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REVISION 1
WELL R-28 COMPLETION REPORT
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO
PROJECT NO. 37151/16.12

Prepared for:

The United States Department of Energy and the
National Nuclear Security Administration through the
United States Army Corps of Engineers
Sacramento District

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February 9, 2005

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LIST OF ACRONYMS AND ABBREVIATIONS

AITH	array induction tool, version H
ASTM	American Society for Testing and Materials
bgs	below ground surface
°C	degrees Celsius
CA	casing advance
CD	compact disc
CMR™	Combinable Magnetic Resonance
CNTG	compensated neutron tool, model G
CQMP	Contractor Quality Management Plan
DOE	Department of Energy
DP	drilling plan
DTH	down-the-hole
DTW	depth to water
DVD	digital video disc
EES	Earth and Environmental Sciences
EnviroWorks	EnviroWorks, Inc.
FMI	formation microimager
ft	feet
gal.	gallon
GPS	global positioning system
g	grams
HSA	hollow-stem auger
ID	inner diameter
in	inches
Kleinfelder	Kleinfelder, Inc.
KBr	potassium bromide
LANL	Los Alamos National Laboratory
MDL	Method Detection Limit
mil	1/1000 of an inch
NAD	North American Datum
NGS	natural gamma spectroscopy
NGVD	National Geodetic Vertical Datum
NMED	New Mexico Environment Department
NOI	Notice of Intent
NTU	nephelometric turbidity unit
OD	outer diameter
OH	open hole
PMP	Project Management Plan
psi	pounds per square inch
RCT	Radiation Control Technician
SAP	sampling and analysis plan
SSHASP	Site-Specific Health and Safety Plan
TD	total depth
TLD	triple detector lithodensity
TOC	Total Organic Carbon
USACE	United States Army Corps of Engineers

µS/cm	microsiemens per centimeter
WDC	WDC Exploration & Wells

ABSTRACT

Well R-28 (R-28) was installed at Los Alamos National Laboratory (LANL) for LANL's Groundwater Protection Program as part of the "Mortandad Canyon Groundwater Work Plan" (LANL, August 2003, LA-UR-03-6221). The Department of Energy contracted and directed the installation of R-28 with the technical assistance of LANL. The well is intended to provide hydrogeologic and water quality data for regional groundwater in the vicinity of potential contaminant sources in Mortandad Canyon. The data will be used with similar data from other wells in the area to improve the conceptual model for geology, hydrogeology, and hydrochemistry in this wet canyon and provide constraints on numerical models that address contaminant migration in the vadose (unsaturated) zone and the regional aquifer.

At R-28, fieldwork was conducted from November 7, 2003 through Spring 2004.

Phase I of fieldwork was conducted from November 10 to November 21, 2003, and consisted of drilling a corehole to collect continuous core for geochemical analysis, contaminant profiling and identification of perched water zones. Continuous core was collected from the surface to a depth of 325.0 feet (ft) below ground surface (bgs). No significant perched water zones were identified during drilling.

In Phase II drilling, November 20 to December 9, 2003, a borehole was drilled to a depth of 1005 ft bgs using air and fluid-assisted air-rotary methods. Samples of drill cuttings were collected at regular intervals for stratigraphic, petrographic, and geochemical analysis. The stratigraphy encountered during borehole drilling included, in descending order, alluvium and colluvium, ash-flow tuffs of the Otowi Member of the Bandelier Tuff, the Guaje Pumice Bed of the Otowi Member, Cerros del Rio basalt and the Puye Formation. The R-28 well was installed in the regional aquifer with a screen interval from 934.3 ft to 958.1 ft bgs. Three groundwater screening samples were collected during drilling and one groundwater well sample was collected after well development. Groundwater samples were submitted to LANL for analysis. Additionally, a constant rate pumping test was conducted at Well R-28 to determine aquifer properties.

1.0 INTRODUCTION

This completion report summarizes the drilling, well construction, well development, and related activities conducted from November 7, 2003 to Spring, 2004 for Well R-28 (R-28). R-28 was drilled and installed for LANL's Groundwater Protection Program as part of the "Hydrogeologic Workplan" (LANL 1998, 59599). The R-28 investigation was funded and directed by the Department of Energy (DOE). Kleinfelder, Inc. (Kleinfelder), under contract to the US Army Corps of Engineers (USACE), was responsible for executing the drilling, installation, testing, and sampling activities.

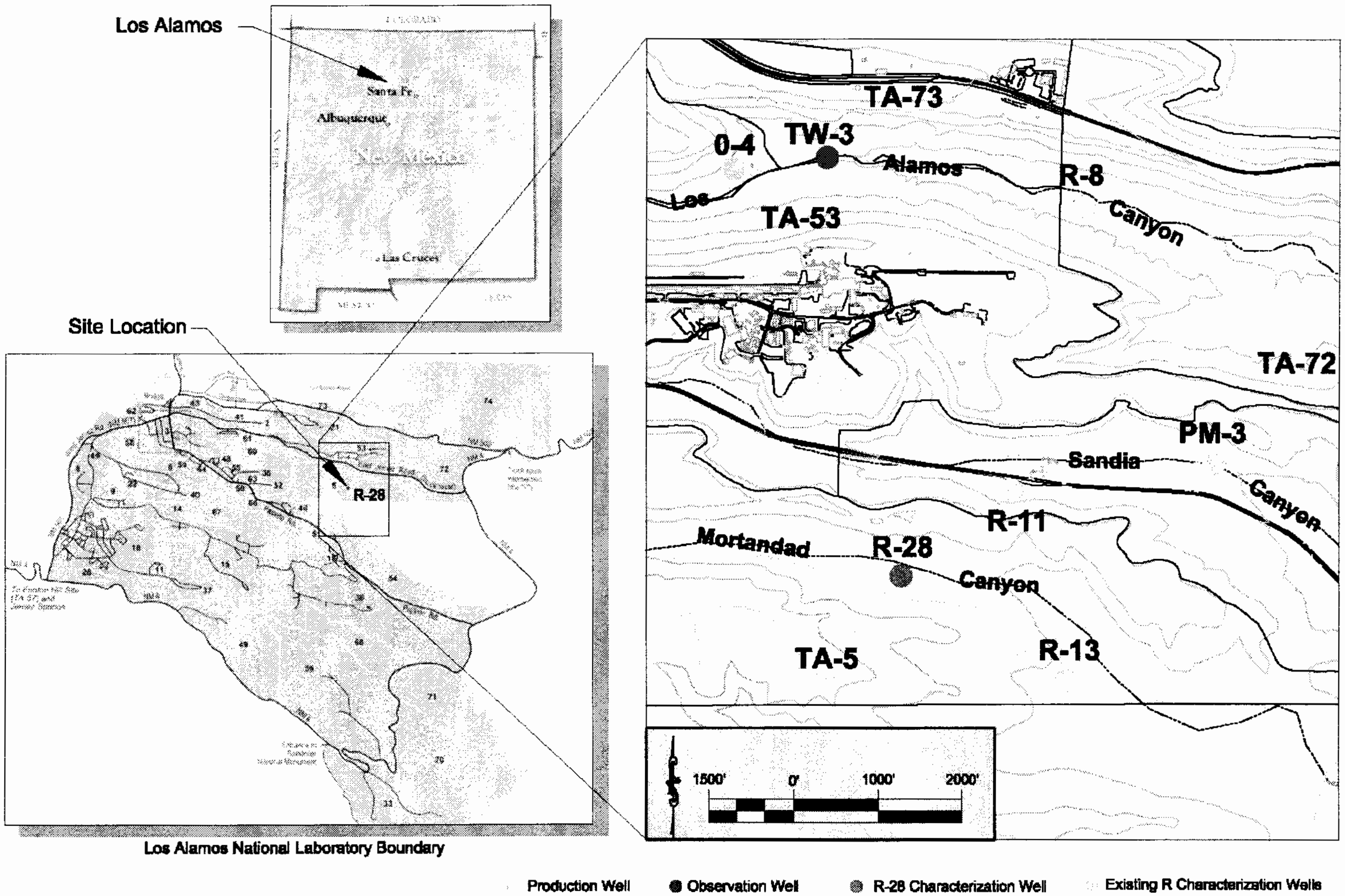
The information presented in this report was compiled from field reports and activity summaries generated by Kleinfelder, LANL and subcontractor personnel. Original records, including field reports, field logs, and survey records are on file in Kleinfelder's Albuquerque office. Results of these activities are discussed briefly and shown in tables and figures contained in this report. Detailed analysis and interpretation of geologic, geochemical, and hydrologic data will be included in separate technical documents prepared by LANL.

R-28 is located in Mortandad Canyon and will provide a contaminant analysis-and-monitoring point for comparison with regional well R-15, located upstream; R-11, located to the northeast in Sandia Canyon; and R-13, located to the southeast, downstream in Mortandad Canyon (as shown in Figure 1.0-1). As indicated in the LANL-prepared Sampling and Analysis Plan (SAP) (LANL 2003, 03-8324), contaminants have been identified in alluvial and perched intermediate groundwater and in the regional aquifer within Mortandad Canyon. Historically, constituents that have been detected in surface water and alluvial groundwater include: americium-241; cesium-137; plutonium-238 and plutonium-239, 240; strontium-90; tritium; uranium-234, 235, 236, 238; nitrate; perchlorate; chloride; sulfate; fluoride; and total dissolved solids ([TDS] ESP 1999, 68661; ESP 2001, 73876; ESP 2002, 71301). Mortandad Canyon and its tributaries have received effluents from Los Alamos National Laboratory (LANL or the Laboratory) since the early 1950s. These effluents discharged from TA-3, TA-35, TA-48, and TA-50 have contained a variety of contaminants including nitrate, perchlorate, tritium, cesium-137, strontium-90, americium-241, and several isotopes of uranium and plutonium (LANL 1997, 56835). Active outfalls at TA-3 and TA-50 discharged to Mortandad Canyon. Most contaminants found in Mortandad Canyon are associated with TA-50 discharges into Effluent Canyon except for sources of strontium-90 (LANL 1997, 56835), nitrate, and perchlorate. Strontium-90, nitrate, and perchlorate were discharged from TA-35 into Pratt Canyon; total masses of nitrate and perchlorate discharged are not known.

Data from R-28 will be evaluated in conjunction with data from other area wells to form the technical basis for the design of a groundwater monitoring system, if needed. Water quality, geochemical, hydrologic, and geologic information obtained from R-28 will augment knowledge of regional subsurface characteristics and distribution of contaminants downgradient of potential release sites.

2.0 PRELIMINARY ACTIVITIES

Preliminary activities at R-28 included administrative and site preparation.



Note: R-28 Well Identification Modified from Proposed R Characterization Well Location Map Provided by Los Alamos National Laboratory

KLEINFELDER		SITE LOCATION MAP Well R-28 Location LANL Well Program Los Alamos National Laboratory Los Alamos, New Mexico	FIGURE **1.0-1**
Drawn By: C. Landon	Date: March 2004		
Project No.: 37151	Filename: FIGURE 1.0-1		
Scale: 1" = 2000'	Revision: 0		

2.1 Administrative Preparation

Kleinfelder received contractual authorization to start administrative preparation tasks in the form of a notice to proceed on July 11, 2003. As part of this preparation, Kleinfelder developed a Project Management Plan (PMP), a Contractor's Quality Management Plan (CQMP), a Site-Specific Health and Safety Plan (SSHASP), a traffic control plan, and a Drilling Plan (DP) for the work at R-28. The host facility signed a Facility-Tenant Agreement (FTA) to provide access and security controls for site preparation, drilling and well installation activities. Necessary permits and access agreements were obtained prior to beginning fieldwork.

2.2 Site Preparation

EnviroWorks, Inc. (EnviroWorks) was subcontracted by Kleinfelder to conduct site preparation. Activities included site clearing, access road improvement, construction of the drill pad, and construction of a lined borehole-cuttings containment area. Site preparation was begun on November 7, 2003 and completed on November 12, 2003. Radiation Control Technicians (RCTs) contracted from HSR-1 were present to screen the site during preparation activities.

An access road, located to avoid archaeological sites, was constructed to R-28. The R-28 site was then cleared of vegetation. The drilling pad was developed by grading an area with a front-end loader. A primary layer of base-course gravel was distributed over the drill pad, equipment storage area and on the access road, as necessary. Drill pad construction was completed with an additional graded layer of base-course gravel. To store R-28 drilling fluids and borehole cuttings, a 25-ft wide by 60-ft long by 7-ft deep containment area was excavated along the pad boundary. A secondary containment area was constructed with straw bales and lined with 6-mil polyethylene to accommodate a 21,000-gallon (gal) tanker trailer used for storing potable water. Safety barriers and signs were installed around the borehole-cuttings containment area and at the site entrance. Office and supply trailers, generators, and safety lighting equipment were moved to the site during subsequent mobilization of drilling equipment.

Potable water was trucked to the R-28 site from the hydrant located on the mesa south of Mortandad Canyon. A backflow prevention system was installed at the hydrant.

3.0 SUMMARY OF DRILLING ACTIVITIES

Drilling activities at the R-28 site were completed in two phases during November and December 2003.

Phase I core drilling at R-28 was performed from November 10 to 20, 2003. The goal of Phase I was to collect continuous rock core samples for geologic characterization and determination of moisture, anion, stable isotope, radionuclide, metals, and tritium distributions in the upper part of the geologic section. To accomplish this, drilling was performed without the addition of water or other additives. The core was visually examined for lithologic description and to determine geologic unit contacts. Additionally, groundwater samples were collected from perched water zones. The planned total depth (TD) of the R-28 corehole, estimated to be about 9 ft below into Cerros del Rio lavas, was 336 ft below ground surface (bgs).

Phase II borehole drilling was performed from November 20 to December 9, 2003. Phase II objectives were to collect cuttings of intersected geologic formations, collect groundwater samples from perched water and the regional aquifer, and provide a borehole for geophysical logging and installation of a single-screen monitoring well in the regional aquifer. The planned TD of the R-28 borehole was approximately 967 ft bgs or, as necessary, to approximately 100 ft below the top of the regional water table.

Phase I and II drilling activities were performed generally in one 12-hour shift per day, seven days per week by the drill crew and two site geologists.

Figure 3.0-1 summarizes well data and graphically depicts groundwater and geologic conditions encountered during core and borehole drilling at R-28. A chronology of drilling and other on-site activities is presented as Table 3.0-1. Sections 3.1 and 3.2 discuss specific Phase I and Phase II drilling activities, respectively.

3.1 Phase I Drilling Activities

On November 10, 2003, Kleinfelder mobilized the StrataStar SS15 hollow-stem auger (HSA) drill rig equipped with a 5-ft-long, 3.0-in-outer diameter (OD) continuous sample barrel and support equipment to the R-28 site. Drilling from ground surface to 93 ft bgs was performed with 8-in OD HSA to advance and stabilize the hole. Continuous core samples were collected using a continuous sample barrel and Lexan liners from surface to 93 ft bgs through unconsolidated alluvium and colluvium and into the Otowi Member of the Bandelier Tuff.

Due to drilling conditions, a split-spoon sampler was used to sample the interval from 93 ft to 95 ft bgs. On November 12, 2003, drillers began coring with air, alternating between using a conventional core barrel and a Geobarrel, from 95 ft to 130 ft bgs.

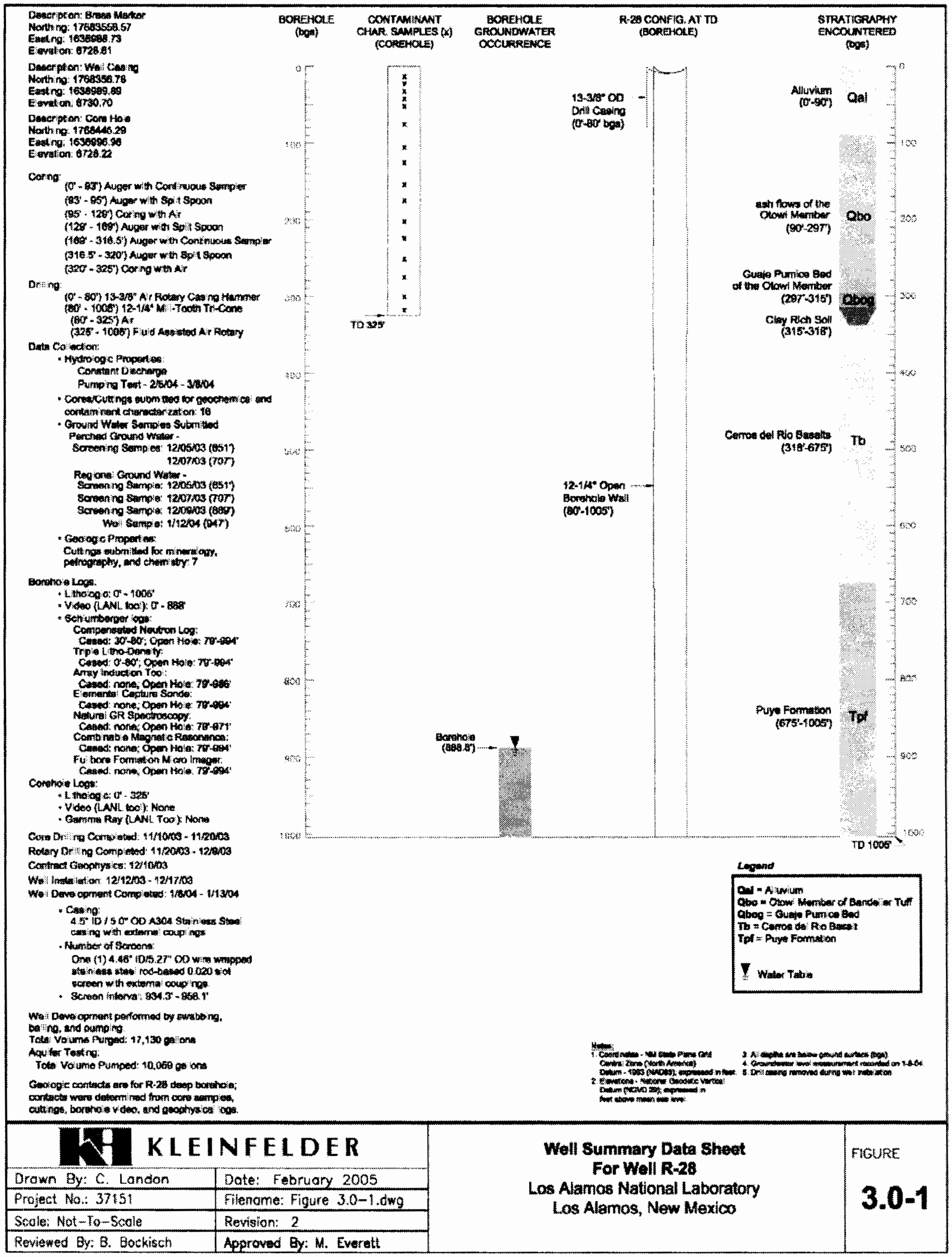
On November 13, 2003, due to poor recovery while coring with air, Kleinfelder changed sampling methods to a split-spoon sampler driven by a down-the-hole (DTH) hammer. The corehole was advanced from 130 ft to 169 ft bgs. Drillers returned to continuous sampling methods in the interval from 169 ft to 316.5 ft bgs, advancing the corehole through ash flows of the Otowi Member and into the Guaje Pumice Bed. On November 19, 2003, due to tight conditions in the hole, the drillers changed to split-spoon sampling methods and continued drilling in the Guaje Pumice Bed and into the top of the Cerros del Rio Basalt to a depth of 320 ft bgs. The interval from 320 ft to 325 ft bgs was core-drilled with air using a conventional core barrel. On November 20, 2003, DOE and LANL declared the corehole to be completed at 325 ft bgs due to encountering the top of the basalt at an elevation higher than predicted.

A confirmatory depth-to-water (DTW) measurement was collected after drilling ceased. No water was present in the hole. No zones of perched water were observed during drilling.

The R-28 corehole was plugged and abandoned on November 20 and 21, 2003. Bentonite pellets were tremied through the augers and hydrated with potable water in the interval from 325 ft to ground surface. A total of 125 bags of 3/8-in Hole-Plug® bentonite pellets were used in the backfilling process.

3.2 Phase II Drilling Activities

Phase II drilling was performed by WDC Exploration & Wells (WDC) using a Dresser™ T70 drill rig equipped with conventional circulation drilling rods, tricone bits, DTH hammer bits, and support equipment. R-28 was drilled using air-rotary and fluid-assisted air-rotary drilling techniques. Drilling fluids were used as needed to improve borehole stability, minimize fluid



Well Summary Data Sheet For Well R-28
Los Alamos National Laboratory
Los Alamos, New Mexico

FIGURE 3.0-1

Table 3.0-1 Operations Chronology for R-28

TASK DESCRIPTIONS	DATE: Nov 03	Dec 03	Jan 04	Feb 04	Mar 04
SITE PREPARATION ACTIVITIES	11/7-12				
CORE HOLE DRILLING AND SAMPLING	11/10-21				
Mobilization	11/10				
Continuous Coring	11/16-20				
Plug & Abandon Corehole	11/20-21				
BOREHOLE DRILLING AND SAMPLING	11/20-12/9				
Mobilization	11/19				
Air-Rotary	11/20	12/3			
Fluid Assisted Air-Rotary		12/1-9			
Groundwater Screening Sampling		12/5, 12/7, 12/9			
BOREHOLE GEOPHYSICS					
Schlumberger Logging		12/10			
LANL Video		12/11			
WELL DESIGN AND CONSTRUCTION		12/11-17			
WELL DEVELOPMENT			1/8-13		
GROUNDWATER WELL SAMPLING			1/12		
HYDROLOGIC TESTING				2/5	3/8
SITE RESTORATION				End of February	

loss, and facilitate cuttings removal from the borehole. Drilling fluids consisted of a mixture of municipal water with QUIK-FOAM® surfactant and EZ-MUD® polymer. DTW measurements were taken at the beginning and end of every shift to check for the presence of water. Drilling equipment was removed from the borehole at the end of each shift to facilitate measurement of possible groundwater.

On November 19, 2003, WDC mobilized drilling equipment and supplies to the R-28 site. The following day, drillers installed 13 3/8-in OD drill casing in the alluvium from ground surface to a depth of 80 ft bgs. The borehole advanced open-hole through the alluvium and into the Otowi Member of the Bandelier Tuff to 185 ft bgs using a 12 ¼-in milltooth tricone bit and air- rotary methods. Drilling activities were temporarily suspended between November 21 and 30, 2003 for maintenance and rig repairs.

On December 1, 2003, WDC resumed OH drilling using air-rotary techniques with the 12 ¼-in milltooth tricone bit. The borehole was advanced from 185 ft to 325 ft bgs through Otowi Member ash flows, the Guaje Pumice Bed, and into the Cerros del Rio basalt.

Fluid-assisted air-rotary drilling was initiated at 325 ft bgs due to difficult drilling conditions encountered in the basalt. Table 3.2-1 shows the total amount of drilling fluids introduced and recovered from the borehole during drilling activities. Potassium bromide (KBr) was added to the drilling fluid as a tracer to aid in determining perched water or when the regional aquifer was encountered. Results of the tracer test are discussed in Section 6.2 of this report. Drilling continued in the Cerros del Rio basalt from 325 ft to 342 ft bgs. Due to slow drilling rates, WDC tripped out of the hole at 342 bgs to switch drill bits.

Table 3.2-1
Introduced and Recovered Fluids

Material	Amount (Gallons)
QUIK-FOAM®	105
EZ-MUD®	39
Potable Water	15,200
Recovered Fluids[a]	28,050

[a] Recovered fluids represents approximate fluids recovered during drilling and well development.

On December 2, 2003, drilling resumed in basalt from 342 ft to 355 ft bgs with a 12 ¼-in DTH hammer button bit. Formation instability and caving of material around the DTH hammer button bit prompted WDC to trip out of the hole and use bentonite to seal off an apparent fracture zone in the basalt. One super sack (41.4 cu. ft) of bentonite chips was added to the hole and hydrated using 200 gallons of municipal water. On December 3, 2003, fluid assisted drilling continued with a 12 ¼-in milltooth tricone bit, advancing the hole in basalt from 355 ft to 434 ft bgs. At 434 ft bgs, drillers experienced a change in drilling conditions and again tripped out of the hole.

On December 4, 2003, WDC tripped back in and drilled from 434 ft to 665 ft bgs using a 12 ¼-DTH hammer button bit. On December 5, 2003, after tripping out of the hole, drillers measured a DTW at 651 ft bgs and a one-gallon groundwater screening sample (Sample ID: GW28-04-52763) was collected for contaminant screening. Drilling continued with the hammer button bit, advancing the hole through the basalt and into the Puye Formation from 665 ft to 725 ft bgs. The base of the Cerros del Rio basalt was intersected at 675 ft bgs. Drilling activities were not performed on December 6, 2003.

On December 7, 2003, with borehole drilled to 725 ft bgs, WDC measured a DTW at 707 ft bgs in the open borehole. Another groundwater screening sample (Sample ID: GW28-04-52764) was collected. Drillers resumed drilling in Puye sediments from 725 ft to 905 ft bgs. On December 8, 2003, a DTW of 888.7 ft bgs (regional aquifer) was measured in the open borehole. On December 9, 2003, WDC continued drilling in the Puye Formation from 905 to 1005 ft bgs, and drilling was terminated. An additional groundwater screening sample (Sample ID: GW28-04-52765) was collected for analysis at a depth of 889 ft bgs. The R-28 well was installed in this borehole and completed in the regional aquifer with a screened interval from 934.3 ft to 958.1 ft bgs. Well design and construction are discussed in Section 7.0.

4.0 SAMPLING AND ANALYSIS OF CORE, CUTTINGS, AND GROUNDWATER

During drilling at R-28, soil and groundwater samples were collected according to the LANL-prepared Sampling and Analysis Plan (SAP) (SAP for Drilling and Testing Characterization Wells R-1, R-28, R-33, R-34, LA-UR-03-4782). Soil and groundwater samples were submitted to LANL for analysis. Core was collected from R-28 and analyzed for geochemical analysis and contaminant profiling. Cuttings collected from R-28 may be analyzed for mineralogic, petrographic, and geochemical properties. Groundwater samples were analyzed for organic, inorganic, and radiochemical compounds.

4.1 Core and Cuttings Sampling

During Phase I drilling, sixteen samples of core were collected from the unsaturated zone during drilling from 10 ft to 325 ft bgs. Approximately 500 grams (g) to 1,000 g of core samples were placed in appropriate sample jars and protective plastic bags before being delivered to Earth and Environmental Sciences (EES)-6, Coastal Science Laboratories, Inc., and General Engineering Laboratories (GEL) for laboratory analysis.

As Phase II drilling conditions permitted, a sufficient quantity of cuttings were collected from the discharge line at 5-ft intervals. A portion of the cuttings were sieved (at >#10 and >#35 mesh or >#35 and >#60 for finer-grained samples) and placed in chip-tray bins along with an unsieved portion. These chip trays were studied to determine lithologic characteristics and used to prepare the lithologic logs. The remaining cuttings were sealed in Ziploc® bags, labeled and archived in core boxes. Up to seven samples may be removed by LANL for mineralogic, petrographic, and geochemical analyses. No cuttings samples were submitted for contaminant characterization. However, all core and cuttings were screened by the RCTs prior to being moved off site.

Sample analysis results will be included in a future LANL investigation report for Mortandad Canyon.

4.2 Groundwater Sampling

Groundwater screening samples were collected during drilling of the R-28 borehole. An additional groundwater sample was collected after development from the completed R-28 well. Two groundwater screening samples were collected on December 5 at 651 ft bgs (Sample ID: GW28-04-52763), and December 7, 2003 at 707 ft bgs (Sample ID: GW28-04-52764). On December 9, 2003, a groundwater screening sample was collected from the regional aquifer at a depth of approximately 889 ft bgs (Sample ID: GW28-04-52765). A well sample (Sample ID: GW28-04-52766) was obtained from the screened interval (934.3 ft to 958.1 ft bgs) after well development on January 12, 2004. The samples were submitted to LANL for analysis.

4.3 Geochemistry of Sampled Waters

The screening samples collected and analyzed (IDs GW28-04-52763 and GW28-04-52764) from the potential perched zones were determined, based on the analytical results, to be a mixture of drilling fluid and potable water rather than perched groundwater (P. Longmire, LANL, 2004). Further discussion of the analytical results for GW28-04-52764 is provided in Appendix A.

Sample ID GW28-04-52765, a screening sample collected from the regional aquifer at the conclusion of drilling, was analyzed and determined to contain both drilling fluids and groundwater (P. Longmire, LANL, 2004). The analysis for this sample is not included in Appendix A because more representative data are available from Sample ID GW28-04-52766. This sample was collected after well development using a submersible pump.

Temperature, pH, turbidity, and specific conductance were determined on-site during sampling of the regional aquifer. Both filtered (metals, trace elements, and major cations and anions) and non filtered (tritium, radionuclides, TOC, and stable isotopes) samples were collected for chemical analyses. Further discussion on testing methods and analytical results for this sample are provided in Appendix A.

5.0 BOREHOLE GEOPHYSICS

Using LANL-owned and subcontractor-owned tools, Kleinfelder and Schlumberger performed borehole geophysics logging operations at R-28.

5.1 Kleinfelder-Supported Video Logging

On December 11, 2003, video logging was performed in the R-28 borehole using downhole tools provided by LANL. The video log was used to identify perched water zones and aid in lithologic contact identification. The video log did not show visual evidence of any perched water zones in the borehole. The video log of the open borehole was digitized onto a digital video disc (DVD) and is included as Appendix B.

5.2 Schlumberger Geophysical Logging

Schlumberger personnel conducted geophysical logging in the R-28 borehole on December 10, 2003. The primary purpose of the Schlumberger logging was to characterize the conditions in the hydrogeologic units penetrated by the R-28 borehole, with emphasis on gathering moisture distribution data, identifying water zones, measuring capacity for flow (porosity and moisture), and obtaining lithologic/stratigraphic data. Secondary objectives included evaluating borehole geometry and determining the degree of drilling fluid invasion along the borehole wall.

Schlumberger personnel used a suite of geophysical logging tools in the cased and uncased portions of the borehole; the suite included the following:

- Combinable Magnetic Resonance (CMRTM) measures the nuclear magnetic resonance response of the formation, which is used to evaluate total and effective water-filled porosity of the formation and to estimate pore size distribution and in situ hydraulic conductivity.

- Array Induction Tool, version H (AITH™) measures formation electrical resistivity and borehole fluid resistivity, thus evaluating the drilling fluid invasion into the formation, the presence of moist zones away from the borehole wall, and the presence of clay-rich zones.
- Triple Detector Litho-Density (TLD™) measures formation bulk density related to porosity, photoelectric effect related to lithology, and borehole diameter using a single-arm caliper.
- Natural Gamma Spectroscopy (NGS™) measures spectral and overall natural gamma ray activity including potassium, thorium, and uranium concentrations, thus evaluating geology and lithology.
- Elemental Capture Spectroscopy (ECS™) measures concentrations of hydrogen, silicon, calcium, sulfur, iron, aluminum, potassium, titanium, chlorinity, and gadolinium to characterize mineralogy, lithology, and water content of the formations.
- Epithermal Compensated Neutron Tool, model G (CNTG™) measures volumetric water content beyond the casing to evaluate formation moisture content and porosity.
- Full-Bore Formation Micro-Imager (FMI™) measures electrical conductivity images of the borehole wall and the borehole diameter with a two-axis caliper to evaluate geologic bedding and fracturing including strike and dip of these features, fracture apertures, and rock textures.

Additionally, a calibrated natural gamma tool was used to record gross natural gamma-ray activity with each logging method (except the NGS™ run) to correlate depth runs between each of the surveys conducted.

Table 5.2-1 summarizes geophysical well logging conducted in R-28 by Schlumberger, Kleinfelder and LANL. Schlumberger's report is presented in Appendix C along with the interpretive logging report and the geophysical logs, compiled as a montage (on the CD on the back cover).

Table 5.2-1
Borehole Logging Surveys Conducted in R-28

Operator	Date	Method	Cased Footage (ft bgs)	Open-hole Interval (ft bgs)	Remarks
Schlumberger	December 10, 2003	Logging suite[a]	0-80	90-994[b]	Schlumberger borehole logging conducted prior to well installation
Kleinfelder/ LANL	December 11, 2004	Video Log	0-80	80-888	Video logging in open borehole to identify perched water in the zone of saturation

[a] Schlumberger suite of borehole logging surveys included triple detector litho-density, array induction tool, epithermal compensated neutron tool, elemental capture spectrometry, full-bore formation microimager, and natural gamma spectrometry, combinable magnetic resonance.
[b] Variable effective depths, see Figure 3.0-1 and Appendix C.

6.0 LITHOLOGY AND HYDROGEOLOGY

A preliminary assessment of the hydrogeologic features encountered during drilling operations at R-28 is presented below. Included are summary descriptions of geologic units identified during characterization of the core and cuttings samples only. LANL EES-6 staff provided preliminary geologic contact zones. Groundwater occurrences are discussed based on drilling evidence, open-hole video logging, geophysical logging, and water-level measurements.

6.1 Stratigraphy and Lithologic Logging

Rock units and stratigraphic relations are interpreted from the visual examination of R-28 core and drill samples, and preliminary interpretation of geophysical data, and are briefly discussed in order of younger to older occurrence. The interpretations presented below are preliminary and may be revised upon future analysis of petrographic, geochemical, mineralogical, and geophysical logging data. A lithologic log for R-28 containing detailed descriptions that identify texture and composition of sample intervals is presented in Appendix D.

Alluvium, Qal (0 ft to 90 ft bgs)

R-28 core/cuttings indicated that unconsolidated alluvium exists from ground surface to approximately 90 ft bgs. The position of the alluvium/Otowi contact is uncertain and additional geologic characterization is underway to identify this contact. Samples from 0 ft to 90 ft bgs were silty to clayey sands with gravel that are typically comprised of volcanic lithics, tuff fragments, and quartz and sanidine crystals. The composition is comparable to the Bandelier Tuff from which these sediments are likely derived.

Otowi Member of the Bandelier Tuff, Qbo (90 ft to 297 ft bgs)

Rhyolitic ash-flow tuff representing the Otowi Member of the Bandelier Tuff was intersected in R-28 from 90 ft to 297 ft bgs. Core and cuttings showed that the Otowi Member is locally pumiceous, lithic-bearing, and partly welded to nonwelded. The coarse-fraction (i.e., the plus No. 10 sieve-size) of most cuttings samples in this interval are made up of more than 50% vitric pumice fragments (locally as much as 90% by volume) and less than 50% dacitic and andesitic lithic fragments that represent xenolithic inclusions. Fine-fraction samples (i.e., the plus No. 35 sieve-size) are made up dominantly of quartz and sanidine crystals with subordinate abundances of volcanic lithics and pumice.

Guaje Pumice Bed, Bandelier Tuff, Qbog (297 ft to 315 ft bgs) and soil (315 ft to 318 ft bgs)

The Guaje Pumice Bed is made up of air-fall tephra and pumiceous surge deposits that form the basal subunit of the Otowi Member of the Bandelier Tuff. The Qbog section intersected in R-28 from 297 ft to 315 ft bgs appears to be made up of nonwelded pumiceous tephra. Core samples exhibit up to 40% white vitric pumices, up to 40% quartz and sanidine crystals, and 10 to 20% volcanic lithic fragments. Cuttings in the interval were severely milled in the process of drilling, to the extent that none of the plus-No. 10-sieve fraction was preserved in any of the samples, indicating the friable nature of this unit. The plus-No. 35- sieve fraction contained dominant proportions (i.e., more than 50% by volume) of vitric pumice with subordinate abundances of quartz and sanidine crystals, and lithic fragments of intermediate volcanic composition. A thin clay-rich soil lies beneath the Guaye Pumic Bed from 315 ft to 318 ft bgs.

Cerros del Rio Basalt, Tb (318 ft to 675 ft bgs)

The Cerros del Rio basalt, comprised of basaltic lavas and intercalated scoria deposits, was encountered in the R-28 borehole from 318 ft to 675 ft bgs. Cuttings indicated that this section is comprised of medium to dark gray, massive to vesicular basalt that is composed of olivine, pyroxene, and plagioclase feldspar phenocrysts in an aphanitic groundmass. Groundmass frequently exhibits strong weathering and/or pervasive alteration (i.e., seriticization) resulting in a somewhat bleached and pitted texture given to the drill chips. Distinctive reddish intervals of oxidized scoriaceous basalt were observed from 415 ft to 435 ft bgs and from 565 ft to 630 ft bgs.

Puye Formation, Tpf (675 ft to 1005 ft bgs)

The Puye Formation in R-28 is made up of volcaniclastic silty and clayey sand and gravel deposits and was encountered in R-28 borehole from 675 ft to 1005 ft bgs (TD). Cuttings indicated that this sedimentary section is made up of poorly cemented, fine to coarse detritus representing a wide range of volcanic constituents that include porphyritic dacite, rhyodacite, andesite, basalt, vitrophyre, and pumice. Sample chips are commonly broken or subrounded, indicating an abundance of gravel-size clasts throughout the section.

6.2 Groundwater Occurrences and Characteristics

The SAP identified two stratigraphic intervals with a potential to contain perched groundwater: (1) the alluvium, between 0 ft and 72 ft bgs; and (2) the Cerro Toledo Interval, between 72 ft and 107 ft bgs. Regional groundwater was anticipated to occur in the Puye Formation at approximately 867 ft bgs.

During Phase I drilling, no perched groundwater zones were observed from 0 ft to 325 ft bgs TD. A depth-to-water (DTW) measurement was taken approximately 12 hrs after the corehole was completed to confirm that no groundwater had been encountered. Again, no perched groundwater was identified; therefore, no piezometer was installed in the R-28 corehole.

During Phase II drilling, possible perched groundwater was detected at 651 ft bgs and a one-gallon sample (Sample ID GW28-04-52763) was obtained. Another possible perched groundwater zone was encountered at 707 ft bgs and a second groundwater screening sample (Sample ID GW28-04-52764) was collected. Potassium bromide (KBr) was added to the drilling fluid as a tracer to aid in determining perched water or when the regional aquifer was encountered. No KBr samples were collected from approximately 550 ft bgs to approximately 790 ft bgs due to errors using the permanent probe; therefore, no data were available to corroborate the possible perched zones. Geochemical analysis of these samples indicated that they consisted of a mixture of drilling fluid and potable water rather than perched groundwater (P. Longmire, LANL, March 2004).

The processed geophysical logs indicate a decrease in water content at 887 ft and above, likely corresponding to a transition from fully water-saturated conditions below to a vadose zone above. Unsaturated conditions in the interval above 890 ft bgs are corroborated by a sharp, almost 60% decrease in the ELAN water saturation estimate from 890 ft to 887 ft bgs. In the remainder of the section above 737 ft bgs the processed logs indicate some zones of higher water saturation, but no fully saturated zones. ELAN logs and interpretations are included in Appendix C.

The regional aquifer was encountered in the open R-28 borehole at a depth of 888.7 ft bgs and a groundwater sample was collected (Sample ID: GW28-04-52765). The depth of the borehole at the time of measurement was 905 ft bgs. A comparison of the KBr concentration in the inflow and the cuttings shows a decrease in the KBr values between approximately 860 ft and 905 ft bgs as shown in Figure 6.2-1. This change in concentration coincides with the observed occurrence of regional groundwater at 888.7 during drilling. After completion of drilling (December 9, 2003), the DTW was again measured in the open borehole. The water level was 889.0 ft bgs.

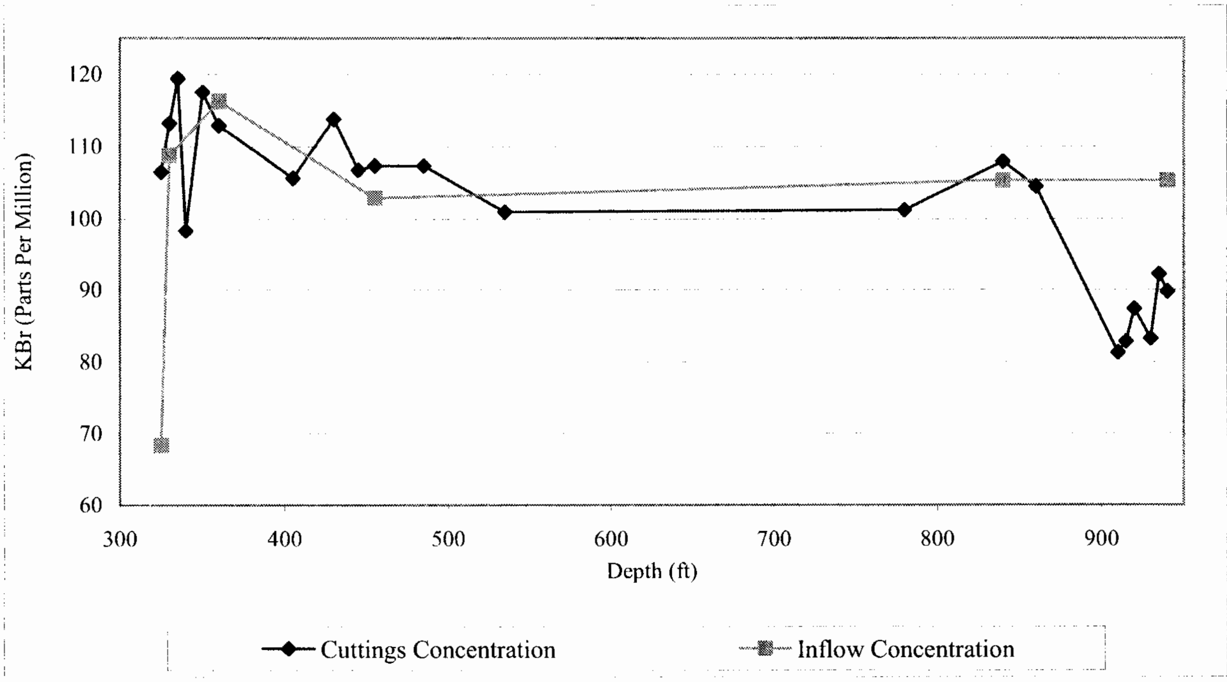


Figure 6.2-1. KBr Concentrations in Borehole at Well R-28

The depth to the regional aquifer in the R-28 well was verified by electric sounder measurement to be at 888.8 ft bgs after the completion of well development on January 8, 2004. A final well sample (sample ID: GW-28-04-52766) was obtained from the screened interval and submitted for lab analysis. The analysis for this sample is included in Appendix A.

The processed geophysical log results indicate that R-28 penetrates a fully water-saturated zone at 890 ft bgs. The estimated pore volume water saturation computed from the ELAN integrated log analysis is over 80% from 890 ft bgs to the bottom of the log interval (1002 ft bgs).

Water-filled and total porosity ranges 25 to 40% across this interpreted saturated interval below 890 ft. The highest total and effective porosity occurs at the bottom of the well in the zone 932 ft to 1000 ft bgs. Detailed results of geophysical surveys and the ELAN analysis relating to water occurrence and logs for the Schlumberger surveys are presented in Appendix C.

7.0 WELL DESIGN AND CONSTRUCTION

R-28 was installed as a hydrogeologic characterization and groundwater monitoring well. Following approval of the well design by DOE, LANL and NMED, Kleinfelder received the final construction specifications for R-28 on December 11, 2003. Well installation activities were performed from December 12 to December 17, 2003.

7.1 Well Design

Data from geophysical logs, borehole cuttings, field water level, and field observations were analyzed to determine the screen placement interval for R-28. Design of Well R-28 was performed in accordance with Section 2.2 of the Contractor's Quality Management Program prepared by Kleinfelder for this project. The well was designed with a single screen interval to monitor potential contaminants and groundwater chemistry in the uppermost productive zone of the regional aquifer in the Puye Formation.

7.2 Well Construction

R-28 was constructed of 4.46-in inner diameter (ID)/5.0-in-OD, type A304 stainless-steel casing fabricated to American Society for Testing and Materials (ASTM) A312 standards. The casing and screens were factory-cleaned before shipment and delivery to the site. Additional decontamination of the stainless-steel components was performed on site prior to well construction using a high-pressure steam cleaner and scrub brushes. Two nominal 12-ft lengths of 5-in OD compatible, 0.020-in continuous slot rod-based well screens were used. The screened interval in R-28 is 934.3 ft to 958.1 ft bgs. Stainless-steel casing was placed below the screen to construct a 22.2 ft sump. Figure 7.2-1 is a schematic as-built diagram of the completed R-28 well.

External couplings, also of type A304 stainless steel fabricated to American Society for Testing and Materials (ASTM) A312 standards, were used to connect individual casing and screen joints. Centralizers were installed above, at and below the well screen. In addition, another centralizer was placed approximately 122.3 ft above the screen interval. Centralizers for R-28 are located at 812 ft, 933 ft, 946 ft, and 959 ft bgs (Figure 7.2-1).

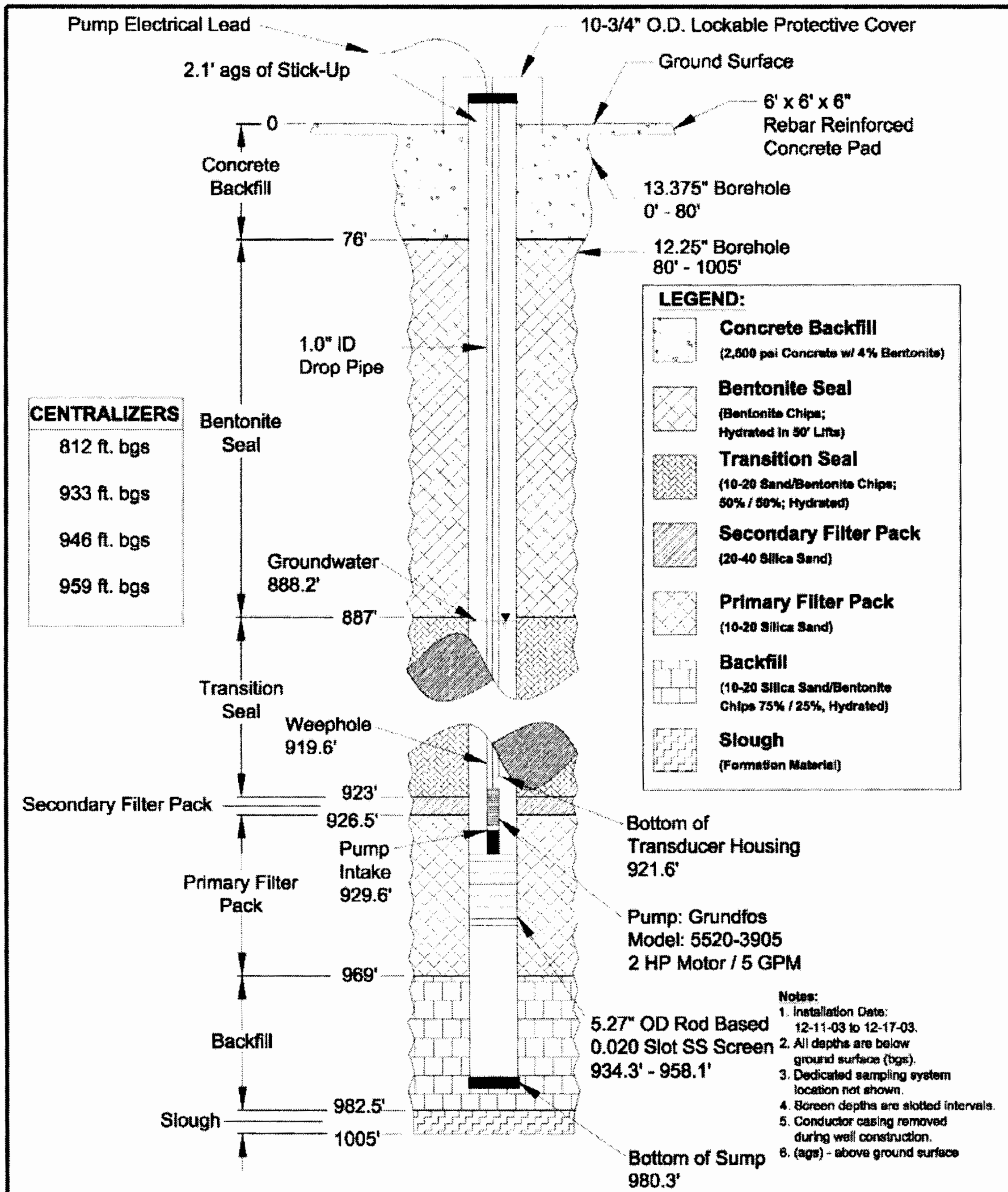
7.2.1 Annular Fill Placement

Well casing and screens were lowered in the hole and the bottom of the sump positioned at 980.3 ft bgs. Approximately 22.5 ft of formation material sloughed into the borehole from 1005 ft to 982.5 ft bgs. Placement of annular fill consisted of using a 2.5-in OD steel tremie pipe to deliver various materials to specified backfill intervals. Backfill consisting of a 75:25 mixture of 10/20 sand and $^3/_8$-in hydrated bentonite chips was placed from 982.5 ft to 969 ft bgs. A primary filter pack consisting of 10/20 silica sand was placed across the screen interval from 969 ft to 926.5 ft bgs. A secondary filter pack of 20/40 silica sand was placed above the primary filter pack from 926.5 ft to 923 ft bgs. Prior to placement, filter pack materials were mixed with municipal water to form a slurry. The filter pack was then swabbed to induce settling prior to bentonite placement. Next, a transition seal consisting of a 50:50 mixture of 10/20 sand and bentonite chips was placed above the secondary filter pack in the annular space between 923 ft and 887 ft bgs. The annulus was then filled from 887 ft to 76 ft with a bentonite seal consisting of $^3/_8$-in bentonite chips. The bentonite chips were hydrated in approximately 50-ft lifts. After removing the $13^3/_8$-in drill casing, concrete backfill, consisting of 2,500 pounds per square inch (psi) concrete with 4 percent bentonite, was placed from 76 ft bgs to the ground surface. The quantities of annular fill materials used in the completion of R-28 are presented in Table 7.2-1.

Table 7.2-1
Annular Fill Materials Used in Well R-28

Material	Amount	Unit[a]	Mix[b]
Backfill: 10/20 sand and bentonite	21 sand/5.5 bentonite	Bag	75:25
Primary Filter Seal: 10/20 sand	118	Bag	-
Secondary Filter Seal: 20/40 sand	8	Bag	-
Transition seal: 10/20 sand and bentonite	47 sand/35 bentonite	Bag	50:50
Bentonite Seal: 3/8-in. Chips	17/137	Supersack/Bag	-
Concrete Backfill (September 10, 2003)	22	Cubic Feet	2,500 psi concrete with 4% bentonite
Potable Water	11,340	Gallons	-

[a] Sand bag = 45 lb each, bentonite bag/bucket = 50 lb ea, bentonite supersack = 3,000 lb ea.
Sand bag = 0.5 ft^3 each, bentonite bag/bucket = 0.67 ft^3 ea. bentonite supersack = 41.4 ft^3 ea.
[b] Mix ratios by volume.



KLEINFELDER

Drawn By: C. London	Date: August 2004	**Schematic Diagram of Well R-28** Los Alamos National Laboratory Los Alamos, New Mexico	FIGURE **7.2-1**
Project No.: 37151	Filename: Figure 7.2-1 Rev1		
Scale: Not-To-Scale	Revision: 1		
Reviewed By: B. Bockisch	Approved By: M. Everett		

8.0 WELL DEVELOPMENT, HYDROLOGIC TESTING AND COMPLETION ACTIVITIES

Well development activities at R-28 were conducted from January 8 to January 13, 2004. Well development procedures included well screen swabbing, bailing, and pumping. Aquifer tests, consisting of a constant rate pumping and recovery test, began on February 5, 2004 and were completed on March 8, 2004. A total of 27,189 gal of water were removed during well development and testing activities.

8.1 Well Development

Well development at R-28 was performed in two stages. The initial stage consisted of bailing and swabbing the screened interval and sump to remove bentonite materials, drilling fluids, and formation sands and fines that had been introduced into the well during drilling and installation activities. Bailing activities were conducted by WDC using a 5-gal capacity, 3-in OD by 10-ft long stainless-steel bailer attached to the backend of a Ford F550, Pulstar 12000 rig. Bailing activities continued until water clarity improved. Water turbidity was not measured during the bailing and swabbing process. Bailing was followed by swabbing across the screened interval to enhance filter-pack development. The swabbing tool consisting of a 4.25-in OD, 1-in thick rubber disc attached to the drill rod that was lowered into the well and drawn repeatedly across the screened interval for approximately one hour.

Following swabbing, pump development procedures were applied to the screened interval (934.3 ft to 958.1 ft bgs) using a 10 horsepower, 4-in Grundfos submersible pump. The pump intake was lowered to the screened interval and cycled on at a nominal rate of approximately 17.0 gal per minute (gpm). The pump intake was then drawn across the length of the screened interval. While pumping at R-28, water samples were collected for water quality parameter measurements.

Criteria for well development were based on field water-quality parameters (pH, temperature, specific conductance, turbidity, and total organic carbon [TOC]). To monitor progress during each development stage, samples of water were periodically collected and parameter measurements were recorded. The primary objective of well development was to remove suspended sediment from the water until turbidity, measured in nephelometric turbidity units (NTU), and was less than 5 NTUs for three consecutive samples. TOC provides a quantitative measurement for evaluating potential residual drilling fluid including EZ-MUD® and QUIK-FOAM®. Similarly, other measured parameters were required to stabilize before terminating development procedures. Table 8.1-1 presents the final water quality parameter data values measured during the well development process.

Table 8.1-1
Water Removed and Final Water Quality Parameters During R-28 Well Development and Aquifer Testing

Method	Water Removed (gal.)	pH	Temperature (°C)	Specific Conductance (mS/cm) [(a)]	Turbidity (NTU)	TOC (ppm)
Bailing/Swabbing Screen	40	NM[(b)]	NM	NM	NM	NM
Pumping Screen	15,210	6.1	20.7	289	1.79	0.44
Aquifer Testing	10,059	NM	NM	NM	NM	NM
Total	**25,309**	–	–	–	–	–

[(a)] Specific conductance is reported in millisiemens per centimeter (mS/cm).
[(b)] NM = Not measured.

Figure 8.1-1 illustrates the effects of well development on measured field parameters.

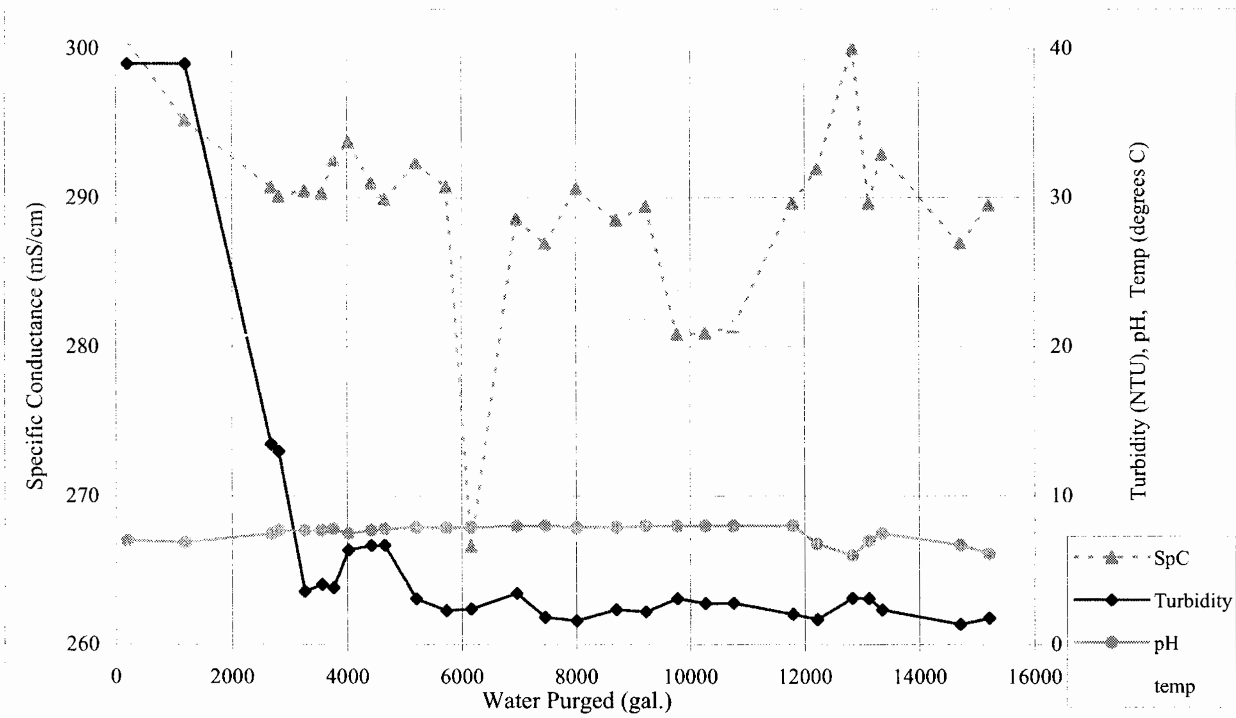


Figure 8.1-1. Effects of Well Development on Water Quality Parameters at Well R-28

8.2 Hydrologic Testing

Two 24-hour constant-rate pumping tests were performed on R-28 in February and March, 2004. R-28 pumping tests were performed using an inflatable packer. The inflatable packer was used to eliminate the effects of casing storage. Packer implementation also largely eliminated water level fluctuation response to barometric pressure changes. The complete report is included in Appendix E.

R-28 was first test pumped in early February 2004. Results of that test were not entirely satisfactory because of leaks in the pumping string installed in the well. The result was a changing (decreasing) discharge rate during the test. Also, the check valve on the pump leaked following both the constant-rate pumping test and the step-drawdown test (prior to the constant-rate test), allowing water in the lower portion of the drop pipe to drain back into the well. This affected both the time-drawdown and recovery data sets.

Because of these occurrences, the test was rerun in early March to obtain additional hydraulic data, particularly early recovery data. During the second test, despite installing two additional check valves immediately above the pump, a very slow check valve leak occurred, affecting the time-drawdown data slightly, but having no effect on the recovery data.

Test 1 was started on February 5, 2004 at 9.8 gpm and continued for 24 hours until February 6. Following pump shutoff, recovery data were measured for an additional 24 hours. After collecting the recovery data set, water level monitoring continued until February 9. The late data served as a background data set. Test 2 was started on March 7 at 12.9 gpm and continued to March 8.

The following information was determined from the pumping and recovery tests on R-28:

1. Test 1 produced a screen-interval hydraulic conductivity of 158 feet per day using very early recovery data.
2. Test 2 produced screen-interval hydraulic conductivities of 144 and 149 feet per day using very early recovery data.
3. Test 2 produced a hydraulic conductivity of greater than 120 feet per day and a vertical anisotropy of approximately 10^{-3} using the entire recovery data set and partial penetration analysis.
4. The specific capacity of R-28 implied a lower-bound conductivity of 73 feet per day, fully consistent with the above calculations.
5. Late data suggested a transmissivity possibly well in excess of 100,000 gpd/ft at the location of R-28. The effective thickness of the corresponding permeable sediments is not known.

8.3 Dedicated Sampling System Installation

In the Spring of 2004, Spectrum, Inc. installed a permanent submersible pump and a transducer tube in R-4. The Grundfos Model 5S20-39DS, two-horsepower pump was placed at an intake depth of 929.6 ft bgs. The transducer tube with a bottom end cap is at 921.6 ft bgs, and its slotted interval is 20 ft, from 901.6 to 921.6 ft bgs.

8.4 Wellhead Completion

The surface completion for R-28 was completed on December 17, 2003 and involved placing a reinforced (2,500 psi) concrete pad, 4.92-ft wide by 4.92-ft long by 6-in. thick, around the well casing for long-term structural integrity of the well. A brass survey pin was installed in the northwest corner of the pad. A 10.75-in. steel casing with locking lid protects the well riser. The pad was designed to be slightly elevated, with base course graded up around the pad to allow for drainage.

8.5 Geodetic Survey

The location of Well R-28 was determined by geodetic survey on March 8, 2004, using a Leica TCR303 electronic total station. Lynn Engineering and Surveying, Inc. conducted the survey. Coordinates and elevations were obtained from LANL Monument MCOBT-4.4 using a Static Global Positioning System (GPS).

This survey located the brass cap monument at Well R-28 in the concrete pad, the top of the stainless-steel well casing and the corehole. Table 8.5-1 summarizes the results of readings conducted for various components of the completed wellhead. The coordinates shown are in New Mexico State Plane Grid Coordinates, Central Zone (North American Datum, 1983 [NAD 83]), expressed in feet. Elevation is expressed in ft amsl relative to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Table 8.5-1
Geodetic Data for Well R-28

Description	Northing	Easting	Elevation [a]
Brass cap in R-28 pad	1768358.57	1638988.73	6728.61
Top of stainless-steel casing	1768356.78	1638989.89	6730.70
Corehole	1768445.29	1638996.98	6728.22

[a] Measured in ft amsl relative to the National Geodetic Vertical Datum of 1929.

8.6 Site Restoration

Fluids and cuttings produced during drilling and development were sampled in accordance with the Notice of Intent (NOI) to Discharge, Hydrogeologic Workplan Wells and filed with the NMED. Approval to discharge drilling and development water is pending. A copy of the NMED discharge approval will be included in Appendix F of the final R-28 report. The sample analysis is included in Appendix F.

Silt fencing and straw bales have been left in place to minimize possible sediment impacts from future precipitation.

Site restoration activities included (1) removing and applying water from the borehole cuttings containment area, (2) removing the polyethylene liner and borehole cuttings from the borehole cuttings containment area, (3) removing the containment area berms, (4) backfilling and grading the containment area, (5) thin-spreading the cuttings on-site after NMED approval was obtained, and (6) reseeding the site.

9.0 DEVIATIONS FROM THE R-28 SAP

Appendix G compares the actual characterization activities performed at R-28 with the planned activities described in the "Hydrogeologic Workplan" (LANL 1998, 59599) and the R-28 SAP

(LANL 2003, 03-8324). For the most part, drilling, sampling, and well construction at R-28 was performed as specified in the SAP. The main deviations from planned activities are summarized as follows:

- Planned corehole depth – the SAP stated that continuous coring would extend from ground surface to a depth of 335 ft bgs and water samples for contaminant analysis would be collected at each of the two anticipated perched groundwater zones. The Phase I corehole was completed at 325 ft bgs TD, 10 feet above the planned depth. The top of the Cerros del Rio basalt was reached at 318 ft bgs; therefore, drilling stopped after penetrating 7 ft into the lavas. Both continuous and spot core sampling methods were used. No zones of perched moisture were identified and no water samples were collected in the vadose zone during Phase I.

- Planned borehole depth – the SAP anticipated that the deep borehole would be drilled to a TD of 967 ft bgs, or approximately 100 ft below the regional water table that was projected to occur at 867 ft bgs. The completed R-28 borehole was drilled to 1005 ft bgs TD, 116 ft below the measured depth to the regional aquifer that was determined to be at 888.8 ft bgs on January 8, 2003.

- Number of core and cuttings samples collected for contaminant and moisture analysis – up to 15 samples from specified intervals between 10 and 336 ft bgs in the unsaturated zone, were planned in the R-28 SAP. A total of 16 were actually collected over the interval ranging from 10 to 325 ft bgs.

10.0 ACKNOWLEDGEMENTS

D. Schafer of Schafer and Associates contributed the hydrologic testing section of this report.

E. Tow, P. Schuh, and R. Lawrence of Tetra Tech EM, Inc., Albuquerque, NM, contributed to the preparation of this report.

EnviroWorks, Inc provided site preparation and restoration activities.

Lynn Engineering & Surveying, Inc. provided the final geodetic survey of finished well components.

N. Clayton of Schlumberger provided processing and interpretation of borehole geophysical data.

P. Longmire of LANL contributed the geochemistry section of this report.

Tetra Tech EM, Inc. provided support for well site geology, sample collection, and hydrologic testing.

WDC Exploration & Wells provided rotary drilling services.

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