borehole Log

**TA-54 Regional Aquifer Wells**

**Well Location ID:** R-37

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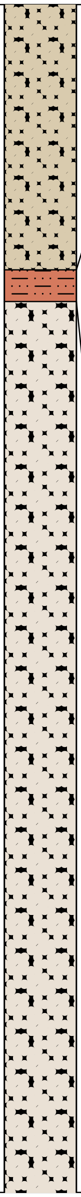
| Depth (ft) | Radiological Screening | Cuttings Sample |
|---|---|---|
|  | NDA | chips |
| 210 | NDA | chips |
|  | NDA | chips |
| 220 | NDA | chips |
|  | NDA | chips |
| 230 | NDA | chips |
|  | NDA | chips |
| 240 | NDA | chips |
|  | NDA | chips |
| 250 | NDA | chips |
|  | NDA | chips |
| 260 | NDA | chips |
|  | NDA | chips |
| 270 | NDA | chips |
|  | NDA | chips |
| 280 | NDA | chips |
|  | NDA | chips |
| 290 | NDA | chips |
|  | NDA | chips |
| 300 | NDA | chips |
|  | NDA | chips |
| 310 | NDA | chips |
|  | NDA | chips |

24" Casing (0 to 20')

16" Casing (0' to 565'): 16-inch welded steel casing (abandoned in place)

12" casing (0 to 1080'): 12-inch welded steel casing (removed)

Graphic Log



**Lithology**

Qbt1g continued. SAA, pinkish gray 5YR6/2 vitric, weakly indurated, ash flow tuff.

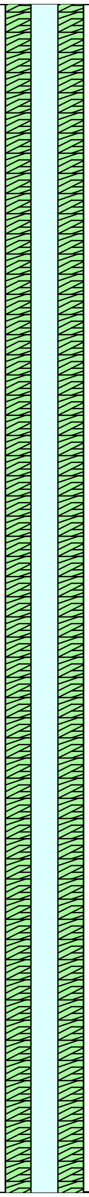
From 225 ft to 228 ft, pumice lapilli up to 20% indicate Tsankawi Pumice Bed at lower conact.

(228.0, 231.0)
Qct: Tephras and volcaniclastic sediments of the Cerro Toledo interval; mostly reworked Otowi Formation tuff and pumice deposits, some sand and gravel lenses, few dacite cobbles and boulders.

(231.0, 490.0)
Qbo: Otowi Member; pinkish gray 5YR7/2 vitric ash flow tuff, vitric pumice fragments, phenocrysts are quartz and sanidine, lithics are mostly dacite, slightly magnetic from minute magnetite crystals.

**Notes**

R-37 Well Construction



Annular Backfill Material: Bentonite Seal

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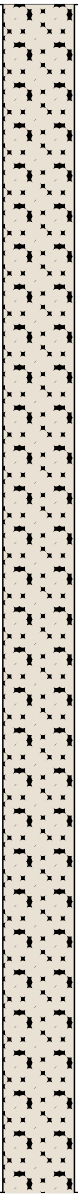
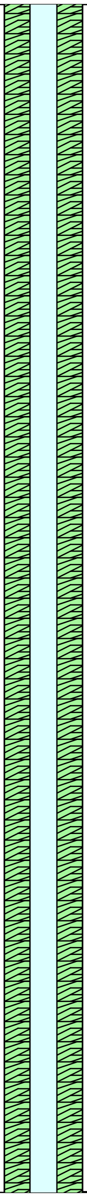
# Borehole Log

**TA-54 Regional Aquifer Wells**

**Well Location ID:** R-37





| Depth (ft) | Radiological Screening | 24" Casing (0 to 20') | 16" Casing (0' to 565') | 12" casing (0 to 1080') | Cuttings Sample | Graphic Log | Lithology | Notes | R-37 Well Construction | Annular Backfill Material |
|---|---|---|---|---|---|---|---|---|---|---|
| 320 | NDA | | 16-inch welded steel casing (abandoned in place) | 12-inch welded steel casing (removed) | chips | | Otowi Member continued. Pinkish gray 5YR7/2 vitric ash flow tuff, vitric pumice fragments, phenocrysts are quartz and sanidine, lithics are mostly dacite. | | | Bentonite Seal |
| | NDA | | | | chips | | | | | |
| 330 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 340 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 350 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 360 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 370 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 380 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 390 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 400 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 410 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 420 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |

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# LATA-Sharp Remediation Services, Inc.
# Borehole Log

**TA-54 Regional Aquifer Wells**

**Well Location ID:** R-37

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| Depth (ft) | Radiological Screening | 24" Casing (0 to 20') | 16" Casing (0' to 565') | 12" casing (0 to 1080') | Cuttings Sample | Graphic Log | Lithology | Notes | R-37 Well Construction | Annular Backfill Material |
|---|---|---|---|---|---|---|---|---|---|---|
| 430 | NDA | | 16-inch welded steel casing (abandoned in place) | 12-inch welded steel casing (removed) | chips | | Otowi Member continued. Pinkish gray 5YR7/2 vitric ash flow tuff, vitric pumice fragments, phenocrysts are quartz and sanidine, lithics are mostly dacite. | | | Bentonite Seal |
| | NDA | | | | chips | | | | | |
| 440 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 450 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 460 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 470 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 480 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 490 | NDA | | | | chips | | (490.0, 501.0)<br>Qbog: Guaje Pumice Bed consisting of whitish gray, vitric and equant pumice lapilli up to 3 cm, ash, and dacite lithics. | | | |
| | NDA | | | | chips | | | | | |
| 500 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | (501.0, 933.0)<br>Tb4: Cerros del Rio basalt; dark gray N4/1, massive, slightly magnetic, few small (< 1mm) vesicles.<br>From 501 ft to 525 ft, SAA, weathered basalt, weakly oxidized. | | | |
| 510 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 520 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 530 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 540 | NDA | | | | chips | | | | | |

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## Borehole Log

**TA-54 Regional Aquifer Wells**

**Well Location ID:** R-37

| Depth (ft) | Radiological Screening | 24" Casing (0 to 20') | 16" Casing (0' to 565') | 12" casing (0 to 1080') | Cuttings Sample | Graphic Log | Lithology | Notes | R-37 Well Construction | Annular Backfill Material |
|---|---|---|---|---|---|---|---|---|---|---|
| 540 | | | 16-inch casing | 12-inch welded steel casing (removed) | | | At 540 ft, very dark gray 5YR3/1, massive, no vesicles, moderately magnetic. | | | Bentonite Seal |
| | NDA | | | | chips | | | | | |
| 550 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 560 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | From 565 ft to 580 ft, well sorted medium grained basalt gravel. | | | |
| 570 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 580 | NDA | | | | chips | | From 580 ft to 590 ft, highly vesicular basalt to moderately oxidixed scoria. | | | |
| | NDA | | | | chips | | | | | |
| 590 | NDA | | | | chips | | From 590 ft to 595 ft, gray 5YR5/1, massive basalt, few euhedral olivine crystals up to 0.5 mm. | | | |
| | NDA | | | | chips | | | | | |
| 600 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 610 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 620 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | From 625 ft to 645 ft, basalt, moderately oxidized, slightly vesicular. | | | |
| 630 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 640 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | From 645 ft to 660 ft, slightly oxidized, highly vesicular. | | | |
| 650 | NDA | | | | chips | | | | | |

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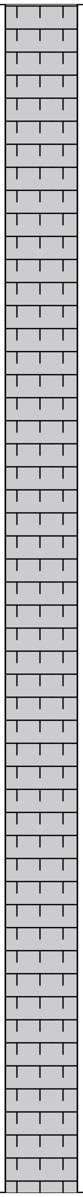
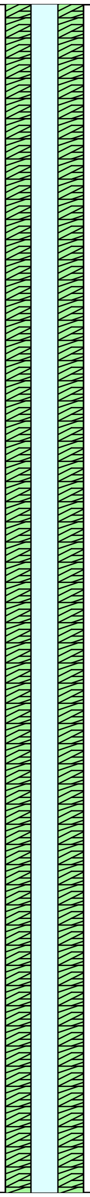
# Borehole Log

**TA-54 Regional Aquifer Wells**

**Well Location ID:** R-37

| Depth (ft) | Radiological Screening | 24" Casing (0 to 20') | 16" Casing (0' to 565') | 12" casing (0 to 1080') | Cuttings Sample | Graphic Log | Lithology | Notes | R-37 Well Construction | Annular Backfill Material |
|---|---|---|---|---|---|---|---|---|---|---|
| | NDA | | | 12-inch welded steel casing (removed) | chips | | | | | Bentonite Seal |
| **660** | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | From 660 ft to 670 ft, massive aphanitic basalt, dark gray 5YR4/1, slightly- to moderately-magnetic. | | | |
| **670** | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | From 670 ft to 685 ft, SAA, coated with light gray dust. | | | |
| **680** | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| **690** | NDA | | | | chips | | From 685 ft to 695 ft, SAA, 20% weakly oxidized basalt. | | | |
| | NDA | | | | chips | | From 695 ft to 705 ft, SAA, non- to slightly-magnetic. | | | |
| **700** | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| **710** | NDA | | | | chips | | From 705 ft to 725 ft, slightly oxidized, moderately vesicular to scoriaceous. | | | |
| | NDA | | | | chips | | | | | |
| **720** | NDA | | | | chips | | From 725 ft to 730 ft, mostly SAA massive basalt with 20% fine-grained felsic sandstone, reddish brown 5YR 5/3. | | | |
| | NDA | | | | chips | | | | | |
| **730** | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | From 730 ft to 930 ft, massive aphanitic unoxidixed basalt, dark gray 5YR4/1, few minute vesicles < 0.2 mm, slightly to moderately magnetic. | | | |
| **740** | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| **750** | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| **760** | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |





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# LATA-Sharp Remediation Services, Inc.
## Borehole Log

**TA-54 Regional Aquifer Wells**
**Well Location ID:** R-37

| Depth (ft) | Radiological Screening | 24" Casing (0 to 20') | 16" Casing (0' to 565') | 12" casing (0 to 1080') | Cuttings Sample | Graphic Log | Lithology | Notes | R-37 Well Construction | Annular Backfill Material |
|---|---|---|---|---|---|---|---|---|---|---|
| 770 | NDA | | | 12-inch welded steel casing (removed) | chips | | Massive aphanitic unoxidixed basalt continued. | Massive basalt from 730 ft to 930 ft is the basal flow the Cerros del Rio basalt, Qb4. | | Bentonite Seal |
| | NDA | | | | chips | | | | | |
| 780 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 790 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 800 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 810 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 820 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 830 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 840 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 850 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 860 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |
| 870 | NDA | | | | chips | | | | | |
| | NDA | | | | chips | | | | | |

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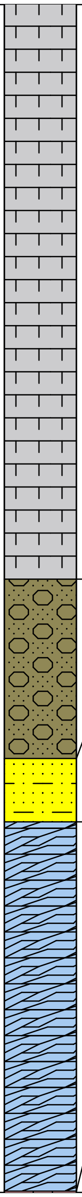
# Borehole Log

**TA-54 Regional Aquifer Wells**

**Well Location ID:** R-37

| Depth (ft) | Radiological Screening | 24" Casing (0 to 20') | 16" Casing (0' to 565') | 12" casing (0 to 1080') | Cuttings Sample |
|---|---|---|---|---|---|
| 880 | NDA | | | 12-inch welded steel casing (removed) | chips |
| | NDA | | | | chips |
| 890 | NDA | | | | chips |
| | NDA | | | | chips |
| 900 | NDA | | | | chips |
| | NDA | | | | chips |
| 910 | NDA | | | | chips |
| | NDA | | | | chips |
| 920 | NDA | | | | chips |
| | NDA | | | | chips |
| 930 | NDA | | | | chips |
| | NDA | | | | chips |
| 940 | NDA | | | | chips |
| | NDA | | | | chips |
| 950 | NDA | | | | chips |
| | NDA | | | | chips |
| 960 | NDA | | | | chips |
| | NDA | | | | chips |
| 970 | NDA | | | | chips |
| | NDA | | | | chips |
| 980 | NDA | | | | chips |
| | NDA | | | | chips |
| 990 | NDA | | | | chips |

Graphic Log



## Lithology

From 885 ft to 930 ft, SAA massive basalt with few euhedral light green olivine crystals.

(933.0, 950.0)
Tpf basaltic gravel: Well-rounded basalt gravel and cobbles with up to 30% light brown to pinkish gray 5YR7/2 siltstone, slightly magnetic.

(950.0, 956.0)
Tpf silts and fine gravel: Pinkish gray 5YR7/2, slightly magnetic.

(956.0, 991.0)
Tpf claystone: Light gray 5YR7/1 clay, shale, and siltstone, non-magnetic.

(991.0, 1000.0)
Tpf basaltic scoria gravel:

## Notes

DTW of perched groundwater on 6/29/09, 16 hours after packer installed.

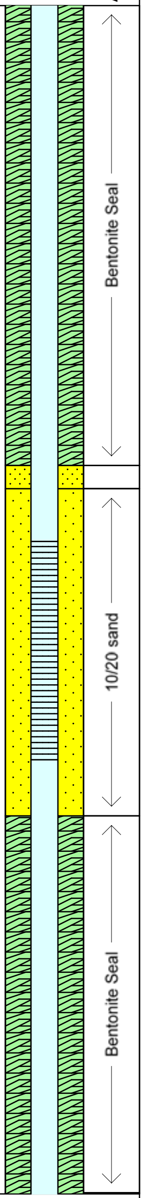
Transition sand, 20/40 =>

R-37 Screen 1: 20-slot wire-wrapped SS from 929.3 ft to 950 ft bgs.

In the 1st borehole, this subunit was 60 ft thick and was mostly fine-grained quartz sand with accessory muscovite.

Drilling pressure rose from 956 ft to 991 ft.

R-37 Well Construction / Annular Backfill Material



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## Borehole Log

**TA-54 Regional Aquifer Wells**

**Well Location ID:** R-37

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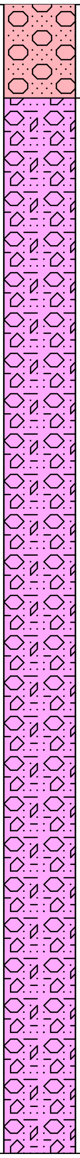
| Depth (ft) | Radiological Screening | 24" Casing (0 to 20') | 16" Casing (0' to 565') | 12" casing (0 to 1080') | Cuttings Sample |
|---|---|---|---|---|---|
| 990 | | | | 12-inch welded steel casing (removed) | |
| | NDA | | | | chips |
| 1000 | NDA | | | | chips |
| | NDA | | | | chips |
| 1010 | NDA | | | | chips |
| | NDA | | | | chips |
| 1020 | NDA | | | | chips |
| | NDA | | | | chips |
| 1030 | NDA | | | | chips |
| | NDA | | | | chips |
| 1040 | NDA | | | | chips |
| | NDA | | | | chips |
| 1050 | NDA | | | | chips |
| | NDA | | | | chips |
| 1060 | NDA | | | | chips |
| | NDA | | | | chips |
| 1070 | NDA | | | | chips |
| | NDA | | | | chips |
| 1080 | NDA | | | | chips |
| | NDA | | | | chips |
| 1090 | NDA | | | | chips |
| | NDA | | | | chips |
| 1100 | NDA | | | | chips |

Graphic Log



**Lithology**

Moderately oxidized highly vesicular to scoriaceous basalt gravel, non-magnetic.

(1000.0, 1100.0)
Tpf: Puye Formation fanglomerate deposits consisting mostly of poorly sorted porphyritic dacite sand, gravel, pebbles, cobbles, and boulders.

Boulder from 1015 ft to 1020 ft.

Boulder from 1074 ft to 1078 ft.

Boulder from 1088 ft to 1092 ft.

TD = 1,100 ft bgs

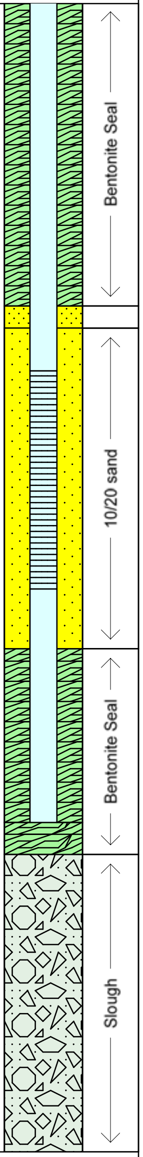
**Notes**

DTW of regional groundwater on 6/29/09, 16 hours after packer installed.

Transition sand, 20/40 =>

R-37 Screen 2: 20-slot wire-wrapped SS from 1026.0 ft to 1046.6 ft bgs.

R-37 Well Construction / Annular Backfill Material



bgs = below ground surface; DTW = Depth to Water (ft bgs); NDA = No Detectable Activity > 2 X daily- and location-specific radiological background value; Radiological Screening peformed on cuttings for curation; SAA = same as above; SS = A304 stainless steel; TD = Total Depth;

# Appendix C

*Groundwater Analytical Results*

## C-1.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT R-37

Five groundwater-screening samples were collected during drilling of two of the three boreholes before installing well R-37. Two groundwater-screening samples were collected from the first borehole, and three groundwater-screening samples were collected from the third borehole at R-37. The second borehole did not encounter perched or regional aquifer groundwater due to broken casing that could not be removed from the borehole. Drilling to greater depths was abandoned at this borehole site. One groundwater-screening sample was collected at borehole 1 from a perched intermediate depth zone within the Puye Formation at a depth of 925 ft bgs. Four additional regional aquifer water samples were collected during drilling, including one sample collected from R-37 borehole 1 at a depth of 1070 ft below ground surface (bgs) and three samples pumped from R-37 borehole 3 at depths of 1020, 1040, and 1052 ft bgs. These four borehole-screening samples were collected within the Puye Formation. The borehole-screening samples were analyzed for dissolved cations, anions, perchlorate, and metals. A total of 13 groundwater-screening samples were collected from well R-37 during development only for analyses of total organic carbon (TOC). Eight groundwater-screening samples were collected from R-37 screen 1 at depths of 906.6 and 980 ft bgs, and five samples were collected from R-37 screen 2 at a depth of 1044.4 ft bgs. A total of 18,645 gal. of groundwater was pumped from R-37 during development, and an additional 10,390 gal. of groundwater was pumped from the well during aquifer performance testing.

### C-1.1 Field Preparation and Analytical Techniques

Chemical analyses of groundwater-screening samples were performed at Los Alamos National Laboratory's (LANL's or the Laboratory's) Earth and Environmental Sciences Group 14 (EES-14). Groundwater samples were filtered (0.45-µm membranes) before preservation and chemical analyses. Samples were acidified at the EES-14 wet chemistry laboratory with analytical grade nitric acid to a pH of 2.0 or less for metal and major cation analyses.

Groundwater samples were analyzed using techniques specified by the U.S. Environmental Protection Agency (EPA) methods for water analyses. Ion chromatography (IC) (EPA Method 300, Rev. 2.1) was the analytical method for bromide, chloride, fluoride, nitrate, nitrite, oxalate, perchlorate, phosphate, and sulfate. The instrument detection limits for perchlorate were 0.002 and 0.005 ppm (or mg/L) (EPA Method 314.0, Rev. 1). Inductively coupled (argon) plasma optical emission spectroscopy (ICPOES) (EPA Method 200.7, Rev. 4.4) was used for analyses of dissolved aluminum, barium, boron, calcium, total chromium, iron, lithium, magnesium, manganese, potassium, silica, sodium, strontium, titanium, and zinc. Dissolved aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, cesium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silver, thallium, thorium, tin, vanadium, uranium, and zinc were analyzed by inductively coupled (argon) plasma mass spectrometry (ICPMS) (EPA Method 200.8, Rev. 5.4). The precision limits (analytical error) for major ions and trace elements were generally less than ±7% using ICPOES and ICPMS. Total carbonate alkalinity (EPA Method 310.1) was measured using standard titration techniques. No groundwater samples were collected for TOC analyses at R-37 before well development. Analyses of TOC were performed on groundwater samples collected during well development following EPA Method 415.1. Charge balance errors for total cations and anions were generally less than ±5% for complete analyses of the above inorganic chemicals. The negative cation-anion charge balance values indicate excess anions for the filtered samples.

## C-1.2 FIELD PARAMETERS

### C-1.2.1 Well Development

Results of field parameters, consisting of pH, temperature, dissolved oxygen (DO), specific conductance, and turbidity measured during development at well R-37, are provided in Table C-1.2-1. Oxidation-reduction potential (ORP) was not measured in groundwater pumped from well R-37 screens 1 and 2. Field measurements of pH and temperature varied from 7.44 to 8.62 and from 16.1°C to 28.9°C, respectively, in groundwater pumped from well R-37 screen 1 during development. Background minimum, mean, median, and maximum pH values are 6.73, 7.62, 7.39, and 10.14, respectively, for perched intermediate groundwater (LANL 2007, 095817), which provides a basis for selecting reliable pH values for well R-37 screen 1 during development and aquifer testing. Typical groundwater temperatures within perched intermediate depth aquifers range from 15°C to 18°C at Los Alamos. Background temperature and median pH measurements are generally consistent with those measured at several other perched intermediate depth wells, including LAOI-3.2, LAO-3.2a, R-6i, LAOI-7, R-3i, MCOI-4, MCOI-5, and MCOI-6. Concentrations of DO ranged from 0.01 to 1.05 mg/L during development of well R-37 screen 1. These DO values are not considered to be reliable and representative of the known relatively oxidizing conditions characteristic of perched intermediate zones beneath the Pajarito Plateau. Specific conductance varied from 246 to 321 microsiemens per centimeter (μS/cm), and turbidity ranged from 0 to 398 nephelometric turbidity units (NTUs) during development of R-37 screen 1 (Table C-1.2-1).

Field measurements of pH and temperature varied from 6.4 to 8.75 and from 17.2°C to 27.1°C, respectively, in groundwater pumped from well R-37 screen 2 during development. Background minimum, mean, median, and maximum pH values are 6.43, 7.83, 7.82, and 8.96, respectively, in regional aquifer groundwater (LANL 2007, 095817), which provides a basis for selecting reliable pH values for well R-37 screen 2 during development and aquifer testing. Typical groundwater temperatures within the regional aquifer range from 18°C to 22°C at Los Alamos. Concentrations of DO ranged from 0.81 to 10.75 mg/L. Realistic concentrations of DO in groundwater samples collected from the regional aquifer range from 3.0 to 7.0 mg/L with lower concentrations of DO occurring in samples with higher temperatures. Specific conductance generally decreased from 326 to 223 μS/cm, and turbidity varied from 4 to 134 NTUs during development of well R-37 screen 2 (Table C-1.2-1).

### C-1.2.2 Aquifer Performance Testing

During aquifer performance testing at well R-37 screen 1, 26 measurements of pH and temperature varied from 7.54 to 8.69 and from 15.9°C to 27.8°C, respectively (Table C-1.2-1). Concentrations of DO varied from 0.11 to 0.45 mg/L during aquifer performance testing of well R-37 screen 1. Specific conductance varied from 246 to 323 μS/cm and turbidity decreased from 8 to 0 NTUs for groundwater pumped from well R-37 screen 1 during aquifer performance testing. Only 1 of the 26 measurements exceeded 5 NTUs during this phase of testing at the well.

During aquifer performance testing conducted at well R-37 screen 2, 25 measurements of pH and temperature varied from 6.88 to 8.03 and from 17.6°C to 23.1°C, respectively (Table C-1.2-1). Concentrations of DO varied from 0.74 to 1.54 mg/L during aquifer performance testing of well R-37 screen 2. Specific conductance and turbidity generally decreased from 286 to 197 μS/cm and from 6 to 1 NTUs for groundwater pumped from R-37 screen 2 during aquifer performance testing. Only 1 of the 25 measurements exceeded 5 NTUs during this phase of testing at the well.

### C-1.3 Analytical Results for Groundwater-Screening Samples

#### C-1.3.2 Borehole Samples

Analytical results for groundwater-screening samples collected at R-37 during drilling, well development, and aquifer performance testing are provided in Table C-1.3-1. Anions, including chloride, fluoride, nitrate, perchlorate, and sulfate, are discussed because they can occur as contaminant tracers released from the Laboratory. A discussion about trace metals, excluding molybdenum, chromium, and uranium, is not presented for the borehole-screening water samples. Water pumped from R-37 boreholes 1 and 3 during drilling contains regional aquifer groundwater, municipal supply water used during drilling, and dissolved and suspended chemicals released from the disaggregation of aquifer material containing clay minerals, ferric (oxy)hydroxide, manganese oxide, and silicates. Elevated concentrations of aluminum, iron, and manganese typically occur in the borehole water samples, resulting from disaggregation and partial mineral dissolution in the presence of organic-based drilling fluid (AQF-2) used during drilling.

Calcium and sodium are the dominant cations measured in the R-37 borehole-screening sample collected from the perched intermediate depth zone (Table C-1.3-1). Dissolved concentrations of calcium and sodium were 16.66 and 21.20 ppm, or mg/L, respectively, in a sample collected from the first borehole on August 20, 2008. Concentrations of chloride, fluoride, nitrate(N), and sulfate in this filtered sample were 5.22, 1.61, 1.15, and 9.61 ppm, respectively. The dissolved concentration of molybdenum was 0.089 ppm (0.089 mg/L, 89 ppb, or 89 μg/L) in the borehole sample. Dissolved concentrations of chromium and uranium were 0.001 and 0.0006 ppm, respectively (Table C-1.3-1). Concentrations of fluoride, nitrate(N), and molybdenum in the borehole-screening sample are elevated above those typically observed in background-perched intermediate depth wells installed on the Pajarito Plateau. Lubricants used during drilling of R-37 are the most likely source of molybdenum detected in borehole water samples collected from R-37. Concentrations of molybdenum generally decrease to the low part per billion range (<3 ppb) during development and aquifer testing in the absence of contamination resulting from past cooling tower releases that contained soluble sodium molybdate.

Calcium and sodium are the dominant cations in regional aquifer groundwater collected from R-37 during drilling. Dissolved concentrations of calcium and sodium ranged from 12.91 to 19.48 ppm (or mg/L) and from 17.03 to 39.40 ppm, respectively (Table C-1.3-1). Dissolved concentrations of chloride and fluoride ranged from 6.21 to 14.48 ppm and from 0.38 to 0.70 ppm, respectively, in the borehole water samples collected from the regional aquifer. Dissolved concentrations of nitrate(N) and sulfate ranged from 0.09 to 0.51 ppm and from 4.37 to 16.12 ppm, respectively. Concentrations of perchlorate were less than analytical detection (<0.002 and <0.005 ppm, IC method) in borehole-screening samples collected from R-37 (Table C-1.3-1).

Dissolved concentrations of molybdenum ranged from 0.025 to 0.064 ppm in regional aquifer borehole samples collected from R-37 (Table C-1.3-1). Concentrations of dissolved chromium ranged from 0.001 to 0.003 ppm in borehole water samples collected from R-37. Dissolved chromium concentrations can be less than background (3 to 7 ppb) for the regional aquifer during drilling because natural chromium either adsorbs onto abundant suspended particles with high surface areas present in turbid water samples and/or precipitates from solution as chromium hydroxide in the presence of organic drilling fluid (AQF-2) acting as a chemical reductant. Concentrations of dissolved uranium ranged from 0.0006 to 0.0036 ppm in the borehole water samples. Exposure of fresh mineral surfaces during drilling may have enhanced leaching or desorption of uranium from aquifer material.

### C-1.3.3 Aquifer Performance Testing

TOC was the only constituent analyzed during well development to monitor removal of residual drilling fluids from R-37. Concentrations of TOC varied from 0.62 to 60.5 milligrams carbon per liter (mgC/L) in groundwater-screening samples collected from R-37 screen 1 during development. The concentration of TOC was 1.78 mgC/L in the final sample collected during well development of R-37 screen 1. This analyte generally decreased in concentration from 1.11 to 0.70 mgC/L in samples collected from R-37 screen 2 during development. Median background concentrations of TOC are 0.45 and 0.34 mgC/L for perched intermediate and regional aquifer groundwater, respectively (LANL 2007, 095817).

## C-2.0 REFERENCE

*The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.*

*Copies of the master reference set are maintained at the New Mexico Environment Department Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.*

LANL (Los Alamos National Laboratory), May 2007. "Groundwater Background Investigation Report, Revision 3," Los Alamos National Laboratory document LA-UR-07-2853, Los Alamos, New Mexico. (LANL 2007, 095817)

## Table C-1.2-1
## Well Development and Aquifer Test Volumes and Field Water-Quality Parameter Measurements at Well R-37 Screen 2

| Date | Time | pH | SP[a] (µS/cm) | T[b] (°C) | Turbidity (NTU) | DO[c] (mg/L) | TOC Result (ppm) | End-of-Day Cumulative Purge Volume (gal.) |
|---|---|---|---|---|---|---|---|---|
| **Screen 2 Well Development** | | | | | | | | |
| 06/11/09 | 1023 | 9.54 | 273 | 19 | 999 | —[d] | — | 500 bailed |
| 06/15/09 | 1035 | — | — | — | — | — | 1.1 | — |
| 06/15/09 | 1046 | 6.73 | 271 | 21.4 | 46 | 2.15 | — | — |
| 06/15/09 | 1056 | 6.56 | 271 | 20.4 | 67 | 8.55 | — | — |
| 06/15/09 | 1106 | 6.55 | 270 | 21.3 | 69 | 2.06 | — | — |
| 06/15/09 | 1110 | 6.49 | 258 | 21.1 | 63 | 9.4 | — | — |
| 06/15/09 | 1120 | 6.71 | 267 | 21.4 | 69 | 8.13 | — | — |
| 06/15/09 | 1132 | 6.7 | 267 | 21.6 | 69 | 8.73 | — | — |
| 06/15/09 | 1140 | 6.7 | 264 | 20.2 | 99 | 8.6 | — | — |
| 06/15/09 | 1149 | 6.8 | 263 | 21.3 | 71 | 8.74 | — | — |
| 06/15/09 | 1201 | — | 266 | 20.9 | 134 | 8.71 | — | — |
| 06/15/09 | 1225 | 6.4 | 318 | 22.3 | 52 | 8.33 | — | — |
| 06/15/09 | 1348 | 6.9 | 313 | 23.7 | 25 | 7.95 | — | — |
| 06/15/09 | 1400 | 7.3 | 317 | 21.7 | 44 | 7.7 | — | — |
| 06/15/09 | 1416 | 7.74 | 314 | 22.7 | 68 | 8.03 | — | — |
| 06/15/09 | 1448 | 7.54 | 314 | 23.2 | 60 | 7.7 | — | — |
| 06/15/09 | 1511 | 7.69 | 309 | 22.5 | 40 | 7.76 | — | — |
| 06/15/09 | 1517 | 7.76 | 307 | 21.9 | 32 | 8.84 | — | — |
| 06/15/09 | 1523 | 8.58 | 307 | 21.2 | 42 | 8.72 | — | — |
| 06/15/09 | 1529 | 8.56 | 305 | 21 | 43 | 8.59 | — | — |
| 06/15/09 | 1534 | 7.58 | 305 | 20.9 | 29 | 8.35 | — | — |
| 06/15/09 | 1541 | 7.53 | 305 | 21.8 | 23 | 8.15 | — | — |
| 06/15/09 | 1600 | 7.55 | 307 | 22 | 48 | 8.52 | — | — |
| 06/15/09 | 1640 | 7.46 | 304 | 22.1 | 68 | 8.12 | — | — |
| 06/15/09 | 1645 | 7.53 | 296 | 21.2 | 71 | 8.06 | — | — |
| 06/15/09 | 1700 | 7.71 | 297 | 21.7 | 8 | 8.24 | 0.69 | 3614.4 |
| 06/16/09 | 0705 | — | — | — | — | — | — | — |
| 06/16/09 | 0720 | 8.16 | 306 | 19.7 | 65 | 8.36 | 0.82 | — |
| 06/16/09 | 0820 | 8.04 | 326 | 21 | 10 | 0.81 | — | — |
| 06/16/09 | 0920 | 8.26 | 390 | 21.7 | 7 | 0.87 | — | — |
| 06/16/09 | 0920 | 8.26 | 390 | 21.7 | 7 | 0.87 | — | — |
| 06/16/09 | 1020 | 8.19 | 315 | 23.3 | 7 | 0.85 | — | — |
| 06/16/09 | 1122 | 8.09 | 277 | 24.1 | 6 | 0.99 | — | — |
| 06/16/09 | 1221 | 8.16 | 280 | 24.2 | 8 | 1.01 | — | — |

### Table C-1.2-1 (continued)

| Date | Time | pH | SP[a] (µS/cm) | T[b] (°C) | Turbidity (NTU) | DO[c] (mg/L) | TOC Result (ppm) | End-of-Day Cumulative Purge Volume (gal.) |
|---|---|---|---|---|---|---|---|---|
| 06/16/09 | 1321 | 8.07 | 273 | 26 | 7 | 1.03 | — | — |
| 06/16/09 | 1600 | 8.36 | 259 | 25 | 65 | 8.28 | — | — |
| 06/16/09 | 1627 | 8.18 | 254 | 22.1 | 14 | — | — | — |
| 06/16/09 | 1635 | 7.97 | 254 | 20.3 | 7 | — | 0.75 | — |
| 06/16/09 | 1644 | 7.92 | 251 | 20.3 | 82 | 8.47 | — | — |
| 06/16/09 | 1655 | — | — | — | — | — | — | 7684.4 |
| 06/17/09 | 0703 | — | — | — | — | — | — | — |
| 06/17/09 | 0720 | 7.92 | 264 | 17.2 | 75 | 8.43 | — | — |
| 06/17/09 | 0732 | — | — | — | — | — | 0.7 | — |
| 06/17/09 | 0746 | 7.77 | 258 | 17.5 | 66 | 8.62 | — | — |
| 06/17/09 | 0900 | 8.0 | 252 | 21.2 | 9 | 8.42 | — | — |
| 06/17/09 | 1000 | 8.25 | 251 | 21.8 | 8 | 9.25 | — | — |
| 06/17/09 | 1100 | 7.72 | 231 | 24.1 | 10 | 8.36 | — | — |
| 06/17/09 | 1200 | 7.62 | 230 | 25 | 10 | 8.3 | — | — |
| 06/17/09 | 1300 | 8.02 | 265 | 22.5 | 8 | 10.75 | — | — |
| 06/17/09 | 1400 | 8.17 | 239 | 20.8 | 6 | 8.32 | — | — |
| 06/17/09 | 1500 | 8.3 | 238 | 23.4 | 6 | 9.24 | — | — |
| 06/17/09 | 1600 | 8.12 | 227 | 23.6 | 5 | 9.34 | — | — |
| 06/17/09 | 1700 | 8.29 | 227 | 22.2 | 5 | 9.24 | — | 12,974.1 |
| 06/18/09 | 0703 | 8.75 | 228 | 18.3 | 17 | 8.82 | — | — |
| 06/18/09 | 0710 | 7.63 | 228 | 19.1 | 11 | 8.21 | — | — |
| 06/18/09 | 0740 | 7.58 | 228 | 19.7 | 9 | 8.02 | — | — |
| 06/18/09 | 0820 | 7.94 | 225 | 19.9 | 4 | — | — | — |
| 06/18/09 | 0833 | 7.89 | 223 | 20.3 | 4 | — | — | — |
| 06/18/09 | 0839 | — | — | — | — | — | — | 14,184.4 |
| **Screen 2 24-H Pumping Test** | | | | | | | | |
| 06/21/09 | 0600 | — | — | — | — | — | — | — |
| 06/21/09 | 0625 | 7.15 | 286 | 17.6 | 6 | 0.82 | — | — |
| 06/21/09 | 0725 | 7.18 | 268 | 19.1 | 4 | 0.74 | — | — |
| 06/21/09 | 0800 | 7.43 | 252 | 17.8 | 5 | 0.81 | — | — |
| 06/21/09 | 0900 | 7.47 | 236 | 19.9 | 4 | 0.96 | — | — |
| 06/21/09 | 1000 | 7.5 | 231 | 17.6 | 4 | 1.1 | — | — |
| 06/21/09 | 1050 | 7.49 | 228 | 21.8 | 4 | 1.18 | — | — |
| 06/21/09 | 1135 | 7.49 | 223 | 22.9 | 3 | 1.17 | — | — |
| 06/21/09 | 1203 | 7.6 | 222 | 22.9 | 3 | 1.17 | — | — |
| 06/21/09 | 1303 | 7.7 | 221 | 22.8 | 3 | 1.21 | — | — |
| 06/21/09 | 1405 | 7.1 | 217 | 22.9 | 2 | 1.33 | — | — |
| 06/21/09 | 1505 | 7.4 | 217 | 23.5 | 2 | 1.54 | — | — |
| 06/21/09 | 1605 | 7.38 | 212 | 23.1 | 2 | 1.33 | — | — |

## Table C-1.2-1 (continued)

| Date | Time | pH | SP[a] (µS/cm) | T[b] (°C) | Turbidity (NTU) | DO[c] (mg/L) | TOC Result (ppm) | End-of-Day Cumulative Purge Volume (gal.) |
|---|---|---|---|---|---|---|---|---|
| 06/21/09 | 1705 | 7.29 | 214 | 22.4 | 1 | 1.31 | — | — |
| 06/21/09 | 1805 | 6.88 | 213 | 22.4 | 2 | 1.34 | — | — |
| 06/21/09 | 1905 | 7.62 | 208 | 21.6 | 2 | 1.4 | — | — |
| 06/21/09 | 2005 | 7.4 | 206 | 20.8 | 1 | 1.22 | — | — |
| 06/21/09 | 2105 | 7.29 | 203 | 20.7 | 2 | 1.02 | — | — |
| 06/21/09 | 2205 | 7.39 | 204 | 21 | 2 | 1.07 | — | — |
| 06/21/09 | 2305 | 7.48 | 203 | 20.7 | 1 | 1 | — | — |
| 06/21/09 | 2400 | — | — | — | — | — | — | 29,048.2 |
| 06/22/09 | 0005 | 7.59 | 203 | 20.4 | 2 | 1 | — | — |
| 06/22/09 | 0100 | 7.44 | 200 | 20.3 | 2 | 1.11 | — | — |
| 06/22/09 | 0200 | 7.76 | 200 | 20.5 | 1 | 1.1 | — | — |
| 06/22/09 | 0300 | 7.79 | 199 | 20.3 | 1 | 1.1 | — | — |
| 06/22/09 | 0400 | 7.92 | 198 | 20.2 | 1 | 1.1 | — | — |
| 06/22/09 | 0500 | 8.03 | 197 | 20.2 | 1 | 1.01 | — | — |
| 06/22/09 | 0600 | — | — | — | — | — | — | 33,437.6 |
| **Well Development** | | | | | | | | |
| 06/30/09 | 0908 | —[c] | —[c] | —[c] | —[c] | —[c] | 1.68 | 450 |
| 07/01/09 | 1520 | — | — | — | — | — | — | — |
| 07/01/09 | 1527 | 7.71 | 321 | 28.9 | 234 | — | — | — |
| 07/01/09 | 1606 | 8.24 | 300 | 21.7 | 398 | 0.62 | — | — |
| 07/01/09 | 1626 | 7.9 | 305 | 22.3 | 240 | 0.56 | — | — |
| 07/01/09 | 1700 | 7.69 | 305 | 22.8 | 39 | 0.65 | 0.79 | 952.7 |
| 07/02/09 | 0707 | — | — | — | — | — | — | — |
| 07/02/09 | 0723 | 8.26 | 304 | 16.6 | 32 | 0.05 | — | — |
| 07/02/09 | 0726 | 7.75 | 289 | 17.2 | 38 | -0.28 | — | — |
| 07/02/09 | 0744 | 7.58 | 248 | 18 | 27 | — | — | — |
| 07/02/09 | 0758 | 7.44 | 294 | 19.2 | 10 | 0.07 | — | — |
| 07/02/09 | 0815 | 7.47 | 297 | 19.5 | 9 | 0.04 | — | — |
| 07/02/09 | 0822 | 7.52 | 302 | 19.2 | 7 | 0.04 | — | — |
| 07/02/09 | 0848 | 7.59 | 307 | 22.2 | 6 | 0.01 | — | — |
| 07/02/09 | 0904 | 7.57 | 310 | 20.6 | 5 | 0 | — | — |
| 07/02/09 | 0939 | 7.77 | 314 | 18.6 | 5 | 0.13 | — | — |
| 07/02/09 | 0954 | 7.78 | 310 | 21.7 | 7 | 0.03 | — | — |
| 07/02/09 | 1045 | 8.03 | 301 | 23.9 | 11 | 0.27 | — | — |
| 07/02/09 | 0954 | 7.78 | 310 | 21.7 | 7 | 0.03 | — | — |
| 07/02/09 | 1045 | 8.03 | 301 | 23.9 | 11 | 0.27 | — | — |
| 07/02/09 | 1132 | 8.15 | 268 | 25.4 | 36 | 0.37 | — | — |
| 07/02/09 | 1201 | 8.25 | 293 | 24.4 | 37 | 0.35 | — | — |
| 07/02/09 | 1239 | 8.3 | 294 | 24.4 | 43 | 0.43 | — | — |

## Table C-1.2-1 (continued)

| Date | Time | pH | SP[a] (µS/cm) | T[b] (°C) | Turbidity (NTU) | DO[c] (mg/L) | TOC Result (ppm) | End-of-Day Cumulative Purge Volume (gal.) |
|---|---|---|---|---|---|---|---|---|
| 07/02/09 | 1306 | 8.44 | 294 | 24.6 | 69 | 0.46 | — | — |
| 07/02/09 | 1318 | 8.44 | 294 | 23.1 | 50 | 0.3 | — | — |
| 07/02/09 | 1345 | 8.27 | 293 | 23.6 | 32 | — | — | — |
| 07/02/09 | 1354 | 8.27 | 290 | 23.4 | 30 | 0.27 | — | — |
| 07/02/09 | 1451 | 8.41 | 292 | 25.8 | 14 | 0.47 | — | — |
| 07/02/09 | 1526 | 8.51 | 293 | 25.1 | 9 | 0.32 | — | — |
| 07/02/09 | 1610 | 8.3 | 290 | 25.1 | 8 | 0.46 | — | — |
| 07/02/09 | 1630 | 8.26 | 291 | 20.9 | 6 | 0.51 | — | — |
| 07/02/09 | 1646 | 8.14 | 290 | 24.1 | 6 | 0.49 | 0.62 | — |
| 07/02/09 | 1700 | — | — | — | — | — | — | 1759.2 |
| 07/06/09 | 1004 | — | — | — | — | — | — | — |
| 07/06/09 | 1012 | 8.41 | 294 | 16.1 | 11 | -0.17 | — | — |
| 07/06/09 | 1024 | 8.29 | 229 | 17.5 | 36 | -0.45 | — | — |
| 07/06/09 | 1045 | 7.91 | 303 | 19 | 28 | -0.03 | — | — |
| 07/06/09 | 1100 | 7.62 | 302 | 20.6 | 9 | 0.03 | — | — |
| 07/06/09 | 1110 | 8.74 | 307 | 20.8 | 4 | 0.06 | — | — |
| 07/06/09 | 1152 | 8.37 | 318 | 23 | 1 | 0 | — | — |
| 07/06/09 | 1408 | 8.49 | 314 | 24.4 | 5 | 0.16 | — | — |
| 07/06/09 | 1529 | 8.78 | 313 | 24 | 7 | 0.23 | — | — |
| 07/06/09 | 1608 | 8.77 | 311 | 22.7 | 10 | 0.31 | — | 2161.3 |
| 07/07/09 | 0710 | — | — | — | — | — | — | — |
| 07/07/09 | 0845 | 8.29 | 292 | 21.8 | 0 | -0.07 | — | — |
| 07/07/09 | 0858 | 8.17 | 303 | 22.2 | 2 | -0.02 | — | — |
| 07/07/09 | 0903 | 8.18 | 303 | 22.2 | 0 | 0 | — | — |
| 07/07/09 | 0907 | 8.21 | 303 | 22.2 | 0 | 0 | — | — |
| 07/07/09 | 0918 | 8.25 | 303 | 22.4 | 0 | 0.01 | — | — |
| 07/07/09 | 0925 | 8.24 | 304 | 22.6 | 0 | 0 | — | — |
| 07/07/09 | 0930 | 8.21 | 306 | 22.8 | 0 | 0 | — | — |
| 07/07/09 | 0935 | 8.21 | 306 | 22.9 | 0 | -0.02 | — | — |
| 07/07/09 | 0951 | 8.25 | 307 | 22.9 | 0 | 0.03 | — | — |
| 07/07/09 | 0957 | 8.23 | 308 | 23.1 | 1 | 0.02 | — | — |
| 07/07/09 | 1001 | 8.21 | 308 | 23.2 | 0 | 0.02 | — | — |
| 07/07/09 | 1025 | 8.28 | 307 | 23.4 | 0 | 0.03 | — | — |
| 07/07/09 | 1037 | 8.29 | 309 | 23.3 | 1 | 0.05 | — | — |
| 07/07/09 | 1043 | 8.26 | 309 | 23.4 | 0 | — | — | — |
| 07/07/09 | 1046 | 8.3 | 309 | 23.3 | 0 | 0.1 | — | — |
| 07/07/09 | 1058 | 8.28 | 307 | 23.7 | 2 | 0.04 | — | — |
| 07/07/09 | 1103 | 8.29 | 307 | — | 1 | 0.06 | — | — |
| 07/07/09 | 1110 | 8.29 | 305 | 23.8 | 2 | 0.05 | — | — |

## Table C-1.2-1 (continued)

| Date | Time | pH | SP[a] (µS/cm) | T[b] (°C) | Turbidity (NTU) | DO[c] (mg/L) | TOC Result (ppm) | End-of-Day Cumulative Purge Volume (gal.) |
|---|---|---|---|---|---|---|---|---|
| 07/07/09 | 1119 | 8.31 | 304 | 23.8 | 1 | 0.08 | — | — |
| 07/07/09 | 1129 | 8.34 | 305 | 24 | 1 | 0.1 | — | — |
| 07/07/09 | 1150 | 8.34 | 299 | 24.3 | 1 | 0.09 | — | — |
| 07/07/09 | 1300 | 8.5 | 297 | 25.1 | 17 | 0.34 | — | — |
| 07/07/09 | 1400 | 8.46 | 292 | 26.1 | 8 | 0.55 | — | — |
| 07/07/09 | 1500 | 8.5 | 292 | 26.2 | 9 | 0.57 | — | — |
| 07/07/09 | 1600 | 8.62 | 297 | 26.7 | 6 | 0.54 | — | — |
| 07/07/09 | 1700 | 8.55 | 294 | 25.4 | 15 | 0.37 | — | — |
| 07/07/09 | 1705 | — | — | — | — | — | 4 | 2757.1 |
| **Screen 1 Mini-Pumping Tests** | | | | | | | | |
| 07/10/09 | — | — | — | — | — | — | — | 2864.9 |
| **Screen 1 24-H Pumping Test** | | | | | | | | |
| 07/12/09 | 0700 | — | — | — | — | — | — | — |
| 07/12/09 | 0715 | 8.32 | 302 | 16.2 | 8 | 0.12 | — | — |
| 07/12/09 | 0747 | 7.54 | 302 | 15.9 | 2 | -0.05 | — | — |
| 07/12/09 | 0835 | 7.83 | 310 | 18.4 | 4 | 0.11 | — | — |
| 07/12/09 | 0912 | 8.13 | 308 | 20.4 | 2 | 0.06 | — | — |
| 07/12/09 | 0955 | 8.27 | 308 | 22.2 | 0 | 0.33 | — | — |
| 07/12/09 | 1114 | 8.57 | 319 | 27.7 | 0 | 0.28 | — | — |
| 07/12/09 | 1239 | 8.52 | 323 | 28.8 | 0 | 0.27 | — | — |
| 07/12/09 | 1334 | 8.42 | 321 | 29.3 | 0 | 0.28 | — | — |
| 07/12/09 | 1404 | 8.53 | 316 | 27.5 | 0 | 0.32 | — | — |
| 07/12/09 | 1447 | 8.44 | 317 | 28.1 | 0 | 0.26 | — | — |
| 07/12/09 | 1601 | 8.62 | 312 | 29.3 | 0 | 0.23 | — | — |
| 07/12/09 | 1645 | 8.57 | 309 | 27 | 0 | 0.24 | — | — |
| 07/12/09 | 1745 | 8.53 | 308 | 27.7 | 0 | 0.32 | — | — |
| 07/12/09 | 1900 | 8.34 | 304 | 26.2 | 0 | 0.33 | — | — |
| 07/12/09 | 2000 | 8.34 | 301 | 24.2 | 0 | 0.26 | — | — |
| 07/12/09 | 2100 | 8.46 | 299 | 22 | 1 | 0.18 | — | — |
| 07/12/09 | 2200 | 8.21 | 299 | 21.6 | 0 | 0.19 | — | — |
| 07/12/09 | 2300 | 8.33 | 299 | 22 | 1 | 0.18 | — | — |
| 07/12/09 | 2400 | — | — | — | — | — | — | 3573.1 |
| 07/13/09 | 0000 | 7.88 | 296 | 21.7 | 0 | 0.05 | — | — |
| 07/13/09 | 0100 | 8.18 | 295 | 19.2 | 1 | 0.26 | — | — |
| 07/13/09 | 0200 | 8.19 | 245 | 18.7 | 1 | 0.19 | — | — |
| 07/13/09 | 0300 | 8.12 | 292 | 18.5 | 1 | 0.2 | — | — |
| 07/13/09 | 0400 | 8.07 | 292 | 18.5 | 1 | 0.26 | — | — |
| 07/13/09 | 0500 | 8.06 | 292 | 18.5 | 1 | 0.26 | — | — |
| 07/13/09 | 0600 | 8.12 | 246 | 19.7 | 1 | 0.45 | — | — |

### Table C-1.2-1 (continued)

| Date | Time | pH | SP[a] (µS/cm) | T[b] (°C) | Turbidity (NTU) | DO[c] (mg/L) | TOC Result (ppm) | End-of-Day Cumulative Purge Volume (gal.) |
|---|---|---|---|---|---|---|---|---|
| 07/13/09 | 0700 | 8.12 | 246 | 19.7 | 1 | 0.45 | — | 4002 |
| 07/14/09 | 0820 | 8.24 | 289 | 24.8 | 3 | 0.8 | — | — |
| 07/14/09 | 1100 | 8.35 | 312 | 25.8 | 3 | 0.86 | — | — |
| 07/14/09 | 1200 | 8.29 | 302 | 26.1 | 3 | 0.67 | — | — |
| 07/14/09 | 1230 | — | — | — | — | — | >60 | — |
| 07/14/09 | 1300 | 8.4 | 314 | 25.4 | 3 | 0.74 | — | — |
| 07/14/09 | 1330 | 8.45 | 306 | 26.9 | 4 | 0.74 | >15 | — |
| 07/14/09 | 1400 | 8.39 | 309 | 26.8 | 4 | 0.85 | — | — |
| 07/14/09 | 1500 | 8.4 | 305 | 26.8 | 5 | 0.75 | — | — |
| 07/14/09 | 1600 | 8.69 | 302 | 27.8 | 5 | 1.02 | — | — |
| 07/14/09 | 1700 | 8.64 | 305 | 27.4 | 3 | 1.01 | — | — |
| 07/14/09 | 1800 | 8.66 | 298 | 25.1 | 3 | 1.05 | 1.8 | 4460.3 |

[a] SP = Specific conductance.

[b] T = Temperature.

[c] DO measured by the Horiba instrument in a flow-through cell.

[d] — = Analysis not conducted.

## Table C-1.3-1
## Analytical Results for Groundwater-Screening Samples Collected at R-37

| Sample ID | Date Collected | Date Received | ER/RRES-WQH | Sample Type | Depth (ft) | Aquifer | Ag rslt (ppm) | stdev (Ag) | Al rslt (ppm) | stdev (Al) | As rslt (ppm) | stdev (As) | B rslt (ppm) | stdev (B) | Ba rslt (ppm) | stdev (Ba) | Be rslt (ppm) | stdev (Be) | Br(-) ppm | TOC rslt (ppm) | Ca rslt (ppm) | stdev (Ca) | Cd rslt (ppm) | stdev (Cd) | Cl(-) ppm | ClO4(-) ppm |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GW37-08-15104 | 8/20/2008 | 8/21/2008 | 08-1735 | Borehole 1 | 925 | Perched Intermediate | 0.001 | U[a] | 1.40 | 0.05 | 0.0005 | 0.0000 | 0.055 | 0.000 | 0.048 | 0.000 | 0.001 | U | 0.09 | NA[b] | 16.86 | 0.07 | 0.001 | U | 5.22 | 0.005, U |
| GW37-08-15105 | 8/22/2008 | 8/25/2008 | 08-1750 | Borehole 1 | 1070 | Regional | 0.001 | U | 0.004 | 0.001 | 0.0005 | 0.0000 | 0.032 | 0.000 | 0.045 | 0.003 | 0.001 | U | 0.12 | NA | 19.48 | 0.06 | 0.001 | U | 5.64 | 0.005, U |
| GW37-09-9723 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1040 | Regional | 0.001 | U | 0.046 | 0.000 | 0.0010 | 0.0001 | 0.040 | 0.001 | 0.065 | 0.001 | 0.001 | U | 0.02 | NA | 18.33 | 0.15 | 0.001 | U | 6.21 | 0.002, U |
| GW37-09-9724 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1020 | Regional | 0.001 | U | 0.003 | 0.000 | 0.0007 | 0.0000 | 0.034 | 0.000 | 0.045 | 0.000 | 0.001 | U | 0.03 | NA | 19.39 | 0.09 | 0.001 | U | 6.60 | 0.005, U |
| GW37-09-9725 | 5/22/2009 | 5/24/2009 | 09-2023 | Borehole 3 | 1052 | Regional | 0.001 | U | 0.012 | 0.002 | 0.0004 | 0.0000 | 0.041 | 0.001 | 0.068 | 0.000 | 0.001 | U | 0.06 | NA | 12.91 | 0.09 | 0.001 | U | 14.48 | 0.005, U |
| GW37-09-1560 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1.11 | NA | NA | NA | NA | NA | NA |
| GW37-09-1561 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.70 | NA | NA | NA | NA | NA | NA |
| GW37-09-1562 | 6/16/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.83 | NA | NA | NA | NA | NA | NA |
| GW37-09-1563 | 6/16/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.75 | NA | NA | NA | NA | NA | NA |
| GW37-09-1564 | 6/17/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.70 | NA | NA | NA | NA | NA | NA |
| GW37-09-1566 | 6/30/2009 | 7/6/2009 | 09-2550 | Screen 1 | 906.6 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1.68 | NA | NA | NA | NA | NA | NA |
| GW37-09-1567 | 7/1/2009 | 7/6/2009 | 09-2550 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.79 | NA | NA | NA | NA | NA | NA |
| GW37-09-1568 | 7/2/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 0.62 | NA | NA | NA | NA | NA | NA |
| GW37-09-1569 | 7/6/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1.89 | NA | NA | NA | NA | NA | NA |
| GW37-09-1570 | 7/8/2009 | 7/8/2009 | 09-2573 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 4.45 | NA | NA | NA | NA | NA | NA |
| GW37-09-1571 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 60.5 | NA | NA | NA | NA | NA | NA |
| GW37-09-1572 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 13.0 | NA | NA | NA | NA | NA | NA |
| GW37-09-1573 | 7/14/2009 | 7/15/2009 | 09-2649 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | 1.78 | NA | NA | NA | NA | NA | NA |

### Table C-1.3-1 (continued)

| Sample ID | Date Collected | Date Received | ER/RRES-WQH | Sample Type | Depth (ft) | Aquifer | Co rslt (ppm) | stdev (Co) | Alk-CO3 rslt (ppm) | Cr rslt (ppm) | stdev (Cr ) | Cs rslt (ppm) | stdev (Cs) | Cu rslt (ppm) | stdev (Cu) | F(-) ppm | Fe rslt (ppm) | stdev (Fe) | Alk-CO3+HCO3 rslt (ppm) | Hg rslt (ppm) | stdev (Hg) | K rslt (ppm) | stdev (K) | Li rslt (ppm) | stdev (Li) | Mg rslt (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GW37-08-15104 | 8/20/2008 | 8/21/2008 | 08-1735 | Borehole 1 | 925 | Perched Intermediate | 0.003 | 0.000 | 0, U | 0.001 | 0.000 | 0.001 | U | 0.006 | 0.000 | 1.61 | 0.544 | 0.004 | 101 | 0.00010 | 0.00000 | 3.89 | 0.01 | 0.054 | 0.000 | 4.49 |
| GW37-08-15105 | 8/22/2008 | 8/25/2008 | 08-1750 | Borehole 1 | 1070 | Regional | 0.001 | U | 0, U | 0.001 | U | 0.001 | U | 0.001 | 0.000 | 1.17 | 0.010 | U | 120 | 0.00005 | U | 4.40 | 0.02 | 0.042 | 0.000 | 4.75 |
| GW37-09-9723 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1040 | Regional | 0.001 | U | 0.8, U | 0.002 | 0.000 | 0.001 | U | 0.002 | 0.000 | 0.38 | 0.356 | 0.003 | 131 | 0.00034 | 0.00003 | 4.90 | 0.01 | 0.038 | 0.000 | 4.90 |
| GW37-09-9724 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1020 | Regional | 0.001 | U | 0.8, U | 0.001 | 0.000 | 0.001 | U | 0.001 | U | 0.44 | 0.015 | 0.004 | 116 | 0.00028 | 0.00001 | 3.92 | 0.04 | 0.037 | 0.000 | 4.88 |
| GW37-09-9725 | 5/22/2009 | 5/24/2009 | 09-2023 | Borehole 3 | 1052 | Regional | 0.001 | U | 0.8, U | 0.003 | 0.000 | 0.001 | U | 0.002 | 0.000 | 0.70 | 0.047 | 0.000 | 139 | 0.00011 | 0.00001 | 11.48 | 0.09 | 0.047 | 0.002 | 3.79 |
| GW37-09-1560 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1561 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1562 | 6/16/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1563 | 6/16/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1564 | 6/17/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1566 | 6/30/2009 | 7/6/2009 | 09-2550 | Screen 1 | 906.6 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1567 | 7/1/2009 | 7/6/2009 | 09-2550 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1568 | 7/2/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1569 | 7/6/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1570 | 7/8/2009 | 7/8/2009 | 09-2573 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1571 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1572 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1573 | 7/14/2009 | 7/15/2009 | 09-2649 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-1.3-1 (continued)

| Sample ID | Date Collected | Date Received | ER/RRES-WQH | Sample Type | Depth (ft) | Aquifer | stdev (Mg) | Mn rslt (ppm) | stdev (Mn) | Mo rslt (ppm) | stdev (Mo) | Na rslt (ppm) | stdev (Na) | Ni rslt (ppm) | stdev (Ni) | NO2 (ppm) | NO2-N rslt | NO3 ppm | NO3-N rslt | C2O4 rslt (ppm) | Pb rslt (ppm) | stdev (Pb) | pH | PO4(-3) rslt (ppm) | Rb rslt (ppm) | stdev (Rb) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GW37-08-15104 | 8/20/2008 | 8/21/2008 | 08-1735 | Borehole 1 | 925 | Perched Intermediate | 0.01 | 0.086 | 0.002 | 0.089 | 0.000 | 21.20 | 0.10 | 0.001 | 0.001 | 0.19 | 0.06 | 5.11 | 1.15 | 0.18 | 0.0008 | 0.0000 | 7.65 | 0.01, U | 0.008 | 0.000 |
| GW37-08-15105 | 8/22/2008 | 8/25/2008 | 08-1750 | Borehole 1 | 1070 | Regional | 0.02 | 0.072 | 0.000 | 0.064 | 0.001 | 17.30 | 0.20 | 0.001 | 0.000 | 0.01 | 0.00, U | 5.29 | 1.20 | 0.03 | 0.0002 | U | 7.73 | 0.01 | 0.007 | 0.000 |
| GW37-09-9723 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1040 | Regional | 0.01 | 0.140 | 0.001 | 0.025 | 0.000 | 19.18 | 0.08 | 0.002 | 0.000 | 0.31 | 0.09 | 2.14 | 0.48 | 0.08 | 0.0013 | 0.0000 | 7.91 | 0.01, U | 0.007 | 0.000 |
| GW37-09-9724 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1020 | Regional | 0.02 | 0.073 | 0.000 | 0.051 | 0.000 | 17.03 | 0.05 | 0.002 | 0.000 | 0.48 | 0.15 | 2.27 | 0.51 | 0.33 | 0.0003 | 0.0000 | 7.86 | 0.01, U | 0.005 | 0.000 |
| GW37-09-9725 | 5/22/2009 | 5/24/2009 | 09-2023 | Borehole 3 | 1052 | Regional | 0.01 | 0.797 | 0.001 | 0.035 | 0.001 | 39.40 | 0.11 | 0.005 | 0.000 | 0.93 | 0.28 | 0.40 | 0.09 | 1.17 | 0.0002 | U | 7.50 | 0.01, U | 0.017 | 0.001 |
| GW37-09-1560 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1561 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1562 | 6/16/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1563 | 6/16/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1564 | 6/17/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1566 | 6/30/2009 | 7/6/2009 | 09-2550 | Screen 1 | 906.6 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1567 | 7/1/2009 | 7/6/2009 | 09-2550 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1568 | 7/2/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1569 | 7/6/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1570 | 7/8/2009 | 7/8/2009 | 09-2573 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1571 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1572 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1573 | 7/14/2009 | 7/15/2009 | 09-2649 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

### Table C-1.3-1 (continued)

| Sample ID | Date Collected | Date Received | ER/RRES-WQH | Sample Type | Depth (ft) | Aquifer | Sb rslt (ppm) | stdev (Sb) | Se rslt (ppm) | stdev (Se) | Si rslt (ppm) | stdev (Si) | SiO2 rslt (ppm) | stdev (SiO2) | Sn rslt (ppm) | stdev (Sn) | SO4(-2) rslt (ppm) | Sr rslt (ppm) | stdev (Sr) | Th rslt (ppm) | stdev (Th) | Ti rslt (ppm) | stdev (Ti) | Tl rslt (ppm) | stdev (Tl) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GW37-08-15104 | 8/20/2008 | 8/21/2008 | 08-1735 | Borehole 1 | 925 | Perched Intermediate | 0.001 | U | 0.001 | 0.000 | 20.3 | 0.2 | 43.4 | 0.2 | 0.001 | U | 9.61 | 0.075 | 0.000 | 0.001 | U | 0.051 | 0.003 | 0.001 | U |
| GW37-08-15105 | 8/22/2008 | 8/25/2008 | 08-1750 | Borehole 1 | 1070 | Regional | 0.001 | U | 0.001 | U | 9.6 | 0.0 | 20.5 | 0.1 | 0.001 | U | 9.82 | 0.068 | 0.003 | 0.001 | U | 0.002 | U | 0.001 | U |
| GW37-09-9723 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1040 | Regional | 0.001 | U | 0.001 | U | 25.0 | 0.1 | 53.5 | 0.2 | 0.001 | U | 4.37 | 0.08 | 0.00 | 0.001 | U | 0.036 | 0.002 | 0.001 | U |
| GW37-09-9724 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1020 | Regional | 0.001 | U | 0.001 | U | 9.1 | 0.0 | 19.5 | 0.1 | 0.001 | U | 5.76 | 0.08 | 0.00 | 0.001 | U | 0.002 | 0.000 | 0.001 | U |
| GW37-09-9725 | 5/22/2009 | 5/24/2009 | 09-2023 | Borehole 3 | 1052 | Regional | 0.001 | U | 0.001 | U | 6.9 | 0.0 | 14.7 | 0.0 | 0.001 | U | 16.12 | 0.07 | 0.00 | 0.001 | U | 0.004 | 0.000 | 0.001 | U |
| GW37-09-1560 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1561 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1562 | 6/16/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1563 | 6/16/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1564 | 6/17/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1566 | 6/30/2009 | 7/6/2009 | 09-2550 | Screen 1 | 906.6 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1567 | 7/1/2009 | 7/6/2009 | 09-2550 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1568 | 7/2/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1569 | 7/6/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1570 | 7/8/2009 | 7/8/2009 | 09-2573 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1571 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1572 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1573 | 7/14/2009 | 7/15/2009 | 09-2649 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

## Table C-1.3-1 (continued)

| Sample ID | Date Collected | Date Received | ER/RRES-WQH | Sample Type | Depth (ft) | Aquifer | U rslt (ppm) | stdev (U) | V rslt (ppm) | stdev (V) | Zn rslt (ppm) | stdev (Zn) | TDS (ppm) | Cations | Anions | Balance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| GW37-08-15104 | 8/20/2008 | 8/21/2008 | 08-1735 | Borehole 1 | 925 | Perched Intermediate | 0.0006 | 0.0000 | 0.003 | 0.000 | 0.005 | 0.000 | 215 | 2.25 | 2.20 | 0.01 |
| GW37-08-15105 | 8/22/2008 | 8/25/2008 | 08-1750 | Borehole 1 | 1070 | Regional | 0.0027 | 0.0001 | 0.002 | 0.001 | 0.004 | 0.001 | 209 | 2.24 | 2.48 | -0.05 |
| GW37-09-9723 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1040 | Regional | 0.0036 | 0.0001 | 0.003 | 0.000 | 0.003 | 0.000 | 246 | 2.29 | 2.48 | -0.04 |
| GW37-09-9724 | 5/21/2009 | 5/22/2009 | 09-1988 | Borehole 3 | 1020 | Regional | 0.0027 | 0.0001 | 0.002 | 0.000 | 0.004 | 0.000 | 197 | 2.22 | 2.28 | -0.01 |
| GW37-09-9725 | 5/22/2009 | 5/24/2009 | 09-2023 | Borehole 3 | 1052 | Regional | 0.0002 | U | 0.001 | U | 0.004 | 0.000 | 256 | 3.00 | 3.09 | -0.01 |
| GW37-09-1560 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1561 | 6/15/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1562 | 6/16/2009 | 6/16/2009 | 09-2340 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1563 | 6/16/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1564 | 6/17/2009 | 6/17/2009 | 09-2357 | Screen 2 | 1044.4 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1566 | 6/30/2009 | 7/6/2009 | 09-2550 | Screen 1 | 906.6 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1567 | 7/1/2009 | 7/6/2009 | 09-2550 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1568 | 7/2/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1569 | 7/6/2009 | 7/6/2009 | 09-2557 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1570 | 7/8/2009 | 7/8/2009 | 09-2573 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1571 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1572 | 7/14/2009 | 7/14/2009 | 09-2620 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| GW37-09-1573 | 7/14/2009 | 7/15/2009 | 09-2649 | Screen 1 | 980 | Regional | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |

[a] U = Not detected.

[b] NA = Not analyzed. Analytes were not requested by customer.

# Appendix D

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## *Los Alamos National Laboratory Geophysical Logging Results (on CD included with this document)*

# Appendix E

## *Aquifer Testing Report*

## E-1.0 INTRODUCTION

This appendix describes the hydraulic analysis of pumping tests at well R-37 screens 1 and 2, located on an unnamed mesa between Cañada del Buey and the south fork of Cañada del Buey at Technical Area 54 (TA-54). The tests were conducted in June and July 2009 to quantify the properties of the formations screened by the wells.

Screen 1 is set in a tight perched zone, while screen 2 is completed in a permeable zone at the top of the regional aquifer. When the well was open to both screens, screen 1 was dry, that is, the composite static water level fell below the bottom of screen 1. Therefore, screen 2 was tested first, after which a TAM single-set packer was set between the screens to isolate screen 1 from the underlying regional aquifer. This allowed the groundwater level at screen 1 to recover so that well development could be performed and test pumping could proceed. Initially, screen 1 produced only a fraction of a gallon per minute, too little production to support operation of a submersible pump. Extensive swabbing and bailing were performed, eventually increasing the yield to around 1 gpm so that continuous pumping could be conducted.

Testing consisted of constant-rate pumping tests. Consistent with most of the R-well pumping tests conducted on the plateau, an inflatable packer system was used in R-37 to isolate the screens and try to minimize the effects of casing storage on the test data. This approach was successful with respect to screen 2. Screen 1, however, exhibited significant storage effects. Pumping screen 1 pulled the water level into the screen and filter pack, dewatering a portion of the well. Also, previous dewatering and resaturation of screen 1 likely trapped air in the filter pack above the screen. Such trapped air would have expanded and contracted in response to pumping and recovery, causing a storagelike effect.

No other wells were monitored during the testing of R-37 because there were no monitoring wells within a half mile of the R-37 site.

### E-1.1 Conceptual Hydrogeology

R-37 is a dual-screen well completed primarily in the Puye Formation. Screen 1 is 20.7 ft long and was installed between the depths of 929.3 and 950 ft below ground surface (bgs). The top of the Puye Formation is 933 ft bgs, so the upper few feet of screen 1 extend into overlying Cerros del Rio basalt sedimentary interbeds. At the time of testing, the static water level was measured at 906.9 ft bgs on July 9, 2009. The land-surface elevation at R-37 was estimated by preliminary global positioning system measurement at 6870.24 ft above mean sea level (amsl), making the perched intermediate water-table elevation in screen 1 approximately 5963 ft amsl.

Screen 2 is within the Puye Formation. It is 20.68 ft long, extending from 1025.96 to 1046.64 ft bgs. The static water level measured in screen 2 on June 29, 2009, was 1009.6 ft bgs, making the regional water-table elevation approximately 5860 ft amsl, about 103 ft deeper than the groundwater level in screen 1.

### E-1.2 R-37 Screen 1 Testing

R-37 screen 1 was tested from July 9 to July 15, 2009, using conventional constant-rate pumping methods with a 3-hp electric submersible pump. After pumping to fill the drop pipe on July 9, testing consisted of brief trial pumping on July 10, a 24-h constant-rate pumping test that was begun on July 12, and a final purge development pumping event on July 14.

Trial 1 was conducted on July 10 for 30 min from 7:30 to 8:00 a.m. and was followed by 60 min of recovery until 9:00 a.m. Trial 2 was conducted for 60 min from 9:00 to 10:00 a.m., followed by 315 min of recovery until 3:15 p.m. After trial 2, the discharge plumbing was modified to facilitate water sampling that was scheduled for the end of the 24-h test. This necessitated running the pump again to reset the discharge rate for the subsequent 24-h test. Brief pumping from 3:15 to 3:35 p.m. was performed to achieve this. After shutdown, background groundwater-level data were collected until 7:00 a.m. on July 12.

At 7:00 a.m. on July 12, the 24-h pumping test was begun at a rate of 0.81 gpm. Pumping continued until 7:00 a.m. on July 13. Following shutdown, recovery measurements were recorded for 1440 min until 7:00 a.m. on July 14, when the packer was deflated.

Additional purge development and sampling for total organic carbon were requested on July 14, so the packer was reinflated and screen 1 was pumped at 0.81 gpm for an additional 564 min from 8:30 a.m. to 5:54 p.m. Following shutdown, recovery was recorded for 786 min until 7:00 a.m. on July 15.

### E-1.3 R-37 Screen 2 Testing

R-37 screen 2 was tested before screen 1 from June 20 to June 24 2009, using conventional constant-rate pumping methods. Testing consisted of brief trial pumping on June 20, a 24-h constant-rate pumping test that was begun on June 21, background data collection until June 24, and final purge development pumping on June 24.

After initial filling of the drop pipe, trial 1 was conducted on June 20 for 15 min from 1:45 to 2:00 p.m. and was followed by 60 min of recovery until 3:00 p.m. Trial 2 was conducted for 60 min from 3:00 to 4:00 p.m., followed by 840 min of recovery until 6:00 a.m. on June 21.

At 6:00 a.m. on June 21, the 24-h pumping test was begun at a rate of 12.5 gpm. Pumping continued until 6:00 a.m. on June 22. Following shutdown, recovery/background measurements were recorded for 3210 min until 11:30 a.m. on July 24.

A final test (trial 3) was conducted on June 24 for 180 min from 11:30 a.m. to 2:30 p.m. and was followed by 956 min of recovery until 6:26 a.m. on June 25.

## E-2.0 BACKGROUND DATA

The background water-level data collected in conjunction with running the pumping tests allow the analyst to see what water-level fluctuations occur naturally in the aquifer and help distinguish between water-level changes caused by conducting the pumping test and changes associated with other causes.

Background water-level fluctuations have several causes, among them barometric pressure changes, operation of other wells in the aquifer, Earth tides, and long-term trends related to weather patterns. The background data hydrographs from the monitored wells were compared with barometric pressure data from the area to determine if a correlation existed.

Previous pumping tests on the plateau have demonstrated a barometric efficiency for most wells between 90% and 100%. Barometric efficiency is defined as the ratio of water-level change divided by barometric pressure change, expressed as a percentage. In the initial pumping tests conducted on the early R-wells, downhole pressure was monitored using a *vented* pressure transducer. This equipment measures the *difference* between the total pressure applied to the transducer and the barometric pressure, this difference being the true height of water above the transducer.

Subsequent pumping tests, including R-37, have used *nonvented* transducers. These devices simply record the total pressure on the transducer, that is, the sum of the water height plus the barometric pressure. This results in an attenuated "apparent" hydrograph in a barometrically efficient well. Take as an example a 90% barometrically efficient well. When monitored using a vented transducer, an *increase* in barometric pressure of 1 unit causes a decrease in recorded downhole pressure of 0.9 unit because the water level is forced downward 0.9 unit by the barometric pressure change. However, using a nonvented transducer, the total measured pressure increases by 0.1 unit (the combination of the barometric pressure increase and the water-level decrease). Thus, the resulting apparent hydrograph changes by a factor of 100 minus the barometric efficiency and in the same direction as the barometric pressure change, rather than in the opposite direction.

Barometric pressure data were obtained from the TA-54 tower site from the Waste and Environmental Services Division–Environmental Data. The TA-54 measurement location is at an elevation of 6548 ft amsl, whereas the wellhead elevation is approximately 6860 ft amsl. The static water levels in R-37 screens 1 and 2 were about 907 and 1010 ft below land surface, making the water-table elevations roughly 5953, 5850 ft amsl, respectively. Therefore, the measured barometric pressure data from TA-54 had to be adjusted to reflect the pressure at these elevations.

The following formula was used to adjust the measured barometric pressure data:

$$P_{WT} = P_{TA54} \exp\left[ -\frac{g}{3.281R} \left( \frac{E_{R37} - E_{TA54}}{T_{TA54}} + \frac{E_{WT} - E_{R37}}{T_{WELL}} \right) \right] \qquad \textbf{Equation E-1}$$

where, $P_{WT}$ = barometric pressure at the water table in a given screen in R-37

$P_{TA54}$ = barometric pressure measured at TA-54

$g$ = acceleration of gravity, in m/sec$^2$ (9.80665 m/sec$^2$)

$R$ = gas constant, in J/Kg/degree Kelvin (287.04 J/Kg/degree Kelvin)

$E_{R37}$ = land-surface elevation at R-37 site, in feet (6870 ft estimated)

$E_{TA54}$ = elevation of barometric pressure measuring point at TA-54, in feet (6548 ft)

$E_{WT}$ = elevation of the water levels in R-37, in feet (approximately 5963 and 5860 ft for screens 1 and 2, respectively)

$T_{TA54}$ = air temperature near TA-54, in degrees Kelvin (assigned values of 75.5 and 66.0 degrees Fahrenheit [297.3 and 292.1 degrees Kelvin] for screens 1 and 2, respectively)

$T_{WELL}$ = air temperature inside R-37, in degrees Kelvin (assigned a value of 63.3 degrees Fahrenheit, or 290.5 degrees Kelvin, for both screens 1 and 2)

This formula is an adaptation of the ideal gas law and standard physics principles. An inherent assumption in the derivation of the equation is that the air temperature between TA-54 and the well is temporally and spatially constant and that the temperature of the air column in the well is similarly constant.

The corrected barometric pressure data reflecting pressure conditions at the water table were compared with the water-level hydrographs to discern the correlation between the two.

## E-3.0 ANALYTICAL METHODS

A variety of analytical methods are applied to data from pumping tests. Following is a discussion of techniques applicable to pumping tests conducted on the plateau.

### E-3.1 Importance of Early Data

When pumping or recovery first begins, the vertical extent of the cone of depression is limited to approximately the well screen length, the filter pack length, or the aquifer thickness in relatively thin permeable strata. For many pumping tests on the plateau, the early pumping period is the only time that the effective height of the cone of depression is known with certainty. Thus, the early data often offer the best opportunity to obtain hydraulic conductivity information because conductivity would equal the earliest-time transmissivity divided by the well screen length.

Unfortunately, in many pumping tests, casing-storage effects dominate the early-time data, hindering the effort to determine the transmissivity of the screened interval. The duration of casing-storage effects can be estimated using the following equation (Schafer 1978, 098240):

$$t_c = \frac{0.6\left(D^2 - d^2\right)}{\frac{Q}{s}}$$

**Equation E-2**

where, $t_c$ = duration of casing-storage effect, in minutes

$D$ = inside diameter of well casing, in inches

$d$ = outside diameter (O.D.) of column pipe, in inches

$Q$ = discharge rate, in gallons per minute

$s$ = drawdown observed in pumped well at time $t_c$, in feet

For wells screened across the water table or wells in which the pumping water level is pulled into the screen, there is additional storage contribution from the filter pack around the screen. Therefore, the casing-storage duration must be increased to account for the additional volume of water that drains and refills the filter pack, as follows:

$$t_c = \frac{0.6\left[\left(D^2 - d^2\right) + S_y\left(D_B^2 - D_C^2\right)\right]}{\frac{Q}{s}}$$

**Equation E-3**

where, $S_y$ = short-term specific yield of filter media (typically around 0.2)

$D_B$ = diameter of borehole, in inches

$D_C$ = O.D. of well casing, in inches

This equation was derived from Equation E-2 on a proportional basis by increasing the computed time in direct proportion to the additional volume of water expected to drain from the filter pack. (To prove this, note that the left-hand term within the brackets is directly proportional to the annular area [and volume] between the casing and drop pipe, while the right-hand term is proportional to the area [and volume] between the borehole and the casing, corrected for the drainable porosity of the filter pack. Thus, the summed term within the brackets accounts for all of the volume [casing water and drained filter pack water] appropriately.)

In some cases, such as R-37 screen 1, the static water level is above the screen and filter pack but is pulled down into the screen during the pumping test. In such instances, the casing-storage effect is more complicated than described by the above equations but often can be approximated, based on the estimated length of dewatered screen and/or filter pack.

In some instances, it is possible to eliminate casing-storage effects by setting an inflatable packer above the tested screen interval before conducting the test. Therefore, this approach has been implemented for the R-well testing program. Use of an inflatable packer was successful in eliminating storage effects in screen 2. However, the data from screen 1 were storage-affected because the screen was dewatered both during the test and before testing. Previous dewatering and resaturation of the screen could have trapped air in the filter pack above the screen, causing a persistent storage effect.

### E-3.2 Time-Drawdown Methods

Time-drawdown data can be analyzed using a variety of methods. Among them is the Theis method (1934-1935, 098241). The Theis equation describes drawdown around a well as follows:

$$s = \frac{114.6Q}{T} W(u)$$ **Equation E-4**

where,

$$W(u) = \int_u^{\infty} \frac{e^{-x}}{x} dx$$ **Equation E-5**

and

$$u = \frac{1.87r^2S}{Tt}$$ **Equation E-6**

and where, $s$ = drawdown, in feet

$Q$ = discharge rate, in gallons per minute

$T$ = transmissivity, in gallons per day per foot

$S$ = storage coefficient (dimensionless)

$t$ = pumping time, in days

$r$ = distance from center of pumpage, in feet

To use the Theis method of analysis, the time-drawdown data are plotted on log-log graph paper. Then, Theis curve matching is performed using the Theis type curve, a plot of the Theis well function $W(u)$ versus $1/u$. Curve matching is accomplished by overlaying the type curve on the data plot and, while keeping the coordinate axes of the two plots parallel, shifting the data plot to align with the type curve, effecting a match position. An arbitrary point, referred to as the match point, is selected from the overlapping parts of the plots. Match-point coordinates are recorded from the two graphs, yielding four values: $W(u)$, $1/u$, $s$, and $t$. Using these match-point values, transmissivity and storage coefficient are computed as follows:

$$T = \frac{114.6Q}{s} W(u) \qquad \textbf{Equation E-7}$$

$$S = \frac{Tut}{2693r^2} \qquad \textbf{Equation E-8}$$

where, $T$ = transmissivity, in gallons per day per foot

$S$ = storage coefficient

$Q$ = discharge rate, in gallons per minute

$W(u)$ = match-point value

$s$ = match-point value, in feet

$u$ = match-point value

$t$ = match-point value, in minutes

An alternative solution method applicable to time-drawdown data is the Cooper–Jacob method (1946, 098236), a simplification of the Theis equation that is mathematically equivalent to the Theis equation for most pumped well data. The Cooper–Jacob equation describes drawdown around a pumping well as follows:

$$s = \frac{264Q}{T} \log \frac{0.3Tt}{r^2 S} \qquad \textbf{Equation E-9}$$

The Cooper–Jacob equation is a simplified approximation of the Theis equation and is valid whenever the $u$ value is less than about 0.05. For small radius values (e.g., corresponding to borehole radii), $u$ is less than 0.05 at very early pumping times and therefore is less than 0.05 for most or all measured drawdown values. Thus, for the pumped well, the Cooper–Jacob equation usually can be considered a valid approximation of the Theis equation.

According to the Cooper–Jacob method, the time-drawdown data are plotted on a semilog graph, with time plotted on the logarithmic scale. Then a straight line of best fit is constructed through the data points and transmissivity is calculated using

$$T = \frac{264Q}{\Delta s} \qquad \textbf{Equation E-10}$$

where, $T$ = transmissivity, in gallons per day per foot

$Q$ = discharge rate, in gallons per minute

$\Delta s$ = change in head over one log cycle of the graph, in feet

### E-3.3 Recovery Methods

Recovery data were analyzed using the Theis recovery method. This is a semilog analysis method similar to the Cooper–Jacob procedure.

In this method, residual drawdown is plotted on a semilog graph versus the ratio *t/t'*, where *t* is the time since pumping began and *t'* is the time since pumping stopped. A straight line of best fit is constructed through the data points and *T* is calculated from the slope of the line as follows:

$$T = \frac{264Q}{\Delta s}$$ **Equation E-11**

The recovery data are particularly useful compared with time-drawdown data. Because the pump is not running, spurious data responses associated with dynamic discharge rate fluctuations are eliminated. The result is that the data set is generally “smoother” and easier to analyze.

A second method that is applicable to early-recovery data is to apply the Theis curve matching time-drawdown analysis to a plot of feet of recovery versus time since pumping stopped, analogous to time-drawdown analysis. This method has value for early data in which the *u*-value criterion is not satisfied.

### E-3.4 Specific Capacity Method

The specific capacity of the pumped well can be used to obtain a lower-bound value of hydraulic conductivity. The hydraulic conductivity is computed using formulas that are based on the assumption that the pumped well is 100% efficient. The resulting hydraulic conductivity is the value required to sustain the observed specific capacity. If the actual well is less than 100% efficient, it follows that the actual hydraulic conductivity would have to be greater than calculated to compensate for well inefficiency. Thus, because the efficiency is unknown, the computed hydraulic conductivity value represents a lower bound. The actual conductivity is known to be greater than or equal to the computed value.

For fully penetrating wells, the Cooper–Jacob equation can be iterated to solve for the lower-bound hydraulic conductivity. However, the Cooper–Jacob equation (assuming full penetration) ignores the contribution to well yield from permeable sediments above and below the screened interval. To account for this contribution, it is necessary to use a computation algorithm that includes the effects of partial penetration. One such approach was introduced by Brons and Marting (1961, 098235) and augmented by Bradbury and Rothchild (1985, 098234).

Brons and Marting introduced a dimensionless drawdown correction factor, $s_P$, approximated by Bradbury and Rothschild as follows:

$$s_P = \frac{1-\frac{L}{b}}{\frac{L}{b}}\left[\ln\frac{b}{r_w} - 2.948 + 7.363\frac{L}{b} - 11.447\left(\frac{L}{b}\right)^2 + 4.675\left(\frac{L}{b}\right)^3\right]$$ **Equation E-12**

In this equation, *L* is the well screen length, in feet. Incorporating the dimensionless drawdown parameter, the conductivity is obtained by iterating the following formula:

$$K = \frac{264Q}{sb}\left(\log\frac{0.3Tt}{r_w^2 S} + \frac{2s_P}{\ln 10}\right)$$ **Equation E-13**

To apply this procedure, a storage coefficient value must be assigned. Unconfined conditions were assumed for the tested screens in R-37. Storage coefficient values for unconfined conditions can be expected to range from about 0.01 to 0.25 for unconsolidated sediments (Driscoll 1986, 104226). For the permeable zone pumped by screen 2, an assumed value of 0.1 was considered appropriate. For the tighter sediments at screen 1, a slightly lower value of 0.05 was assigned in the calculation. Because the computed lower-bound hydraulic conductivity is not particularly sensitive to the value of storage coefficient, a rough approximation of the storage coefficient value is adequate for calculation purposes.

The analysis also requires assigning a value for the saturated aquifer thickness, *b*. For calculation purposes, the screen 1 perched zone was assumed to extend from the water table to the bottom of the well screen. This resulted in an assigned aquifer thickness value for screen 1 of 43.1 ft. For R-37 screen 2 that partially penetrates the top of the Puye sediments, an arbitrary thickness of 100 ft was assigned in the calculations.

Computing the lower-bound estimate of hydraulic conductivity can provide a useful frame of reference for evaluating the other pumping test calculations.

## E-4.0 WELL R-37 SCREEN 1 DATA ANALYSIS

This section presents the data obtained from the R-37 screen 1 pumping tests and the results of the analytical interpretations. Data are presented for the trial tests, the 24-h test, the final purge development pumping event and background monitoring.

### E-4.1 Well R-37 Screen 1 Background Data Analysis

Background aquifer pressure data collected during the R-37 screen 1 tests were plotted along with barometric pressure to determine the barometric effect on water levels.

Figure E-4.1-1 shows aquifer pressure data from screen 1 along with barometric pressure data from TA-54 that have been corrected to equivalent barometric pressure in feet of water at the water table. The screen 1 data are referred to in the figure as the apparent hydrograph because the measurements reflect the sum of water pressure and barometric pressure, having been recorded using a nonvented pressure transducer. The times of the pumping periods for the R-37 screen 1 pumping tests are included in the figure for reference.

It appears in Figure E-4.1-1 that changes in barometric pressure were reflected in the apparent hydrograph but at a subdued magnitude. The data were replotted in Figure E-4.1-2 with two modifications. First, the water-level data were plotted as a rolling average to eliminate some of the noise in the signal. Second, the barometric pressure data were adjusted for an assumed barometric efficiency. The barometric efficiency was varied until the new curve matched the hydrograph.

With these manipulations, the background hydrograph data from midday on July 11 to the start of the 24-h test on July 12 matched the barometric pressure signal quite well. Water-level data from earlier on July 11 fell below the barometric pressure curve, reflecting lingering residual drawdown from antecedent pumping. Similarly, data from July 10 lagged the barometric pressure curve, showing residual drawdown from interflow that had occurred before setting the TAM packer between screens 1 and 2. As well, water-level data from July 13 to 14 fell below the barometric pressure curve, again showing the effects of residual drawdown from the 24-h pumping test. In those areas where the hydrograph fell beneath the barometric pressure plot, the shapes of the plots were similar, implying correlation between the data sets.

Data from R-37 screen 1 recorded during the previous screen 2 pumping tests were plotted for comparison to barometric pressure. Figure E-4.1-3 shows the resulting apparent hydrograph and barometric pressure record. The pumping times for the screen 2 tests are included in the graph for reference. Again, the hydrograph appeared to be an attenuated form of the barometric pressure curve. As before, the data were replotted as a rolling average hydrograph and barometric pressure adjusted for 62% barometric efficiency.

Figure E-4.1-4 shows the modified plot of aquifer pressure and adjusted barometric pressure. The background data collected on June 13 and 14 show excellent correlation to the adjusted barometric pressure, confirming the barometric efficiency of 62% for R-37 screen 1.

Unique to Figure E-4.1-4 was the reverse water-level trend observed during the 24-h constant-rate test conducted on screen 2 and the first 24 h of recovery. Note that when screen 2 pumping proceeded, the aquifer pressure measured at screen 1 rose relative to the barometric pressure curve; when screen 2 pumping ceased, the screen 1 pressure dropped similarly. The magnitude of the effect was about 0.06 ft. This effect may have been caused by water leaking through the drop-pipe coupling joints above the inflatable packer into the screen 1 zone. Such leakage through the pipe joints has been well documented in numerous pumping tests, including the 24-h test on R-37 screen 1, as described below. Alternatively, the observed water-level perturbations could have been an elastic response of some sort, either simple stretching and contraction of the drop pipe during pumping and recovery or an elastic formation effect associated with reverse water-level fluctuations related to pore-pressure changes (Wolff 1970, 098242; Rodrigues 1983, 098239; Heish 1996, 098238). This latter alternative is least likely because of the lack of an unsaturated interval of sediments between screens 1 and 2.

### E-4.2 Well R-37 Screen 1 Trial 1

Figure E-4.2-1 shows a semilog plot of the drawdown data collected from trial 1 conducted at a discharge rate of 0.75 gpm. The data showed classic casing-storagelike response even though the pumping water level remained above the bottom of the annular seal above screen 1. This implied the likelihood that air had been trapped in the filter pack above the screen when screen 1 gradually filled with water following installation of the TAM single-set packer. Expansion of the trapped air in response to drawdown caused by pumping created the apparent storagelike effect.

A review of well construction records showed that screen 1 required three times the volume of filter pack theoretically calculated for completion. Excess borehole size and filter pack material would tend to add to the duration of any resulting storage phenomenon.

While storage formulas have not been developed for this situation, a rough estimate of storage duration can be computed by replacing “drawdown” in Equations E-2 or E-3 with the estimated change in the height of the trapped air space in the filter pack. Crude estimates suggested that the duration of storage effects would have exceeded the test duration for the trial 1 and 2 pumping tests.

Figure E-4.2-2 shows the recovery data recorded following pump shutdown after trial 1. The response was highly unusual, with an extended storage effect followed by a late-time flattening of the curve in the last few tenths of a foot of recovery. Because of storage effects, the data were not analyzed.

### E-4.3 Well R-37 Screen 1 Trial 2

Figure E-4.3-1 shows a semilog plot of the drawdown data collected from trial 2. The discharge rate was 0.68 gpm for the first 10 min of the test and was increased to 1.02 gpm for the balance of the pumping period. As with trial 1, the data were storage-dominated. After 30 min of pumping, the piezometric surface was pulled into the filter pack above the screen. The effect of physical dewatering of the filter pack was to lengthen the duration of the storage effect even more.

Figure E-4.3-2 shows the recovery data recorded following pump shutdown after trial 2. The response was similar to that from trial 1, with an extended storage effect followed by a late-time flattening of the curve in the last few tenths of a foot of recovery. Because of storage effects, the data were not analyzed.

### E-4.4 Well R-37 24-H Constant-Rate Test

Figure E-4.4-1 shows a semilog plot of the drawdown data from the 24-h constant-rate pumping test conducted at a discharge rate of 0.81 gpm. It is evident that the water level was pulled into the well screen during the test. The transmissivity value obtained from the graph was 12.4 gpd/ft. Presumably, this was an underestimate because of the effects of casing storage.

Usually, at late time there is some flattening of the drawdown curve, even when the effects of casing storage are still present. The continuing steep decline in water level seen here was unusual and suggested the possibility that the water level may have been pulled below the contributing zone.

Figure E-4.4-2 shows the recovery data recorded following pump shutdown after the 24-h test. The data trace was exceedingly odd, showing storage effects throughout most of the recovery distance and a flattening in just the last few tenths of a foot of water-level recovery.

A plot was made of the recovery rate as a function of recovery time, as shown in Figure E-4.4-3. Generally, the rate of recovery should decline continuously over time. As shown in the figure, however, the recovery rate remained nearly constant for the first 30 to 40 min of water-level rise. This suggested negligible water contribution from the section of the well spanned by the water-level change over that period, approximately the well screen interval.

This idea was illustrated further in Figure E-4.4-4, a linear plot of residual drawdown. As shown, the portion of the recovery curve through the well screen length was nearly straight, suggesting a constant recovery rate over that interval and therefore little contribution to the well yield from that zone. The balance of the graph was difficult to interpret because it reflected complex response to recovery coupled with compression of the airspace above the water table as levels rose inside the well.

The late-recovery data were plotted on an expanded scale, as shown in Figure E-4.4-5. The effect of barometric pressure changes can be seen as “waves” in the data plot.

Before analysis, the recovery data were corrected for barometric pressure changes using the estimated barometric efficiency of 62%. Figure E-4.4-6 shows the resulting plot of corrected data. A transmissivity value of 1530 gpd/ft was computed from the graph. It was not known if delayed yield associated with unconfined conditions was reflected in the slope of the line shown in the figure. Delayed yield would have the effect of flattening the data trace, resulting in an overestimate of transmissivity. Therefore, the computed value may be viewed as an upper bound of the perched zone transmissivity.

Following the recovery period, the inflatable packer above screen 1 was deflated by bleeding off the compressed nitrogen very slowly. Figure E-4.4-7 shows the head buildup measured during this procedure. The head rose about 1.5 ft and took many minutes to dissipate, indicating that water had built up above the packer during the pumping tests. This was an indication that the coupling joints in the 1.5-in. stainless-steel drop pipe had leaked a small volume of fluid during the tests, consistent with previous performance of this pipe.

### E-4.5 Well R-37 Screen 1 Purge Development

Figure E-4.5-1 shows a semilog plot of the drawdown data from the final purge development performed at a discharge rate of 0.81 gpm. Again the water level was pulled into the well screen during the test, likely exacerbating storage effects. There was no trend of flattening of the drawdown curve over time, suggesting the possibility that the water level may have been pulled below the contributing zone. The transmissivity calculated from the line of fit on the graph was 11.9 gpd/ft, presumably an underestimate caused by the exaggerated slope attributable to either storage effects or pulling the pumping water level below the producing zone.

Figure E-4.5-2 shows the recovery data recorded following pump shutdown. As with the other tests, the recovery curve was exceedingly odd, showing storage effects throughout most of the recovery distance, and a flattening in just the last few tenths of a foot of water-level recovery.

A plot was made of the recovery rate as a function of recovery time, as shown in Figure E-4.5-3. Again, the recovery rate remained nearly constant for the first 30 to 40 min of water-level rise consistent with minimal water contribution from the distance spanned by the water-level change over that period.

Figure E-4.5-4 shows a linear plot of residual drawdown. As observed in the 24-h recovery data, the portion of the recovery curve through the well screen length was nearly straight, suggesting a constant recovery rate over that interval and therefore little contribution to the well yield from that zone. The balance of the graph was difficult to interpret because it reflected complex response to recovery, coupled with compression of the airspace above the water table as levels rose inside the well.

The late-recovery data were plotted on an expanded scale, as shown in Figure E-4.5-5. The effect of barometric pressure changes can be seen as waves in the data plot.

Before analysis, the recovery data were corrected for barometric pressure changes using the estimated barometric efficiency of 62%. Figure E-4.5-6 shows the resulting plot of corrected data. A transmissivity value of 1640 gpd/ft was computed from the graph. It was not known if delayed yield associated with unconfined conditions was reflected in the slope of the line shown in the figure. Delayed yield would have the effect of flattening the data trace, resulting in an overestimate of transmissivity. Therefore, the computed value may be viewed as an upper bound of the perched zone transmissivity.

Following the recovery period, the inflatable packer above screen 1 was deflated by bleeding off the compressed nitrogen very slowly. Figure E-4.5-7 shows the head change measured during this procedure. The head declined more than a foot in response to the volume reduction associated with deflating the packer. Contrary to the previous packer deflation, there was no head buildup and no indication that the coupling joints in the 1.5-in. stainless-steel drop pipe had leaked during the purge development test.

### E-4.6 Well R-37 Screen 1 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound transmissivity value for the perched zone penetrated by R-37 screen 1. This was done to provide a frame of reference for evaluating the foregoing analyses.

In addition to specific capacity, other input values used in the calculations included an assigned storage coefficient value of 0.05, a screen length of 20.7 ft, a saturated formation thickness of 43.1 ft (from the static water level to the bottom of the screen) and an estimated borehole radius of 1 ft. The drilled borehole radius was 0.51 ft, but the large volume of filter pack required to complete the well implied a larger average radius on the order of 1 ft.

R-37 screen 1 produced 0.81 gpm with a drawdown of 34.5 ft after 1440 min of pumping for a specific capacity of 0.0235 gpm/ft. Applying the Brons and Marting method to these inputs (1961, 098235) yielded a lower-bound transmissivity value of 26.6 gpd/ft. No correction for dewatering was incorporated into these calculations because of the complexity of accounting from both partial penetration and dewatering simultaneously and the uncertainty as to the source of most of the production from screen 1. It is sufficient to point out that had a correction been applied, the input drawdown parameter would have been smaller, resulting in a somewhat larger lower-bound transmissivity value than 26.6 gpd/ft.

Note that the specific capacity analysis reinforces the idea that the transmissivity values of 12.4 and 11.9 gpd/ft obtained from the time-drawdown analyses (Figures E-4.4-1 and E-4.5-1, respectively) were underestimates, consistent with prolonged storage effects or the idea that much of the production to screen 1 came from above the screened interval.

## E-5.0 WELL R-37 SCREEN 2 DATA ANALYSIS

This section presents the data obtained from the R-37 screen 2 pumping tests and the results of the analytical interpretations. Data are presented for the initial trial tests, the 24-h test, the final trial test, and background monitoring

### E-5.1 Well R-37 Screen 2 Background Data

Background aquifer pressure data collected during the R-37 screen 2 testing were plotted along with barometric pressure to determine the barometric effect on water levels.

Figure E-5.1-1 shows aquifer pressure data from R-37 screen 2 along with barometric pressure data from TA-54 that have been corrected to equivalent barometric pressure at the water table in feet of water. The screen 2 data are referred to in the figure as the apparent hydrograph because the measurements reflect the sum of water pressure and barometric pressure, having been recorded using a nonvented pressure transducer. The times of the pumping periods for the screen 2 pumping tests are included in the figure for reference. According to the graph, changes in barometric pressure had little or no effect on total aquifer pressure, suggesting a barometric efficiency near 100%.

Figure E-5.1-2 shows a similar plot except that the water-level data are shown as a rolling average to reduce the noise in the signal. This plot confirmed the high barometric efficiency. The only perturbations in the apparent hydrograph were fluctuations of just a couple hundredths of a foot, unrelated to barometric pressure changes and likely an Earth tide response.

### E-5.2 Well R-37 Screen 2 Trial 1

Trial 1 consisted of pumping screen 2 for 15 min at an average discharge rate of 10.6 gpm. Following shutdown, recovery was monitored for 60 min.

Figure E-5.2-1 shows the recovery data following the brief trial 1 pumping test. The line of fit shown on the graph suggested an early-time transmissivity of 3300 gpd/ft. Dividing this value by the screen length of approximately 20.7 ft yielded a hydraulic conductivity on 159 gpd/ft$^2$, or 21.3 ft/d.

Of note was that the first few data points fell off the straight line, as did the late data points. The early data deviated from the straight-line relationship because the *u*-value criterion of the Cooper–Jacob method was not met. The combination of large storage coefficient (unconfined conditions), large well radius (washout zones in screen 2 requiring twice as much filter pack as theoretically predicted), relatively low transmissivity, and early time resulted in the unusual circumstance of failing to meet the *u*-value criterion for the first few data points.

To accommodate the early data, Theis curve matching was performed to analyze the early data. Figure E-5.2-2 shows a log-log plot of feet of recovery versus recovery time for trial 1. The graph produced a transmissivity of 3600 gpd/ft, making the hydraulic conductivity 174 gpd/ft$^2$, or 23.3 ft/d.

It was possible that the foregoing transmissivity calculations reflected a slightly greater sediment thickness than the well screen length. Thus, the hydraulic conductivity value computed using the well screen length may overstate the true value somewhat. In other words, the computed hydraulic conductivity values may be considered upper bounds for the actual value.

The flat slope observed at late time in Figure E-5.2-1 was likely an indication of vertical expansion of the cone of depression beyond the well screen length due to partial penetration and/or leakage. The flat portion of the curve may have included a delayed yield contribution component also.

### E-5.3 Well R-37 Screen 2 Trial 2

Trial 2 consisted of pumping screen 2 for 60 min at multiple rates. Figure E-5.3-1 shows the time-drawdown graph from the pumping period. The valve on the discharge line was faulty and required readjustment numerous times accounting for the step-function appearance in the data. The average discharge rate during trial 2 was 11.9 gpm, while the rate toward the end of the test was 12.9 gpm. The erratic variation in discharge rate precluded analysis of the data.

Figure E-5.3-2 shows recovery data recorded following the trial 2 pump shutdown. The transmissivity value determined from the line of fit on the graph was 3290 gpd/ft, making the upper-bound hydraulic conductivity value 159 gpd/ft$^2$, or 21.2 ft/d.

Again, the early data did not conform to the straight-line analysis. Therefore, Theis curve matching was performed as shown in Figure E-5.3-3. The transmissivity computed from the match was 3650 gpd/ft, making the hydraulic conductivity 176 gpd/ft$^2$, or 23.6 ft/d.

Again the late-time recovery data showed a flatter slope caused by either leakage, vertical expansion of the cone of depression beyond the well screen length and/or delay yield.

### E-5.4 Well R-37 Screen 2 24-H Test

The 24-h pumping test was begun at a rate of 12.9 gpm for the first several minutes of pumping. Then the rate fell to around 12.5 gpm and remained there for the balance of the test.

Figure E-5.4-1 shows the drawdown data from the 24-h test. The transmissivity computed from the line of fit on the graph was 3250 gpd/ft, making the hydraulic conductivity 157 gpd/ft$^2$, or 21.0 ft/d.

Theis curve matching was performed to utilize more of the early data than could be incorporated into the semilog analysis. Figure E-5.4-2 shows the resulting analysis revealing a transmissivity value of 3700 gpd/ft, making the hydraulic conductivity 179 gpd/ft$^2$, or 23.9 ft/d.

The late data shown in Figures E-5.4-1 and E-5.4-2 show a progressive reduction in slope as the cone of depression grew vertically over time.

Figure E-5.4-3 shows recovery data recorded following pump shutdown. The transmissivity computed from the line of fit on the graph was 2800 gpd/ft, making the hydraulic conductivity 135 gpd/ft$^2$, or 18.1 ft/d. The late drawdown and recovery data showed a steady flattening of the drawdown curve caused be either delayed yield or the cone of depression expanding vertically around screen 2.

To utilize the early data, Theis curve matching was performed as shown in Figure E-5.4-4. The transmissivity computed from the curve match was 3300 gpd/ft, making the hydraulic conductivity 159 gpd/ft$^2$, or 21.3 ft/d.

### E-5.5 Well R-37 Screen 2 Trial 3

Following the 24-h pumping test, a final brief pumping event was performed at the maximum discharge rate of the pump. Screen 2 was pumped at 16.9 gpm for a period of 180 min.

Figure E-5.5-1 shows the drawdown data recorded during the pumping test. The early data showed a transmissivity value of 2970 gpd/ft, making the hydraulic conductivity 143 gpd/ft$^2$, or 19.2 ft/d.

After 60 min of pumping, the data showed a remarkable rise in water level for 60 minutes followed by a decline in level over the final 60 min. There was no explanation for this unusual water-level response. Manual flow-rate measurements during the test confirmed that the pumping rate remained constant throughout the pumping period so variable flow rate could not have caused the observed response. Leakage of overlying water past the inflatable packer was ruled out as a possible cause as well. The packer pressure was maintained constant throughout the test. Also, as illustrated previously in Figure E-4.1-4, the water levels in screen 1 fluctuated only in response to barometric pressure changes and did not show a drop in level on June 24 that would have signaled leakage of water past the underlying packer. It was possible that the transducer may have malfunctioned, but all other data collected during the testing appeared normal. Finally, it was possible that the screen zone may have “developed” by producing sand and cleaning up in response to the high pumping rate applied in trial 3, which could have increased its pumping efficiency during the test. These possibilities are mere speculation; as yet, the cause of the water-level rise during trial 3 is not understood.

Although the data may have been compromised, analyses were performed on the recovery data set. Figure E-5.5-2 shows a semilog plot of the recovery data. The transmissivity computed from the graph was 3080 gpd/ft, making the hydraulic conductivity 149 gpd/ft$^2$, or 19.9 ft/d. These results were consistent with previous results.

Theis curve matching was used to estimate transmissivity as shown in Figure E-5.5-3. The transmissivity calculated from the curve match was 3500 gpd/ft, making the hydraulic conductivity 169 gpd/ft$^2$, or 22.6 ft/d.

As in the other tests, the late-time recovery data showed a flatter slope caused by either leakage, vertical expansion of the cone of depression beyond the well screen length, and/or delay yield.

### E-5.6 Well R-37 Screen 2 Specific Capacity Data

Specific capacity data were used along with well geometry to estimate a lower-bound transmissivity value for the zone penetrated by R-37 screen 2. This was done to provide a frame of reference for evaluating the foregoing analyses.

In addition to specific capacity, other input values used in the calculations included an assigned storage coefficient value of 0.1, a screen length of 20.7 ft, an arbitrary saturated formation thickness of 100 ft, and an estimated borehole radius of 0.7 ft. The drilled borehole radius was 0.51 ft, but the large volume of filter pack required to complete the well implied a larger effective radius on the order of 0.7 ft.

R-37 screen 2 produced 12.5 gpm with a drawdown of 4.0 ft after 1440 min of pumping for a specific capacity of 3.13 gpm/ft. Applying the Brons and Marting method to these inputs (1961, 098235) yielded a lower-bound hydraulic conductivity value of 16.7 ft/d. This was consistent with the foregoing pumping test analyses, which produced an overall average hydraulic conductivity of 21.4 ft/d.

## E-6.0 SUMMARY

Constant-rate pumping tests were conducted on R-37 screens 1 and 2 located on an unnamed mesa between the south fork of Cañada del Buey and Cañada del Buey Canyon at TA-54. Several conclusions and observations were made from the analysis of the test data as described below.

Screen 1 is completed in a perched zone in saturated sediments in the Puye Formation and overlying Cerros del Rio basalt sedimentary interbeds. The water table measured at screen 1 was at an elevation of about 5963 ft (June 13, 2009). Screen 2 is completed in the Puye Formation near the top of the regional aquifer having a static water elevation of approximately 5860 ft (June 22, 2009), 103 ft lower than that of screen 1.

Screen 1 showed a barometric efficiency lower than most deep wells on the plateau, 62%.

The screen 1 response to pumping was complex and difficult to interpret. Much of the data was storage-affected. Later data indicated the possibility that the pumping water level had fallen below the contributing zones. Linear-recovery response suggested the possibility that much of the production to screen 1 may come from sediments above the top of the screen.

Conventional drawdown analysis produced an average transmissivity of about 12 gpd/ft, likely an erroneously low value based on the foregoing conditions. Late-recovery data suggested an average transmissivity of around 1600 gpd/ft. This may be the true transmissivity of sediments largely above the screen zone, or it may be erroneously high—an artifact of delayed yield associated with unconfined conditions. Whichever interpretation is correct cannot be ascertained from the test data.

Screen 1 produced 0.81 gpm with 34.5 ft of drawdown after 1 d of pumping for a specific capacity of 0.0235 gpm/ft. This implied a lower-bound transmissivity of about 27 gpd/ft. This result contradicted the very low time-drawdown values but also did not comport well with the relatively higher values from the recovery analysis.

Screen 2 showed a barometric efficiency of near 100%, typical of most deep wells on the plateau.

Drawdown and recovery data analyses of several tests produced consistent results, indicating an average hydraulic conductivity value for screen 2 of 21.4 ft/d. This may be a slight overestimate of the hydraulic conductivity, as the computed transmissivity values supporting this average may have included some sediment thickness beyond the well screen interval. Thus, this value was considered an upper bound of the hydraulic conductivity.

Screen 2 produced 12.5 gpm with 4.0 ft of drawdown after 1 d of pumping for a specific capacity of 3.13 gpm/ft. This implied a lower-bound hydraulic conductivity of 16.7 ft/d for the screen 2 sediments. This provided good corroboration of the pumping test value of 21.4 ft/d and helped bracket the hydraulic conductivity nicely.

Late-pumping and recovery data from screen 2 showed steady flattening over time, consistent with either delay-yield effects and/or continued vertical growth of the cone of depression into deeper sediments associated with leakage or partial penetration.

## E-7.0 REFERENCES

*The following list includes all documents cited in this appendix. Parenthetical information following each reference provides the author(s), publication date, and ER ID. This information is also included in text citations. ER IDs are assigned by the Environmental Programs Directorate's Records Processing Facility (RPF) and are used to locate the document at the RPF and, where applicable, in the master reference set.*

*Copies of the master reference set are maintained at the New Mexico Environment Department Hazardous Waste Bureau and the Directorate. The set was developed to ensure that the administrative authority has all material needed to review this document, and it is updated with every document submitted to the administrative authority. Documents previously submitted to the administrative authority are not included.*

Bradbury, K.R., and E.R. Rothschild, March-April 1985. "A Computerized Technique for Estimating the Hydraulic Conductivity of Aquifers from Specific Capacity Data," *Ground Water,* Vol. 23, No. 2, pp. 240-246. (Bradbury and Rothschild 1985, 098234)

Brons, F., and V.E. Marting, 1961. "The Effect of Restricted Fluid Entry on Well Productivity," *Journal of Petroleum Technology,* Vol. 13, No. 2, pp. 172-174. (Brons and Marting 1961, 098235)

Cooper, H.H., Jr., and C.E. Jacob, August 1946. "A Generalized Graphical Method for Evaluating Formation Constants and Summarizing Well-Field History," *American Geophysical Union Transactions,* Vol. 27, No. 4, pp. 526-534. (Cooper and Jacob 1946, 098236)

Driscoll, F.G., 1986. Excerpted pages from *Groundwater and Wells*, 2nd Ed., Johnson Filtration Systems Inc., St. Paul, Minnesota. (Driscoll 1986, 104226)

Heish, P.A., November-December 1996. "Deformation-Induced Changes in Hydraulic Head During Ground-Water Withdrawal," *Ground Water,* Vol. 34, No. 6, pp. 1082-1089. (Hsieh 1996, 098238)

Rodrigues, J.D., 1983. "The Noordbergum Effect and Characterization of Aquitards at the Rio Maior Mining Project," *Ground Water,* Vol. 21, No. 2, pp. 200-207. (Rodrigues 1983, 098239)

Schafer, D.C., January-February 1978. "Casing Storage Can Affect Pumping Test Data," *The Johnson Drillers Journal,* pp. 1-6, Johnson Division, UOP, Inc., St. Paul, Minnesota. (Schafer 1978, 098240)

Theis, C.V., 1934-1935. "The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Ground-Water Storage," *American Geophysical Union Transactions,* Vol. 15-16, pp. 519-524. (Theis 1934-1935, 098241)

Wolff, R.G., December 1970. "Relationship Between Horizontal Strain Near a Well and Reverse Water Level Fluctuation," *Water Resources Research,* Vol. 6, No. 6, pp. 1721-1728. (Wolff 1970, 098242)

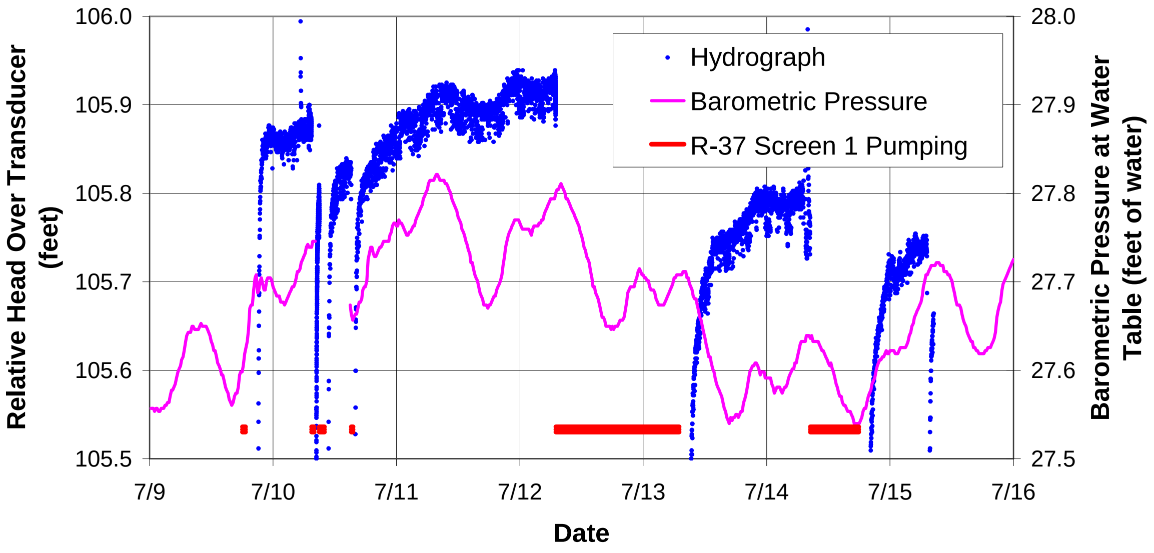

**Figure E-4.1-1 R-37 screen 1 apparent hydrograph**

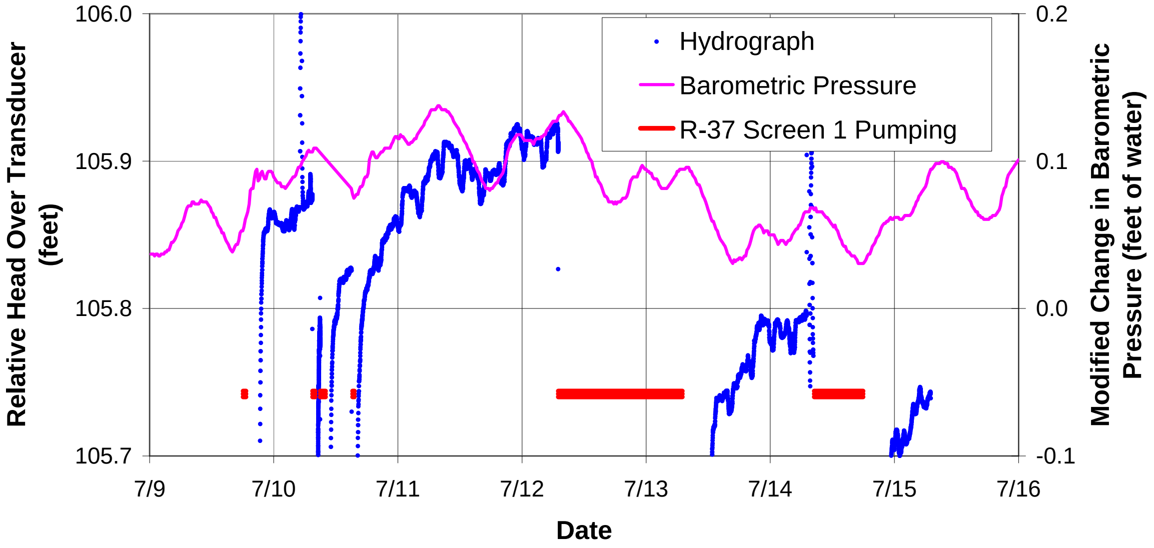

**Figure E-4.1-2 R-37 screen 1 rolling average hydrograph and barometric pressure corrected for 62% efficiency**

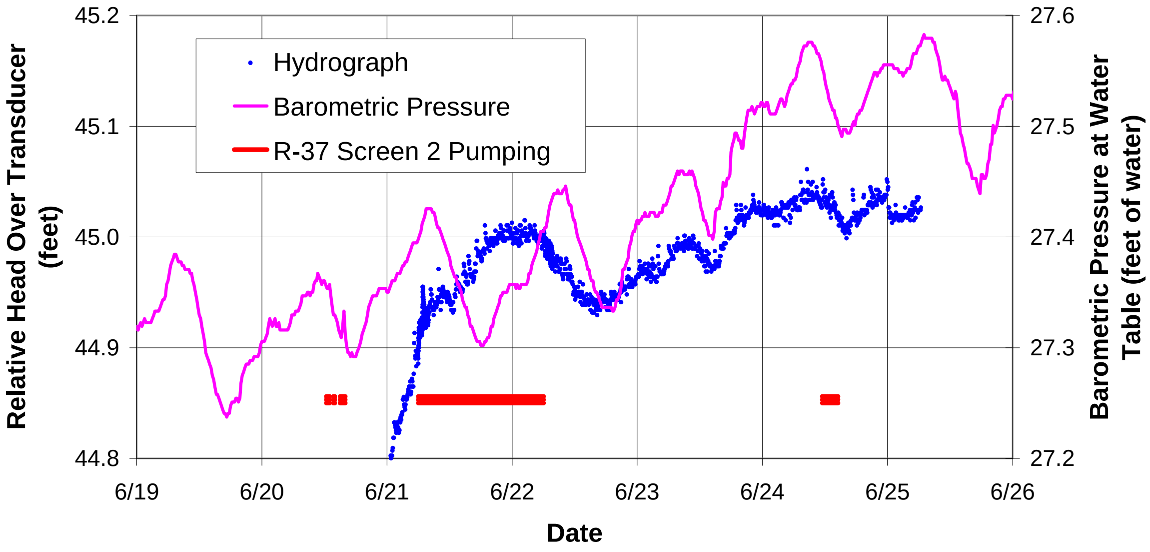

Figure E-4.1-3 R-37 screen 1 apparent hydrograph during screen 2 pumping test

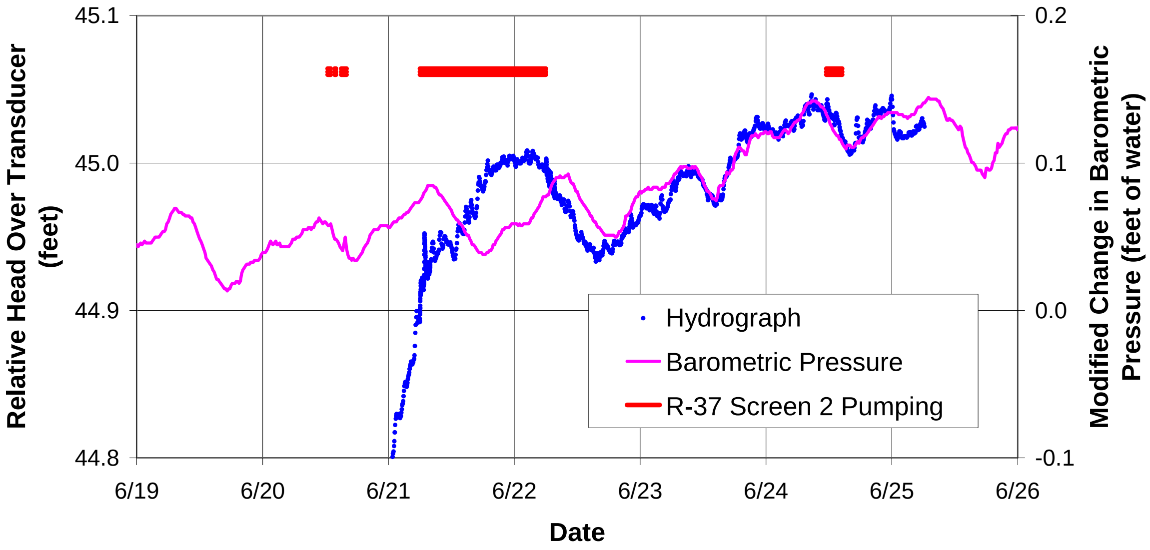

Figure E-4.1-4 R-37 screen 1 rolling average hydrograph during screen 2 pumping test and barometric pressure corrected for 62% efficiency

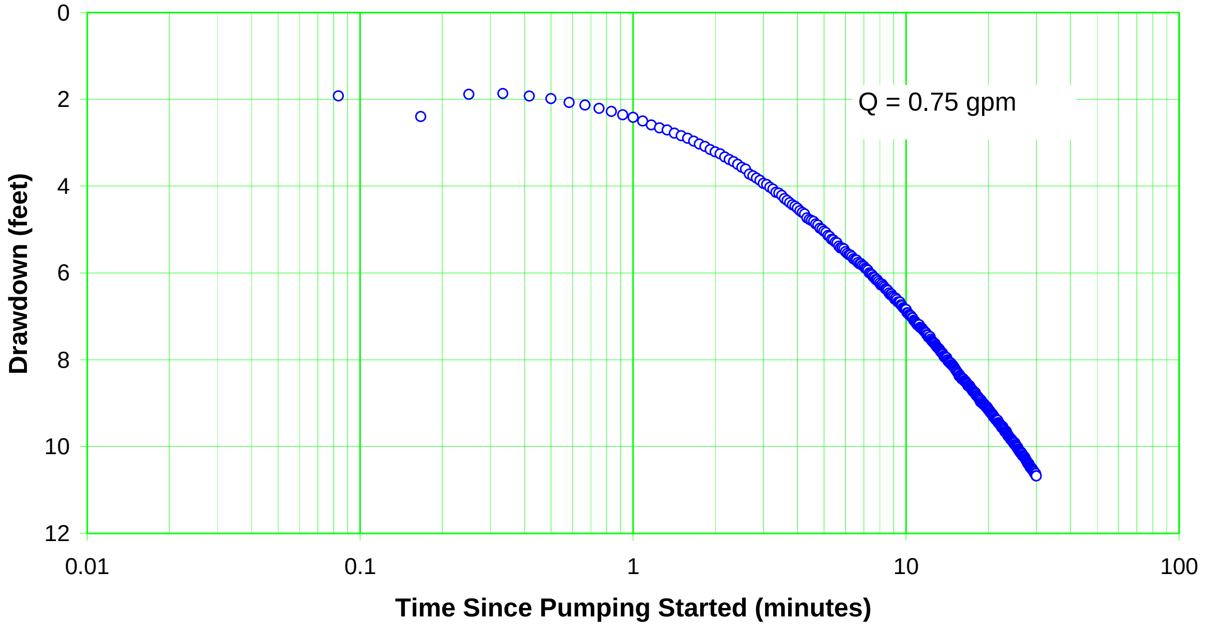

**Figure E-4.2-1  Well R-37 screen 1 trial 1 drawdown**

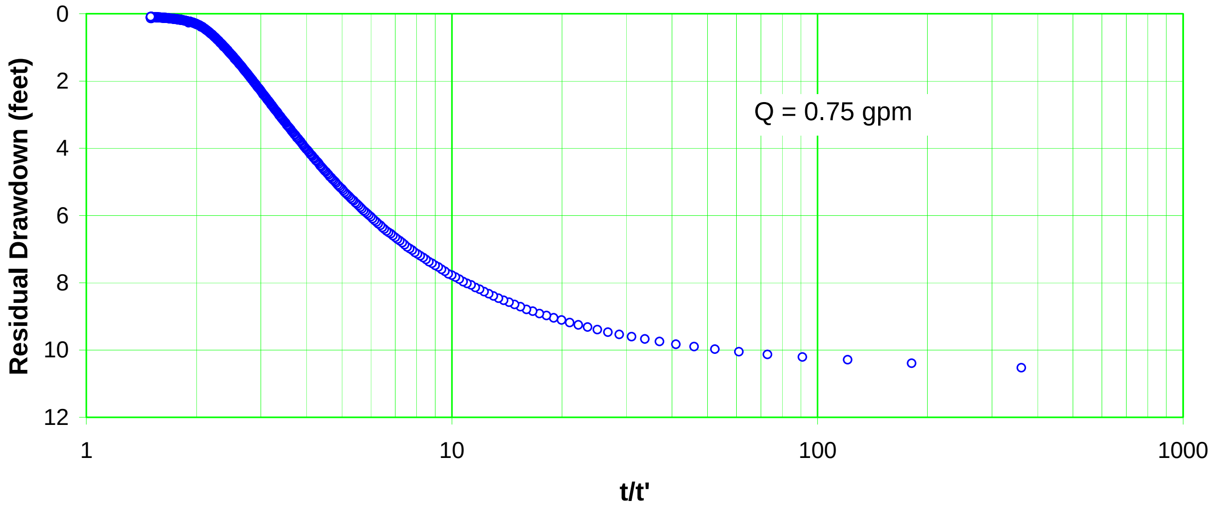

**Figure E-4.2-2  Well R-37 screen 1 trial 1 recovery**

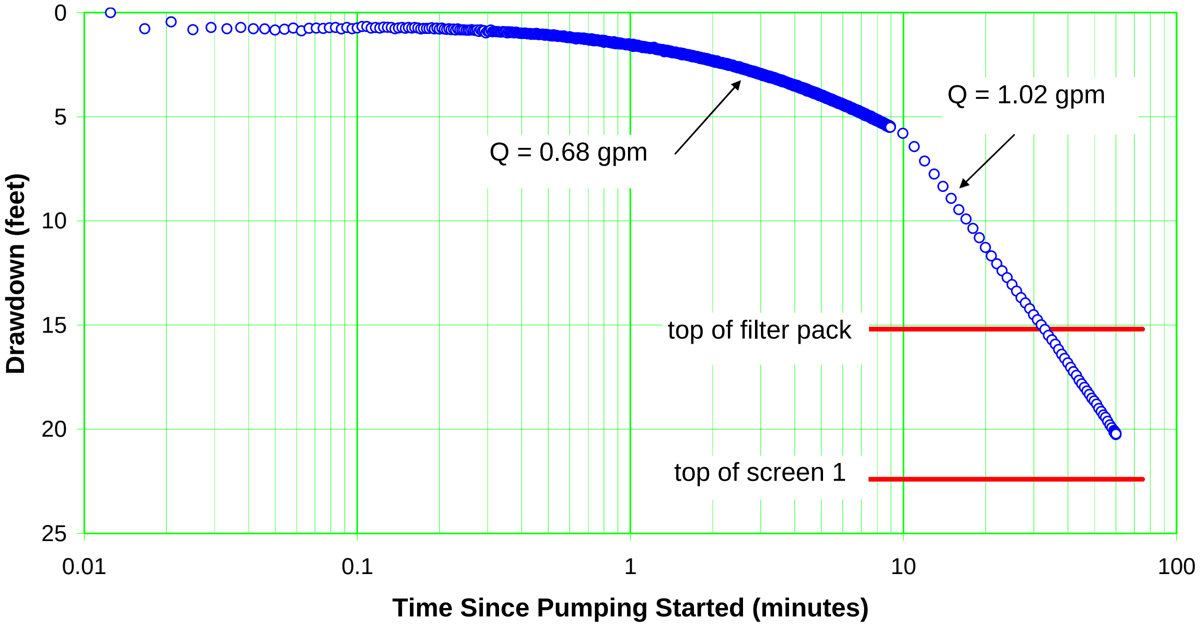

**Figure E-4.3-1  Well R-37 screen 1 trial 2 drawdown**

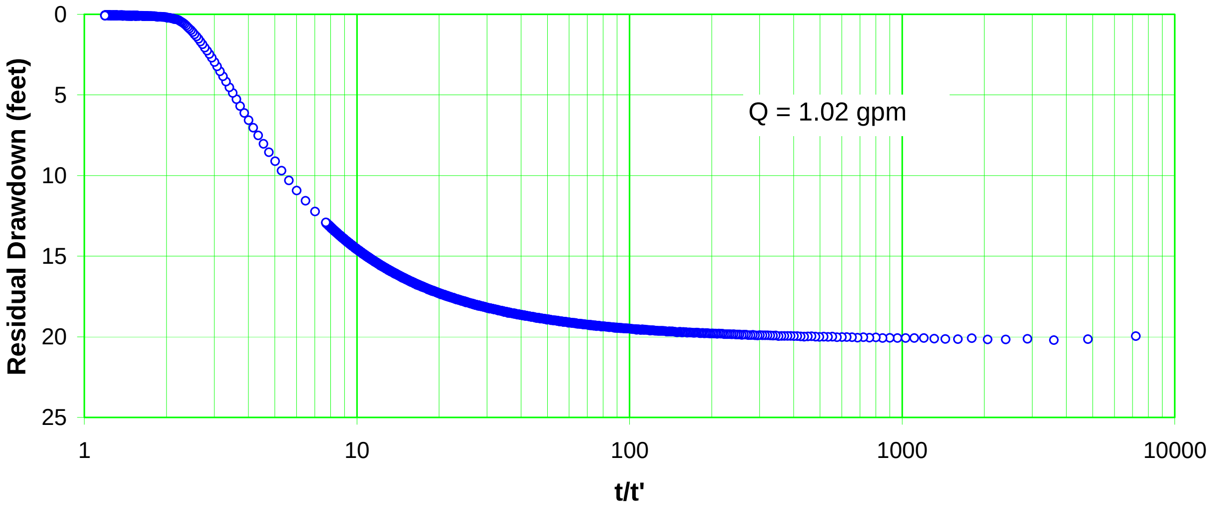

**Figure E-4.3-2  Well R-37 screen 1 trial 2 recovery**

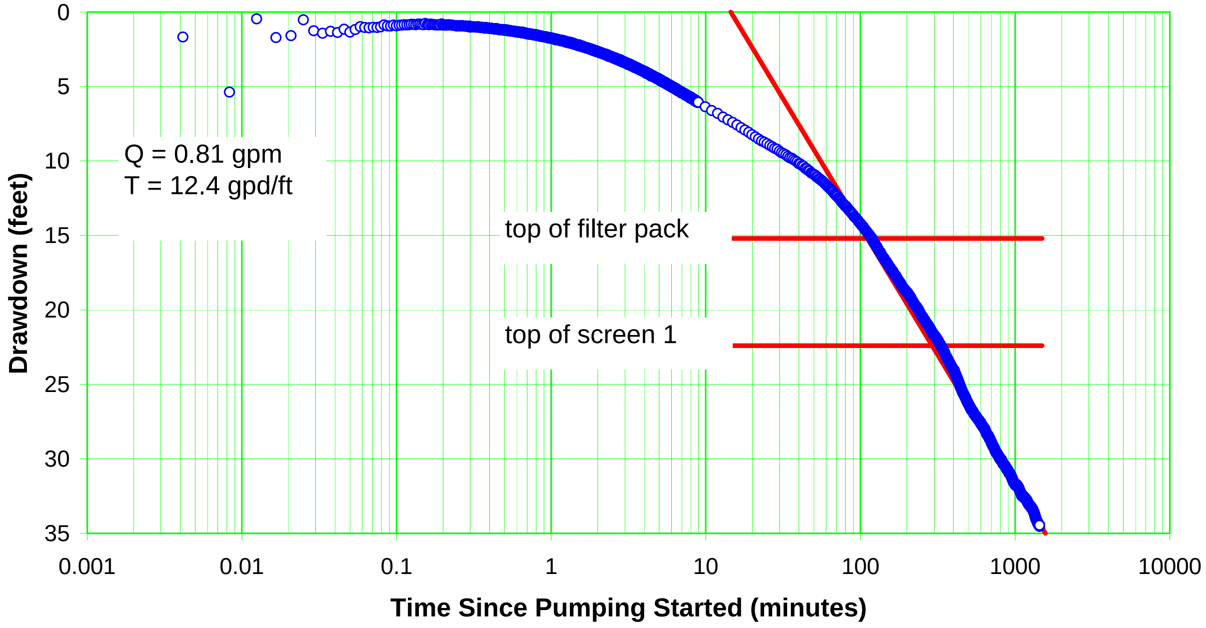

**Figure E-4.4-1  Well R-37 screen 1 drawdown**

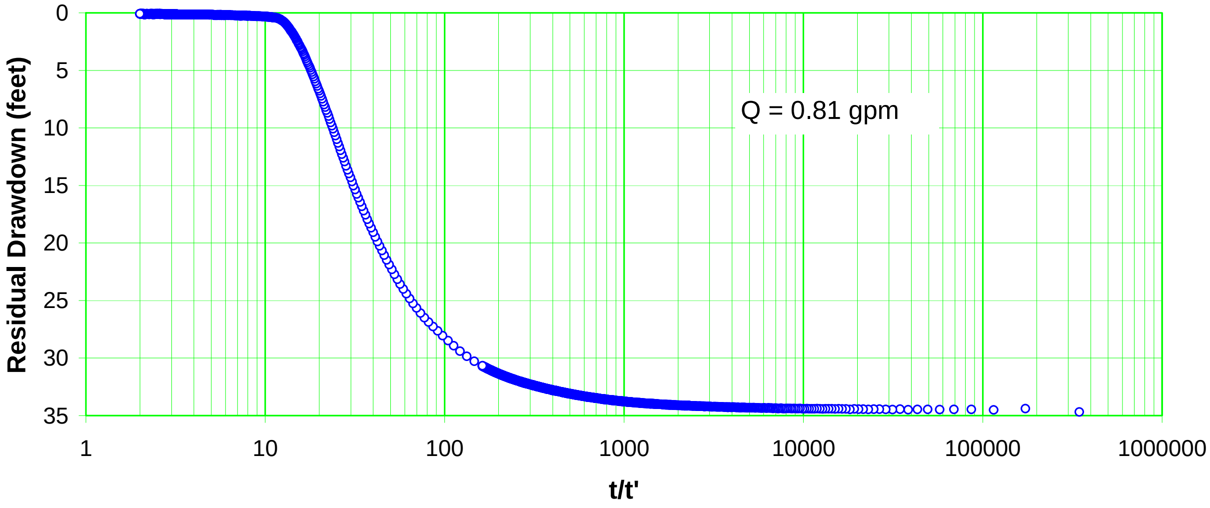

**Figure E-4.4-2  Well R-37 screen 1 recovery**

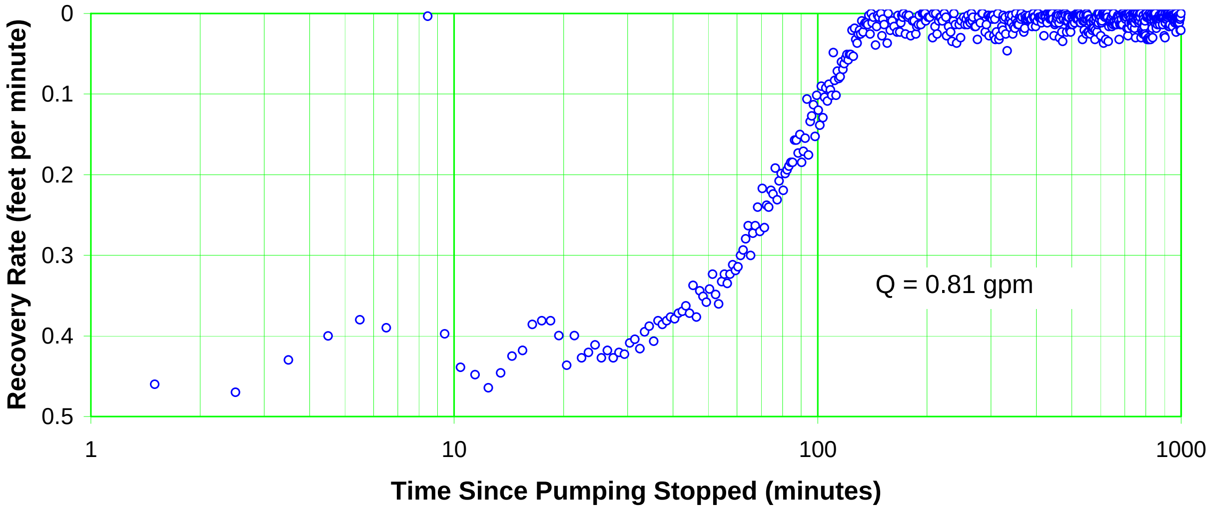

**Figure E-4.4-3 Well R-37 screen 1 calculated recovery rate**

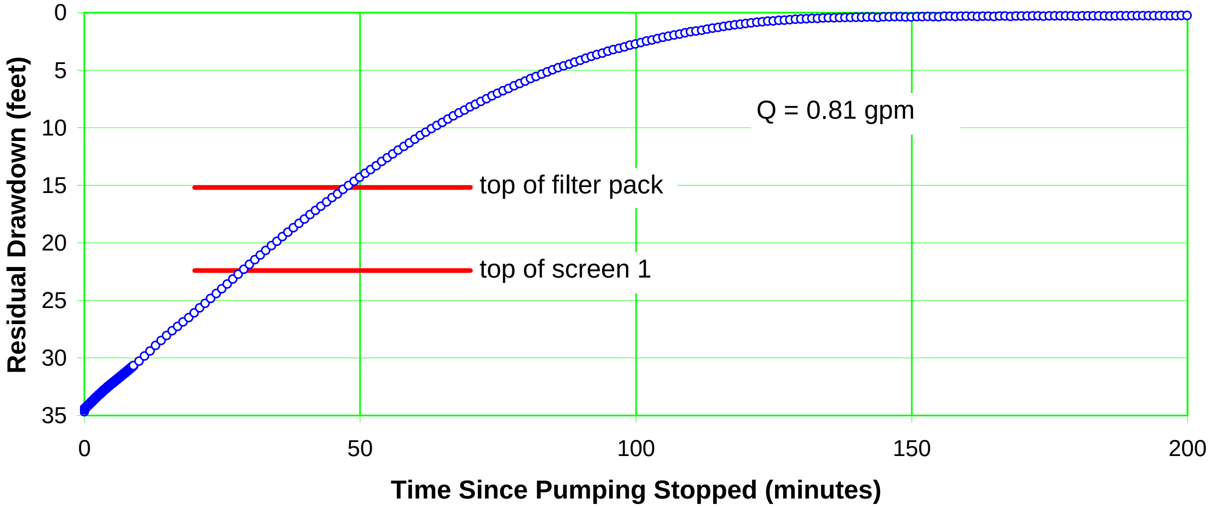

**Figure E-4.4-4 Well R-37 screen 1 recovery—linear plot**

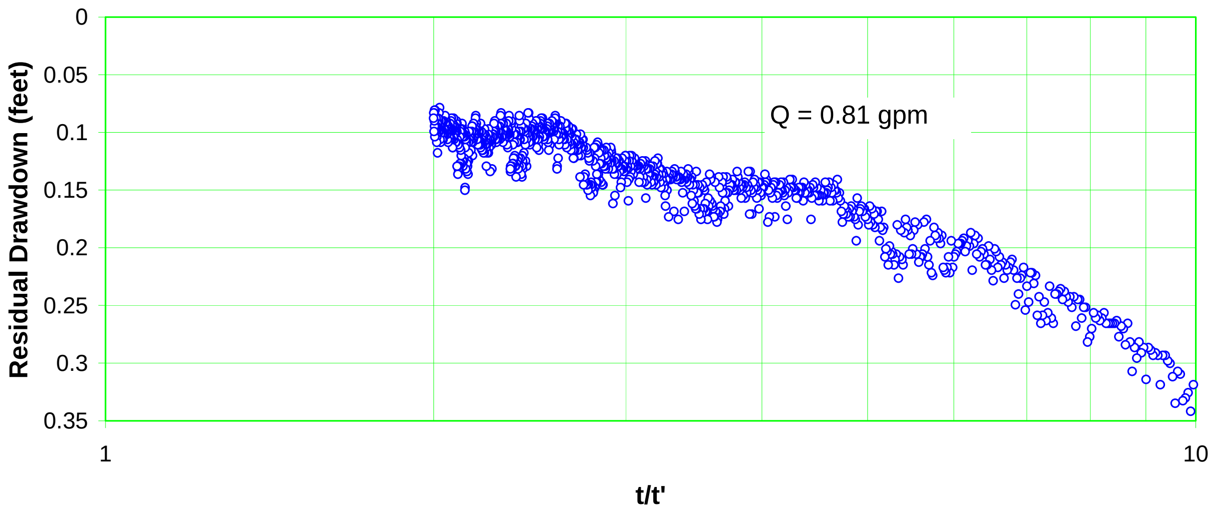

Figure E-4.4-5 Well R-37 screen 1 recovery—expanded scale

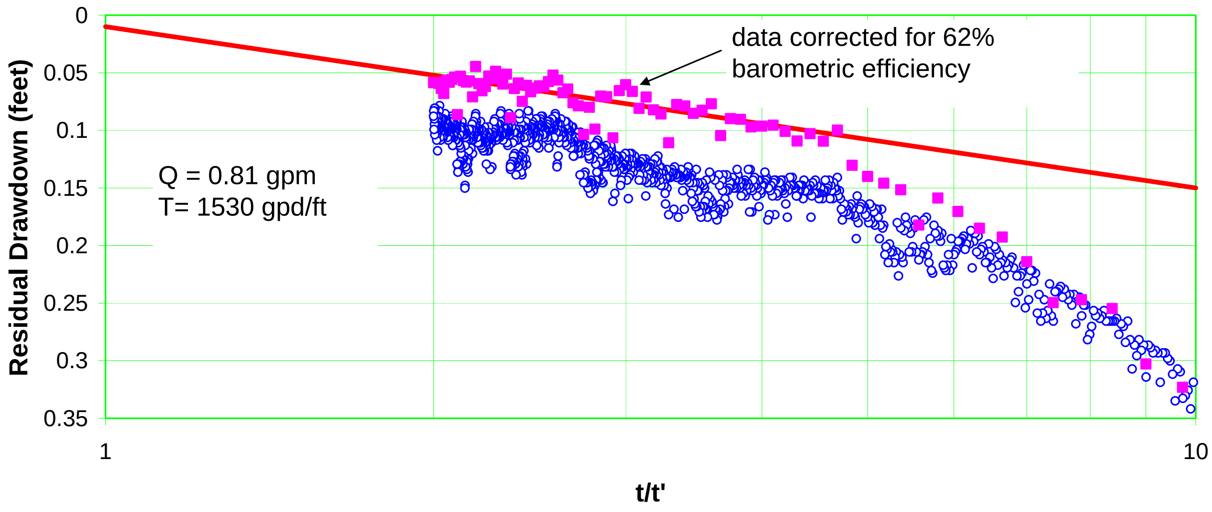

Figure E-4.4-6 Well R-37 screen 1 recovery—corrected data

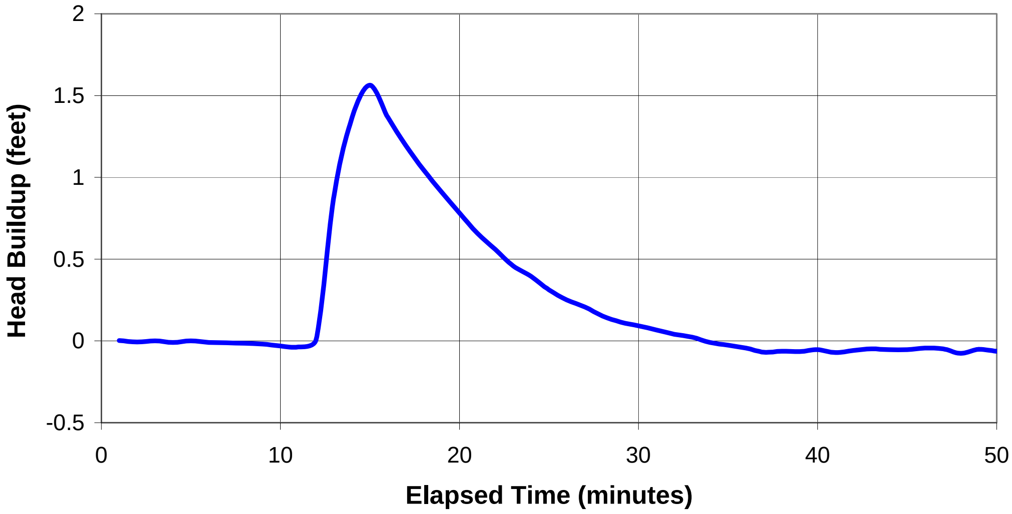

**Figure E-4.4-7 Well R-37 screen 1 packer deflation following 24-h test**

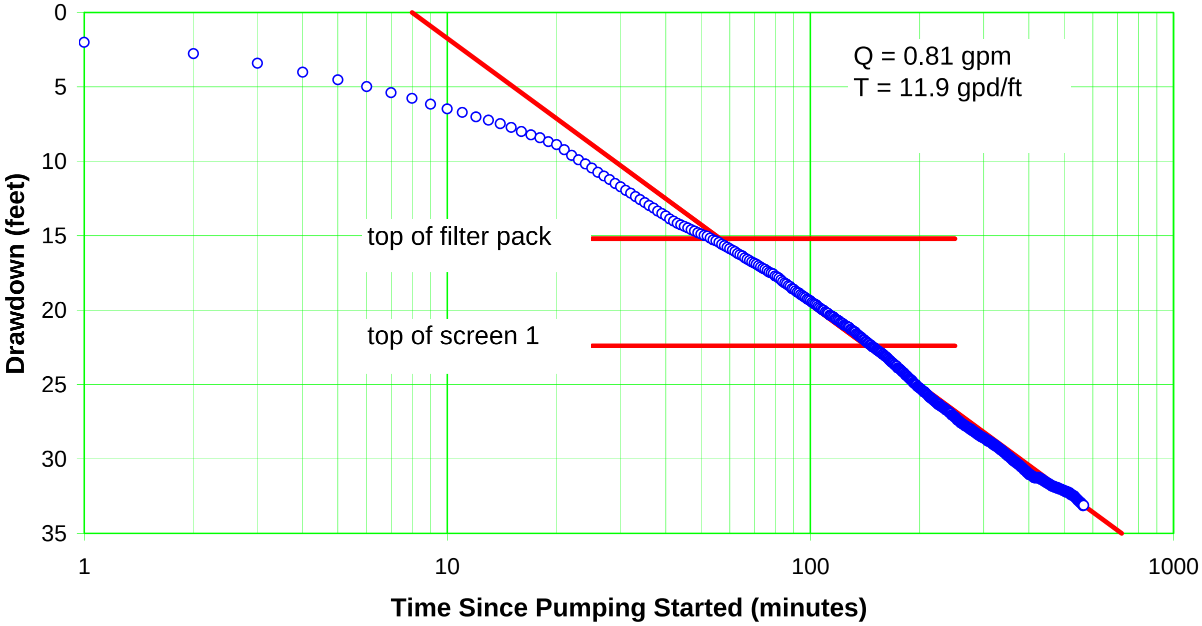

**Figure E-4.5-1 Well R-37 screen 1 purge development drawdown**

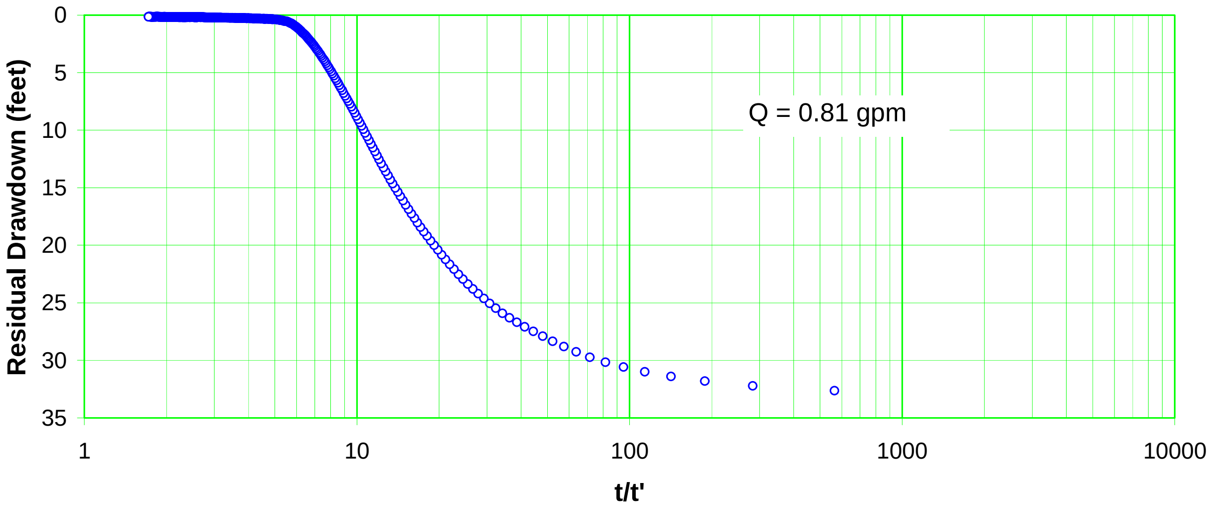

**Figure E-4.5-2  Well R-37 screen 1 purge development recovery**

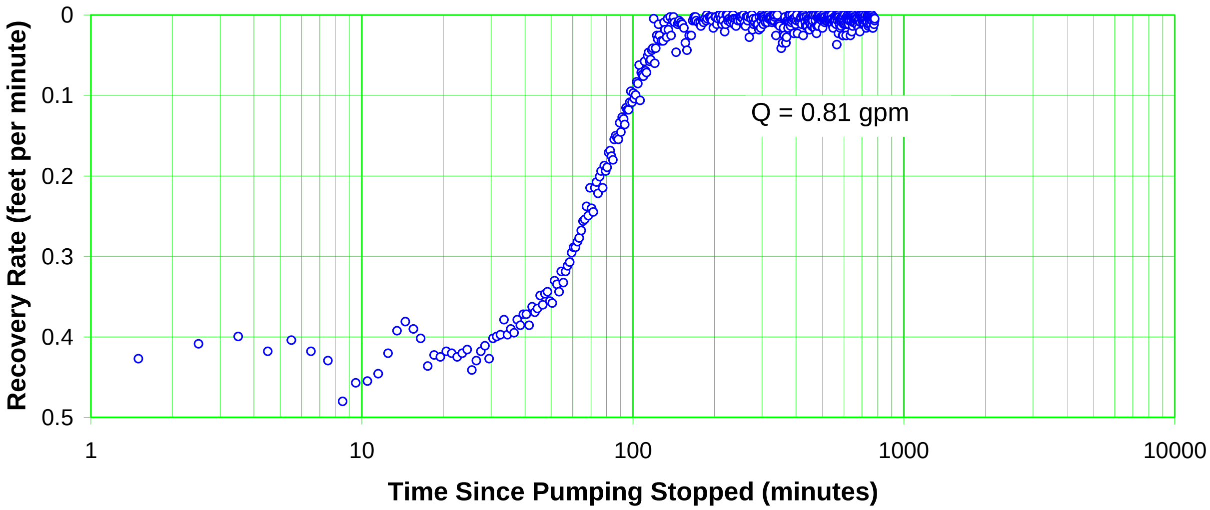

**Figure E-4.5-3  Well R-37 screen 1 purge development calculated recovery rate**

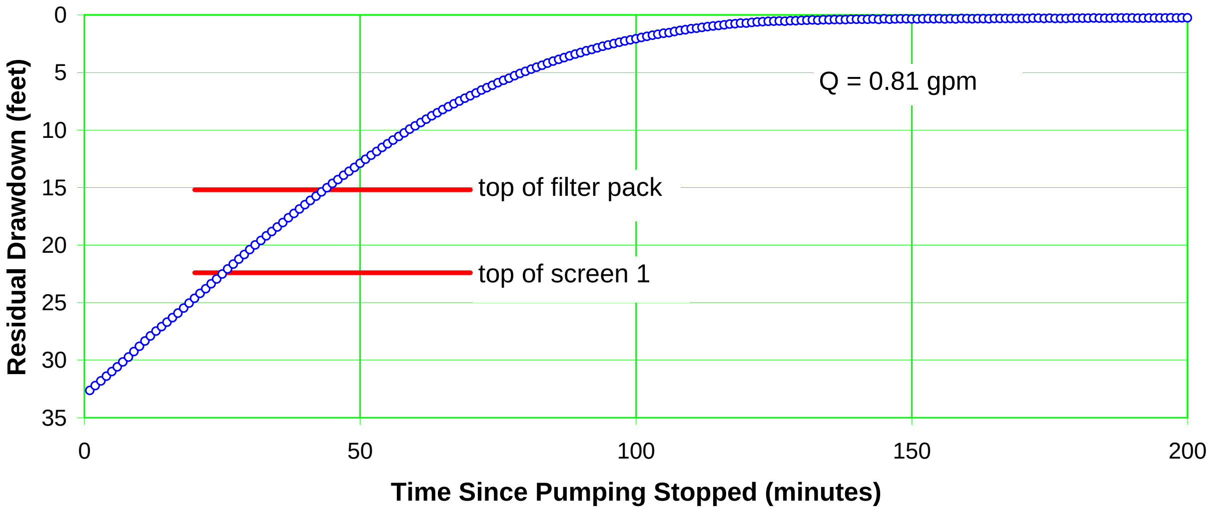

Figure E-4.5-4 Well R-37 screen 1 purge development recovery—linear plot

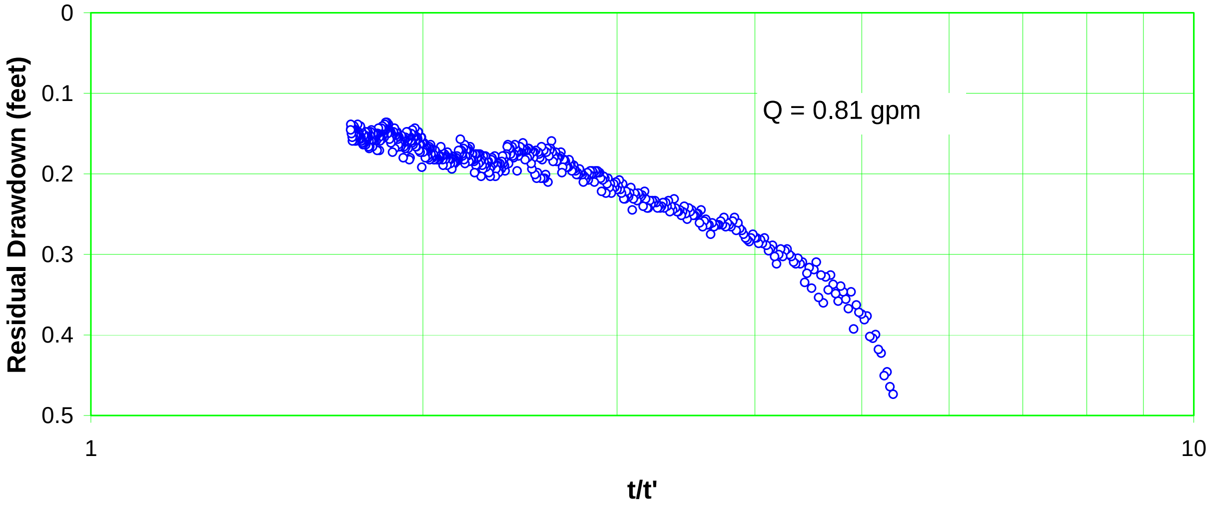

Figure E-4.5-5 Well R-37 screen 1 purge development recovery—expanded scale

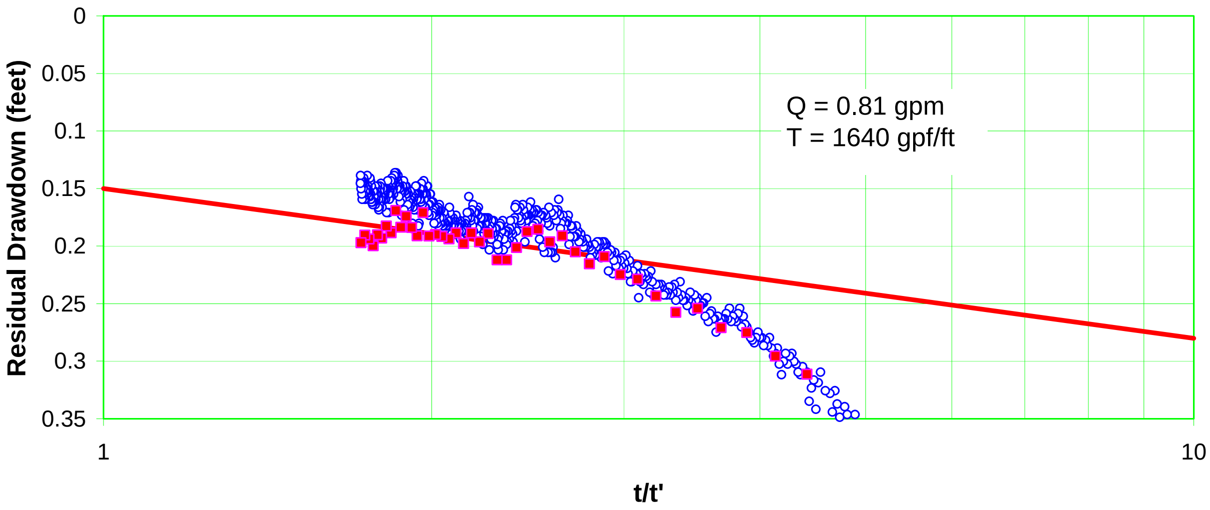

**Figure E-4.5-6  Well R-37 screen 1 purge development recovery—corrected data**

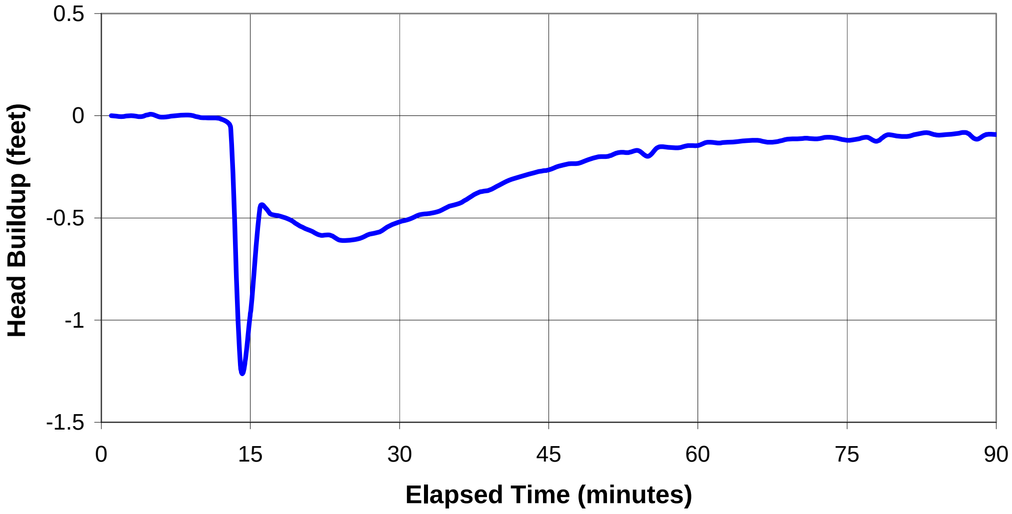

**Figure E-4.5-7  Well R-37 screen 1 packer deflation following purge development**

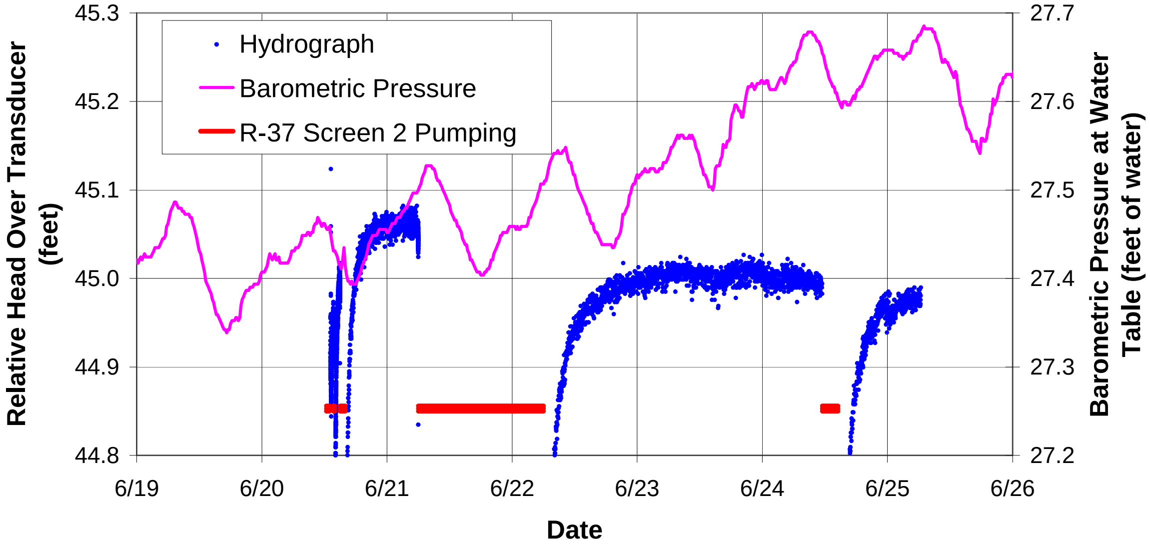

**Figure E-5.1-1  Well R-37 screen 2 apparent hydrograph**

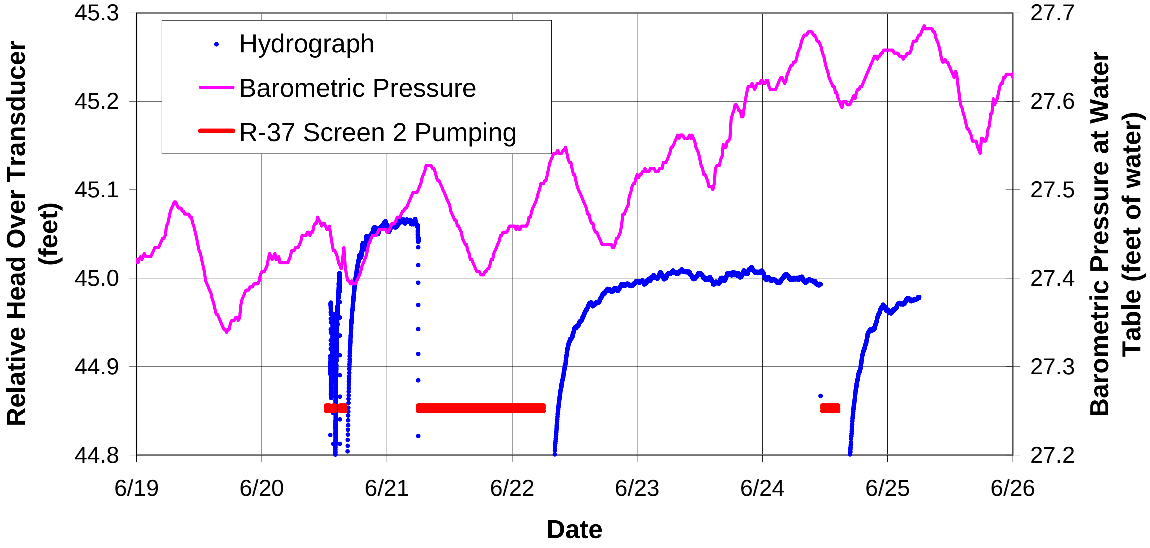

**Figure E-5.1-2  Well R-37 screen 2 apparent hydrograph—rolling average**

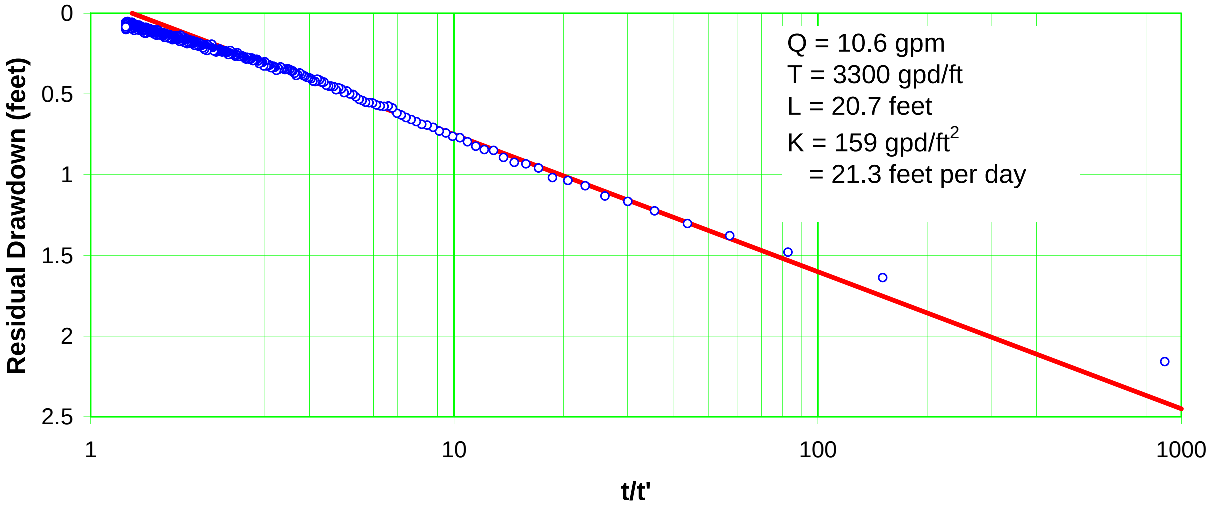

**Figure E-5.2-1 Well R-37 screen 2 trial 1 recovery**

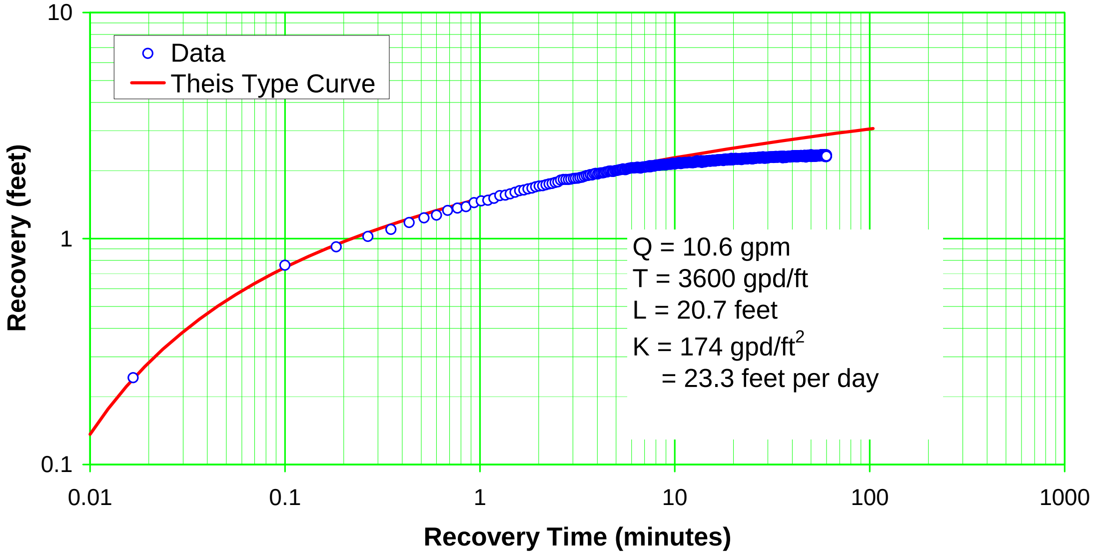

**Figure E-5.2-2 Well R-37 screen 2 trial 1 recovery—Theis analysis**

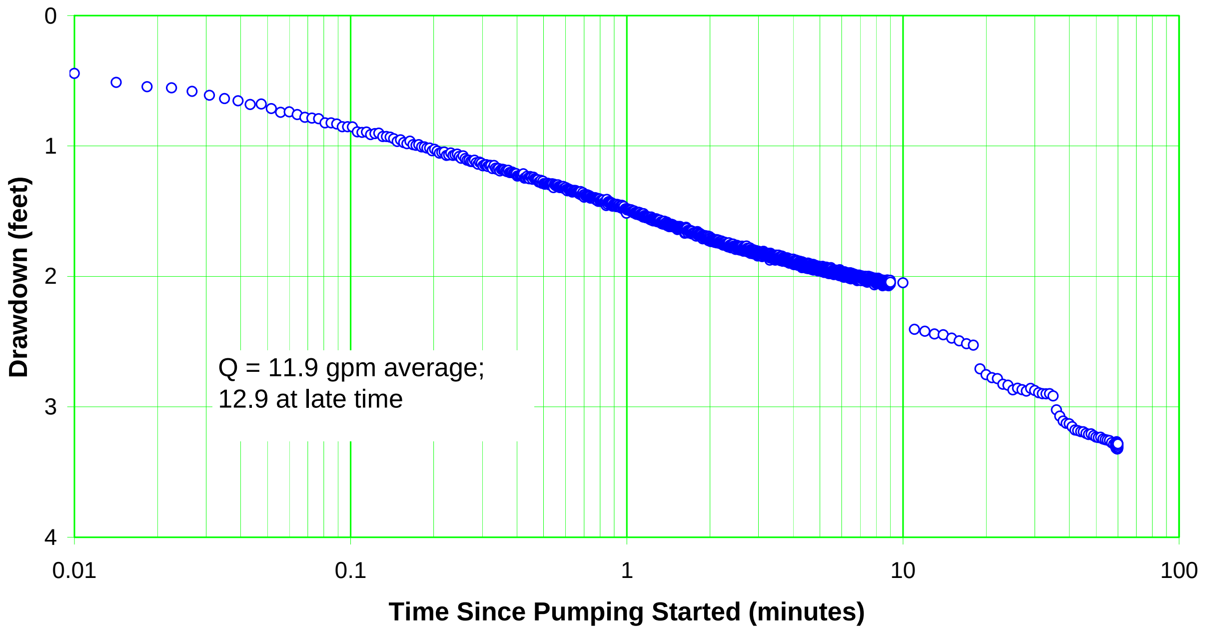

**Figure E-5.3-1  Well R-37 screen 2 trial 2 drawdown**

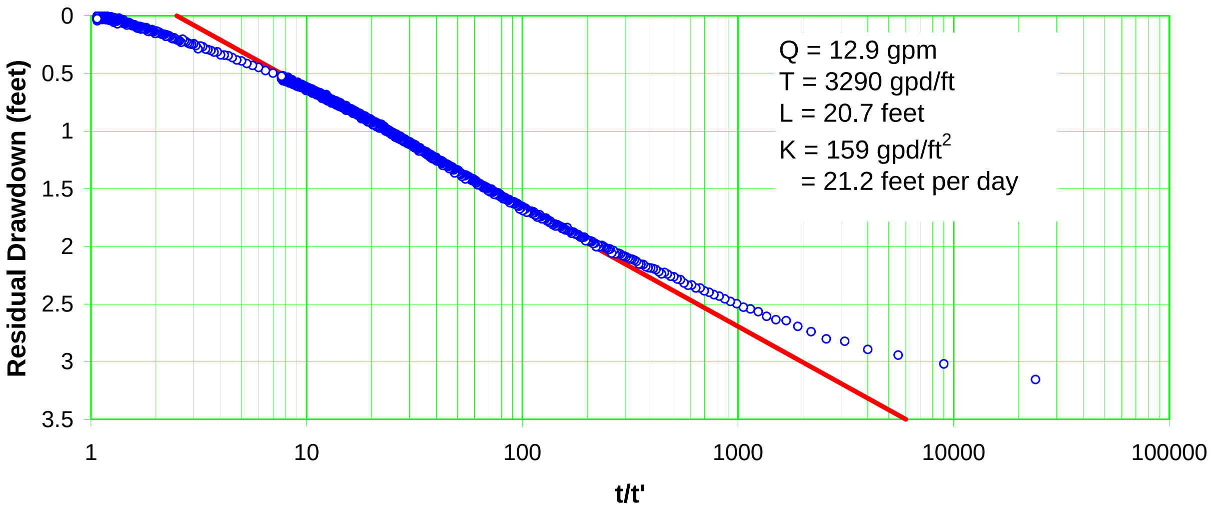

**Figure E-5.3-2  Well R-37 screen 2 trial 2 recovery**

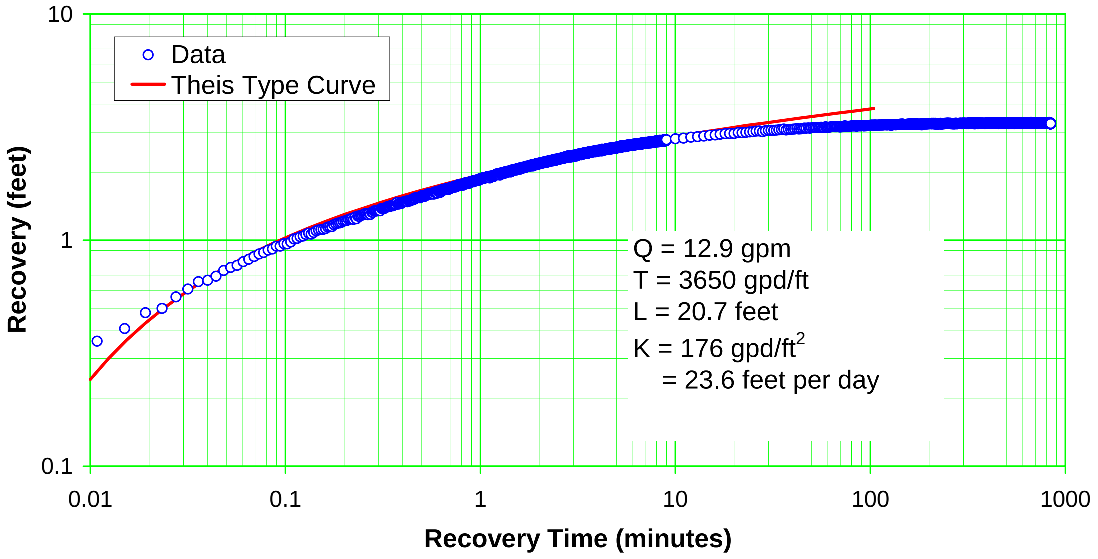

**Figure E-5.3-3 Well R-37 screen 2 trial 2 recovery—Theis analysis**

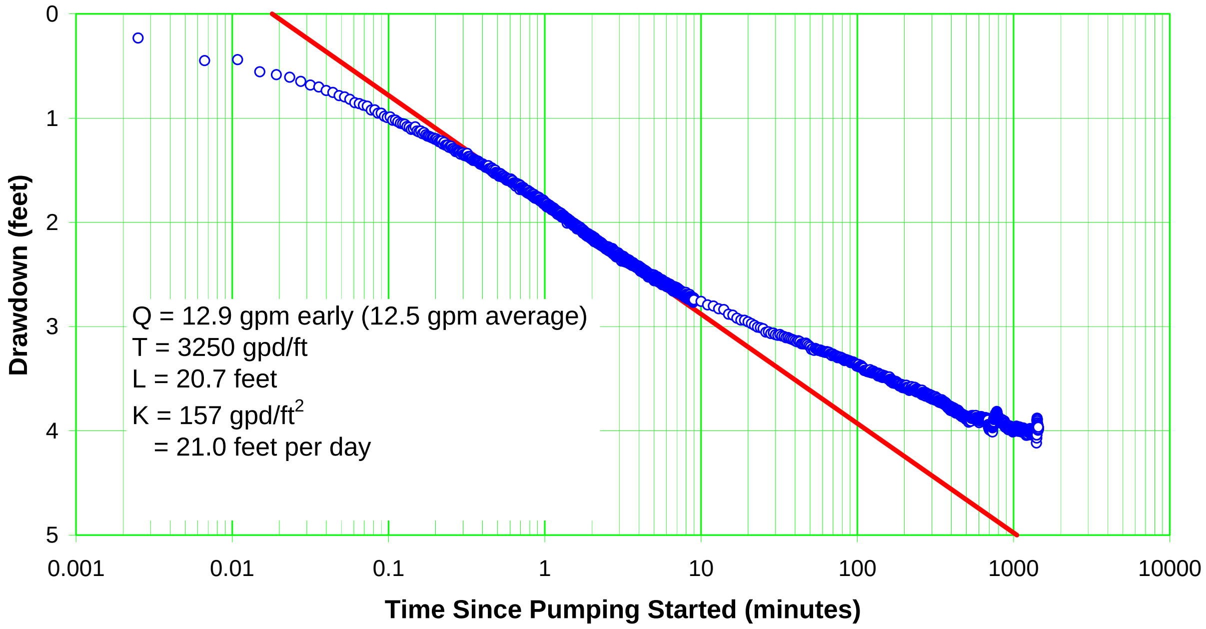

**Figure E-5.4-1 Well R-37 screen 2 drawdown**

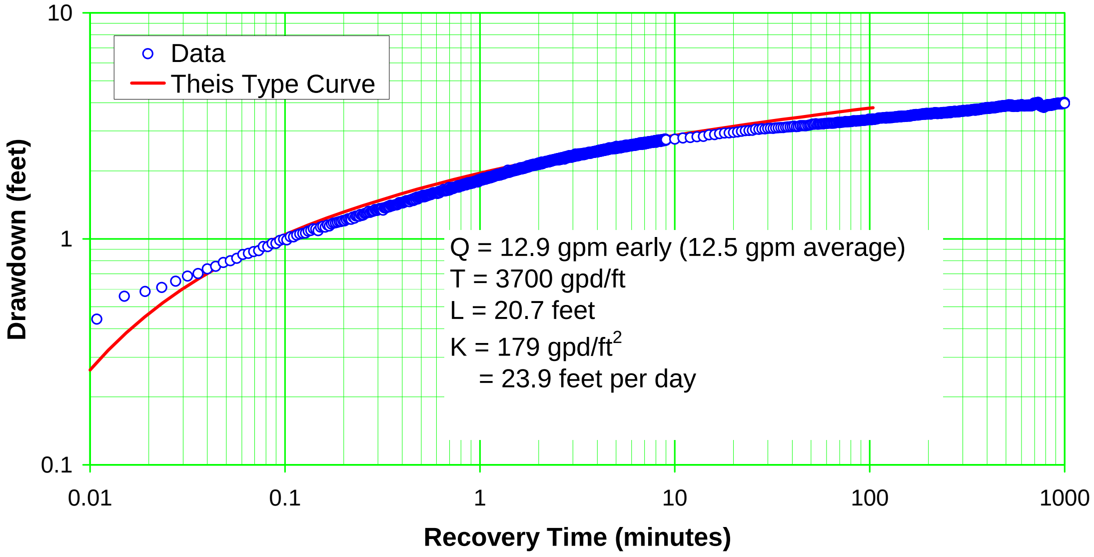

Figure E-5.4-2  Well R-37 screen 2 drawdown—Theis analysis

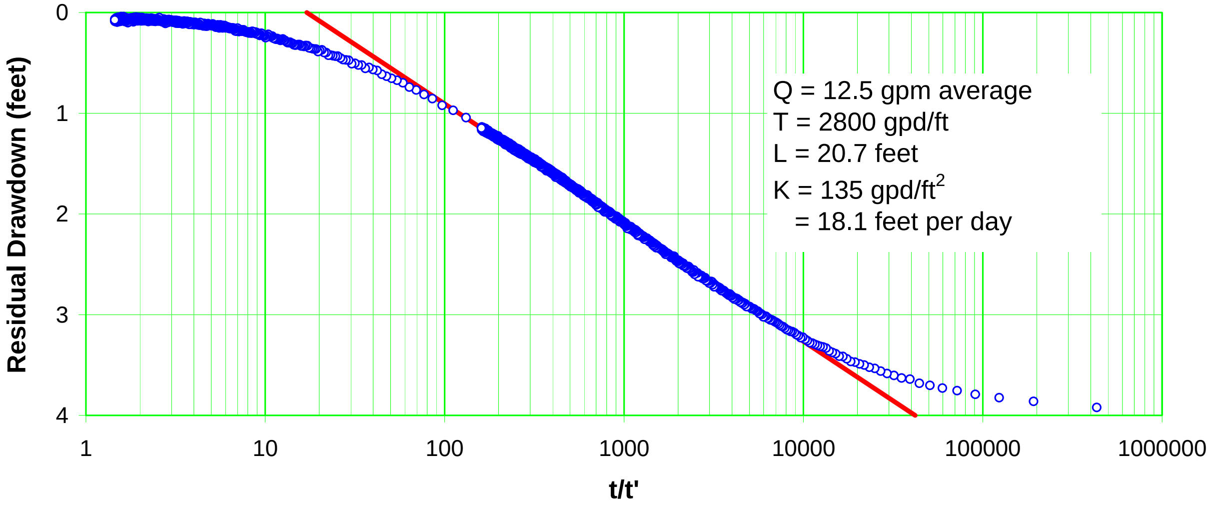

Figure E-5.4-3  Well R-37 screen 2 recovery

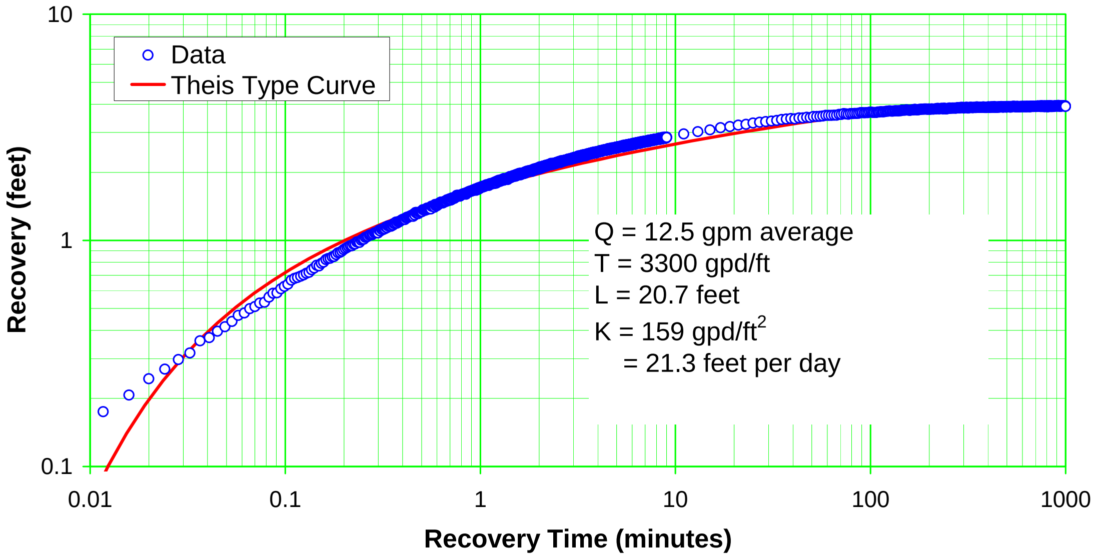

**Figure E-5.4-4  Well R-37 screen 2 recovery—Theis analysis**

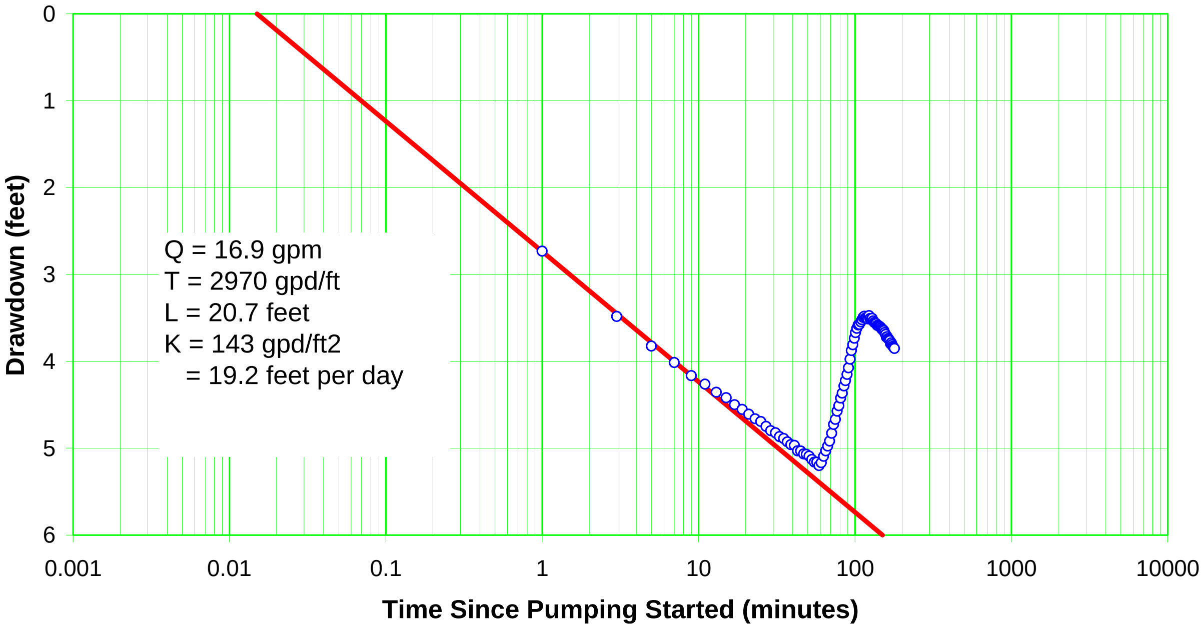

**Figure E-5.5-1  Well R-37 screen 2 trial 3 drawdown**

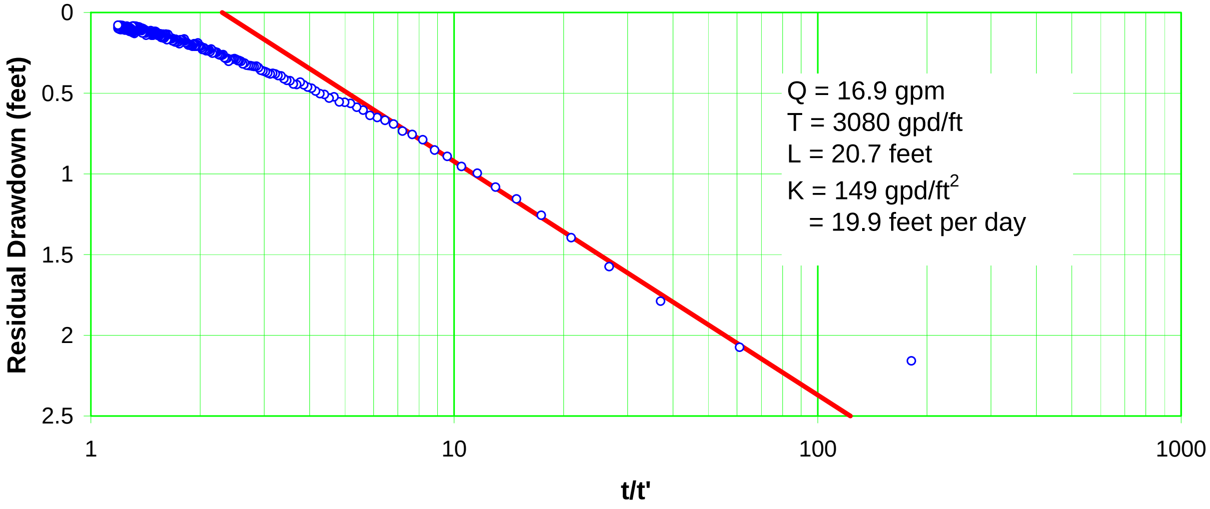

**Figure E-5.5-2  Well R-37 screen 2 trial 3 recovery**

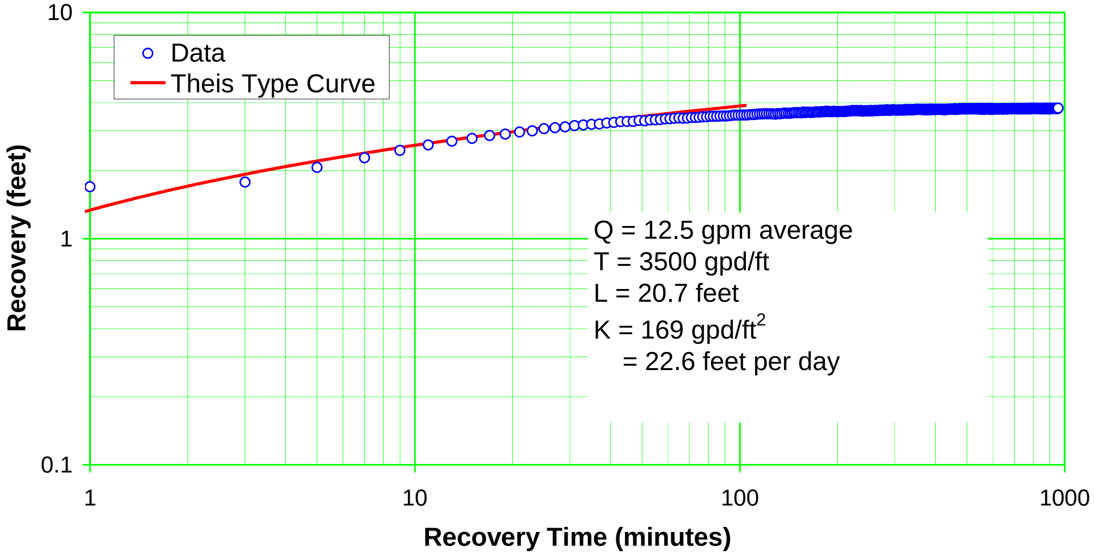

**Figure E-5.5-3  Well R-37 screen 2 trial 3 recovery—Theis analysis**

# Appendix F

## *Borehole Abandonment Information Form*

## ATTACHMENT 1: MONITORING WELL AND BOREHOLE ABANDONMENT INFORMATION

Records Use only

**5034-1**

**Monitoring Well and Borehole Abandonment Information**

**Date/Time:** 08/06/2009 - 16:36

**Sheet** 1 **of** 1

**Technical Area:** 54

**Focus Area (if applicable, or other location details):** LWSP

**Borehole ID:** R-37 1st Borehole

**Well Type (monitoring, etc.):** Monitoring

**Site Work Plan:** Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54

**Depth from Surface to Bottom of Hole:** 0 to 1080 ft.

**Grout Depth/Location:** Volclay bentonite gel from 920 ft to 1020 ft

**Bentonite Depth/Location:** 3/8-in bentonite chips from 450 ft to 920 ft

**Other Fill Material Depth/Location:** Cement from 1 to 450 ft. Borehole slough from 1020 ft to 1080 ft.

**Surface Construction:** No surface construction

**Grout/Backfill Composition:**

**Additional Comments/Details:** Drilling start date: 07/26/2008; drilling end date: 09/26/2008; borehole coordinates are easting = 1638031.1, northing = 1762513.7, elevation = 6864 ft. Abandoned casing (830' - 848'), (645' - 805'); tremie (100' - 460')

**Attach "Borehole/Well Completion Information Form" or the original "as-completed" drawings for the abandoned hole.**

## ATTACHMENT 1: MONITORING WELL AND BOREHOLE ABANDONMENT INFORMATION

**5034-1**

**Monitoring Well and Borehole Abandonment Information**

Records Use only

**Date/Time:** 08/06/2009 - 16:36

**Sheet** 1 **of** 1

**Technical Area:** 54

**Focus Area (if applicable, or other location details):** LWSP

**Borehole ID:** R-37 2nd Borehole

**Well Type (monitoring, etc.):** Monitoring

**Site Work Plan:** Drilling Work Plan for Regional and Intermediate Wells at Technical Area 54

**Depth from Surface to Bottom of Hole:** 0 to 890 ft.

**Grout Depth/Location:** NA

**Bentonite Depth/Location:** NA

**Other Fill Material Depth/Location:** Cement from 8 to 890 ft.

**Surface Construction:** No surface construction

**Grout/Backfill Composition:**

**Additional Comments/Details:** Drilling start date: 10/24/2008; drilling end date: 01/28/2009; borehole coordinates are easting = 1638049.3, northing = 1762552.4, elevation = 6862.9 ft. Abandoned casing (870’ - 890’)

**Attach "Borehole/Well Completion Information Form" or the original "as-completed" drawings for the abandoned hole.**