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Date: October 27, 2008
Refer To: EP2008-0490

James P. Bearzi, Bureau Chief
Hazardous Waste Bureau
New Mexico Environment Department
2905 Rodeo Park Drive East, Building 1
Santa Fe, NM 87505-6303

Subject: Submittal of the Well Completion Report for R-25b

Dear Mr. Bearzi:

Enclosed please find two hard copies with electronic files of the Well Completion Report for R-25b and the Well Construction Diagram and Well Summary Data Sheets included as figures. The well has been completed within the targeted zone to replace Screen 1 at existing R-25 (738 to 758 ft below ground surface). To date, well development continues to show elevated turbidity even though a substantial amount of water has been purged. As discussed in our meeting with the New Mexico Environment Department (NMED) on October 21, 2008, we are evaluating the nature of the suspended solids in the development water and will continue to develop the well to achieve lower turbidity. The results of the continued development and the analysis of the suspended solids will be presented in an addendum to the R-25b report, which we propose to submit to NMED by December 15, 2008.

If you have any questions, please contact Mark Everett at (505) 667-5931 (meverett@lanl.gov) or Nancy Werdel at (505) 665-3619 (nwerdel@doeal.gov).

Sincerely,

B G Schappell for
Susan G. Stiger, Associate Director
Environmental Programs
Los Alamos National Laboratory

Sincerely,

Nancy Werdel
for
David R. Gregory, Project Director
Environmental Operations
Los Alamos Site Office

SS/DG/PH/ME:sm

Enclosures: 1) Two hard copies with electronic files - Well Completion Report for R-25b (LA-UR-08-5879)

Cy: (w/enc.)
Neil Weber, San Ildefonso Pueblo
Mark Everett, EP-LWSP, MS M992
RPF, MS M707 (with two CDs)
Public Reading Room, MS M992

Cy: (Letter and CD only)
Laurie King, EPA Region 6, Dallas, TX
Steve Yanicak, NMED-OB, White Rock, NM
Kim Nelson, Cabrera, Los Alamos, NM
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Tom Skibitski, NMED-OB, Santa Fe, NM
Alison Bennett, DOE-LASO (date-stamped letter emailed)
Susan G. Stiger, ADEP, MS M991
Alison M. Dorries, WES-DO, MS M992
Paul Huber, EP-LWSP, MS M992
IRM-RMMSO, MS A150 (date-stamped letter emailed)

LA-UR-08-5879
October 2008
EP2008-0490

Completion Report for Well R-25b

Los Alamos NATIONAL LABORATORY
EST. 1943

Prepared by the Environmental Programs Directorate

LA-UR-08-5879
EP2008-0490

Completion Report for Well R-25b

October 2008

Responsible project leader:

Mark Everett	Mark Everett	Project Leader	Environmental Programs	10-23-08
Printed Name	Signature	Title	Organization	Date

Responsible LANS representative:

Susan G. Stiger	B. G. Schappell for SGS	Associate Director	Environmental Programs	10-23-08
Printed Name	Signature	Title	Organization	Date

Responsible DOE representative:

David R. Gregory	Nancy Werdel for	Project Director	DOE-LASO	10/23/08
Printed Name	Signature	Title	Organization	Date

EXECUTIVE SUMMARY

This well completion report describes the drilling, installation, and testing of Los Alamos National Laboratory (the Laboratory) upper saturated zone well R-25b located on the mesa top in Technical Area 16 (TA-16), Los Alamos, New Mexico. This single-screen well is set at depth in the upper saturated zone to replace screen 1 in the existing R-25 well. R-25 was installed to provide hydrogeology and water-quality data as required by the March 1, 2005, Compliance Order on Consent for environmental remediation at the Laboratory. Well R-25b was installed to identify potential presence of perched groundwater and contamination in the upper saturated zone that may be associated with effluents containing high explosives discharged from the TA-16-260 Outfall.

The R-25b borehole was successfully drilled to a total depth (TD) of 786 ft below ground surface (bgs) and was terminated in the Otowi Member of the Bandelier Tuff. A well was installed with a screen interval of 750 to 770 ft bgs. Cuttings were collected at 10-ft intervals from the ground surface to TD and at 5-ft intervals within targeted zones where there was no recovery during completion of the companion borehole R-25c.

The drilling method for borehole R-25b was direct air rotary and casing hammer with water and foam assist, as needed, above the known saturation interval. Casing advance using the STRATEX system was used to drill below 524 ft to the TD of 786 ft bgs.

A cased-hole suite of geophysical logs (0 to 610 ft) was completed in R-25c (located 50 ft from R-25b) for hydrogeologic characterization. No geophysical characterization was conducted in the R-25b borehole.

The well was completed in accordance with the New Mexico Environment Department–approved well design, with the screened interval installed to intercept the first water-bearing zone. The well is currently under development, with a total of 3110 gal. removed as of October 23, 2008.

CONTENTS

Figures

Tables

Appendixes

1.0 INTRODUCTION

This monitoring well completion report summarizes the site preparation, drilling, well construction, aquifer evaluation, and related activities completed to date for monitoring well R-25b. Monitoring well R-25b was drilled and completed in October 2008 at Los Alamos National Laboratory (LANL or the Laboratory) for the Environmental Programs Water Stewardship Program.

The R-25 site is located on the mesa top in Technical Area 16 (TA-16) at the Laboratory (Figure 1.0-1). A detail of the R-25 site layout is shown in Figure 1.0-2. TA-16, also known as S-Site, contains many of the Laboratory's high explosives (HE) facilities, the Laboratory's state-of-the-art tritium facility, and several administrative support buildings. Activities involve fabricating and testing HE, plastics, and adhesives; conducting research in process development for manufacturing HE, plastics, adhesives, and other materials; and tritium processing.

The existing R-25 well was installed to monitor for potential contamination in groundwater that may be associated with effluents containing HE that were discharged from an HE manufacturing facility outfall at TA-16-260 (Figure 1.0-1). R-25 was completed in 1999 and includes nine separate screened intervals. The first three screen intervals (screens 1, 2, and 3) of R-25 are believed to be compromised (screen 3 was drilled out because of damage during installation, and screened intervals 1 and 2 appear to be impacted by the activities conducted in screen 3).

R-25b is intended to be a replacement well for the first screened interval (screen 1). Well R-25b was designed to monitor upper saturated zone water-quality data at 750 to 770 ft below ground surface (bgs). The purpose of monitoring well R-25b is to provide hydrogeology and water-quality data as required by the March 1, 2005, Compliance Order on Consent (the Consent Order) for environmental remediation at the Laboratory. A separate well (R-25c) was installed to monitor the screen 3 interval in R-25. Activities related to R-25c are detailed in a separate well completion report (LANL 2008, 103408). The location and placement of screened intervals in both wells (R-25b and R-25c) was at the direction of the New Mexico Environment Department (NMED), in accordance with the Consent Order.

The R-25b borehole was successfully drilled to a total depth (TD) of 786 ft bgs and was terminated in the Otowi Member of the Bandelier Tuff. A well was installed with a screen interval between 750 and 770 ft bgs. Cuttings were collected at 10-ft intervals from the ground surface to TD from the drill discharge hose, with samples at 5-ft intervals from those horizons in which no cuttings were recovered in borehole R-25c.

Postinstallation activities, including well development, surface completion, dedicated water-level monitoring and pumping system installation, site restoration, and wellhead surveying, will be completed and reported in an addendum to this report by December 15, 2008.

The information presented in this report was compiled from field reports and activity summaries. Records, including the field reports, field logs, and survey information are on file at the Environmental Programs Directorate's Records Processing Facility (RPF). This report contains brief descriptions of all activities associated with the R-25b project as well as supporting figures, tables, and appendixes.

2.0 PRELIMINARY ACTIVITIES

Preliminary activities included preparing administrative planning documents and improvements to the drill site (Figure 1.0-2).

2.1 Administrative Preparation

The following documents were used to guide the implementation of the scope of work for this well:

- “Drilling Work Plan for Well R-25b” (LANL 2008, 100696)
- “Storm Water Pollution Prevention Plan for R-25b and R-25c Well Drilling Construction Site,” which is an addendum to “Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan” (LANL 2006, 092600)
- “Waste Characterization Strategy Form for the R-25 Monitoring Well Installation” (June 2008 EP2008-0340)
- “Drilling Work Plan for Intermediate Aquifer Well R-25b” (LANL 2007, 098121), which includes the NMED-approved well completion design

2.2 Site Preparation

Site preparation was performed from June 18 to June 30, 2008, and included implementation of best management practices in accordance with the Storm Water Pollution Prevention Plan. This included minimal clearing of vegetation and expansion of the existing R-25 pad and lay-down areas; excavating and lining cuttings containment pits; and installing berms, silt fences, and straw waddles to control stormwater runoff and minimize erosion. An office trailer, sanitary facilities, and other field equipment were also moved to the site during this time. The drill pad measured approximately 60 ft × 220 ft and is covered with base-course gravel.

Two cuttings pits were constructed on the R-25 site, one each for R-25c and R-25b. Each of these pits was constructed with a central berm so cuttings from above the saturated interval could be segregated from those below. This was done to potentially minimize the volume of cuttings requiring off-site disposal because there is a reasonable expectation that the formation above saturation is not contaminated. The two R-25b cells each measured approximately 45 ft × 30 ft with an 8-ft average depth. The two pits were lined with plastic sheeting, 10 mil in thickness.

Radiation control technicians from the Laboratory’s Radiation Protection Group-1 performed radiological screening of all construction equipment entering the S-Site limited access area, as necessary. All equipment or vehicles that were taken off-road or otherwise came into contact with soils were screened for HE by representatives from TA-16 Access Control before exiting from the S-Site limited access area.

Potable water used for drilling, dust suppression, and well installation was obtained from an existing Laboratory fire hydrant (#618), approximately 500 ft west of the site on Burning Grounds Road. The water was temporarily contained in a 2500-gal. water tank in the hull of the rod truck at the site.

Safety barriers and signs were installed around the borehole cuttings containment pits and at the pad entrance.

On June 30, 2008, WDC Exploration & Wells (WDC) mobilized drilling equipment to the site. On July 1, 2008, a decontamination pad was constructed, and downhole equipment that would be used to advance the borehole was pressure-washed with a steam cleaner using the potable water source. The Laboratory conducted a mast-up drill rig equipment inspection at the site before drilling activities began on July 2, 2008. Borehole R-25c was completed first, and then the drill rig was moved to the R-25b location on September 11, 2008. All downhole tools and equipment were pressure-washed before use in borehole R-25b to prevent potential cross-contamination.

3.0 DRILLING ACTIVITIES

The proposed drilling method for borehole R-25b was direct air rotary and casing hammer with water and foam assist, as needed, above the expected saturation interval. Foam was not used to advance the borehole within approximately 150 ft of the first saturated interval. The borehole was completed using a Failing Co. Speedstar 50K drill rig (WDC Rig 111). Air used for drilling the borehole was provided by one deck-mounted 900 ft^3/min compressor and three trailer-mounted auxiliary air compressors.

On September 11, 2008, a 16-in.-outside diameter (O.D.) permanent surface conductor casing (¼-in.-thick steel) was set to 18.7 ft bgs and was grouted in place. A bentonite plug was set at the base of the borehole, which was subsequently drilled out as the borehole was advanced. On September 12, 2008, the 14 ¾-in.-diameter open borehole was advanced to 145 ft bgs with a tricone button bit, roller stabilizer, and drill collar assembly using air and water to lift the drill cuttings. From September 13 to September 16, 2008, the open hole was advanced from 145 to 524 ft bgs with the same equipment; however, approved drilling foam (Baroid AQF-2) was added to the injected water to aid in lifting the drill cuttings to the surface. No drilling fluid other than water was used below 524 ft bgs (approximately 150 ft above the potential saturated horizon). See Table 3.0-1 for fluid quantities used.

To minimize circulation and borehole stability problems as encountered in R-25c, steel casing (11 ¾-in.-O.D.) was set from the surface to 524 ft bgs in the open borehole. From September 24 to September 27, 2008, the WDC crew advanced casing using a STRATEX drive shoe to total borehole depth of 786 ft bgs. The STRATEX casing bit overreams the borehole to approximately 13 ¼-in.-diameter. Upon reaching borehole TD, the casing was then retracted to 724 ft for video logging.

On September 28 and again on September 29, 2008, the Laboratory ran a video survey of the borehole to a depth of approximately 775 ft to confirm the presence of saturation in the borehole below the bottom of the casing and to observe the condition of the formation in the interval targeted for screening. The camera confirmed the bottom of the casing shoe at 724 ft bgs and also confirmed the tagged water level at 750 ft bgs on September 28 and at 759 ft bgs on September 29. On either date, there was no visual evidence of water seepage from the borehole wall between the standing water level and the bottom of the casing shoe. One other observation from the video survey was that a borehole wall “skin” was apparent in the open interval between the bottom of the casing and the standing water level. This skin was likely the result of smearing of the formation (Otowi Member of the Bandelier Tuff) during borehole advancement.

Based on the observed static water levels during borehole completion, the Laboratory approved a well design with the screened interval from 750 to 770 ft bgs to ensure this water-bearing zone is represented. Well construction activities commenced on September 29, 2008.

4.0 SAMPLING ACTIVITIES

This section describes the cuttings and groundwater sampling activities at R-25b.

4.1 Cuttings Sampling

Cuttings samples were collected from R-25b at approximately 10-ft intervals from the ground surface to the TD of 786 ft bgs, except in those intervals in borehole R-25c in which there was no recovery. Bulk samples of varying volumes were collected from the discharge hose and retained as an unsieved (whole rock) fraction. For those intervals with no recovery in R-25c, sieved fractions (>#10 and >#35 mesh) were collected at 5-ft intervals and retained in chip trays along with an unsieved (whole rock) fraction. All unsieved material was sealed in labeled Ziploc bags for eventual transfer to the Laboratory Sample Management Facility. No cuttings samples were submitted for laboratory analysis.

4.2 Water Sampling

No water samples were collected during the drilling of monitoring well R-25b.

5.0 GEOLOGY AND HYDROGEOLOGY

A brief description of the geologic and hydrogeologic features encountered at R-25b is presented below.

The Laboratory's geology task leader and site geologists used cuttings examination along with Laboratory and Schlumberger geophysical logs collected in borehole R-25c to determine the geologic contacts at this location. While cuttings were collected from borehole R-25b to augment data and observations already reported for R-25c, no changes were made to the lithology and contacts as reported in the R-25c lithologic log (LANL 2008, 103408, Appendix A). Drilling observations, video logging, water-level measurements, and geophysical logs were used to describe groundwater characteristics encountered at both R-25b and R-25c.

5.1 Stratigraphy

Borehole stratigraphy for the R-25b borehole is presented below in order of youngest to oldest geologic units. Figure 5.1-1 illustrates the stratigraphy at R-25b. A detailed lithologic log (based on samples from R-25b and R-25c) is presented in Appendix A.

Quaternary Alluvium, Qal (0 to 5 ft bgs)

Quaternary alluvium, consisting of poorly to moderately sorted loose sand, was encountered from 0 to 5 ft bgs. No evidence of alluvial groundwater was observed.

Tshirege Member of the Bandelier Tuff, Qbt (5 to 384 ft bgs)

Four subunits of the Tshirege Member of the Bandelier Tuff—Qbt 1, Qbt 2, Qbt 3, and Qbt 4—were encountered at R-25c from 5 to 384 ft bgs. Qbt 1 and Qbt 3 have been further subdivided, as indicated below.

Qbt 4 was present from 0 to 84 ft bgs. It consisted of a pale yellowish brown to light brownish gray, nonwelded to moderately welded crystal-rich devitrified ash-flow tuff. Cuttings from this interval typically contained fine ash matrix material with abundant quartz and sanidine crystals, and minor intermediate composition volcanic lithics.

The interval from 84 ft to 228 ft bgs includes an upper subunit Qbt 3t, with chemical properties that are transitional between lower Qbt 3 and Qbt 4. Qbt 3t and Qbt 3 were present in the R-25c borehole from 84 to 155 ft bgs and from 155 to 228 ft bgs, respectively. Both units are composed of a pale yellowish brown, brownish black, or medium gray, nonwelded to moderately welded, devitrified, crystal-rich ash-flow tuff and are mineralogically and texturally similar. Cuttings samples contained abundant welded, crystal-rich tuff with quartz and sanidine phenocrysts and generally minor quantities of intermediate composition volcanic lithics and feldspar crystals.

Qbt 2, from 228 to 332 ft bgs, is a grayish-brown to grayish-red, moderately to strongly welded, crystal-rich devitrified ash-flow tuff. Samples are generally composed of crystal-rich tuff fragments and quartz and sanidine crystals. Occasional intermediate to mafic composition volcanic lithics and vapor-phase altered pumice fragments are also observed.

The basal-cooling unit of the Tshirege Member is divided into an upper devitrified (Qbt 1v) and lower glassy (Qbt 1g) subunit (Broxton and Reneau 1995, 049726). Qbt 1v was present from 332 to 369 ft bgs as a grayish-brown to dusky brown, nonwelded to partially welded, devitrified, ash-flow tuff. Matrix tuff fragments are crystal rich with quartz and sanidine crystals. Rare mafic composition volcanic lithic fragments and minor vapor-phase altered pumice were observed. Qbt 1g was present from 369 to 384 ft bgs as a medium gray, nonwelded, vitric ash-flow tuff. Pinkish-gray fibrous vitric pumice was common.

Cerro Toledo Interval, Bandelier Tuff, Qct (384 to 740 ft bgs)

Volcaniclastic sedimentary and tephra deposits of the Cerro Toledo interval separate the Tshirege and Otowi Members of the Bandelier Tuff. The Cerro Toledo interval occurred in borehole R-25c from 384 to 740 ft bgs.

This interval contained poorly sorted uncemented fine to coarse-grained deposits of sand and fine gravel. Clasts are predominantly angular to rounded fragments from dacitic and rhyolitic flows, vitric pumice, nonwelded tephras, and abundant felsic crystals including bipyramidal quartz and sanidine. Rare fine sandstone was also observed. Clasts are generally light to dark gray and reddish brown. Pumice and tephras are light brown and white or orange where oxidized. The presence of quartz and sanidine crystals, up to 2 mm in diameter, indicates that the Cerro Toledo interval includes a component of reworked Otowi Member tuff.

Otowi Member of the Bandelier Tuff, Qbo (740 to 843 ft bgs)

The Otowi Member of the Bandelier Tuff is present in R-25c from 740 to 843 ft bgs. The depth interval for the Otowi Member is constrained primarily by natural gamma logs collected in R-25c. The Otowi Member is a lithic-bearing, partly pumiceous, and nonwelded ash-flow tuff. It contains reddish gray to gray, subangular to subrounded, intermediate composition volcanic rocks up to 15 mm. Pale yellow to white pumice lapilli are vitric and contain conspicuous phenocrysts of quartz and sanidine. Borehole R-25b was completed in this unit.

5.2 Groundwater

Groundwater was first recognized in R-25b during drilling at approximately 750 ft bgs in the Otowi Member of the Bandelier Tuff. This depth is similar to that encountered in R-25 but is significantly higher than that encountered in R-25c. The water level measured during drill casing advance ranged from 749 to 759.1 ft bgs.

A synthesis of groundwater observations made during the drilling of R-25b and R-25c will be presented in the revised corrective measure evaluation report for intermediate and regional groundwater at Consolidated Unit 16-021(c)-99.

6.0 BOREHOLE LOGGING

A suite of cased-hole geophysical logs (conducted by Schlumberger; Appendix B) and multiple downhole video and natural gamma surveys (conducted by the Laboratory) were run during the drilling and installation of R-25c. The logs from these surveys are included in the R-25c well completion report (LANL 2008, 103408, Appendix A). No geophysical logging was conducted during drilling of R-25b; however, video logging was conducted in R-25b to evaluate borehole conditions in the vicinity of the first water-bearing horizon. A summary of video (R-25b only) and geophysical logging (R-25c only) runs is presented in Table 6.0-1, and described in the following sections.

6.1 Video Logging

Video logs were collected to evaluate borehole conditions and confirm water-bearing horizons during advancement of R-25b but are not presented in this report because they provided no additional detail on geological and groundwater features. Table 6.0-1 details individual video logging runs pertinent to the R-25b borehole interval.

- The Laboratory completed a video survey of R-25b on September 28, 2008, to verify depths to water (as documented by tagline) and to the casing shoe, to observe the condition of the borehole wall below the casing shoe, and to determine if there was any evidence of water seepage from the formation between the casing and the apparent static water level of 750 ft. The casing shoe was noted at 724 ft bgs, and there was no evidence of water seepage between the casing shoe and the standing water level. An approximately ¼-in. borehole wall “skin” of apparent smeared formation was observed in this interval.
- On September 29, 2008, the Laboratory ran a second video survey of R-25b. The water level in the borehole was observed at 759 ft bgs and no seepage below the casing was noted.

6.2 Geophysical Logging

While no geophysical logging was conducted in borehole R-25b, logging activities by the Laboratory and Schlumberger in borehole R-25c were conducted within the interval common to R-25b. The logs relevant to R-25b are summarized below.

On July 12, 2008, the Laboratory ran a natural gamma ray and an induction log of the uncased R-25c borehole to 609.1 ft bgs (in addition to performing a video log of the borehole).

- A suite of Schlumberger geophysical logs was run inside the drill casing of R-25c on August 13 and August 14, 2008. At the time of logging, the bottoms of the two casing strings in the R-25c borehole were located at the following depths:
    - bottom of 16-in. casing: 19.8 ft bgs
    - bottom of 11.75-in. casing: 848.5 ft bgs
- On August 13, 2008, the Schlumberger geophysical suite included hostile-environment natural gamma spectroscopy (HNGS) and elemental capture spectroscopy (ECS). HNGS was run uphole inside the casing from 850 to 700 ft bgs. ECS was run uphole inside the casing from 850 to 600 ft bgs.
- On August 14, 2008, the geophysical suite included triple lithodensity detector (TLD) and accelerator porosity sonde (APS). Both were run uphole inside the casing from 850 to 600 ft bgs.

The final Schlumberger logs and report from the R-25c survey will be amended to this report, when available, because they are pertinent to the screened interval of well R-25b. The geophysical logging data collected from the open borehole (R-25c) and a preliminary report and log montage of the cased borehole on August 13–14, 2008, by Schlumberger are included in Appendix B.

7.0 WELL INSTALLATION

R-25b well casing and annular fill were installed between September 29 and October 13, 2008.

7.1 Well Design

The well design was submitted as part of R-25b screen replacement work plan and approved by NMED (2007, 098996). The original screen interval in R-25 was 738 to 758 ft bgs; however, R-25b was constructed with a screened interval of 750 to 770 ft bgs. The shift downhole of 12 ft was based on observations made during drilling and downhole video logging conducted on September 28 and 29, 2008 (see section 6.1 for further discussion).

7.2 Well Construction

The R-25b well casing was constructed of 5.0-in.-inside diameter (I.D.)/5.563-in.-O.D. 304 (non–American Petroleum Institute [API]) stainless-steel blank casing joints fabricated to American Society for Testing and Materials A312 standards. Casing ends, screen ends, and couplings were threaded with 5-in. eight round short-casing threads in compliance with API Standard 5B. The well screen consists of two consecutive 10-ft lengths of 5.0-in.-I.D./5.563-in.-O.D. rod-based 0.020-in. (slot-size) wire-wrapped well screen. The casing and screen were factory cleaned and also steam cleaned on-site. R-25b was constructed with a screened interval from 750 to 770 ft bgs. A 10.44-ft long piece of blank well casing was placed below the well screen for a sump. Figure 7.2-1 shows construction details for the completed well.

On September 29, 2008, well construction began with the placement of a 2-in.-I.D. steel integral joint tremie pipe in the borehole to a depth of 750 ft bgs. The tremie pipe was used to deliver annular fill materials during well construction.

The borehole was backfilled to approximately 778 ft bgs with 10/20 Colorado silica sand to provide a stable base for the well string. A 2-ft seal consisting of ⅜-in. bentonite chips was installed around the well sump from 778 to 776 ft bgs.

The primary filter pack of 10/20 silica sand was placed from 6 ft below the bottom of the screened interval to 5 ft above the top of the screen (776 to 745 ft bgs). The screened interval was set from 750.0 to 770.8 ft bgs. A transition sand collar of 20/40 silica sand was then placed above the primary filter pack from 745 to 742.5 ft bgs. Following placement of the fine sand collar, the drill crew installed another ⅜-in. bentonite chip seal from 742.5 to 718 ft bgs to protect the well screen from the bentonite slurry being placed above the seal.

Upon completing the placement of the bentonite chip seal to 718 ft bgs, the drill crew began backfilling the annular space from 718 to 574 ft bgs with a high-solids bentonite grout. In response to problems with grout emplacement in R-25c, a small quantity of soda ash was added to the first two lifts of high solids bentonite slurry from approximately 718 to 684 ft bgs. Addition of the soda ash was not beneficial; therefore, its use was discontinued above 684 ft. High-solids bentonite grout emplacement continued to 574 ft.

Observations made by the well construction crew confirmed observations in well R-25c that the borehole diameter was taking on more than the calculated volume of grout required to bring the backfill to depth. To seal the borehole more effectively, from 574 to 84 ft bgs, bentonite chips were placed in the annulus and hydrated after approximately every 10 ft. lift. A Portland cement seal with 2% bentonite was placed from 84 to approximately 8 ft bgs. The well casing was cut approximately 3 ft bgs to facilitate well completion. Well construction was completed on October 13, 2008, at which time the water level was measured at 759.1 ft bgs. Figure 7.2-1 depicts depths and volumes of materials used in each interval. Table 7.2-1 details volumes of materials used during well construction.

8.0 POSTINSTALLATION ACTIVITIES

A wellhead surface pad will be installed at the well location, and a geodetic survey will be performed following completion of well R-25b. Site restoration activities will commence once the final disposition of drill cuttings and groundwater is determined in accordance with the NMED-approved waste decision trees.

8.1 Well Development

Well development began on October 13, 2008. Initially, the screen was bailed and swabbed to remove formation fines in the filter pack. Bailing and swabbing continued until October 15, with a total of approximately 740 gal. of water removed by bailing. Well response suggested that the well could be pumped at a reduced flow rate, and a 1 HP pump was installed on October 16, 2008. Water-quality parameters (pH, specific conductance, temperature, turbidity, oxygen, and redox potential) were monitored periodically during development. The results are summarized in Table 8.1-1. As of October 23, 2008, 3110 gal. has been removed from the well. A total of 2740 gal. of potable water was introduced during drilling activities within the saturated zone. While water-quality parameters have stabilized as of the report date (Figure 8.1-1), the water remains turbid. Details on the nature of the turbidity and final well development will be provided in the addendum to this report by December 15, 2008.

8.2 Dedicated Monitoring System Installation

A dedicated In-Situ transducer will be installed in a polyvinyl chloride (PVC) tube to continuously monitor water levels. The transducer tube is 1.0-in.-I.D. flush-threaded PVC with a 6-in. 0.010-in. screen-slot interval at the bottom of the tube. The transducer tube is capped on the bottom below the screen. A dedicated pump and motor will also be installed for the purpose of groundwater sampling. Stainless-steel tubing pipe will be used to house the pump assemblage. Postinstallation construction and monitoring component installation details for R-25b will be added to Figure 8.2-1 in the addendum to this report.

8.3 Wellhead Completion

A reinforced concrete surface pad, 10 ft × 10 ft and 6 in. thick, will be installed at R-25b, following completion of well development activities. The pad will provide long-term structural integrity for the well. A brass survey pin will be embedded in the northwest corner of the pad. A 10-in.-I.D. steel protective casing with a locking lid will be installed around the well riser. The concrete pad will be slightly elevated above the ground surface, with base-course gravel graded up around the edges, to minimize potential for infiltration within the borehole annulus.

8.4 Geodetic Survey

Geodetic survey data for the well casing top cap, protective casing, brass pin, and ground surface at R-25b will be collected upon wellhead completion. The survey data is presented in Table 8.4-1 and will be updated in the addendum.

8.5 Site Restoration and Waste Management

Fluids and cuttings produced during drilling and development were containerized and sampled in accordance with the 2008 “Waste Characterization Strategy Form for the R-25 Monitoring Well Installation” (LANL 2008, EP2008-0340), prepared for the R-25 well drilling at the Laboratory. Characterization samples of the various waste streams will be collected, and a summary of the samples collected and the analytical results for the R-25b well will be presented in Table 8.6-1 in the addendum.

Fluids and solids produced during drilling and well development are anticipated to be land-applied after review of associated analytical results per the waste characterization strategy form and the Laboratory Environmental Protection Directorate Standard Operating Procedure 010.0, Land Application of Groundwater in accordance with the notice of intent decision tree (revised July 26, 2006). NMED approval was received via a letter dated November 21, 2006 ("NOI Decision Tree: Drilling, Development, Rehabilitation and Sampling Purge Water"), and/or "NOI Decision Tree for Management of Investigation-Derived Waste Solids from Drilling Operations," November 2007. Solids produced during drilling are anticipated to be used to restore the areas of the cuttings pits to grade. Both liquid and solid land application will be conducted in accordance with the approved decision trees.

Waste generation and characterization for the R-25b project include a small quantity of contact waste, decontamination fluids, cuttings, discharged drilling water, and purged groundwater. Additionally, one drum of New Mexico special waste was generated following a diesel refueling overfill event on one of the air compressors. The waste material consisted of adsorbent cloth and diesel-contaminated soil. Analysis of the material is pending. The waste profile will be finalized and the drum scheduled for pickup and disposal as New Mexico special waste, as soon as the analytical results are received.

Site restoration activities will include removing water from the cuttings containment pits and land-applying it on-site, in accordance with the decision tree, removing cuttings from the cuttings containment pits, removing the polyethylene liner, removing the containment area berms and backfilling, and regrading the containment area. Cuttings will be used in accordance with governing documents outlined above. The site will be reseeded with a native seed mix consisting of Indian rice grass, mountain broam, blue stem, sand drop, and slender wheat grass seed. The seed mix will be applied at a rate of 20 lb/acre. Biosol fertilizer will be applied at a rate of 80 lb/acre.

9.0 DEVIATION FROM PLANNED ACTIVITIES

In general, drilling, sampling, and well construction at R-25b was performed as specified in the "Drilling Work Plan for Intermediate Aquifer Well R-25b" (LANL 2007, 098121). However, the screened interval was shifted downhole 10 ft (top of screen from 740 to 750 ft bgs) from the proposed well design (LANL 2007, 098121) to address the measured standing water-level fluctuations as observed during casing advance below 750 ft.

10.0 ACKNOWLEDGMENTS

Cabrera Services, Inc., provided management and oversight on all preparatory, reporting, and field-related activities.

EnviroWorks prepared the site for drilling activities.

Kleinfelder provided geologic field support and technical oversight and input related to drilling and aquifer evaluation, as well as preliminary report preparation.

Schlumberger conducted cased-borehole geophysical surveys.

WDC Exploration & Wells drilled the R-25 borehole and installed the well.

11.0 REFERENCES AND MAP DATA SOURCES

11.1 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 number. This information is also included in text citations. ER ID numbers 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; DOE-Los Alamos Site Office; the U.S. Environmental Protection Agency, Region 6; 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.

Broxton, D.E., and S.L. Reneau, August 1995. "Stratigraphic Nomenclature of the Bandelier Tuff for the Environmental Restoration Project at Los Alamos National Laboratory," Los Alamos National Laboratory report LA-13010-MS, Los Alamos, New Mexico. (Broxton and Reneau 1995, 049726)

LANL (Los Alamos National Laboratory), March 2006. "Storm Water Pollution Prevention Plan for SWMUs and AOCs (Sites) and Storm Water Monitoring Plan," Los Alamos National Laboratory document LA-UR-06-1840, Los Alamos, New Mexico. (LANL 2006, 092600)

LANL (Los Alamos National Laboratory), June 2007. "Drilling Work Plan for Intermediate Aquifer Well R-25b," Los Alamos National Laboratory document LA-UR-07-3952, Los Alamos, New Mexico. (LANL 2007, 098121)

LANL (Los Alamos National Laboratory), February 2008. "Drilling Work Plan for Well R-25c," Los Alamos National Laboratory document LA-UR-08-0337, Los Alamos, New Mexico. (LANL 2008, 100696)

LANL (Los Alamos National Laboratory), September 2008. "Completion Report for Well R-25c," Los Alamos National Laboratory document LA-UR-08-5878, Los Alamos, New Mexico. (LANL 2008, 103408)

NMED (New Mexico Environment Department), November 2, 2007. "Approval of the Drilling Work Plan for Regional Aquifer Well R-25b," 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, 098996)

11.2 Map Data Sources

Spatial data sources for map # 07-0071-3:

Locations for proposed wells are approximate and not yet surveyed. Locations provided by Los Alamos National Laboratory, Environmental Programs Directorate, Water Stewardship Project, February 2008.

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

Modeled Surface Drainage, 1991; Los Alamos National Laboratory, ENV Environmental Remediation and Surveillance Program, ER2002-0591; 1:24,000 Scale Data; Unknown publication date.

Paved and Dirt Road Arcs; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 10 September 2007.

Penetrations (Wells); Los Alamos National Laboratory, Environment and Remediation Support Services, EP2007-0442; 1:2,500 Scale Data; 16 July 2007.

Potential Release Sites; Los Alamos National Laboratory, Waste and Environmental Services Division, GIS/Geotechnical Services Group, EP2007-0682; 1:2,500 Scale Data; 29 October 2007.

Structures; Los Alamos National Laboratory, KSL Site Support Services, Planning, Locating and Mapping Section; 06 January 2004; as published 27 April 2007.

Technical Area Boundaries; Los Alamos National Laboratory, Site Planning & Project Initiation Group, Infrastructure Planning Division; 19 September 2007.

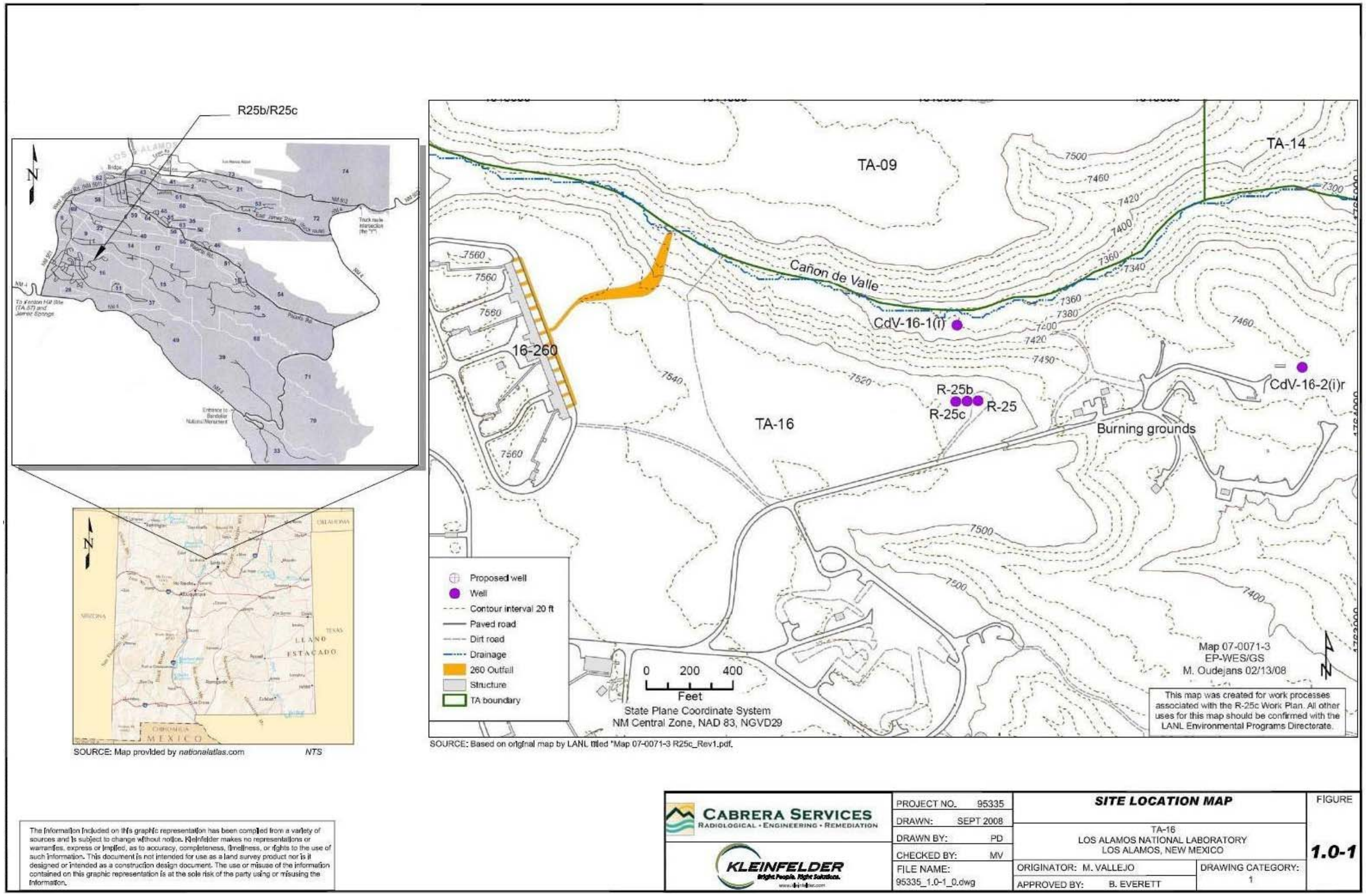

Figure 1.0-1 Site location

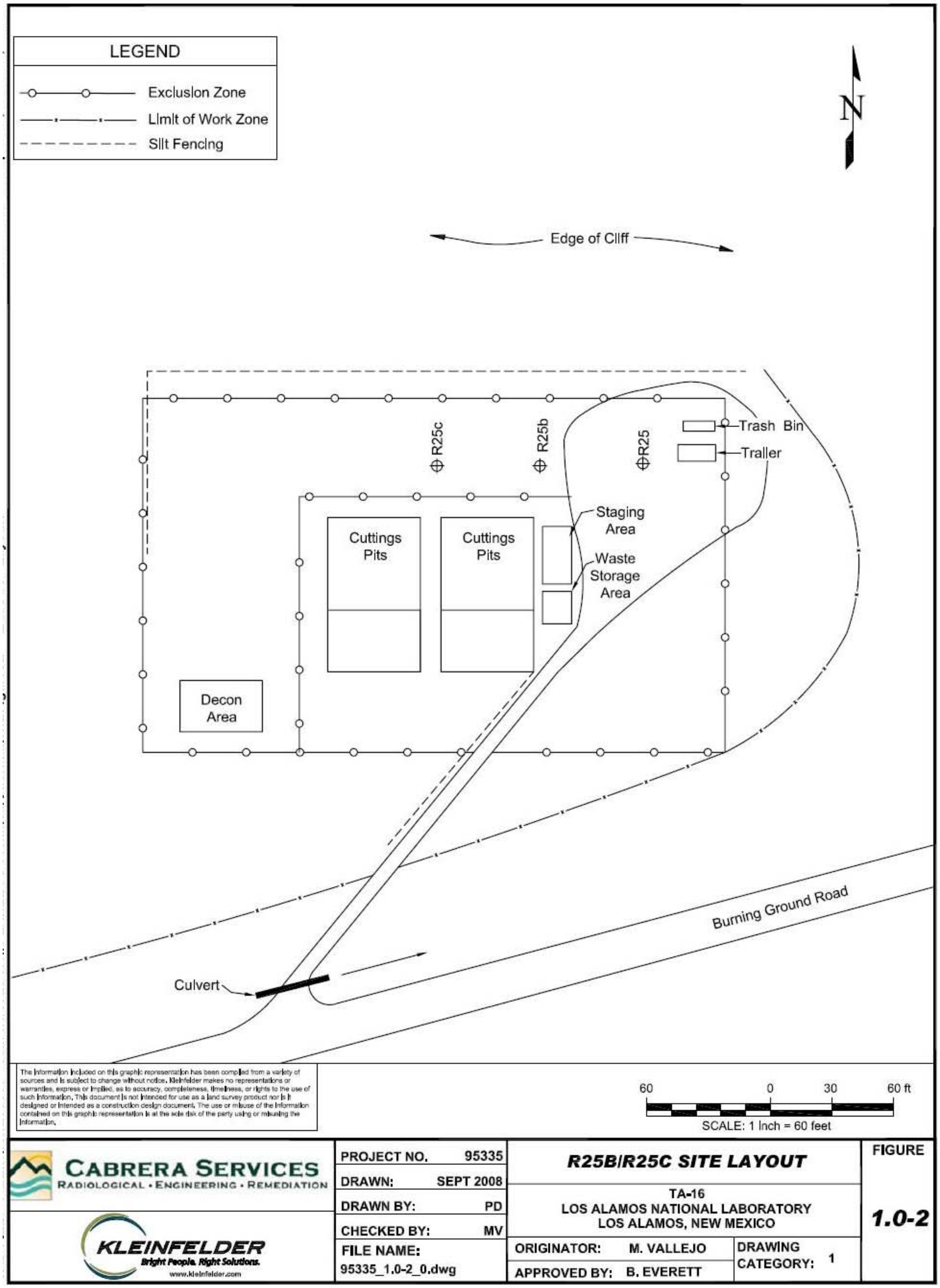

Figure 1.0-2 Site layout

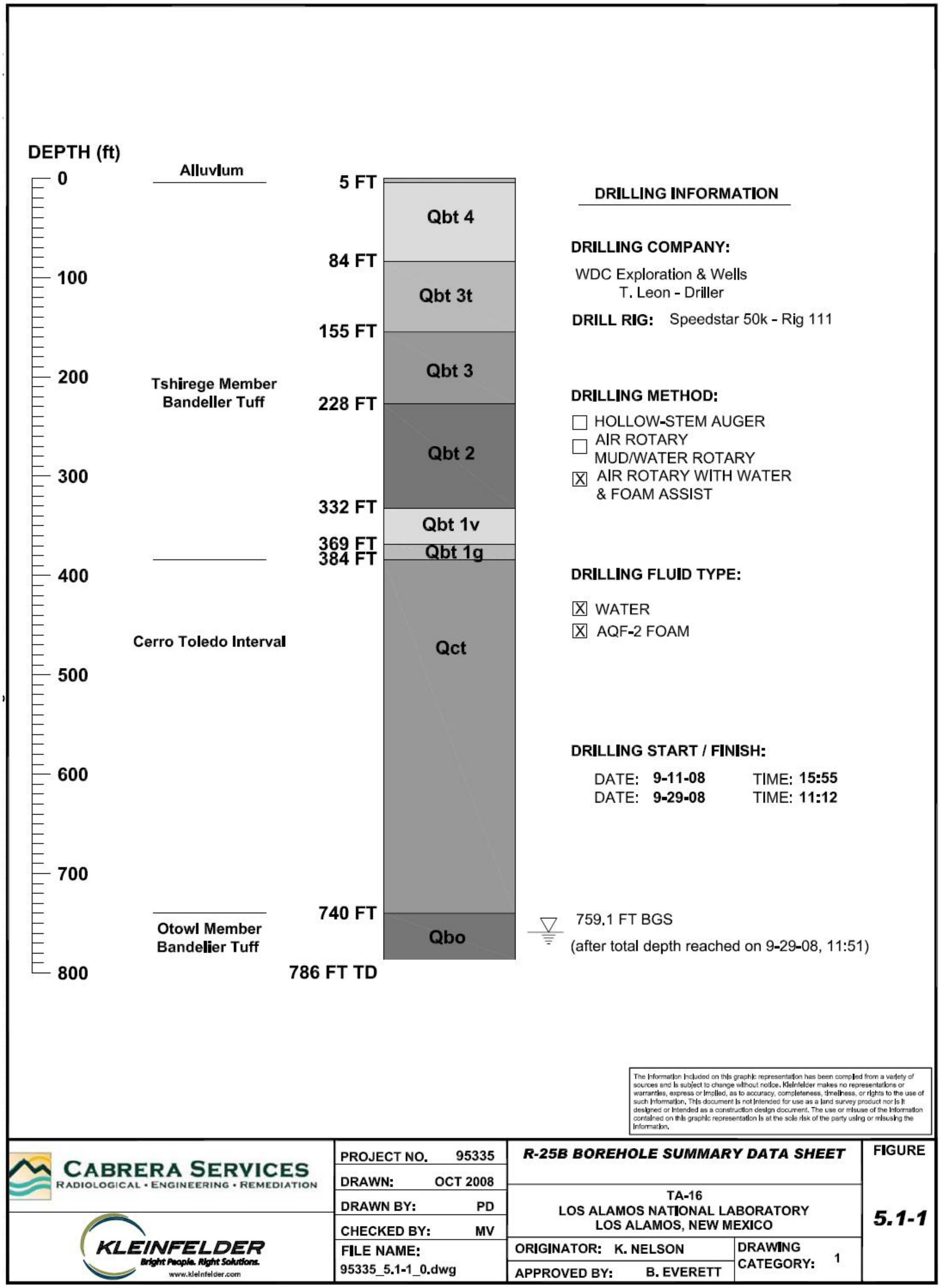

Figure 5.1-1 R-25b borehole summary data sheet

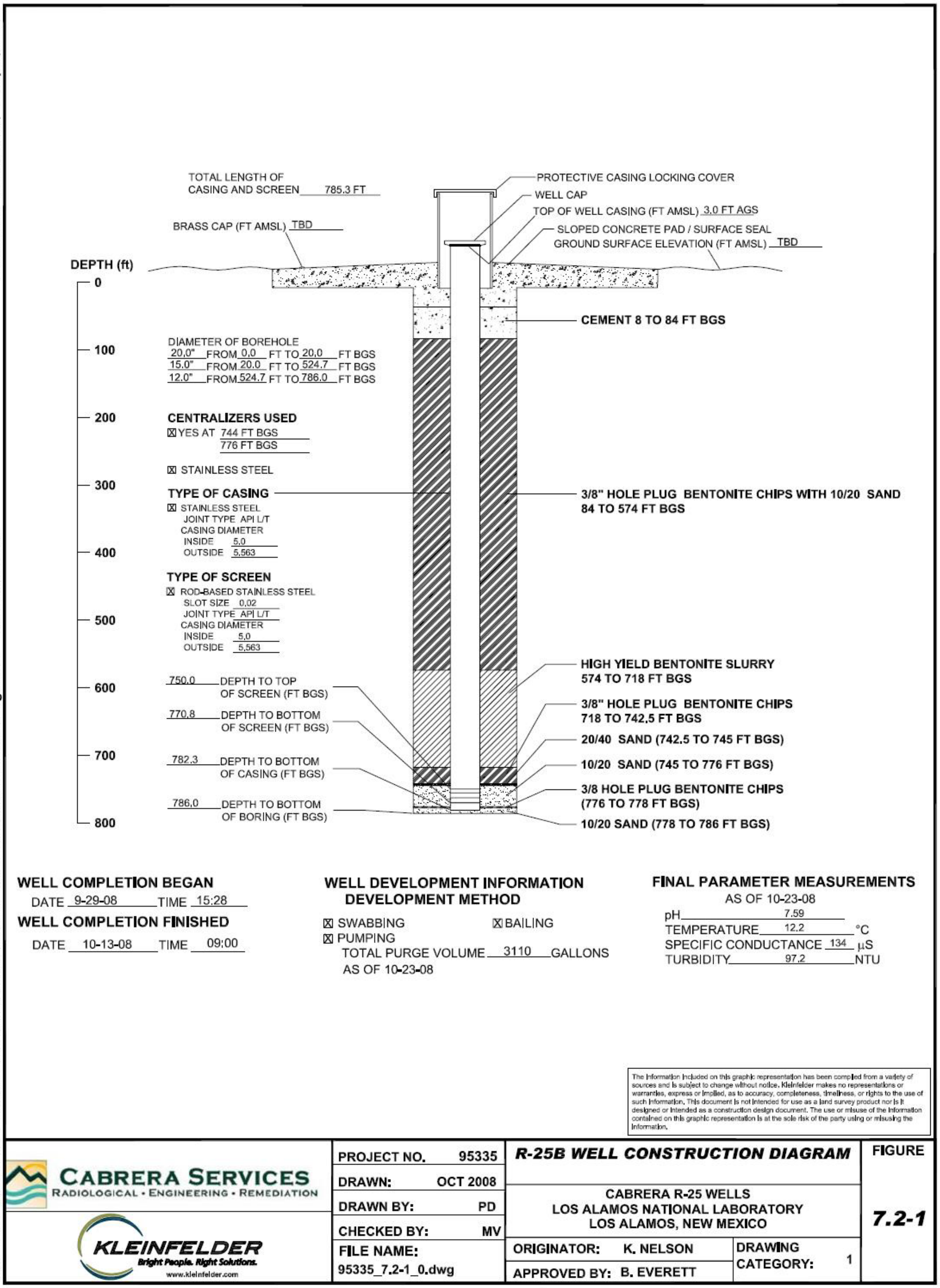

Figure 7.2-1 R-25b well construction diagram

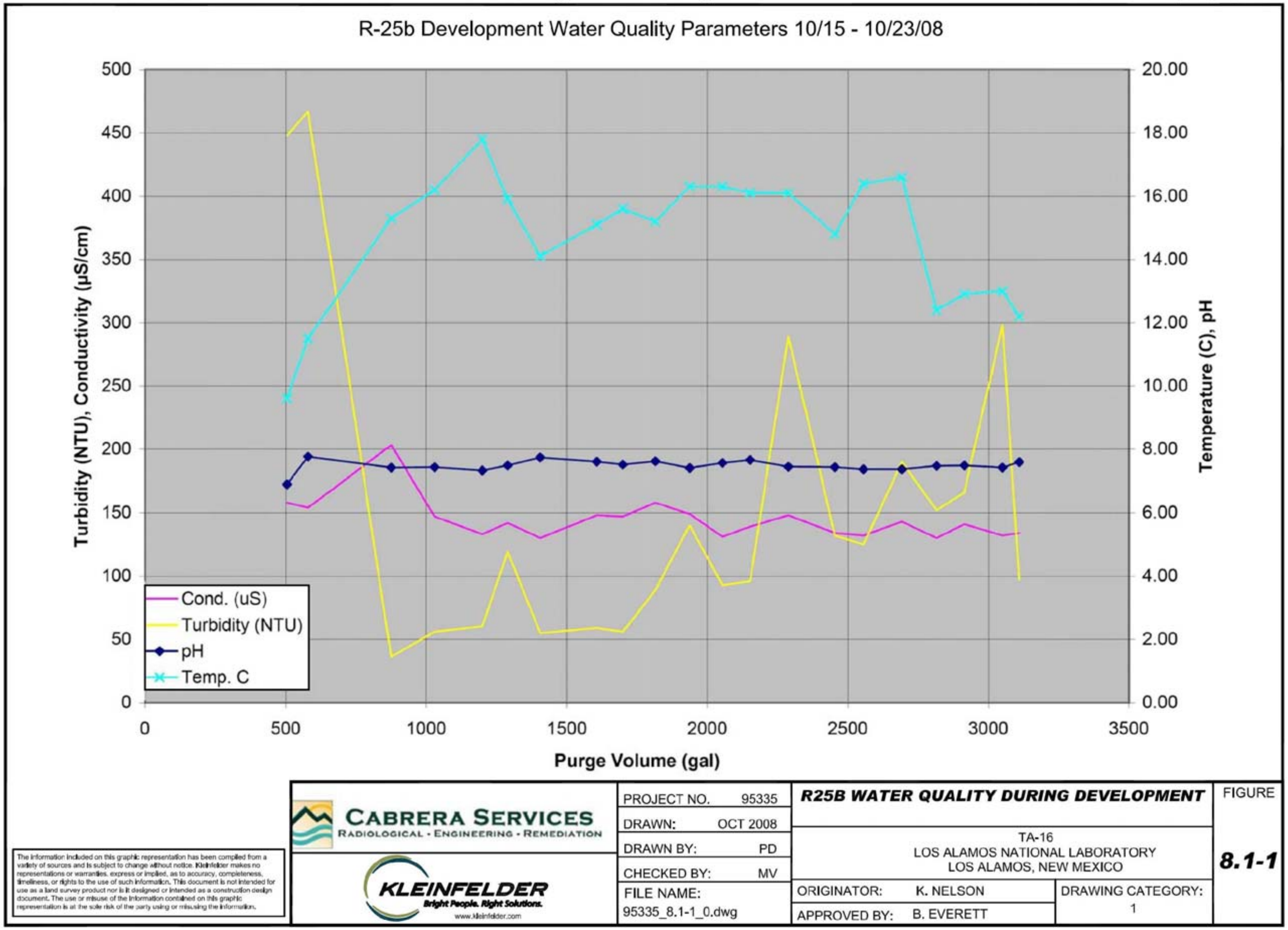

Figure 8.1-1 R-25b water-quality data through October 23, 2008

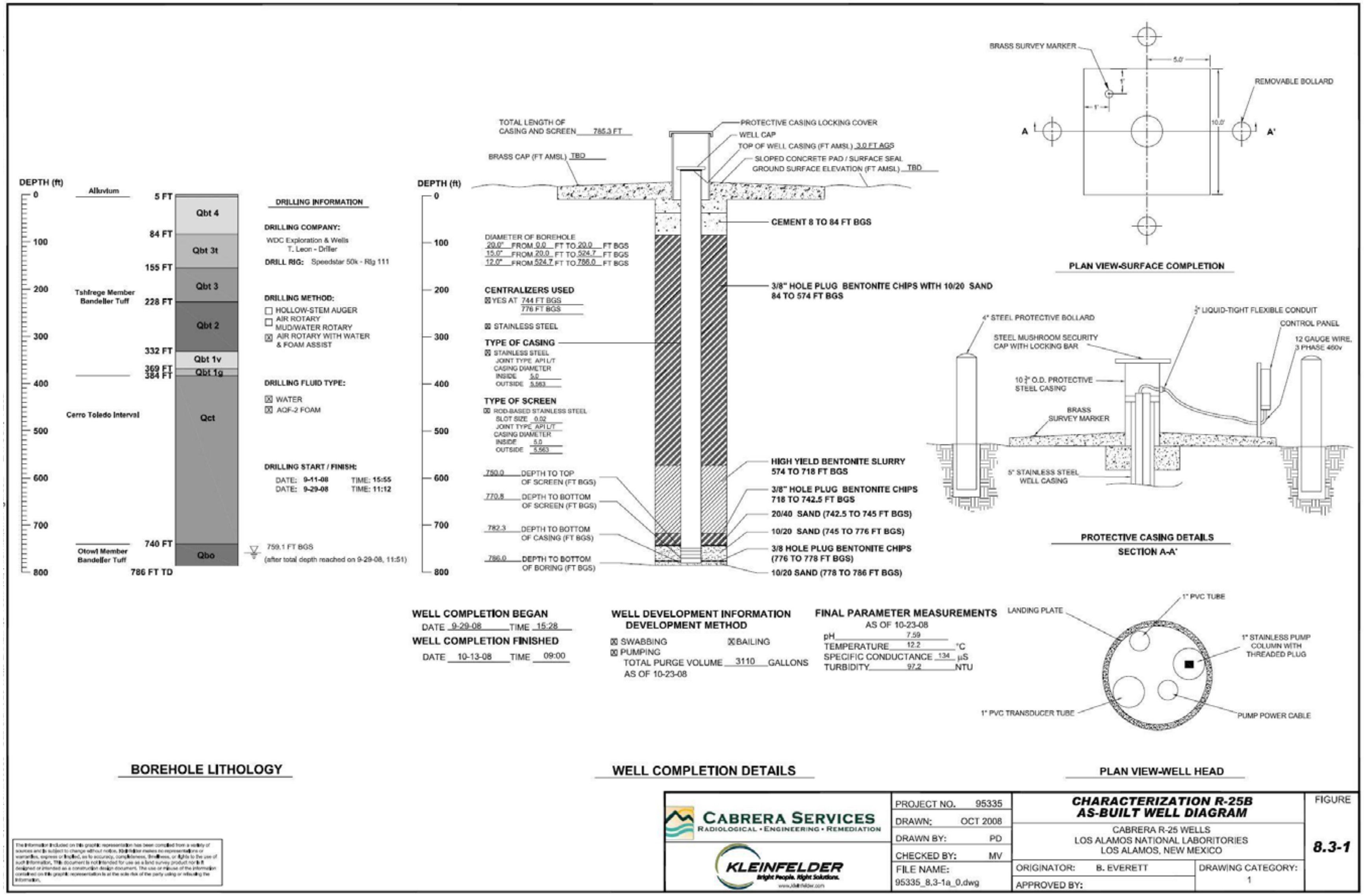

Figure 8.3-1 R-25b as-built well diagram

TECHNICAL NOTES FOR FIGURE 8.3-1:[1]

Survey Information[2]

Brass Marker

Northing: To be determined (TBD)

Easting: TBD

Elevation: TBD

Well Casing (top of stainless steel)

Northing: TBD

Easting: TBD

Elevation: TBD

BOREHOLE GEOPHYSICAL LOGS

Natural gamma ray, induction, neutron (ECS) and APS, gamma-gamma density (TLD)

DRILLING INFORMATION

Drilling Company

WDC Exploration & Wells

Drill Rig

Failing Co. SpeedStar 50K WDC Rig #111

Drill Methods

Air rotary with water and foam assist

Drilling Fluids

0–524 ft Baroid, AQF-2 foaming agent, air, and potable water

524–786 ft air and potable water

MILESTONE DATES

Drilling

Start: 09/11/2008

Finished: 09/29/2008

Well Completion

Start: 09/29/2008

Finished: 10/13/2008

WELL DEVELOPMENT/AQUIFER EVALUATION

Development Methods

Performed swabbing, bailing, -740 gal. removed

Total volume purged (as of 10/23/08): 3110 gal.

Parameter Measurements (on 10/23/08)

pH: 7.59

Temperature: 12.2°C

Specific Conductance: 134 μS

Turbidity: 97.2 nephelometric turbidity units

NOTES

1. Additional information available in “Final Completion Report, Characterization Wells R-25b, Los Alamos National Laboratory, Los Alamos, New Mexico, October 2008.

2. Coordinates based on New Mexico State Plane Grid Coordinates, Central Zone (NAD83); elevation expressed in feet above mean sea level using the National Geodetic Vertical Datum of 1929.

TBD = Information will be provided in the addendum to the well construction report after activities are complete.

Table 3.0-1
Fluid Quantities Used during Drilling and Well Construction

Borehole	Date	Water (gal.)	Cumulative Water (gal.)	Foam (gal.)	Cumulative Foam (gal.)	Cumulative Returns in Pit: Fluids (gal.)
Drilling						
R-25b	09/11/08	300	300	0	0	—[a]
	09/12/08	0	300	0	0	—
	09/13/08	4000	4300	10	10	—
	09/14/08	1000	5300	0	10	—
	09/15/08	2000	7300	15	25	—
	09/16/08	2000	9300	25	50	—
	09/17/08	No drilling	9300	0	50	—
	09/18/08	No drilling	9300	0	50	—
	09/19/08	No drilling	9300	0	50	—
	09/20/08	No drilling	9300	0	50	—
	9/21/2008	No drilling	9300	0	50	—
	9/22/2008	0	9300	0	50	—
	9/23/2008	0	9300	0	50	9575
	9/24/2008	2000	11300	0	50	—
	9/25/2008	70	11370	0	50	—
	9/26/2008	0	11370	0	50	—
	9/27/2008	0	11370	0	50	—
	9/28/2008	0	11370	0	50	—
	9/29/2008	300	11670	0	50	—
Well Construction						
R-25b	9/29/2008	0	11670	n/a[b]	n/a	n/a
	9/30/2008	150	11820	n/a	n/a	n/a
	10/01/2008	2000	13820	n/a	n/a	n/a
	10/02/2008	250	14070	n/a	n/a	n/a
	10/03/2008	0	14070	n/a	n/a	n/a
	10/04/2008	0	14070	n/a	n/a	n/a
	10/05/2008	0	14070	n/a	n/a	n/a
	10/06/2008	0	14070	n/a	n/a	n/a
	10/07/2008	500	14570	n/a	n/a	n/a
	10/08/2008	1000	15570	n/a	n/a	n/a
	10/09/08	3000	18570	n/a	n/a	n/a
	10/10/2008	1200	19770	n/a	n/a	n/a
	10/11/2008	7500	27270	n/a	n/a	n/a

Table 3.0-1 (continued)

Borehole	Date	Water (gal.)	Cumulative Water (gal.)	Foam (gal.)	Cumulative Foam (gal.)	Cumulative Returns in Pit: Fluids (gal.)
R-25b	10/12/2008	0	27270	n/a	n/a	n/a
	10/13/2008	0	27270	n/a	n/a	n/a
Total (gal.)			27270		50	9575
Total Volume R-25b (gal.)		**27,270**				

Note: Foam use and pit use discontinued after drilling activities; therefore, no additional fluids were produced.

[a] — = No observations were taken.

[b] n/a = Not applicable.

Table 6.0-1
R-25b Video and R-25c Geophysical Logging Runs Relevant to R-25b

Date	Depth (ft)	Description
07/12/08	0–609.2	LANL video, natural gamma ray, and induction surveys run through open hole. Less than 1 ft of water (likely, fluids were introduced during drilling) was observed in bottom of the borehole.
08/13/08	850–700	Schlumberger HNGS survey run uphole in cased borehole (16-in.-steel casing from surface to 19.8 ft bgs; 11.75-in.-steel casing from surface to 848.5 ft bgs).
08/13/08	850–700	Schlumberger ECS survey run uphole in cased hole (16-in.-steel casing from surface to 19.8 ft bgs; 11.75-in.-steel casing from surface to 848.5 ft bgs). Poor quality log because instrument would not sit on casing wall. A bow spring centralizer was installed on the instrument, and the hole was successfully ECS logged.
08/14/08	850–600	Schlumberger TLD survey run uphole in cased hole (16-in. steel casing from surface to 19.8 ft bgs; 11.75-in.-steel casing from surface to 848.5 ft bgs; open hole (10-in.-diameter) from 848.5 to 1140 ft bgs).
08/14/08	850–600	Schlumberger APS survey run uphole in cased hole (16-in.-steel casing from surface to 19.8 ft bgs; 11.75-in.-steel casing from surface to 848.5 ft bgs; open hole (10-in.-diameter) from 848.5 to 1140 ft bgs).
09/28/08	0–782	LANL conducted a video survey of the borehole. The casing shoe was noted at 724 ft bgs and there was no evidence of water seepage between the casing shoe and the standing water level of 750 ft bgs. An approximately ¼-in. borehole wall “skin” of apparent smeared formation was observed in this interval.
09/29/08	0–782	LANL conducted a video survey of the borehole to confirm depth to water and look for evidence of seepage from formation. Water level was observed to be 759 ft bgs, and there was still no evidence of seepage between the bottom of the casing shoe (724 ft) and the standing water level.

Table 7.2-1
Annular Fill Materials

Material	Volume in R-25b
Surface seal: cement slurry	76 ft^3
Bentonite seal: bentonite chips	490 ft^3
Bentonite seal: high solids bentonite grout	144 ft^3
Upper annular seal: bentonite chips	17.8 ft^3
Fine sand collar: 20/40 silica sand	1.3 ft^3
Primary filter: 10/20 silica sand	23.5 ft^3
Lower annular seal: bentonite chips	4.0 ft^3
Backfill material: 10/20 silica sand	3.5 ft^3
Potable water	15, 600 gal.

Table 8.1-1
R-25b Water-Quality Data during Well Development (through October 23, 2008)

Date	Cumulative Purge Volume (gal.)	pH	Cond. (µS)	Turbidity (NTU)	Temperature (C)	O2 (%)	ORP (mV)
10/15/08	505	6.90	158	448.0	9.6	72.0	212
	580	7.76	154	467.0	11.5	74.0	208
10/17/08	875	7.42	203	36.2	15.3	70.0	172
	1030	7.43	147	56.2	16.2	71.9	163
	1200	7.33	133	60.4	17.8	65.3	223
10/18/08	1290	7.48	142	119.0	15.9	92.2	219
	1405	7.74	130	54.9	14.1	71.8	236
	1606	7.61	148	58.9	15.1	68.2	223
10/19/08	1700	7.51	147	56.0	15.6	89.1	189
	1815	7.62	158	89.0	15.2	70.2	163
	1937	7.41	149	140.0	16.3	68.2	174
10/20/08	2054	7.56	131	92.6	16.3	66.0	157
	2152	7.66	139	96.0	16.1	63.9	128
	2289	7.44	148	289.0	16.1	64.9	184
10/21/08	2454	7.43	134	132.0	14.8	57.0	176
	2555	7.36	132	125.0	16.4	63.3	128
	2692	7.36	143	190.0	16.6	91.7	168
10/22/08	2816	7.47	130	152.0	12.4	59.2	171
	2914	7.49	141	166.0	12.9	60.2	168
	3050	7.42	132	298.0	13.0	61.1	166
10/23/08	3110	7.59	134	97.2	12.2	57.8	159.0

Table 8.4-1
R-25b and R-25c Geodetic Survey Data

Northing	Easting	Elevation	Identification
TBD	TBD*	TBD	Brass cap embedded in pad
TBD	TBD	TBD	Top of protective casing
TBD	TBD	TBD	Top of well cap

*TBD = To be determined.

Appendix A

Lithologic Logs

Los Alamos National Laboratory
Regional Hydrogeologic Characterization Project
Borehole Lithologic Log

BOREHOLE IDs: R-25b and R-25c	**TECHNICAL AREA (TA):** 16	**PAGES: 5**
DRILLING COMPANY: WDC	**START DATE/TIME:** 07/07/08:1425	**END DATE/TIME:** 08/22/08:1755
DRILLING METHOD: Air Rotary	**MACHINE:** Failing Co. SpeedStar 50K	**SAMPLING METHOD:** Drill Cuttings
GROUND ELEVATION: **** ft above mean sea level (amsl)	**TOTAL DEPTH (TD):** 1140 ft below ground surface (bgs)	
DRILLERS: J. Leon/S. Huston	**LOGGERS:** M. Ivers/M. Pitterle	

DEPTH (ft)	LITHOLOGY	LITHOLOGIC SYMBOL	Notes
0–5	**ALLUVIUM:** Predominantly silt and fine sand (SM), with <5% medium to coarse sand, brown (5YR 4/4). Dry.	-	**Alluvium:** (0–5 ft bgs) Cuttings are very dirty; was not possible to distinguish individual components.
5–35	**TSHIREGE MEMBER, BANDELIER TUFF:** Pale yellowish brown (10YR 6/2), nonwelded to partially welded, devitrified ash-flow tuff. WR: Fine ash matrix with sparse crystals of quartz and sanidine, <1 mm, rare pumice, and rare dark, volcanic lithics of intermediate composition. +35F: Predominantly crystals, <1 mm. Dry.	Qbt 4	**Qbt 4 Tshirege Member of Bandelier Tuff:** (5–84 ft bgs) Samples from 20 to 50 ft are contaminated with bentonite pellets used to set seal at the bottom of the surface casing before grouting.
35–55	**35–55 ft bgs:** Light brownish gray (5YR 6/1) to light gray (10YR 7/1), nonwelded to moderately welded, devitrified ash-flow tuff. WR: Sparse crystals of sanidine and quartz, rare pumice, lithics not observed (cuttings are coated with dust). +35F: Predominantly crystals, 1 mm or less. Dry.		
55–84	**55–84 ft bgs:** Pale yellowish brown (10YR 6/2) to medium gray (N5), nonwelded to partially welded, devitrified ash-flow tuff. WR: Fine ash matrix with abundant felsic crystals of sanidine and quartz, mostly 2–3 mm, up to 5 mm at the base of the interval, common white pumice, and minor volcanic lithics of intermediate composition up to 2 cm. +35F: Predominantly crystals. Wet. 55–60 ft bgs: predominantly crystals, up to 2 mm. Many appear rounded.		

BOREHOLE IDs: R-25b and R-25c	**TECHNICAL AREA (TA):** 16	**PAGES: 5**	
84–105	**TSHIREGE MEMBER, BANDELIER TUFF:** Brown (5YR 4/4), nonwelded, devitrified ash-flow tuff. WR: Matrix of fine ash (95%) with minor crystals of sanidine and quartz, minor dark volcanic lithics of intermediate composition, mostly <3 mm, and rare pumice. +10F: Rounded tuff clasts (matrix) with minor crystals. +35F: 95% crystals, 5% tuff clasts and lithics. Dry to wet.	Qbt 3t	**Qbt 3t Tshirege Member of Bandelier Tuff:** (84–155 ft bgs)
105–145	**105–145 ft bgs:** Pale yellowish brown (10YR 6/2), nonwelded, devitrified ash-flow tuff. WR: Matrix of fine ash (80%–90%), abundant crystals of sanidine, quartz and feldspar, rare pumice, minor volcanic lithics of crystal-rich tuff of intermediate composition. +10F: Predominantly lithics up to 12 mm. +35F: Roughly equal proportions of lithics and crystals. Dry.		
145–155	**145–155 ft bgs:** Brownish black (5YR 2/1) to medium gray (N5), moderately welded, devitrified ash-flow tuff. WR: Ash matrix with abundant (18%–20%) crystals of sanidine and quartz, 2–3 mm, rare pumice, very light gray (N8) to white, minor light brown (5YR 5/6) and reddish brown volcanic lithics. +10F: Tuff matrix clasts. +35F: Predominantly crystals, with lesser tuff clasts and lithics. Wet.		
155–215	**TSHIREGE MEMBER, BANDELIER TUFF:** Nonwelded, devitrified, ash-flow tuff. WR: Predominantly crystals, light gray (N8) tuff clasts, lithics and rare pumice. +10F: Tuff clasts and lithics. +35F: 95% crystals.	Qbt 3	**Qbt 3 Tshirege Member of Bandelier Tuff:** (155–228 ft bgs)
215–225	**215–225 ft bgs:** No recovery		
225–228	**225–228 ft bgs:** Nonwelded, devitrified, ash-flow tuff. WR: Predominantly crystals, light gray (N8) tuff clasts, lithics and rare pumice. +10F: Tuff clasts and lithics. +35F: 95% crystals. **Note:** Poorly recovered. An increase in the penetration rate indicates soft formation, possibly the white, nonwelded tuff at the base of Qbt 3.		Poorly recovered. An increase in the penetration rate indicates soft formation, possibly the white, nonwelded tuff at the base of Qbt 3.

BOREHOLE IDs: R-25b and R-25c	**TECHNICAL AREA (TA):** 16	**PAGES: 5**	
228–240	**TSHIREGE MEMBER, BANDELIER TUFF:** Grayish red (10R 4/2), moderately to strongly welded, devitrified ash-flow tuff. WR: Recovered >75% crystals of sanidine and quartz, lesser tuff clasts, lithics and rare pumice. +35F: 90%–95% crystals.	Qbt 2	**Qbt 2 Tshirege Member of Bandelier Tuff:** (228–332 ft bgs) **Note:** The very low penetration rate through the interval suggests a moderately to strongly welded tuff; however, the lack of recovery of tuff (matrix) may indicate a nonwelded tuff.
240–305	**240–305 ft bgs:** Grayish brown (5YR 3/2), partially to moderately welded, devitrified ash-flow tuff. WR: Tuff matrix is crystal-rich, 20%+ sanidine and quartz, light gray (N8) to white, vapor-phase altered pumice are common, minor dark, volcanic lithics. +10F: Tuff clasts (matrix) with minor lithics. +35F: 80%–90% crystals with lesser tuff clasts and minor lithics. **270–280 ft bgs:** Matrix is yellowish brown (10YR 6/2), nonwelded to partially welded (very poor recovery of matrix).		
305–332	**305–332 ft bgs:** Grayish brown (5YR 3/2), moderately welded, devitrified ash-flow tuff. WR: Tuff matrix is crystal-rich, 20%+ sanidine and quartz, minor light gray (N8) to white, vapor-phase altered pumice, rare dark, volcanic lithics. +10F: Tuff clasts (matrix) with minor lithics. +35F: 80%–90% crystals with lesser tuff clasts and minor lithics.		
332–355	**TSHIREGE MEMBER, BANDELIER TUFF:** Grayish brown (5YR 3/2) to dusky brown (5YR 2/2), nonwelded to partially welded, devitrified ash-flow tuff. WR: Tuff matrix is crystal rich (+30%). Vapor-phase alteration of the matrix is not readily apparent in the cuttings, although the color is lighter. Minor vapor-phase altered pumice (sugary texture), and rare dark volcanic lithics. +10F: Tuff clasts (matrix) with minor lithics. +35F: 80%–90% crystals with lesser tuff clasts and minor lithics.	Qbt 1v	**Qbt 1v Tshirege Member of Bandelier Tuff:** (332–369 ft bgs)
355–369	**355–369 ft bgs:** Very poor recovery of the matrix (recovered mostly crystals) indicates the tuff may be nonwelded or could to vapor-phase alteration of the matrix.		
369–384	**TSHIREGE MEMBER, BANDELIER TUFF:** Medium gray (N5), nonwelded, devitrified ash-flow tuff. WR: Recovery consists predominantly of crystals of sanidine and quartz, and abundant dark gray to reddish brown volcanic lithics of intermediate compositions, up to 16 mm. Pinkish gray, vitric pumice with fibrous textures are common. +10F: Predominantly lithics. +35F: Predominantly crystals with minor lithics and tuff matrix. **380–382 ft bgs:** Increase in vitric pumice, pale yellowish brown (10YR 6/2) to grayish orange pink (5YR 7/2), up to 1 cm; higher concentration of volcanic lithics.	Qbt 1g	**Qbt 1g Tshirege Member of Bandelier Tuff:** (369–384 ft bgs)

BOREHOLE IDs: R-25b and R-25c	TECHNICAL AREA (TA): 16	PAGES: 5	
384–385	**CERRO TOLEDO INTERVAL:** Volcaniclastic sediments. WR: Poorly sorted, fine to coarse sand and fine gravel size clasts, predominantly angular to subangular, locally subrounded (especially pumice and nonwelded tephras). Clasts are predominantly volcanic tuffs and lavas of rhyolitic to intermediate compositions, pumice (mostly vitric), nonwelded tephras, abundant felsic crystal fragments (noted bipyramidal quartz), and rare siltstones. Clasts are generally light to dark gray (N8-4) and reddish brown. Pumice and tephras are light brown to white and orange where altered (oxidized).	Qct	**Cerro Toledo Interval:** (384–740 ft bgs)
385–395	**385–395 ft bgs:** No recovery		
395–500	**415–430 ft bgs:** Decrease in pumice, less orange coloration (oxidation); pumice are generally white. **430–435 ft bgs:** No recovery **440–445 ft bgs:** Interval contains approximately 75% white to slightly orange, vitric pumice.		
500–520	**500–515 ft bgs:** Crystal-rich tephra (very poor recovery of the tuff matrix). WR: White to light gray and grayish pink, moderately indurated ash. +10F: Tephra clasts. +35F: +95% felsic crystal fragments. **515–520 ft bgs:** No recovery		
520–591	**520–591 ft bgs:** Volcaniclastic sediments. Same as above, with an increase in mafic volcanics, very dark gray (N3) to black (N2.5), andesites, dacites, and rare volcanic siltstones. **530–535 ft bgs:** No recovery		
591–610	**591–616 ft bgs:** Brown (10YR 5/3) to dark yellow (10YR 3/4) (wet), nonwelded, devitrified ash-flow tuff. WR: Ash matrix with rare light gray (N7-8) to dark yellowish orange (10YR 6/6), vitric pumice, common felsic crystals, sparse dark volcanic lithics of intermediate composition. +10F: Predominantly tuff matrix (rounded clasts) with minor lithics. +35F: Tuff clasts, pumice, minor lithics and crystals.	Qct	
610–640	**610–640 ft bgs:** No recovery		
640–650	**640–650 ft bgs:** Very light gray (N9) to dark yellow orange (10 YR 6/6) medium–coarse sand size pumice fragments, subround, trace clear phenocrysts.		
650–690	**650–690 ft bgs:** No recovery		

BOREHOLE IDs: R-25b and R-25c		**TECHNICAL AREA (TA):** 16	**PAGES: 5**
690–740	**690–740 ft bgs:** Yellowish orange (10YR 6/4) (check color), nonwelded, vitric ash-flow tuff. WR: Fine ash matrix with common pumice, vitric, vesicular/frothy textures, white (N9) to light gray (10YR 7/2) and yellowish orange (10YR 6/4), common sanidine and quartz, minor volcanic lithics of intermediate compositions, dark gray to very dark gray (N5-3) and yellowish red (5YR 4/4). Pumice have very fine mafic crystals. +10F: Vitric pumice and lesser tuff clasts, and minor lithics. +35F: Predominantly crystals with roughly equal parts of tuff matrix and pumice, and common lithics.		
740–843	**OTOWI MEMBER, BANDELIER TUFF:** White, partially welded, vitric ash-flow tuff. WR: Fine ash with abundant vitric pumice, white (N9), porous, vesicular textures (difficult to distinguish between tuff matrix and pumice in cuttings), minor to common sanidine and quartz, common dark volcanic lithics of intermediate compositions. +10F: Predominantly pumice with lesser tuff matrix clasts, and common lithics. +35F: Generally equal parts pumice/tuff clasts, crystals and lithics.		
843–850	**GUAJE PUMICE BED:** Cannot be readily distinguished from the Otowi in cuttings. However, a marked increase in larger, rounded pumice in the +10F from 840 to 845 ft may represent the top of the Guaje Pumice Bed. Otherwise, the interval is the same as the Otowi Member above.	Qbo g	**Guaje Pumice Bed:** (843–850 ft bgs)
850–1045	**PUYE FORMATION:** Volcaniclastic sediments. WR: Poorly sorted, medium to coarse sand and fine gravel size clasts (up to 3.5 cm) of angular to subangular, and rarely subrounded volcanic flows and tuffs of intermediate composition. Clasts range from very light gray (N8) to dark gray (N4), with lesser dusky red (2.5YR 3-4/4), light brown (7.5YR 6/4) and light gray (5YR 7/1). Tuffs and rhyolite flows are generally lighter in color, are partially to densely welded, often crystal rich, and occasionally vitric. +35F: Generally the same as WR but includes minor amounts of felsic crystal fragments, <5%.	Tpf	**Puye Formation:** (850–1140 ft bgs) **Note:** Sample recovery through the interval was very poor. Because of the large volumes air needed to drill and the large quantities of water produced from the formation, it was not possible to recover the fines, and sample quality is poor.
1045–1140	**1045–1140 ft bgs:** Volcaniclastic sediments, as above. Noted an increase in darker intermediate volcanic clasts, and a decrease in clast size; fine gravel is rare to absent. Felsic crystal fragments are rare to absent.		

Appendix B

Schlumberger Geophysical Logging Executive Summary

CABRERA SERVICES, INC.

Report on:
Advanced Borehole Geophysical Logging of LANL Well R-25c Los Alamos, New Mexico

Prepared for
Cabrera Services

By

Schlumberger
WATER SERVICES

September 29, 2008

Executive Summary

Geophysical logging was performed by Schlumberger in characterization well R-25C in August 2008 before well completion. The logging measurements were acquired from 566 to 850 feet (ft) below ground surface (bgs), when the borehole contained 11.75 inch (in.) outer diameter (OD) freestanding steel casing from ground surface to 850 ft, drilled with an approximately 12 in. diameter bit size. Access with the logging tools into the uncased borehole below 850 ft could not be achieved due to a borehole obstruction.

The primary purpose of the geophysical logging was to characterize the geology and hydrogeology across the depth section where well screens were being considered, with emphasis on determining regional aquifer groundwater level, relative water saturation, depths of porous aquifer zones, and stratigraphy/lithology of geologic units. These objectives were accomplished by measuring, nearly continuously, along the length of the well (1) total water-filled porosity from which, in combination with lithologic composition estimated from the other logs, an indirect estimate of hydraulic conductivity (production capacity) is made; (2) bulk density (sensitive to total water plus air-filled porosity and grain density); (3) neutron induced gamma ray spectroscopy, providing bulk concentrations of a number of important mineral-forming elements, as well as hydrogen; and (4) spectral natural gamma ray, including potassium, thorium, and uranium concentrations.

The following Schlumberger geophysical logging tools were used in the project (Table 1):

- Accelerator Porosity Sonde (APS*)
- Triple Detector Litho-Density (TLD*) tool
- Elemental Capture Spectroscopy (ECS*) tool
- Hostile Natural Gamma Spectroscopy (HNGS*) and gamma ray (GR)

Table 1: Geophysical Logging Tool, Technology, Corresponding Measured Properties

Tool	Technology	Parameters
Accelerator Porosity Sonde (APS*)	Epithermal neutron porosity and neutron capture cross-section	Water/moisture content, lithologic and grain size variations
Triple Detector Litho-Density (TLD*)	Gamma-gamma bulk density	Bulk density, total porosity, lithology
Elemental Capture Spectroscopy (ECS*)	Neutron induced gamma ray spectroscopy	Formation matrix geochemistry, lithology and mineralogy, formation hydrogen content
Hostile Natural Gamma Spectroscopy (HNGS*) and gamma ray (GR)	Gross and spectral natural gamma ray, including potassium, thorium, and uranium concentrations	Formation matrix geochemistry, lithology and mineralogy

A more detailed description of these geophysical logging tools can be found on the Schlumberger website (http://www.slb.com/content/services/evaluation/index.asp?).

Once the Cabrera Services well drilling project team provided Schlumberger final notification that R-25C was ready for geophysical well logging, the Schlumberger district in Farmington, NM, mobilized a wireline logging truck, the appropriate wireline logging tools and associated equipment, and crew to the job site. Schlumberger was asked by Cabrera to bring both the open and cased hole geophysical logging tool suites, with the hope of running the open hole suite if the borehole remained stable enough. However, due to an obstruction in the open borehole below the bottom of the casing, the open hole suite could not be run and the cased hole suite was run instead. The Schlumberger logging crew first ran the HNGS and ECS logging tools, then rigged down and moved off the site to allow the drilling crew to try to retrieve the drilling collar. The drilling crew was not immediately successful, so the logging crew returned the next to complete the cased hole logging suite. Table 2 summarizes the geophysical logging runs performed in R-25C.

Table 2: Geophysical logging services, their combined tool runs and intervals logged, as performed by Schlumberger in well R-25C

Date of Logging	Run #	Tool 1 (bottom)	Tool 2 (top)	Depth Interval (ft bgs)
13-Aug-2008	1	HNGS	GR	692–850 ft
	2	ECS	GR	588–850 ft
14-Aug-2008	3	TLD	GR	606–850 ft
	4	APS	GR	566–850 ft

Preliminary results of these measurements were generated in the logging truck at the time the geophysical services were performed and are documented in field logs provided on site. However, the measurements presented in the field results are not fully corrected for borehole conditions (particularly casing) and are provided as separate, individual logs. The field results were reprocessed by Schlumberger to (1) correct/improve the measurements, as best as possible, for borehole/formation environmental conditions; (2) perform an integrated analysis of the log measurements so that they are all coherent and provide consistent hydrogeologic and geologic results; and (3) combine the logs in a single presentation, enabling integrated interpretation. The reprocessed log results provide better quantitative property estimates that are consistent for all applicable measurements, as well as estimates of properties that otherwise could not be reliably estimated from the single measurements alone (e.g., total porosity inclusive of all water and air present, water saturation, relative hydraulic conductivity, lithology).

The geophysical log measurements from Well R-25c provide, overall, good quality results that are consistent with each other across the logged interval. However, the existence, extent, and effect on the geophysical logs of a water or air-filled annulus between the casing and the borehole wall (voids behind the casing) is difficult to determine and, thus, there is uncertainty about how well some of the log measurements represent true geologic formation conditions (unaffected by drilling). The distance between the logging tool sensor and formation is unknown and, thus, difficult to account for or correct for. The measurements most affected by voids behind the casing were ones that have a shallow depth of investigation and that require close contact to the uncased borehole wall—the bulk density and the neutron porosity measurements. One indicator that the bulk density is being adversely affected by voids behind the casing is when the computed density porosity is unrealistically high. As shown in Figure 1 below (first track on the left), where the density porosity (red shading) reaches above 60% the bulk density measurement is likely being affected by voids.

Important results from the processed geophysical logs in R-25C include the following:

1. The well standing water level in R-25C dropped from 779 ft bgs at the time of the ECS logging run to 810 ft bgs the next day at the time of the APS logging run.
2. The water content logs from the APS and ECS exhibit fairly high water content throughout the logged interval, ranging from a low of approximately 12% of total rock volume at 694 ft bgs to a high of around 40% at various depths below 810 ft bgs (see Figure 1, track 1 on the left). It is important to note that the low water content at 694 ft correlates with unrealistically high density porosity (over 80%), which, as described above, indicates a large void behind casing – likely resulting in a lower water content than is representative of the formation. Overall, water content increases with depth, particularly below 694 ft.
3. The density porosity log, derived from the casing-corrected bulk density measurement and an assumed formation matrix grain density, is considerably higher than the measured water content above 810 ft bgs, even when a very low matrix grain density is used (a lower grain density computes a lower density porosity). This indicates, in itself, that the total porosity is higher than water-filled porosity and, thus, the formation is not fully water saturated above 810 ft. It is possible there is consistent gap between the casing and the borehole wall, although this would be unusual compared to previous LANL wells. Another possibility is that the formation in the vicinity of the borehole drained after the well water level dropped prior to the logging, resulting in a lower water content and unsaturated conditions as measured by the geophysical logs compared to true formation conditions.

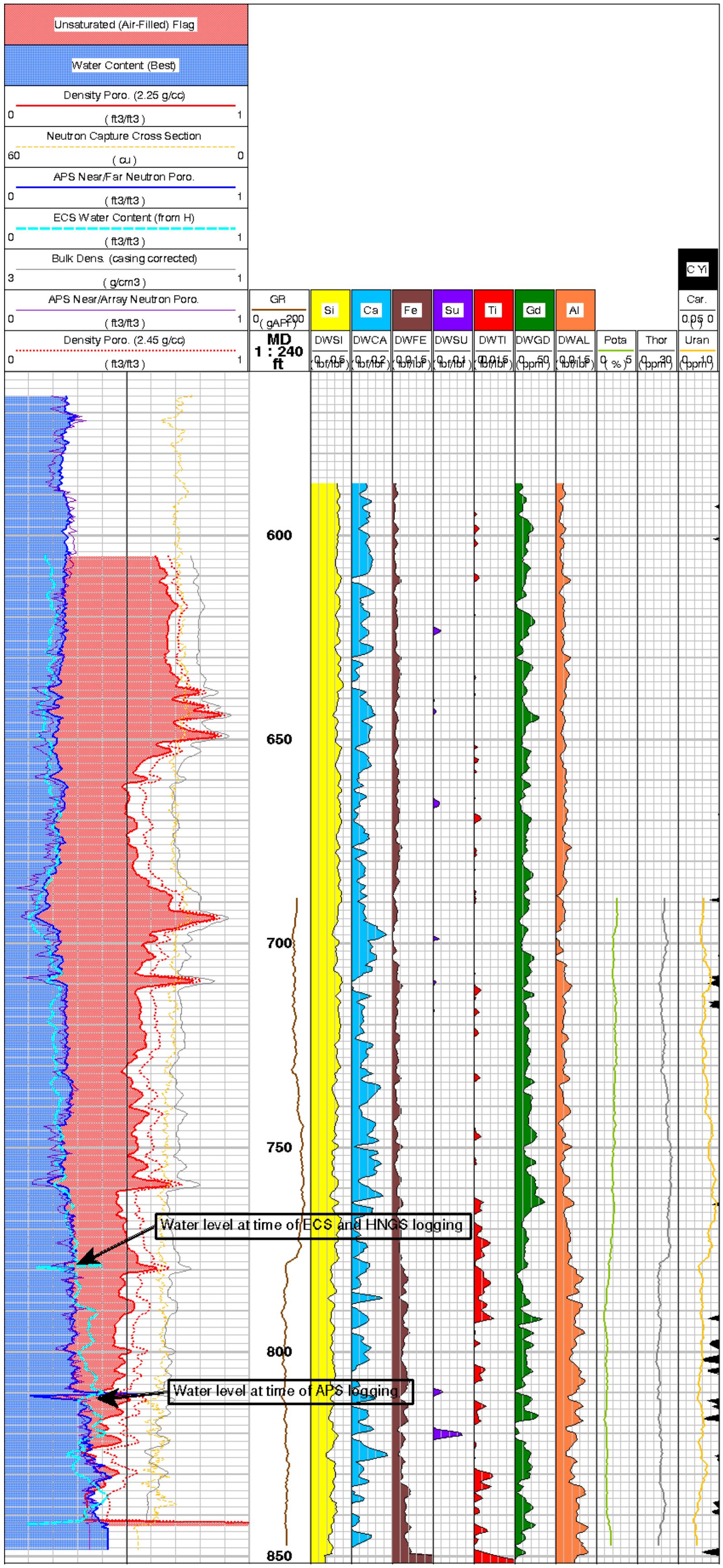

Figure 1: Initial post-processed geophysical log summary composite