FINAL
COMPLETION REPORT
INTERMEDIATE WELL R-3i
LOS ALAMOS NATIONAL LABORATORY
LOS ALAMOS, NEW MEXICO
PROJECT NO. 49436

Prepared for:

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

Prepared by:

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February 2007

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LIST OF ACRONYMS AND ABBREVIATIONS

amsl	above mean sea level
bgs	below ground surface
°C	degrees Celcius
DOE	US Department of Energy
DTW	depth to water
EES-6	Earth and Environmental Sciences Division, Group 6
ft	foot/feet
ft^3	cubic feet
gal.	gallon/gallons
hr/hrs	hour/hours
ID	inner diameter
in.	inch/inches
Kleinfelder	Kleinfelder, Inc.
LANL	Los Alamos National Laboratory
NM	not measured
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
OD	outer diameter
ppm	parts per million
Qal	Quaternary alluvium
RCT	radiation control technician
Spectrum	Spectrum Exploration, Inc.
SC	Specific Conductance
TA	Technical Area
TD	total depth
TOC	total organic carbon
Tb4	Cerros del Rio basalt/Cerros del Rio maar
Tpf	Puye Formation
µS/cm	microSiemens per centimeter

ABSTRACT

Intermediate Well R-3i was installed during implementation of the "Drilling Work Plan for Characterization Well R-3, Final" (Kleinfelder 2005a). Drilling activities were funded and directed by the US Department of Energy. Los Alamos National Laboratory personnel provided technical assistance. Kleinfelder, Inc, under contract to the US Army Corps of Engineers, conducted the drilling, installation and sampling at R-3i.

R-3i is located in Technical Area 74 in Pueblo Canyon. The corehole was drilled to collect core samples for nitrate, perchlorate, and tritium analysis. Due to perched groundwater being encountered, the corehole was completed as a 2-inch well.

R-3i was drilled to 268.3 feet below ground surface using a track-mounted coring rig and air drilling methods. The stratigraphy encountered during borehole drilling included, in descending order, Quaternary Alluvium, Pliocene Puye Formation, Cerros del Rio basalt, and the Puye Formation. The well was installed within the Cerros del Rio basalt with a screened interval from 215.2 to 220.0 feet below ground surface. The depth to water after well installation was 191.50 feet below ground surface.

Four screening groundwater samples were collected during drilling, from perched water zones in the Cerros del Rio basalt and the Puye Formation. A final groundwater sample was collected after the well was installed and developed. Boron was detected at concentrations ranging from 0.078 to 0.21 ppm in the perched intermediate zone screening samples during drilling and at 0.096 ppm in a groundwater sample collected at the end of well development at R-3i. Mercury was detected at concentrations ranging from 0.0064 to 0.026 ppm in the perched intermediate zone screening samples during drilling and at 0.00008 ppm in a groundwater sample collected at the end of well development at R-3i. Nitrate (as N) was detected at concentrations ranging from 3.0 to 4.07 ppm in the perched intermediate zone screening samples during drilling and at 3.87 ppm in a groundwater sample collected at the end of well development at R-3i. Perchlorate was not detected in the perched intermediate zone screening samples from borehole R-3i, but was tentatively detected at a concentration of 0.0013 ppm in a sample collected after well development. Uranium was detected at concentrations ranging from 0.0032 to 0.0052 ppm in the perched intermediate zone screening samples during drilling and at 0.0057 ppm in a groundwater sample collected at the end of well development at R-3i.

1.0 INTRODUCTION

This completion report summarizes the site preparation, drilling, well construction, well development and related activities for Intermediate Well R-3i, drilled in August 2005 at Los Alamos National Laboratory (LANL). The well was drilled and installed in accordance with the Compliance Order on Consent (New Mexico Environmental Department [NMED] 2005).

Drilling activities were funded and directed by the US Department of Energy (DOE). Kleinfelder, Inc. (Kleinfelder), under contract to the US Army Corps of Engineers, was responsible for executing the drilling, installation and sampling activities with technical assistance from LANL. Activities were conducted according to the "Drilling Work Plan for Characterization Well R-3, Final" (Kleinfelder 2005a).

R-3i is located in Pueblo Canyon within Technical Area 74, as shown in Figure 1.0-1. The corehole was drilled to collect core samples for nitrate, perchlorate, and tritium analysis. Due to perched groundwater being encountered the corehole was completed as a 2-inch (in.) well.

The planning document specified that the R-3 corehole would be drilled to 300 feet (ft) below ground surface (bgs). The well was cored to a total depth (TD) of 268.3 ft bgs. Perched intermediate groundwater was encountered within the Cerros del Rio basalt and a well was installed with a single screened interval between 215.2 and 220.0 ft bgs. Post-installation activities included well development, groundwater sampling, and wellhead surveying. As of February 2007, the site has not yet been restored.

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. Copies have been provided to the LANL Records Processing Facility. This report contains brief descriptions of all activities associated with R-3i as well as supporting figures, tables and appendices. Detailed analysis and interpretation of geologic, geochemical and aquifer data will be included in separate technical documents to be prepared by LANL.

2.0 PRELIMINARY ACTIVITIES

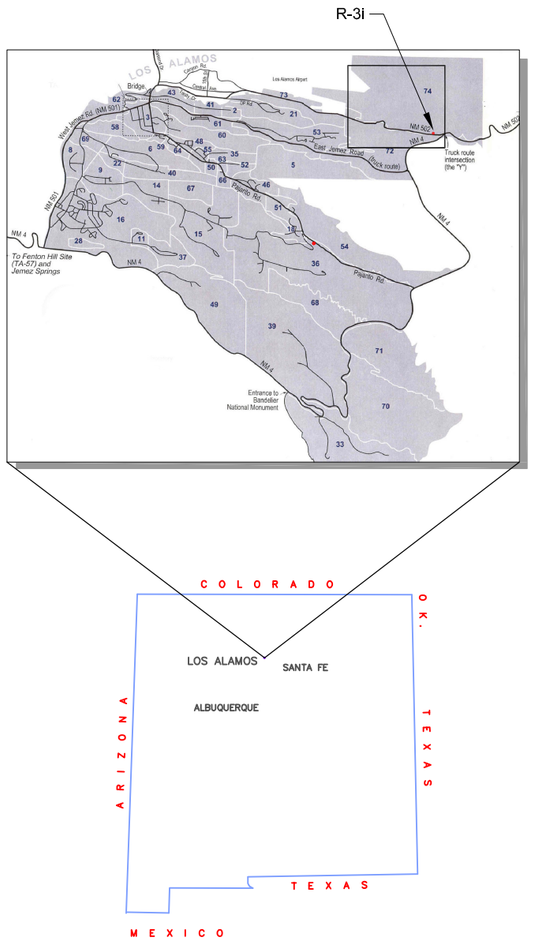
Preliminary activities included preparing administrative planning documents and constructing the drill site.

2.1 Administrative Preparation

Kleinfelder received contractual authorization as a notice to proceed on May 27, 2005. The following documents were prepared to guide the implementation of the scope of work for this well: Drilling Work Plan (Kleinfelder 2005a), Contractor's Quality Management Plan (Kleinfelder 2005b), Site-Specific Health and Safety Plan (Kleinfelder 2005c), and Storm Water Pollution Prevention Plan (Kleinfelder 2005d).

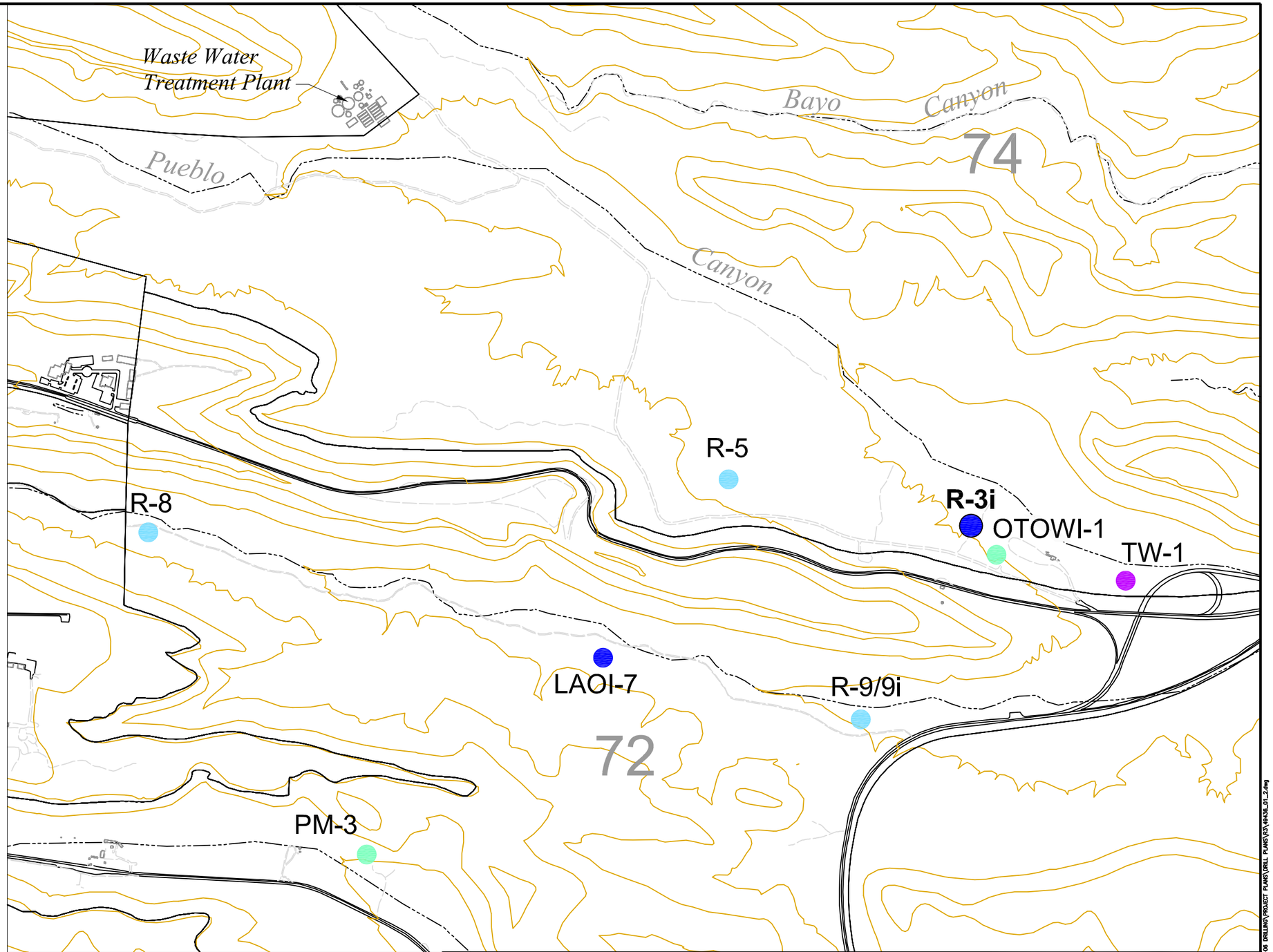
Legend

- = Intermediate perched zone well R-3i
- = Intermediate perched zone well
- = Regional aquifer wells installed since 1998
- = Older test well
- = Water supply wells
- 72 = Technical area identification
- = 100-ft contours



VICINITY MAP

NOT TO SCALE



1000 0 500 1000

SCALE: 1 inch = 1000 ft

KLEINFELDER	
Drawn By: D. Tideman	Date: February 2007
Project No.: 49436	Filename: 49436_01_2.dwg
Scale: 1 inch = 2000 ft	Revision: –

SITE LOCATION MAP
Characterization Well R-3i
Pueblo Canyon
Los Alamos National Laboratory
Los Alamos, New Mexico

FIGURE
1.0-1

G:\ENVIRON\49436\DOC-LAN-2005-06 DRILLING\PROJECT PLANS\DRILL PLANS\R3\49436_01_2.dwg

2.2 Site Preparation

Site preparation consisted of clearing the site of vegetation and placement of gravel, excavating and lining a pit for cuttings collection, installing silt fencing to prevent erosion and runoff from the drill site, and setting up the exclusion zone. Best management practices, also known as BMPs, were installed as specified in the Storm Water Pollution Prevention Plan (Kleinfelder 2005d). EnviroWorks, Inc. completed these tasks on July 25, 2005. A radiation control technician (RCT) from LANL's Health, Safety, and Radiation Protection Group-1 screened the site before site preparation activities. A geology trailer, generator, air compressor, and safety lighting equipment were moved to the site during the subsequent mobilization of drilling equipment.

3.0 DRILLING ACTIVITIES

R-3i was drilled to a TD of 268.3 ft bgs between August 02 and August 14, 2005. A well was completed with one 5-ft screened interval in the perched intermediate zone from 215.2 to 220.0 ft bgs. Drilling activities were performed generally in one 12-hour (hr) shift per day, 7 days per week, by the drill crew and two site geologists. Depth-to-water (DTW) measurements were taken at the beginning and end of most shifts to check for the presence of groundwater. Recovered core was also inspected for relative moisture content. A chronology of drilling and associated activities for R-3i is presented in Table 3.0-1.

Spectrum Exploration, Inc. (Spectrum) drilled R-3i with a Delta Base 540 track-mounted HQ coring rig. R-3i was cored using air; no other fluids were used during coring.

On August 01, 2005, Spectrum mobilized drilling equipment and supplies to the site. On August 02, Spectrum began collecting core with a 2.0-in. outer diameter (OD) split-spoon sampler to 6 ft bgs, then set 5 ft of 6⅝-in. casing. Spectrum then switched to a 3.9-in. bit and continued coring to 52.8 ft bgs.

On August 03, due to lost circulation the previous day, Spectrum switched to a 7 3/8-in. eccentric hammer bit and began driving 6⅝-in. casing to 55 ft bgs. The hammer bit was replaced with the 3.9-in. bit and coring continued to 88.3 ft bgs. The drill crew then went on days off.

On August 08, the corehole was advanced to 157.8 ft bgs.

On August 09, Spectrum resumed coring past 157.8 ft bgs. Due to lost circulation at 162.1 ft bgs, the drill string became stuck in the corehole. The drill string was freed and circulation was regained. The corehole was advanced to 193.3 ft bgs.

On August 10, DTW in the corehole was 184.3 ft bgs with a corehole depth of 193.3 ft bgs. Water sample EU05070GR3101 was collected and coring resumed. The corehole was advanced to 197.3 ft bgs at which time the drill string was tripped out and the drill crew put on standby in order to perform video and geophysical logging of the corehole. During the video logging, water was noted trickling down the corehole walls beginning at 192.5 ft bgs, and DTW was noted at 194 ft bgs. Upon completion of corehole logging, the 6⅝-in. casing was advanced to 80 ft bgs.

Table 3.0-1
Chronology of Activities

TASK	DATES																					
	Jul-05	Aug-05					Sep-05				Oct-05		Nov-05		Dec-05				Jan-06	
SITE PREPARATION ACTIVITIES	7/25																			
BOREHOLE DRILLING/SAMPLING																				
Mobilization		8/1																		
Coring		8/02-8/14																		
Groundwater Screening Sampling			8/10,12,13,14																	
BOREHOLE LOGGING																				
Geophysical Logging			8/10, 14																	
Video Logging			8/10, 14																	
WELL CONSTRUCTION				8/15, 16																
WELL DEVELOPMENT					8/29 - 9/12															
GROUNDWATER WELL SAMPLING							9/12													
PUMP INSTALLATION [a]																				
SITE RESTORATION [b]																				

[a] Pump and transducer will be installed in 2007.

[b] Cuttings pit was dewatered in November 2006 based upon permission by LANL. Remaining site restoration will occurr in 2007.

On August 11, the 6⅝-in. casing was advanced to 195 ft bgs. Upon tripping-out the drill string, the hammer became stuck inside the casing at 40 ft bgs. Work was stopped for the shift due to lightning.

On the morning of August 12, the drill string was freed from the casing and DTW was measured at 194.43 ft bgs. Spectrum advanced the corehole to 218.3 ft bgs and DTW was measured at 217.38 ft bgs. The corehole was then advanced to 223.3 ft bgs and DTW was measured at 188.50 ft bgs. DTW was monitored for one hour at which time it was measured at 177.22 ft bgs. Water sample EU05070GR3102 was collected and the corehole was advanced to 240 ft bgs. DTW was measured at 216.41 ft bgs.

On the morning of August 13, the DTW was measured at 213.94 ft bgs prior to any activity. Water sample EU05070GR3103 was collected and the drill crew advanced the 6⅝-in. casing to 239 ft bgs. Coated bentonite pellets were poured down hole to seal the casing and allowed to hydrate for one hour. DTW was measured at 223.37 ft bgs and coring resumed to 260.3 ft bgs. DTW was measured at 238.9 ft bgs.

On the morning of August 14, the corehole was advanced to the TD of 268.3 ft bgs. DTW was measured and the corehole was dry. The drill string was tripped out and the 6⅝-in. casing was retracted to 150 ft bgs. LANL personnel again performed video and geophysical logging of the corehole. Upon completion of logging activities, the DTW was measured at 192.5 ft bgs. Water sample EU05070GR3104 was collected.

4.0 SAMPLING ACTIVITIES

This section describes the core and groundwater sampling at R-3i. Sampling activities were generally conducted in accordance with the Drilling Plan (Kleinfelder 2005a).

4.1 Core Sampling

Lithologic core was continuously collected at R-3i using an HQ wireline coring system. The Drilling Plan specified that core samples were to be collected for laboratory analysis every 10 ft to a depth of 100 ft bgs and at 50-ft intervals thereafter. Radiological screening samples were to be collected every 50 ft.

Table 4.1-1 shows the core samples collected and submitted for laboratory analysis. Core recovery was intermittent at R-3i; when core recovery was incomplete, samples were collected from core nearest to the specified sampling depth. The core from R-3i was labeled, placed in core boxes and submitted to the Field Sampling Facility for archiving. LANL RCTs screened all cuttings and core before they were removed from the site.

4.2 Water Sampling

Four screening groundwater samples were collected from the open corehole with disposable bailers during drilling at R-3i. Screening samples were collected from several feet below the DTW measured at the time of collection. A final groundwater sample was collected from 218 ft bgs in the well after development was complete. Table 4.2-1 summarizes dates and collection depths for the water samples. The groundwater samples were submitted to the LANL Earth and Environmental Sciences Division, Group 6 (EES-6) for anions, cations and metals analyses.

Table 4.1-1
Core Samples

Sample ID	Date	Time	Interval (ft bgs)	Radio-logical Screening	Anions, Moisture, $N^{14}N^{15a}$	H^{3b}	$D^2H + O^{18}O^{16c}$	$Am^{241} + GS + ISO\ Pu + Sr^{90d}$
GW03-05-63014	8/03/05	16:00	9.0-10.4	X	X		X	
GW03-05-63015	8/03/05	16:45	18.8-20.0	X	X		X	
GW03-05-63016	8/03/05	17:15	29.8-32.0	X	X	X	X	X
GW03-05-63017	8/03/05	17:30	38.9-41.2	X	X	X	X	X
GW03-05-63018	8/04/05	08:00	47.2-49.8	X	X	X	X	X
GW03-05-63019	8/04/05	08:30	59.6-61.3	X	X	X	X	X
GW03-05-63020	8/04/05	10:30	65.2-69.3	X	X	X	X	X
GW03-05-63021	8/04/05	11:30	82.5-84.2	X	X			
GW03-05-63022	8/08/05	12:33	98.3-100.6	X	X			
GW03-05-63023	8/08/05	16:36	145.2-147.8	X	X			
GW03-05-63056	8/12/05	13:33	213.3-218.3	X	X		X	X
GW03-05-63057	8/13/05	16:45	243.3-244.8	X	X			

[a] nitrogen 14 and 15 isotopes
[b] tritium
[c] deuterium and oxygen isotopes
[d] americium-241, gamma spectroscopy, plutonium isotopes and strontium-90

Table 4.2-1
Groundwater Samples

Sample Number	Date	DTW (ft bgs)	Corehole Depth (ft bgs)	Water-bearing Unit
EU05070GR3101	8/10/05	184.3[a]	193.3	Cerros del Rio basalt
EU05070GR3102	8/12/05	177.22[a]	223.3	Cerros del Rio basalt
EU05070GR3103	8/13/05	213.94[a]	240.0	Cerros del Rio basalt
EU05070GR3104	8/14/05	192.5[a]	237.0	Cerros del Rio basalt
EU05090G3iR01	9/12/05	218[b]	220.3 (well casing depth)	Cerros del Rio basalt

[a] Sample collected with disposable plastic bailer just below water level in open corehole
[b] Sample collected from completed well after well development

5.0 COREHOLE LOGGING

Video and geophysical logs were run at R-3i. Table 5.0-1 summarizes the dates and types of logging. A DVD of the August 10 and August 14, 2005 video logs is presented in Appendix C, and Appendix D contains the geophysical logging spreadsheets and charts.

Table 5.0-1
Corehole Logging

Operator	Date	Tools	Cased Footage (ft bgs)	Open hole Interval (ft bgs)	Logged Interval (ft bgs)	Remarks
LANL	8/10/05	Video, Natural Gamma, Induction	1 ft ags – 54 ft bgs	54 – 197.3	0 – 194	Depth to water 194 ft
LANL	8/14/05	Video, Natural Gamma, Induction	0 – 150[a]	150 – 268.3	0 – 193 (video) 150 – 243 (gamma/induction)	

[a] Drill casing was in the corehole to 230 ft bgs.
ags – above ground surface

6.0 HYDROGEOLOGY

This section contains a brief description of the hydrogeologic features encountered at R-3i. The stratigraphy section discusses geologic units at R-3i as identified by the site geologists and LANL's EES-6 staff. The groundwater section describes groundwater encountered at R-3i and is based on drilling observations, open-hole video logging and water level measurements.

6.1 Stratigraphy

This section presents a brief summary of the lithology encountered at R-3i. The following formations were present in order of youngest to oldest: Quaternary Alluvium, Pliocene Puye Formation, Cerros del Rio basalt, and the Puye Formation. Figure 6.1-1 summarizes the stratigraphy at R-3i and Figure 6.1-2 shows the plotted gamma and induction geophysical logs. A detailed lithologic log for R-3i is presented in Appendix A.

Quaternary Alluvium, Qal (0 to 27.3 ft bgs)

The surficial alluvial deposits are primarily unconsolidated silty sand and gravel, ranging in color from grayish orange to yellowish brown. They are generally poorly sorted, subangular to subrounded, felsic to intermediate composition volcanic silt, sand and gravel. Clasts of Bandelier Tuff are also present.

Puye Formation, Tpf (27.3 to 53 ft bgs)

The sedimentary Puye Formation, from 27.3 to 53 ft bgs, consists of yellowish brown to light brown sandy silt and silty sand that is angular to subrounded, poorly to well sorted and poorly consolidated. It contains minor amounts of vitric pumice and lithic gravel.

Cerros del Rio basalt, Tb4 (53 to 240 ft bgs)

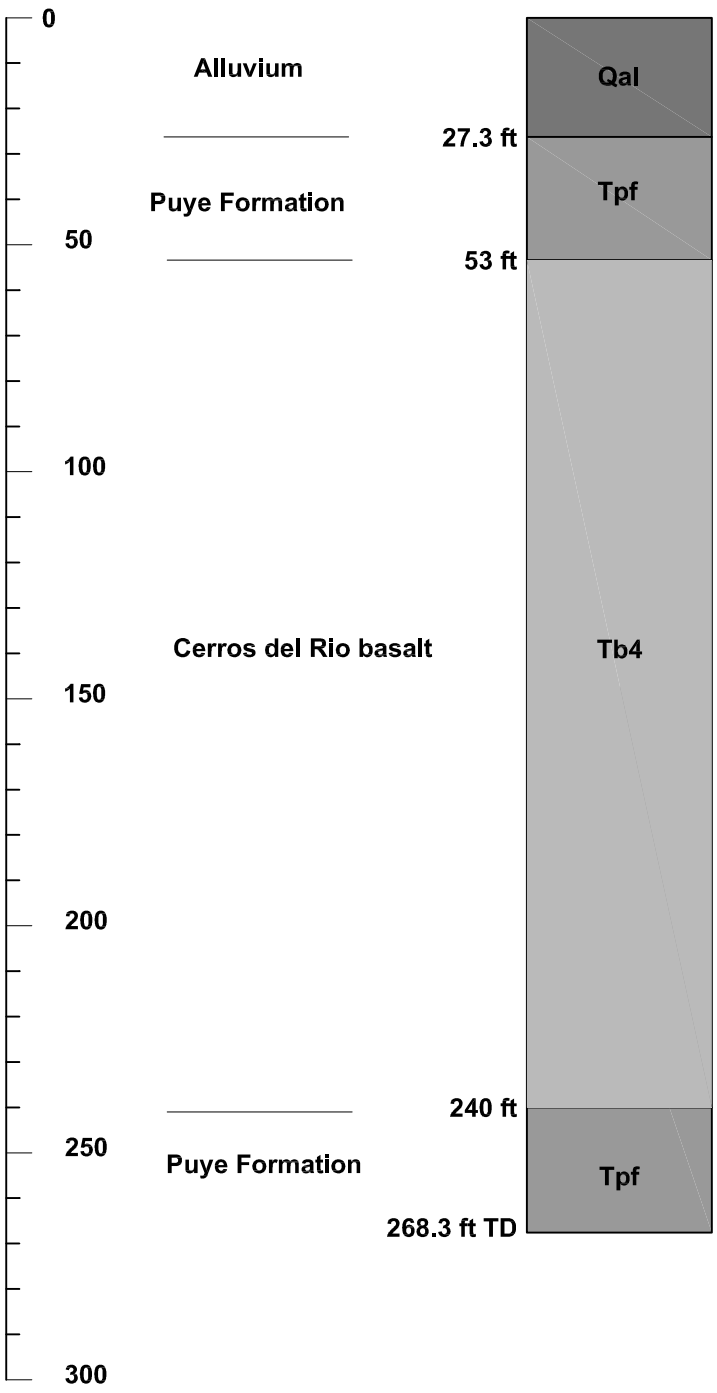
Lavas of the Cerros del Rio basalt comprise the majority of the corehole at R-3i, extending from 53 to 240 ft bgs. The basalt lavas consist of medium dark gray to grayish black, highly fractured, vesicular zones alternating with medium dark gray, massive basalt containing few vesicles. Both vesicular and massive basalts contained 1 to 5% olivine phenocrysts. Thin interflow breccia zones were noted from 61.3 to 68.3 ft bgs, 82.5 to 86.3 ft bgs, 159.2 to 162.3 ft bgs, 169.0 to 170.0 ft bgs, and from 231.2 to 234.2 ft bgs. Secondary clay commonly filled vesicles and fractures throughout the formation.

Puye Formation, Tpf (240 to 268.3 ft bgs)

The Puye Fanglomerate was present from 240.0 ft bgs to the TD of 268.3 ft bgs and consisted of silty sandstone to gravelly silty sandstone. The sandstone deposits were moderate to dark yellowish brown and poorly to moderately sorted. The sand grains were primarily subangular to subrounded intermediate composition volcanics. Gravels consisted of lithic fragments, as well as vitric and altered pumice.

6.2 Groundwater

Intermediate perched groundwater zones were encountered at R-3i. Perched intermediate groundwater was observed in the Cerros del Rio basalt from approximately 184.3 to 193.3 ft bgs in a highly fractured interval underlain by massive basalt with minor vesicles. Another zone of



DRILLING INFORMATION

DRILLING COMPANY/PERSONNEL

Spectrum Exploration
S. Jager, B. Husted, R. Padilla

DRILL RIG
DeltaBase 540

DRILLING METHOD

☒ HQ Coring

DRILLING FLUID TYPE

☒ AIR

DRILLING START / FINISH

DATE 08/02/05 TIME 09:00
DATE 08/14/05 TIME 09:30

Note:
Geologic contacts are preliminary and subject to change.

KLEINFELDER		COREHOLE SUMMARY DATA SHEET R-3i **Pueblo Canyon** Los Alamos, New Mexico	FIGURE **6.1-1**
Drawn By: D. Tideman	Date: February 2007		
Project No.: 49436	Filename: 49436_01_1.dwg		
Scale: not-to-scale	Revision: 1		

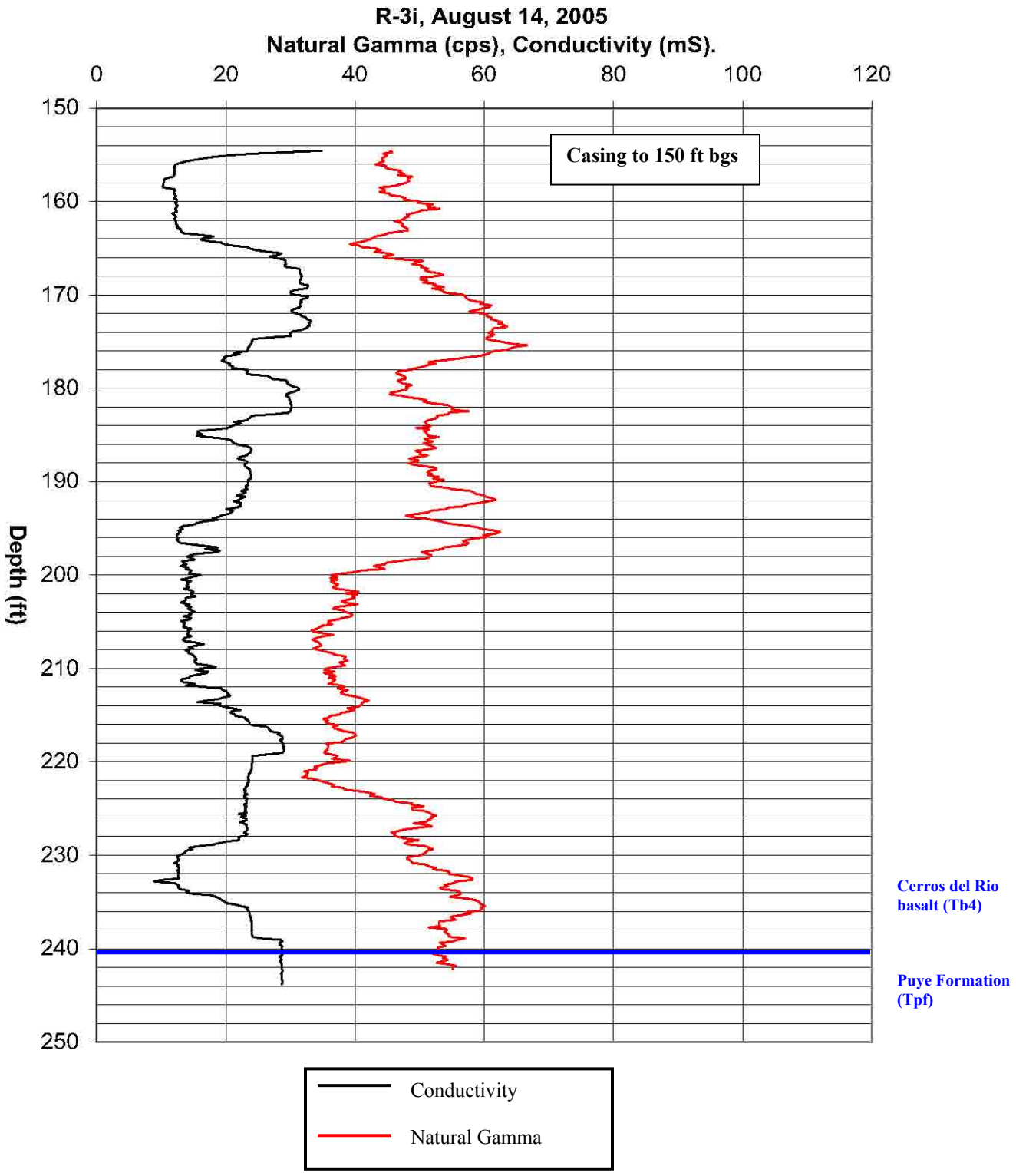


Figure 6.1-2
Gamma and Induction Logs

perched groundwater occurred from 218.3 to 223.3 ft bgs in massive basalt. A third zone of perched groundwater was noted at the contact between the Cerros del Rio basalt and the Puye Formation from 239.3 to 240.0 ft bgs. The basalt at this depth is a grainy, laminated maar deposit. The interior of core samples from the Puye Formation were dry.

At the borehole TD of 268.3 ft bgs on August 14, 2005, standing water was measured in the open borehole at 193.1 ft bgs. After the well was installed, the DTW was 191.50 ft bgs on August 16, 2005.

6.3 Preliminary Groundwater Analytical Results

Analytical data for the five groundwater samples collected from R-3i are presented and briefly summarized in Appendix B. Boron was detected at concentrations ranging from 0.078 to 0.21 parts per million (ppm) in the perched intermediate zone screening samples during drilling and at 0.096 ppm in a groundwater sample collected at the end of well development at R-3i. Chromium was not detected (<0.001 ppm) in the perched intermediate zone screening samples collected during drilling and at the end of well development at R-3i. Mercury was detected at concentrations ranging from 0.0064 to 0.026 ppm in the perched intermediate zone screening samples during drilling and at 0.00008 ppm in a groundwater sample collected at the end of well development at R-3i. Nitrate (as N) was detected at concentrations ranging from 3.0 to 4.07 ppm in the perched intermediate zone screening samples during drilling and at 3.87 ppm in a groundwater sample collected at the end of well development at R-3i. Perchlorate was not detected in the perched intermediate zone screening samples from borehole R-3i, but was tentatively detected at a concentration of 0.0013 ppm in a sample collected after well development. Uranium was detected at concentrations ranging from 0.0032 to 0.0052 ppm in the perched intermediate zone screening samples during drilling and at 0.0057 ppm in a groundwater sample collected at the end of well development at R-3i.

7.0 WELL INSTALLATION

Data from geophysical logs, core, and water level measurements were evaluated to determine the placement of the screened interval for the well. The well was installed between August 15 and 16, 2005.

7.1 Well Design

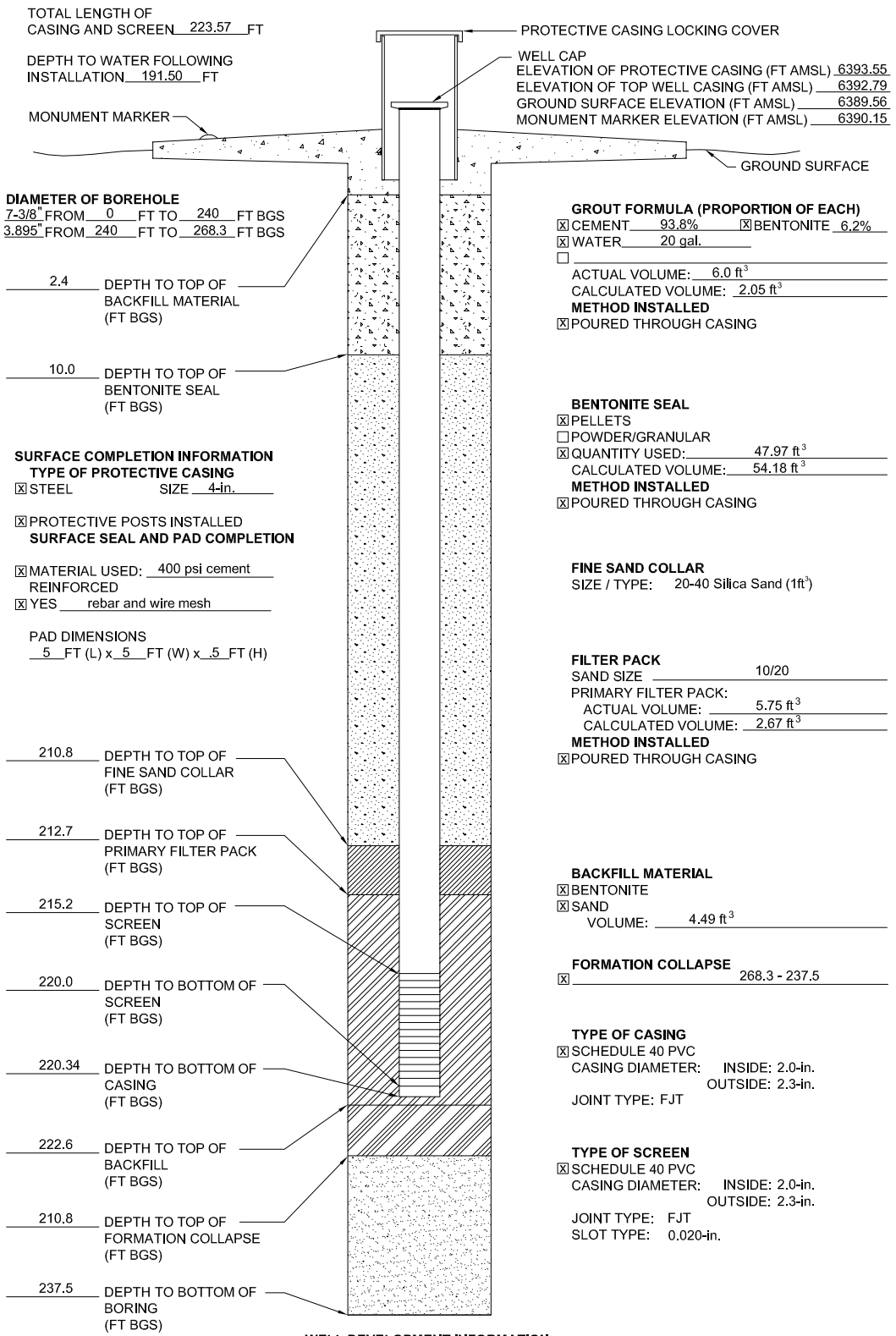
The well was designed in accordance with LANL Standard Operating Procedure for Well Construction, Revision 3 (LANL 2001); DOE and LANL provided an approved well design to Kleinfelder. The selected design called for a single screened interval from 215 to 220 ft bgs to monitor groundwater quality in the intermediate perched zone within the Cerros del Rio basalt. NMED reviewed and approved the well design prior to well installation.

7.2 Well Construction

R-3i was constructed of 2.0-in. inner diameter (ID)/2.3-in. OD, schedule 40 PVC fabricated to American Society for Testing and Materials A312 standards. A nominal 5-ft length of 2.3-in. OD, 0.020-in. slotted well screen was used. The casing and screen were factory-cleaned and wrapped in plastic before shipment and delivery to the site.

The corehole collapsed to 237.5 ft bgs and was backfilled with bentonite and 10/20 sand from 237.5 to 222.6 ft bgs prior to well construction. The screened interval chosen for the well was 215 to 220 ft bgs with a 0.3-ft-long PVC end cap below the well screen. Figure 7.2-1 is an as-built schematic showing construction details for R-3i.

The drill casing was set at 150 ft bgs in order to place the coated bentonite pellets and 10/20 sand. The well casing, screen and sump were then lowered into the corehole, placing the screen from 215.2 to 220 ft bgs, and the annular materials were added between the drill casing and the PVC well casing. The primary filter pack of 10/20 silica sand was placed between 222.6 and 212.7 ft bgs. A transition filter pack of 20/40 silica sand was then placed from 212.7 to 210.8 ft bgs. A bentonite seal was placed above the fine sand collar to a depth of 10 ft bgs. The cement grout surface seal was emplaced from 10 to 2.4 ft bgs; it consisted of 93.8% cement and 6.2% bentonite (by dry weight). Table 7.2-1 summarizes the volumes of annular fill materials used to complete R-3i.



WELL DEVELOPMENT INFORMATION

WELL DEVELOPMENT BEGAN
DATE 08/29/05 TIME 1515
WELL DEVELOPMENT FINISHED
DATE 09/12/05 TIME 1540
WELL COMPLETION BEGAN
DATE 08/15/05 TIME 1115
WELL COMPLETION FINISHED
DATE 08/16/05 TIME 1800

DEVELOPMENT METHOD
☒ SWABBING ☒ BAILING
☒ PUMPING
TOTAL PURGE VOLUME 1015 GALLONS

PARAMETER MEASUREMENTS (ONGOING)
pH 7.87
TEMPERATURE 16.5 °C
SPECIFIC CONDUCTANCE 473 µS
TURBIDITY 0.92 NTU

KLEINFELDER

Drawn By: D. Tideman	Date: February 2007
Project No.: 49436	Filename: 49436_02_1.dwg
Scale: not-to-scale	Revision: 1

WELL SUMMARY DATA SHEET R-3i
Pueblo Canyon
Los Alamos, New Mexico

FIGURE
7.2-1

G:\ENVIRON\49436\2005-06 INTERMEDIATE WELLS\R-3\FIGURES\49436_02_1.dwg

Table 7.2-1 Annular Fill Materials

Material	Volume
Surface seal: cement grout seal	6.0 ft^3
Bentonite seal: bentonite chips/pellets	47.97 ft^3
Transition filter pack: 20/40 silica sand	1.0 ft^3
Primary filter: 10/20 silica sand	5.75 ft^3
Backfill material: bentonite pellets + 10/20 sand	4.49 ft^3
Potable water	135 gallons (gal.)

ft^3 = cubic feet

8.0 POST-INSTALLATION ACTIVITIES

Following well installation, the well was developed and the wellhead was completed and surveyed. Development water collected in the cuttings pit was discharged on site on November 1 and 2, 2006 based upon approval by LANL. As of February 2007, further site restoration activities have not been performed.

8.1 Well Development

R-3i was developed intermittently between August 29 and September 12, 2005. The development crew initially bailed and swabbed the screened interval to help remove formation fines from the well. Approximately 90 gallons (gal.) of water were removed during swabbing and bailing. A Grundfos submersible pump was used for the final stage of well development. The pump intake was set within the screened interval at 218 ft bgs, and 925 gal. of water were removed.

Turbidity, pH, temperature, specific conductance, and total organic carbon (TOC) were measured during development; these parameters were required to stabilize before terminating well development. The parameters stabilized over approximately 9 hours (hrs). The final turbidity reading was 0.92 nephelometric turbidity units (NTUs) and the TOC level was <1 ppm, less than the target TOC concentration of 2.0 ppm. Table 8.1-1 shows the volume of water removed during well development and the resultant water quality parameters and TOC levels. Figure 8.1-1 shows the water quality parameters measured during the course of well development.

Table 8.1-1
Final Water Quality Parameters

Method	Water Removed (gal.)	pH	Temper-ature (°Celsius)	Specific Conductance (µS/cm)	Turbidity (NTUs)	Total Organic Carbon (ppm)
Bailing/Swabbing	90	8.03	18.8	329.4	>999	NM
Pumping	925	7.87	16.5	473	0.92	<1

µS/cm = microSiemens per centimeter
NM = not measured
NTU = nephelometric turbidity units

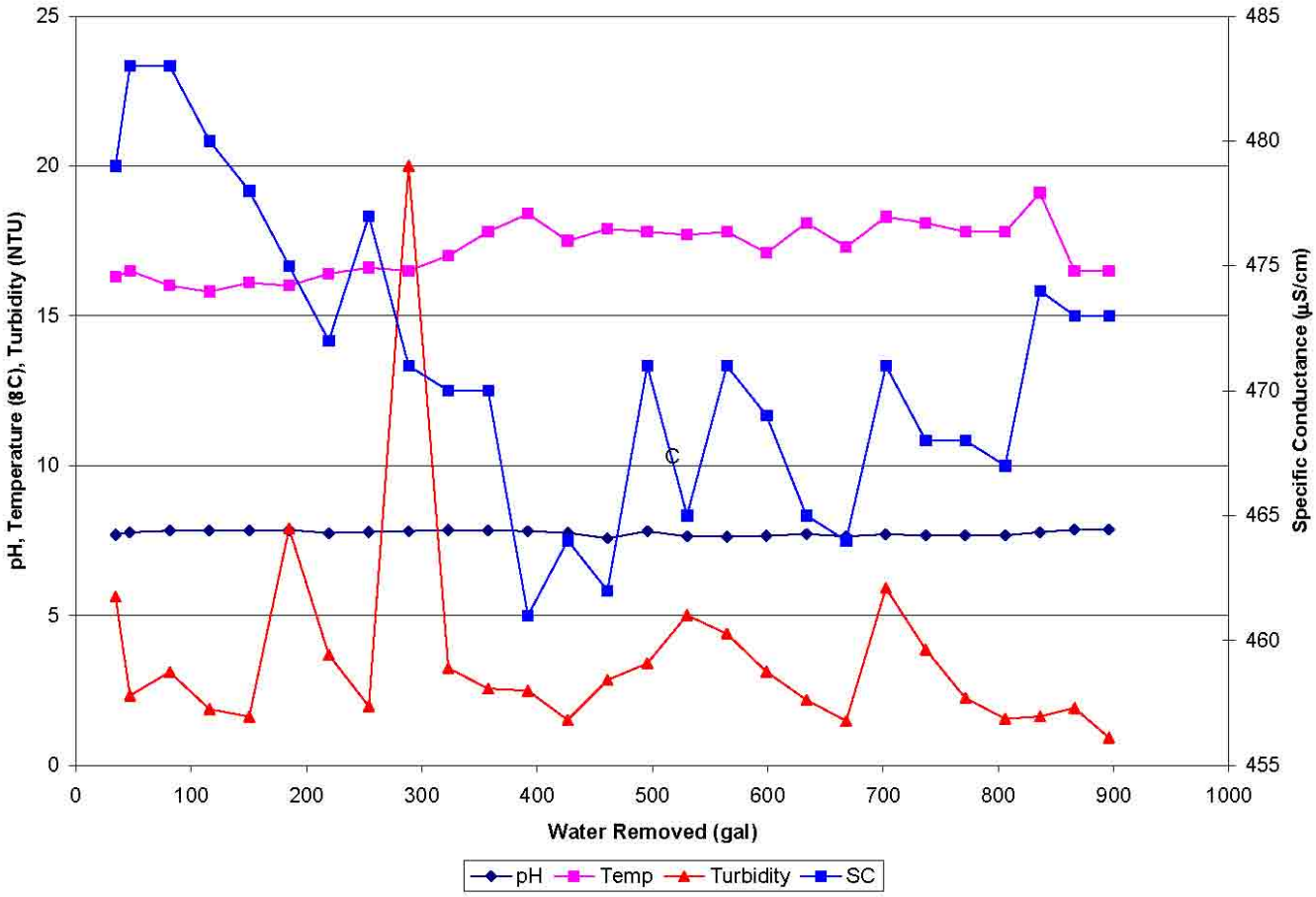


Figure 8.1-1.
Water Quality Parameters During Development

8.2 Aquifer Testing

An aquifer test was not planned for R-3i; therefore, as of February 2007 one has not been performed.

8.3 Dedicated Sampling System Installation

As of February 2007, neither a pump nor a transducer has been installed. LANL will install both in 2007. R-3i is currently being sampled with a portable Bennett pump.

8.4 Wellhead Completion

A reinforced 4,000 pounds per square inch concrete pad, 5 ft by 5 ft by 6 in. thick, was installed around the well casing to provide long-term structural integrity for the well and to prevent surface water from flowing down the outside of the casing. A brass survey pin was embedded in the northwest corner of the pad. A 4-in. by 4-in. square steel casing with a locking lid was installed to protect the well riser. The concrete pad was elevated slightly above the ground surface, with base-course gravel graded up around the edges.

8.5 Geodetic Survey

Table 8.5-1 presents the geodetic survey data for R-3i.

Table 8.5-1
Geodetic Data

Description	Northing	Easting	Elevation[a]
Brass cap in R-3i pad	1772599.19	1649196.45	6390.15
Top of PVC well casing	1772597.14	1649196.57	6392.79
Ground surface beside pad	1772601.22	1649196.59	6389.56

[a] Measured in feet above mean sea level relative to the National Geodetic Vertical Datum of 1929.

8.6 Site Restoration

Fluids produced during drilling and development were containerized and sampled in accordance with the July 12, 2005 "Waste Characterization Strategy Form" prepared for the 2005 well drilling program at LANL (Appendix C in Kleinfelder 2005a). Fluid sample results were compared to the State of New Mexico Water Quality Control Commission Regulation 3103 groundwater standards and applicable Resource Conservation and Recovery Act regulatory limits. Water generated during development was discharged on-site on November 1 and 2, 2006 in accordance with the "Workplan Notice of Intent Decision Tree," revised July 15, 2002, and in coordination with NMED.

Site restoration is pending a waste determination of the soil cuttings. Once a disposal option is selected, site restoration will be completed. Remaining activities will include backfilling the pit, removing the silt fencing, and reseeding the disturbed portions of the site.

9.0 DEVIATIONS FROM PLANNED ACTIVITIES

Appendix E compares the actual drilling and well construction activities at R-3i with the planned activities described in the Drilling Work Plan. In general, drilling, sampling, and well construction were performed as specified in the Drilling Work Plan. The main deviations from planned activities were:

- Planned Borehole Depth – The Drilling Work Plan called for the borehole to be drilled to a target TD of 300 ft bgs; it was drilled to a TD of 268.3 ft bgs after fully penetrating the Cerros del Rio basalt.
- Core Sampling – The Drilling Work Plan called for core samples to be submitted for laboratory analysis at 50-ft intervals below 100 ft bgs. However, dense basalt encountered at 100, 150 and 200 ft bgs was not submitted for analysis because contaminants would not be retained in the low porosity matrix. Instead, samples of clay filling vesicles and fractures in the basalt were submitted at 145.2, 213.3, and 243.3 ft bgs.

- Well Installation – The Drilling Work Plan did not specify that a well would be completed in the corehole.

10.0 ACKNOWLEDGEMENTS

D. Broxton and D. Vaniman of LANL worked with site geologists to identify the geologic contacts.

EnviroWorks, Inc. prepared the drill site.

P. Longmire of LANL evaluated the hydrochemistry.

Spectrum Exploration, Inc. drilled the R-3i corehole and installed the monitoring well.

11.0 REFERENCES

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NMED, 2005, Compliance Order on Consent between New Mexico Environmental Department and Los Alamos National Laboratory and the University of California, March 2005.

Appendix A

Lithologic Log

Geologic Unit	Lithologic Description	Interval (ft)	Elevation (ft amsl)
Quaternary Alluvium (Qal)	Gravelly silty/clayey sand, grayish orange (10YR 7/4), moderately- to well-sorted, non-indurated. Composed of: 50-60% sand, felsic, subangular to subrounded; 30-40% silt/clay; 5-10% gravel, inter. comp. volcanics (gray to brown, up to 4 mm, subrounded) and minor felsic crystals (predominately quartz, up to 2 mm, subrounded). Dry. Gravel percentage increases with depth. Note: Split spoon sampler used to collect core from 0-6.0 ft bgs; HQ coring used to advance and collect core below 6.0 ft bgs. • 1.6-2.0 ft, no recovery • 3.6-4.0 ft, no recovery • 5.7-6.0 ft, no recovery • 6.0-6.3 ft, not attempted	0-6.3	6389.56 - 6383.26
	Sandy gravel, moderate yellowish brown (10YR 5/4) to very light gray (N8), moderately- to poorly-sorted, non-indurated. Composed of: 55-70% sand, predominately felsic crystals with minor inter. comp. volcanics, subangular to subrounded; 30-40% gravel, predominately inter. comp. volcanics (brown to gray to light olive green, generally 2-6 mm, up to greater than 100 mm, subangular) with trace pumice (vitric, pale orange, up to 3 mm, rounded); 5-10% clay/silt. Dry. Gravel percentage decreases and silt percentage increases with depth. • 6.5-8.8 ft, no recovery • 10.7-12.3 ft, no recovery	6.3-12.3	6383.26 – 6377.26
	Silty/clayey sand, grayish orange (10YR 7/4), moderately- to well-sorted, non-indurated. Composed of: 55-65% sand, felsic, subangular to subrounded; 35-45% silt/clay; 0-2% gravel, predominately inter. comp. volcanics (gray to brown, up to 4 mm, subrounded) with minor felsic crystals (predominately quartz, up to 2 mm, subrounded). Dry.	12.3-12.8	6377.26 – 6376.76
	Sandy gravel, moderate yellowish brown (10YR 5/4) to very light gray (N8), moderately- to poorly-sorted, non-indurated. Composed of: 55-70% sand, predominately felsic crystals with minor inter. comp. volcanics, subangular to subrounded; 25-40% gravel, predominately inter. comp. volcanics (brown to gray, generally 2-6 mm, up to greater than 100 mm, subangular) with trace pumice (vitric, pale orange, up to 3 mm, rounded); 5-10% clay/silt. Dry. • 12.4-14.8 ft, no recovery • 16.5-17.3 ft, no recovery	12.8-17.3	6376.76 – 6372.26
	Gravel, medium dark gray (N4) to white (N9) to light brownish gray (5YR 6/1), poorly-sorted, non-indurated. Composed of: 90-100% gravel, predominately inter. comp. volcanics (gray to brown, sanidine phenocrysts) with minor welded tuff (pale orange to tan), generally 10-15 mm, up to 100 mm, subangular to rounded; 0-10% sand, felsic, subangular to subrounded. Dry. • 18.0-18.8 ft, no recovery • 21.1-22.3 ft, no recovery • 22.3-22.8 ft, dacitic boulder with plagioclase phenocrysts • 22.8-24.8 ft, no recovery • 25.5-27.3 ft, no recovery	17.3-27.3	6372.26 – 6362.26

Puye Formation (Tpf)	Sandy siltstone/claystone, pale yellowish brown (10YR 6/2), well-sorted, poorly- to moderately-indurated. Composed of: 80-85% silt/clay; 15% sand, predominately inter. comp. volcanics, subangular to subrounded; 0-5% gravel, predominately inter. comp. volcanics (medium to dark gray to brownish gray, generally 3-5 mm, subangular to subrounded) with minor pumice (altered, light gray, generally 2 mm, subrounded to rounded). Damp. Gravel percentage increases with depth. Root casts observed throughout, possible paleosol. • 28.0-29.8 ft, no recovery	27.3-32.3	6362.26 – 6357.26
	Siltstone, pale yellowish brown (10YR 6/2), poorly- to moderately-sorted, moderately-indurated. Composed of: 95% silt; 5% sand, predominately felsic, subangular to subrounded. Damp.	32.3-33.5	6357.26 – 6356.06
	Gravelly silty/clayey sandstone, moderate yellowish brown (10YR 5/4), moderately-sorted, poorly-indurated. Composed of: 80-85% sand, predominately felsic crystals with inter. comp. volcanics, angular to subrounded; 10-15% gravel, inter. comp. volcanics, medium to dark gray to brownish gray, up to 10 mm, subangular to subrounded; 5% silt/clay. Damp. Gradational contact with overlying siltstone.	33.5-35.0	6356.06 – 6354.56
	Sandy siltstone/claystone, pale yellowish brown (10YR 6/2), well-sorted, poorly- to moderately-indurated. Composed of: 80-85% silt/clay; 15% sand, predominately inter. comp. volcanics, subangular to subrounded; 0-5% gravel, predominately inter. comp. volcanics (medium to dark gray to brownish gray, generally 3-5 mm, subangular to subrounded) with minor pumice (altered, light gray, up to 3 mm, subrounded to rounded). Damp. Root casts. • 35.3-38.6 ft, no recovery	35.0-38.6	6354.56 – 6350.96
	Gravelly silty/clayey sandstone, moderately yellowish brown (10YR 5/4), poorly-sorted, moderately-indurated. Composed of: 60% sand, predominately felsic crystals with minor inter. comp. volcanics, subangular to subrounded; 35% silt/clay; 5% gravel, predominately inter. comp. volcanics, up to 5 mm, subangular to subrounded. Damp. Numerous open root pores with thin brown clay linings. • 41.2-41.5 ft, no recovery • 44.0-44.3 ft, no recovery	38.6-44.3	6350.96 – 6345.26
	Gravelly sandy siltstone/claystone, pale yellowish brown (10YR 6/2), moderately-sorted, poorly- to moderately-indurated. Composed of: 80-85% silt/clay; 15% sand, predominately inter. comp. volcanics, subangular to subrounded; 0-5% gravel, predominately inter. comp. volcanics (medium to dark gray to brownish gray, generally 3-5 mm, subangular to subrounded) with minor pumice (altered, light gray, up to 3 mm, subrounded to rounded). Damp. Root casts. • 45.1-47.0 ft, no recovery	44.3-48.0	6345.26 – 6341.56
	Sandy silty/clayey conglomerate, light brown (5 YR 6/4 to 5YR 5/6), poorly-sorted, non-indurated. Composed of: 45-50% gravel, predominately inter. comp. volcanics with minor basalt, medium to very dark gray to brownish gray, up to 40 mm, angular to subangular; 25-30% silt/clay; 20-25% sand, felsic crystals and inter. comp. volcanics, subangular. Damp. • 49.8-52.8 ft, no recovery • 52.8-53.0 ft, not attempted due to lost circulation	48.0-53.0	6341.56 – 6336.56

Cerros del Rio Basalt (Tb4)	Basalt, medium dark gray (N4), vesicular. Composed of: aphanitic groundmass; 3-5% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral, altered with reddish brown rims. Damp (moist on collection and on freshly exposed surfaces). Fractures clay-lined (moderate orange pink (10R 7/4)). Note: Coring was not attempted from 52.8 to 55.0 ft due to lost circulation. The top of the Tb4 is interpolated to be at 53.0 ft bgs, based on gamma log. • 53.0-55.0 ft, not attempted due to lost circulation • 55.2-55.5 ft, basalt, as above, 70° fracture, 1-3 mm aperture, clay-filled • 56.0 ft, basalt, as above, 3° fracture, 1-3 mm aperture, clay-filled • 57.0 ft, basalt, as above, 3° fracture, 1-3 mm aperture, clay-filled • 57.6-58.3 ft, no recovery • 58.5-58.6 ft, basalt, as above, 30° fracture, 1 mm aperture, clay-filled. • 59.0-61.0 ft, basalt, as above, 80° fracture, 8 mm aperture, clay-filled, fracture intersects a clay-filled vesicle	53.0-61.3	6336.56 – 6328.26
	Interflow breccia, medium dark gray (N4), vesicular basalt rubble blocks. Basalt composed of: aphanitic groundmass; 3-5% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral, altered. Damp. Rubble blocks generally coated with clay (moderate orange pink (10R 7/4)). • 61.3-63.3 ft, no recovery • 66.5-68.3 ft, no recovery	61.3-68.3	6328.26 – 6321.26
	Basalt, medium dark gray (N4), vesicular. Composed of: aphanitic groundmass; 3-5% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral, altered with reddish brown rims. Damp. Fractures are clay-lined (moderate orange pink (10R 7/4)). • 69.8 ft, basalt, as above, 5° fracture, 1-3 mm aperture, clay-filled • 70.0-72.0 ft, basalt, as above, with increase in density and average size of vesicles • 72.0-72.5 ft, basalt, as above, 60° fracture, 1 mm aperture, clay-filled • 72.5-72.8 ft, basalt, as above, 75° fracture, 2 mm aperture, clay-filled • 75.3 ft, basalt, as above, 20° fracture, 3 mm aperture, clay-filled • 75.4-78.3 ft, basalt, as above, with decrease in vesicle density • 77.3 ft, basalt, as above, 15° fracture, 3 mm aperture, clay-filled	68.3-78.3	6321.26 – 6311.26

Cerro del Rio Basalt (Tb4)	Basalt, medium gray (N5), massive with minor vesicles. Composed of: aphanitic groundmass; 5-7% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral. Dry. Fractures are clay-filled (moderate orange pink (10R 7/4) to medium dark gray (N4)). • 78.3-78.5 ft, basalt, as above, 60° fracture, 1 mm aperture, clay-filled • 80.3 ft, linear vesicle tracks • 80.3-80.4 ft, basalt, as above, 45° fracture, 3 mm aperture, clay-filled • 80.5 ft, linear vesicle tracks • 81.2 ft, basalt, as above, 25° fracture, 0-5 mm aperture, clay-filled • 82.5 ft, basalt, as above, vesicle, clay-filled	78.3-82.5	6311.26 – 6307.06
	Interflow breccia, medium gray (N5), vesicular basalt rubble blocks. Basalt composed of: aphanitic groundmass; 5-7% olivine phenocrysts, moderate olive brown, 2 mm, anhedral. Damp. Rubble generally coated with clay (moderate orange pink (10R 7/4)). • 84.2-85.5 ft, no recovery	82.5-86.3	6307.06 – 6303.26
	Basalt, grayish black (N2), vesicular. Composed of: aphanitic groundmass; <1% olivine phenocrysts, moderate olive brown, 3-5 mm, anhedral. Damp. Fractures clay-filled (light brown (5YR 5/6). • 87.2-87.3 ft, basalt, as above, 30° fracture, 2 mm aperture, clay-filled • 88.6-93.3 ft, no recovery • 93.7 ft, basalt, as above, 25° fracture, 60 mm aperture, and 20 mm by 750 mm vesicle, clay-filled, trace felsic sand	86.3-95.0	6303.26 – 6294.56
	Basalt, medium dark gray (N4), massive with minor vesicles. Composed of: aphanitic groundmass; 2% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral, occasional altered reddish brown rims. Damp. Fractures clay-filled (moderate orange pink (5YR 8/4) to medium gray (N5)). • 97.1 ft, basalt, as above, 15° fracture, 2 mm aperture, clay-filled, clay has platy texture • 97.5-97.7 ft, basalt, as above, 50° fracture, 2 mm aperture, clay-lined	95.0-98.3	6294.56 – 6291.26
	Rubbleized basalt, possible interflow breccia, dark gray (N3), vesicular basalt rubble blocks. Basalt composed of: aphanitic groundmass, 1% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral. Damp. Rubble surfaces and fractures are clay-lined (light brown (5YR 5/6) to dark yellowish brown (10YR 4/2), waxy texture). Larger (>50 mm) vesicles have clay in bottom and/or blackish red alteration. Clay abundance decreases below 100.6 ft. • 100.6-102.8 ft, no recovery	98.3-105.4	6291.26 – 6284.16

Cerro del Rio Basalt (Tb4)	Basalt, medium dark gray (N4), massive with minor vesicles. Composed of: aphanitic groundmass; 2% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral, occasional altered reddish brown rims. Damp. Fractures clay-filled (moderate orange pink (5YR 8/4) to medium gray (N5)). • 106.5 ft, basalt, as above, 10° fracture, 3 mm aperture, clay-filled • 107.1 ft, basalt, as above, 15° fracture, 2 mm aperture, clay-filled • 107.3-107.8 ft, basalt, rubbleized zone, clay-rich • 107.8-108.2, basalt, as above, 85° fracture, 1 mm aperture, clay-filled • 109.6 ft, basalt, as above, 15° fracture, 2 mm aperture, clay-filled • 110.0 ft, basalt, as above, vesicles filled with laminated clay • 110.2-110.8 ft, basalt, rubbleized zone • 112.5 ft, basalt, as above, 20° fracture, 1 mm aperture, clay-filled • 114.1 ft, basalt, as above, 10° fracture, 1 mm aperture, clay-filled • 117.4-117.8 ft, no recovery	105.4-117.8	6284.16 – 6271.76
	Basalt, medium dark gray (N4), massive with minor vesicles. Composed of: aphanitic groundmass; <1% olivine phenocrysts, moderate olive brown, 1 mm, anhedral. Damp. Minor fractures, clay-lined (light brown (5YR 5/6) to dark yellowish brown (10YR 4/2) to moderate yellow (5Y 7/6)). • 123.9-124.0 ft, basalt, as above, 40° fracture, 2 mm aperture, clay-filled • 124.1-124.3 ft, basalt as above, 70° fracture, 2 mm aperture, clay-filled • 124.5 ft, basalt, as above, 5° fracture, 1 mm aperture, clay-filled • 130.9-132.0 ft, basalt, as above, 90° fracture, 4 mm aperture, clay-filled • 131.5-132.0 ft, basalt, as above, 90° fracture, 1-2 mm aperture, clay-filled	117.8-132.8	6271.76 – 6256.76
	Basalt, medium dark gray (N4), vesicular. Composed of: aphanitic groundmass; 2-3% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral. Damp. Fractures clay-lined (light brown (5YR 5/6) to medium gray (N5)). • 134.6-134.7 ft, basalt, as above, 40° fracture, 2 mm aperture, clay-filled	132.8-135.2	6256.76 – 6254.36
	Rubbleized basalt, possible interflow breccia, medium dark gray (N4), vesicular basalt rubble blocks. Basalt composed of: aphanitic groundmass, 2-3% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral. Damp. Rubble blocks are 10-50 mm, block surfaces are clay-coated (light brown (5YR 5/6) to medium gray (N5), up to 3 mm thick). • 136.0-137.8 ft, no recovery	135.2-137.8	6254.36 – 6251.76

Cerro del Rio Basalt (Tb4)	Basalt, medium dark gray (N4), vesicular. Composed of: aphanitic groundmass: 2-3% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral. Wet. Fractures clay-lined (light brown (5YR 5/6) to medium gray (N5)). • 137.8-138.0 ft, basalt, as above, 85° fracture, 5 mm aperture, clay-filled, medium gray clay is evenly distributed, light brown clay occurs in nodules with distinct laminations • 138.0 ft, basalt, as above, 30° fracture, 2 mm aperture, clay-filled as in 137.8-138.0 ft above • 141.6-141.8 ft, basalt, as above, 50 mm vesicle, clay-lined, individual olivine crystals (1-2 mm) on weathered surface, freshly broken surfaces expose water-filled vesicles • 142.1 ft, basalt, as abov3e, horizontal fracture, 3 mm aperture, clay-filled, intersects a 150 mm vug, clay-filled	137.8-145.2	6251.76 – 6244.36
	Rubbleized/highly-fractured basalt, possible interflow breccia, medium dark gray (N4), vesicular basalt rubble blocks. Basalt composed of: aphanitic groundmass; 2-3% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral. Damp. Rubble blocks are 30-120 mm, block surfaces are coated with clay (light brown (5YR 5/6) to medium gray (N5), up to 4 mm thick). Fracture orientations range from horizontal to 90°, 1-5 mm apertures, clay-filled (light brown (5YR 5/6)). Most prominent fractures are described below. • 146.4-146.8 ft, basalt, as above, 30° fracture, 4 mm aperture, clay-filled • 147.0-147.1 ft, basalt, as above, 10° fracture, 4 mm aperture, clay-filled • 147.4 ft, basalt, as above, horizontal fracture, 2 mm aperture, clay-filled	145.2-148.2	6244.36 – 6241.36
	Basalt, medium dark gray (N4), vesicular. Composed of: aphanitic groundmass; 2-3% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral. Damp. Fractures clay-lined (light brown (5YR 5/6) to moderate yellow (5Y 7/6)). • 150.2-150.6 ft, basalt, as above, 85° fracture, 2 mm aperture, clay-filled • 150.7-150.8 ft, basalt, as above, 50° fracture, 3 mm aperture, clay-filled • 151.9-152.0 ft, basalt, as above, 20° fracture, 1 mm aperture, clay-filled	148.2-155.7	6241.36 – 6233.86
	Basalt, medium dark gray (N4), massive with minor vesicles. Composed of: aphanitic groundmass; 2-3% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral. Damp. Fractures clay-lined (light brown (5YR 5/6)). • 156.2-156.9 ft, basalt, as above, 60° fracture, 1 mm aperture, clay-filled • 156.7-157.0 ft, basalt, as above, 60° fracture, 1 mm aperture, clay-filled • 157.2 ft, basalt, as above, vesicle, 3 mm, clay-filled, clay is laminated	155.7-159.2	6233.86 – 6230.36

Cerro del Rio Basalt (Tb4)	Rubbleized/highly fractured basalt, possible interflow breccia, medium dark gray (N4), vesicular basalt rubble blocks. Basalt composed of: aphanitic groundmass; 2-3% olivine phenocrysts, moderate olive brown, 1-3 mm, anhedral. Damp. Rubble blocks and fractures clay-coated (light brown (5YR 5/6) to moderate yellow (5Y 7/6)). Most prominent fractures are described below. • 162.3 ft, basalt, as above, horizontal fracture, 2 mm aperture, vesicles open to fracture are clay filled, clay has waxy texture and is laminated • 162.4 ft, basalt, as above, horizontal fracture, 2 mm aperture, vesicles open to fracture are clay filled, clay has waxy texture and is laminated • 162.9 ft, basalt, as above, horizontal fracture, 5 mm aperture, clay-filled, clay has waxy texture • 163.2-167.1 ft, no recovery • 167.6-168.3 ft, no recovery	159.2-170.0	6230.36 – 6219.56
	Basalt, medium dark gray (N4), massive with minor vesicles. Composed of: aphanitic groundmass; 1% olivine phenocrysts, moderate olive green, 1-2 mm, anhedral. Damp. Minor fractures, clay-filled (light brown (5YR 5/6) to olive gray (5Y 4/1)). • 172.6-173.3, no recovery	170.0-173.6	6219.56 – 6215.96
	Rubbleized/highly-fractured basalt, possible interflow breccia, medium dark gray (N4), vesicular basalt rubble blocks. Basalt composed of: aphanitic groundmass, 2-3% olivine phenocrysts, moderate olive brown, 1-2 mm, anhedral. Damp. Rubble blocks are 5-180 mm, block surfaces and fractures are clay-coated (light brown (5YR 5/6)). Fracture orientations range from horizontal to 80°, 1-8 mm apertures. Most prominent fractures are described below. • 174.4-175.6 ft, no recovery • 176.5-177.4 ft, no recovery • 181.0-181.6, basalt, as above, 80° fracture, 1 mm aperture, clay-filled • 181.6-183.3 ft, no recovery • 183.5 ft, basalt, as above, 2 mm aperture, clay-filled • 183.9-184.0 ft, basalt, as above, 3 mm aperture, clay-filled • 185.9-186.0 ft, basalt, as above, 65° fracture, 5 mm aperture, clay-filled • 186.5 ft, basalt, as above, horizontal fracture, 3 mm aperture, clay-filled • 186.9-188.0 ft, no recovery	173.6-188.0	6215.96 – 6201.56

Cerro del Rio Basalt (Tb4)	Basalt, dark gray (N3), massive with minor vesicles and common fractures. Composed of aphanitic groundmass; 1-2% olivine phenocrysts, moderate olive green, 1-2 mm, anhedral. Wet. Fractures clay-coated to clay-filled (light brown (5YR 5/6) to brownish black (5YR 2/1)). Dark reddish brown alteration around some vesicles. Note: From 190.0-208.3 ft, basalt is collected as rubbleized/fractured blocks rather than as continuous core. • 188.0-188.3 ft, no recovery • 190.0-190.1 ft, basalt, as above, 20° fracture, 3 mm aperture, clay-filled • 191.4-191.6 ft, basalt, as above, 70° fracture, 3 mm aperture, clay-filled • 191.9-193.3 ft, no recovery • 195.3-195.8 ft, basalt, as above, 8° fracture, 3 mm aperture, clay-filled, clay is saturated • 195.8-197.3 ft, no recovery • 197.7 ft, basalt, as above, horizontal fracture, 3 mm aperture, clay-coated • 199.3-199.7 ft, basalt, as above, 1 mm aperture, trace clay • 200.5-200.7 ft, basalt, as above, 60° fracture, 2 mm aperture, trace clay • 201.2 ft, basalt, as above, clay-lined vesicle • 201.3, basalt, as above, horizontal fracture, 4 mm aperture, trace clay • 203.1-203.3 ft, no recovery • 203.6 ft, basalt, as above, clay-filled vesicles • 205.0-205.1 ft, basalt, as above, 70° fracture, 3 mm aperture, clay-filled • 206.4-206.5 ft, basalt, as above, 50° fracture, 5 mm aperture, clay-filled • 208.7-208.3 ft, no recovery	188.0-208.3	6201.56 – 6181.26
	Basalt, medium dark gray (N4), vesicular. Composed of: aphanitic groundmass; 1-2% olivine phenocrysts, moderate olive green, 1-2 mm, anhedral. Wet. Fractures and some vesicles are clay-coated to clay-filled (light brown (5YR 6/4) to brownish black (5YR2/1)). • 210.8-211.0 ft, basalt, as above, 45° fracture, 2 mm aperture, clay-filled • 211.3-211.5 ft, basalt, as above, 45° fracture, 3 mm aperture, clay-filled • 212.1-213.3 ft, no recovery • 213.8-214.1 ft, basalt, as above, horizontal fracture, 100 mm aperture, clay-filled, clay is damp • 215.1-215.2 ft, basalt, as above, 25° fracture, 5 mm aperture, clay-filled • 215.0-220.0, basalt, as above, vesicles up to 100 mm • 215.8-218.3, no recovery • 219.6-219.8, basalt, as above, 40° fracture, 4 mm aperture, clay-filled	208.3-220.5	6181.26 – 6169.06

Cerro del Rio Basalt (Tb4)	Basalt, medium dark gray (N4), massive with minor vesicles. Composed of : aphanitic groundmass; 1% olivine phenocrysts, moderate olive brown, 1-2 mm, anhedral. Wet. Fractures clay-filled (light brown (5YR 6/4) to brownish black (5YR 2/1), damp). • 221.1-221.2 ft, basalt, as above, 30° fracture, 2 mm aperture, clay-filled • 222.5-223.3 ft, no recovery • 223.55-224.0 ft, basalt, as above, horizontal fracture, 150 mm, clay-filled, clay has waxy texture • 224.6-225.0 ft, basalt, as above, 50° fracture, 2 mm aperture, trace clay • 225.5-225.6 ft, basalt, as above, 15° fracture, 2 mm aperture, tract clay • 226.9 ft, basalt, as above, 15° fracture, 2 mm aperture • 227.4-227.5, basalt, as above, 40° fracture, 2 mm aperture, trace clay	220.5-231.2	6169.06 – 6158.36
	Interflow breccia, medium dark gray (N4), vesicular basalt rubble blocks. Basalt composed of: aphanitic groundmass; 1% olivine phenocrysts, moderate olive brown, 1-2 mm, anhedral. Wet. Rubble blocks are coated with clay (light brown (5YR 4/4)). • 232.2-233.3 ft, no recovery	231.2-234.2	6158.36 – 6155.36
	Basalt, medium dark gray (N4), vesicular. Composed of: aphanitic groundmass; 1% olivine phenocrysts, moderate olive brown, 1-2 mm, anhedral. Wet. Some vesicles clay-coated (light brown (5YR 6/4) to brownish black (5YR 2/1)).	234.2-239.3	6155.36 – 6150.26
Cerros del Rio Maar (Tb4)	Maar deposit, medium dark gray (N4), well sorted, moderately-indurated. Composed of: 100% basaltic glass, medium dark gray, up to 2 mm, subrounded to rounded, minor reddish brown alteration of individual grains; <1% crystals, clear, up to 1 mm, subangular. Damp. Laminated.	239.3-240.0	6150.26 – 6149.56
Puye Formation (Tpf)	Silty/clayey sandstone, moderate yellowish brown (10YR 5/4), moderately-sorted, poorly-indurated. Composed of: 77% sand, predominately felsic with minor inter. comp. volcanics (gray to grayish brown) and trace pumice (white to pale yellowish orange), subangular to subrounded; 20% silt/clay; 3% gravel, predominantly inter. comp. volcanics (gray to grayish brown) with trace pumice (vitric, white to pale yellowish orange, altered), up to 10 mm, subrounded to rounded. Damp. Apparent increase in gravel percentage with depth. • 240.7-243.3 ft, no recovery • 245.0-248.3 ft, no recovery • 248.7-265.8 ft, no recovery • 253.3 ft, cobble encountered during drilling • 256.0 ft, boulder encountered during drilling	240.0-265.8	6149.56 – 6123.76
	Gravelly silty/clayey sandstone, dark yellowish brown (10YR 4.2), poorly sorted, non-indurated. Composed of: 55% sand, felsic and inter. comp. volcanics (medium gray to grayish brown to light brown), subrounded; 25% silt/clay; 20% gravel, inter. comp. volcanics (medium gray to grayish brown to light brown, felsic and rare biotite phenocrysts), up to 40 mm, subrounded. Damp. Note: drilling behavior (erratic "clanking" and difficulty advancing) suggests presence of cobbles, although no cobbles were recovered. • 266.3-268.3 ft, no recovery	265.8-268.3	6123.76 - 6121.26

	TOTAL DEPTH OF COREHOLE IS 268.3 FT BGS.		

References

Dutro, J. T., Dietrich, R. V., and Foose, R. M., 1989, American Geological Institute. Data Sheets, 3rd Edition.
Geological Society of America, 1995, Rock-Color Chart, 8th Printing.
Tucker, M.E., 1991, Sedimentary Petrology, An Introduction to the Origin of Sedimentary Rocks, Blackwell Science Limited.

Classification System

Field geologists used principles identified in the AGI Data Sheets (Dutro, J. T, et al., 1989) to describe lithology. Specifically, AGI Data Sheets 32.1, 32.2 as well 29.1 (the modified Wentworth scale for grain-size classification) were used for sedimentary units. The AGI approach was augmented by the classification system presented in Sedimentary Petrology, An Introduction to the Origin of Sedimentary Rocks (Tucker, 1991).

Groundwater Occurrences

Please refer to section 6.0 of the report for a description of groundwater occurrences.

Appendix B

Groundwater Analytical Results

1.0 SAMPLING AND ANALYSIS OF GROUNDWATER AT R-3i

Shallow alluvial and perched intermediate groundwater was encountered at R-3i. Four screening groundwater samples were collected during drilling from the intermediate zone and one sample was collected from the completed well near the end of development. No groundwater samples were collected from the alluvium, because multiple samples have been collected from nearby alluvial wells, including APCO-1. Screening groundwater samples were collected from the borehole at depths of 177.2, 184.3, 192.5, and 213.9 feet below ground surface (bgs). The groundwater samples were analyzed for anions, including perchlorate, cations and metals. The groundwater sample obtained at the end of well development was collected within the screened interval (215 and 220 ft bgs) at R-3i. During well development, a water sample was submitted for total organic carbon (TOC) analysis, even though the well was drilled without fluid additives.

1.1 Analytical Techniques

Groundwater samples were filtered prior to analyses for metals, trace elements, and major cations and anions. Aliquots of the samples were filtered through 0.45-micrometer membranes. Samples were acidified with analytical grade nitric acid to a pH of 2.0 or less for metal and major cation analyses. Total carbonate alkalinity was measured at Los Alamos National Laboratory's Earth and Environmental Sciences Group 6 (EES-6) using standard titration techniques. Samples collected for TOC analyses were not filtered.

Groundwater samples were analyzed by EES-6 using techniques specified in the US Environmental Protection Agency SW-846 manual. Ion chromatography (IC) was the analytical method for bromide, chloride, fluoride, nitrate, nitrite, oxalate, perchlorate, phosphate, and sulfate. The instrument detection limits (IDLs) for perchlorate analyses were 0.002 and 0.005 parts per million (ppm) for the screening groundwater samples.

Inductively coupled (argon) plasma optical emission spectroscopy (ICPOES) was used for analyses of calcium, iron, magnesium, potassium, silica, and sodium. Aluminum, antimony, arsenic, barium, beryllium, cadmium, cesium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, nickel, rubidium, selenium, silver, thallium, thorium, tin, vanadium, uranium, and zinc were analyzed by inductively coupled (argon) plasma mass spectrometry (ICPMS). The precision limits (analytical error) for major ions and trace elements were generally less than ±10% using ICPOES and ICPMS.

1.2 Analytical Results

Analytical results for groundwater samples collected at R-3i are provided in Table 1.2-1.

Boron was detected at concentrations ranging from 0.078 to 0.21 ppm in the perched intermediate zone screening samples during drilling and at 0.096 ppm in a groundwater sample collected at the end of well development at R-3i.

Chromium was not detected (<0.001 ppm) in the perched intermediate zone screening samples collected during drilling and at the end of well development at R-3i.

Mercury was detected at concentrations ranging from 0.0064 to 0.026 ppm in the perched intermediate zone screening samples during drilling and at 0.00008 ppm in a groundwater sample collected at the end of well development at R-3i.

Nitrate (as N) was detected at concentrations ranging from 3.0 to 4.07 ppm in the perched intermediate zone screening samples during drilling and at 3.87 ppm in a groundwater sample collected at the end of well development at R-3i.

Perchlorate was not detected in the perched intermediate zone screening samples from borehole R-3i, but was tentatively detected at a concentration of 0.0013 ppm in a sample collected after well development.

Uranium was detected at concentrations ranging from 0.0032 to 0.0052 ppm in the perched intermediate zone screening samples during drilling and at 0.0057 ppm in a groundwater sample collected at the end of well development at R-3i.

The concentration of TOC was less than analytical detection (1 ppm) in a sample collected after well development. This sample had a turbidity value of 0.92 nephelometric turbidity units (NTU).

Table 1.2-1. Hydrochemistry of Groundwater Samples Collected from Intermediate Groundwater at R-3i (filtered samples, except as noted)

SAMPLE ID	EU05070GR3101	EU05070GR3102	EU05070GR3103	EU05070GR3104	EU05090G3iR01
SAMPLE TYPE	During drilling	During drilling	During drilling	During Drilling	After development
DEPTH (ft bgs)	184.3	177.2	213.9	192.5	215 to 220
WATER-BEARING UNIT	Perched intermediate	Perched intermediate	Perched intermediate	Perched intermediate	Perched intermediate
GEOLOGIC UNIT	Cerros del Rio basalt	Cerros del Rio basalt	Cerros del Rio basalt	Cerros del Rio basalt	Cerros del Rio basalt
DATE	08/10/05	08/112/05	08/18/05	08/14/05	09/12/05
Charge Balance (%)	-1.71	-5.0	-3.84	-2.29	-1.71
Specific Conductance (µS/cm)	Not measured	Not measured	Not measured	Not measured	473
Temperature (°C)	Not measured	Not measured	Measured	Not measured	16.5
pH (Field)	Not measured	Not measured	Not measured	Not measured	7.87
pH (Lab)	7.64	7.51	7.44	7.82	7.63
Ag (ppm)	U [0.001]	U [0.001]	U [0.001]	U [0.001]	U [0.001]
Al (ppm)	U [0.002]	U [0.002]	U [0.002]	U [0.002]	0.004
Alkalinity (ppm $CaCO_3$/L)	140	144	128	136	148
As (ppm)	0.0013	0.0008	0.0005	0.0006	0.0008
B (ppm)	0.14	0.095	0.21	0.078	0.096
Ba (ppm)	0.067	0.038	0.035	0.11	0.084
Be (ppm)	U [0.001]	U [0.001]	U [0.001]	U [0.001]	U [0.001]
Br (ppm)	0.12	0.14	0.13	0.15	0.18
Ca (ppm)	43.2	44.2	38.5	44.3	50.8
Cd (ppm)	U [0.001]	U [0.001]	U [0.001]	U [0.001]	U [0.001]
Cl (ppm)	41.7	36.6	33.4	38.0	38.3
ClO_4 (ppm)	U [0.005]	U [0.002]	U [0.002]	U [0.002]	0.0013
Co (ppm)	0.0031	0.0015	U [0.001]	0.0014	U [0.001]
CO_3 (ppm)	0	0	0	0	0
Cr – Total (ppm)	U [0.001]	U [0.001]	U [0.001]	U [0.001]	U [0.001]
Cs (ppm)	U [0.001]	U [0.001]	U [0.001]	U [0.001]	U [0.001]
Cu (ppm)	0.0045	0.0053	0.0016	0.0026	0.0013
F (ppm)	0.63	0.74	0.84	0.52	0.32
Fe (ppm)	U [0.01]	U [0.01]	U [0.01]	U [0.01]	U [0.01]
HCO_3 (ppm)	171	176	156	166	181
Hg (ppm)	0.024	0.0085	0.026	0.0064	0.00008
K (ppm)	7.23	4.42	4.72	6.82	5.04
Li (ppm)	0.033	0.026	0.038	0.013	0.014
Mg (ppm)	12.9	13.2	11.4	13.1	14.3
Mn (ppm)	0.10	0.14	0.15	0.25	0.0038
Mo (ppm)	0.008	0.039	0.19	0.058	0.0016
Na (ppm)	29.3	19.0	20.8	24.1	21.6
Ni (ppm)	0.012	0.011	0.0081	0.012	0.0077
NO_2(as N) (ppm)	0.073	U [0.003]	0.046	U [0.003]	U [0.003]
NO_3(as N) (ppm)	3.52	3.42	3.0	4.07	3.87
C_2O_4 (ppm)(oxalate)	0.02	U [0.01]	U [0.01]	U [0.01]	U [0.01]
Pb (ppm)	U [0.0002]	U [0.0002]	U [0.0002]	U [0.0002]	0.0006
PO_4 (ppm)	0.49	0.14	U [0.01]	0.04	0.09
Rb (ppm)	0.016	0.0097	0.010	0.015	0.013
Sb (ppm)	0.0015	0.0027	0.0019	U [0.001]	U [0.001]
Se (ppm)	0.0012	0.0011	U [0.001]	0.0014	U [0.001]
SiO_2 (ppm)	48.5	36.1	19.2	37.1	49.2
SO_4 (ppm)	27.4	23.4	21.2	30.3	29.4
Sn (ppm)	U [0.001]	U [0.001]	U [0.001]	U [0.001]	U [0.001]
Sr (ppm)	0.21	0.21	0.18	0.24	0.26
Th (ppm)	U [0.001]	0.004	U [0.001]	U [0.001]	U [0.001]
Ti (ppm)	U [0.001]	U [0.001]	U [0.001]	U [0.001]	U [0.001]
Tl (ppm)	U [0.001]	U [0.001]	U [0.001]	U [0.001]	U [0.001]
U (ppm)	0.0048	0.0050	0.0032	0.0052	0.0057
V (ppm)	0.004	0.002	U [0.001]	U [0.001]	0.004
Zn (ppm)	0.027	0.036	0.024	0.005	0.018
TOC (ppm) (non-filtered, NF)	Not analyzed	Not analyzed	Not analyzed	Not analyzed	U, [1]
Turbidity (NTU) (NF)	Not measured	Not measured	Not measured	Not measured	0.92
TDS (calculated)	398.9	369.7	320.4	379.2	408.0

Notes: U = Undetected at the IDL shown in brackets. Bicarbonate (HCO_3) concentrations were calculated from measured total carbonate alkalinity. Silica was calculated from concentration of silicon. µS/cm means microSiemens per centimeter. NTU means nephelometric turbidity units.

Appendix C

Borehole Video Log

Appendix D

Geophysical Logging Files

Geophysical logging spreadsheets and charts are located on the final report CD.

Appendix E
Deviations from Planned Activities

Activity	Drilling Work Plan for R-3i (Kleinfelder 2005a)	R-3i Actual Work
Planned Depth	Target total depth (TD) of 300 feet (ft) below ground surface (bgs).	R-3i was drilled to 268.3 ft bgs after fully penetrating the Cerros del Rio basalt.
Drilling Method	Air coring rig.	Drilled with an air coring rig.
Amount of Core	Coring to be collected continuously.	Continuous core was collected.
Screening Water Samples for Contaminant Analysis	If perched water is encountered in the unsaturated zone, groundwater samples are to be collected from each perched zone for screening analysis.	Four screening groundwater samples were collected during drilling.
Groundwater Samples Collected During Well Development	Samples to be collected daily during well development and submitted for Total Organic Carbon (TOC) analysis.	One TOC sample was analyzed during the pumping phase of well development, which took 3 days.
Post-Well Development Groundwater Sample	One groundwater sample to be collected following well development	A final water sample was collected immediately after well development was complete.
Water Sample Analysis	Groundwater samples to be analyzed for anions, cations (including perchlorate).	Screening and final groundwater samples were submitted for analysis of anions, cations (including perchlorate) and metals.
Core Samples to be Collected for Contaminant Analysis	Core samples to be collected every 10 ft to 100 ft bgs, at 50-ft intervals thereafter.	Core samples were collected for contaminant analysis as specified, except clay filling vesicles/fractures from 145.2, 213.3 and 243.3 ft bgs was submitted for analysis rather than basalt core because the low matrix porosity would not retain contaminants.
Geophysics	Natural gamma and array induction to be conducted.	Logged as specified.
Water Level Measurements	Water levels to be determined for each saturated zone by water level meter or video camera.	Electric water level meter and video camera used to identify zones of perched saturation.
Well Installation	Not planned. The R-3 corehole was to be backfilled after reaching TD.	A 2-in well was installed in the corehole due to the presence of perched water.